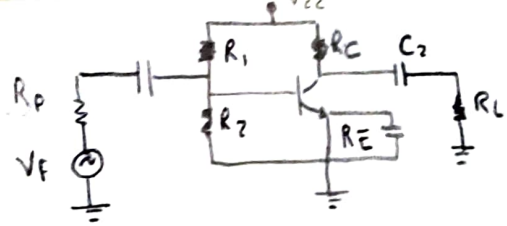


$V_{CC} = 30$
$R_1 = 25K\Omega$
$R_2 = 5K\Omega$
$R_C = 900$
$R_E = 250$
$R_L = 1K$
$R_f = 1K$

$\beta = 100$
$V_{BE} = .7V$

V_{CEQ}, I_{CQ}
Rectas carga
V_{ss}
Modelo señal pequeña
A_v, A_i
V_L / V_f
i_L / i_f

$$V_{BB} = \frac{V_{CC} R_2}{R_1 + R_2} = \frac{(30)(5000)}{25000 + 5000} = 5\ [V] \qquad R_B = \frac{R_1 R_2}{R_1 + R_2} = \frac{(25000)(5000)}{25000 + 5000} = 4{,}166.67\ [\Omega]$$

$$I_{CQ} = \beta\left(\frac{V_{BB} - V_{BE}}{R_B + \beta R_E}\right) = (100)\left[\frac{5 - .7}{4166.67 + (100)(250)}\right] = 14.74\ [mA]$$

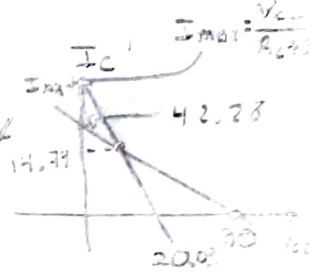
$$V_{CEQ} = V_{CC} - I_{CQ}(R_C + R_E) = 30 - (14.74 \times 10^{-3})(900 + 250) = 13.049\ [V]$$

Rectas carga

$$R_{AC} = (R_C \parallel R_L) = \frac{R_C R_L}{R_C + R_L} = \frac{(900)(1000)}{900 + 1000} = 473.68\ [\Omega]$$

$$V_{CC}' = (R_{AC})(I_{CQ}) + V_{CEQ} = (473.68)(14.74 \times 10^{-3}) + 13.049 = 20.03\ [V]$$

$$I_C' = \frac{V_{CEQ}}{R_{AC}} + I_{CQ} = \frac{13.049}{473.68} + 14.74 \times 10^{-3} = 42.28\ [mA]$$



$$V_{ss} = V_{CC}' - V_{CEQ} = 20.03 - 13.049 = 6.981\ [V]$$

$$A_V = \frac{R_C}{R_e} = \frac{900}{1.69} = 530.64$$

$$R_e = \frac{V_{termico}}{I_{CQ}} = \frac{.026}{14.74 \times 10^{-3}} = 1.69$$

Nota: Cambio Fase
$\therefore A_V = -530.64$

$$A_i = \beta = 100$$

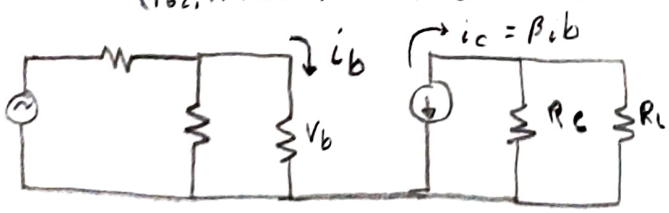
$$\frac{V_L}{V_f} = \left(\frac{R_{in}}{R_{in} + R_f}\right)(A_V)\left(\frac{R_L}{R_C + R_L}\right) \qquad R_{in} = \frac{R_B R_\pi}{R_B + R_\pi} \qquad r_\pi = \beta R_e$$

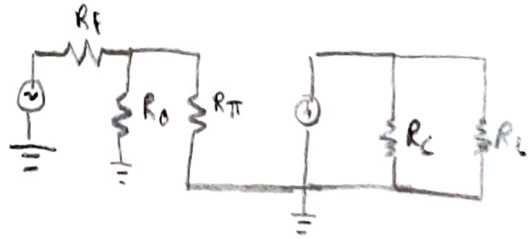
$$r_\pi = (100)(1.69) = 169 \qquad R_{in} = \frac{(4166.67)(169)}{4166.67 + 169} = 162.41$$

