Materiais Elétricos e Magnéticos para Engenharia

Professor: Marcus V. Batistuta

Laboratório #6

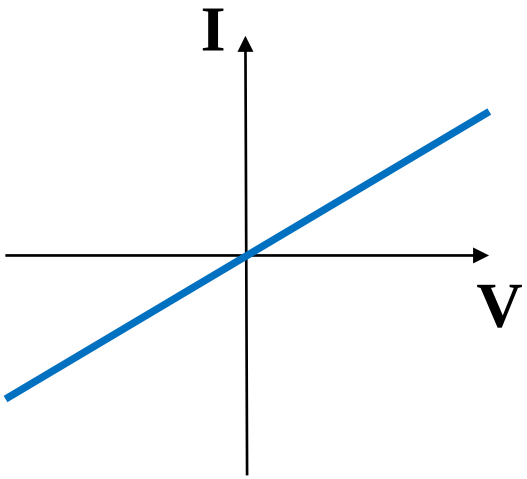
Diodo Zener

1º Semestre de 2018

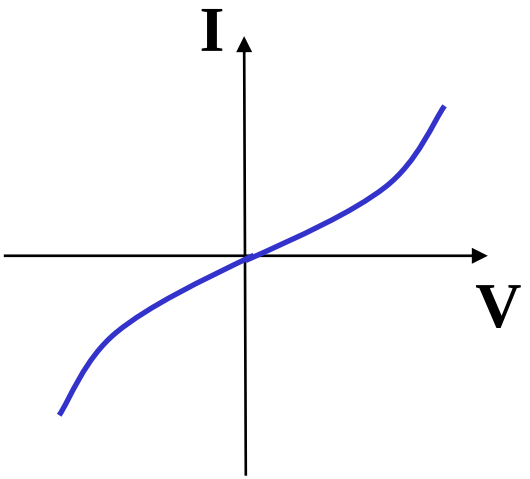
FGA - Universidade de Brasília

Simetria em Curvas IxV

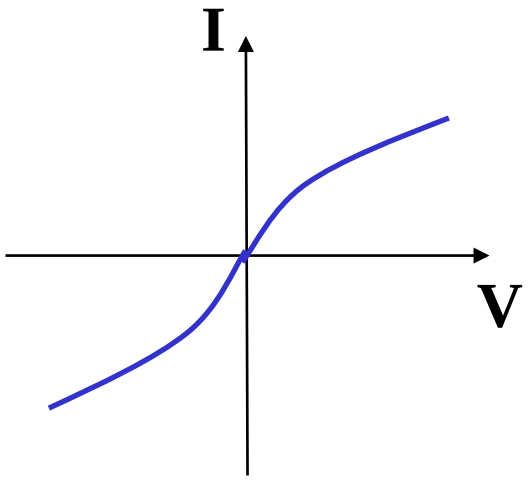
Dispositivos de Dois Terminais



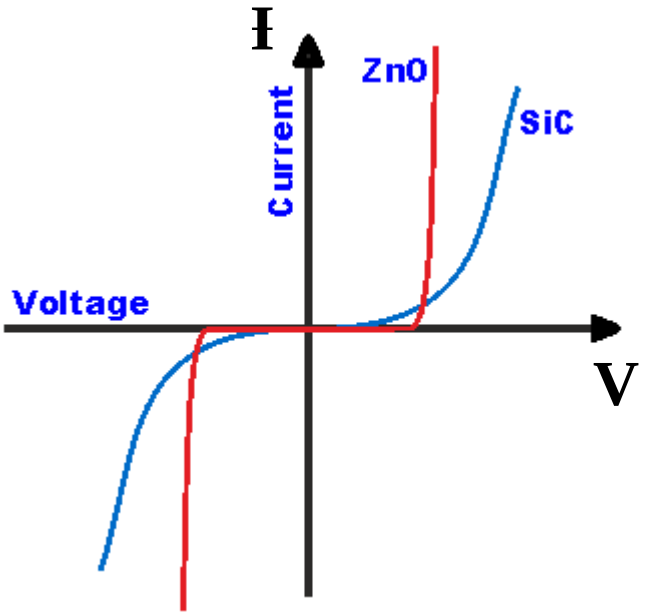
Resistor



Termistor NTC

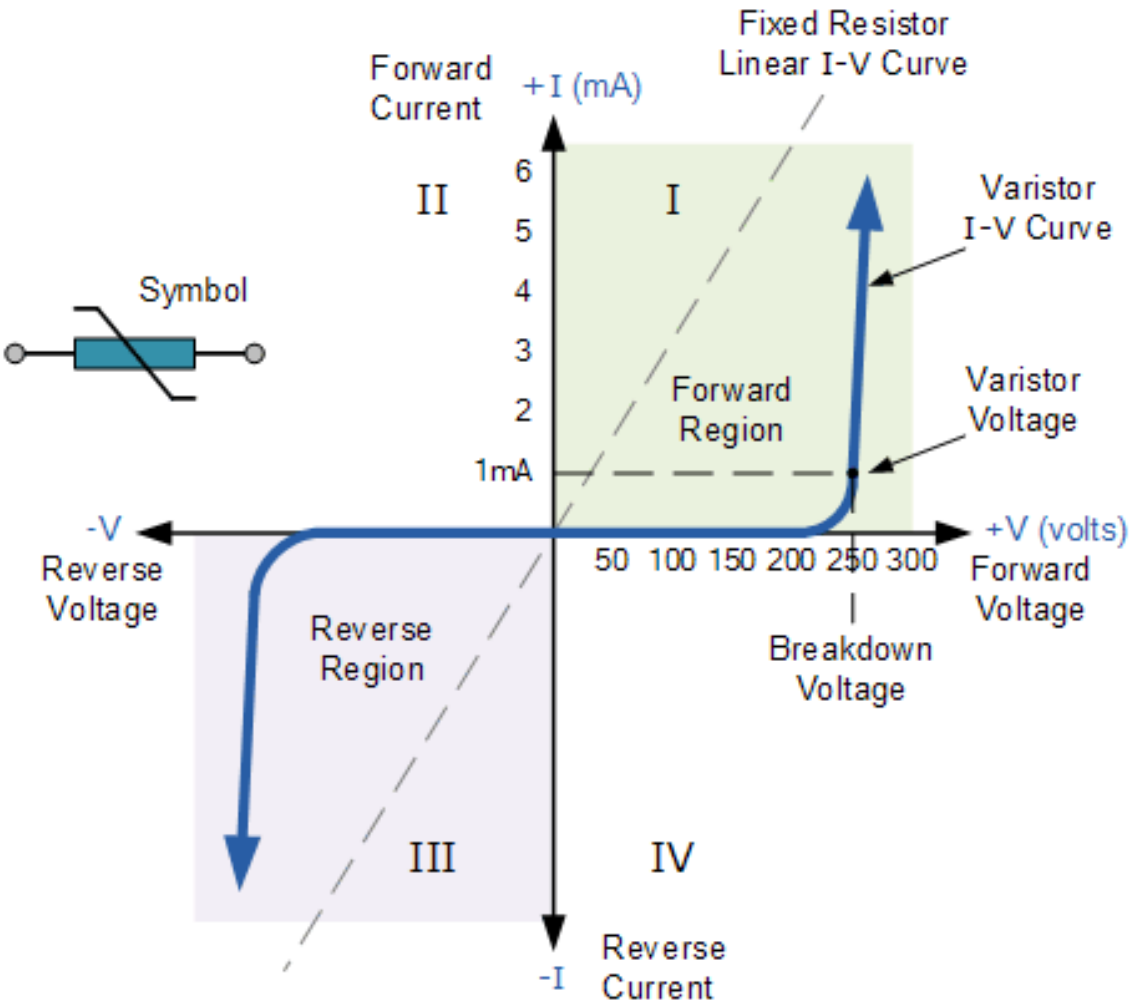


Lâmpada de Filamento
Termistor PTC



Varistor (Avalanche)

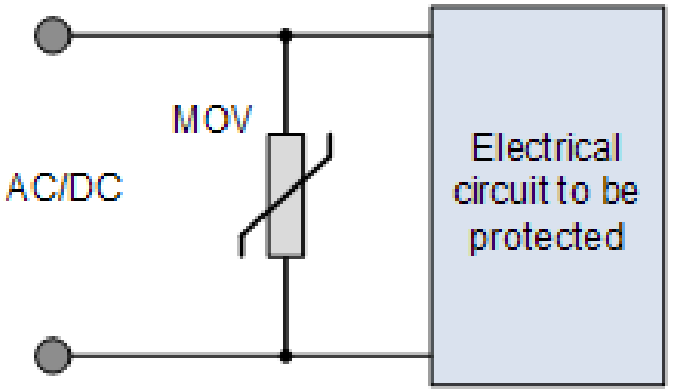
Varistor



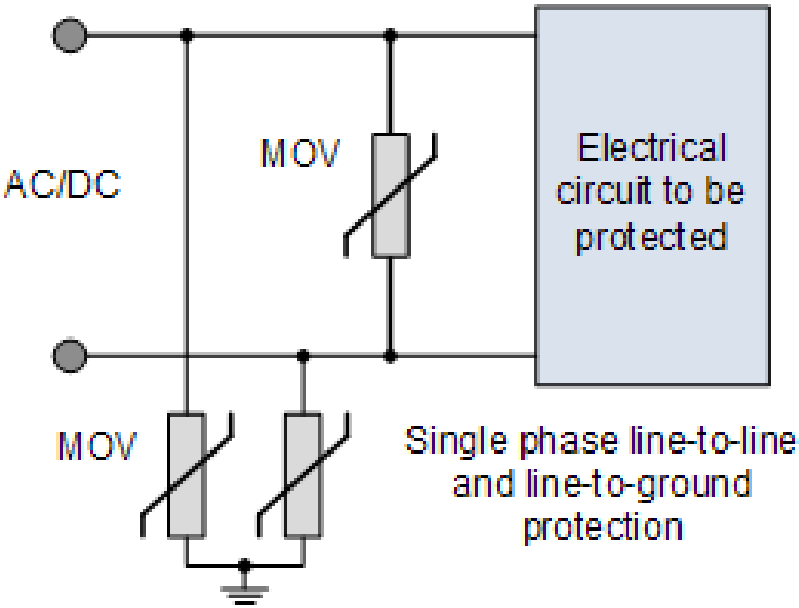
Type (untaped) SIOV-	Ordering code	V_{RMS} V	V_{DC} V	I_{max} 8/20 µs A	W_{max} (2 ms) J	P_{max} W
S07K75	B72207S0750K101	75	100	1200	5,9	0,25

