

Calcule V_0

$Q_1, Q_2, Q_3: \beta = 200 \quad V_{BE_{ZAD}} = 0.7V$
 $D1: V_Z = 0.6V \quad V_Z = 1.1V$

1 INSPECCION

- Q_1 y Q_2 PARECEN en ZAD pues la tensión de entrada no se acerca a 5V y R_B moderadamente grande (115, 130K)
- Q_3 supondré en ZAD y $D1$ en ZENER.

2 SUPOSICION

D1 Zener	Q_1 ZAD	Q_2 ZAD	Q_3 ZAD
$V_{BE} = 0.7V$ $I_Z = 1.1V$	$V_{BE1} = 0.7V$ $I_{C1} = \beta I_{B1}$	$V_{BE2} = 0.7V$ $I_{C2} = \beta I_{B2}$	$V_{BE3} = 0.7V$ $I_{C3} = \beta I_{B3}$
$I_Z > 0$ (2mA)	$V_{CE1} > 0.2V$ (2.6V)	$V_{CE2} > 0.2V$ (2.6V)	$V_{CE3} > 0.2V$ (1.902V)

4 COMPROBACION

— 2ª Ec de Rama por $V_0 \rightarrow 130K \rightarrow V_{BE2} \rightarrow$

$$V_0 - 0 = I_{B2} \cdot 130K + V_{BE2}$$

$$\frac{V_0 - 0.7V}{130K} = I_{B2} \Rightarrow I_{C2} = 200 \left[\frac{V_0 - 0.7}{130K} \right]$$

— SE $I_{E3} = I_Z$

$$SE \quad I_{E3} = (\beta + 1) I_{B3} \quad (ZAD \rightarrow I_{B3} = \frac{I_Z}{201})$$

$$SE \quad I_Z = I_{B2} + V_0 / 1K$$

$$SE \quad \bar{I} = I_{C1} + I_{C2} = 4mA + \beta \left[\frac{V_0 - 0.7V}{130K} \right]$$

— 3ª Ec de RAMA de 5V $\rightarrow 0.2K \rightarrow V_{BE3} \rightarrow 1.1V \rightarrow V_0$

$$5 - V_0 = (\bar{I} + I_{B3}) 0.2K + V_{BE3} + 1.1V$$

$$3.2V = V_0 + 0.2K \left(4mA + 200 \left[\frac{V_0 - 0.7}{130K} \right] + \frac{1}{201} \left(\frac{V_0 - 0.7}{130K} + \frac{V_0}{1K} \right) \right)$$

$$3.2V = V_0 + 0.2 \left[\frac{200}{130} V_0 + \frac{V_0}{201 \cdot 130} + \frac{V_0}{201} \right] + 0.2 \left(4 - \frac{200 \cdot 0.7}{130} - \frac{0.7}{201 \cdot 130} \right)$$

$$3.2V = 1.3087 V_0 + 0.5846$$

$$V_0 = 1.9985V \approx 2V \Rightarrow$$

$$\begin{cases} I_{C2} = 1.998mA \approx 2mA \rightarrow \bar{I} = 5.998mA \approx 6mA \\ I_{B2} = 0.009988mA \approx 0.01mA \\ I_{E3} = I_Z = 2.0085mA \approx 2mA \Rightarrow I_{B3} = 0.01004mA \end{cases}$$

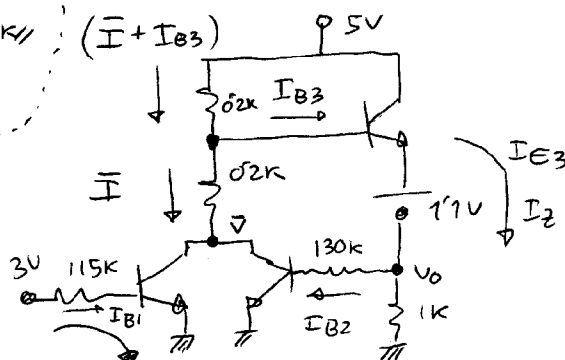
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3 APLICAR MODELOS

— 1ª Ec de RAMA por 3V $\rightarrow 115K \rightarrow$

$$3V - 0V = I_{B1} \cdot 115K + V_{BE1}$$

$$\Rightarrow \begin{cases} I_{B1} = 0.02mA \\ I_{C1} = \beta I_{B1} = 4mA \end{cases}$$



