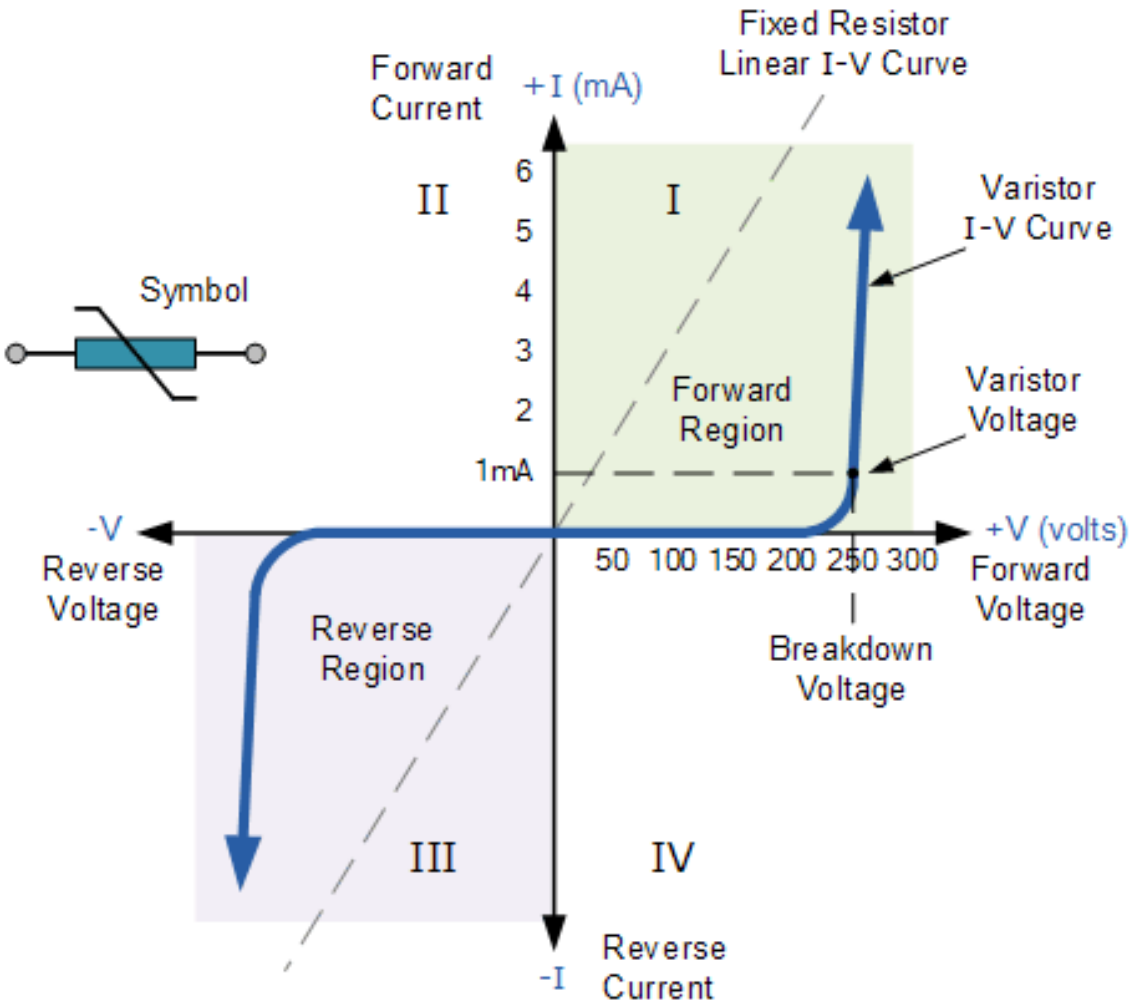
Prática de Física dos Dispositivos Eletrônicos

FGA0100

Laboratório-8

Diodos: Zener e Schottky

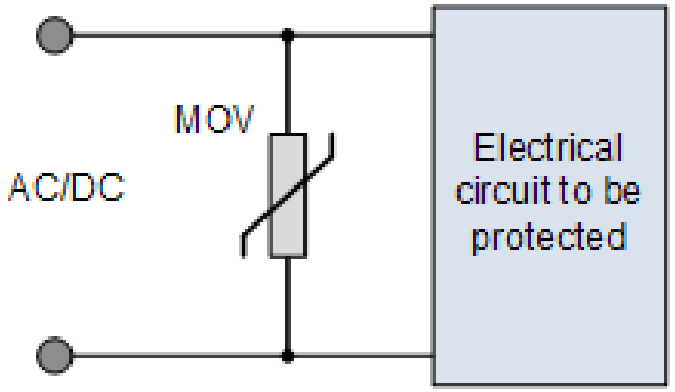
Varistor



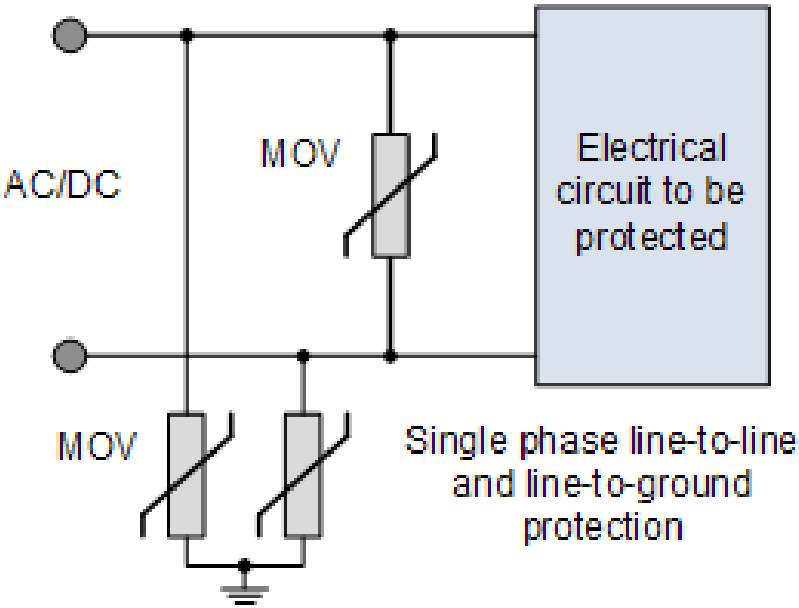
Type (untaped) SIOV-	Ordering code	V_{RMS} V	V_{DC} V	I_{max} 8/20 µs A	W_{max} (2 ms) J	P_{max} W
S07K75	B72207S0750K101	75	100	1200	5,9	0,25

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

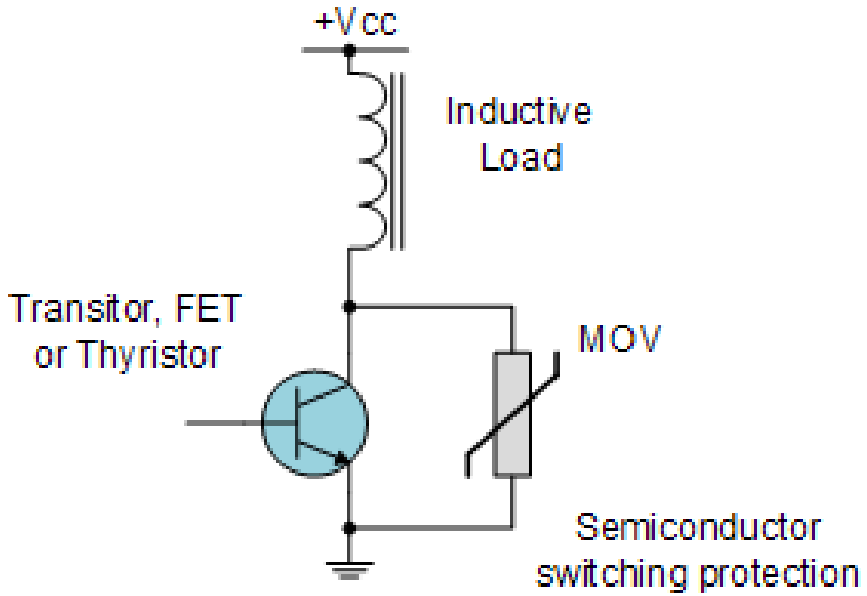
Varistor Applications



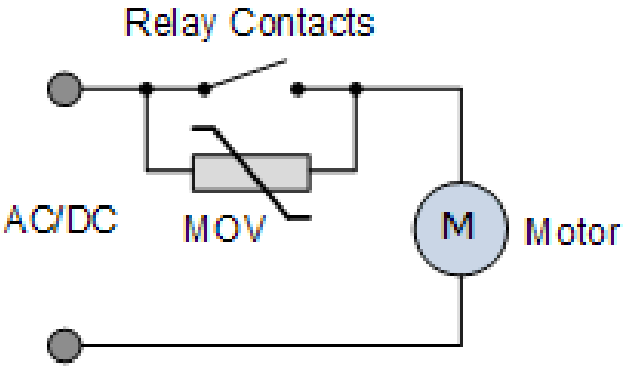
Single phase line-to-line protection



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



Semiconductor switching protection

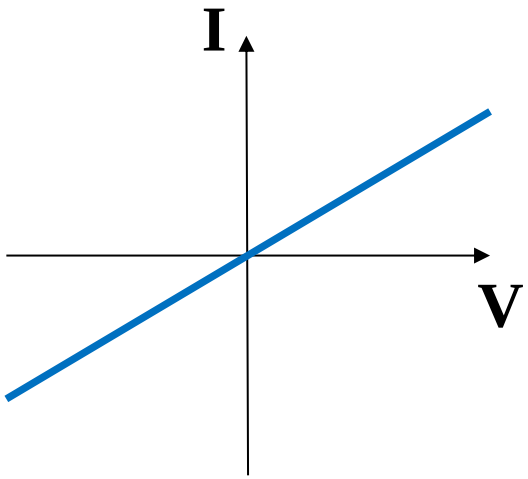


Contact arcing protection

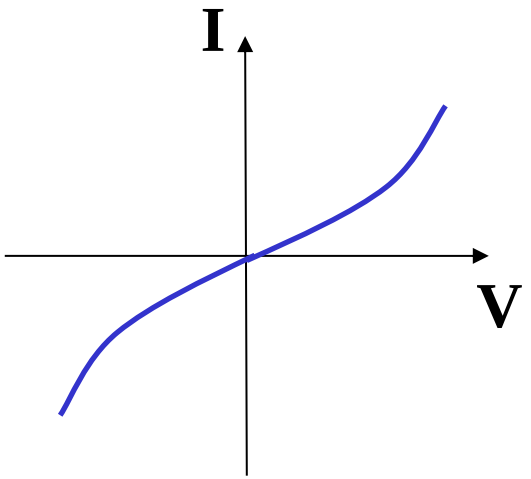
https://www.electronics-tutorials.ws/resistor/varistor.html

Simetria em Curvas I x V

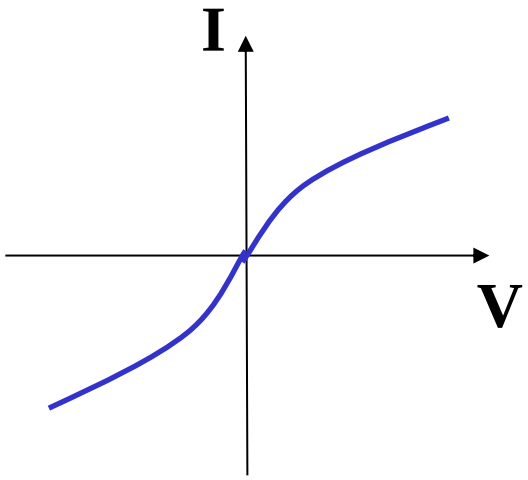
Dispositivos de Dois Terminais



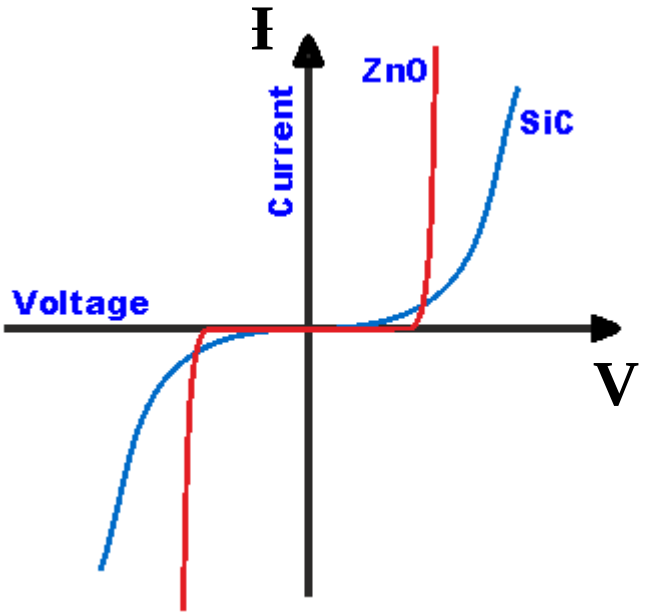
Resistor



Termistor NTC



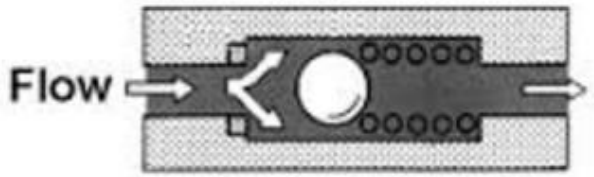
Lâmpada de Filamento
Termistor PTC

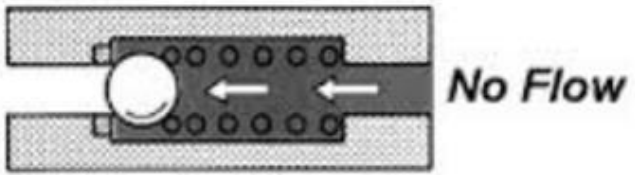


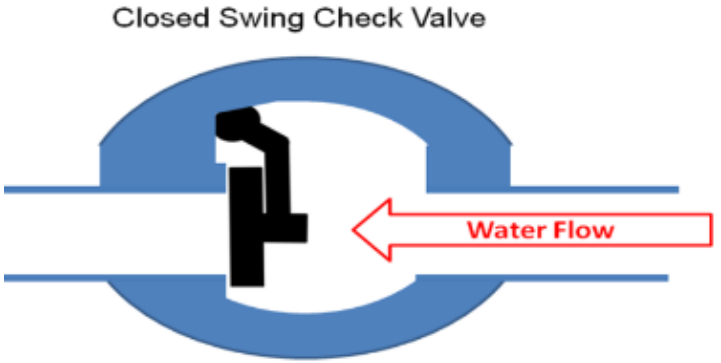
Varistor (Avalanche)

