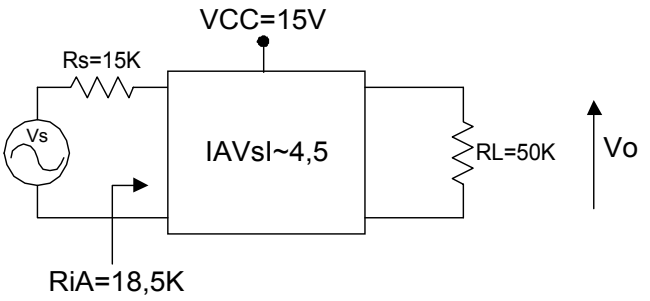
Problema 22

Diseñar una etapa amplificadora que tenga las siguientes características:

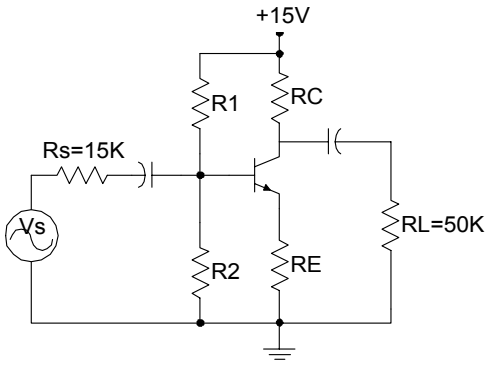


$$|AVs| \cong 4{,}5$$
$$RiA = 18{,}5K$$
$$VCC = 15V$$
$$Tr{:}BC548B$$
$$Rs = 15K$$
$$RL = 50K$$

Calcular Ro, RoA, Ros y la excursión simétrica máxima de la tensión de salida.

$$BVCE0 = 20 \Rightarrow VCC_{MAX} = 15V$$

Circuito propuesto:



$$AVS = AV \cdot \frac{Ri_A}{Ri_A + Rs} \quad \Rightarrow \quad AVS = \frac{AV}{1{,}8} = \frac{Rd}{RE} \cdot 0{,}55$$

Imponemos: $ICQ=2mA$, $VCEQ=5V$ $\Rightarrow$ $hFE=280$, $hfe=330$, $hie=4200\Omega$, $hoe=30\mu s$

entonces $$AV \cong 8AVS \therefore AV \cong 8 = \frac{Rd}{RE} \Rightarrow Rd = 8 \cdot RE$$

como $$RL >> RC \Rightarrow Rd \cong RC \therefore AV \cong \frac{RC}{RE} = 8 \Rightarrow RC = 8 \cdot RE$$

luego:

$$VCC = VCEQ + ICQ \cdot \left(RC + RE\right) \Rightarrow RE = \frac{VCC - VCEQ}{9 \cdot ICQ} = 555\Omega$$

$$RC = 8 \cdot RE = 4444\Omega$$

Para que $Ri_A = 18{,}5K$:

$$Ri = hie + RE \cdot hfe \Rightarrow RE \cdot hfe = 183150\Omega \Rightarrow Ri = 187350\Omega$$

$$Ri_A = RB \| Ri = 18{,}5K \Rightarrow RB = 20526\Omega$$

Para la Ro:

$$Ro \cong \frac{1}{hoe} \cdot \left(1 + \frac{hfe \cdot RE}{\left(Rs \| RB\right) + RE + hie}\right) + \left(RE \| hie\right) = 492K$$

$$Ro_A = Ro \| RC \cong RC = 4444\Omega$$

$$Ro_S = Ro \| Rd \cong Rd = 4081\Omega$$

luego para hallar VBB:

$$ICQ = \frac{VBB - VBE}{RE + \frac{RB}{hFE}} \Rightarrow VBB = ICQ \cdot \left(RE + \frac{RB}{hFE}\right) + VBE = 1{,}96V$$

Para hallar $R1$ y $R2$:

$$R1 \cdot VBB = VCC \cdot RB \Rightarrow R1 = \frac{VCC \cdot RB}{VBB} = 157358\Omega$$

$$\frac{1}{RB} = \frac{1}{R1} + \frac{1}{R2} \Rightarrow R2 = 23605\Omega$$

Valores estandarizados de los resistores:

$R1=150K \quad R2=22K \quad RC=4700\Omega \quad RE=560\Omega$

Verificación:

$$VBB = VCC \cdot \frac{R2}{R1 + R2} = 1{,}92V$$

$$RB = R1 \| R2 = 19186\Omega$$

$$VCEQ = VCC - ICQ \cdot (RC + RE) = 4{,}69V$$

$$ICQ = \frac{VBB - VBE}{RE} = 2{,}18mA \rightarrow hFE = 290$$

$$ICQ = \frac{VBB - VBE}{RE + \frac{RB}{hFE}} = 1{,}95mA \rightarrow hFE = 270$$

$$AV = -\frac{Rd}{RE} \cong 7{,}68 \qquad |AVS| = |AV| \cdot \frac{Ri_A}{Ri_A + Rs} \cong 4{,}14$$

$$n = \frac{RE}{\frac{RB}{hFE_{min}}} \cong 6$$

$$Ri = hie + RE \cdot hfe = 189000\Omega$$

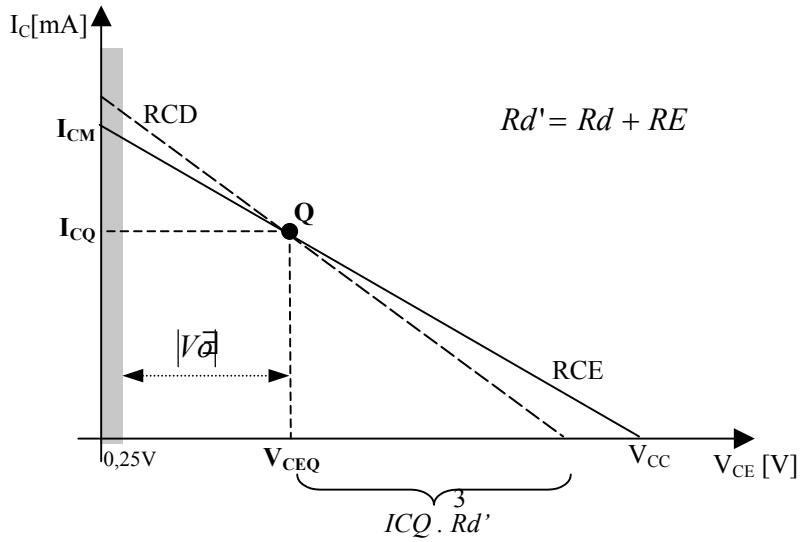
$$Ri_A = RB \| Ri = 17{,}5K$$

$$Ro \cong \frac{1}{hoe} \cdot \left(1 + \frac{hfe \cdot RE}{(Rs \| RB) + RE + hie}\right) + (RE \| hie) = 500K$$

$$Ro_A = Ro \| RC \cong 4692\Omega$$

$$Ro_S = Ro \| Rd \cong 4300\Omega$$

Para la máxima excursión de Vo:



$$Rd' = Rd + RE$$

$$VCE_{SAT} = 0{,}25V$$

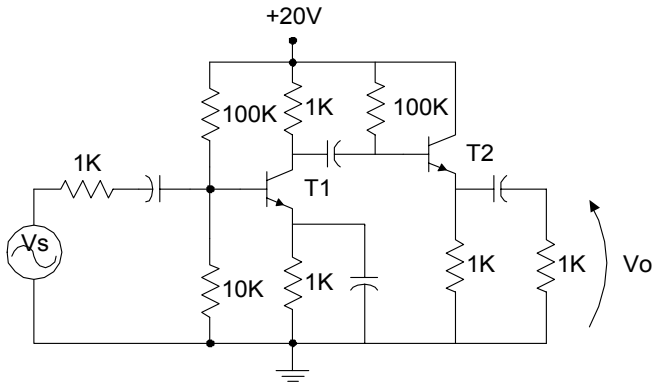
$$VCEQ - VCE_{SAT} < ICQ \cdot Rd'$$

$$4{,}44V < 9{,}48V$$

$$|Va| = \left(VCEQ - VCE_{SAT}\right) \cdot \frac{Rd}{Rd'} = 3{,}9V$$

Problema 40

Calcular la AV y la máxima amplitud simétrica de la tensión de salida del amplificador de la figura. Suponer que los transistores son idénticos y tienen un hFE=100. Graficar la recta de carga dinámica de ambos transistores.



$$hFE \cong hfe = 100$$

$$AV = -gm \cdot Rd \quad \text{y además} \quad gm = \frac{1}{hib}$$

$$gm = 40 \cdot ICQ_1$$

Averiguo las corrientes de polarización:

