Universidad
Carlos III de Madrid
www.uc3m.es

Session 8
Diodes and Applications

Electronic Components and Circuits

Isabel Pérez

www.uc3m.es/portal/page/portal/dpto_tecnologia_electronica/Personal/IsabelPerez

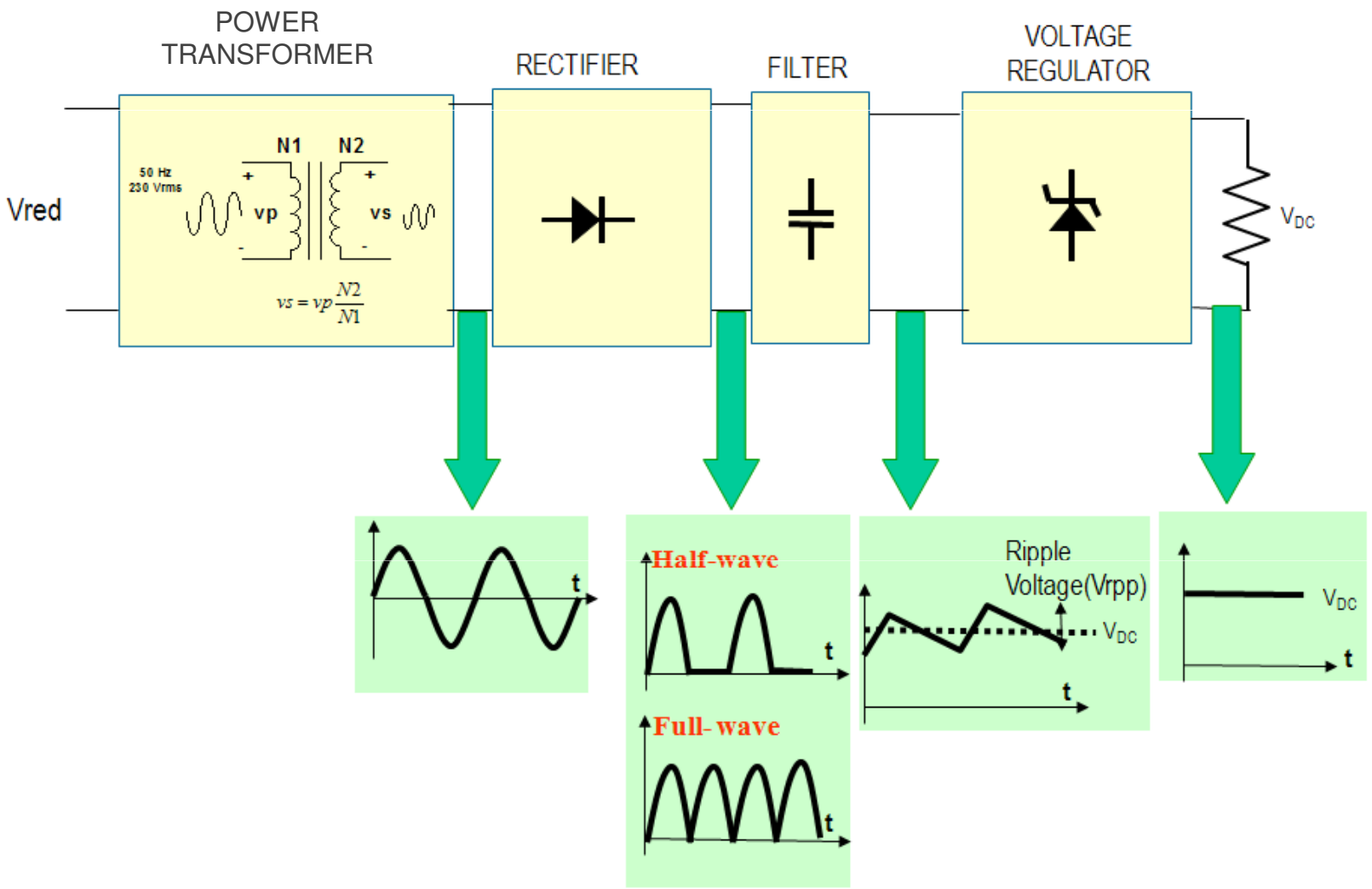
Diode Applications

SKILLS

- To obtain and to interpret the signals and parameters (ripple voltage, PIV, dissipated power) in rectifiers circuits
- To know the parameters (Zener voltage, minimum current, maximum power…) and applications of Zener diodes
- To know the basics parameters of light-emitting (LED y LASER) and light-detecting (photodiodes) diodes

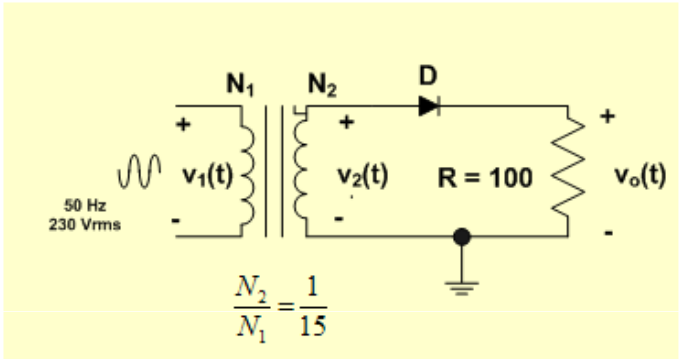
Applications

Power Supply (AC-DC Converter)



