Centro Federal de Educação Tecnológica de Santa Catarina
Departamento Acadêmico de Eletrônica

Retificadores

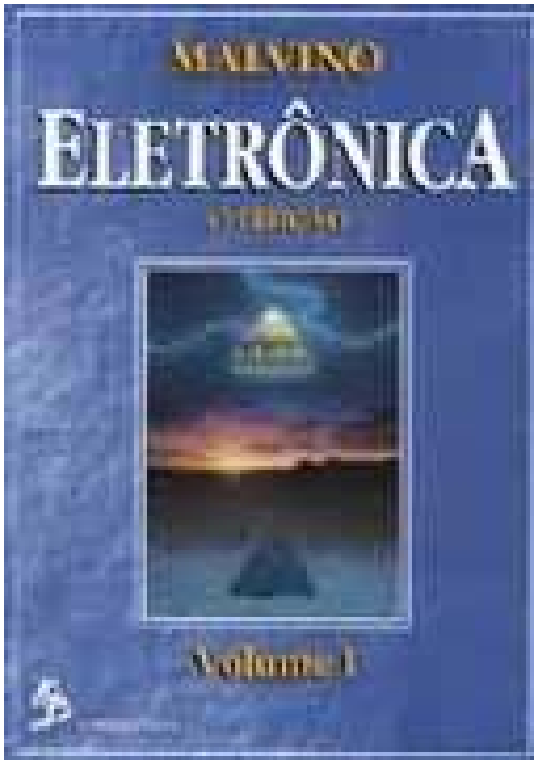
Diodos e dispositivos especiais
Parte 1

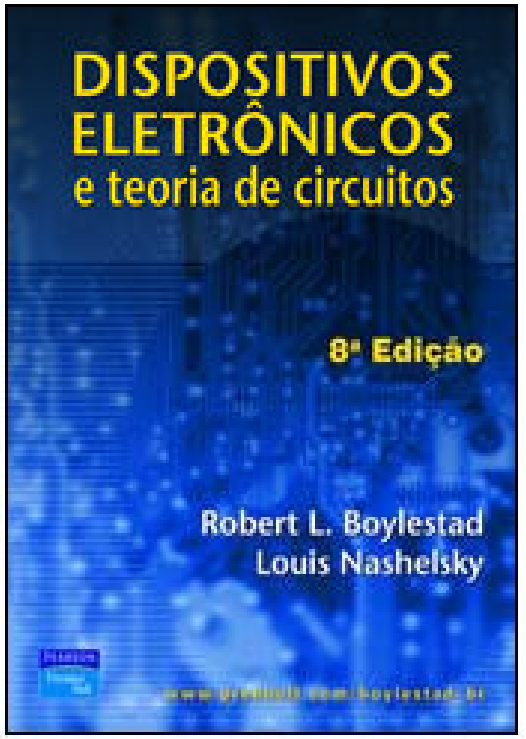
Prof. Clóvis Antônio Petry.

Florianópolis, maio de 2008.

Bibliografia para esta aula

1. Diodos e dispositivos especiais – Parte 1.





www.cefetsc.edu.br/~petry

Nesta aula

Seqüência de conteúdos:

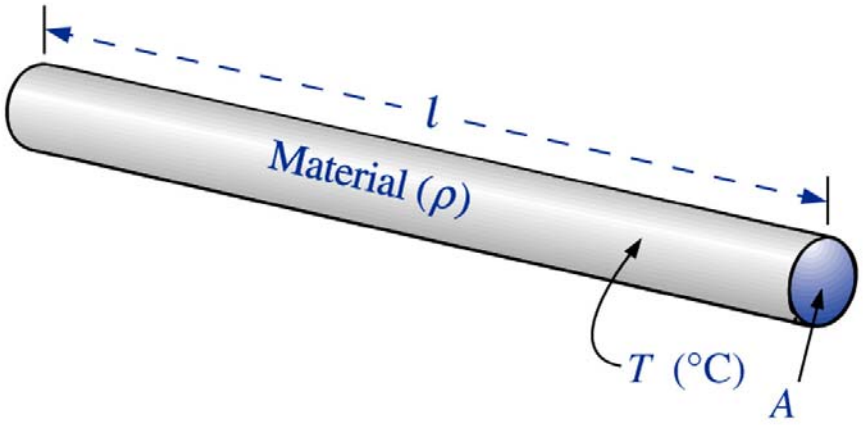
1. Parte A – Resistores:
   - Resistores;
   - Termistores;
   - LDRs;
   - Varistores;
2. Parte B – Capacitores:
   - Capacitores;
3. Parte C – Diodos:
   - Zener;
   - Diodos de barreira Schottky;
   - Varicap;
   - Diodos túnel;
   - Diodos Shockley;
   - Diac;
   - Retificador controlado de silício (SCR);
   - Triac.

Resistores

Resistores

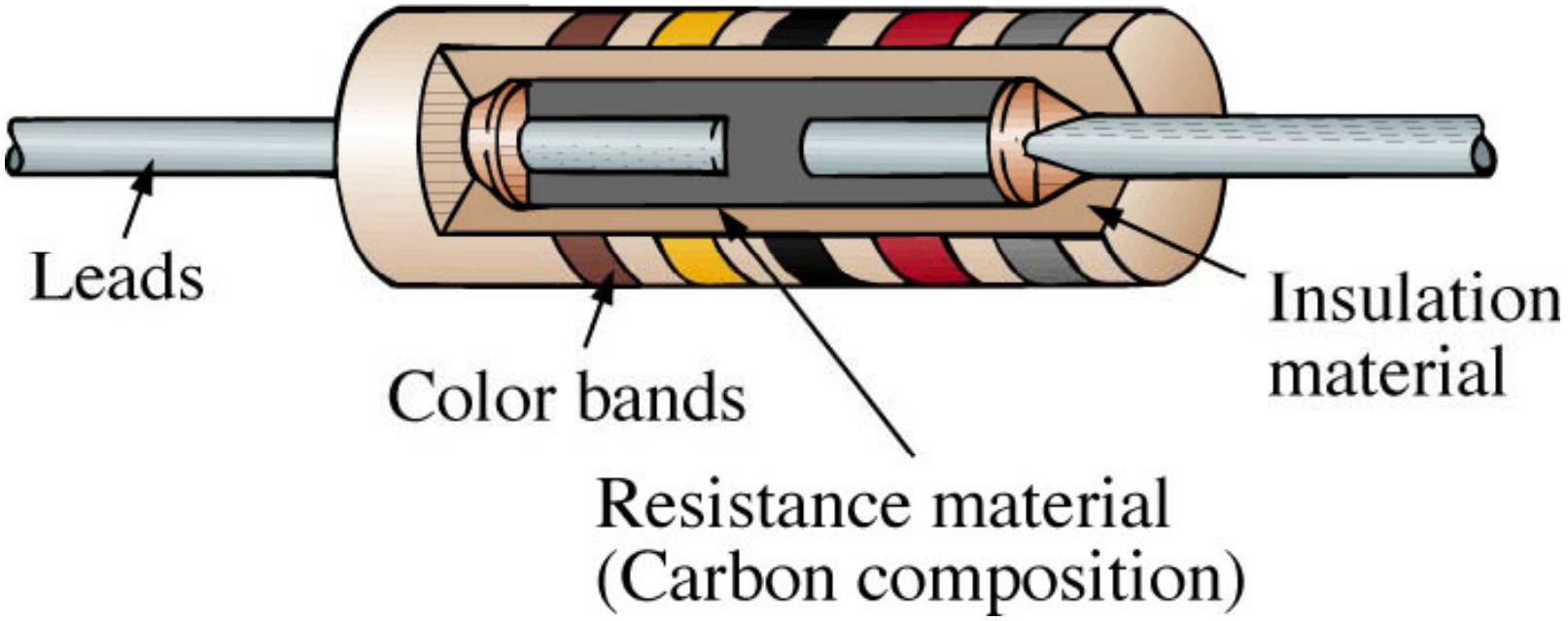
Resistência depende de:

- Material;
- Comprimento;
- Área da seção reta;
- Temperatura.



Resistores

Tipos de resistores:

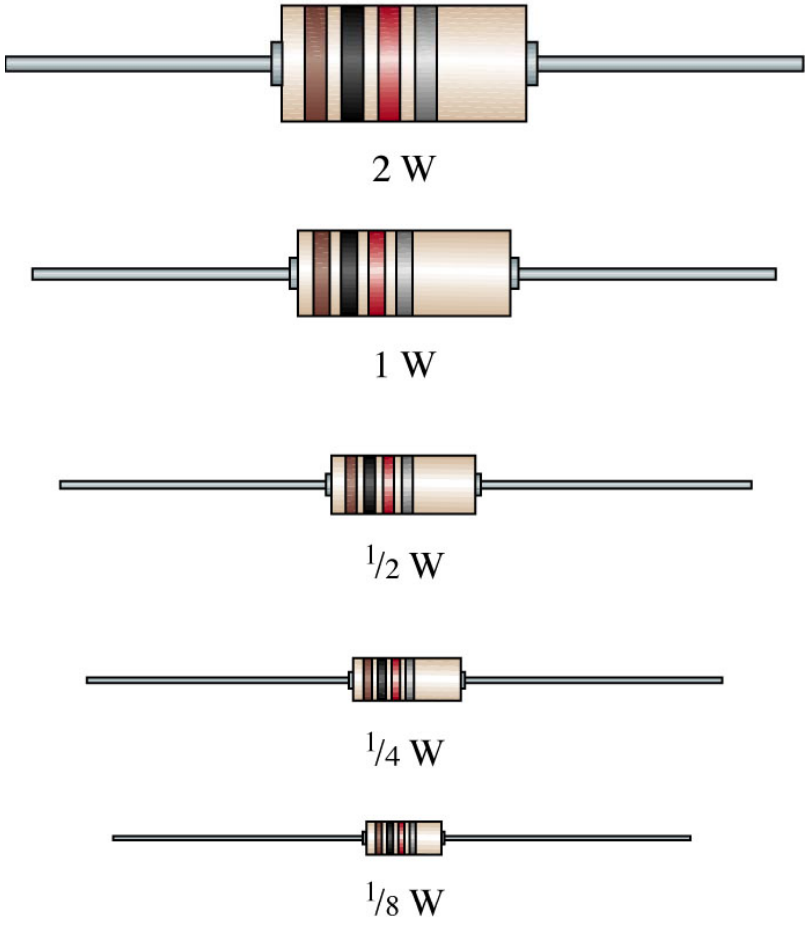


Resistor fixo de carbono.

Resistores

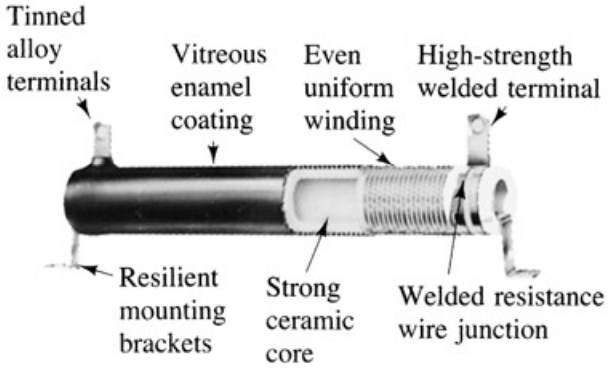
Tipos de resistores:

Resistores fixos de carbono com potências diferentes.



Resistores

Tipos de resistores:



(a) Vitreous-enameled wire-wound resistor
App: All types of equipment

Resistores de potência de fio.

(b) High-voltage cermet film resistors (on a high grade ceramic body).
App: For high-voltage applications up to 10 kV requiring high levels of stability.

Resistores para altas tensões.

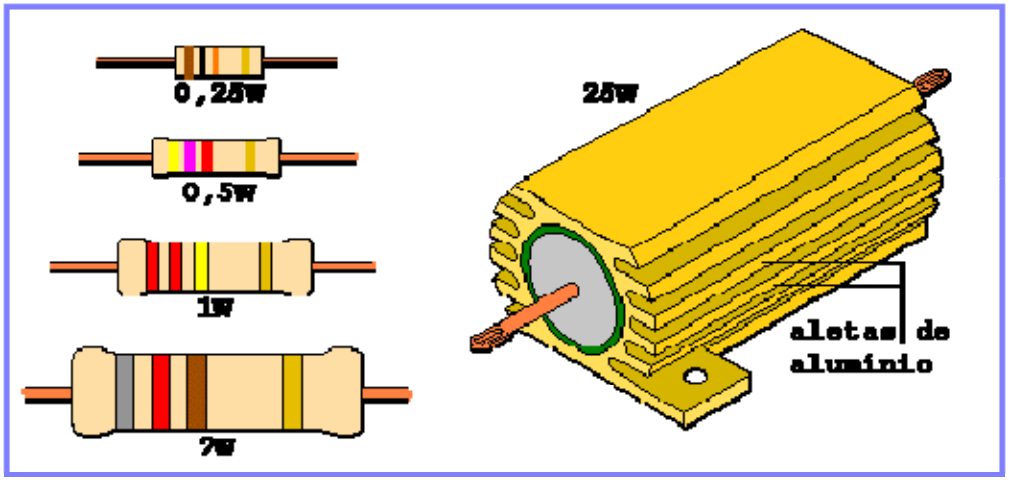
(c) Metal-film precision resistors
App: Where high stability, low temperature coefficient, and low noise level desired

Resistores de precisão de filme metálico.

Resistores

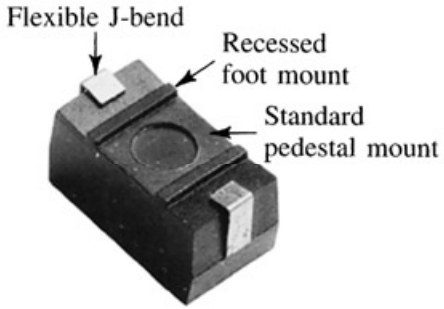
Tipos de resistores:

Resistores de potência.



Resistores

Tipos de resistores:

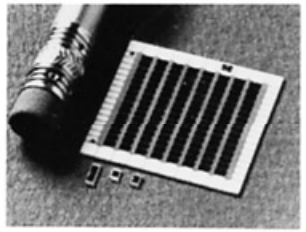


(a) Surface mount power resistor ideal for printed circuit boards. Patented J-bends eliminate need for solder connections. (0.8 W to 3 W in wire-wound, film, or power film construction)

Resistores de potência de fio.

(b) Precision power wire-wound resistors with ratings as high as 2 W and tolerances as low as 0.05%. Temperature coefficients as low as 20 ppm/°C are also available.

Resistores de precisão de fio.

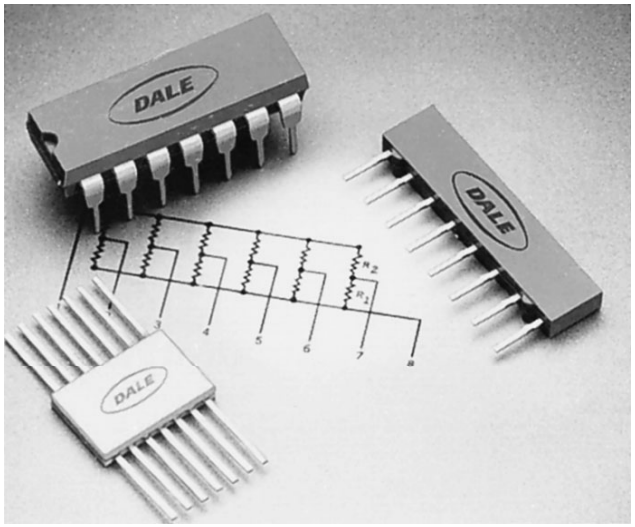


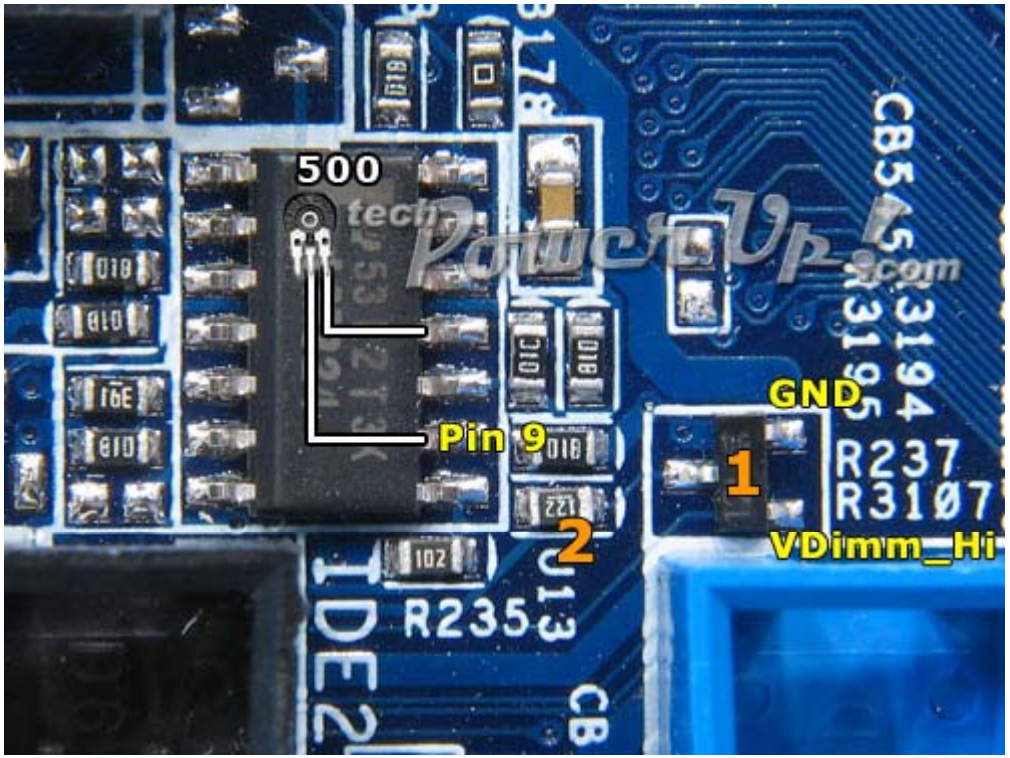
(c) Thick-film chip resistors for design flexibility with hybrid circuitry. Pre-tinned, gold or silver electrodes available. Operating temperature range −55°C to +150°C.

