Literature:

Diode: p 167-172 187, 211-216

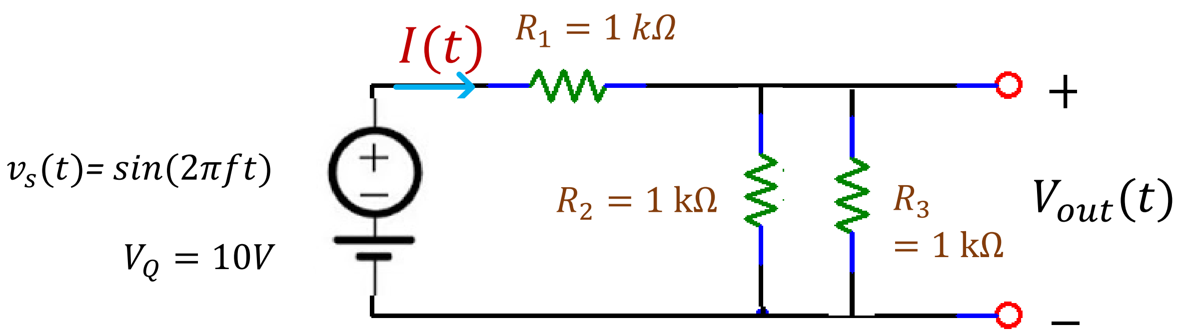
Assignments:

3.1:

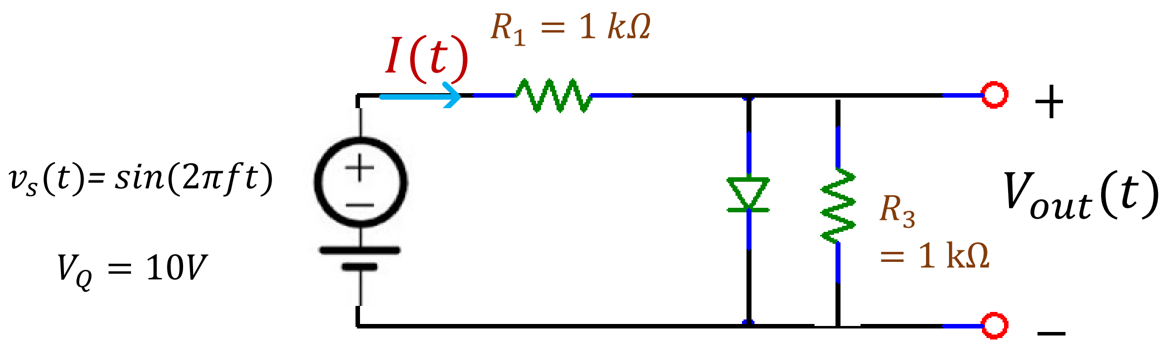
Assume the diode has a voltage drop of 0.7 V when only DC voltage V_Q is applied. For the circuits in Fig. 1 (a) and (b),

- What is the expression of $V_{out}(t)$?
- The input voltage change is 1/10 = 10%, what is the output change?

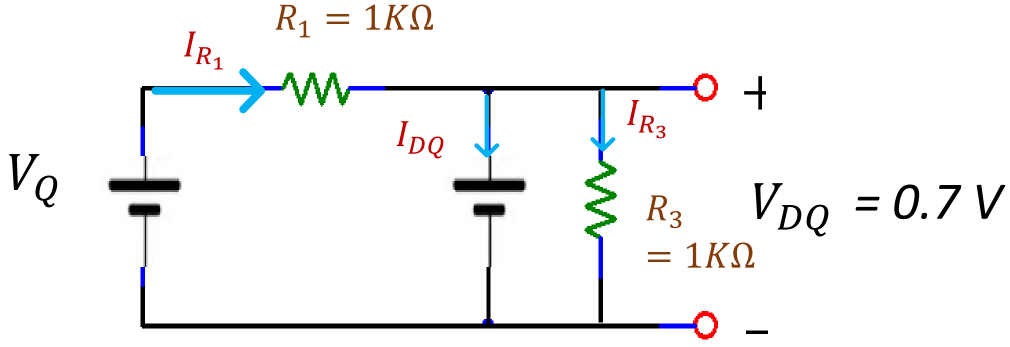
Hint: For Fig. 1(b), use the small-signal model.



