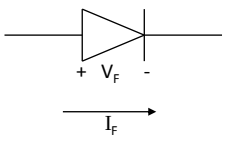
Materiales Eléctricos

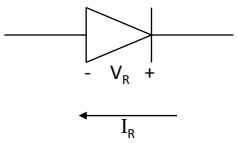
Diodo

Definición:

- Dispositivo Semiconductor
- Dos terminales
- Permite la Circulación de corriente (I) en un solo sentido

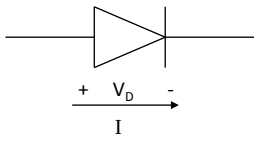
Símbolo y Convenciones V - I:





Materiales Eléctricos

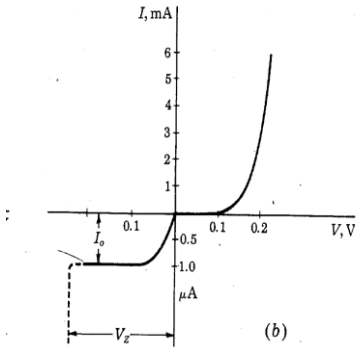
Relación V – I (Modelo Diodo Ideal)

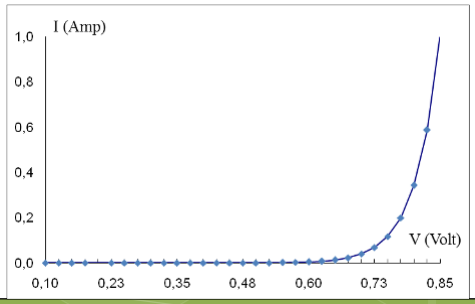


$$I = Is\ [\ \exp\ (V_D/U_T) - 1]$$

Is ⟶ Fabricación

$$U_T = k\ T\ /\ q$$

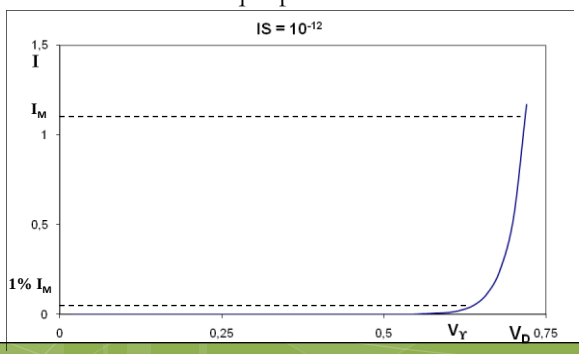




Materiales Eléctricos

$$I = Is\ [\ \exp\ (V_D/U_T) - 1]$$

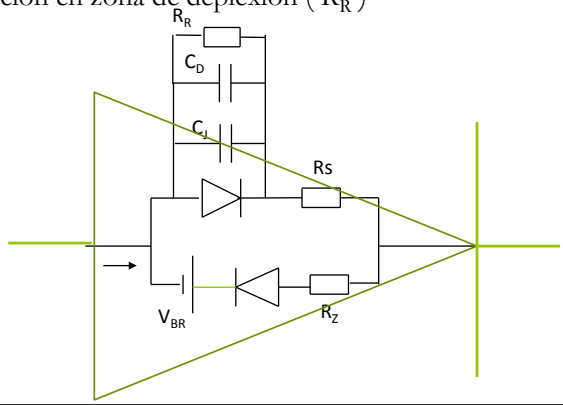
- Dos diodos se diferencian entre si a través del valor de Is
- Is refleja el proceso de fabricación (material, concentraciones, dimensiones)
- Is depende de la temperatura.
- La V_γ (Tensión umbral) se define como la tensión que produce el 1% del valor de corriente máxima que puede conducir el Diodo



Materiales Eléctricos

Limitaciones del modelo del Diodo Ideal

1. Resistencia serie (Rs)
2. Máxima Tensión Inversa (V_{BR})
3. Capacidad de Juntura (C_j)
4. Capacidad de difusión (C_D)
5. Generación en zona de deplexión (R_R)

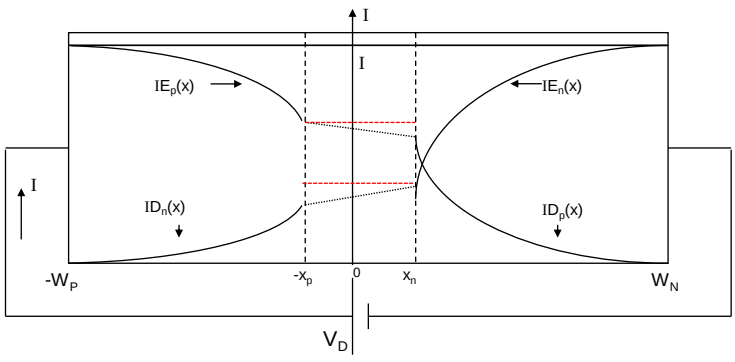


Materiales Eléctricos

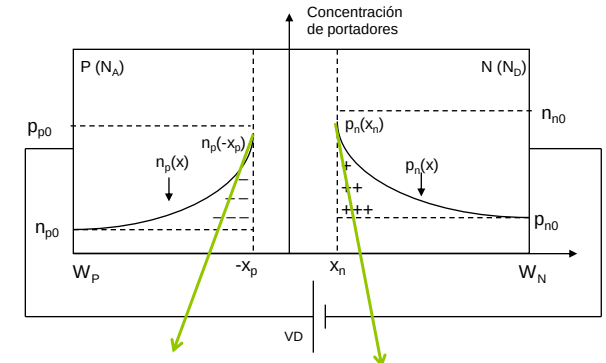
Recombinación en Zona de Deplexión

$$I = Is\ [\exp(V_D/\eta U_T) - 1]$$

$\eta \cong 2$ **Para Si**



Inyección de Alto Nivel



Cuando $n_p(-x_p) \cong p_{p0}$ o $p_n(x_n) \cong n_{n0}$

Se produce la ruptura de la neutralidad eléctrica

El campo se opone al paso de los portadores

La corriente disminuye → $I = Is\ [\exp(V_D/\eta U_T) - 1]$

$$p_n(x_n) = p_{n0} e^{\frac{V_D}{U_T}} \qquad p_{n0} = \frac{{n_i}^2}{N_A} \qquad p_n(x_n) = \frac{{n_i}^2}{N_A} e^{\frac{V_D}{U_T}}$$

Condición de inyección de alto nivel → $p_n(x_n) = p_{p0} = N_A$

$$N_A = \frac{{n_i}^2}{N_A} e^{\frac{V_D}{U_T}}$$

TENSION DE POLARIZACION A LA QUE COMIENZA LA INYECCION DE ALTO NIVEL →

$$V_D = 2U_T ln \frac{N_A}{n_i}$$

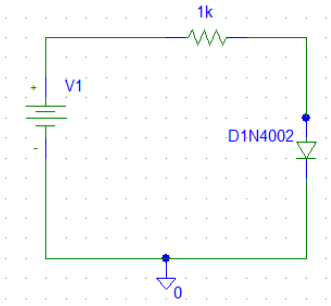
Ejemplo: Juntura N^+P con $N_D = 10^{17}$ $N_A = 10^{15}$ $T = 300$ °K

