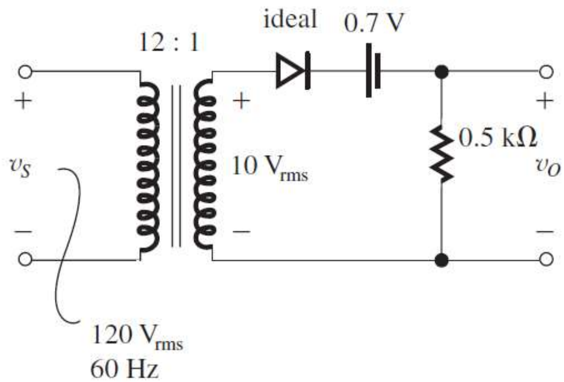
EMTR 1030 – Electronics

Assignment 3 Reference Solutions

Problem 4.68



$\hat{v}_O = 10\sqrt{2} - 0.7 = 13.44$ V

Conduction begins at

$10\sqrt{2}\sin\theta = 0.7$

$$\theta = \sin^{-1}\left(\frac{0.7}{10\sqrt{2}}\right) = 2.84^\circ$$

$= 0.0495$ rad

Conduction ends at $\pi - \theta$.

$\therefore$ Conduction angle $= \pi - 2\theta = 3.04$ rad

The diode conducts for

$$\frac{3.04}{2\pi} \times 100 = 48.4\% \text{ of the cycle}$$

$$v_{O,\text{avg}} = \frac{1}{2\pi} \int_{\theta}^{\pi-\theta} (10\sqrt{2}\sin\phi - 0.7)\, d\phi$$

$= 4.15$ V

$$i_{D,\text{avg}} = \frac{v_{O,\text{avg}}}{0.5} = 8.3 \text{ mA}$$

Problem 4.69

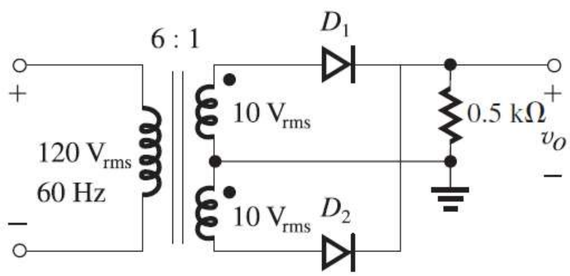
$\hat{v}_O = 10\sqrt{2} - V_D = 13.44$ V

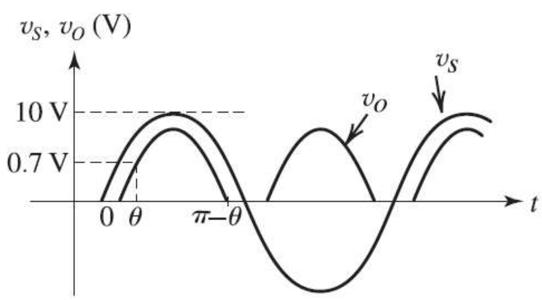
Conduction starts at $\theta = \sin^{-1}\dfrac{0.7}{10\sqrt{2}} =$

$2.84^\circ = 0.05$ rad

and ends at $\pi - \theta$. Conduction angle $=$ $\pi - 2\theta = 3.04$ rad in each half cycle. Thus the fraction of a cycle for which one of the two diodes conduct $= \dfrac{2(3.04)}{2\pi} \times 100 = 96.8\%$

Note that during 96.8% of the cycle there will be conduction. However, each of the two diodes conducts for only half the time, i.e., for 48.4% of the cycle.



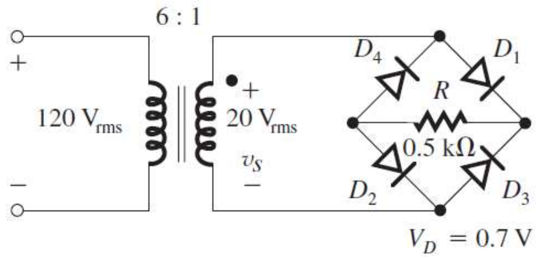


$$v_{O,\text{avg}} = \frac{1}{\pi}\int_{\theta}^{\pi-\theta}(10\sqrt{2}\sin\phi - 0.7)d\phi$$

