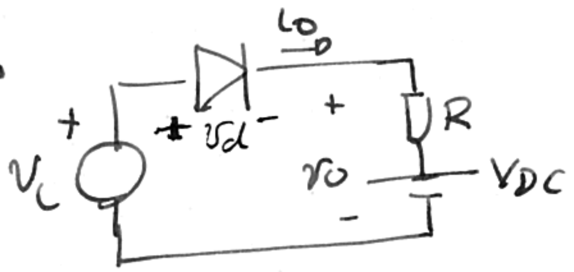
Rectifying circuits
Annex

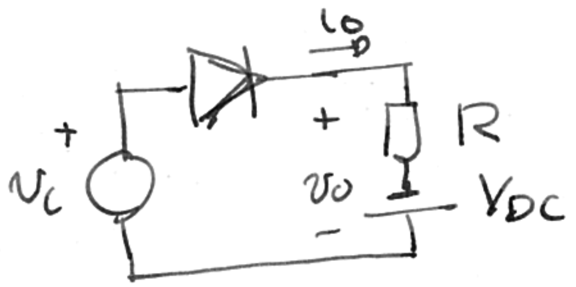
Half Wave

- 

$$\begin{cases} v_i > V_{DC} \Rightarrow \text{ON} \begin{cases} (v_o = v_i) \\ (i_o \neq 0) \end{cases} \\ v_i < V_{DC} \Rightarrow \text{OFF} \begin{cases} (i_o = 0) \\ v_o = V_{DC} \end{cases} \end{cases}$$

$$v_i > V_{DC} \Rightarrow v_o = v_i \Rightarrow \begin{cases} i_o = \dfrac{v_i - V_{DC}}{R} \\ v_o = v_i \\ v_d = 0 \end{cases}$$

$$v_i < V_{DC} \Rightarrow v_o = V_{DC} \Rightarrow \begin{cases} i_o = 0 \\ v_d = v_i - V_{DC} \end{cases}$$

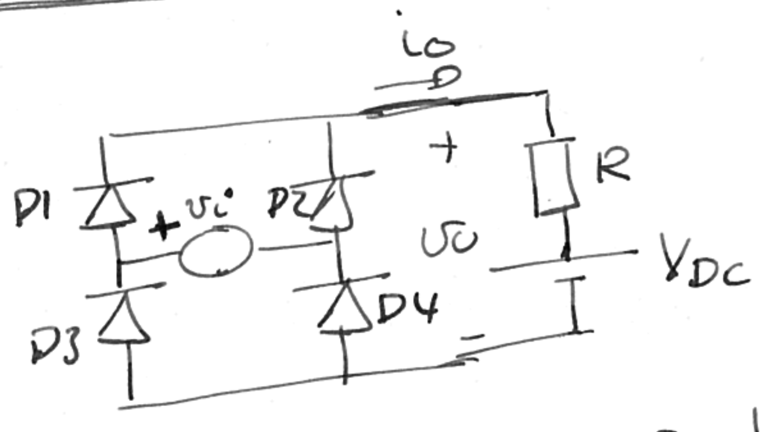
- 

$$\begin{cases} v_i > -V_{DC} \Rightarrow \text{ON} \begin{cases} v_o = v_i \\ i_o \neq 0 \end{cases} \\ v_i < -V_{DC} \Rightarrow \text{OFF} \begin{cases} v_o = -V_{DC} \\ i_o = 0 \end{cases} \end{cases}$$

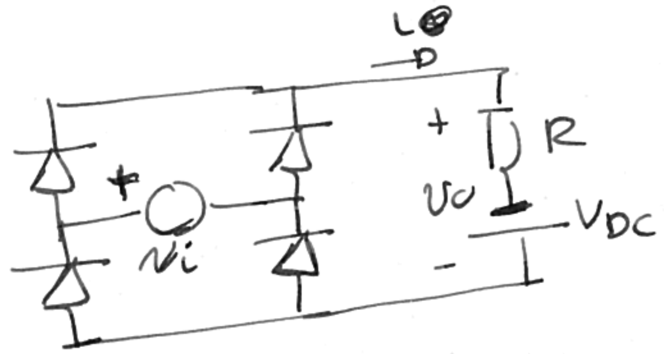
$$v_i > -V_{DC} \Rightarrow v_o = v_i \Rightarrow i_o = \frac{v_i + V_{DC}}{R}$$

$$v_i < -V_{DC} \Rightarrow v_o = -V_{DC} \Rightarrow i_o = 0$$

Full wave



$$\begin{cases} |v_i| > V_{DC} \Rightarrow \text{ON} \begin{cases} v_o = |v_i| \\ i_o \neq 0 \end{cases} \Rightarrow i_o = \dfrac{|v_i| - V_{DC}}{R} \\ |v_i| < V_{DC} \Rightarrow \text{OFF} \begin{cases} v_o = V_{DC} \\ i_o = 0 \end{cases} \Rightarrow i_o = 0 \end{cases}$$