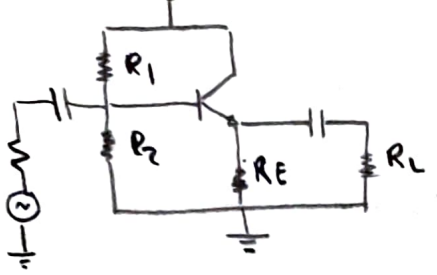
$$\frac{V_L}{V_f} = \left(\frac{162.41}{162.41 + 1000}\right)(-530.63)\left(\frac{1000}{900 + 1000}\right) = -39.02$$

$$\frac{i_L}{i_F} = -\left(\frac{R_F}{R_{in} + R_F}\right)(A_i)\left(\frac{R_e}{R_L + R_C}\right)$$

$$= -\left(\frac{1000}{162.41 + 1000}\right)(100)\left(\frac{900}{1000 + 900}\right) = -40.75$$







$V_{CC} = 25$
$R_1 = 15\,K$
$R_2 = 10\,K$
$R_E = 500$
$R_L = 250$
$R_f = 500$
$\beta = 100$
$V_{BE} = .7$

- $V_{BB} = \frac{V_{CC} R_2}{R_1 + R_2} = \frac{(25)(10\times10^3)}{15\times10^3 + 10\times10^3} =$
$= 10\,[V]$
- $R_B = \frac{R_1 R_2}{R_1 + R_2} = \frac{(15\,K)(10\,K)}{15K + 10K} = 6000$
- $r_L = \frac{R_E R_L}{R_E + R_L} = \frac{(500)(250)}{500+250} = 166.67$

$I_{CQ} = \frac{\beta(V_{BB} - V_{BE})}{R_B + \beta R_E} = \frac{(100)(10 - .7)}{6000 + (100)(500)} = 16.6\,[mA]$

$r_e = \frac{.026}{16.6\times10^{-3}} = \frac{V_{térmico}}{I_{CQ}} = 1.5\,\Omega$

$R_\pi = \beta(R_e + R_L) = 100(1.5 + 166.67) = 16817$

$R_{in} = \frac{(R_B)(R_\pi)}{R_B + R_\pi} = \frac{(60000)(16817)}{60000 + 16817} = 4422.22$

$\frac{V_L}{V_F} = \left(\frac{R_{in}}{R_f + R_{in}}\right)\left(\frac{R_2}{r_e + R_2}\right)$
// Colector común
$= \left(\frac{4422.22}{500 + 4422.22}\right)\left(\frac{166.67}{1.5 + 166.67}\right) = 8 -$

$\frac{i_L}{i_F} = \left(\frac{R_f}{R_{in} + R_f}\right)(A_i)\left(\frac{R_E}{R_L + R_E}\right) = \left(\frac{500}{4422.25 + 500}\right)(100)\left(\frac{500}{250 + 500}\right) = 6.77\,[A]$

// Emisor Común

$A_v = 3$
$V_{CC} = 30\ V$
$R_L = 700\ \Omega$
$\beta = 100$
$V_{BE} = .7\ V$

- $R_e = \frac{1}{2} R_L$
- if $R_c = 0$
- $R_c = x R_L \quad (x > 1)$
- if $R_L \to \infty$
- $R_c = x R_L \quad (x < 1)$

- $R_c = \frac{1}{2}(700) = 350$

$R_c \| R_L = \frac{(350)(700)}{350 + 700} = 233.33$

$R_e' = \frac{R_c \| R_L}{A_v} = \frac{233.33}{3} = 77.78\,[\Omega]$

$R_{AC} = R_E' + (R_c \| R_L) = 77.78 + 233.33 = 311.11$
$R_{DC} = R_c + R_c' = 350 + 77.78 = 427.78$

$I_{CQ} = \frac{V_{CC}}{R_{DC} + R_{AC}} = \frac{30}{311.11 + 427.78} =$
$= 40.6\times10^{-3}\ A$

$r_e = \frac{V_{térmico}}{I_{CQ}} = \frac{.026}{40.6\times10^{-3}} = .615\,\Omega$