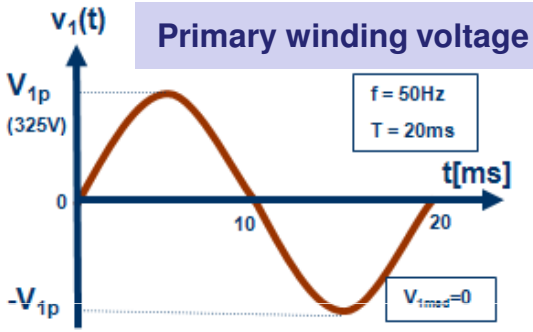
Rectifiers

Half-Wave Rectifier

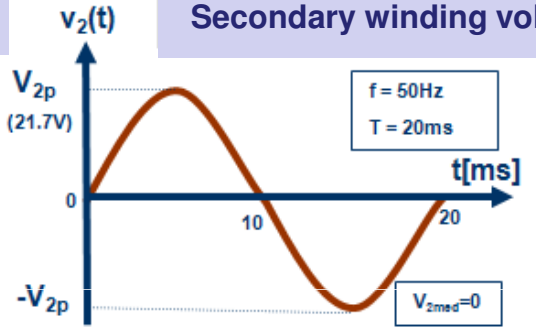


$$\frac{N_2}{N_1} = \frac{1}{15}$$

Primary winding voltage

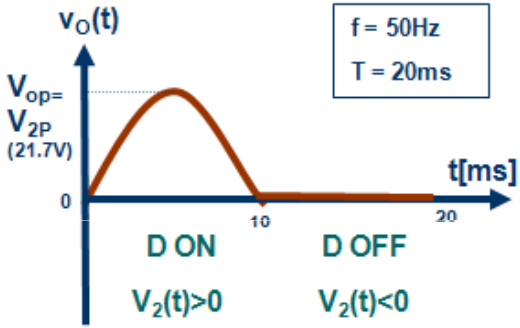


Secondary winding voltage



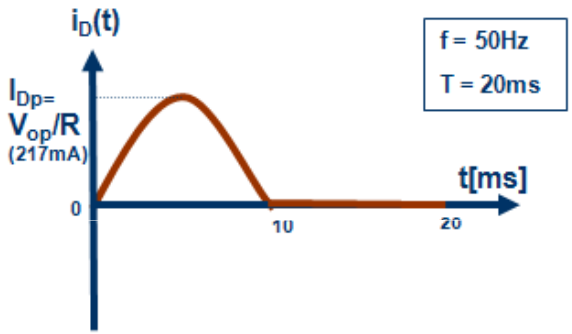
Ideal Diode

Output voltage

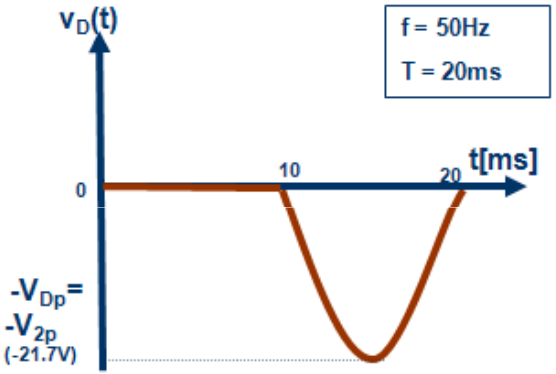


$$\overline{v_o} = \frac{V_{op}}{\pi}$$

Diode current



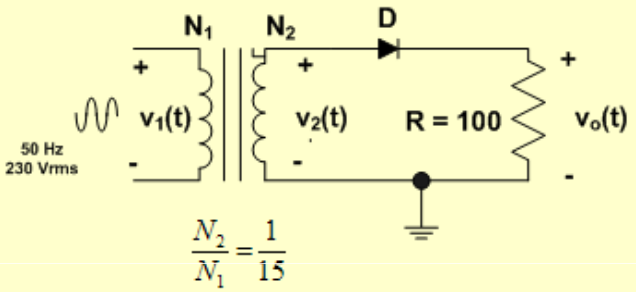
Diode voltage



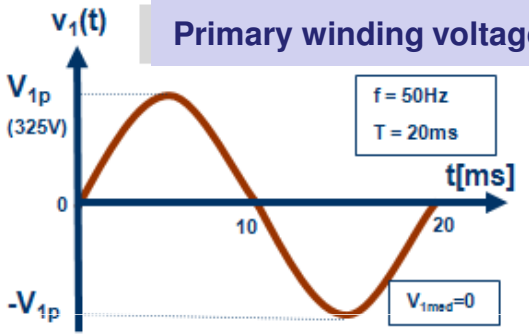
PIV= V_{2p}

Rectifiers

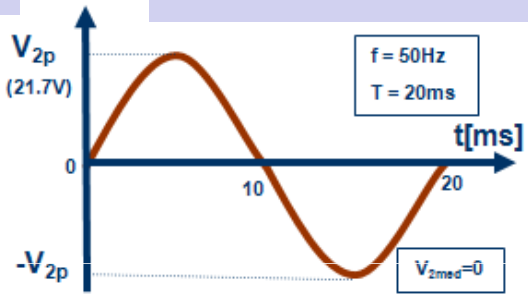
Half-Wave Rectifier



Primary winding voltage

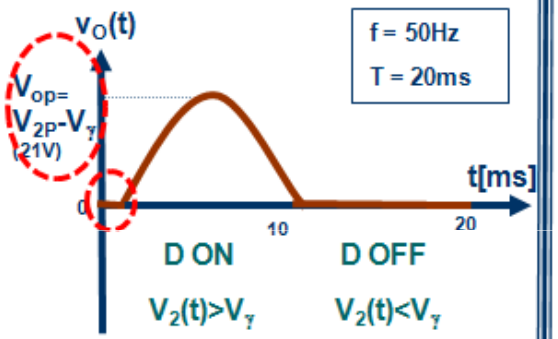


Secondary winding voltage



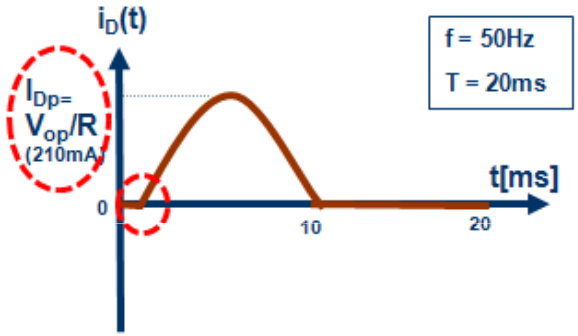
Diode 2º approximation (Vγ ON)