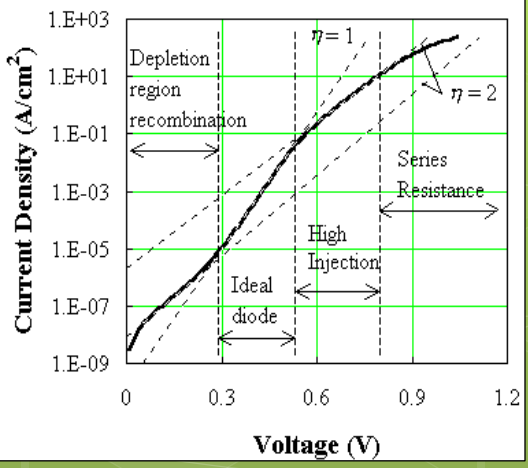
$$V_D = 2 \times 0.026 \ln \frac{10^{15}}{10^{10}} = 0.598\ V$$

Materiales Eléctricos

$I = Is\ [\exp(V_D/\eta U_T) - 1]$

$$ln\frac{I}{I_S} = \frac{V_D}{\eta U_T}$$

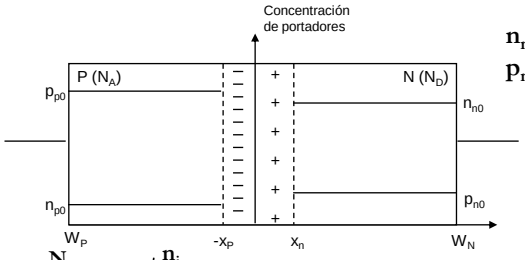




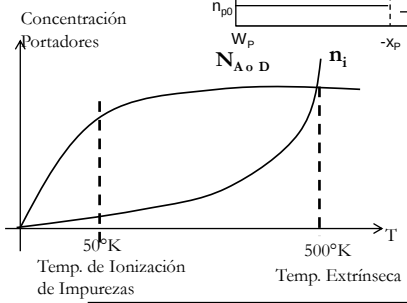
Materiales Eléctricos

Máxima Temperatura de Juntura (T_{jM})

$p_{p0} = N_A$
$n_{p0} = n_i^2 / N_A$



$n_{n0} = N_D$
$p_{n0} = n_i^2 / N_D$



$$n_i^2 = A_\circ T^3 e^{-E_G/kT}$$

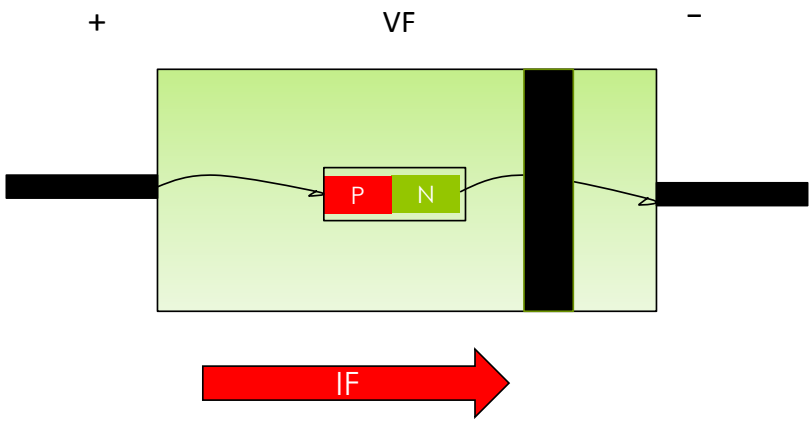
Para $T = T_{Extrinseca} \Rightarrow n_i \cong N_D$ o NA

$n_{n0} \cong p_{n0}$ o $p_{p0} \cong n_{p0}$

El semiconductor deja de ser EXTRINSECO

Materiales Eléctricos

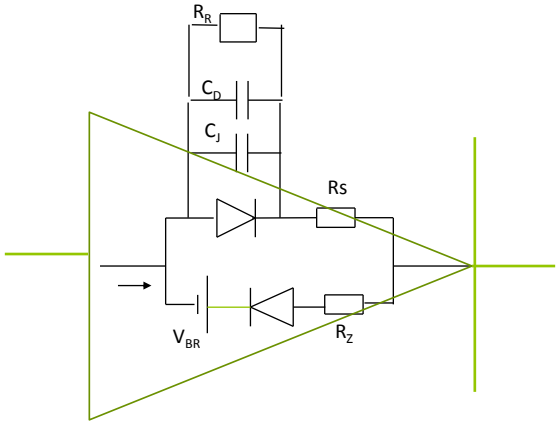
Máxima Corriente Directa (I_{FM})



Materiales Eléctricos

Modelo Del Diodo

$$I = Is\ [\exp(V_D/\eta U_T) - 1]$$



Materiales Eléctricos

Parámetros Del Modelo

I_S R_S V_{BR} C_{j0} T_T η V_{j0}

Ecuaciones Del Modelo

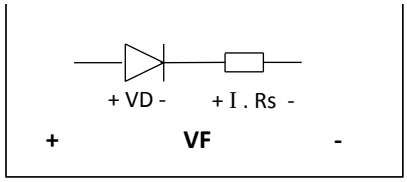
$I = Is\ [\exp(V_D/\eta U_T) - 1]$

$I_R = M\ I_S$

$$M = \frac{1}{1-(\frac{V_R}{V_{BR}})^n}$$

$$C_j = \frac{C_{j0}}{\sqrt{(1+\frac{V_R}{V_{j0}})}}$$

$$C_D = T_T \frac{I_D}{U_T}$$

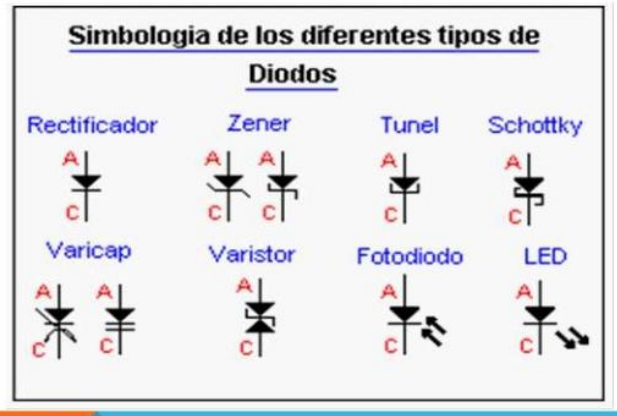


$V_F = V_D + I \cdot Rs$

Materiales Eléctricos

Clasificación De Los Diodos

- FUNCION EN LOS CIRCUITOS
  - RECTIFICADORES
    - Normales
    - Rapidos
    - Ultrarapidos
    - Schottky
  - REGULADORES (ZENER)
  - CAPACITORES (VARICAP)
  - EMISORES DE LUZ (LEDS)
  - DETECTORES DE LUZ (FOTODETECTORES)
- MATERIAL
- POTENCIA

