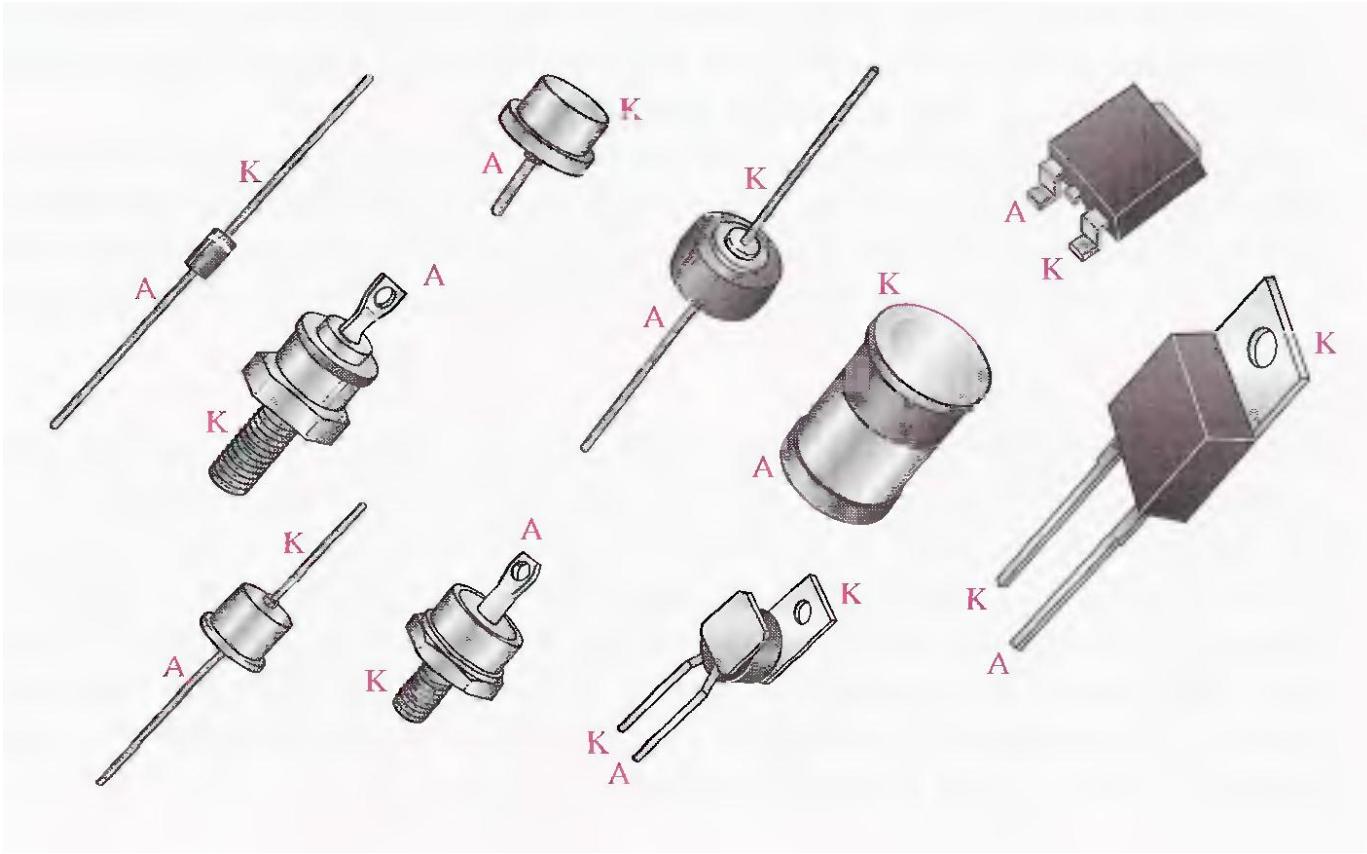




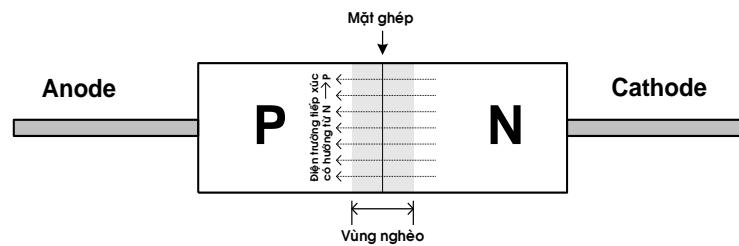
*Chương 1:*  
**LINH KIỆN BÁN DẪN 2 LỚP  
VÀ ỨNG DỤNG (TT)**

# DIODE

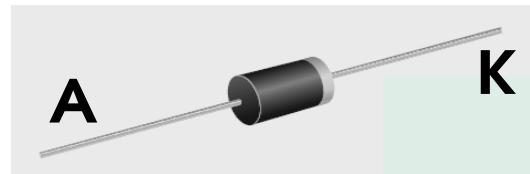
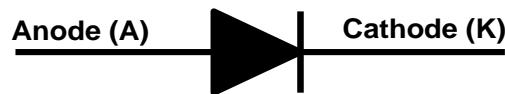


# Diode chỉnh lưu

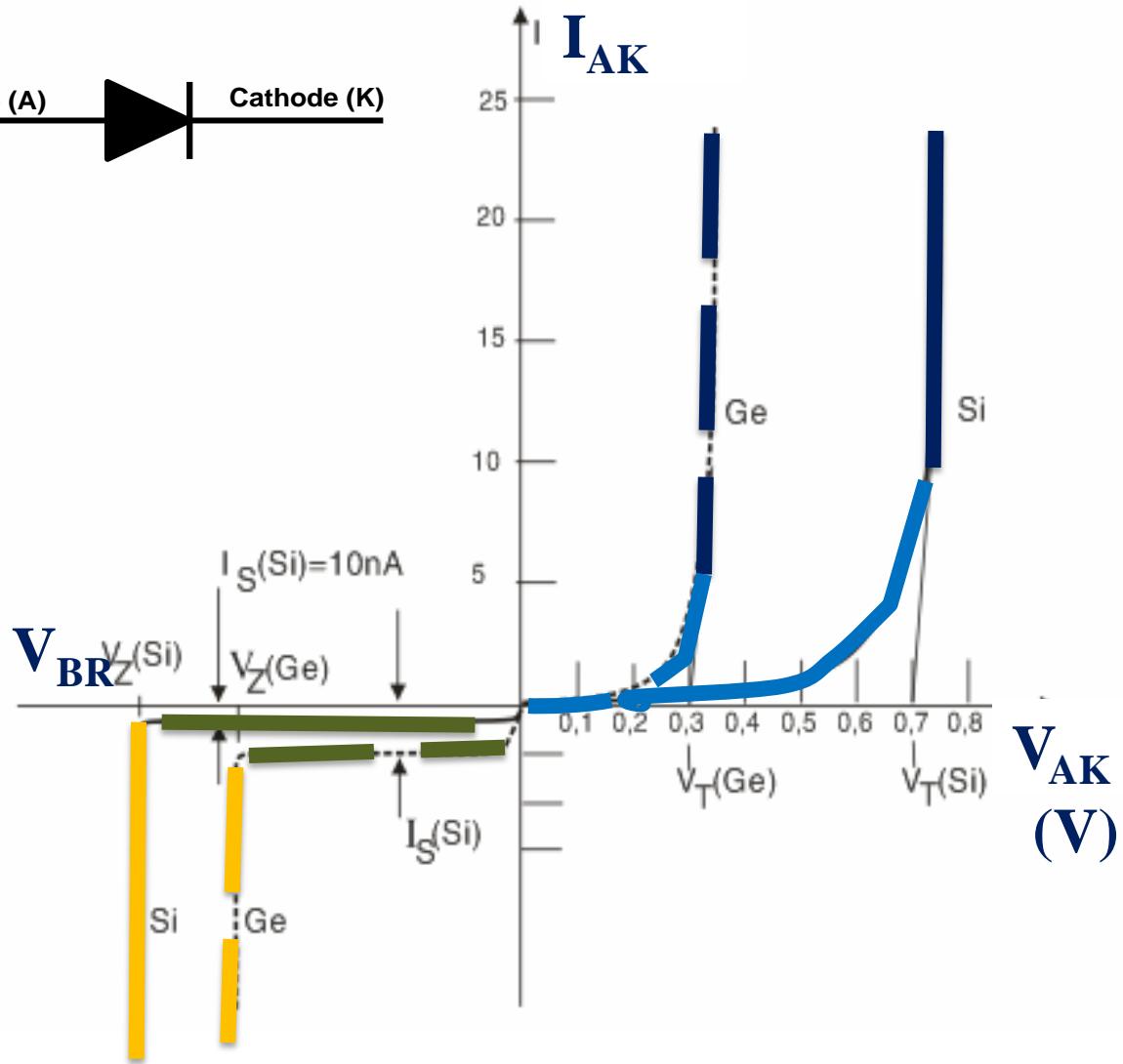
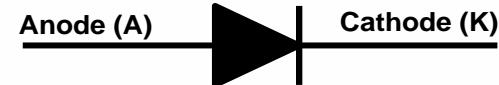
## Cấu tạo



## Symbol:



# Đặc tuyến Volt Ampere

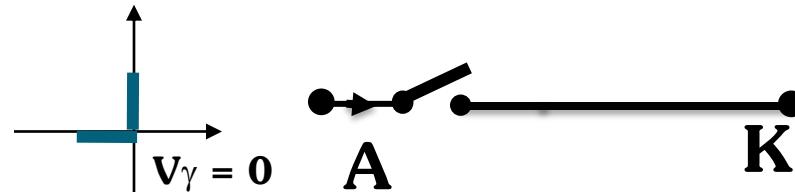


Vùng đánh thủng

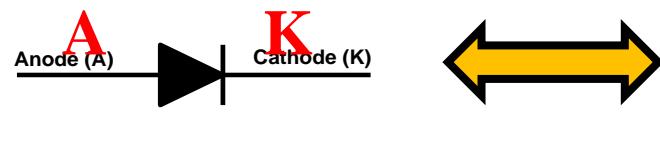
Vùng dẫn  $V_{AK} > V_\gamma$

Vùng phân cực ngược

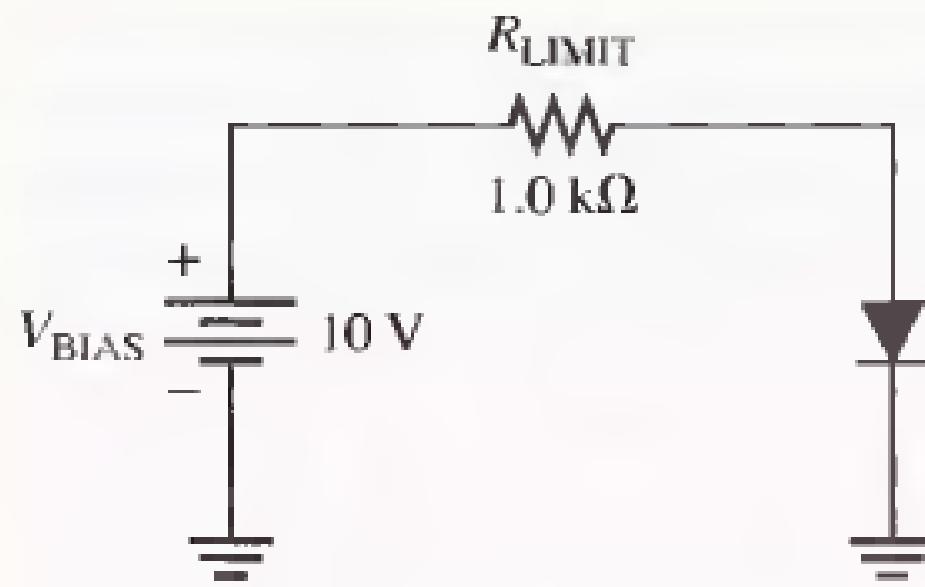
# Models of Diode



**Ideal Model  $V_\gamma = 0$  (Diode lý tưởng)**



**Practical Model (Sự áp là hằng số)**



Ideal model:

$$V_F = 0 \text{ V}$$

$$I_F = \frac{V_{BIAS}}{R_{LIMIT}} = \frac{10 \text{ V}}{1.0 \text{ k}\Omega} = 10 \text{ mA}$$

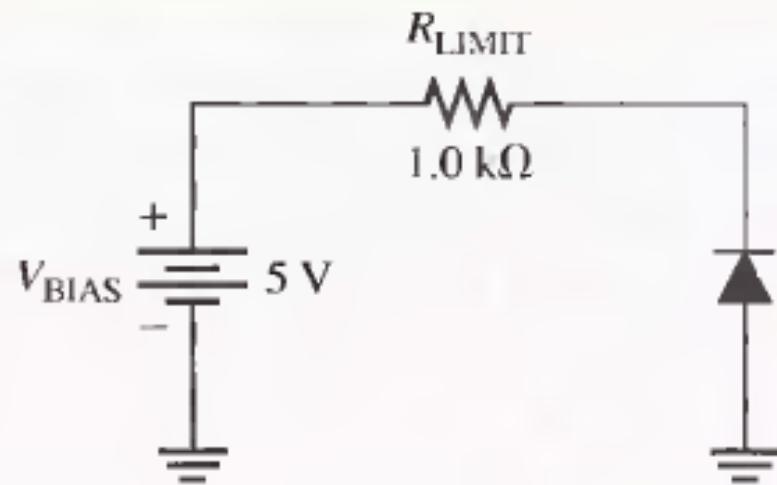
Practical model:

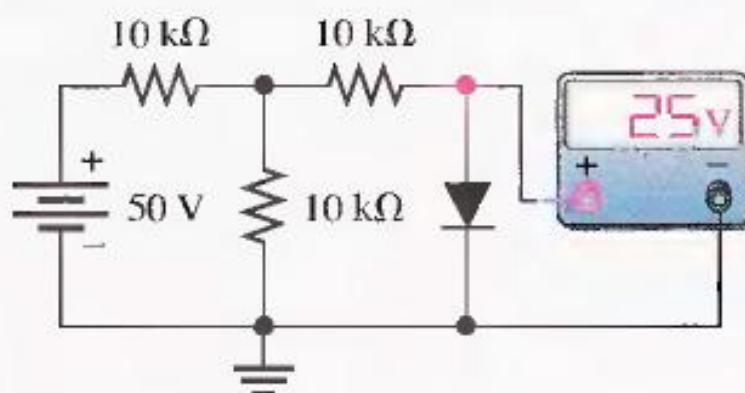
$$V_F = 0.7 \text{ V}$$

$$I_F = \frac{V_{BIAS} - V_F}{R_{LIMIT}} = \frac{10 \text{ V} - 0.7 \text{ V}}{1.0 \text{ k}\Omega} = \frac{9.3 \text{ V}}{1.0 \text{ k}\Omega} = 9.3 \text{ mA}$$