Output voltage

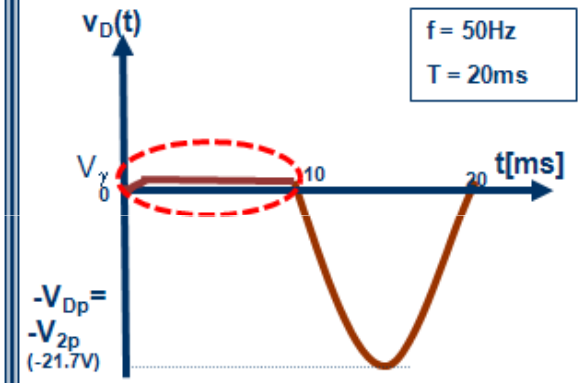


$$\overline{v_o} \approx \frac{V_{op}}{\pi}$$

Diode current



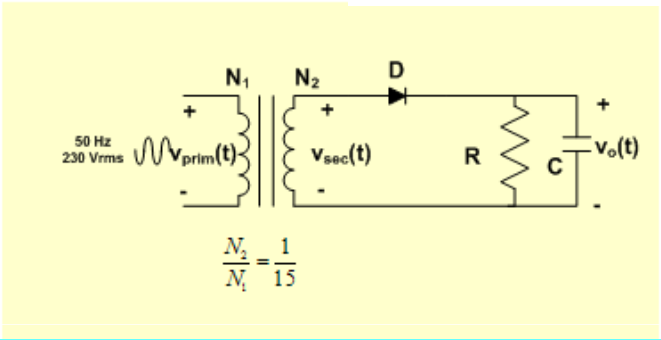
Diode voltage



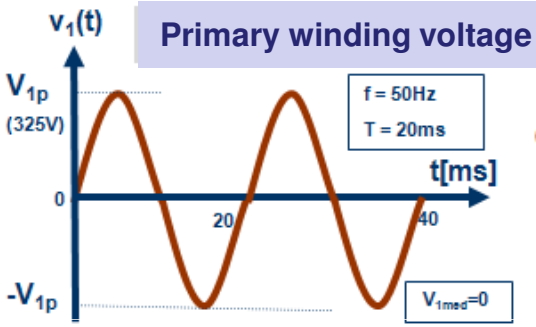
PIV= V_{2p}

Rectifiers

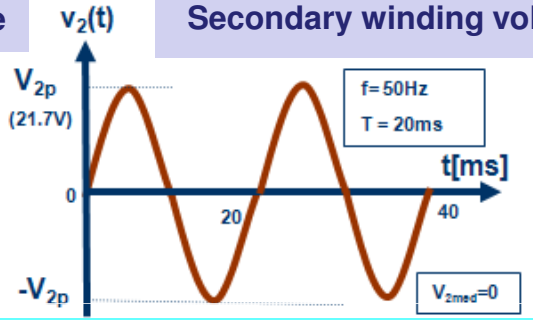
Half-Wave Rectifier + Filter



Primary winding voltage

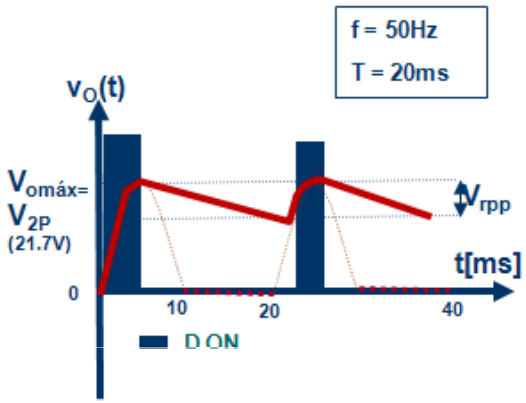


Secondary winding voltage



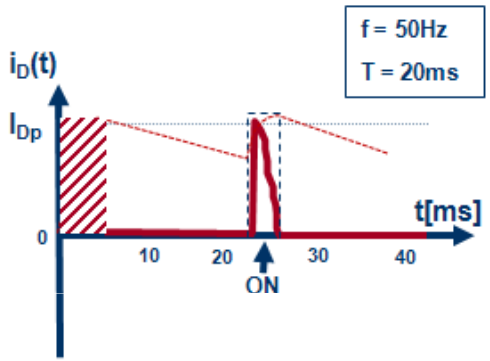
Ideal Diode

Output voltage



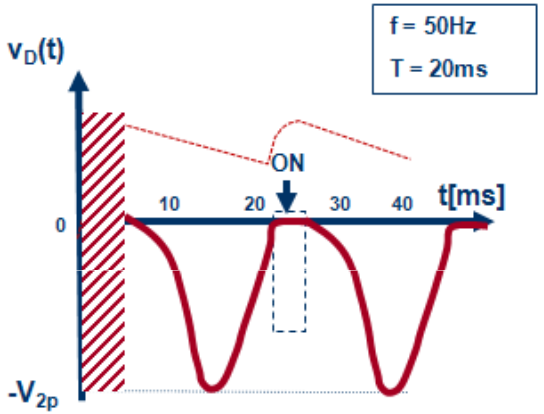
$$V_{rpp} = \frac{V_{2p} \cdot T}{RC} = \frac{V_{2p}}{f \cdot RC}$$

Diode current



$i_D(t)=i_R(t)+i_C(t)$

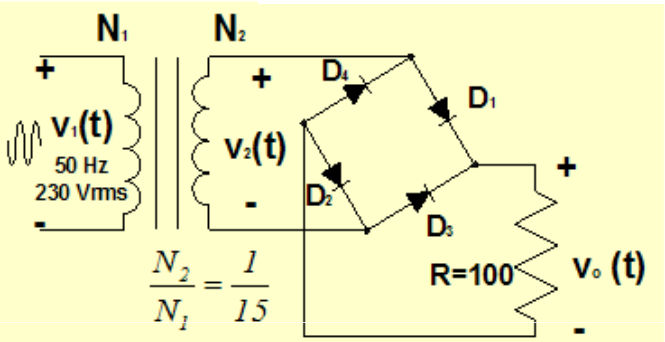
Diode voltage

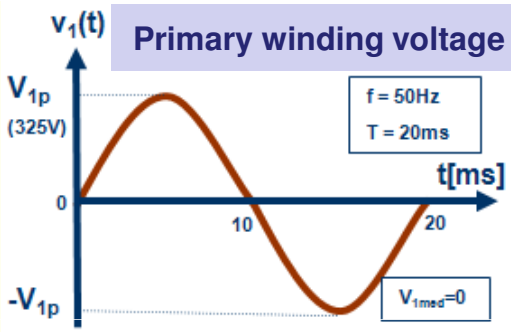


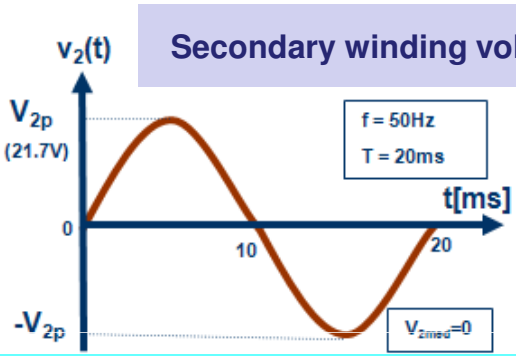
T: Secondary winding voltage period
f: Secondary winding voltage frequency

Rectifiers

Full-Wave Rectifier (Bridge rectifier)