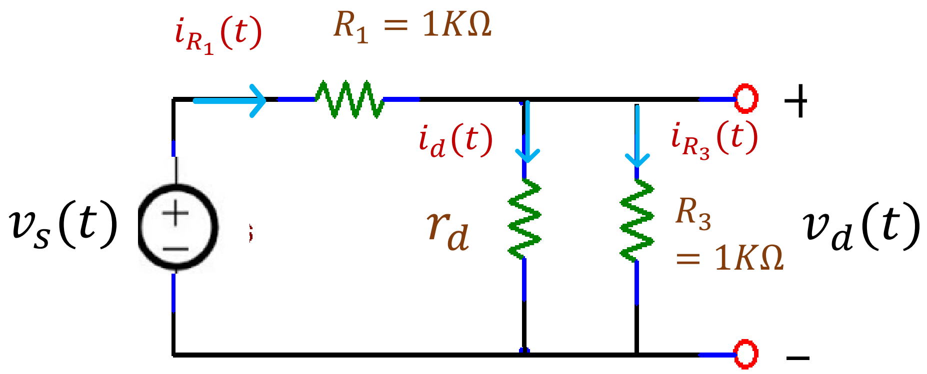
(a)



(b)



DC biased circuit



Small-signal circuit

(c)

Fig. 1

Solution:

For Fig. 1 (a):

$R_{23} = R_2||R_3 = 0.5\ K\Omega$ ---$R_2\ and\ R_3$ are in parallel

- $V_{out}(t) = \frac{R_{23}}{R_1+R_{23}}V(t) = \frac{1}{3}[10 + \sin(2\pi ft)]$
- When input changes 10%, i.e., $V(t)$ changes from $V(t_1)$=10 V to $V(t_2)$ =11 V,

  ➔ $V_{out}(t)$ changes from $V_{out}(t_1) = \frac{10}{3}$ V to $V_{out}(t_2) = \frac{11}{3}$ V

  ➔$\frac{V_{out}(t_2)-V_{out}(t_1)}{V_{out}(t_1)} = 10\%$, i.e., the output also changes 10%.

For Fig. 1 (b):

Decompose the circuit into the DC biased circuit (top) and small-signal circuit(bottom) as in Fig.1 (c).

Do DC analysis to obtain I_{DQ} and r_d according to the DC biased circuit.

KVL: $V_Q = I_{R_1}R_1 + V_{DQ}$ ➔$I_{R_1} = \frac{V_Q - V_{DQ}}{R_1} = \frac{10-0.7}{1000} = 9.3$ mA

The voltage drop across R_3 is equal to $V_{DQ} = 0.7$ V ➔$I_{R_3} = \frac{V_{DQ}}{R_3} = \frac{0.7}{1000} = 0.7$ mA

KCL: $I_{R_1} = I_{DQ} + I_{R_3}$ ➔$I_{DQ} = I_{R_1} - I_{R_3} = 8.6$ mA

➔$r_d = \frac{V_T}{I_{DQ}} = \frac{26\ mV}{8.6\ mA} = \ 3.0\ \Omega$

According to the small-signal circuit:

$R_{d,3} = r_d || R_3 \approx 3\ \Omega$ ---$r_d\ and\ R_3$ are in parallel

➔$v_d(t) = \frac{R_{d,3}}{R_{d,3}+R_1} v_s(t) = \frac{3}{1003} v_s(t)$

- $V_{out}(t) = V_{DQ} + v_d(t) = 0.7 + \frac{3}{1003} v_s(t)$
- When input changes 10%, i.e., $V(t)$ changes from $V(t_1)$=10 V to $V(t_2)$ =11 V ($v_d(t_2) = 1\ V$)
  ➔ $V_{out}(t)$ changes from $V_{out}(t_1)$ = 0.7 V to $V_{out}(t_2)$ =($0.7 + \frac{3}{1003}$) V
  ➔$\frac{V_{out}(t_2) - V_{out}(t_1)}{V_{out}(t_1)} = 0.43\%$, i.e., the output also changes only 0.43%. The output voltage is insensitive to the input voltage changes.

