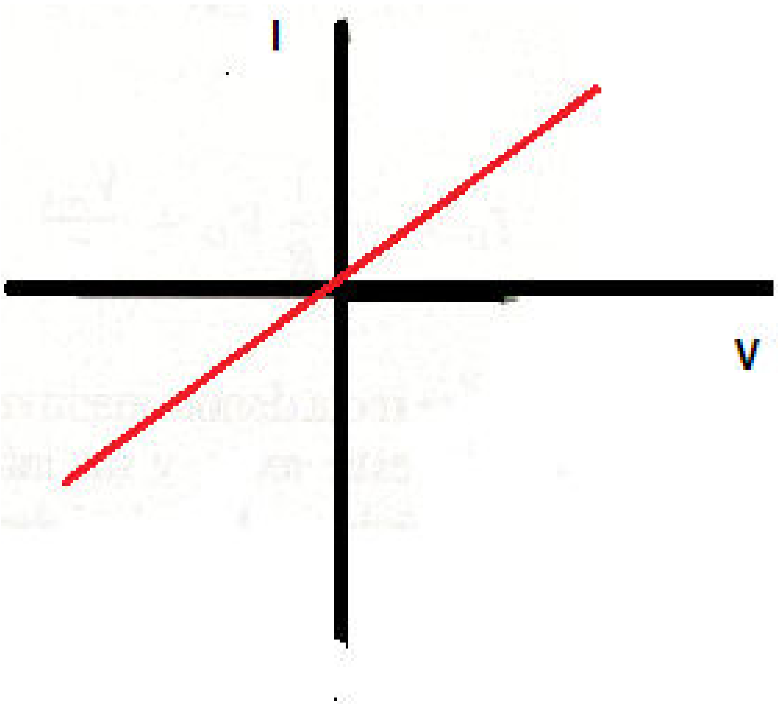
Aula teórica 1: **“Diodo semicondutor ”**

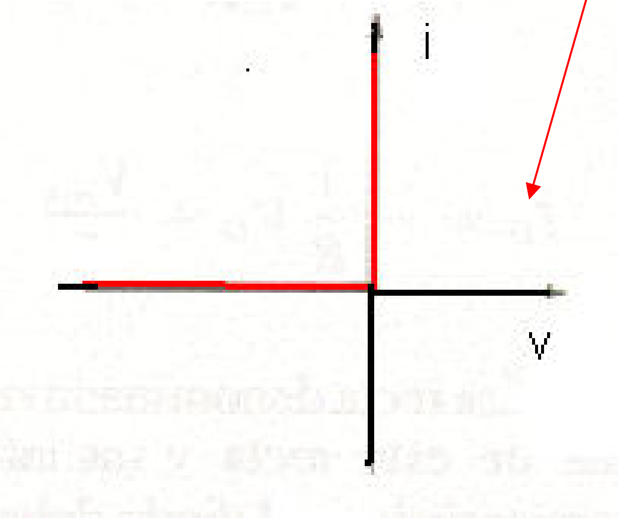
Dr. José A. Chaljub Duarte

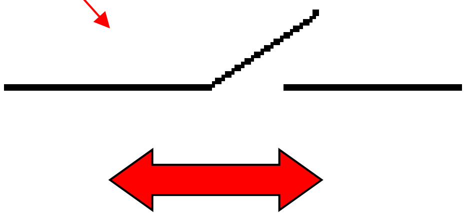
Resistencia (V vs I)

