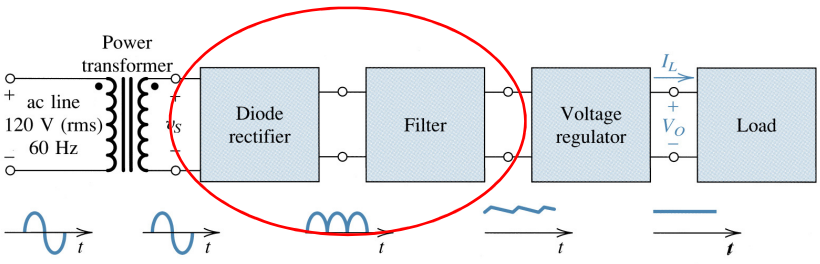
EE 530 Eletrônica Básica I

Aplicações e circuitos com Diodos

Prof. Pedro Xavier

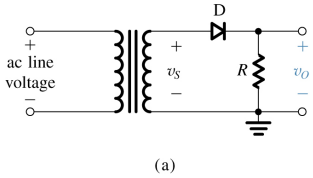
Diagrama em blocos de uma fonte cc



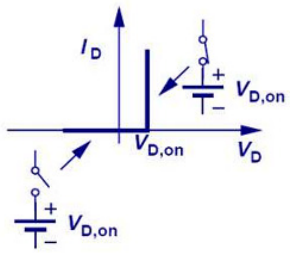
Prof. Pedro Xavier

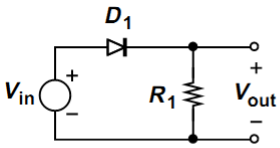
Retificador ½ onda

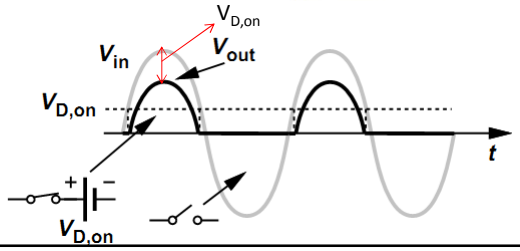
- Modelo com queda de tensão constante



(a)

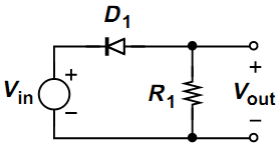


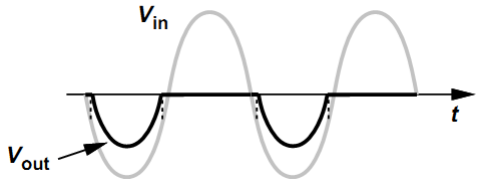




Retificador ½ onda

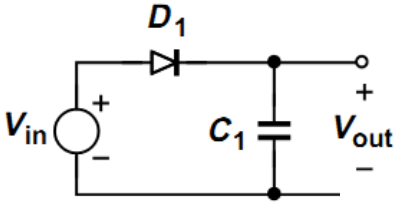
- V_{out}?



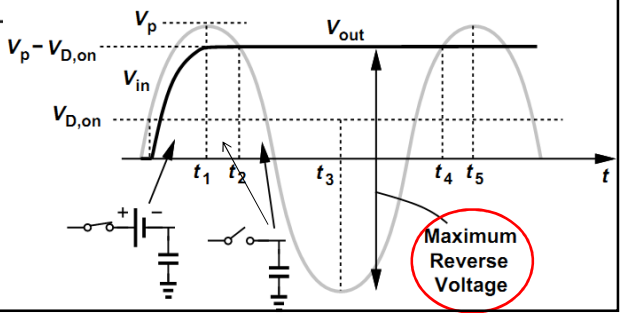


Retificador ½ onda

- Circuito capacitor com capacitor de filtro

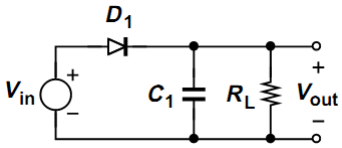


- O capacitor carrega até V_p-V_{Don} (V_{in}=V_p, t_1)
- Para t_1<t<t_2, 0<V_D<VD_{on}→chave aberta
- Para t≥t_2, V_D<0<VD_{on}→chave aberta