3.2:

Run the full-wave rectifier LT spice simulation as illustrated in Fig. 2

- Plot the voltage curve at point: chan1 to GND;
- Plot the current curve through the Rtest.

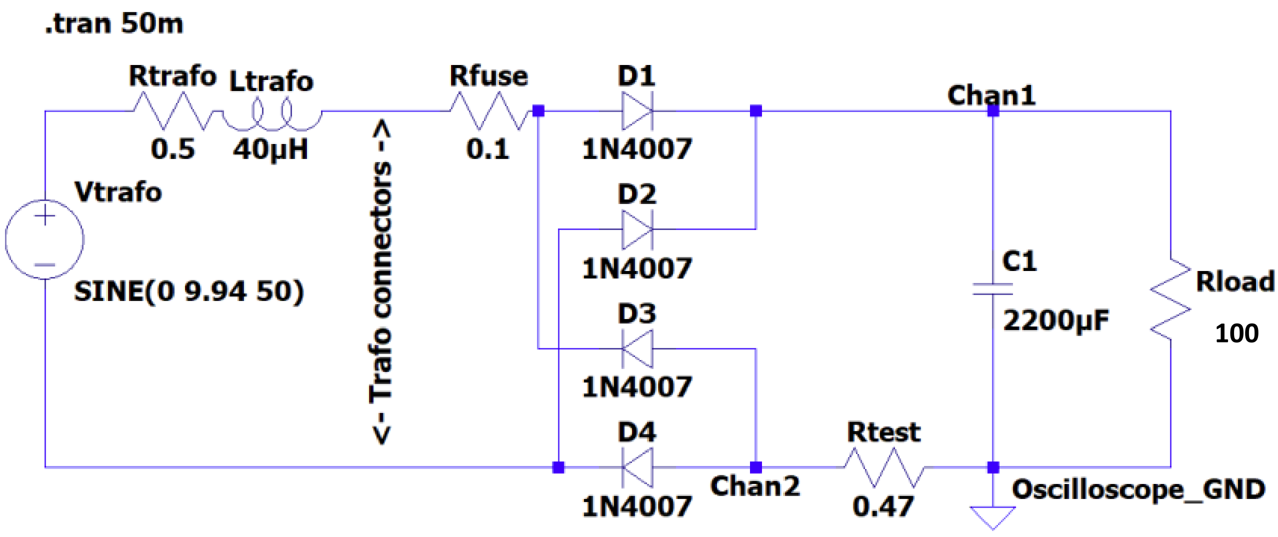
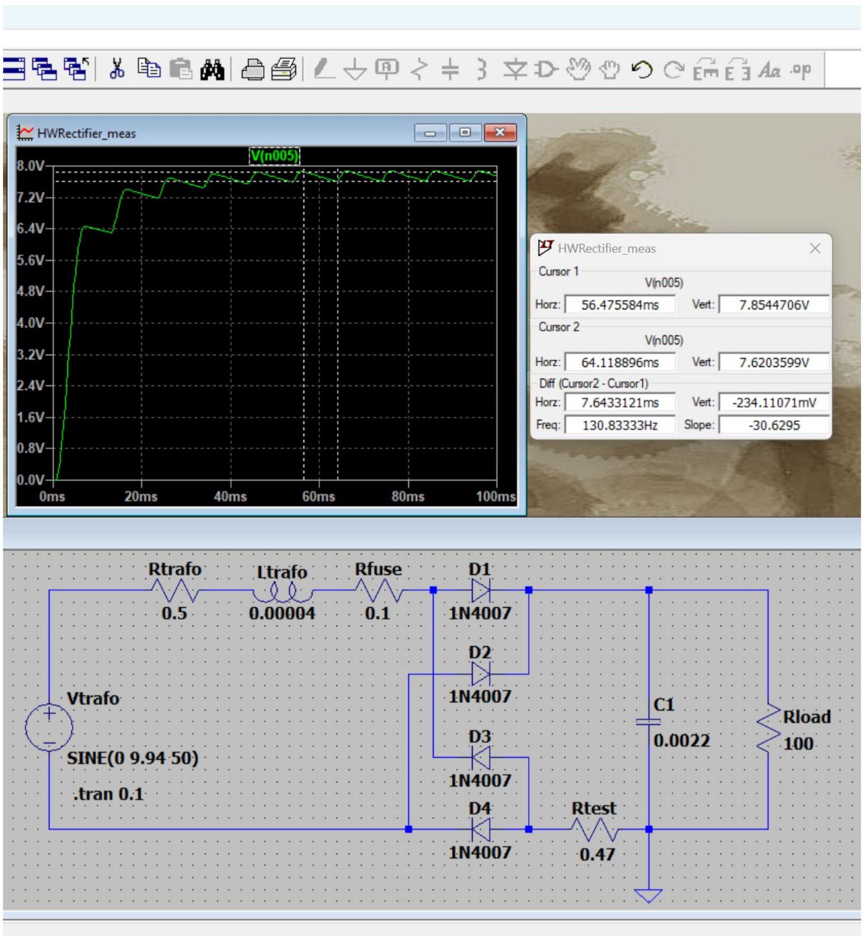