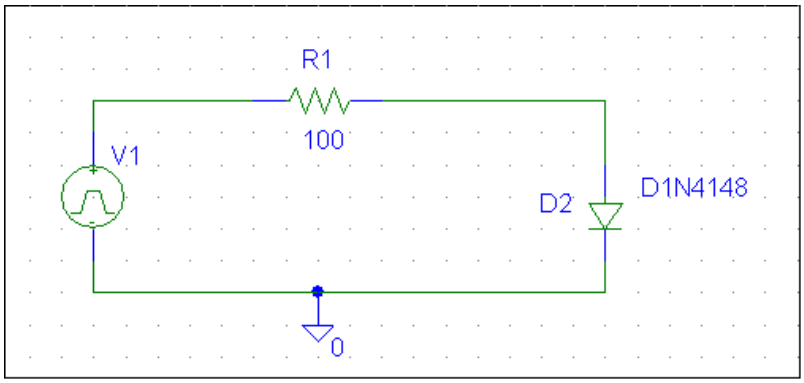


Materiales Eléctricos

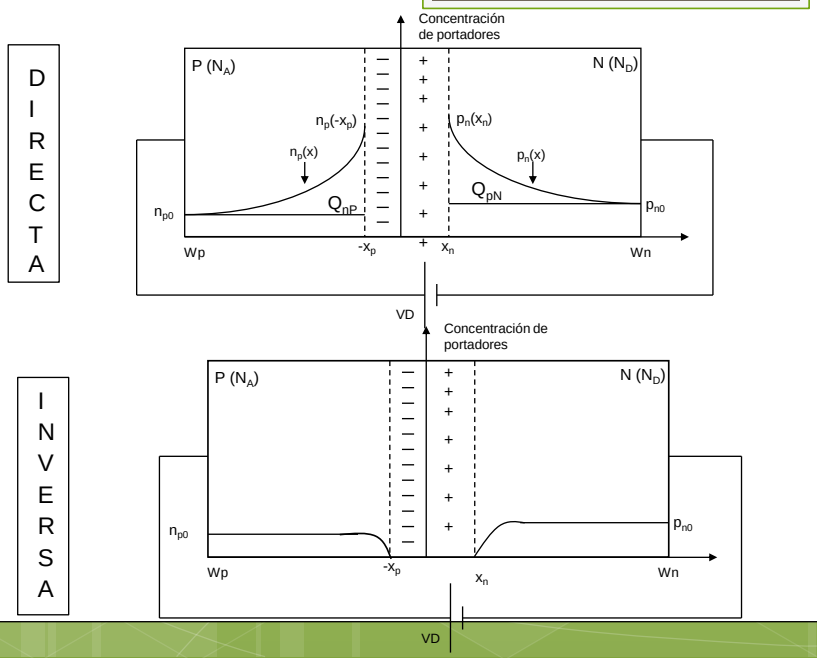
Máximos Absolutos
Características Eléctricas
Curvas y Gráficos

Materiales Eléctricos

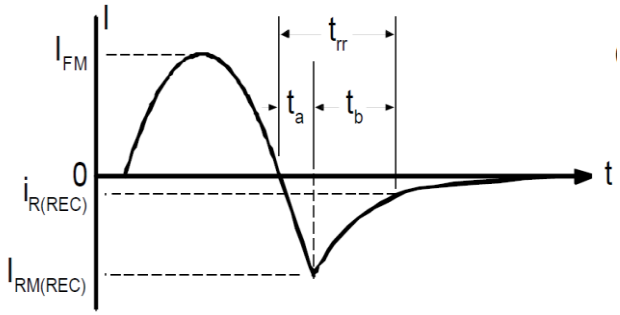
Tiempo de Recuperación t_{rr}



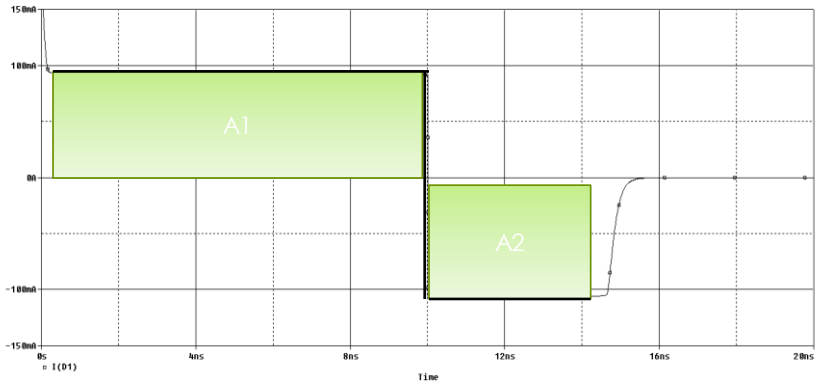
Materiales Eléctricos



Tiempo de Recuperación t_{rr}



Máxima Frecuencia de Rectificación



Debe ser A1 >> A2 $\frac{T}{2} \gg t_{rr}$ $\frac{T}{2} = 10t_{rr}$ $T = 20t_{rr}$ $f = \frac{1}{T}$

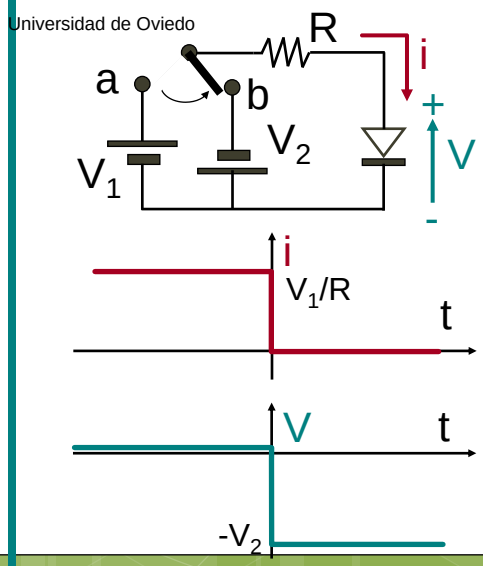
$$f_{max} \leq \frac{1}{20t_{rr}}$$

5ª Velocidad de conmutación

Universidad de Oviedo

DIODOS DE POTENCIA

- **Comportamiento ideal de un diodo en conmutación**



Transición de “a” a “b”, es decir, de conducción a bloqueo (apagado)

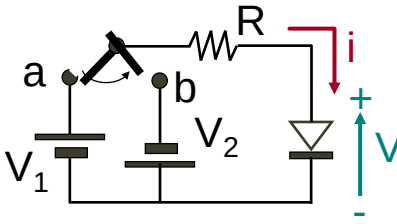
5ª Velocidad de conmutación

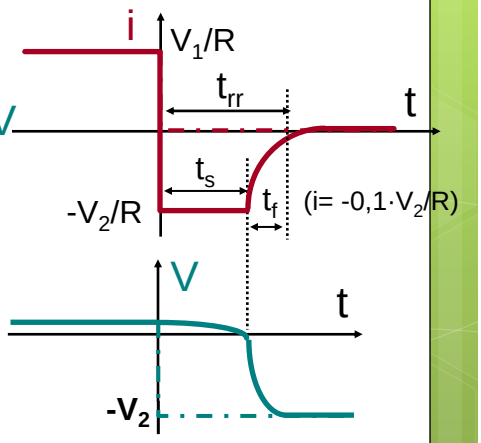
Universidad de Oviedo

DIODOS DE POTENCIA

- **Comportamiento real de un diodo en conmutación**

Transición de “a” a “b”, es decir, de conducción a bloqueo (apagado)





t_s = tiempo de almacenamiento (storage time)

t_f = tiempo de caída (fall time)

