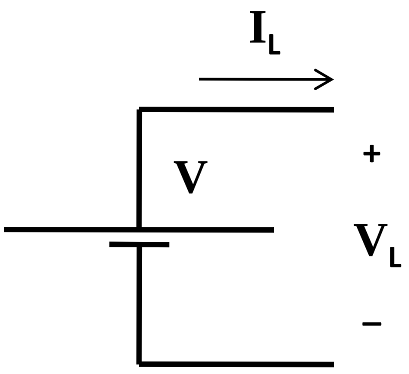
Fuente de tensión regulada

Fuente ideal de tensión

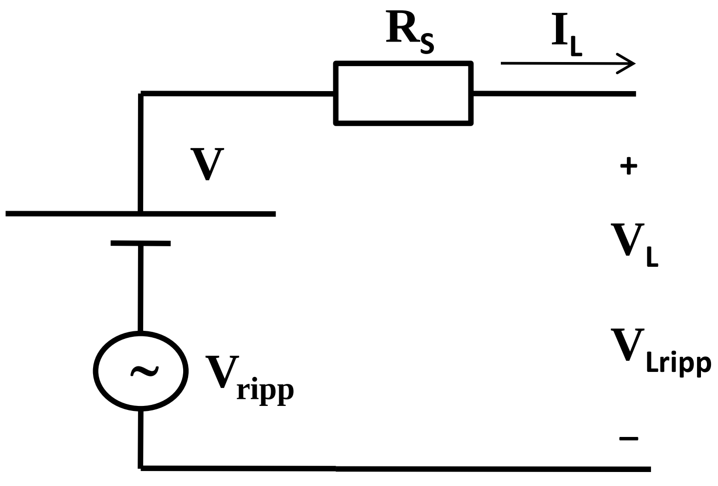


V = cte.

V_L = cte.

I_L sin limitación de valor

Fuente real de tensión



$V \neq$ cte.

$V_L \rightarrow f(I_L)$

V_{Lripp}

$T_{AMB} < T_{MAX}$

$I_L < I_{MAX}$

Parámetros p/Caracterizar Fuentes de Tensión

Z0 y Tiempo de recup

1 – Tensión de salida → $V_{LN}|_{V_i}^{I_L - T_{AMB}}$

2 – Tolerancia de la tensión de salida → $\frac{\Delta V_{LN}}{V_{LN}}\%$

3– Corriente de carga máxima → $I_{LMAX}|_{V_{iMAX}}^{T_{MAX}}$

4– Ripple en la carga → $\hat{V}_{Lripp}|_{V_i \to cte}^{I_L = I_{LMAX}}$

5– Temperatura de trabajo máxima → T_{MAX}

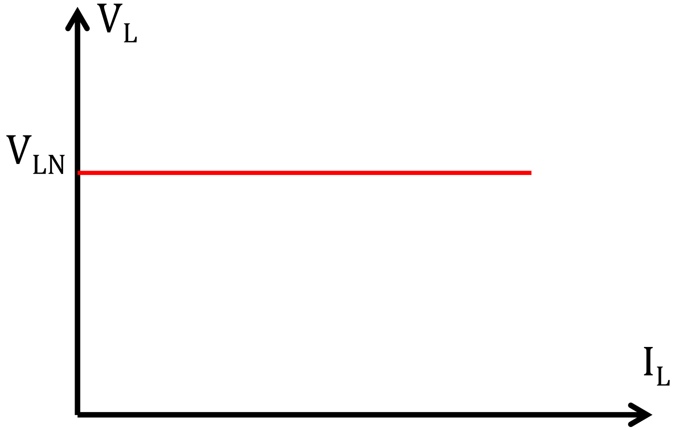
6 – Regulación de Carga

$$r_c\% = \frac{1}{V_{LN}} \frac{\Delta V_L}{\Delta I_L} \times 100 \Big|_{V_{i \to cte}}^{\frac{\Delta I_{IL}}{I_L} \to 100\%}$$

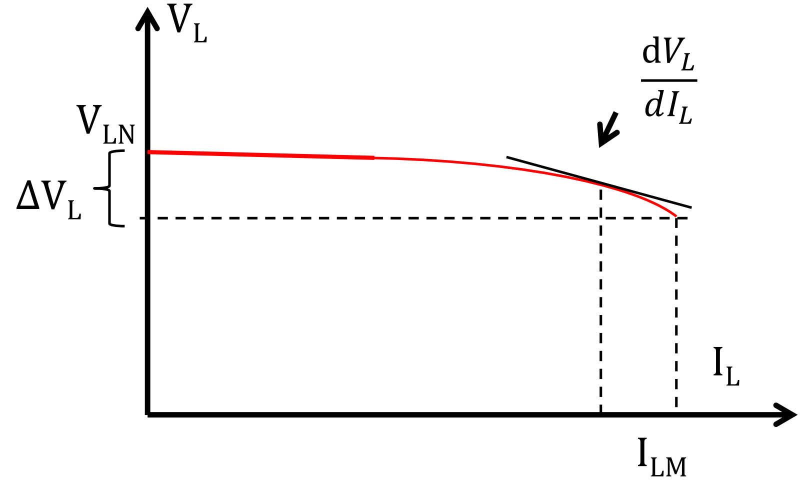
7 – Regulación de Línea

$$r_l\% = \frac{1}{V_{LN}} \frac{\Delta V_L}{\Delta V_i} \times 100 \Big|_{I_{L \to cte}}^{\frac{\Delta V_i}{V_i} \to \pm 15\%}$$

PARAMETROS DE LA FUENTE DE TENSION



Fuente Ideal



Fuente Real

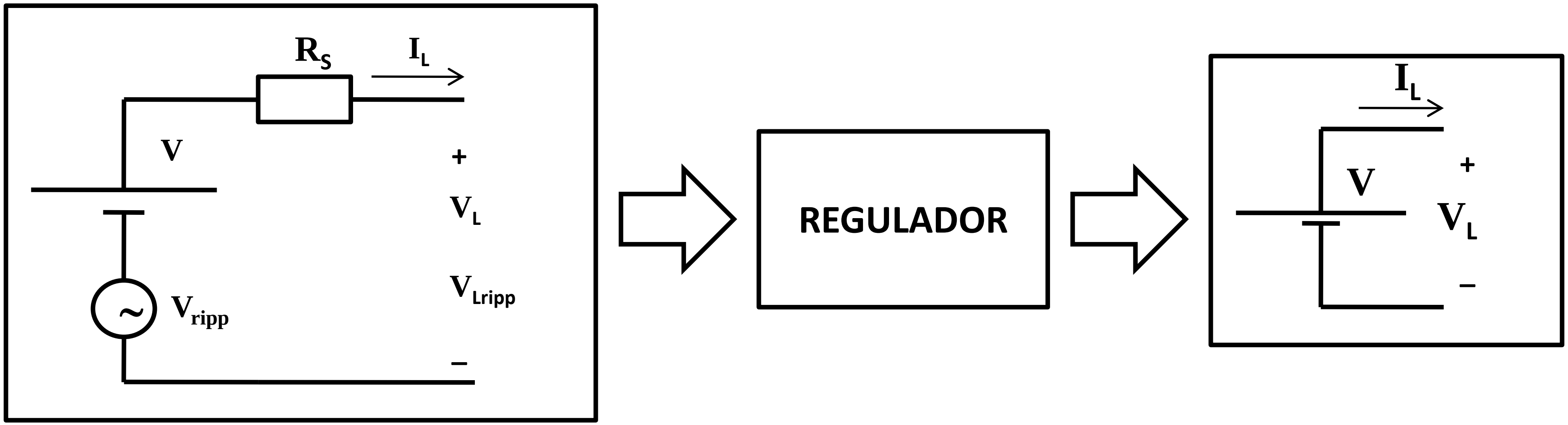
Regulación de carga

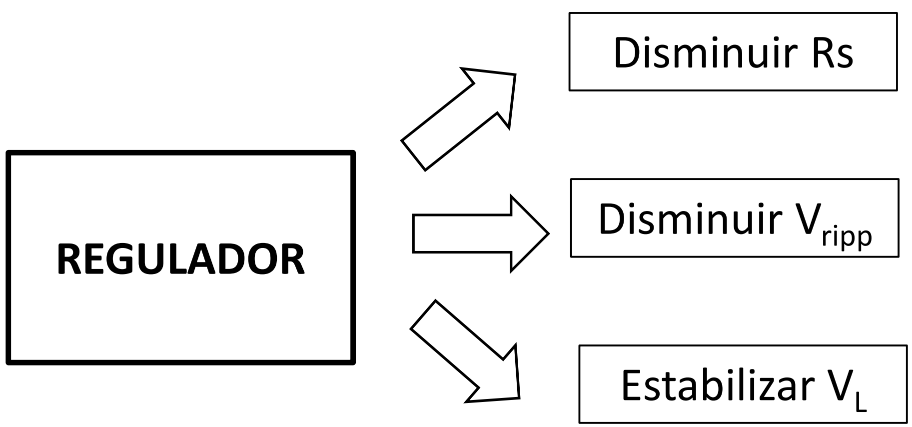
$$r_c = \frac{\Delta V_L}{V_L} \xrightarrow[\frac{\Delta I_L}{I_L}=100\%]{V_i=cte.}$$