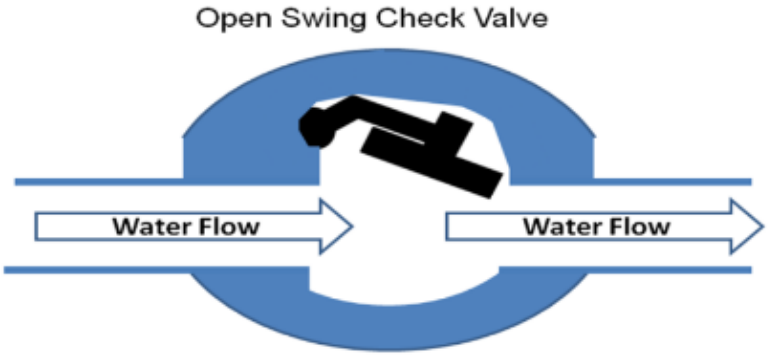
Válvulas Direcionais

Analogia Hidráulica



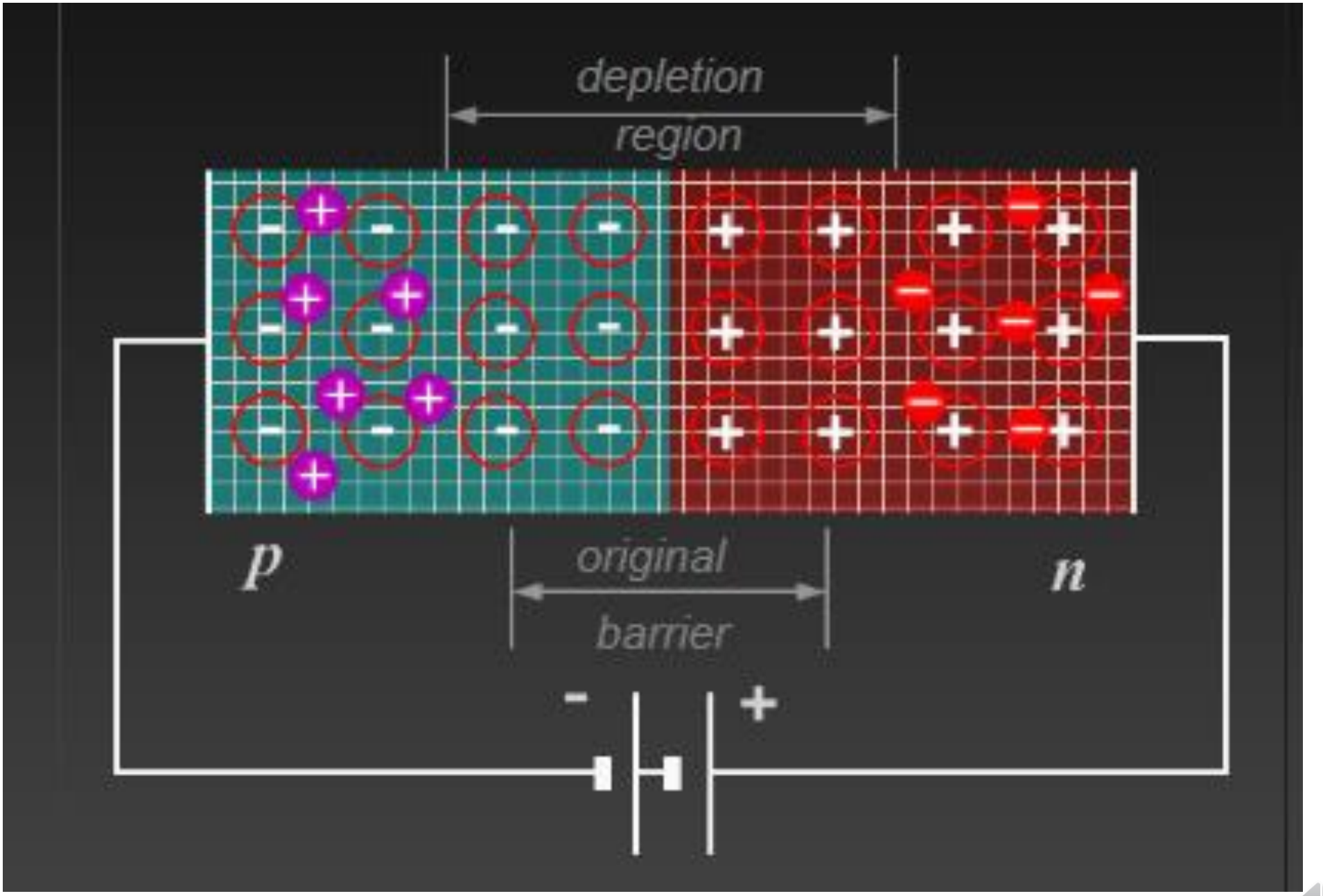




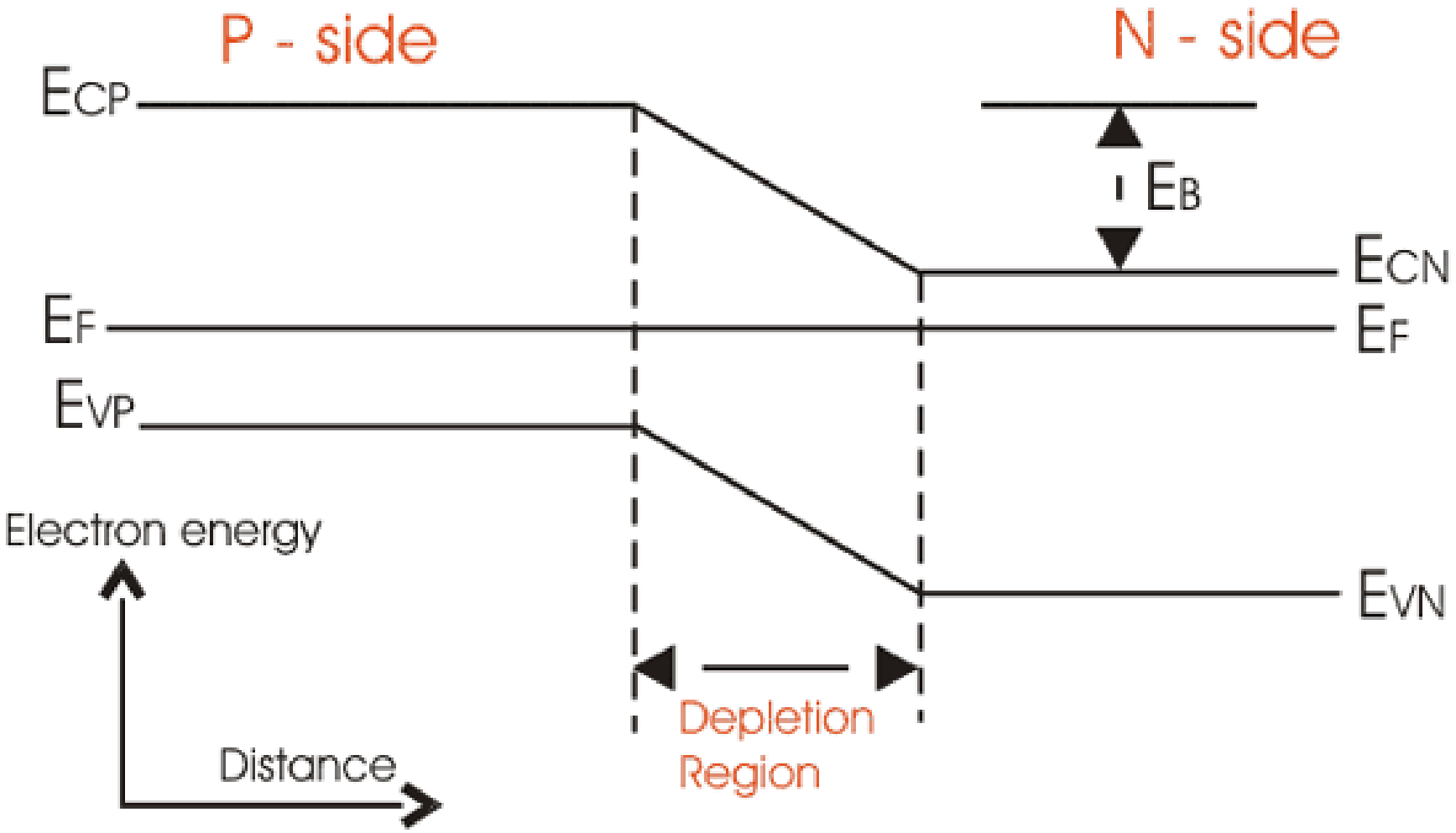


Existe equivalente elétrico?

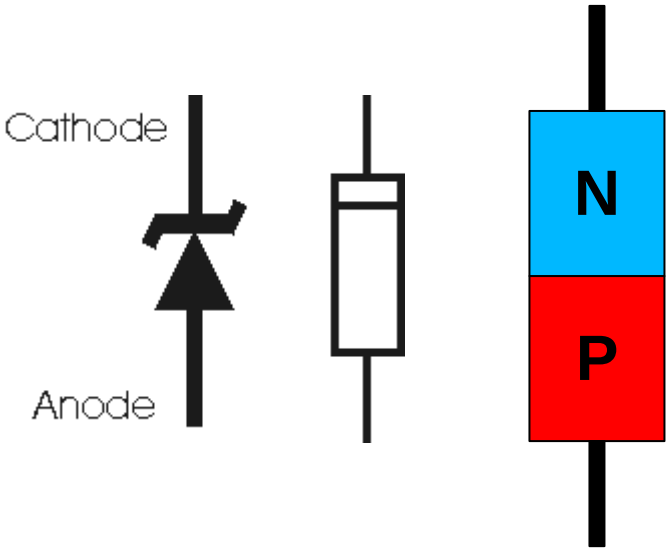
Junção PN (Diodo)