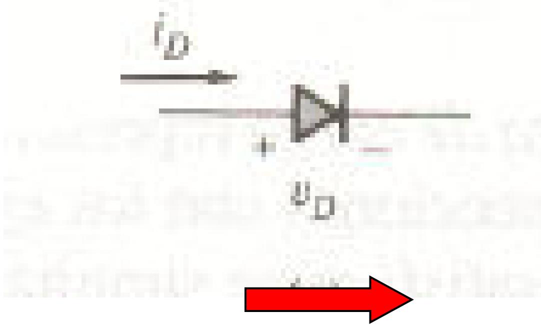


Diodo ideal

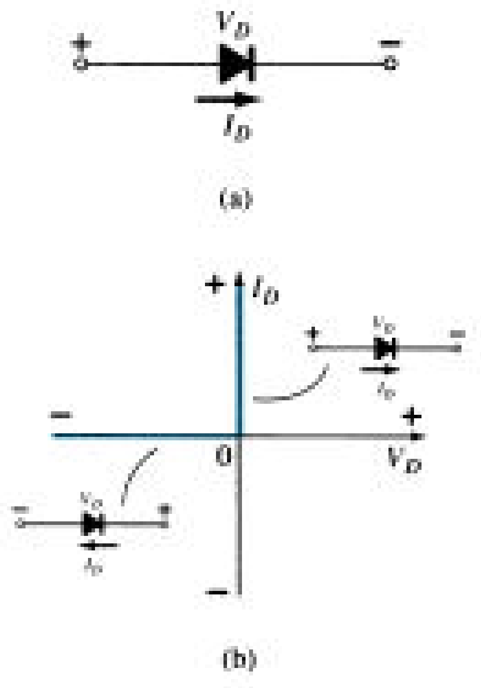
semejante



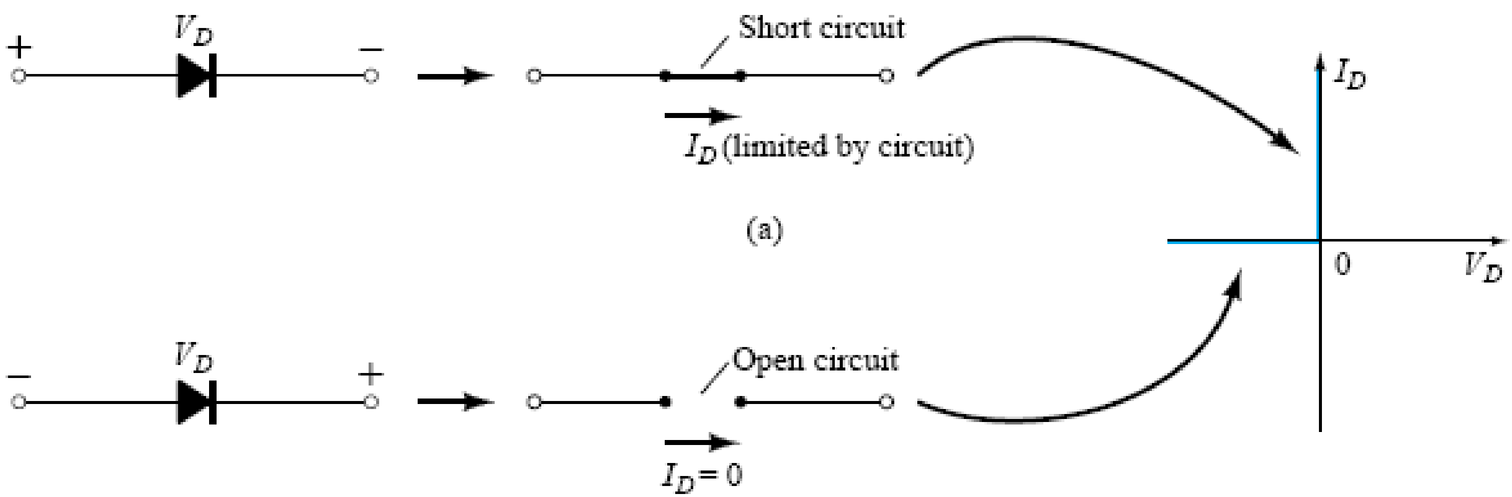




Diodo ideal

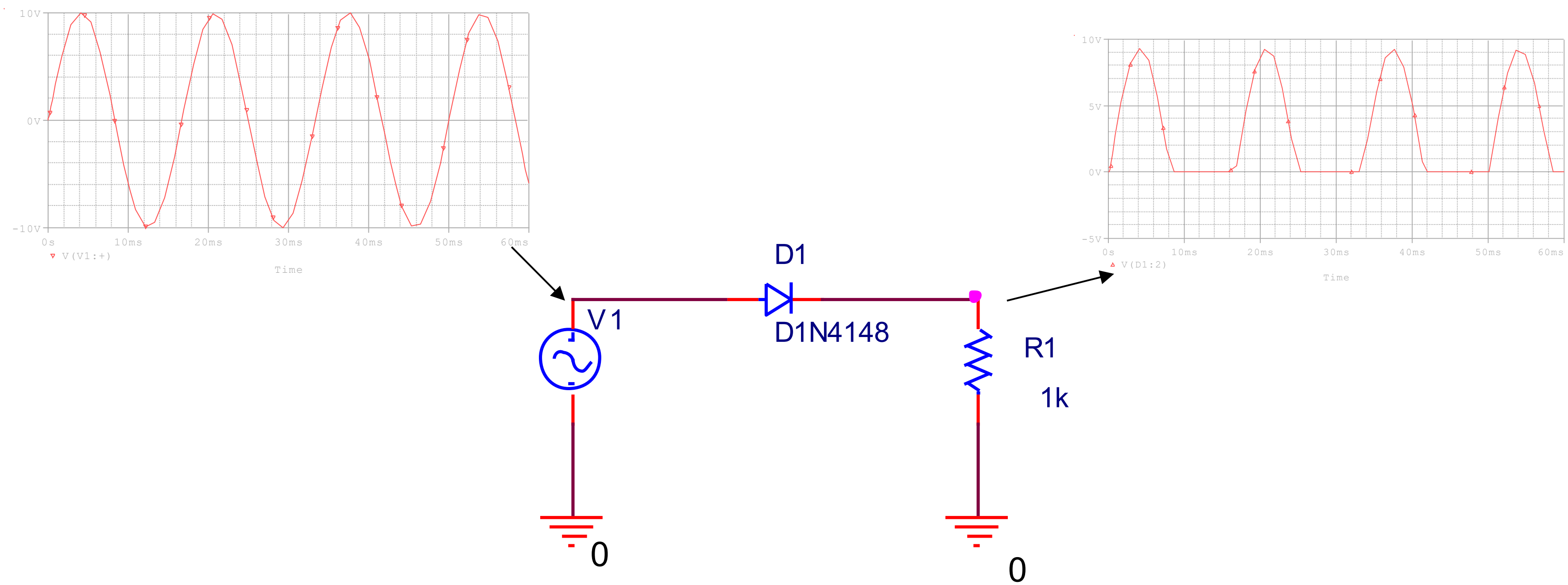


Diodo ideal



+
V_D
−
Short circuit
I_D (limited by circuit)
(a)
−
V_D
+
Open circuit
$I_D = 0$
I_D
0
V_D

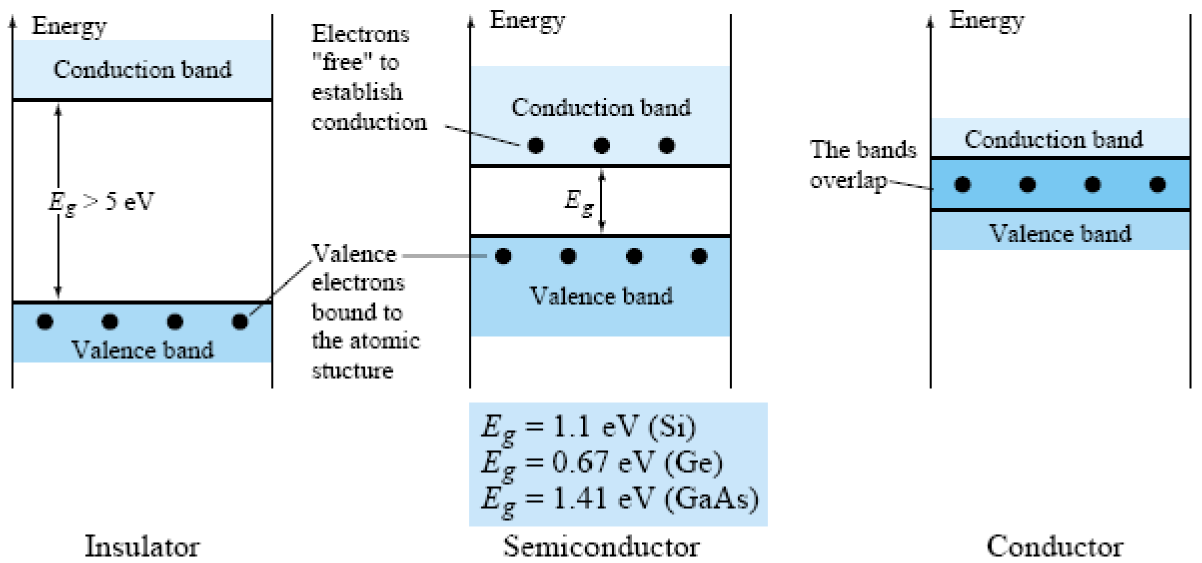
Retificação>> A corrente circula em um só sentido pela carga



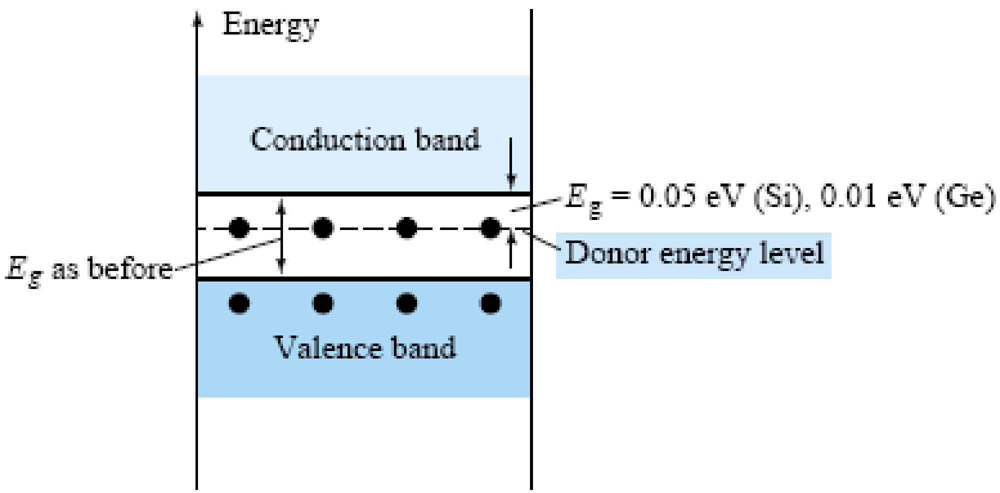
Como construir um dispositivo com uma característica semelhante ao diodo ideal?