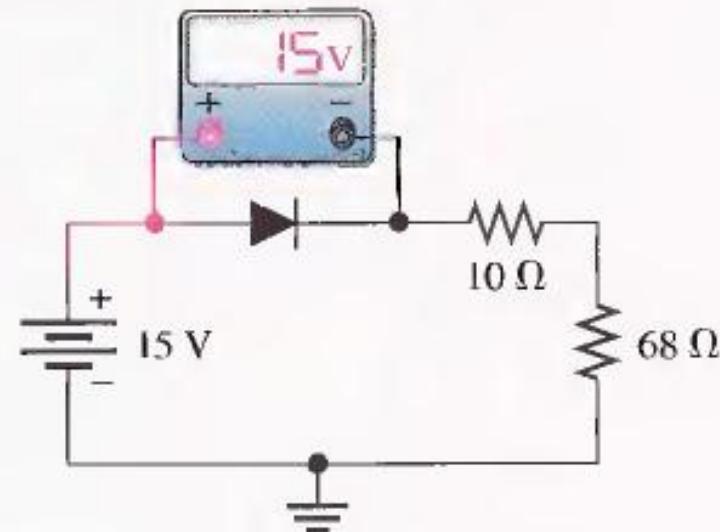
$$V_{R_{LIMIT}} = I_F R_{LIMIT} = (9.3 \text{ mA})(1.0 \text{ k}\Omega) = 9.3 \text{ V}$$

**Reverse bias :  $I_R = 0$**

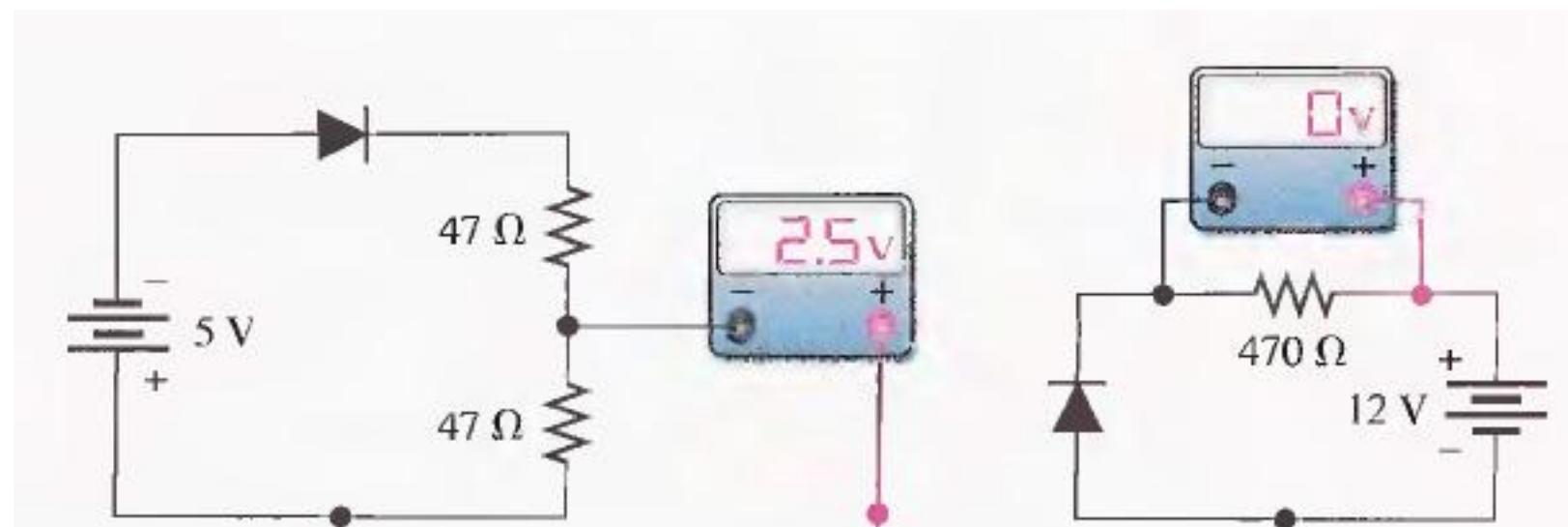




(a)



(b)



## Axial Lead Standard Recovery Rectifiers

This data sheet provides information on subminiature size, axial lead mounted rectifiers for general-purpose low-power applications.

### Mechanical Characteristics

- Case: Epoxy, Molded
- Weight: 0.4 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes:  
220°C Max. for 10 Seconds, 1/16" from case
- Shipped in plastic bags, 1000 per bag.
- Available Tape and Reeled, 5000 per reel, by adding a "RL" suffix to the part number
- Polarity: Cathode Indicated by Polarity Band
- Marking: 1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

**1N4001  
thru  
1N4007**

1N4004 and 1N4007 are  
Motorola Preferred Devices

**LEAD MOUNTED  
RECTIFIERS  
50–1000 VOLTS  
DIFFUSED JUNCTION**



CASE 59-03  
DO-41

**MAXIMUM RATINGS**

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007
*Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RRM}$ $V_{RWM}$ $V_R$	50	100	200	400	600	800	1000
*Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	$V_{RSM}$	60	120	240	480	720	1000	1200
*RMS Reverse Voltage	$V_R(RMS)$	35	70	140	280	420	560	700
*Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 8, $T_A = 75^\circ\text{C}$ )	$I_O$				1.0			
*Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 2)	$I_{FSM}$				30 (for 1 cycle)			
Operating and Storage Junction Temperature Range	$T_J$ $T_{stg}$				– 65 to +175			

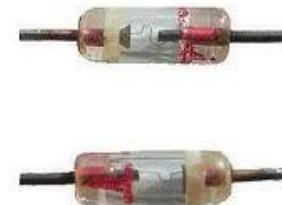
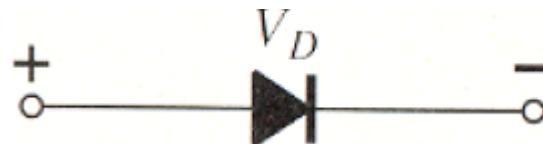
**ELECTRICAL CHARACTERISTICS\***

Rating	Symbol	Typ	Max
Maximum Instantaneous Forward Voltage Drop ( $i_F = 1.0$ Amp, $T_J = 25^\circ\text{C}$ ) Figure 1	$v_F$	0.93	1.1
Maximum Full-Cycle Average Forward Voltage Drop ( $I_O = 1.0$ Amp, $T_L = 75^\circ\text{C}$ , 1 inch leads)	$v_{F(AV)}$	—	0.8
Maximum Reverse Current (rated dc voltage) ( $T_J = 25^\circ\text{C}$ ) ( $T_J = 100^\circ\text{C}$ )	$I_R$	0.05 1.0	10 50
Maximum Full-Cycle Average Reverse Current ( $I_O = 1.0$ Amp, $T_L = 75^\circ\text{C}$ , 1 inch leads)	$I_{R(AV)}$	—	30

# CÁC LOẠI DIODE

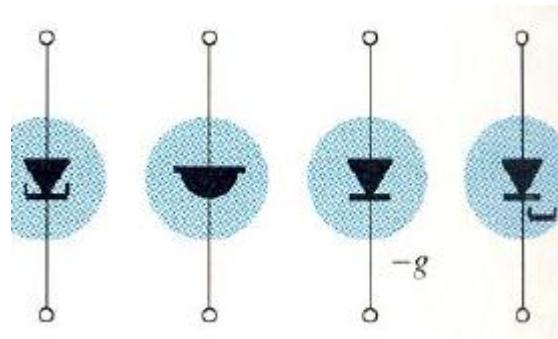


Diode tách sóng : sử dụng tiếp xúc điểm để điện dung bé → làm việc ở tần số cao

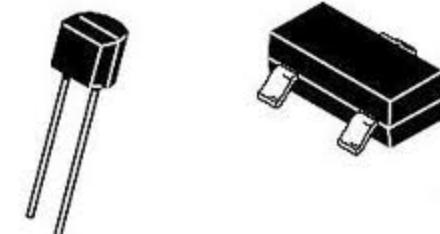
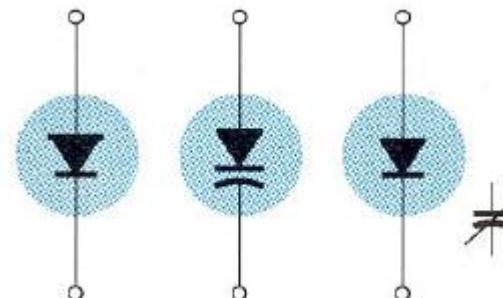


Diffidix.com

Diode tunnel : nồng độ tạp chất rất cao → ứng dụng trong các mạch siêu cao tần



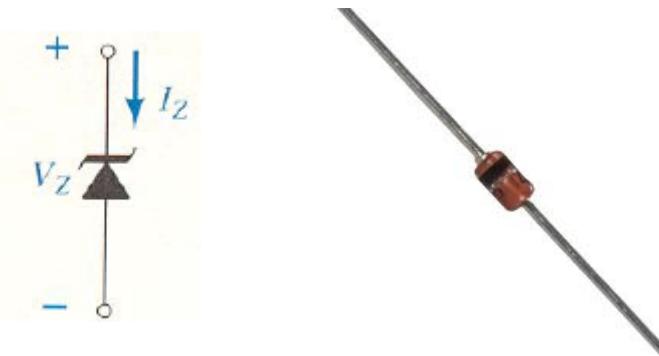
Diode biến dung : có lớp tiếp xúc đặc biệt để điện dung khá tuyến tính với điện áp ngược → tạo sóng điều tần dễ điều chỉnh tần số cộng hưởng



Diode Schottky : tiếp xúc Schottky (bán dẫn, kim loại) → ứng dụng cho những mạch cần tốc độ chuyển mạch cao



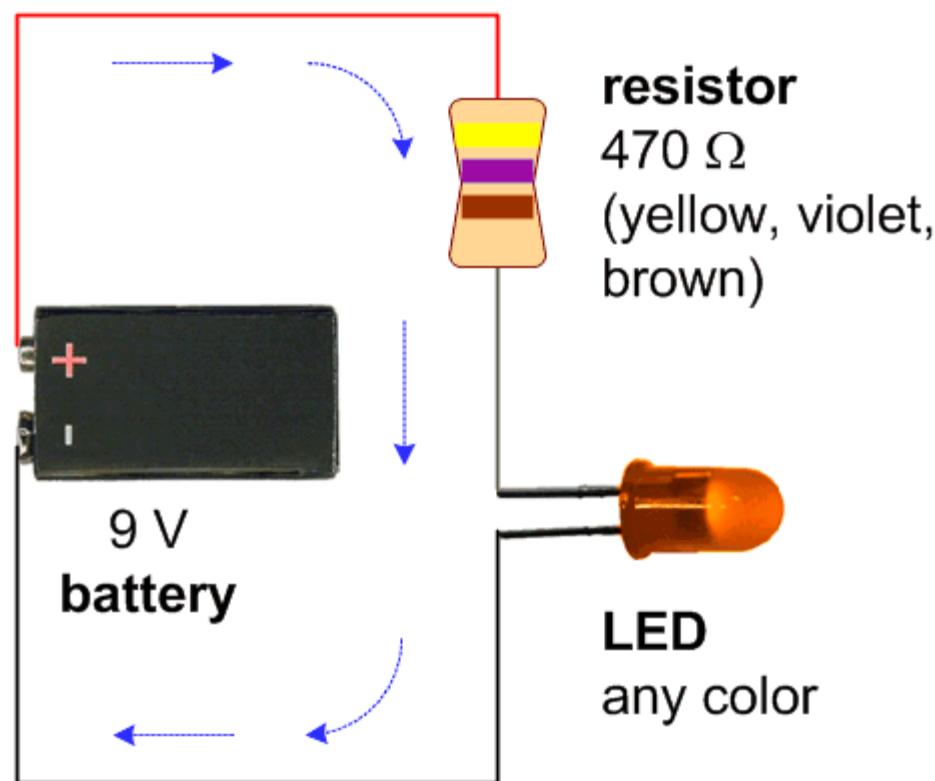
Diode Zener : thường bằng vật liệu Si chịu nhiệt và tỏa nhiệt tốt hoạt động chủ yếu vùng zener từ (1,8 ÷ 200)V

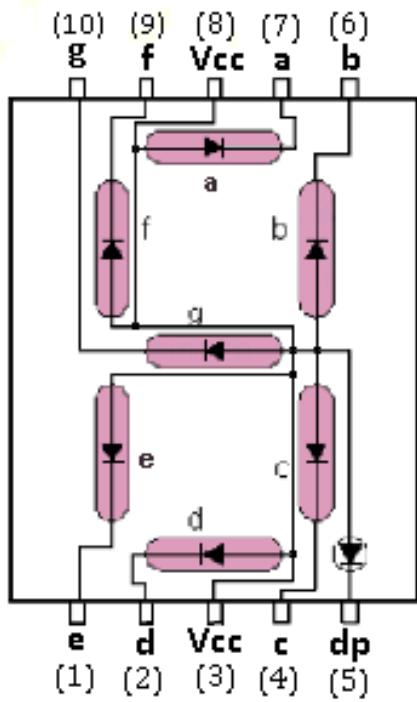
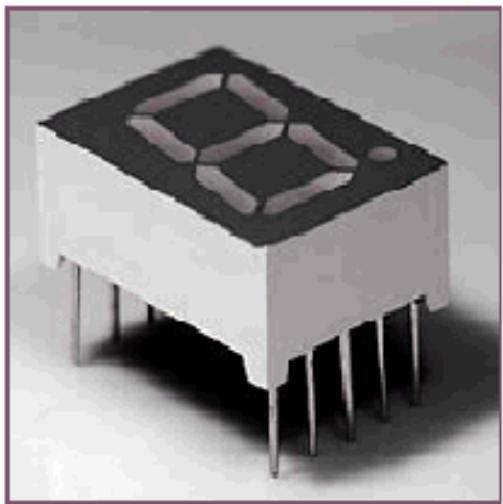
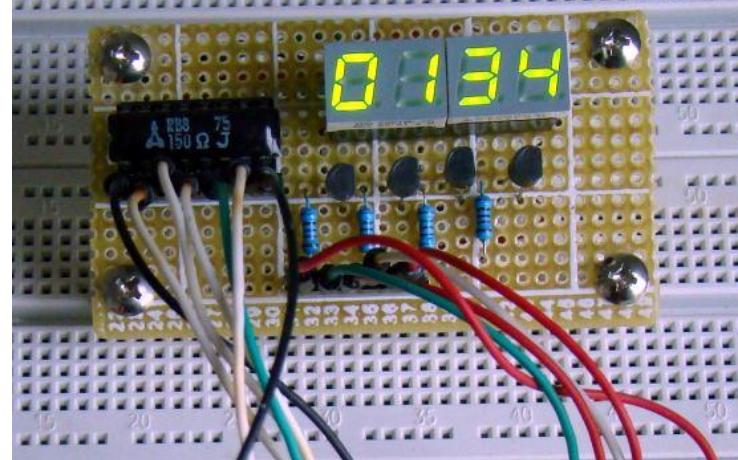


