ELECTRÓNICA DE POTENCIA

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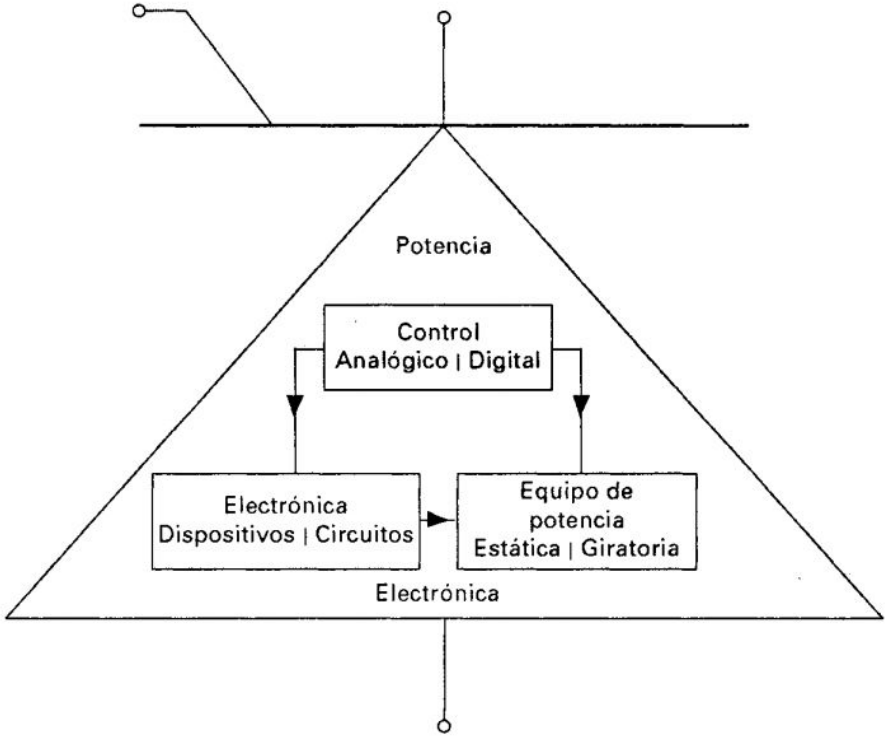
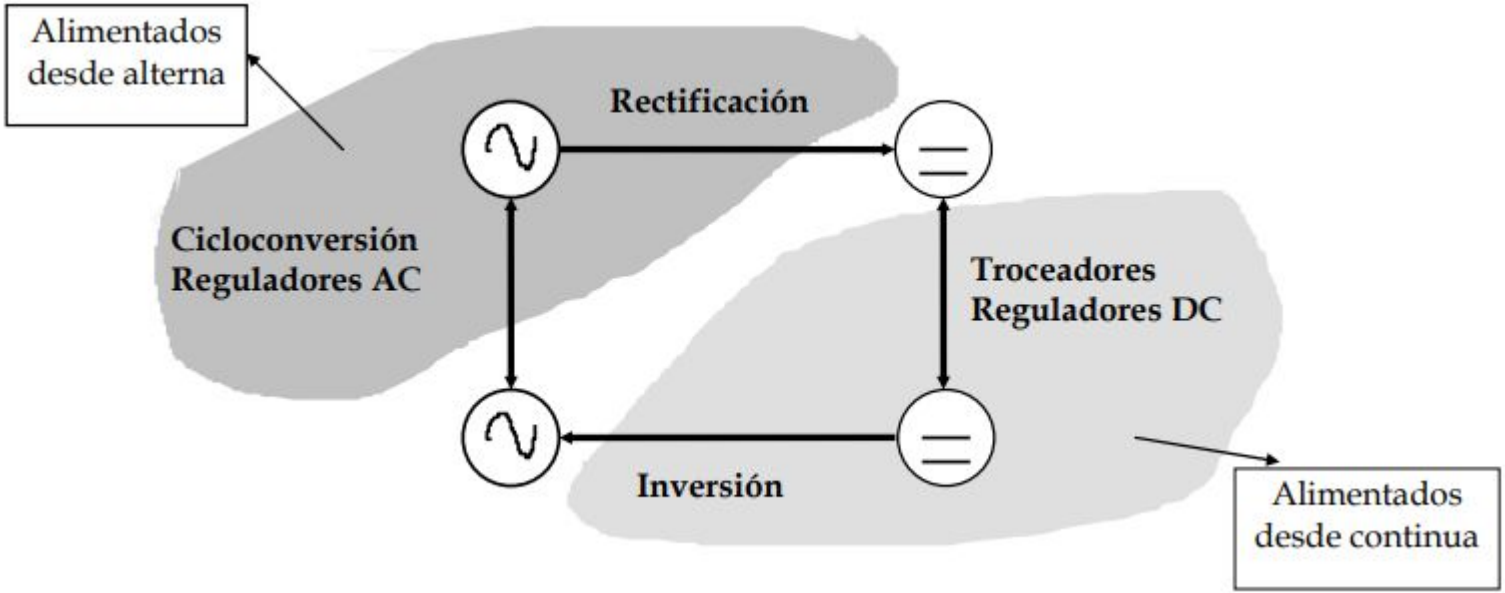
Ing. Mecatrónica

INTRODUCCIÓN

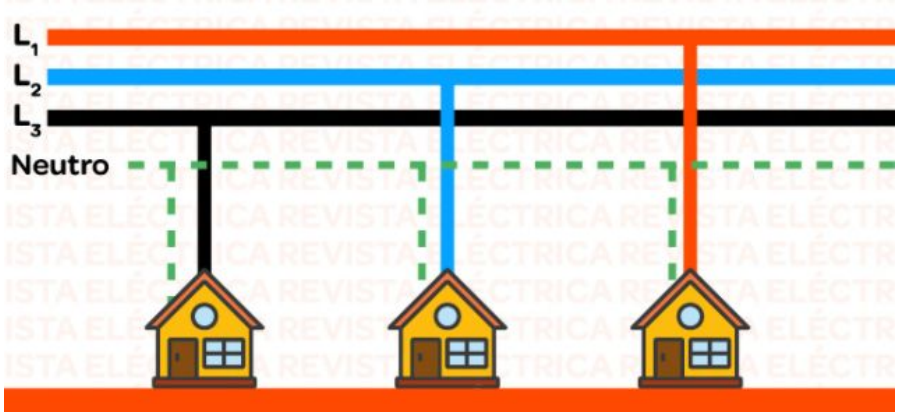
- Procesamiento, control y conversión de la energía eléctrica
- Aplicaciones
- Circuitos en **conmutación** (natural/forzada) y no en **amplificación**
- Semiconductores de potencia

