

Electrónica de potencia

1 Introducción Componentes

ELECTRÓNICA

SEÑALES

- DE COMUNICACIONES
- ANALÓGICA
- DIGITAL
- INSTRUMENTACIÓN
- DE POTENCIA**

POTENCIA, ENREGÍA RENDIMIENTO

COMPONENTES DE LA ELECTRÓNICA DE POTENCIA

PASIVOS

Transformadores
Bobinas
Condensadores

....

Componentes

No controlados

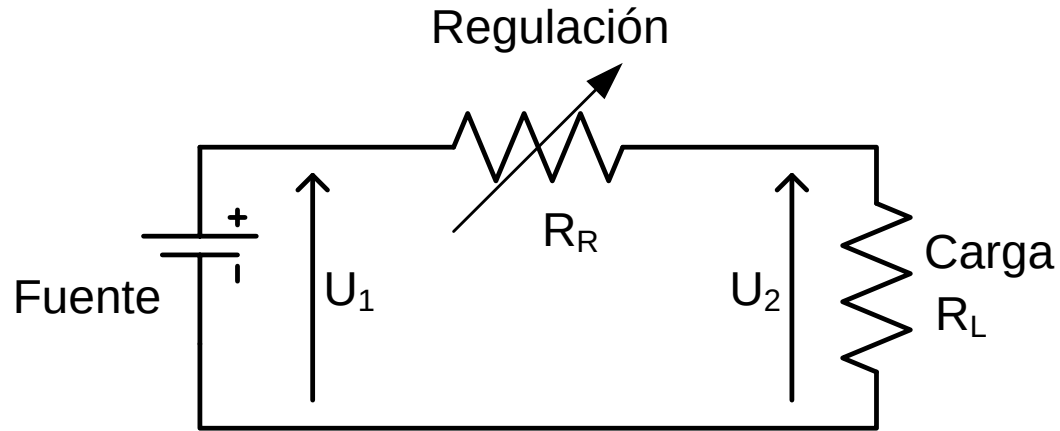
Diodos

Controlados

Control total

Control de encendido

Es necesario transformar la energía eléctrica de las fuentes para ser utilizada adecuadamente por las cargas

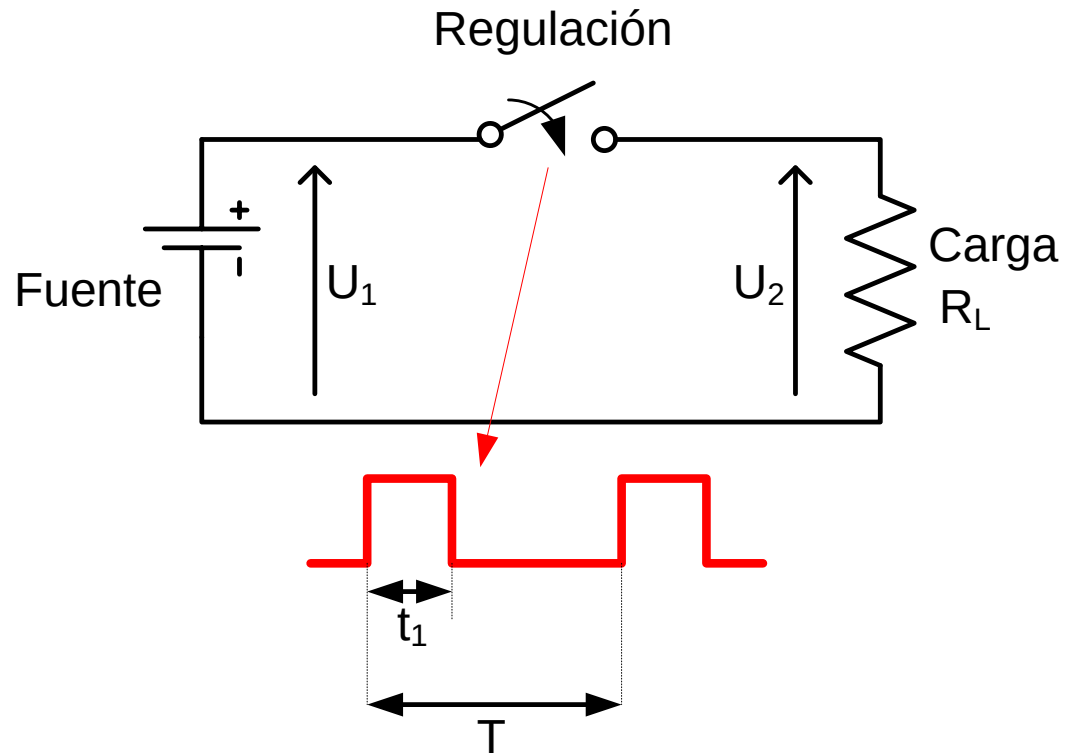


Rendimiento

$$U_2 = \frac{R_L}{R_L + R_R} U_1$$

$$\eta = \frac{U_2 I}{U_1 I} = \frac{R_L}{R_L + R_R}$$

Mejora del rendimiento

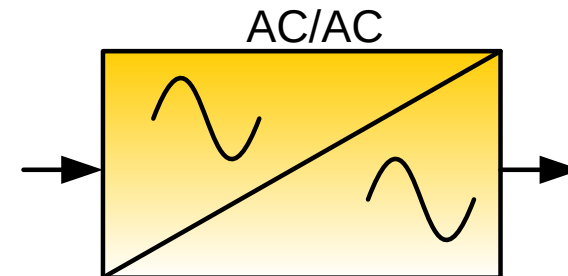
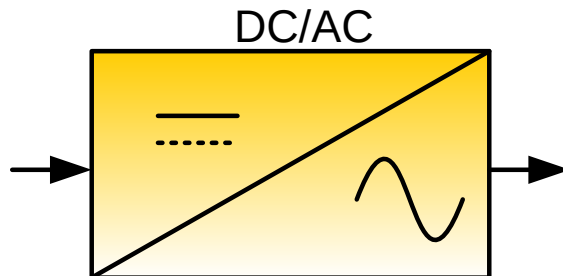
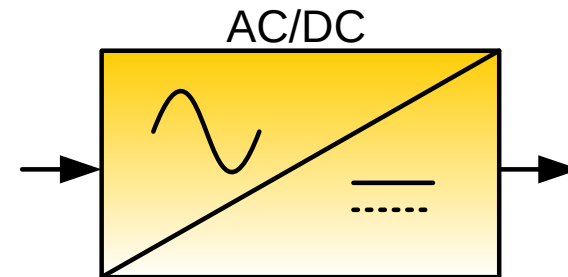
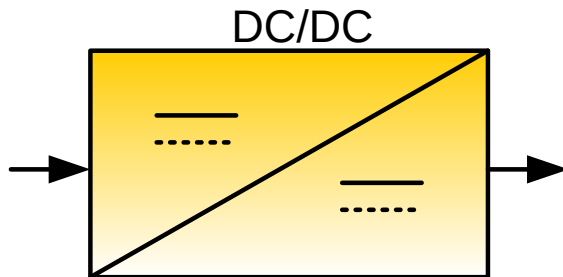


$$U_2 = \frac{t_1}{T} U_1$$

$$\eta = 1$$

CONVERTIDORES: TIPOS

- | | |
|------------------------|--------------|
| ▪ TROCEADORES | <i>DC/DC</i> |
| ▪ RECTIFICADORES | <i>AC/DC</i> |
| ▪ INVERSORES | <i>DC/AC</i> |
| ▪ (CICLO)CONVERTIDORES | <i>AC/AC</i> |



COMPONENTES DE LA ELECTRÓNICA DE POTENCIA

■ NO CONTROLADOS

- o *Diodo*
- o *Diac*

CONTROLADOS

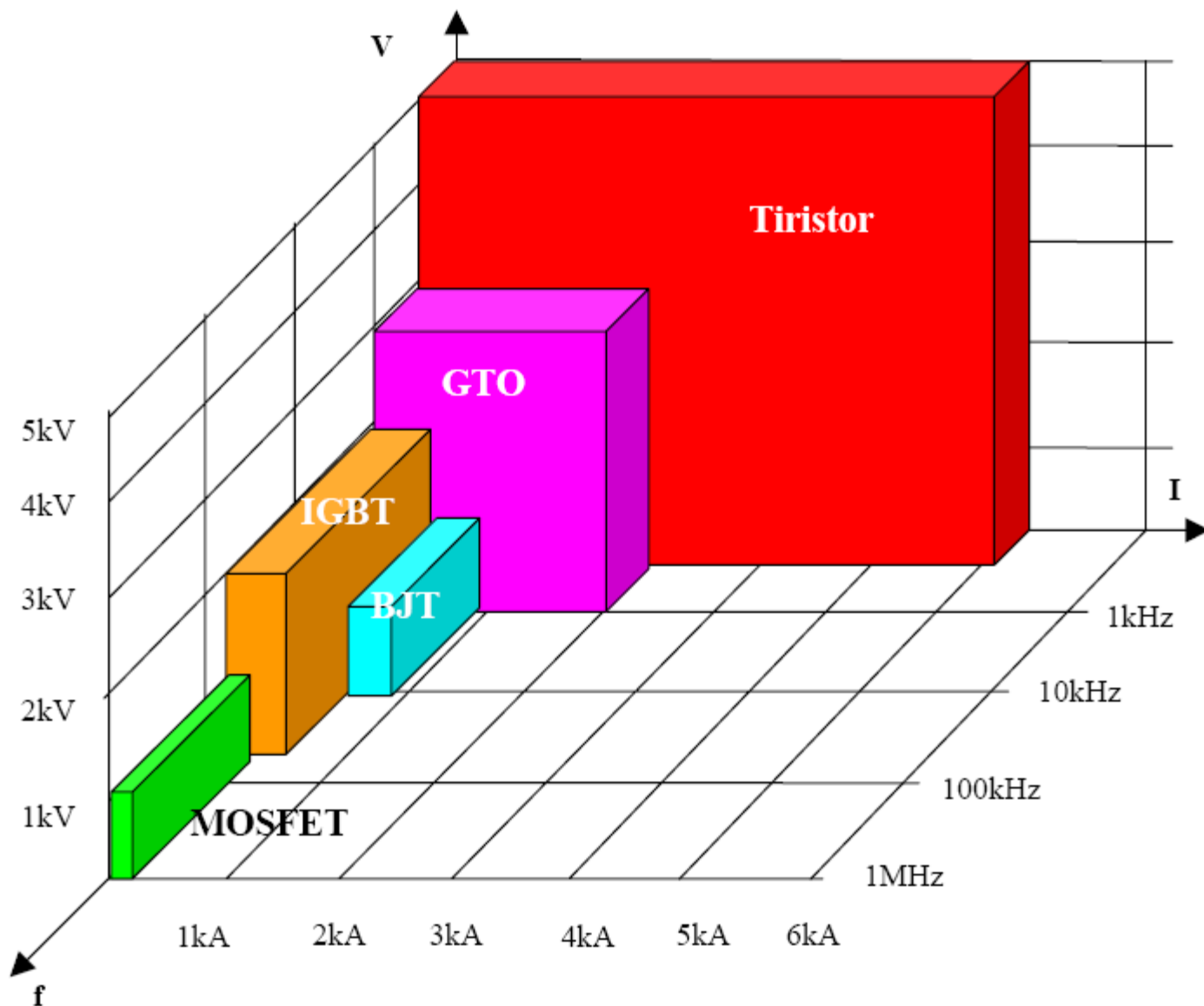
o *Transistores*

- Bipolar
- MOS
- IGBT

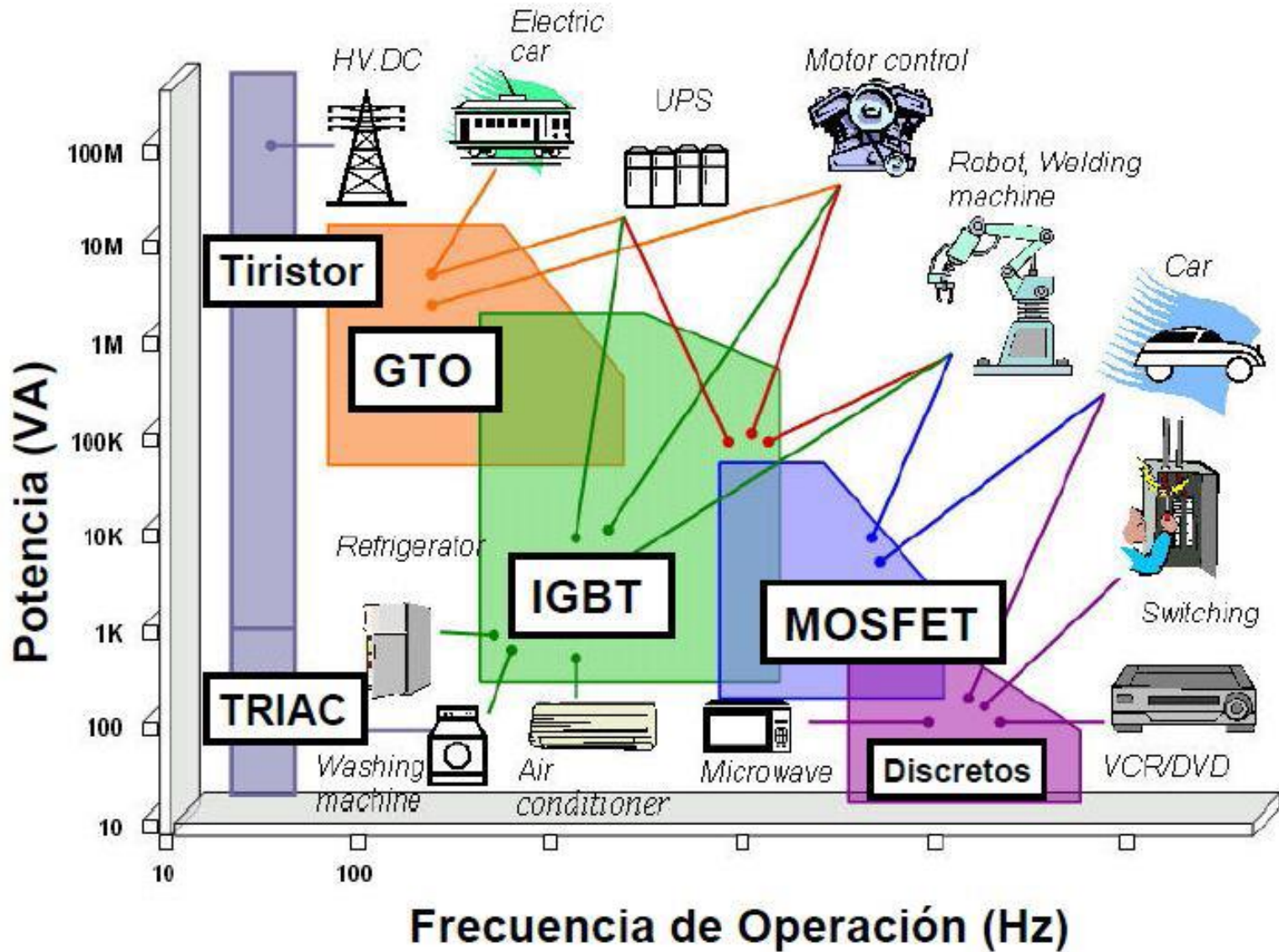
o *Tiristores*

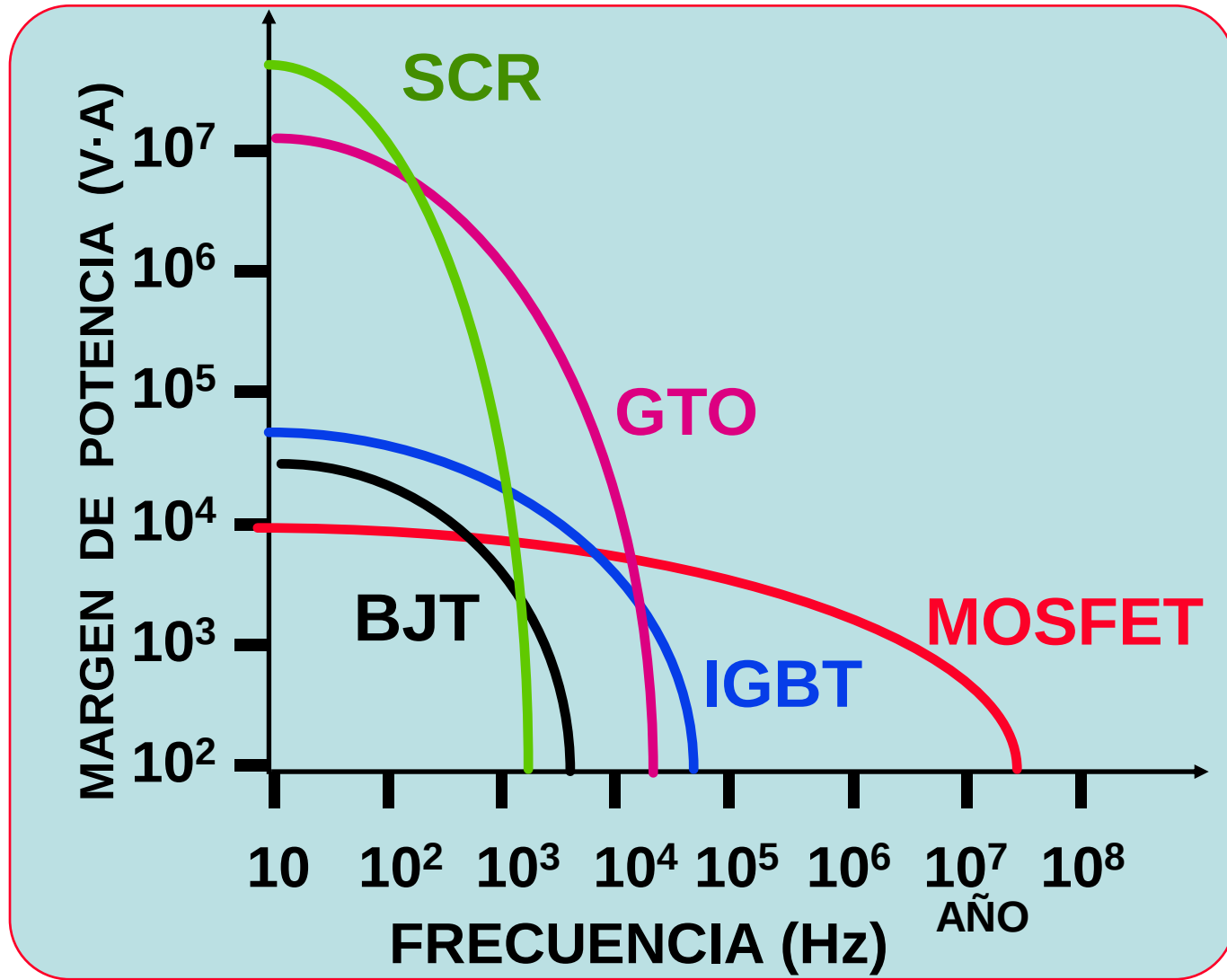
- Tirisitor
- GTO
- IGCT
- Triac
- ETO

COMPONENTES: Límites de utilización



COMPONENTES: Aplicaciones





COMPONENTES: Comparativa

	<i>Dispositivos</i>					
	DIODO	SCR	GTO	BJT	MOSFET	IGBT
Características de disparo	-----	En corriente	En corriente	En corriente	En tensión	En tensión
Potencia del circuito de mando	-----	Media - Alta	Alta	Media - Alta	Muy baja	Muy Baja
Complejidad del circuito de mando	-----	Baja	Alta	Alta	Muy Baja	Muy Baja
Densidad de corriente	Media p/ Alta	Alta	Media - Alta	Media	Alta - Baja	Alta
Máxima tensión inversa	Media	Alta	Alta	Baja - Media	Media - Baja	Media - Alta
Perdidas en conmutación (circuitos convencionales)	Baja p/ media	Alta	Alta	Media - Alta	Muy Baja	Media - Alta

COMPONENTES “ON/OFF”

Tiristores

EST (Emitter-Switched Thyristor)

IGTT (Insulated Gate Turn-off Thyristor)

IGT (Insulated Gate Thyristor)

MTO (MOS Turn-Off thyristor)

GTO (Gate Turn-Off thyristor)

MCT (MOS-Controlled Thyristor)

FCT (Field-Controlled Thyristor)

IGCT (Integrated Gate-Commutated Thyristor)