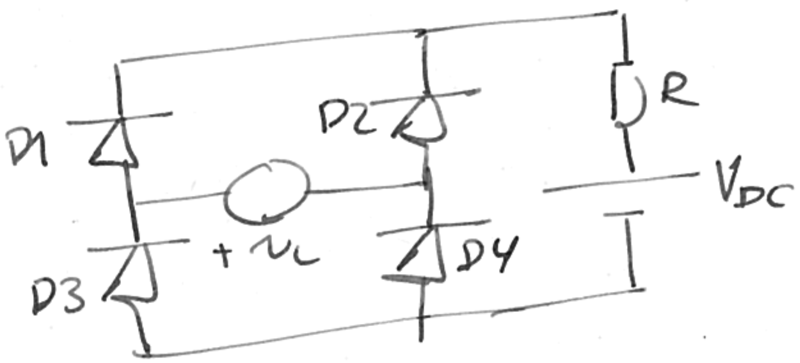


Always on $\Rightarrow$ $v_o = |v_i|$ $\Rightarrow$ $i_o = \dfrac{|v_i| + V_{DC}}{R}$

DIODE'S VOLTAGES

(Remark: 

)



① $v_i > V_{DC} \Rightarrow$ { D1 + D4 ON ; D2 + D3 OFF } $\Rightarrow$ $v_{D1} = v_{D4} = 0$, $v_{D2} = v_{D3} = -v_i$, $v_o = v_i$

(v_i is >0)

② $v_i < -V_{DC} \Rightarrow$ { D2 + D3 ON ; D1 + D4 OFF } $\Rightarrow$ $v_{D2} = v_{D3} = 0$, $v_{D1} = v_{D4} = +v_i$, $v_o = -v_i$

(v_i is <0)

③ $-V_{DC} < v_i < V_{DC} \Rightarrow$ { D_1, D_2, D_3, D_4 OFF } $\Rightarrow$ $v_o = V_{DC}$

③.1 $v_{D_1} = v_{D4}$ (why not??) $\Longrightarrow$

$v_{D_2} = v_{D3}$ (why not??)

$$-2v_{D_1} + v_i = V_{DC} \Rightarrow v_{D1} = \frac{-V_{DC} + v_i}{2} = v_{D4}$$

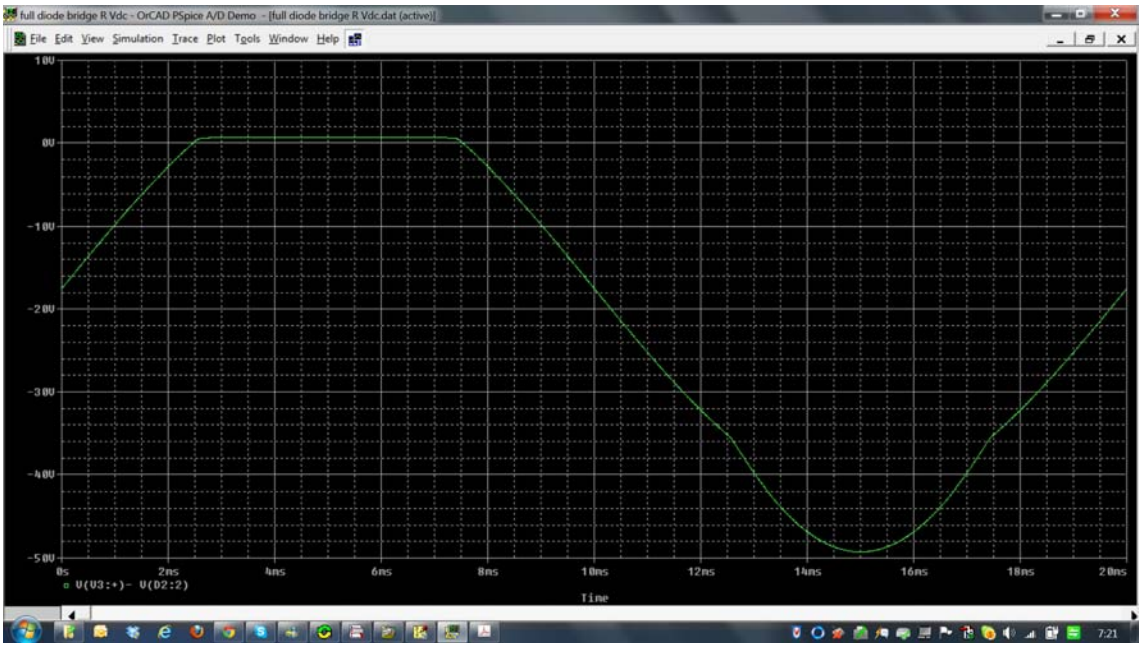
$$-2v_{D_2} - v_i = V_{DC} \Rightarrow v_{D2} = -\left(\frac{V_{DC} + v_i}{2}\right) = v_{D3}$$

Voltage D1 diode

V_i= 50 sin(100πt)