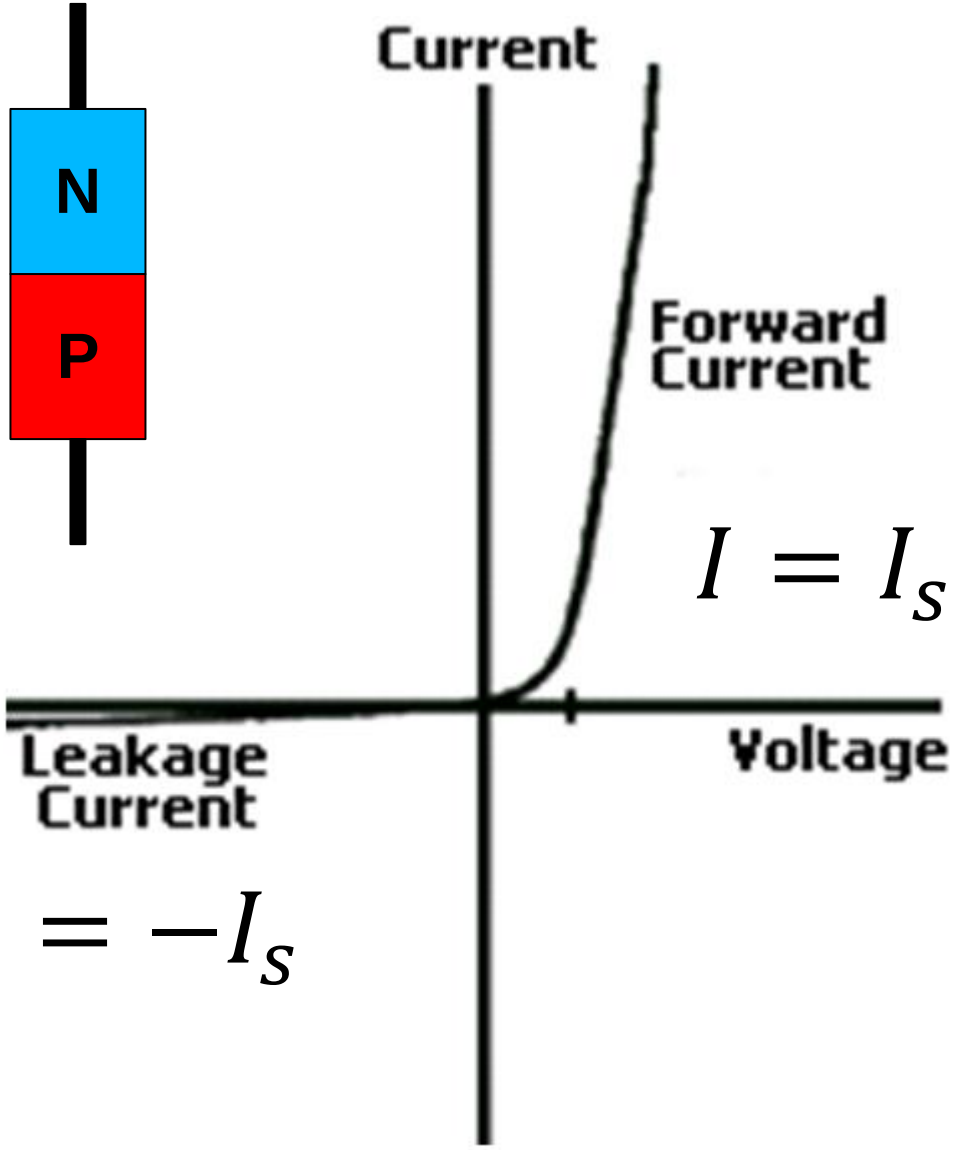


Junção PN (Diodo)
Estrutura de Bandas



Curva I x V do Diodo de Junção PN



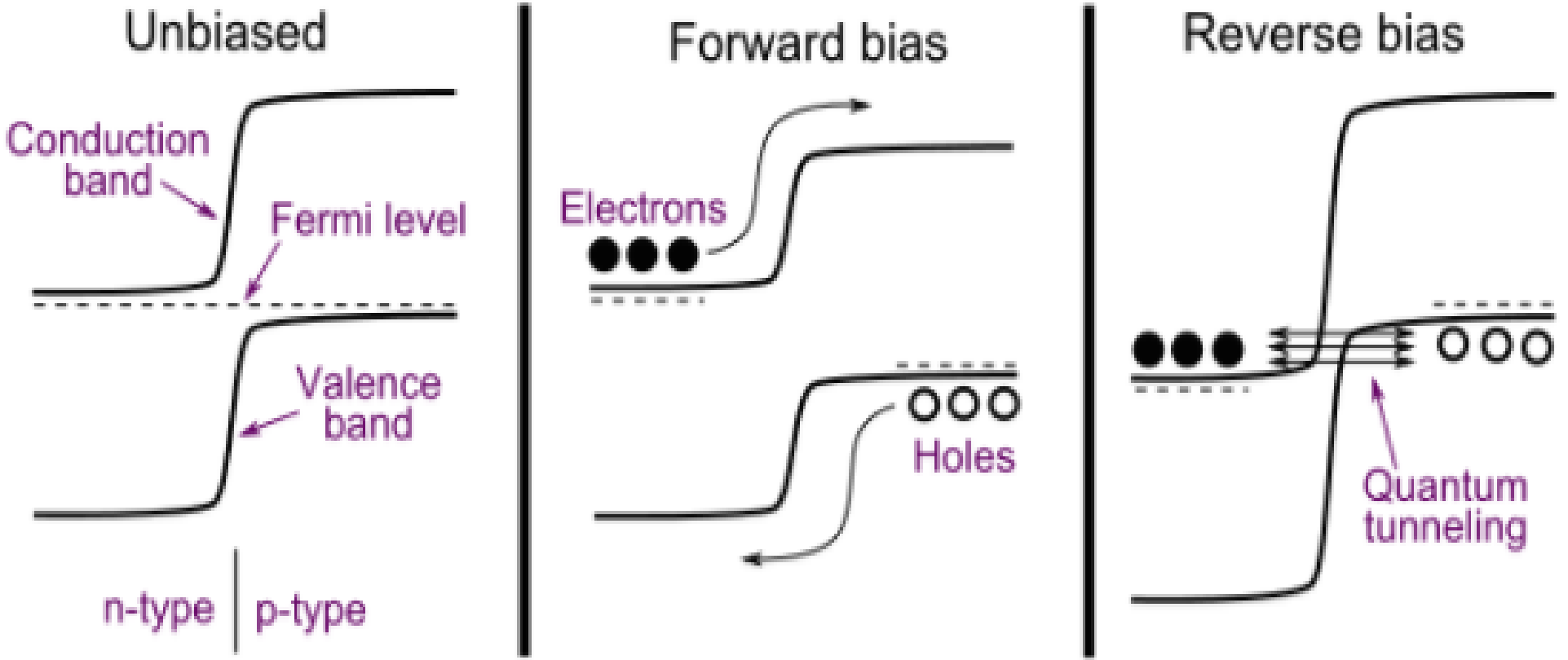


$$I = I_s(e^{\frac{eV}{k_b T}} - 1)$$

$$I = -I_s$$

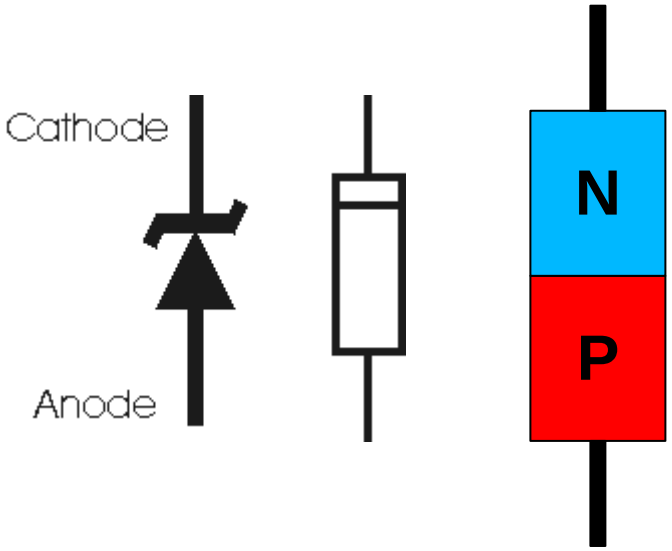
Diodo Zener

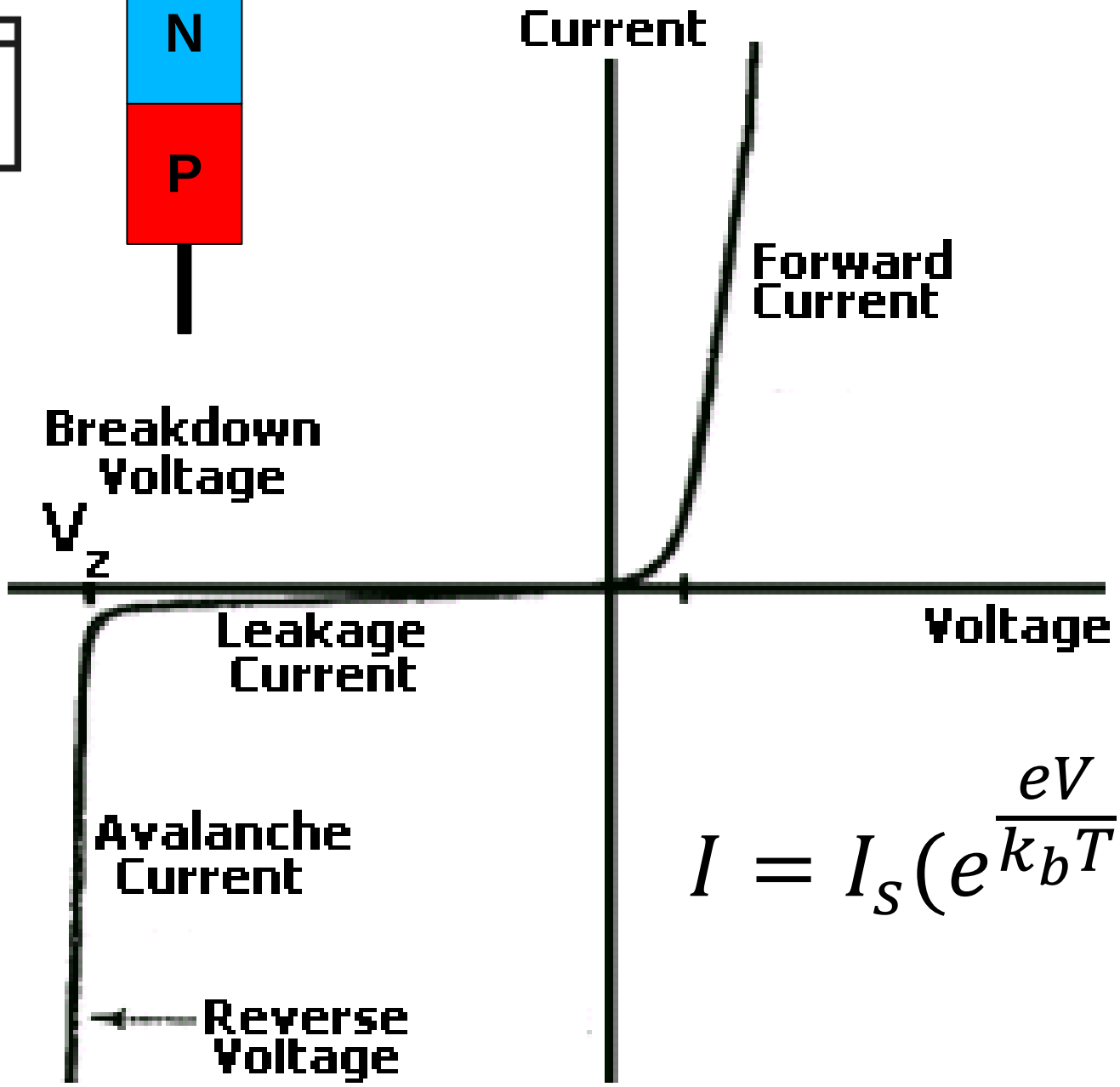
Estrutura de Bandas vs. Polarização



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

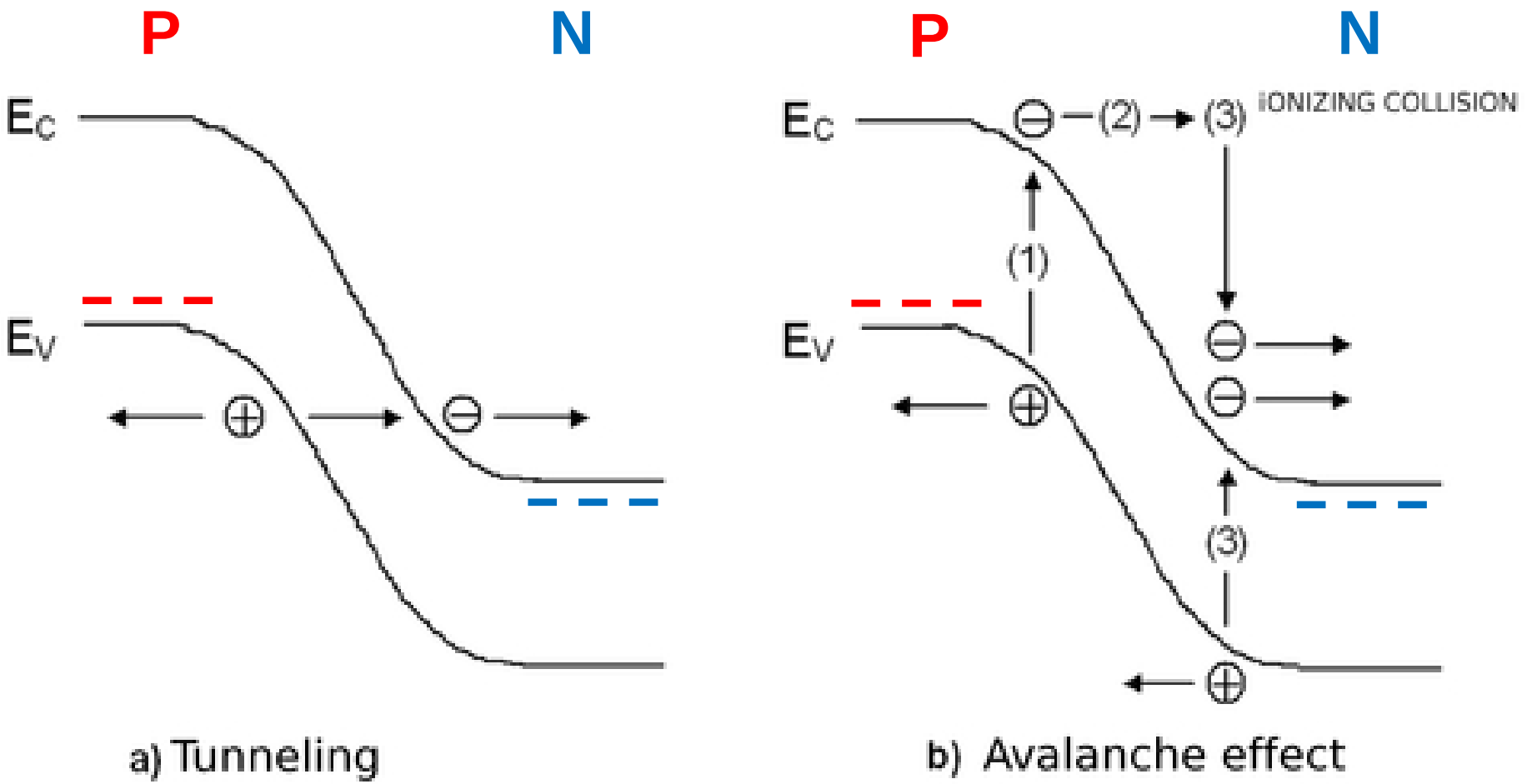
Curva I x V do Diodo Zener





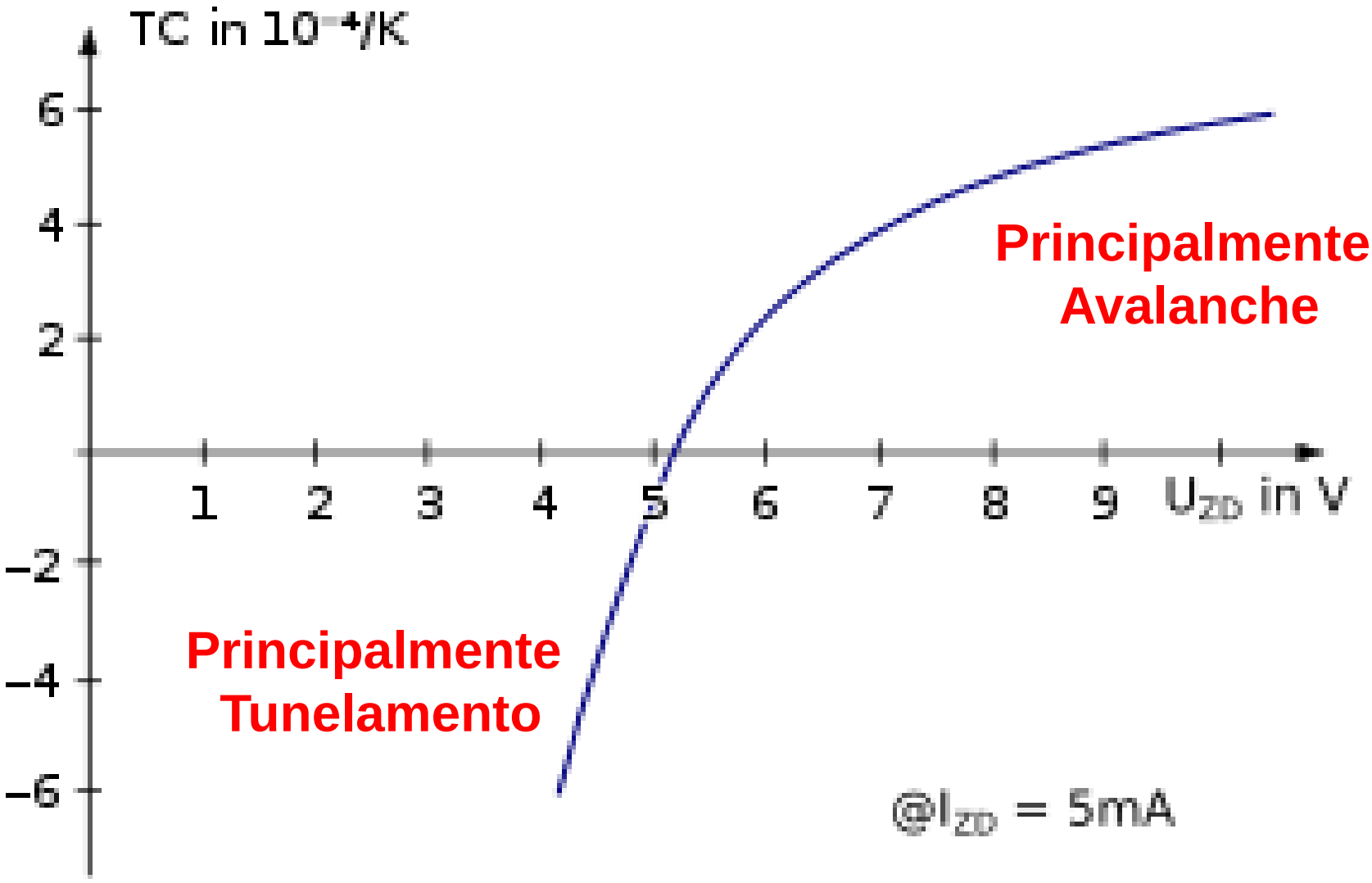
$$I = I_s(e^{\frac{eV}{k_b T}} - 1)$$

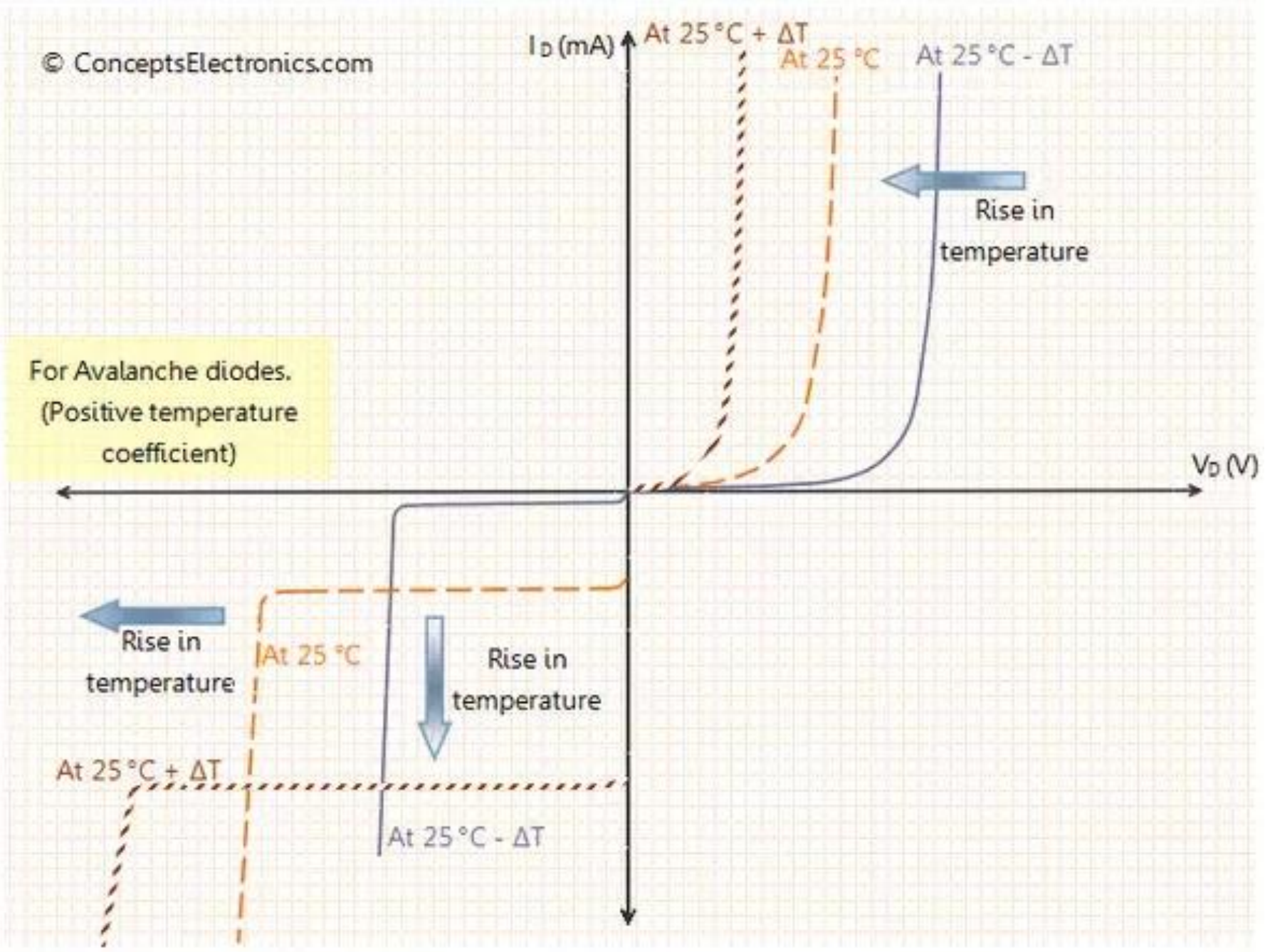
Tunelamento e Avalanche