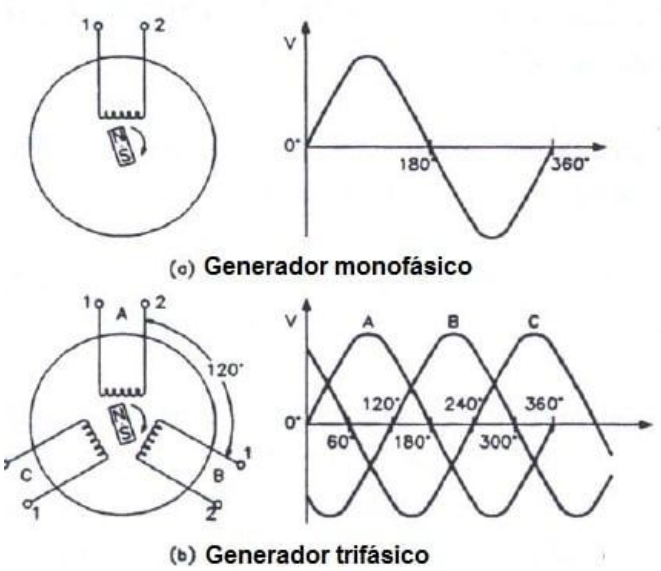


CONVERTIDORES



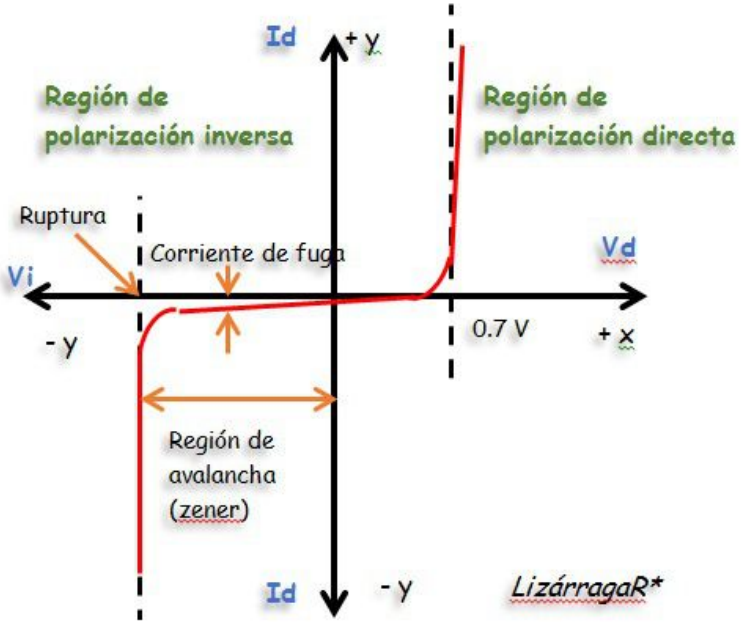
SISTEMAS MONOFÁSICOS Y TRIFÁSICOS

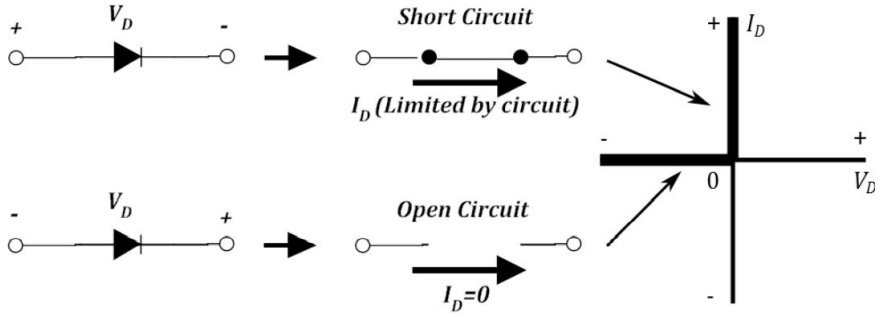


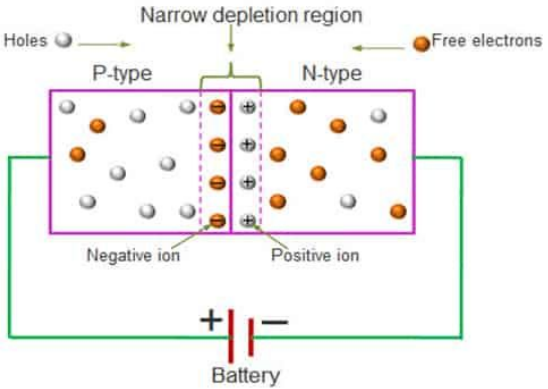


Comparación de las salidas monofásica y trifásica

DIODOS DE POTENCIA



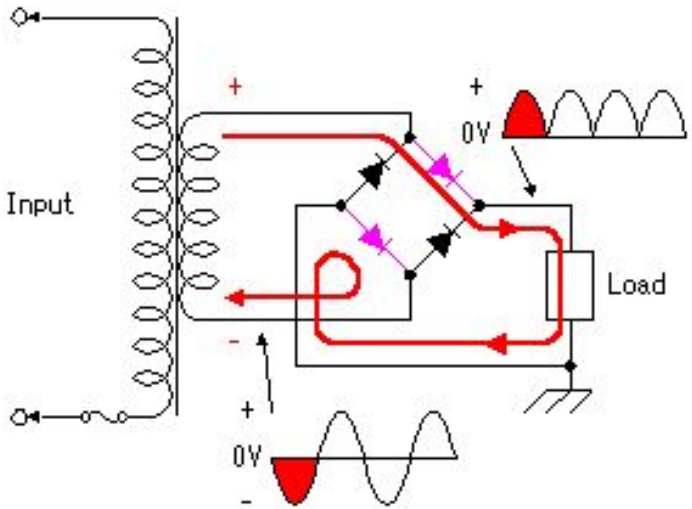




Forward bias

CONVERTIDOR CA/CD

- Se le conoce como rectificador
  - Media onda
  - Onda completa
  - Monofásico, trifásico
- Diodos semiconductores de potencia
- Aplicaciones:
  - Alimentación
  - Cargador
  - Control motores industriales
  - Transporte c.c. alta tensión



RECTIFICADOR DE MEDIA ONDA

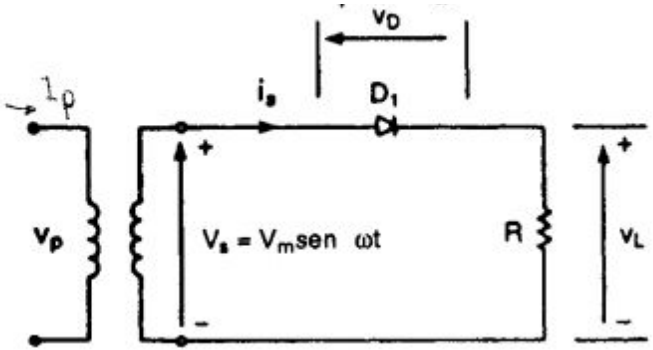
Eficiencia de conversión(σ) = 40.7%

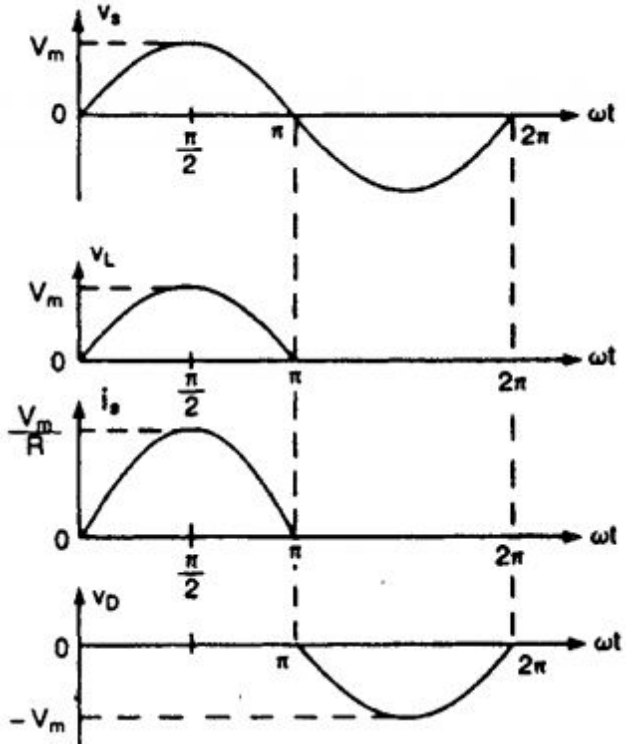
$$V_{cd} = \frac{V_m}{\pi} = 0.318V_m$$

$$I_{cd} = \frac{V_{cd}}{R} = \frac{0.318V_m}{R}$$

$$V_{rms} = \left[\frac{1}{T}\int_0^{T/2} (V_m \operatorname{sen} \omega t)^2 \, dt\right]^{1/2} = \frac{V_m}{2} = 0.5V_m$$

$$I_{rms} = \frac{V_{rms}}{R} = \frac{0.5V_m}{R}$$





RECTIFICADOR MONOFÁSICO DE ONDA COMPLETA

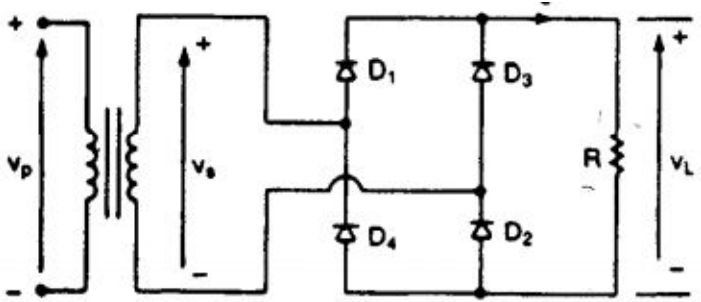
$$V_{cd} = \frac{2V_m}{\pi} = 0.6366V_m$$

