# Identify the building blocks

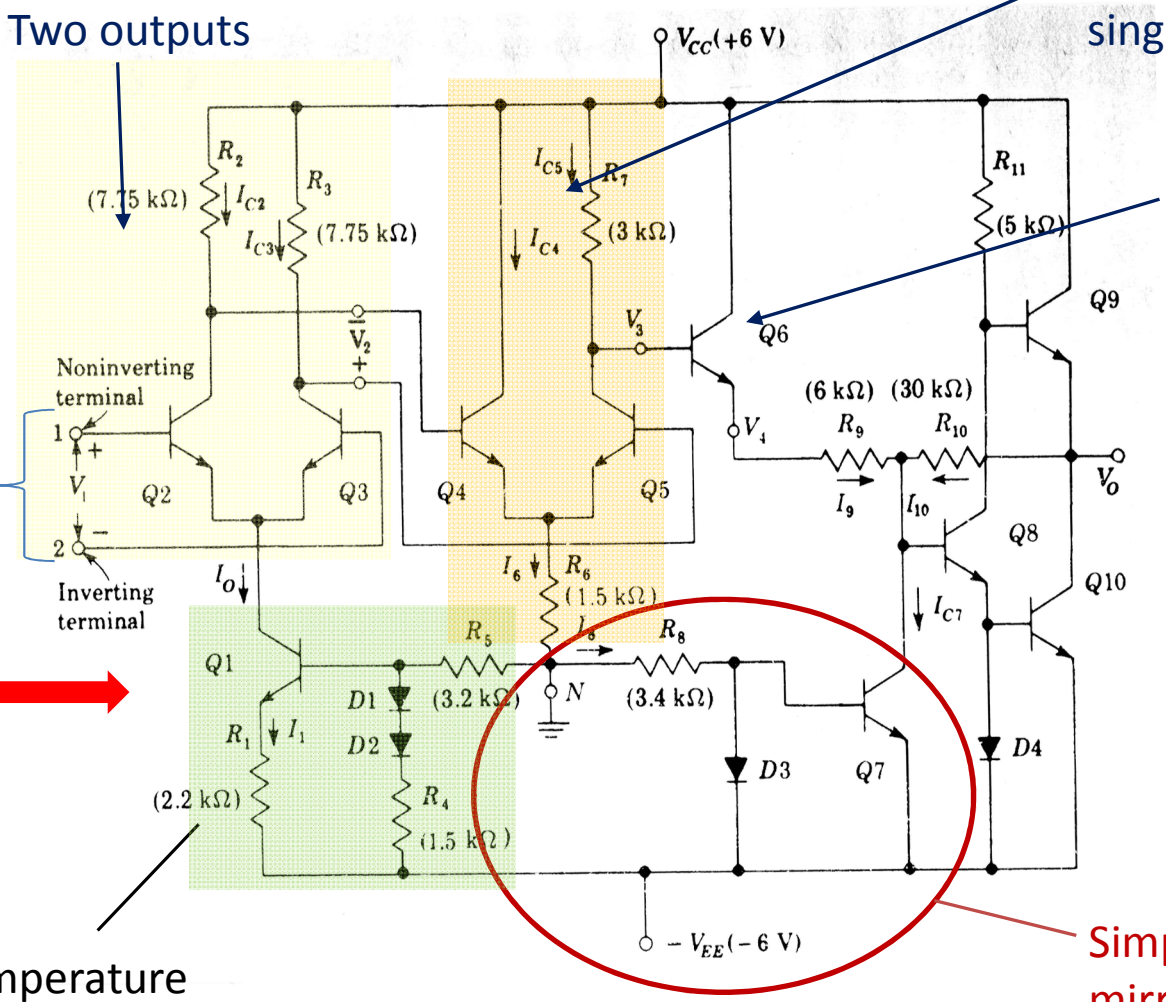
Differential amplifier
Two outputs

Differential amplifier
single output

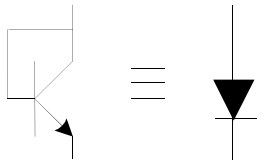
Emitter-follower to 'match' the stages

Two inputs

Ensures a good CMRR - Rejects the CM signals



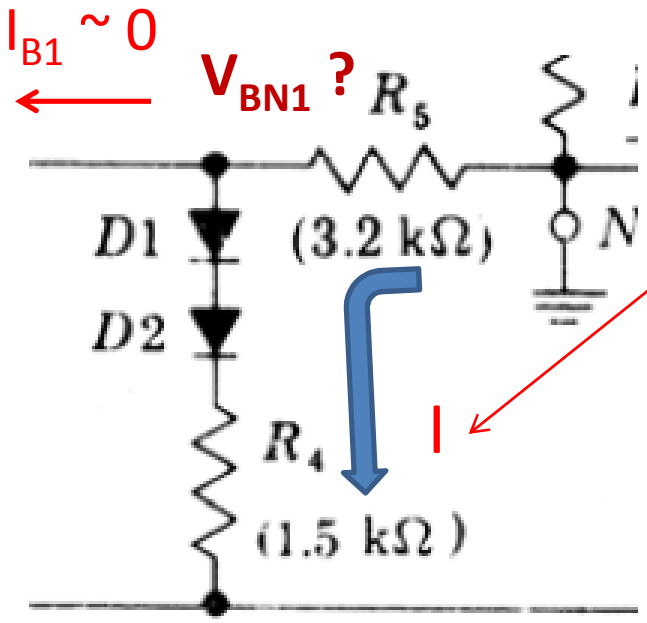

- Identify building blocks
- Perform a d.c. analysis
- Perform an a.c. analysis