Polarização Reversa (Terceiro Quadrante)

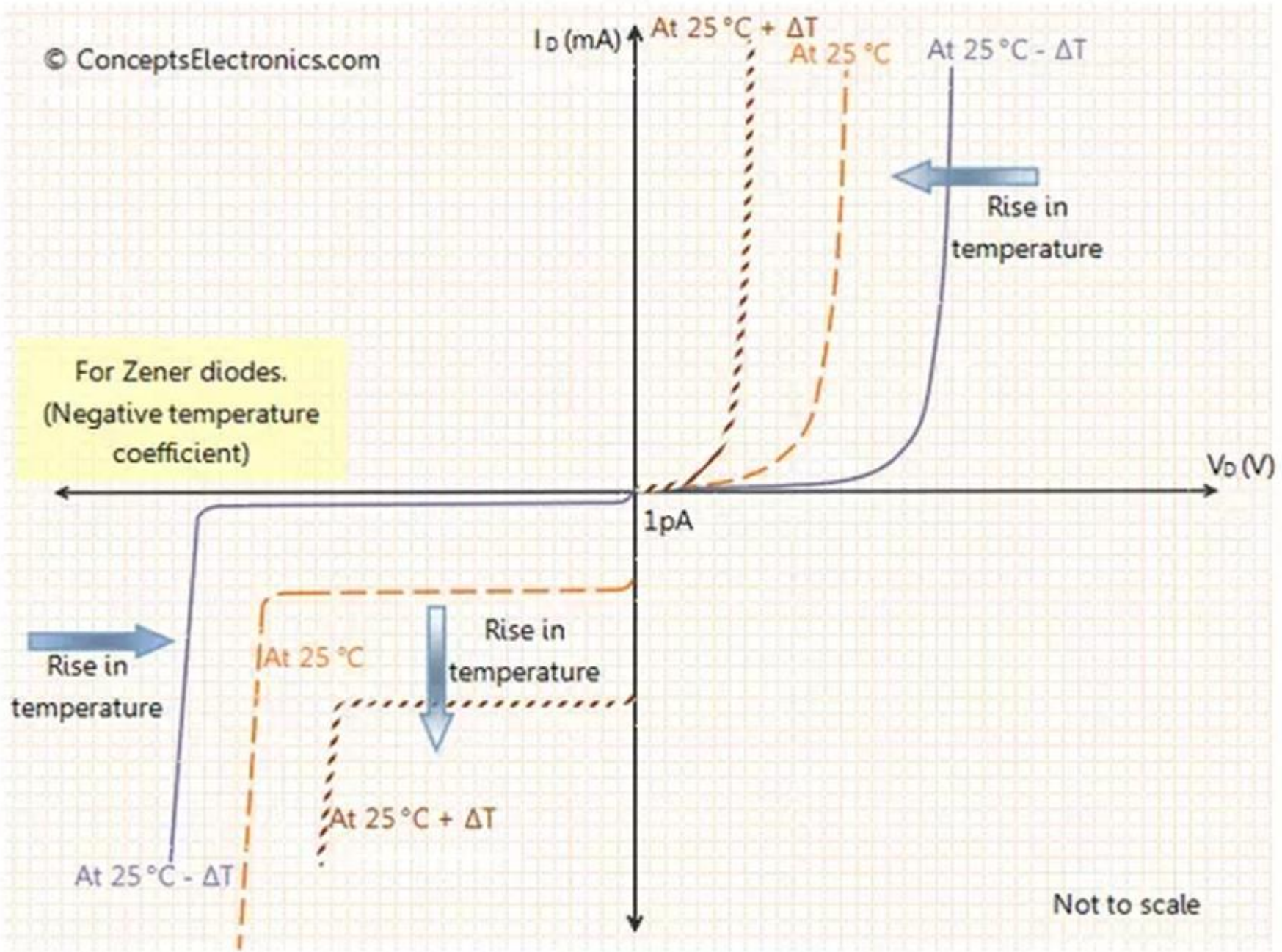
DIODO ZENER
Coeficiente de Temperatura para a Tensão Zener Reversa





Effect of temperature on avalanche diodes

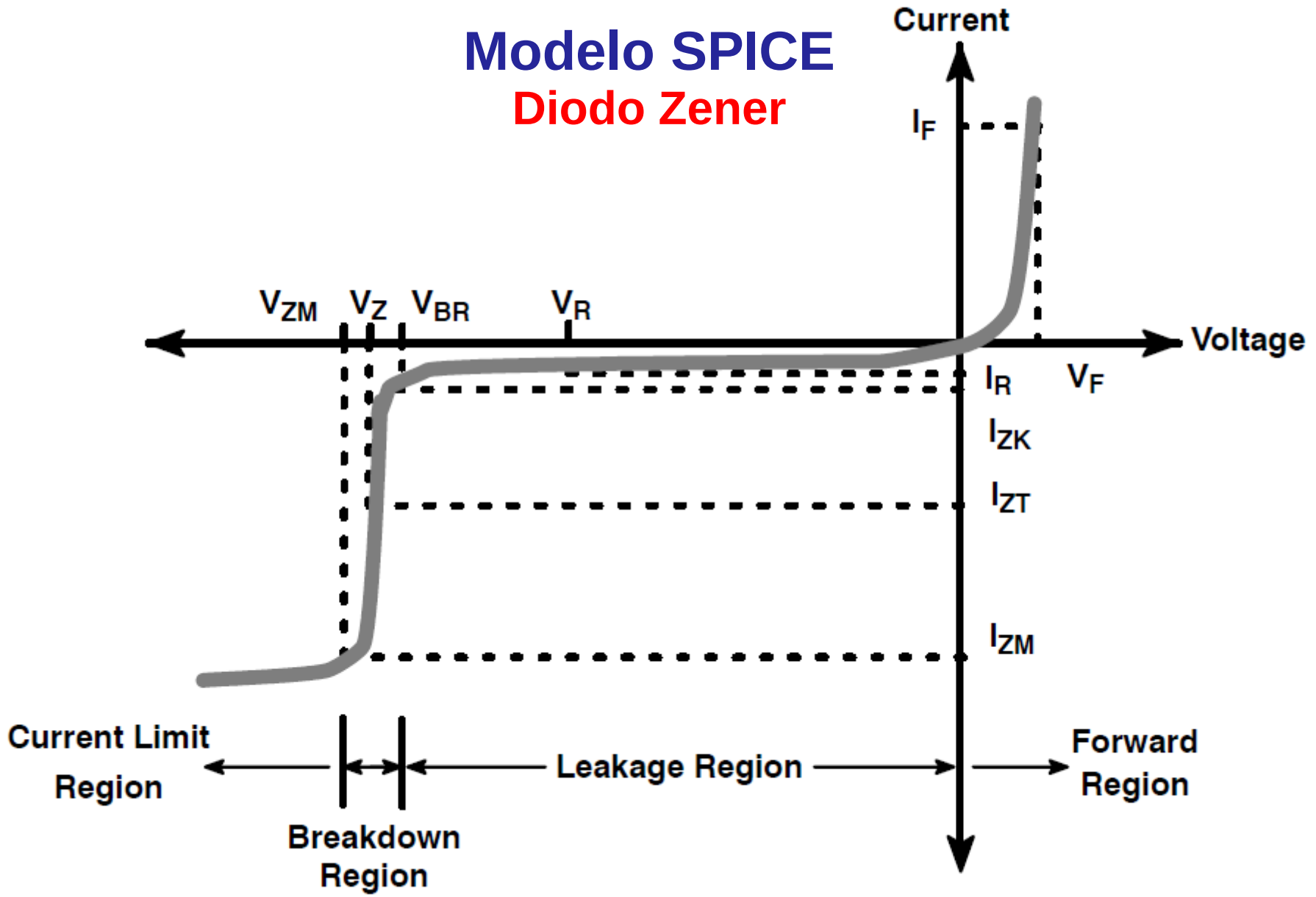
https://www.quora.com/What-is-the-effect-of-temperature-on-semiconductor-diode



Effect of temperature on zener diodes

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

Modelo SPICE
Diodo Zener



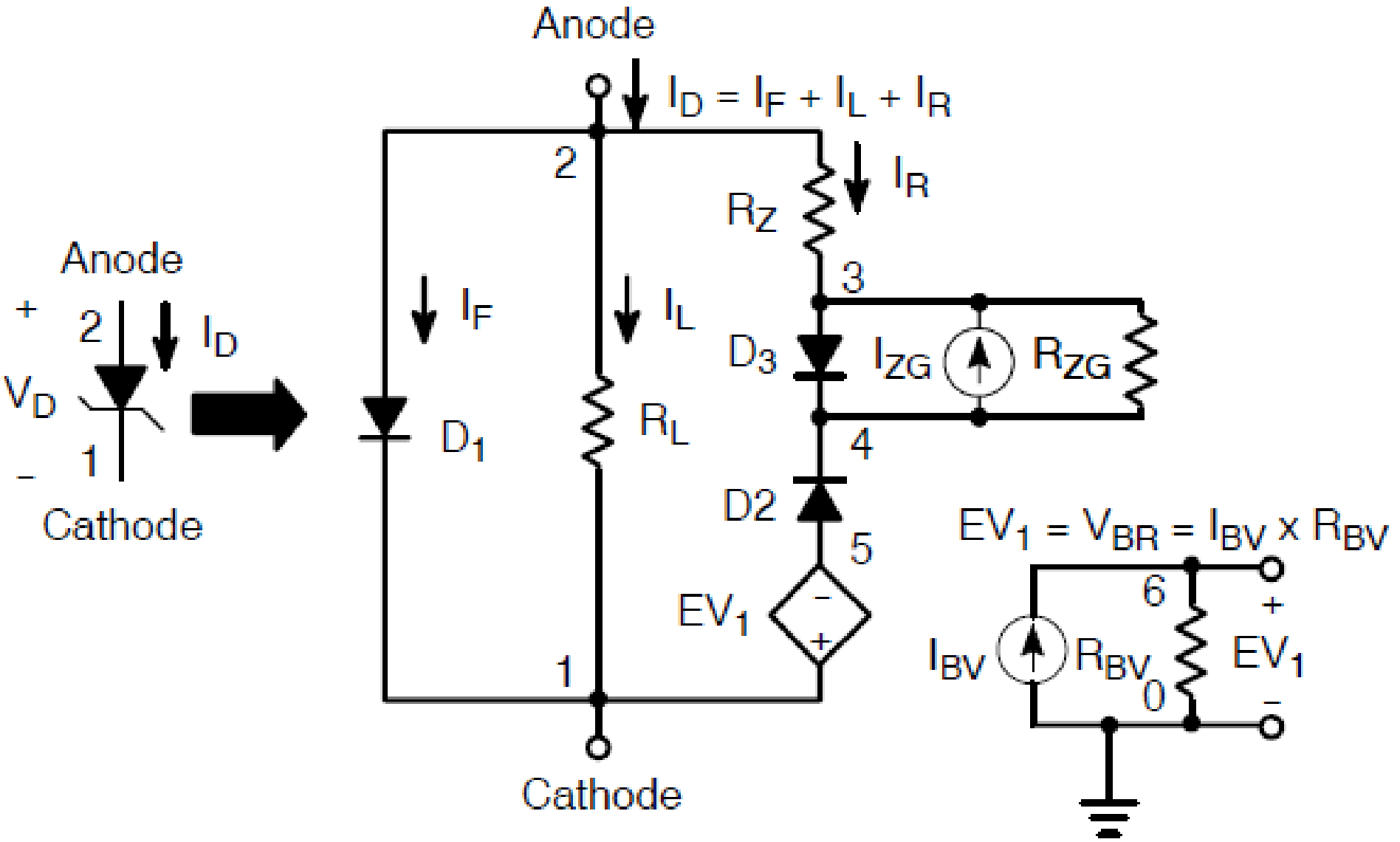
I_F = Forward current
V_F = Voltage at I_F
I_R = Reverse leakage current
V_R = Voltage at I_R
I_{ZK} = Test current for voltage V_{BR}