T1) $RB = R1 \| R2 = 9{,}1K$

$$VBB = VCC \cdot \frac{R2}{R1 + R2} = 1{,}82V$$

$$ICQ = \frac{VBB - VBE}{RE + \frac{RB}{hFE}} = 1mA$$

$$VCEQ = VCC - IC \cdot (RC + RE) = 18V$$

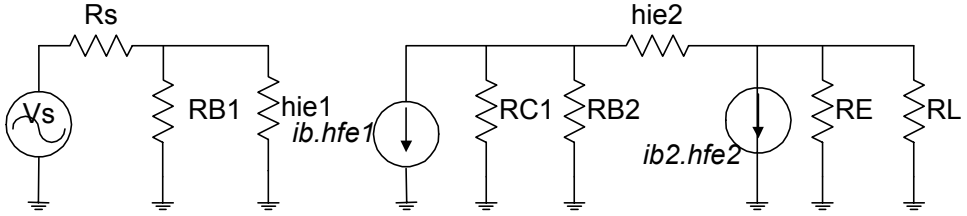
T2) $RB = 100K$

$$VCC = \frac{IC}{hFE} \cdot RB + VBE + IC \cdot RE$$

$$ICQ = \frac{VCC - VBE}{RE + \frac{RB}{hFE}} = 9{,}65mA$$

$$VCEQ = VCC - IC \cdot (RC + RE) = 10{,}35V$$

Planteo el circuito dinámico:



$$hib_1 = \frac{1}{gm_1} = 25\Omega \qquad hib_2 = \frac{1}{gm_2} = 2{,}6\Omega$$

$$hie_1 = hib_1 \cdot hfe = 2{,}5K \qquad hie_2 = hib_2 \cdot hfe = 260\Omega$$

$$Ri_2 = hie + \left(RE \cdot hfe\right) \| \left(RL \cdot hfe\right) = 260\Omega + 50K = 50260\Omega$$

$$Ri_A = RB_2 \| Ri_2 = 33{,}3K$$

Planteo de las ganancias:

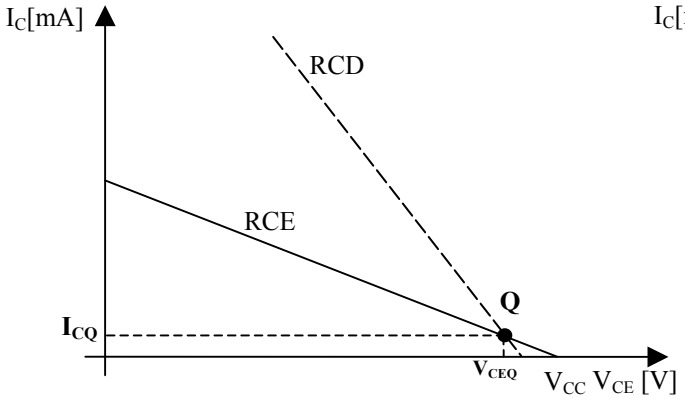
$$AV_1 = -gm \cdot Rd = -gm \cdot \left(RC \| Ri_{A2}\right) = -39$$

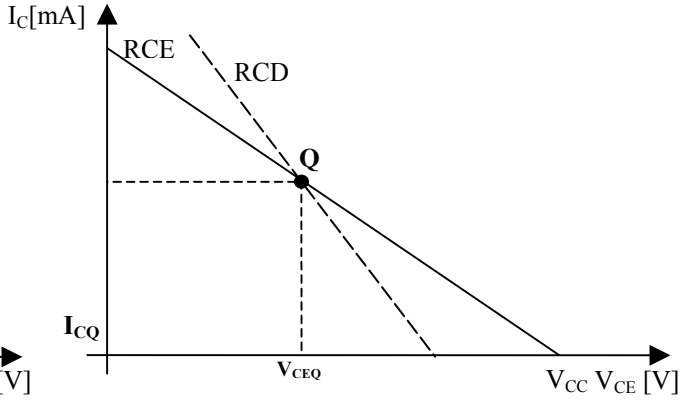
$$Ri_A = RB \| hie_1 = 1{,}96K$$

$$AVs_1 = \frac{AV \cdot Ri_A}{Ri_A + Rs} = -25{,}8$$

$$AVs_2 = \frac{Vo}{Vi_2} = \frac{\left(RE_2 \| RL\right) \cdot hfe}{hie + \left(RE_2 \| RL\right) \cdot hfe} = 0{,}995$$