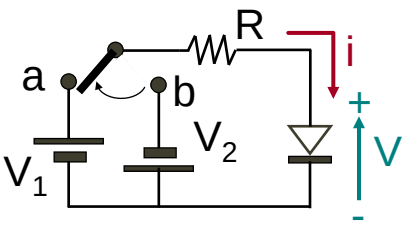
t_{rr} = tiempo de recuperación inversa (reverse recovery time)

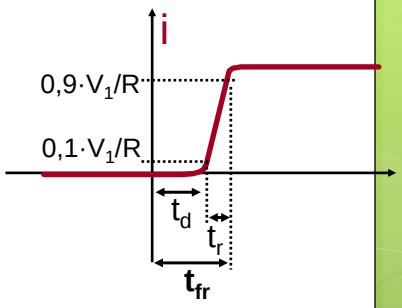
5ª Velocidad de conmutación

Universidad de Oviedo

• **Comportamiento real de un diodo en conmutación**

Transición de "b" a "a", de bloqueo conducción (encendido)





t_d = **tiempo de retraso (delay time)**

t_r = **tiempo de subida (rise time)**

$t_{fr} = t_d + t_r$ = **tiempo de recuperación directa (forward recovery time)**

El tiempo de recuperación directa genera menos problemas reales que el de recuperación inversa

5ª Velocidad de conmutación

Universidad de Oviedo

• **La velocidad de conmutación (valorada con la t_{rr}) ayuda a clasificar los diodos**

	V_{RRM}	I_F	t_{rr}
• **Standard**	**100 V - 600 V**	**1 A – 50 A**	**> 1 µs**
• **Fast**	**100 V - 1000 V**	**1 A – 50 A**	**100 ns – 500 ns**
• **Ultra Fast**	**200 V - 800 V**	**1 A – 50 A**	**20 ns – 100 ns**
• **Schottky**	**15 V - 150 V**	**1 A – 150 A**	**< 2 ns**

Las características de todos los semiconductores (por supuesto, también de los diodos) se pueden encontrar en Internet (pdf)

Direcciones web

- **www.irf.com**
- **www.onsemi.com**
- **www.semikron.com.ar**
- **www.philips.com**
- **www.vishay.com**

FAIRCHILD SEMICONDUCTOR®

1N4001 - 1N4007

Features

- Low forward voltage drop.
- High surge current capability.

DO-41
COLOR BAND DENOTES CATHODE

General Purpose Rectifiers (Glass Passivated)

Absolute Maximum Ratings*

T_A = 25°C unless otherwise noted

Symbol	Parameter	Value							Units
		4001	4002	4003	4004	4005	4006	4007	
V_{RRM}	Peak Repetitive Reverse Voltage	50	100	200	400	600	800	1000	V
$I_{F(AV)}$	Average Rectified Forward Current, .375 " lead length @ T_A = 75°C	1.0							A
I_{FSM}	Non-repetitive Peak Forward Surge Current 8.3 ms Single Half-Sine-Wave	30							A
T_{stg}	Storage Temperature Range	-55 to +175							°C
T_J	Operating Junction Temperature	-55 to +175							°C

*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

Electrical Characteristics

T_A = 25°C unless otherwise noted

Symbol	Parameter	Device							Units
		4001	4002	4003	4004	4005	4006	4007	
V_F	Forward Voltage @ 1.0 A	1.1							V
I_{rr}	Maximum Full Load Reverse Current, Full Cycle T_A = 75°C	30							µA
I_R	Reverse Current @ rated V_R T_A = 25°C T_A = 100°C	5.0 500							µA µA
C_T	Total Capacitance V_R = 4.0 V, f = 1.0 MHz	15							pF

Thermal Characteristics

Symbol	Parameter	Value	Units
P_D	Power Dissipation	3.0	W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	50	°C/W

Typical Characteristics

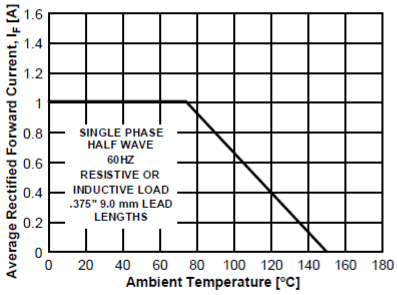


Figure 1. Forward Current Derating Curve

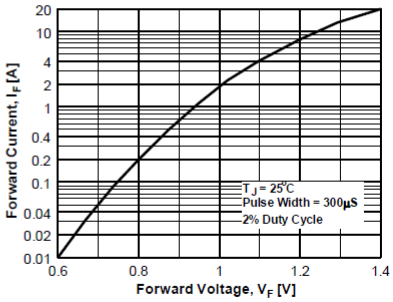


Figure 2. Forward Voltage Characteristics

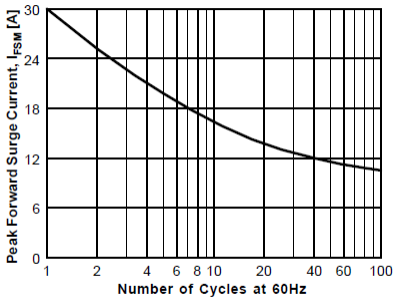


Figure 3. Non-Repetitive Surge Current

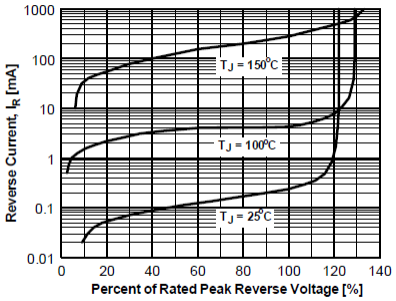


Figure 4. Reverse Current vs Reverse Voltage

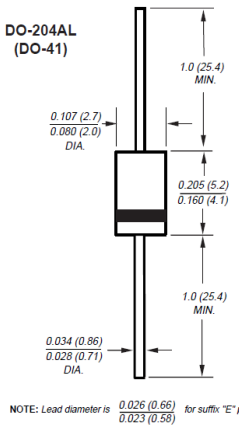
VISHAY

1N4001 thru 1N4007

Vishay Semiconductors
formerly General Semiconductor

General Purpose Plastic Rectifier

Reverse Voltage
50 to 1000V
Forward Current 1.0A



NOTE: Lead diameter is 0.026 (0.66) / 0.023 (0.58) for suffix "E" part numbers

Features

- Plastic package has Underwriters Laboratories Flammability Classification 94V-0
- Construction utilizes void-free molded plastic technique
- Low reverse leakage
- High forward surge capability
- High temperature soldering guaranteed: 350°C/10 seconds, 0.375" (9.5mm) lead length, 5 lbs. (2.3kg) tension

Mechanical Data

Case: JEDEC DO-204AL, molded plastic body
Terminals: Plated axial leads, solderable per MIL-STD-750, Method 2026
Polarity: Color band denotes cathode end
Mounting Position: Any
Weight: 0.012 oz., 0.3 g

Maximum Ratings & Thermal Characteristics

Ratings at 25°C ambient temperature unless otherwise specified.