Diode phát quang : thường dùng bán dẫn hợp chất có mức  $W_g$  thay đổi điều chỉnh được theo nồng độ tạp chất, sử dụng yếu tố phát sáng bước sóng  $\lambda$  nhìn thấy được khi phân cực thuận có sự tái hợp  $e^-$  và lỗ trống

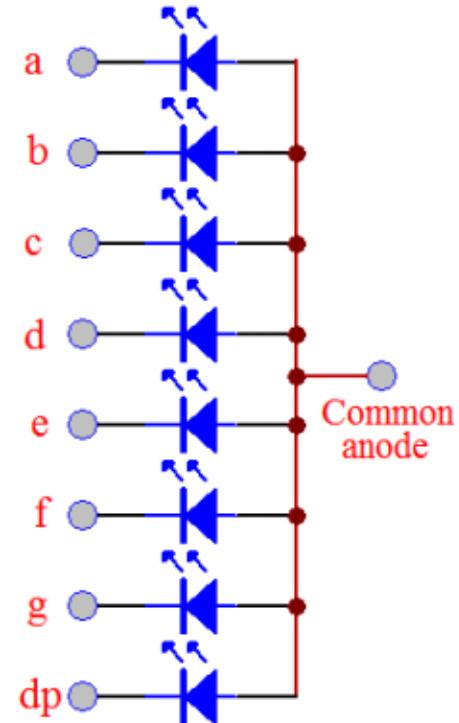
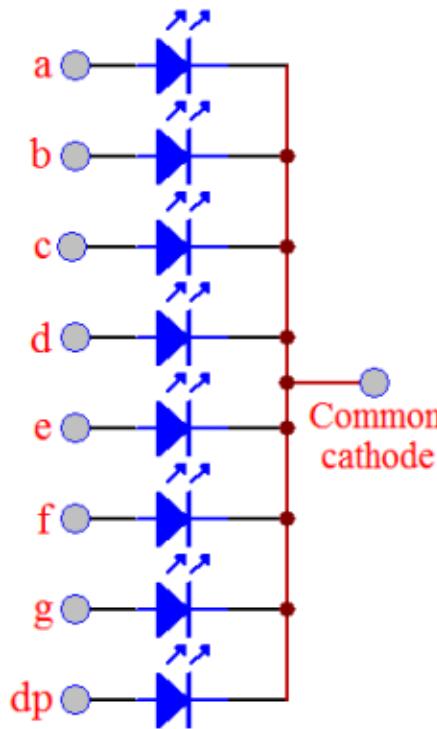


Color of LED	Voltage Drop (Volt)
Red	1.63 ~ 2.03
Yellow	2.10 ~ 2.18
Orange	2.03 ~ 2.10
Blue	2.48 ~ 3.7
Green	1.9 ~ 4.0
Violet	2.76 ~ 4.0
UV	3.1 ~ 4.4
White	3.2 to 3.6





Common Anode Mode

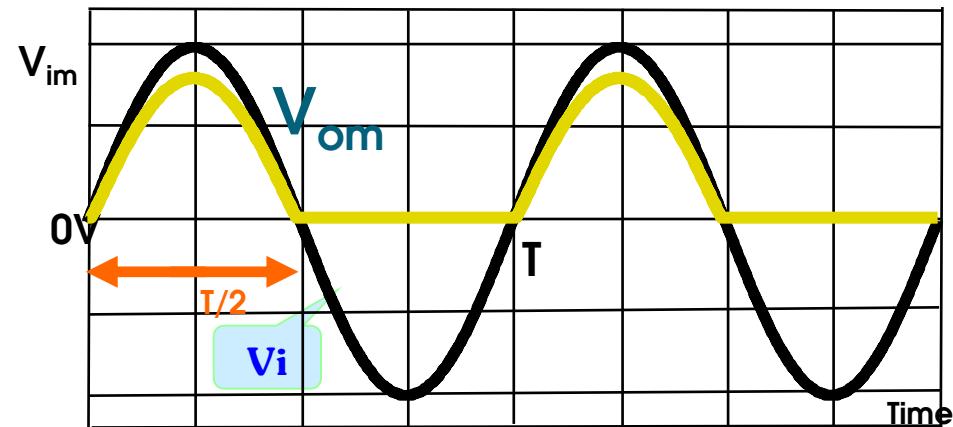
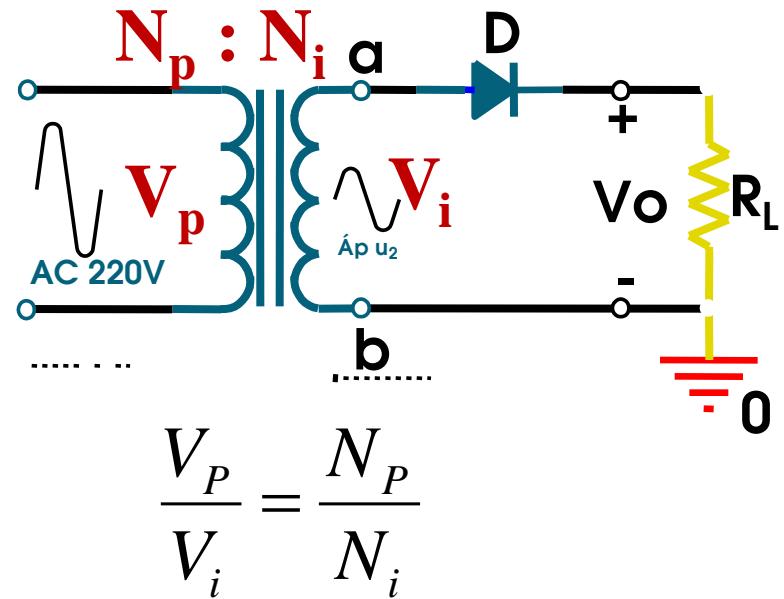


# APPLICATIONS



# Chỉnh lưu - Rectifier(AC → DC)

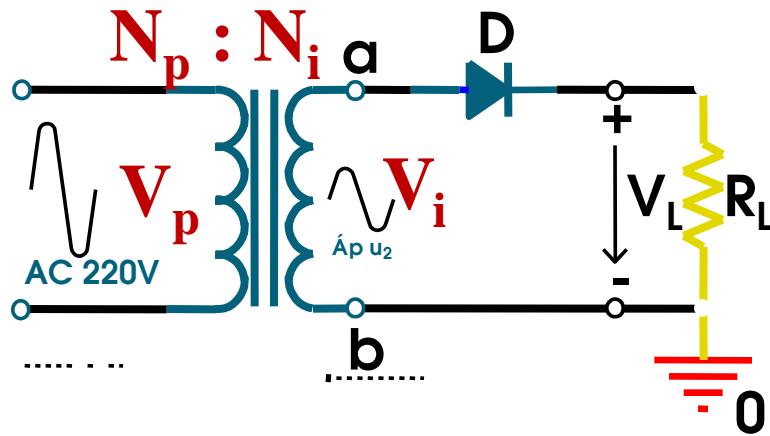
## a. Chính lưu bán kỲ - Half Wave Rectifier



Điện áp trung bình ngõ ra

$$V_{ODC} = \frac{1}{T} \int_0^T V_o(t) dt = \frac{1}{2\pi} \int_0^\pi V_{Om} \sin(\omega t) d(\omega t) = \frac{V_{Om}}{\pi} = \frac{V_{im} - V_\gamma}{\pi}$$





Dòng trung bình qua tải

$$I_{ODC} = \frac{V_{ODC}}{R_L}$$

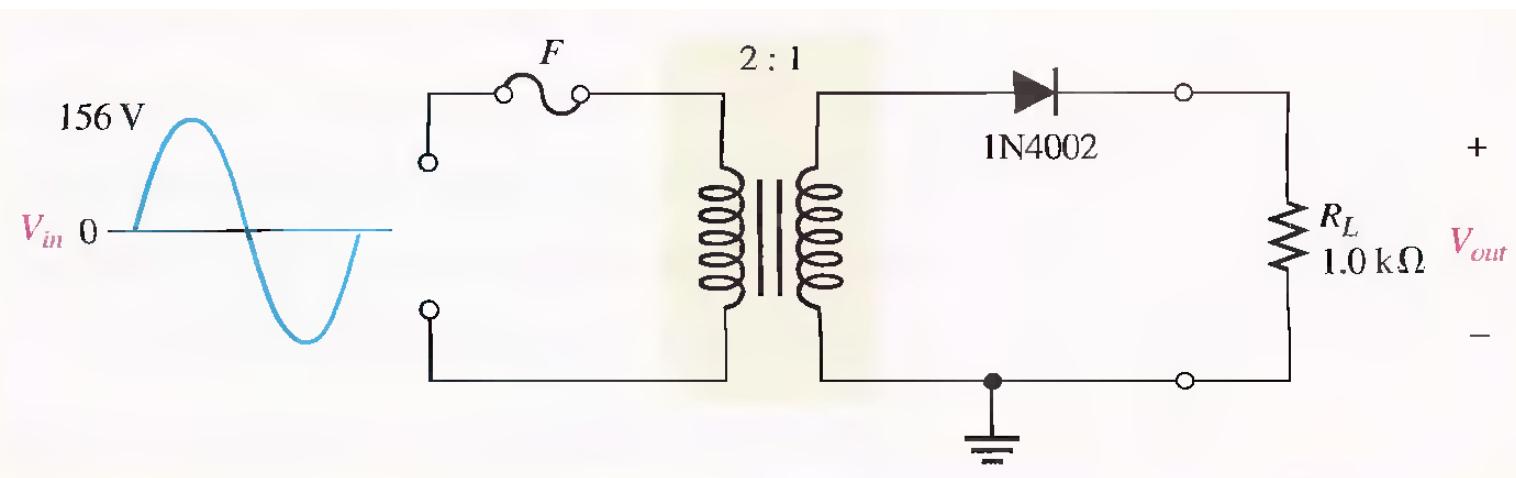
Dòng trung bình qua diode

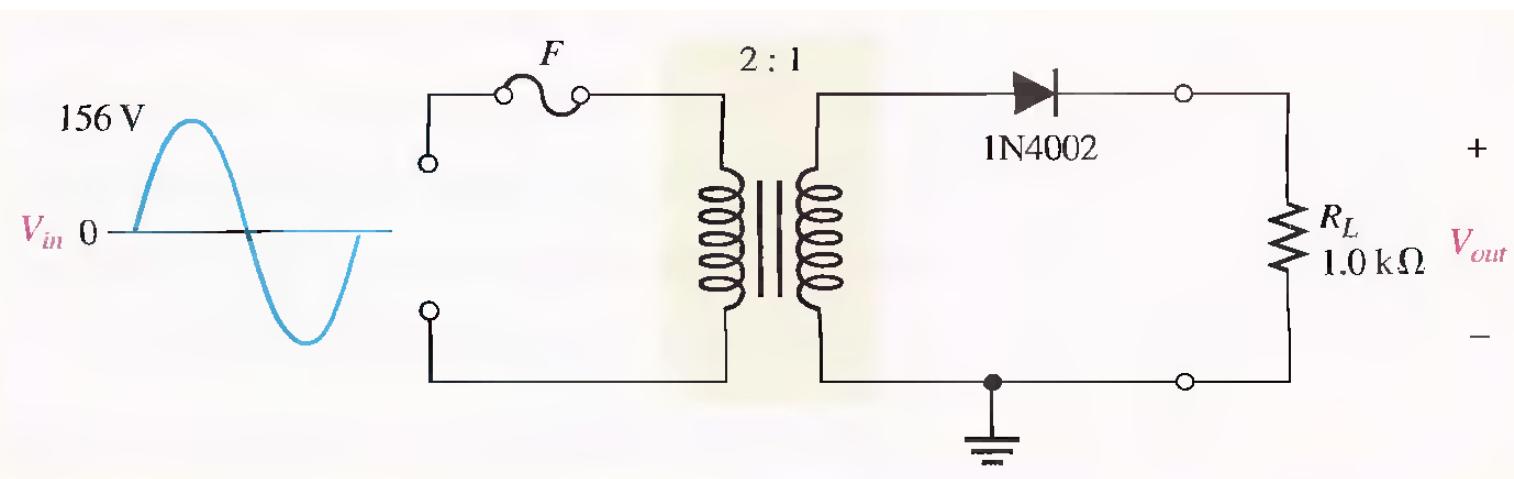
$$I_{DC_{DIODE}} = I_{ODC}$$

(PIV – Peak Inverse Voltage)