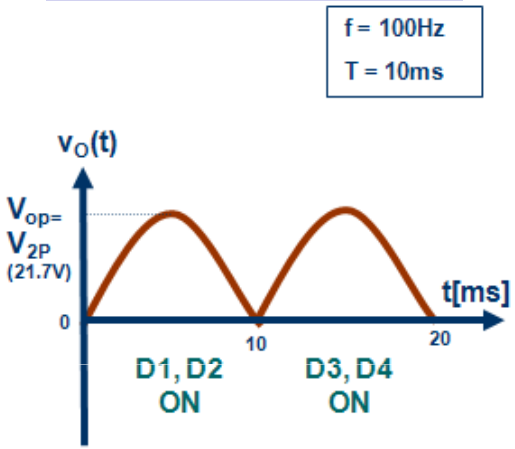






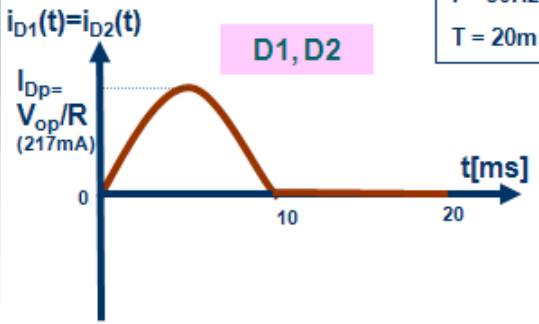
Ideal Diode

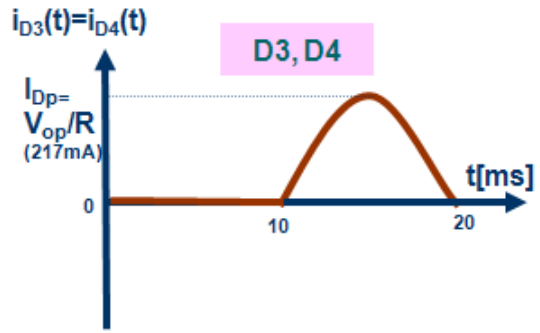
Output voltage



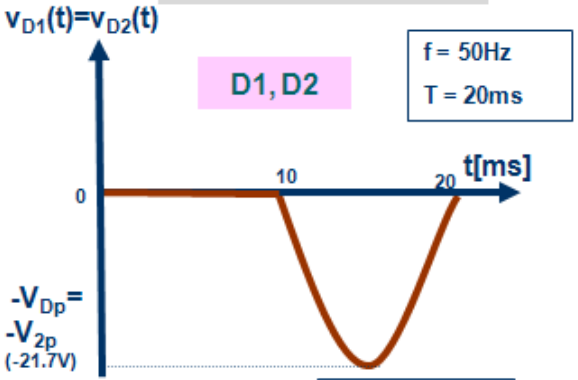
$$\overline{v_o} = \frac{2V_{op}}{\pi}$$

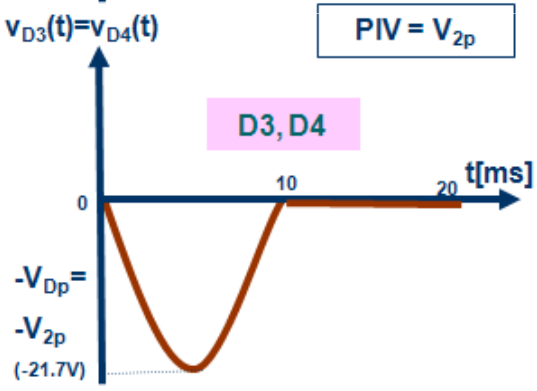
Diode current





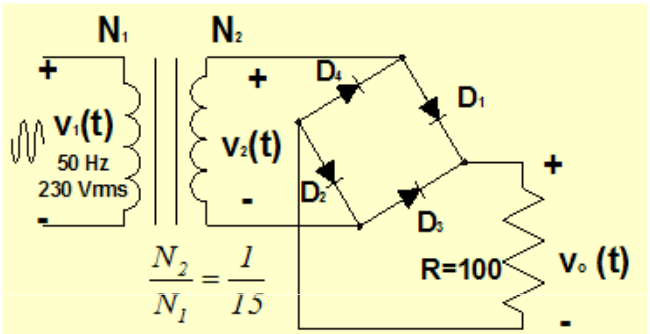
Diodes voltage



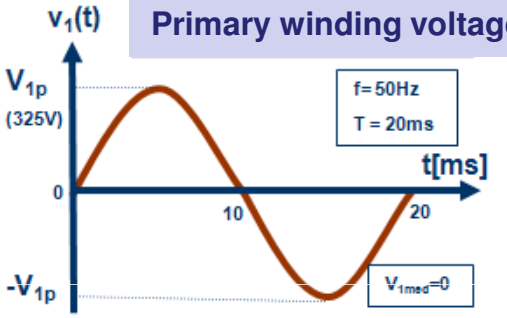


Rectifiers

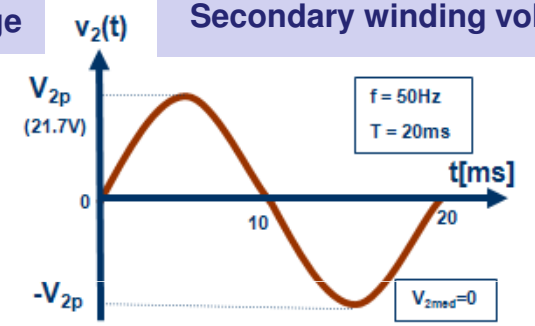
Full-Wave Rectifier (Bridge rectifier)



Primary winding voltage

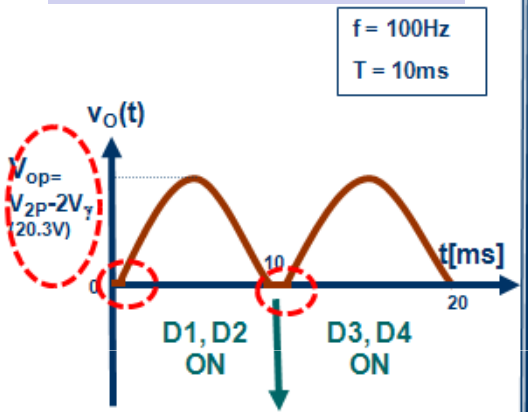


Secondary winding voltage



Diode 2º approximation (Vγ ON)