https://www.electronics-tutorials.ws/resistor/varistor.html

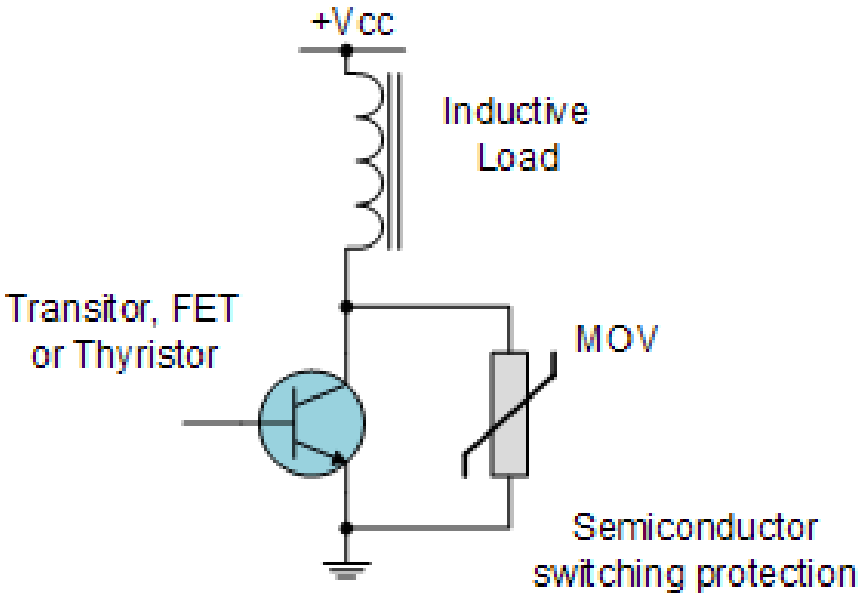
Varistor Applications



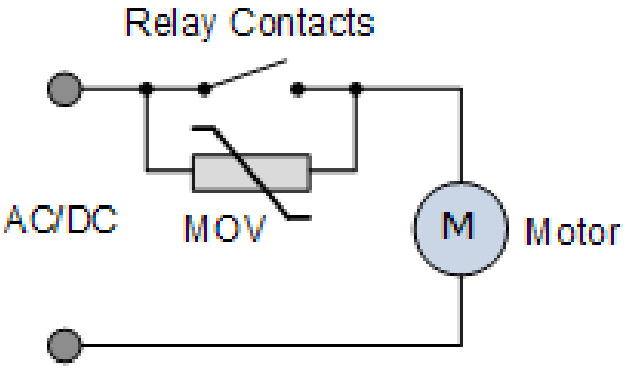
Single phase line-to-line protection



Single phase line-to-line and line-to-ground protection



Semiconductor switching protection

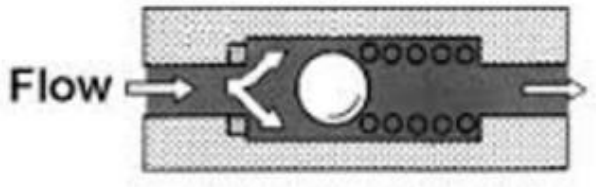


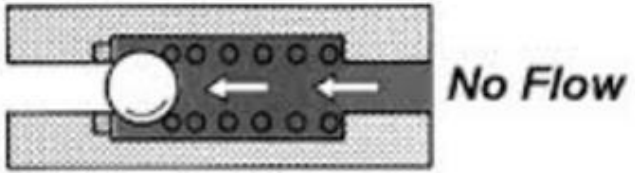
Contact arcing protection

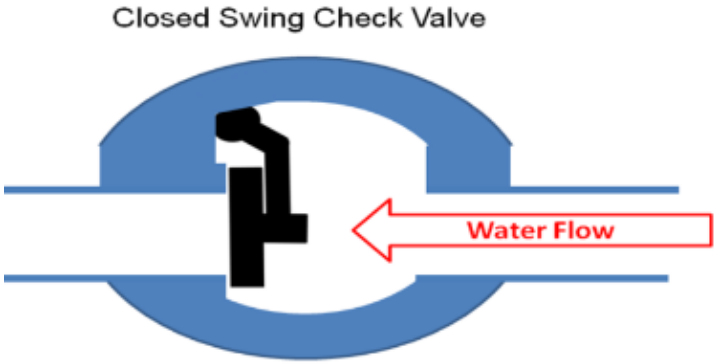
https://www.electronics-tutorials.ws/resistor/varistor.html

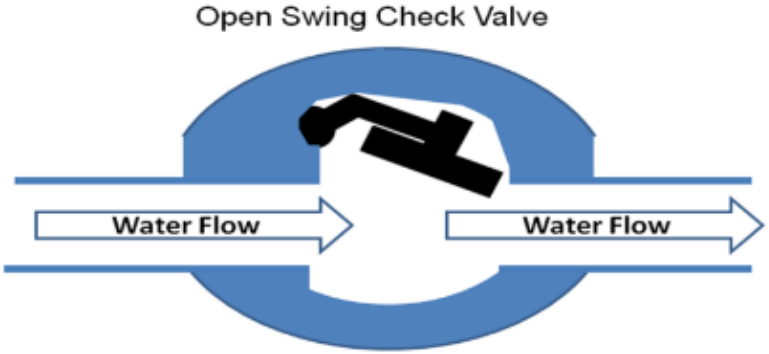
Válvulas Direcionais

Analogia Hidráulica



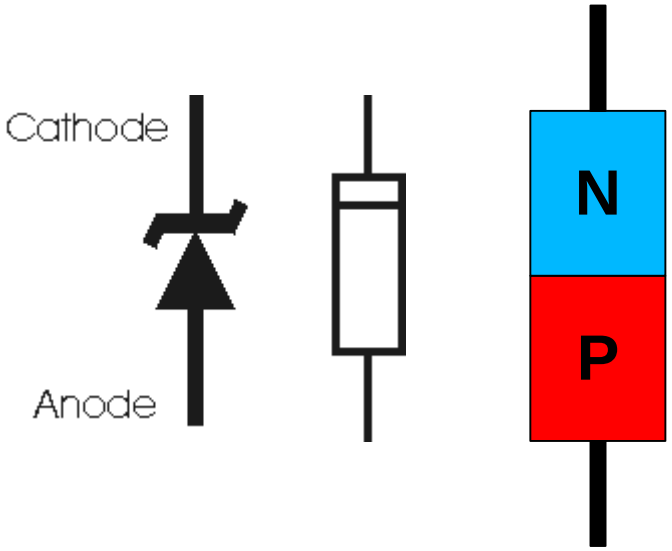


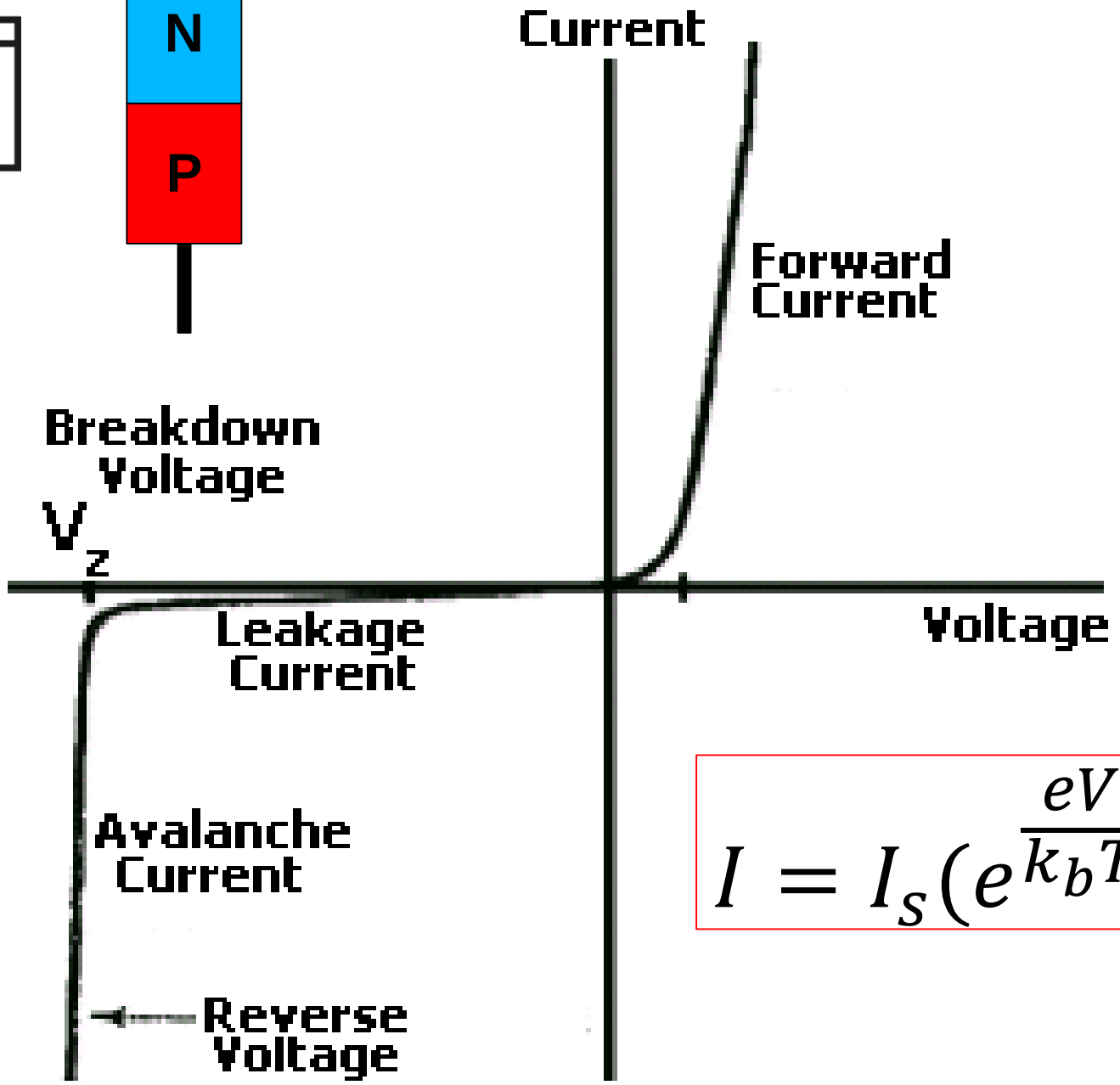




Existe equivalente elétrico?