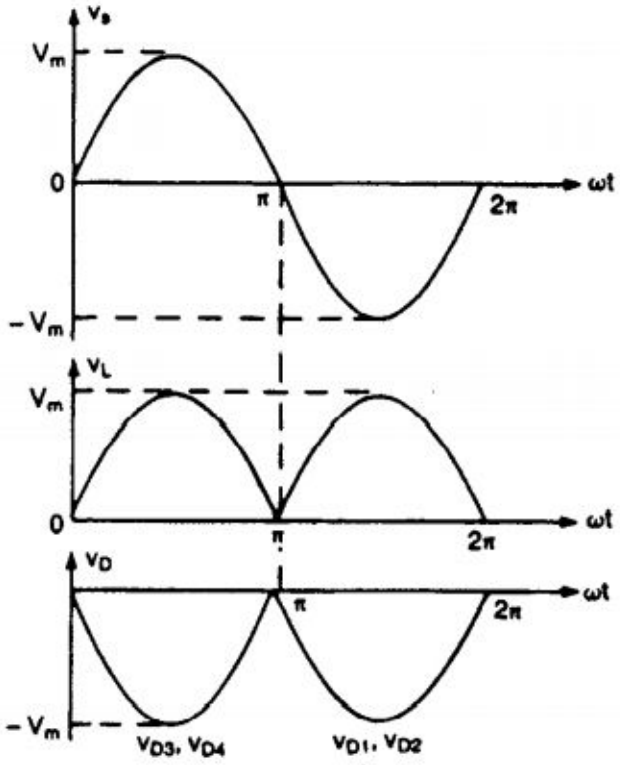
$$I_{cd} = \frac{V_{cd}}{R} = \frac{0.6366V_m}{R}$$

$$V_{rms} = \left[\frac{2}{T}\int_0^{T/2} (V_m \operatorname{sen} \omega t)^2 \, dt\right]^{1/2} = \frac{V_m}{\sqrt{2}} = 0.707V_m$$

$$I_{rms} = \frac{V_{rms}}{R} = \frac{0.707V_m}{R}$$

σ = 81%





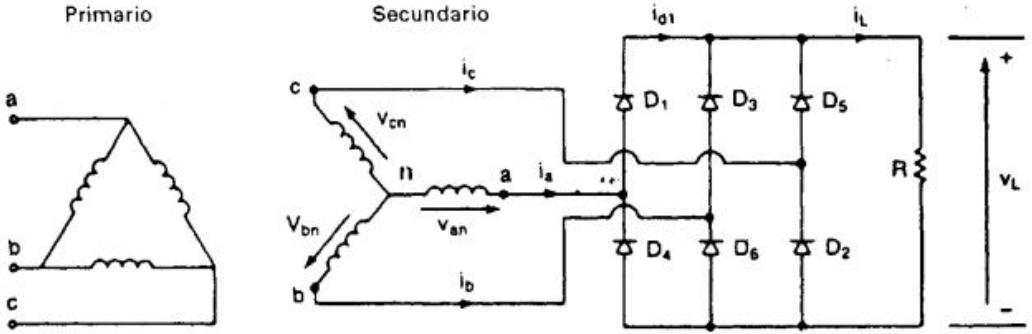
RECTIFICADOR TRIFÁSICO

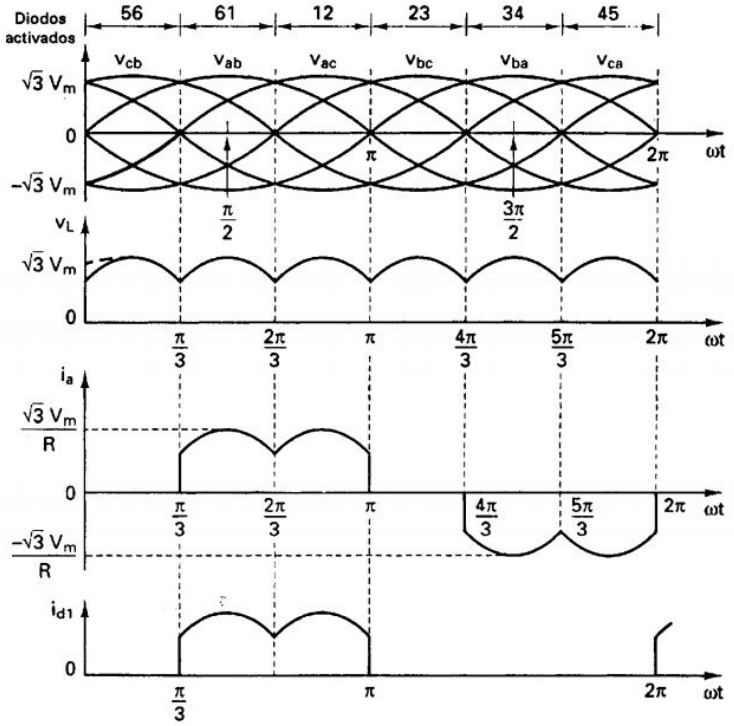
$$V_{cd} = \frac{2}{2\pi/6}\int_0^{\pi/6} \sqrt{3}\, V_m \cos \omega t \, d(\omega t)$$

$$= \frac{3\sqrt{3}}{\pi} V_m = 1.654 V_m$$

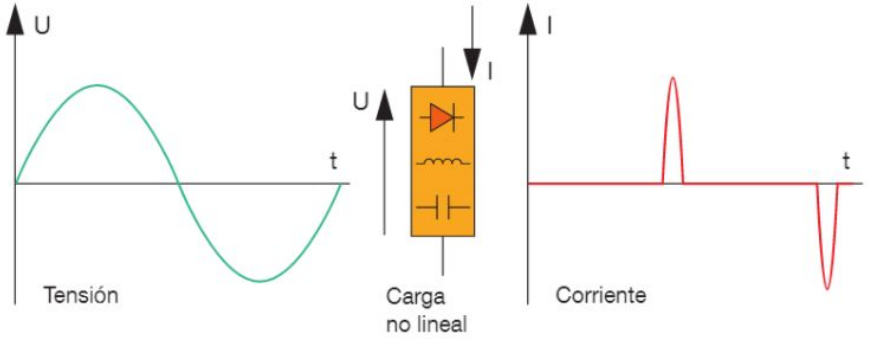
$$V_{rms} = \left[\frac{2}{2\pi/6}\int_0^{\pi/6} 3V_m^2 \cos^2 \omega t \, d(\omega t)\right]^{1/2}$$

$$= \left(\frac{3}{2} + \frac{9\sqrt{3}}{4\pi}\right)^{1/2} V_m = 1.6554 V_m$$

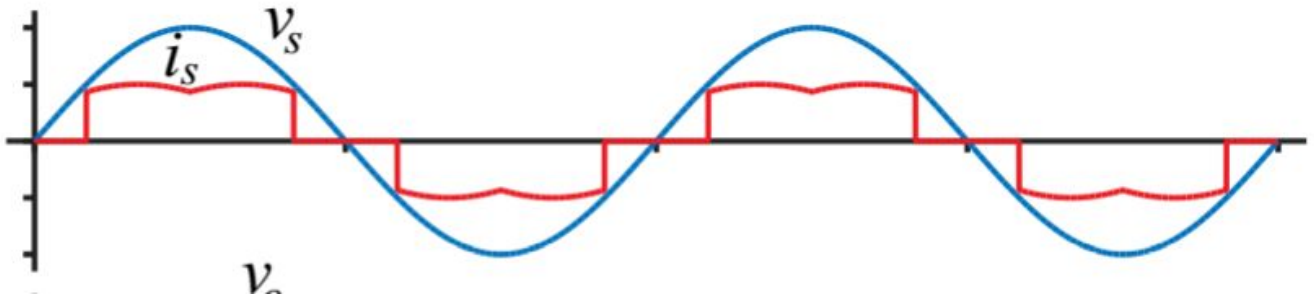




ARMÓNICOS

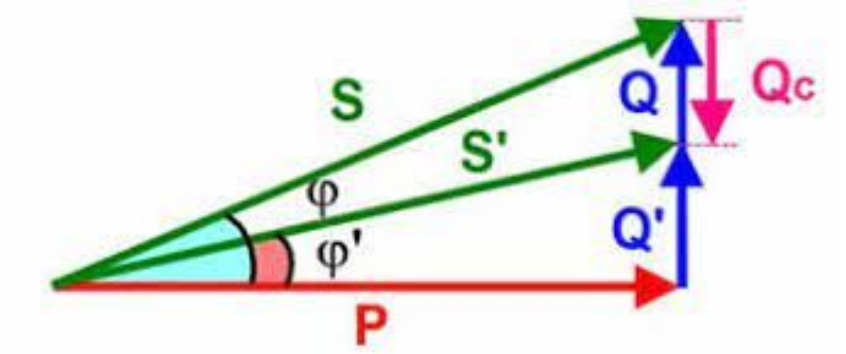


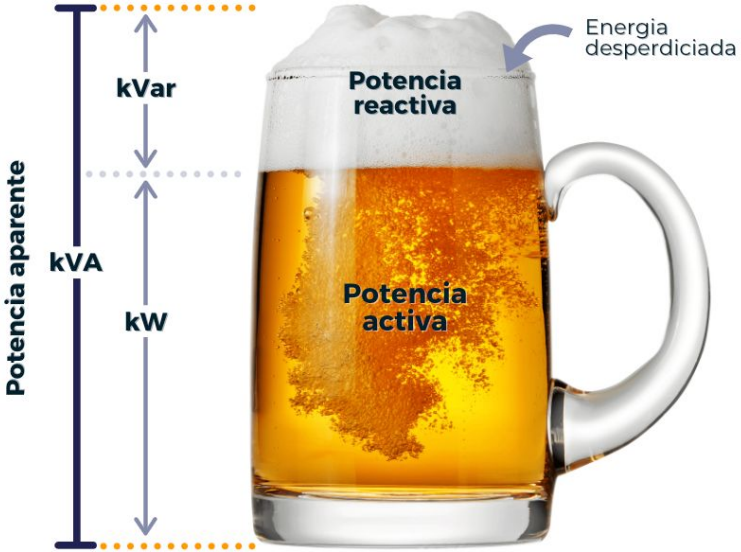
- Carga no lineal
- Distorsiones
- Filtros pasivos (LC) y activos