Transistores

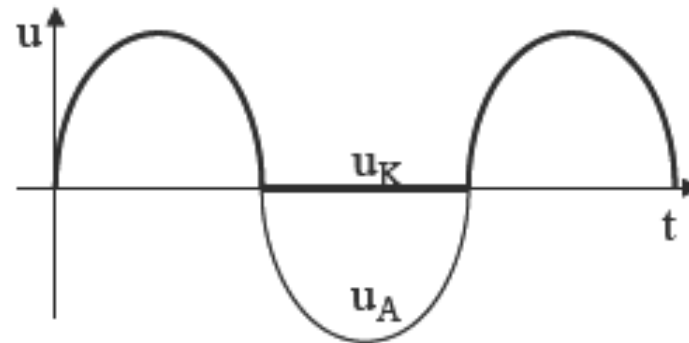
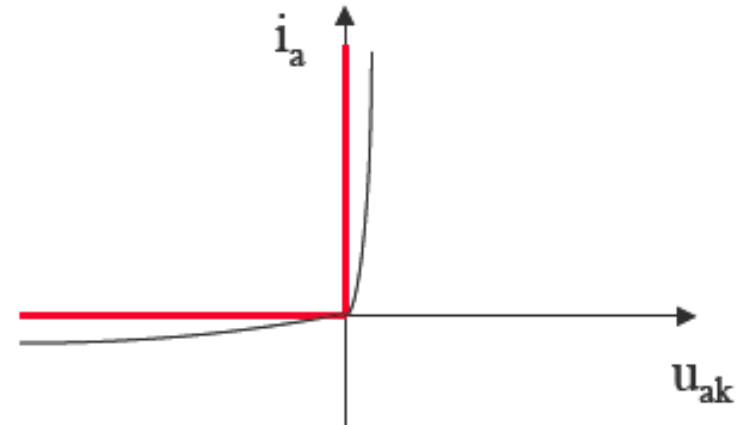
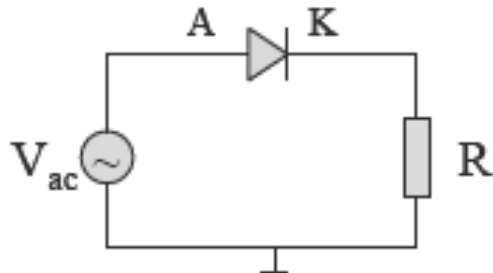
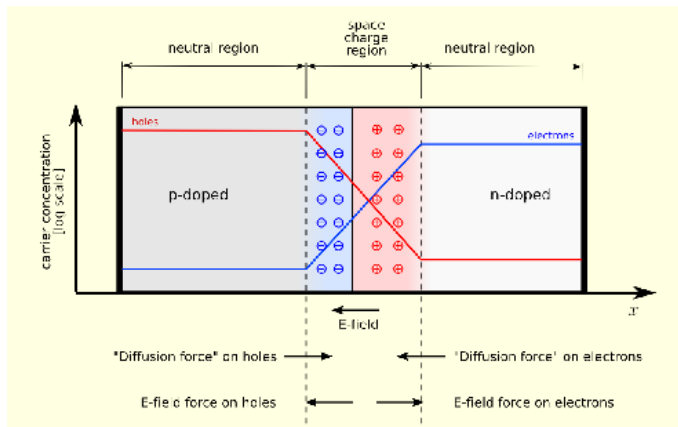
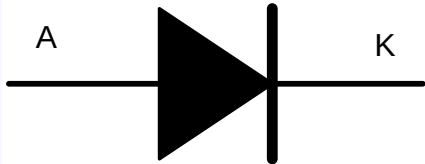
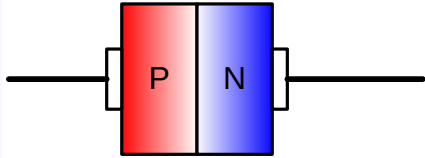
IGBT (Insulated Gate Bipolar Transistor)

Bipolar

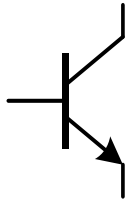
Darlington

MOSFET

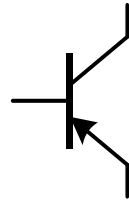
DIODO



Transistor bipolar

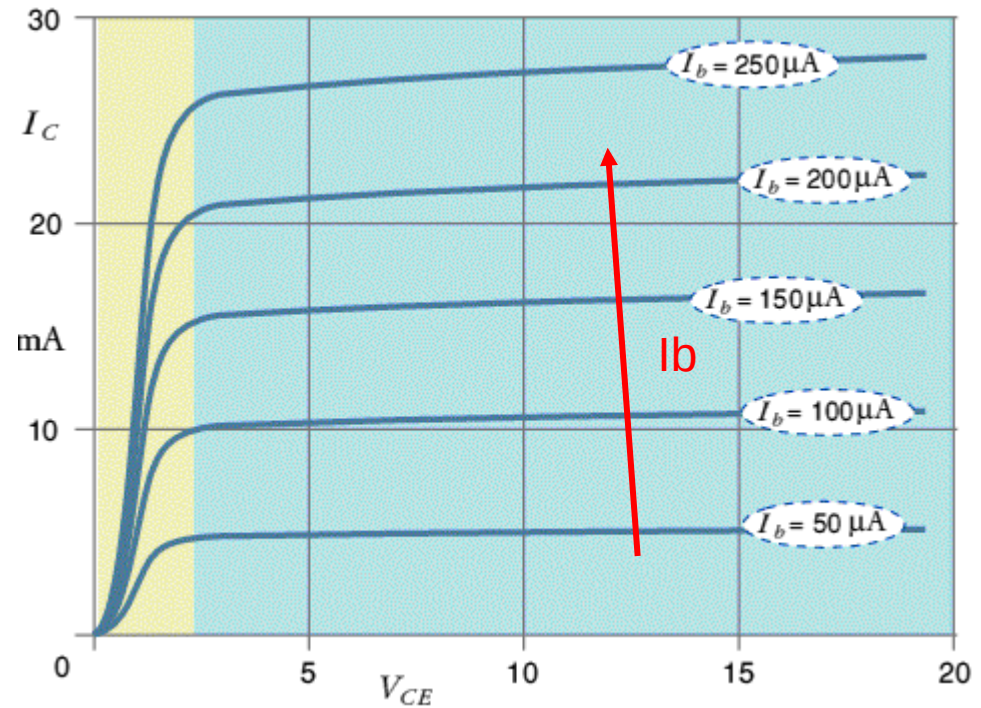
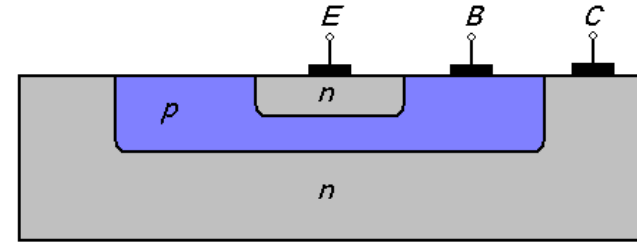


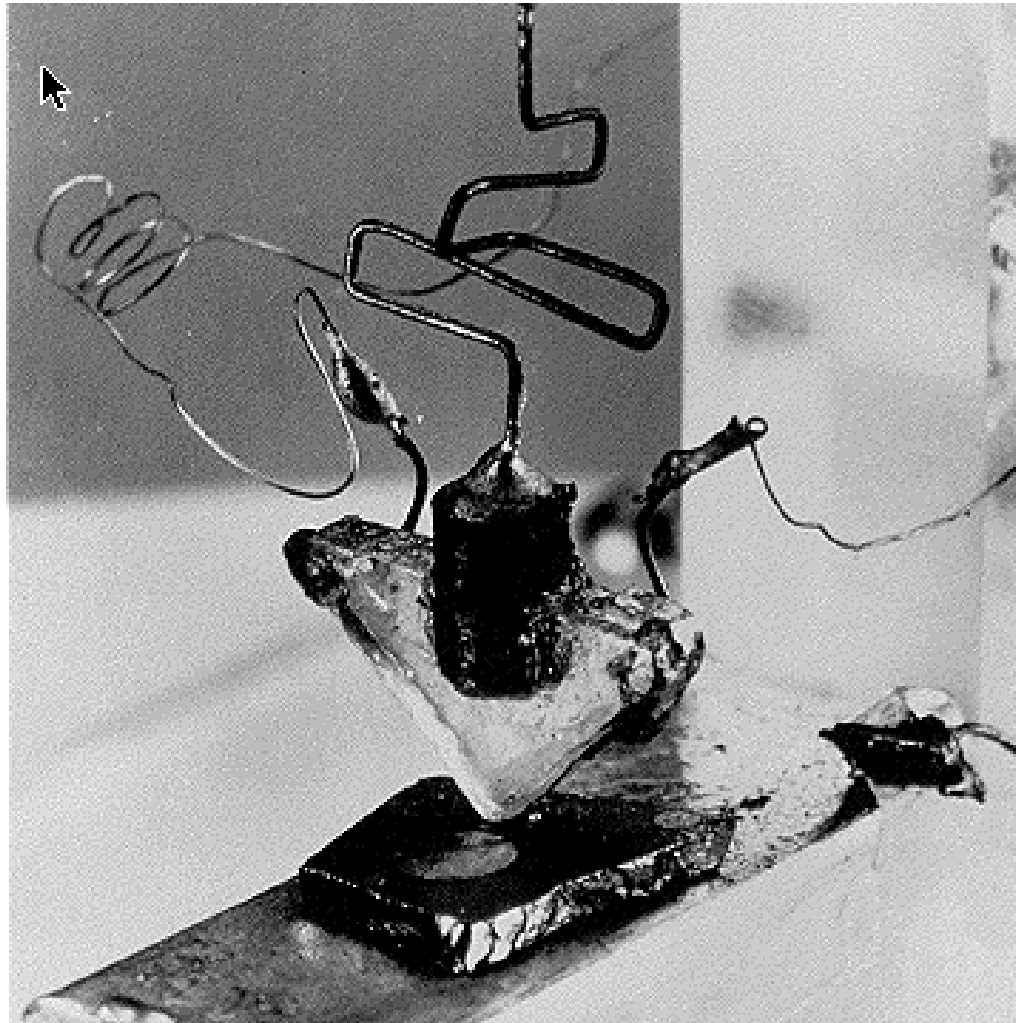
NPN



PNP

Fáciles de controlar
Pérdidas por conducción reducidas
Caída de tensión 1-2V
Frecuencia de conmutación 3 kHz
No soporta potencias muy elevadas



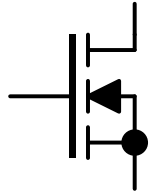


Primer transistor, 1947

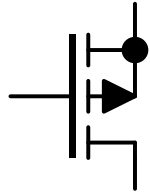
Laboratorios Bell

William Shockley, John Bardeen, and Walter Brattain

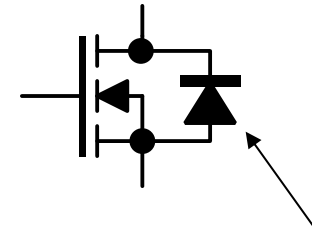
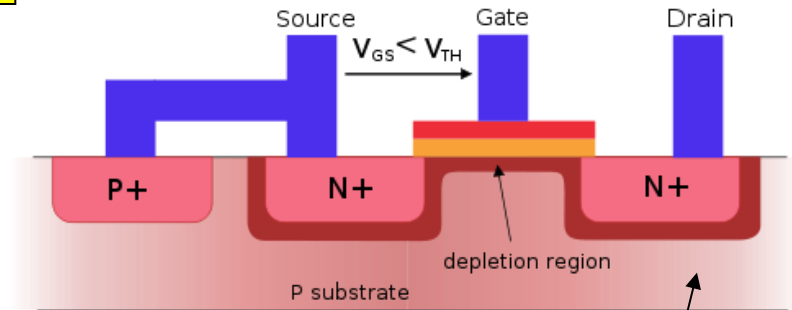
MOSFET



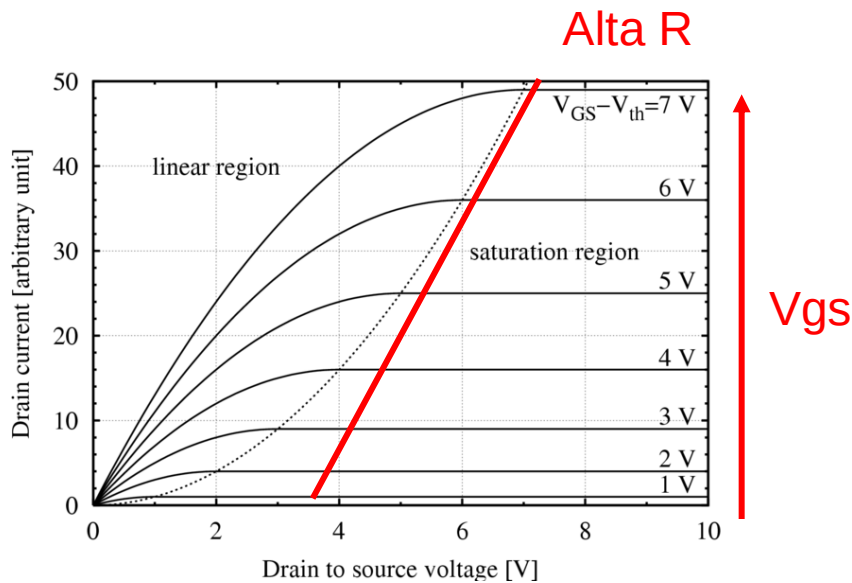
Canal N



Canal P



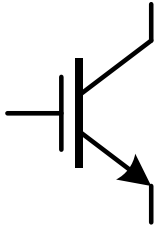
Diodo intrínseco



Fácil de controlar

Frecuencia de conmutación superior a 100 kHz

IGBT (*Insulated Gate Bipolar Transistor*)



Tamaño reducido

Bajo coste de fabricación

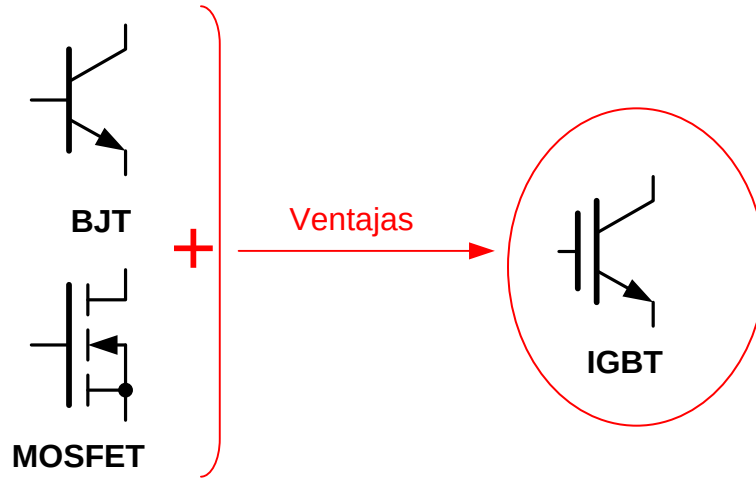
Caída de tensión reducida, independientes de la corriente

Frecuencia máxima 20 kHz

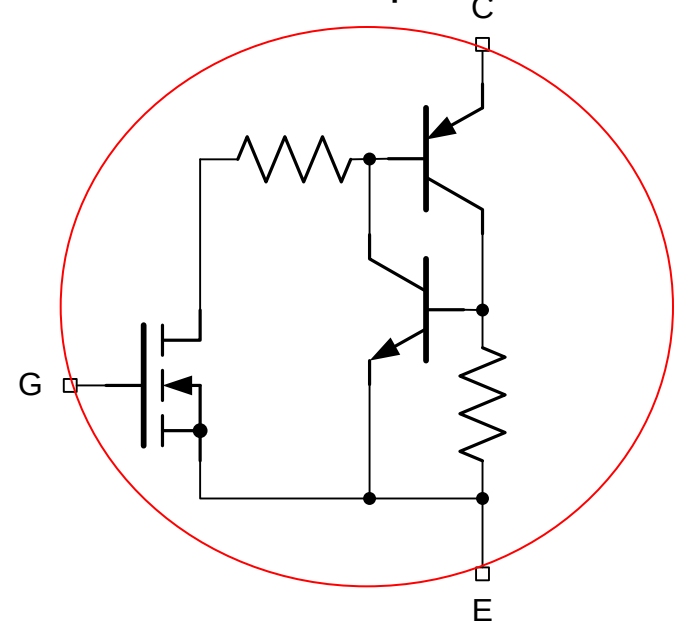
No soporta derivadas altas de tensión

Límites de tensión 3300 V, de corriente 1200 A

IGBT



Circuito equivalente



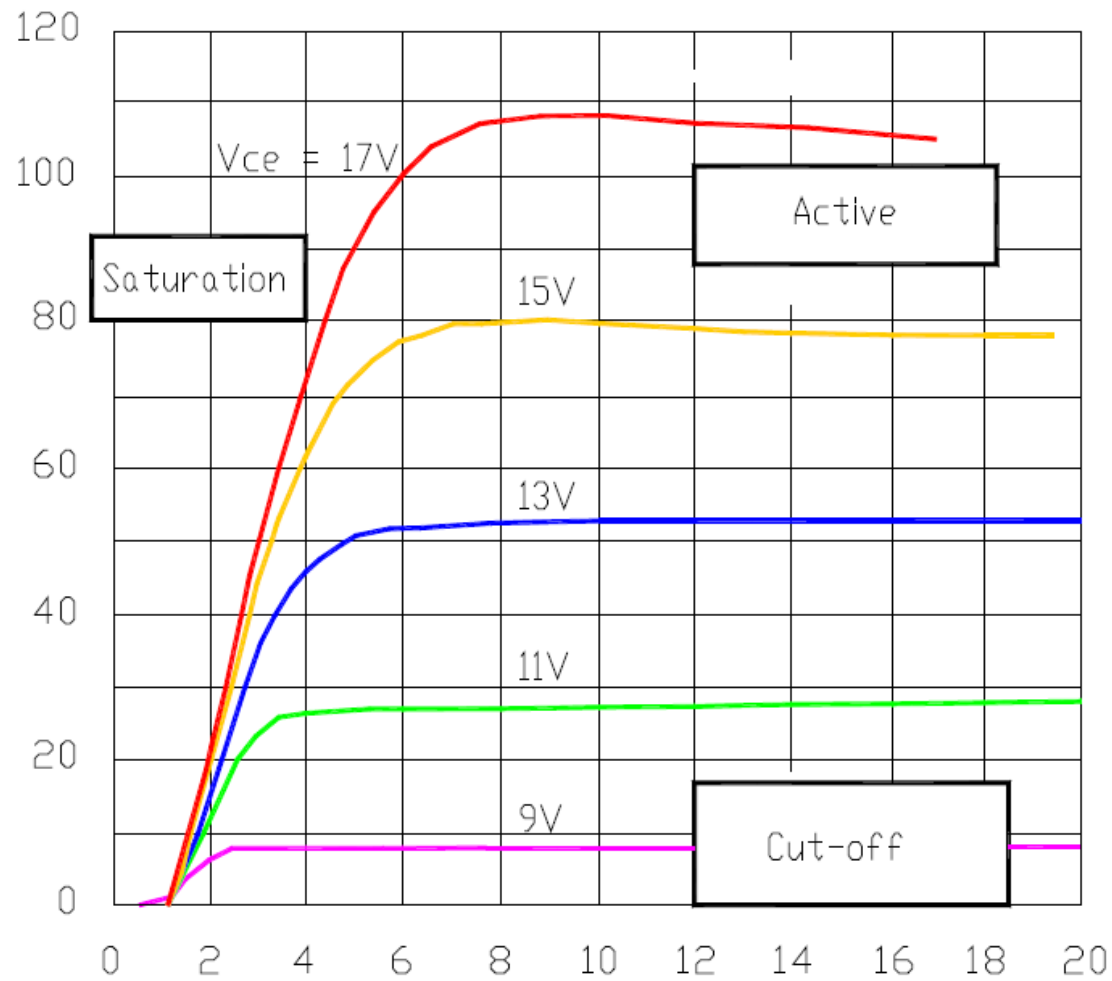
MOSFET

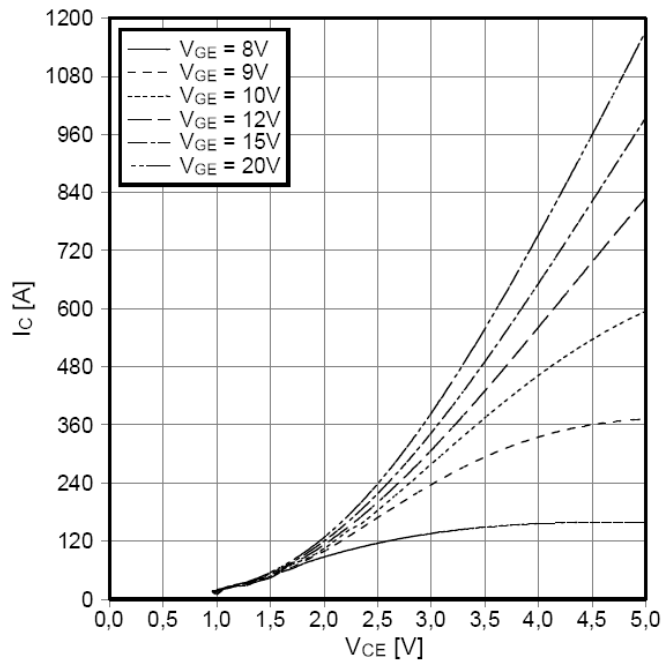
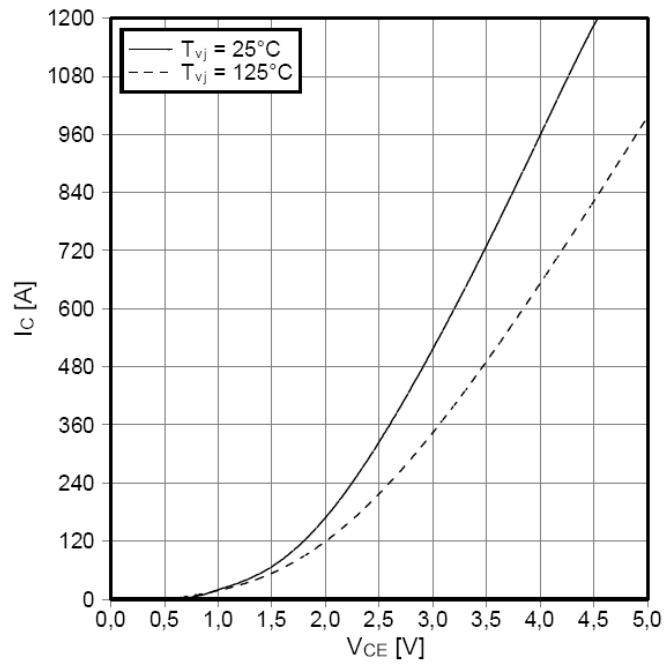
- Alta frecuencia de conmutación (>100 kHz)
- Baja tensión (100's V)