Output voltage

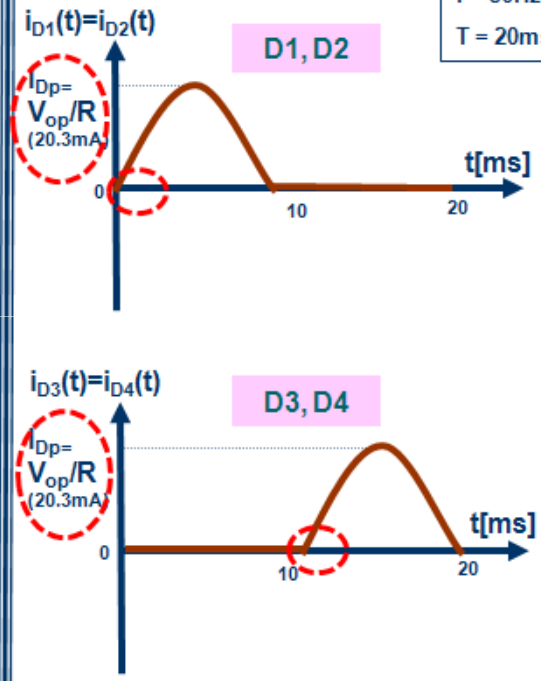


D1,D2,D3 y D4 OFF

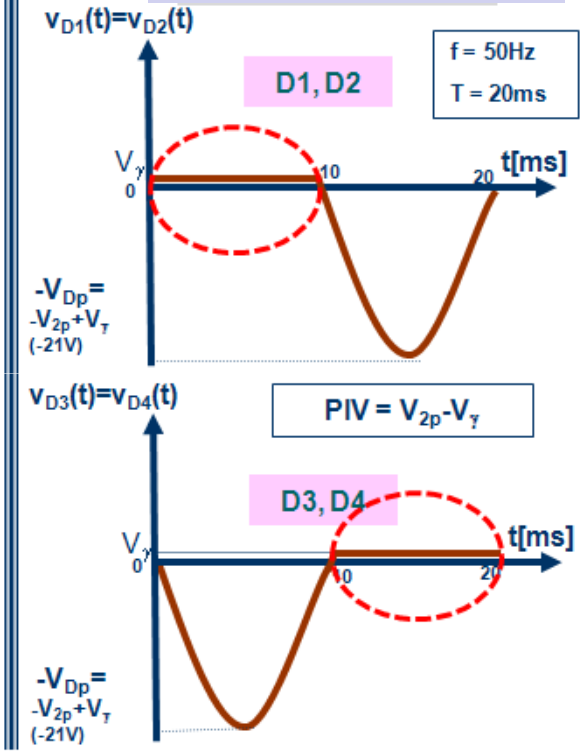
$-2V_\gamma < V_2(t) < 2V_\gamma$

$$\overline{v_o} \approx \frac{2V_{op}}{\pi}$$

Diode current

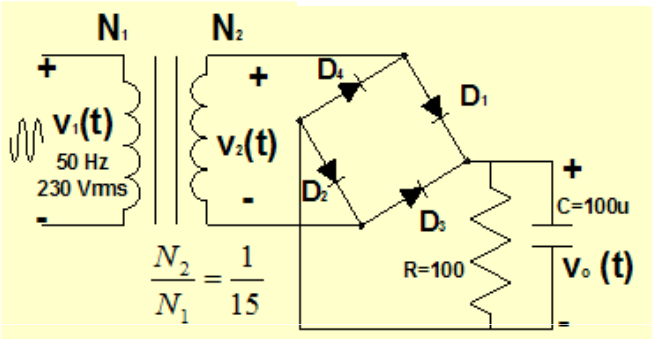


Diodes voltage

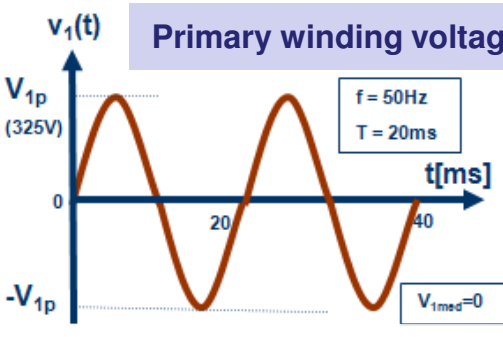


Rectifiers

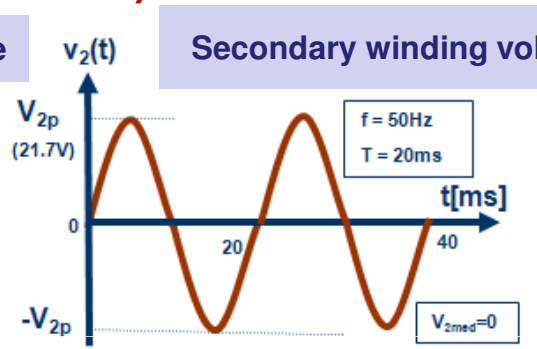
Full-Wave Rectifier (Bridge rectifier) + Filter