FACTOR DE POTENCIA

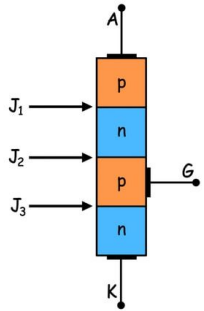
- FP = COSϴ = P/S
- P = VI COSϴ
- Q = VI SENϴ
- S = VI = P+Q
- Carga inductiva retrasa la i (+Q)
- Carga capacitiva adelanta la i (-Q)

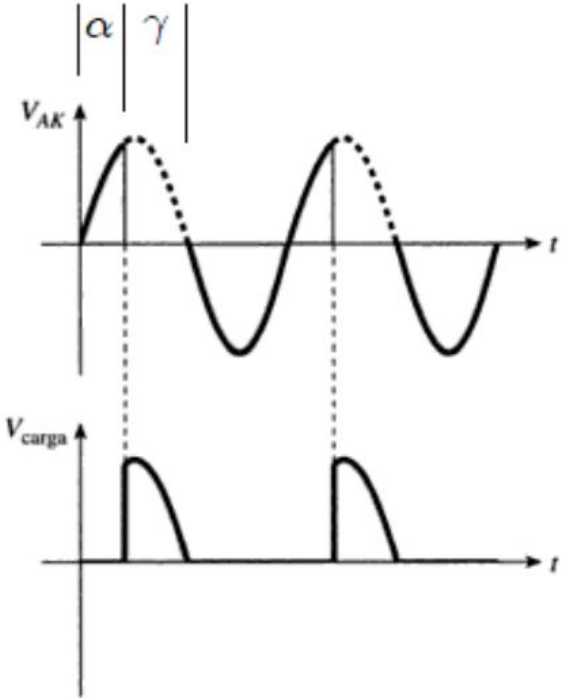


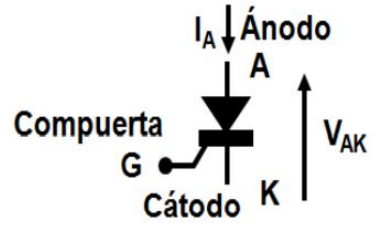


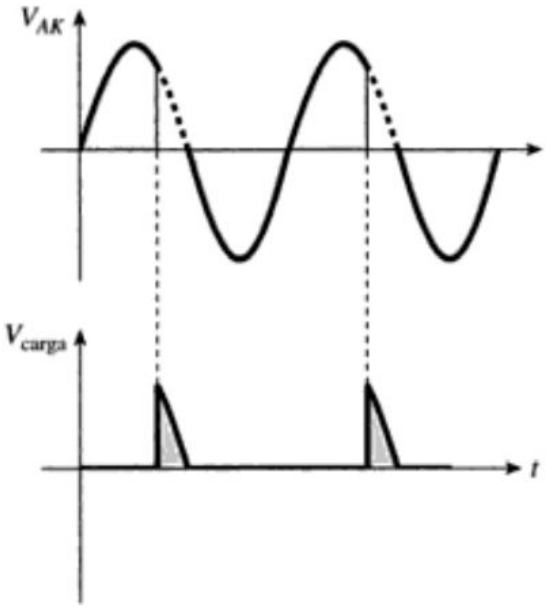
TIRISTORES

- α = angulo de disparo
- ß = ángulo de conducción









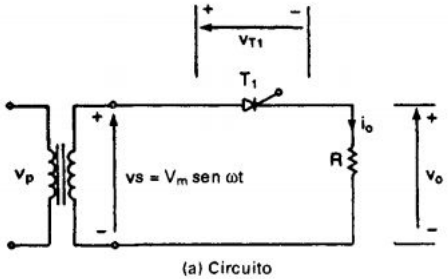
RECTIFICADOR CONTROLADO MEDIA ONDA

$$V_{cd} = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_m \operatorname{sen}\omega t\, d(\omega t) = \frac{V_m}{2\pi}[-\cos\omega t]_{\alpha}^{\pi}$$

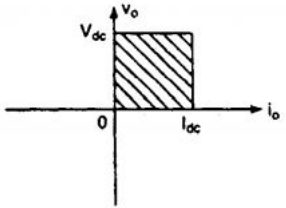
$$= \frac{V_m}{2\pi}(1 + \cos\alpha)$$

$$V_{dm} = \frac{V_m}{\pi}$$

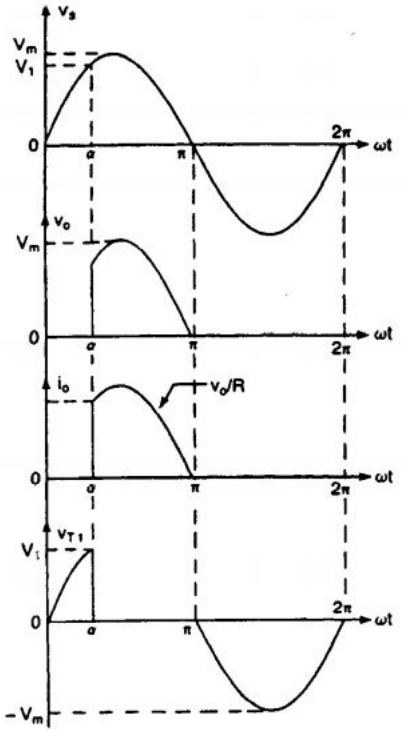
Vdm = 54V



(a) Circuito



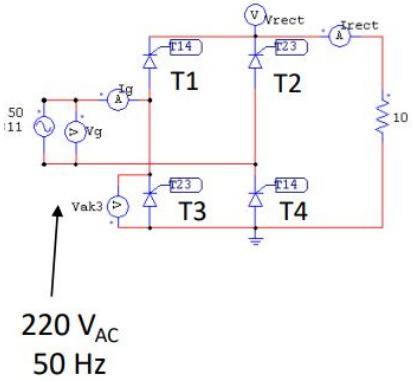
(b) Cuadrante

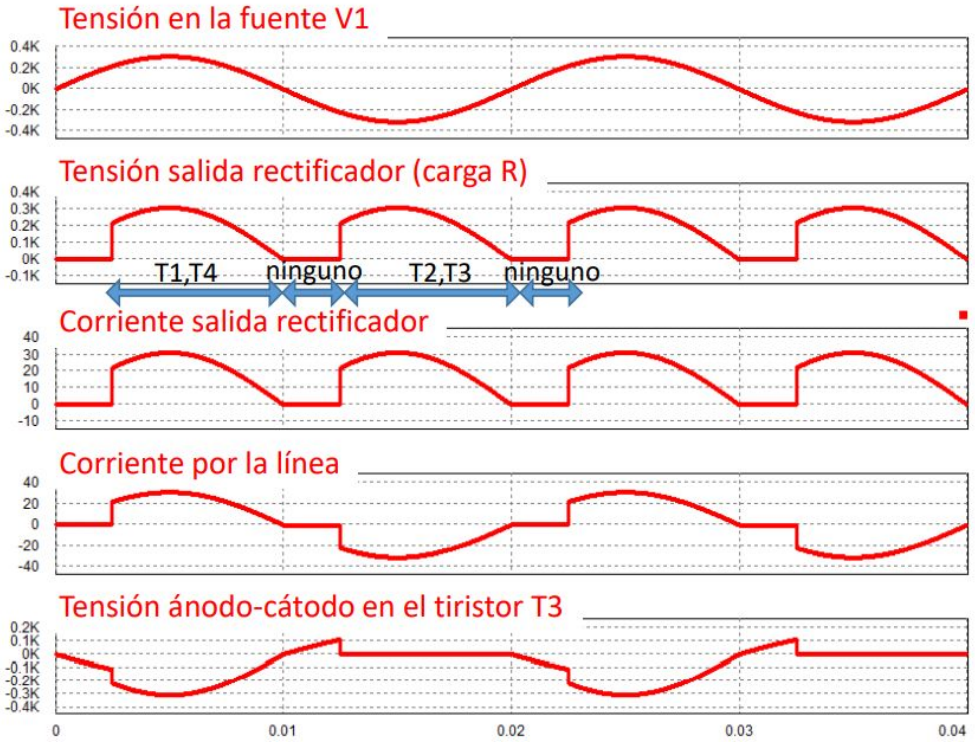


(c) Formas de onda

- Control de motores
- Fuentes de alimentación reguladas
- Control de calefacción
- Control de relevador

