# 九十二學年度台灣大學電資學院電機系電子學(一)期中考

1. A $p^+-n$ diode is one in which the doping concentration in the p region is much greater than that in the n region. In such a diode, the forward current is mostly due to hole injection across the junction. Show that

$$I \cong I_p = Aqn_i^2 \frac{D_p}{L_p N_D}(e^{V/V_T} - 1)$$

For the specific case in which $N_D = 5 \times 10^{16}/\mathrm{cm}^3$, $D_p = 10\mathrm{cm}^2/\mathrm{s}$, $\tau_p = 0.1\,\mathrm{us}$, And $A = 10^4\,\mathrm{um}^2$, find $I_s$ and the voltage $V$ obtained when $I$ = 0.1 mA. Assume operation at 300K where $n_i = 1.5 \times 10^{10}/\mathrm{cm}^3$. Also calculate the excess minority-carrier charge and the value of the diffusion capacitance at $I$ = 0.1 mA.

2. The circuit in Fig.1 implements a comple-mentary-output rectifier. Sketch and clearly label the waveforms of $v_o^+$ and $v_o^-$. Assume a 0.7-V drop across each conducting diode. If the magnitude of the average of each output is to be 15 V, find the required amplitude of the sine wave across the entire secondary winding. What is the PIV of each diode?

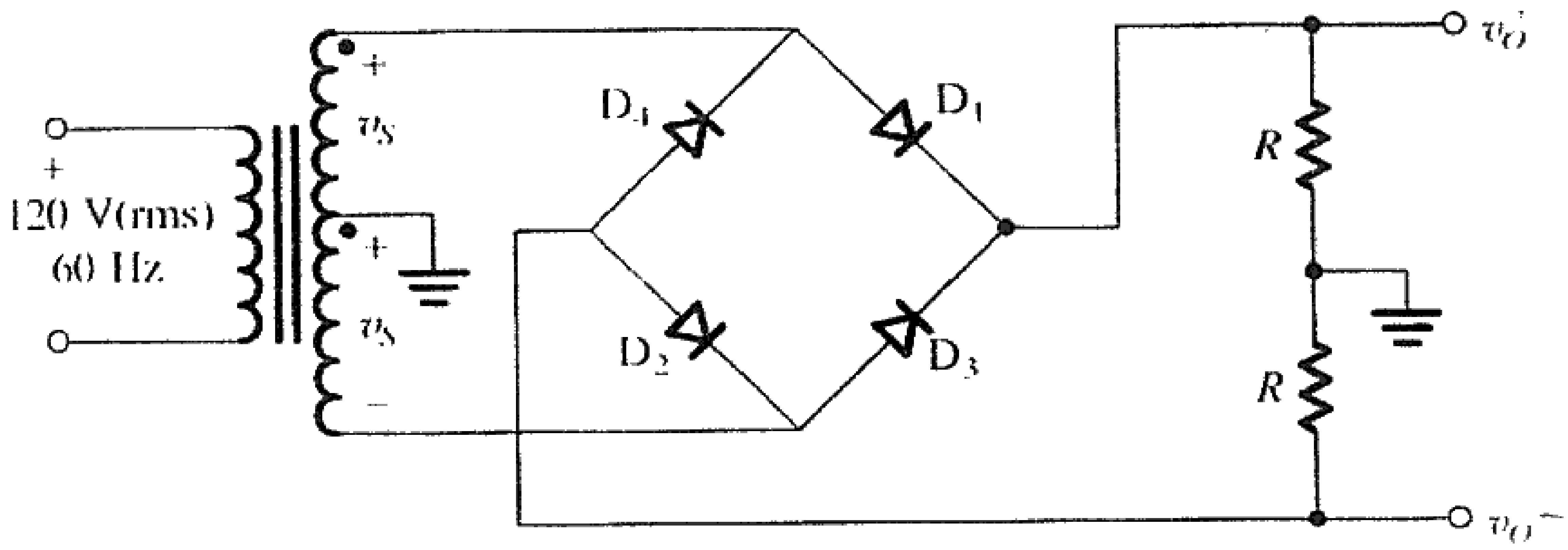



Fig. 1

3. (a) Find the input resistance $R_{in}$ of the circuit in Fig. 2-1. [12%]
   (b) If voltage $v_i$ is applied to the input of the circuit, what is the current flowing into the output of $A_1$? [5%] And what is the current flowing into the output of $A_2$? [5%]
   (c) If the circuit has been modified to the one as shown in Fig. 2-2, what is the differential input resistance $R_{in}$? [7%]

   Hint: assume all op amps are ideal and negative feedback applies for the circuits.