Resistencia de salida R_0

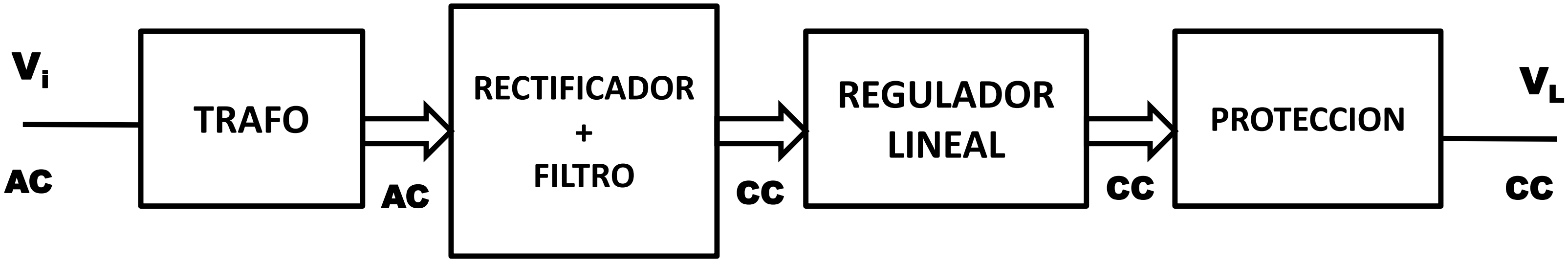
$$R_0 = \frac{dV_L}{dI_L} \xrightarrow[I_L \sim I_{LM}]{V_i=cte.}$$

Fuente de tensión continua regulada

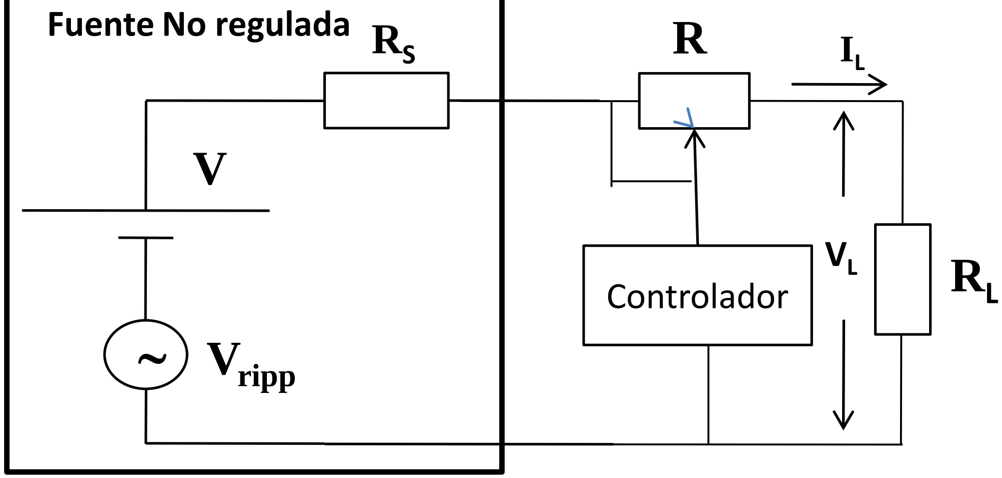




Esquema Fuente Regulada Lineal



REGULADOR LINEAL (PRINCIPIO DE FUNCIONAMIENTO)



$$V_L = \frac{V * R_L}{(R + R_s + R_L)} \qquad si\ (R + R_L) \gg R_s$$

$$V_L \approx \frac{V * R_L}{(R + R_L)} \qquad V_L \approx \frac{V}{\left(1 + \frac{R}{R_L}\right)}$$

Para que V_L = cte.

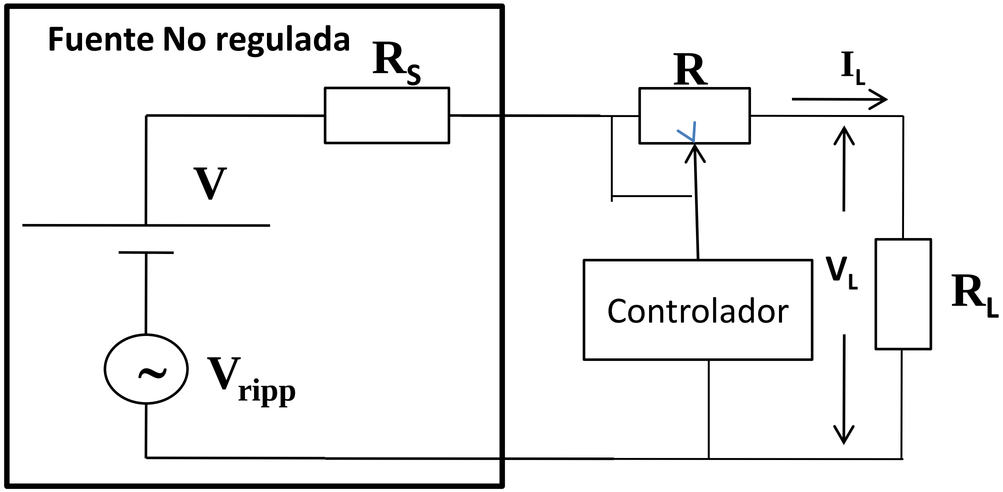
$$R_L \uparrow \Rightarrow \frac{V}{\left(1 + \frac{R}{R_L}\right)} = cte. \Rightarrow R \uparrow$$

$$V \uparrow \Rightarrow \frac{1}{\left(1 + \frac{R}{R_L}\right)} \uparrow \Rightarrow R \uparrow$$

- Elemento de control (R) → Disipa Potencia

REGULADOR LINEAL SERIE

(PRINCIPIO DE FUNCIONAMIENTO)



$$V_L = \frac{V * R_L}{(R + R_s + R_L)}$$

$$si\ (R + R_L) \gg R_s$$

$$V_L \approx \frac{V * R_L}{(R + R_L)}$$

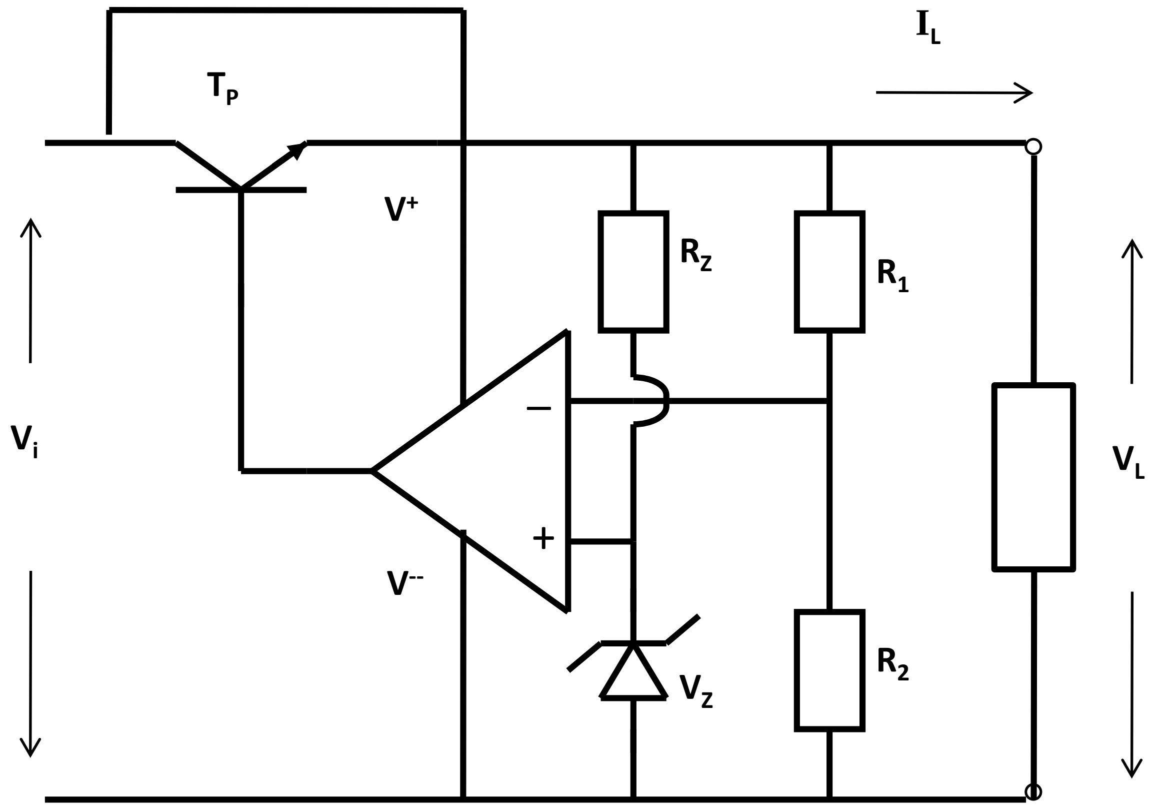
$$V_L \approx \frac{V}{\left(1 + \frac{R}{R_L}\right)}$$

Para que V_L = cte.

$$R_L \uparrow \Longrightarrow \frac{V}{\left(1 + \frac{R}{R_L}\right)} = cte. \Longrightarrow R \uparrow$$