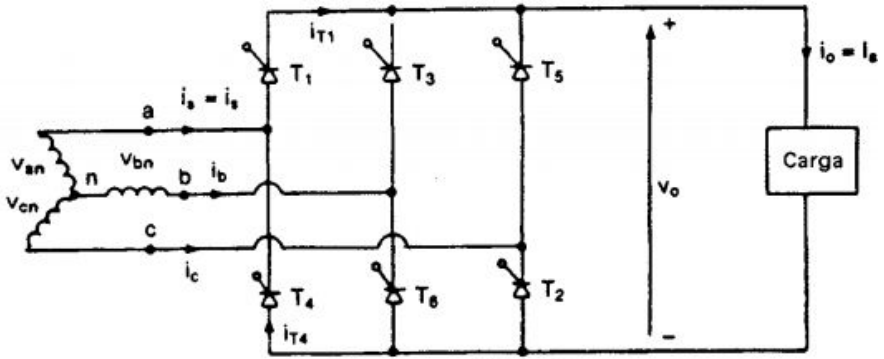
RECTIFICADOR CONTROLADO DE ONDA COMPLETA



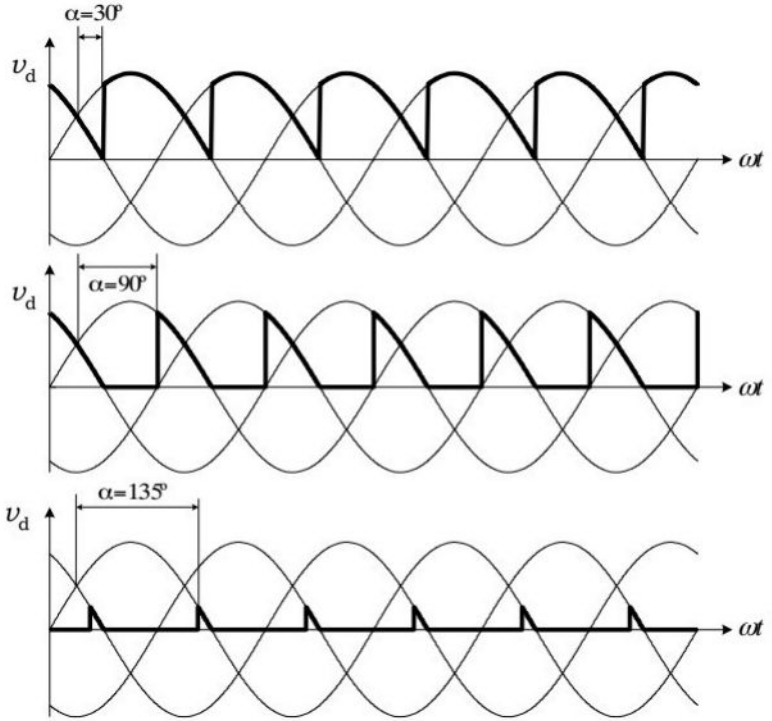


- VCD = A/π (1 + cosα)
- VDm = 2Vm/2
- **VDm = 108V**

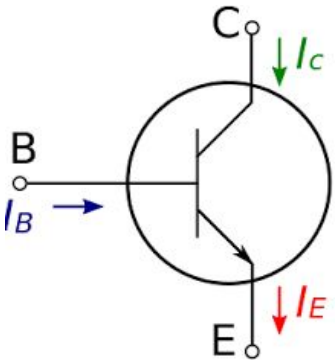
RECTIFICADOR TRIFÁSICO CONTROLADO



(a) Circuito



TRANSISTORES DE POTENCIA



BIPOLAR

Es controlado por corriente (IB)

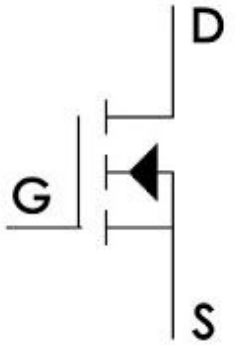
Amplif o conmutar señales

MOSFET (Enriquecimiento)

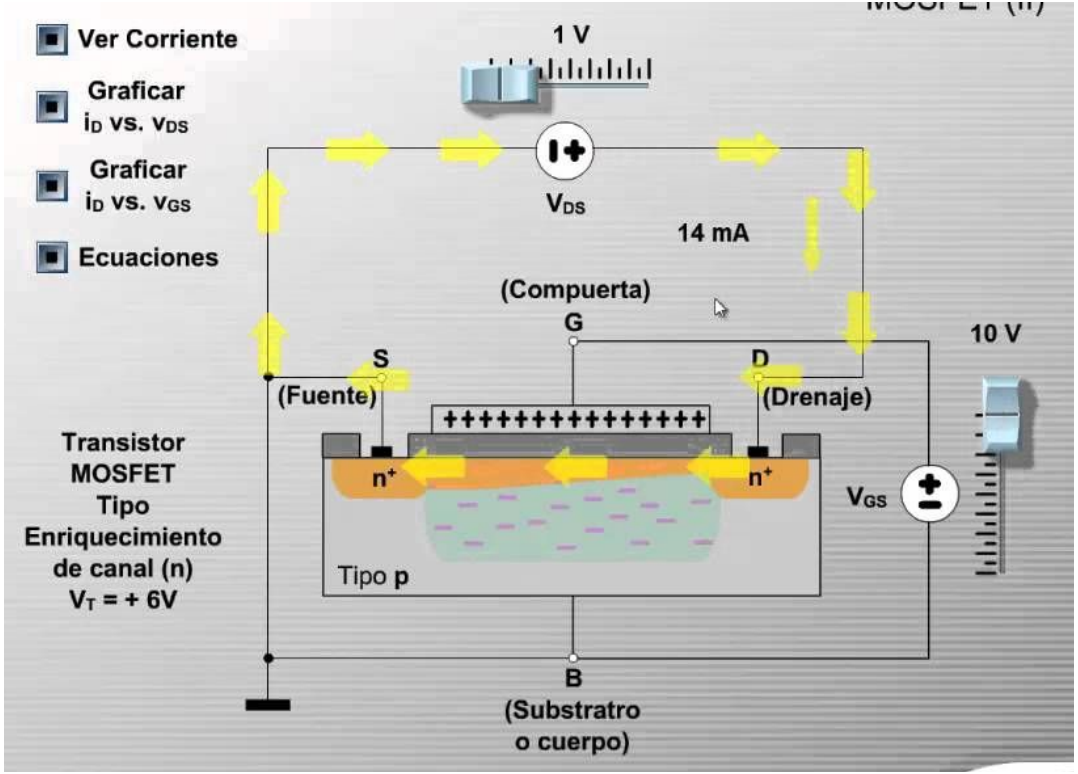
Es controlado por voltaje

Amplif o conmutar señales

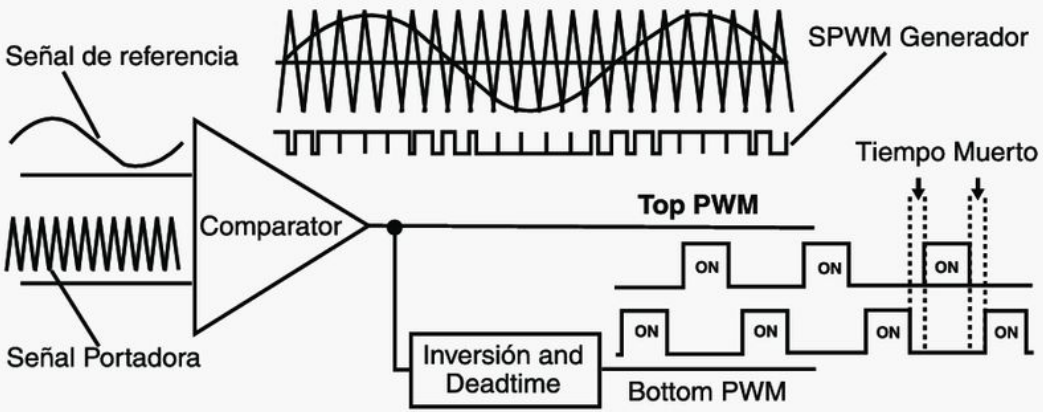
MOSFET Canal N



MOSFET


Ver Corriente
Graficar
i_D vs. v_{DS}
Graficar
i_D vs. v_{GS}
Ecuaciones
1 V
V_{DS}
14 mA
(Compuerta)
G
S
(Fuente)
D
(Drenaje)
10 V
Transistor
MOSFET
Tipo
Enriquecimiento
de canal (n)
V_T = + 6V
n+
n+
Tipo p
V_{GS}
B
(Substratro
o cuerpo)