IGBT

- Menor frecuencia de conmutación (20 kHz)
- Alta tensión (1000's V)

IGBT

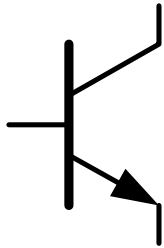




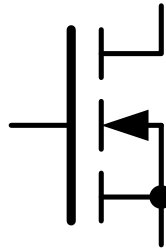
IGBT



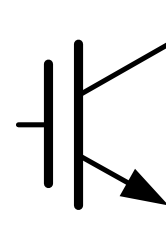
TRANSISTORES DE POTENCIA



BJT



MOSFET



IGBT

Control por corriente

Control por tensión

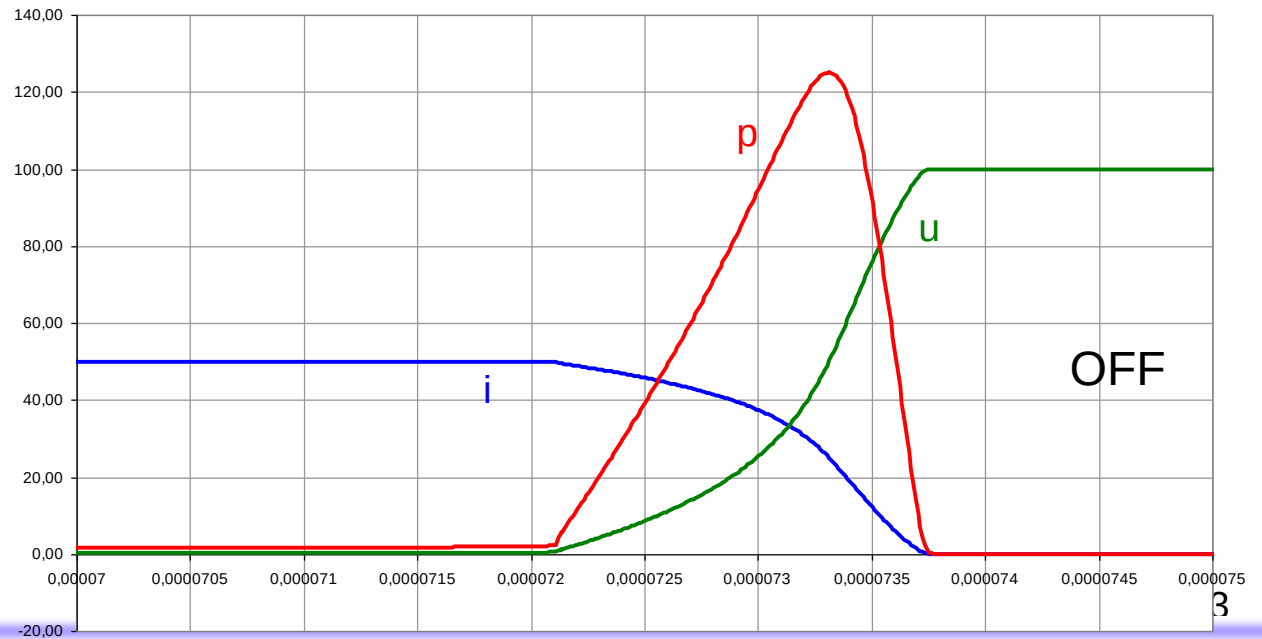
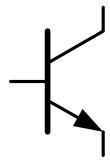
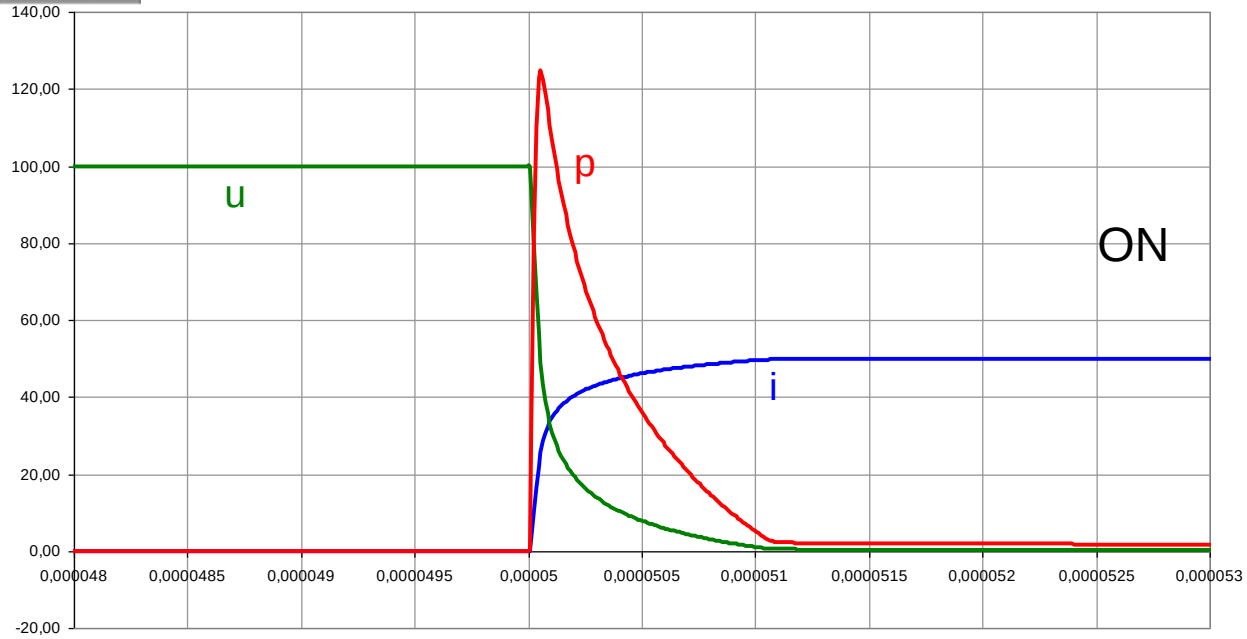


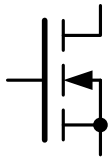
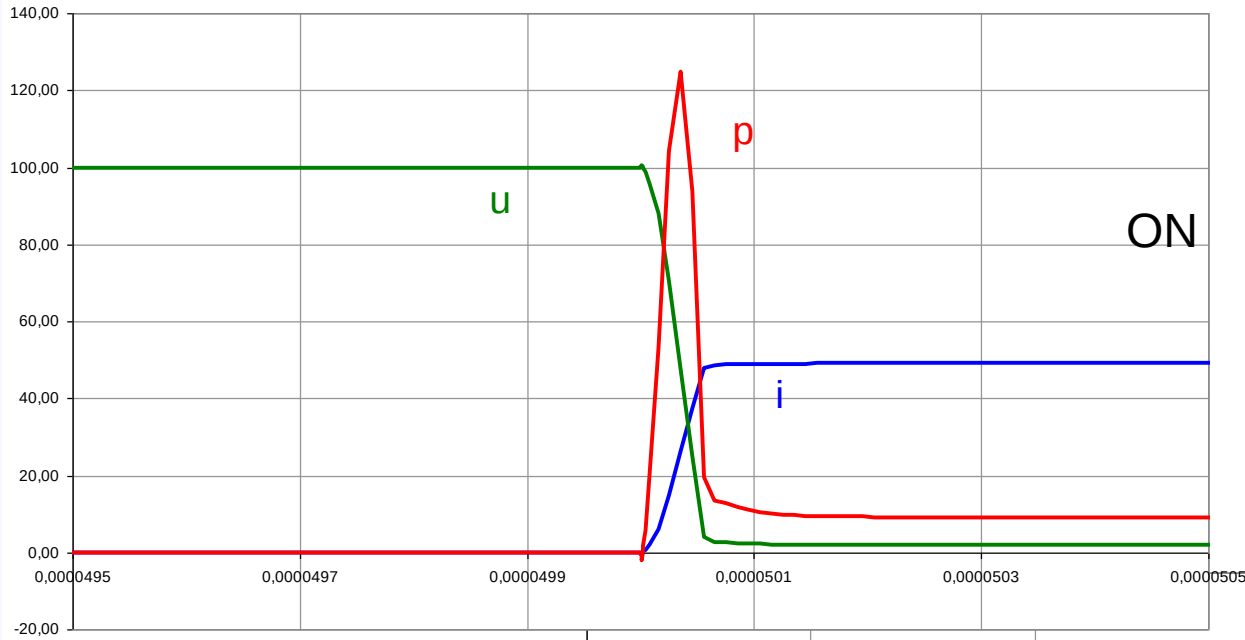
MOSFET 150 V / 600 A



IGBT 3300 V / 1200 A

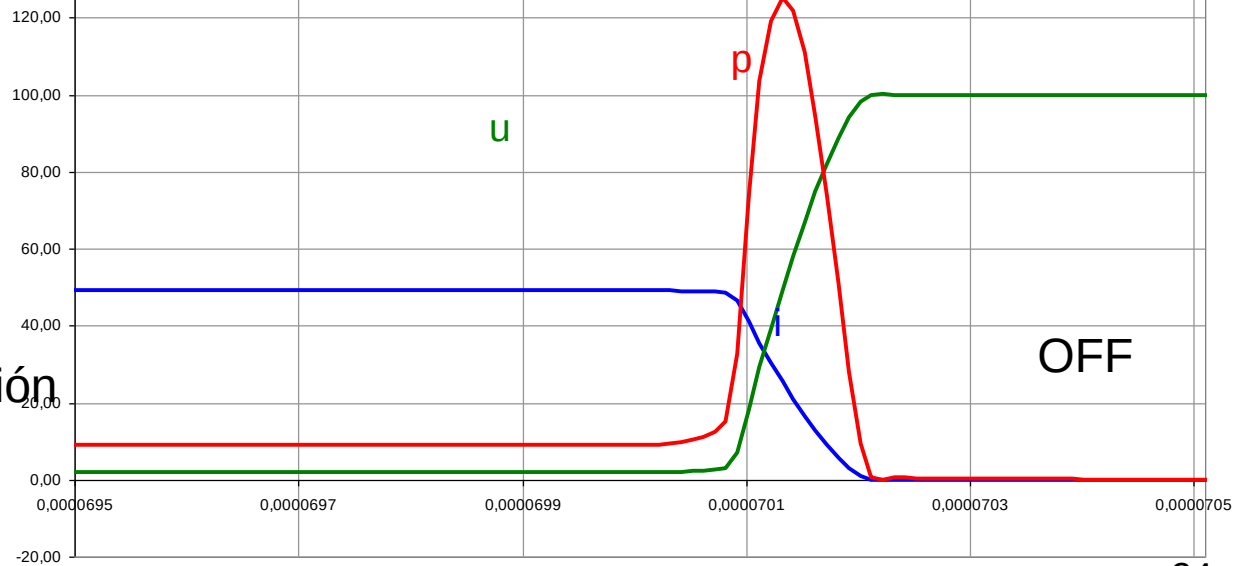




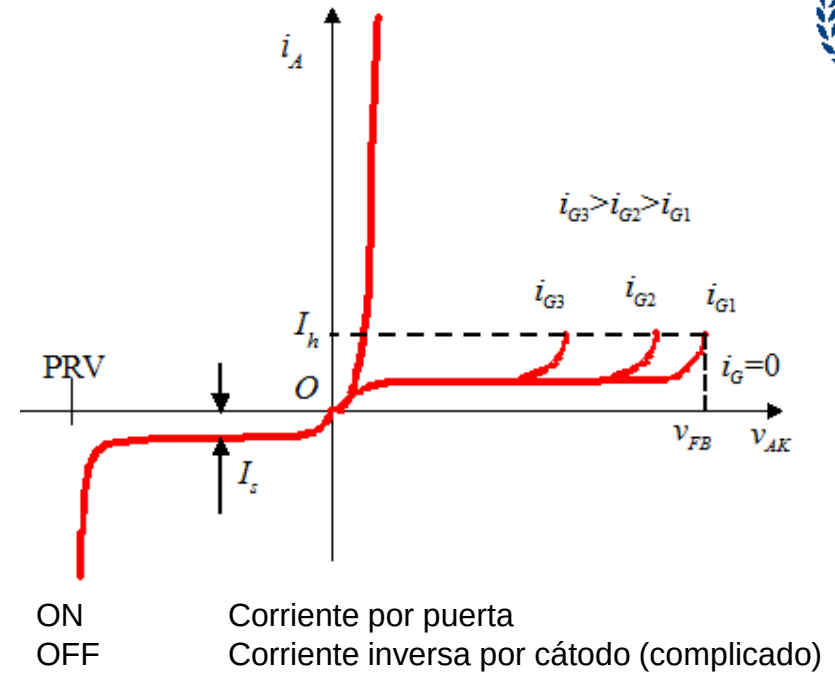
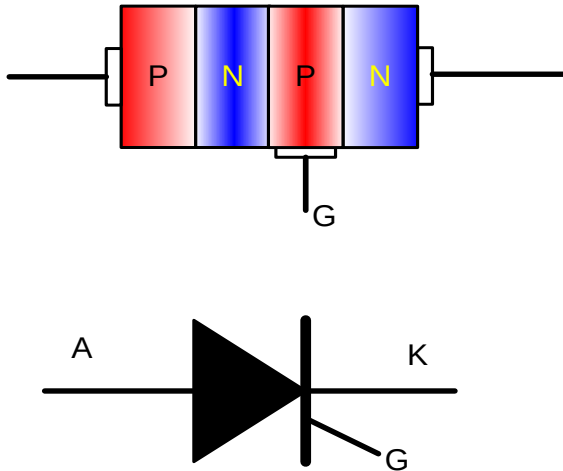


+ rápido

+ pérdidas de conducción



TIRISTOR



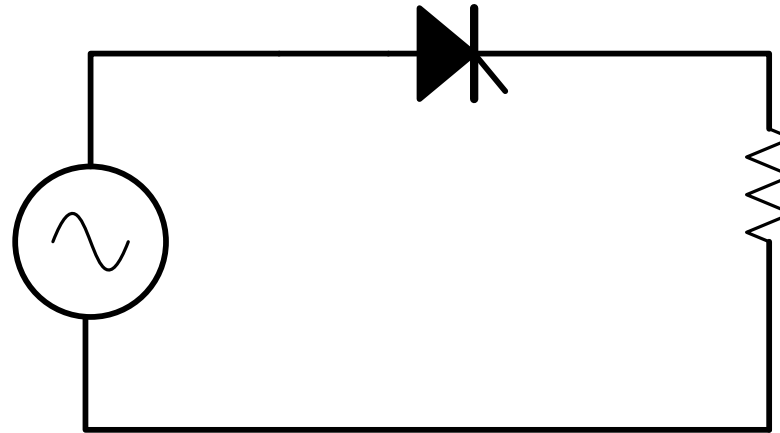
Robusto y fiable

Soporta elevadas sobreintensidades transitorias

Caída de tensión baja, 1-3V

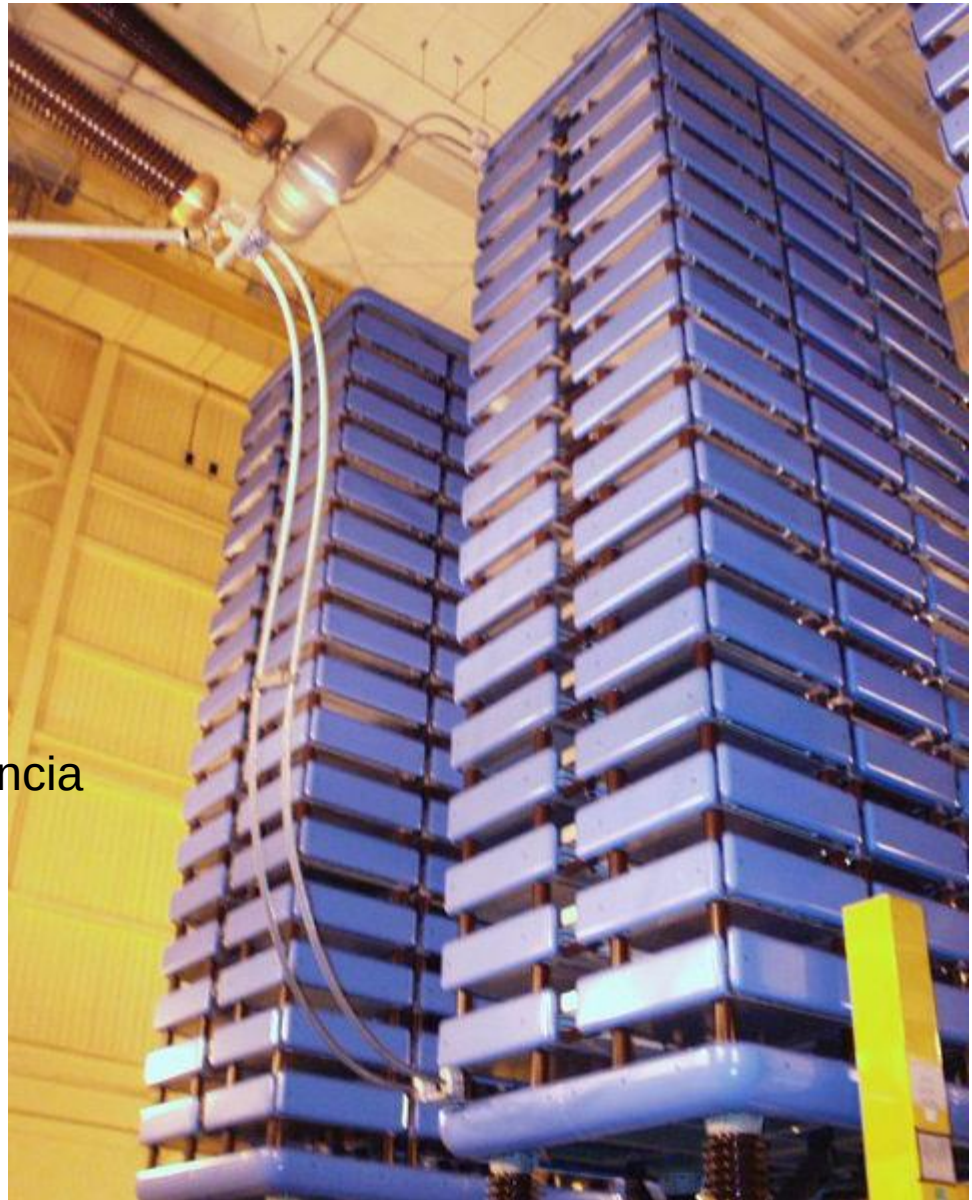
Frecuencia menor de 1 kHz

TIRISTOR: rectificador controlado

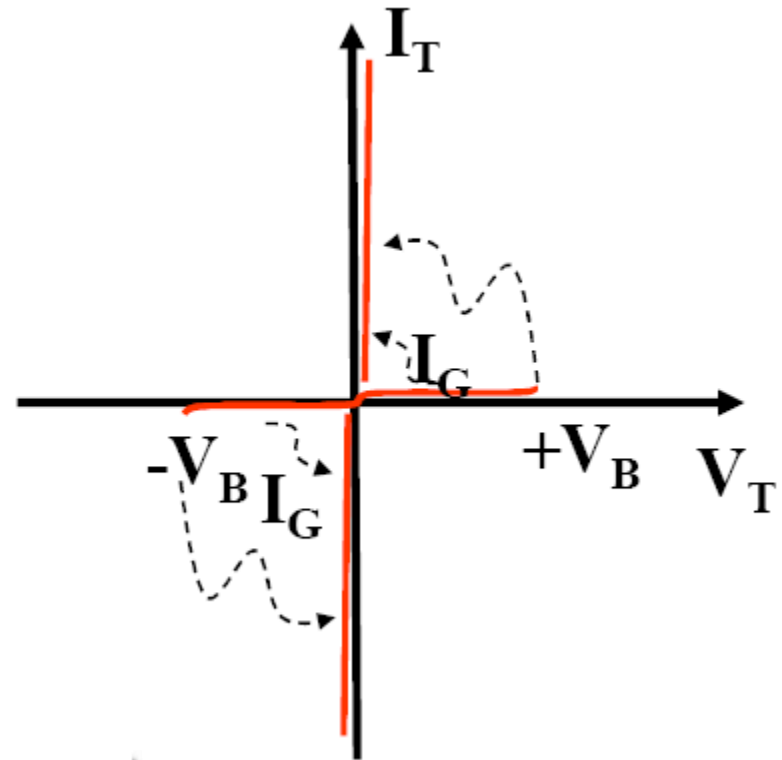
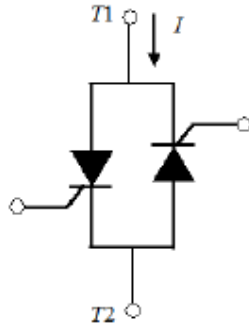
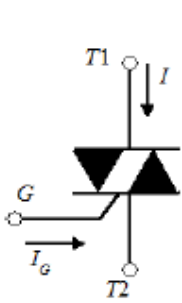