$= 8.3$ V

$$i_{L,\text{avg}} = \frac{8.3}{0.5\text{ k}\Omega} = 16.6\text{ mA}$$

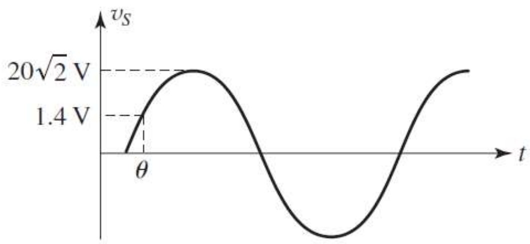
Problem 4.70



Peak voltage across $R = 20\sqrt{2} - 2V_D$

$= 20\sqrt{2} - 1.4$

$= 26.88$ V



$$\theta = \sin^{-1}\frac{1.4}{20\sqrt{2}} = 2.83^\circ = 0.05 \text{ rad}$$

Fraction of cycle that D_1 & D_2 conduct is

$$\frac{\pi - 2\theta}{2\pi} \times 100 = 48.4\%$$

Note that D_3 & D_4 conduct in the other half cycle so that there is 2 (48.4) = 96.8% conduction interval.

$$v_{O,\text{avg}} = \frac{2}{2\pi}\int_{\theta}^{\pi-\theta} (20\sqrt{2}\sin\phi - 2V_D)\, d\phi$$

$$= \frac{1}{\pi}\Big[-20\sqrt{2}\cos\phi - 1.4\phi\Big]_{\theta}^{\pi-\theta}$$

$$= \frac{2(20\sqrt{2}\cos\theta)}{\pi} - \frac{1.4\,(\pi - 2\theta)}{\pi}$$

$= 16.63$ V

$$i_{R,\text{avg}} = \frac{v_{O,\text{avg}}}{R} = \frac{16.63}{0.5} = 33.3 \text{ mA}$$

Problem 5.4

5.4 With v_{DS} small compared to V_{OV}, Eq. (5.13a) applies:

$$r_{DS} = \frac{1}{(\mu_n C_{ox})\left(\frac{W}{L}\right)(v_{OV})}$$

(a) v_{OV} is doubled $\rightarrow$ r_{DS} is halved. Factor $= 0.5$

(b) W is doubled $\rightarrow$ r_{DS} is halved. Factor $= 0.5$

(c) W and L are doubled $\rightarrow$ r_{DS} is unchanged. Factor $= 1.0$

(d) If oxide thickness t_{ox} is halved. Since

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$$

then C_{ox} is doubled. If W and L are also halved, r_{DS} is halved. Factor $= 0.5$.

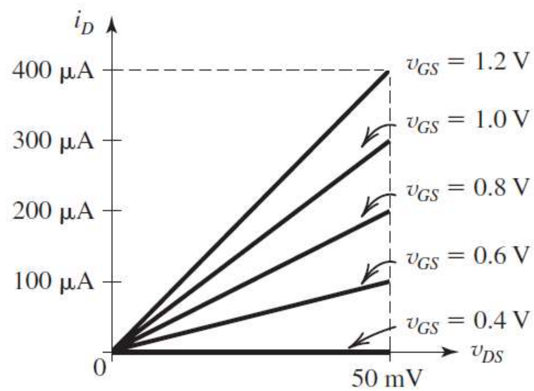
Problem 5.6

5.6 $k_n = 10\ \text{mA/V}^2$, $V_{tn} = 0.4\ \text{V}$,

small v_{DS}

$$i_D = k_n(v_{GS} - V_t)v_{DS} = k_n v_{OV} v_{DS}$$

$$g_{DS} = \frac{1}{r_{DS}} = k_n v_{OV}$$



V_{GS} (V)	V_{OV} (V)	g_{DS} (mA/V)	r_{DS} (Ω)
0.4	0	0	∞
0.6	0.2	2.0	500
0.8	0.4	4.0	250
1.0	0.6	6	167
1.2	0.8	8	125

Problem 5.9

5.9 $v_{DS\text{ sat}} = v_{OV}$

$v_{OV} = v_{GS} - V_t = 0.6 - 0.4 = 0.2\ \text{V}$

$\Rightarrow v_{DS\text{ sat}} = 0.2\ \text{V}$

In saturation:

$$i_D = \frac{1}{2}\, k_n' \left(\frac{W}{L}\right) v_{OV}^2 = \frac{1}{2}\, k_n v_{OV}^2$$

$$i_D = \frac{1}{2} \times \frac{5\ \text{mA}}{\text{V}^2} \times (0.2\ \text{V})^2$$

$i_D = 0.1\ \text{mA}$