Primary winding voltage

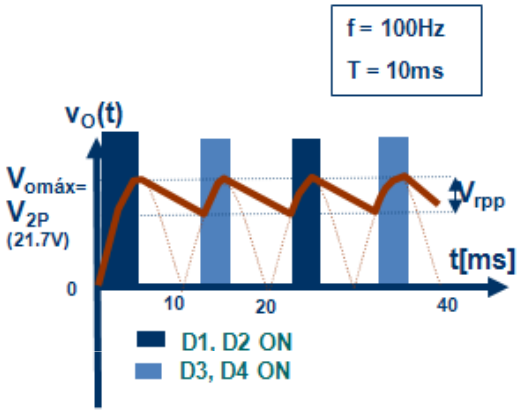


Secondary winding voltage



Ideal Diode

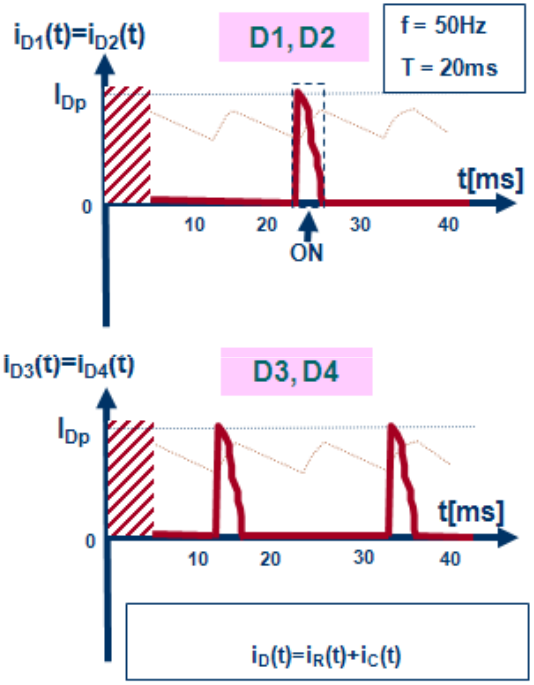
Output voltage



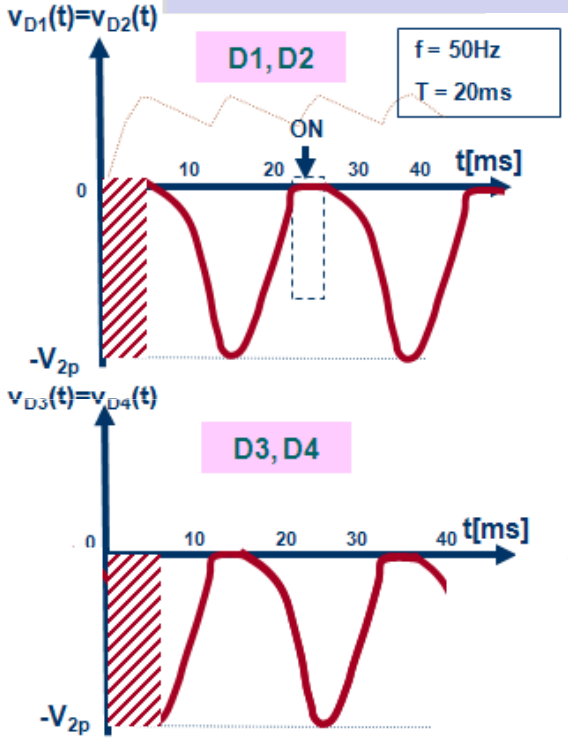
$$V_{rpp} = \frac{V_{2p} \cdot T}{2 \cdot RC} = \frac{V_{2p}}{2 \cdot f \cdot RC}$$