TIRISTOR

Aplicaciones de muy alta potencia

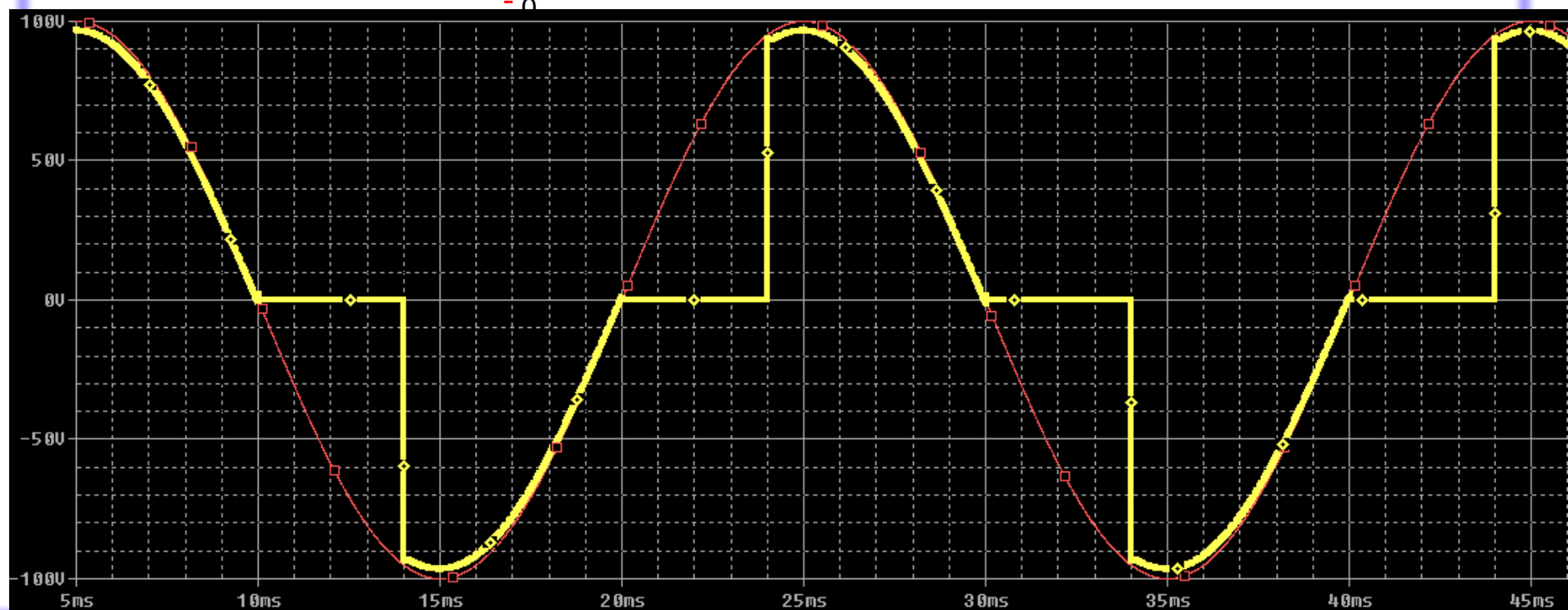
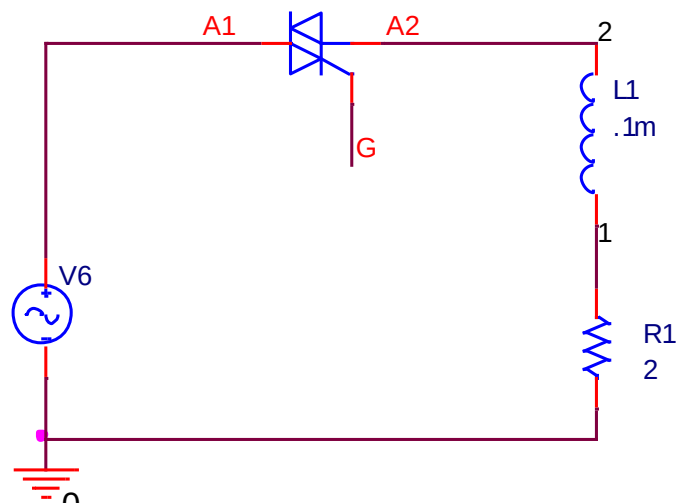


TRIAC

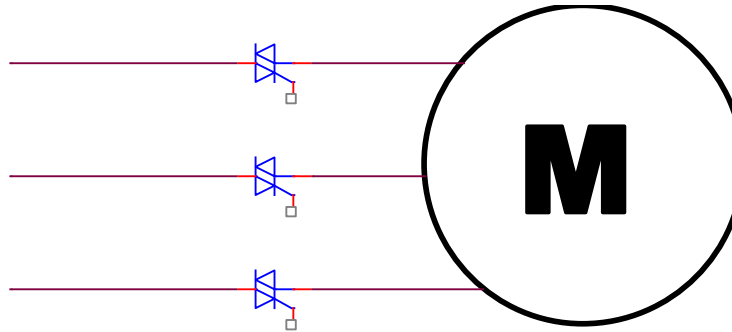


Tiristor bidireccional

TRIAC



TRIAC



Ejemplo de aplicación:
Arranque suave de máquinas

GTO (Gate Turn-Off Thyristor)

Apagado por impulso negativo de corriente por la puerta.

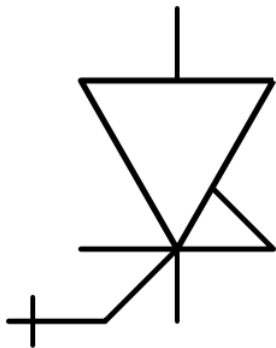
Elevadas pérdidas por conmutación

Bajas pérdidas por conducción

Alta tensiones y corrientes, 4500V – 3000 A

Mejora

IGCT (Integrated Gate-Commutated Thyristor)

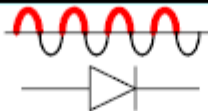
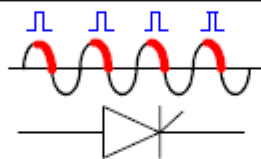
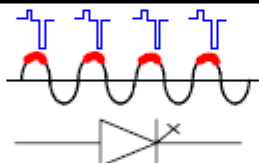
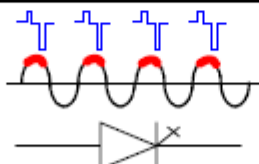
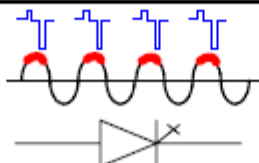


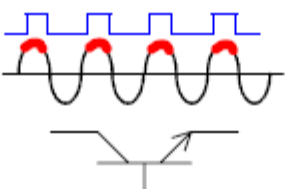
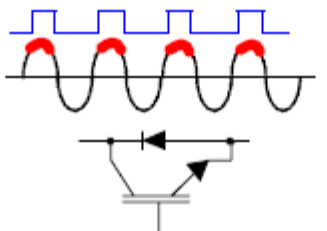
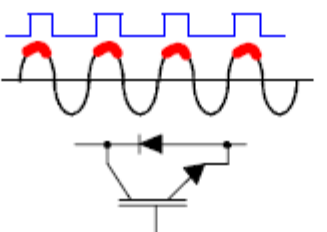
Baja resistencia en conducción.

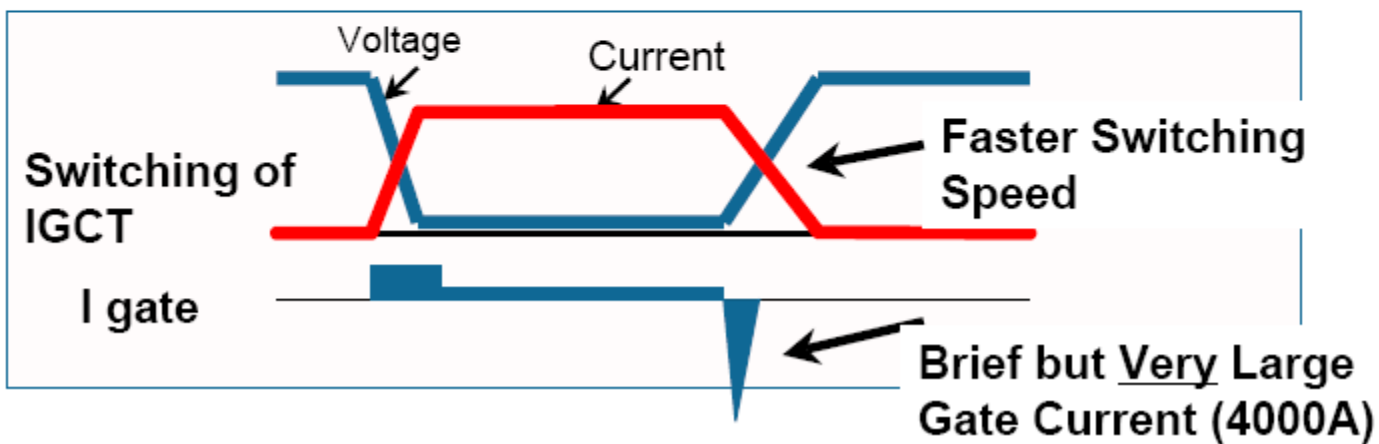
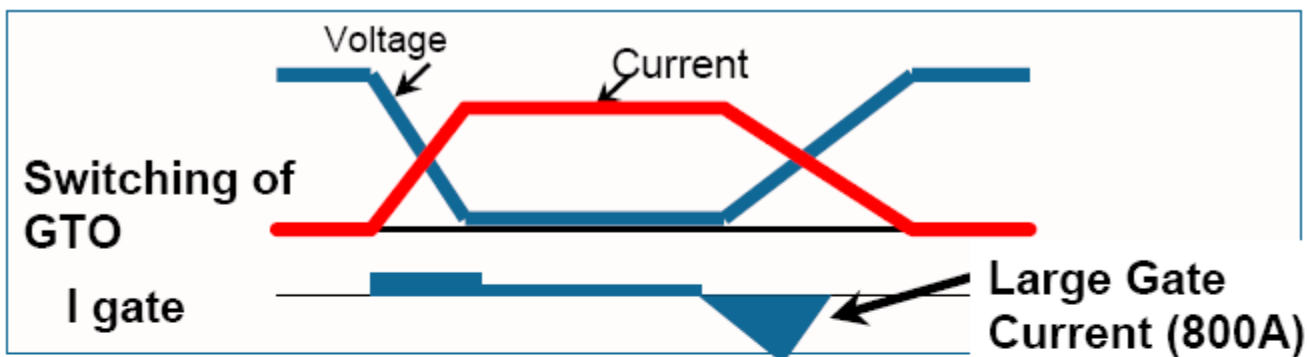
Robustez.

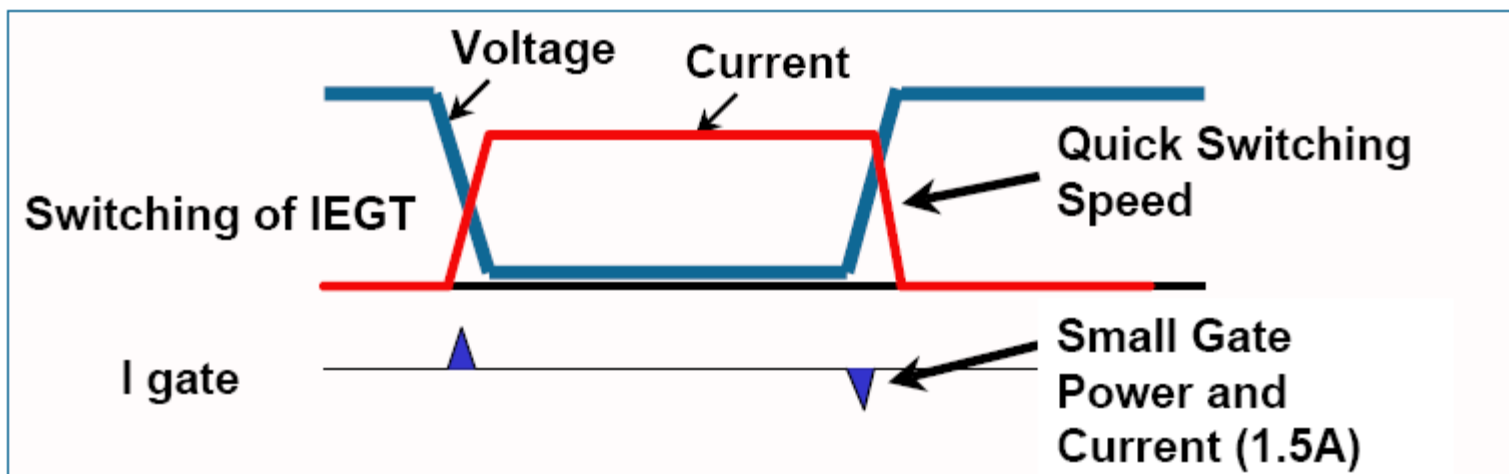
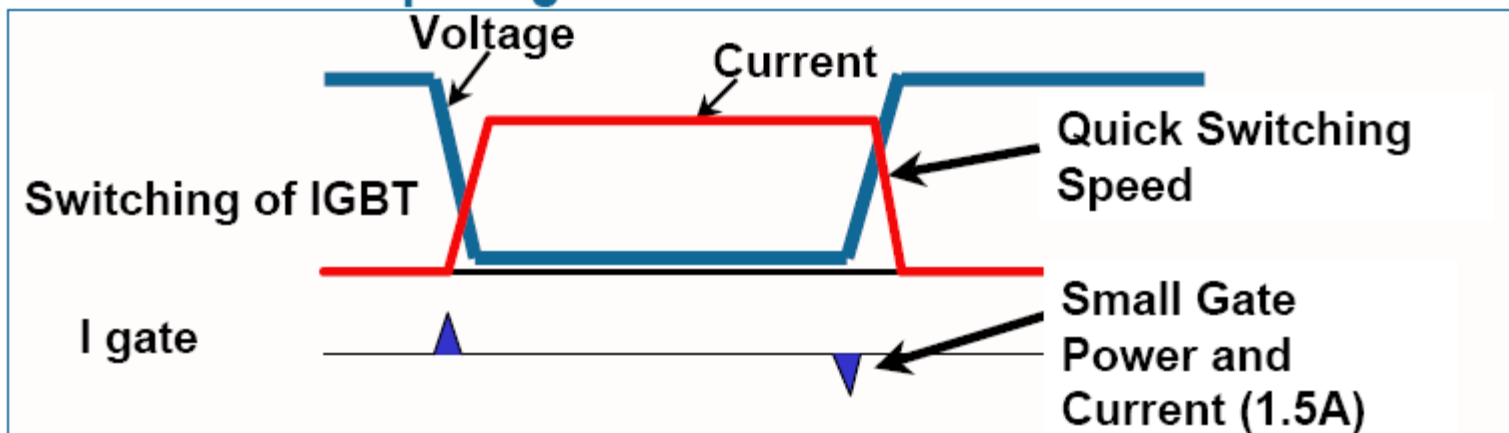
Capacidad de apagado por la puerta.

Pérdidas por conmutación hasta 3 veces menores que las de un IGBT

Device	Operation	Description
Silicon Diode Family of Devices		
Diode		Conducts positive current
Thyristor Family of Devices		
Silicon Controlled Rectifier (SCR)		Gate current triggers the flow of positive current. After loss of gate signal, turns off the positive current at next zero cross over.
Gate Turn Off Thyristor (GTO)		Small positive gate signal turns on positive current, a large reverse gate turns off the positive current.
Integrated Gate Commutated Thyristor (IGCT)		A GTO with electronics for gate control integrated onto a printed circuit wrapped around the device. Blocks voltage in one direction.
Symmetrical Gate Commutated Thyristor (SGCT)		A GTO thyristor similar to the IGCT except that it blocks voltage in both directions.

Device	Operation	Description
Transistor Family of Devices		
Bipolar Power Transistor (BPT)		Controls the flow of positive current with current injected into its base.
Insulated Gate Bipolar Transistor (IGBT)		A hybrid device with very a high input resistance gate transistor providing current to turn it on.
Injection Enhanced Gate Transistor (IEGT)		A high-power advanced form of the IGBT with a very low on-state voltage and even lower losses than the thyristor.