Parameter	Symb.	1N 4001	1N 4002	1N 4003	1N 4004	1N 4005	1N 4006	1N 4007	Unit
Maximum repetitive peak reverse voltage	V_{RRM}	50	100	200	400	600	800	1000	V
* Maximum RMS voltage	V_{RMS}	35	70	140	280	420	560	700	V
* Maximum DC blocking voltage	V_{DC}	50	100	200	400	600	800	1000	V
* Maximum average forward rectified current 0.375" (9.5mm) lead length at T_A = 75°C	$I_{F(AV)}$	1.0							A
* Peak forward surge current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method) T_A = 75°C	I_{FSM}	30							A
* Maximum full load reverse current, full cycle average 0.375" (9.5mm) lead length T_L = 75°C	$I_{R(AV)}$	30							µA
Typical thermal resistance(1)	$R_{\theta JA}$ $R_{\theta JL}$	50 25							°C/W
* Maximum DC blocking voltage temperature	T_A	+150							V
* Operating junction and storage temperature range	T_J, T_{STG}	–50 to +175							°C

Electrical Characteristics

Ratings at 25°C ambient temperature unless otherwise specified.

Maximum instantaneous forward voltage at 1.0A	V_F	1.1	V
* Maximum DC reverse current at rated DC blocking voltage T_A = 25°C T_A = 125°C	I_R	5.0 50	µA
Typical junction capacitance at 4.0V, 1MHz	C_J	15	pF

Note: (1) Thermal resistance from junction to ambient at 0.375" (9.5mm) lead length, P.C.B. mounted *JEDEC registered values

Ratings and Characteristic Curves (TA = 25°C unless otherwise noted)

Fig. 1 – Forward Current Derating Curve

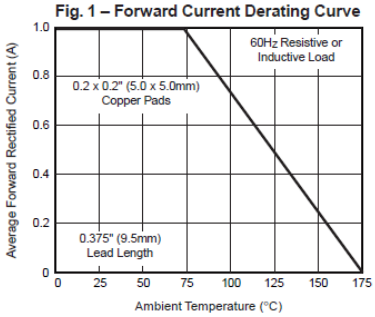


Fig. 2 – Maximum Non-Repetitive Peak Forward Surge Current

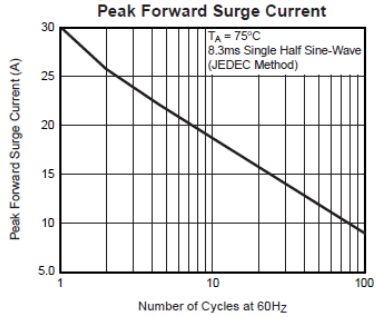


Fig. 3 – Typical Instantaneous Forward Characteristics

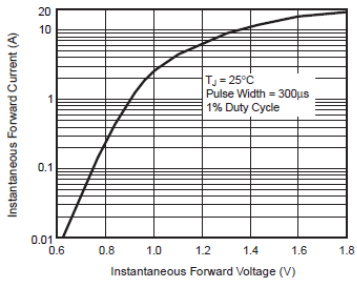


Fig. 4 – Typical Reverse Characteristics

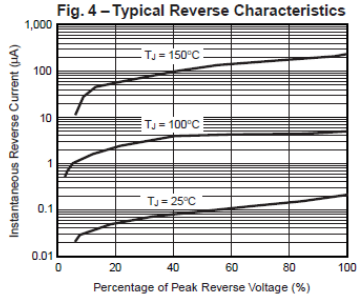


Fig. 5 – Typical Junction Capacitance

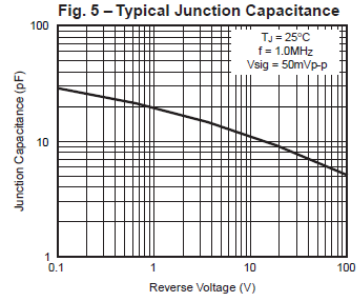
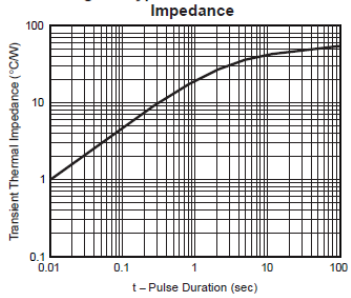


Fig. 6 – Typical Transient Thermal Impedance



1N4728A to 1N4764A

Vishay Semiconductors

Silicon Power Zener Diodes

Features

- Silicon Planar Power Zener Diodes
- For use in stabilizing and clipping circuits with high power rating.

- Standard Zener voltage tolerance suffix "A" for ± 5 % tolerance. Other Zener voltages and tolerances are available upon request.

Applications

Voltage stabilization

Mechanical Data

Case: DO-41 Glass Case
Weight: approx. 350 mg
Packaging Codes/Options:
TR / 5k per 13 " reel , 25k/box
TAP / 5k per Ammo mag. (52 mm tape), 25k/box

Absolute Maximum Ratings

T_{amb} = 25 °C, unless otherwise specified

Parameter	Test condition	Symbol	Value	Unit
Power dissipation	$T_{amb} \leq 50$ °C	P_{Diss}	1	W
Z-current		I_Z	P_V/V_Z	mA
Junction temperature		T_j	200	°C
Storage temperature range		T_{stg}	- 65 to + 200	°C
Junction ambient	l = 9.5 mm (3/8 "), T_L = constant	R_{thJA}	100	K/W

1N4728A to 1N4764A

Vishay Semiconductors

Electrical Characteristics

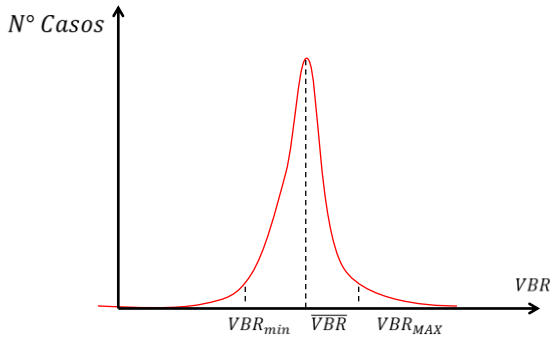
1N4728A...1N4764A

Partnumber	Nominal Zener Voltage[1]	Test Current	Maximum Dynamic Impedance			Maximum Reverse Leakage Current		Surge curent	Maximum Regulator Current[2]
	V_Z @ I_{ZT}	I_{ZT}	Z_{ZT} @ I_{ZT}	Z_{ZK} @ I_{ZK}	I_{ZK}	I_R	Test Voltage V_R	I_R @ T_{amb} = 25 °C	I_{ZM} @ T_{amb} = 50 °C
	V	mA	Ω	Ω	mA	µA	V	mA	mA
1N4728A	3.3	76	10	400	1	100	1	1380	276
1N4729A	3.6	69	10	400	1	100	1	1260	252
1N4730A	3.9	64	9	400	1	50	1	1190	234
1N4731A	4.3	58	9	400	1	10	1	1070	217
1N4732A	4.7	53	8	500	1	10	1	970	193
1N4733A	5.1	49	7	550	1	10	1	890	178
1N4734A	5.6	45	5	600	1	10	2	810	162
1N4735A	6.2	41	2	700	1	10	3	730	146
1N4736A	6.8	37	0.5	700	1	10	4	660	133
1N4737A	7.5	34	0	700	0.5	10	5	605	121
1N4738A	8.2	31	0.5	700	0.5	10	6	550	110
1N4739A *	9.1	28	0	700	0.5	10	7	500	100
1N4740A *	10	25	7	700	0.25	10	7.6	454	91
1N4741A *	11	23	8	700	0.25	5	8.4	414	83
1N4742A *	12	21	9	700	0.25	5	9.1	380	76
1N4743A *	13	19	10	100	0.25	5	9.9	344	69
1N4744A *	15	17	14	700	0.25	5	11.4	304	61
1N4745A *	16	15.5	16	700	0.25	5	12.2	285	57
1N4746A *	18	14	20	750	0.25	5	13.7	250	50
1N4747A *	20	12.5	22	750	0.25	5	15.2	225	45
1N4748A *	22	11.5	23	750	0.25	5	16.7	205	41
1N4749A *	24	10.5	25	750	0.25	5	18.2	190	38
1N4750A *	27	9.5	35	750	0.25	5	20.6	170	34
1N4751A *	30	8.5	40	1000	0.25	5	22.8	150	30