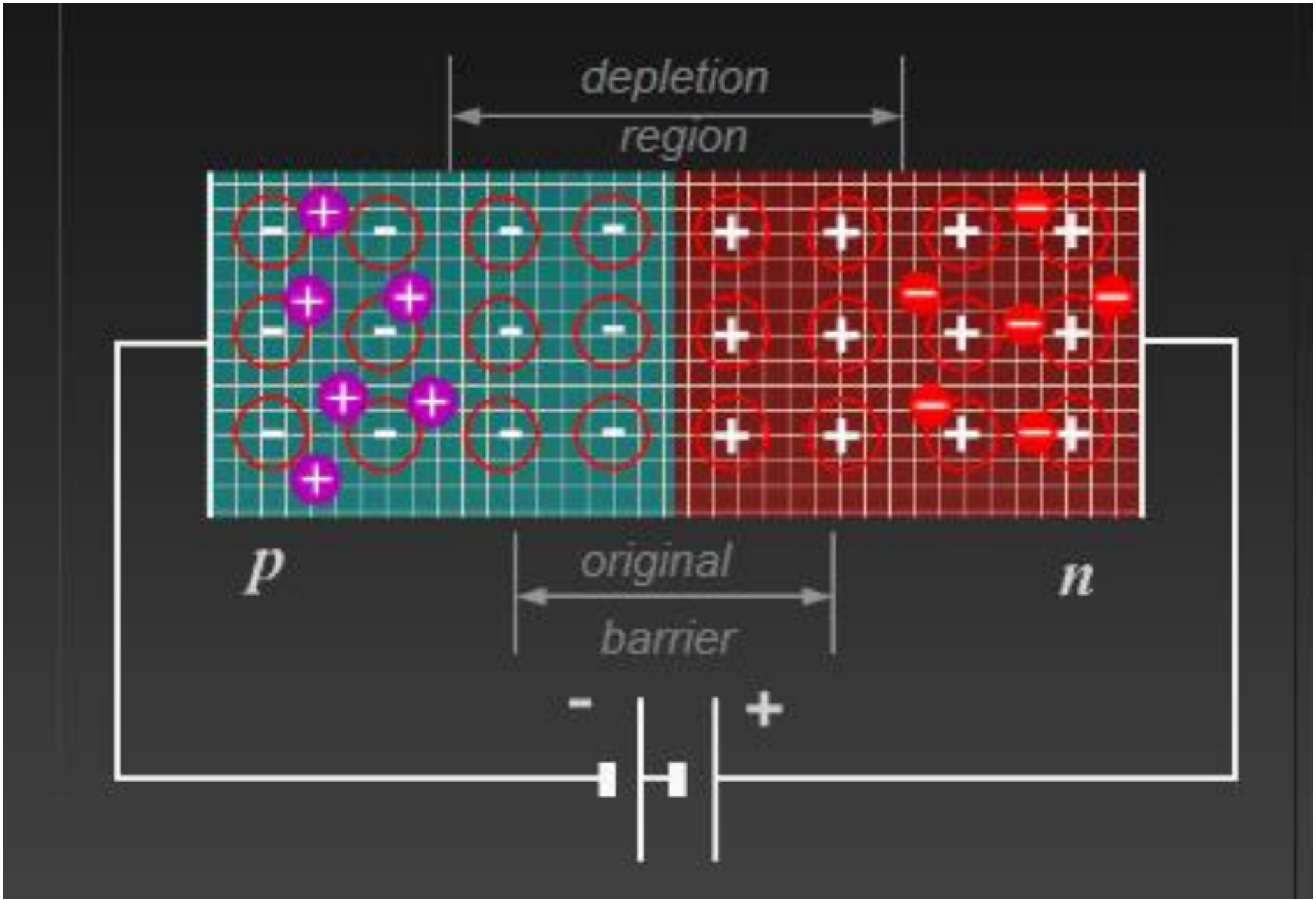
Curva I x V do Diodo Zener



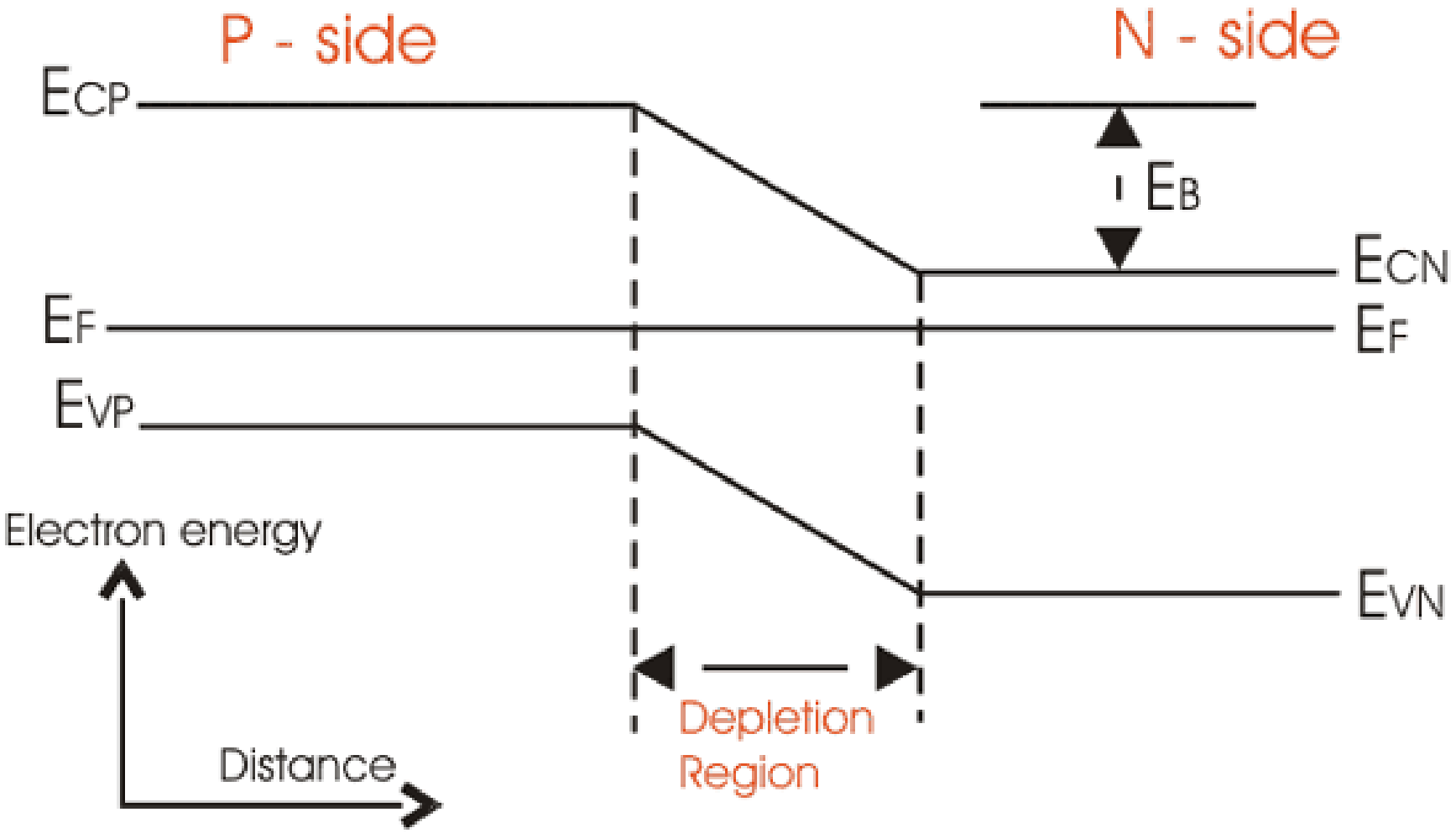


$$I = I_s(e^{\frac{eV}{k_b T}} - 1)$$

Junção PN (Diodo)