Resistores de filme em chip.

Resistores

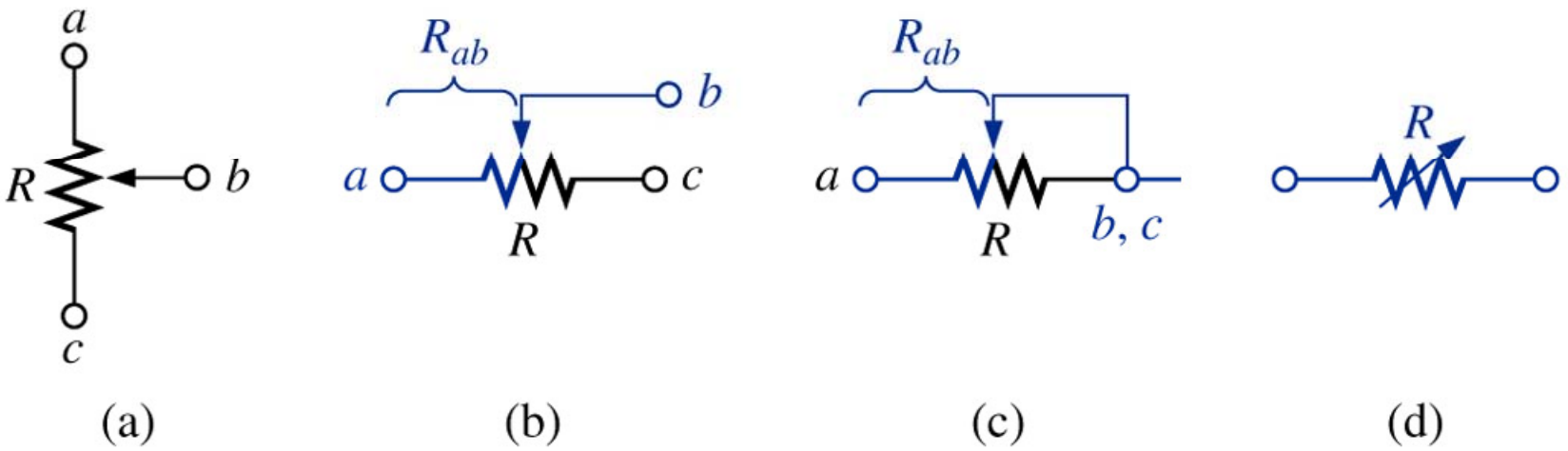
Tipos de resistores:



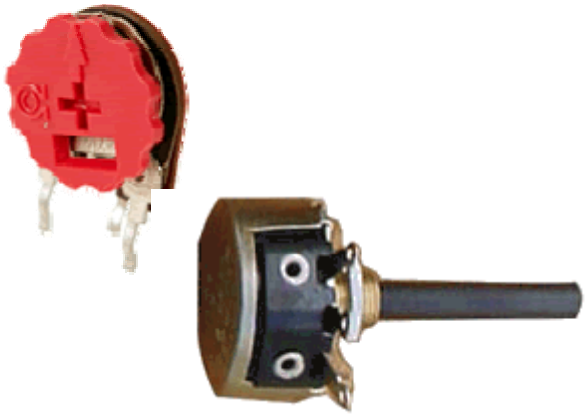


Resistores

Tipos de resistores:

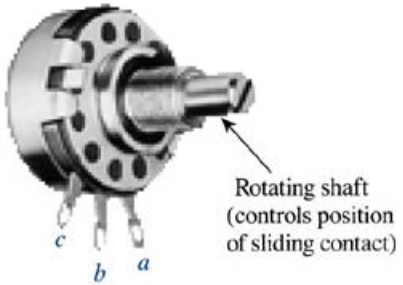


Resistores variáveis e ajustáveis. → Trimpots e potenciômetros.

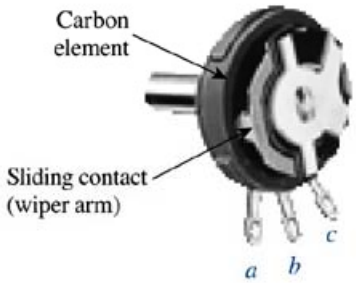


Resistores

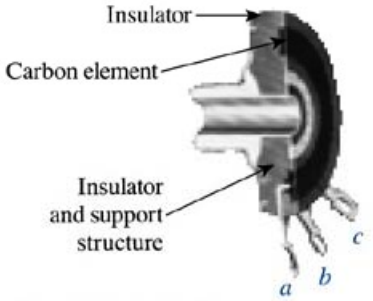
Tipos de resistores:



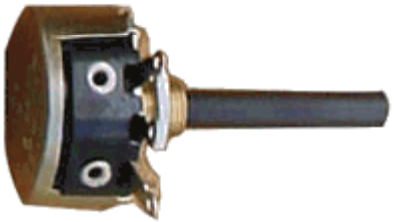
(a) External view

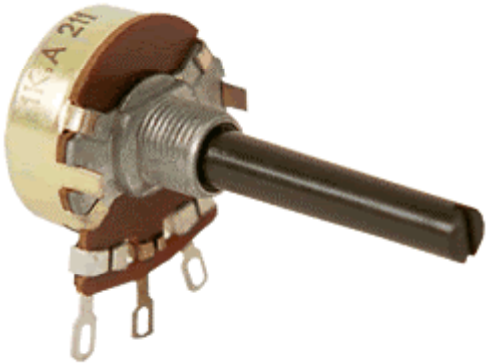


(b) Internal view



(c) Carbon element

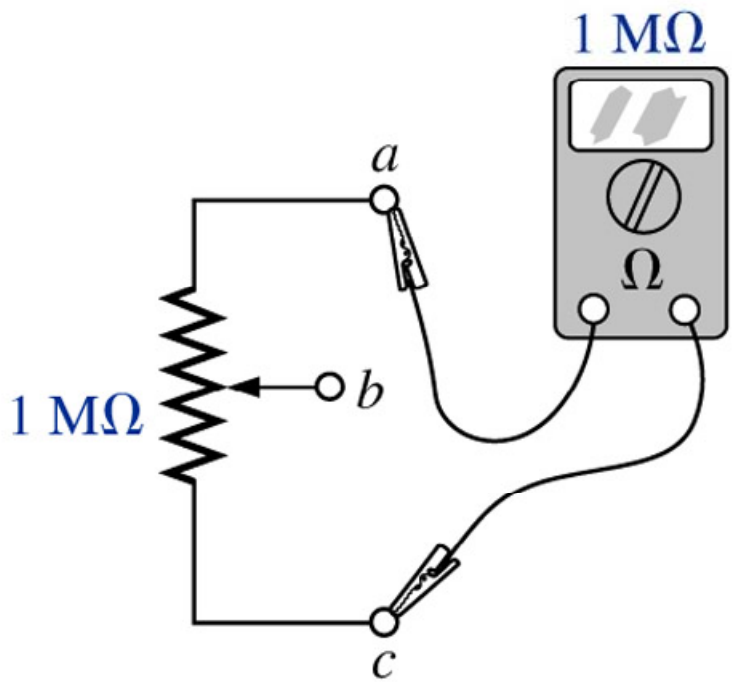




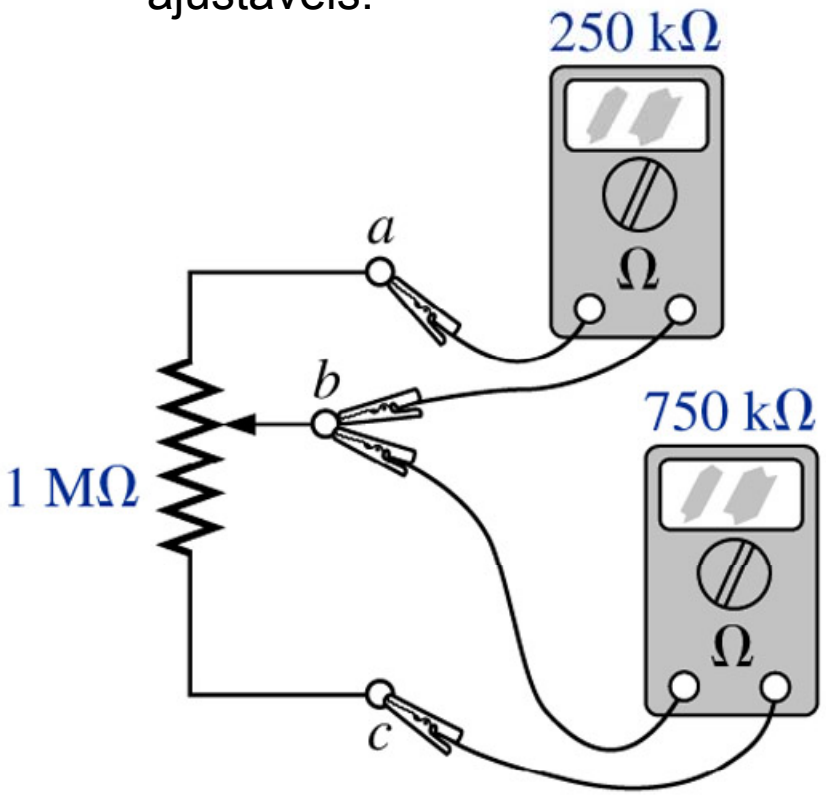
Resistores

Tipos de resistores:

Resistores variáveis e ajustáveis.



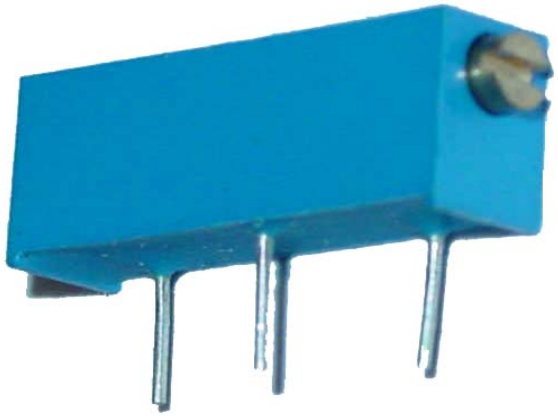
(a)

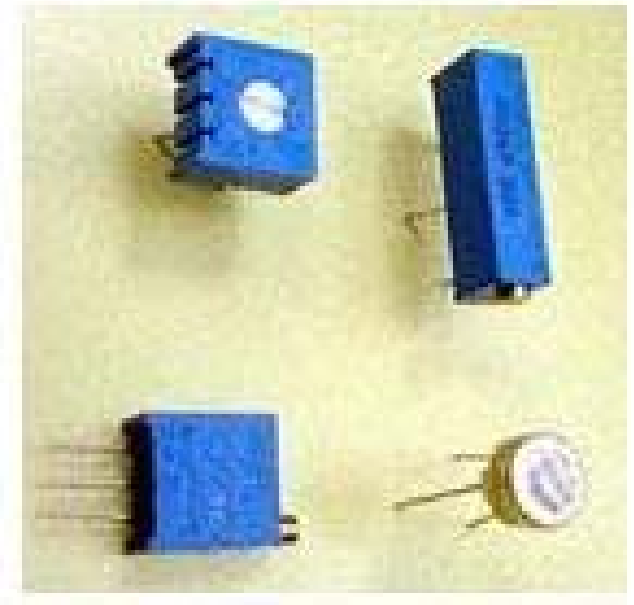


(b)

Resistores

Tipos de resistores:

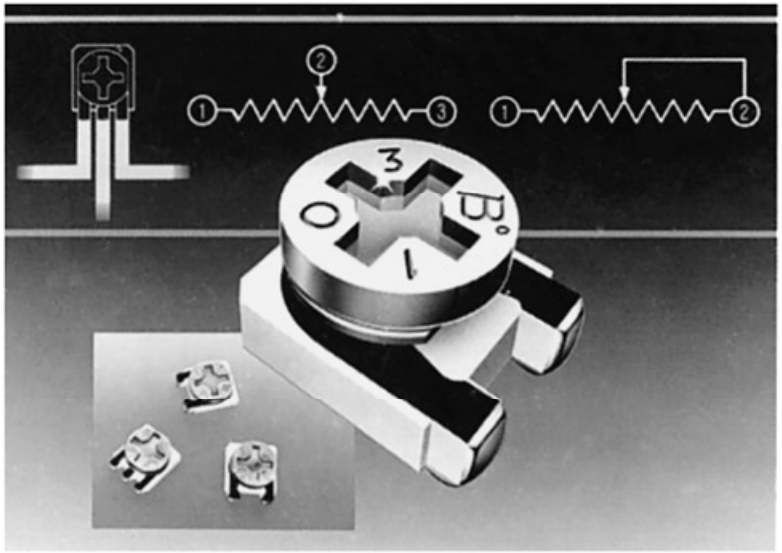




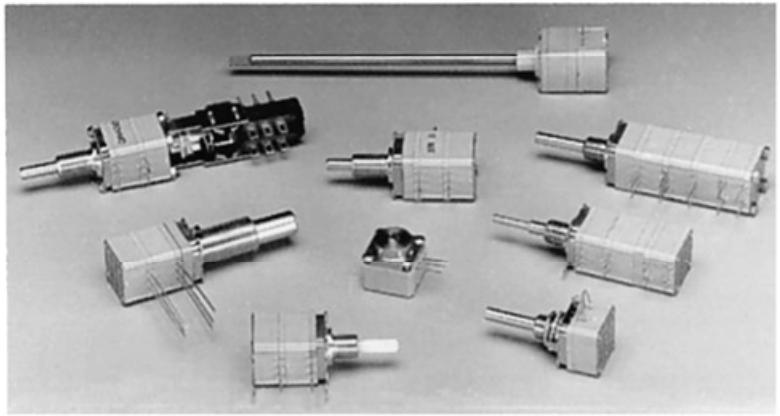
Resistores variáveis e ajustáveis.

Resistores

Tipos de resistores:



(a)



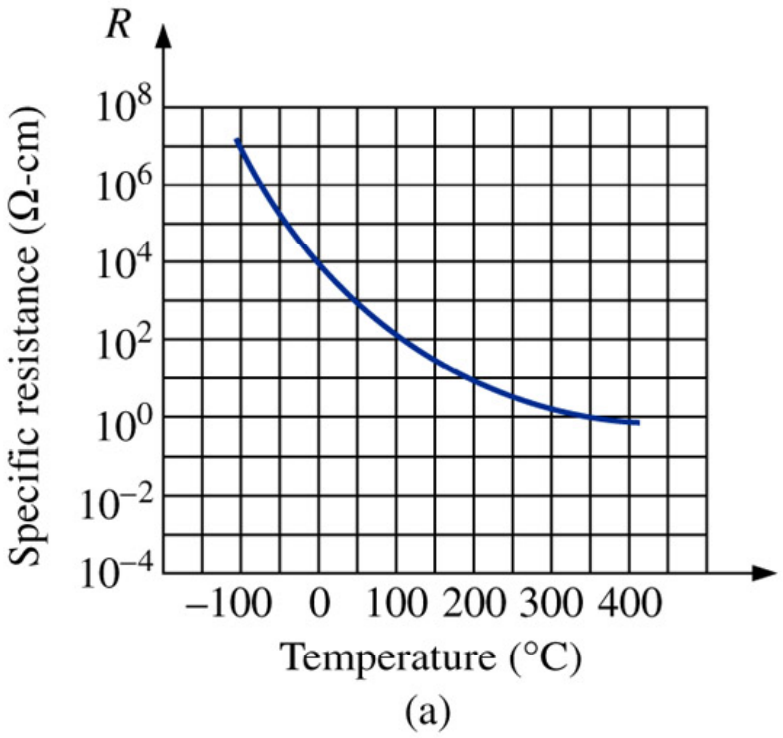
(b)

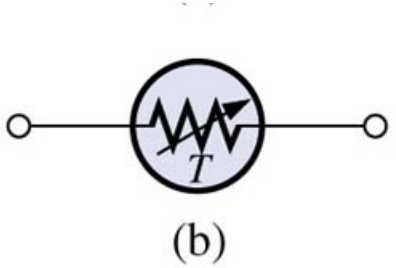
Potenciômetros de precisão ou multivoltas.

Termistores

Termistor:

- Resistor cuja resistência é sensível à variação da temperatura.