isoladores, semicondutores e condutores:

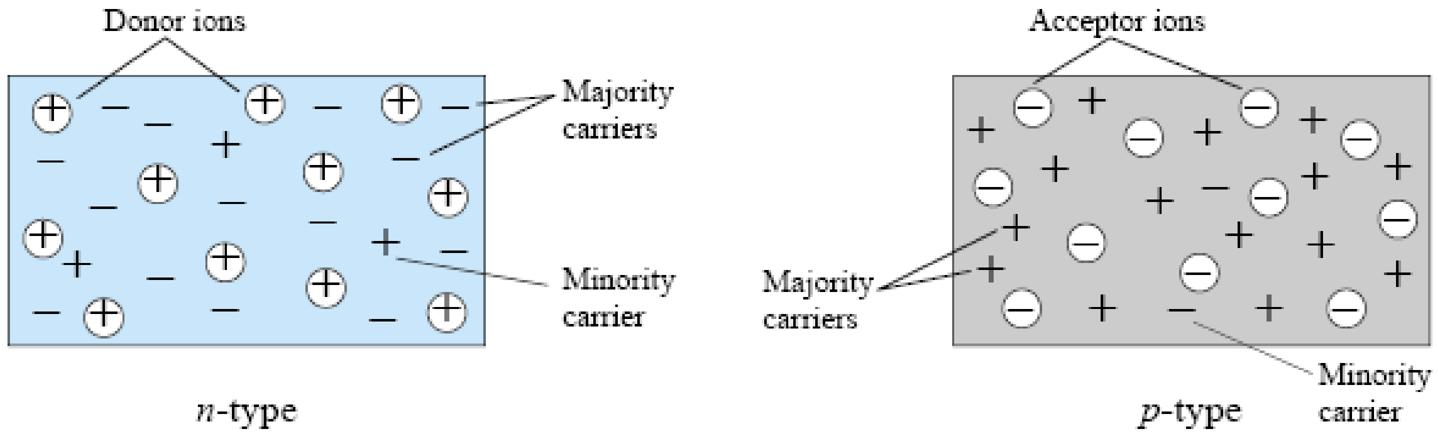
Bandas de energía



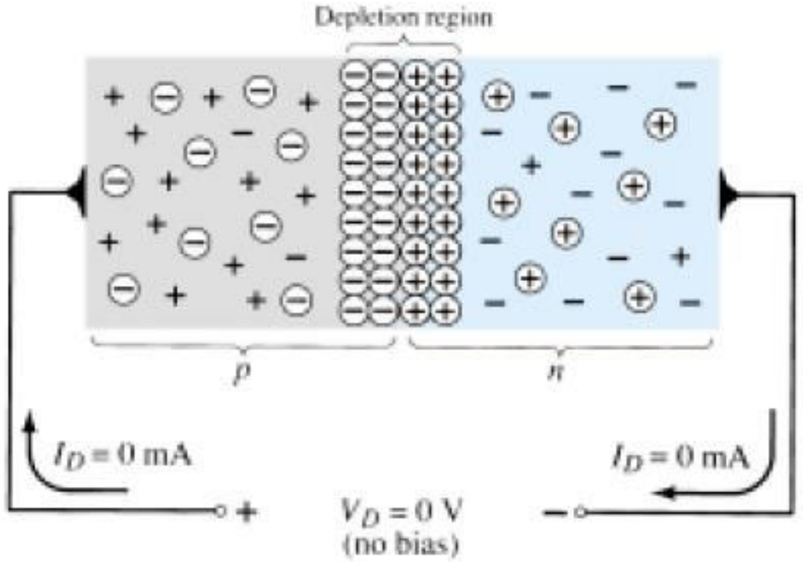
semicondutor com impurezas doadoras

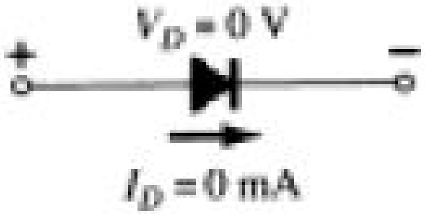


semiconductores

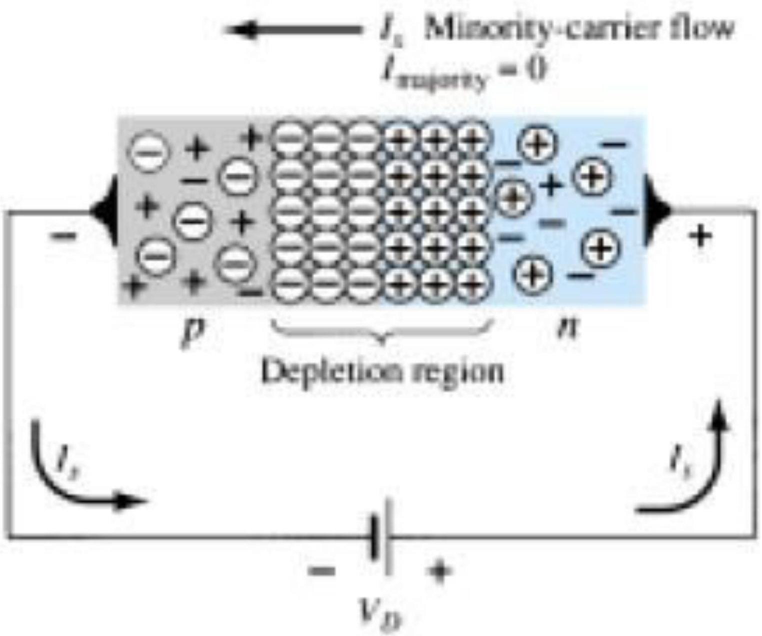


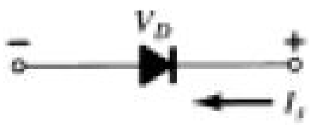
União pn não polarizadaa



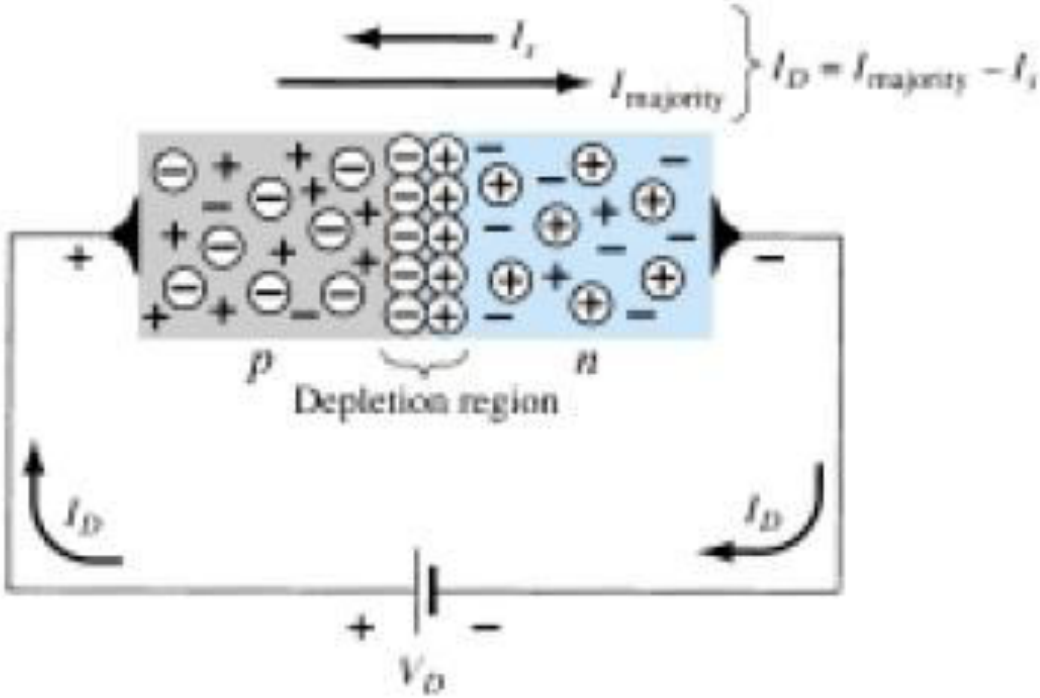


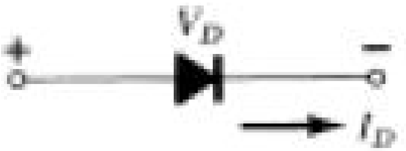