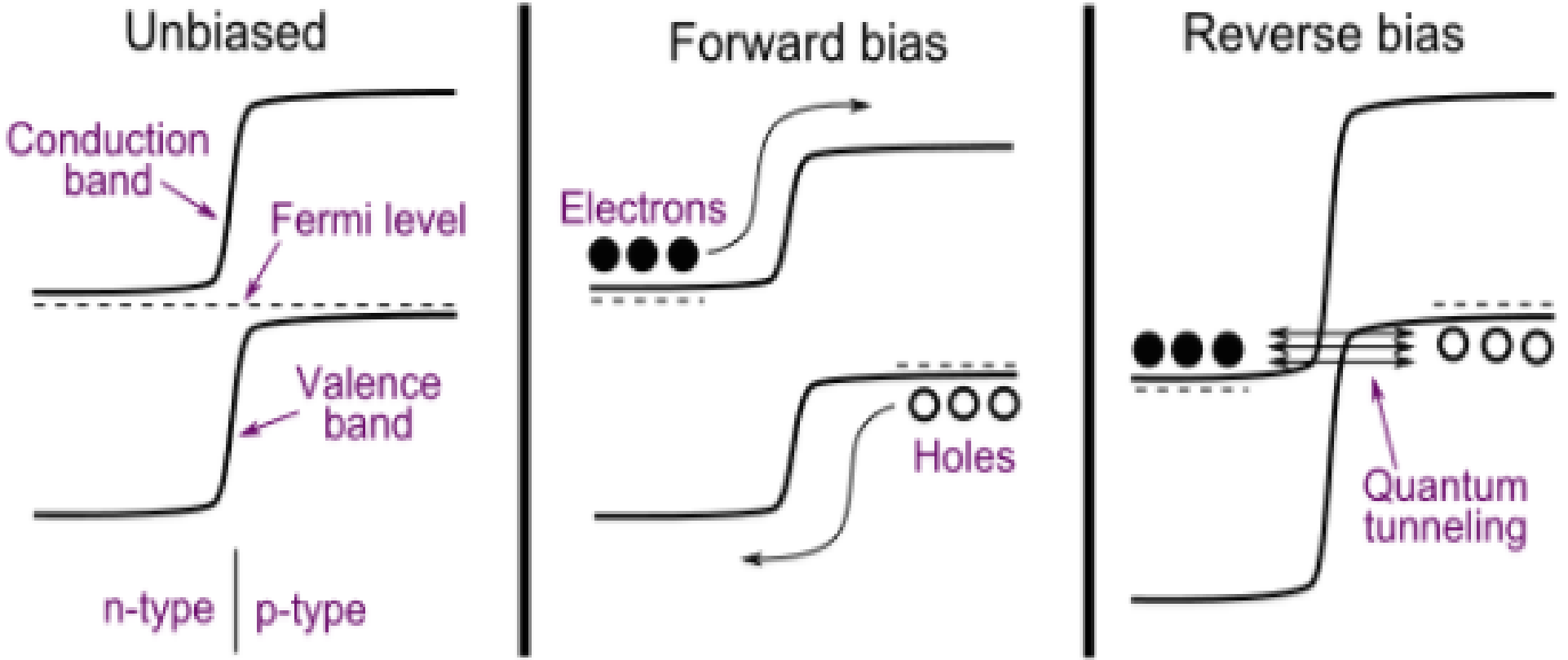


Junção PN (Diodo)
Estrutura de Bandas



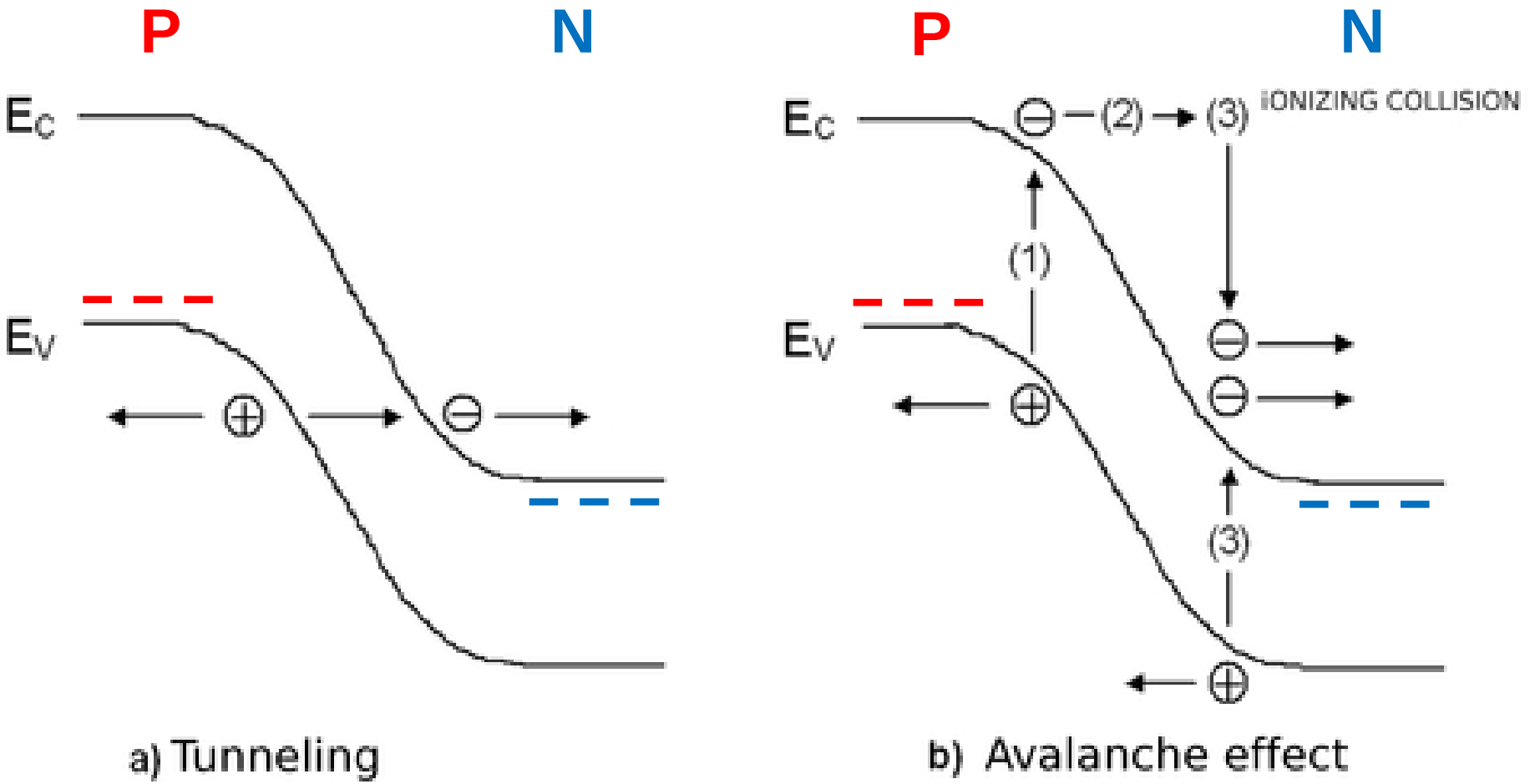
Diodo Zener

Estrutura de Bandas vs. Polarização

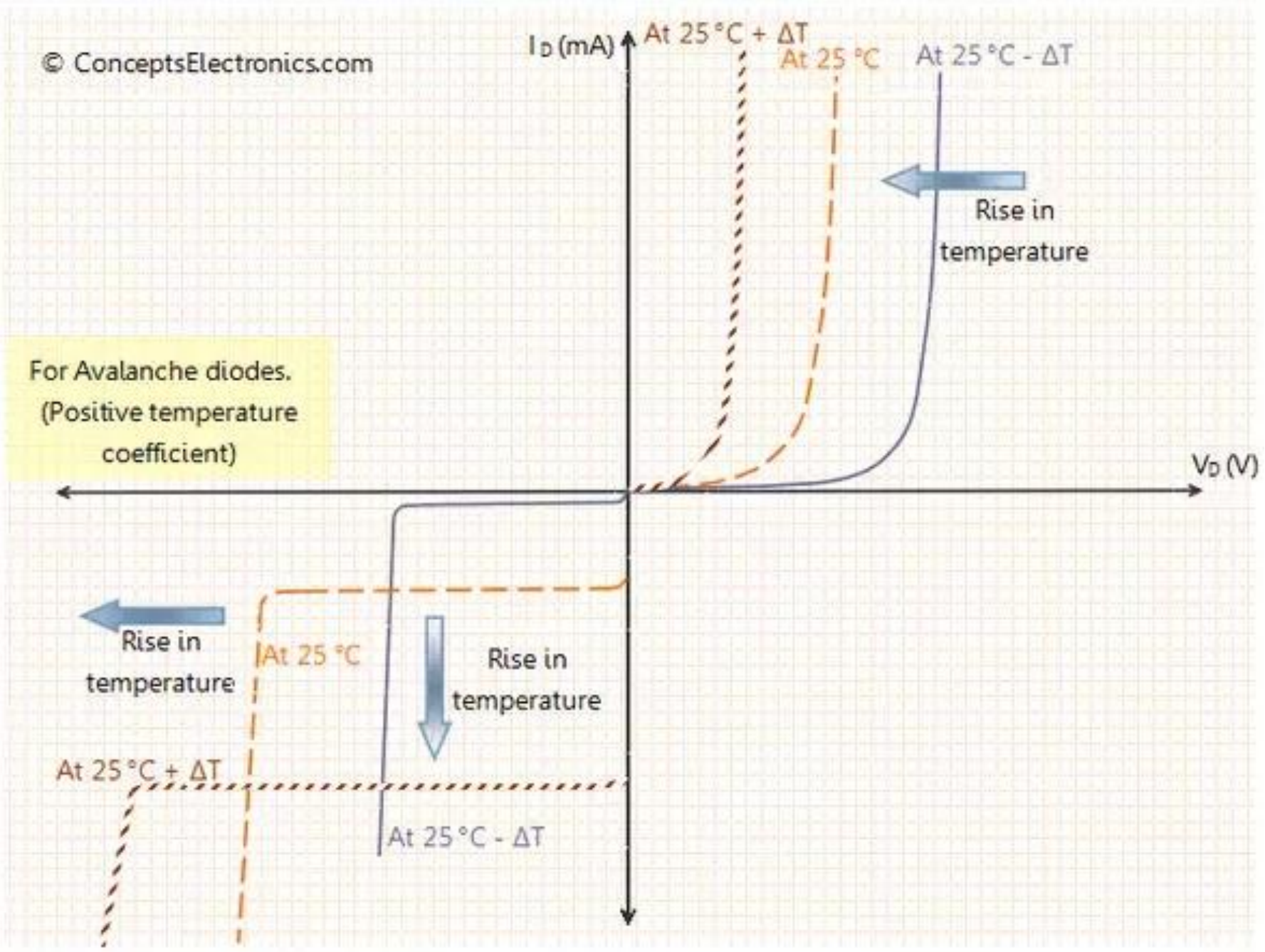


V = 0 **V > 0** **V < 0**

Tunelamento e Avalanche

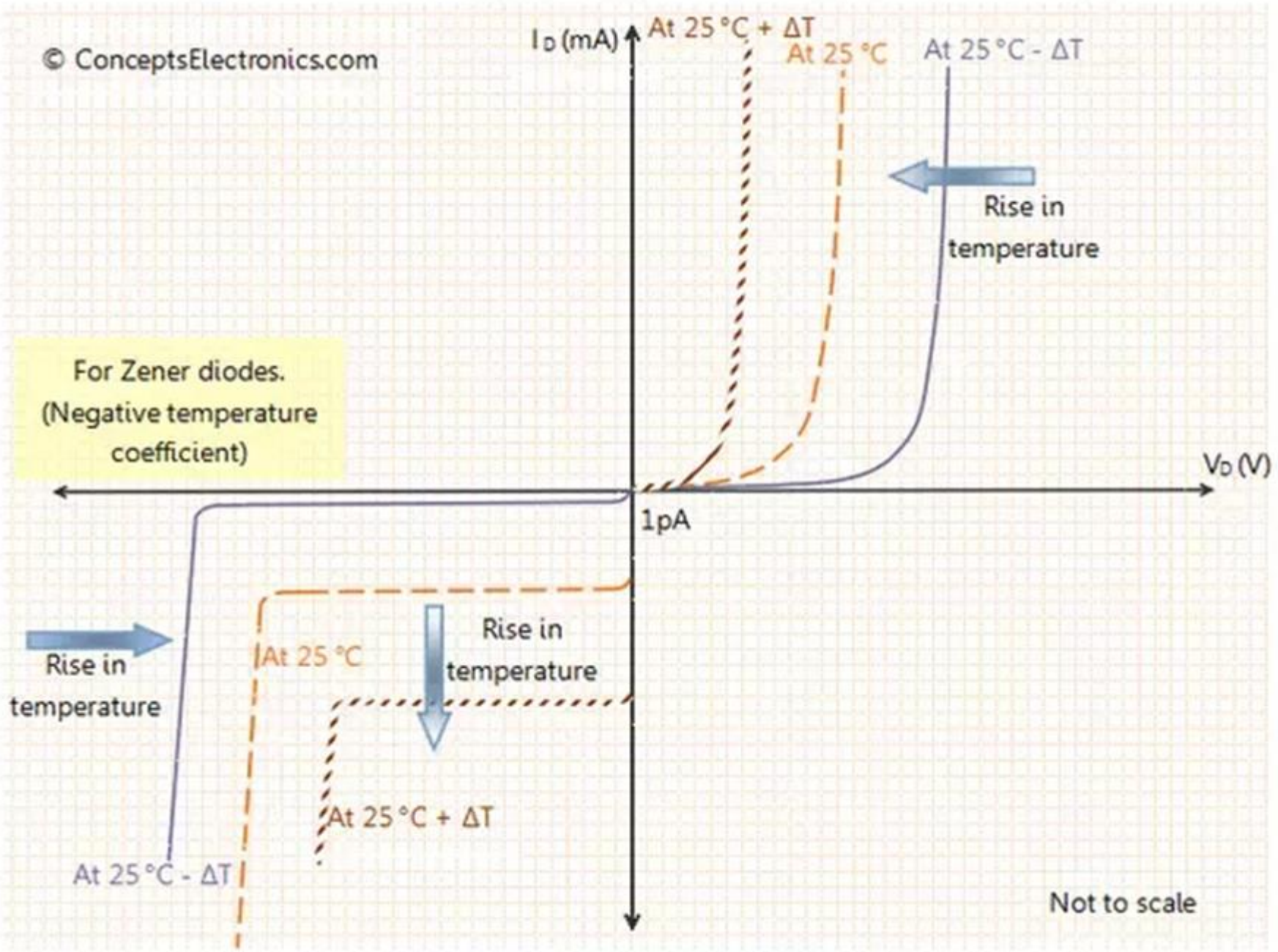


Polarização Reversa (Terceiro Quadrante)