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}

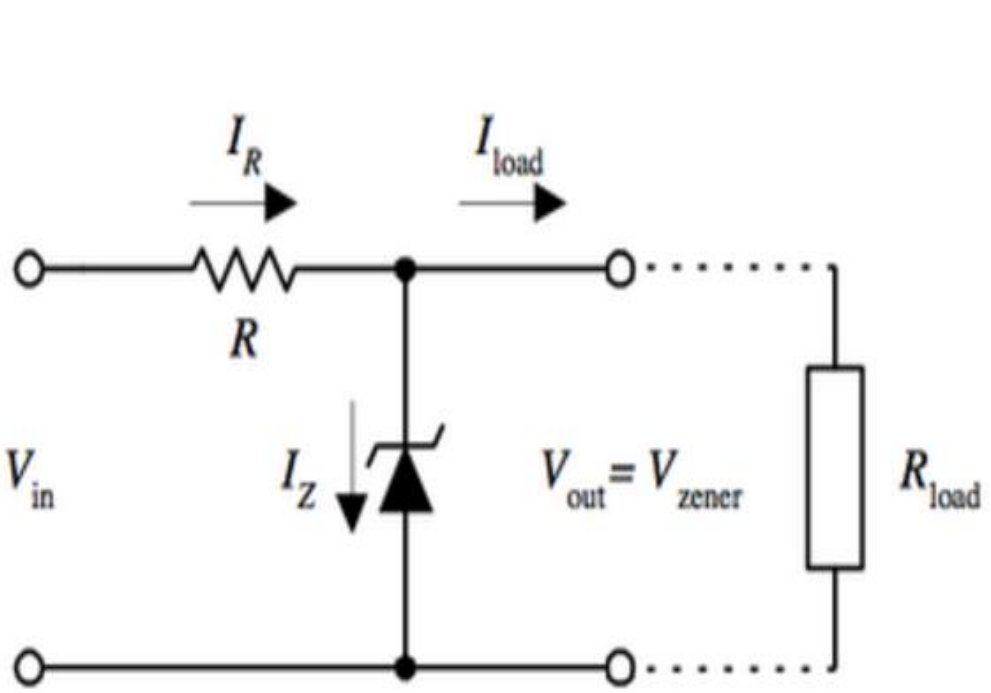
Z_{ZT} = Dynamic impedance at I_{ZT}
$= \Delta V_Z / \Delta I_{ZT}$
I_{ZM} = Maximum DC steady-state current
V_{ZM} = Voltage at I_{ZM} (typically not defined on the data sheet)

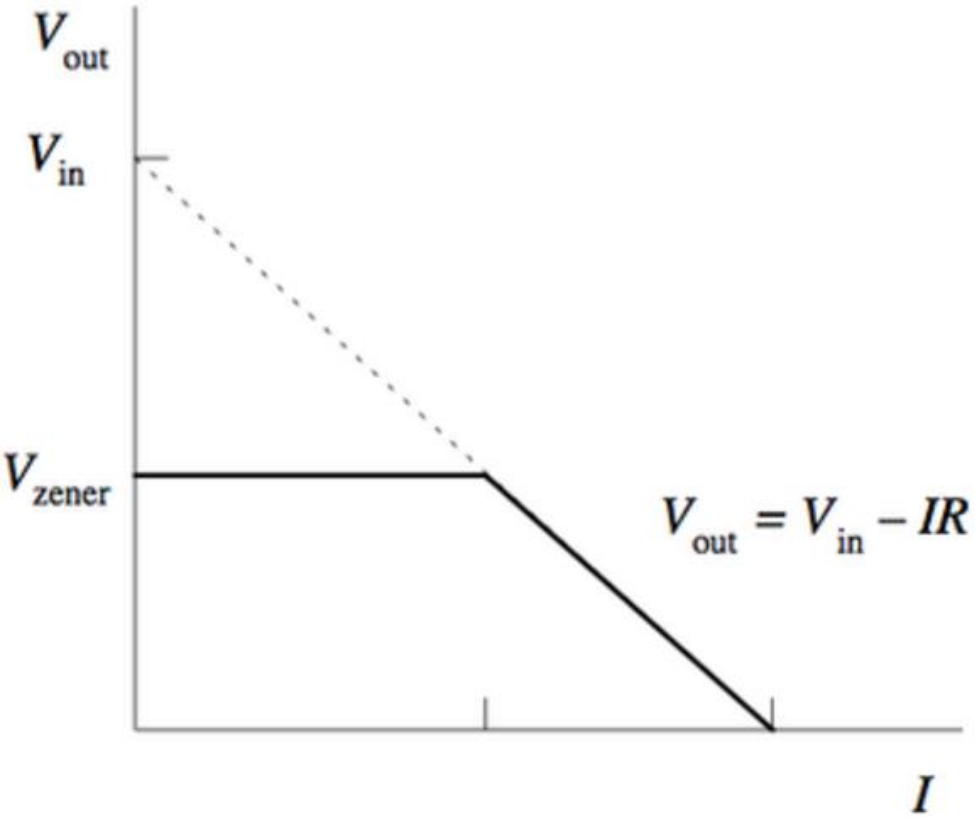
Modelo SPICE

Diodo Zener

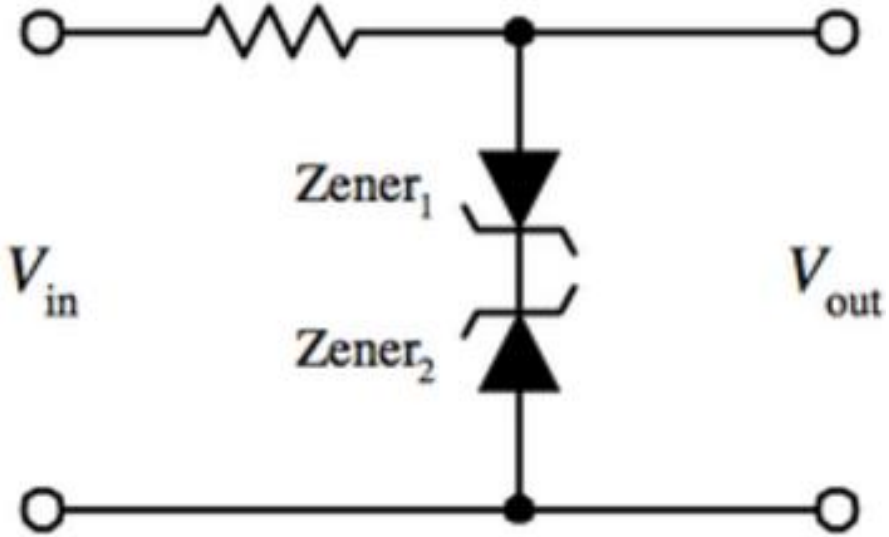


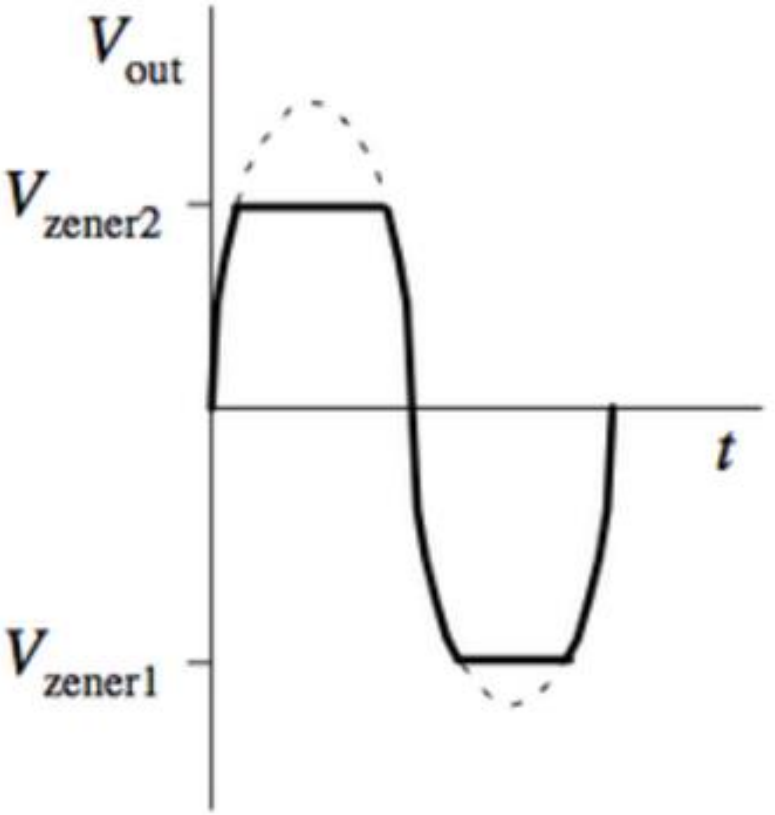
Fonte de Tensão Regulada com Diodo Zener