Temperature compensated current source

Simple current mirror

# i) Voltage at base of Q1




$V_{EE}$ = -6V

Voltage drop across resistors?

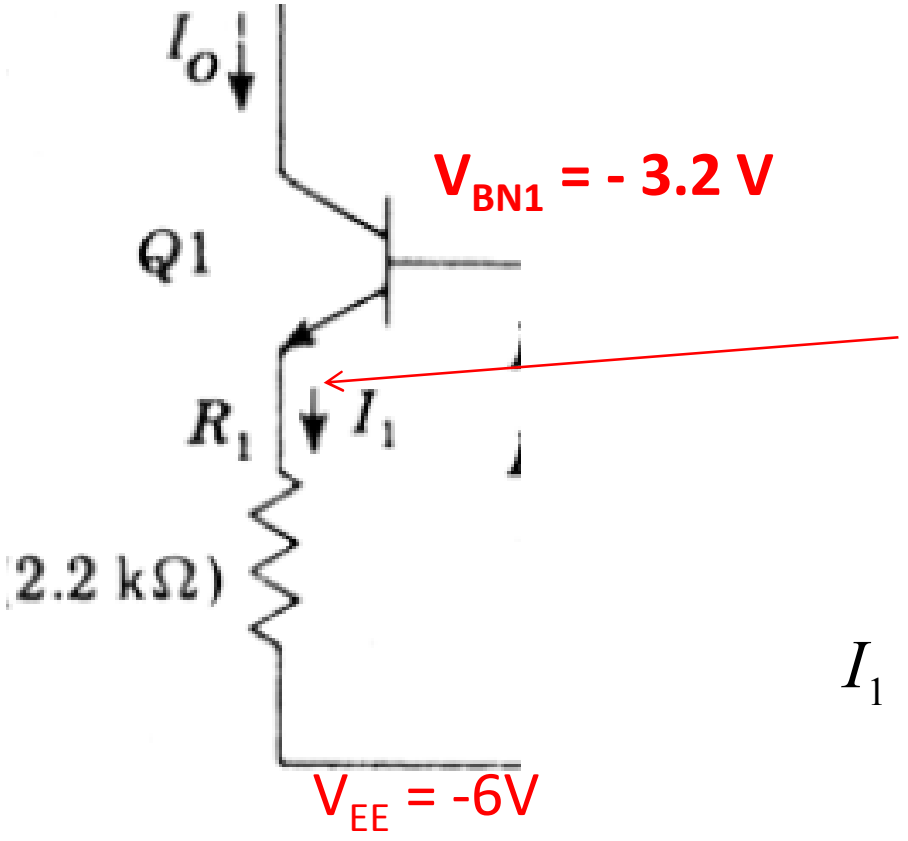
6V – 0.6V – 0.6V = 4.8V

$$I = \frac{6 - 0.6 - 0.6}{3.2k + 1.5k} \approx 1mA$$

$$V_{BN1} = -IR_5 = -1mA \times 3.2k$$
$$= -3.2V$$

**$V_{BN1}$ = - 3.2V**

# ii) $I_1$ , $I_O$




Voltage at emitter of $Q_1$ ?