Effect of temperature on avalanche diodes

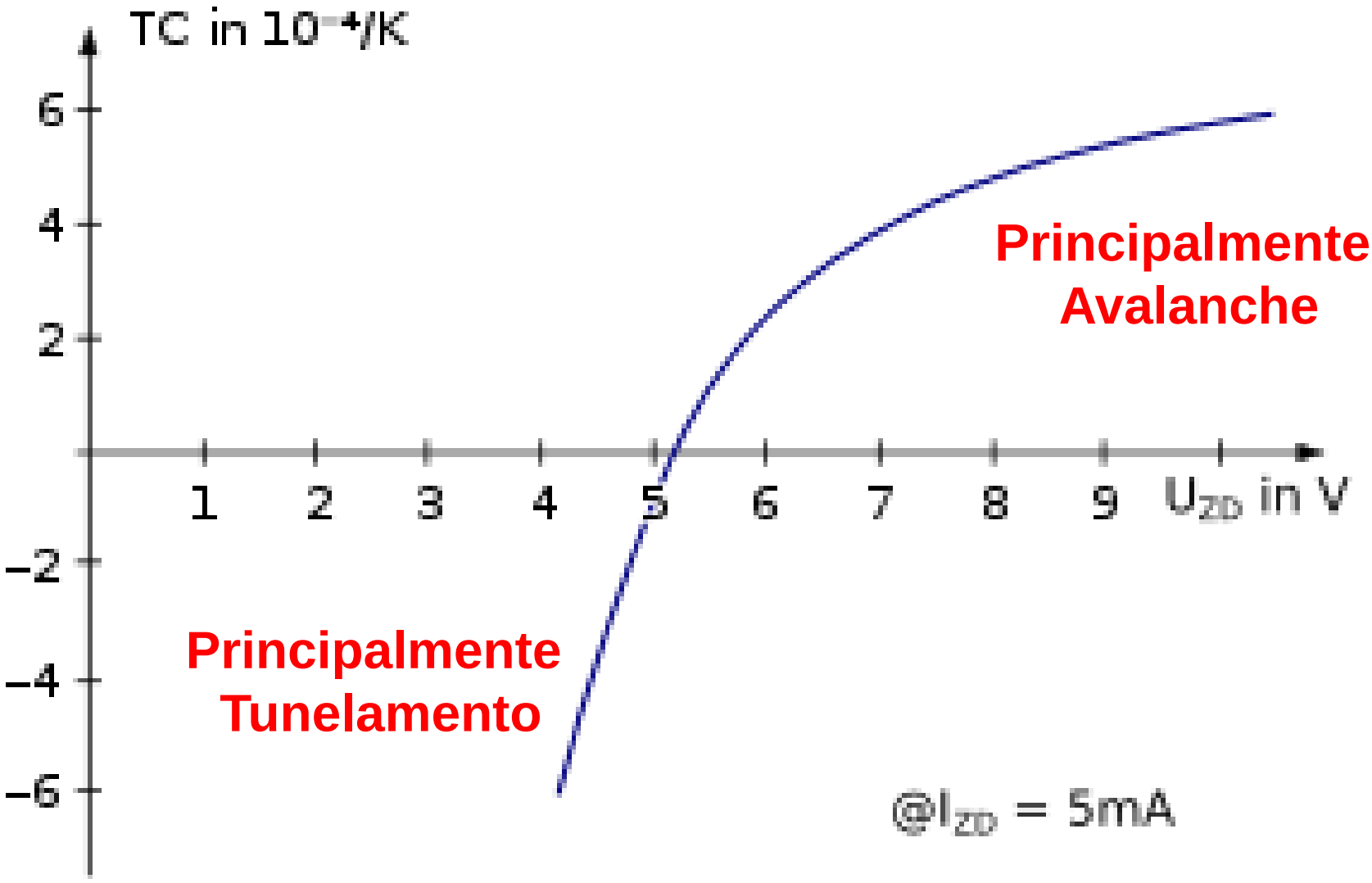
https://www.quora.com/What-is-the-effect-of-temperature-on-semiconductor-diode



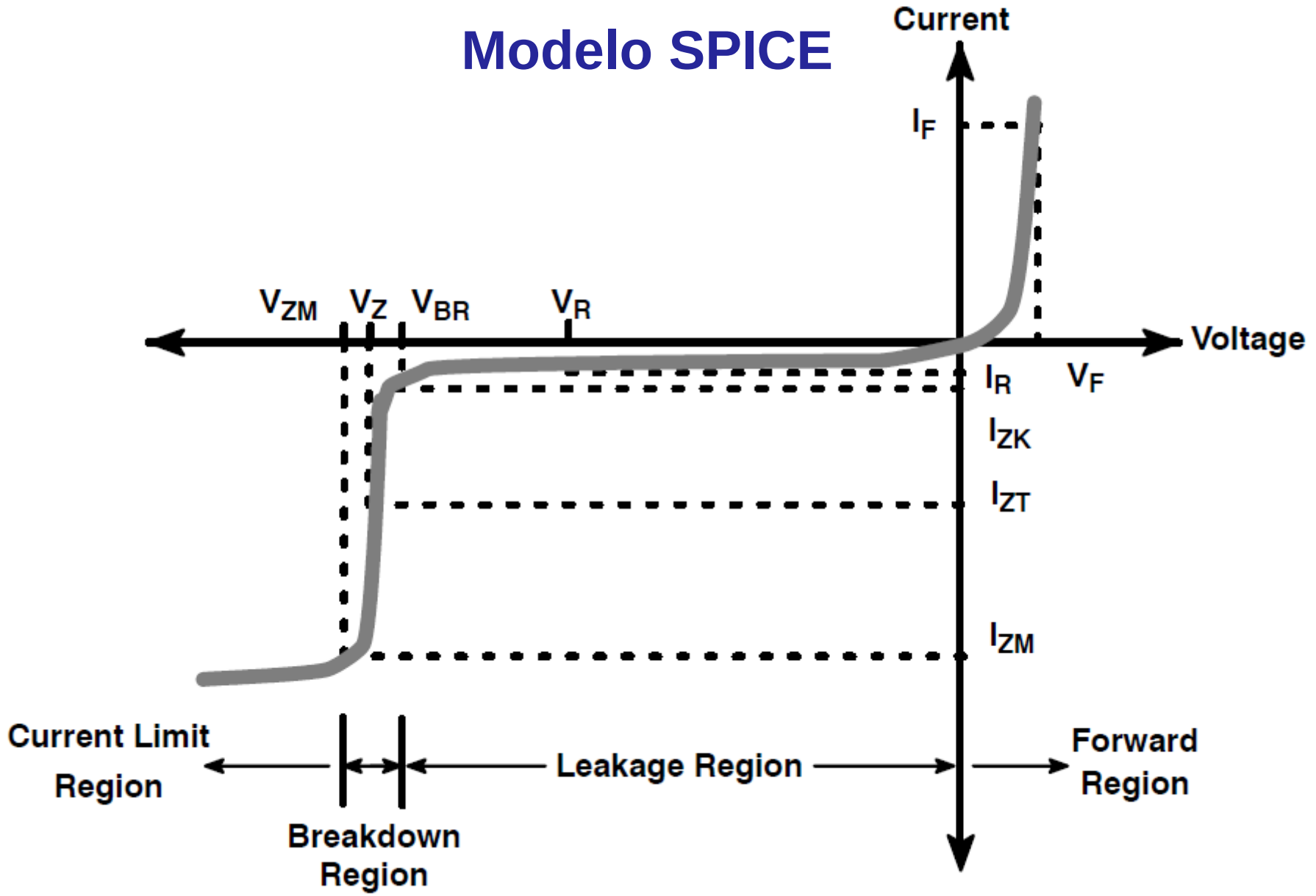
Effect of temperature on zener diodes

https://www.quora.com/What-is-the-effect-of-temperature-on-semiconductor-diode

DIODO ZENER
Coeficiente de Temperatura para a Tensão Zener Reversa



Modelo SPICE

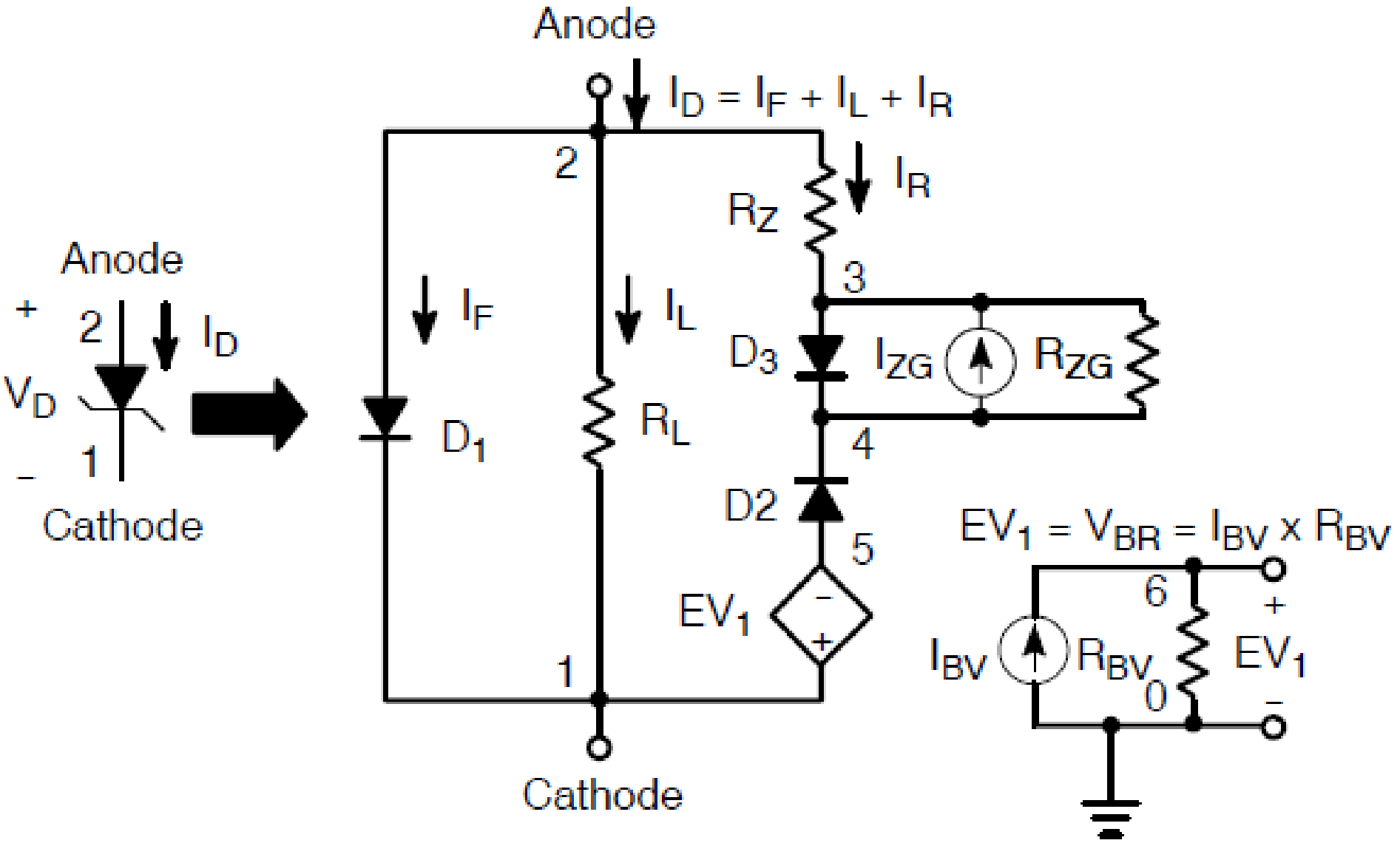


I_F = Forward current
V_F = Voltage at I_F
I_R = Reverse leakage current
V_R = Voltage at I_R
I_{ZK} = Test current for voltage V_{BR}