T: Secondary winding voltage period
f: Secondary winding voltage frequency

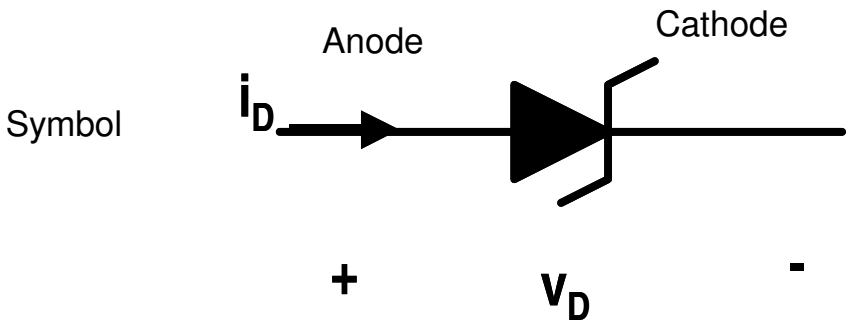
Diode current



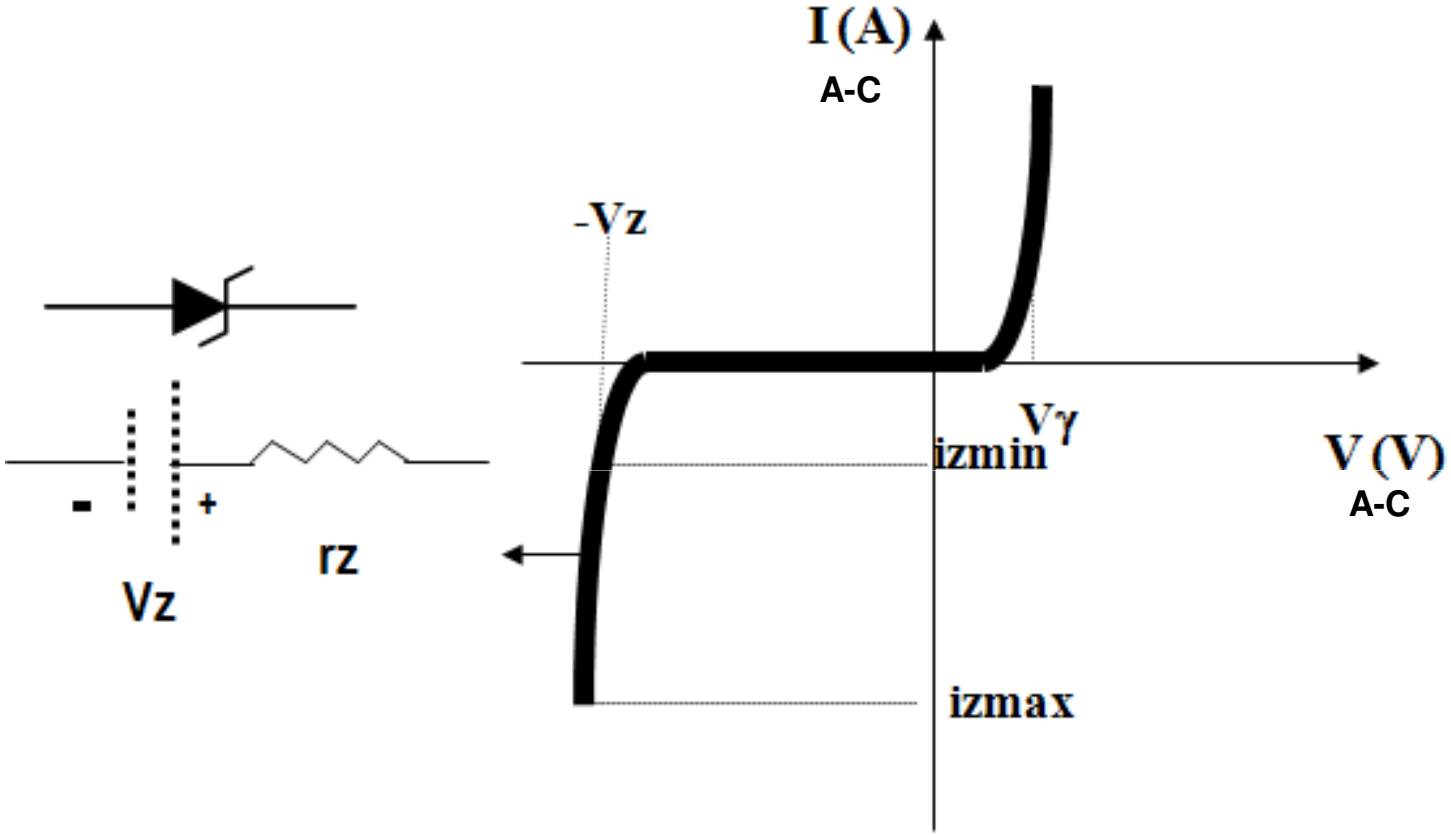
Diodes voltage



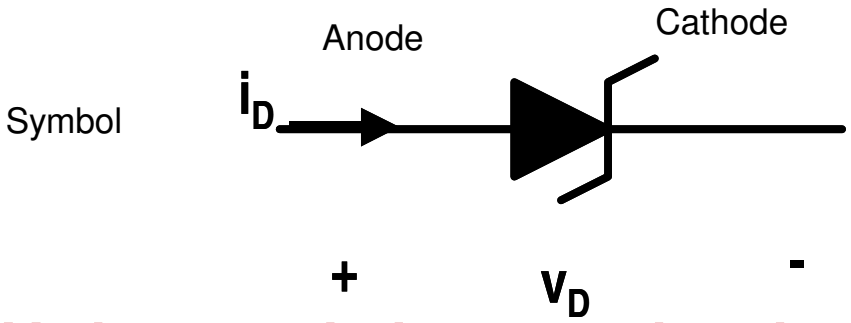
Zener Diodes



I-V characteristic

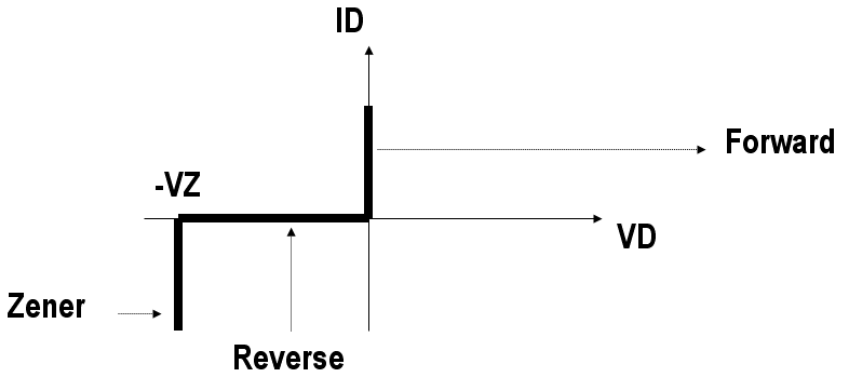


Zener Diodes



I-V characteristic approximations

Ideal Zener

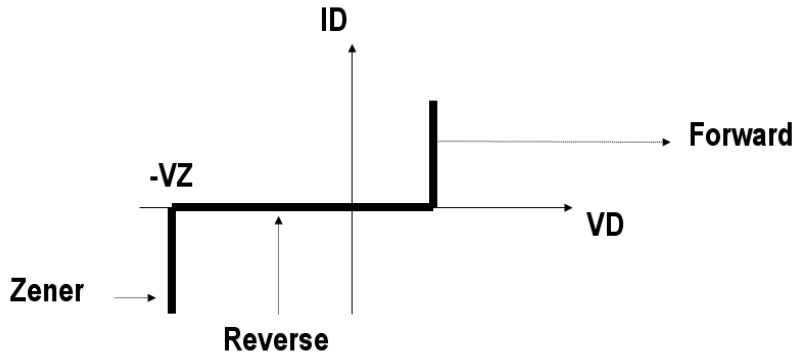


Forward: A C — Short circuit: VD=0, ID>0

Reverse: A C — Open circuit: ID=0, VD<0

Zener: A C (- VZ +) — VA-C=-VZ, ID<0

2º approximation



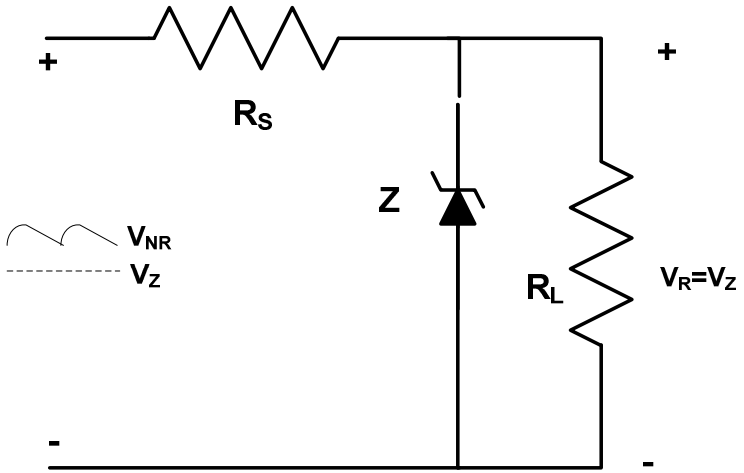
Forward: A C (+ Vγ -) — VA-C =Vγ, ID>0

Reverse: A C — Open circuit: ID=0, VD<0

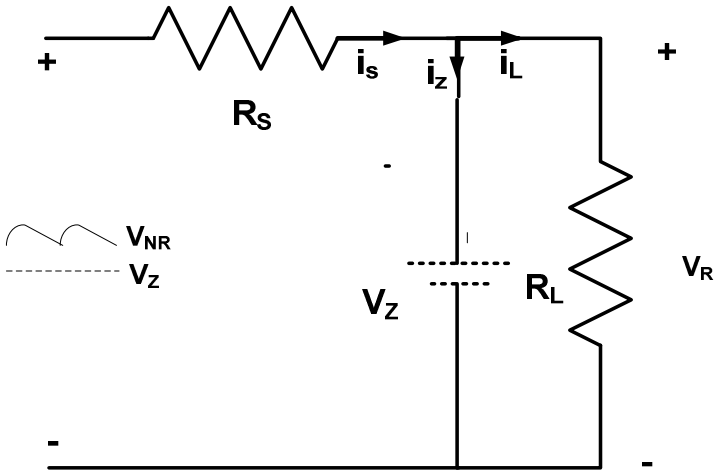
Zener: A C (- VZ +) — VA-C=-VZ, ID<0

Zener Diodes

Applications : Voltage stabilizer



Working in Zener region



$$i_Z = i_S - i_L = \frac{V_{NR} - V_Z}{R_S} - \frac{V_Z}{R_L}$$

Design

$$i_Z > i_{Z\min} \Rightarrow R_{S\max} = \frac{V_{NR(\min)} - V_Z}{i_{L\max} + i_{z\min}}$$

$$i_Z < i_{Z\max} \Rightarrow R_{S\min} = \frac{V_{NR(\max)} - V_Z}{i_{S\max}}$$

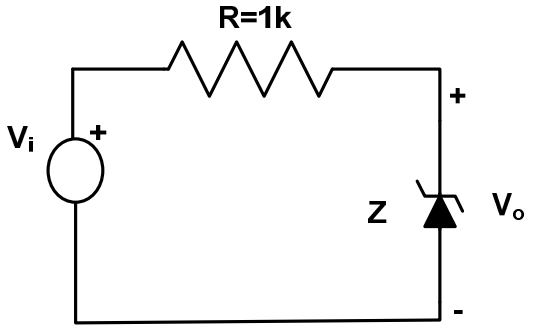
$$P_{RS} = {i_{S\max}}^2 \bullet R_S$$

$$P_Z = V_Z \bullet \left(i_{S\max} - i_{L\min}\right)$$

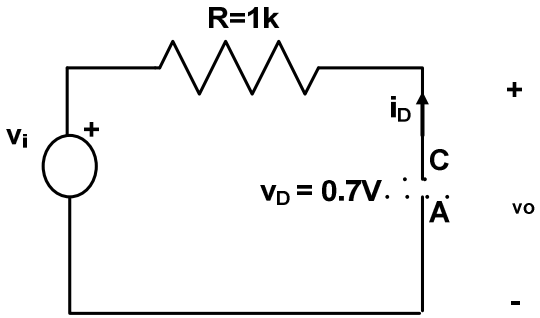
Zener Diodes

Applications : Limiters (using i-v characteristic approximations)

Calculate and draw the transfer function, Vo as a function of Vi , with $V\gamma$=0.7V, VZ=5V.