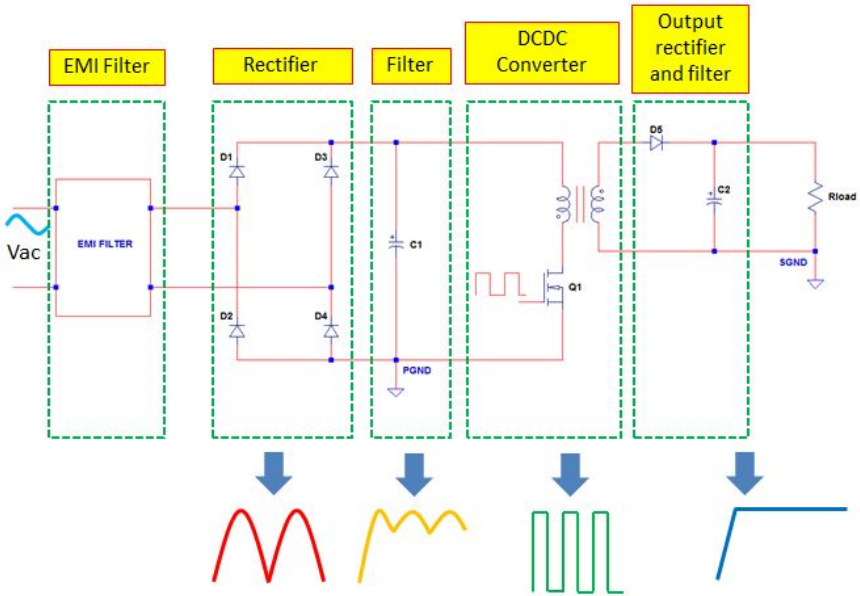
PWM



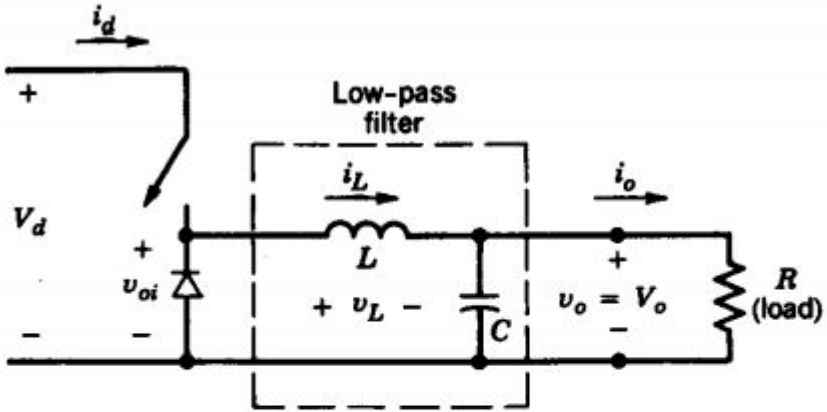
- Sistema de control para convertidores CD/CA y CD/CD
- Índice de amplitud de modulación (**ma**) = **Vp-control/Vp-tri**
- Índice de modulación de frecuencia (**mf**) = **f-tri/f-control**
- **fPWM = f-tri**
- **ton = Vm-control**

CONVERTIDOR CD/CD

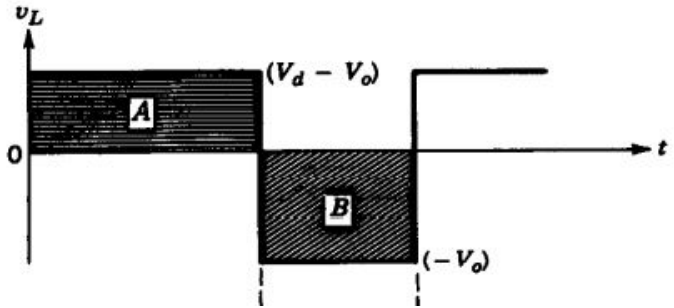
- Voltaje regulado a partir de voltaje no regulado
- Tipos:
  - Bajada (Buck)
  - Subida (Boost)
  - Bajada-Subida (Buck-Boost)
- Aplicaciones:
  - Alimentación y control de motores CD
  - Fuentes de alimentación reguladas

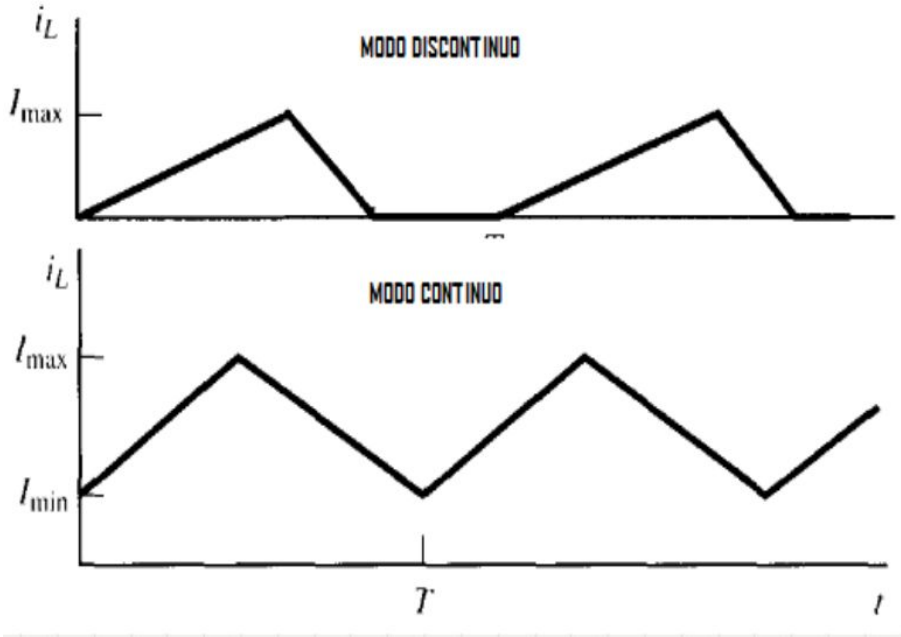


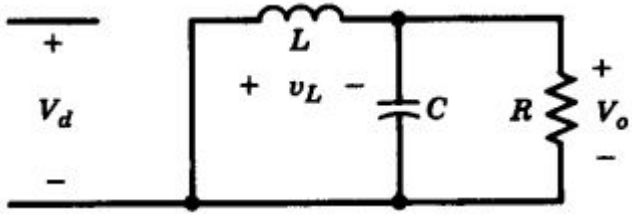
CONVERTIDOR DE BAJADA (BUCK)



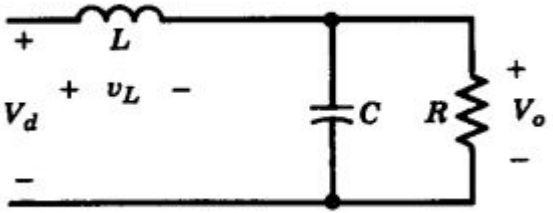
- Voltaje de salida promedio menor al voltaje de alimentación
- **Vo = DVd**
- **Io = Id/D**