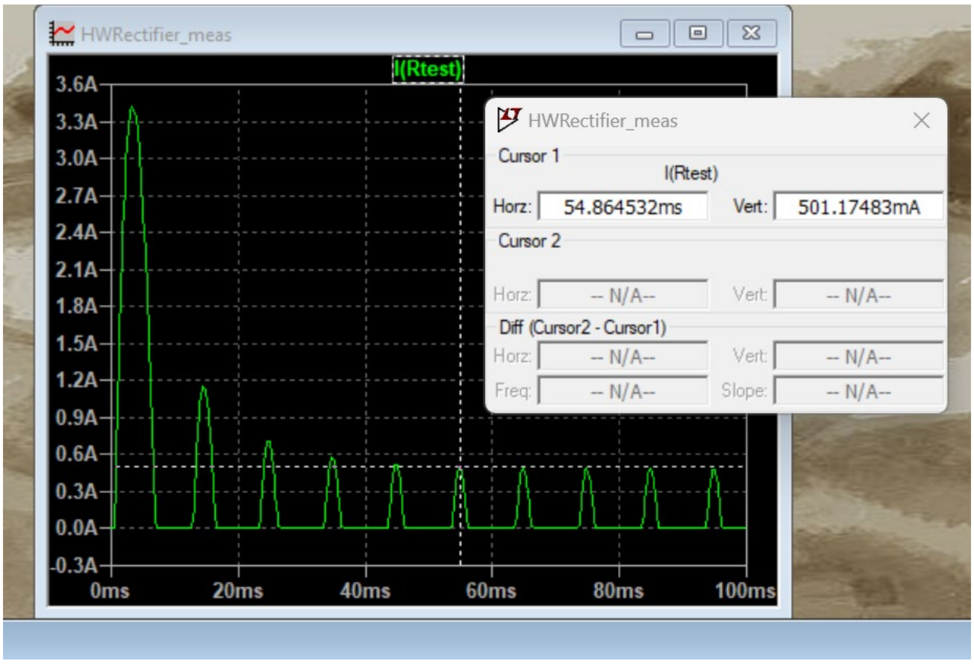


Fig. 2

Solution:



The voltage across the capacitor C1 with a ripple amplitude of 0.2 V



The current flowing through R_test

Do your measurement results match the simulation results?