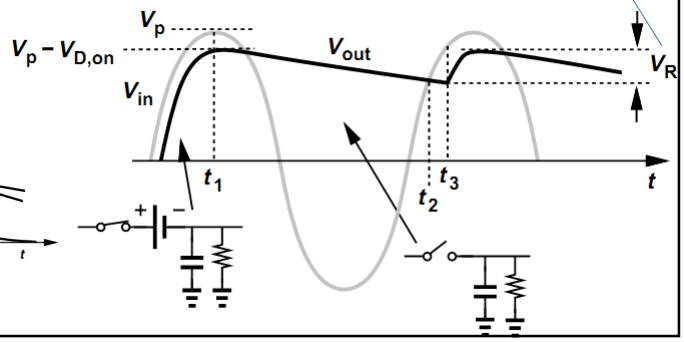


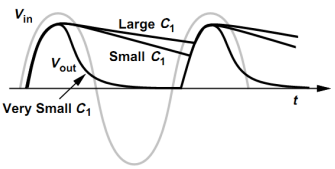
Retificador ½ onda

- Circuito com capacitor de filtro e carga



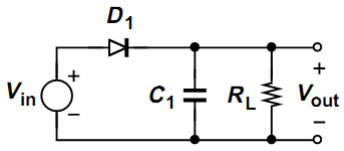
Tensão de ripple

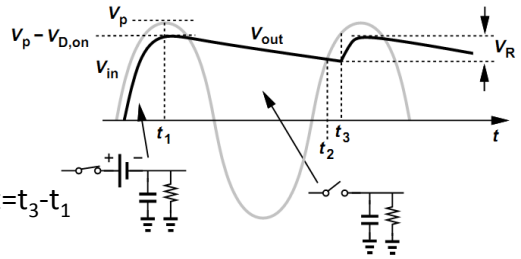




Retificador ½ onda

- Circuito com capacitor de filtro e carga





$$V_{out}(t) = (V_p - V_{D,on})\exp\frac{-\Delta t}{R_L C_1}\ ,\ \Delta t = t_3 - t_1$$

Linearização por Série de Taylor

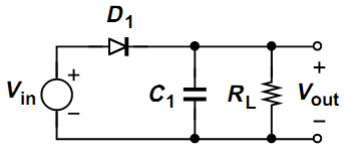
$$V_{out}(t) \approx (V_p - V_{D,on})(1 - \frac{\Delta t}{R_L C_1}) \approx (V_p - V_{D,on}) - \frac{V_p - V_{D,on}}{R_L}\frac{\Delta t}{C_1}\ ,\ \Delta t \cong T$$

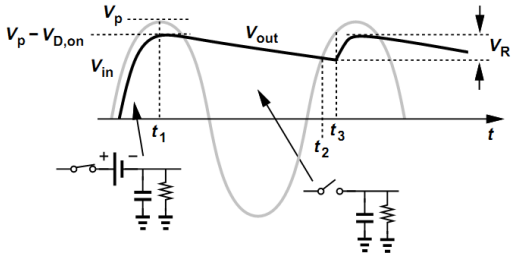
V_R

$$V_R \approx \frac{V_p - V_{D,on}}{R_L}\cdot\frac{T}{C_1} \approx \frac{V_p - V_{D,on}}{R_L C_1 f}$$

Retificador ½ onda

- Circuito com capacitor de filtro e carga



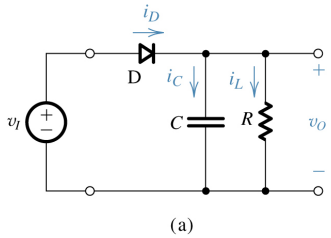


$$V_R \approx \frac{V_p - V_{D,on}}{R_L}\cdot\frac{T}{C_1} \approx \frac{V_p - V_{D,on}}{R_L C_1 f}$$

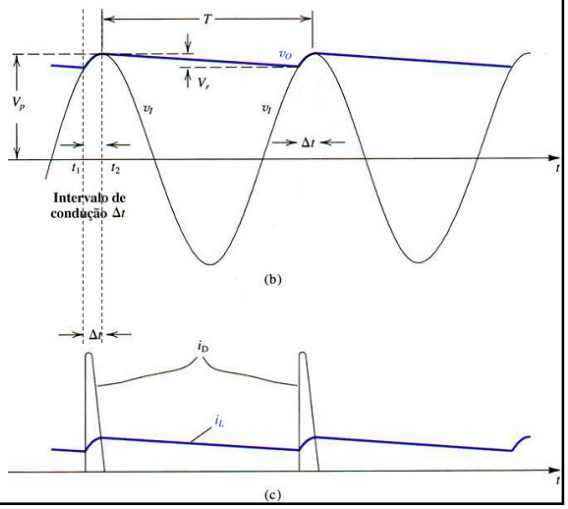
$$V_R \approx I_L \cdot \frac{T}{C_1} \approx \frac{I_L}{C_1 f}$$

Retificador ½ onda

- Circuito com capacitor de filtro e carga



(a)



(b)

(c)

Corrente do diodo

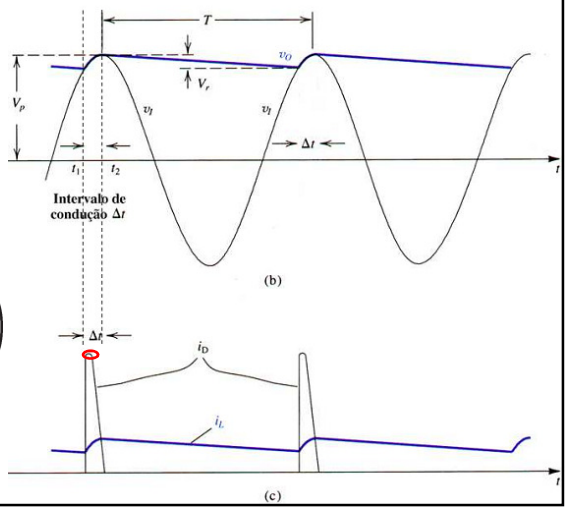
$$i_L = v_O / R$$

$$i_D = i_C + i_L$$

$$i_D = C\frac{dv_o}{dt} + i_L$$

Retificador ½ onda

- Circuito com capacitor de filtro e carga



(b)

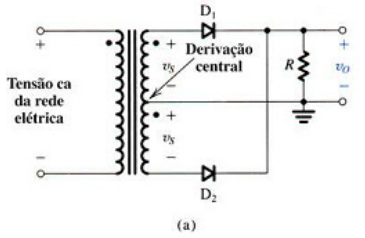
(c)