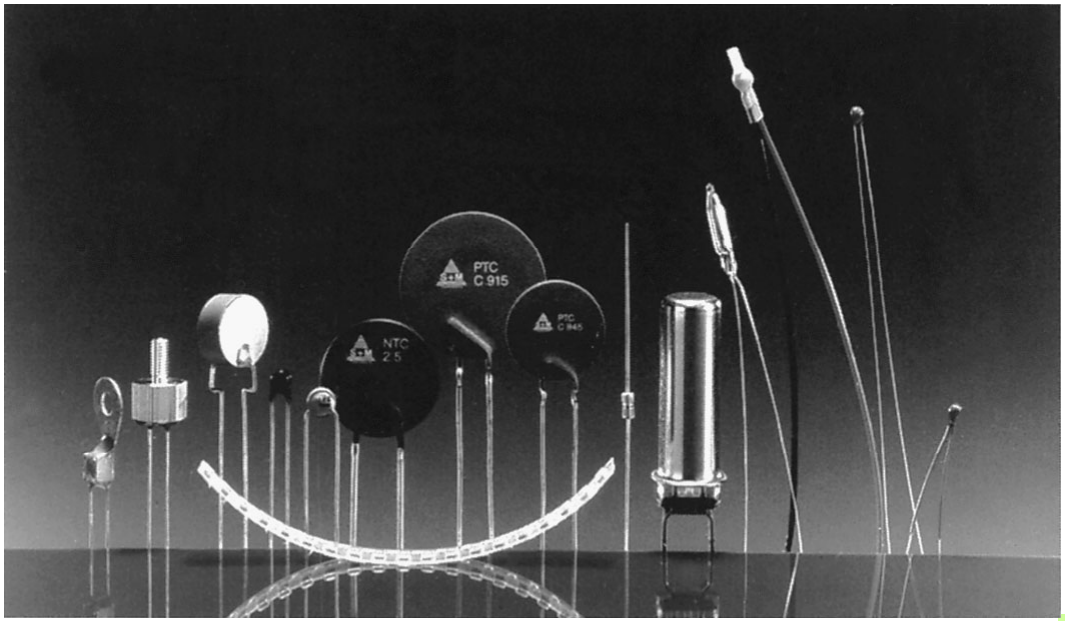
Termistores

Termistor NTC:

- Coeficiente negativo de temperatura;
- Resistência diminui com o aumento da temperatura.

Termistor PTC:

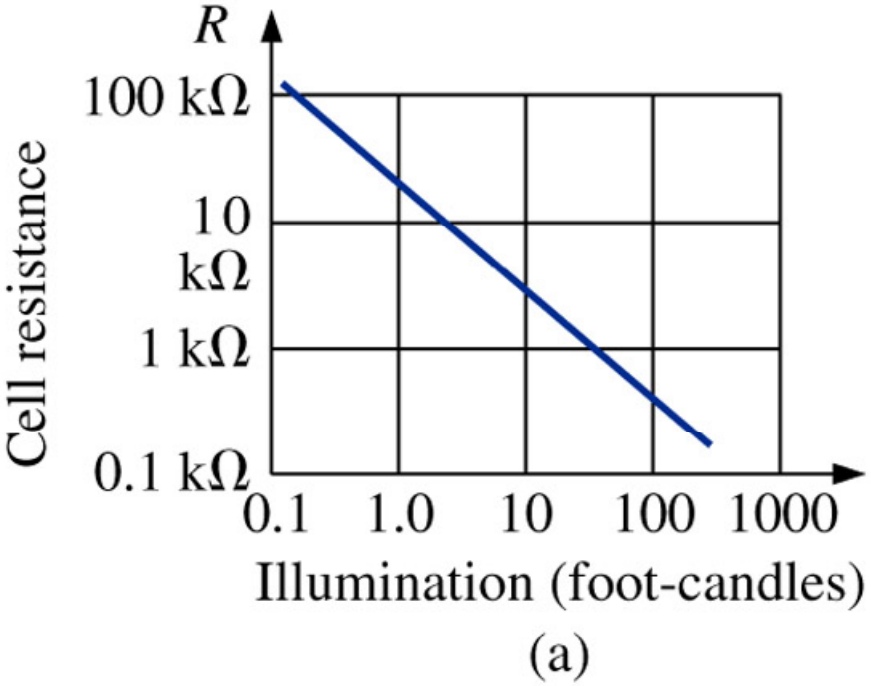
- Coeficiente positivo de temperatura;
- Resistência aumenta com o aumento da temperatura.



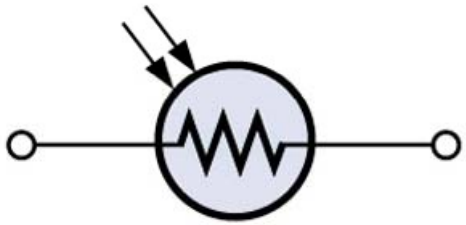
Célula fotocondutora ou LDR

LDR (Light dependent resistor) ou célula fotocondutora:

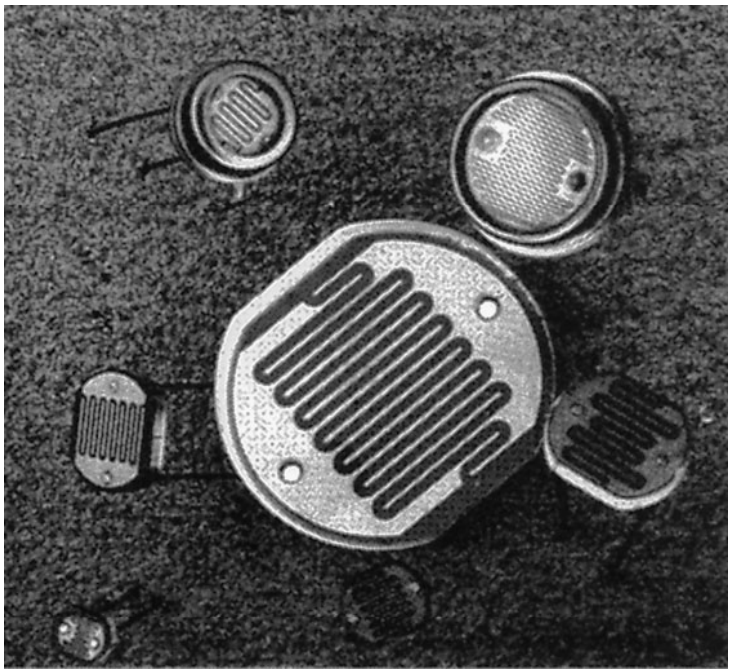
- A resistência é determinada pela intensidade da luz incidente em sua superfície.

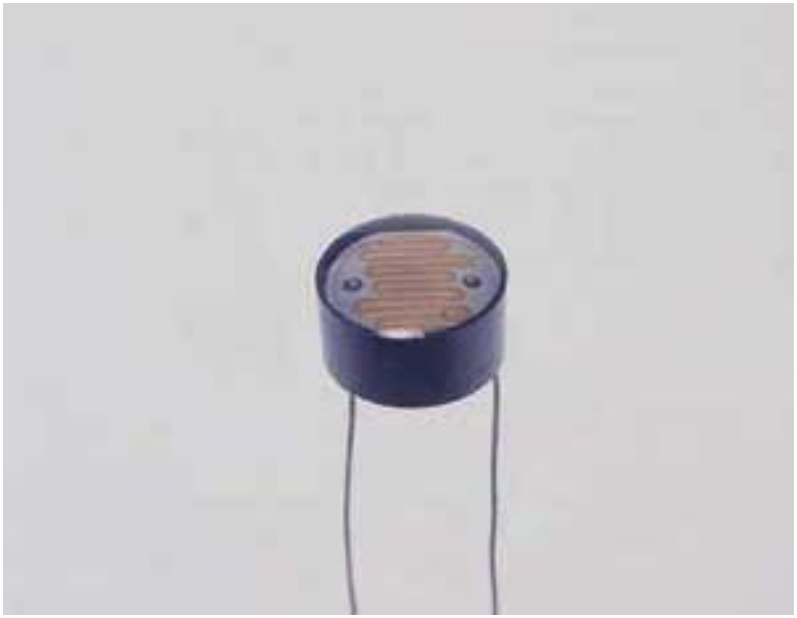


(a)


(b)

Célula fotocondutora ou LDR

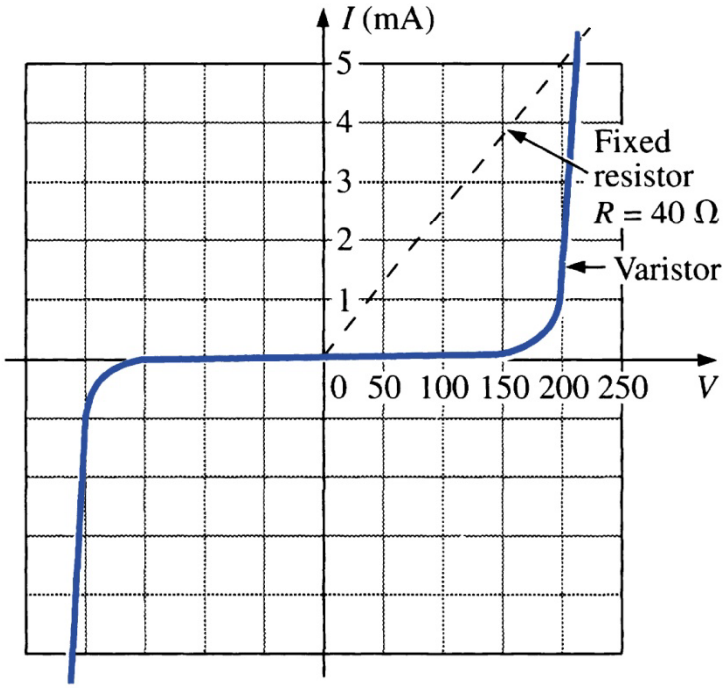




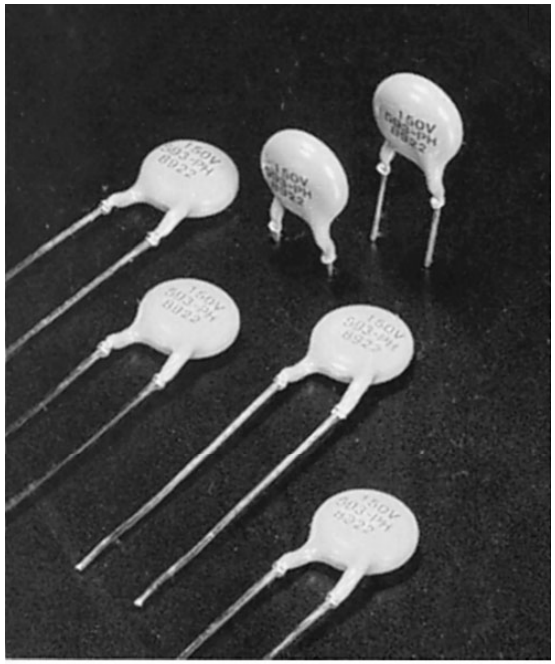
Varistores

Varistores:

- São resistores não-lineares, cuja resistência depende da tensão aplicada, usados para suprimir transientes de alta tensão.



(a)

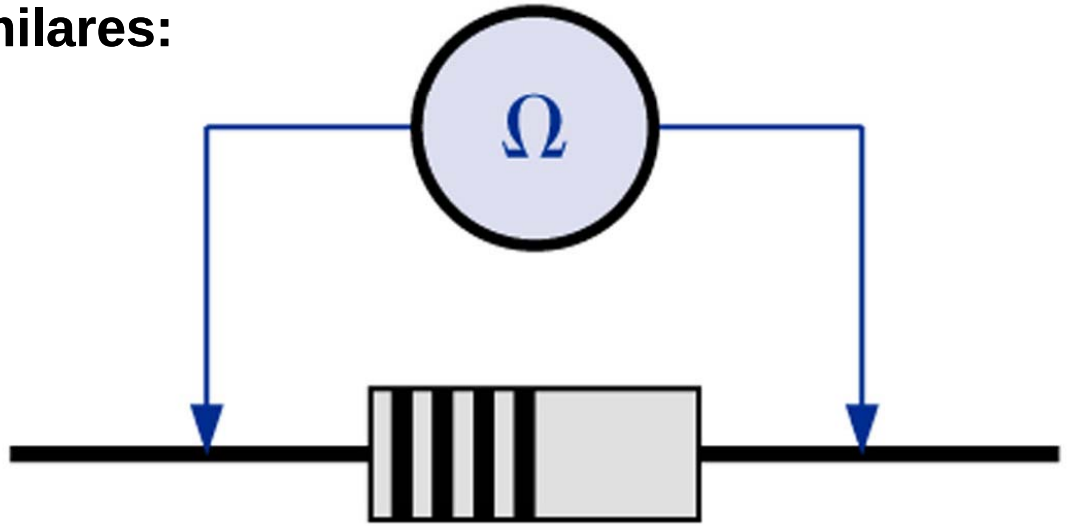


(b)

Resistores e similares

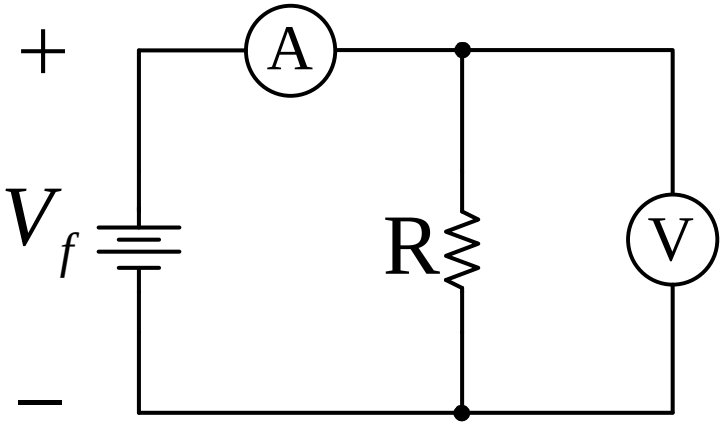
Testando resistores e similares:

Usando multímetro (Ω):



Aplicando a Lei de Ohm:

$$R = \frac{V}{I}$$

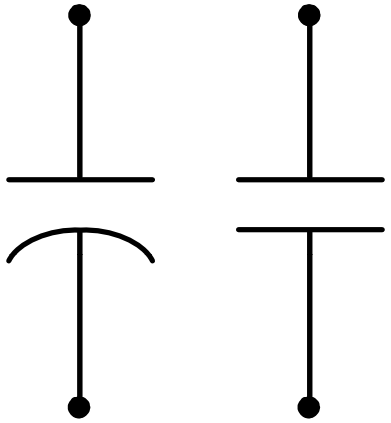


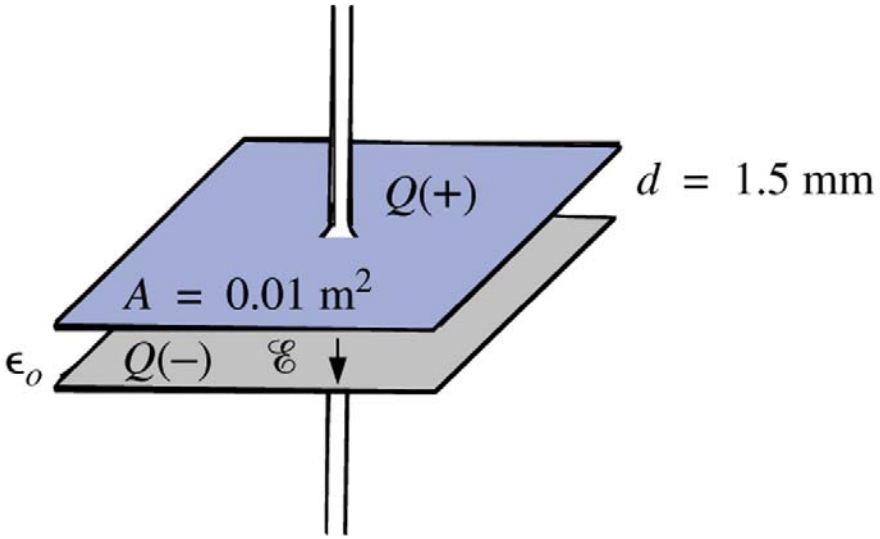
Capacitores

Capacitores

Capacitância depende de:

- Dielétrico (permissividade);
- Área das placas;
- Distância entre as placas.