$$V_E = V_{BN1} - 0.6$$

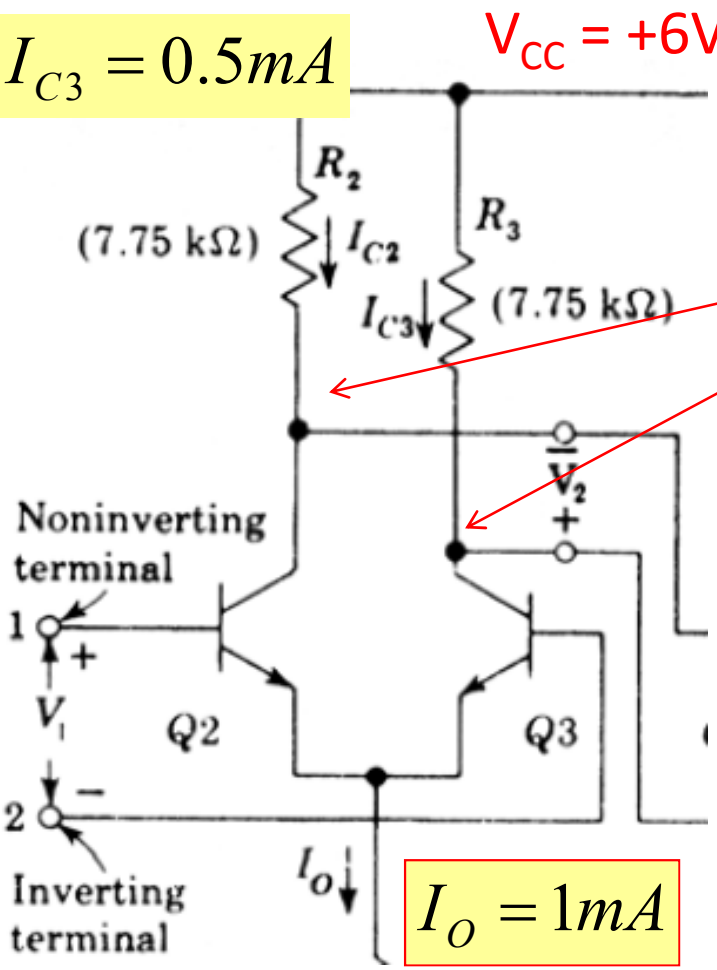
$$V_E = -3.8V$$

$$I_1 = \frac{-3.8-(-6)}{2.2k} = \frac{2.2}{2.2k}$$

$$\boxed{I_1 = 1mA \sim I_O}$$

# ii) contd. $I_{C2} = I_{C3}$?,
# iii) voltage at base of $Q_4$? ($V_{O1,2}$)

$$I_{C2} = I_{C3} = 0.5mA$$




$$I_O = 1mA$$

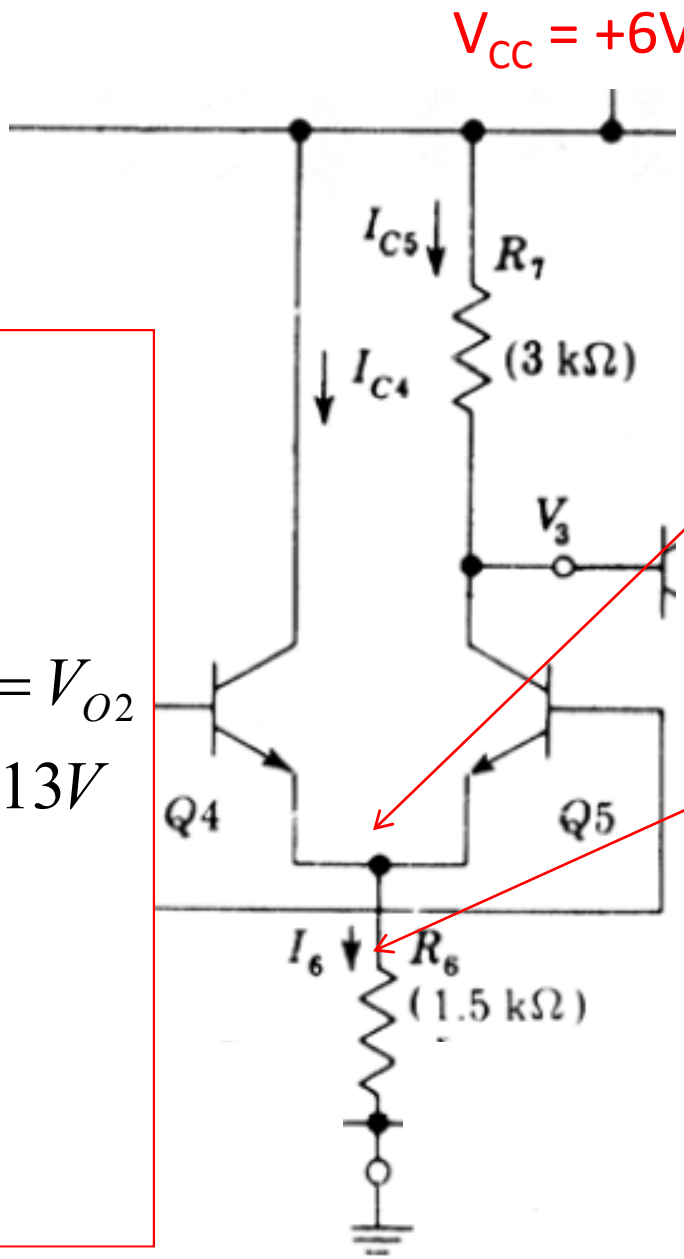
$V_{O1}$ ?