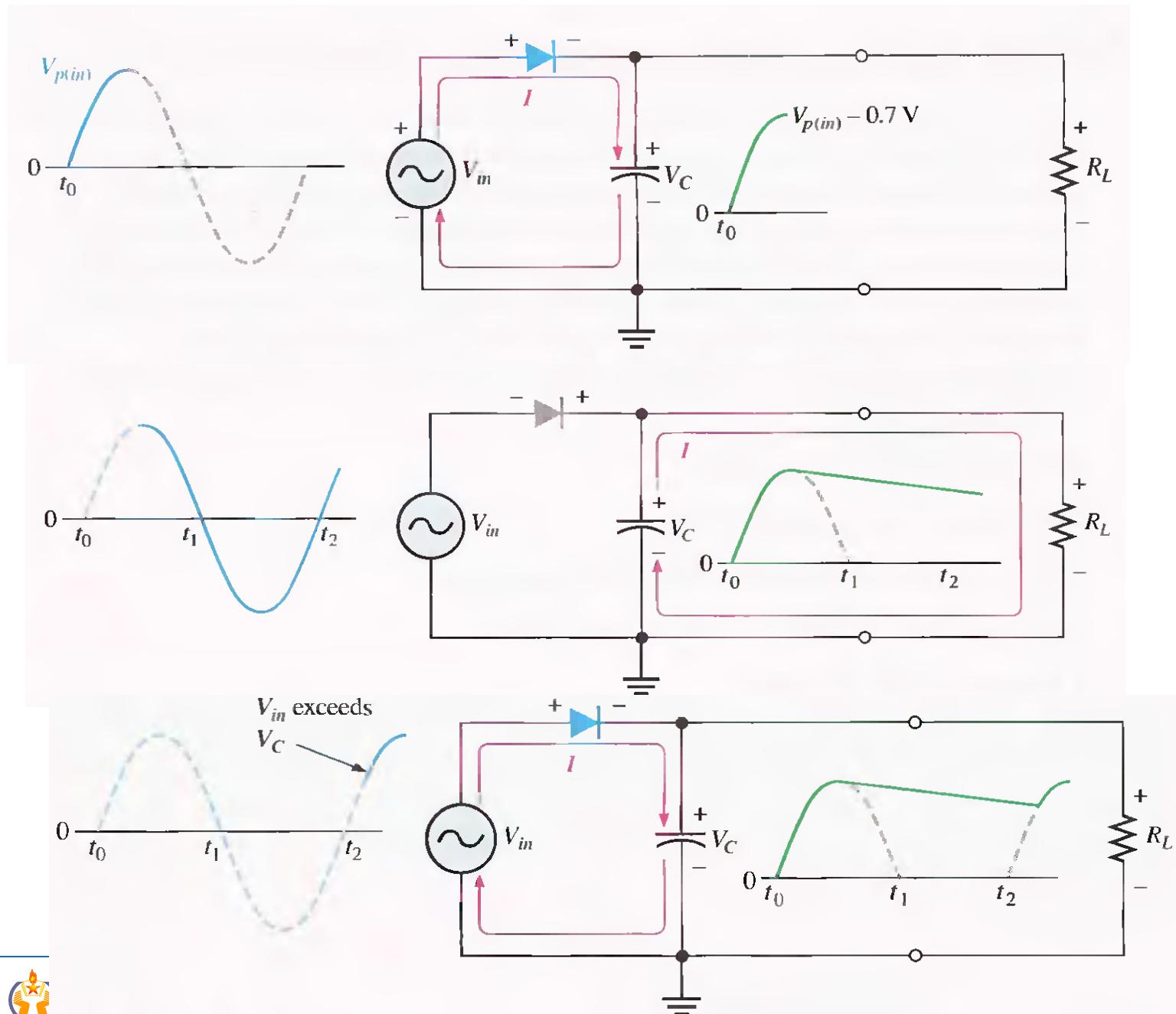
$$PIV = V_{im}$$

Vd:

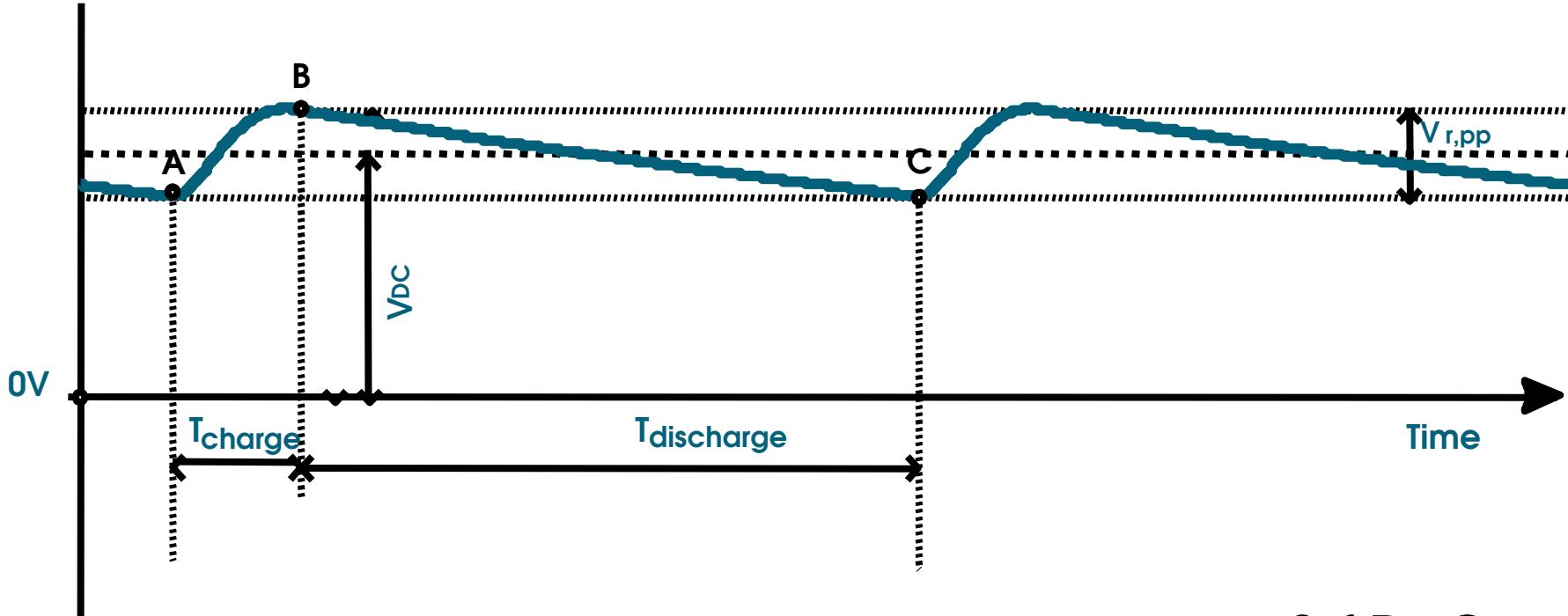




# Chỉnh lưu bán kì có tụ lọc - Half wave rectifier with capacitor - filter



# Chỉnh lưu bán kỲ có tụ lọc - Haft wave rectifier with capacitor - filter



Điện áp trung bình trên tải

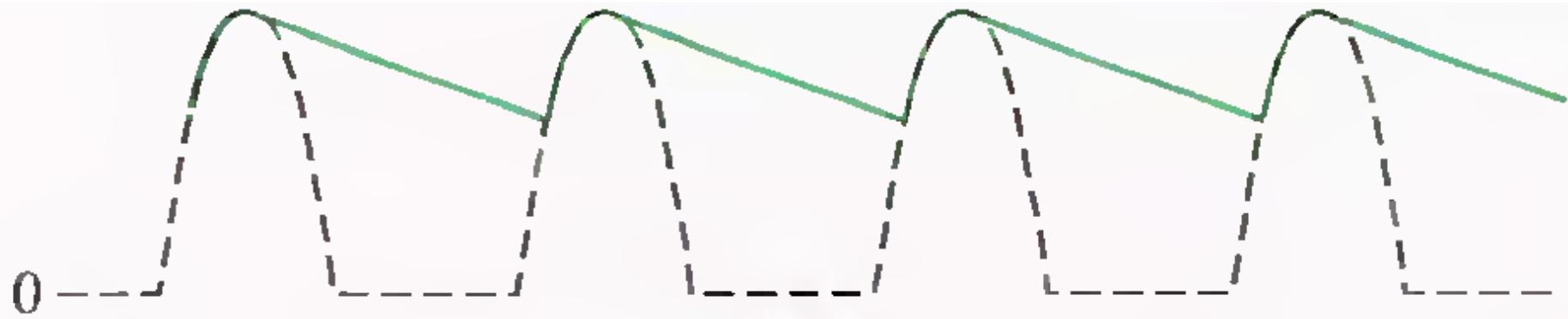
$$U_{ODC} = \frac{2.f.R_L.C}{1 + 2.f.R_L.C} \cdot U_{0m}$$

Độ gợn sóng của điện áp trên tải

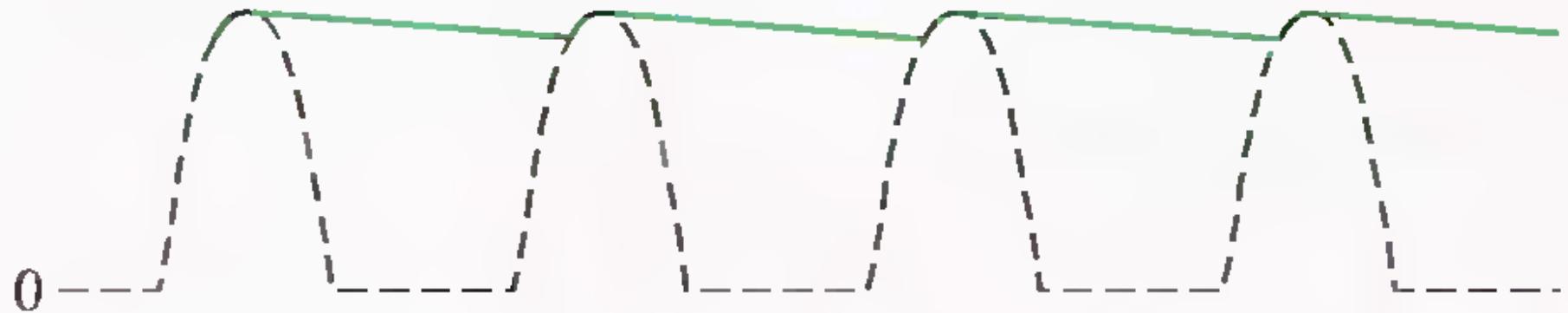
$$r\% = \frac{U_{r,rms}}{U_{ODC}} = \frac{100\%}{2\sqrt{3}.f.R_L.C}$$



