Power Electronics Homework 1

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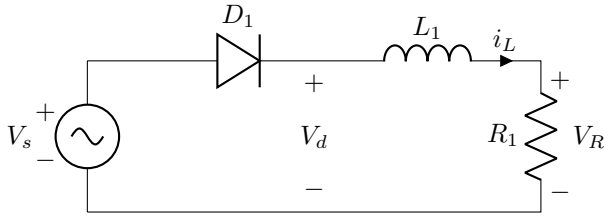
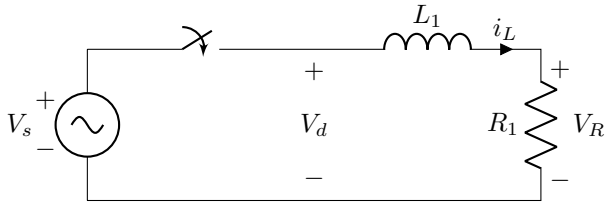
1 Initial Circuit



$$V_s(t) = 110\sqrt{2}\cos(2\pi f t)$$
$$f = 60[\text{Hz}]$$
$$L_1 = 20[\text{mH}]$$
$$R_1 = 10[\Omega]$$

2 Diode is "On"



$$V_d(t) = V_s(t) = V_L(t) + V_R(t)$$
$$V_L(t) = L_1\frac{d}{dt}i_L(t)$$
$$V_R(t) = R_1 i_L(t)$$
$$110\sqrt{2}\cos(120\pi t) = 10i_L(t) + 0.02\frac{d}{dt}i_L(t)$$

Apply Laplace Transform:

$$10I_L(s) + 0.02sI_L(s) + i_L(0) = \frac{110\sqrt{2}s}{14400\pi^2 + s^2}$$

Solve for $I_L(s)$:

$$I_L(s)(10 + 0.02s) = \frac{110\sqrt{2}s}{14400\pi^2 + s^2}$$

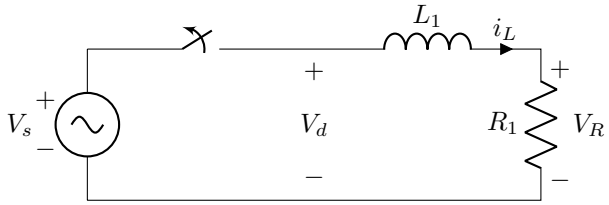
$$I_L(s) = \frac{110\sqrt{2}\,s}{\left(\frac{s}{50} + 10\right)\left(s^2 + 14400\,\pi^2\right)}$$

Apply Inverse Laplace Transform:

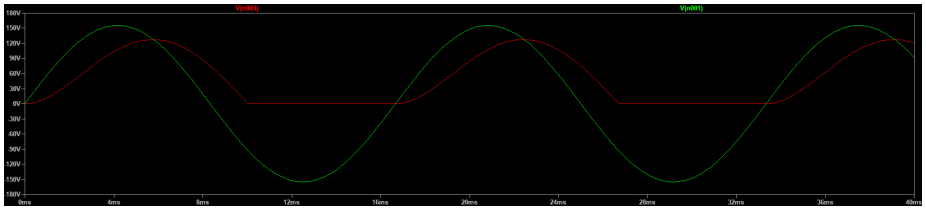
$$i_L(t) = \frac{6875\sqrt{2}\cos(120\,\pi\,t) + 1650\,\pi\sqrt{2}\sin(120\,\pi\,t)}{36\,\pi^2 + 625} - \frac{6875\sqrt{2}\,\mathrm{e}^{-500\,t}}{36\,\pi^2 + 625}$$

$$V_R = \frac{10\left(6875\sqrt{2}\cos(120\,\pi\,t) + 1650\,\pi\sqrt{2}\sin(120\,\pi\,t)\right)}{36\,\pi^2 + 625} - \frac{68750\sqrt{2}\,\mathrm{e}^{-500\,t}}{36\,\pi^2 + 625}$$

3 Diode Is "Off"



4 LTSpice



5 MATLAB

```
syms s t
R_1 = 10;
L_1 = 0.02;
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```
v_s = 110*sqrt(2)*cos(120*pi*t);

V_s = laplace(v_s);
I_L = V_s / (R_1 + s*L_1);
i_L = ilaplace(I_L);

v_o = i_L * R_1
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6 Large Inductor

As the inductor gets proportionally larger than the resistor, the amplitude of the output voltage decreases and the phase shift increases.

7 Large Resistor

As the resistor gets proportionally larger than the inductor, the amplitude of the output approaches the amplitude of the input and the phase shift goes to zero.