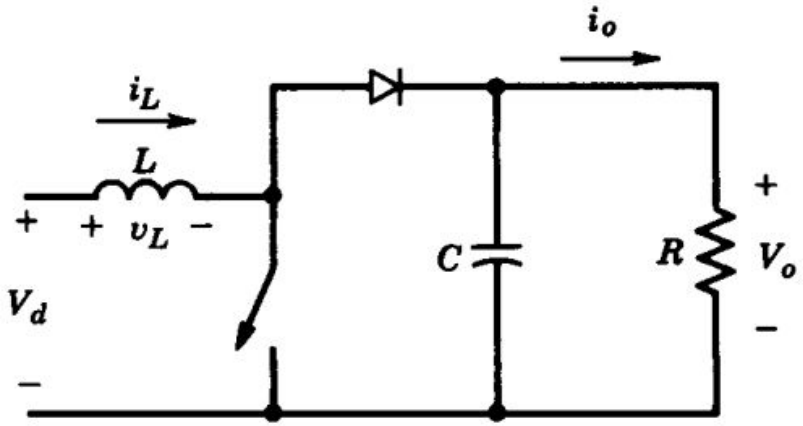


Toff
VL = -Vo
L cambia de polaridad

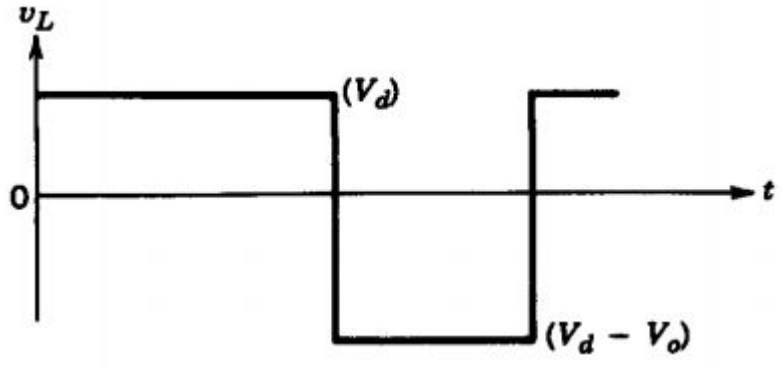


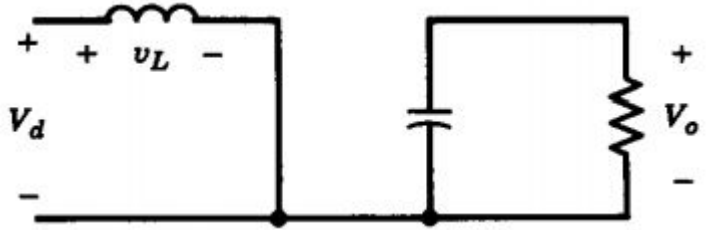
Ton
VL= Vd-Vo

CONVERTIDOR DE SUBIDA (BOOST)



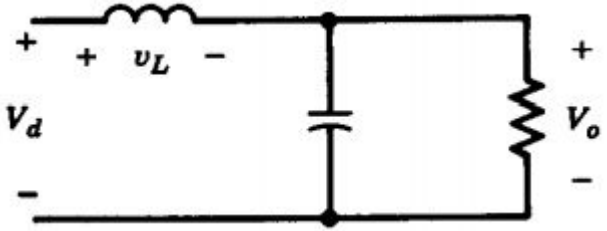
- Voltaje de salida promedio mayor al voltaje de alimentación
- **Vo = Vd/(1-D)**
- **Io = Id(1-D)**





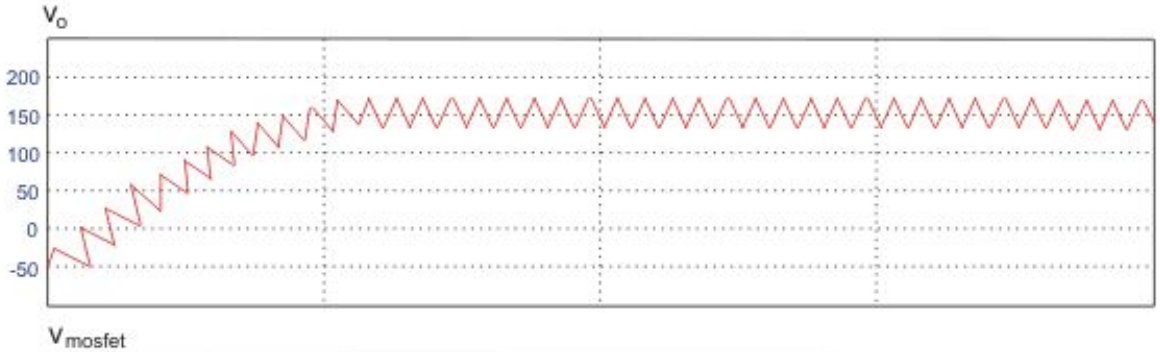
Ton

VL = Vd

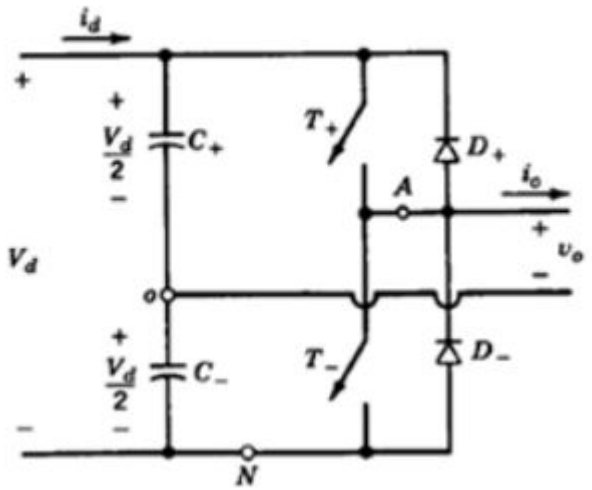


Toff

VL = Vd-Vo

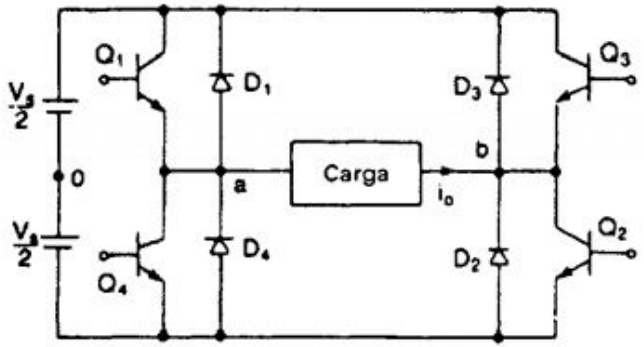


CONVERTIDOR DE CD/CA (INVERSOR)

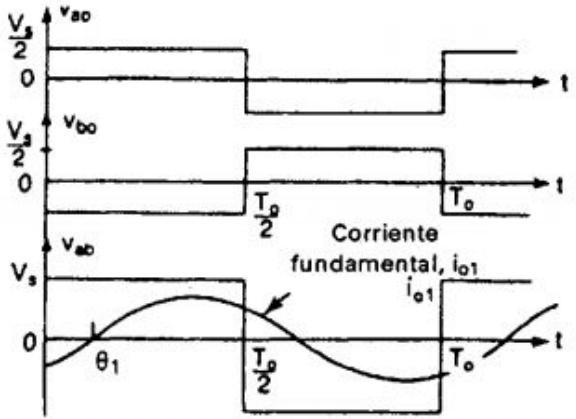


- Transforma CC a CA de frecuencia fija o variable
- Aplicaciones:
  - Convertidores corriente continua en alterna para fuentes no convencionales, tales como la fotovoltaica o eólica

