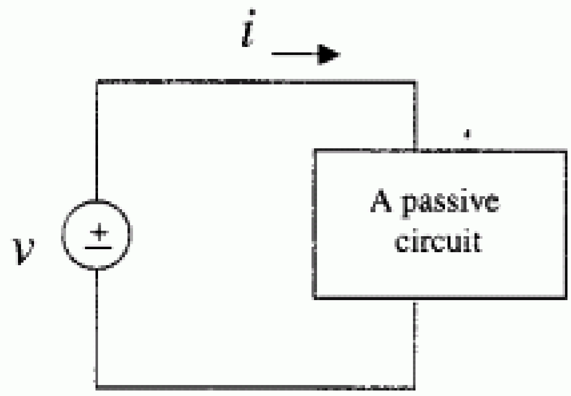
(1) A test is performed on a passive circuit in order to understand its characteristics. In this test, a 1-volt, 1 Hz sinusoidal voltage (v) is connected as the input to the circuit; and, the current (i) is measured. The measured waveforms for v and i are shown in Fig. 1 below. It is known that the circuit is either a RL or a RC circuit. Please determine

(a) the equivalent resistance of the circuit (5 points);

(b) the equivalent inductance (or capacitance) or the circuit (5 points).



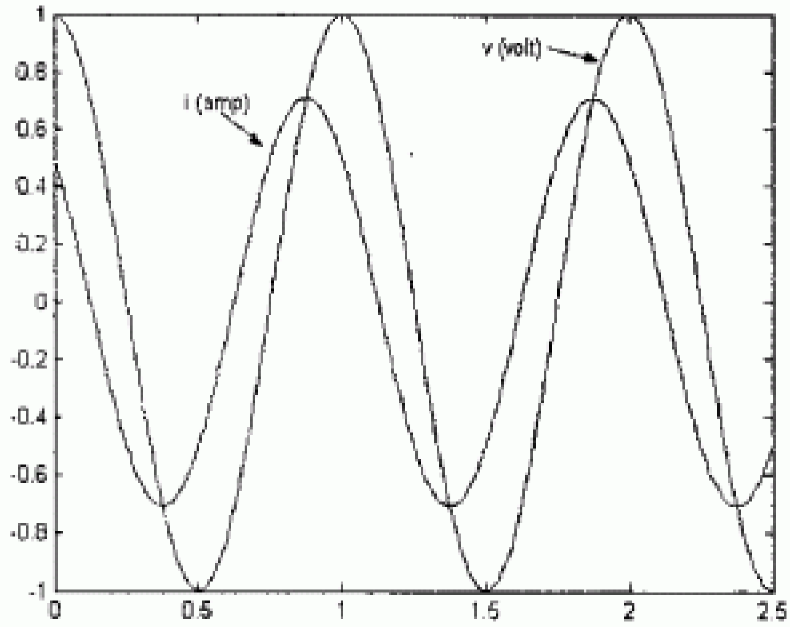


Fig. 1

(2) When connected to a variable resistor, a power supply exhibits the voltage-resistance characteristics as shown in Fig. 2. Please determine the equivalent circuit of the power supply. (6 points)

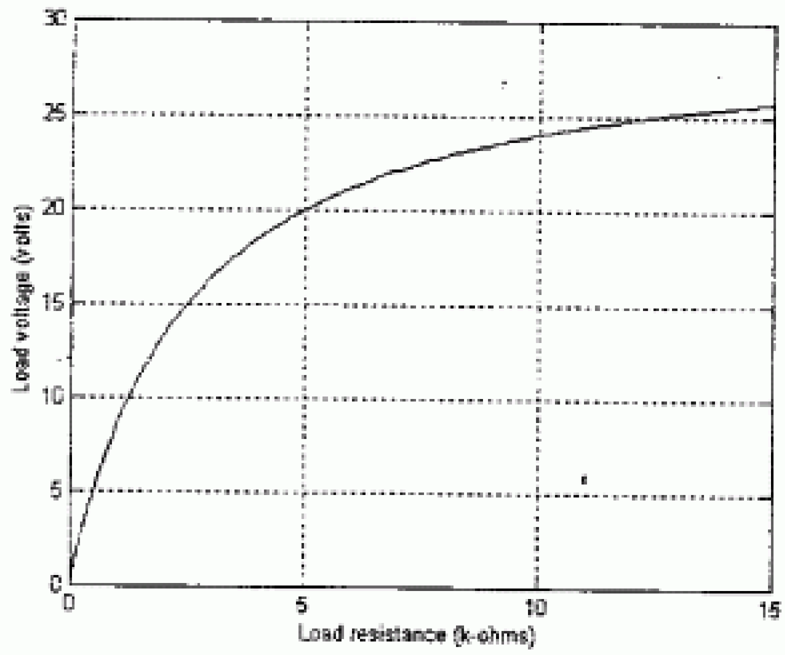


Fig. 2

(3) In the following RLC circuit as shown in Fig. 3, assume that the input is $v_i = \sin(\omega t)$ and the output v_o equals to $V\sin(\omega t + \phi)$ at steady state.