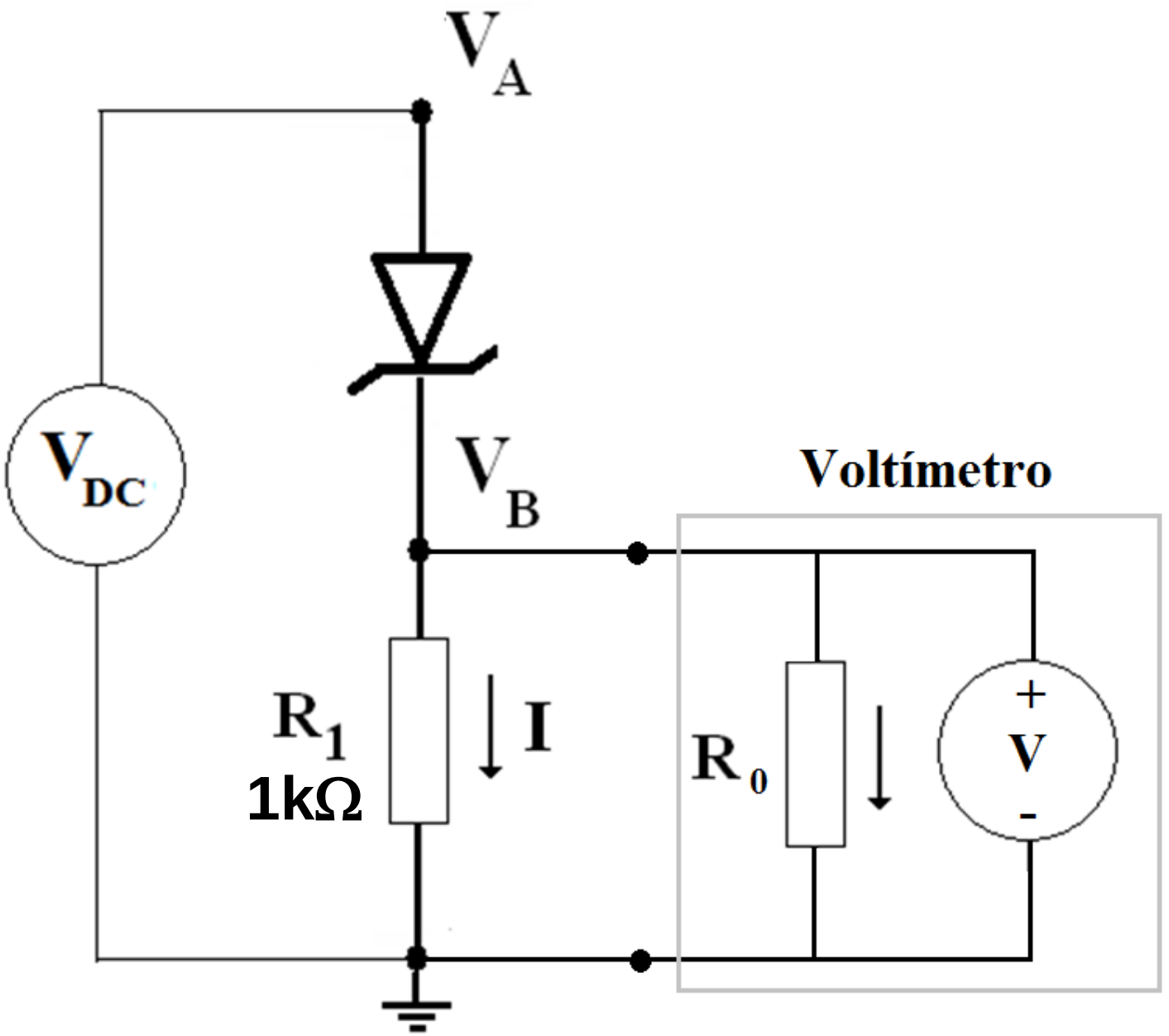
V_{BR} = Voltage at I_{ZK}
Z_{ZK} = Dynamic impedance at I_{ZK}
$= \Delta V_Z / \Delta I_{ZK}$
I_{ZT} = Test current for voltage V_Z
V_Z = Voltage at current I_{ZT}

Z_{ZT} = Dynamic impedance at I_{ZT}
$= \Delta V_Z / \Delta I_{ZT}$
I_{ZM} = Maximum DC steady-state current
V_{ZM} = Voltage at I_{ZM} (typically not defined on the data sheet)

