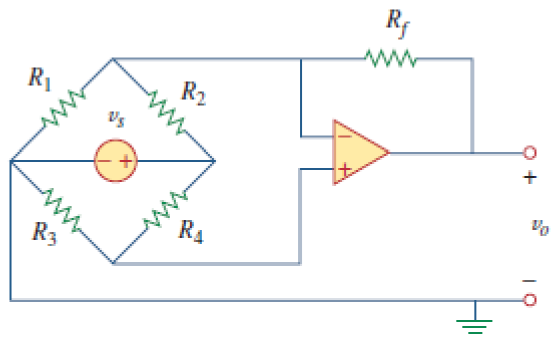
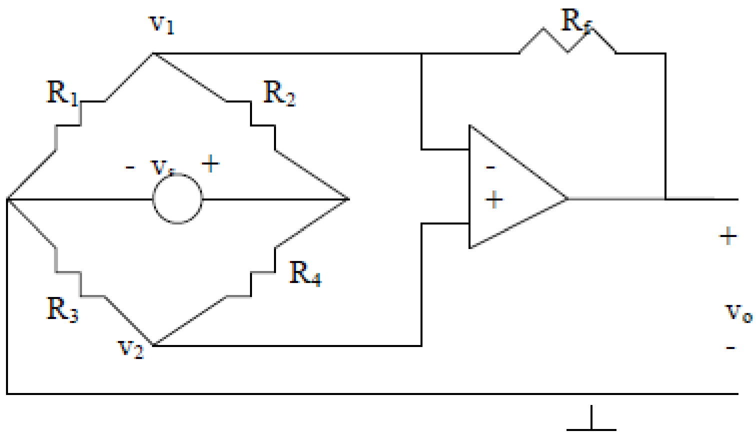
Q1 In the circuit shown below, find k in the voltage transfer function vo = kvs.



Solution



Method-1

$$\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_f}\right)V_1-\frac{V_s}{R_2}=\frac{V_0}{R_f} \quad \text{——(1)}$$

$$V_1=\frac{R_3}{R_3+R_4}V_s \quad \text{——(2)}$$

putting (2) in (1)

$$\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_f}\right)\left(\frac{R_3}{R_3+R_4}\right)V_s-\frac{V_s}{R_2}=\frac{V_0}{R_f}$$

$$\Rightarrow V_s\left[\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_f}\right)\left(\frac{R_3}{R_3+R_4}\right)-\frac{1}{R_2}\right]=\frac{V_0}{R_f}$$

$$\Rightarrow \boxed{K=\frac{V_0}{V_s}=R_f\left[\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_f}\right)\left(\frac{R_3}{R_3+R_4}\right)-\frac{1}{R_2}\right]}$$

Method-2

from (1),

$$V_1\left(\frac{1}{R_1}+\frac{1}{R_f}\right)+\frac{V_1}{R_2}-\frac{V_s}{R_2}=\frac{V_0}{R_f}$$

from (2)

$$V_s=\left(1+\frac{R_4}{R_3}\right)V_1$$

$$\Rightarrow V_1\left(\frac{1}{R_1}+\frac{1}{R_f}\right)+\frac{V_1}{R_2}-\frac{1}{R_2}\left(1+\frac{R_4}{R_3}\right)V_1=\frac{V_0}{R_f}$$

$$\Rightarrow V_1\left(\frac{1}{R_1}+\frac{1}{R_f}\right)+\cancel{\frac{V_1}{R_2}}-\cancel{\frac{V_1}{R_2}}-\frac{V_1R_4}{R_2R_3}=\frac{V_0}{R_f}$$