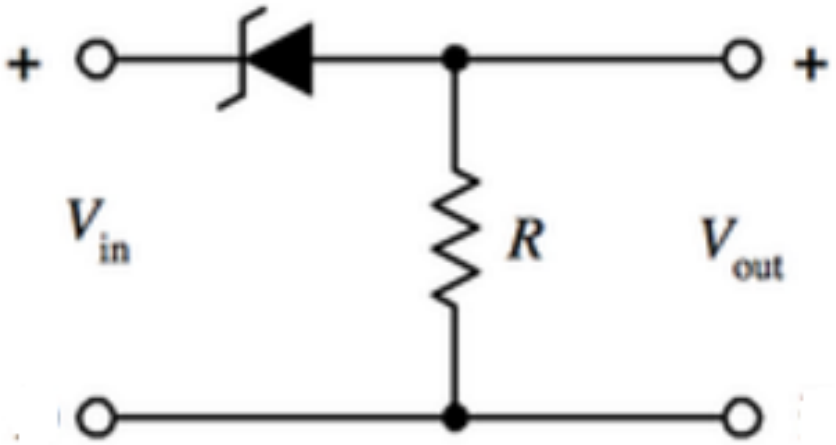


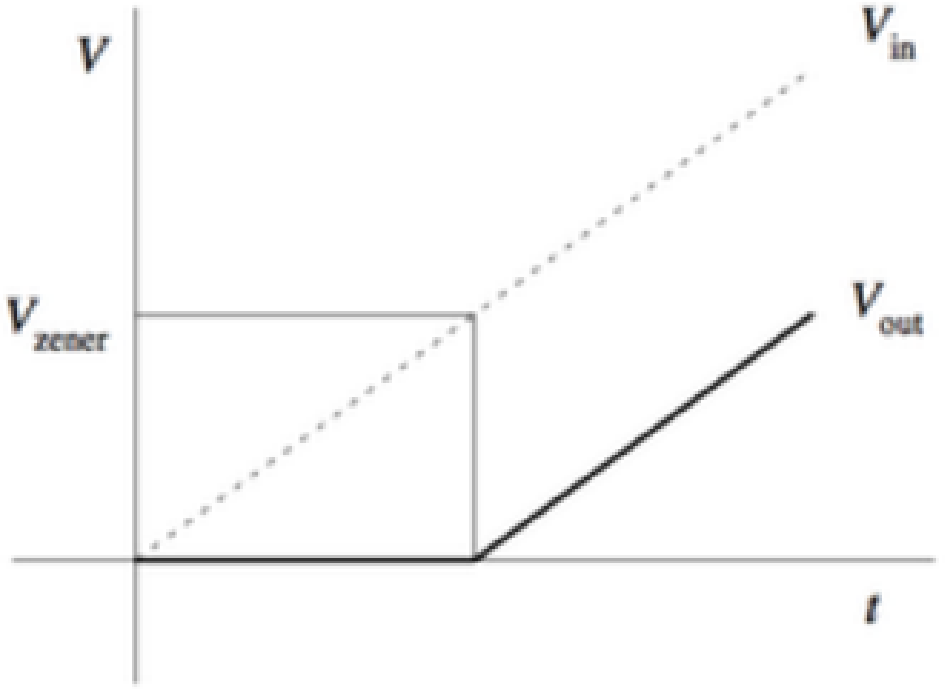
Circuito *Clipper* de Tensão



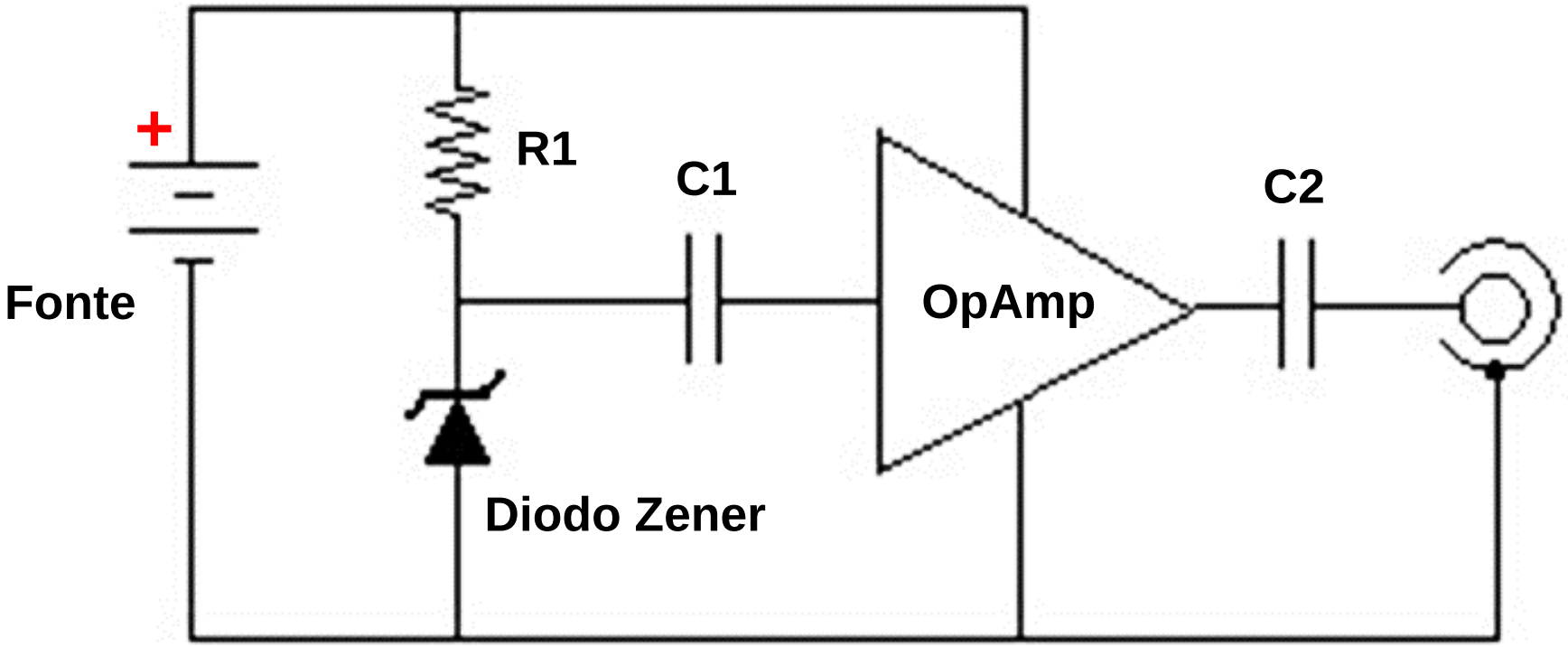


Circuito Deslocador de Tensão



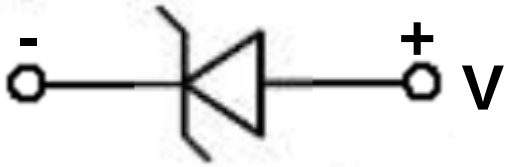


Circuito Gerador de Ruído de Amplo Espectro

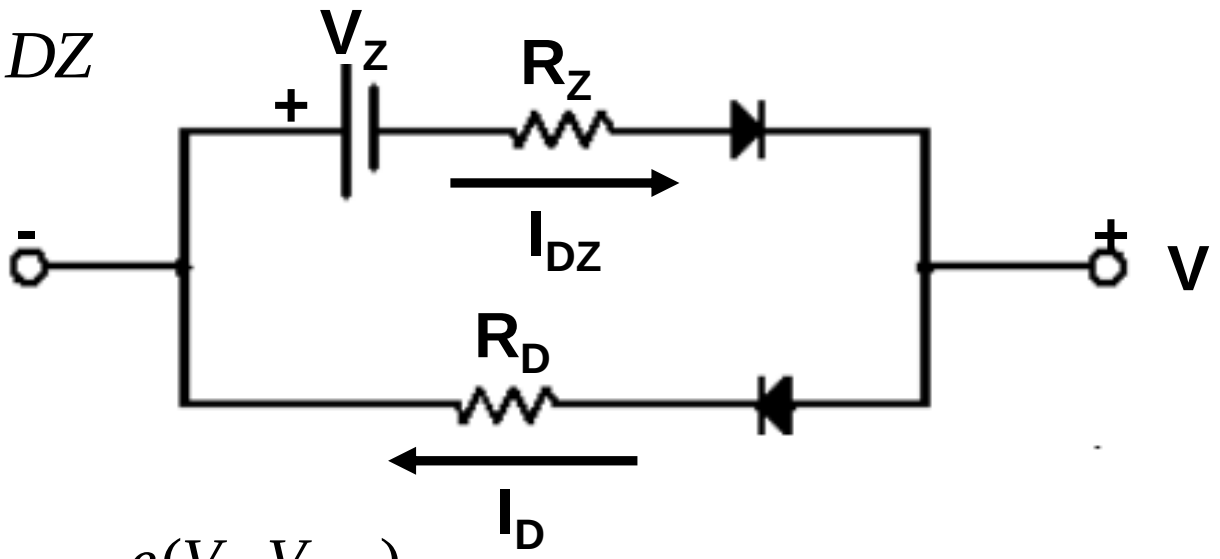


http://www.n5ese.com/noise.htm

Modelo Elétrico Simplificado do Diodo Zener



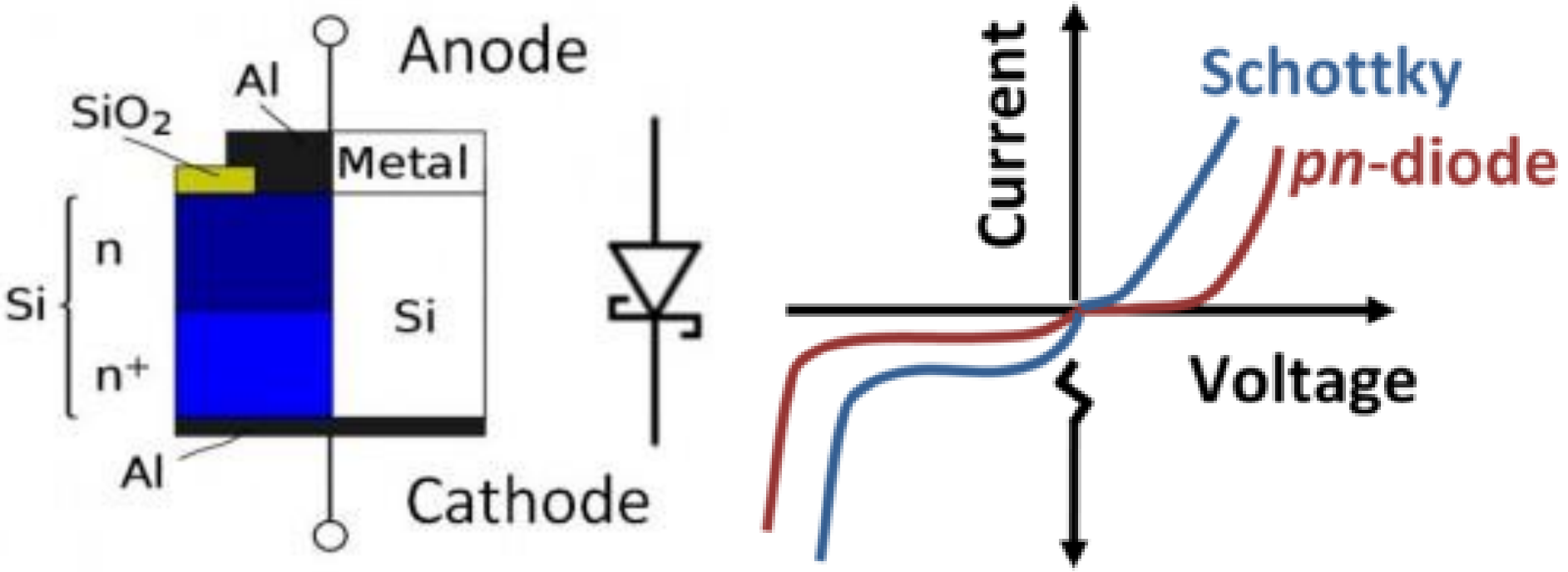
$$I = I_D - I_{DZ}$$



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

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

Diodo Schottky



http://ecetutorials.com/analog-electronics/schottky-barrier-diode/

Circuito Detector de Envelope

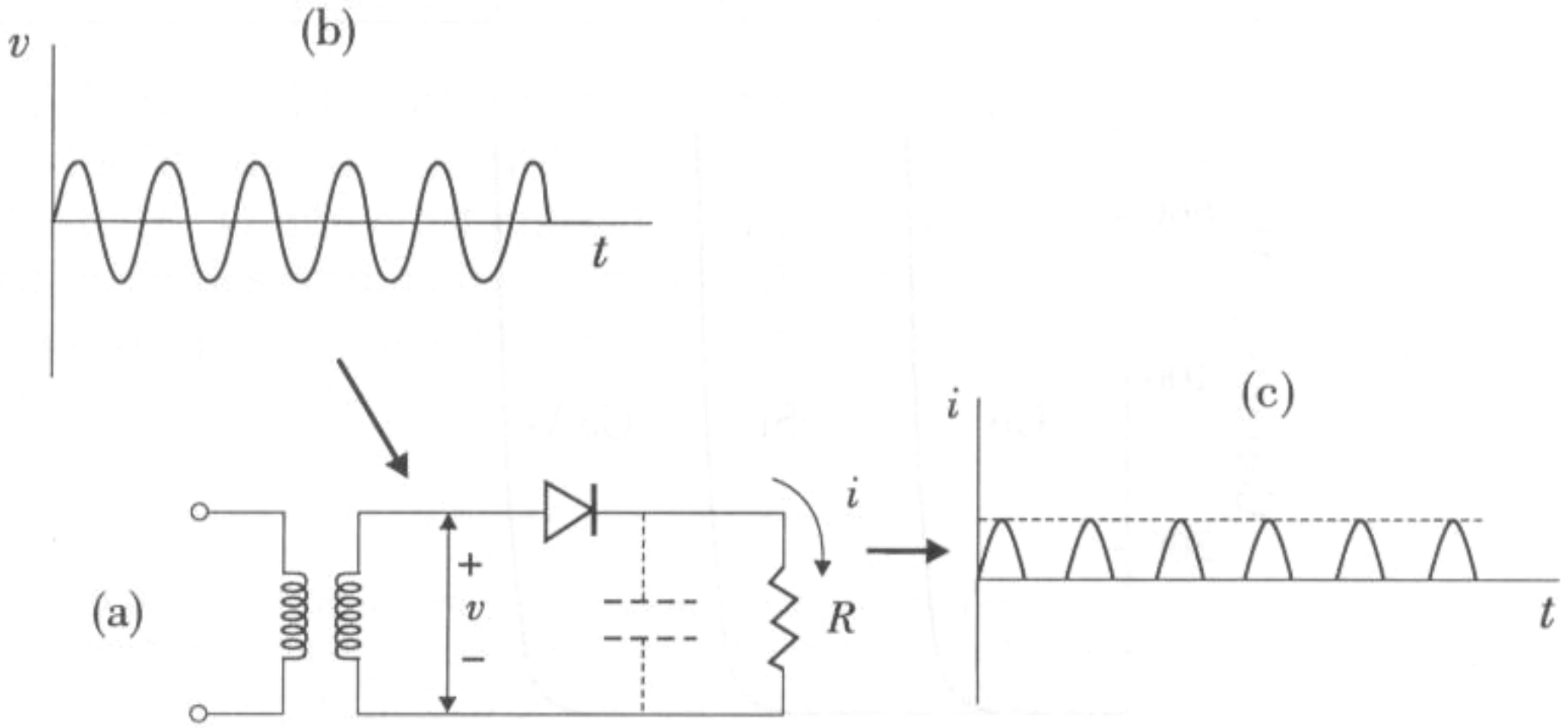


Figura 6.16: Ilustração da operação de um circuito simples retificador de meia-onda. A tensão $v(t)$ no secundário do transformador resulta na corrente $i(t)$ no diodo e na carga. A linha tracejada representa a forma de onda obtida com a adição do capacitor ao circuito.

Rádio a “Cristal”

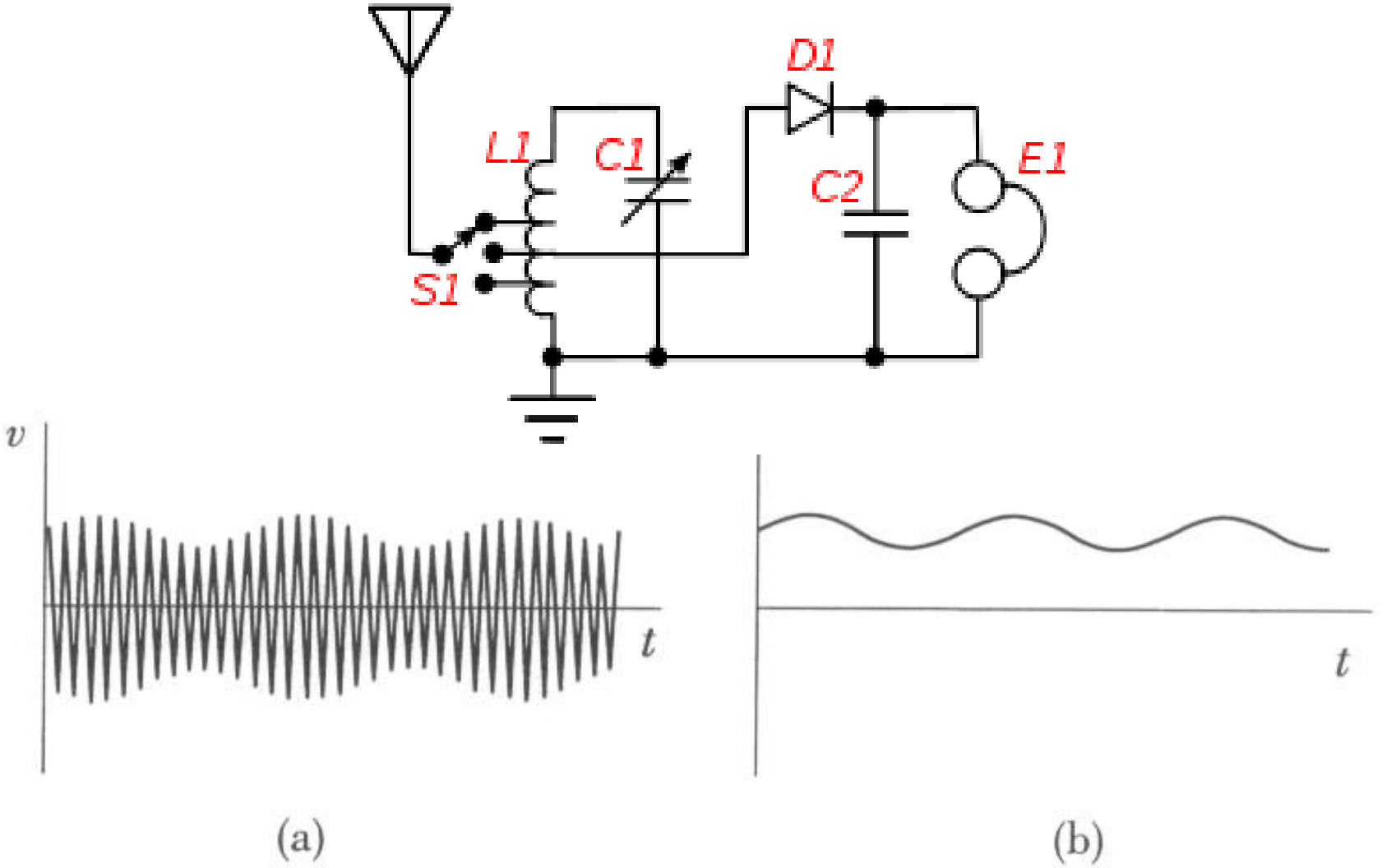
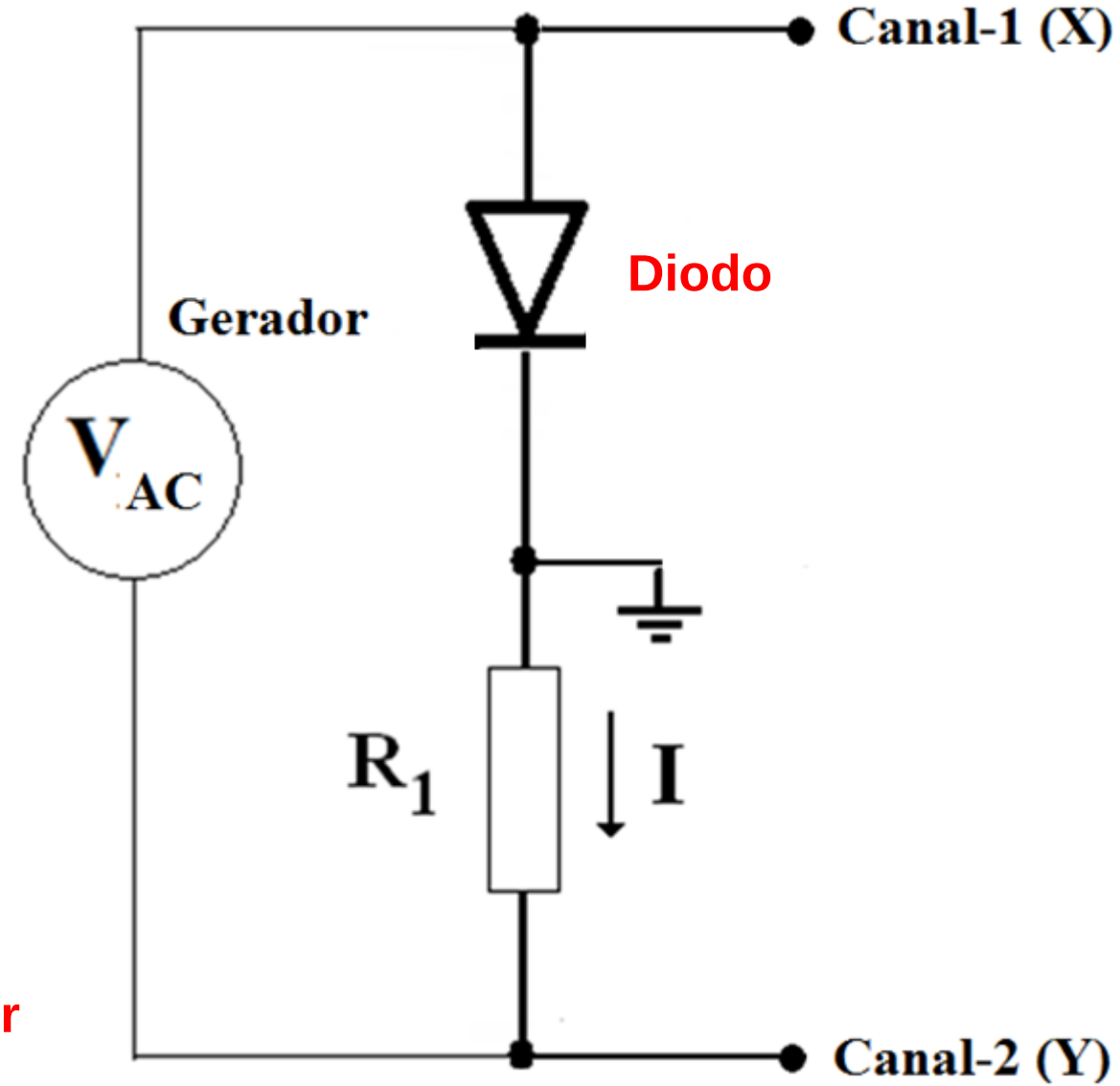