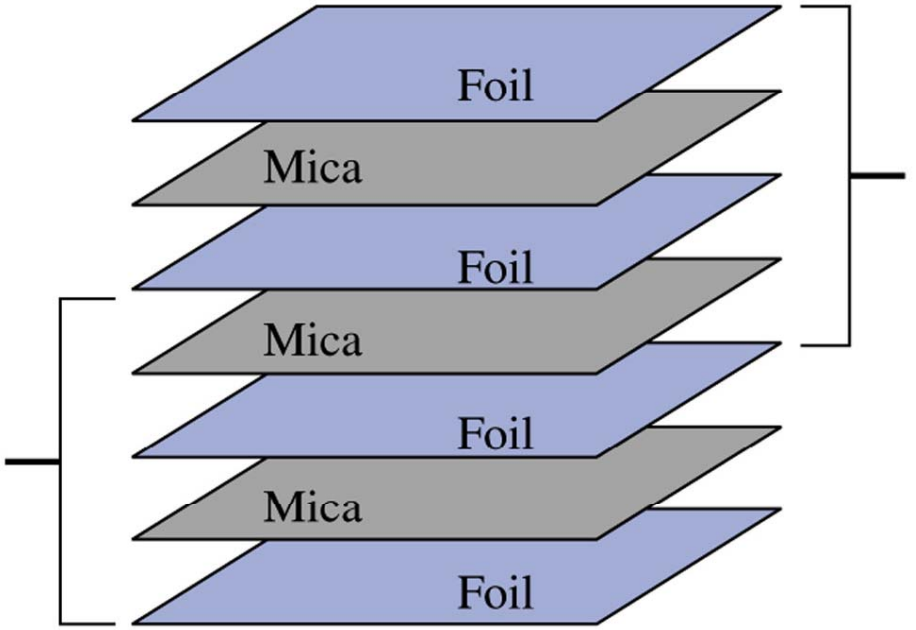


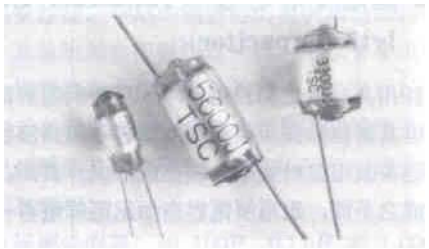


Capacitores

Tipos de capacitores:

Capacitores fixos de mica.

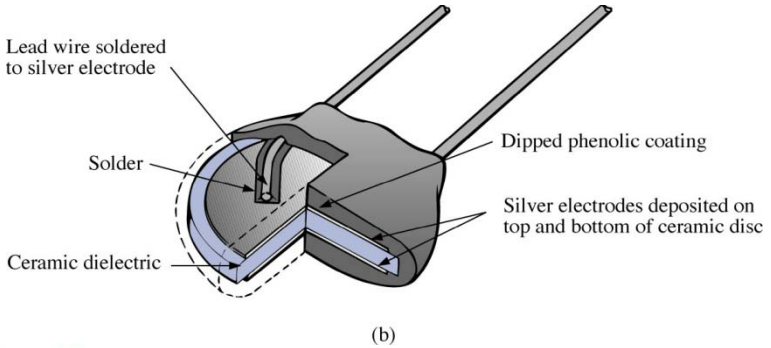




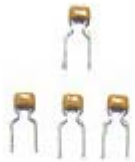
Capacitores

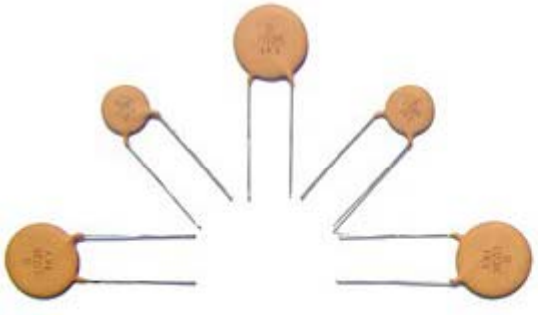
Tipos de capacitores:

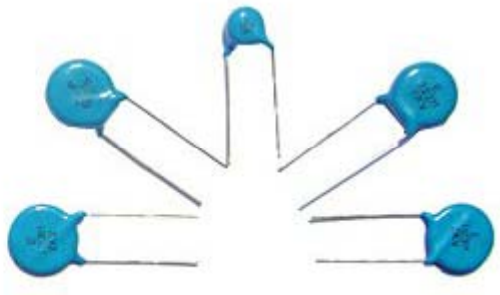
Capacitores de disco de cerâmica.



(b)





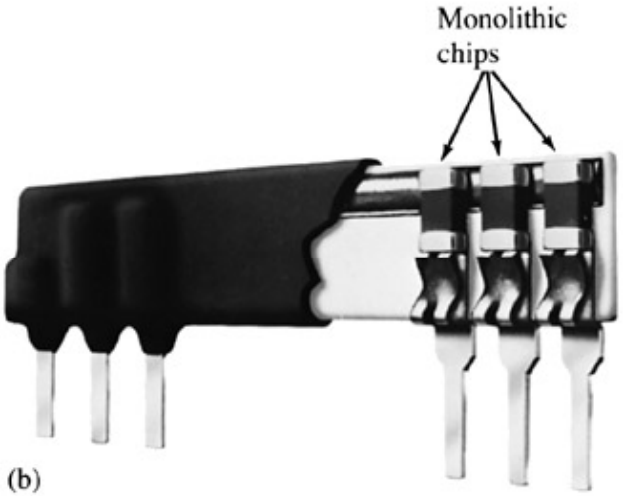


Capacitores

Tipos de capacitores:

Capacitores integrados.

(a)

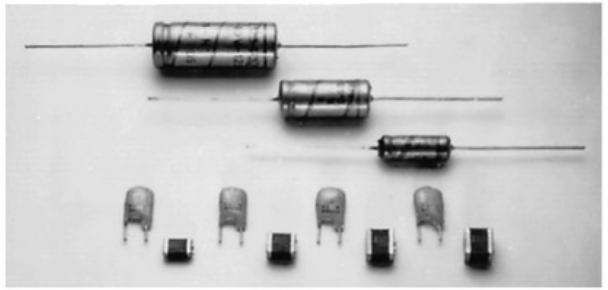


(b)

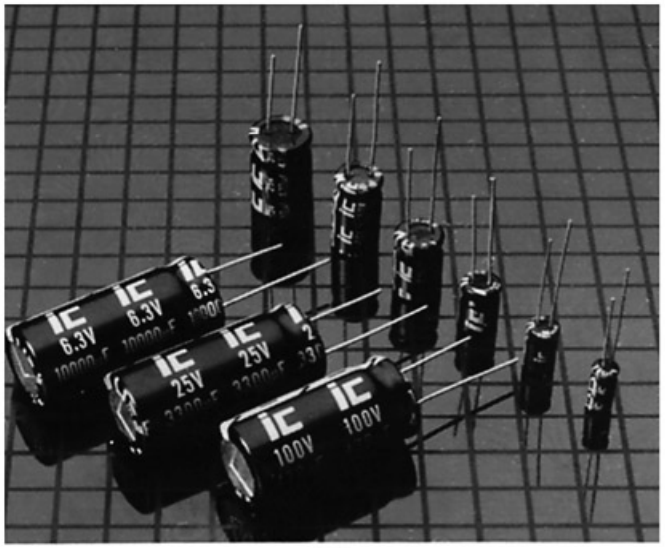
Capacitores

Tipos de capacitores:

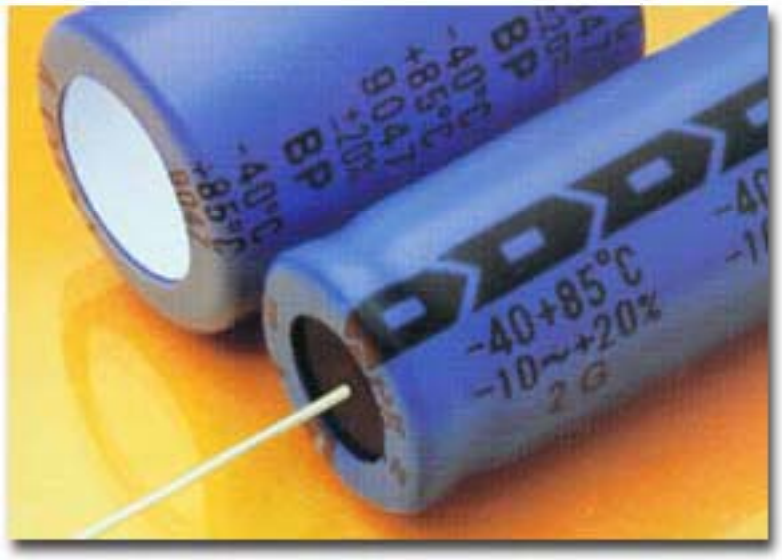
Capacitores eletrolíticos.



(b)



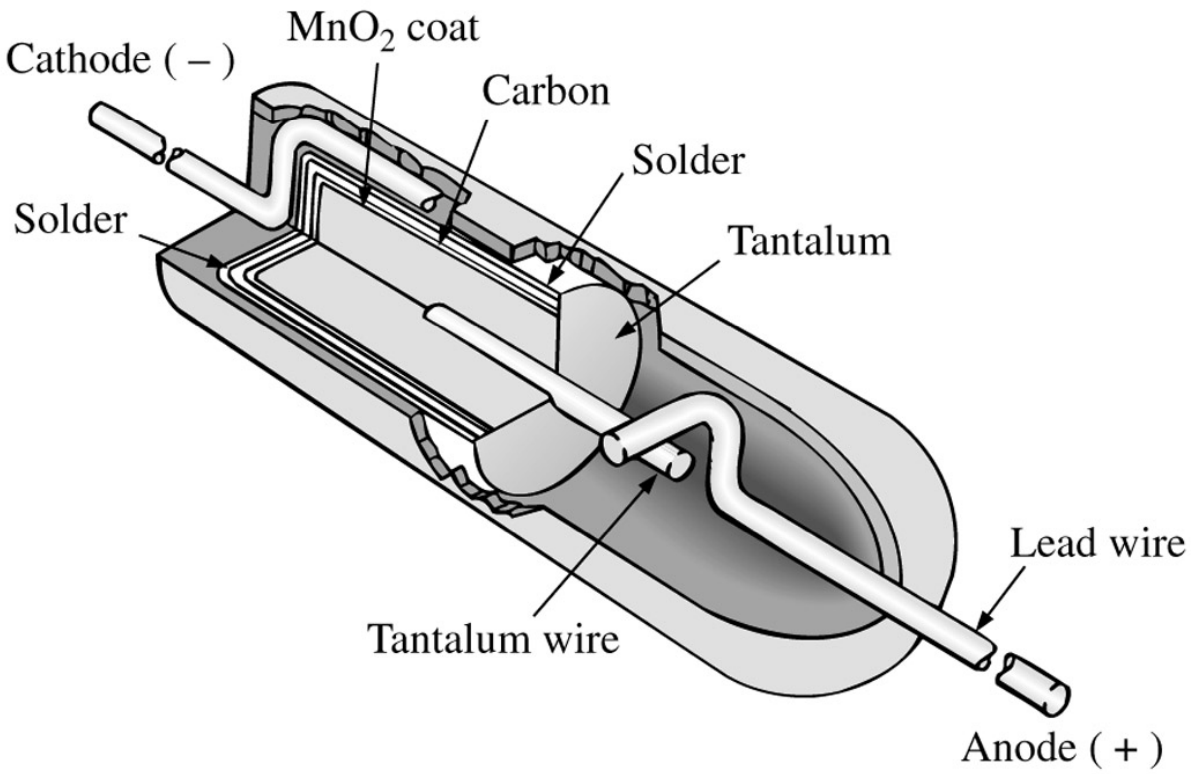
(a)



Capacitores

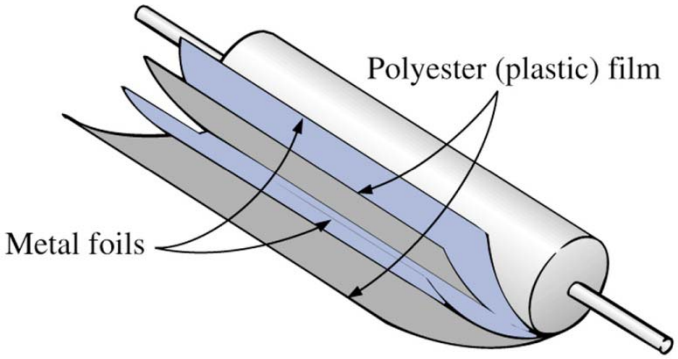
Tipos de capacitores:

Capacitores de tântalo.

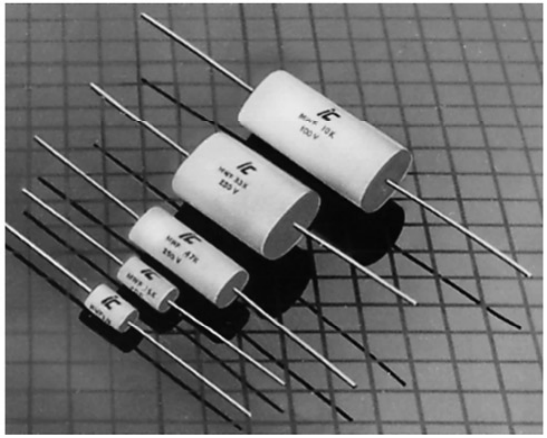


Capacitores

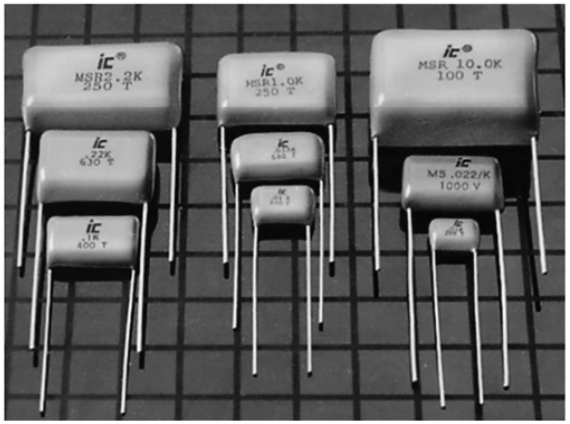
Tipos de capacitores:



Capacitores de filme de poliéster.



(a)

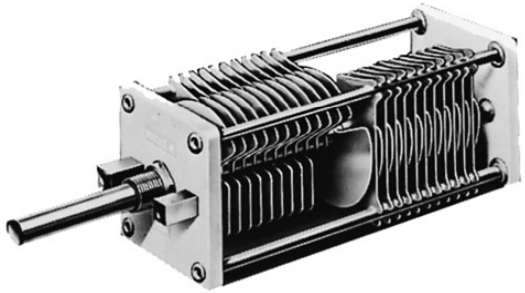


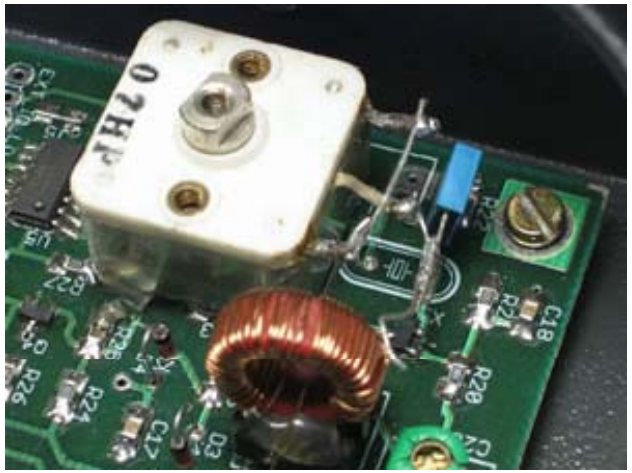
(b)

Capacitores

Tipos de capacitores:

Capacitores variáveis e ajustáveis.





Capacitores

Tipos de capacitores:

Small capacitance	3F, 2.3V – 300F, 2.3V	back-up power, on-board UPS, etc.
Medium capacitance	300F, 2.3V – 5000F, 2.7V	peak power, UPS, etc.
Large capacitance	5000F, 2.7V – 80.000F, 1.8 V	peak power, low maintenance energy storage, etc.
Supercapacitor modules	5V- 700V, capacitance on request.	Higher voltage applications

Super capacitores

Capacitores

Tipos de capacitores, resumo:

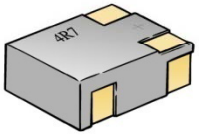
Type: Miniature Axial Electrolytic
Typical Values: 0.1 ∝F to 15,000 ∝F
Typical Voltage Range: 5 V to 450 V
Capacitor tolerance: ±20%
Applications: Polarized, used in DC power supplies, bypass filters, DC blocking.

Type: Miniature Radial Electrolyte
Typical Values: 0.1 ∝F to 15,000 ∝F
Typical Voltage Range: 5 V to 450 V
Capacitor tolerance: ±20%
Applications: Polarized, used in DC power supplies, bypass filters, DC blocking.

Type: Ceramic Disc
Typical Values: 10 pF to 0.047 ∝F
Typical Voltage Range: 100 V to 6 kV
Capacitor tolerance: ±5%, ±10%
Applications: Non-polarized, NPO type, stable for a wide range of temperatures. Used in oscillators, noise filters, circuit coupling, tank circuits.

Type: Dipped Tantalum (solid and wet)
Typical Values: 0.047 ∝F to 470 ∝F
Typical Voltage Range: 6.3 V to 50 V
Capacitor tolerance: ±10%, ±20%
Applications: Polarized, low leakage current, used in power supplies, high frequency noise filters, bypass filter.

Type: Surface Mount Type (SMT)
Typical Values: 10 pF to 10 ∝F
Typical Voltage Range: 6.3 V to 16 V
Capacitor tolerance: ±10%
Applications: Polarized and non-polarized, used in all types of circuits, requires a minimum amount of PC board real estate.



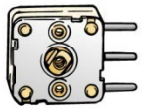
Type: Silver Mica
Typical Value: 10 pF to 0.001 ∝F
Typical Voltage Range: 50 V to 500 V
Capacitor tolerance: ±5%
Applications: Non-polarized, used in oscillators, in circuits that require a stable component over a range of temperatures and voltages.

Type: Mylar Paper
Typical Value: 0.001 ∝F to 0.68 ∝F
Typical Voltage Range: 50 V to 600 V
Capacitor tolerance: ±22%
Applications: Non-polarized, used in all types of circuits, moisture resistant.