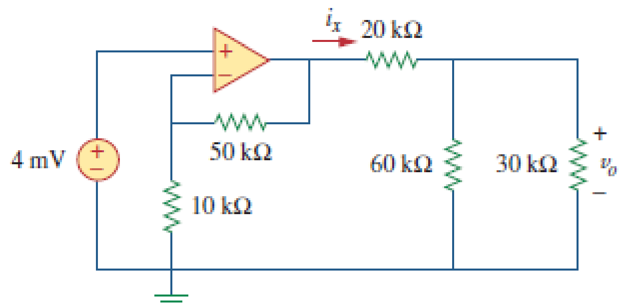
$$\Rightarrow V_1\left[\frac{1}{R_1}+\frac{1}{R_f}-\frac{R_4}{R_2R_3}\right]=\frac{V_0}{R_f}$$

$$\Rightarrow \frac{V_1}{R_3}\left[\frac{R_3}{R_1}+\frac{R_3}{R_f}-\frac{R_4}{R_2}\right]=\frac{V_0}{R_f}$$

$$\Rightarrow \frac{V_s}{R_3+R_4}\left[\frac{R_3}{R_1}+\frac{R_3}{R_f}-\frac{R_4}{R_2}\right]=\frac{V_0}{R_f} \quad [\because \text{from eq}^n (2)]$$

$$\Rightarrow \boxed{K=\frac{V_0}{V_s}=\frac{R_f}{(R_3+R_4)}\left[\frac{R_3}{R_1}+\frac{R_3}{R_f}-\frac{R_4}{R_2}\right]}$$

Q2 Calculate ix and vo in the circuit of Figure shown below. Find the power dissipated by the 60-k resistor.



Solution:

Let v_x = the voltage at the output of the op amp. The given circuit is a non-inverting amplifier.

$$v_x = \left(1+\frac{50}{10}\right)(4\text{ mV}) = 24\text{ mV}$$

$$60 \| 30 = 20k\Omega$$

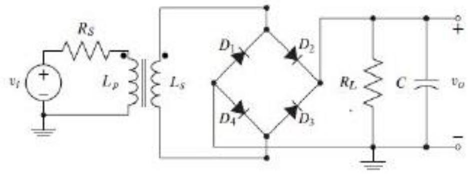
By voltage division,

$$v_o = \frac{20}{20+20}v_x = \frac{v_x}{2} = 12\text{mV}$$

$$i_x = \frac{v_x}{(20+20)k} = \frac{24\text{mV}}{40k} = 600\ \eta\text{A}$$

$$p = \frac{v_o^2}{R} = \frac{144\text{x}10^{-6}}{60\text{x}10^3} = 2.4\eta\text{W}.$$

3. Consider the full-wave rectifier circuit as shown below with C = 47μ F and transformer winding ratio of 14:1. If the input voltage is 120 VAC (RMS) at 60 Hz, what is the load resistor value for a peak-to-peak ripple less than 0.5 V? What is the output DC voltage? Assume ideal diode.



Soln:

Q.3

Solution

Given transformer ratio 14:1, voltage across secondary is,

$$V_m = \frac{120\sqrt{2}}{14} = 12.1\,V$$

As peak-to-peak ripple voltage is given,

$$V_r = \frac{V_m}{2 f_0 R C} = \frac{12.1}{2 \times 60 \times R \times (47 \times 10^{-6})} < 0.5$$

$$R > 4.29\,K\Omega$$

So, load resistance should be greater than 4.29

If exact value calculated, then Output Dc voltage Vdc= Vm-Vr(pp)/2

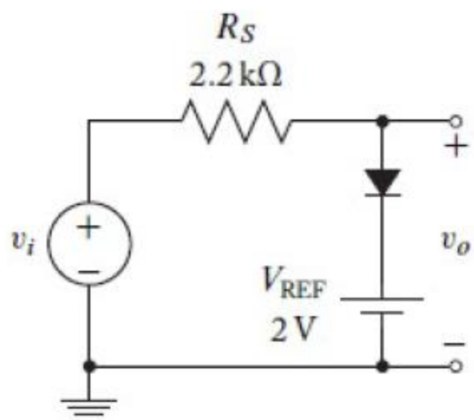
= 12.1-0.25 =11.85

If range, then (11.85,12.1] for Vr<0.5

4. For the clipping circuit shown, find the output waveform v_o for the input voltage,

$$v_i = 5 \text{ sin} w_o \text{t}.$$

The diode has the following characteristics: $r_d = 15\ \Omega$; $V_d = 0.7$ V; and $r_r \approx \infty$

