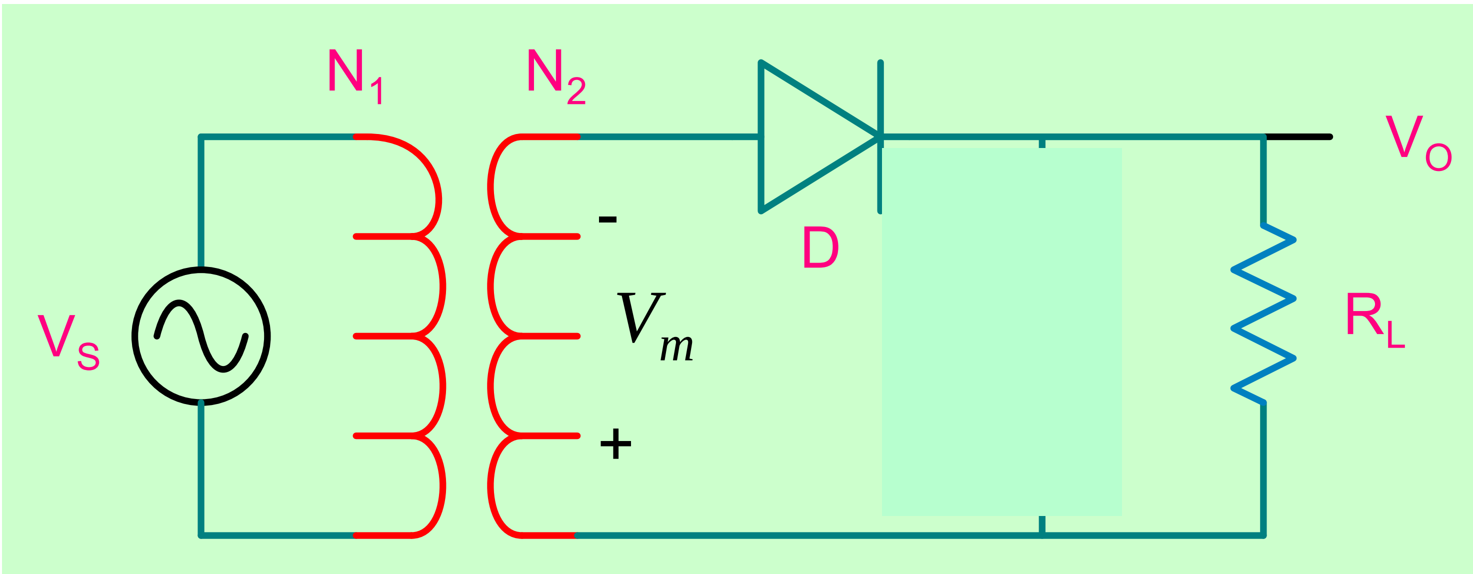
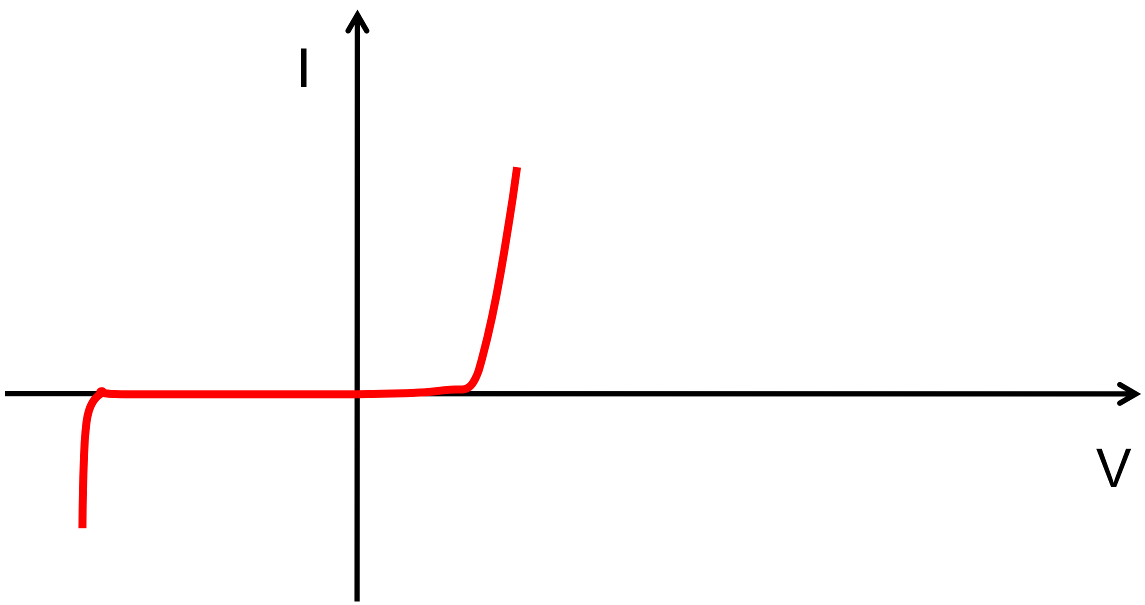
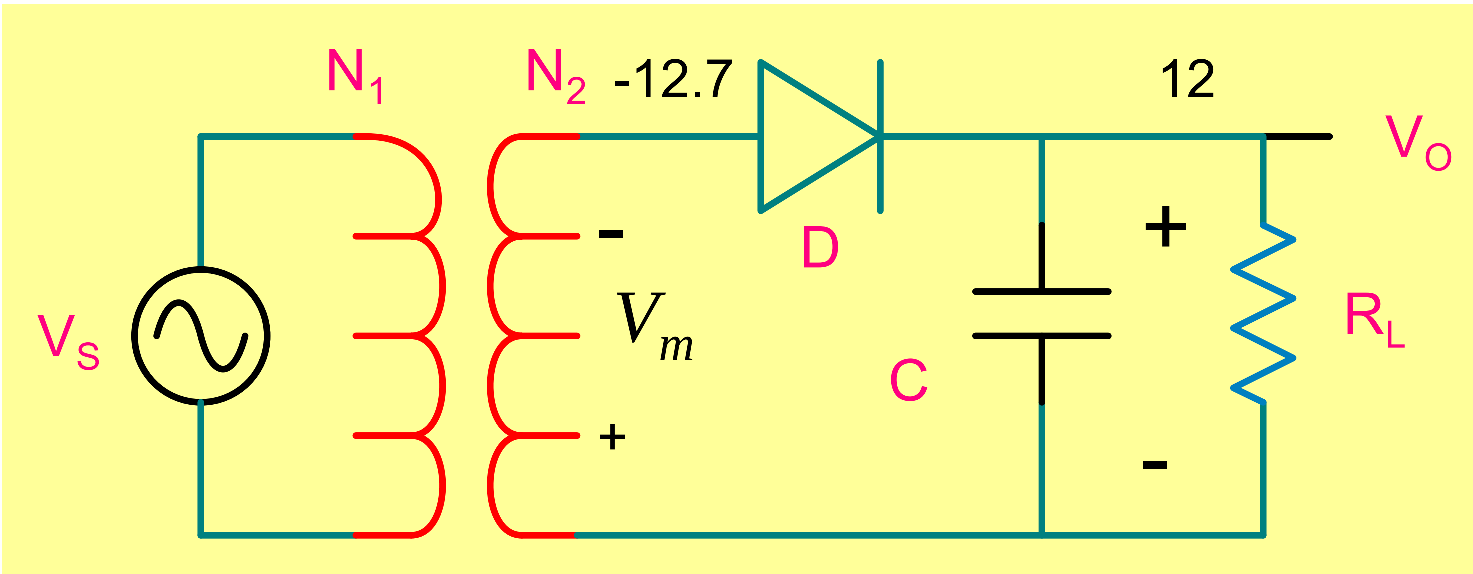
Peak Inverse Voltage