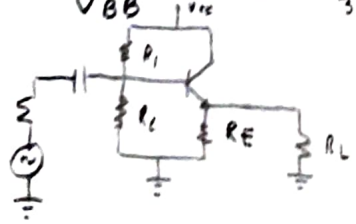
$R_E = R_E' - r_e = 77.78 - .615 = 77.1675$

$R_B = (.01)(\beta)(R_E) = (.01)(100)(77.1675) = 77.16$

$V_{BB} = V_{BE} + (1.01)(R_E)(I_{CQ}) = .7 + (1.01)(77.1675)(40.6\times10^{-3}) = 3.86\,[V]$

$R_1 = \frac{V_{CC}(R_B)}{V_{BB}} = \frac{(30)(77.16)}{3.86} = 599.68\,[\Omega]$

$R_2 = \frac{R_E}{1 - \frac{V_{BB}}{V_{CC}}} = \frac{77.1675}{1 - \frac{3.86}{30}} = 88.66\,[\Omega]$



Formulario | Murrieta Villegas Alfonso

Silicio = .7

$$I_D = I_S\left(e^{\frac{V_D}{V_t}} - 1\right)$$

$V_t = \frac{KT}{q}$ | $K = 1.38 \times 10^{-23}\ [\frac{J}{K}]$ | $T = 26 \times 10^{-3} = .026\ [K^\circ]$ | $q = 1.609 \times 10^{-19}\ [C]$

// Voltaje Térmico

m = mili = 10^{-3}
μ = micro = 10^{-6}
n = nano = 10^{-9}
p = pico = 10^{-12}

// Iteraciones Diodo

$$V_{D_{i+1}} = V_T \ln\left(\frac{V_F - V_{D_i}}{I_S R} + 1\right)$$

$$I_D = \frac{V_F - V_D}{R}$$

// Despejado

$$V_D = V_T \ln\left(\frac{I_D}{I_S} + 1\right)$$

$V_T' = \eta V_T = (\eta)(26 \times 10^{-3})$

// Versiones Complejas

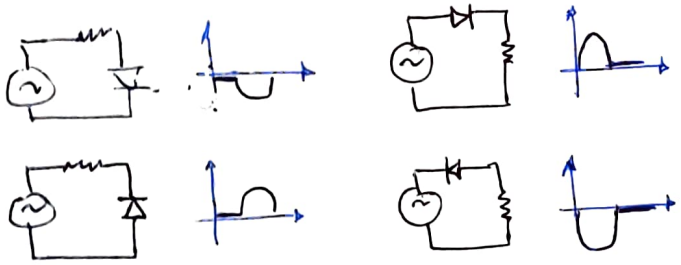
$V_F = I_D R + V_{D_{ON}}$

$I_D = \frac{V_F - V_{D_{ON}}}{R}$

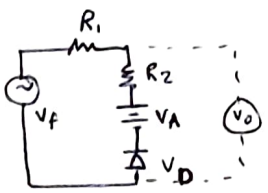
$m = -\frac{1}{R}$

$b = -\frac{V_F}{R}$

// Circuitos Rectificadores



// Otra Fuente



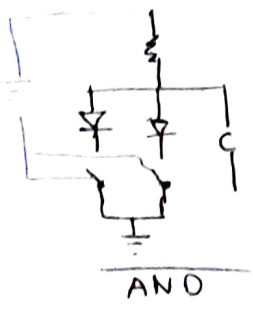
$V_f = I R_1 + I R_2 + V_A + V_D$

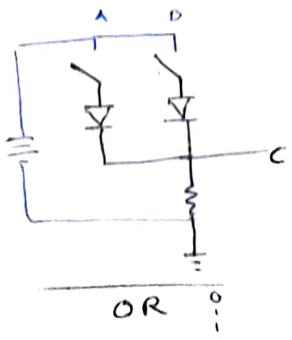
$I = \frac{V_f - V_A - V_D}{R_1 + R_2}$

$V_o = I R_2 + V_A + V_D$

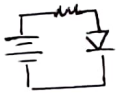
$\therefore V_o = \left(\frac{V_f - V_A - V_D}{R_1 + R_2}\right) R_2 + V_A + V_D \ ; \ V_o = V_A + V_D$