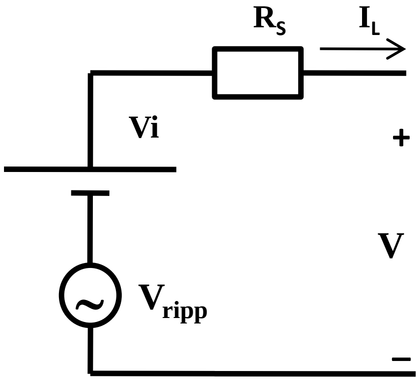
$$V \uparrow \Longrightarrow \frac{1}{\left(1 + \frac{R}{R_L}\right)} \uparrow \Longrightarrow R \uparrow$$

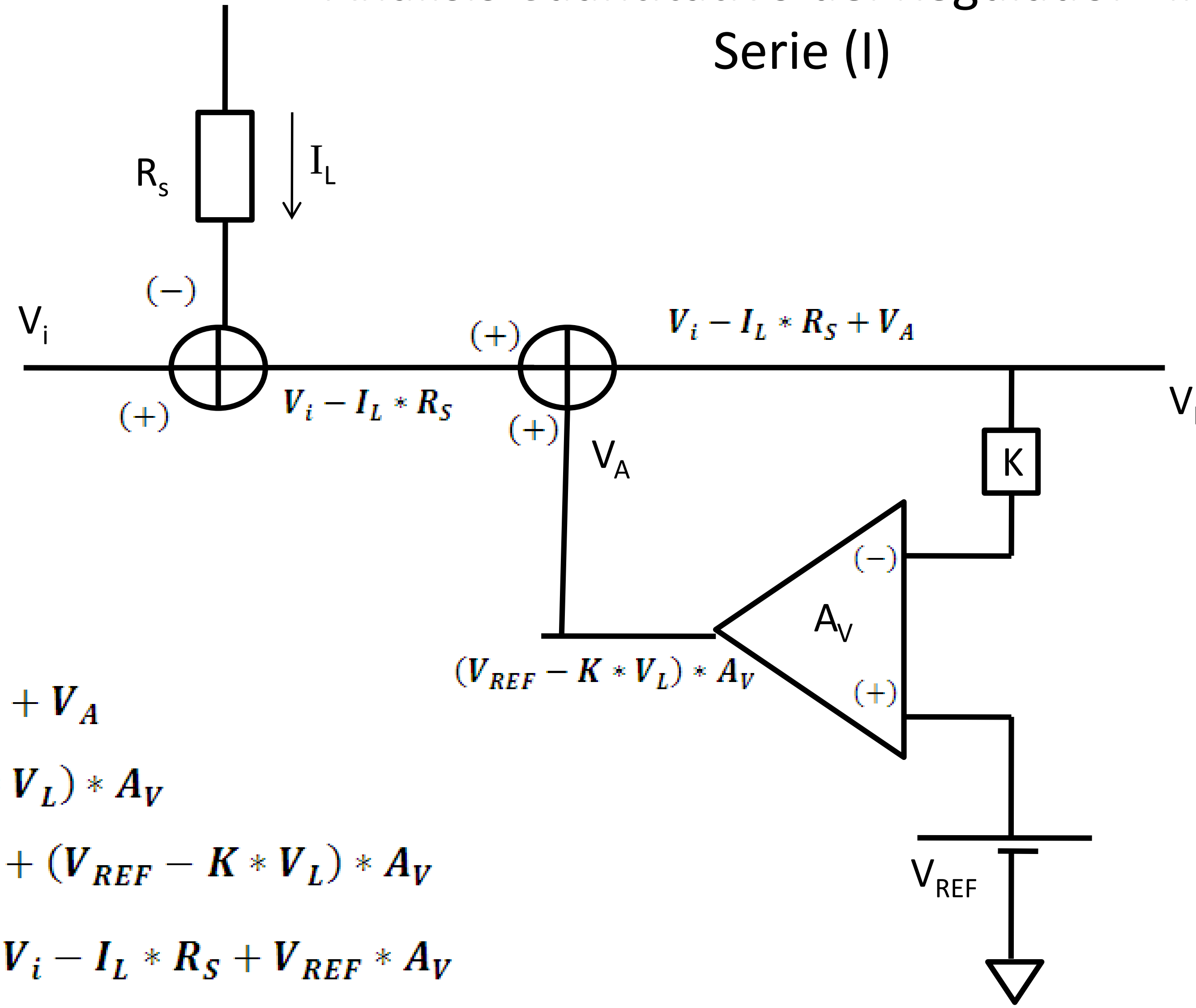
REGULADOR LINEAL SERIE



$$k = \frac{R_2}{R_1 + R_2} \qquad V_L = \frac{V_Z}{k}$$

Análisis Cuantitativo del Regulador Lineal Serie (I)





$$V_L = V_i - I_L * R_S + V_A$$

$$V_A = (V_{REF} - K * V_L) * A_V$$

$$V_L = V_i - I_L * R_S + (V_{REF} - K * V_L) * A_V$$

$$V_L * (1 + kA_v) = V_i - I_L * R_S + V_{REF} * A_V$$

$$V_L = \frac{V_i - I_L * R_S + V_{REF} * A_V}{(1 + kA_v)}$$

Análisis Cuantitativo del Regulador Lineal Serie (II)

$$V_L = \frac{V_i - I_L * R_S + V_{REF} * A_V}{(1 + kA_v)}$$

$$\Delta V_L = \frac{\Delta V_i - \Delta I_L * R_S + \Delta V_{REF} * A_V}{(1 + kA_v)}$$

Cuando I_L = cte y V_{REF} = cte. **$\Delta I_L = 0$ y $\Delta V_{REF} = 0$**

$$\Delta V_L = \frac{\Delta V_i}{(1 + kA_v)}$$

Cuando V_i = cte y V_{REF} = cte. **$\Delta V_i = 0$ y $\Delta V_{REF} = 0$**

$$\Delta V_L = \frac{-\Delta I_L * R_S}{(1 + kA_v)}$$

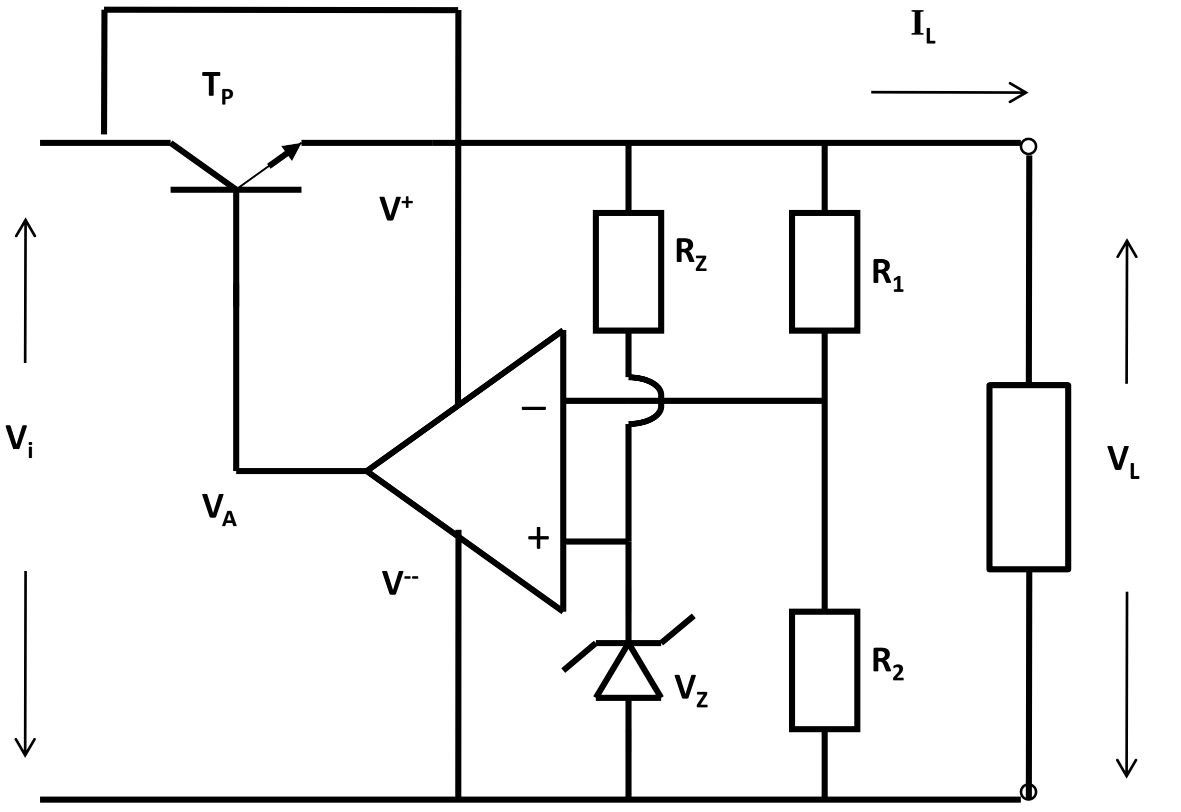
$$\frac{\Delta V_L}{\Delta I_L} = \frac{R_S}{(1 + kA_v)}$$