$$PIV = V_m$$

Peak Inverse Voltage



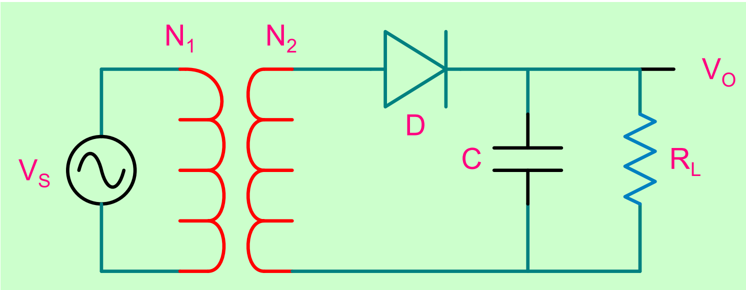
12+12.7=24.7V

$$V_m = 12.7$$

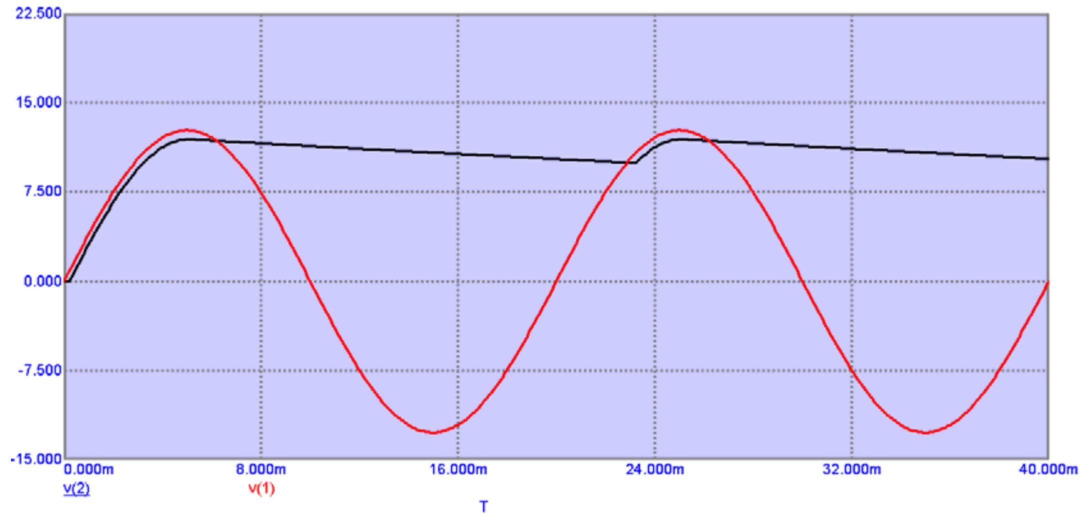
$$PIV \cong 2v_O + 0.7$$

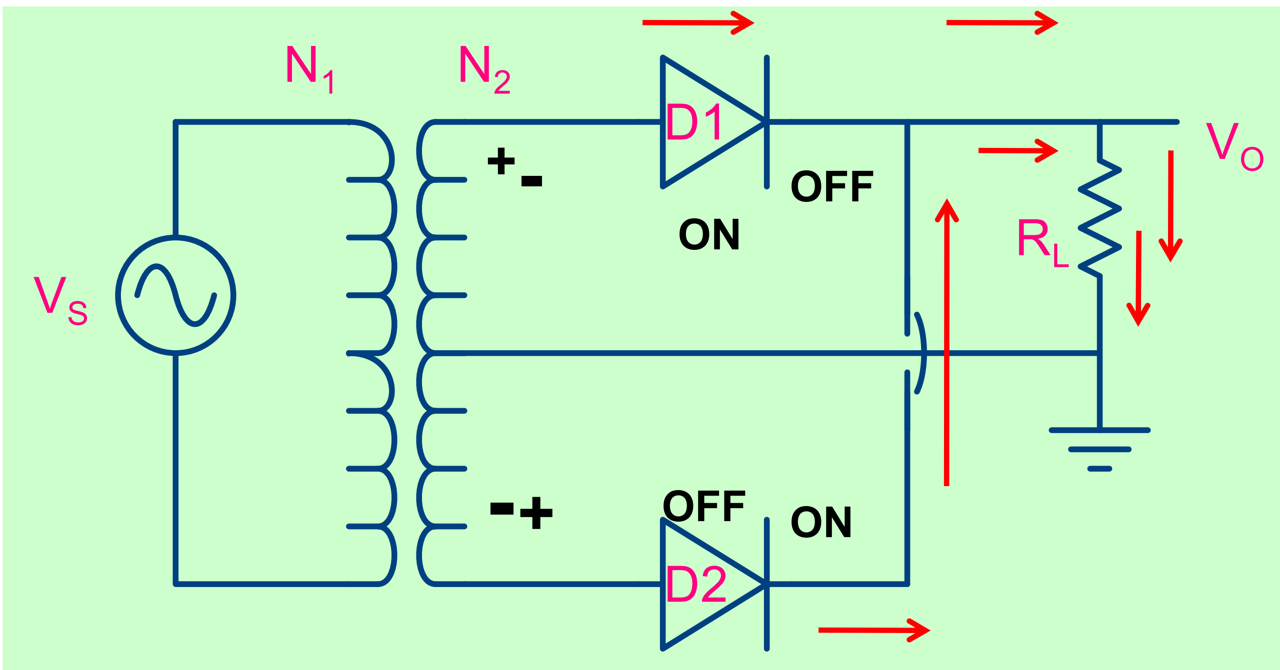
$$PIV = 2V_M + V_\gamma$$

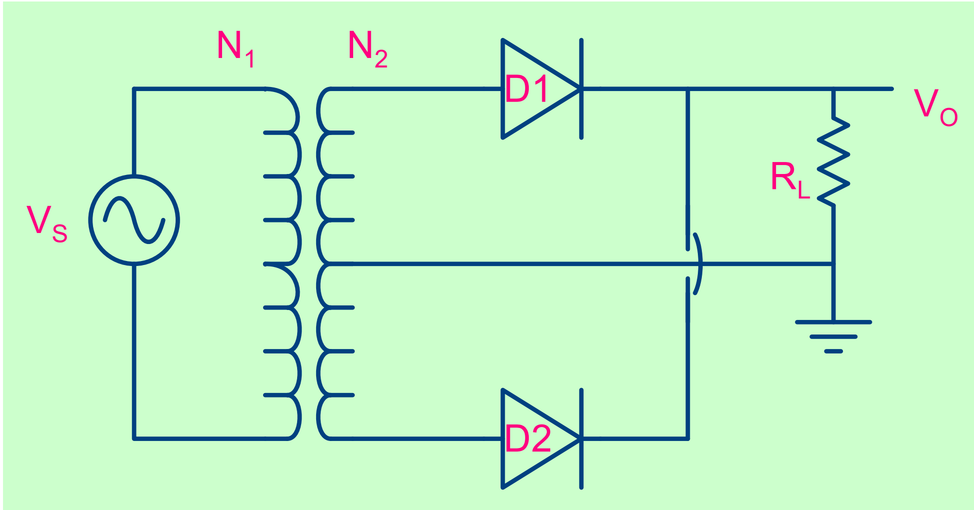
Full wave Rectifier

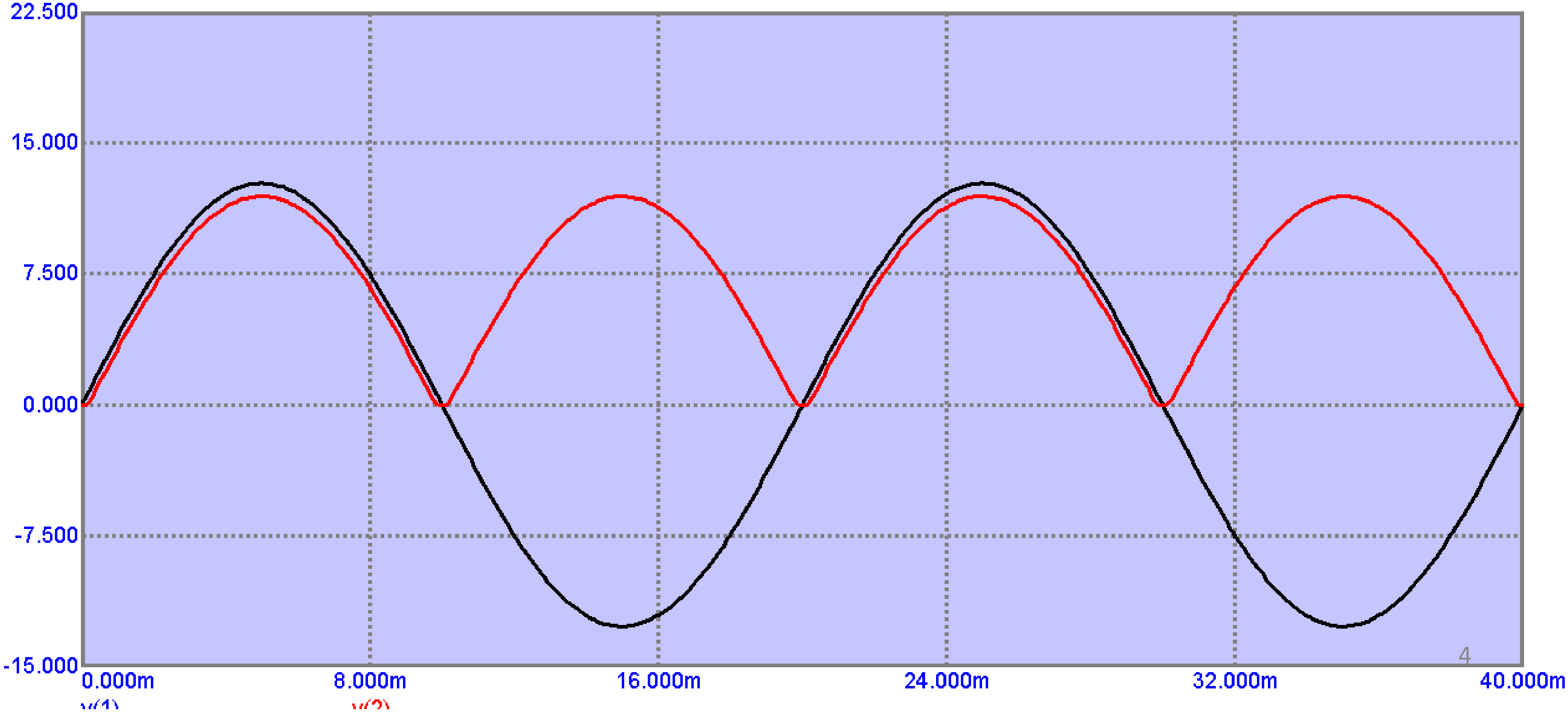


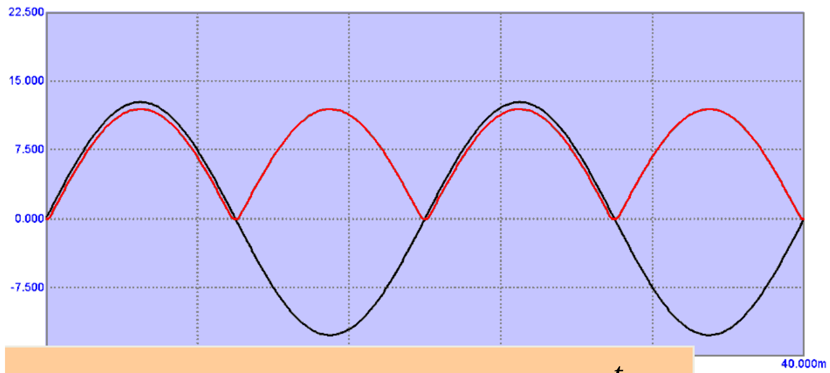
$$V_r \cong \frac{V_M}{fR_L C}$$





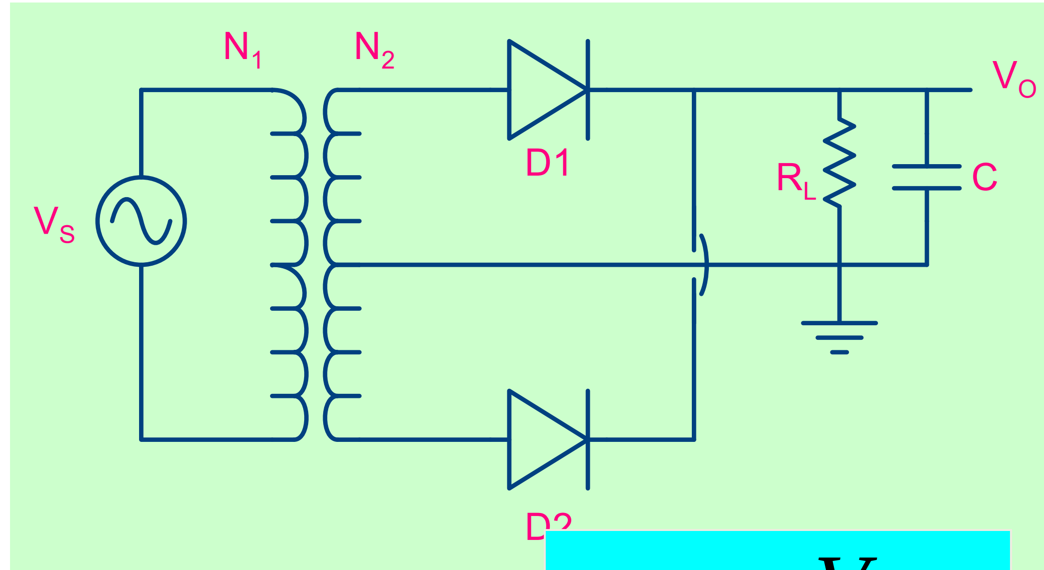

N1
N2
D1
D2
VO
RL
VS


22.500
15.000
7.500
0.000
-7.500
-15.000
0.000m
8.000m
16.000m
24.000m
32.000m
40.000m
4



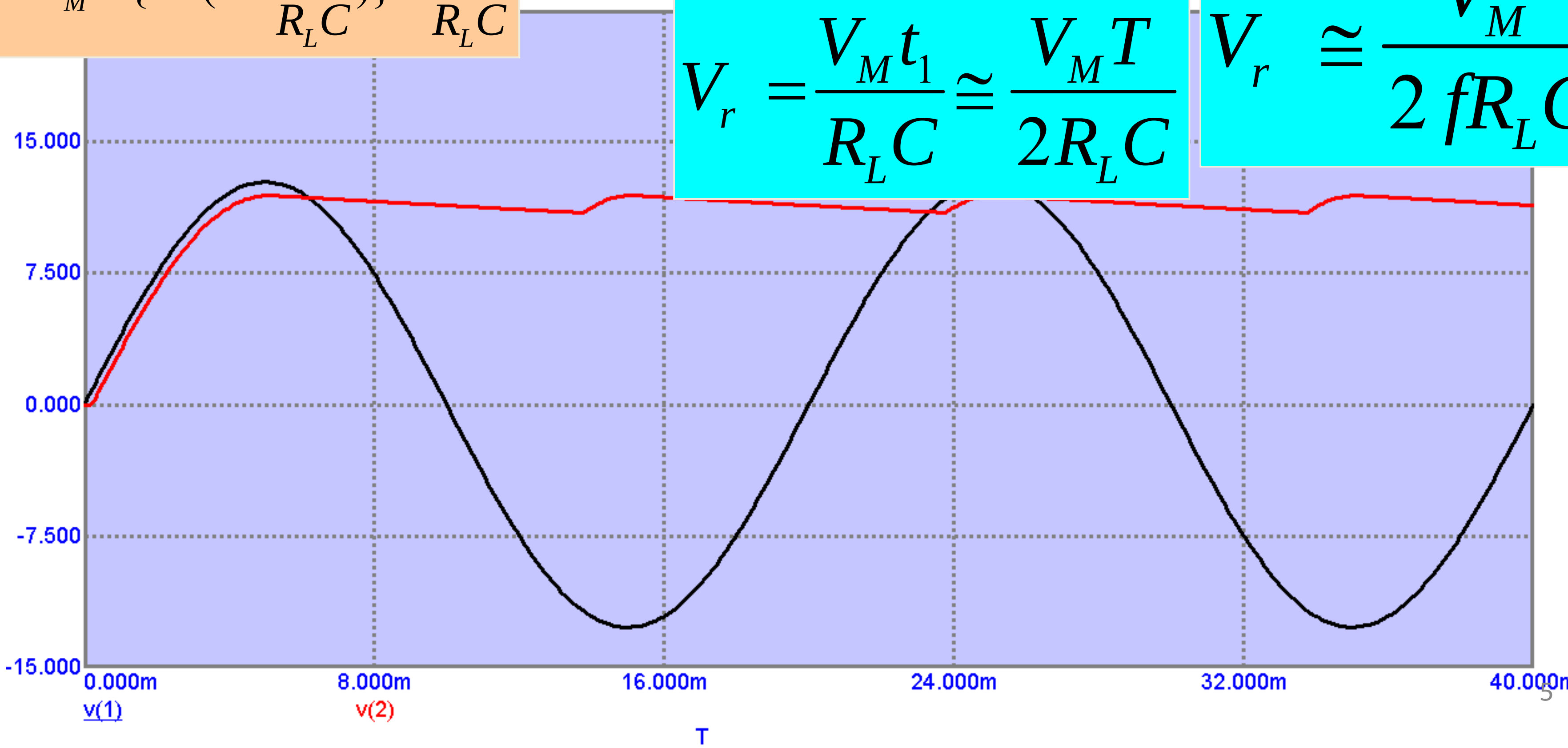
$$V_r = V_M - V_L = V_M \times (1 - e^{-\frac{t_1}{R_L C}})$$