## Chỉnh lưu bán kỳ có tụ lọc

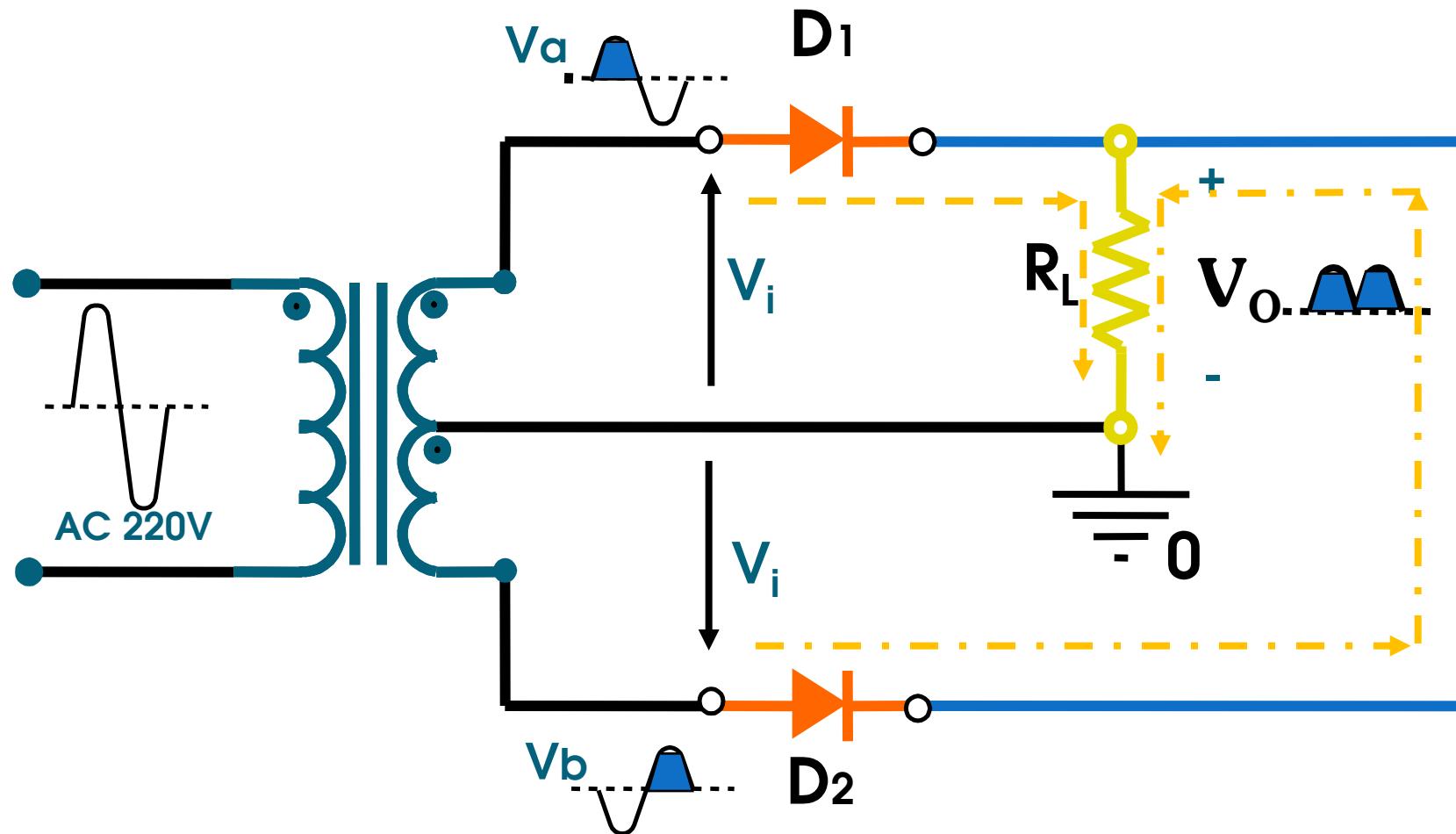


Tụ lọc có giá trị nhỏ  $\rightarrow$  độ gợn sóng lớn

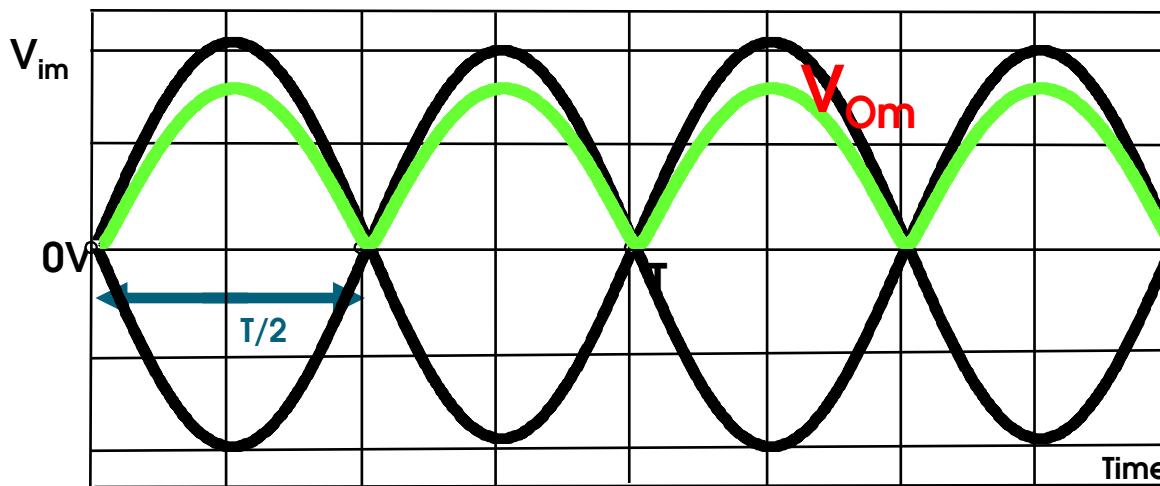


Tụ lọc có giá trị lớn  $\rightarrow$  độ gợn sóng nhỏ

## Chỉnh lưu toàn kỲ dùng biến áp đôi - Full Wave Rectifier using center – tapped transformer



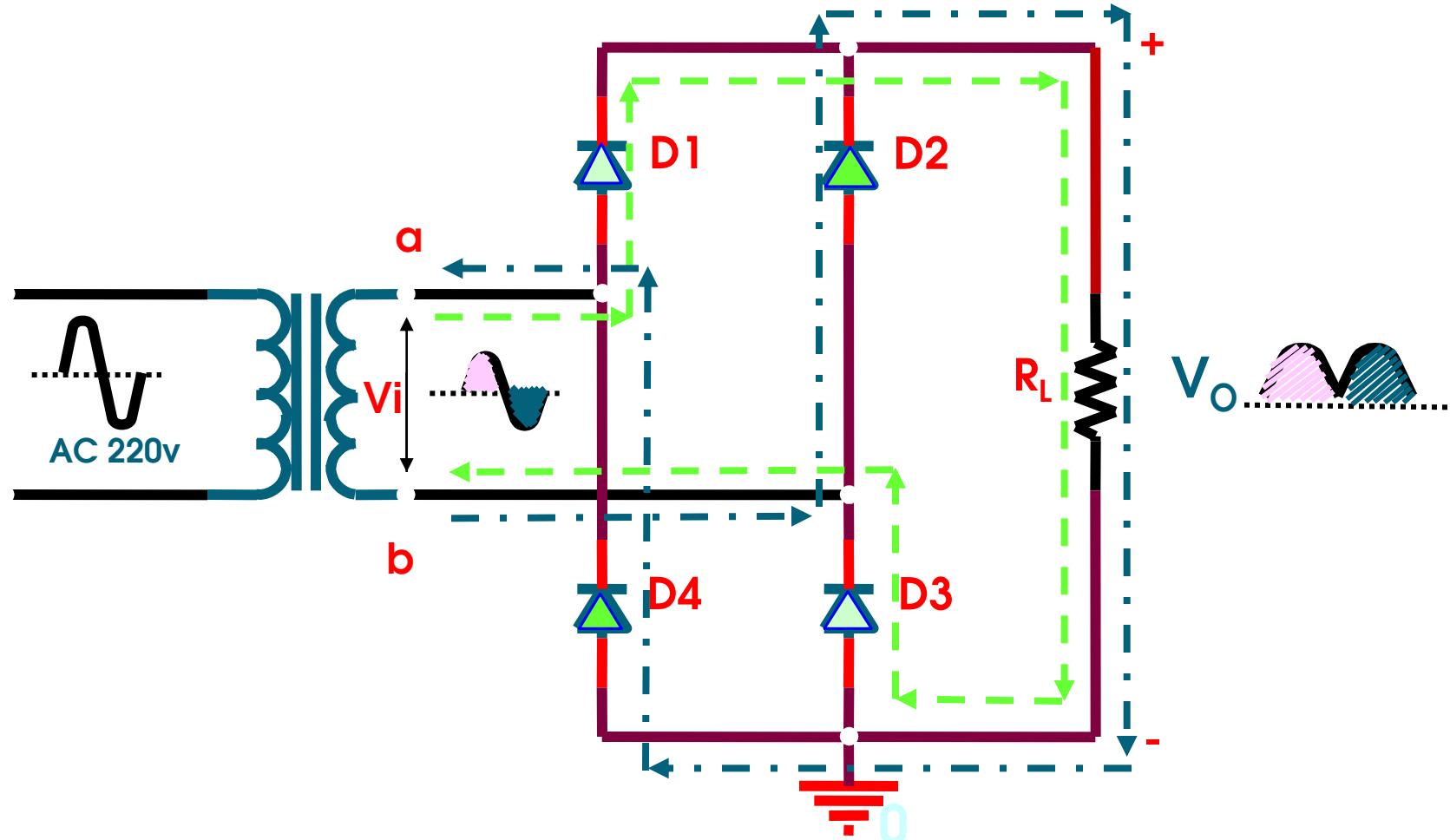
# Chỉnh lưu toàn kỲ dùng biến áp đôi - Full Wave Rectifier using center – tapped transformer



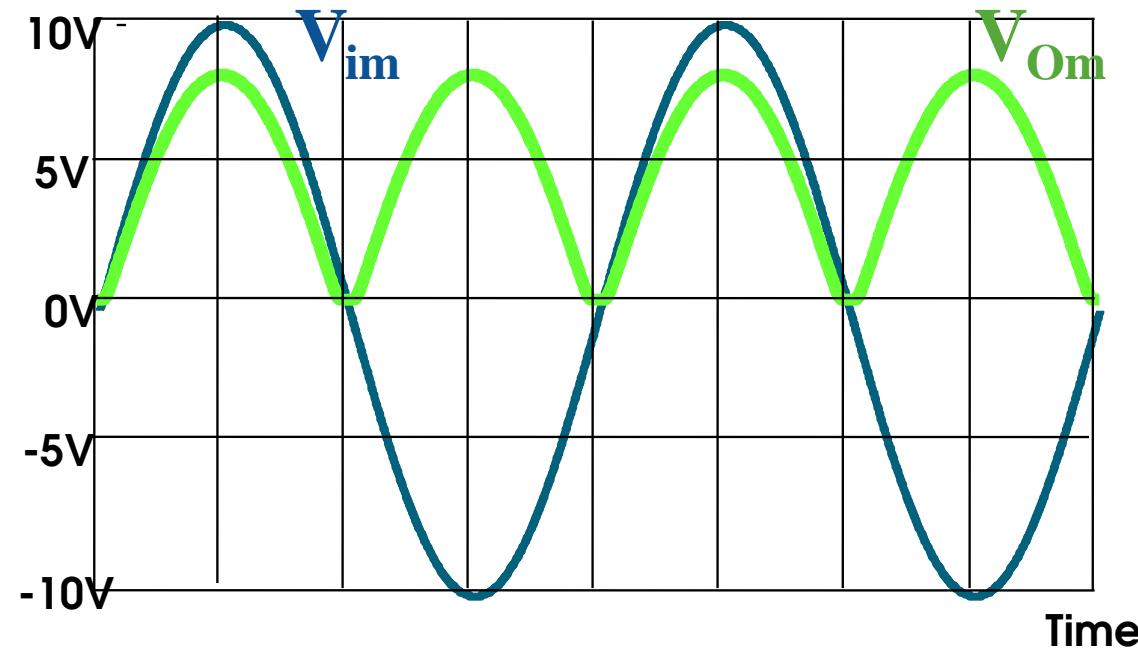
$$V_{ODC} = \frac{1}{T} \int_0^T V_O(t) dt = \frac{1}{2\pi} \int_0^{2\pi} V_{Om} \sin(\omega t) d(\omega t) = 2 \frac{V_{Om}}{\pi} = 2 \frac{V_i - V_\gamma}{\pi}$$

$$PIV = 2V_{im} - V_\gamma \quad I_{ODC} = \frac{V_{ODC}}{R_L} \quad I_{DC_{DIODE}} = \frac{I_{ODC}}{2}$$

## c. Chính lưu toàn kỲ dùng cầu diode - Full wave rectifier using diode bridge



## c. Chính lưu toàn kỲ dùng cầu diode - Full wave rectifier using diode bridge



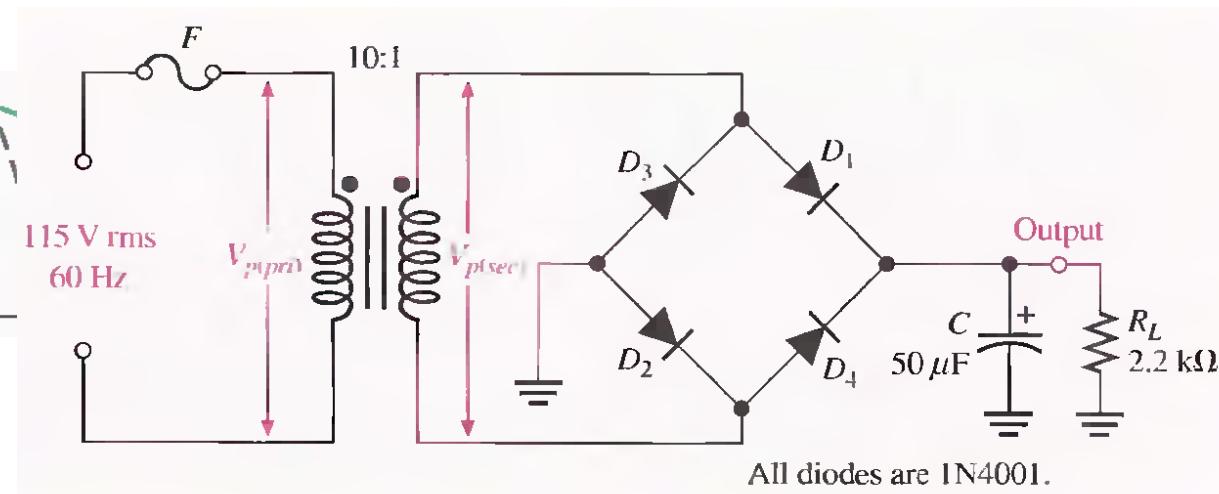
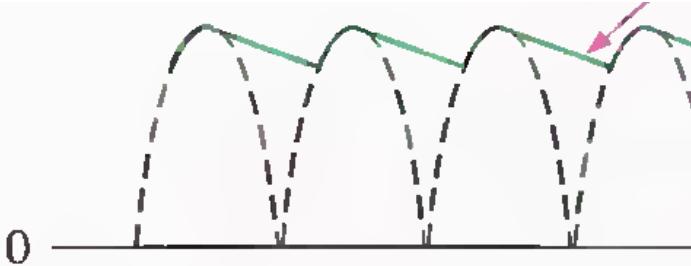
$$V_{ODC} = 2 \frac{V_{Om}}{\pi} = 2 \frac{V_{im} - 2V_\gamma}{\pi}$$

$$I_{DC_{DIODE}} = \frac{I_{ODC}}{2}$$

$$I_{ODC} = \frac{V_{ODC}}{R_L}$$

$$PIV = V_{im} - V_\gamma$$

# Chỉnh lưu toàn kỳ có tụ lọc - Full wave rectifier with capacitor - filter



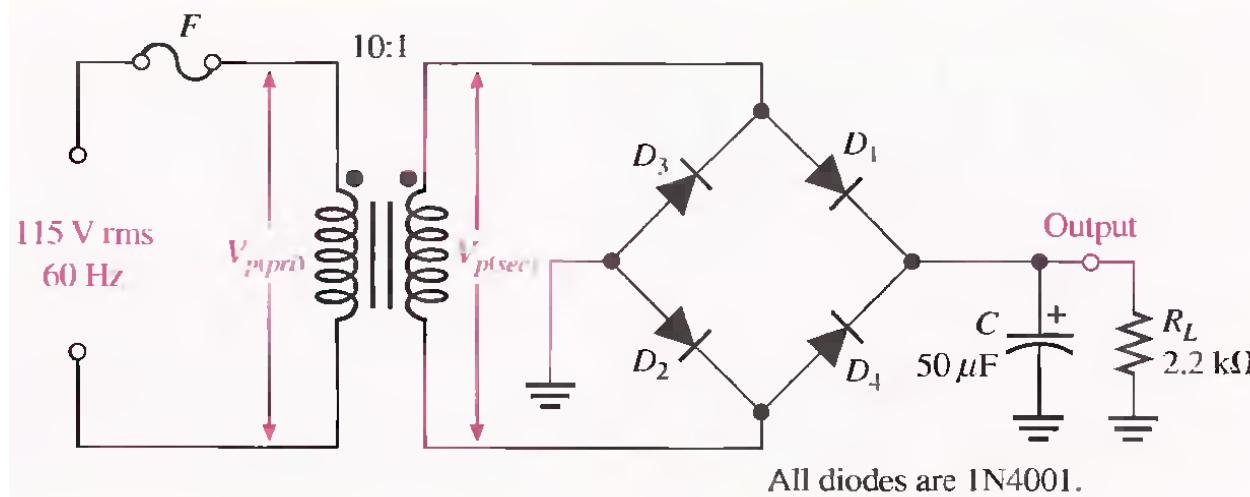
Điện áp trung bình trên tải

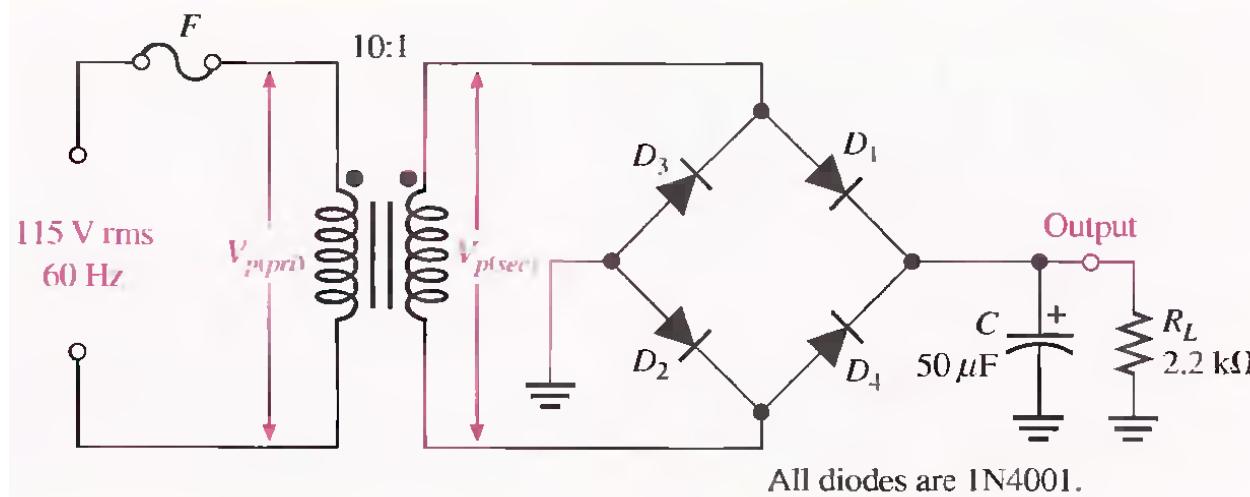
$$U_{ODC} = \frac{4.f.R_L.C}{1 + 4.f.R_L.C} \cdot U_{0m}$$