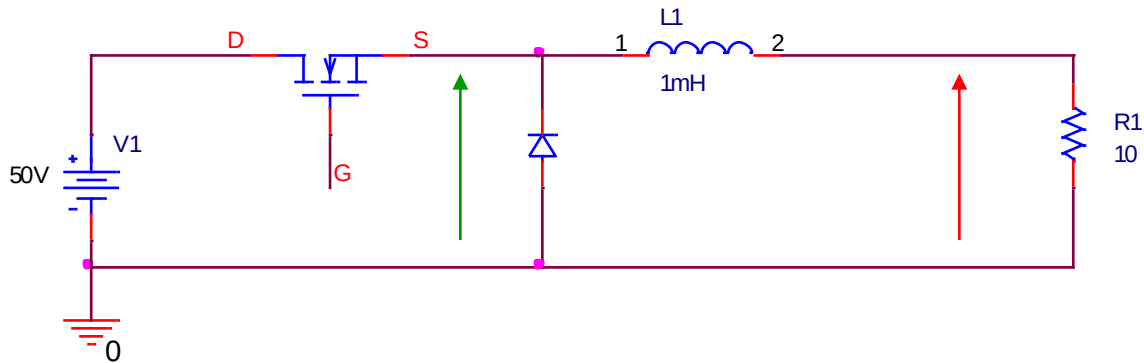


Electrónica de potencia

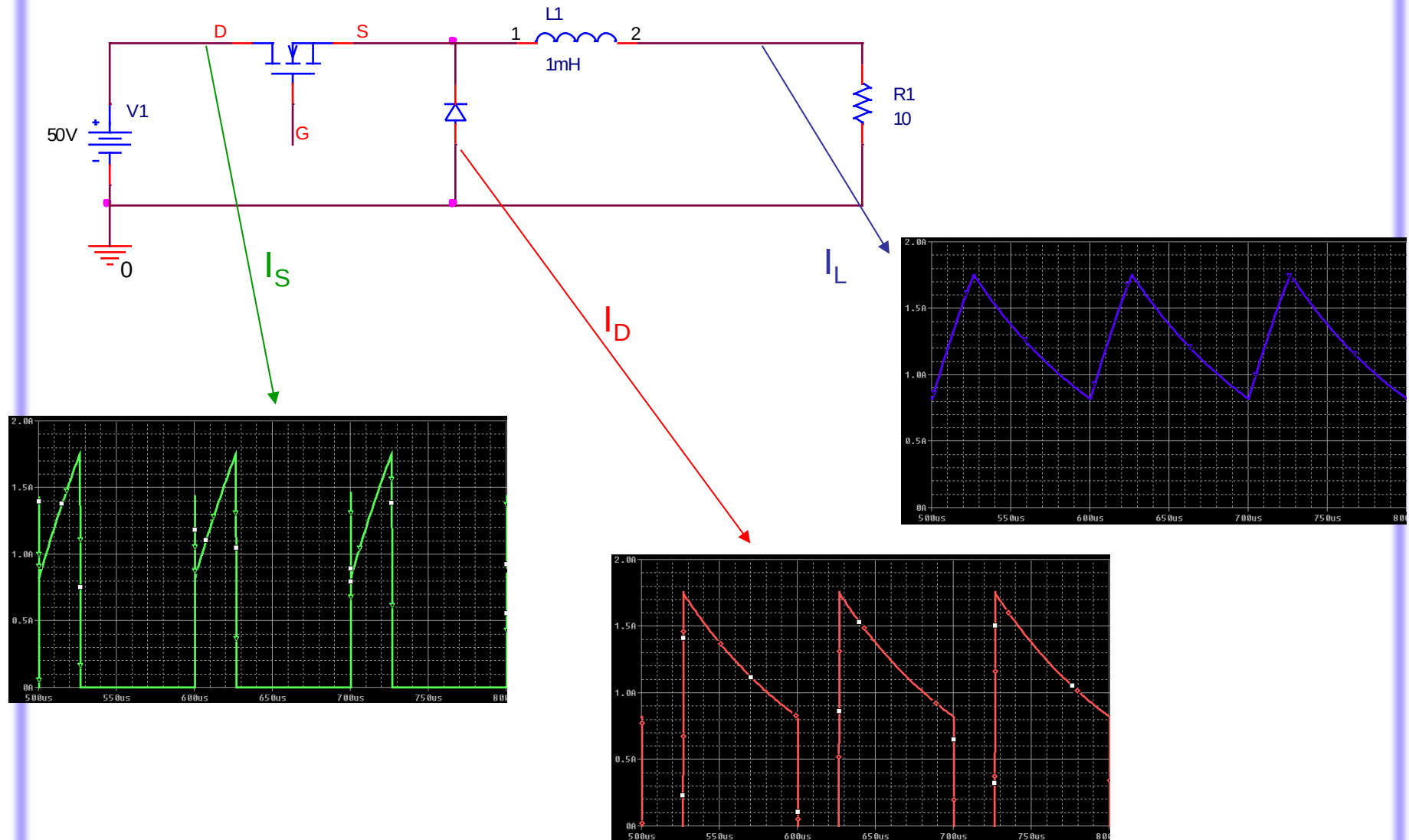
③ TROCEADORES DC/DC

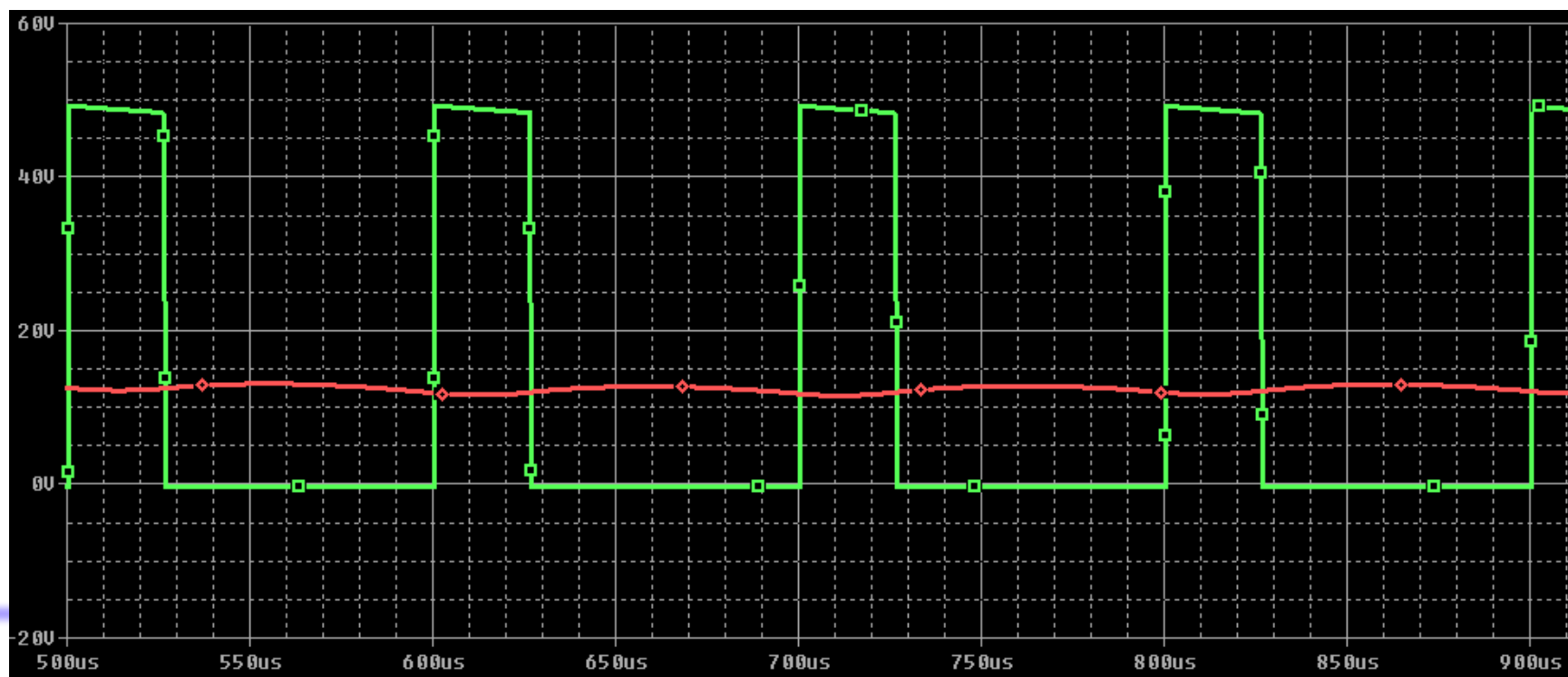
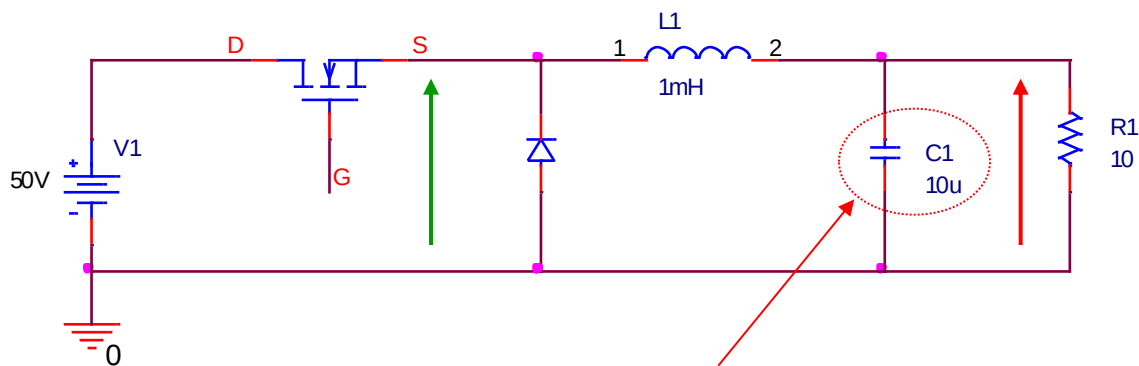
CONVERTIDORES DC/DC

(BUCK: reductor)



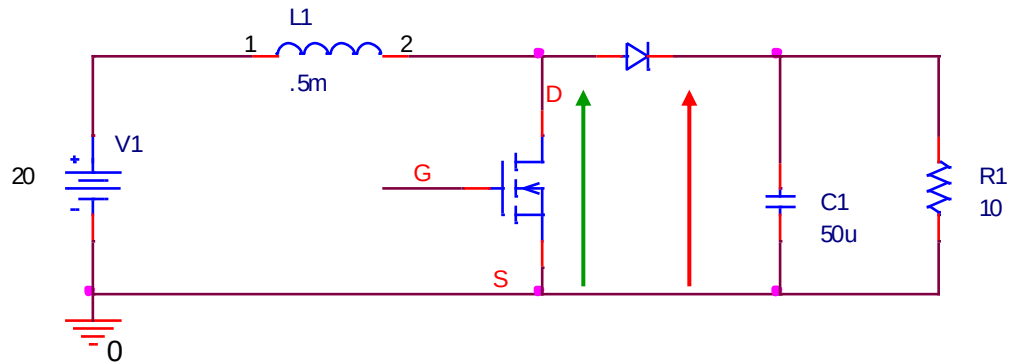
CONVERTIDORES DC/DC



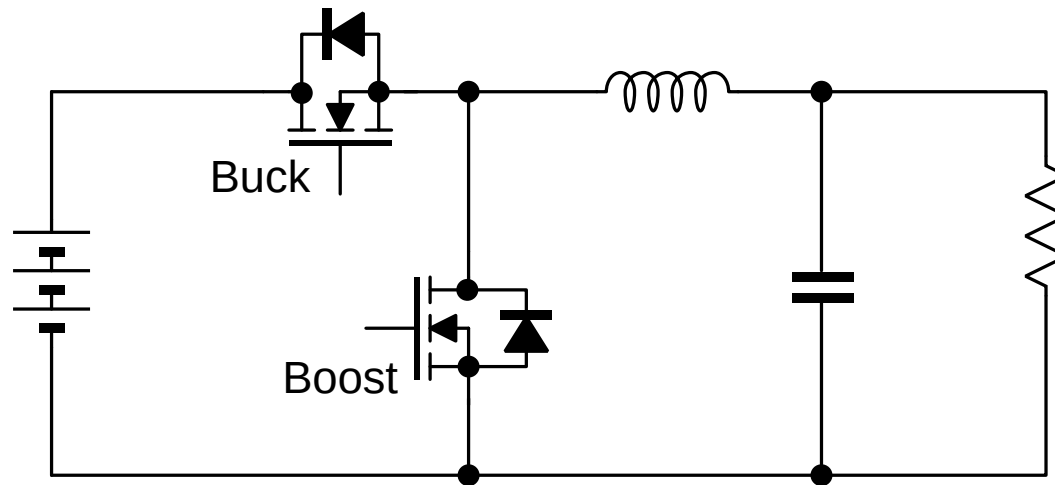


CONVERTIDORES DC/DC

(BOOST: elevador)



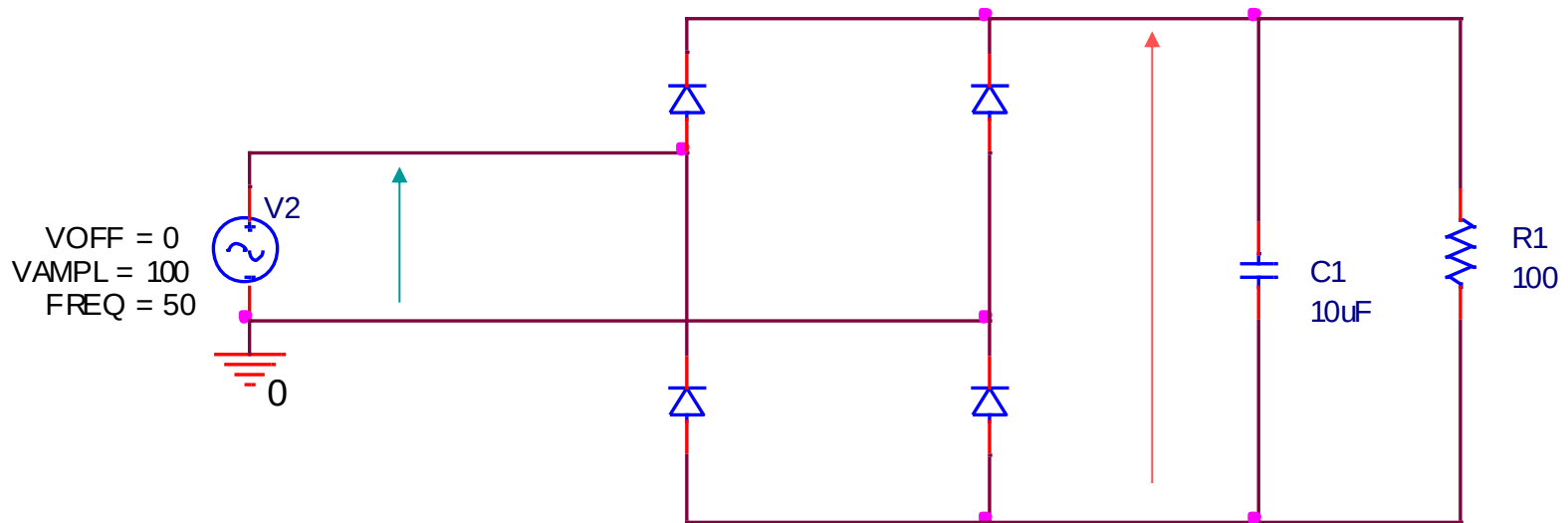
CONVERTIDORES DC/DC: BUCK-BOOST



Electrónica de potencia

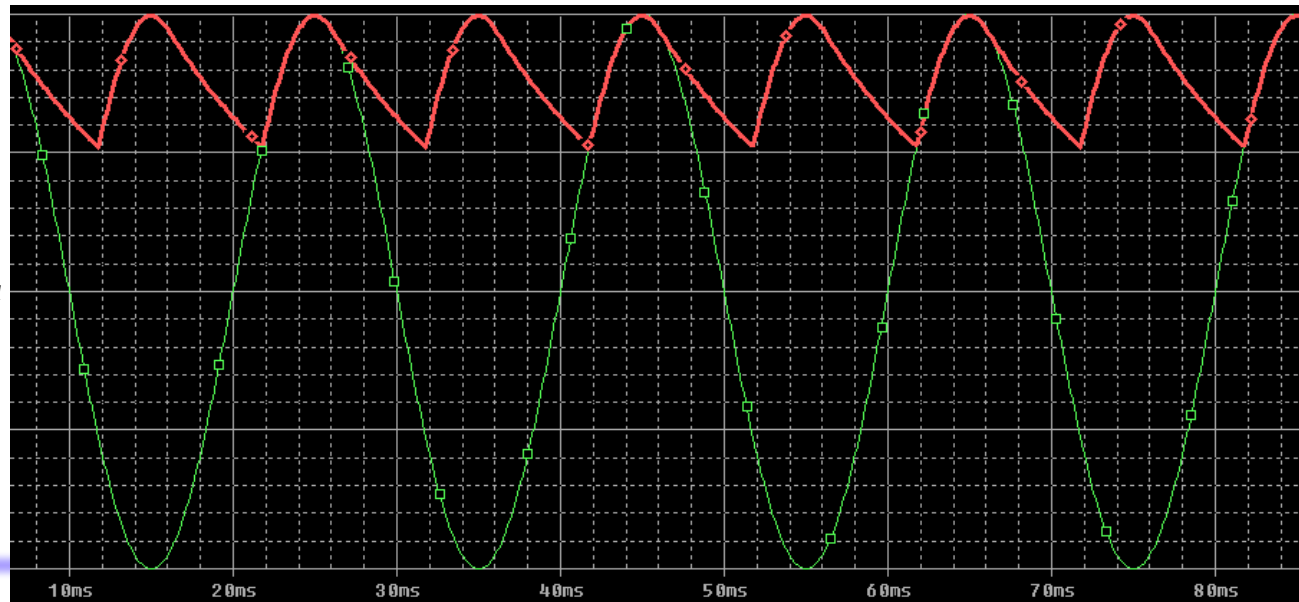
2 RECTIFICADORES AC/DC

RECTIFICADOR

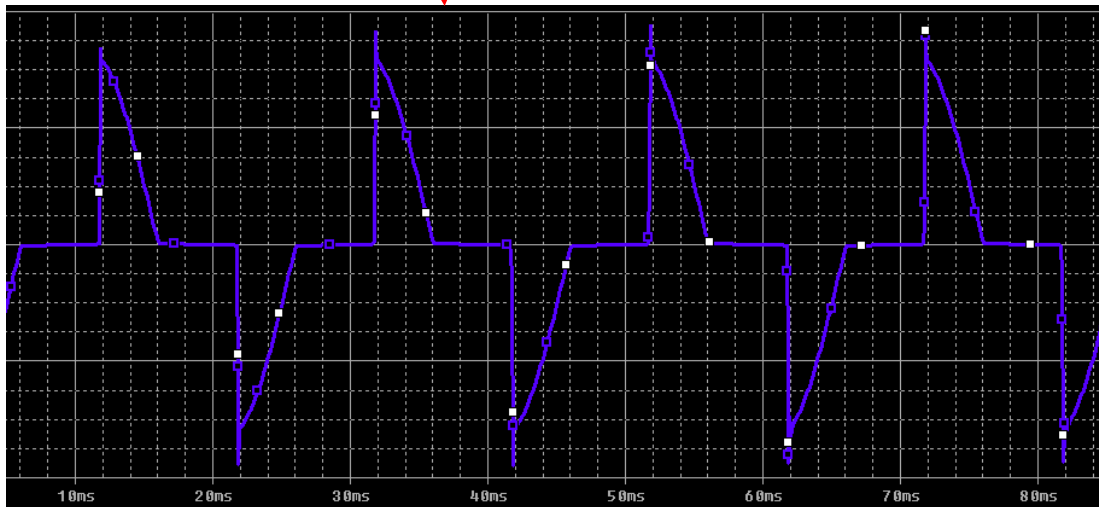
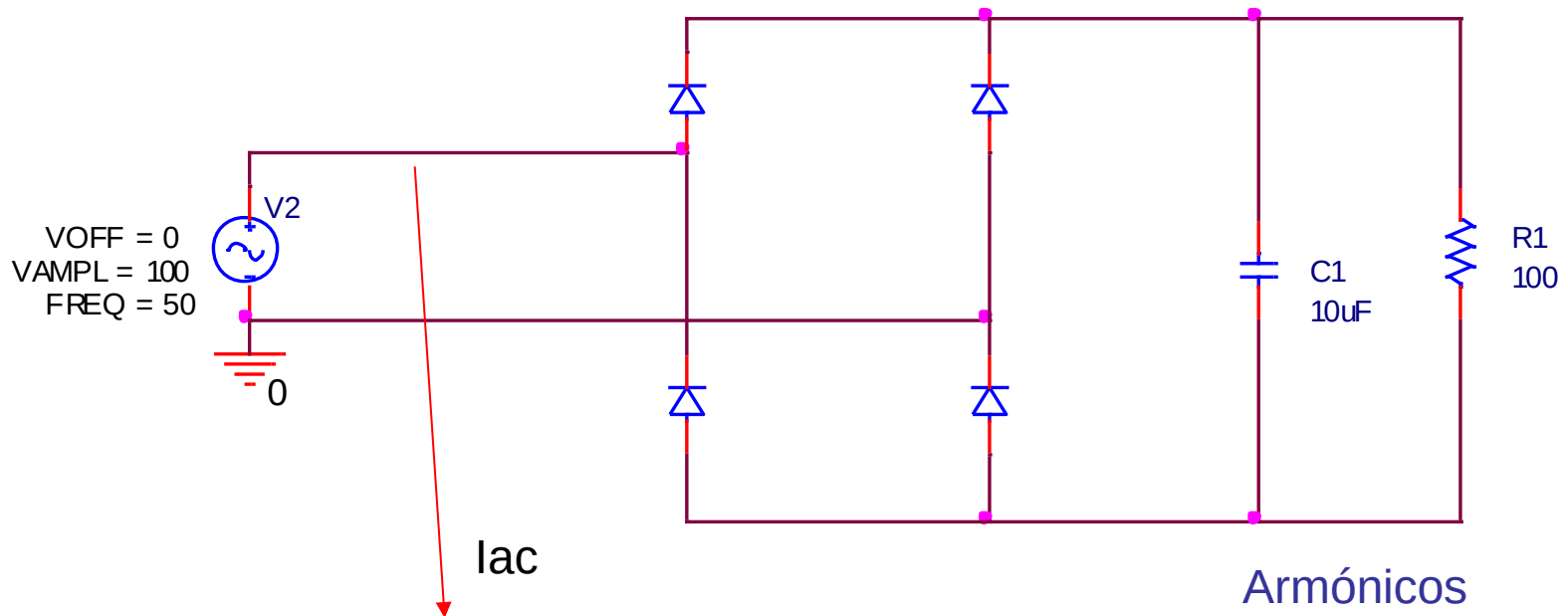


$$U_d = U_a$$

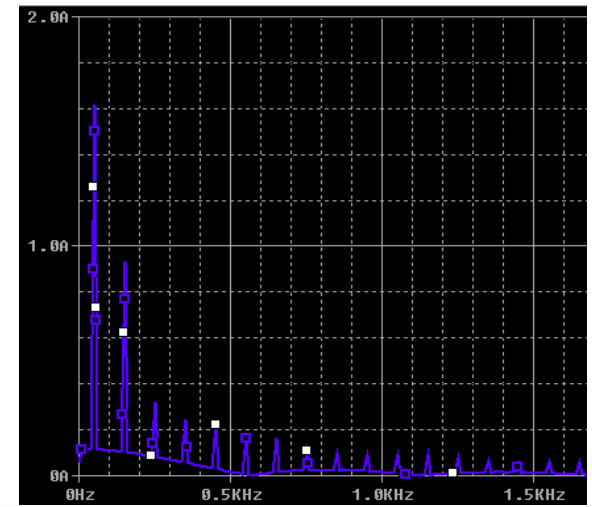
$$U_{d(p)} = \sqrt{2}U_a$$



RECTIFICADOR NO CONTROLADO



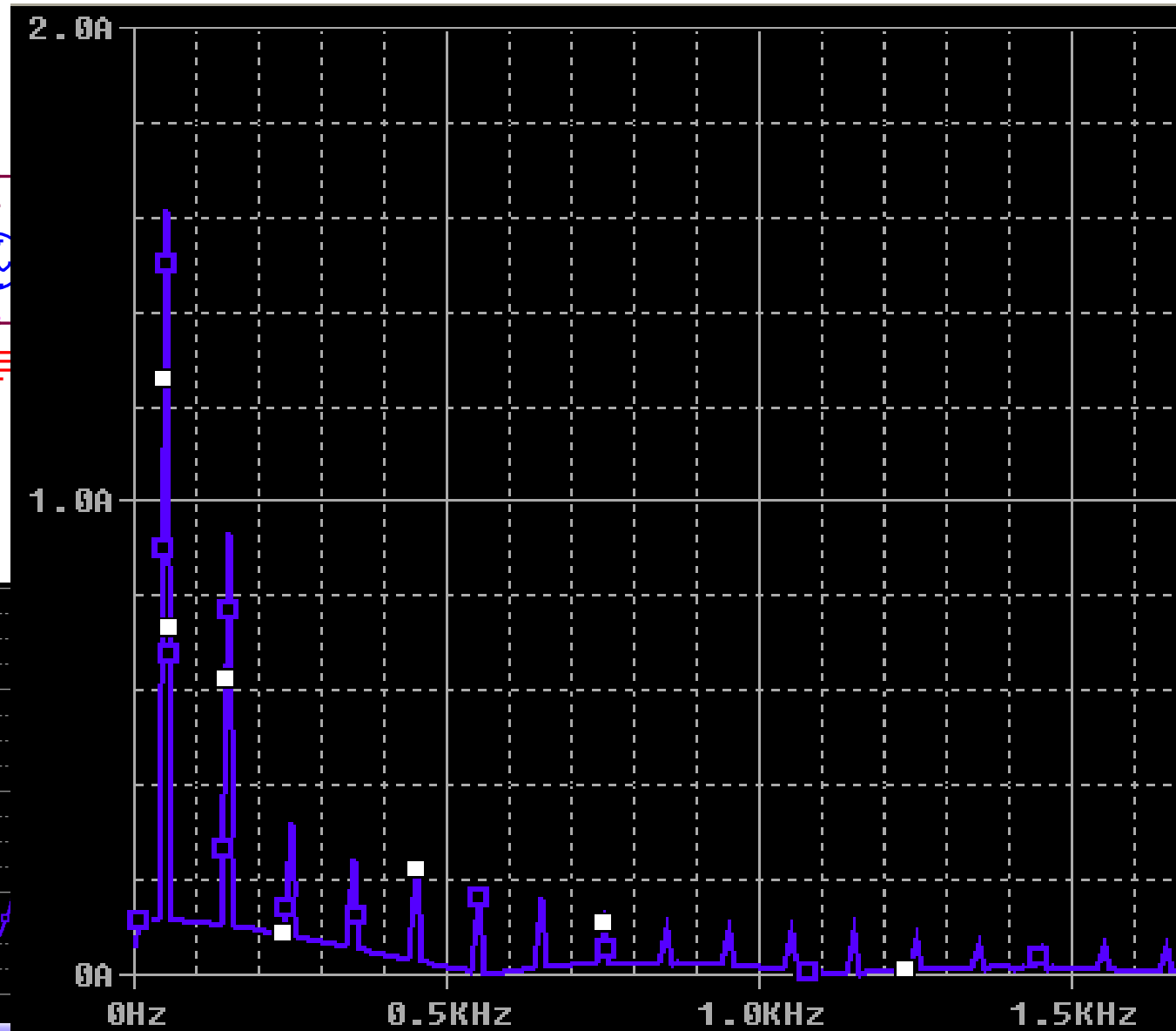
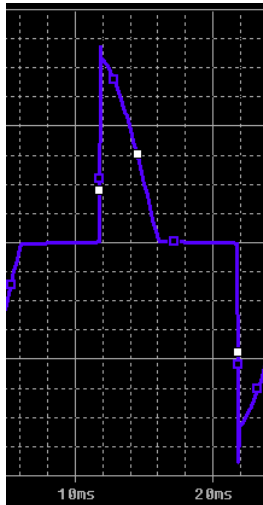
Armónicos