Type: AC/DC Motor Run
Typical Value: 0.25 ∝F to 1200 ∝F
Typical Voltage Range: 240 V to 660 V
Capacitor tolerance: ±10%
Applications: Non-polarized, used in motor run-start, high-intensity lighting supplies, AC noise filtering.

Type: Trimmer Variable
Typical Value: 1.5 pF to 600 pF
Typical Voltage Range: 5 V to 100 V
Capacitor tolerance: ±10%
Applications: Non-polarized, used in oscillators, tuning circuits, AC filters.

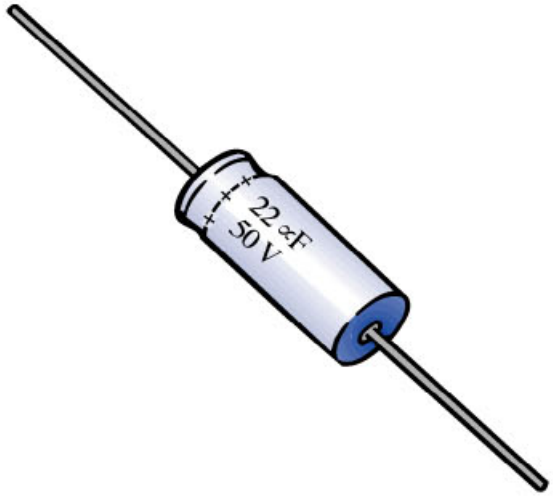
Type: Tuning variable
Typical Value: 10 pF to 600 pF
Typical Voltage Range: 5 V to 100 V
Capacitor tolerance: ±10%
Applications: Non-polarized, used in oscillators, radio tuning circuit.



Capacitores

Tipos de capacitores:

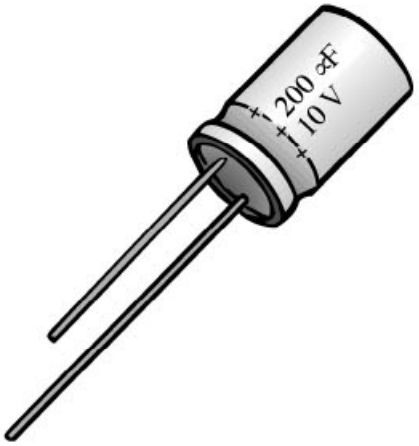
Type: Miniature Axial Electrolytic
Typical Values: 0.1 ∝F to 15,000 ∝F
Typical Voltage Range: 5 V to 450 V
Capacitor tolerance: ±20%
Applications: Polarized, used in DC power supplies, bypass filters, DC blocking.



Capacitores

Tipos de capacitores:

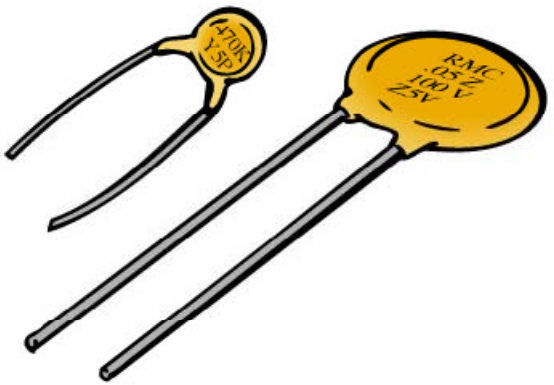
Type: Miniature Radial Electrolyte
Typical Values: 0.1 ∝F to 15,000 ∝F
Typical Voltage Range: 5 V to 450 V
Capacitor tolerance: ±20%
Applications: Polarized, used in DC power supplies, bypass filters, DC blocking.



Capacitores

Tipos de capacitores:

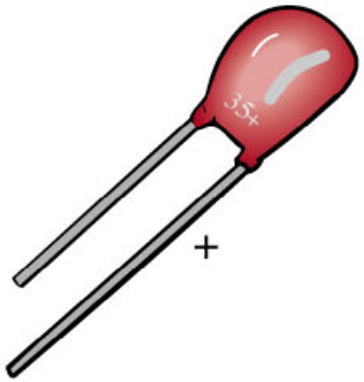
Type: Ceramic Disc
Typical Values: 10 pF to 0.047 ∝F
Typical Voltage Range: 100 V to 6 kV
Capacitor tolerance: ±5%, ±10%
Applications: Non-polarized, NPO type, stable for a wide range of temperatures. Used in oscillators, noise filters, circuit coupling, tank circuits.



Capacitores

Tipos de capacitores:

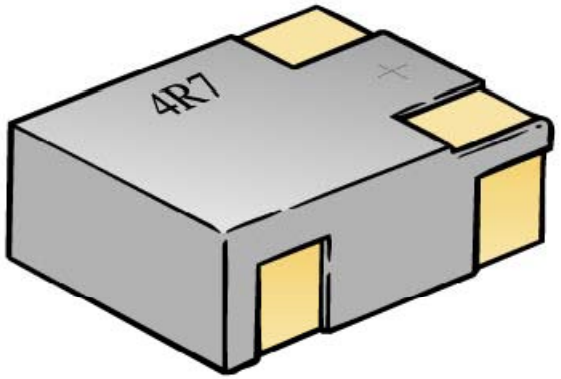
Type: Dipped Tantalum (solid and wet)
Typical Values: 0.047 ∝F to 470 ∝F
Typical Voltage Range: 6.3 V to 50 V
Capacitor tolerance: ±10%, ±20%
Applications: Polarized, low leakage current, used in power supplies, high frequency noise filters, bypass filter.



Capacitores

Tipos de capacitores:

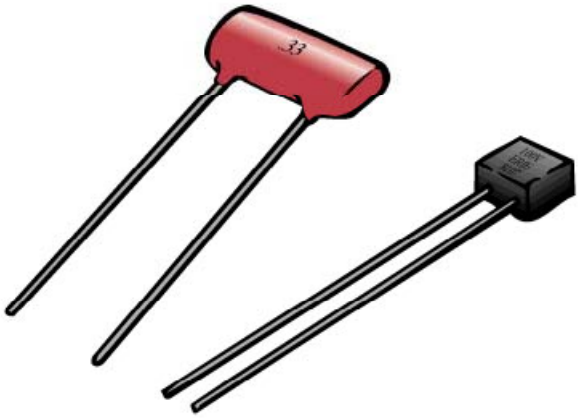
Type: Surface Mount Type (SMT)
Typical Values: 10 pF to 10 ∝F
Typical Voltage Range: 6.3 V to 16 V
Capacitor tolerance: ±10%
Applications: Polarized and non-polarized, used in all types of circuits, requires a minimum amount of PC board real estate.



Capacitores

Tipos de capacitores:

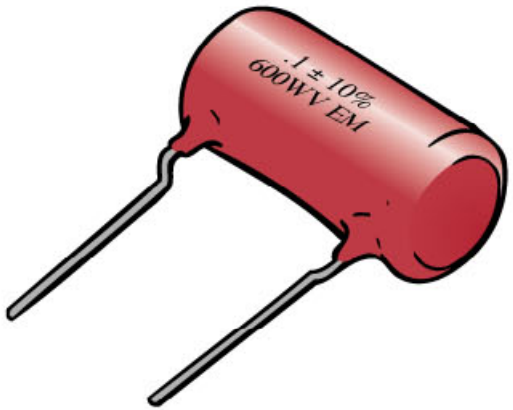
Type: Silver Mica
Typical Value: 10 pF to 0.001 ∝F
Typical Voltage Range: 50 V to 500 V
Capacitor tolerance: ±5%
Applications: Non-polarized, used in oscillators, in circuits that require a stable component over a range of temperatures and voltages.



Capacitores

Tipos de capacitores:

Type: Mylar Paper
Typical Value: 0.001 ∝F to 0.68 ∝F
Typical Voltage Range: 50 V to 600 V
Capacitor tolerance: ±22%
Applications: Non-polarized, used in all types of circuits, moisture resistant.



Capacitores

Tipos de capacitores:

Type: AC/DC Motor Run
Typical Value: 0.25 ∝F to 1200 ∝F
Typical Voltage Range: 240 V to 660 V
Capacitor tolerance: ±10%
Applications: Non-polarized, used in motor run-start, high-intensity lighting supplies, AC noise filtering.

Capacitores

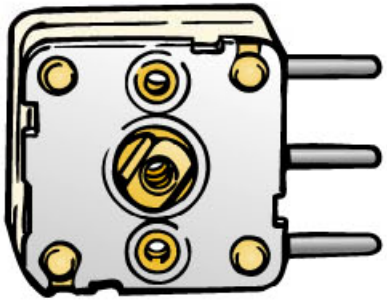
Tipos de capacitores:

Type: Trimmer Variable
Typical Value: 1.5 pF to 600 pF
Typical Voltage Range: 5 V to 100 V
Capacitor tolerance: ±10%
Applications: Non-polarized, used in oscillators, tuning circuits, AC filters.

Capacitores

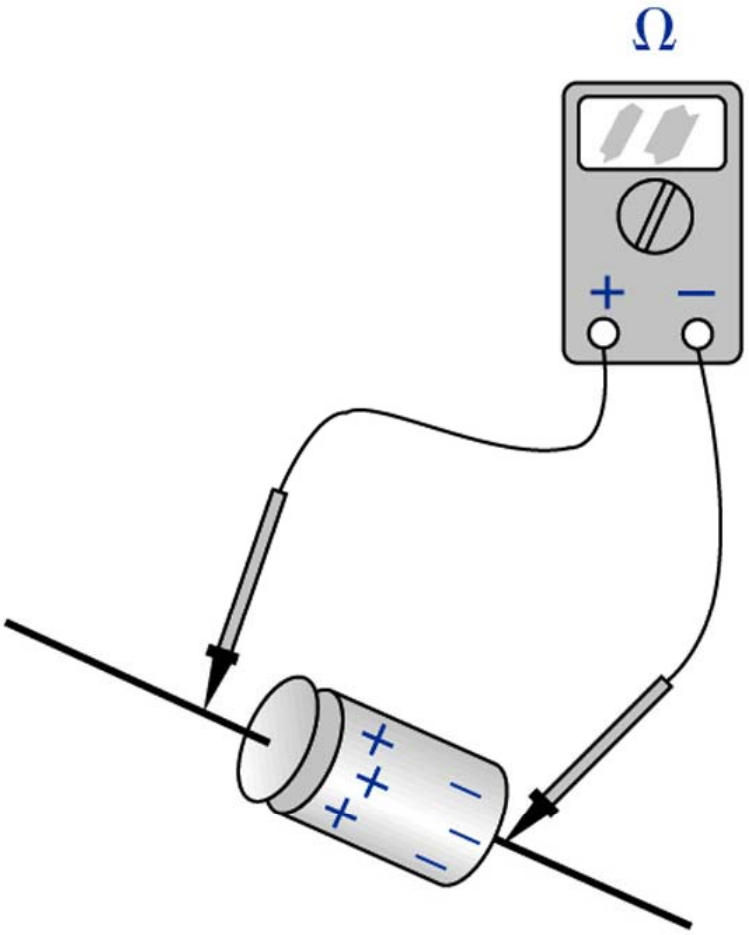
Tipos de capacitores:

Type: Tuning variable
Typical Value: 10 pF to 600 pF
Typical Voltage Range: 5 V to 100 V
Capacitor tolerance: ±10%
Applications: Non-polarized, used in oscillators, radio tuning circuit.



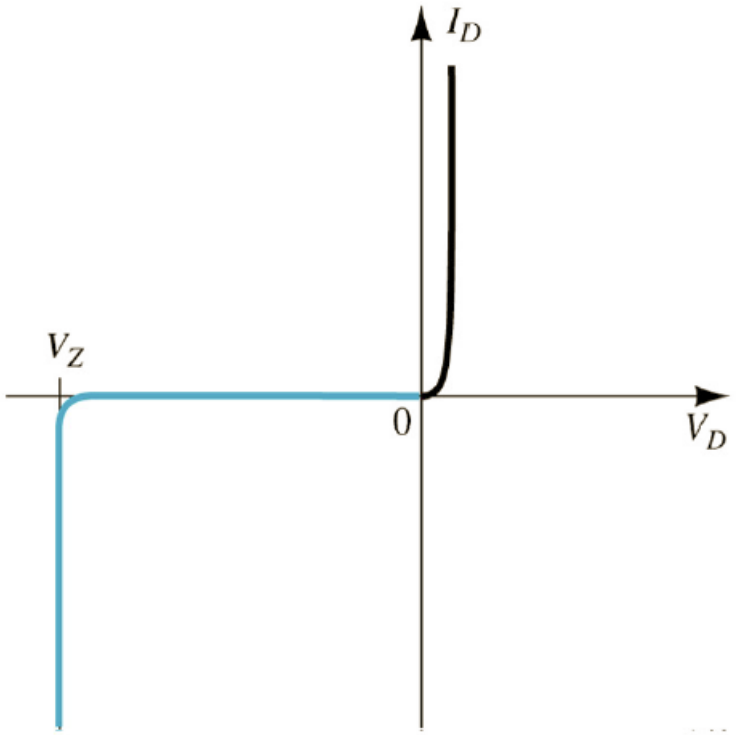
Capacitores

Testando capacitores:

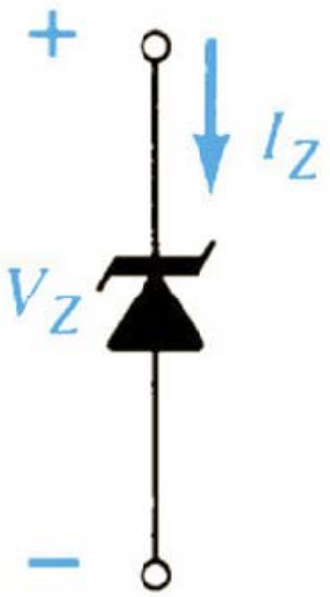


Diodos

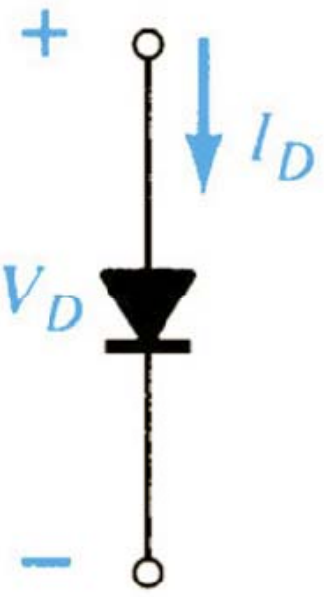
Diodos zener



Curva I_D x V_D

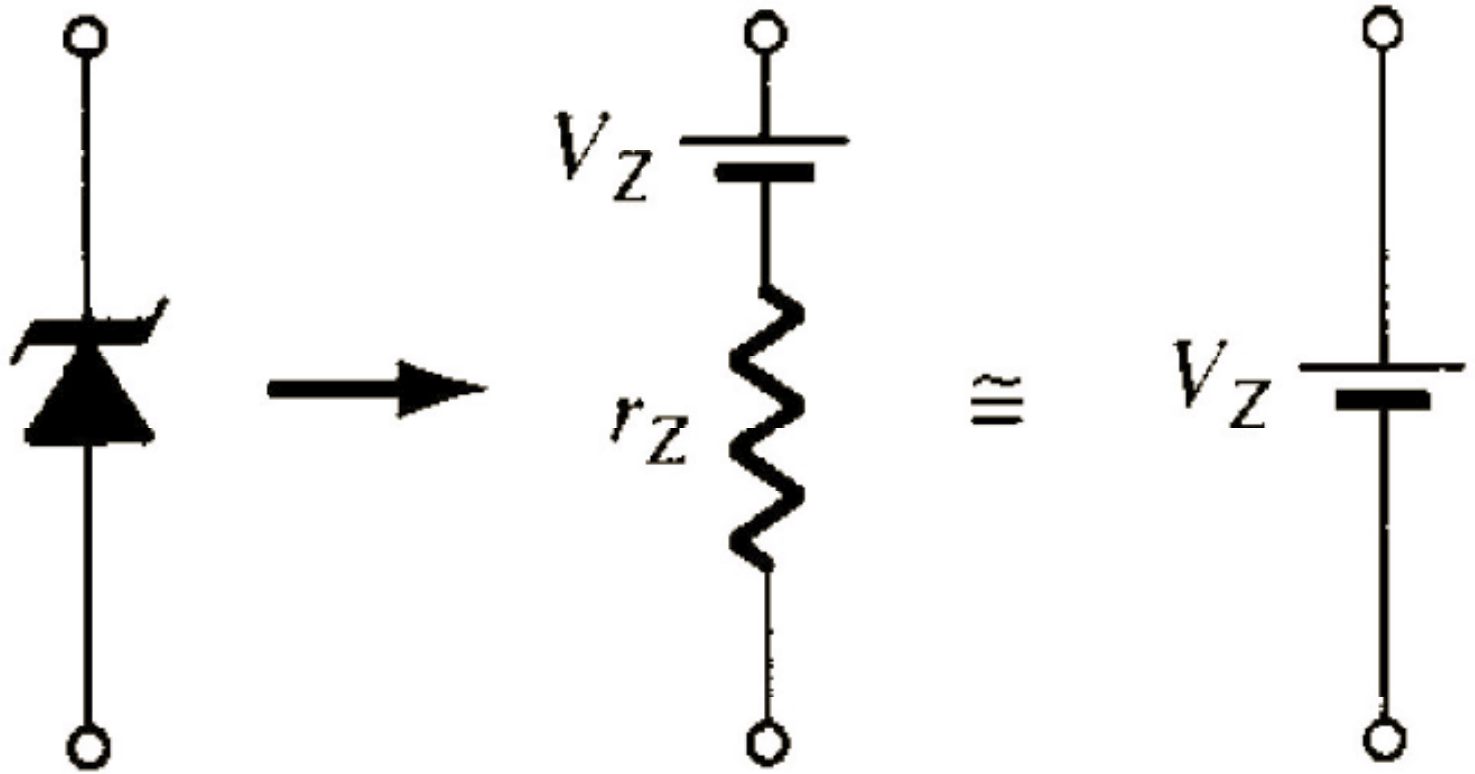


Diodo zener



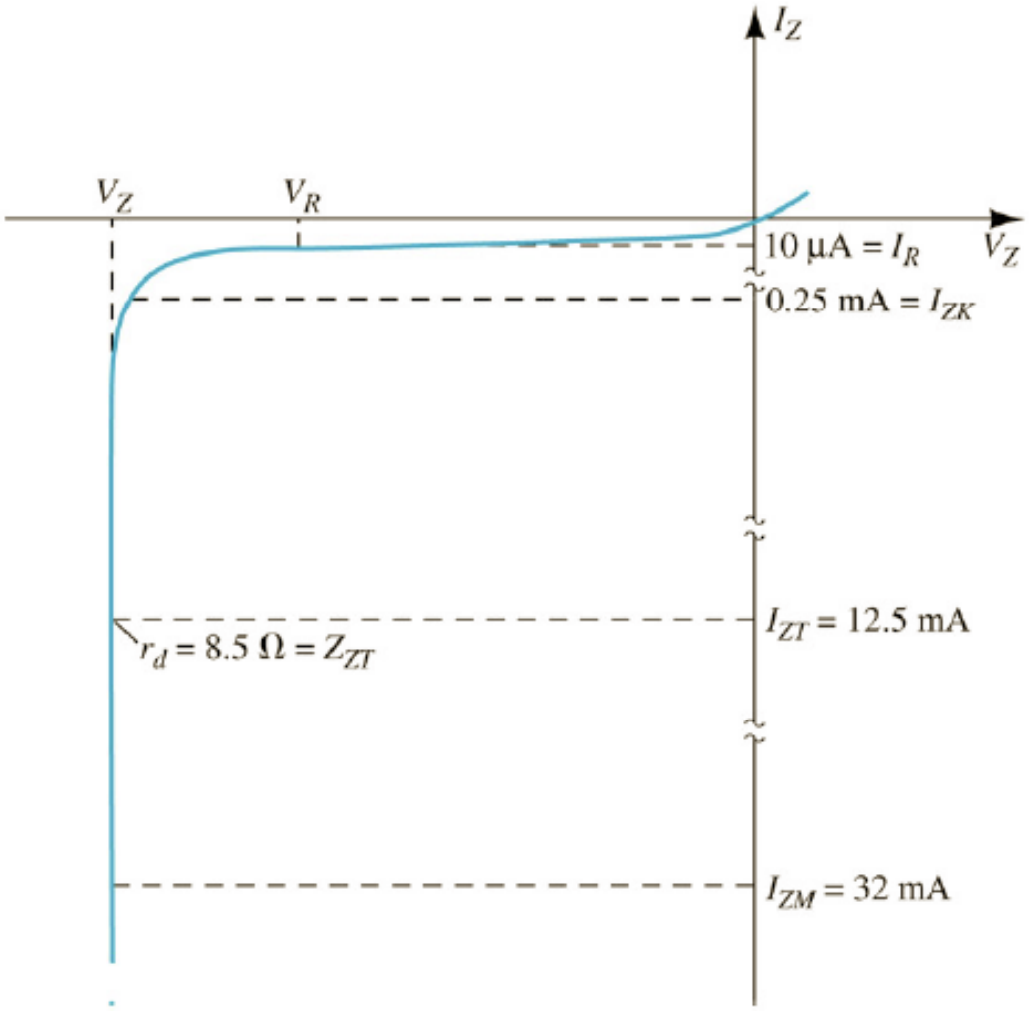
Diodo convencional

Diodos zener



Circuitos equivalentes do diodo zener

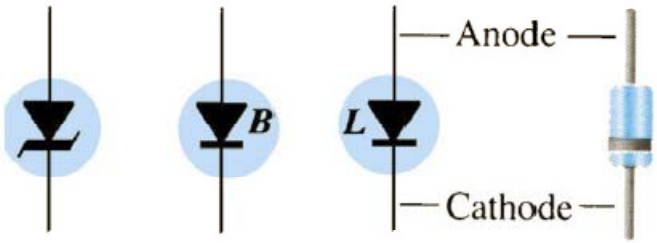
Diodos zener

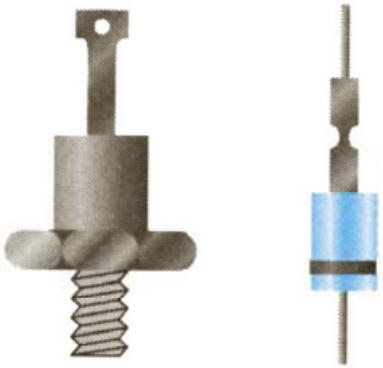


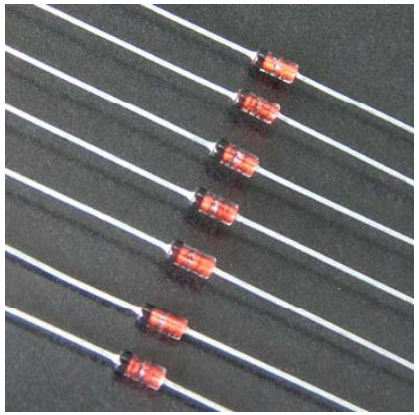
Curva I_D x V_D

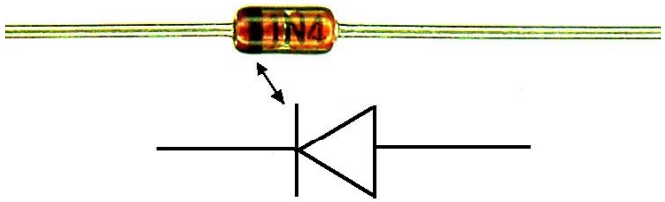
Diodos zener

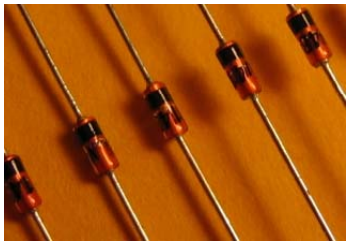
Aspectos de diodos zener:

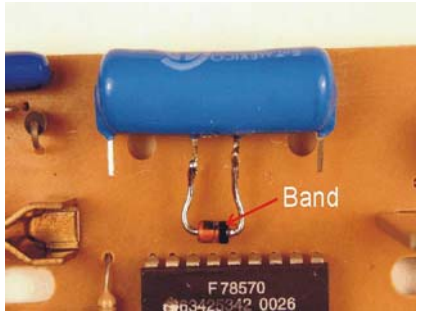




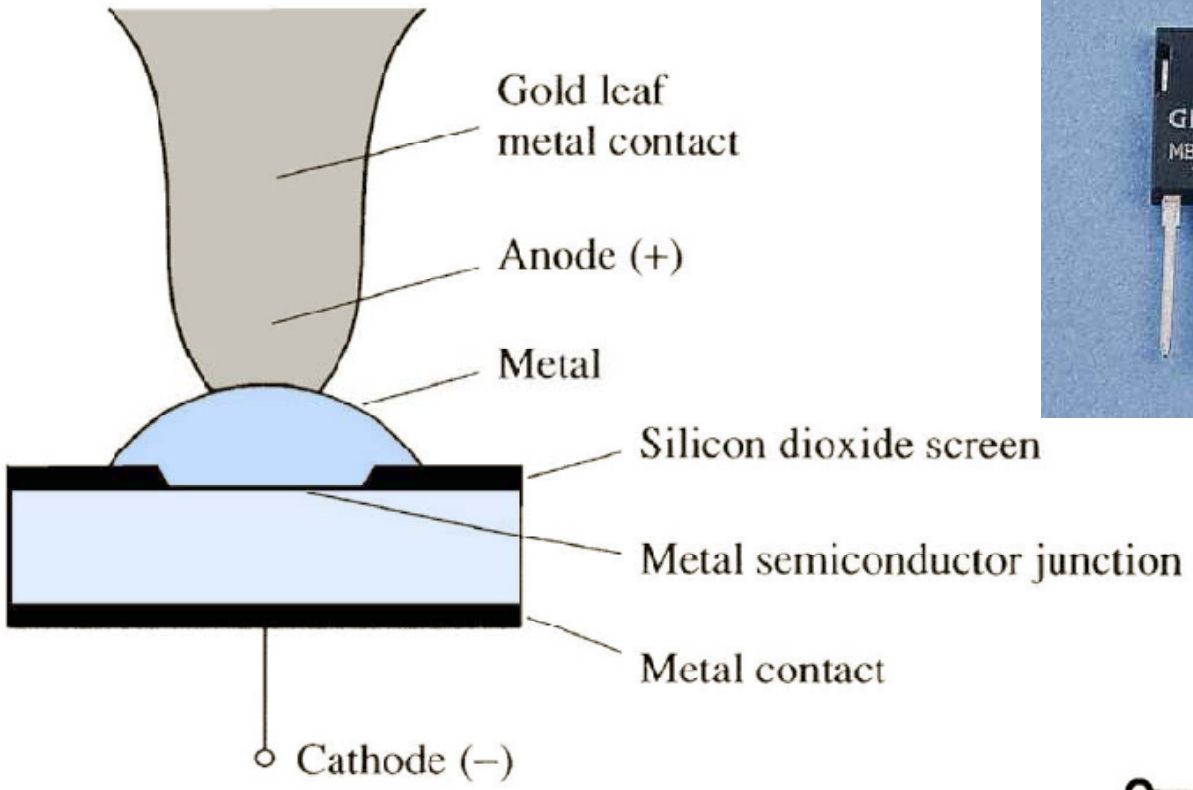


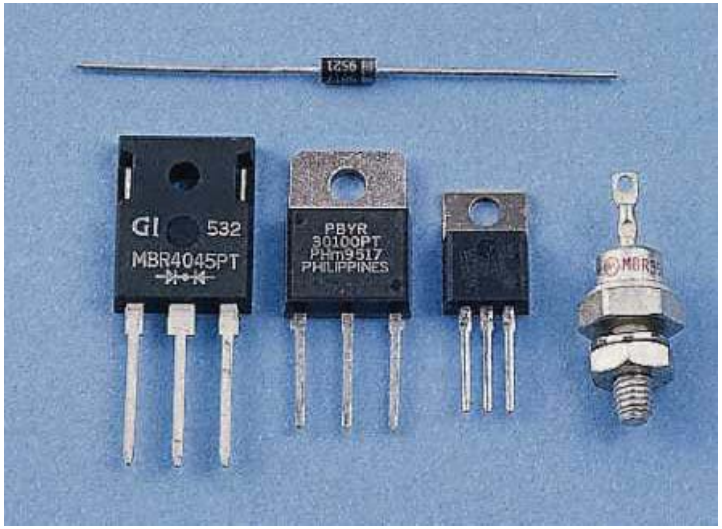


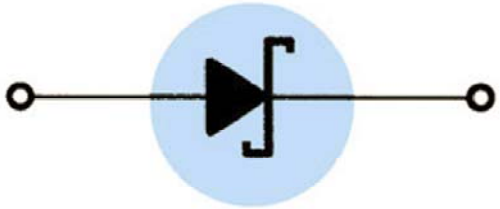




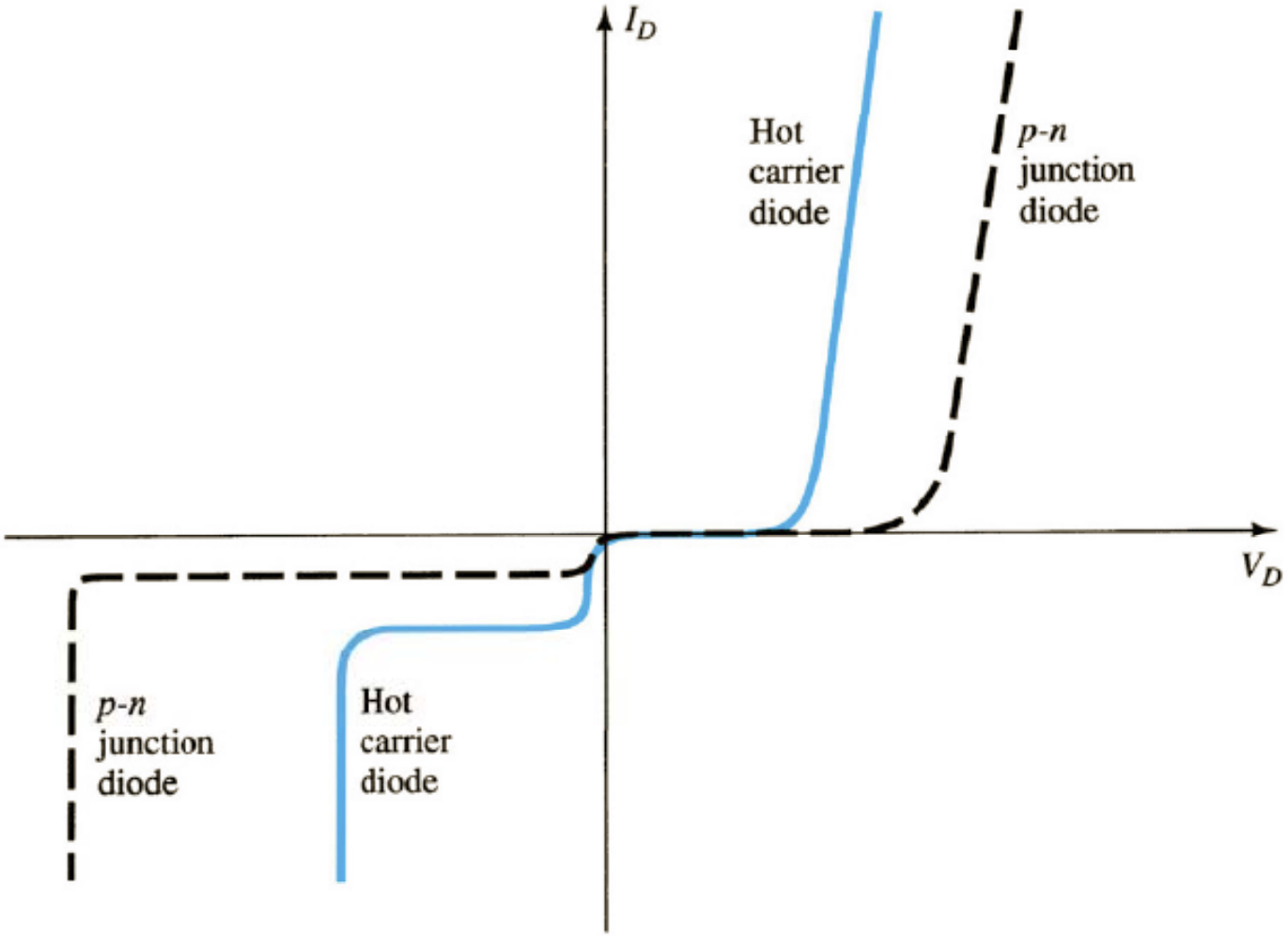
Diodos de barreira Schottky



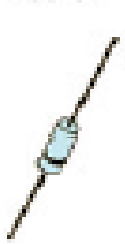
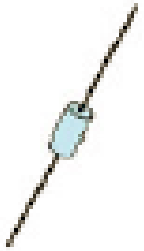




Diodos de barreira Schottky



Diodos de barreira Schottky

V_{RRM} (Volts)	Case / Anode / Cathode:	0.5 A	1.0 A	
		51-02 (DO-7) Glass 	59-04 Plastic 	
20		MBR020	IN5817	MBR120P
30		MBR030	IN5818	MBR130P
35				MBR135P
40			IN5819	MBR140P
I_{FSM} (Amps)		5.0	100	50
T_C @ Rated I_o (°C)				
T_J Max		125°C	125°C	125°C
Max V_F @ $I_{FM} = I_o$		0.50 V	*0.60 V	0.65 V

Symb.	1N 4001	1N 4002	1N 4003	1N 4004	1N 4005
V_{RRM}	50	100	200	400	600
V_{RMS}	35	70	140	280	420
V_{DC}	50	100	200	400	600
$I_{F(AV)}$	1.0				
I_{FSM}	30				
$I_{R(AV)}$	30				
$R_{\theta JA}$ $R_{\theta JL}$	50 25				
T_A	+150				
T_J, T_{STG}	–50 to +175				
V_F	1.1				