// Circuitos Lógicos



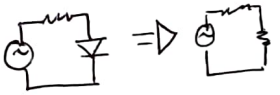


// Superposición / Diodo como Resistencia



$I_D = \frac{V_F - V_{D_{ON}}}{R} = m\ [A]$ /

$R_{AC} = \frac{V_T}{I_{DQ}}$



$R_{AC} = \frac{.026}{m} = m\ [\Omega]$ /

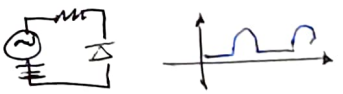
$V_o = \frac{V_{f_2}(R_{AC})}{R + R_{AC}} = \frac{(m \times 10^{-6})(m)}{R + R_{AC}} = \dots$

$= \underbrace{[\ ]}_{\text{diodo}} + \dots \operatorname{sen} \omega t\ [V]$

$\omega = 2\pi f C$

// Circuitos Sujetadores

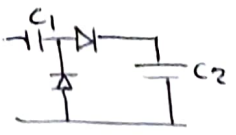
$V_{rms} = \frac{V_p}{\sqrt{2}}$



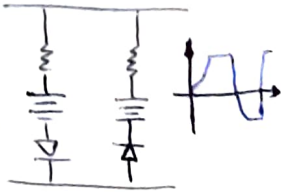
SUJE/RECO

SUJE PICO

Multiplicador



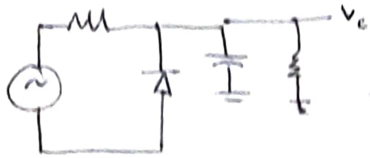
Señal cuadrada



Puente diodos

Circuito Rectificador

¿? → $V_o = \frac{(V_{TP_1})(50)}{(50+10^9)} = 0$



$$V_{in\,min} = V_{in\,max}\, e^{-\frac{t}{\tau}}$$

$\tau = RC \stackrel{\wedge}{=}$ Ct. Tiempo

Disminu size capo → Aumen Frecuen → se hace con Diodo

Versión Linealizada (Medio Onda)

$$C = \frac{V_{in\,max}}{(V_{in\,max} - V_{in\,min})\,R f}$$

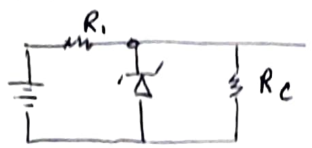
↑ Frecuencia

Con Tap Central

$$C = \frac{V_{in\,max}}{(V_{in\,max} - V_{in\,min})(2)(R)(F)}$$

$$V_{rizo} = V_{in\,max} - V_{in\,min}$$

Zener



$$R_1 = \frac{V_F - V_Z}{I_Z + I_{RC}}$$

$$I_{RC} = \frac{V_Z}{R_C}$$

$$R_{1\,max} = \frac{V_{F\,min} - V_Z}{I_{Z\,min} + I_{C\,max}}$$

// Considero $I_{Z\,min} = 10\%\, I_{Z\,max}$

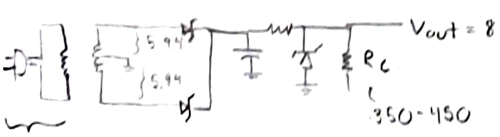
$$\therefore R_{1\,max} = \frac{V_{F\,min} - V_Z}{(.1)\,I_{Z\,max} + I_{C\,max}}$$

$$R_{1\,min} = \frac{V_{F\,max} - V_Z}{I_{Z\,max} + I_{C\,min}}$$

$$\therefore I_{Z\,max} = \frac{I_{C\,min}(V_Z - V_{F\,min}) + I_{C\,max}(V_{F\,max} - V_Z)}{V_{F\,min} - (.9)V_Z - (.1)V_{F\,max}}$$

$$R_1 = \frac{V_{F\,max} - V_Z}{I_{Z\,max} + I_{Z\,min}}$$

Fuente Alimentación



117 ± 15%

$V_{F\,min} = 117 - (117 \times .15) = 99.45$

$V_{F\,max} = \text{〃} + (\text{〃}) = 134.45$ [Vrms]

$I_{C\,min} = .35$

$I_{C\,max} = .45$

$V_{in\,min} = V_{in} + (V_{in} \times \%)$
$= 8 + (8 \times .2) =$
$= 9.6$ [Vrms]