Diodo Rectificador
vs
Diodo Regulador (ZENER)

- La misma fabricación

- Distintas zonas de trabajo
  - Rectificador $|V_{BR}| > V_D$
  - Regulador $|V_{BR}| < V_D$
- Distintas especificaciones en
  - Máximos Absolutos
  - Características Eléctricas

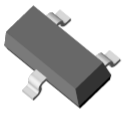


VISHAY

BB814-V-GH

Vishay Semiconductors

Dual Varicap Diode



MECHANICAL DATA

Case: SOT-23

Weight: approx. 8.1 mg

Packaging codes/options:
08/3 k per 7" reel (8 mm tape), 15 k/box

FEATURES

- Silicon epitaxial planar diode
- Common cathode
- AEC-Q101 qualified
- Compliant to RoHS directive 2002/95/EC and in accordance to WEEE 2002/96/EC
- Find out more about Vishay's Automotive Grade Product requirements at: www.vishay.com/applications

AUTOMOTIVE GRADE

Pb-free

e3

RoHS COMPLIANT

GREEN (5-2008)**

APPLICATIONS

- Tuning of separate resonant circuits
- Push-pull circuits in FM range
- Especially for car radios

PARTS TABLE

PART	TYPE DIFFERENTIATION	ORDERING CODE	TYPE MARKING	REMARKS
BB814-1-V-GH	V_{RRM} = 20 V, C_{D2} = 43 pF to 45.5 pF	BB814-1-V-GH-08	SG1	Tape and reel
BB814-2-V-GH	V_{RRM} = 20 V, C_{D2} = 44.5 pF to 46.5 pF	BB814-2-V-GH-08	SG2	Tape and reel

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)				
PARAMETER	TEST CONDITIONS	SYMBOL	VALUE	UNIT
Repetitive peak reverse voltage		V_{RRM}	20	V
Reverse voltage		V_R	18	V
Forward current		I_F	50	mA

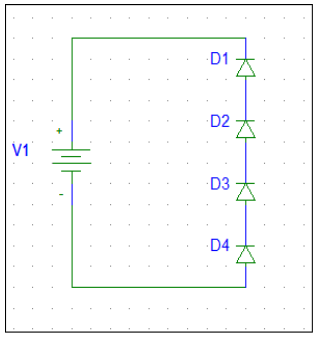
THERMAL CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)				
PARAMETER	TEST CONDITIONS	SYMBOL	VALUE	UNIT
Junction temperature		T_j	125	°C
Storage temperature range		T_{stg}	- 55 to + 150	°C

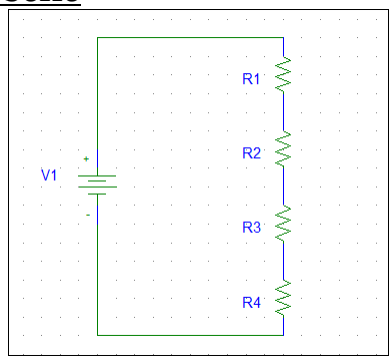
ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)							
PARAMETER	TEST CONDITIONS	PART	SYMBOL	MIN.	TYP.	MAX.	UNIT
Reverse current	V_R = 16 V		I_R			20	nA
	V_R = 16 V, T_j = 60 °C		I_R			200	nA
Diode capacitance (1)	V_R = 2 V	BB814-1-V-GH	C_{D2}	43		45.5	pF
		BB814-2-V-GH	C_{D2}	44.5		46.5	pF
	V_R = 8 V	BB814-1-V-GH	C_{D8}	19.1		21.95	pF
		BB814-2-V-GH	C_{D8}	19.75		22.70	pF
Capacitance ratio	V_R = 2 V, 8 V, f = 1 MHz		C_{D2}/C_{D8}	2.05		2.25	
Series resistance	C_D = 38 pF, f = 100 MHz		R_s			0.5	Ω

Note

(1) In the reverse voltage range of V_R = (2 V to 8 V) for diodes 4 taped in sequence the max. deviation is 3 %

Diodos Serie





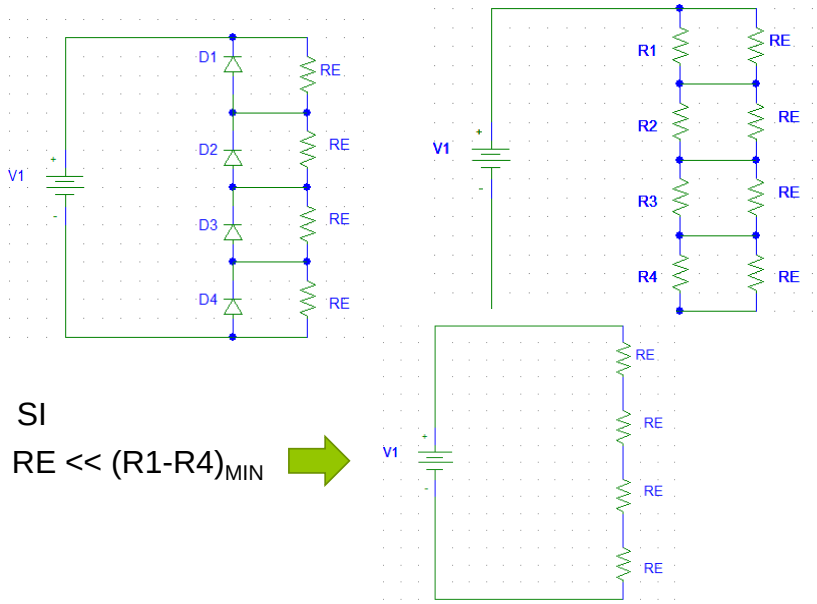
R1- R4 representan la resistencia equivalente de los diodo D1 - D4 en inversa