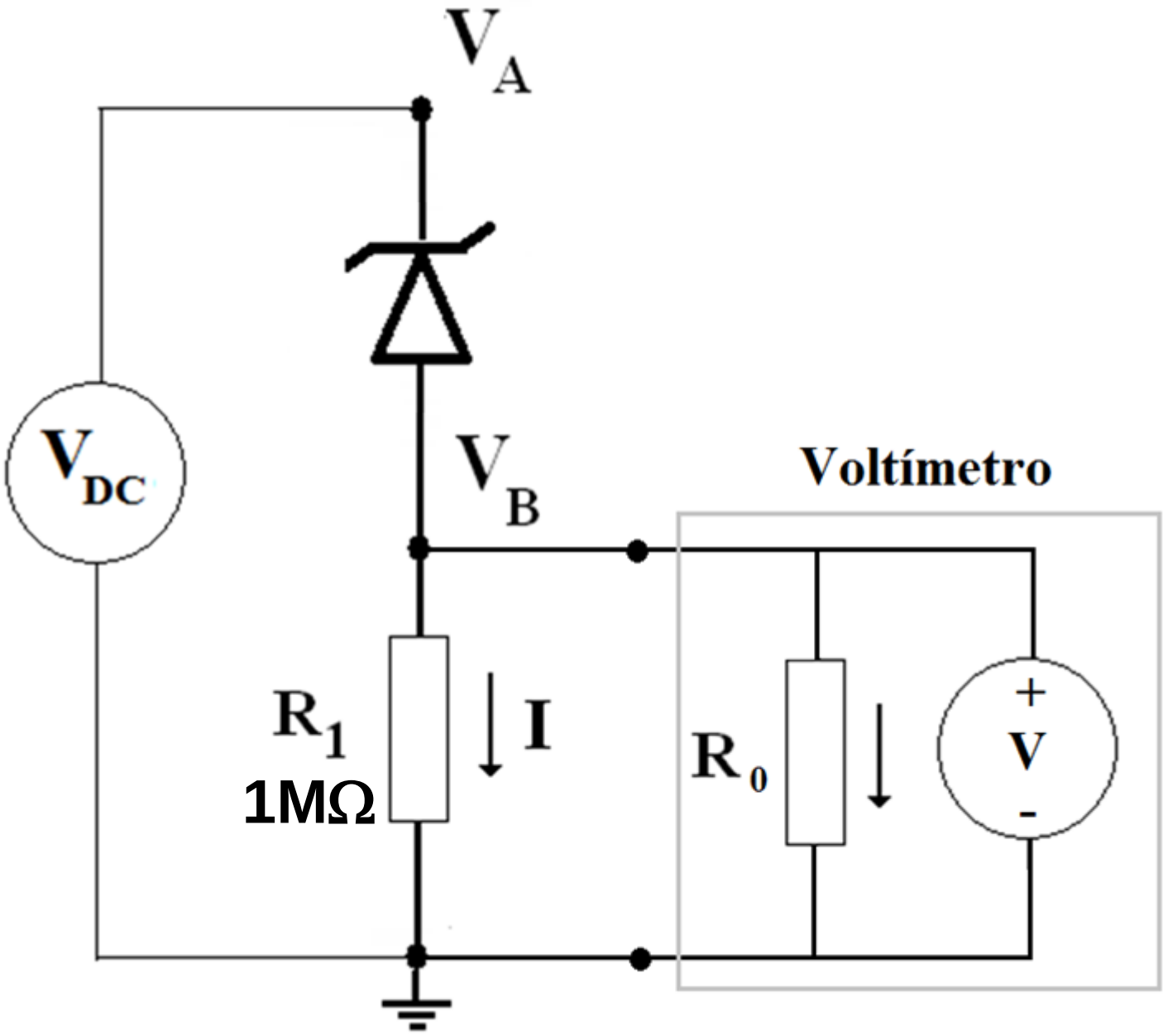
Modelo SPICE



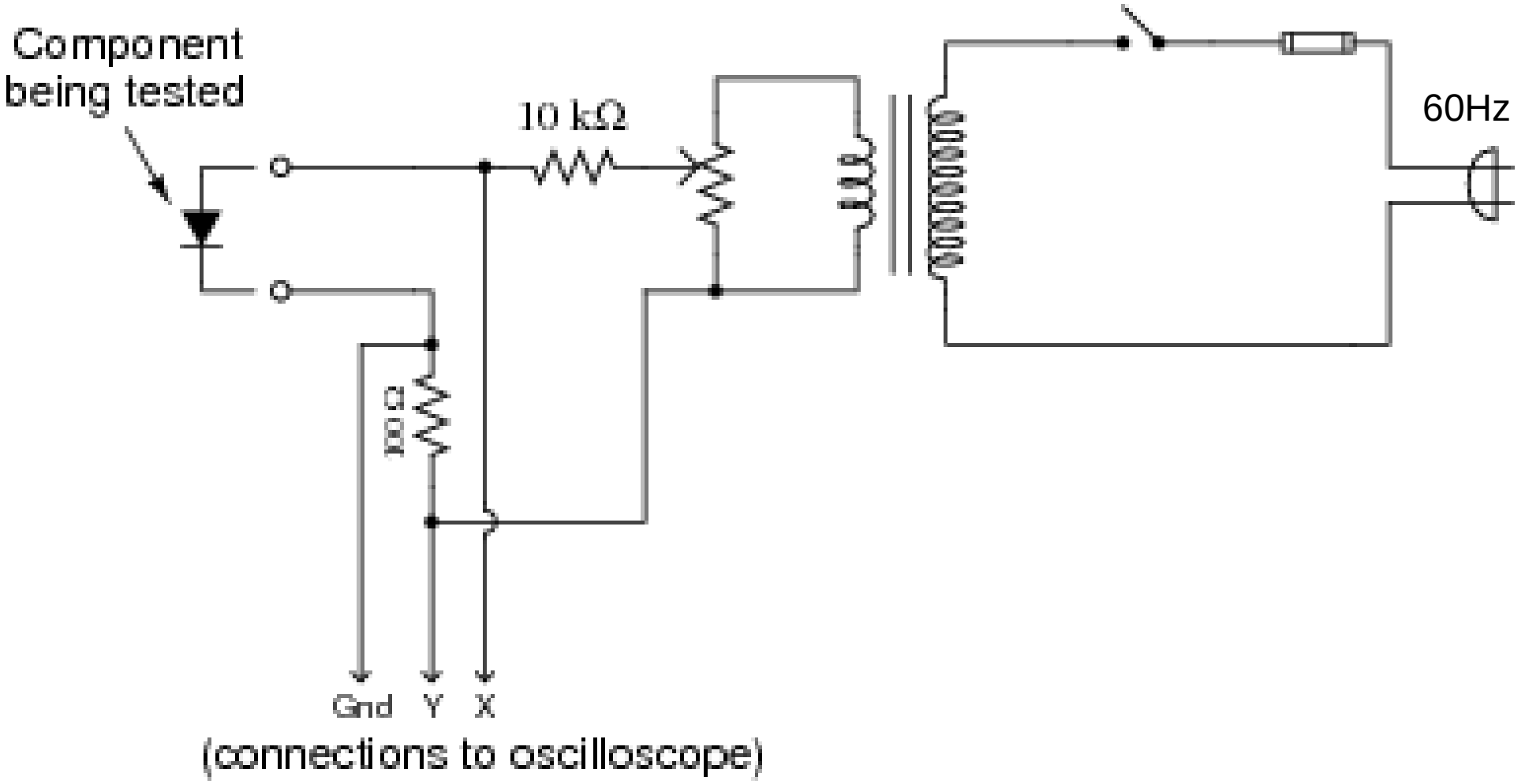
Medidas Elétricas com Voltímetro



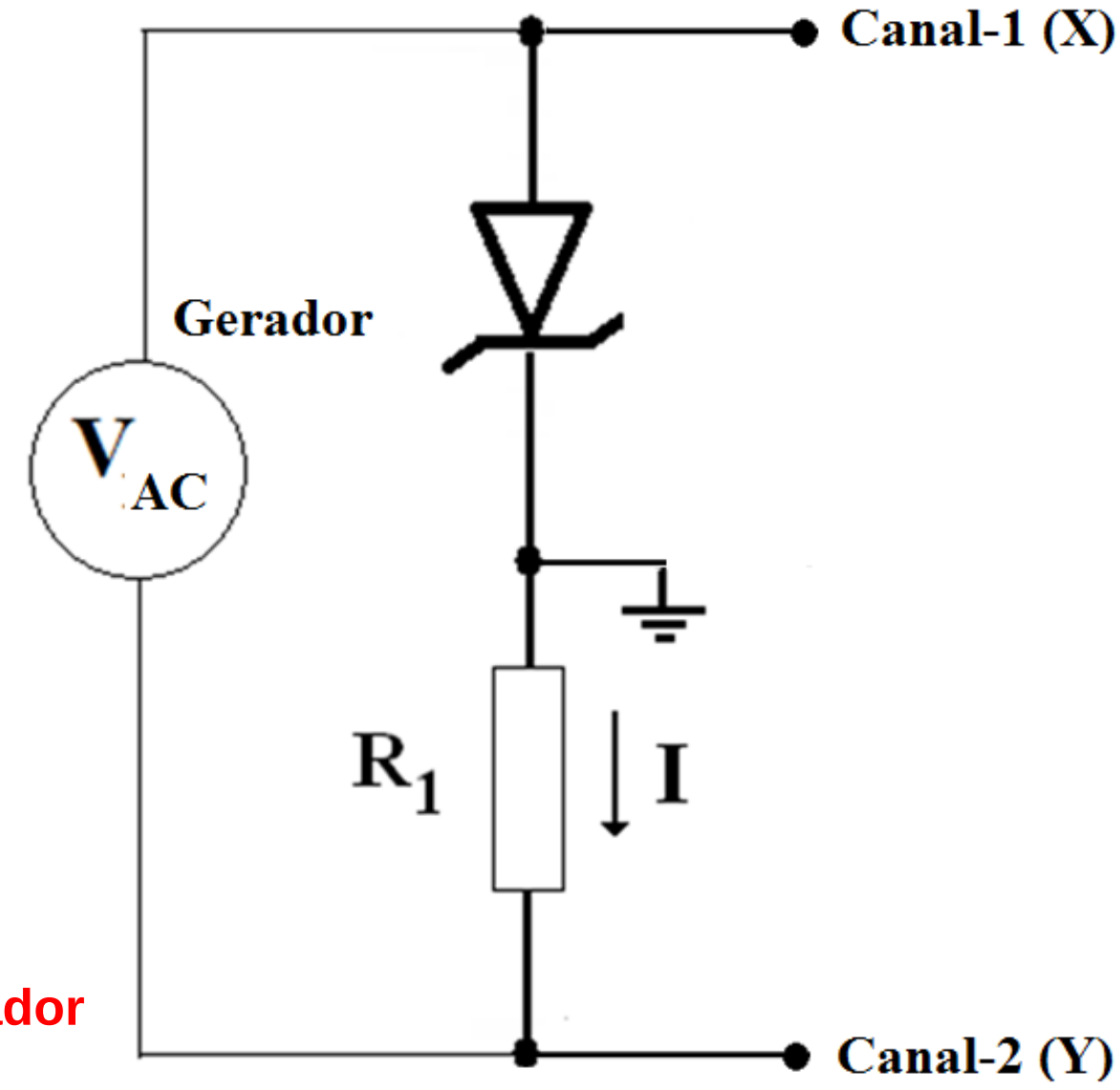
Medidas Elétricas com Voltímetro



Traçador de Curvas I vs. V

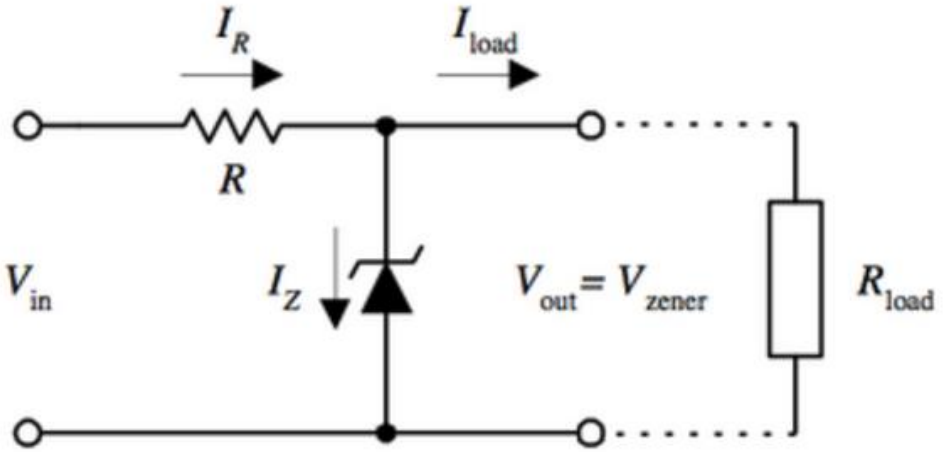


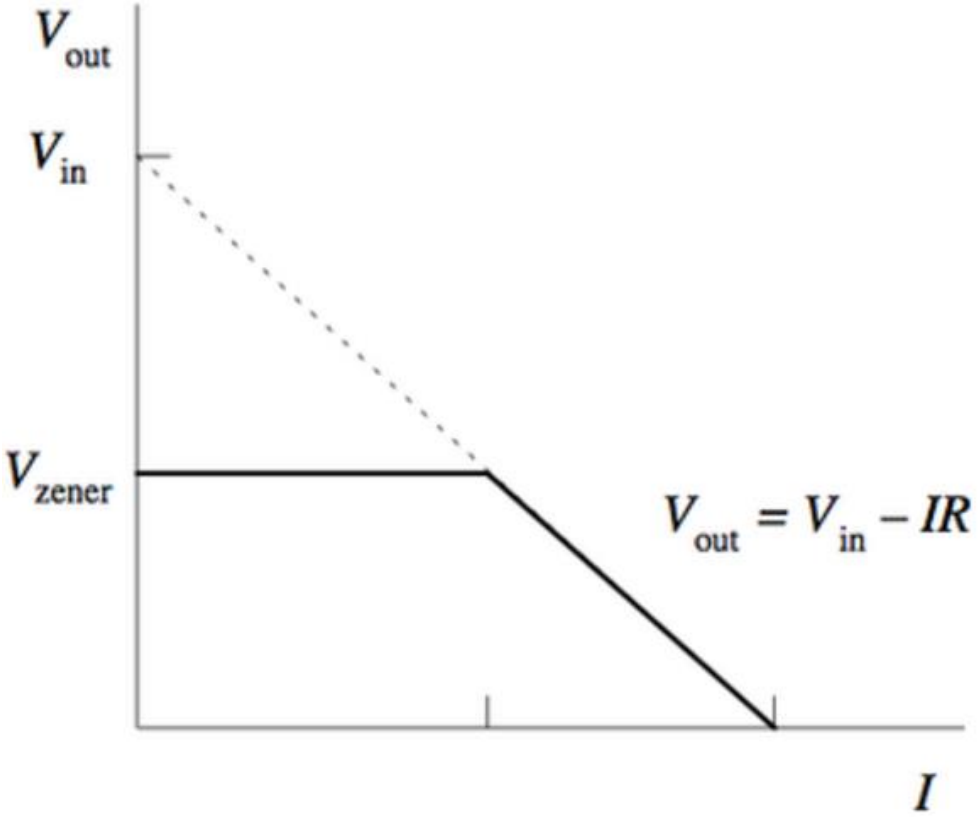
Traçador de Curvas I vs. V



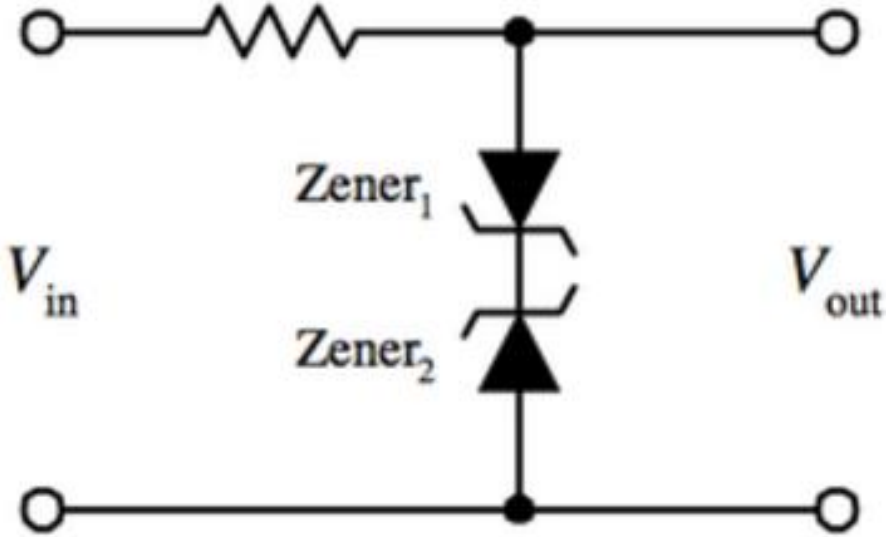
Terra do Gerador Flutuante

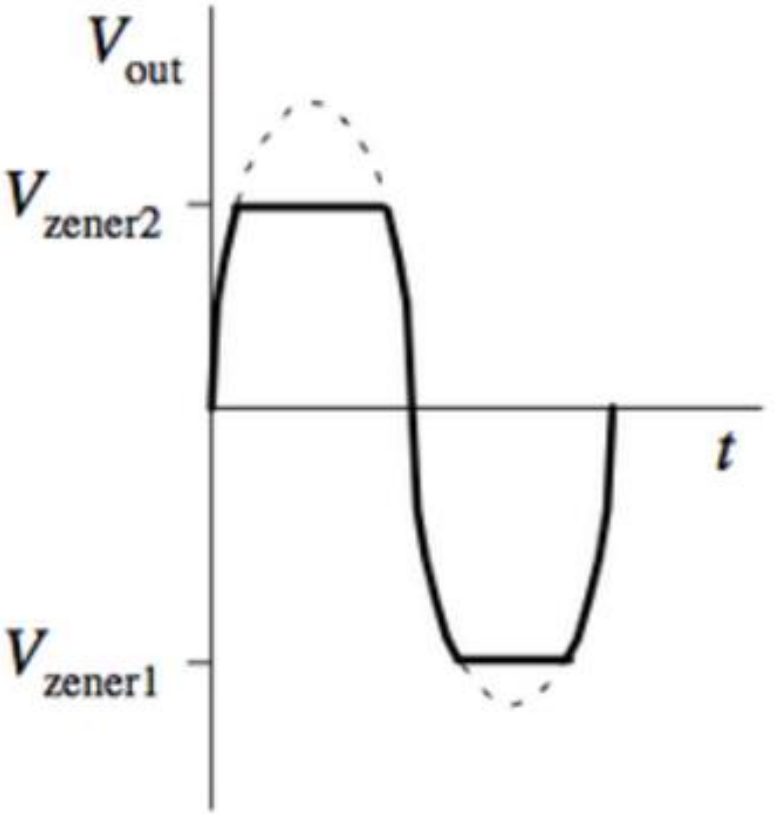
Fonte de Tensão Regulada com Diodo Zener