RECTIFICADOR

Armónicos

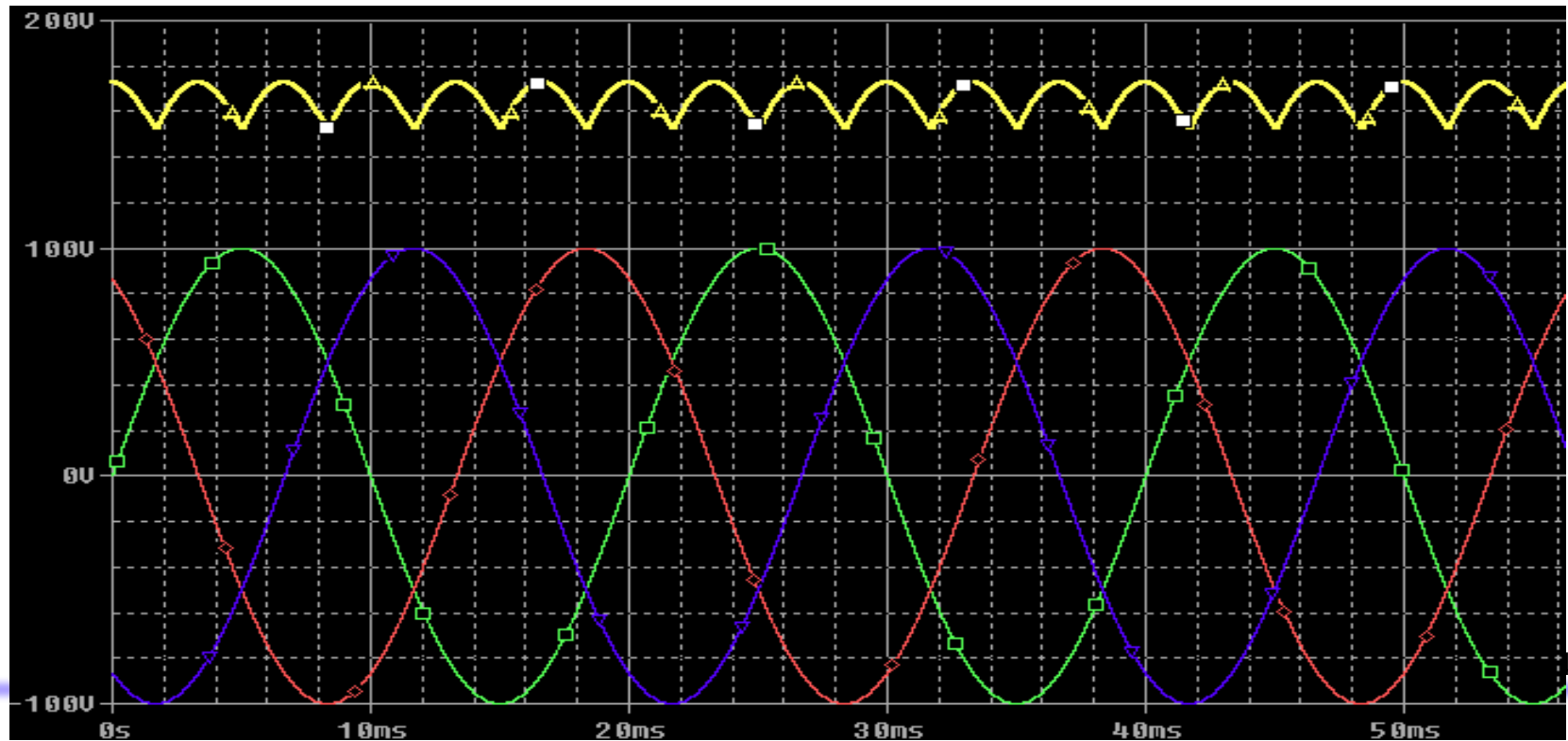
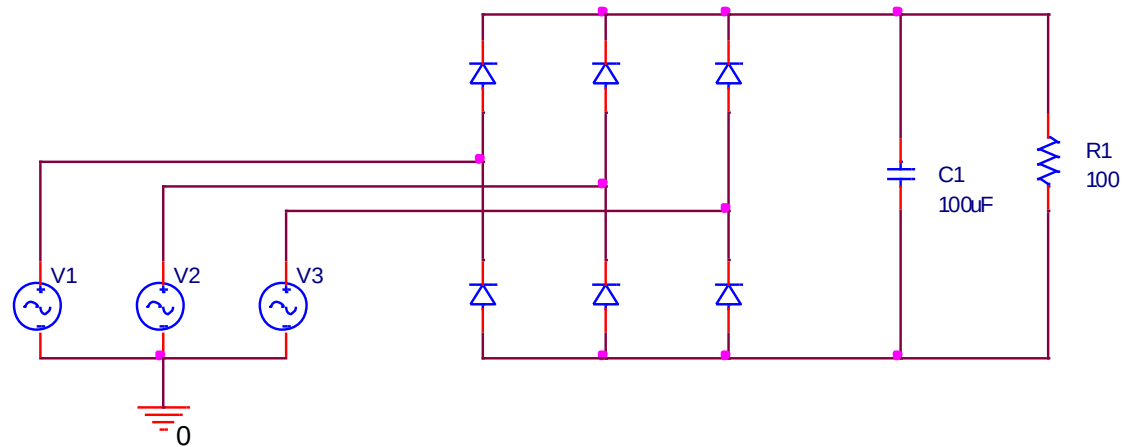
VOFF = 0
VAMPL = 100
FREQ = 50



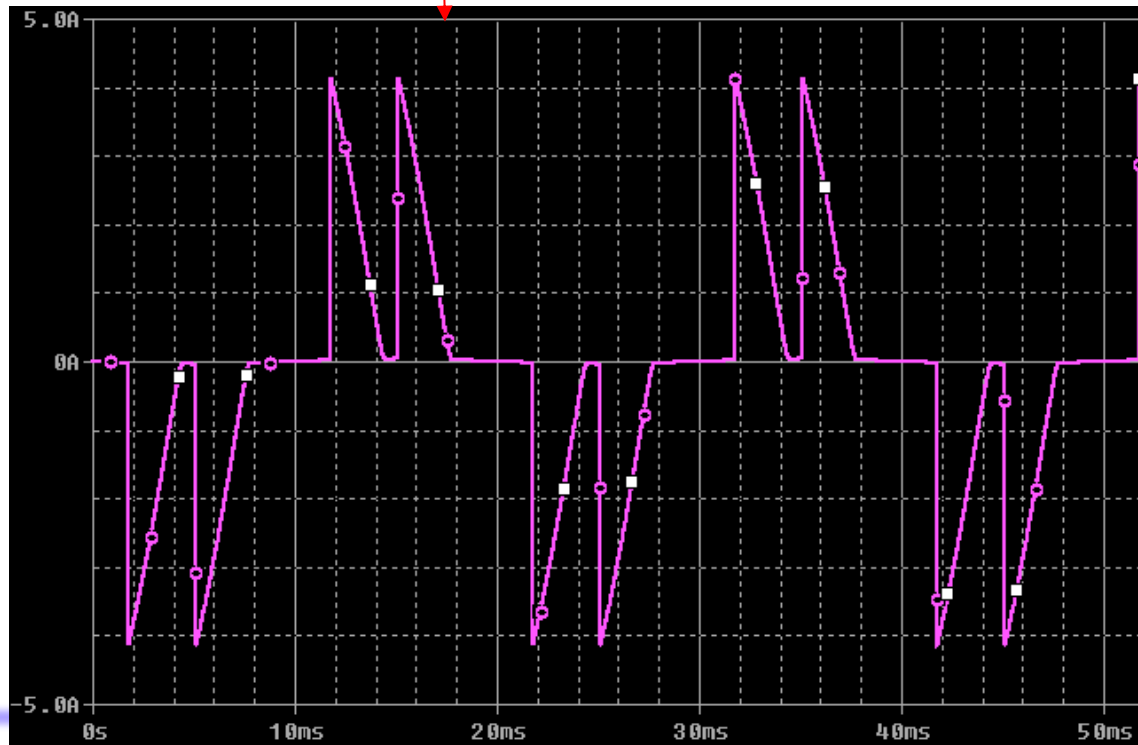
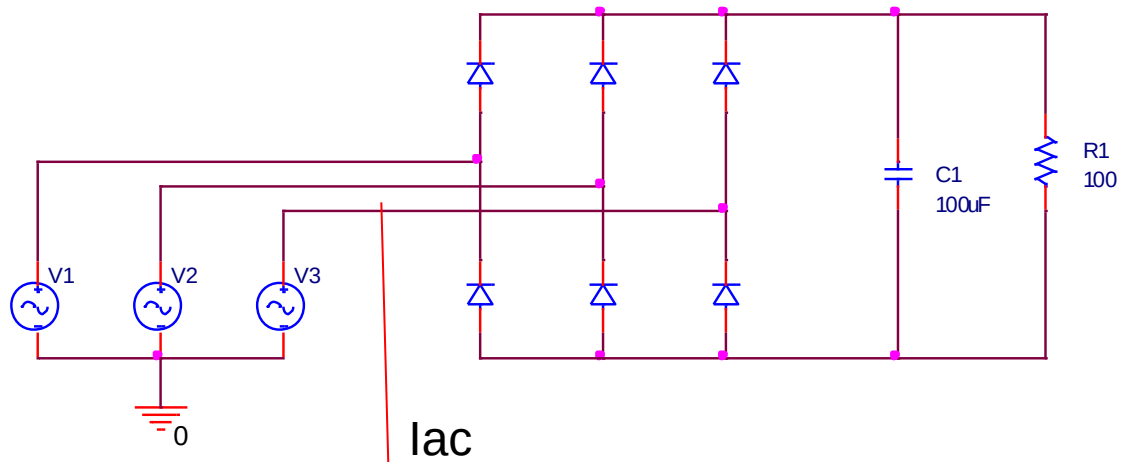
RECTIFICADOR TRIFÁSICO

$$U_d = \frac{3\sqrt{3}}{\pi} U_a$$

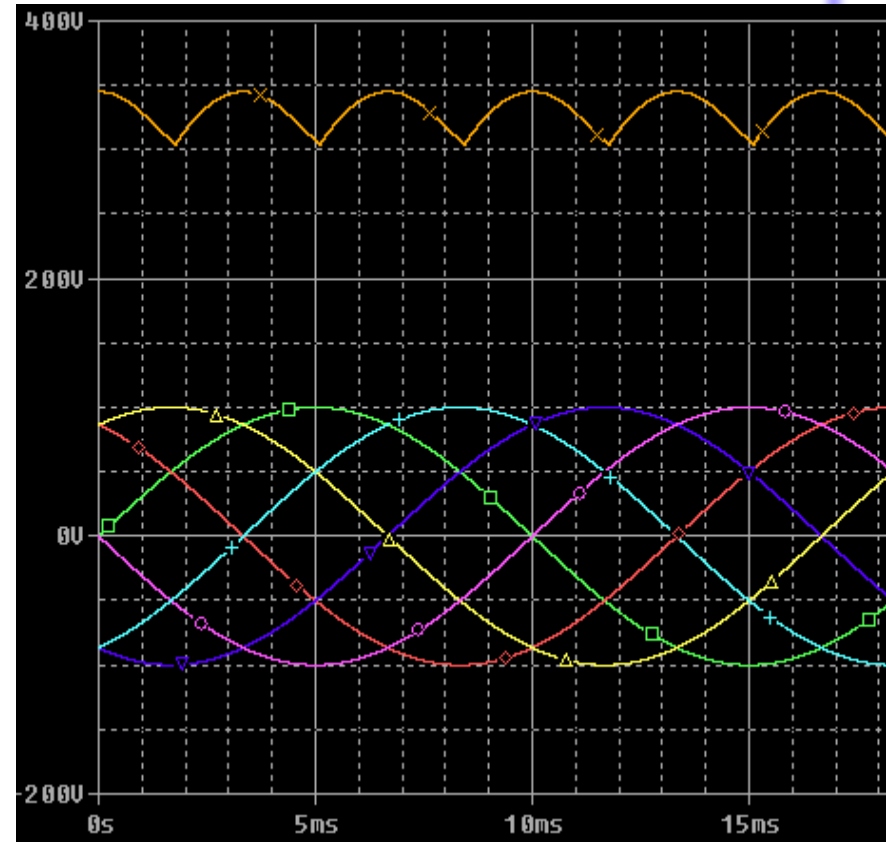
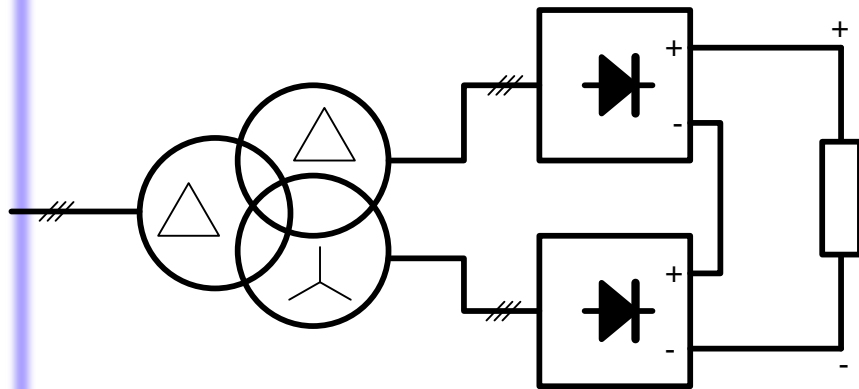
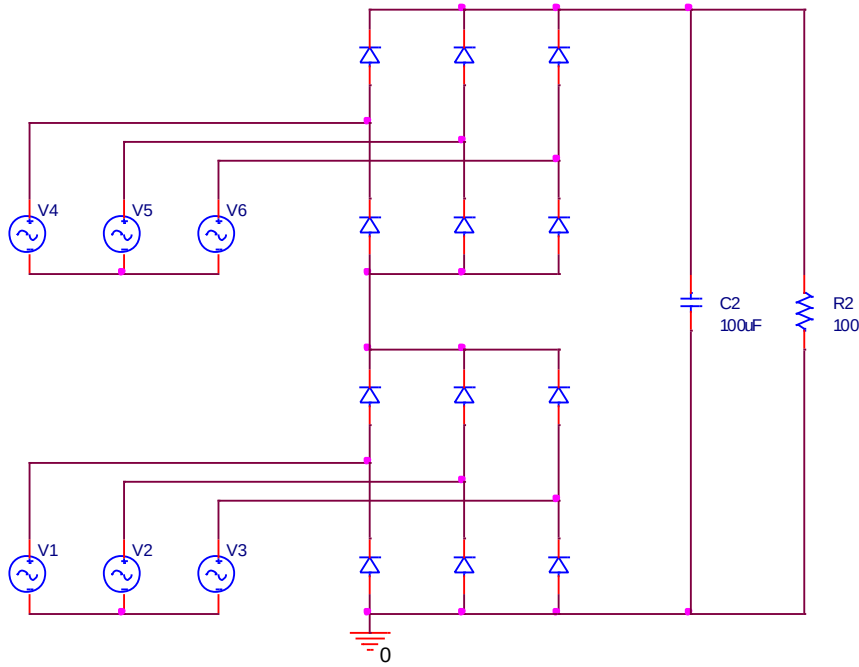
$$U_d = \frac{sq\sqrt{2}}{\pi} \operatorname{sen} \frac{\pi}{q} U_f$$