Figura 6.17: a) Onda senoidal de alta freqüência modulada por sinal senoidal de áudio. A linha formada pelos valores de pico corresponde ao sinal de áudio. b) Sinal de áudio produzido pelo detetor de pico com diodo.

Galena Crystal Radio

Foxhole Radio Receiver

Circuito Traçador de Curvas I vs. V



Terra do Gerador Flutuante

Circuitos para Plotar as curvas I vs. V no Osciloscópio

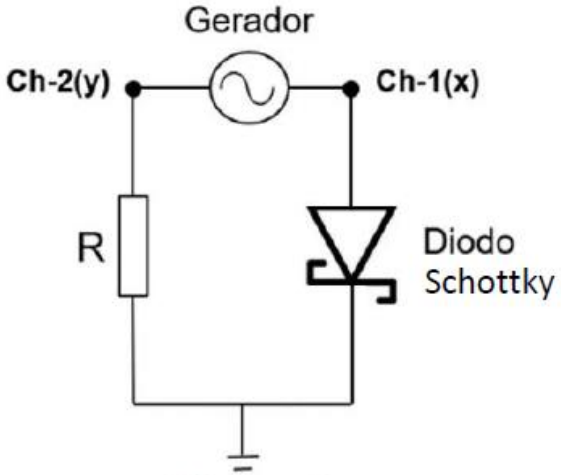


Figura-1

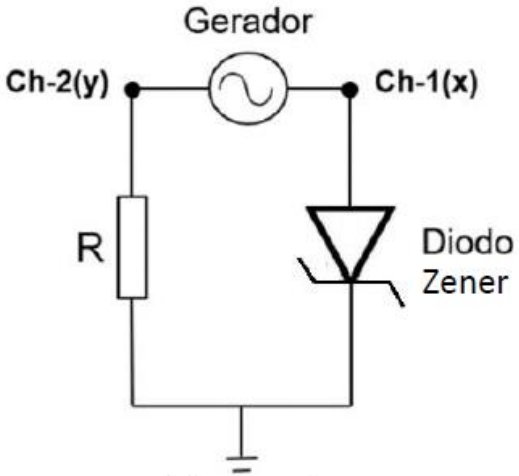


Figura-2

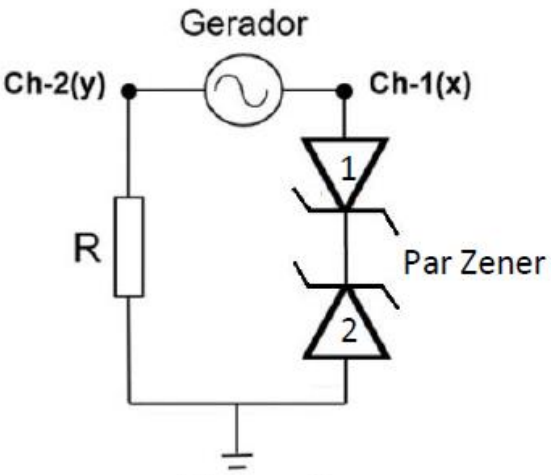
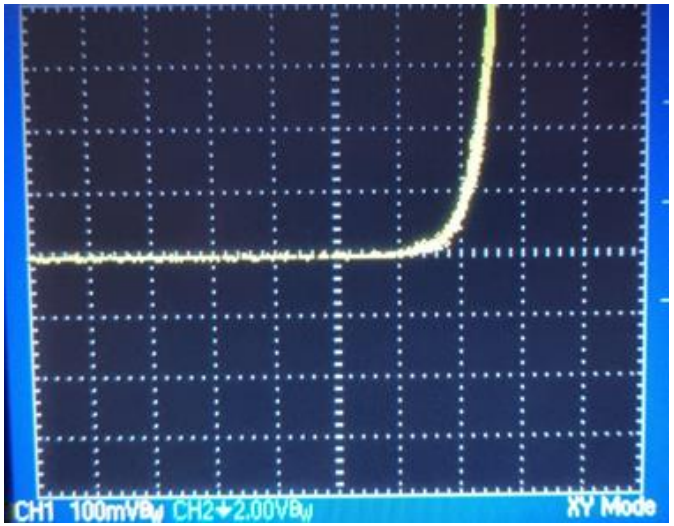
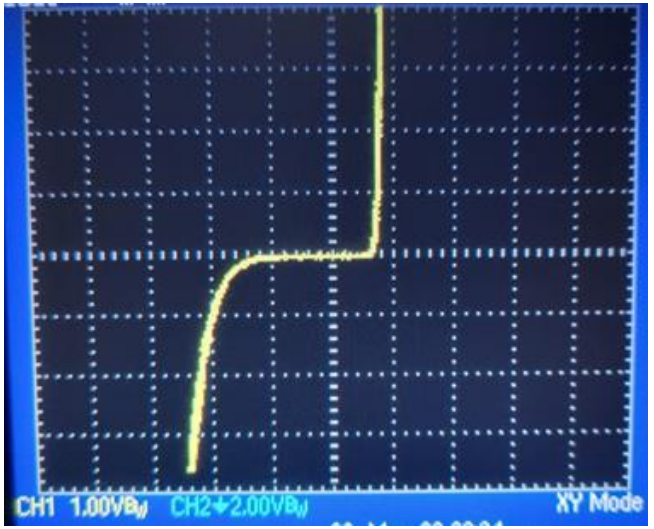