$$V_r \cong V_M \times \{1 - (1 - \frac{t_1}{R_L C})\} = \frac{V_M t_1}{R_L C}$$

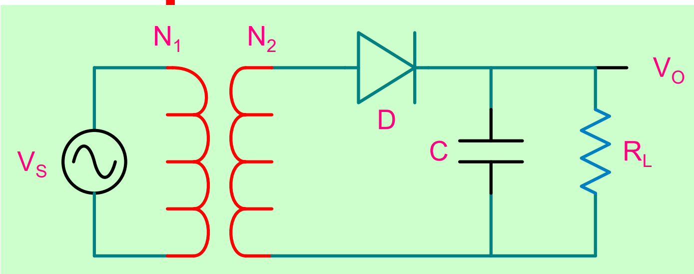


$$V_r = \frac{V_M t_1}{R_L C} \cong \frac{V_M T}{2 R_L C}$$

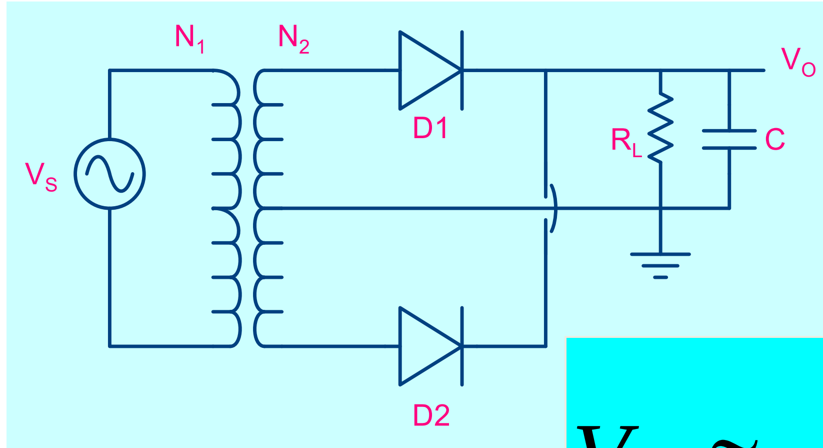
$$V_r \cong \frac{V_M}{2 f R_L C}$$



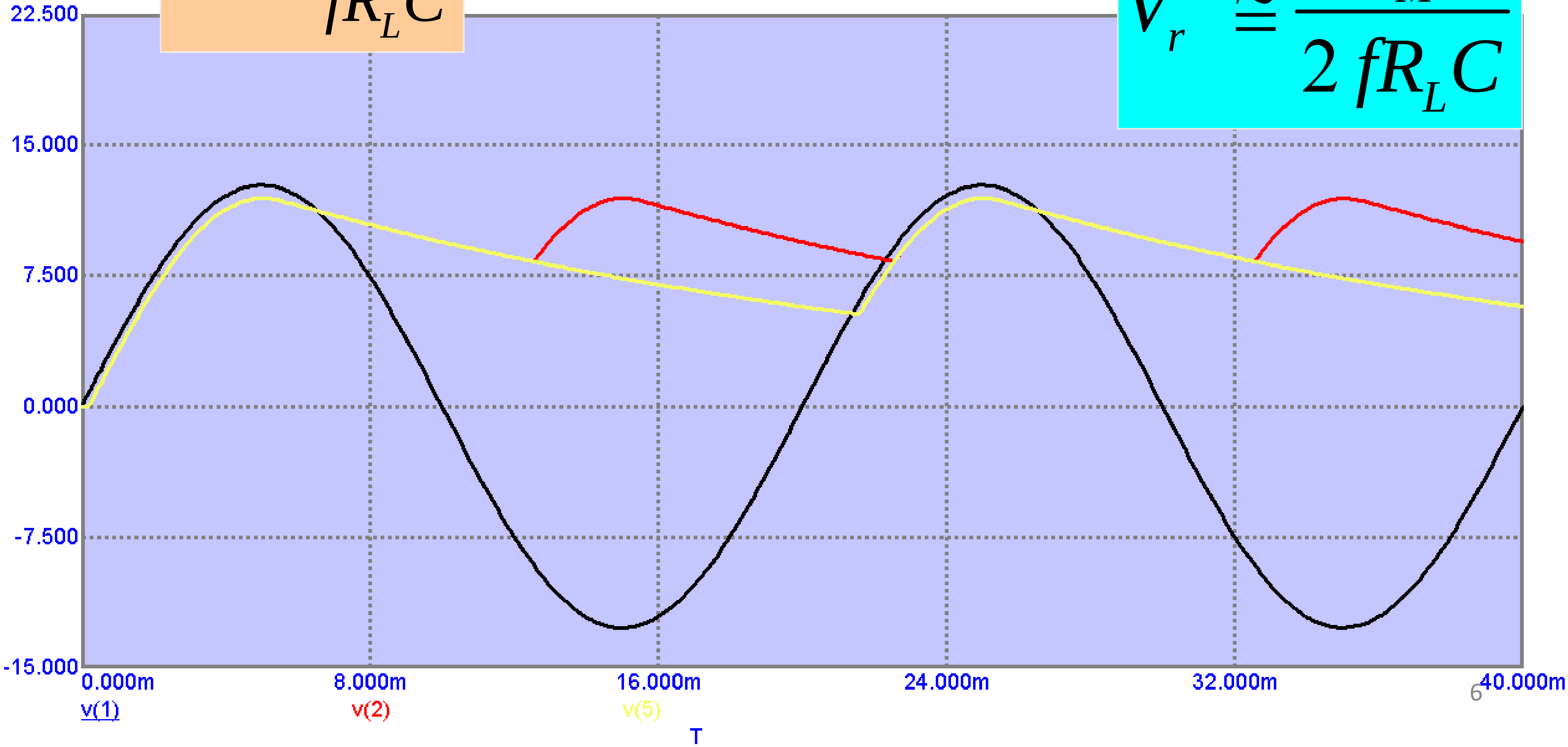
Comparison of Full and Half Wave Rectifier



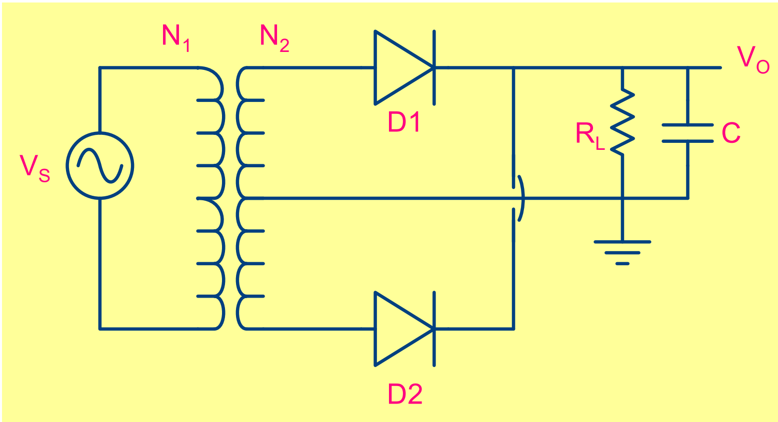
$$V_r \cong \frac{V_M}{fR_L C}$$



$$V_r \cong \frac{V_M}{2\,fR_L C}$$

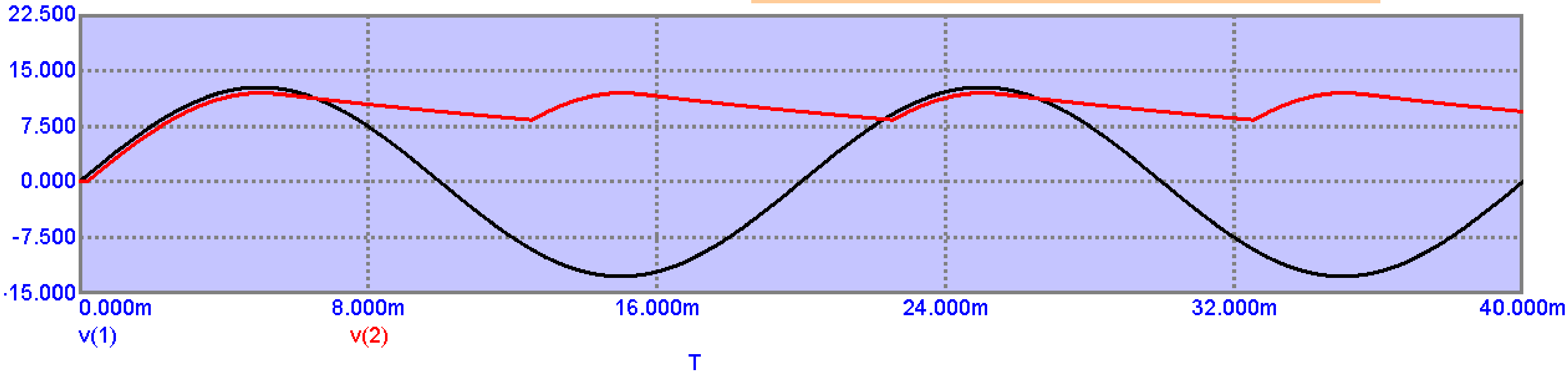


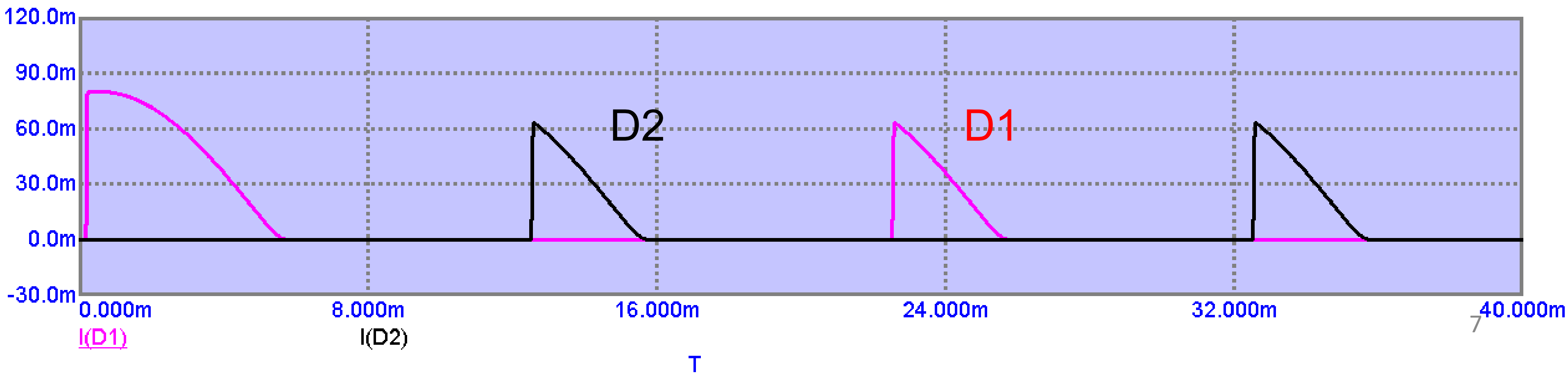
Diode Currents in Full wave Rectifier



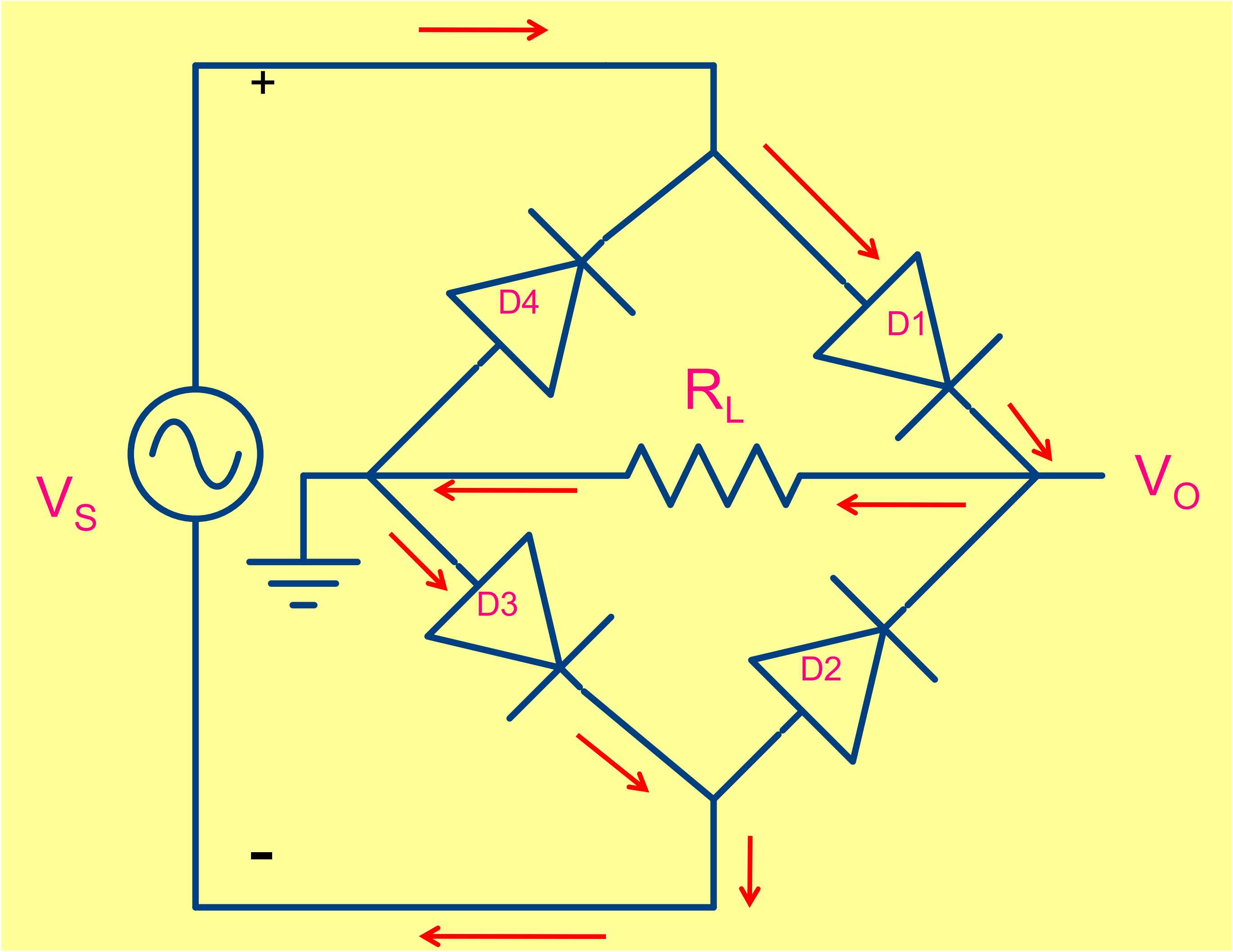
$$i_{D\max} \cong \omega C \times \sqrt{2V_r V_M} + \frac{V_M}{R_L}$$