Cuando I_L = cte y V_i = cte. **$\Delta I_L = 0$ y $\Delta V_i = 0$**

$$\Delta V_L = \frac{\Delta V_{REF} * A_V}{(1 + kA_v)}$$

$$\Delta V_L \approx \frac{\Delta V_{REF}}{k}$$

REGULADOR LINEAL SERIE



Condiciones de diseño

- V_L
- I_{LMAX}
- V_{Lripp}
- T_{AMB}

Seleccionar dispositivos

- Tp
- Amp.Op.
- Diodo zener
- Resistores

Especificar fuente no regulada

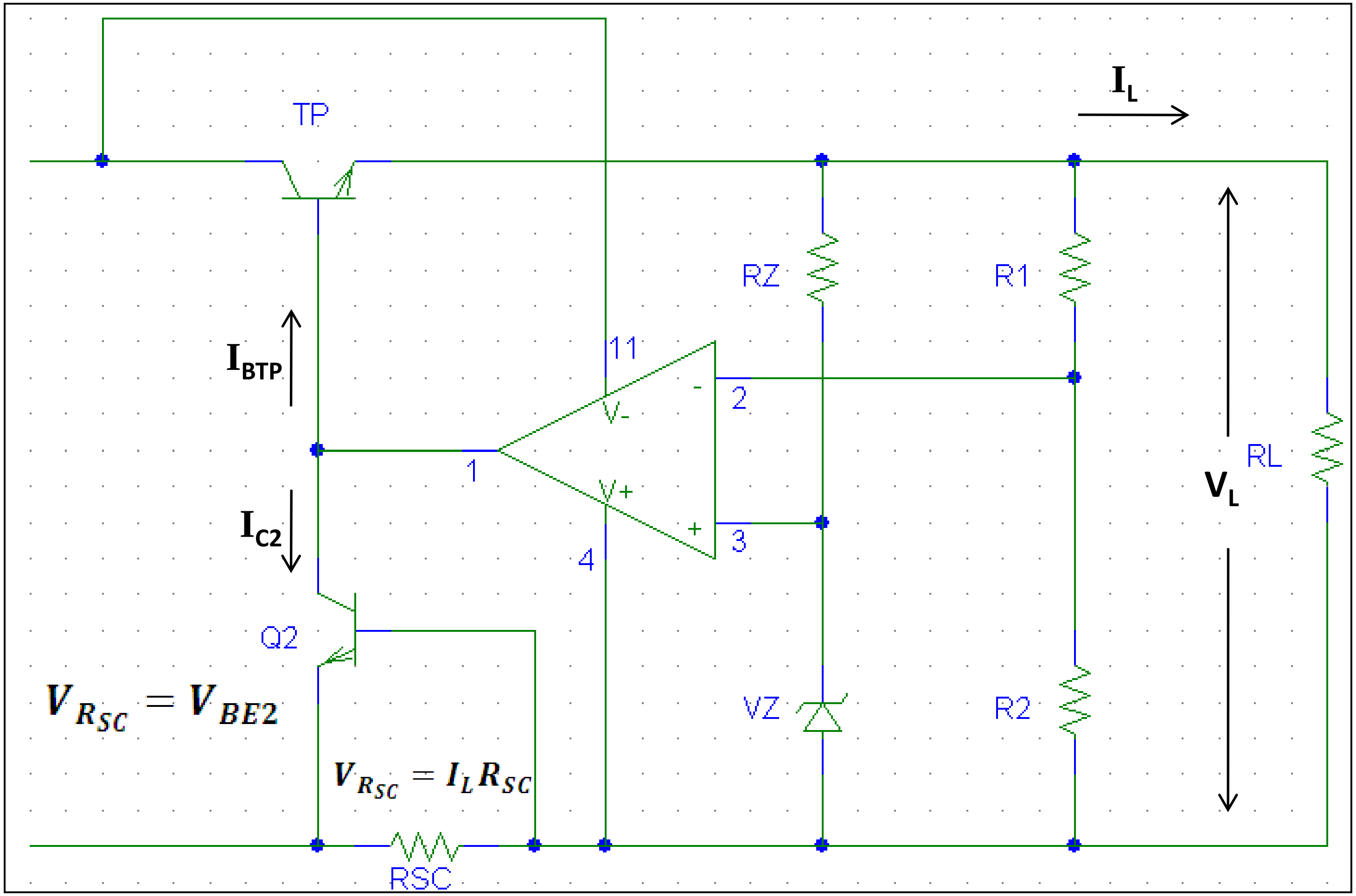
- Vi
- V_{iripp}
- I_{MAX}

CONDICIONES DE DISEÑO

- Transistor de paso T_p
  - En zona activa directa → $V_{im} - V_L \geq V_{CEsat}$
  - Dentro de la zona de operación segura
    - → $(V_i - V_L)_{MAX} < VCE_0$
    - → $I_{LMAX} \leq I_{CMAX}$
    - → $(V_{CE} \times I_C)_{MAX} \leq P_M$
- Amp. Op.
  - Max. Absolutos
    - → $V_{iMAX} \leq (V^+ + V^-)_{MAX}$
    - → $V_{REF} \leq VMC_{MAX}$
    - → $I_{BTp} \leq I_{0MAX}$
  - Operación en zona lineal → $(V^+ - V_A)_{Min} \geq Vsat_{OP}$

PROTECCION (I)

Limitador de Corriente

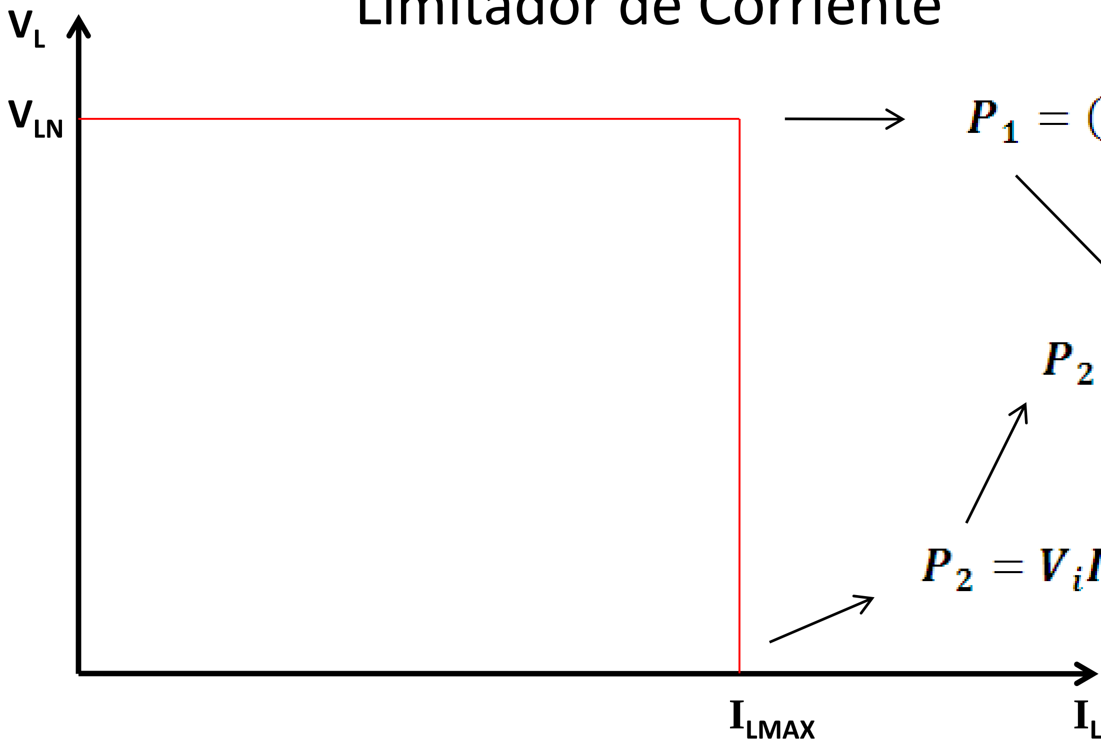


Cuando $V_{RSC} = V_{BEon}$ I_{C2} le quita corriente a la base de T_P

I_L no puede aumentar

PROTECCION (I)