Corrente de pico do diodo

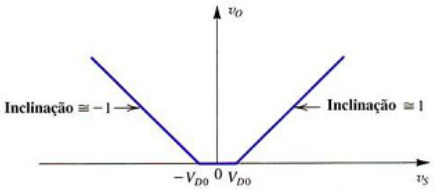
$$I_{Dp} \approx C_1\omega_{in}V_p\sqrt{\frac{2V_R}{V_p}} + \frac{V_p}{R_L}$$

$$I_{Dp} \approx \frac{V_p}{R_L}\left(R_L C_1\omega_{in}\sqrt{\frac{2V_R}{V_p}} + 1\right)$$

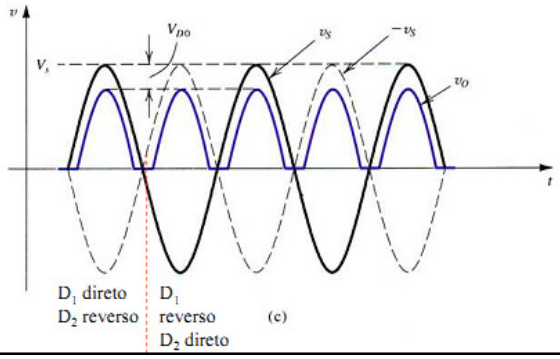
Retificador de onda completa usando transformador com derivação central



(a)

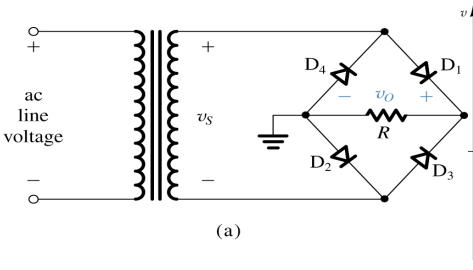


Característica de transferência

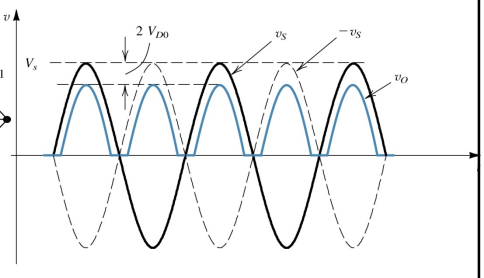


(c)

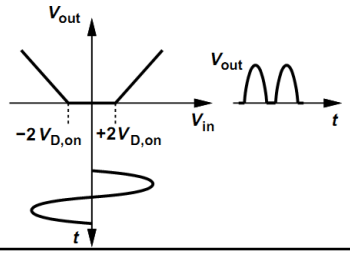
Retificador de onda completa usando Ponte de diodos



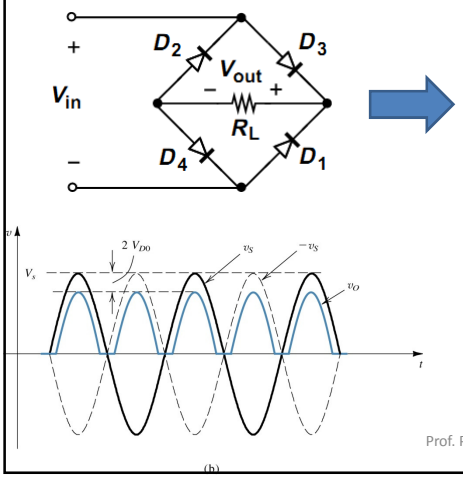
(a)

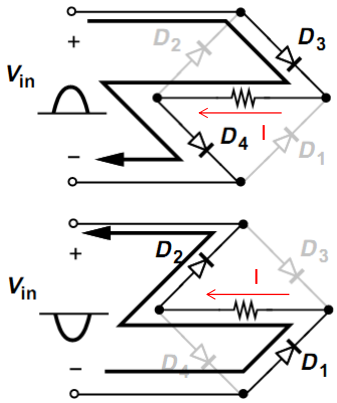


(b)



Retificador de onda completa usando Ponte de diodos

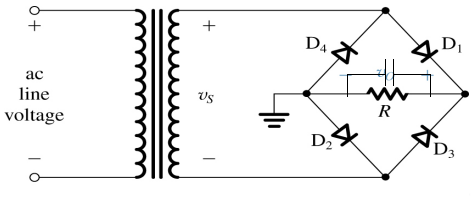




A corrente sempre está no mesmo sentido, independente da entrada.