$$AVs = AVs_1 \cdot AVs_2 = -25{,}7$$





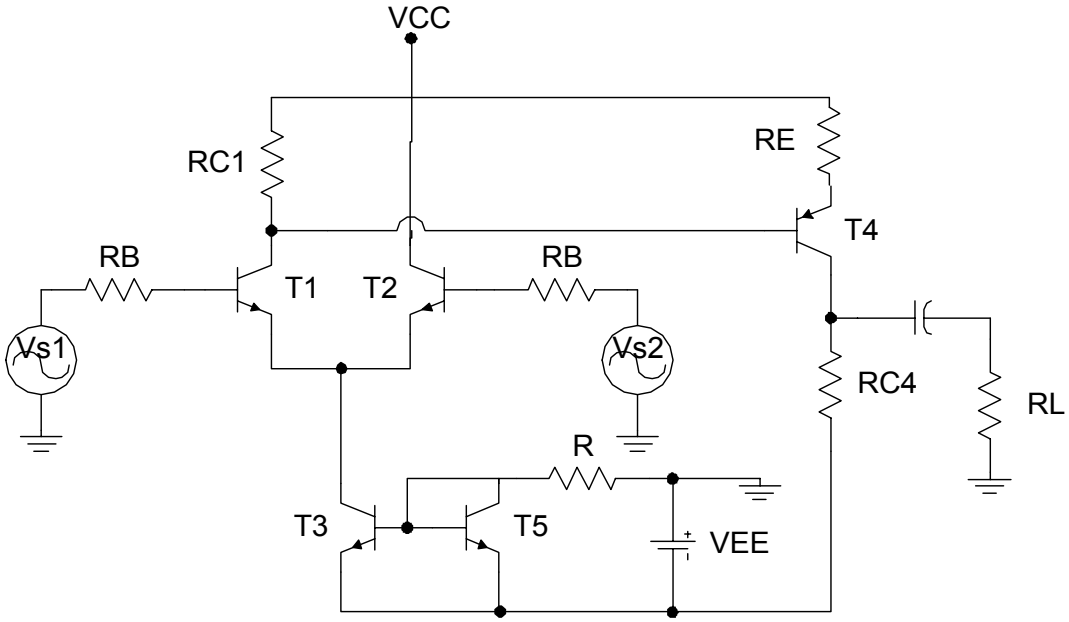
$$Vo = ICQ \cdot Rd = 0{,}97V \qquad Vo = ICQ \cdot Rd = 4{,}8V$$

Problema 41

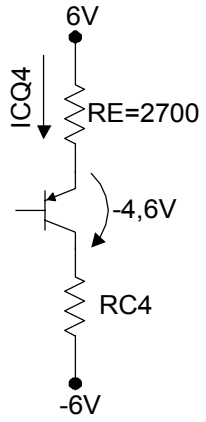
CA3086 ICQ4=1mA
RC1=3K3
VCEQ4=-4,6V
RL=10K

VCC=VEE=6V
RB=100Ω
RE=2700Ω

a) Determinar los valores de los componentes que faltan
b) Encontrar el punto Q de todos los transistores
c) Calcular la ganancia de modo diferencial del sistema, Rid y Ric



a)



$$ICQ4 = 1mA$$

$$ICQ1 = \frac{VCC - VC1T}{RC1} = 1mA$$

$$VRE + VCEQ + VRC_4 = VCC + VEE$$

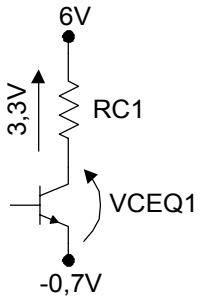
$$VRC_4 = 4,7V \quad \Rightarrow \quad RC_4 = \frac{VRC_4}{ICQ_4} = 4700\Omega$$

Para fijar una corriente de $1mA$ que circule por T1 y T2 debemos calcular R:

$$ICQ_3 = 2mA \quad \Rightarrow \quad R = \frac{VEE - VBE}{ICQ_3 \cdot \left(1 + \frac{2}{hFE}\right)} = 2704\Omega \cong 2700\Omega$$

b)

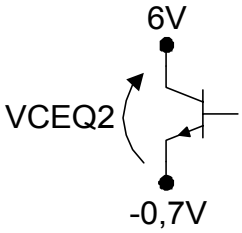
T1:



$$VCC - VRC_1 - VCEQ_1 = -0{,}7V$$

$$VCEQ_1 = VCC - VRC_1 + 0{,}7V = 3{,}4V$$

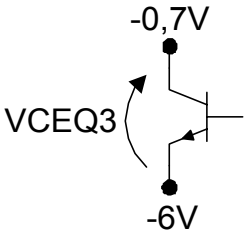
T2:



$$VCC - VCEQ_2 = -0{,}7V$$

$$VCEQ_2 = VCC + 0{,}7V = 6{,}7V$$

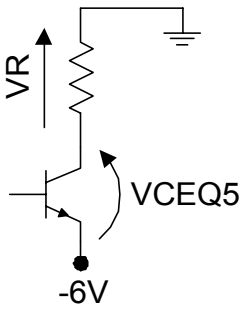
T3:



$$VEE = -VCEQ_3 - 0{,}7V$$

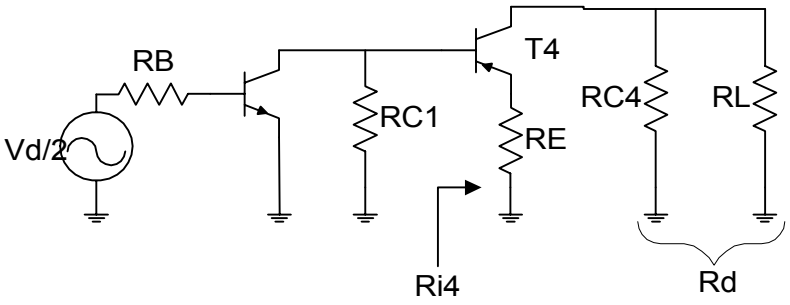
$$VCEQ_3 = -VEE + 0{,}7V = 5{,}3V$$

T5:

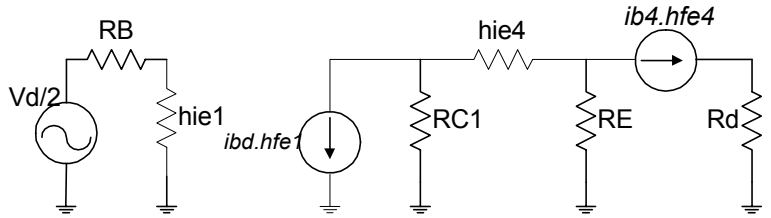


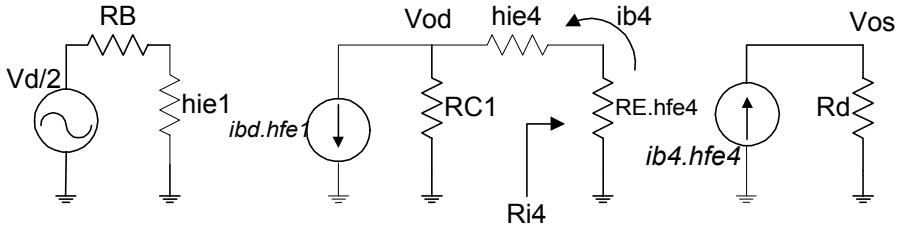
$$VCEQ_5 = VBE_5 = 0{,}7V$$

c) Para hallar la $Avds$ planteamos el circuito equivalente:



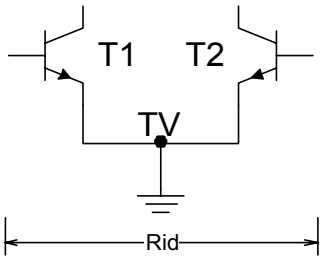
$$hie_{12}\big|_{1mA} = 3500\Omega$$





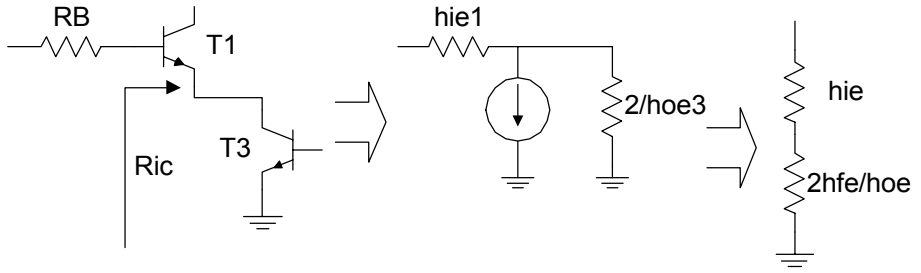
$$|AVds| = \frac{Vos}{Vd} = \frac{Vos}{Vod} \cdot \frac{Vod}{Vd} = \frac{hfe_{12} \cdot \left(RC_1 \| Ri_4\right)}{2 \cdot \left(RB + hie_{12}\right)} \cdot \frac{Rd \cdot hfe_4}{\left(hie_4 + RE \cdot hfe_4\right)} \cong 53$$

Para hallar Rid:



$$Rid = 2 \cdot hie = 7000\Omega$$

Para hallar Ric:



$$Ric = hie + 2 \cdot \frac{hfe}{hoe} \cong 6{,}4\,M\Omega \qquad \text{donde} \qquad hoe3 = 3{,}12 \cdot 10^{-5}\,\frac{A}{V}$$