Limitador de Corriente



$$P_1 = (V_i - V_L)I_{LMAX}$$

$$P_2 > P_1$$

$$P_2 = V_i I_{LMAX}$$

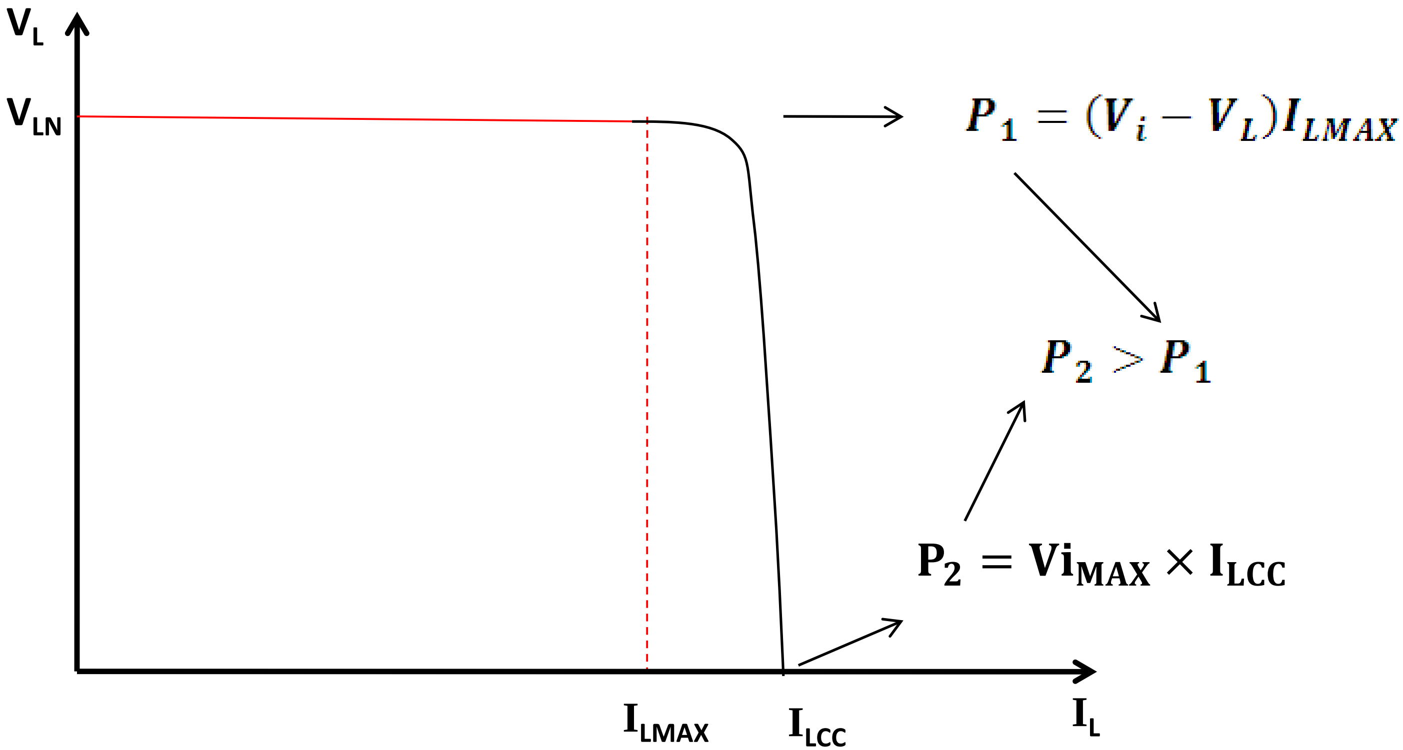
Corriente a la que comienza a proteger el circuito → $I_{LMAX} = \dfrac{V_{BEon}}{R_{SC}}$

Maxima Potencia en funcionamiento normal → $P_{FNMAX} = (Vi_{MAX} - V_{LN}) \times I_{LMAX}$

Maxima Potencia en corto circuito → $P_{CCMAX} = Vi_{MAX} \times I_{LMAX}$

PROTECCION (I)

Limitador de Corriente

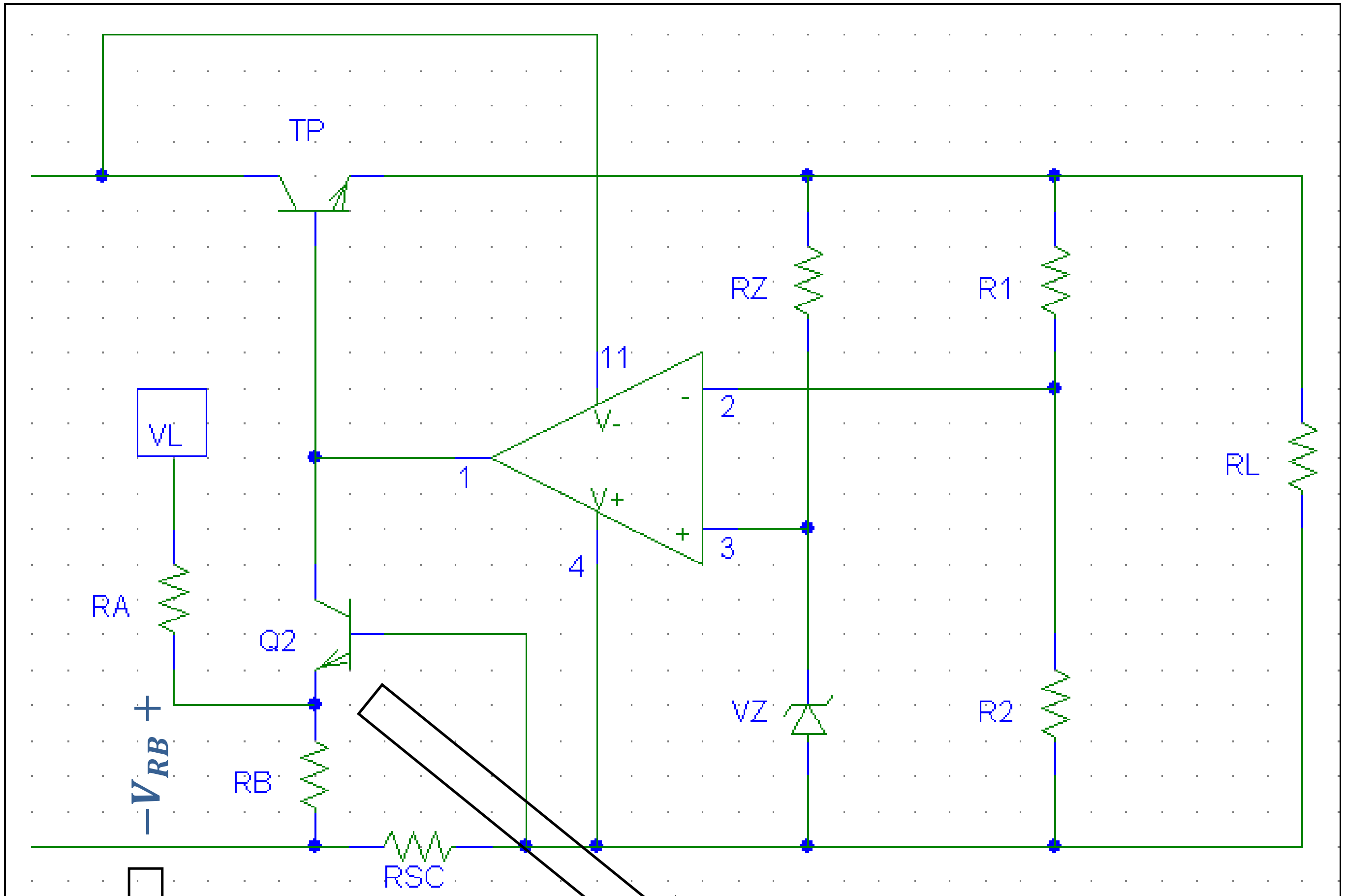


$$I_{LCC} \approx 1.1 I_{LMAX}$$

TP debe dimensionarse para manejar una potencia que solo aparece en la condición de cortocircuito

PROTECCION (II)

Corriente Reentrante



$-V_{RSC}+$

La tensión de disparo de la protección depende de la corriente y la tensión en la carga