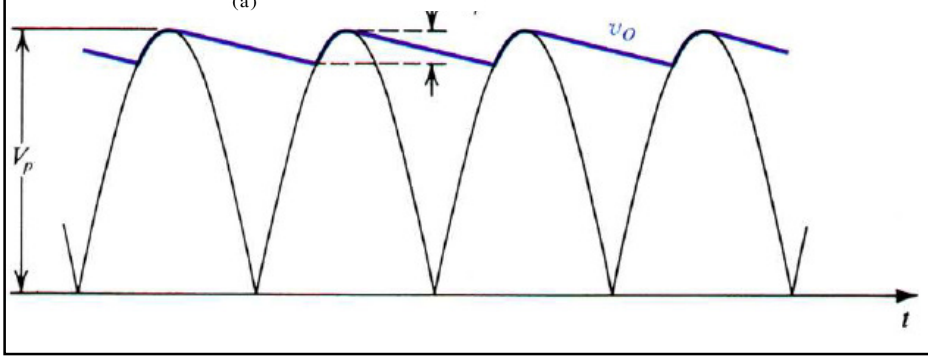
Prof. Pedro Xavier

Forma de onda do retificador de pico de onda completa

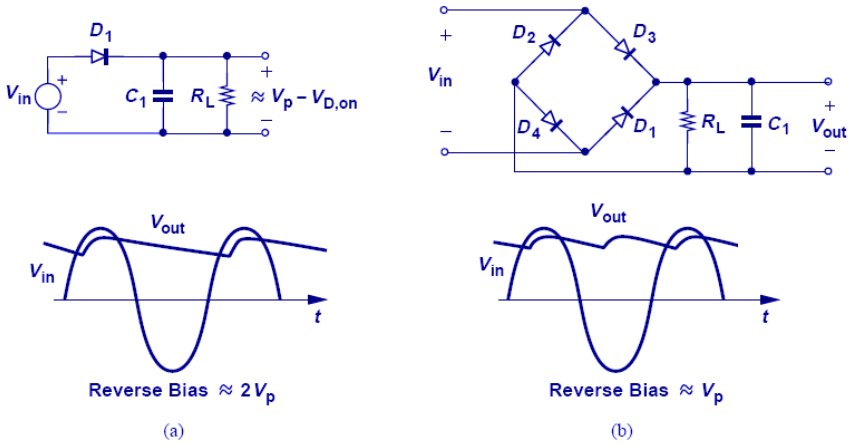


(a)

$$V_r = \frac{V_p}{2fCR}$$

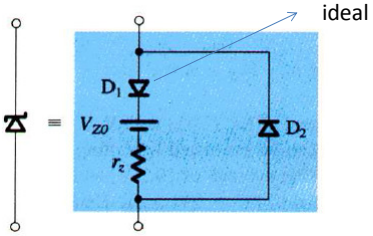


Resumo

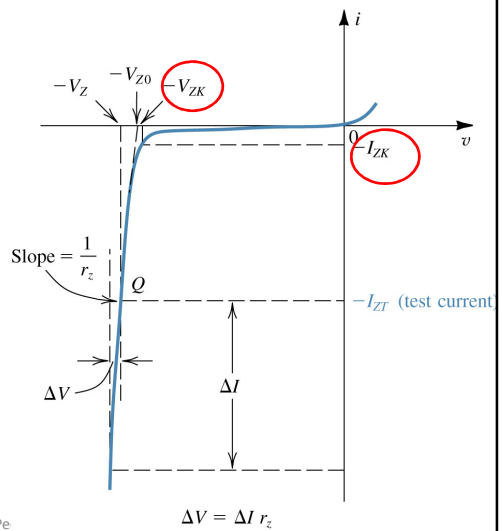


Diodo Zener

- Modelo

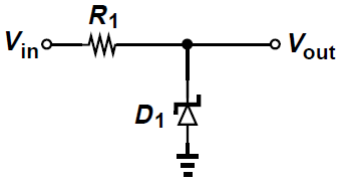


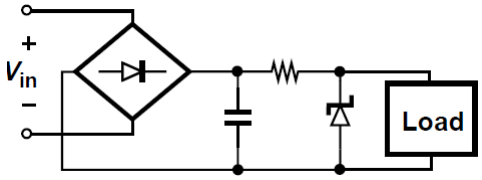
O diodo zener, quando polarizado diretamente, funciona como um diodo normal



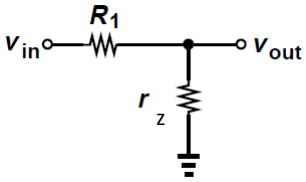
Diodo Zener

- Regulador de tensão





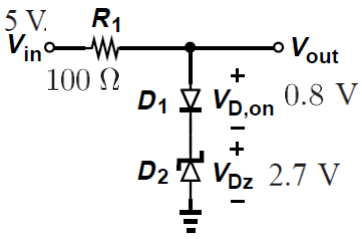
- Modelo de pequenos sinais



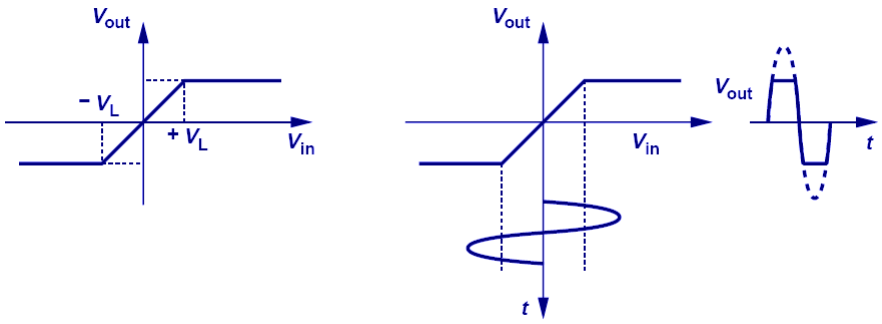
$$v_{out} = \frac{r_z}{r_z + R_1} v_{in}$$

Exercício

- Determine V_{out}. Qual a regulação de linha (relação v_{out} com v_{in})? Qual a relação de carga (relação v_{out} com i_L)? r_z=5Ω