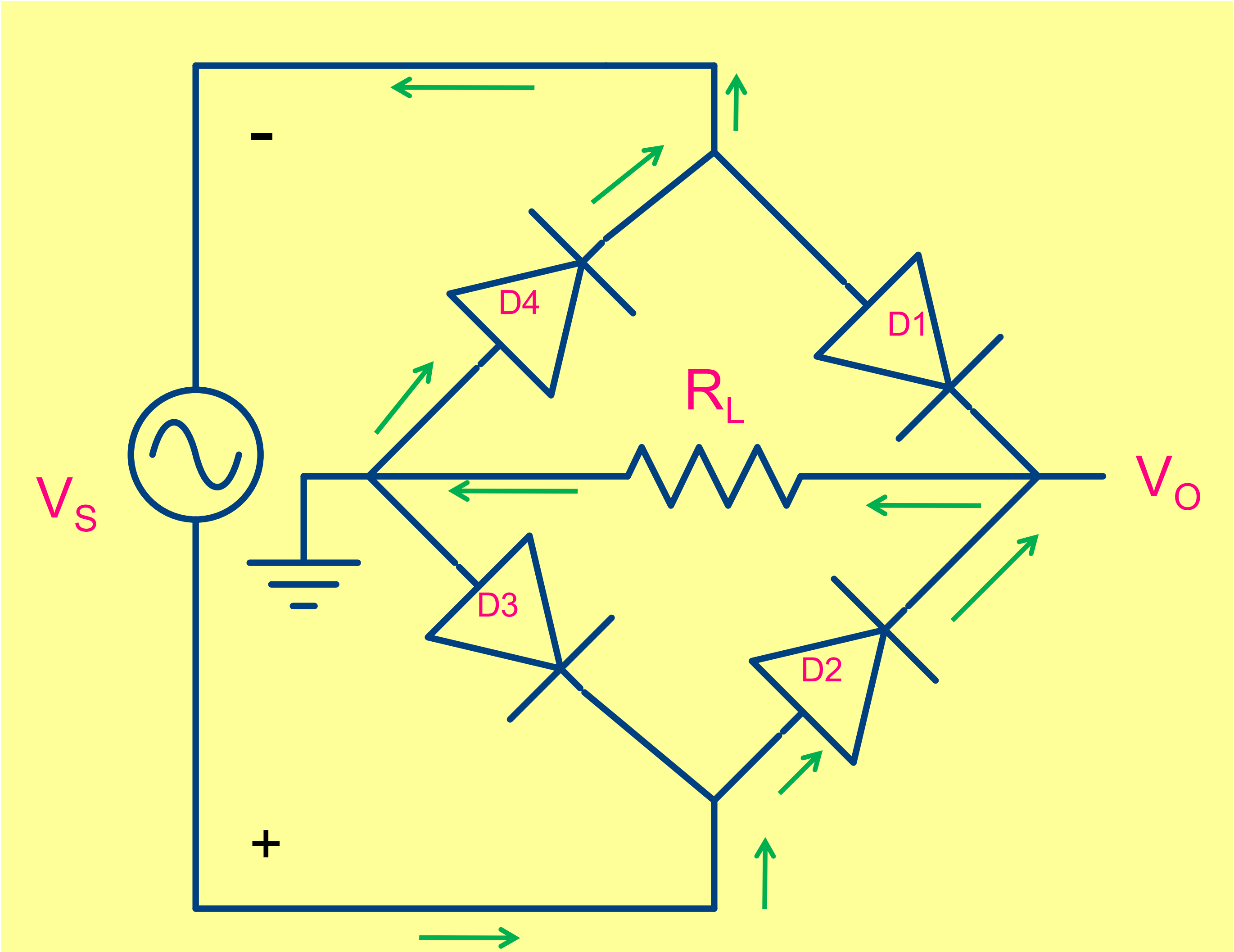
$$i_{D\max} = \frac{V_M}{R_L}\left[1 + \pi\sqrt{\frac{2V_M}{V_r}}\right]$$