$$V_{BEQ2} = I_L R_{SC} - kV_L$$

$$V_{BEQ2} = V_{RSC} - V_{RB}$$

$$V_{RB} = \frac{V_L R_B}{R_A + R_B}$$

$$V_{RSC} = I_L R_{SC}$$

$$k = \frac{R_B}{R_A + R_B}$$

$$V_{BEQ2} = I_L R_{SC} - kV_L$$

Condición de Corto Circuito → $V_L = 0$, $I_L = I_{LCC}$

$$V_{BEQ2} = I_{LCC} R_{SC}$$

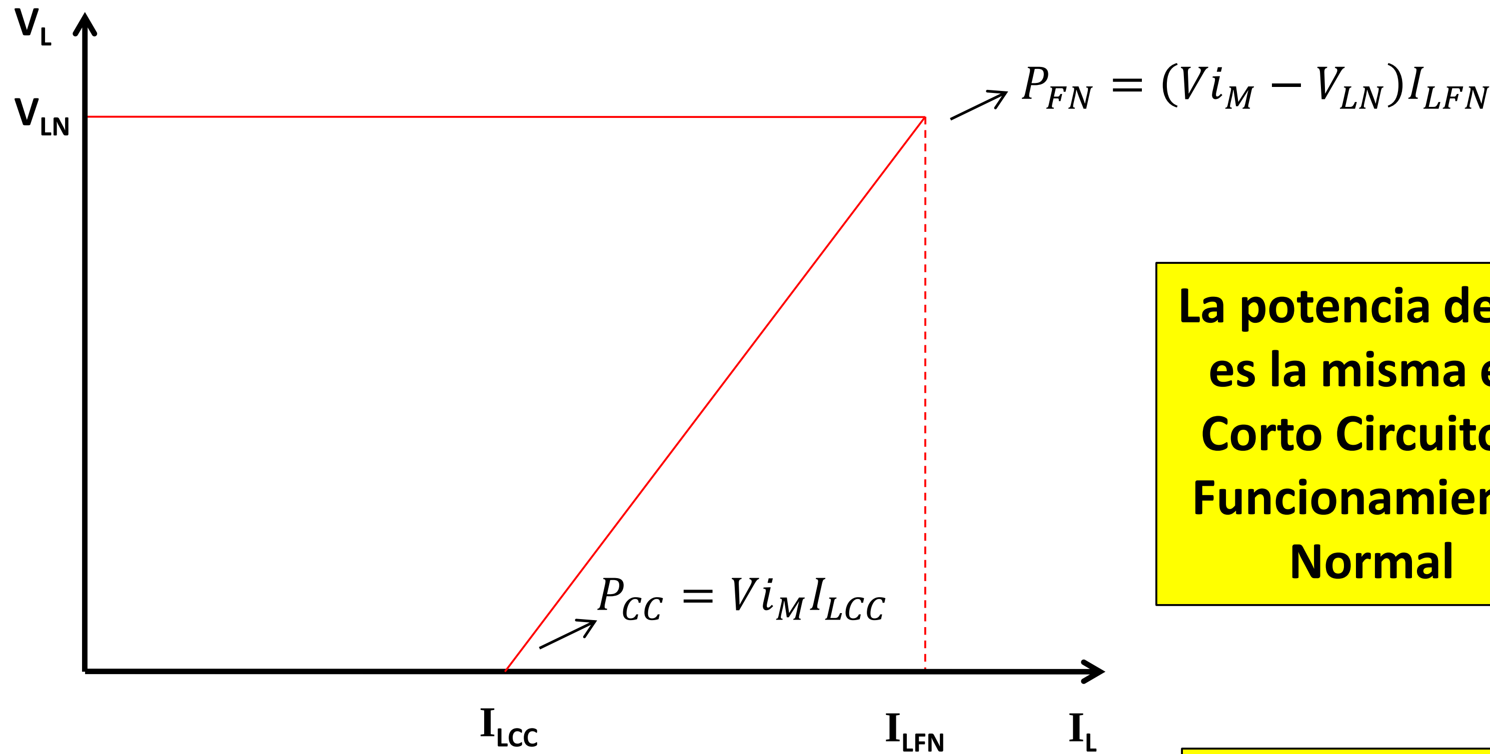
Condición de Funcionamiento Normal → $V_L = V_{LN}$, $I_L = I_{LFN}$

$$V_{BEQ2} = I_{LFN} R_{SC} - kV_{LN}$$

$$I_{LCC} = \frac{VBE_{onQ2}}{R_{SC}}$$

$$I_{LFN} = \frac{VBE_{onQ2} + kV_{LN}}{R_{SC}}$$

$$I_{LFN} > I_{LCC}$$



La potencia de TP es la misma en Corto Circuito y Funcionamiento Normal

Aprovecho mejor el circuito térmico

Coloco un TP que pueda disipar P_{FN}

Ajusto las resistencias R_{SC}, R_A y R_B para obtener

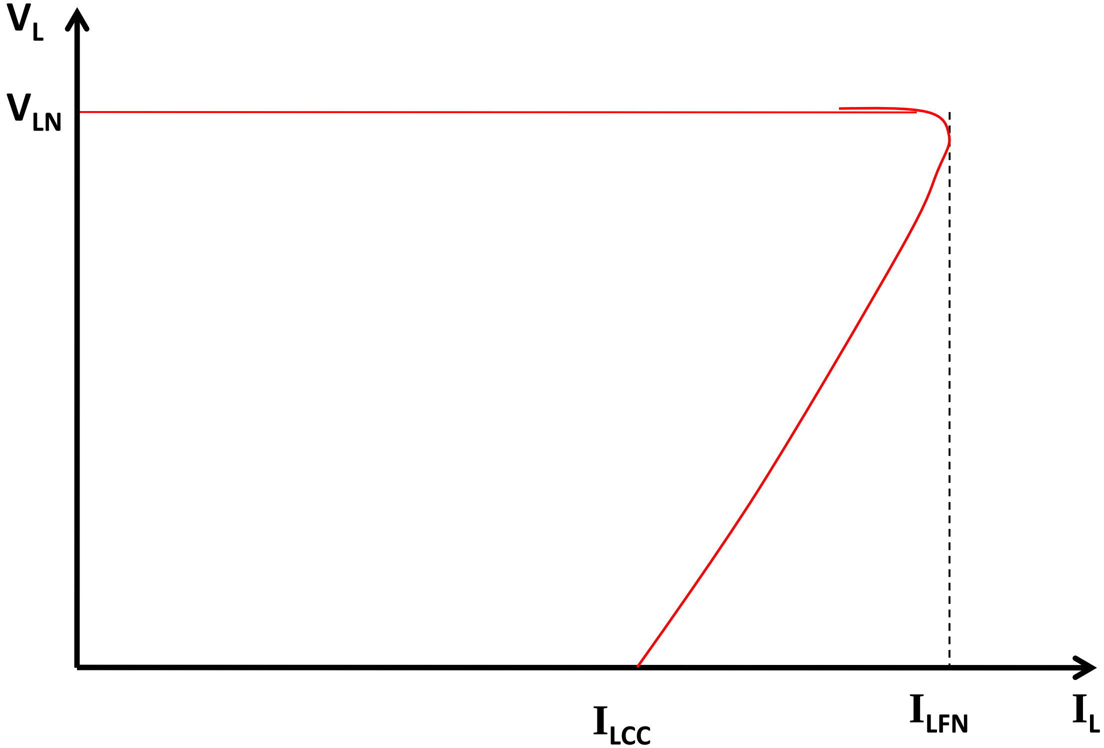
$$P_{CC} = P_{FN}$$

$$Vi_M I_{LCC} = (Vi_M - V_{LN})I_{LFN}$$

$$\boldsymbol{I_{LCC} = \left(1 - \frac{V_{LN}}{Vi_M}\right) I_{LFN}}$$

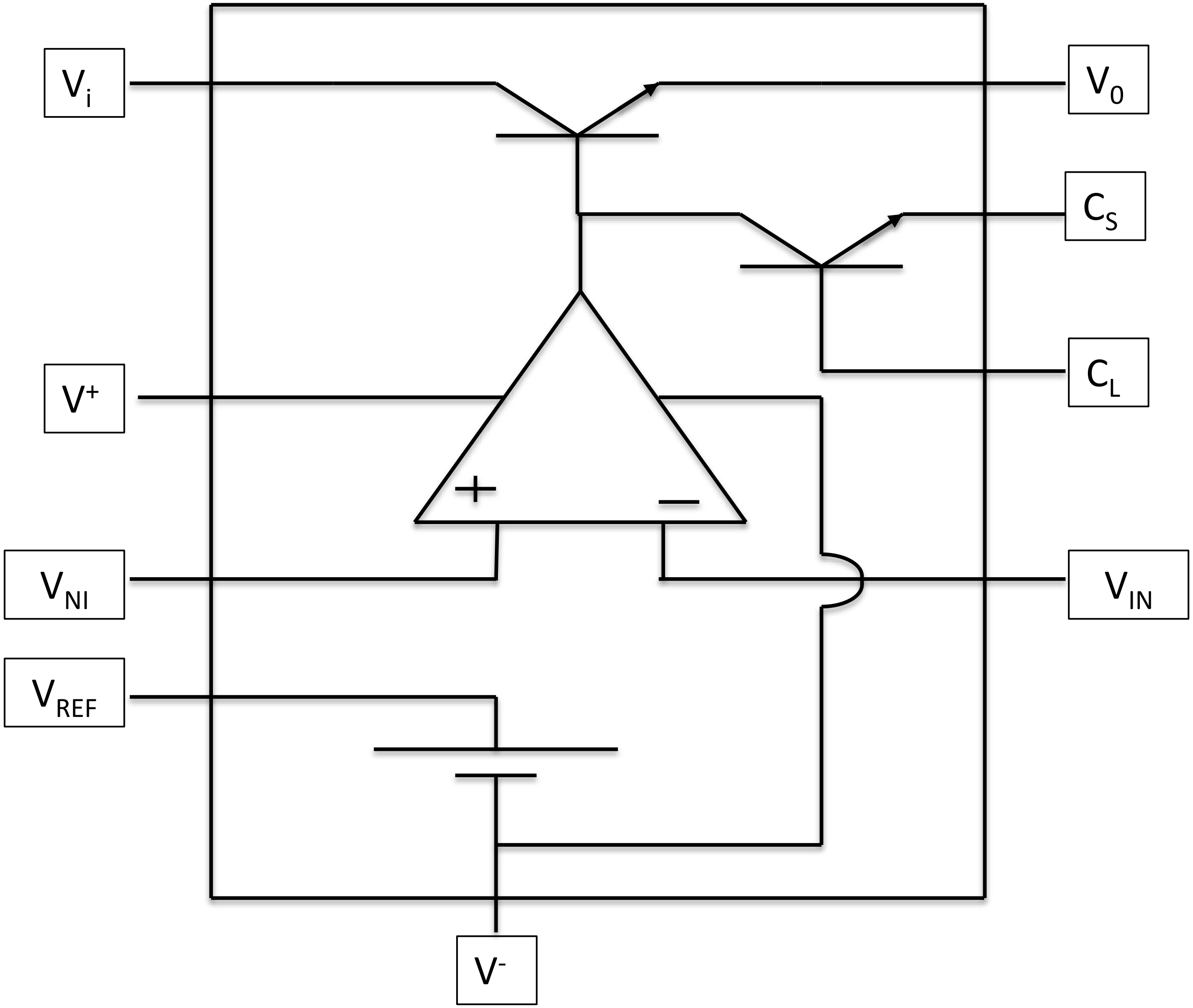
PROTECCION (II)

Corriente Reentrante



- Se dimensiona el circuito térmico para soportar las condiciones de funcionamiento normal y cortocircuito de salida
  - Se diseña la protección para que $P_{FN} = P_{CC}$
- Como la potencia disipada en corto circuito es la misma que la de funcionamiento normal el disipador y el transistor TP se utilizan a pleno.