União pn polarizada em inverso



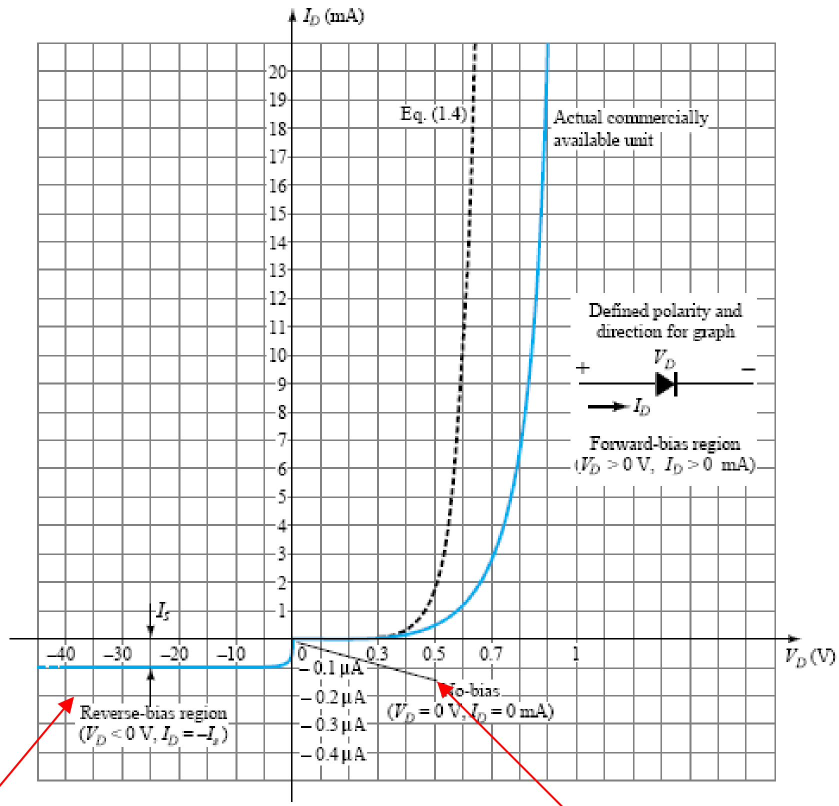


União pn polarizada em direto





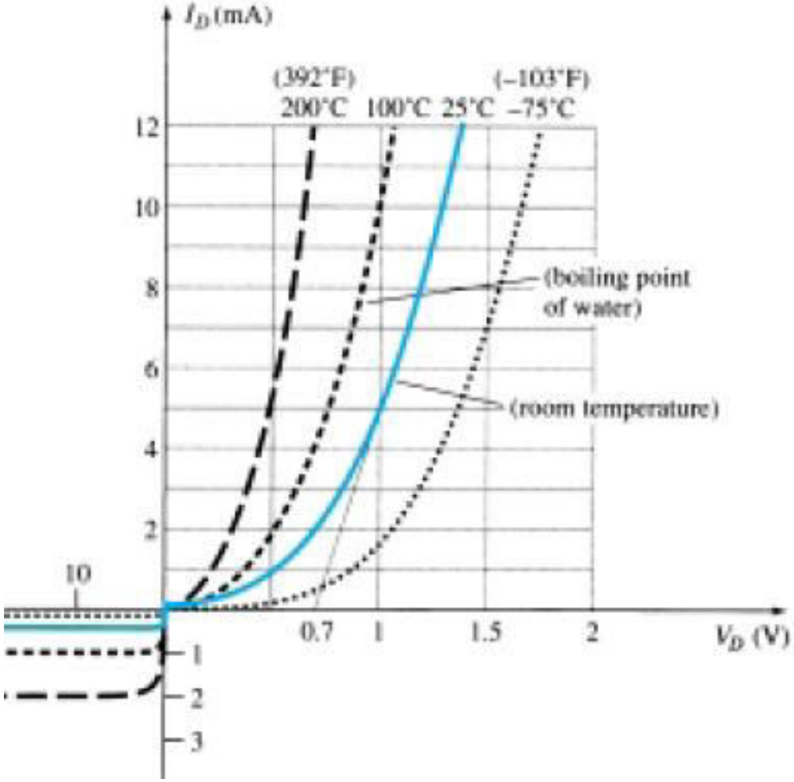
Característica VI da união pn



corrente de fuga (**se duplica por cada 10°C**)

voltagem de joelho **dv/dt=-2.5mV/°C**

Efeitos da temperatura



Modelo analítico da característica VI

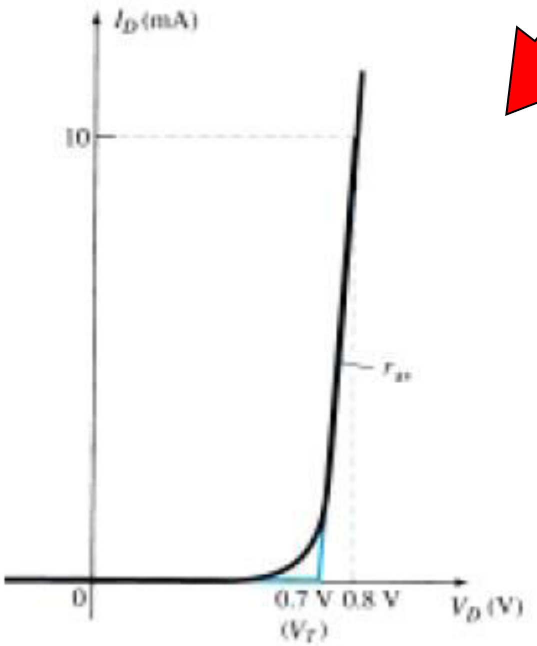
$$\boxed{I_D = I_s(e^{kV_D/T_K} - 1)} \qquad (1.4)$$