(a) Determine the amplitude (V) and the phase (ϕ) as functions of ω. Plot respectively V v.s. ω and ϕ v.s. ω. (10 points)

(b) From the results in (a), determine the frequency ω_0 where V achieves its maximum V_{max} and V_{max}=? (9 points)

(c) Determines the two frequencies (ω_1, ω_2) $V = \frac{1}{\sqrt{2}} V_{max}$. (8 points)

(d) Compute values for R and L to yield a circuit with $\omega_0 = 5kHz$ and $\omega_2 - \omega_1 = 200Hz$ using a $5\mu F$ capacitor. (7 points)

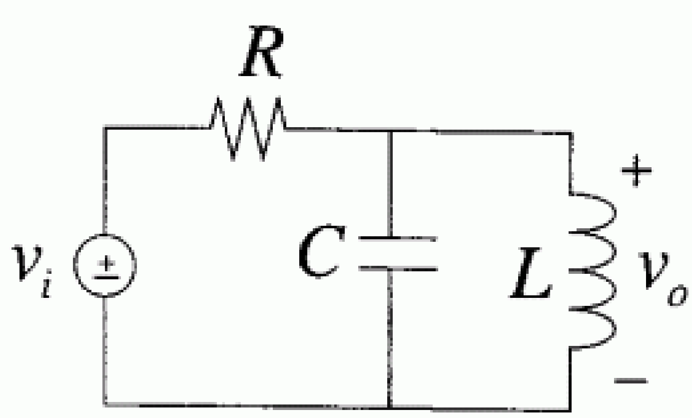


Fig. 3

(4) A pn junction diode built in silicon has the following parameters, which represent data for the diode and silicon at room temperature.

Bandgap energy of silicon = 1.1 eV; Intrinsic free carrier density in silicon = $1.1(10^{10})$ cm^{-3}; N_A (p side) = 10^{18} cm^{-3}; N_D (n side) = 10^{17} cm^{-3}

(a) Determine the built-in potential offset (3 points).

(b) Determine the depletion length both in n-material and in p-material, respectively (4 points).

(c) Sketch the energy band profile for the pn junction diode and label the energy bandgap, depletion region and built in potential (5 points).

(5) Calculate the resistance of a layer of n-type Si which is doped with donor species at a concentration of 10^{17} cm^{-3}, is 10^{-4} cm^2 in area and 5μm thick. Assume an electron mobility of 750 cm^2/volt·sec. This film might represent the major contribution of the series resistance of a pn junction diode. If so, at what forward bias current would the series resistance begin to have an effect on the diode's voltage drop (i.e. when is $r_d < R_{series}$)? Remember that at large forward bias $\eta \equiv 1$ (12 points).

[Hint: Equations may be used in the calculations.]

$$n_i^2 = N_c N_v \exp\left(\frac{-E_g}{kT}\right) \qquad C = \left[\frac{q\varepsilon_s}{2(\phi_i - V_a)\left(\frac{1}{N_a} + \frac{1}{N_d}\right)}\right]^{1/2}$$

$$L_D = \left[\frac{\varepsilon_s kT}{q^2 N_d}\right]^{1/2} \qquad x_n + x_p = \left[2\frac{\varepsilon_s}{q}(\phi_i - V_a)\left(\frac{1}{N_a} + \frac{1}{N_d}\right)\right]^{1/2}$$

$$\phi_n = \frac{kT}{q}\ln\frac{N_d}{n_i} \qquad \bar{J}_{nx} = q\mu_n n\bar{E}_x + q\bar{D}_n\frac{dn}{dx}$$

(6) Which bias applied in a MOSFET has the strongest influence on "channel length modulation"? Why does the channel length modulation result in Early effect? (6 points)

(7) When designing the output stage of a power amplifier, Darlington Configuration has commonly employed for circumventing the low dc β problem.

(a) Please draw a schematic figure to show the Darlington pairs consisting of two npn bipolar transistors (4 points).

(b) Derive the combined current gain for the Darlington pairs if the two npn transistors are assumed to have the same dc β (4 points).

國 立 清 華 大 學 命 題 紙

九十一學年度 動力機械工程 系（所） 乙 組碩士班研究生招生考試

科目 電工學 科號 1402 共 4 頁第 4 頁 *請在試卷【答案卷】內作答

(8) In most op-amp circuits, the linear circuits are based upon negative feedback analysis when details of the circuits are designed.

(a) Please write down the ideal op-amp characteristics that can be concluded from the feedback theory (4 points).

(b) Draw the inverting, non-inverting, and difference amplifiers based upon the feedback concept with ideal op-amps (4 points).

(c) When non-linear components, such as diodes, are used in the design, what are the possible functions of the op-amp circuits? Please draw at least one op-amp circuit and describe the results. (4 points)