Voltage drop across $R_2$?

$$V_{O1} = V_{O2} = 6 - I_{C2,3} \times 7.75k$$

$$V_{O1} = V_{O2} = 6 - 0.5mA \times 7.75k$$

$$V_{O1} = V_{O2} = 2.13V$$




$$V_{O1} = V_{O2} = 2.13V$$

# iv) $I_{C4}$, $I_{C5}$ ?

Voltage at emitter of $Q_{4,5}$ ?

$$V_{O1} - 0.6$$

$$= 2.13 - 0.6 = 1.53V$$

$I_6$ ?

$$I_6 = \frac{1.53}{1.5k} \approx 1mA$$

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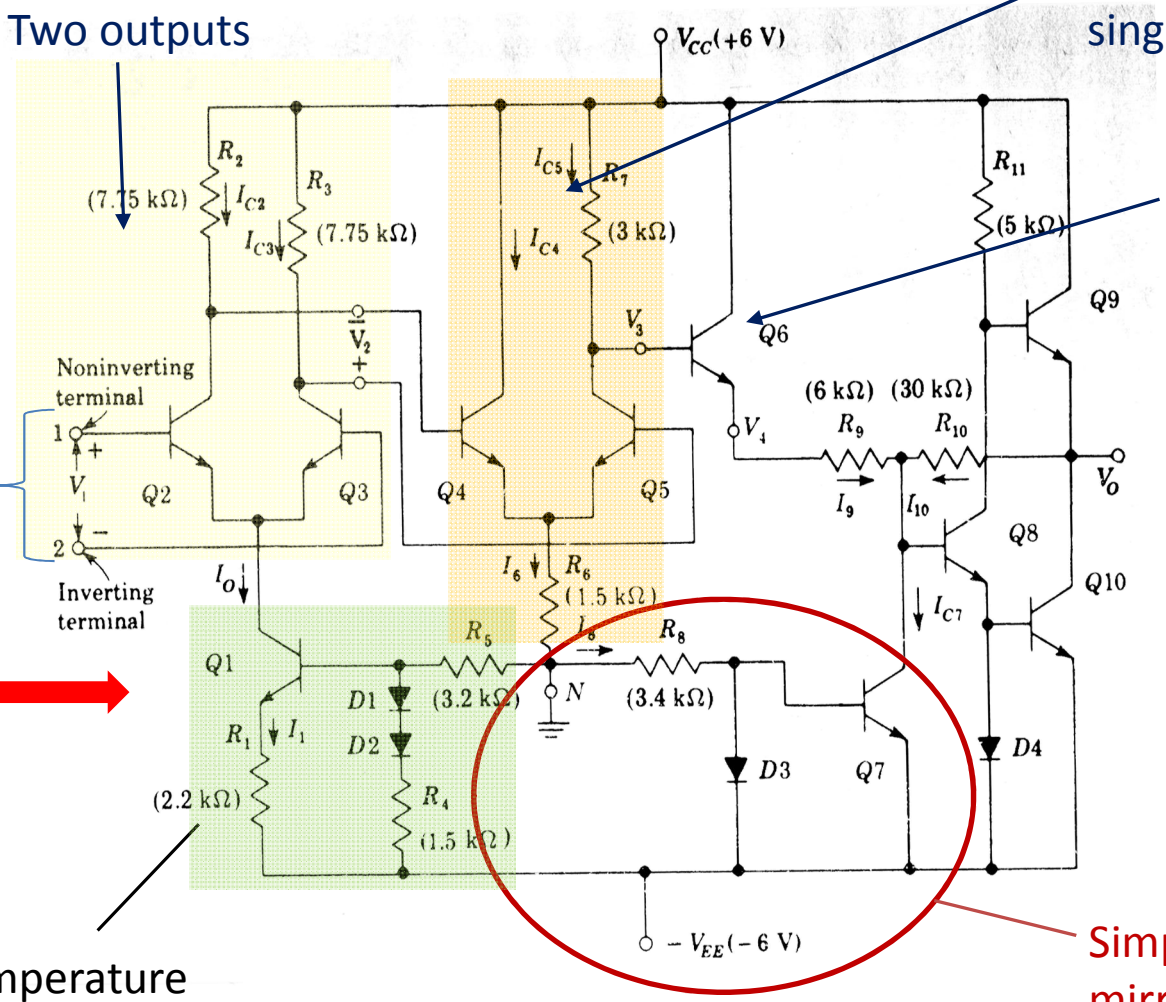