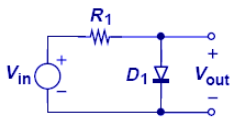


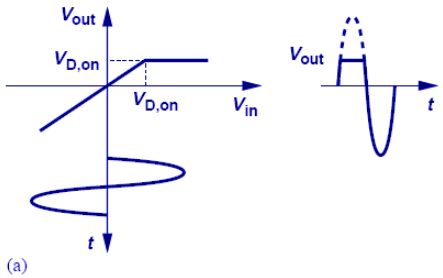
Circuitos limitadores de tensão



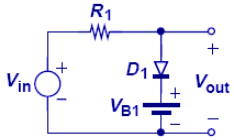
(a) (b)

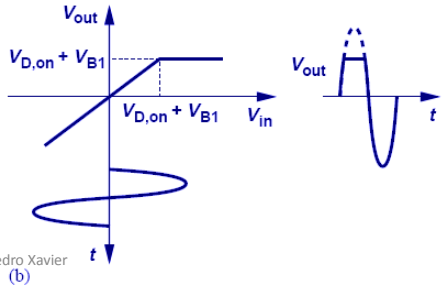
Circuitos limitadores de tensão





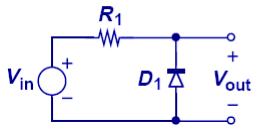
(a)

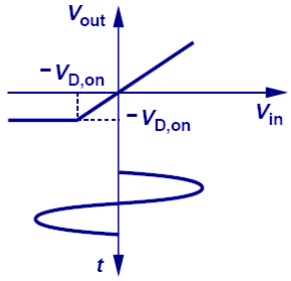


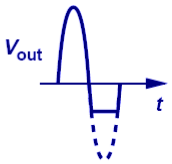


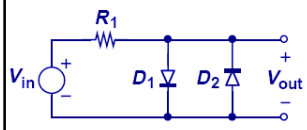
(b)