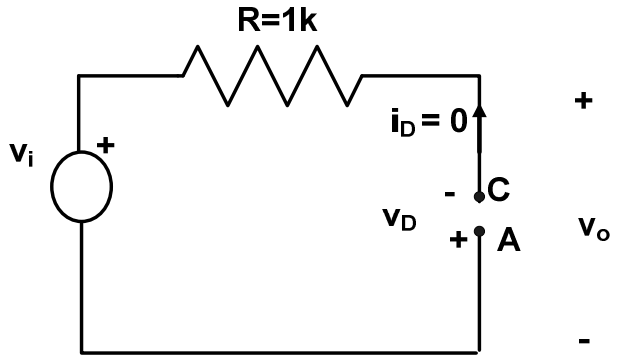
•Zener : Forward region



$v_o = -v_D = -0.7V$

$v_i < -0.7V$

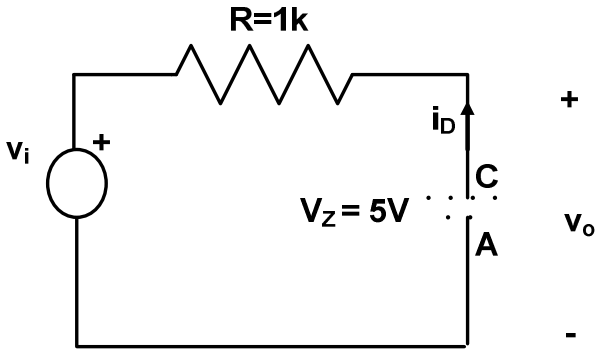
•Zener : Reverse region



$v_o = v_i$

$-0.7 < v_i < 5V$

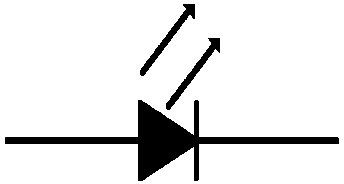
•Zener : Zener region



$v_o = V_Z$

$v_i > 5V$

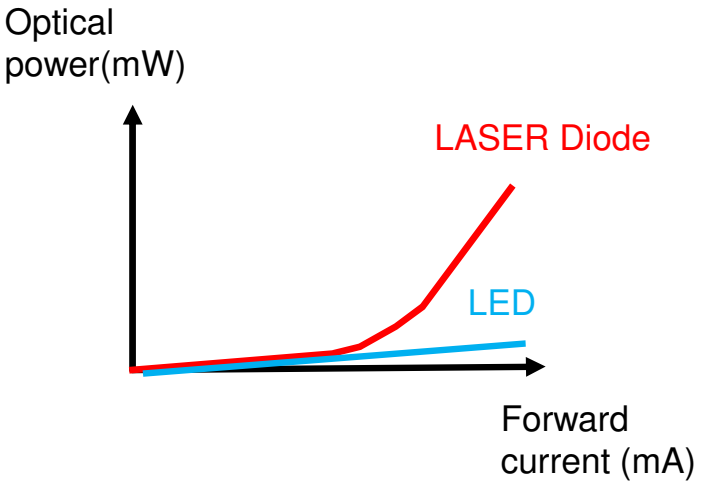
LEDs y LASER Diodes



- Forward region: Current to light conversion
- Emission wavelengths, λ, (different colors).

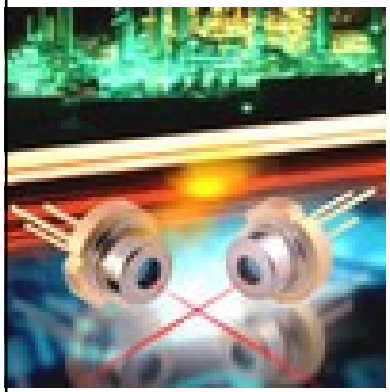
LED (Light Emitting Diode)

- Wide emission spectrum (several λ)
- Conduction threshold voltage (Blue LED: Vγ≈3V; Green LED: Vγ≈2.5V; Yelow LED: Vγ≈1V)



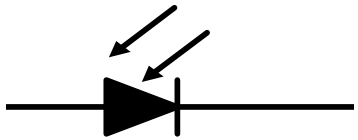
Diodo LASER

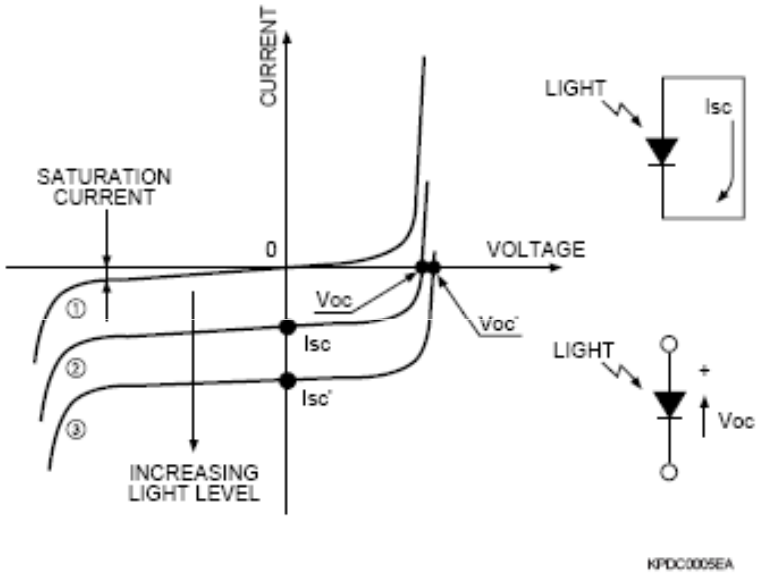
(Light Amplification by Stimulated Emission of Radiation)



- Narrow emission spectrum(≅ only one λ)
- Coherent light

Photodiodes





www.hamamatsu.com

- Reverse region: Light to current conversion
- Wavelength range

Conditioner circuit

(Current- Voltage converter)