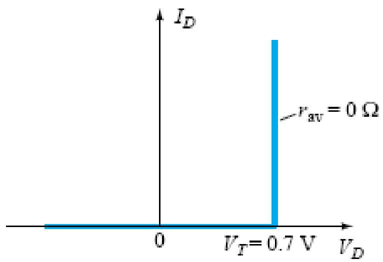
where I_s = reverse saturation current
$k = 11{,}600/\eta$ with $\eta = 1$ for Ge and $\eta = 2$ for Si for relatively low levels of diode current (at or below the knee of the curve) and $\eta = 1$ for Ge and Si for higher levels of diode current (in the rapidly increasing section of the curve)
$T_K = T_C + 273°$

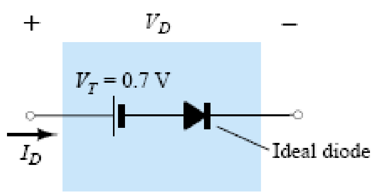
$$I_D = I_o(e^{\frac{V_D}{\eta V_T}} - 1)$$

$$V_T = \frac{T^{\circ}K}{11600} \approx 26mV\ a\ T\ ambiente$$

Aproximação linear de segmentos da característica VI



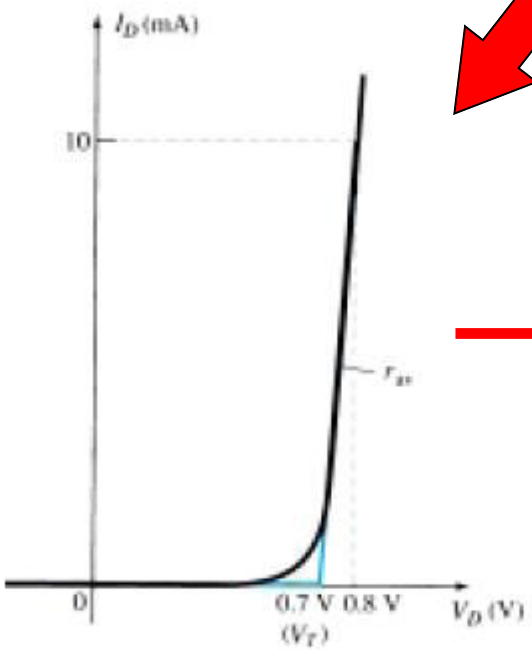


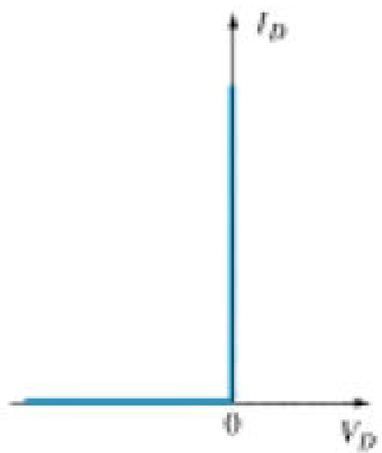


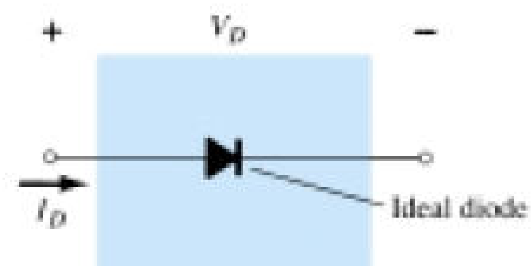
Circuito equivalente

Aproximação linear de segmentos da característica VI

(desprezar a voltagem de joelho)

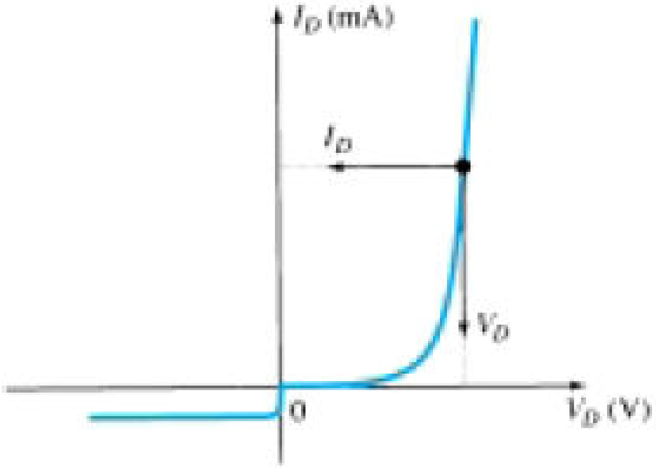






Circuito equivalente

Resistência estática

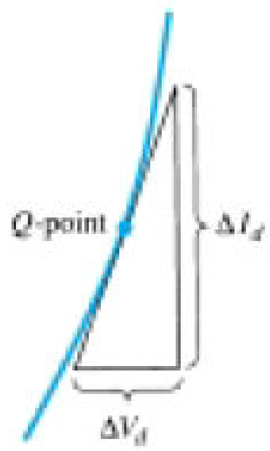


$$R_D = \frac{V_D}{I_D}$$

Resistência dinâmica

$$\boxed{r_d = \frac{\Delta V_d}{\Delta I_d}}$$

where Δ signifies a finite change in the quantity.



Do modelo analítico se obtém:

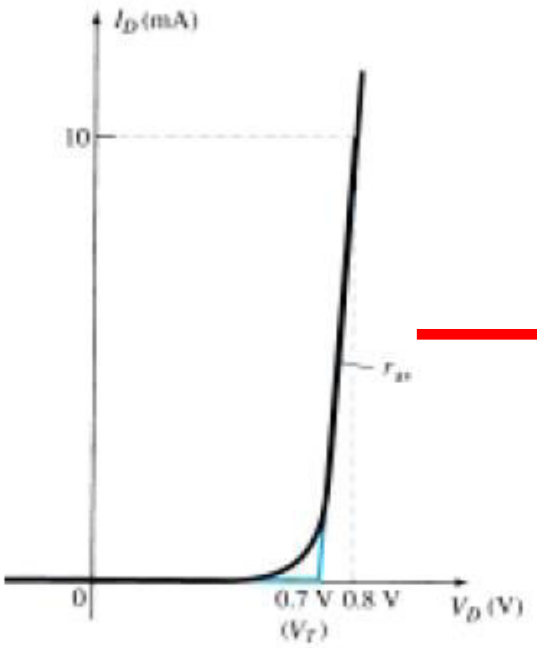
$$I_D = I_o(e^{\frac{V_D}{\eta V_T}} - 1)$$