→ $V_{in\,min\,pico} = \frac{9.6}{\sqrt{2}} = 6.79$

// Tap Central

$V_{pico\,min} = 6.79 \times 2 = 13.58$

// Rela. Trans

$$\eta = \frac{V_{F\,min}}{V_{pico\,min}} = \frac{99.45}{13.58} = 7.37$$

$$V_{pico\,max} = \frac{V_{F\,max}}{\eta} = \frac{134.45}{7.37} = 18.36$$

$$V_{in\,max} = \left(\frac{18.36}{(2)}\right)(\sqrt{2}) = 12.99$$

(2) ← Tap; $\sqrt{2}$ ← Vrms

$$I_{Z\,max} = \frac{(.350)(8 - 9.6) + (.45)(12.99 - 8)}{9.6 - (.9)(8) - (.1)(12.99)} = 1.53\ [A]$$

$V_Z = V_{out}$

$$R_1 = \frac{12.99 - 8}{1.53 + (350 \times 10^{-3})} = 2.65\ [\Omega]$$

¿?

$$P = (V_{F\,max} - V_Z)(I_T) = (12.99 - 8)(1.53 + 380 \times 10^{-3}) = 9.37\ [\text{Watts}]$$

// Iteraciones

$I_S = 500$ [nA]

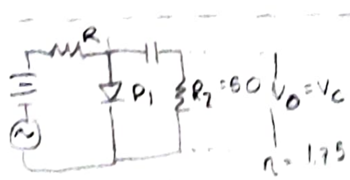
$\eta = 1.75$

$V_F = 3$ $\quad R = 200\,\Omega$

$V_{D_1} = (1.75)(26 \times 10^{-3}) \ln\left(\frac{3 - V_{D_0}^{\;0}}{(200)(500 \times 10^{-9})} + 1\right) = .333$

$V_{D_1} = (\ldots) \ln\left(\frac{3 - .333}{(\ldots)}\right) = .331$

$I_D = \frac{3 - .331}{200} = .013$ [A]



$\eta = 1.75$

$I_S = 750$ [nA] $\quad V_{F_2} = 15 \operatorname{sen} \omega t$ [mV]

$R_1 = 250\ \Omega$ $\quad C = 10$ pf

$V_{F_1} = 5$ V $\quad \omega = 10^3$ [rad/s]

a) DC

$V_D = \eta V_T \ln\left(\frac{V_F - V_D}{R\, I_S} + 1\right)$

$= (.75)(26 \times 10^{-3}) \ln\left(\frac{5}{(750 \times 10^{-9})(250)} + 1\right)$

$= .439$

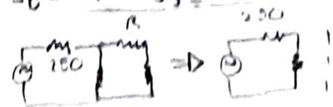
$I_D = \frac{V_F - V_{D_3}}{R} = \frac{5 - .439}{250} = .0182$ [A]

b) AC

$$R_{AC} = \frac{V_T}{I_{DQ}} = \frac{26 \times 10^{-3}}{.0182} = 1.4254\ [\Omega]$$

// Capacitor

$$X_C = \frac{1}{\omega C} = \frac{1}{(10^3)(10 \times 10^{-12})} = 10^9\ [\Omega]$$



$$V = \frac{(V_{F_2})(R_{AC})}{(R_1 + R_{AC})} = \text{〃} \operatorname{sen} \omega t + [\text{Diodo}]$$

$R_{AC} \stackrel{\wedge}{=}$ El equival. + C

Formulario

$V_{BB} = \frac{V_{cc} R_2}{R_1 + R_2}$ | $R_B = \frac{R_1 R_2}{R_1 + R_2}$ | ▸ $I_{cq} = \beta \left(\frac{V_{BB} - V_{BE}}{R_B + \beta R_E} \right)$

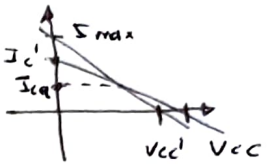
▸ $V_{ccq} = V_{cc} - I_{cq}(R_c + R_E)$