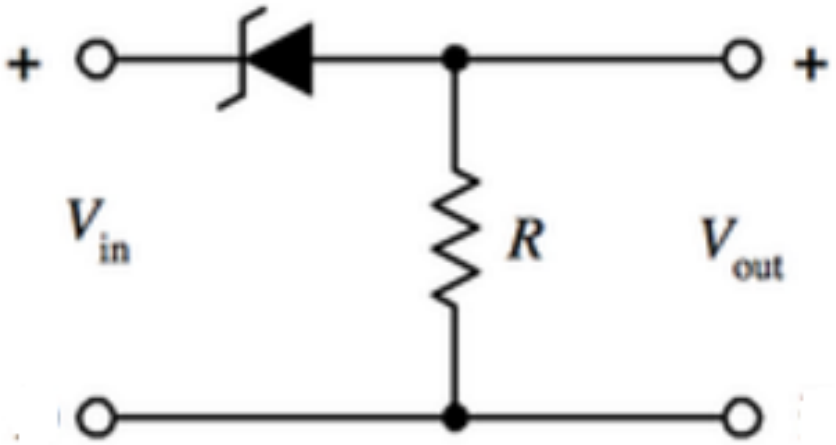


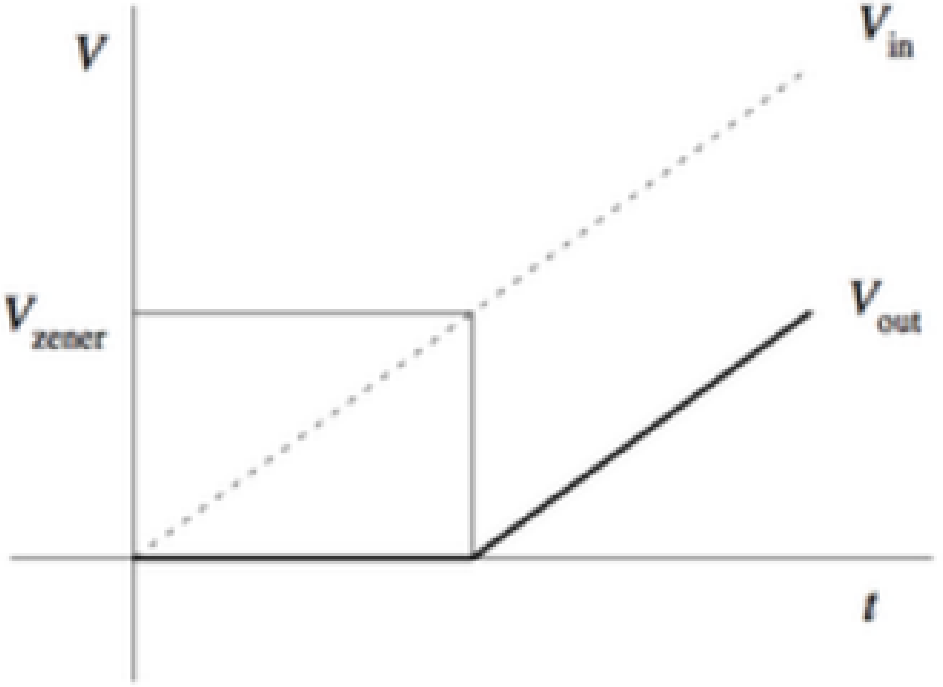
Clipper de Tensão



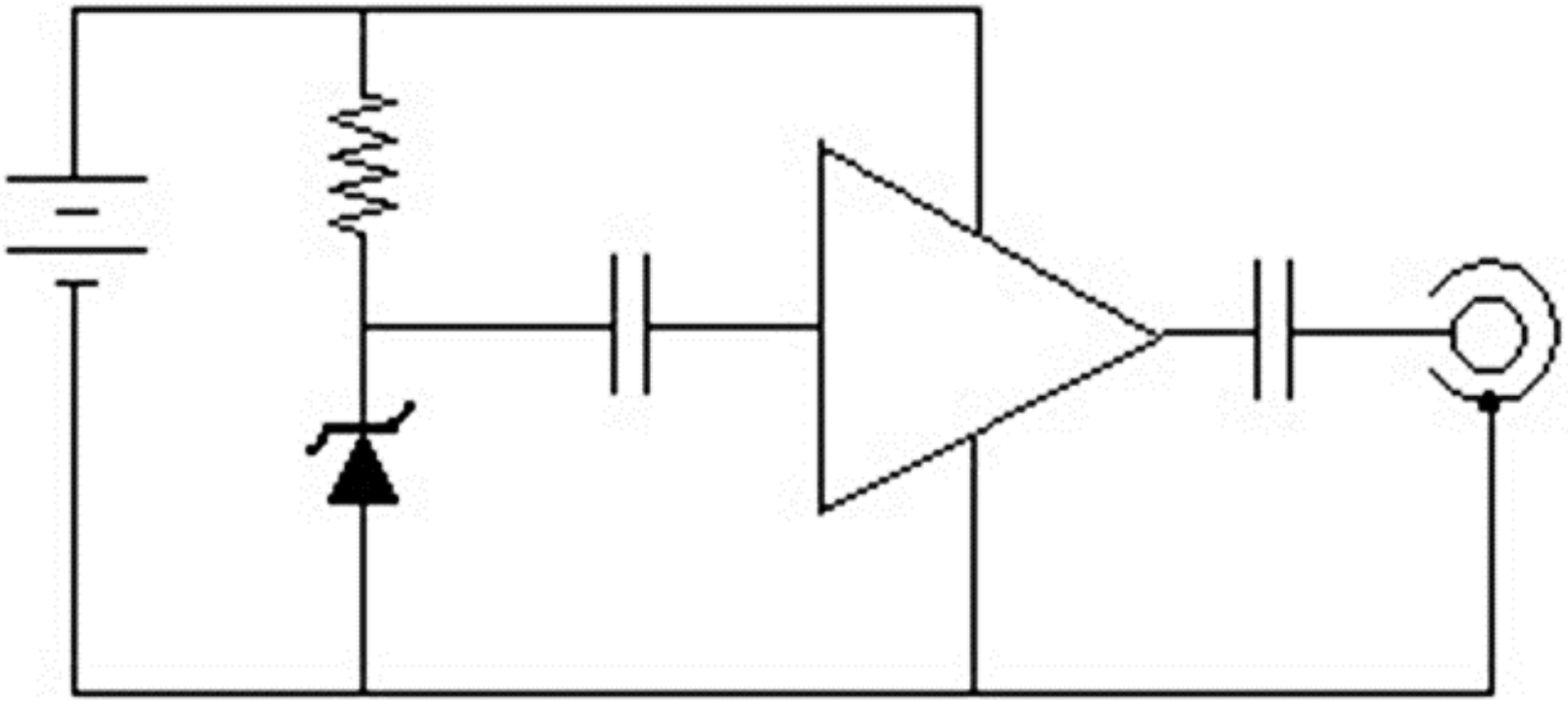


Deslocador de Tensão



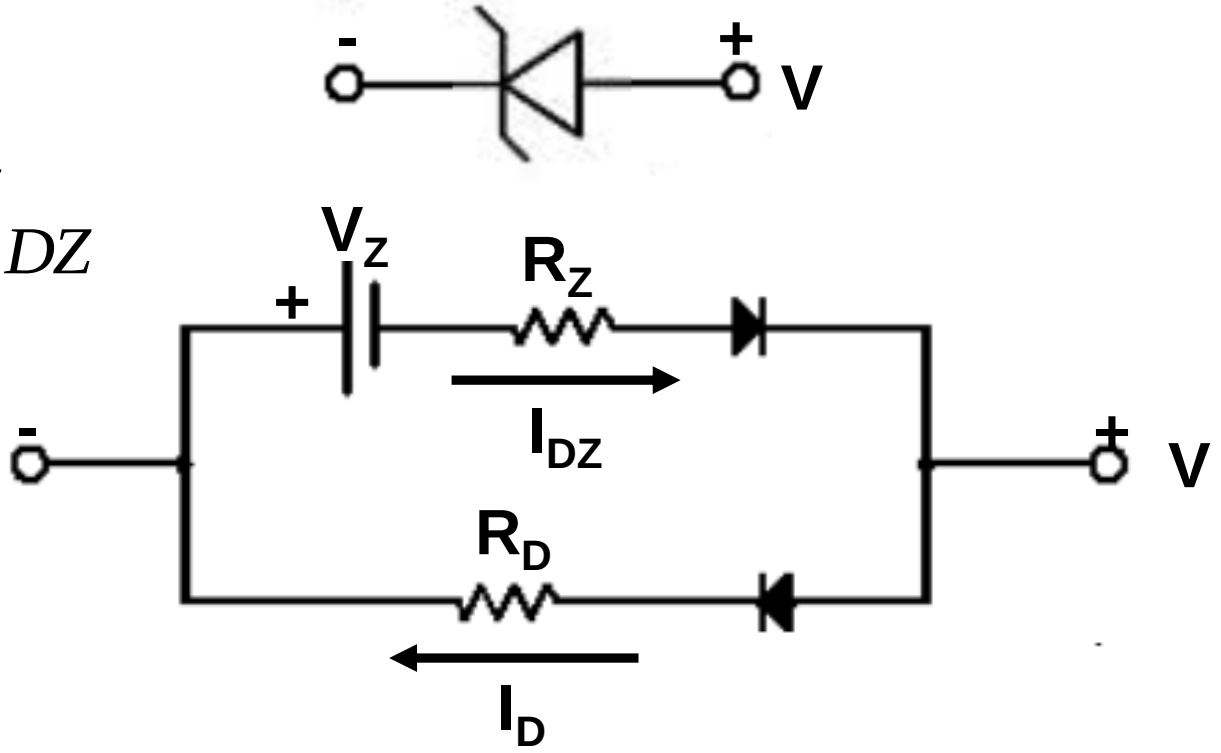


Gerador de Ruído de Amplo Espectro



http://www.n5ese.com/noise.htm

Modelo Elétrico Simplificado do Diodo Zener



$$I = I_D - I_{DZ}$$

$$I_D = I_{SD}\left(e^{\frac{e(V - V_{RD})}{k_B T}} - 1\right) \qquad V_{RD} = I_D R_D$$

$$I_{DZ} = I_{SDZ}\left(e^{\frac{-e(V + V_Z + V_{RZ})}{k_B T}} - 1\right) \qquad V_{RZ} = I_{DZ} R_Z$$

Ajuste do Modelo Elétrico do Diodo Zener

Utilize os pontos experimentais de I x V do Diodo Zener.

1) Ajuste os seguintes parâmetro do modelo pelo método dos mínimos quadrados: (Utilize T = 300K)

$$I_{SD}, R_D, I_{SDZ}, R_Z, V_Z$$

Obs: Utilize sempre unidades SI

2) Plote no mesmo gráfico:

- a curva do modelo ajustado com os pontos experimentais do PRIMEIRO quadrante
(V > 0 e I > 0)

- a curva do modelo ajustado com os pontos experimentais do TERCEIRO quadrante
(V < 0 e I < 0)

Obs: Faça os gráficos no SCILAB, Python, etc.