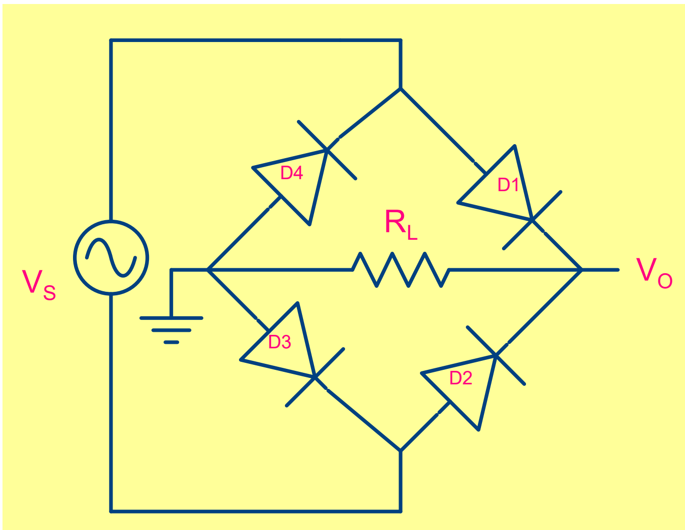
Bridge Rectifier

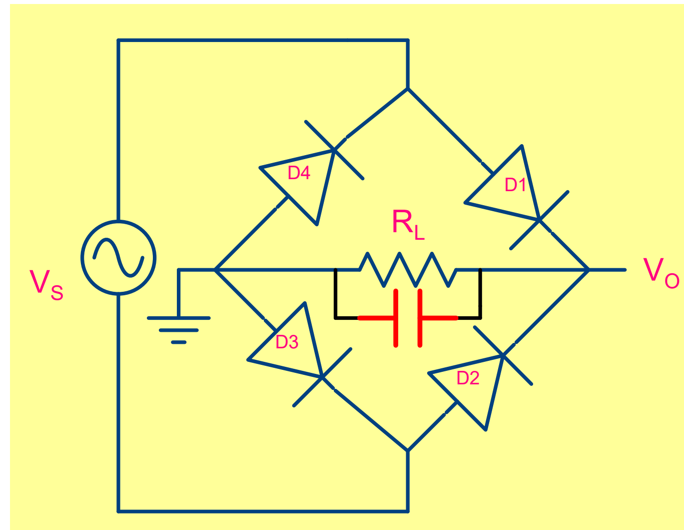


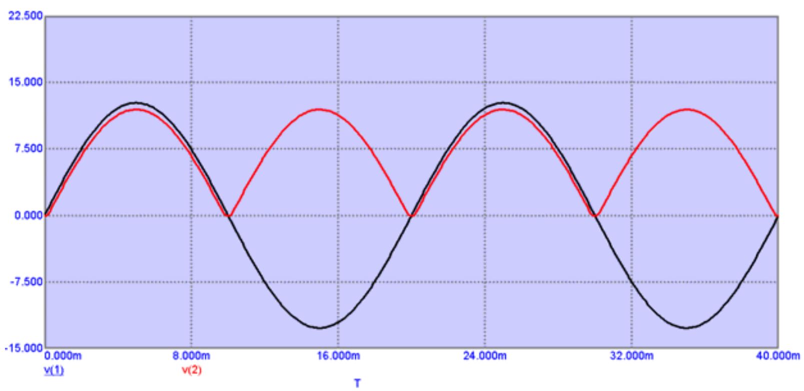


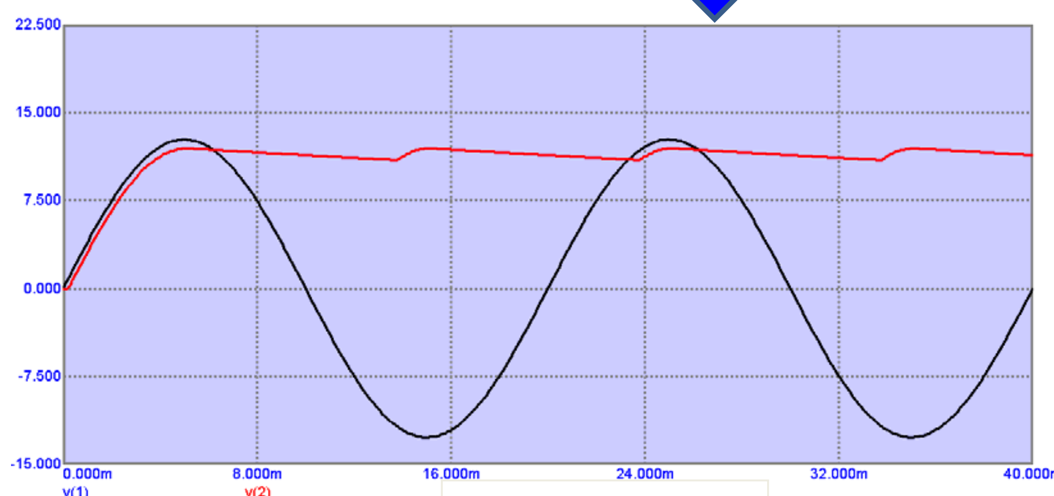
-
D4
D1
R_L
V_S
V_O
D3
D2
+

Power supply using full wave Bridge Rectifier





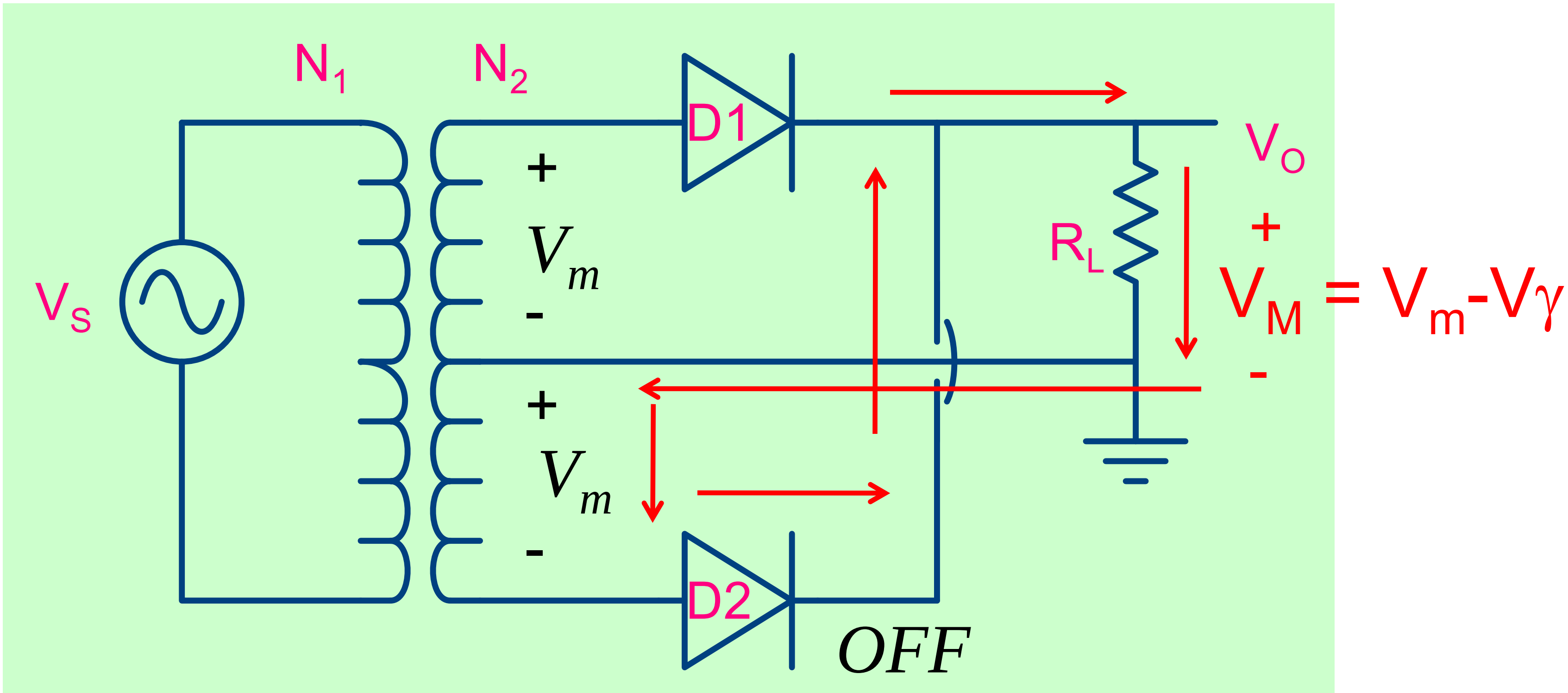




Ripple is smaller in full wave rectifier based power supply

$$V_r \cong \frac{V_M}{2fR_LC}$$

Peak Inverse Voltage

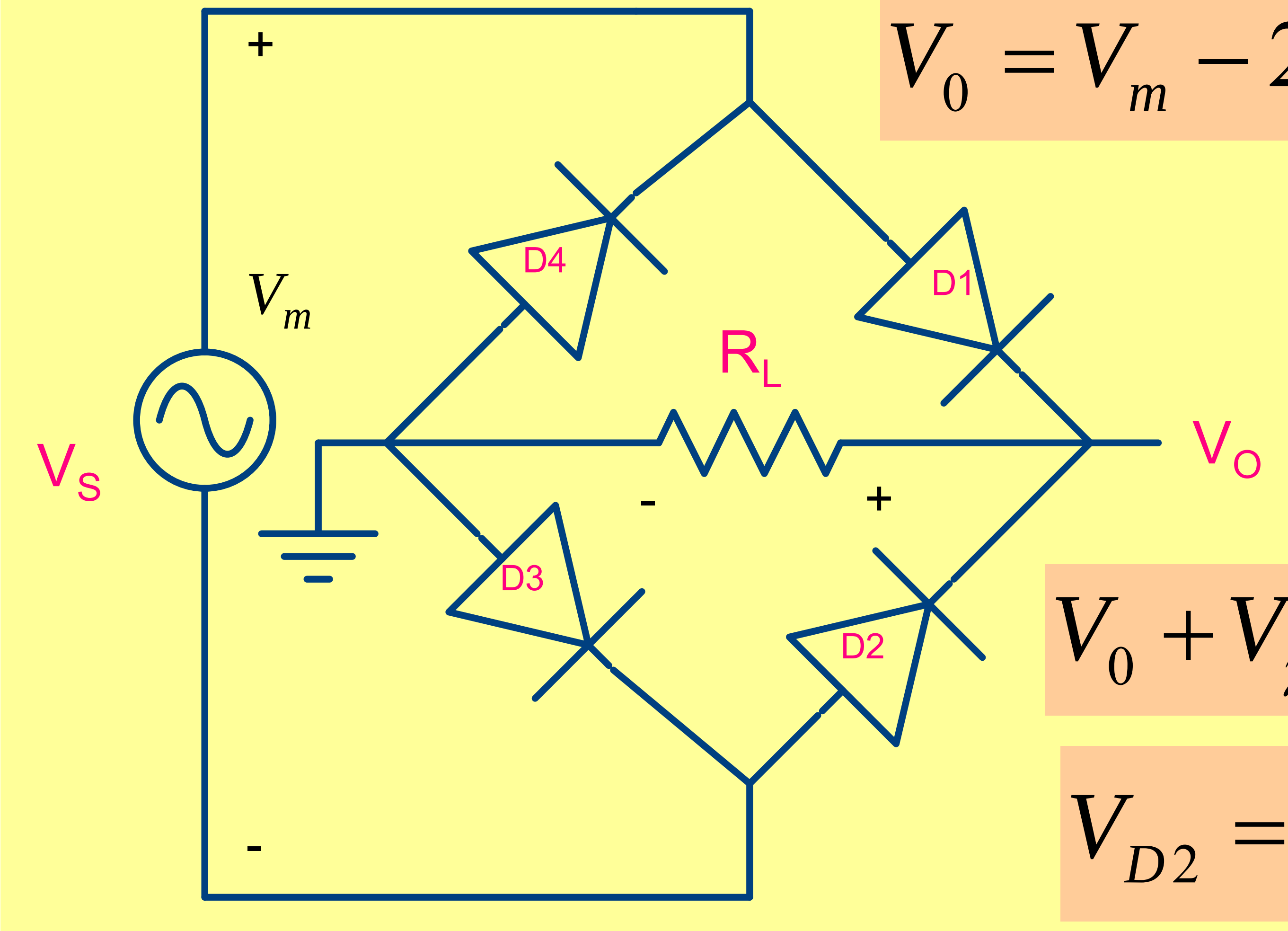


$$V_m \quad +V_D \quad +V_m - V\gamma = 0$$

$$V_D = -\left(2V_m - V_\gamma\right)$$

$$PIV = 2V_m - V_\gamma$$

Peak Inverse Voltage



$$-V_m + V_{\gamma 1} + V_0 + V_{\gamma 3} = 0$$

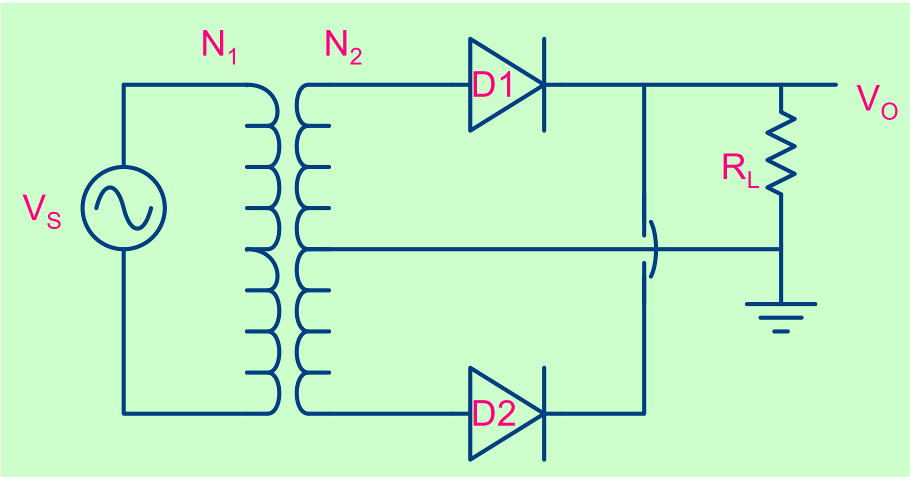
$$V_0 = V_m - 2V_\gamma$$

$$V_0 + V_{\gamma 3} + V_{D2} = 0$$

$$V_{D2} = -\left(V_0 + V_\gamma\right)$$

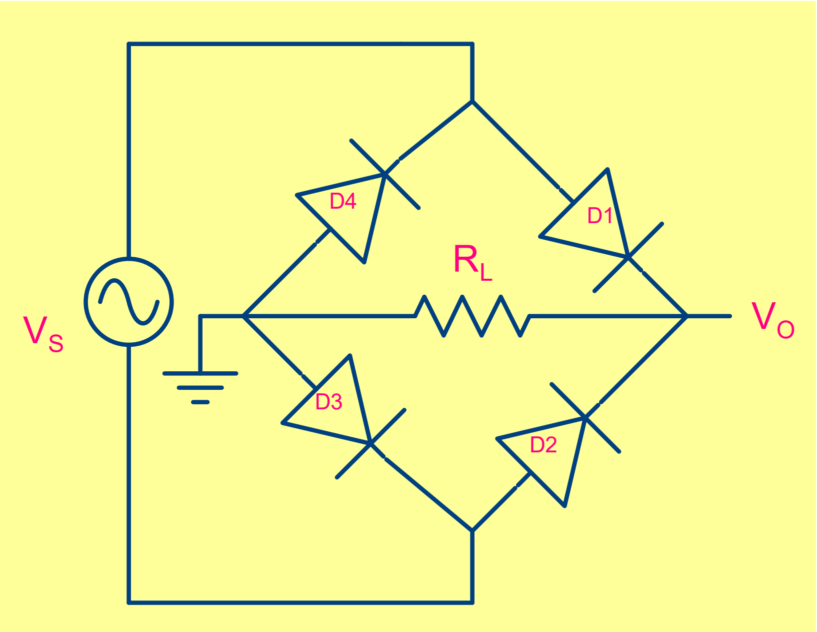
$$PIV = V_0 + V_\gamma = V_m - V_\gamma$$