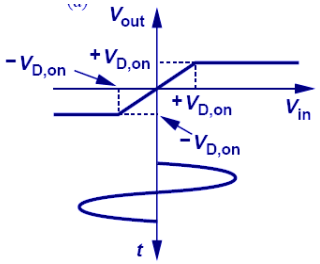
Circuitos limitadores de tensão

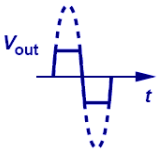




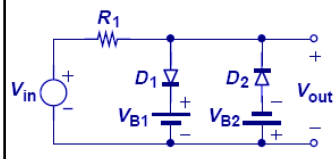


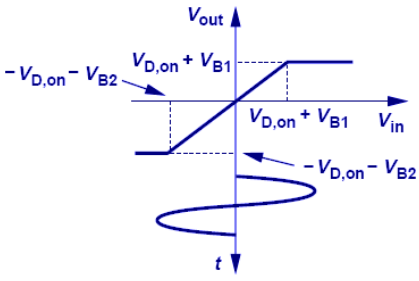


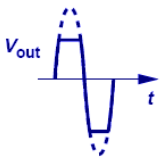




Circuitos limitadores de tensão

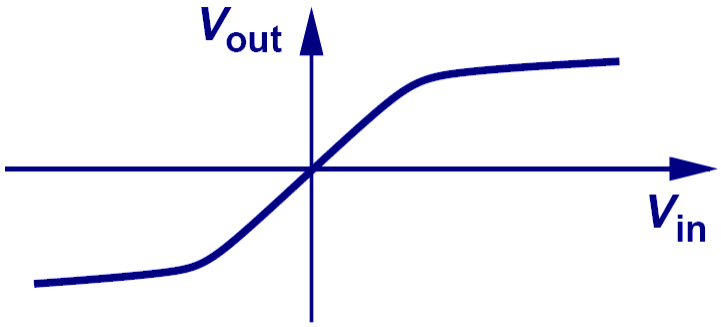




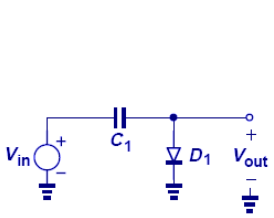


Circuitos limitadores de tensão

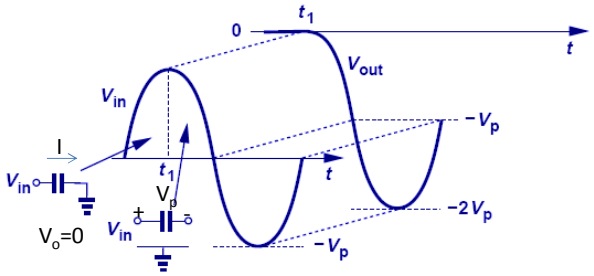
Diodos Reais



Circuitos deslocadores de tensão



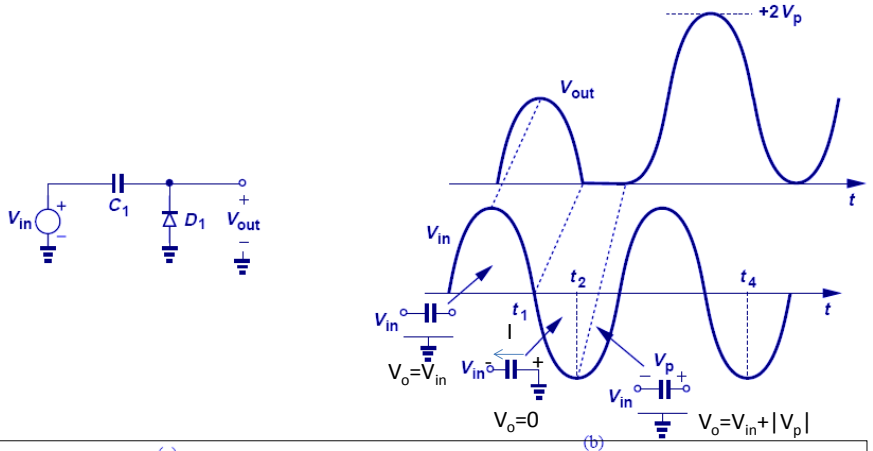
(a)



$V_o = V_{in} - |V_p|$ (b)

- D_1 conduz e o capacitor carrega com V_{in} até t_1
- A partir de t_1, Vin<Vc=Vp e o capacitor tenderia a se descarregar, no entanto, o diodo impede, pois ele não conduz corrente reversa.

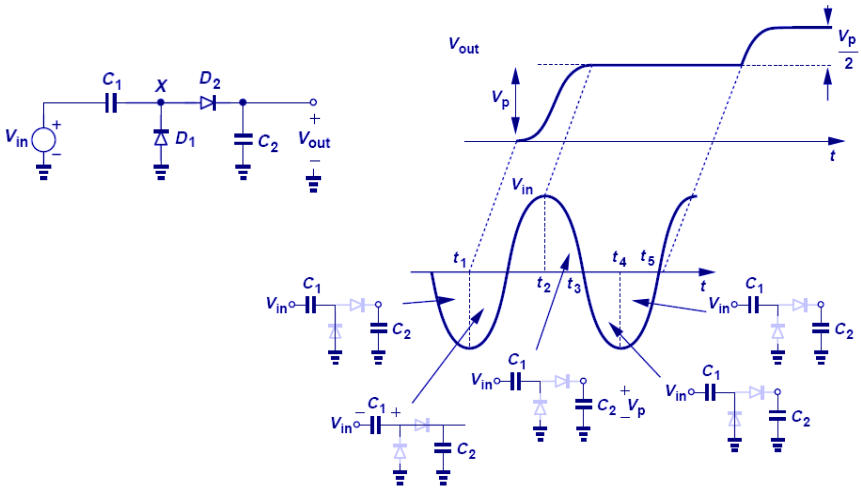
Circuitos deslocadores de tensão



•D_1 conduz e o capacitor carrega com V_{in} de t_1 até t_2

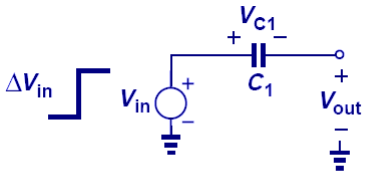
•A partir de t_2, $|Vin|<|Vc|=|Vp|$ e o capacitor tenderia a se descarregar, no entanto, o diodo impede, pois ele não conduz corrente reversa.

Circuito duplicador de tensão

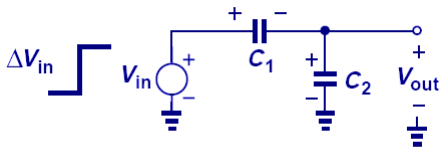


Circuito duplicador de tensão

Circuito divisor capacitivo



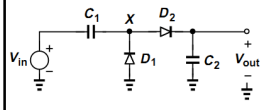
(a)



(b)

$$\Delta V_{out} = \Delta V_{in}$$

$$\Delta V_{out} = \frac{C_1}{C_1 + C_2} \Delta V_{in}$$

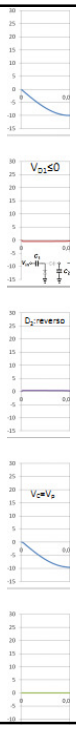


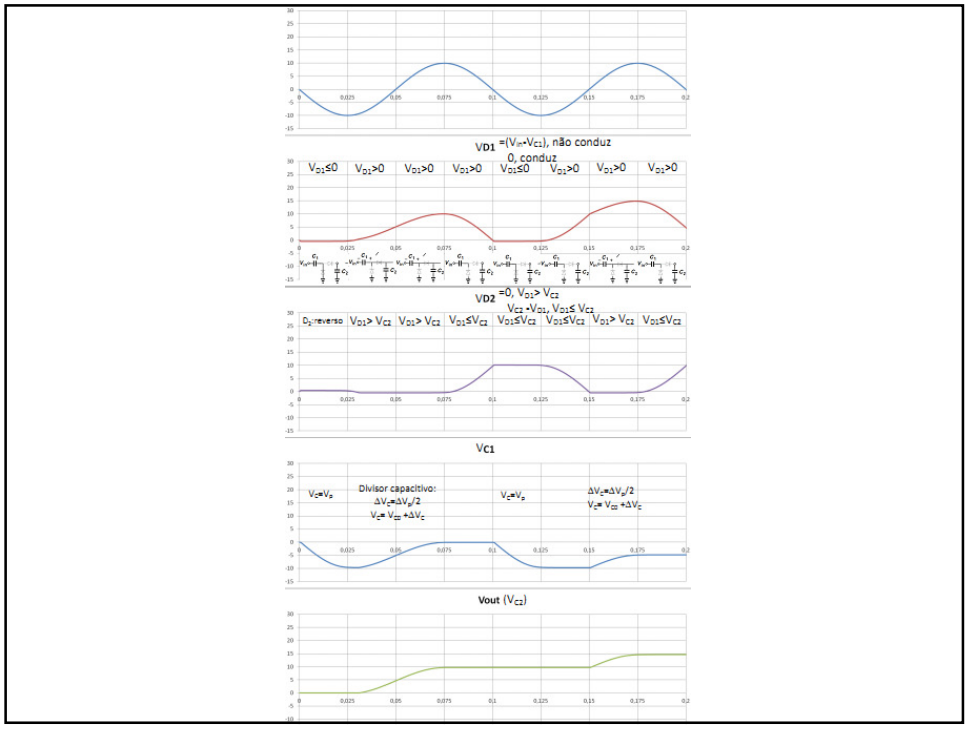
VD1 =(V_{in}-V_{C1}), não conduz
0, conduz