Si las resistencia no son iguales las tensiones en cada diodo no será igual

Ejemplo: Diodos de 1000 V de tensión inversa – Fuente 4000 V

La caída en alguno de los diodos será mayor que 1000 V

Materiales Eléctricos

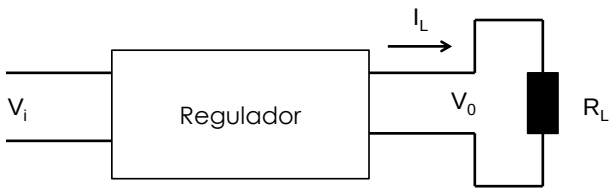


SI

$RE << (R1\text{-}R4)_{MIN}$

Materiales Eléctricos

Regulador de Tensión



Regulación de carga $\frac{\Delta V_L}{V_L} | I_L \; y \; V_i \; cte$

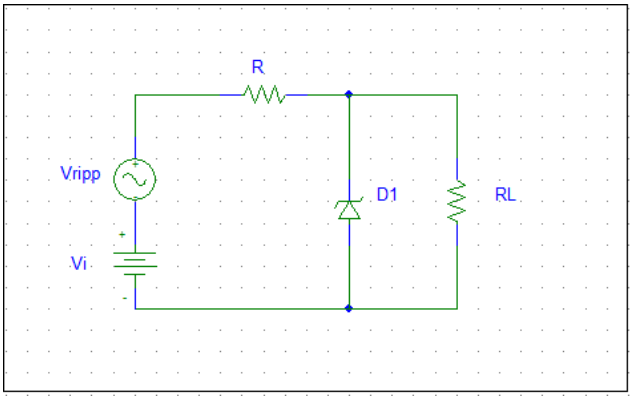
Regulación de línea $\frac{1}{V_L}\frac{\Delta V_L}{\Delta V_i} | I_L \; cte$

I_{LM} - V_{Lripp}

Resistencia de salida R_0 $\frac{\Delta V_L}{\Delta I_L} | V_i \; cte \; y \; \frac{\Delta I_L}{I_L} = 100\%$

Materiales Eléctricos

Regulador con diodo ZENER



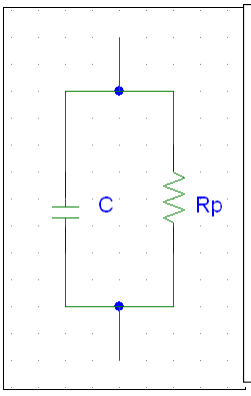
Diodos Reguladores

- Coeficiente térmico
- Diferencia en las especificaciones con los rectificadores
- Hoja de datos de diodo Zener

Materiales Eléctricos

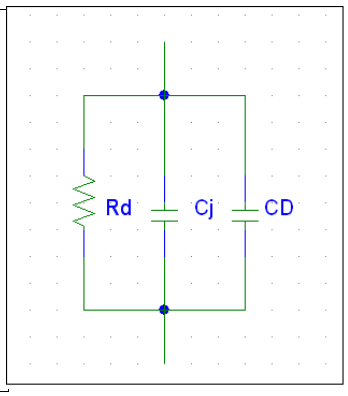
Diodo Varicap

Factor de Calidad (Q) de un capacitor



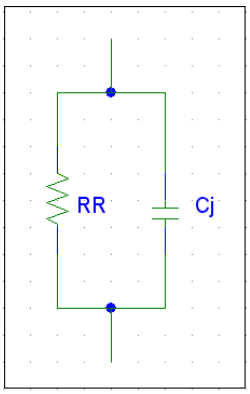
$Q = \omega C R_p$

Diodo en directo



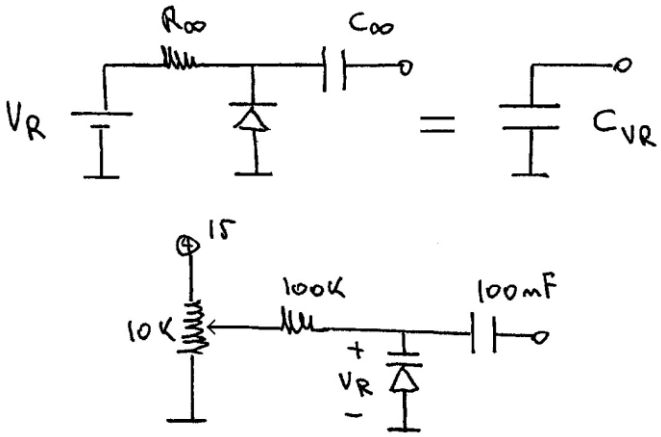
$R_d = U_T / I_D \approx 30\ m\Omega$

Diodo en inverso

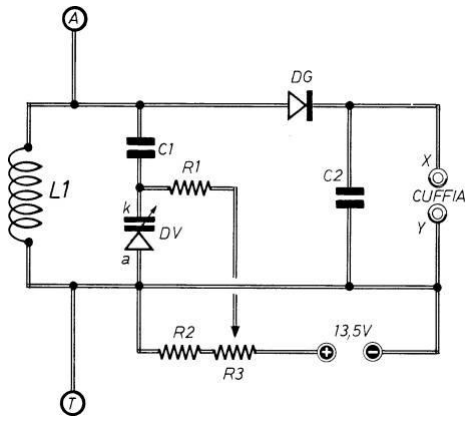


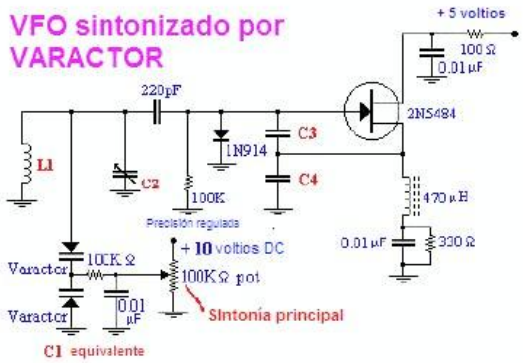
$RR \approx 100\ M\Omega$

Circuitos básicos con DIODO VARICAP



Circuitos básicos con DIODO VARICAP





Diodos Emisores de Luz (Led's)

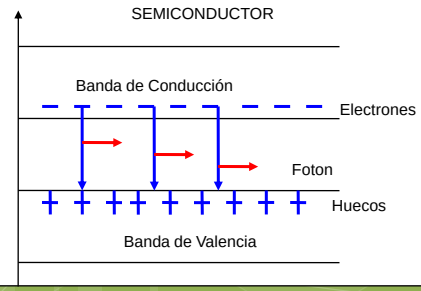
Materiales Eléctricos

Generación De Fotones

•Fenómeno de recombinación de electrones de la banda de Conducción con huecos de la banda de Valencia

• Si el semiconductor es del tipo Directo se genera un Fotón desapareciendo el electrón y el hueco

- •El ARSENIURO DE GALIO GaAs es del tipo Directo
- •El Silicio Si es del tipo Indirecto, la recombinación de electrones de la banda de conducción con huecos de la banda de Valencia genera Fonones (Calor)