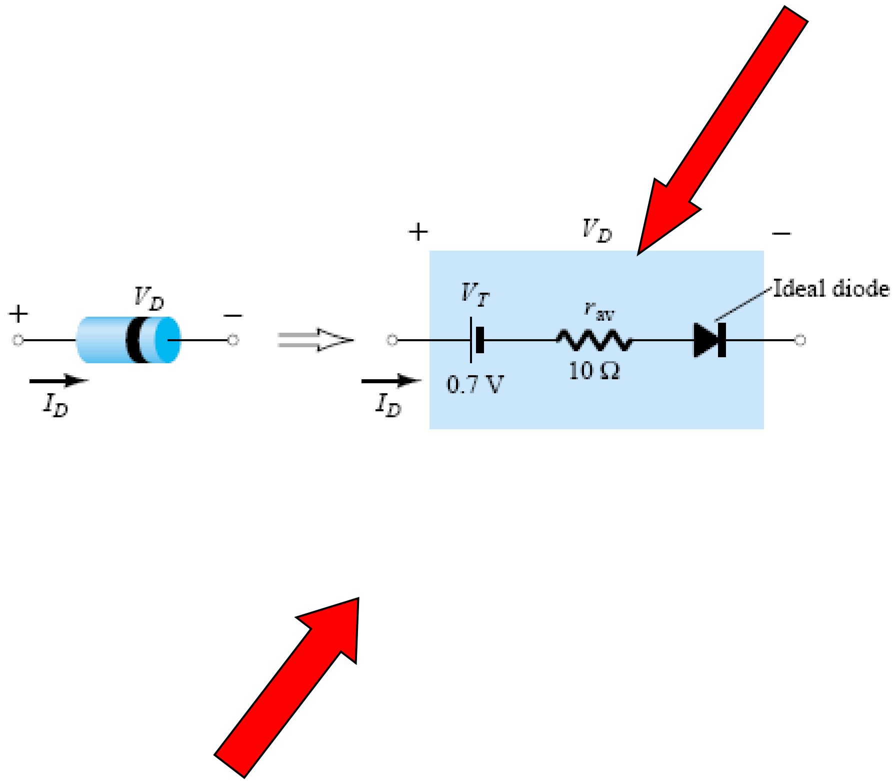
$$V_T = \frac{T^{\circ} K}{11600}$$

$$\Rightarrow$$

$$r_d \approx \frac{V_T}{I_D}$$

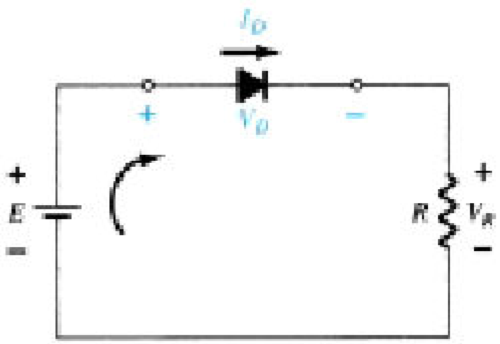
Aproximação considerando a rd





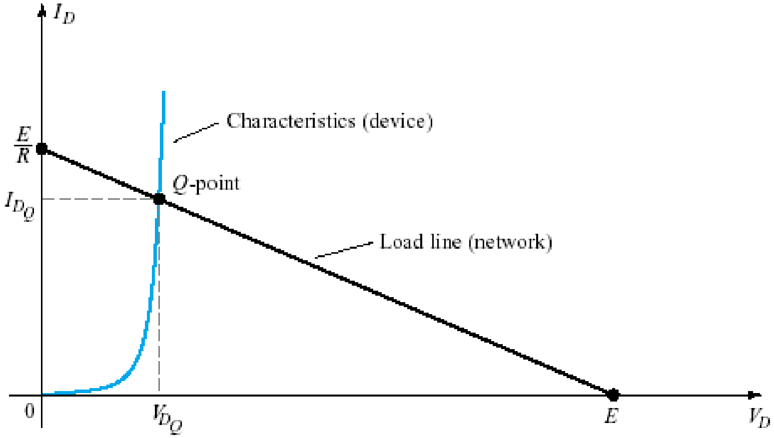
Circuito equivalente

Reta de carga : Método gráfico



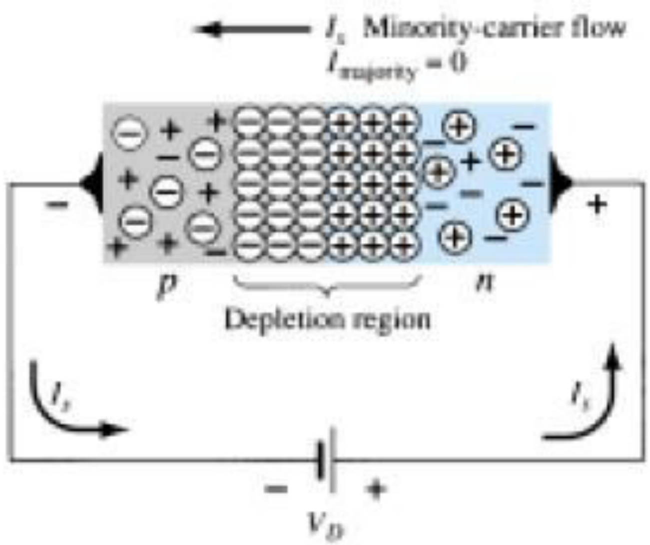
$$E - V_D - V_R = 0$$

$$\boxed{E = V_D + I_D R}$$

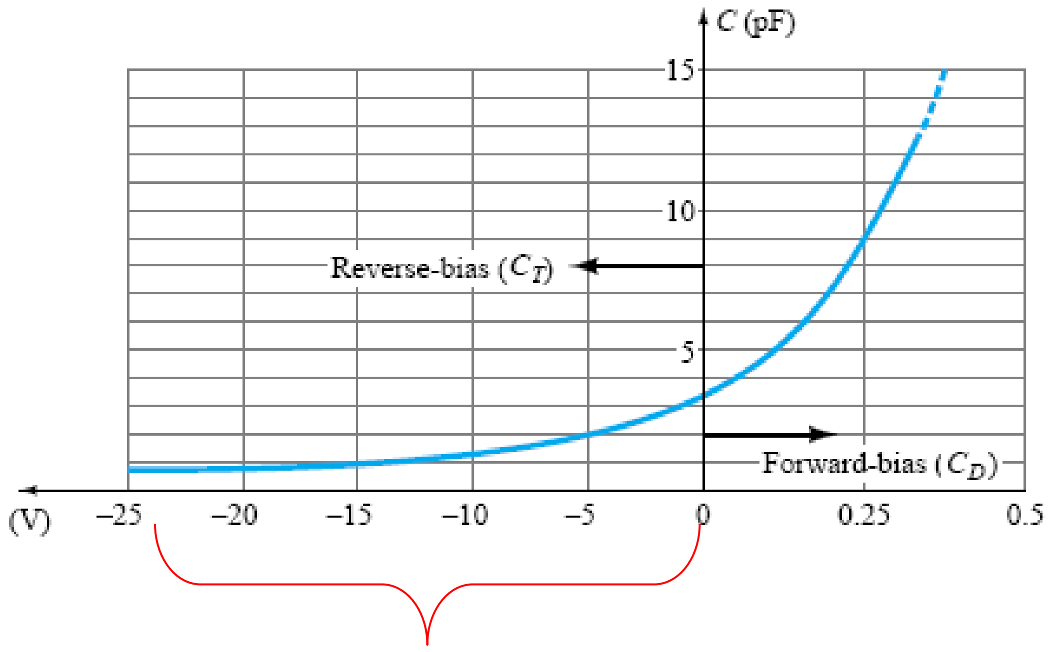


Efeitos capacitivos da união pn

In the reverse-bias region we have the transition- or depletion-region capacitance (C_T), while in the forward-bias region we have the diffusion (C_D) or storage capacitance.