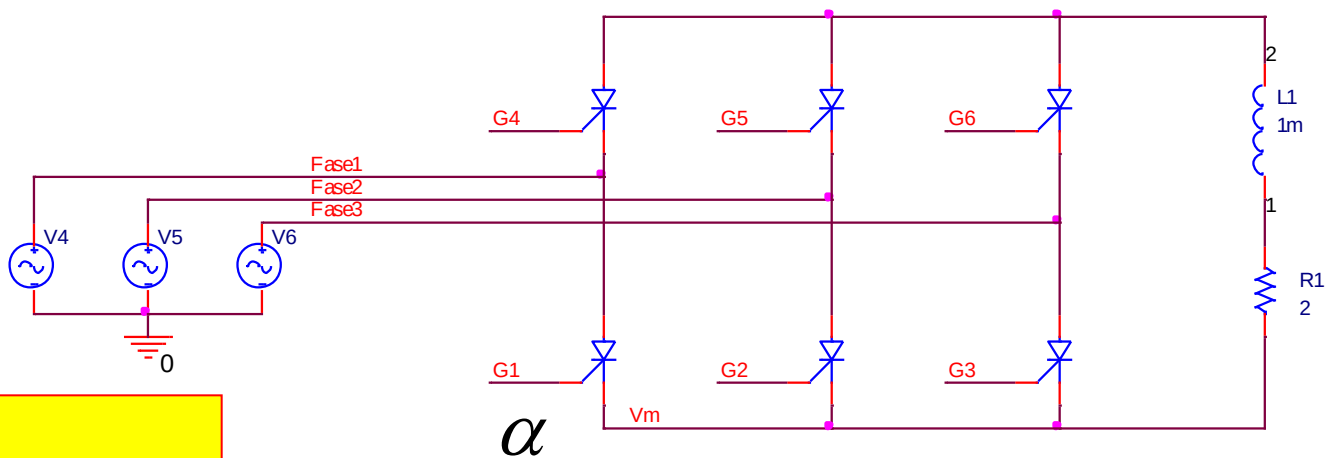
RECTIFICADOR



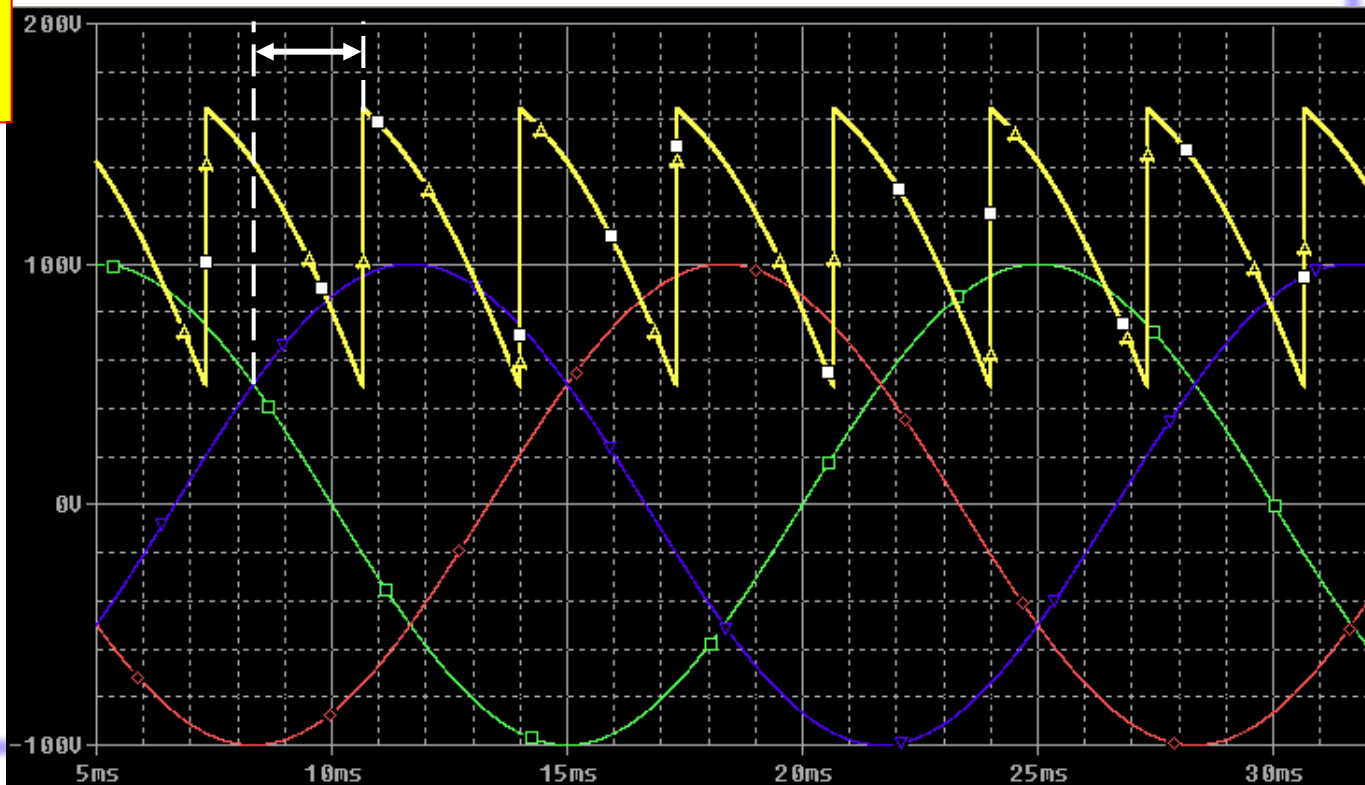
$$U_d = \frac{6\sqrt{3}}{\pi} U_a$$



RECTIFICADOR CONTROLADO



$$U_d = \frac{3\sqrt{3}}{\pi} U_a \cos \alpha$$



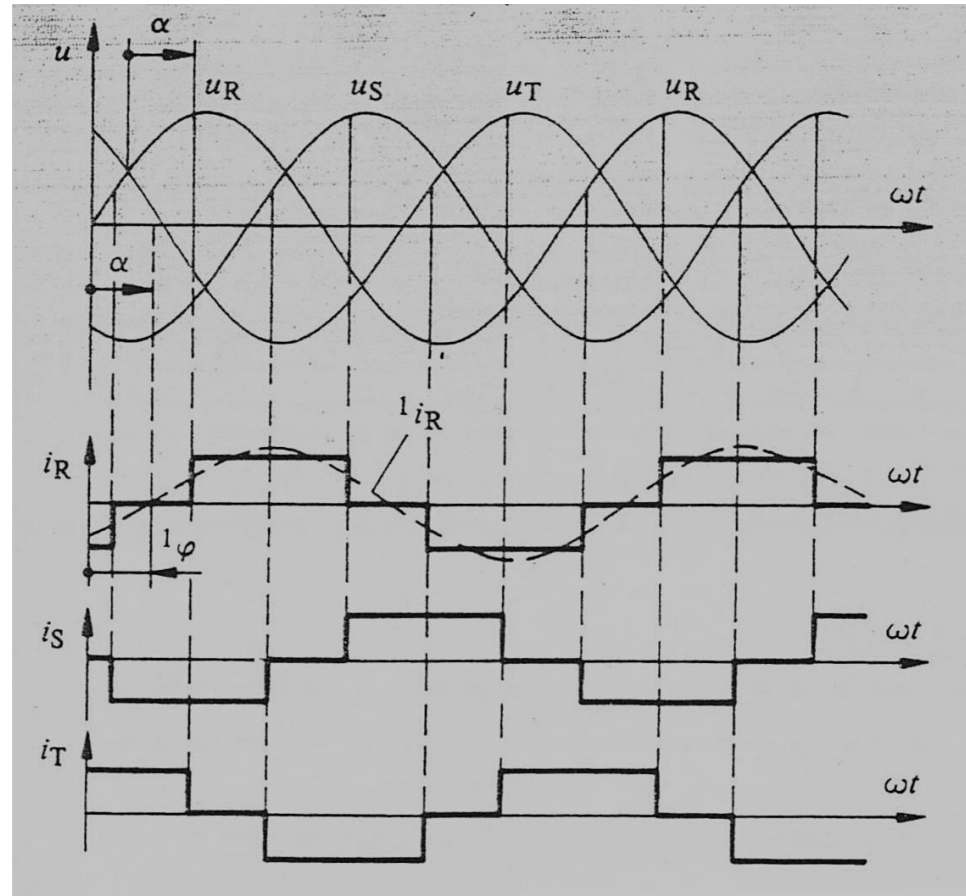
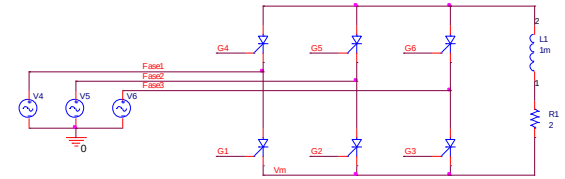
RECTIFICADOR CONTROLADO

$$P = P_1 = 3U_f I_1 \cos \alpha$$

$$Q = Q_1 = 3U_f I_1 \sin \alpha$$

$$I_1 = \frac{\sqrt{6}}{\pi} I_d$$

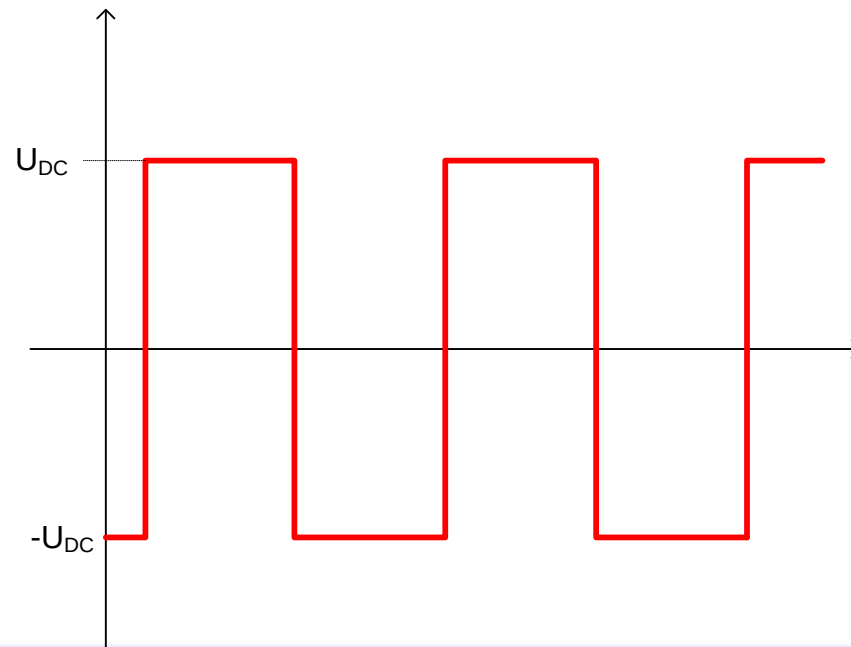
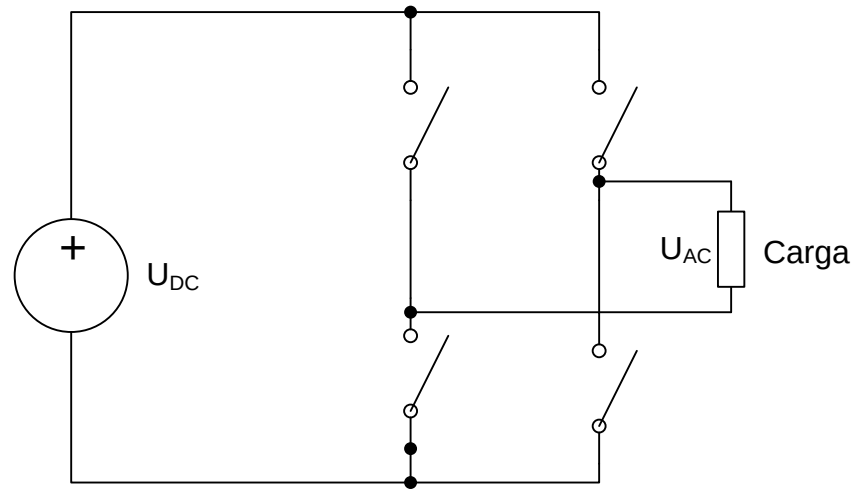
$$S = 3U_f I = 3U_f \sqrt{\frac{2}{3}} I_d$$



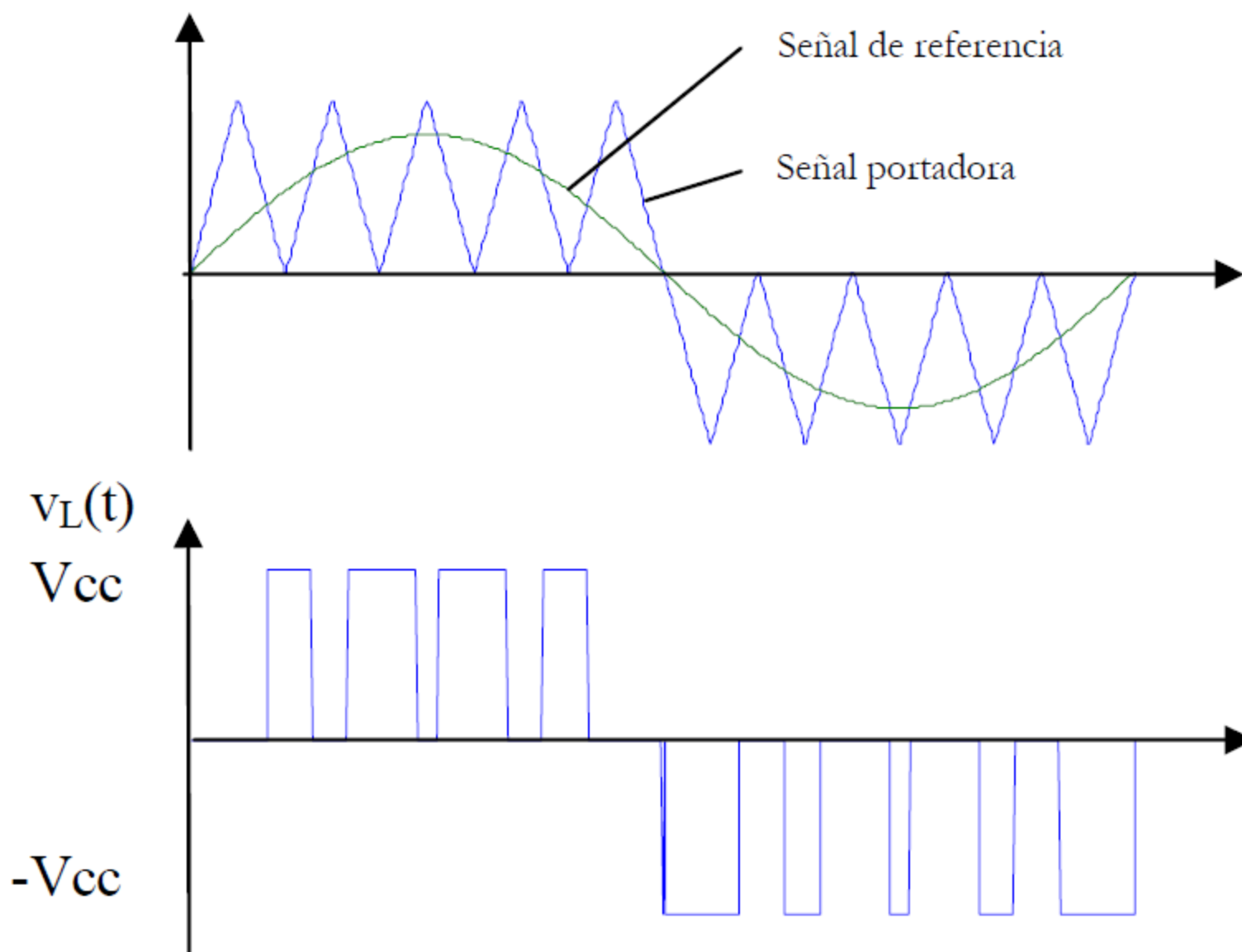
Electrónica de potencia

4 INVERSORES DC/AC

CONVERTIDORES DC/AC

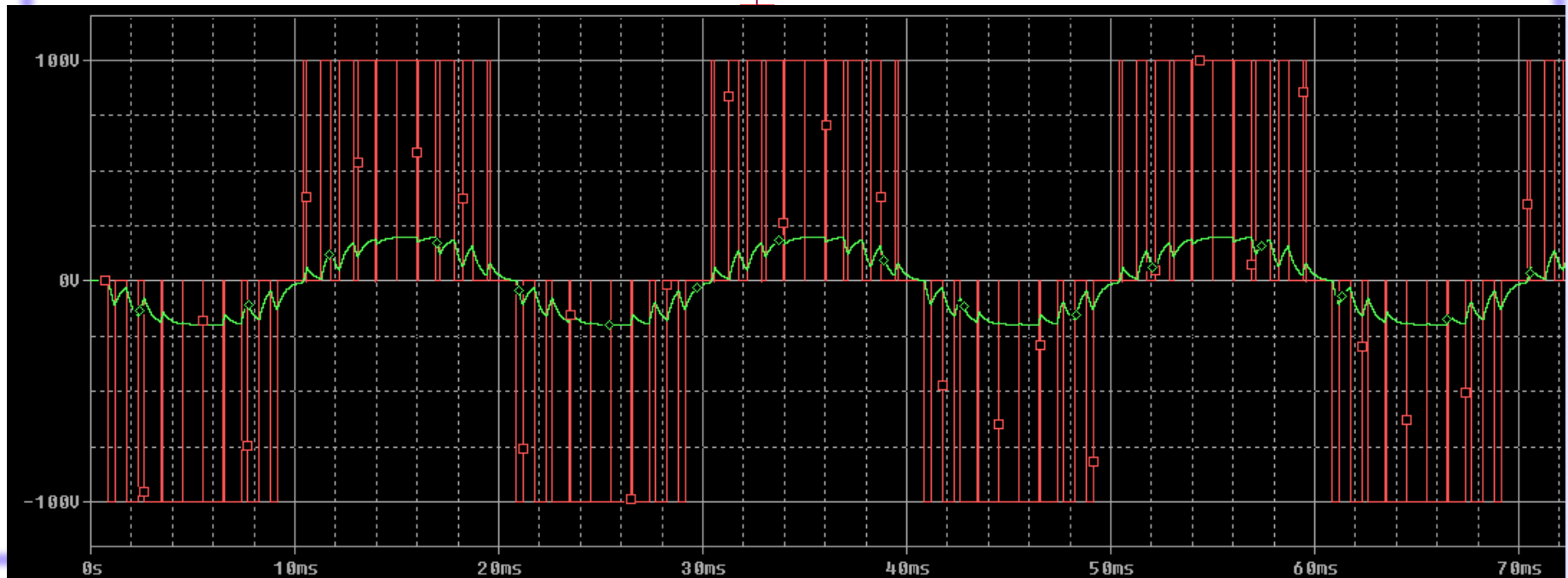
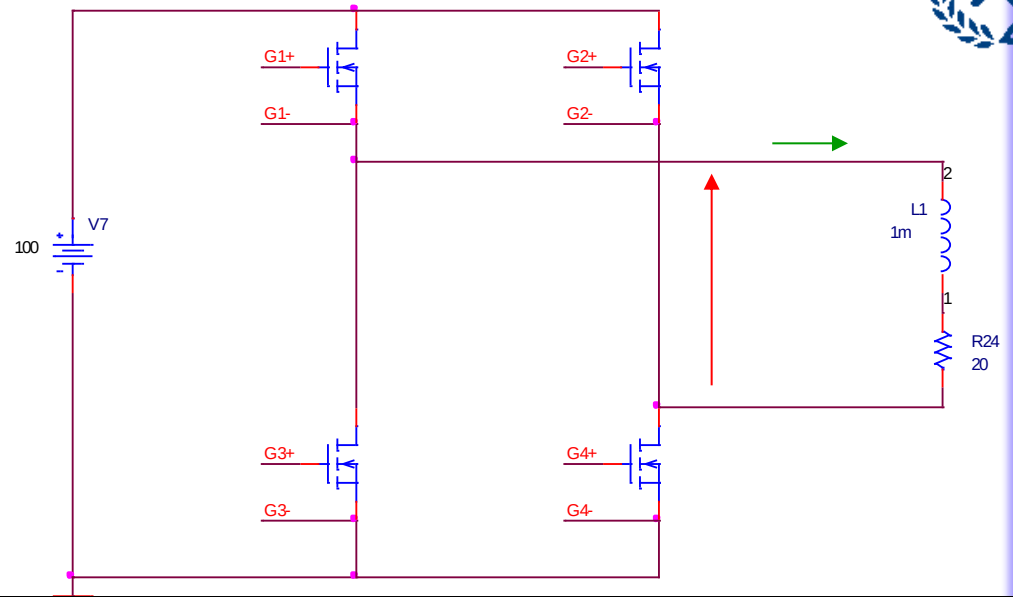