Full wave Rectifier



$$PIV = 2V_m - V_\gamma$$

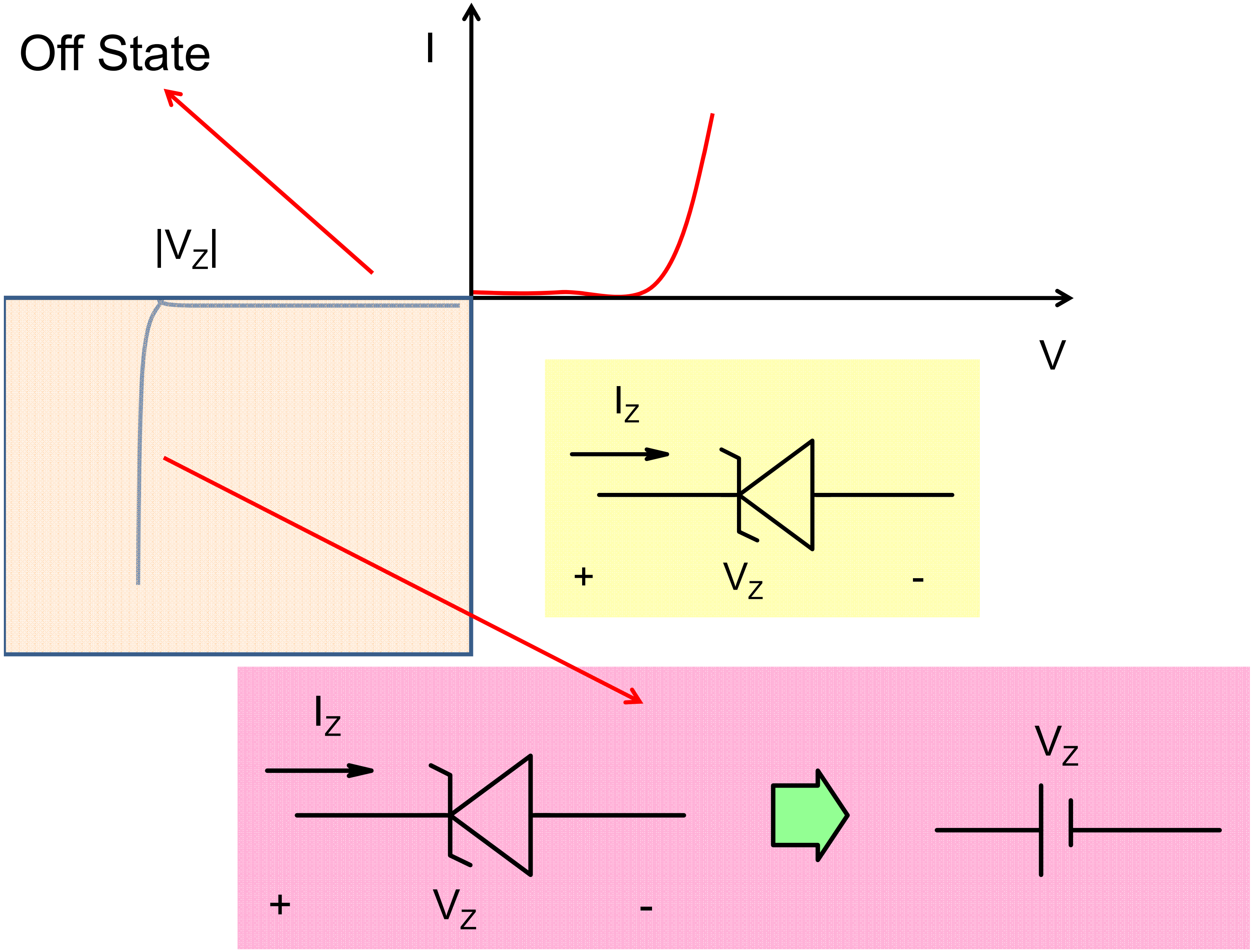
Bridge Rectifier



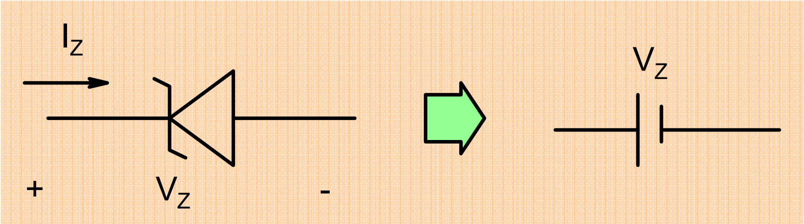
$$PIV = V_m - V_\gamma$$

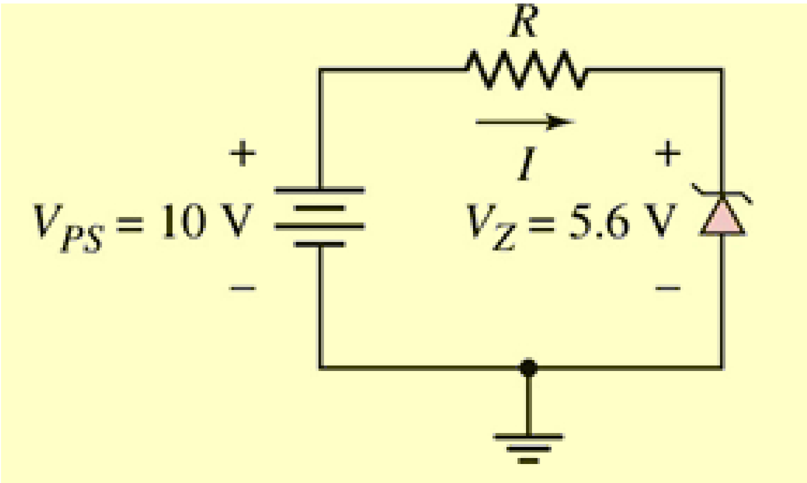
Zener Diode

A diode specially designed to operate in reverse bias and in ‘breakdown’ region



Model



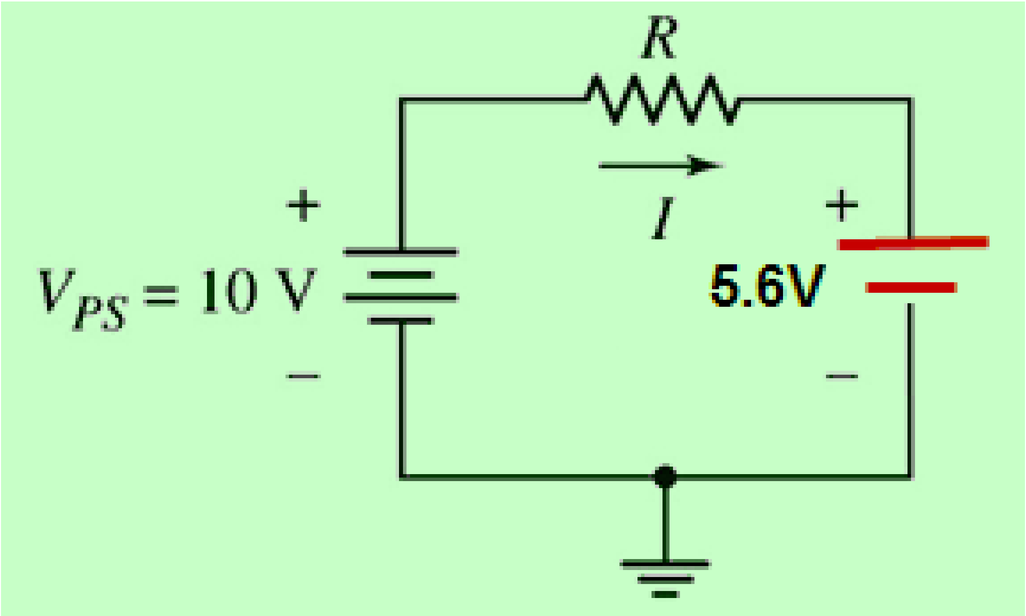


Example

Given $V_Z = 5.6V$

$r_Z = 0\Omega$

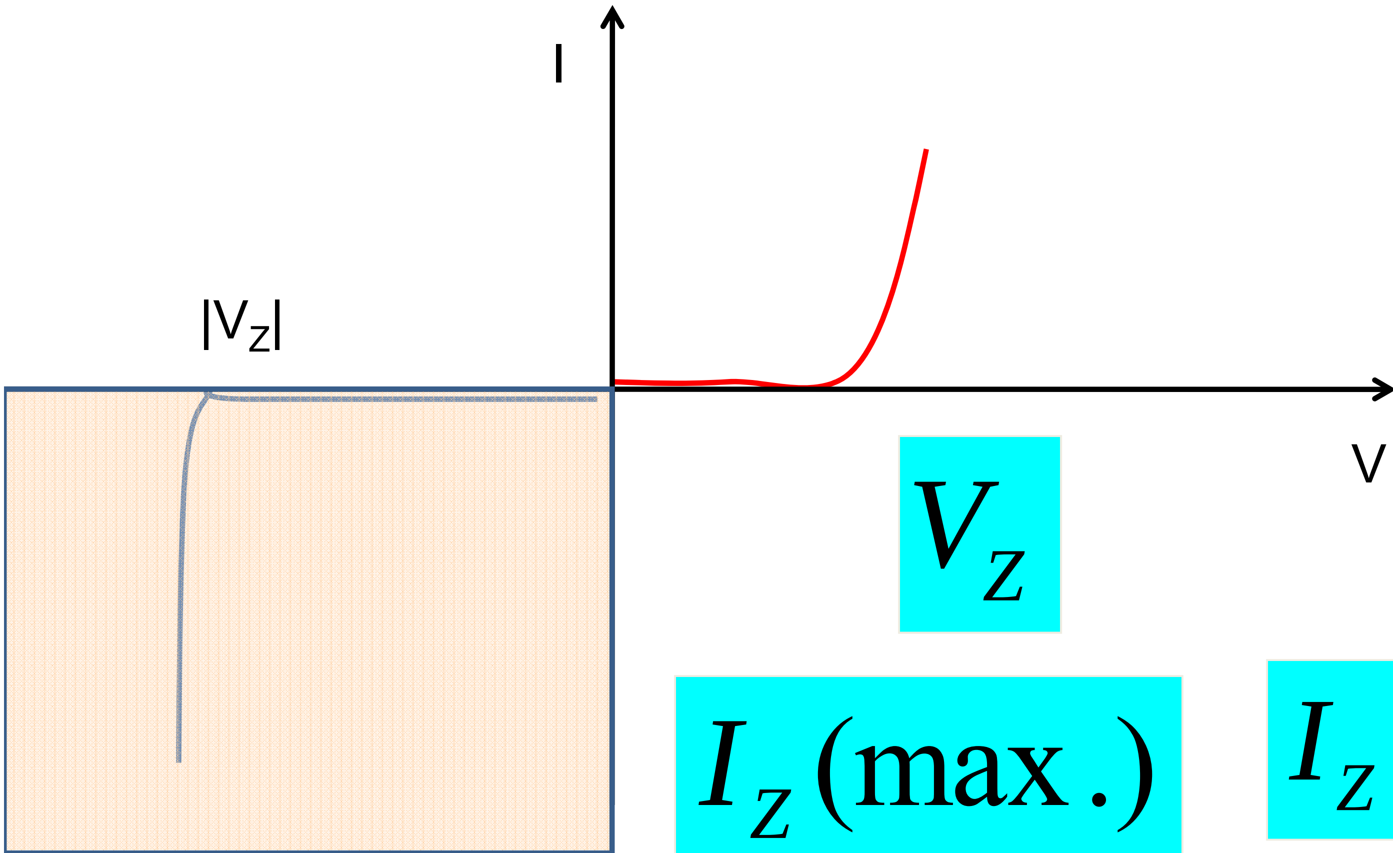
Find a value for R such that the current through the diode is limited to 3mA