// Recta Carga | $R_{AC} = (R_c \| R_L) = \frac{R_c R_L}{R_c + R_L}$

• $V_{cc}' = (R_{AC})(I_{cq}) + V_{CEQ}$

• $I_c' = \frac{V_{CEQ}}{R_{AC}} + I_{cq}$

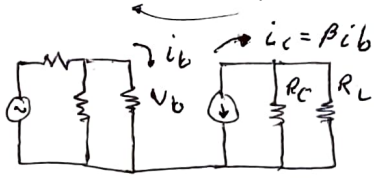
• $I_{max} = \frac{V_{cc}}{R_c + R_E}$

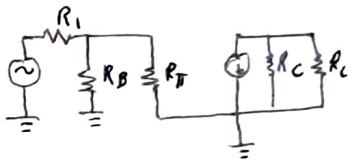


▸ $V_{ss} = V_{cc}' - V_{CEQ}$ ▸ $A_v = \frac{R_c}{R_e}$ ← $R_e = \frac{V_{Termico}}{I_{cq}}$ • $A_i = \beta =$

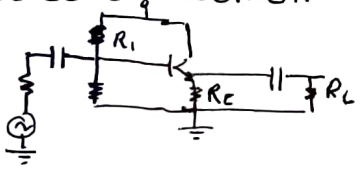
▸ $\frac{V_L}{V_f} = \left(\frac{(R_{in})}{R_{in} + R_f} \right) \left(A_v \right) \left(\frac{R_L}{R_c + R_L} \right)$ | $R_{in} = \frac{R_B R_\pi}{R_B + R_\pi}$ $r_\pi = \beta R_e$

▸ $\frac{i_L}{i_f} = -\left(\frac{R_f}{R_{in} + R_f} \right) \left(A_i \right) \left(\frac{R_c}{R_L + R_c} \right)$





// Colector Común



• $V_{BB} = \frac{V_{cc} R_2}{R_1 + R_2}$ • $R_B = \frac{R_1 R_2}{R_1 + R_2}$ • $R_L = \frac{R_E R_L}{R_E + R_L}$

• $I_{CQ} = \frac{\beta (V_{BB} - V_{BE})}{R_B + \beta R_E} \rightarrow r_e = \frac{V_{Térmico}}{I_{CQ}}$

• $R_\pi = \beta (R_e + R_L) \rightarrow R_{in} = \frac{(R_B)(R_\pi)}{R_B + R_\pi}$

$\frac{V_L}{V_f} = \left(\frac{R_{in}}{R_f + R_{in}} \right) \left(\frac{R_2}{r_e + R_2} \right)$ // No tiene ganancia en voltaje

$\frac{i_L}{i_f} = \left(\frac{R_f}{R_{in} + R_f} \right) \left(A_i \right) \left(\frac{R_E}{R_L + R_E} \right)$

// Emisor Común

• $R_d \| R_L = \frac{(R_d \| R_L)}{R_c + R_L}$ $R_e' = \frac{R_c \| R_L}{A_v}$

$R_{AC} = R_E' + (R_c \| R_L)$ | $R_{DC} = R_c + R_c'$ | $I_{CQ} = \frac{V_{cc}}{R_{DC} + R_{AC}}$

$r_e = \frac{V_{Térmico}}{I_{cq}}$ | $R_E = R_E - r_e$ | $R_B = (.01)(\beta)(R_E)$

$V_{BB} = V_{BE} + (1.01)(R_E)(I_{CQ})$ | $R_1 = \frac{(V_{cc})(R_B)}{V_{BB}}$ $R_2 = \frac{R_E}{1 - \frac{V_{BB}}{V_{cc}}}$

• Base → Corriente / Volt

• Colec → Corrien

• Emisor → Volt

GANANCIA

// Base Común

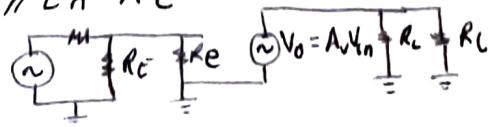
$V_{BB} = \frac{R_2 V_{cc}}{R_1 + R_2}$ $R_B = R_1 \| R_2$

$V_{BB} = I_B R_B + V_{BE} + I_E R_E$

$I_{CQ} = \beta \left(\frac{V_{BB} - V_{BE}}{R_B + \beta R_E} \right)$

• $V_{cc} = I_c R_c + V_{CB} + V_{BE} + I_E R_E$

// En AC



$V_o = i_c R_c$ } $\frac{V_o}{V_{in}} = \frac{R_c}{R_e} = A_v$

$V_{in} = i_e R_e$

$\therefore A_i \approx 1 = \frac{i_c}{i_e}$

$A_{in} = i_e$

$i_o = i_c$