VD2 =0, V_{D1}> V_{C2}
V_{C2} -V_{D1}, V_{D1}≤ V_{C2}

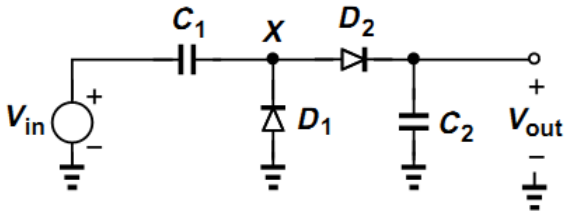
V_{C1} (Vin-VD1)

Vout (V_{C2})

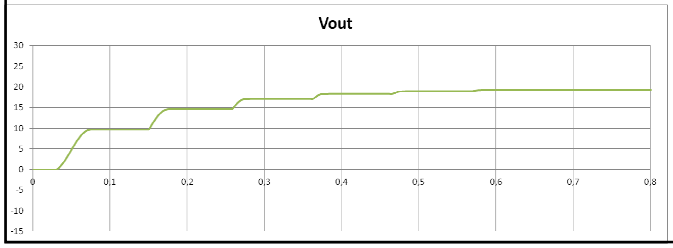




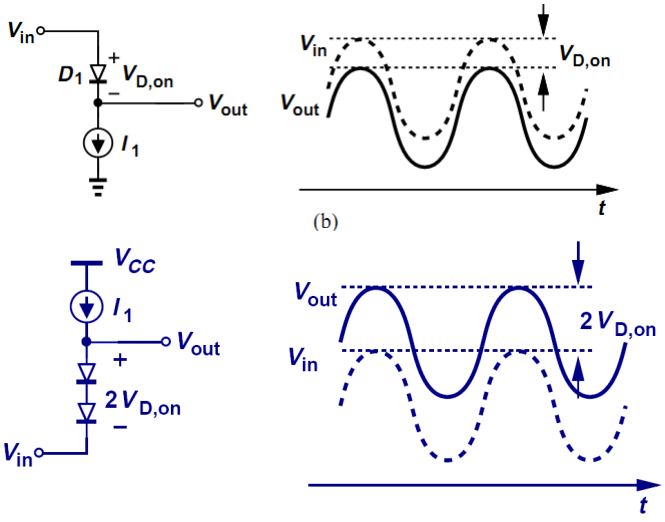
Circuito duplicador de tensão



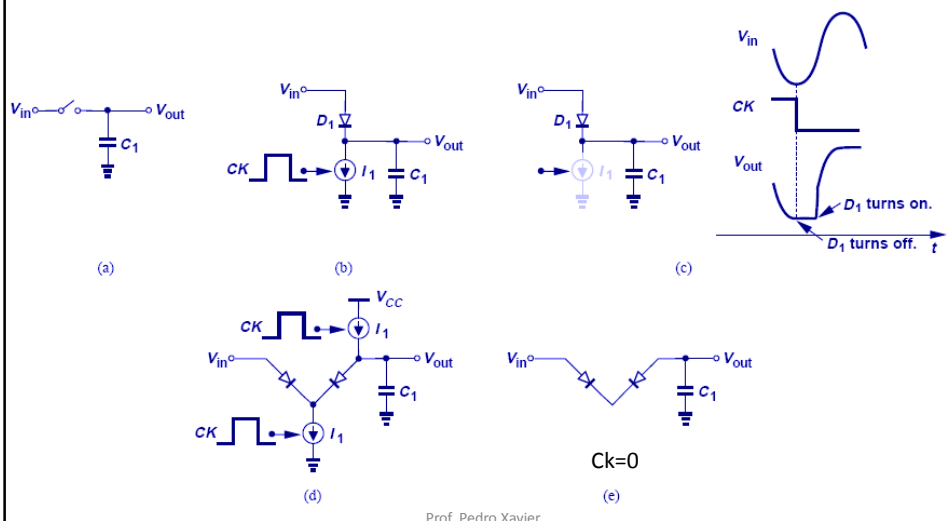
$$V_{out} = V_p\left(1 + \frac{1}{2} + \frac{1}{4} + \cdots\right)$$
$$= \frac{V_p}{1 - \frac{1}{2}}$$
$$= 2V_p.$$