REGULADOR INTEGRADO XX723



LM723/LM723C Voltage Regulator

Check for Samples: LM723, LM723C

FEATURES

- 150 mA Output Current Without External Pass Transistor
- Output Currents in Excess of 10A Possible by Adding External Transistors
- Input Voltage 40V Max
- Output Voltage Adjustable from 2V to 37V
- Can be Used as Either a Linear or a Switching Regulator

DESCRIPTION

The LM723/LM723C is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents up to 150 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting.

The LM723/LM723C is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

The LM723C is identical to the LM723 except that the LM723C has its performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

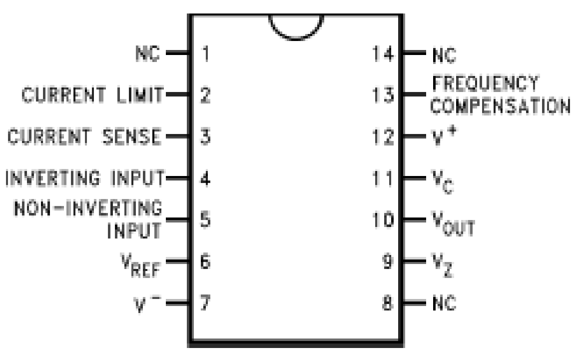
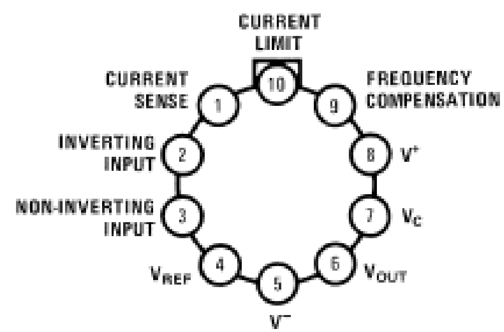


Figure 1. Top View
CDIP Package or PDIP Package
See Package J or NFF0014A

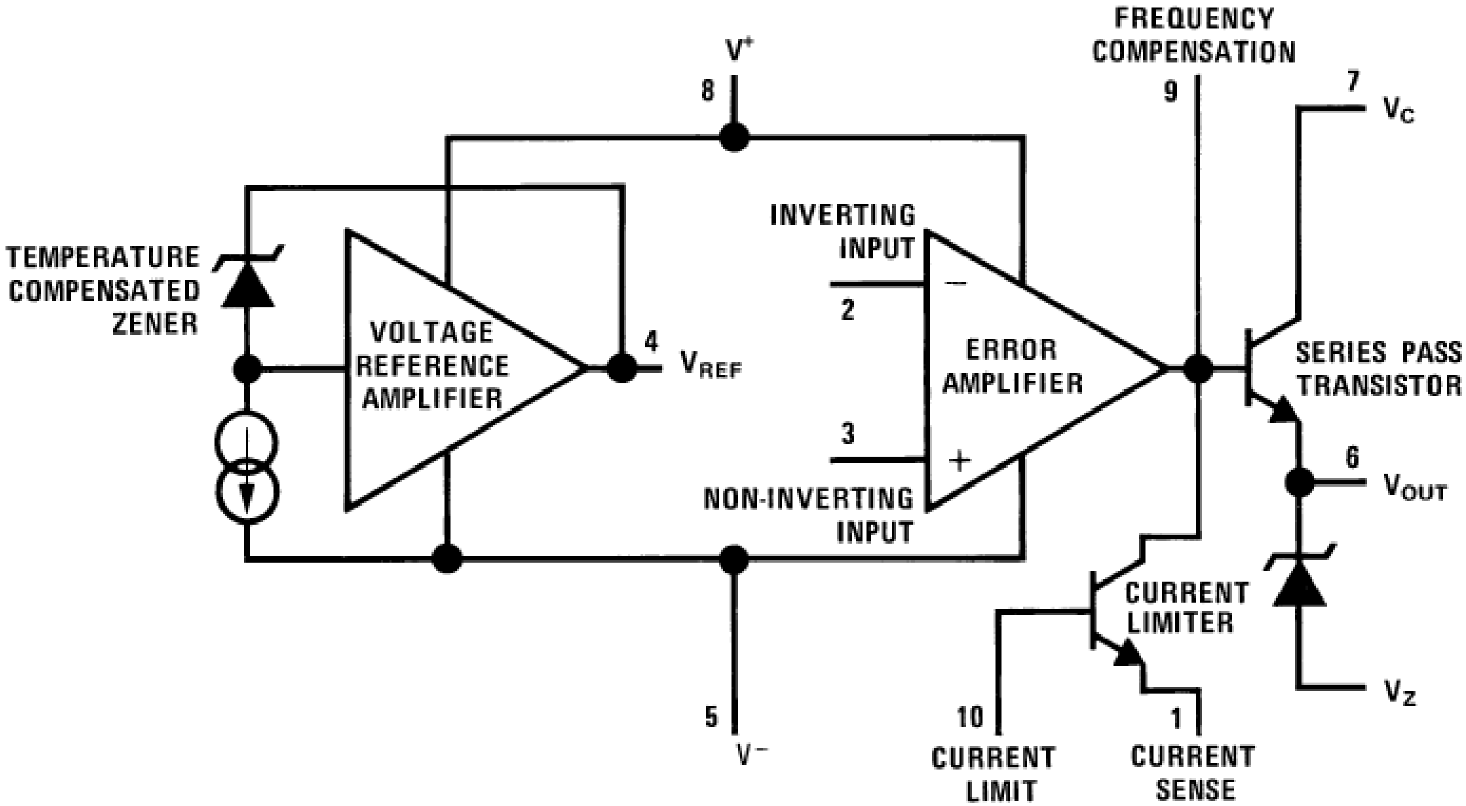


Note: Pin 5 connected to case.

Figure 2. Top View
TO-100
See Package LME

REGULADOR INTEGRADO
XX723

Esquema del Circuito



REGULADOR INTEGRADO
XX723

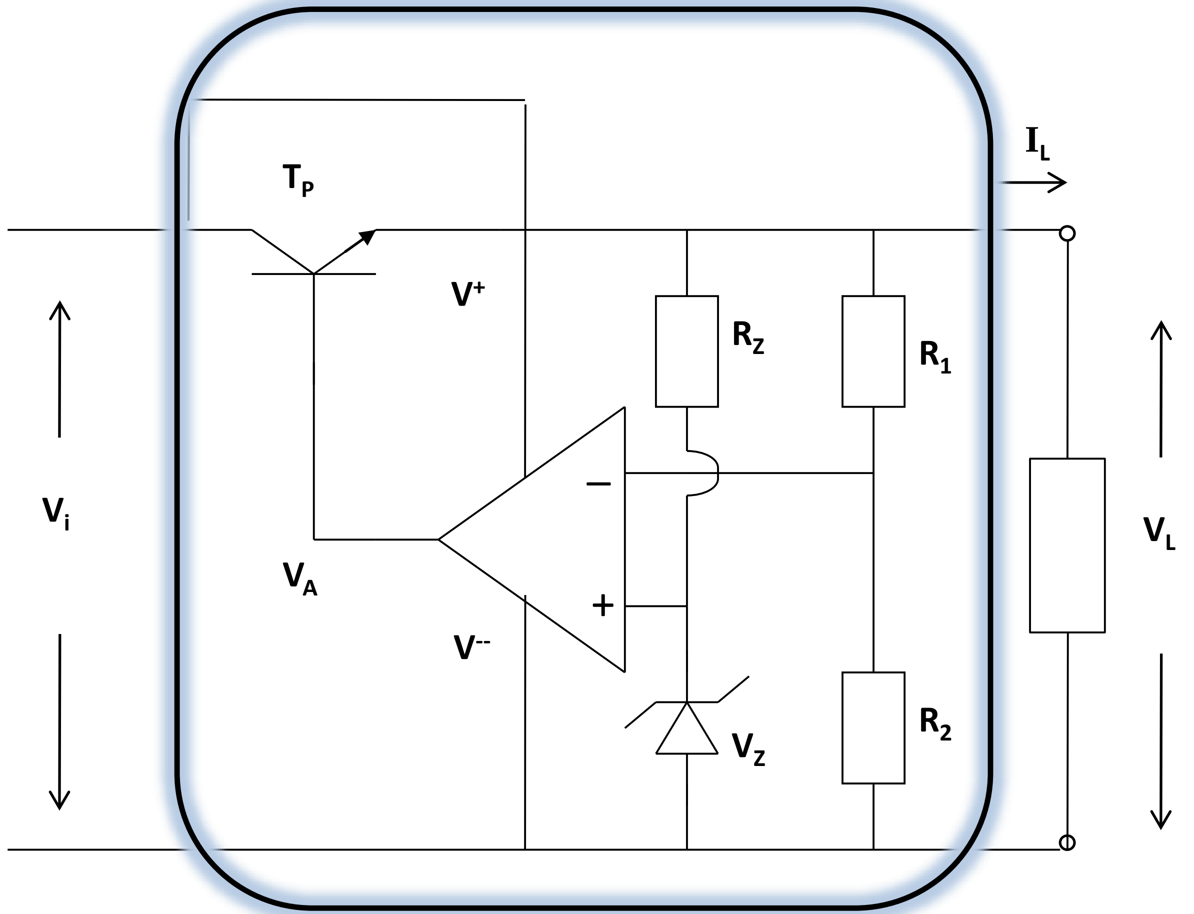
ABSOLUTE MAXIMUM RATINGS [1] [2]