Độ gợn sóng của điện áp ngõ ra

$$r\% = \frac{U_r, \text{rms}}{U_{ODC}} = \frac{100\%}{4\sqrt{3}.f.R_L.C}$$

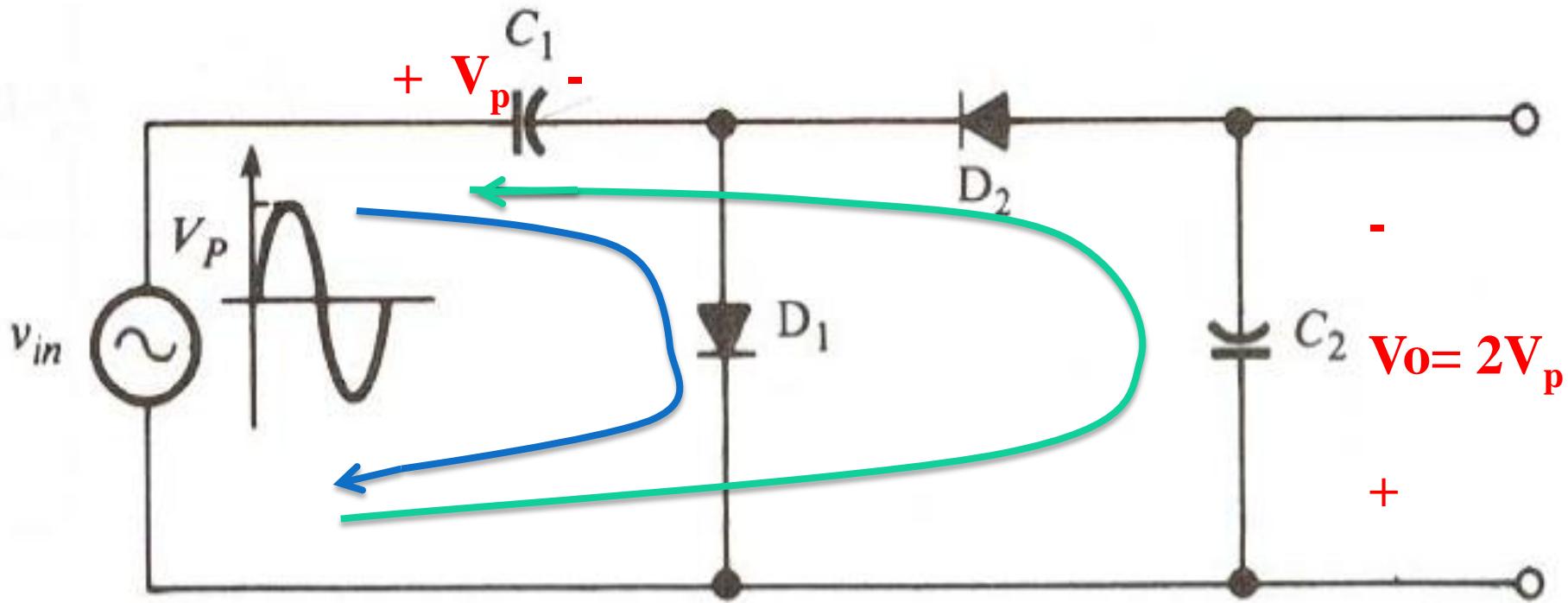




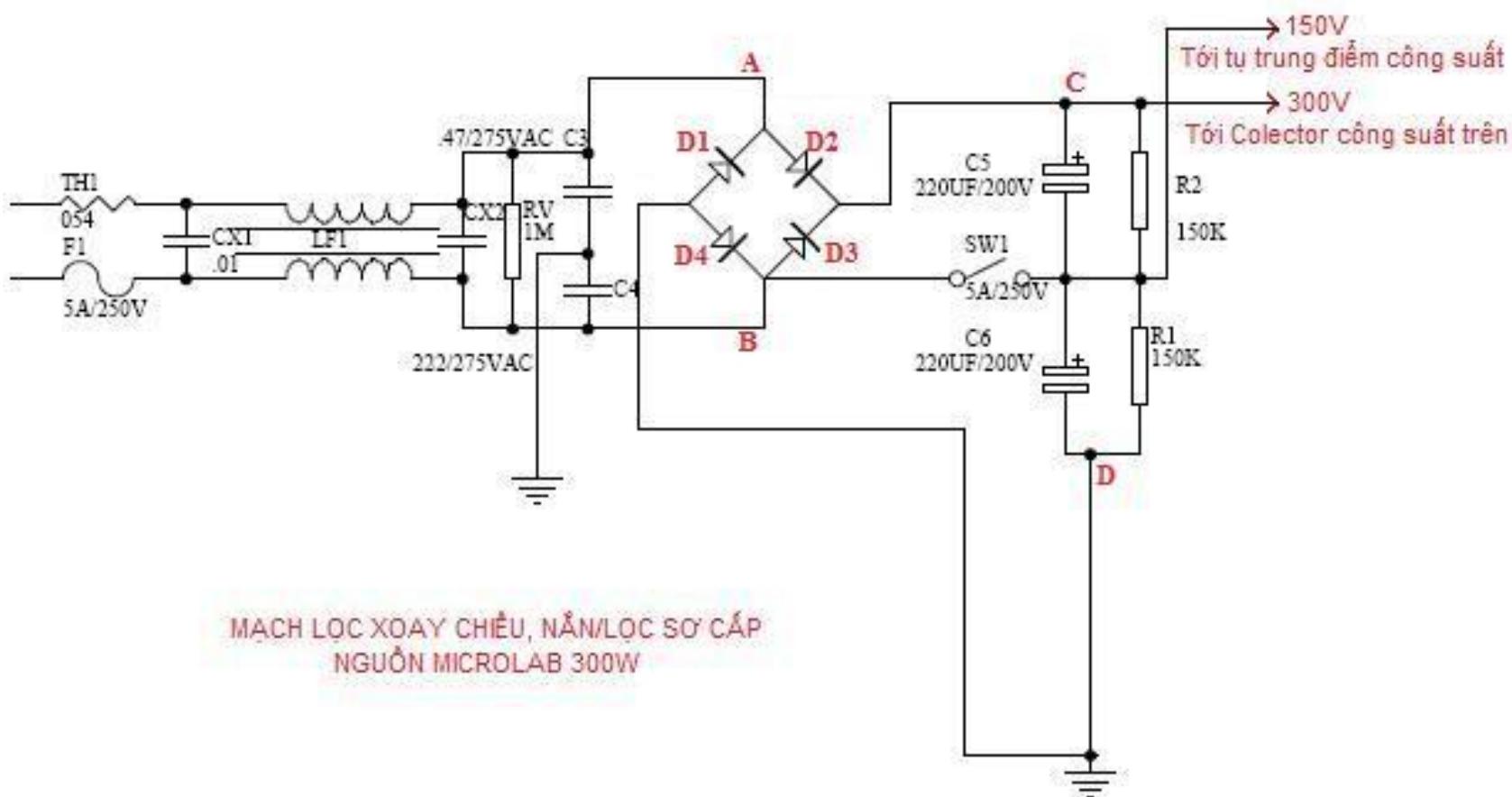


# Mạch nhân áp

## Mạch nhân áp bán kì

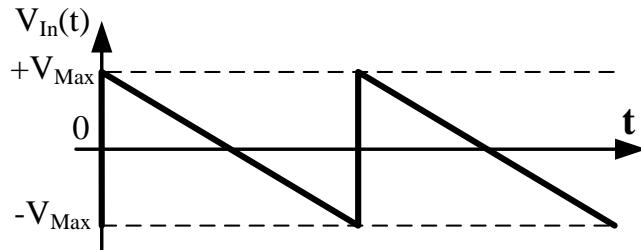
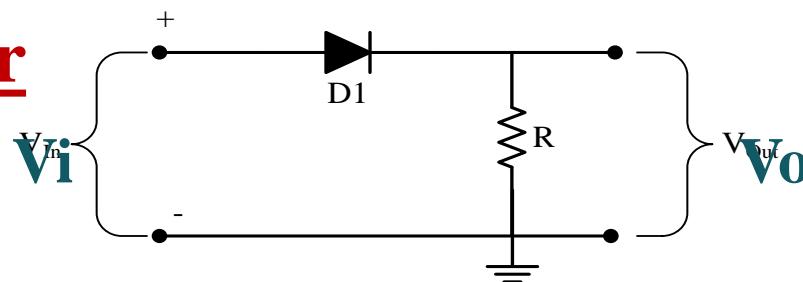


# Ứng dụng

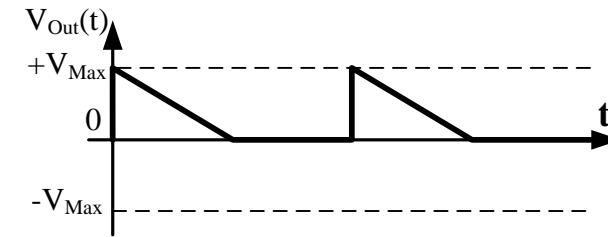


# Mạch xén - Clipper

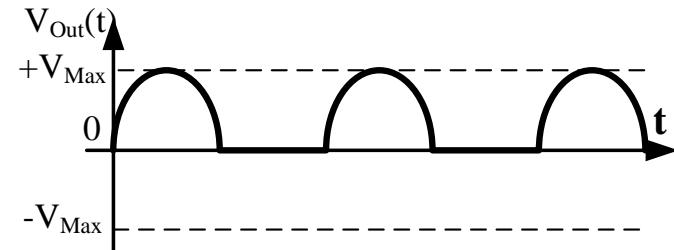
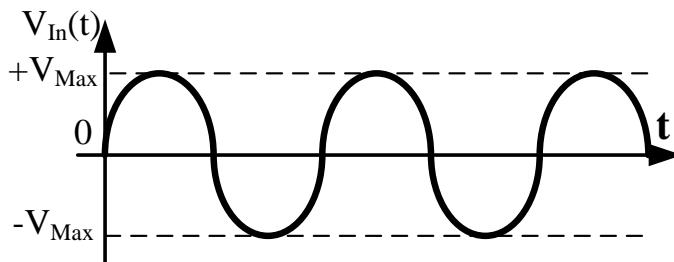
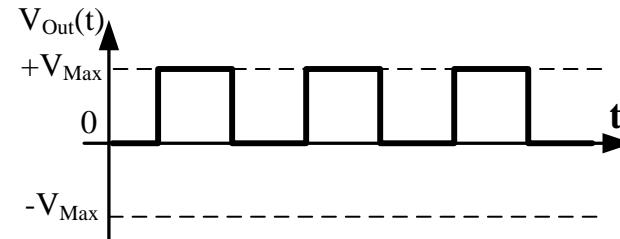
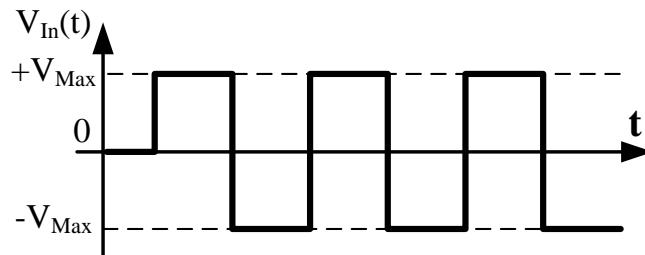
## Mạch xén nối tiếp



$V_i$

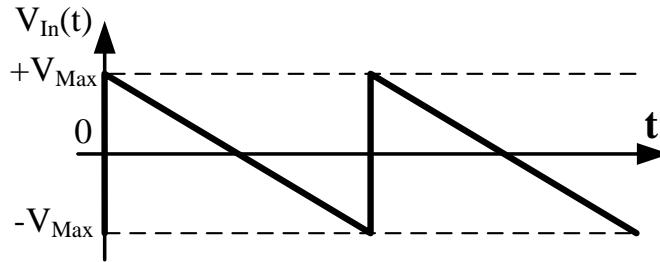
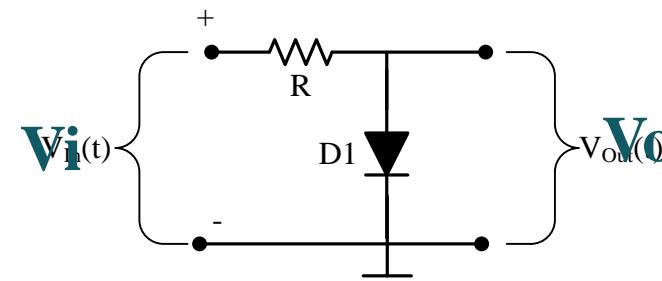


$V_o$

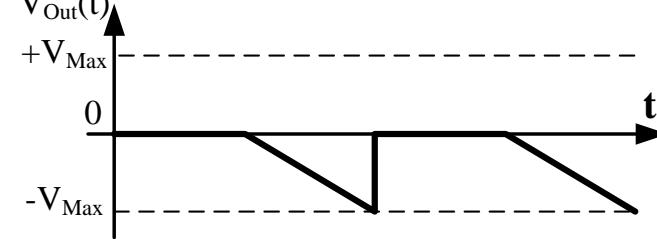


# Mạch xén

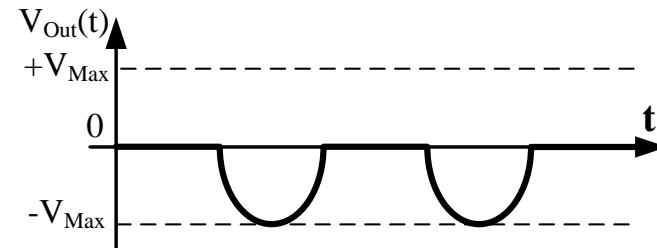
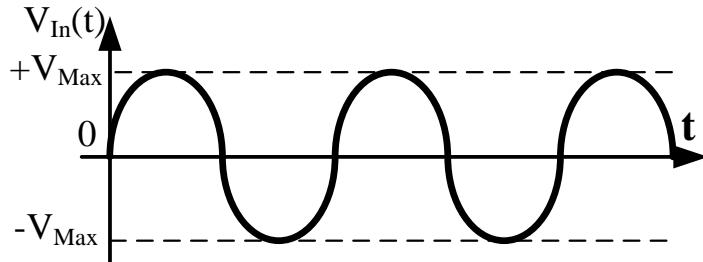
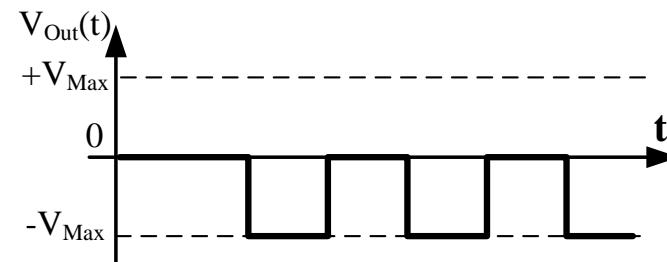
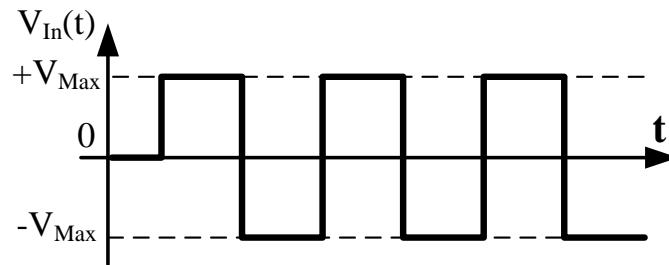
## Mạch xén song song