INVERSOR MONOFÁSICO



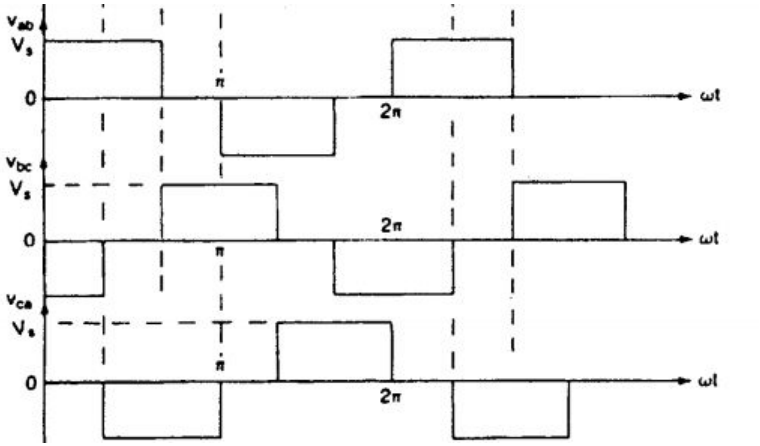
(a) Circuito

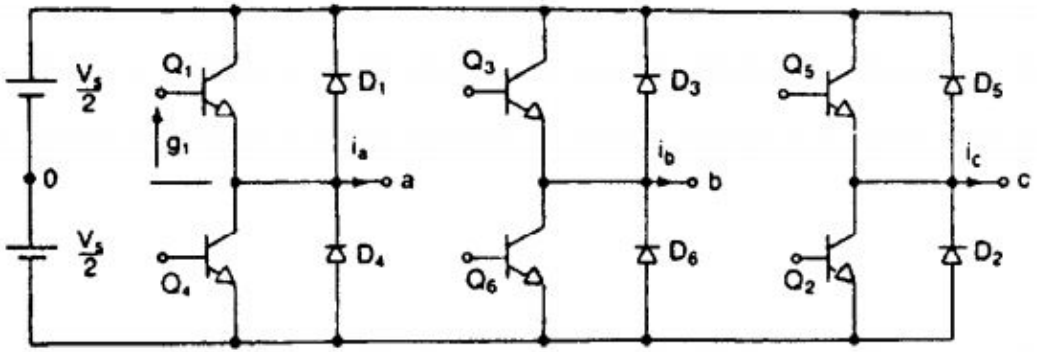


(b) Formas de onda

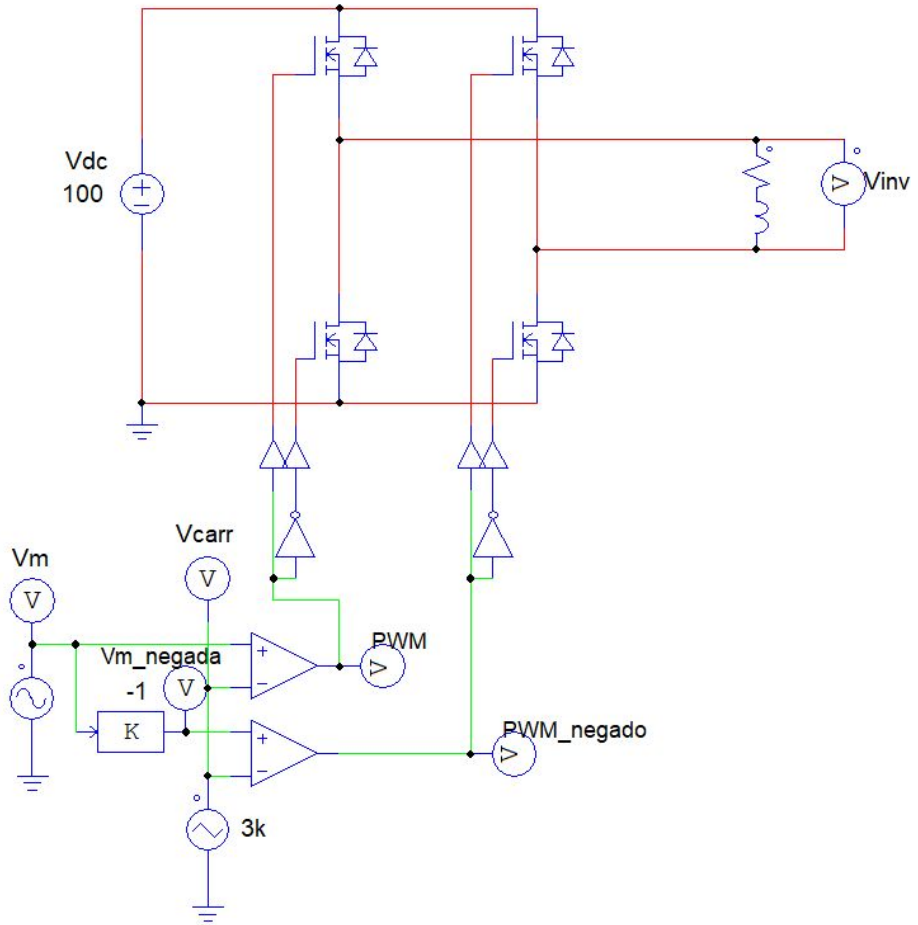
- 2 MOSFETs con PWM
- 2 MOSFETS con PWM negativo

INVERSOR TRIFÁSICO

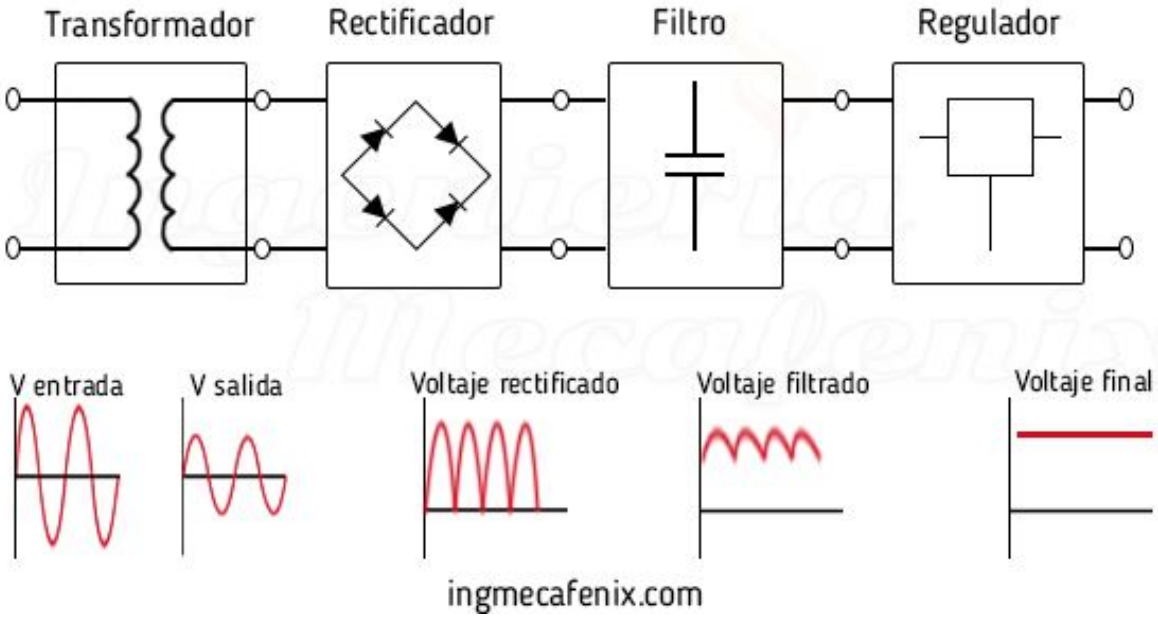




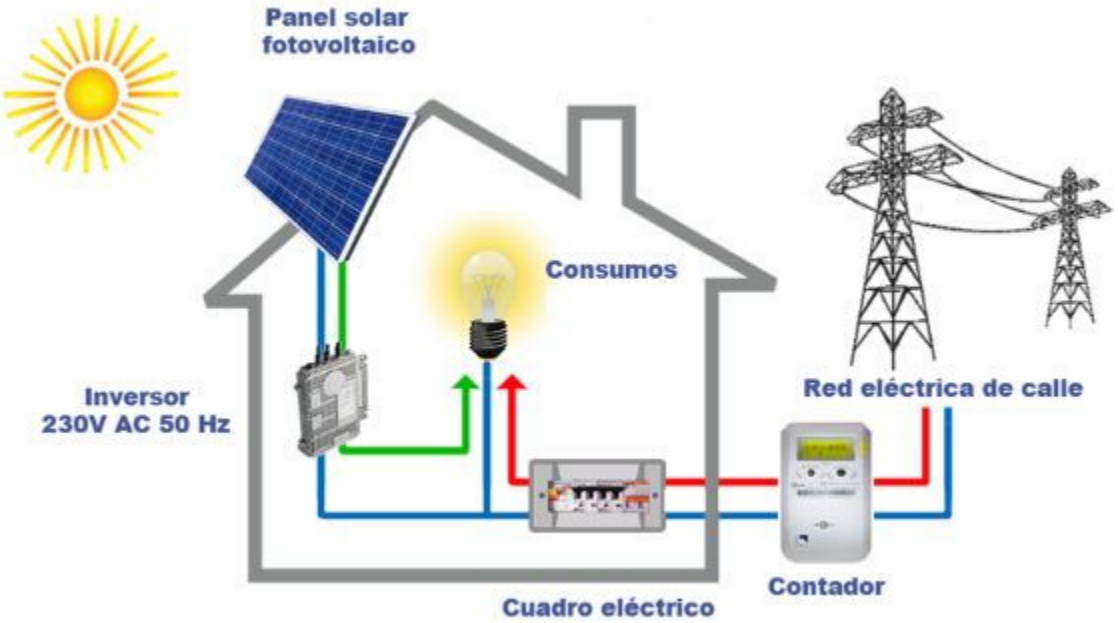
(a) Circuito


Vdc
100
Vinv
Vcarr
Vm
V
Vm_negada
-1
K
PWM
PWM_negado
3k

FUENTES DE PODER



GENERACIÓN FOTOVOLTAICA



TRACCIÓN ELÉCTRICA