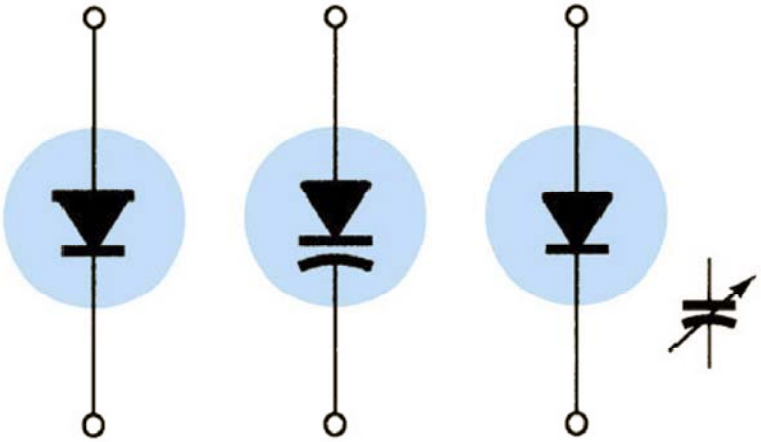
Diodo retificador normal

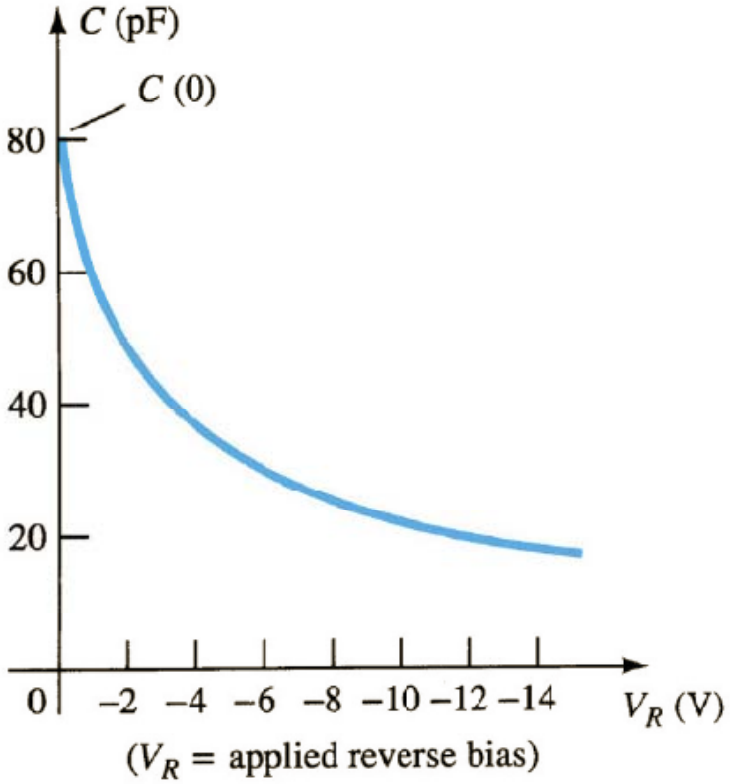
← Diodo Schottky

Diodos varactor (varicap)

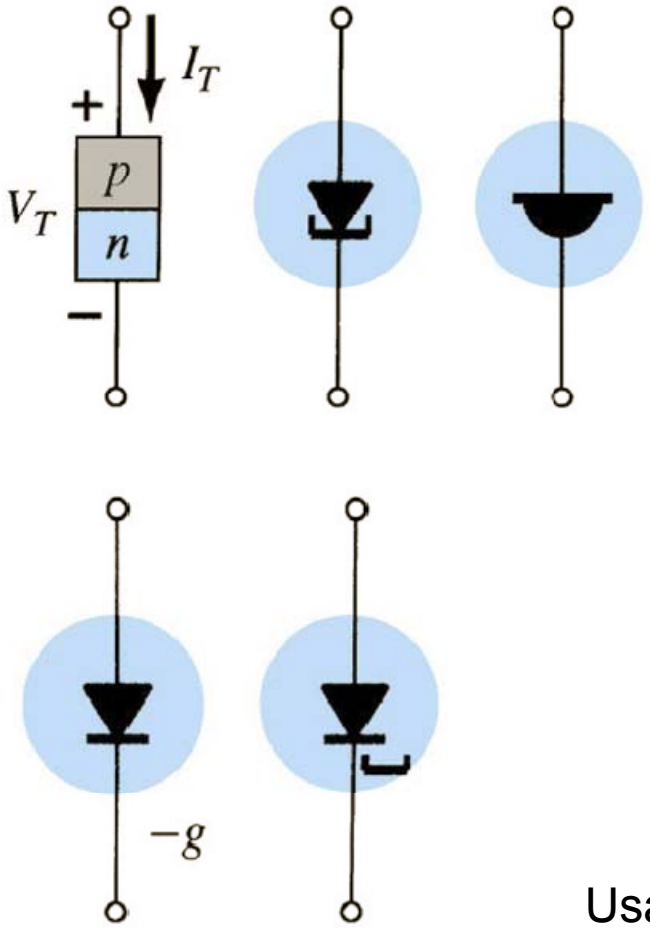
Varicap:

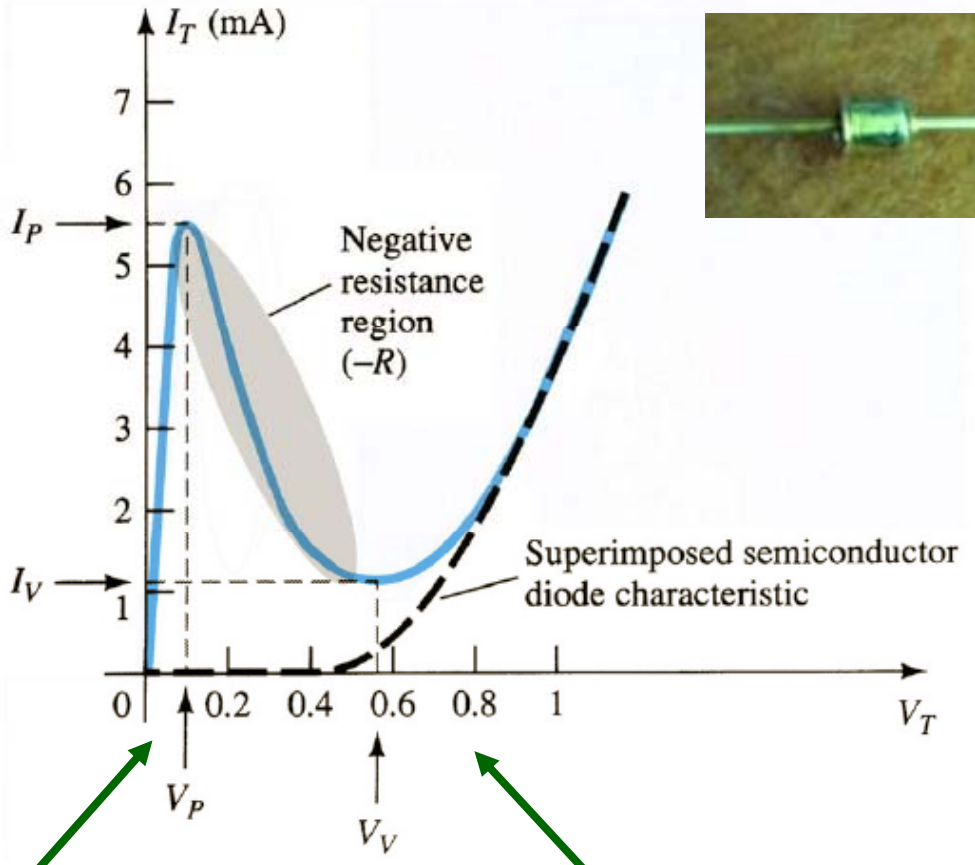
- São diodos que variam sua capacitância com a tensão aplicada nos seus terminais.





Diodos túnel

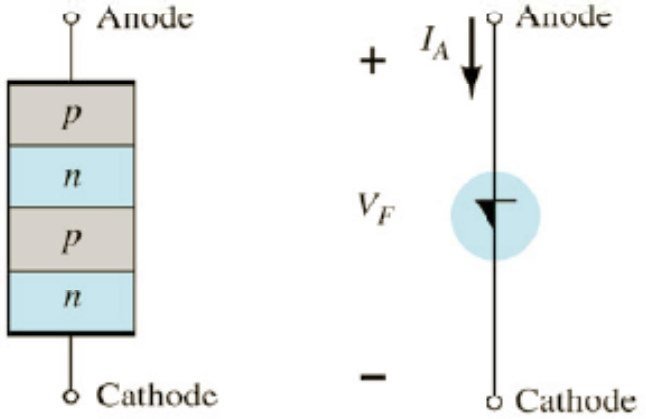


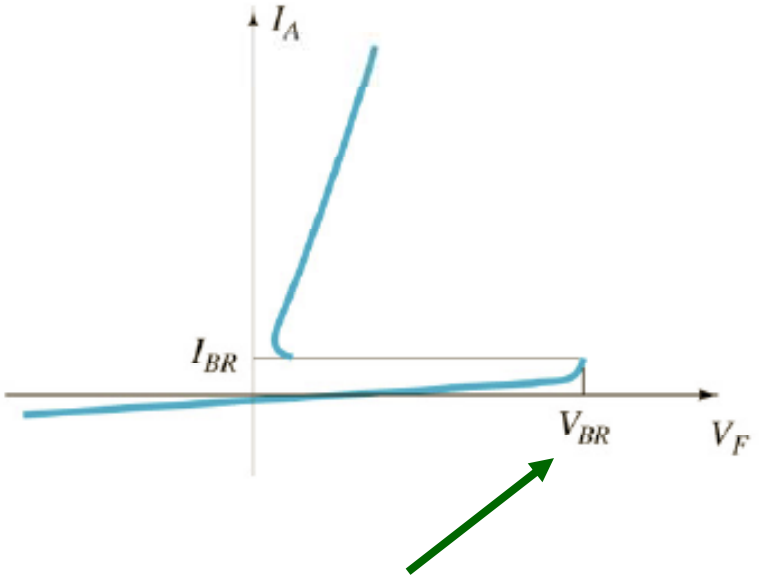


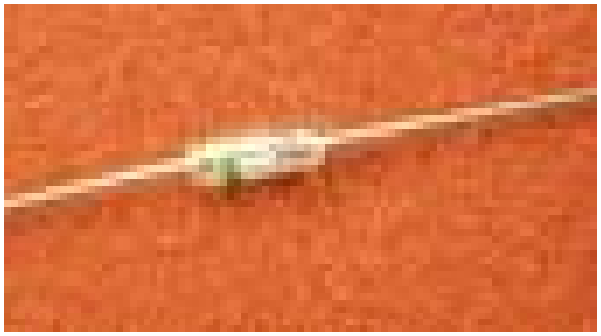
Usado em aplicações que requerem alta velocidade de comutação.

Também usado em circuitos osciladores.

Diodo Shockley



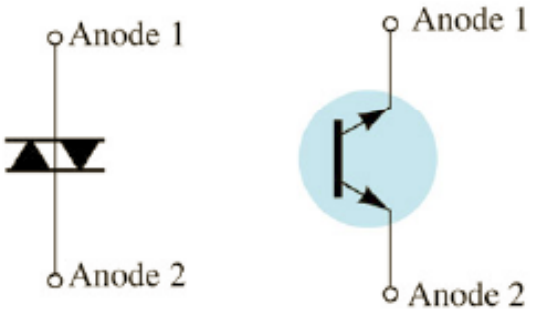


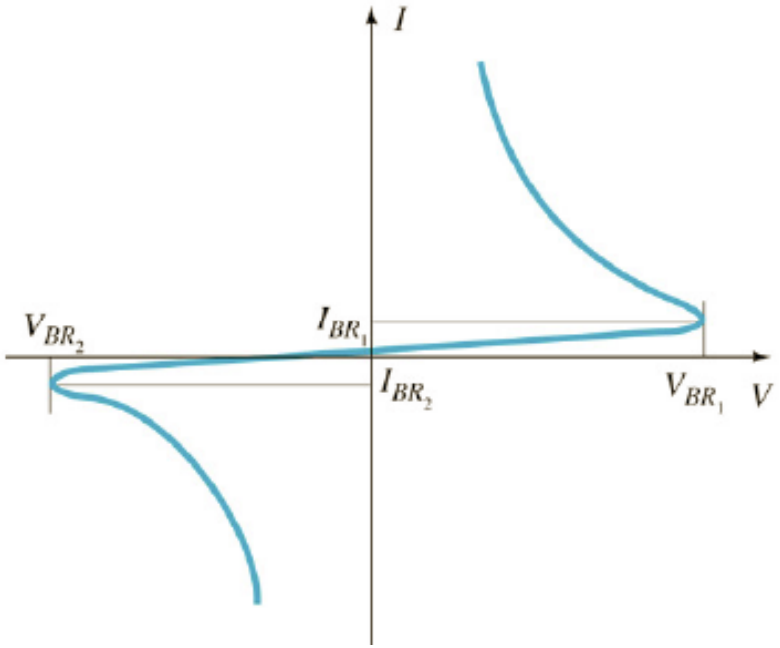


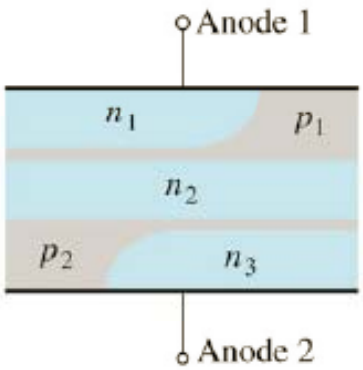
Entra em condução quando é atingida a tensão de ruptura (avalanche).

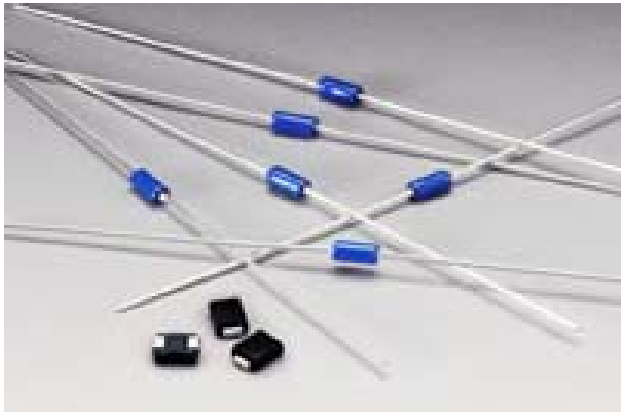
Diac

Diac – Diode for alternating current
(Diodo para corrente alternada)