$V_i$



$V_o$



# Mạch xén (Clippers)

## Các bước làm bài

- Tìm điều kiện của Vi đê Diode dẫn (dùng định luật Kirchhoff)
- Tìm Vo tương ứng khi Diode dẫn.
- Tìm điều kiện Vi đê Diode ngưng dẫn (ngược lại điều kiện dẫn)
- Tìm Vo tương ứng khi Diode không dẫn.
- Vẽ Vo

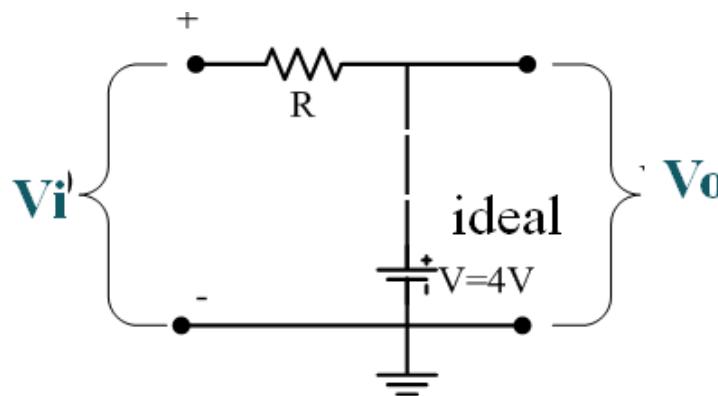


# Mạch xén

## Mạch xén song song

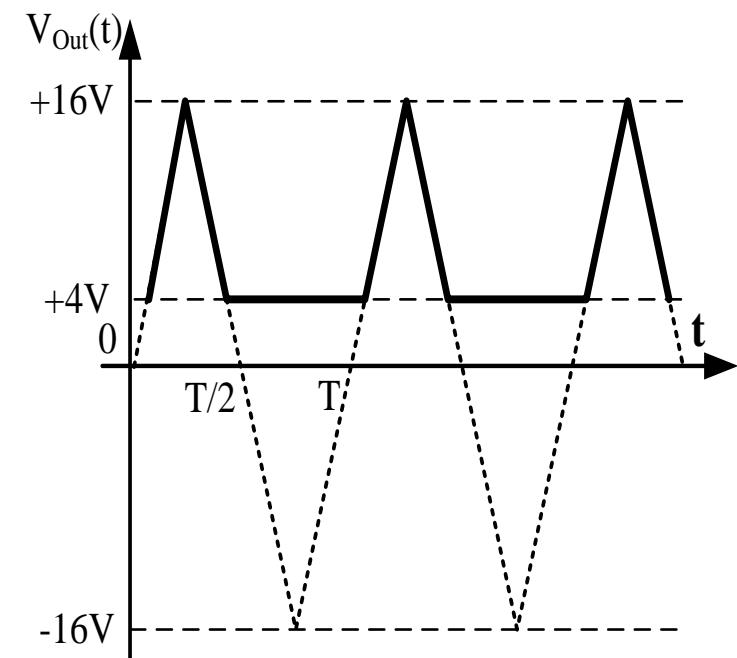
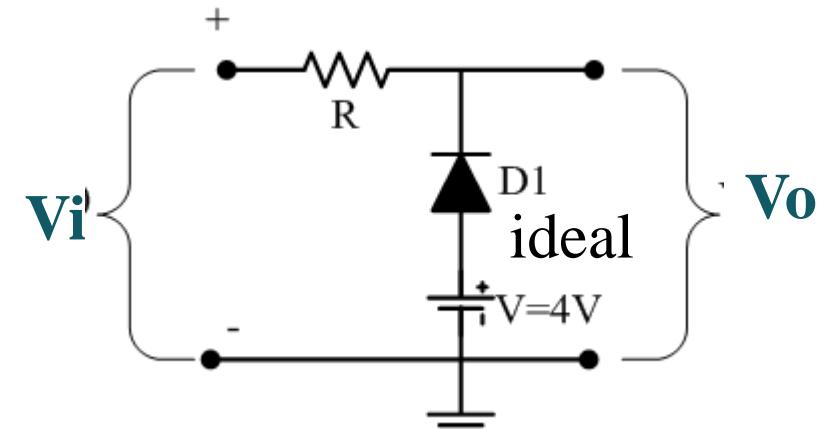
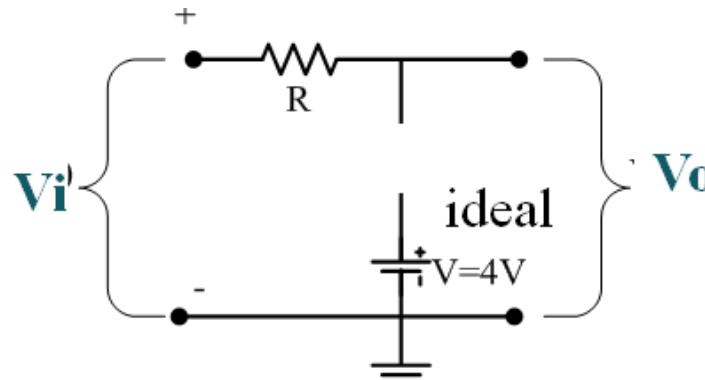
Điều kiện Vi để Diode dẫn  $Vi \leq 4V$

Khi đó  $Vo = 4V$



Diode không dẫn  $Vi \geq 4V$

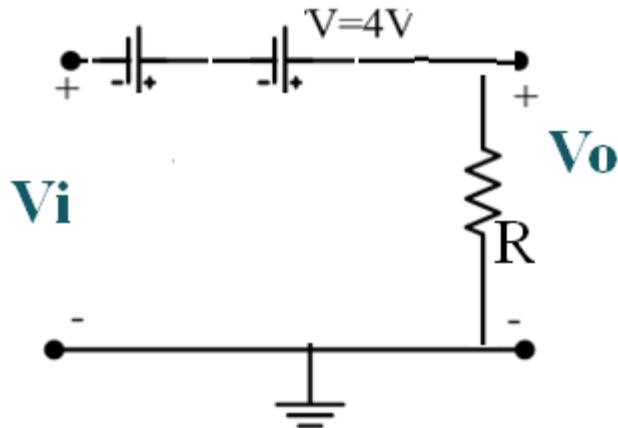
Khi đó  $Vo = Vi$



## Mạch xén nối tiếp

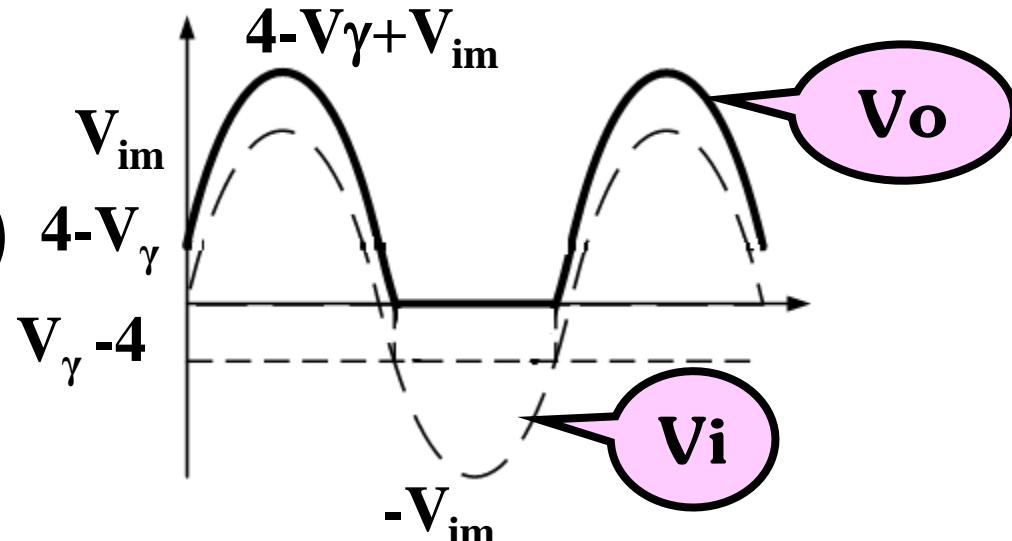
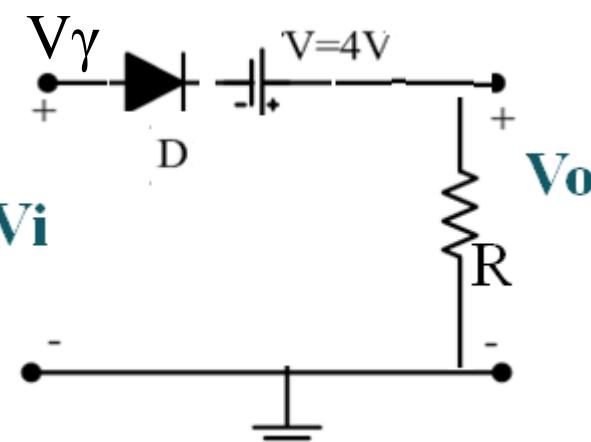
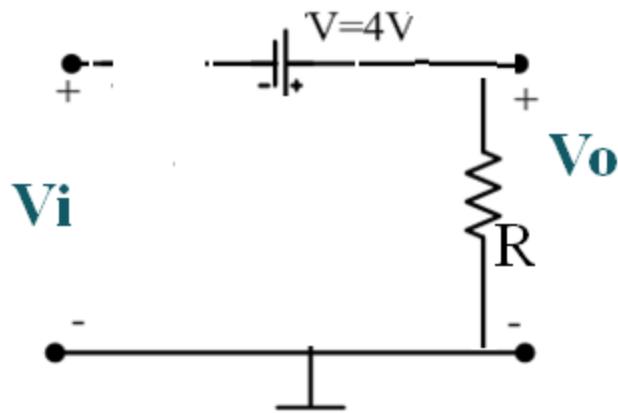
Diode dẫn khi:  $V_i \geq (V_\gamma - 4)$