Pulse Voltage from V^+ to V^- (50 ms)	50V
Continuous Voltage from V^+ to V^-	40V
Input-Output Voltage Differential	40V
Maximum Amplifier Input Voltage (Either Input)	8.5V
Maximum Amplifier Input Voltage (Differential)	5V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation Metal Can [3]	800 mW
CDIP [3]	900 mW
PDIP [3]	660 mW
Operating Temperature Range	
LM723	−55°C to +150°C
LM723C	0°C to +70°C
Storage Temperature Range Metal Can	−65°C to +150°C
PDIP	−55°C to +150°C
Lead Temperature (Soldering, 4 sec. max.)	
Hermetic Package	300°C
Plastic Package	260°C

ELECTRICAL CHARACTERISTICS[1][2][3][4]

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	V_{IN} = 12V to V_{IN} = 15V		0.01	0.1		0.01	0.1	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C			0.3				% V_{OUT}
	0°C ≤ T_A ≤ +70°C						0.3	% V_{OUT}
	V_{IN} = 12V to V_{IN} = 40V		0.02	0.2		0.1	0.5	% V_{OUT}
Load Regulation	I_L = 1 mA to I_L = 50 mA		0.03	0.15		0.03	0.2	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C			0.6				% V_{OUT}
	0°C ≤ T_A ≤ +70°C						0.6	% V_{OUT}
Ripple Rejection	f = 50 Hz to 10 kHz, C_{REF} = 0		74			74		dB
	f = 50 Hz to 10 kHz, C_{REF} = 5 µF		86			86		dB
Average Temperature Coefficient of Output Voltage ([5])	−55°C ≤ T_A ≤ +125°C		0.002	0.015				%/°C
	0°C ≤ T_A ≤ +70°C					0.003	0.015	%/°C
Short Circuit Current Limit	R_{SC} = 10Ω, V_{OUT} = 0		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	BW = 100 Hz to 10 kHz, C_{REF} = 0		86			86		µVrms
	BW = 100 Hz to 10 kHz, C_{REF} = 5 µF		2.5			2.5		µVrms
Long Term Stability			0.05			0.05		%/1000 hrs
Standby Current Drain	I_L = 0, V_{IN} = 30V		1.7	3.5		1.7	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V
θ_{JA}	PDIP					105		°C/W
θ_{JA}	CDIP		150					°C/W
θ_{JA}	H10C Board Mount in Still Air		165			165		°C/W
θ_{JA}	H10C Board Mount in 400 LF/Min Air Flow		66			66		°C/W
θ_{JC}			22			22		°C/W

POTENCIA DISIPADA POR UN REGULADOR LINEAL SERIE



$$\eta = \frac{V_L}{V_i}$$

$$P_R = (V_i - V_L)_{MAX} \times IL_{MAX}$$

$$P_T = P_L + P_R$$

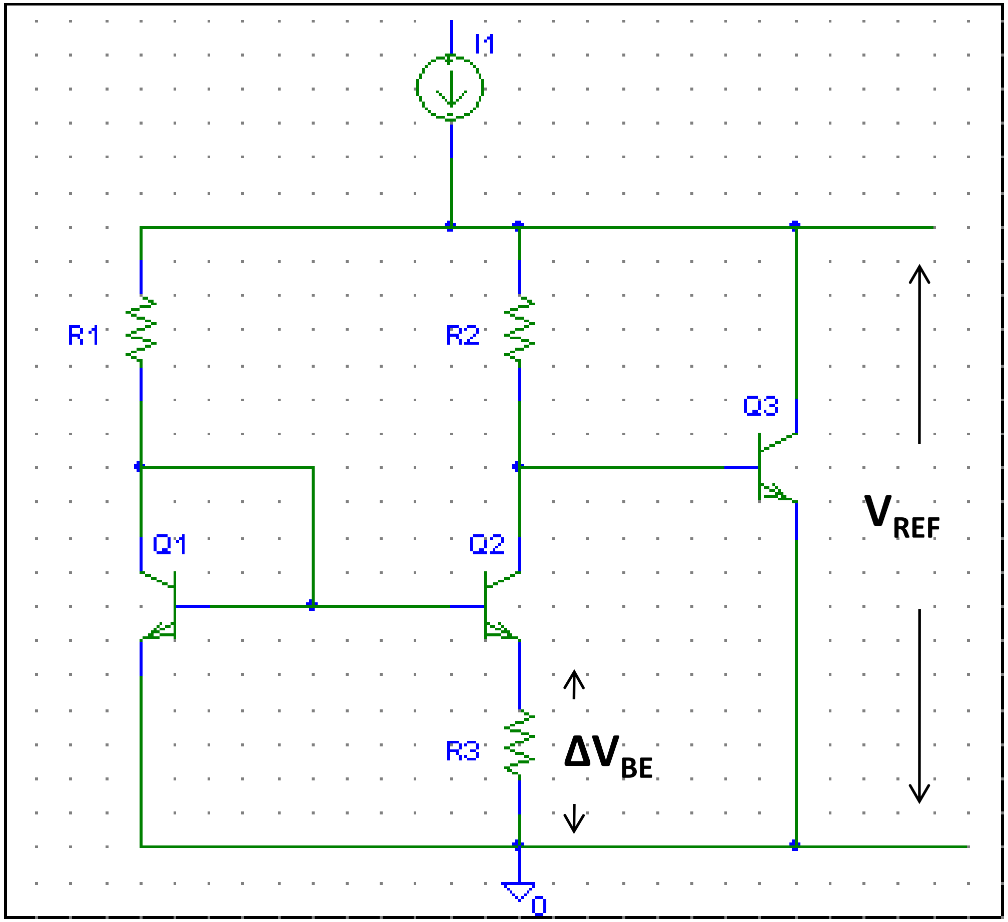
$$P_L = V_L \times IL_{MAX}$$

$$\eta = \frac{P_L}{P_T}$$

$$\eta = \frac{1}{1 + \frac{P_R}{P_L}}$$

$$\eta = \frac{1}{1 + \frac{(V_i - V_L)}{V_L}}$$

Fuente de Referencia de Banda Prohibida (I)



$$V_{REF} = V_{BE3} + V_{R_2}$$

$$V_{R_2} = I_{C2}R_2 = \frac{\Delta V_{BE}}{R_3}R_2$$

$$V_{REF} = V_{BE3} + \Delta V_{BE}\frac{R_2}{R_3}$$

$$I_{C2} = I_{S2}e^{\frac{V_{BE2}}{U_T}} \qquad I_{C1} = I_{S1}e^{\frac{V_{BE1}}{U_T}}$$

$$Q_1 \equiv Q_2 \qquad \frac{I_{C1}}{I_{C2}} = e^{\frac{V_{BE1}-V_{BE2}}{U_T}}$$

$$\Delta V_{BE} = V_{BE1} - V_{BE2} \qquad \Delta V_{BE} = U_T\,ln\frac{I_{C1}}{I_{C2}}$$

$$V_{REF} = V_{BE3} + \frac{R_2}{R_3}U_T\,ln\frac{I_{C1}}{I_{C2}} \qquad V_{REF} = V_{BE3} + \frac{R_2}{R_3}\frac{kT}{q}\,ln\frac{I_{C1}}{I_{C2}}$$

Fuente de Referencia de Banda Prohibida (II)

$$V_{REF} = V_{BE3} + \frac{R_2}{R_3}\frac{kT}{q}\ln\frac{I_{C1}}{I_{C2}}$$

$$V_{BE}(T) = V_{G0}\left(1 - \frac{T}{T_0}\right) + V_{BE0}\left(\frac{T}{T_0}\right) \qquad V_{REF}(T) = V_{BE3}(T) + \frac{R_2}{R_3}\frac{kT}{q}\ln\frac{I_{C1}}{I_{C2}}$$

$$V_{REF}(T) = V_{G0}\left(1 - \frac{T}{T_0}\right) + V_{BE0}\left(\frac{T}{T_0}\right) + \frac{R_2}{R_3}\frac{kT}{q}\ln\frac{I_{C1}}{I_{C2}}$$

$$\frac{dV_{REF}}{dT} = -V_{G0}\frac{1}{T_0} + V_{BE0}\frac{1}{T_0} + \frac{R_2}{R_3}\frac{k}{q}\ln\frac{I_{C1}}{I_{C2}}$$

$$\frac{dV_{REF}}{dT} = 0$$

$$V_{G0} = V_{BE0} + \frac{R_2}{R_3}\frac{kT_0}{q}\ln\frac{I_{C1}}{I_{C2}}$$

Fuente de Referencia de Banda Prohibida (III)