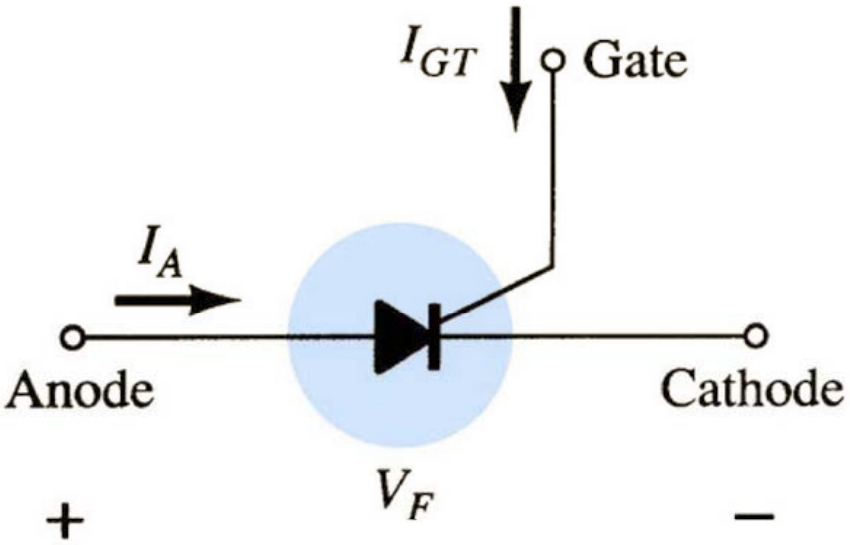


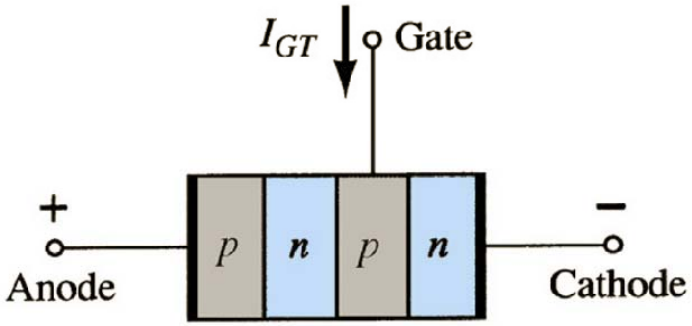


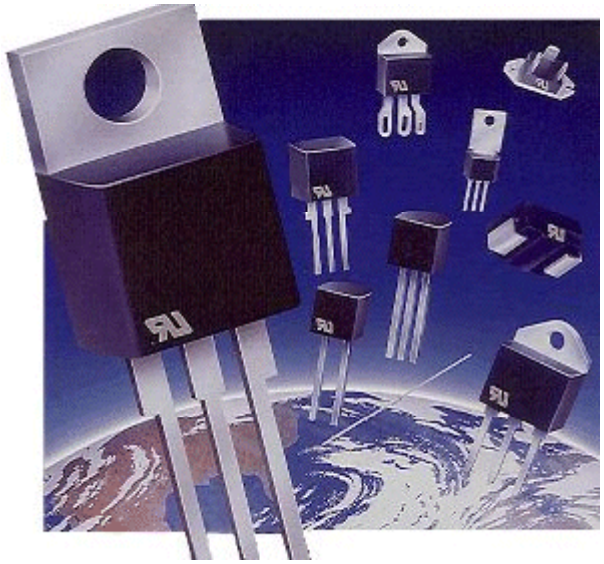




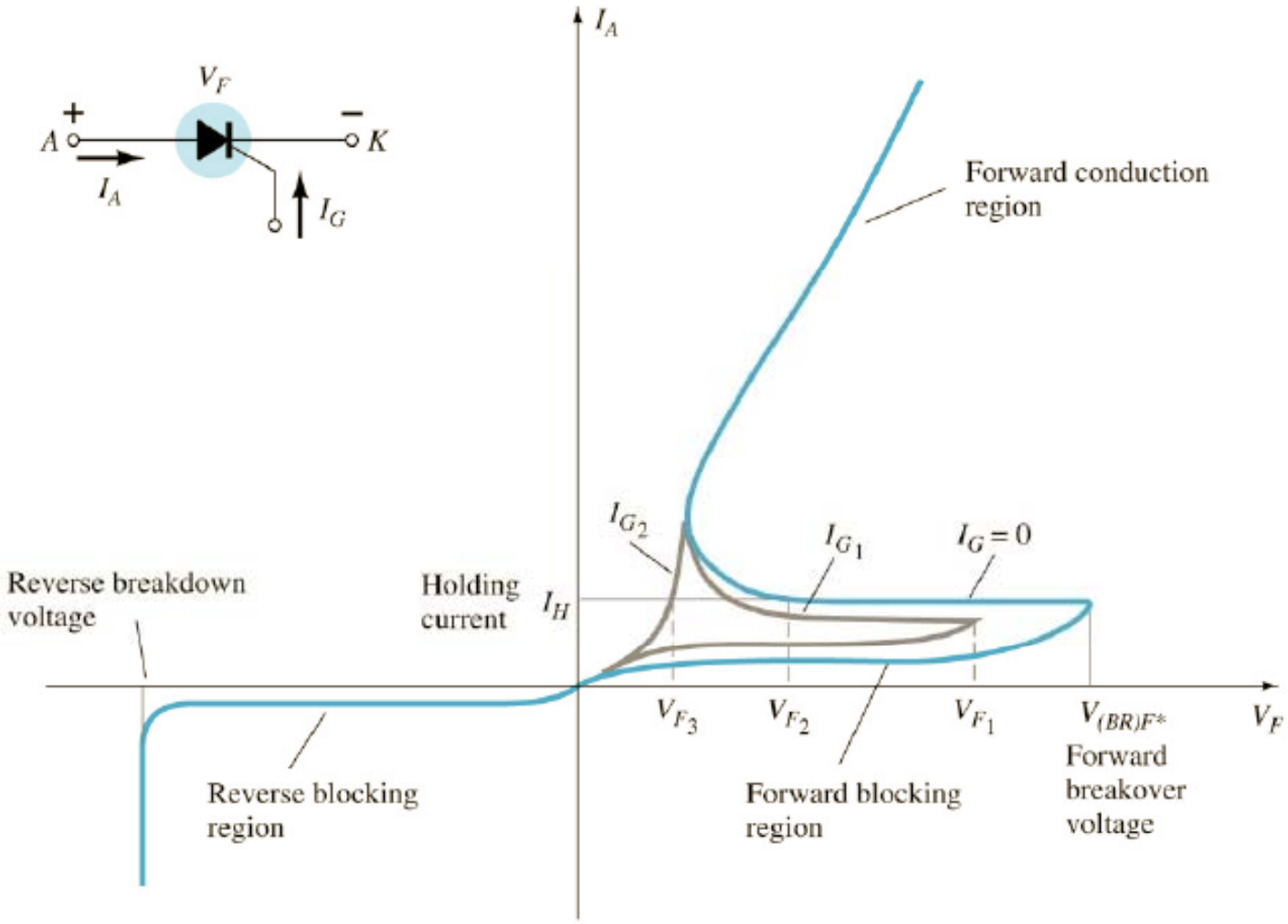
Retificador controlado de silício (SCR)



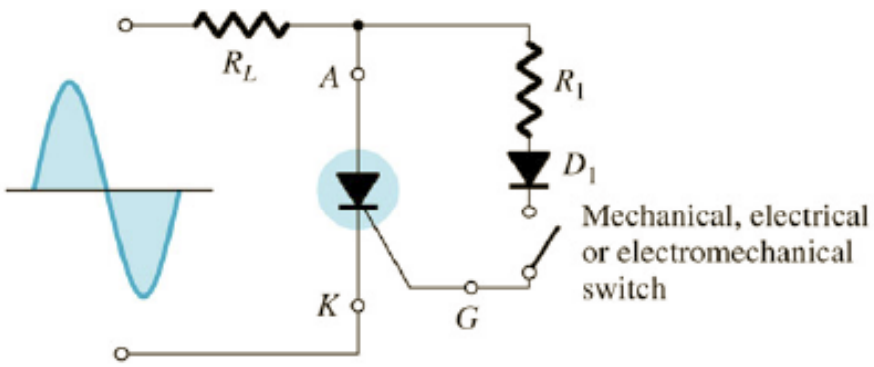


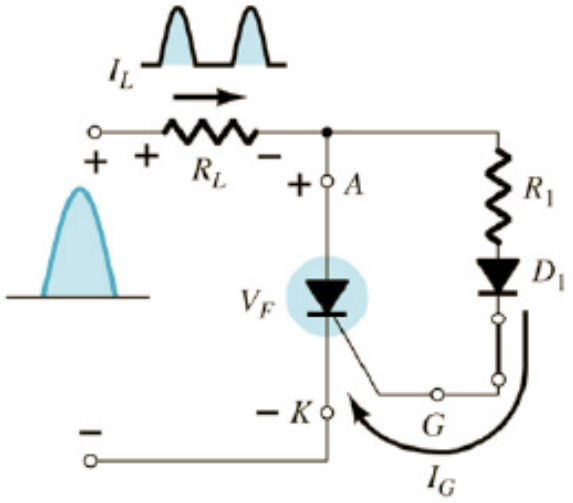


Retificador controlado de silício (SCR)

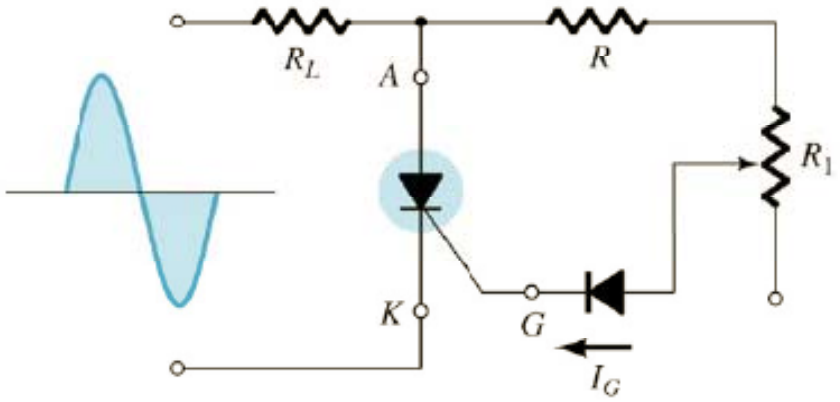


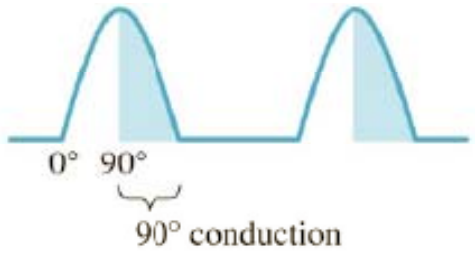
Retificador controlado de silício (SCR)



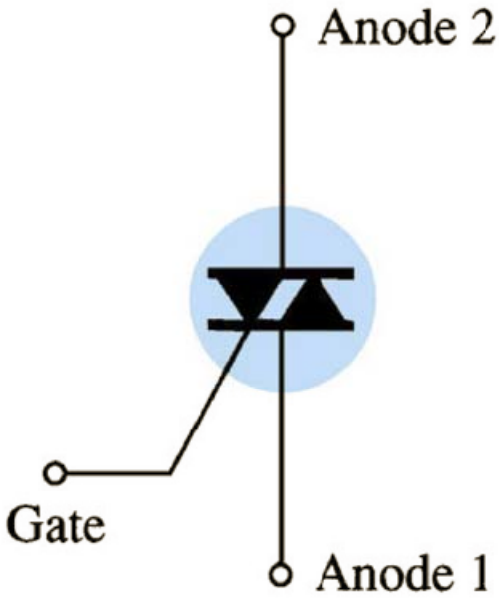


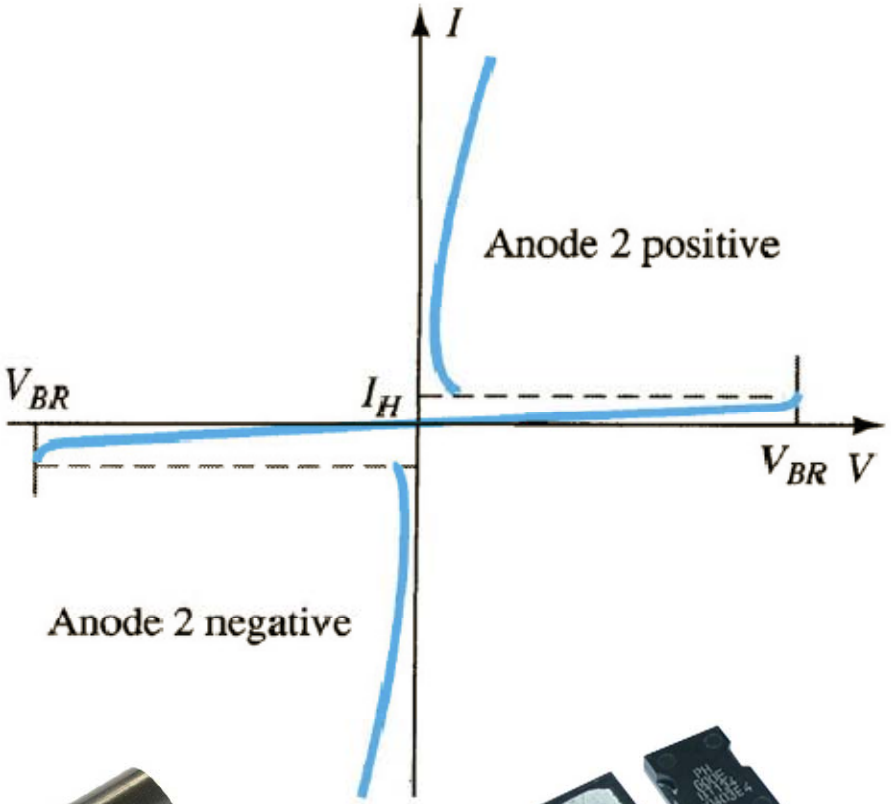
Retificadores de meia onda controlados.

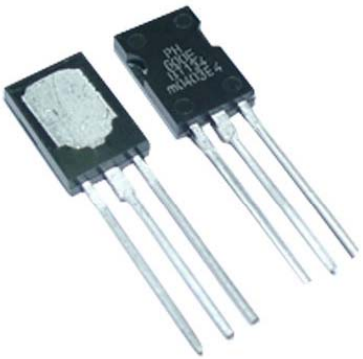




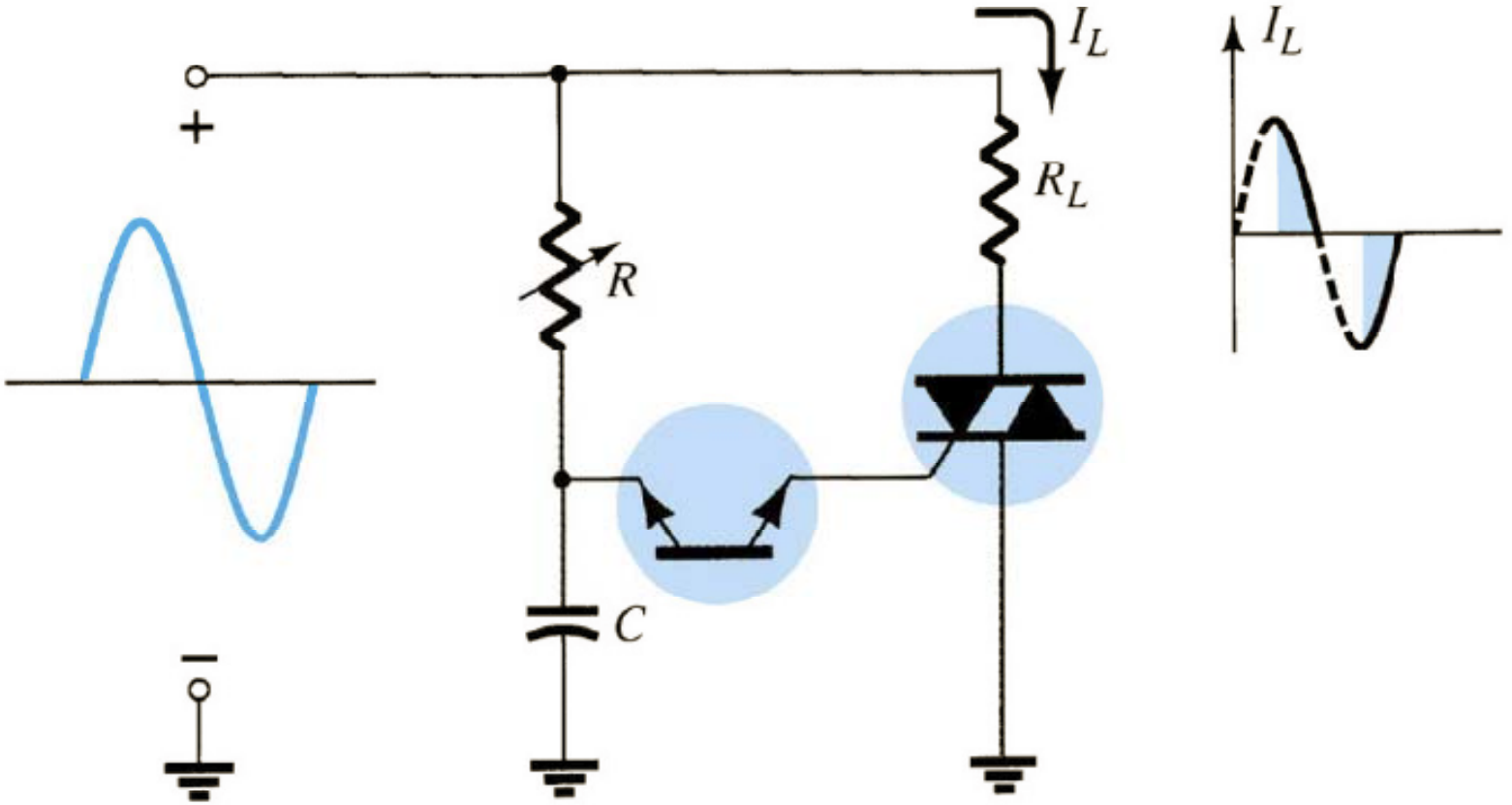
Triac


Anode 2
Gate
Anode 1


I
Anode 2 positive
V_{BR}
I_H
V_{BR} V
Anode 2 negative



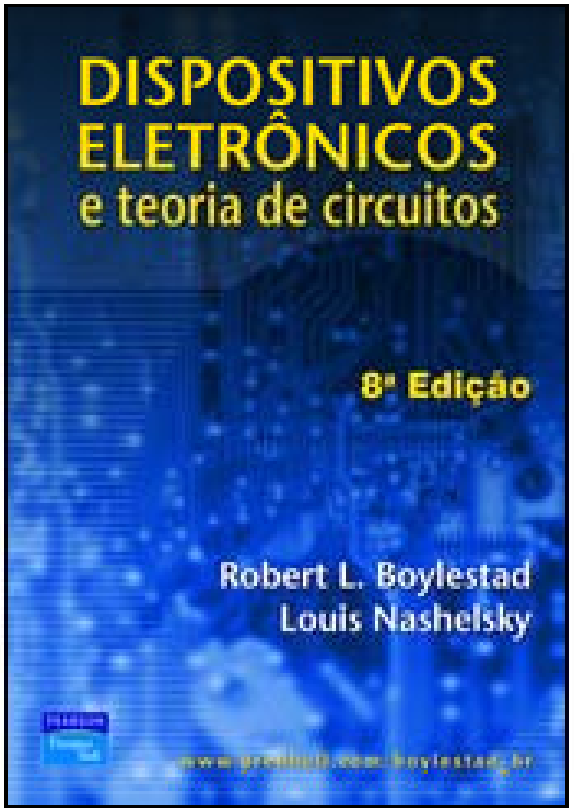
Triac



Na próxima aula

Seqüência de conteúdos:

1. Parte C – Diodos:
   - LEDs;
   - Fotodiodos;
2. Parte D – Transistores:
   - Fototransistores;
   - Optoacopladores;
3. Parte E – Outros dispositivos:
   - Células solares.
4. Parte F – Semicondutores de Carbeto de Silício (Silicon Carbide).



www.cefetsc.edu.br/~petry