Khi đó  $V_o = I \cdot R_L = Vi + 4 - V_\gamma$

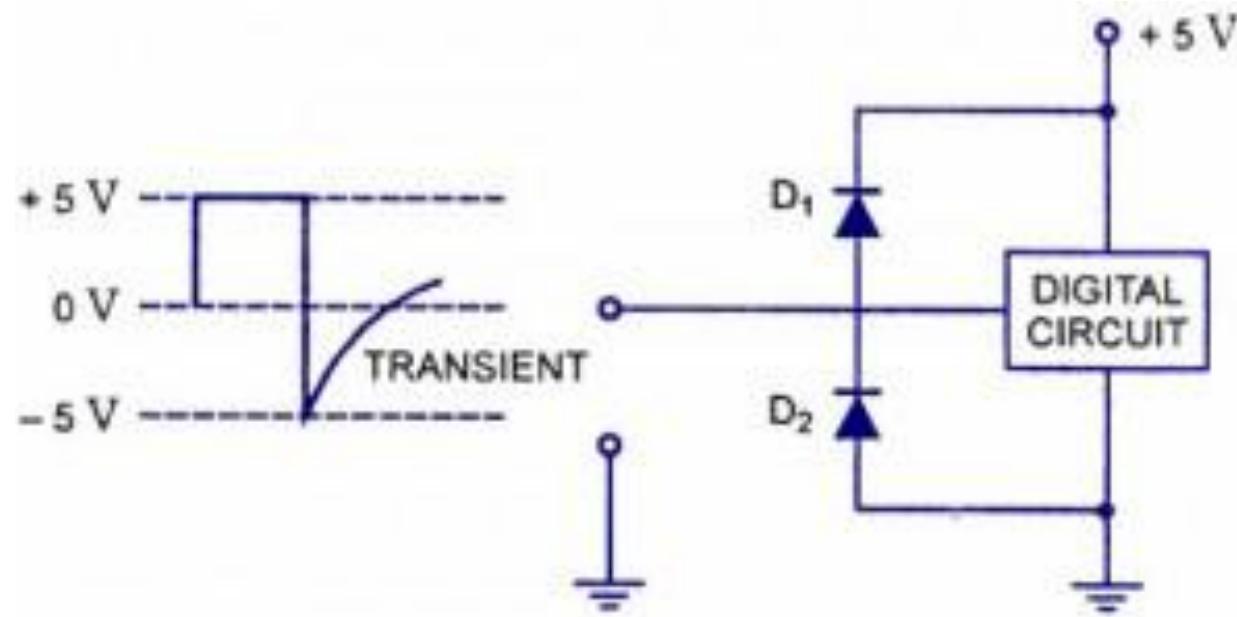


Diode ko dẫn khi:  $V_i \leq (4 + V_\gamma)$

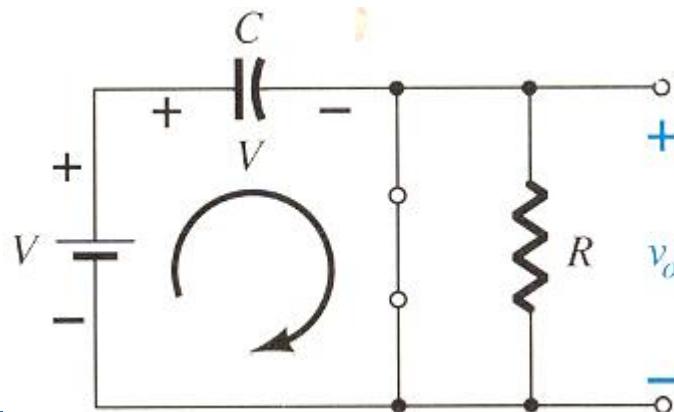
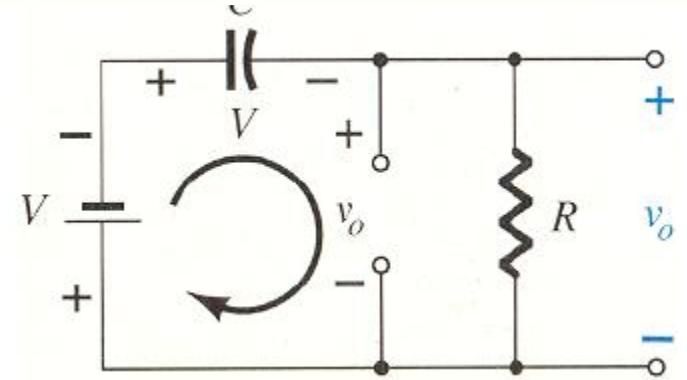
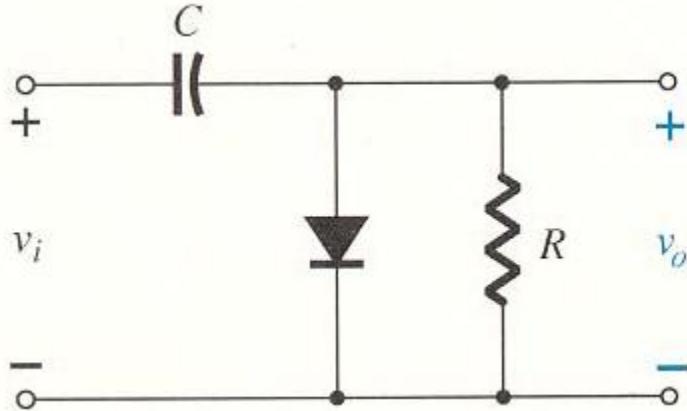
Khi đó  $V_o = IR = 0$



## Ứng dụng mạch xén



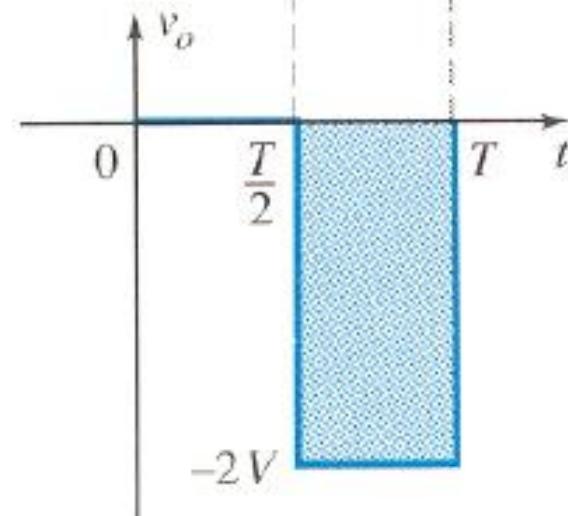
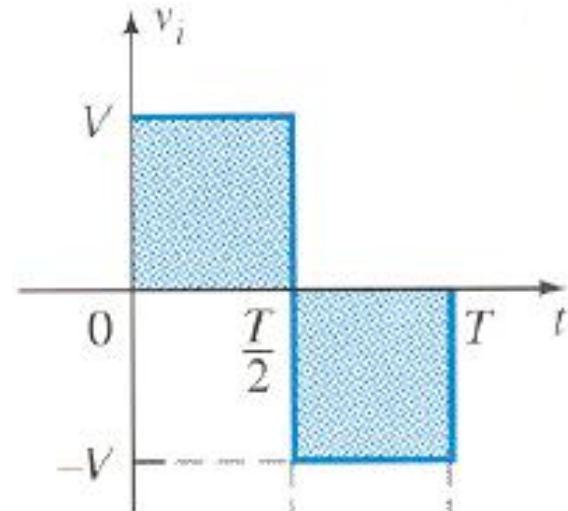
# Mạch kẹp – Mạch dời mức DC (Clampers)



Mạch kẹp

Bán kì âm

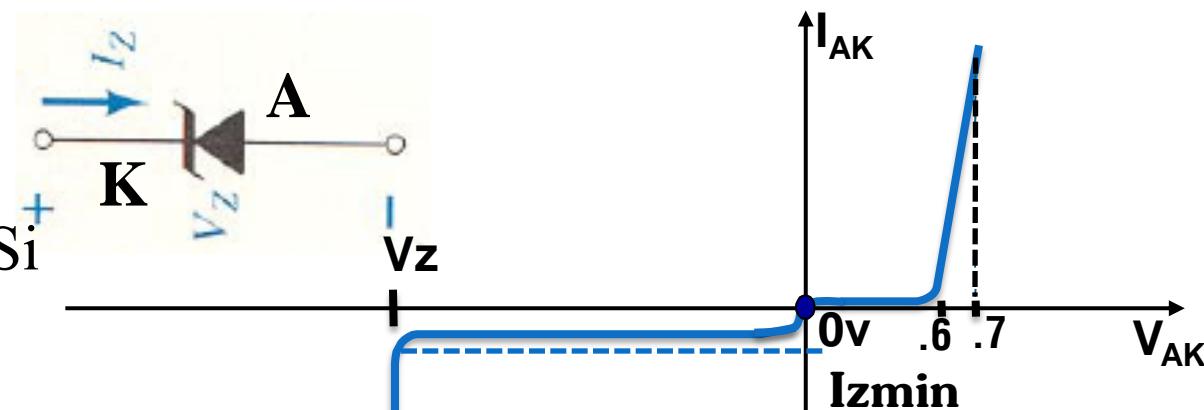
Bán kì dương



# Diode zener

## Cấu tạo

Thường cấu tạo bằng Si



## Phân cực thuận:

Hoạt động giống diode thường  
( $V_g = 0.7V$ , Si)

Vùng Zener

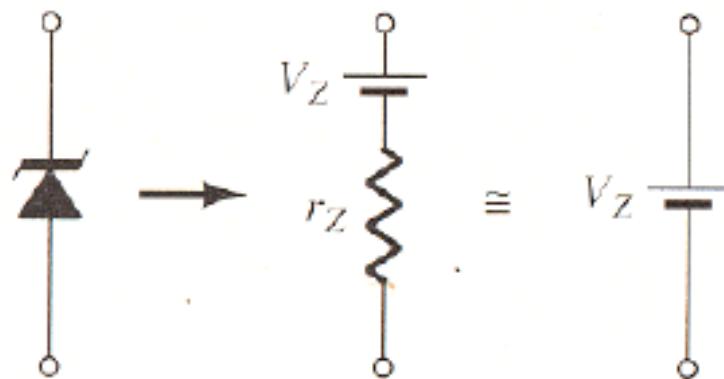
Đặc tuyến  
giới hạn  
công suất

$V_z$ : Điện áp ghim  
của zener



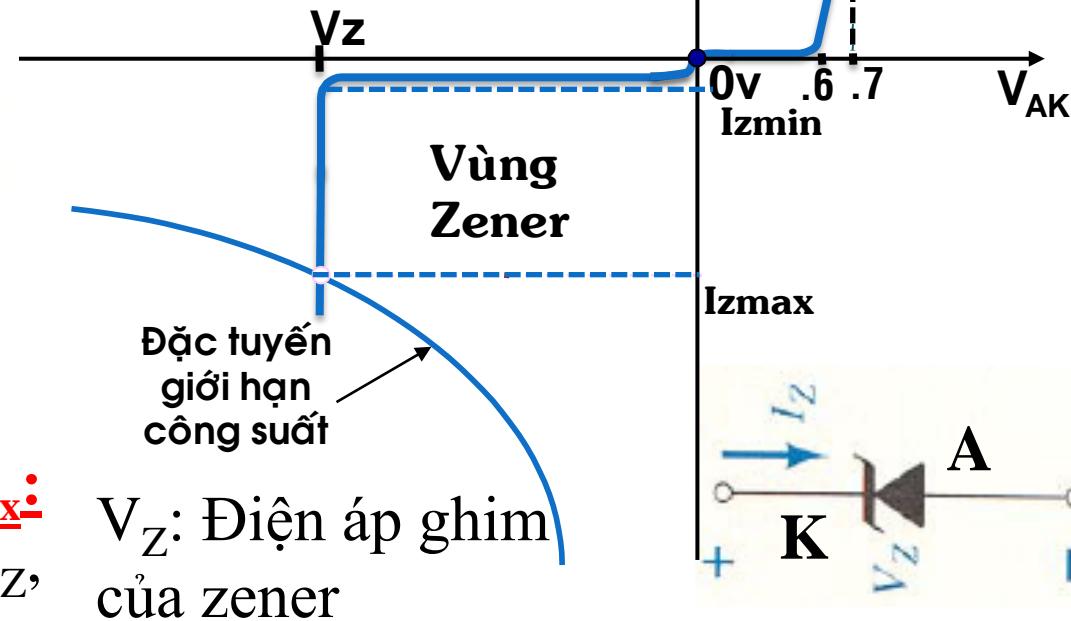
# Diode zener

## Phân cực ngược:



$V_{KA} \geq V_Z$  và  $I_{Zmin} \leq I_Z \leq I_{Zmax}$ :  
zener dẫn ngược  $\rightarrow V_{KA} = V_Z$ ,  
 $I_Z \neq 0$

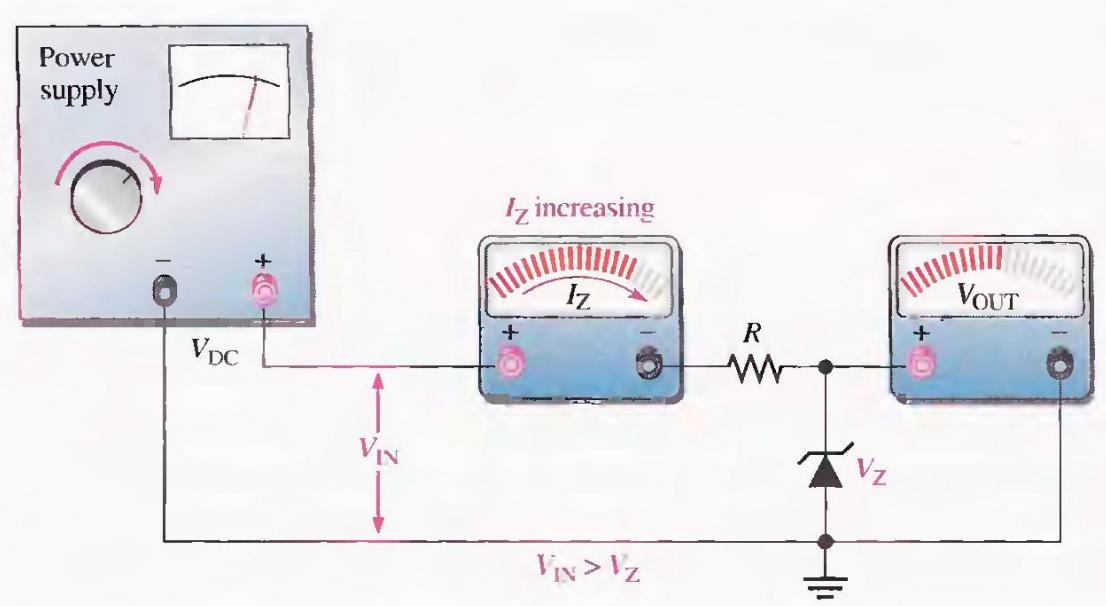
$V_{KA} < V_Z$ : zener không dẫn,  
 $I_Z = 0$



- Ứng dụng phân cực ngược làm mạch ổn áp
- Thực tế  $1.8V \leq V_Z \leq 200V$ , công suất  $0.25W : 50W$



# Diode zener - Ứng dụng mạch ổn áp

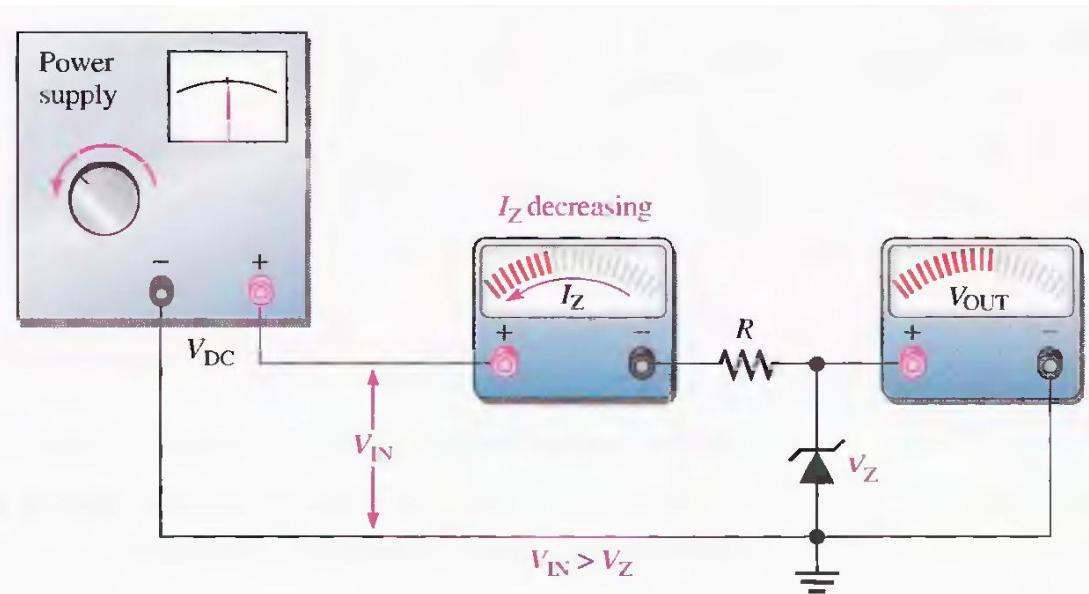


Điện áp vào tăng

$$V_{in} > V_z$$

Dòng qua zener tăng

$$I_{zmin} < I_z < I_{zmax}$$



Điện áp vào giảm

$$V_{in} > V_z$$

Dòng qua zener giảm

$$I_{zmin} < I_z < I_{zmax}$$



# Diode zener - Ứng dụng mạch ổn áp