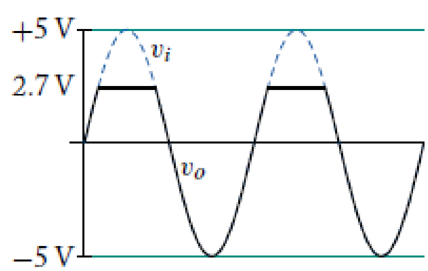


Solution #1:

Since $R_s \gg r_d$, the simplified output voltage result from Table 2.1 can be constructed. That is,

$$\begin{aligned} v_o &= V_d + V_{ref}, & v_i &> V_d + V_{ref} \\ v_o &= v_i, & v_i &\leq V_d + V_{ref}. \end{aligned}$$

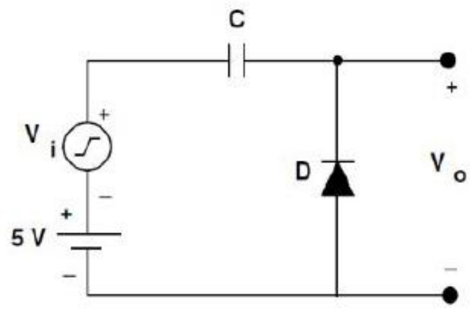
Therefore, when $v_i > 2.7$ V, $v_o = 2.7$ V and when $v_i < 2.7$ V, $v_o = 5 \sin \omega_o t$. The output waveform is shown in Figure 2.15.



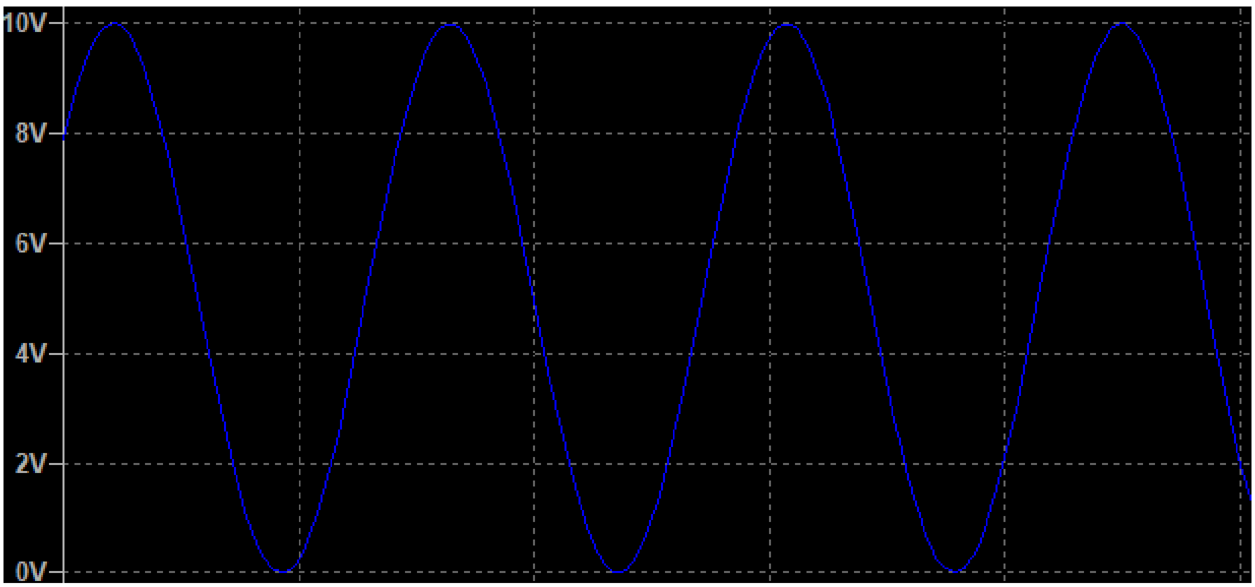
5. For the circuit shown in the figure, draw the waveform of output voltage V_o for the input voltage,

$$v_i = 5\ \sin w_o t.$$

Assume ideal diode D and lossless capacitor C.



Soln:
Explanation 2.5 marks
Input waveform



Output wave form
If cut in voltage of diode is neglected the input waveform = output waveform.

10V
8V
6V
4V
2V
0V