CONVERTIDORES DC/AC: modulación PWM



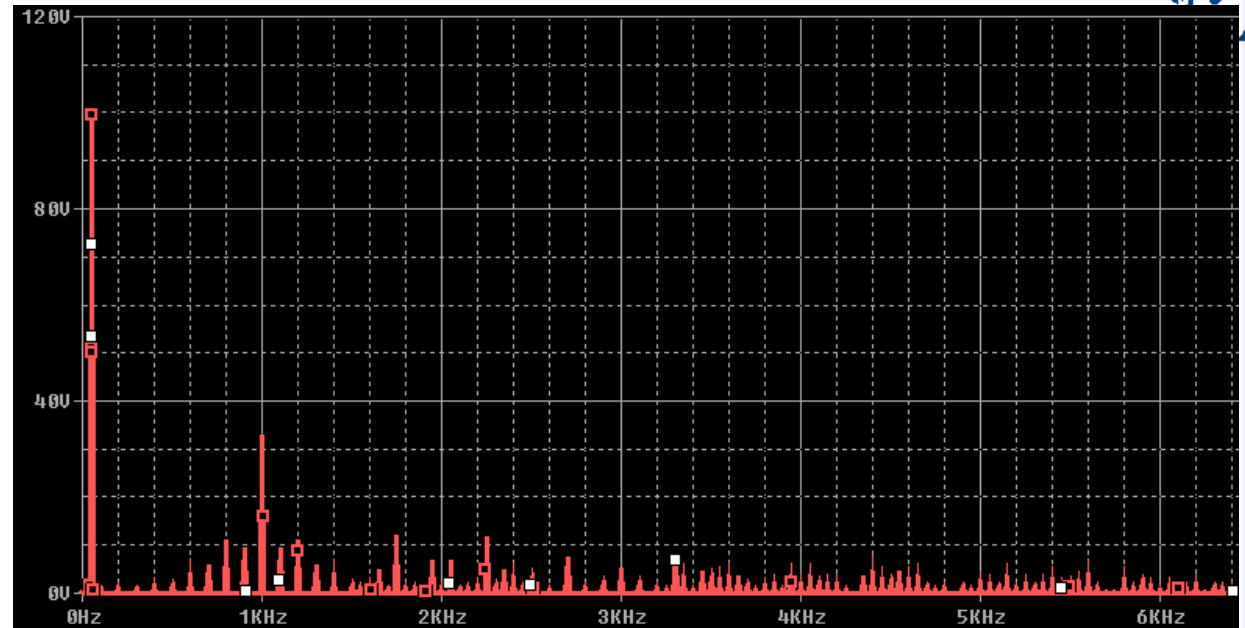
CONVERTIDORES DC/AC

PWM

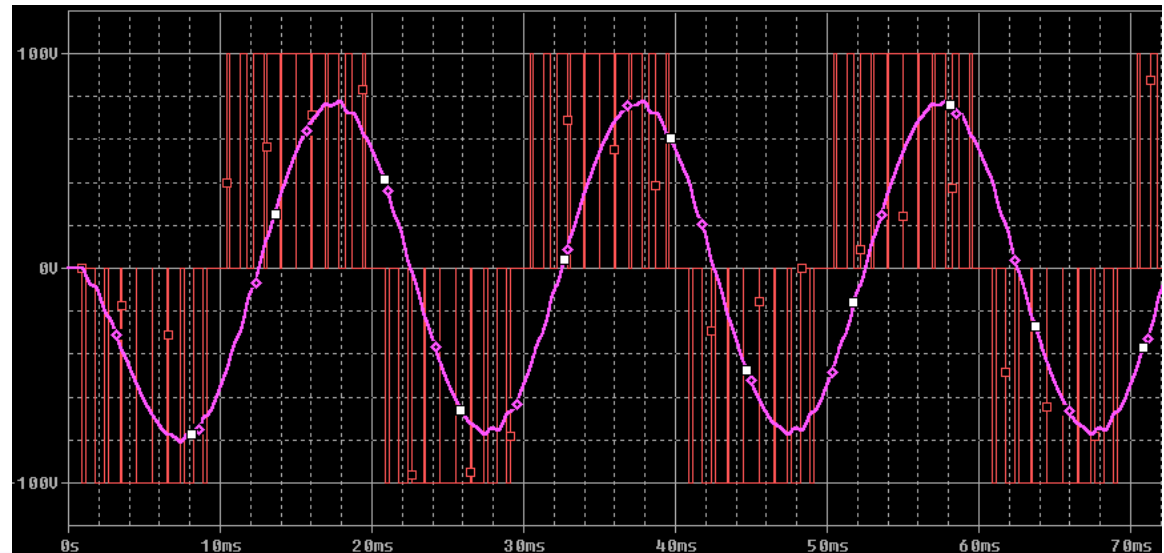


CONVERTIDORES DC/AC

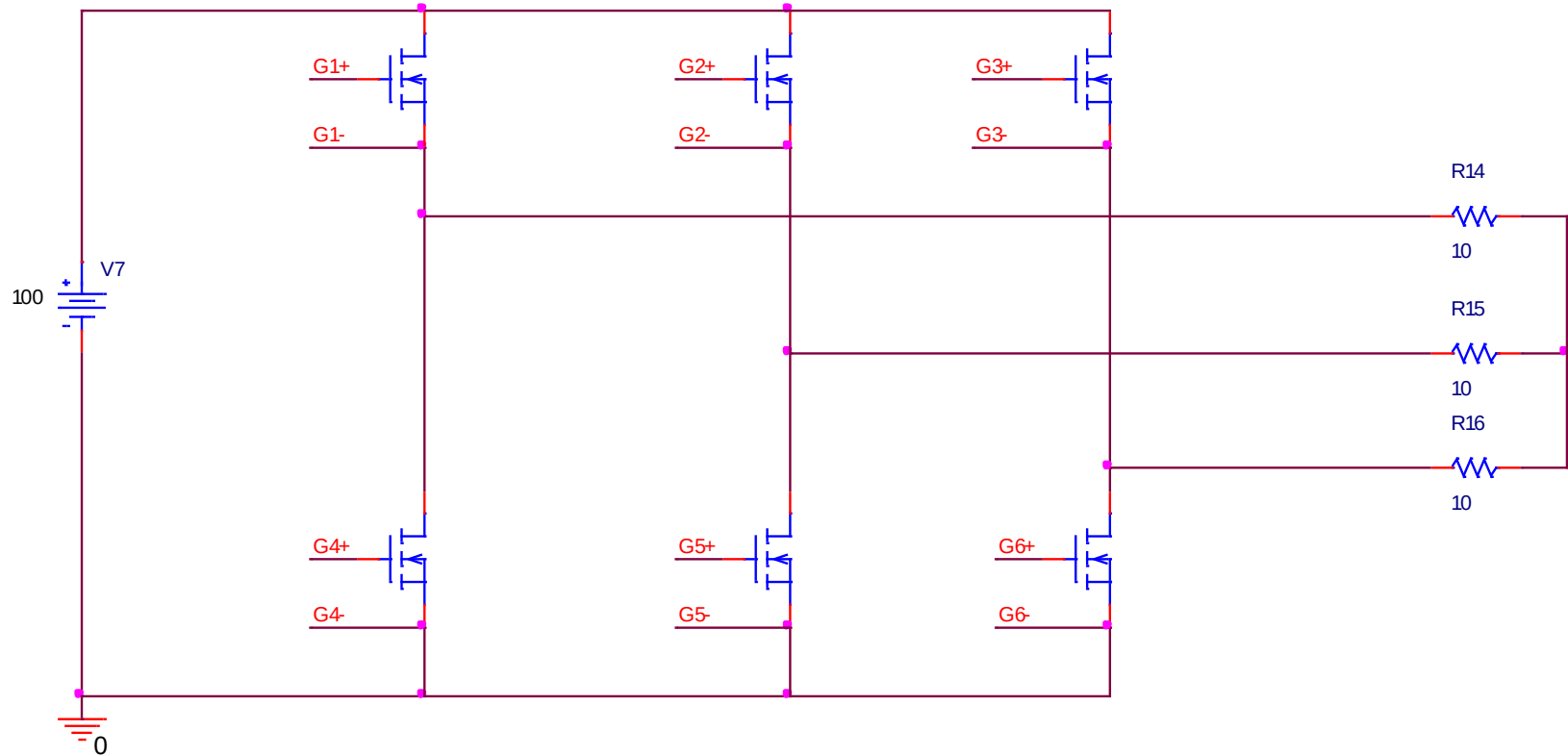
PWM
armónicos



PWM
filtrado



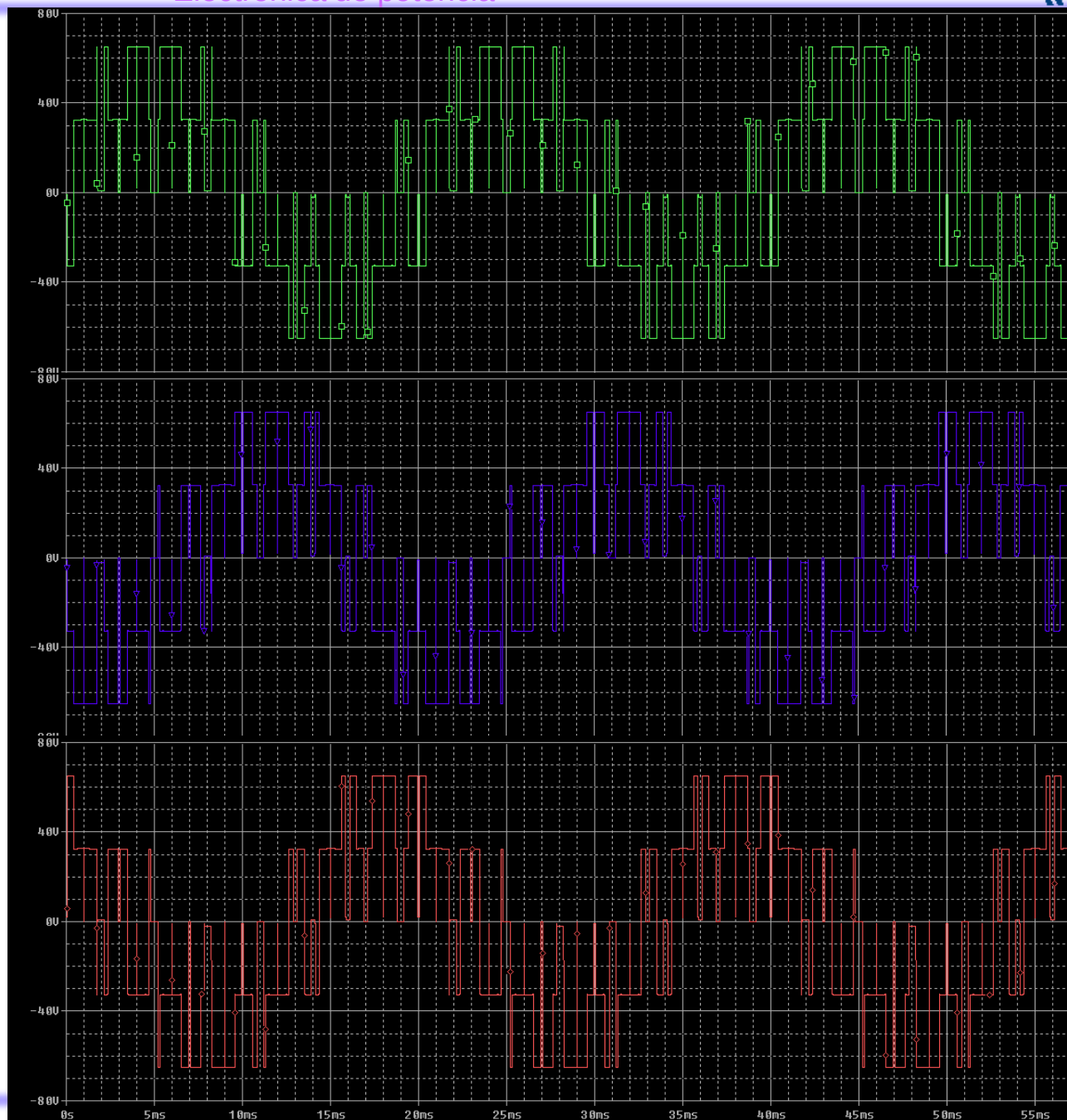
CONVERTIDORES DC/AC (trifásico)



U_{S1}

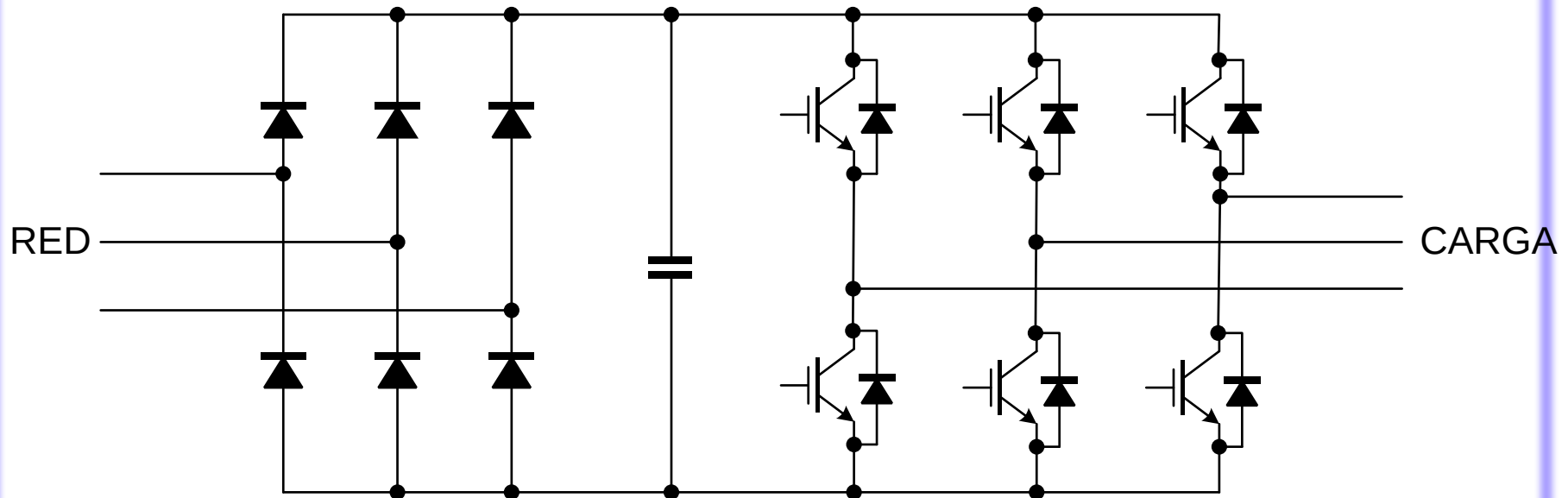
U_{S2}

U_{S3}



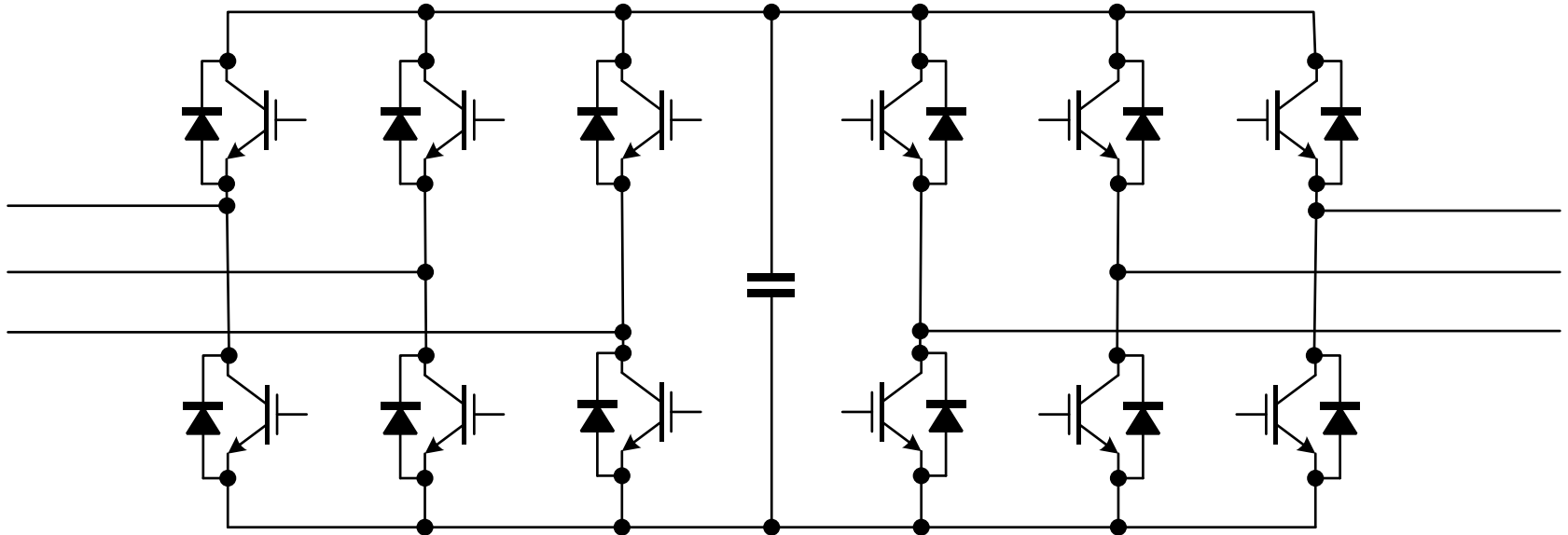
CONVERTIDORES AC/AC

Rectificador+Inversor

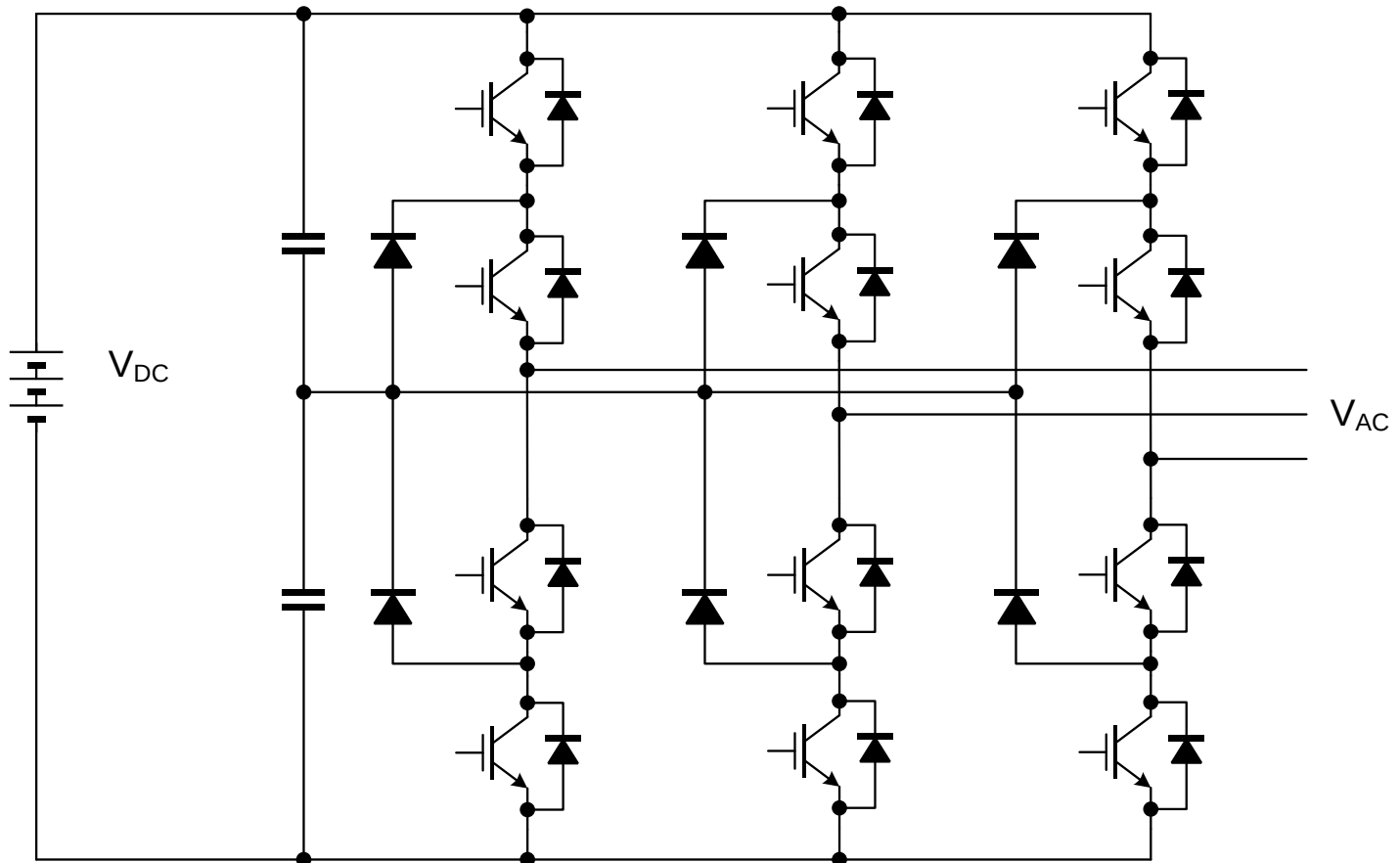


CONVERTIDORES AC/AC

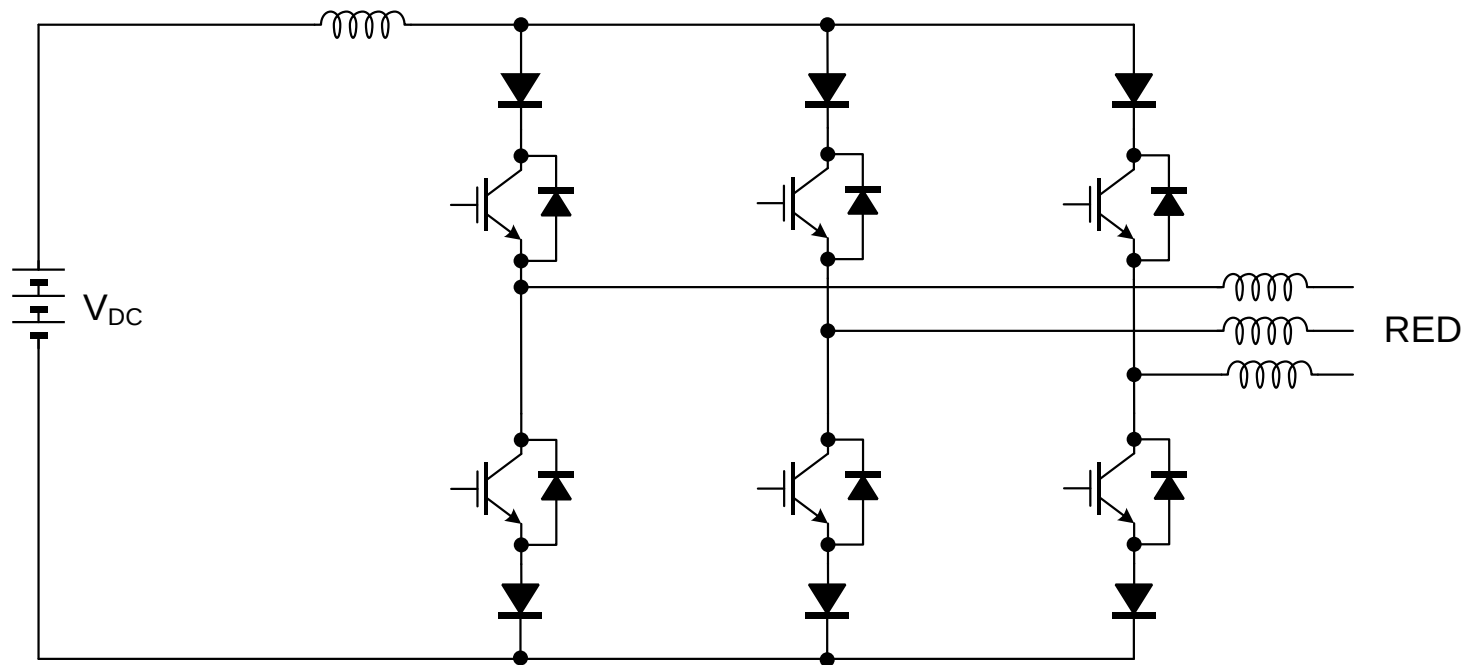
Bidireccional



CONVERTIDORES multinivel



CONVERTIDORES CSI



Troceador-elevador
+
inversor