$$I = \frac{V_{PS} - V_Z}{R}$$

$$R = \frac{V_{PS} - V_Z}{I} = \frac{10V - 5.6V}{3mA} = 1.47k\Omega$$

Zener diode: Important Characteristics



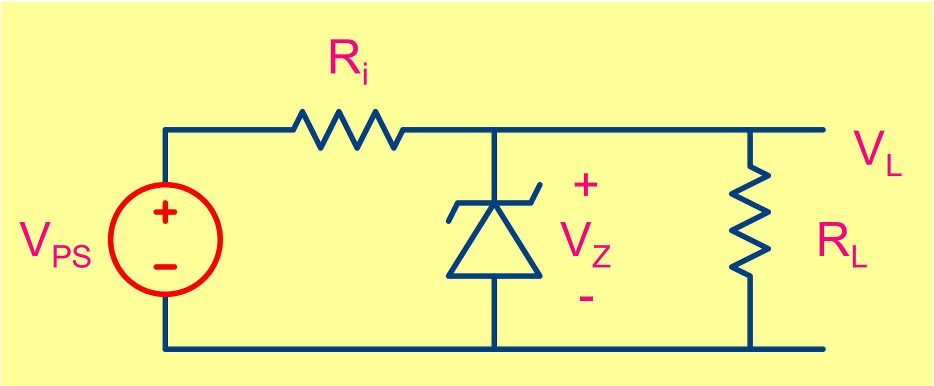
V_Z

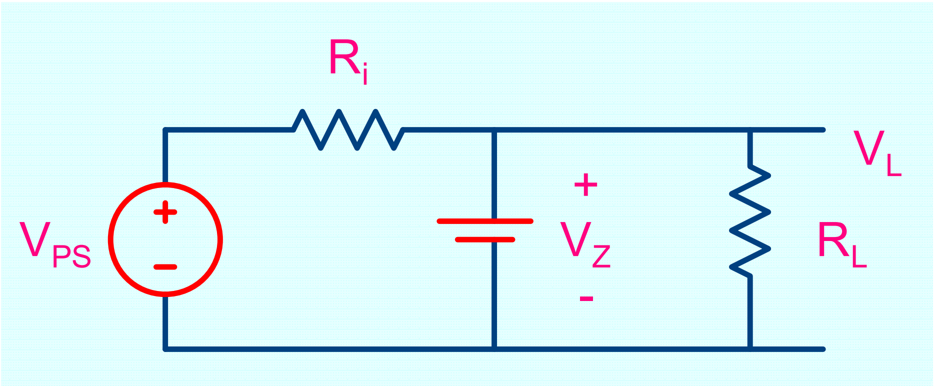
$I_Z(\max.)$

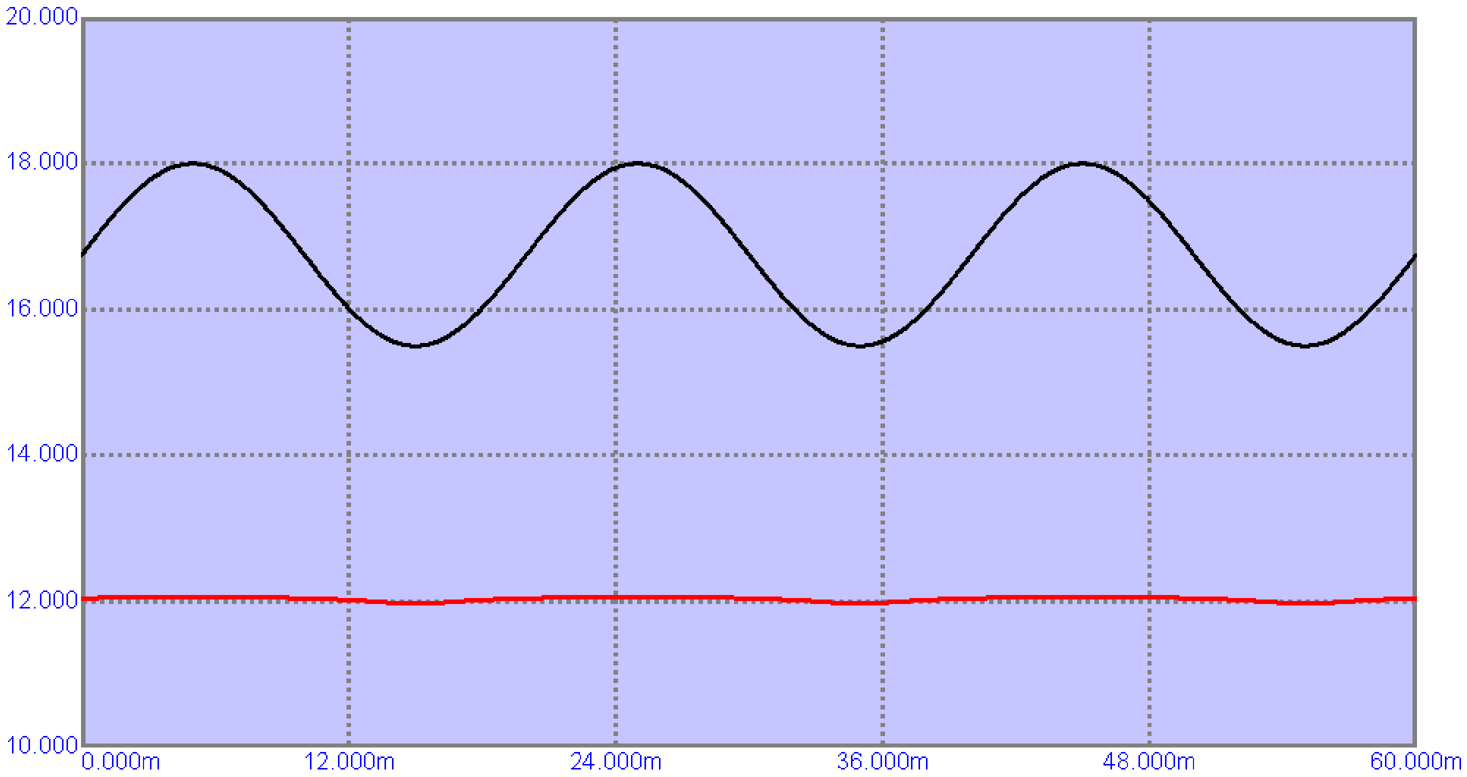
$I_Z(\min.)$

P_Z

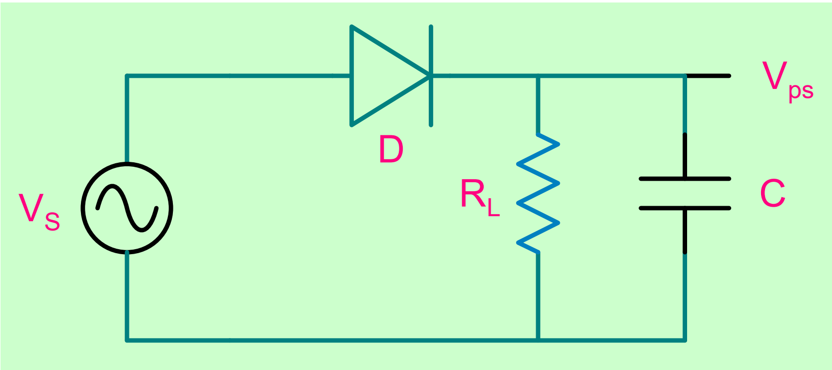
Voltage Reference Circuit

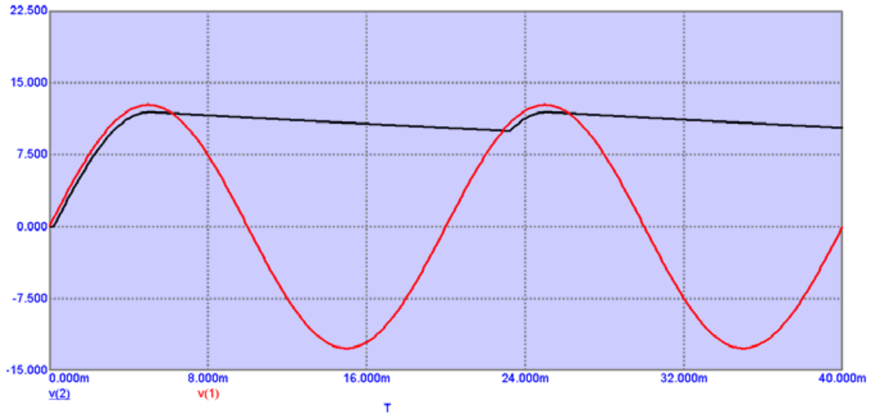


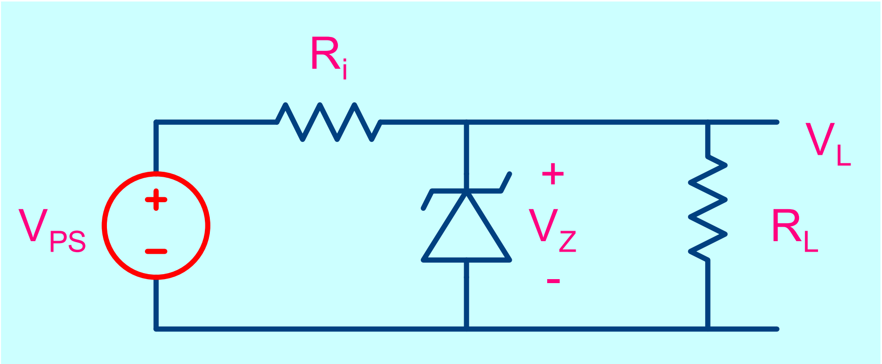


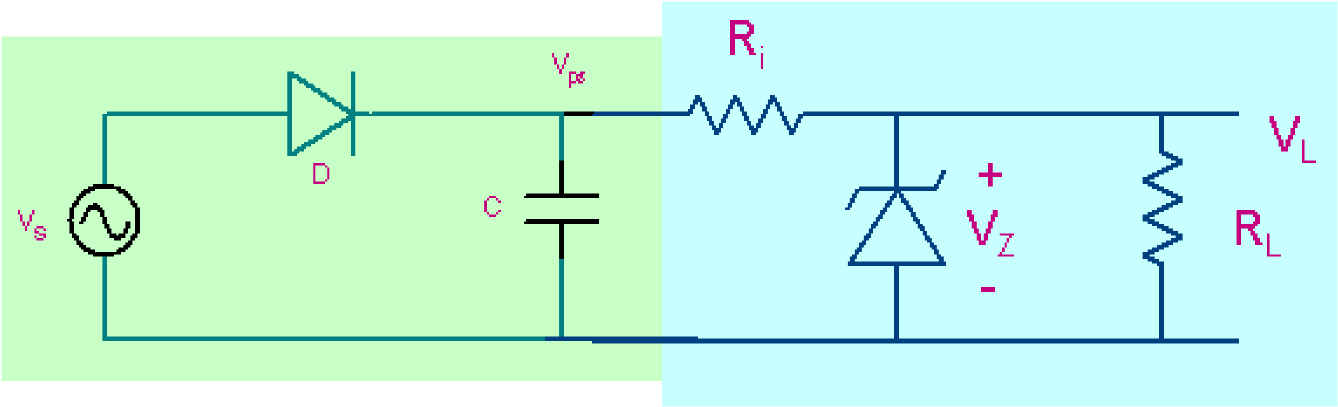


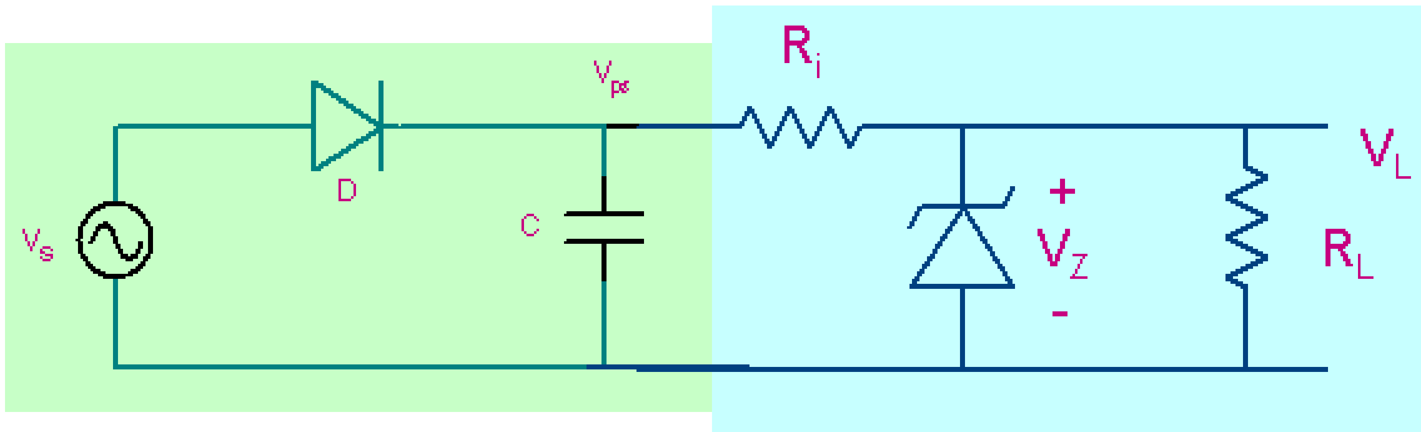
Power supply with regulator



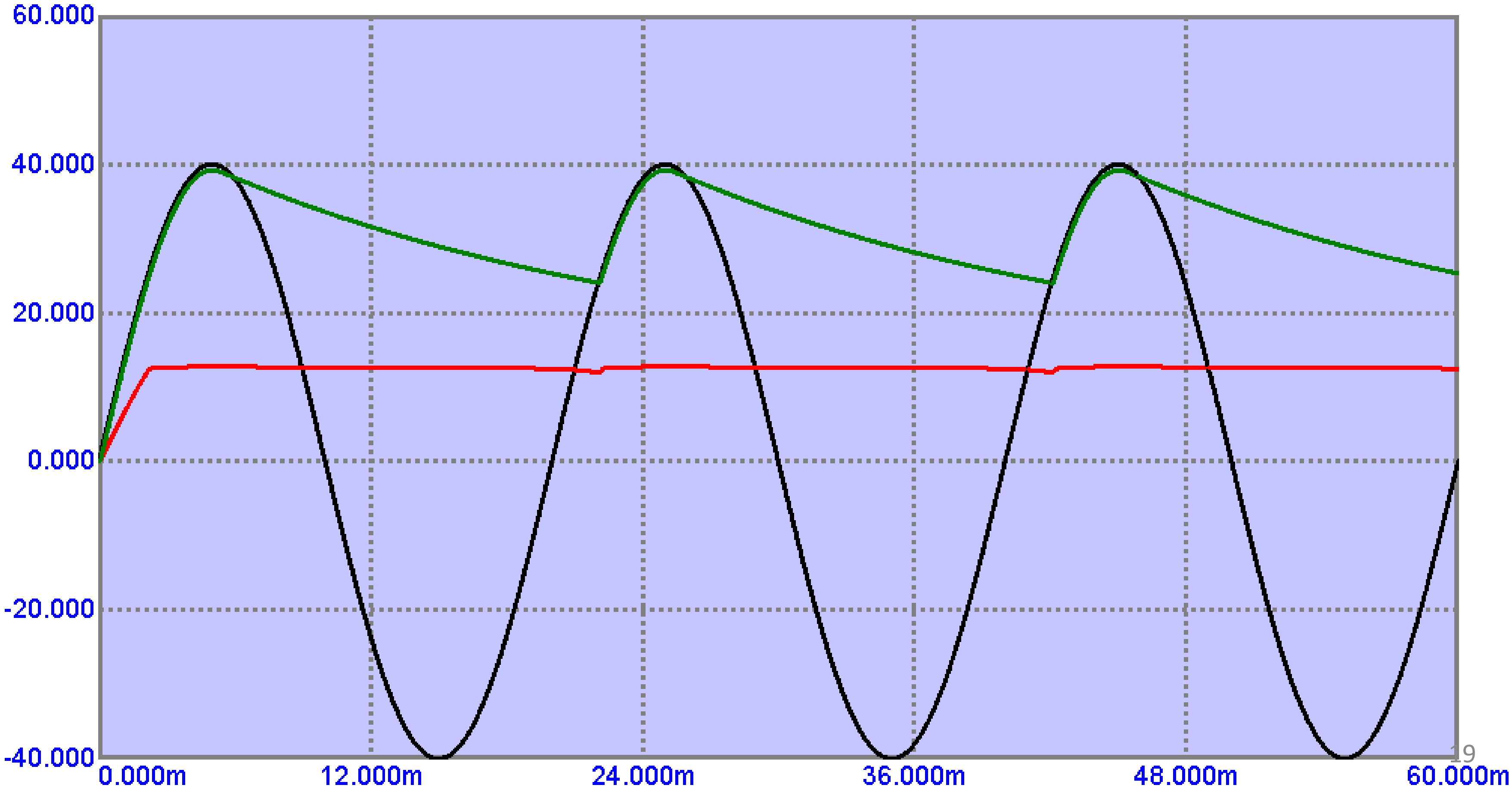






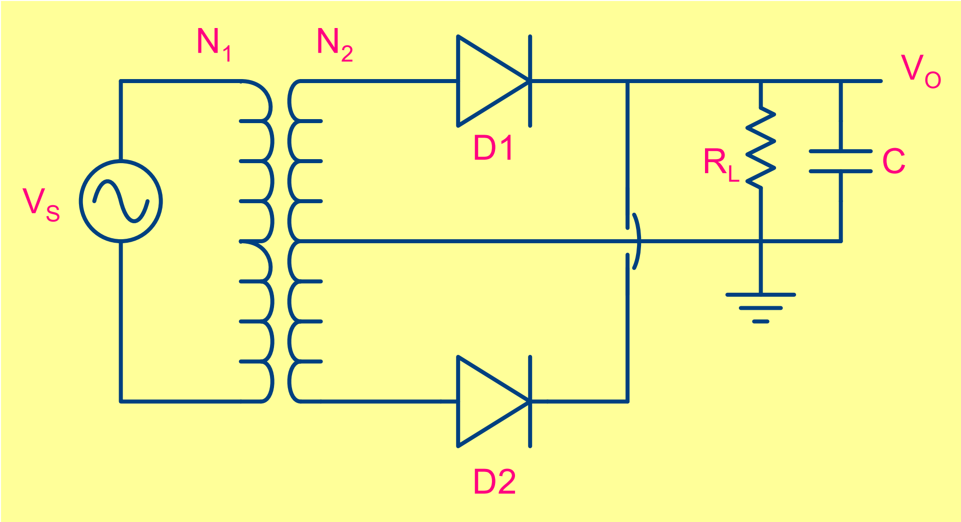


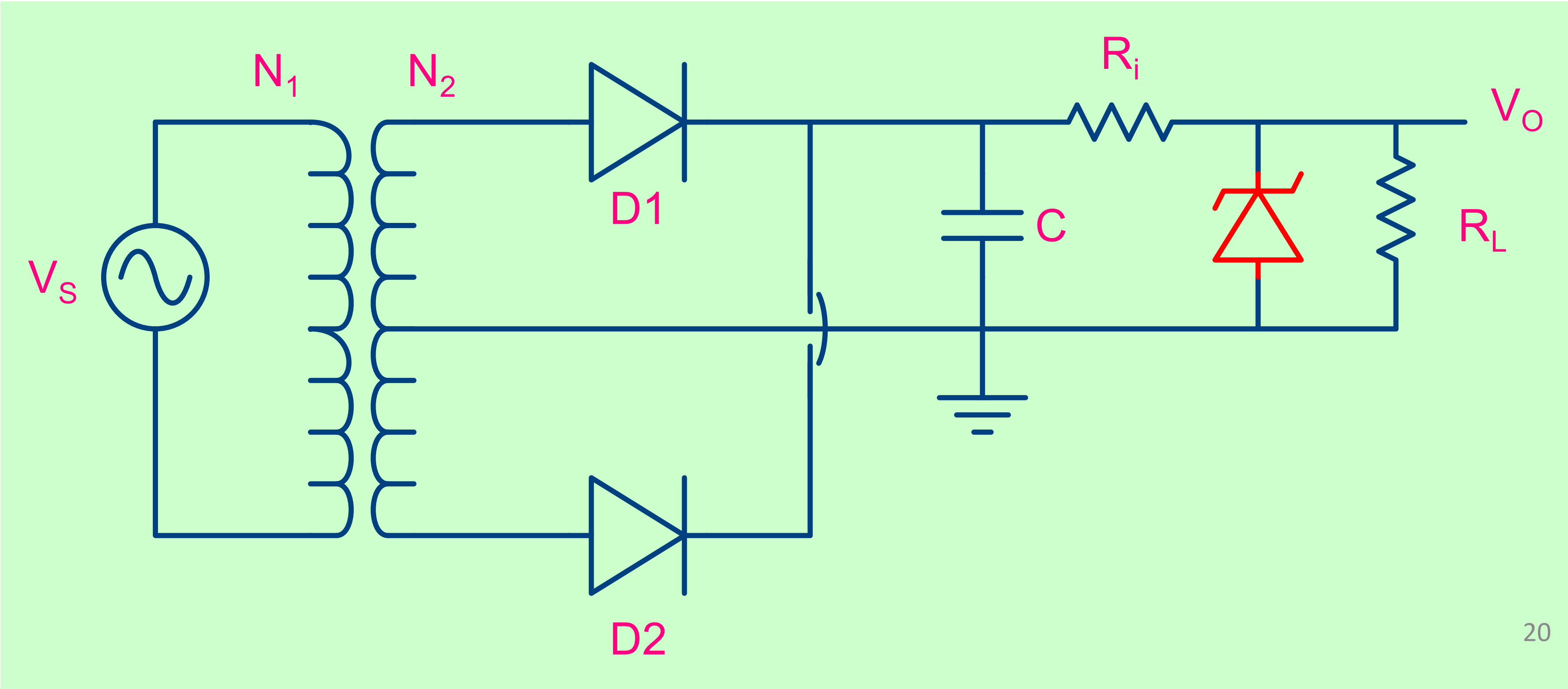
R
V
D
C
V
+
V
-
R
V



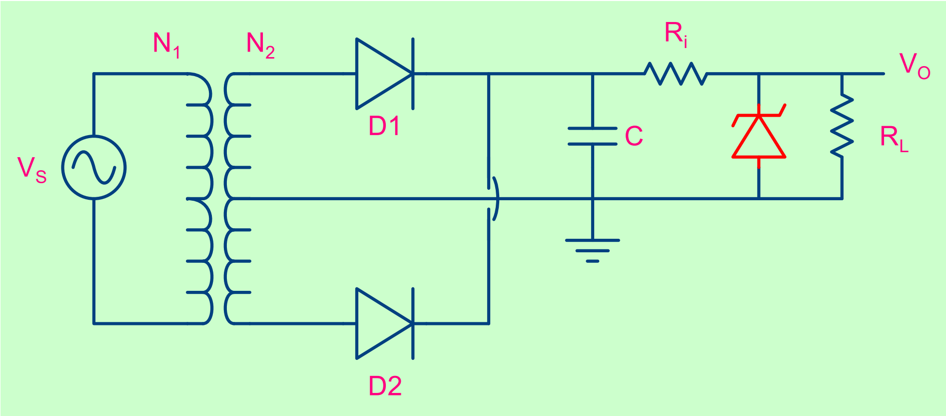
60.000
40.000
20.000
0.000
-20.000
-40.000
0.000m
12.000m
24.000m
36.000m
48.000m
60.000m