— 4ª Ec de RAMA

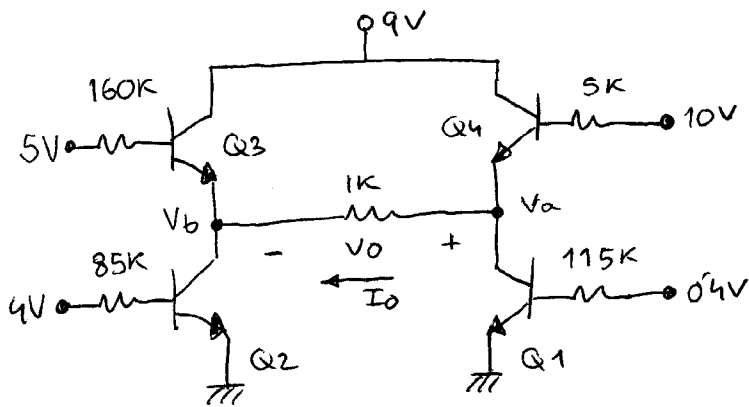
$$5V - V = (\bar{I} + I_{B3}) \cdot 0.2K + \bar{I} \cdot 0.2K$$

$$\Rightarrow V = 2.6V = V_{CE1} = V_{CE2}$$

— 5ª Ec de RAMA

$$5 - V_0 = V_{CE3} + 1.1V$$

$$V_{CE3} = 1.9015V$$



BJTs: $\beta = 200$ $V_{BE-ZAD} = 0.6V$

Calcular V_0 e I_0

1 INSPECCION

- Q1 CASI SEGURO EN CORTE, pues ve $0.4V < V_{BE-ZAD}$
- Q4 CASI SEGURO en SAT., pues ve $10V > 9V$ (alta)
- Q2 y Q3 LOS SUPONEMOS en ZAD

2 SUPOSICION

Q1 CORTE	Q2 ZAD	Q3 ZAD	Q4 SAT
$I_C = \phi$ $I_E = 0$ $I_B = \phi$	$V_{BE2} = 0.6V$ $I_{C2} = \beta I_{B2}$	$V_{BE3} = 0.6V$ $I_{C3} = \beta I_{B3}$	$V_{BE4} = 0.7V$ $V_{CE4} = 0.2V$
$V_{BE1} ? < 0.6V$ $V_{BC1} ? < 0.6V$ $0.4V$ $-8.4V$ OK//	$V_{CE2} ? > 0.2V$ $2.8V$ OK//	$V_{CE3} ? > 0.2V$ $6.2V$ OK//	$I_{C4} ? < \beta I_{B4}$ $5.9mA < 200 \cdot 0.1$ OK//

3 APLICAR MODELOS

$$I_{B1} = I_{115K} = \phi \Rightarrow V_{BE1} = 0.4V$$

— Ec de RAMA en $4V \rightarrow 85K \rightarrow V_{BE2}$

$$4V - 0V = I_{B2} \cdot 85K + V_{BE2}$$

$$I_{B2} = 0.04mA$$

$$I_{C2} = \beta I_{B2} = 8mA$$

4 COMPROBACION

— Como Q4 en SAT $\Rightarrow V_{CE4} = 0.2V \Rightarrow V_a = 8.8V = V_{CQ1} \Rightarrow V_{BC1} = 0.4V - 8.8V$
 $\Rightarrow V_{CE4} = 9V - V_a$ $(V_{B1} - V_{CQ1})$

— Ec de Rama de $10V \rightarrow 5K \rightarrow V_{BE4} \rightarrow V_a$

$$10 - V_a = I_{B4} \cdot 5K + V_{BE4} \rightarrow 0.7V$$

$$\rightarrow 8.8V \rightarrow I_{B4} = 0.1mA$$

— Ec de Rama $5V \rightarrow 160K \rightarrow V_{BE3} \rightarrow V_b$

$$5V - V_b = 160K \cdot I_{B3} + V_{BE3} \rightarrow 0.6V$$

2 INCOGNITAS \rightarrow No puedo despejar

— Ec de Nodo en V_0

$$I_0 + I_{E3} = I_{C2}$$

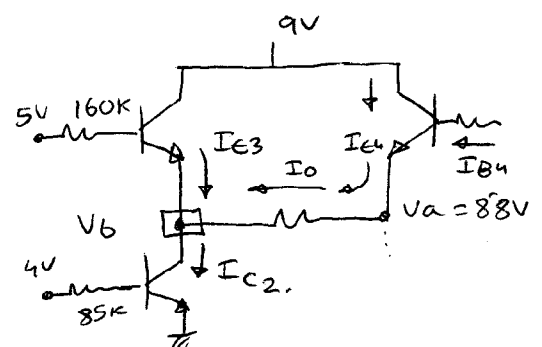
$$\left(\frac{8.8V - V_b}{1K} \right) + (\beta + 1) \left[\frac{5V - V_b - 0.6V}{160K} \right] = I_{C2} = 8mA$$

$$8.8 + 201 \cdot \frac{4.4}{160} - 8 = V_b \left[1 + \frac{201}{160} \right]$$

$$V_b = 2.8044 \approx 2.8V \Rightarrow V_0 = V_a - V_b = 8.8 - 2.8 = 6V \quad V_{CE2} = V_b = 2.8V$$

$$I_0 = V_0 / 1K = 6mA \quad V_{CE3} = 9 - V_b = 6.2V$$

(10)



$$I_{E4} = I_{B4} + I_{C4}$$

$$I_0 = 0.1mA + I_{C4}$$

$$\Rightarrow I_{C4} = 5.9mA$$