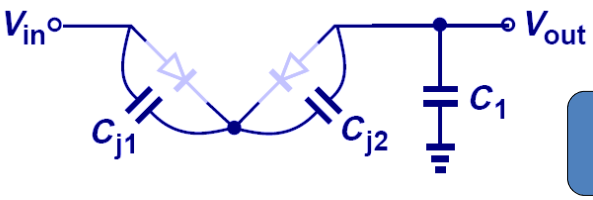
Circuitos deslocadores de nível



Circuito comutador



Circuito comutador

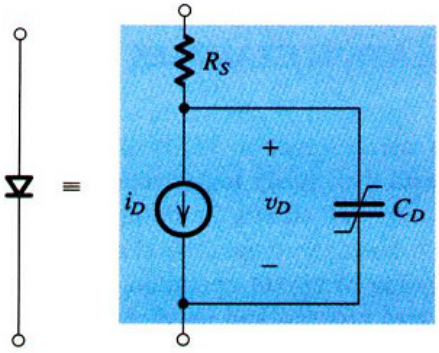


$$\Delta V_{out} = \frac{C_j/2}{C_j/2 + C_1}\Delta V_{in}$$

- Para assegurar que a condutância devido à capacitância de junção seja pequena, $C_1 >> C_j$

Prof. Pedro Xavier

Modelo de grandes sinais para o diodo

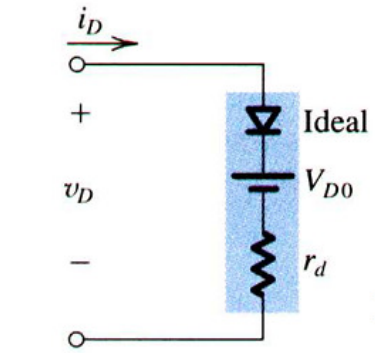


$$i_D = I_S(e^{v_D/nV_T} - 1)$$

$$C_D = \frac{\tau_T}{V_T} I_S e^{v_D/nV_T} + C_{j0}/(1 - \frac{V_D}{V_0})^m$$

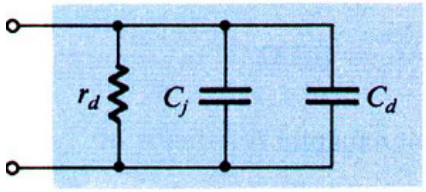
Corrente de saturação	I_S
Coeficiente de emissão	n
Resistência ôhmica	R_S
Tensão interna	V_0
Capacitância de junção para polarização zero	C_{j0}
Coeficiente de graduação da junção	m
Tempo de trânsito	τ_T

Modelo de pequenos sinais (revisão)



$$v_D = V_{D0} + i_D r_d$$
$$= V_{D0} + (I_D + i_d) r_d$$
$$= (V_{D0} + I_D r_d) + i_d r_d$$
$$= V_D + i_d r_d$$

Ponto de polarização: I_D, V_D



$$r_d = nV_T / I_D$$
$$C_d = (\tau_T / V_T) I_D$$
$$C_j = C_{j0} \Big/ \left(1 - \frac{V_D}{V_0}\right)^m \text{ para } V_D < 0$$
$$C_j \cong 2C_{j0}, \text{ para } V_D > 0$$

Parâmetro do modelo SPICE para o diodo

$$I_D = I_S \exp^{V_D/nV_T}$$

Nome do Parâmetro	Símbolo	Nome no SPICE	Unidade	Valor Default
Corrente de saturação	I_S	IS	A	1×10^{-14}
Coeficiente de emissão	n	N	—	1
Resistência ôhmica	R_S	RS	Ω	0
Tensão interna	V_0	VJ	V	1
Capacitância de junção para polarização zero	C_{j0}	CJ0	F	0
Coeficiente de graduação da junção	m	M	—	0,5
Tempo de trânsito	τ_T	TT	s	0
Tensão de ruptura	V_{ZK}	BV	V	∞
Corrente reversa em V_{ZK}	I_{ZK}	IBV	A	1×10^{-10}

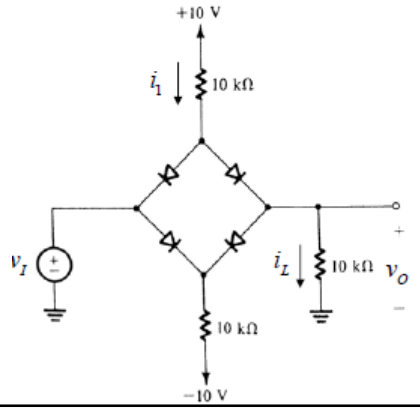
Prof. Pedro Xavier

Exercício K1

Utilize o modelo de queda de tensão constante (0.7 V) for cada diodo.

a) Ache i_1 e i_L em função de v_I

b) Para qual faixa de valores de v_I os 4 diodos conduzirão? Ache a função de transferência para esta condição.



Fontes de figuras da aula

- Aula do prof. Fabiano Fruett
- Introdução à física dos semicondutores (H.A. Mello)
- Fundamentos da microeletrônica (Razavi)
- Microeletrônica (Sedra)

Sugestão de estudo

- Razavi, Cap 3, seção 3.5
- Sedra/Smith Cap. 3 seções 3.7, 3.8 e 3.10
  - Exercícios e problemas correspondentes

R. Boylestad e L. Nashelsky, Dispositivos Eletrônicos