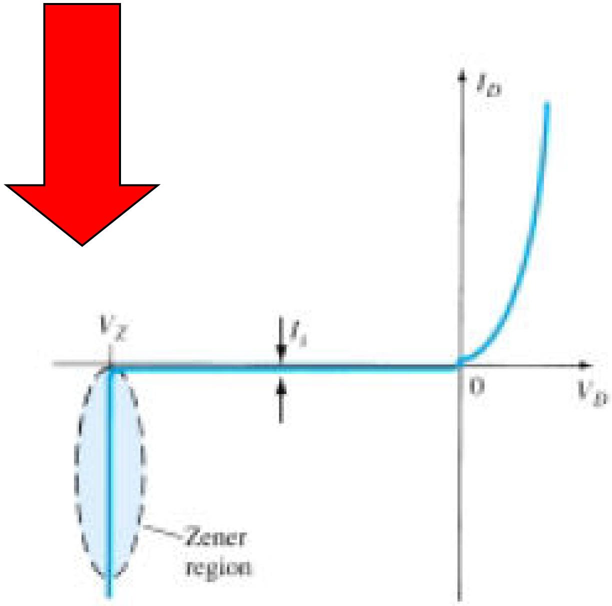


CD e CT em função da diferença de potencial aplicada à união

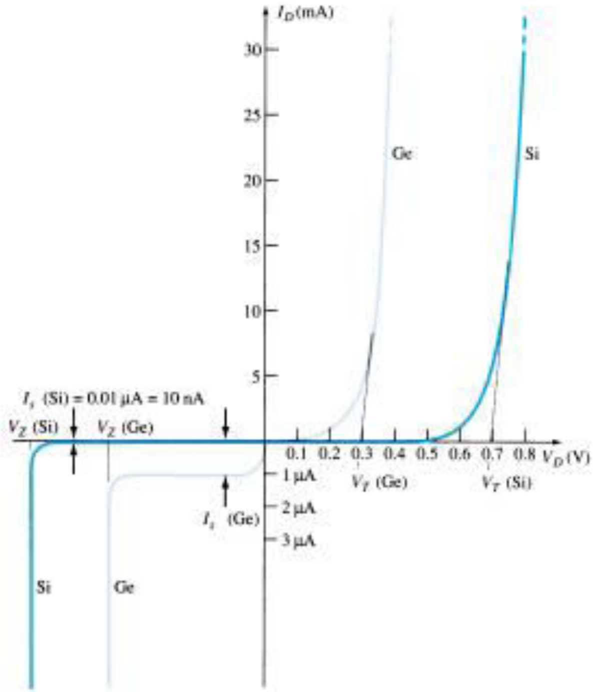


Região de trabalho dos **Varicap**

Região de ruptura

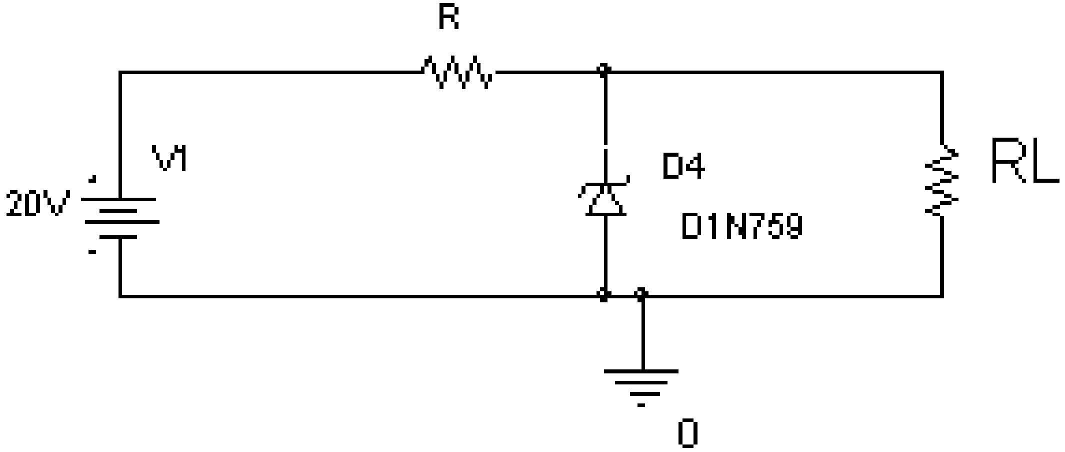


Diodo zener

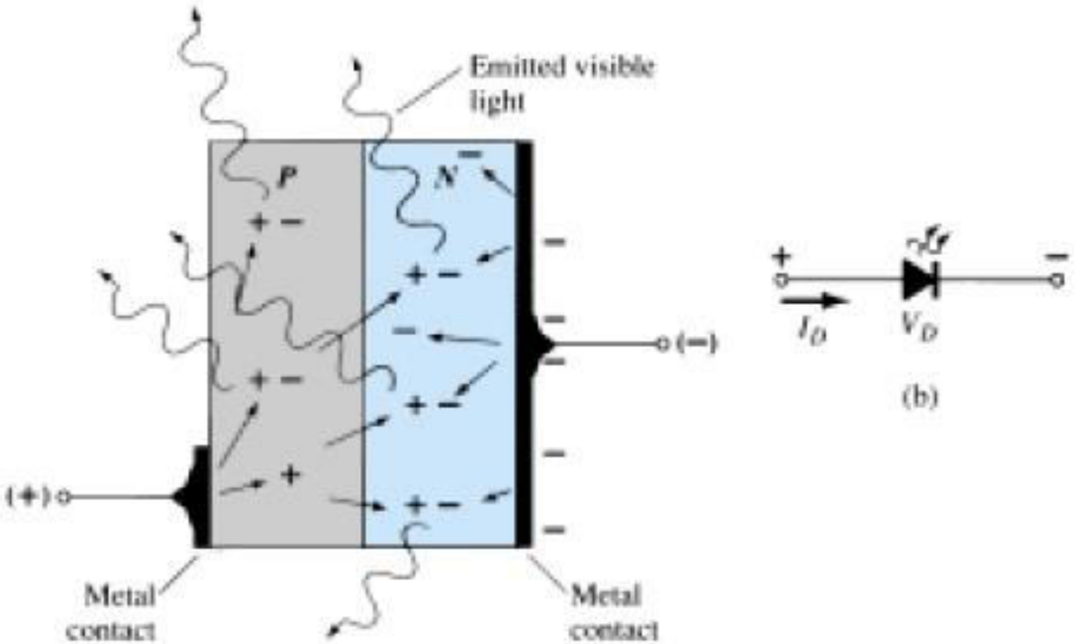


I_D(mA)
30
25
20
15
10
5
Ge
Si
I_s (Si) = 0.01 µA = 10 nA
V_Z (Si)
V_Z (Ge)
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 V_D (V)
1 µA
2 µA
3 µA
V_T (Ge)
V_T (Si)
I_s (Ge)
Si
Ge