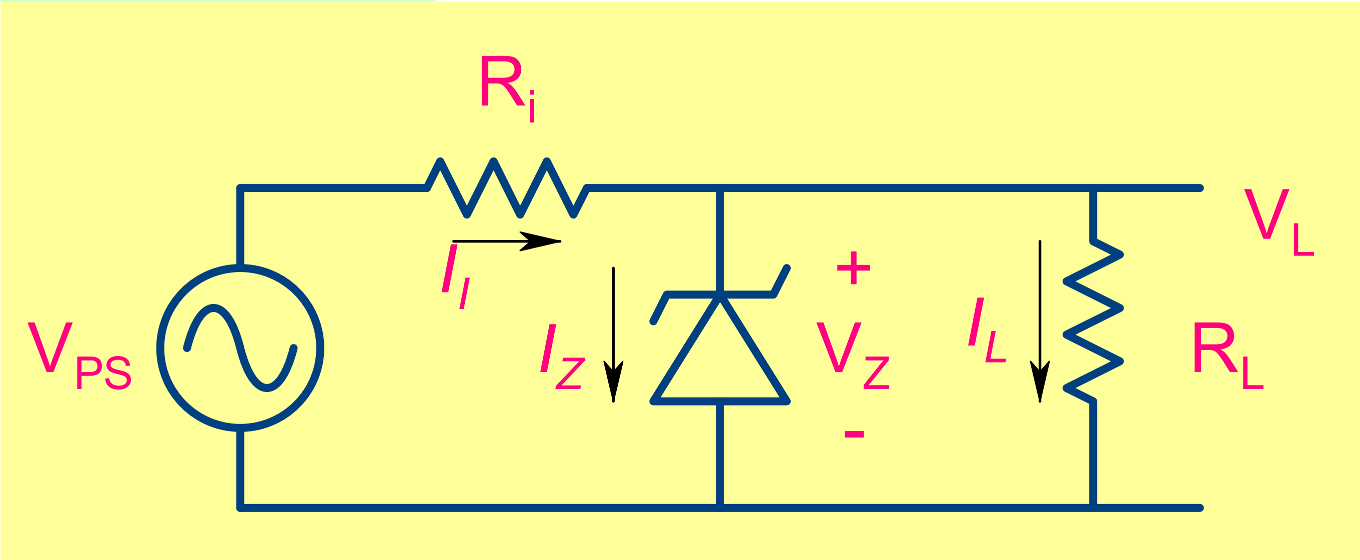
Zener diode as Voltage Regulator





Voltage Reference Circuit

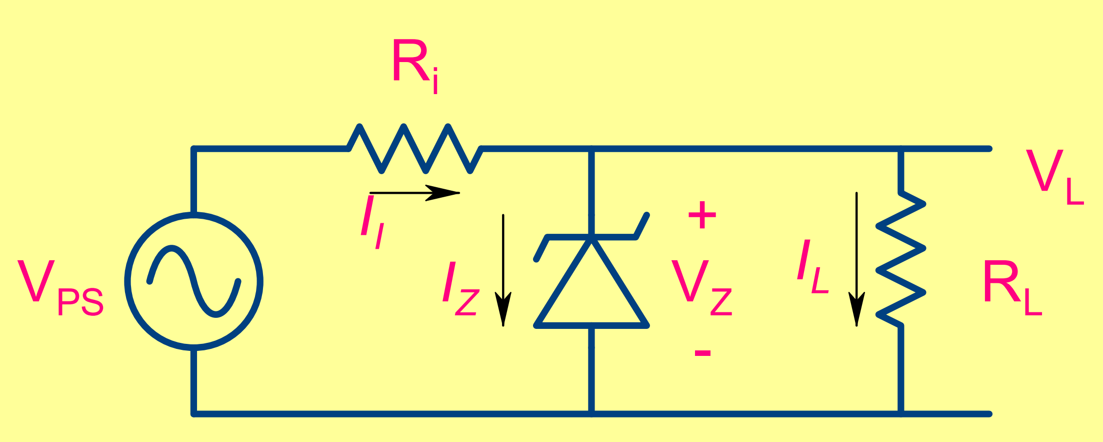




Design Problem: Determine R_i and zener diode specifications such that output voltage is +12 V and ratio of maximum to minimum zener current is 10. The input voltage may vary between 18 to 15.5V. R_L = 108 Ω.

Design Equations

$$P_{Z\max} = V_Z I_{Z\max}$$



$$I_i = \frac{V_{PS} - V_Z}{R_i} = I_Z + I_L$$

$$I_Z = \frac{V_{PS} - V_Z}{R_i} - I_L$$

$$I_{Z\max} = \frac{V_{PS\max} - V_Z}{R_i} - I_L$$

$$I_{Z\min} = \frac{V_{PS\min} - V_Z}{R_i} - I_L$$

$$\frac{I_{Z\max}}{I_{Z\min}} \cong 10$$

$$R_i = \frac{V_{PS\min} - 0.1V_{PS\max} - 0.9V_Z}{0.9I_L}$$

$$I_{Z\max} = \frac{V_{PS\max} - V_Z}{R_i} - I_L$$

$$I_{Z\min} = \frac{V_{PS\min} - V_Z}{R_i} - I_L$$

$$\frac{I_{Z\max}}{I_{Z\min}} \cong 10$$

$$10 = \frac{V_{PS\max} - V_Z - R_i I_L}{V_{PS\min} - V_Z - R_i I_L}$$

$$V_{PS\min} - V_Z - R_i I_L = 0.1\left(V_{PS\max} - V_Z - R_i I_L\right)$$

$$V_{PS\min} - 0.1V_{PS\max} - 0.9V_Z = 0.9R_i I_L$$

$$R_i = \frac{V_{PS\min} - 0.1V_{PS\max} - 0.9V_Z}{0.9I_L}$$

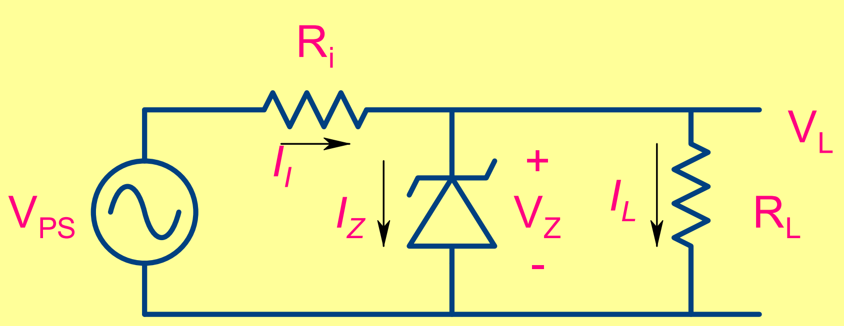
Design Problem: Determine R_i and zener diode specifications such that output voltage is +12V and ratio of maximum to minimum zener current is 10. The input voltage may vary between 18 to 15.5V. R_L = 108 Ω.

$$I_L = \frac{V_L}{R_L} = \frac{12}{108} = \frac{1}{9}$$

$$R_i = \frac{V_{PS\min} - 0.1V_{PS\max} - 0.9V_Z}{0.9I_L}$$

$$= \frac{15.5 - 0.1*18 - 0.9*12}{0.9(1/9)}$$

$$= \frac{15.5 - 1.8 - 10.8}{0.1} = \frac{2.9}{0.1} = 29\Omega$$



$$I_{Z\max} = \frac{V_{PS\max} - V_Z}{R_i} - I_L$$

$$= \frac{18-12}{29} - \frac{1}{9} = \frac{6}{29} - \frac{1}{9} = 0.096A$$

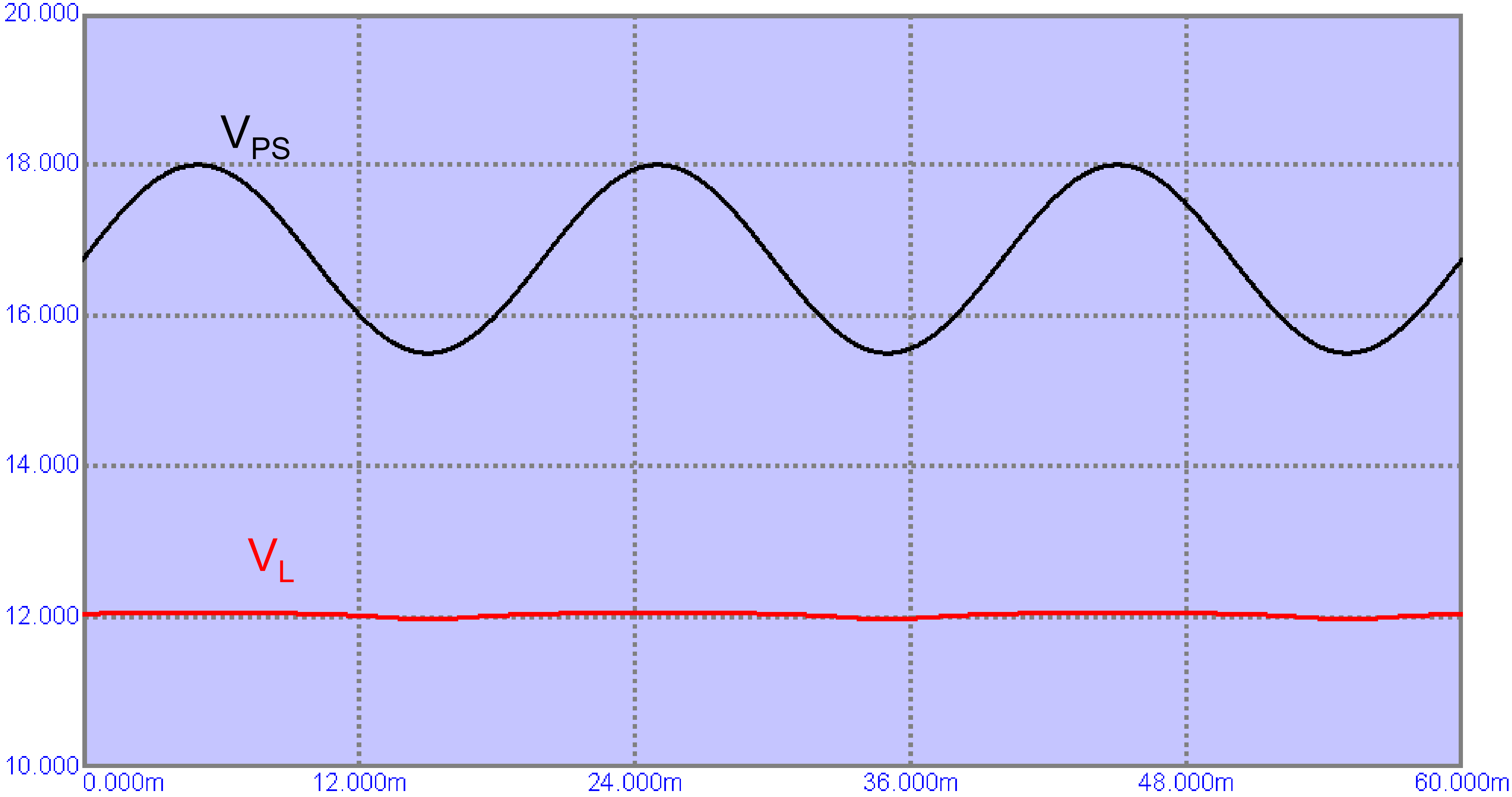
$$I_{Z\min} = \frac{V_{PS\min} - V_Z}{R_i} - I_L$$

$$= \frac{15.5-12}{29} - \frac{1}{9} = \frac{3.5}{29} - -\frac{1}{9}$$

$$= 0.0096 \quad A$$

$$P_{Z\max} = V_Z I_{Z\max}$$

$$= 12*0.096 = 1.152 \quad \mathrm{W}$$


20.000
18.000
16.000
14.000
12.000
10.000
0.000m
12.000m
24.000m
36.000m
48.000m
60.000m
V_PS
V_L