Temperature compensated current source

Simple current mirror

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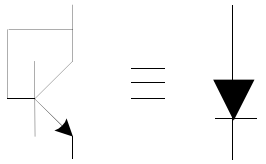
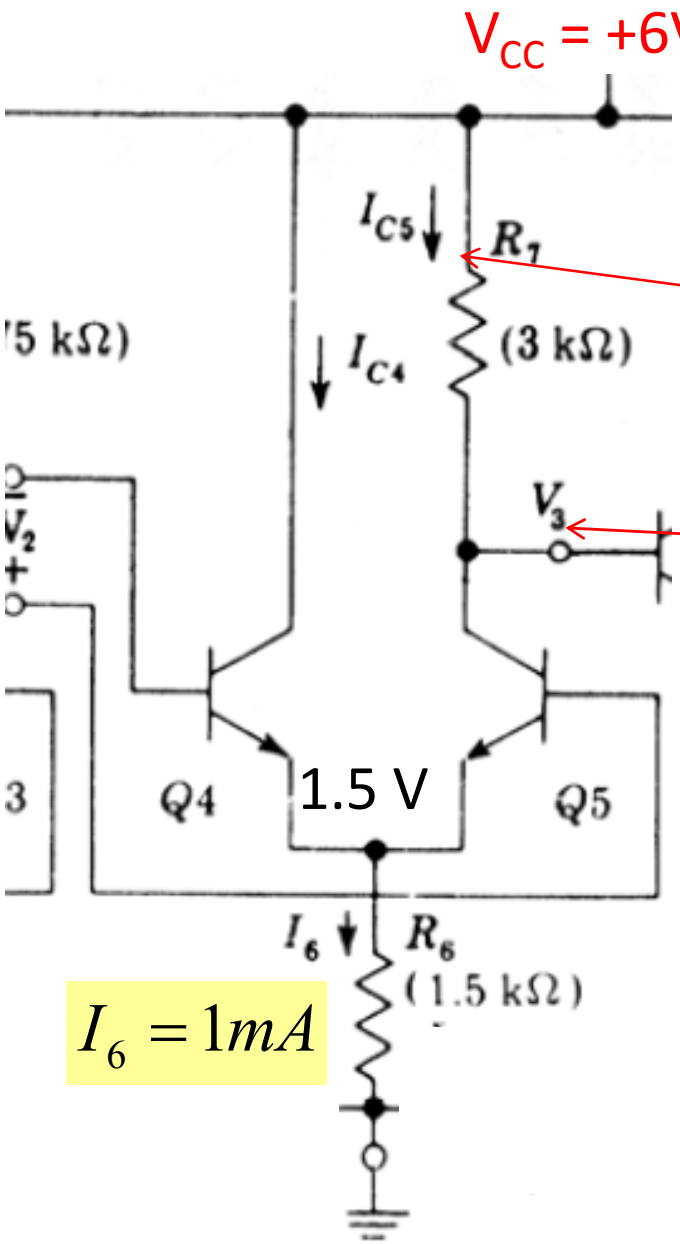





# v) $V_3$ ?

$I_{C5}$ ?

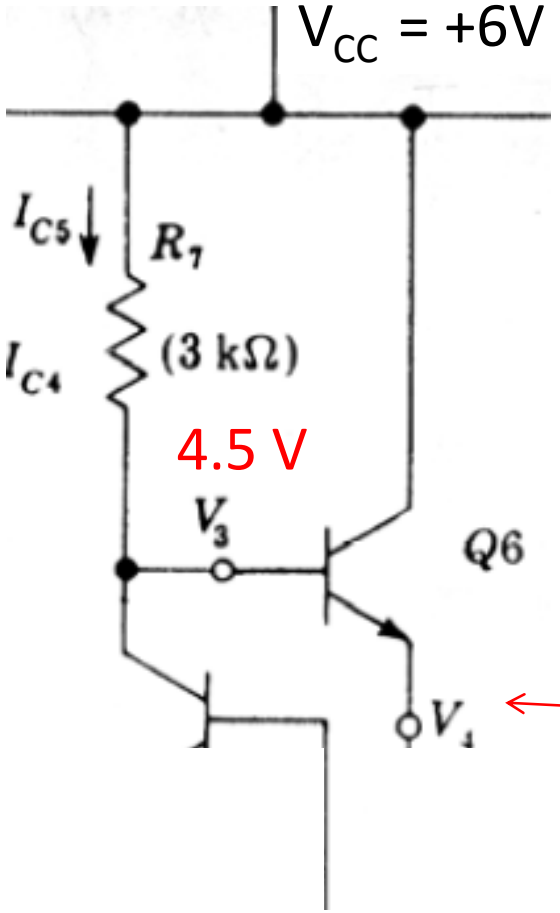
$$I_{C5} \approx \frac{I_6}{2} = 0.5mA$$