Diodo zener



LED


Emitted visible light
P
N
(+)
(−)
Metal contact
Metal contact
+
−
I_D
V_D
(b)

Fotodiodo: para VD negativo y /VD/>>VT

Gerado pela luz

$$I_D = I_o(e^{\frac{V_D}{\eta V_T}} - 1)$$

$$I_D \approx I_o + I_L$$

$$V_T = \frac{T^{\circ}K}{11600}$$

Gerados pelo calor

Diodo Schottky

União retificadora metal semicondutor.
Aluminio e Si tipo n

joelho ≈0,3V
maior velocidade de operação

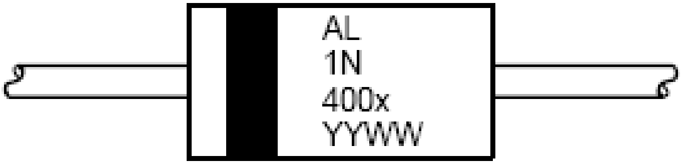
Parâmetros que especificam os fabricantes

- VRM Voltaje de pico inverso máximo
- VRM (de trabajo). Indica el máximo voltaje de pico inverso aplicable de forma repetida.
- P disipación de potencia
- IR corriente inversa de saturación.
- VF caída de potencial en directo.
- CT capacidad de transición.
- Trr Tiempo de recuperación en inverso, Este parámetro es muy importante en los diodos de conmutación. El paso del estado de conducción al de no conducción de un diodo y viceversa, tiene asociado un estado transitorio.

Parâmetros que especificam os fabricantes: Diodo rectificador

LEAD MOUNTED RECTIFIERS
50–1000 VOLTS
DIFFUSED JUNCTION

MARKING DIAGRAM



AL = Assembly Location
1N400x = Device Number
x = 1, 2, 3, 4, 5, 6 or 7
YY = Year
WW = Work Week

This data sheet provides information on subminiature size, axial lead mounted rectifiers for general–purpose low–power applications.

Folha de dados : diodo rectificador

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
*Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
*Non–Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	Volts
*RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
*Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75°C$)	I_O	1.0							Amp
*Non–Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	30 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J T_{stg}	–65 to +175							°C

Folha de dados diodo de sinal 1N4148

High Conductance Fast Diode
(continued)

1N/FDLL 914/A/B / 916/A/B / 4148 / 4448

Electrical Characteristics TA = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Max	Units
B_V	Breakdown Voltage	$I_R = 100\ \mu A$ $I_R = 5.0\ \mu A$	100 75		V V
I_R	Reverse Current	$V_R = 20$ V $V_R = 20$ V, $T_A = 150°C$ $V_R = 75$ V		25 50 5.0	nA µA µA
V_F	Forward Voltage **1N914B / 4448** **1N916B** **1N914 / 916 / 4148** **1N914A / 916A** **1N916B** **1N914B / 4448**	$I_F = 5.0$ mA $I_F = 5.0$ mA $I_F = 10$ mA $I_F = 20$ mA $I_F = 30$ mA $I_F = 100$ mA	620 630	720 730 1.0 1.0 1.0 1.0	mV mV V V V V
C_O	Diode Capacitance **1N916/A/B / 4448** **1N914/A/B / 4148**	 $V_R = 0$, f = 1.0 MHz $V_R = 0$, f = 1.0 MHz		 2.0 4.0	 pF pF
T_{RR}	Reverse Recovery Time	$I_F = 10$ mA, $V_R = 6.0$ V (60 mA), $I_{rr} = 1.0$ mA, $R_L = 100\ \Omega$		4.0	nS

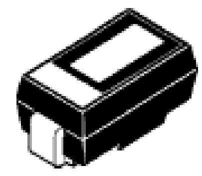
Folha de dados : diodos zener

Electrical Characteristics T_A = 25°C unless otherwise noted

Device	V_Z (V)	$Z_Z(\Omega)$	@ I_Z(mA)	I_{R1}(μA)	@ V_R(V)	I_{R2}(μA)	@ V_R(V) T_A=150°C	T_C (%/°C)	I_{ZRM}* (mA)
1N746A	3.3	28	20	10	1.0	30	1.0	- 0.070	110
1N747A	3.6	24	20	10	1.0	30	1.0	- 0.065	100
1N748A	3.9	23	20	10	1.0	30	1.0	- 0.060	95
1N749A	4.3	22	20	2.0	1.0	30	1.0	+/- 0.055	85
1N750A	4.7	19	20	2.0	1.0	30	1.0	+/- 0.030	75
1N751A	5.1	17	20	1.0	1.0	20	1.0	+/- 0.030	70
1N752A	5.6	11	20	1.0	1.0	20	1.0	+ 0.038	65
1N753A	6.2	7.0	20	0.1	1.0	20	1.0	+ 0.045	60
1N754A	6.8	5.0	20	0.1	1.0	20	1.0	+ 0.050	55

Diodo Schottky

SCHOTTKY RECTIFIER 1 Amp



Major Ratings and Characteristics

Characteristics	10BQ015	Units
$I_{F(AV)}$ Rectangular waveform	1.0	A
V_{RRM}	15	V
I_{FSM} @ tp = 5 µs sine	140	A
V_F @ 1.0 Apk, T_J=125°C	0.32	V

Description/ Features

The 10BQ015 surface mount Schottky rectifier has been designed for applications requiring low forward drop and very small foot prints on PC boards. The proprietary barrier technology allows for reliable operation up to 125°C junction temperature. Typical applications are in disk drives, switching power supplies, converters, free-wheeling diodes, battery charging, and reverse battery protection.

- 125°C T_J operation (V_R < 5V)
- Optimized for OR-ing applications
- Ultra low forward voltage drop
- High frequency operation

Folha de dados fotodiodos

GENERAL PURPOSE PIN PHOTODIODES

SPECIFICATIONS

Responsivity: 0.32 A/W min., 0.38 A/W typ. @ 632.8nm; 0.50 A/W min., 0.62 A/W typ. @ 900nm

Part Number	Total Area (mm²)	Active Area (in)	Shunt Resistance[1] Min. (MΩ)	Dark Current[1] at 5V Typ. (nA)	Dark Current[1] at 5V Max. (nA)	Breakdown Voltage[2] at 10μA Typ. (V)	Capacitance[3] Typ. at 0V (pF)	Capacitance[3] Typ. at 10V (pF)	NEP[4] Typ. (W/√Hz)	Max Linear Current[5] Typ. (mA)	Response Time[6] at 10V Typ. (ns)
SD 057-11-21-015	1.67	0.051 x 0.051	800	0.5	2.0	50	28	6	2.8×10^{-14}	0.17	7
SD 057-11-21-011	1.67	0.051 x 0.051	800	0.5	2.0	50	28	6	2.8×10^{-14}	0.17	7
SD 076-11-21-011 isolated -211	2.91	0.105 x 0.043	450	0.9	3.5	50	50	10	3.2×10^{-14}	0.29	8