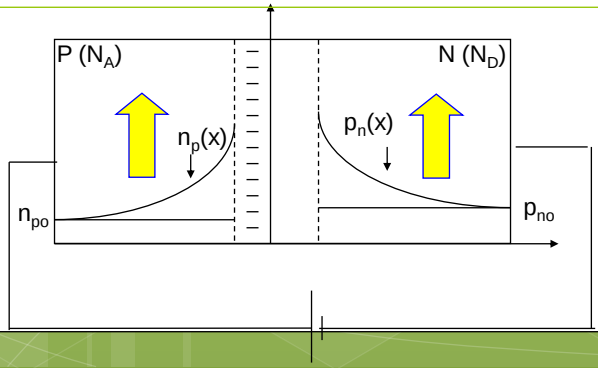


Materiales Eléctricos

LED Light Emiting Diode

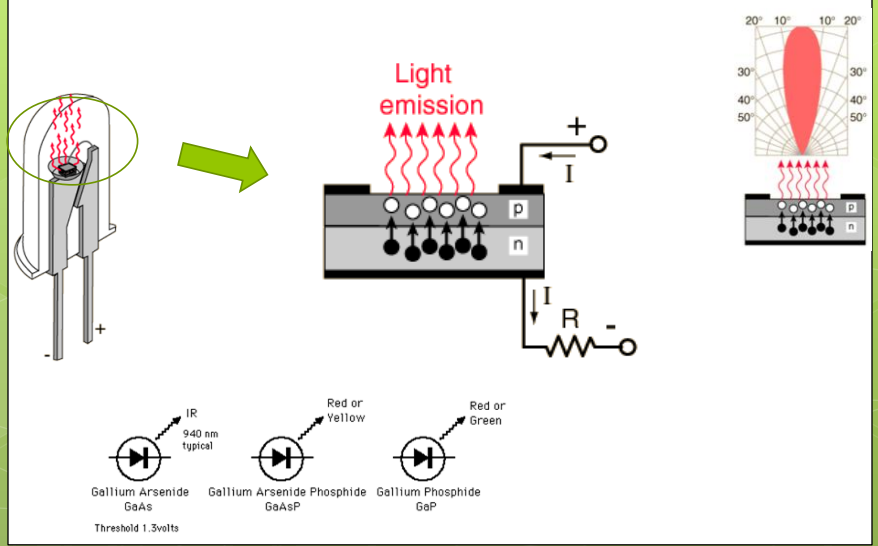
Conversión Electro - Optica

- **Juntura PN polarizada directa para favorecer el fenómeno de recombinación en zonas neutras**



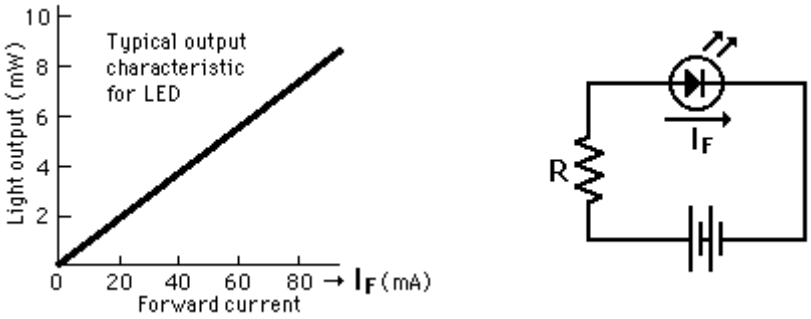
Materiales Eléctricos

Estructura del Diodo LED



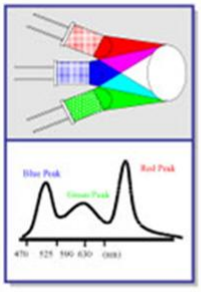
Materiales Eléctricos

Emisión de Luz vs IF



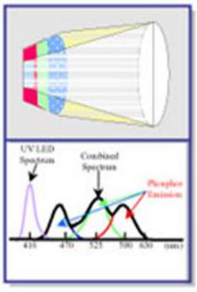
Generating White Light with LEDs

Red + Green + Blue LEDs



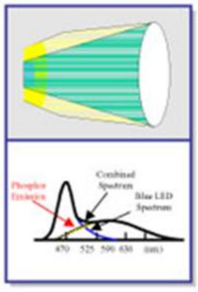
- Dynamic color tuning
- Excellent color rendering
- Large color gamut

UV LED + RGB Phosphor



- White point tunable by phosphors
- Excellent color rendering
- Simple to create white

Blue LED + Yellow Phosphor



- Simple to create white
- Good color rendering

There are various ways to create white light from LEDs, each with specific advantages.

Hoja De Datos Diodo Led

SIEMENS

LR 5480, LS 5480, LY 5480
LG 5480

SIEMENS

GaAs-IR-Lumineszenzdiode
GaAs Infrared Emitter

LD 271, LD 271 H
LD 271 L, LD 271 HL

VISHAY.

Vishay Semiconductors

Color Classification of SMD LED's , MiniLED and 0603 LED

Light Intensity / Color

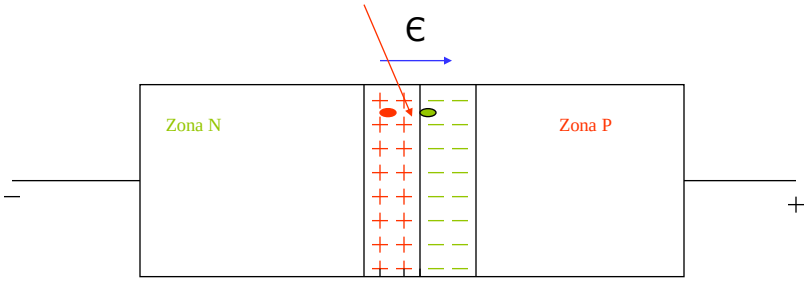
Devices are classified in light intensity and wavelength groups, describing Min./Max. limits by an alphanumeric code. These groups are not order

Materiales Eléctricos

Efecto Fotoeléctrico de Juntura

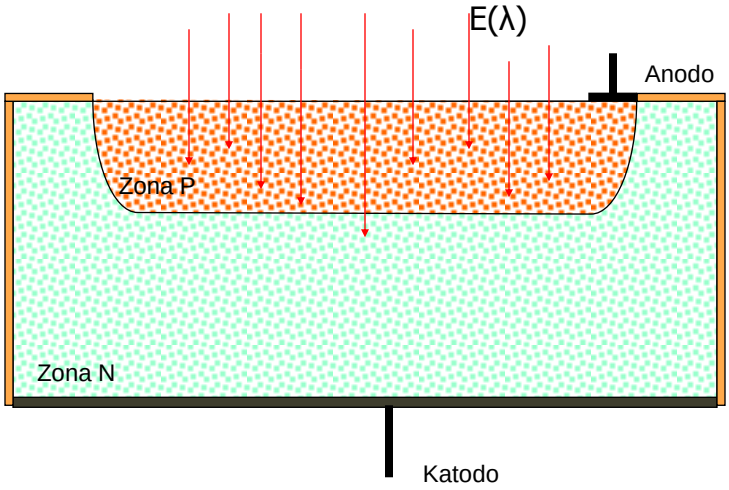
Conversión
Óptica -Electro

- Juntura PN polarizada inversa para favorecer el fenómeno de generación en zonas neutras



Materiales Eléctricos

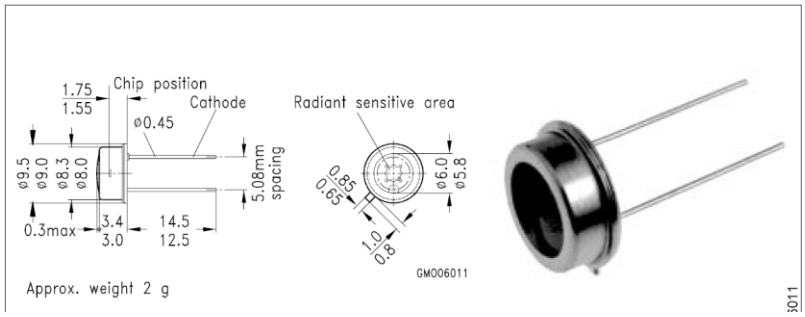
Fotodiodo



Hoja De Datos Fotodiodo

SIEMENS

Silizium-Fotodiode für den sichtbaren Spektralbereich **BPW 21**
Silicon Photodiode for the visible spectral range



Approx. weight 2 g