$V_3$ ?

$$V_3 = 6 - I_{C5} \times R_7$$

$$V_3 = 6 - 0.5mA \times 3k$$
$$= 4.5V$$

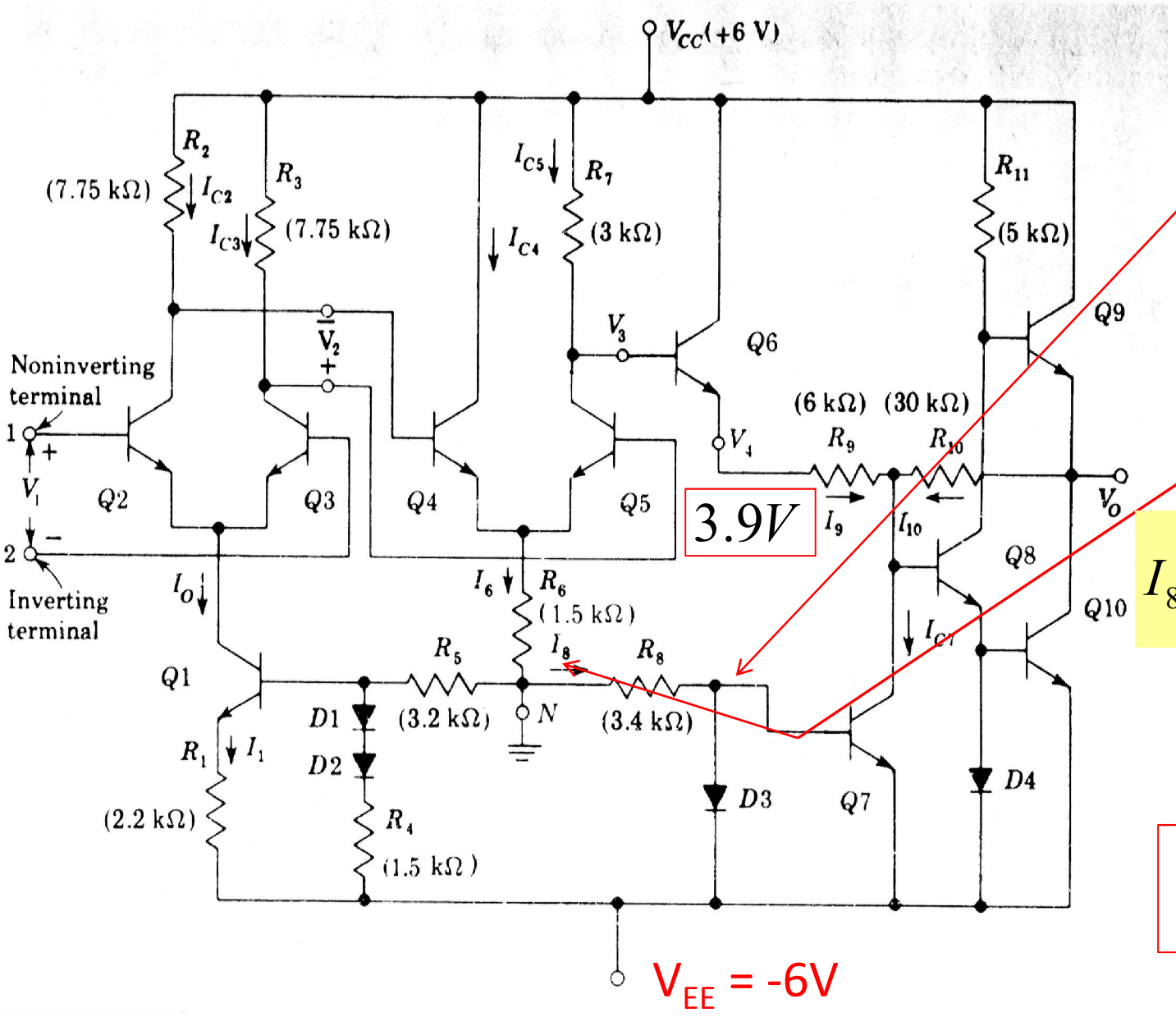
# v) contd. $V_4$ ?