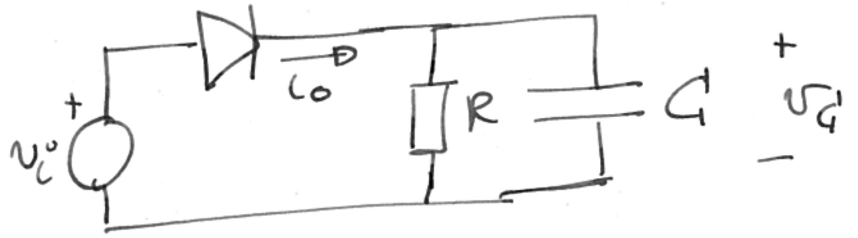
Vdc = 35 V

R_L= 500Ω



Analog circuits
11/2/2012 | 25
DIODES

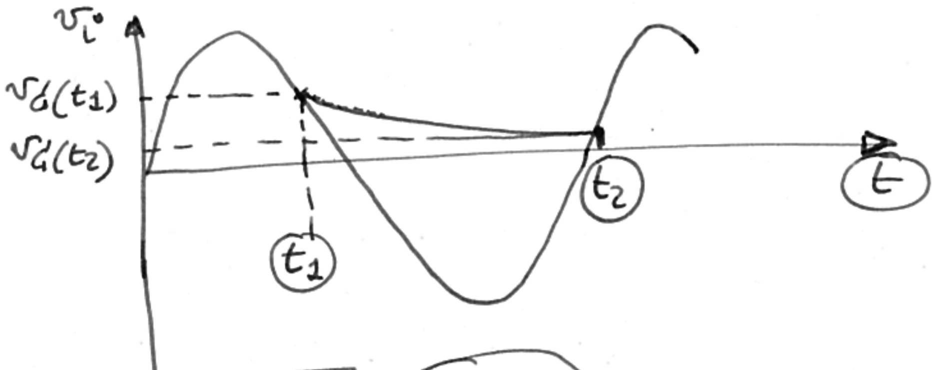
HALF WAVE WITH RC LOAD



$v_i = V \sin \omega t$

First cycle analysis

$v_C(0) = 0$ (Initial condition)



$0 < t < t_1$ (DON)

- $i_o = i_R + i_C = \frac{V}{R} \sin(\omega t) + VC\omega \cos \omega t$

$$\left.\begin{array}{l} i_R > 0 \quad (0 < t < \frac{T}{2}) \\ \oplus \\ \begin{cases} i_C > 0 & (0 < t < \frac{T}{4}) \\ i_C < 0 & (\frac{T}{4} < t < T) \end{cases} \end{array}\right\} \Rightarrow \exists\, t_1 \,/\, i_o = 0$$

(t_1) $\frac{V}{R} \sin \omega t_1 + VC\omega \cos \omega t_1 = 0 \Rightarrow t_1 \Rightarrow$

$$\boxed{v_C(t_1) = V \sin(\omega t_1)}$$

If $\tau = RC$ is ~~high~~ big enough, so that the capacitor will not be discharged ($v_C(t) = 0$ is not reached):

$t_1 < t < t_2$ (DOFF)

$$v_d(t) = v_d(t_1)\left(1 - e^{-\frac{t - t_1}{RC}}\right)$$

$$i_0(t) = 0$$

$$i_R(t) = \frac{v_d(t)}{R} = -i_d(t)$$

obviously

$t_2 < t < T + t_1$ (DON)

and the steady state is already reached.

v_d ripple $= \Delta v_d = V - v_d(t_2)$

~~$\Delta v_d = v_d(t_2) - v_d(t_1)$~~

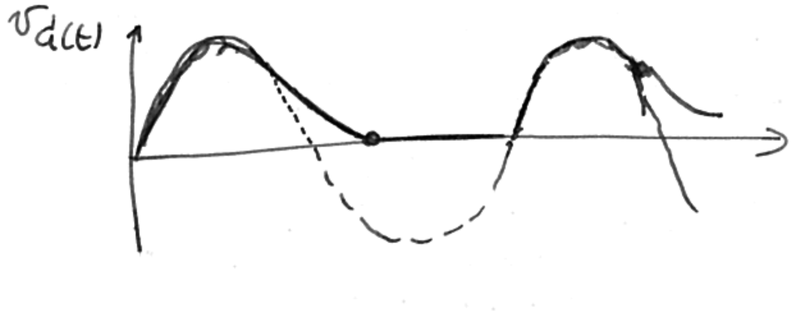
It can be shown:

$\Delta v_d \downarrow\downarrow$ if $C \uparrow\uparrow$ $(R, \omega \equiv ct)$

$\Delta v_d \downarrow\downarrow$ if $\omega \uparrow\uparrow$ $(R, C \equiv ct)$

$\Delta v_d \downarrow\downarrow$ if $R \uparrow\uparrow$ $(C, \omega \equiv ct)$

If $\tau = RC$ is small enough, so that the capacitor is fully discharged



$\Rightarrow \Delta v_d = V$