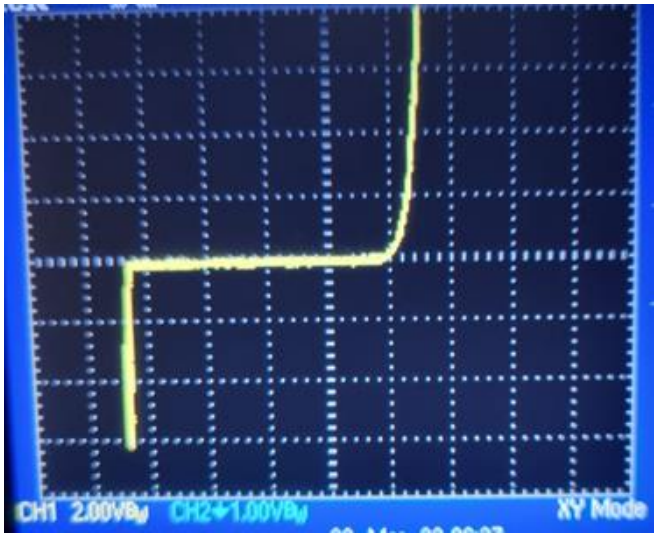
Figura-3



V_D R_D I_S

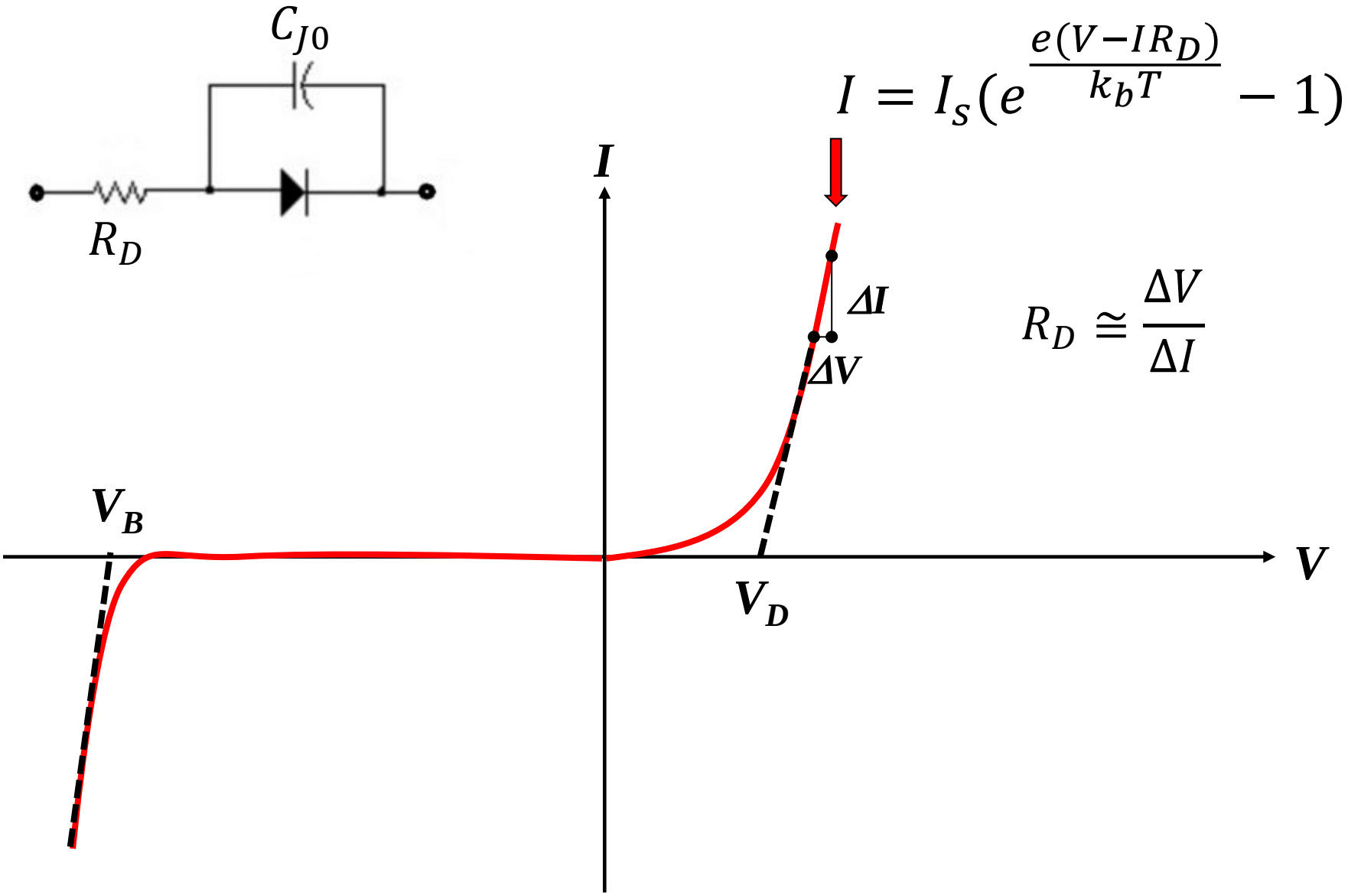


V_D V_B R_D I_S

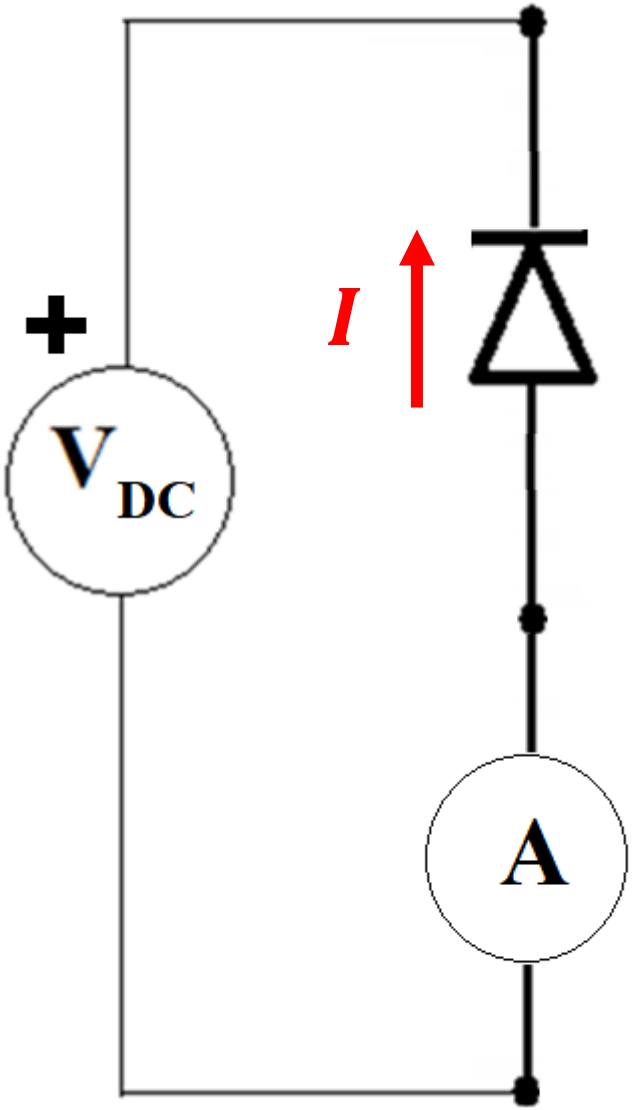


V_{B1} V_{B2}

Extração de Parâmetros das curvas I vs. V do Diodo



Medida da Corrente de Saturação Reversa



$$I = I_s(e^{\frac{e(V-IR_D)}{k_bT}} - 1)$$

Diodo

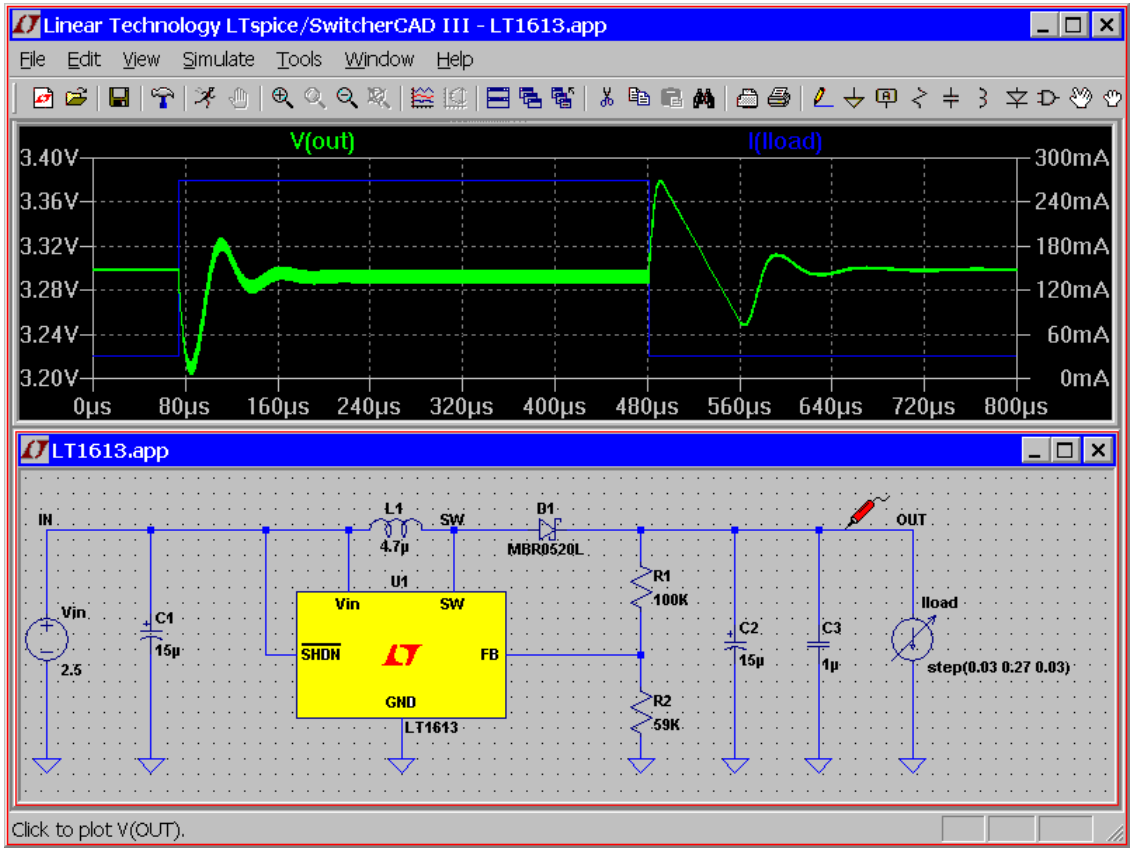
Reversamente Polarizado: $V < 0$

$$I = -I_s$$

Multímetro Digital

Modo: Amperímetro

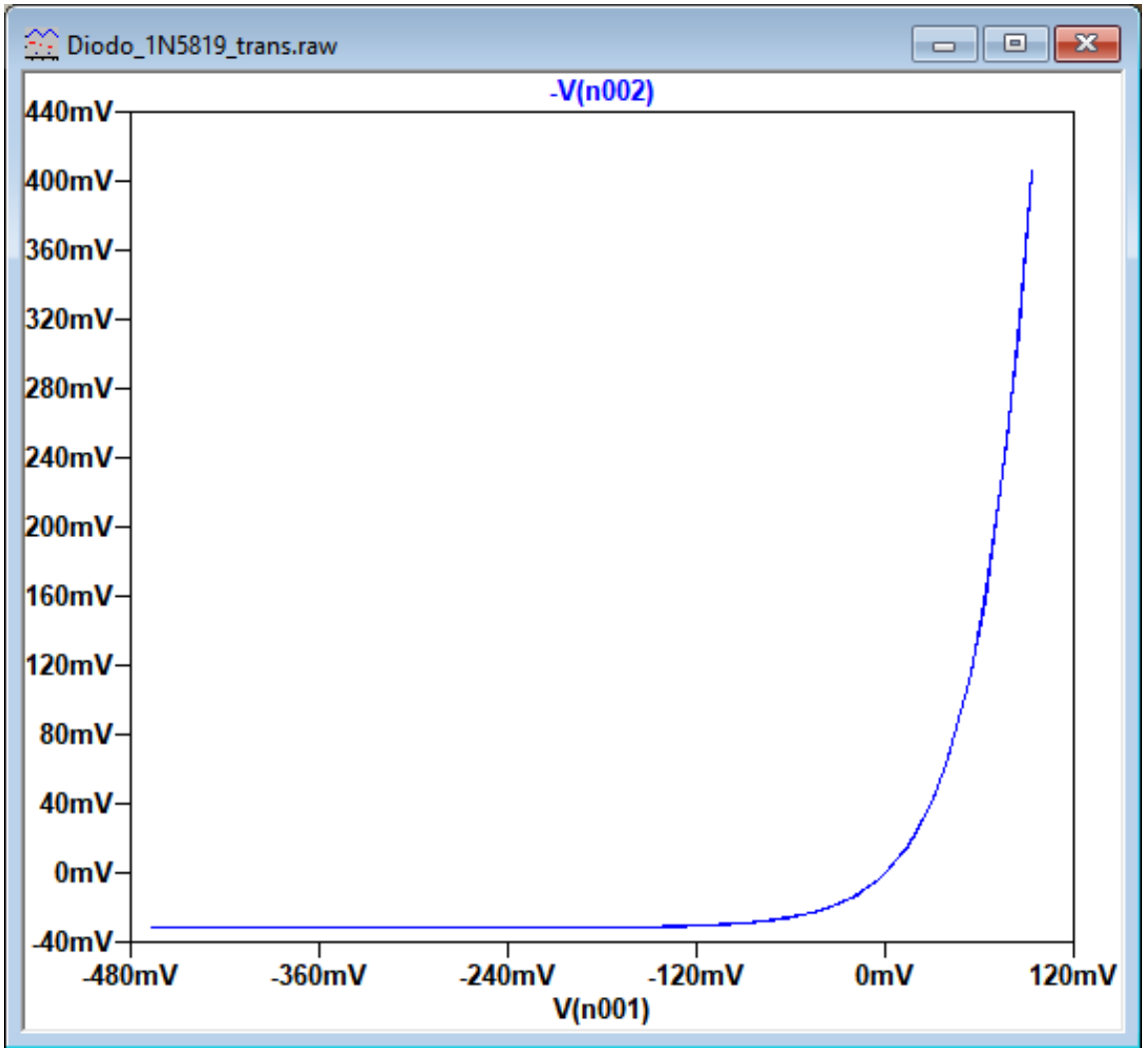
Simulação com LTspice

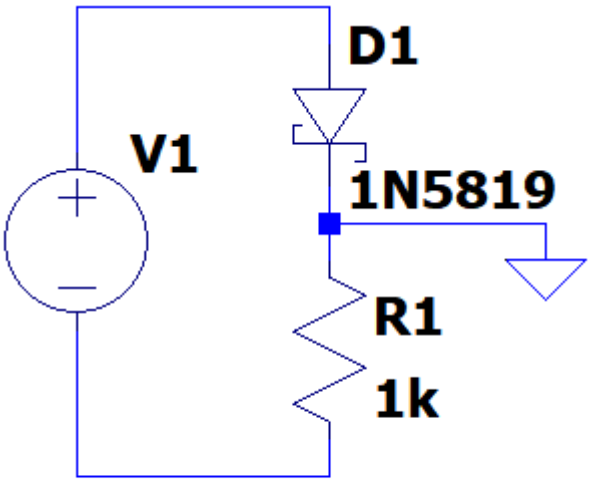


Instale o LTspice!

https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html

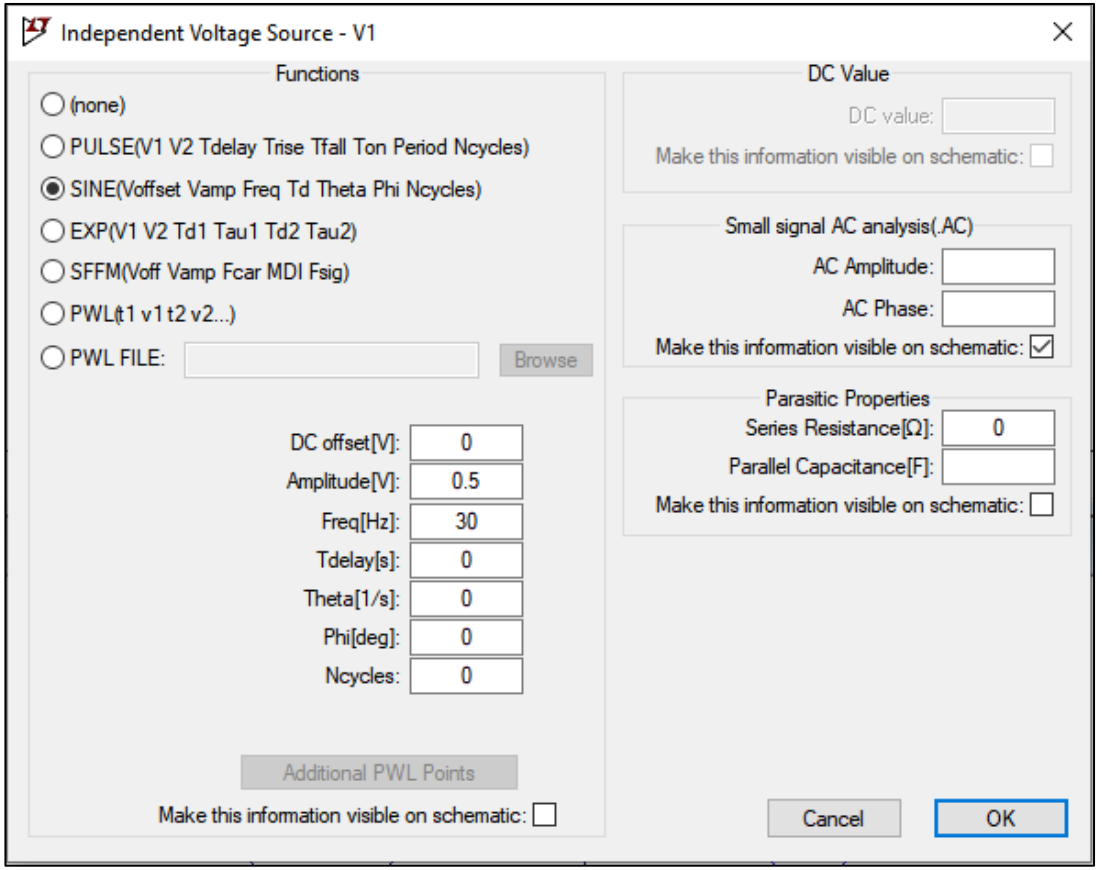
Simulação LTspice: Diodo Schottky 1N5819

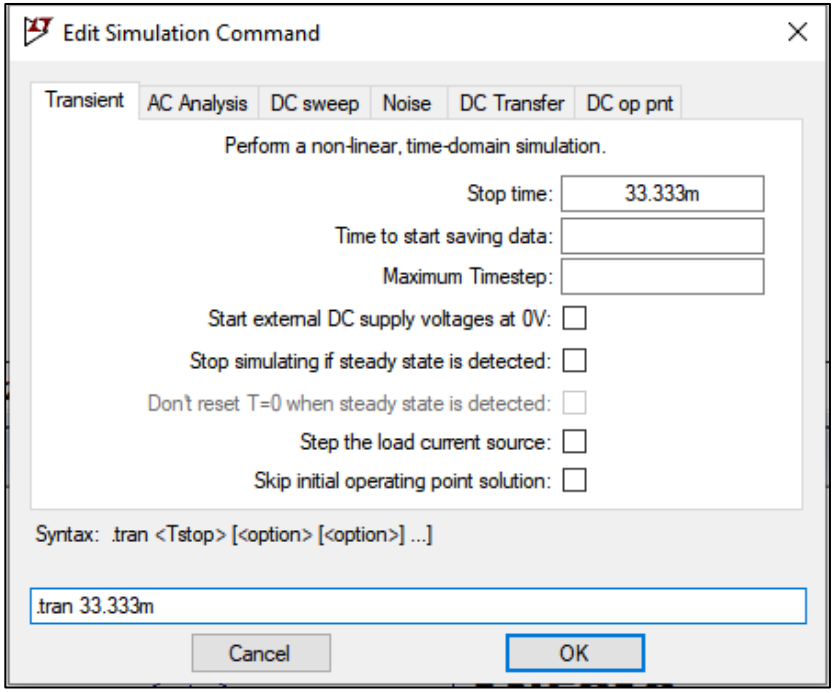


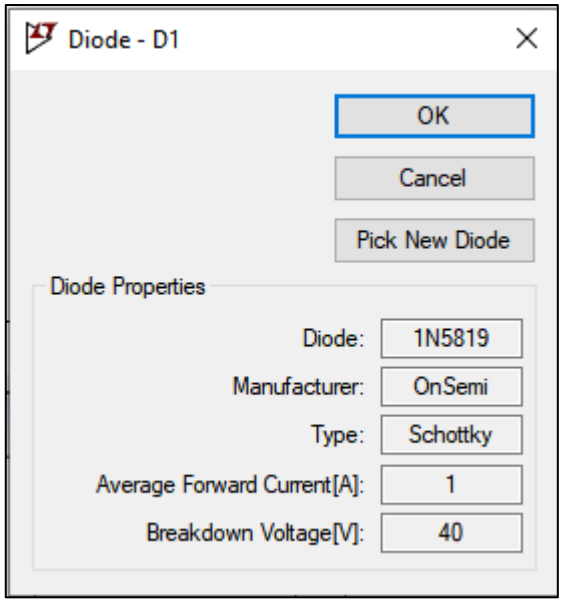


.tran 33.333m

.model 1N5819 D(Is=31.7u Rs=.051 N=1.373 Cjo=110p M=.35 Eg=.69 Xti=2 Iave=1 Vpk=40 mfg=OnSemi type=Schottky)







$$f = 30[Hz]$$

$$T = \frac{1}{f} = \frac{1}{30[Hz]} = 33.333[ms]$$