$V_4$ ?

$$4.5 - 0.6 = 3.9V$$

# vi) $I_8$ hence $I_{C7}$ ?  vii) Voltage at base of $Q_8$ ?




Voltage here?

-6 + 0.6 = -5.4V

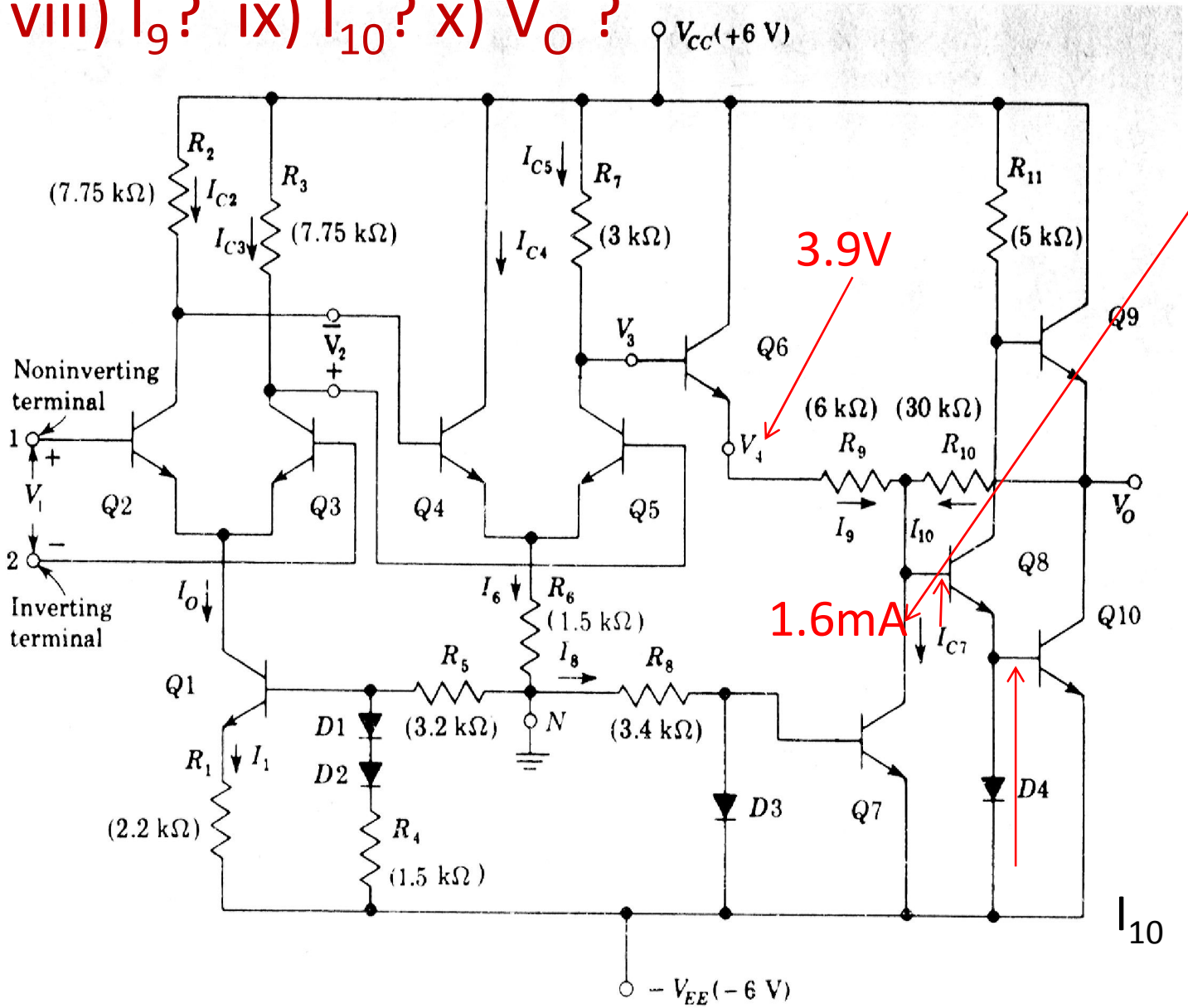
$I_8$ ?

$$I_8 = \frac{5.4}{3.4k} = 1.6mA$$

$I_{C7}$ ?

$I_{C7} = I_8$
By CM action

# viii) $I_9$? ix) $I_{10}$? x) $V_O$ ?




3.9V

1.6mA

$V_{EE}$ = -6V

Voltage here?

-6 + 0.6 + 0.6

**= -4.8V**

$I_9$ ?

$$I_9 = \frac{3.9 - (-4.8V)}{R_9}$$

$$= 1.45mA$$

$I_{10}$ ?

KCL: $I_9 + I_{10} = I_{C7}$

$I_{10}$ = 1.6mA – 1.45mA

= 0.15mA

$V_O$ ?

# Now calculate gain

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Two outputs

Differential amplifier
single output

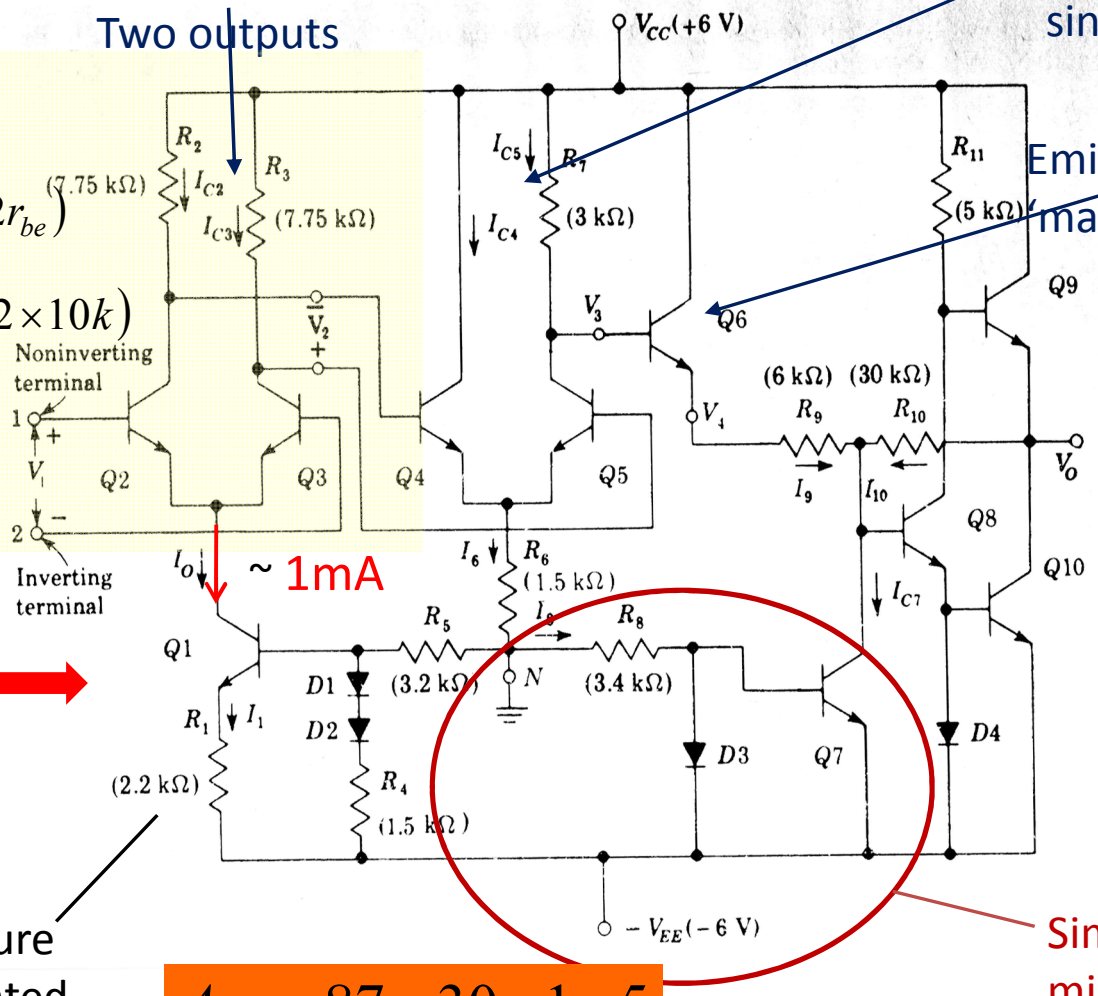
Emitter-follower to 'match' the stages

$$A_{Vd} = g_m\left(R_C \,//\, R_{i2}\right)$$

$$A_{Vd} = 40 \times \frac{1}{2} mA\left(R_C \,//\, 2r_{be}\right)$$

$$A_{Vd} = 20mA \times \left(7.75k \,//\, 2 \times 10k\right)$$

$$A_{Vd} = 87$$

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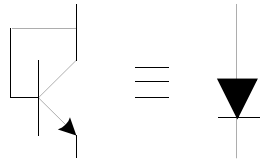

$$A_{Vd} = 87 \times 30 \times 1 \times 5$$
$$= 1{,}310$$

# Tuesday 23rd Feb

- No lecture tomorrow
- See you on Wednesday