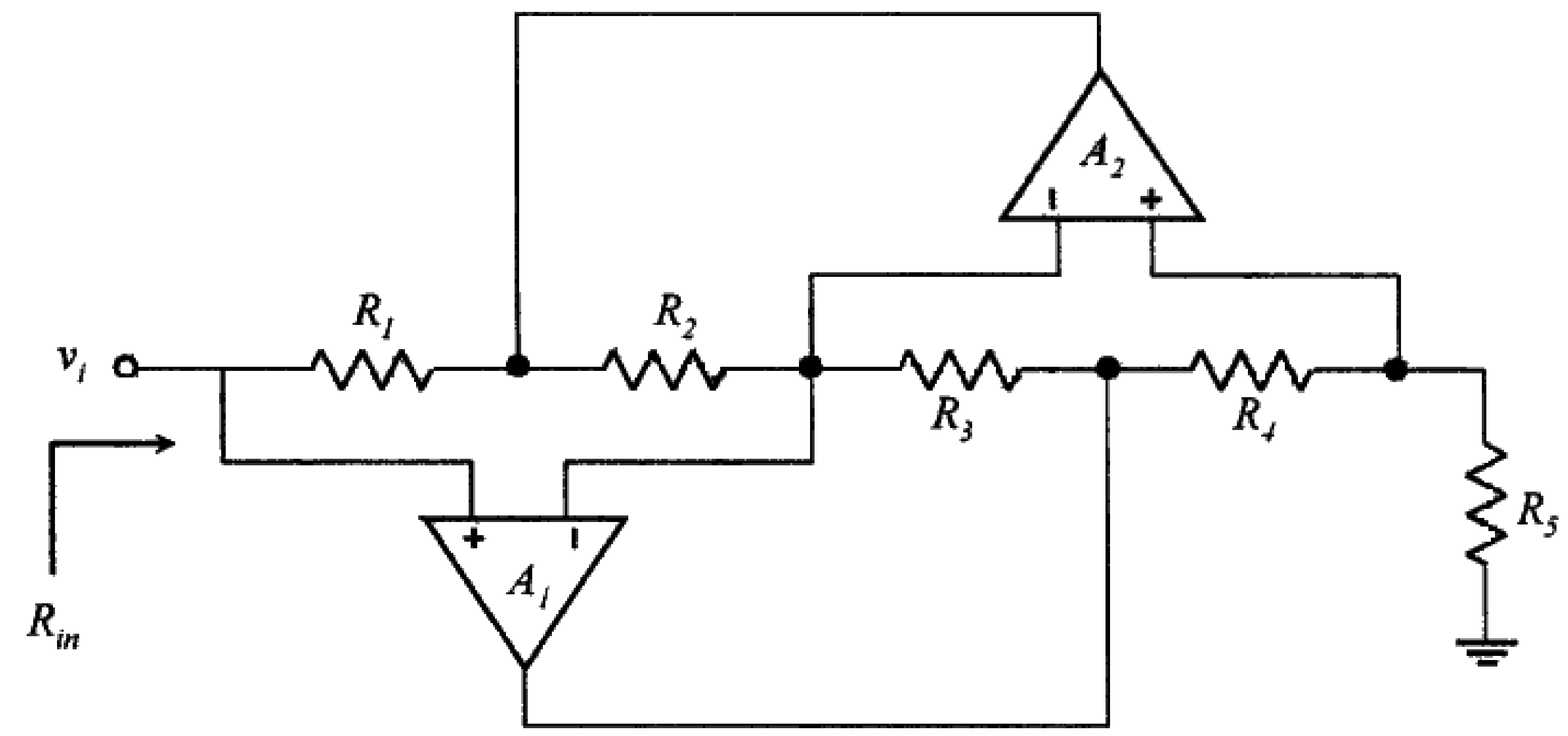



Fig. 2-1

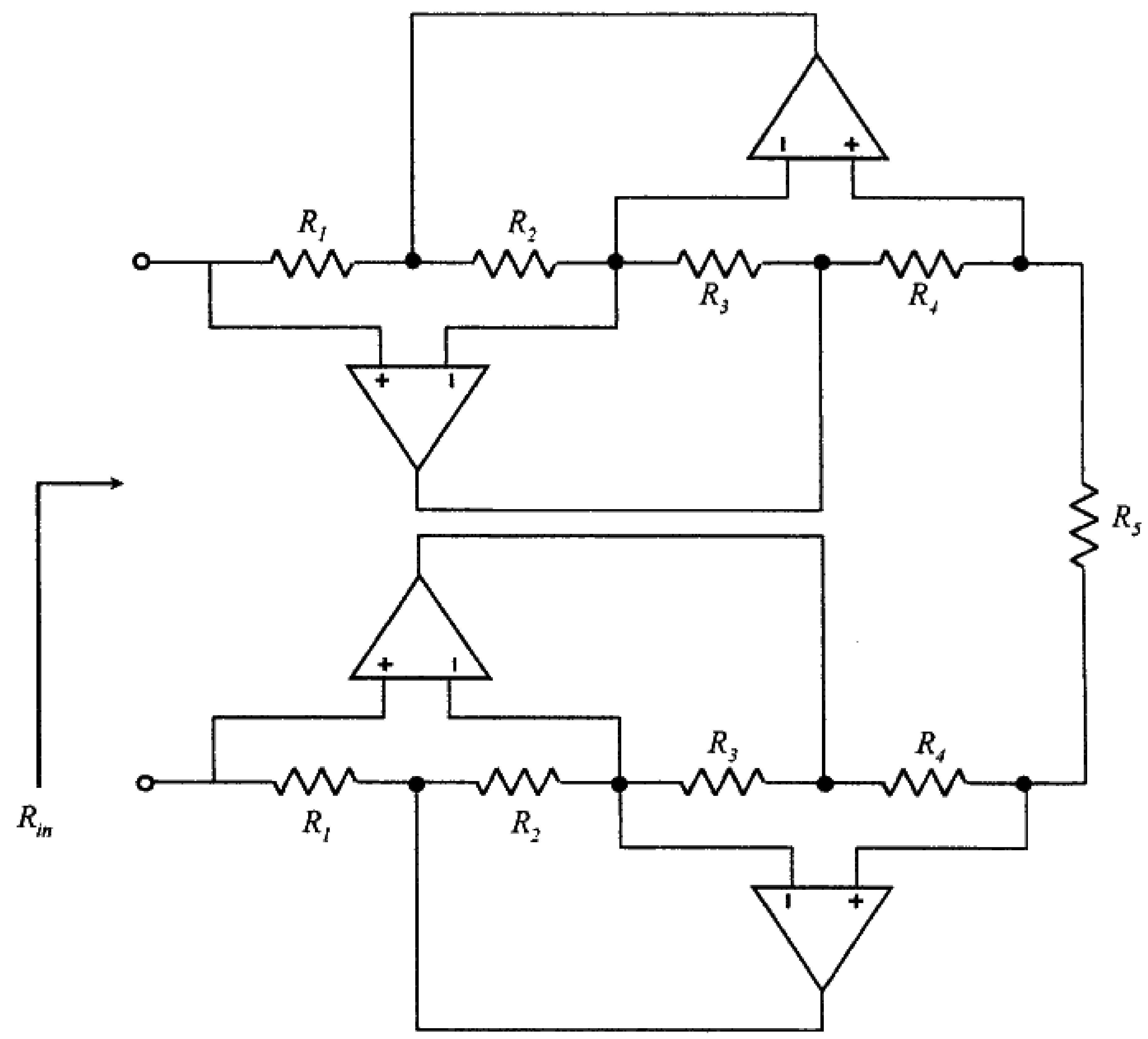



Fig. 2-2

4. Fig. 3 shows an OPAMP inverting amplifier, the slew rate of the OPAMP is 5V/μs. The maximum amplitude of the input signal $v_I$ is 80 m V. Find the maximum amplitude of the output signal $v_O$ and the full-power bandwidth, $f_M$. (14%)

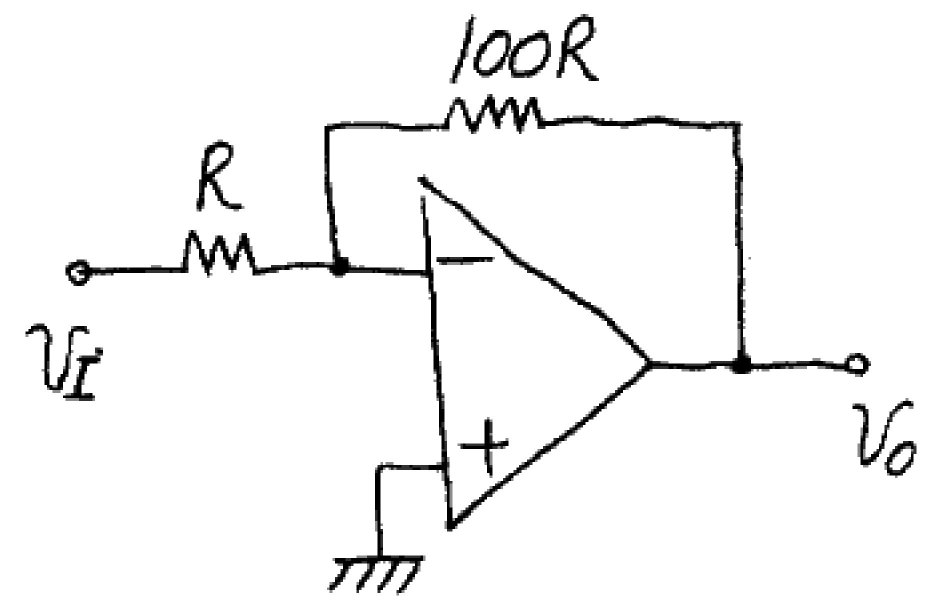



Fig. 3

5. The depletion width W of a one-side abrupt PN junction ($N_A >> N_D$) is

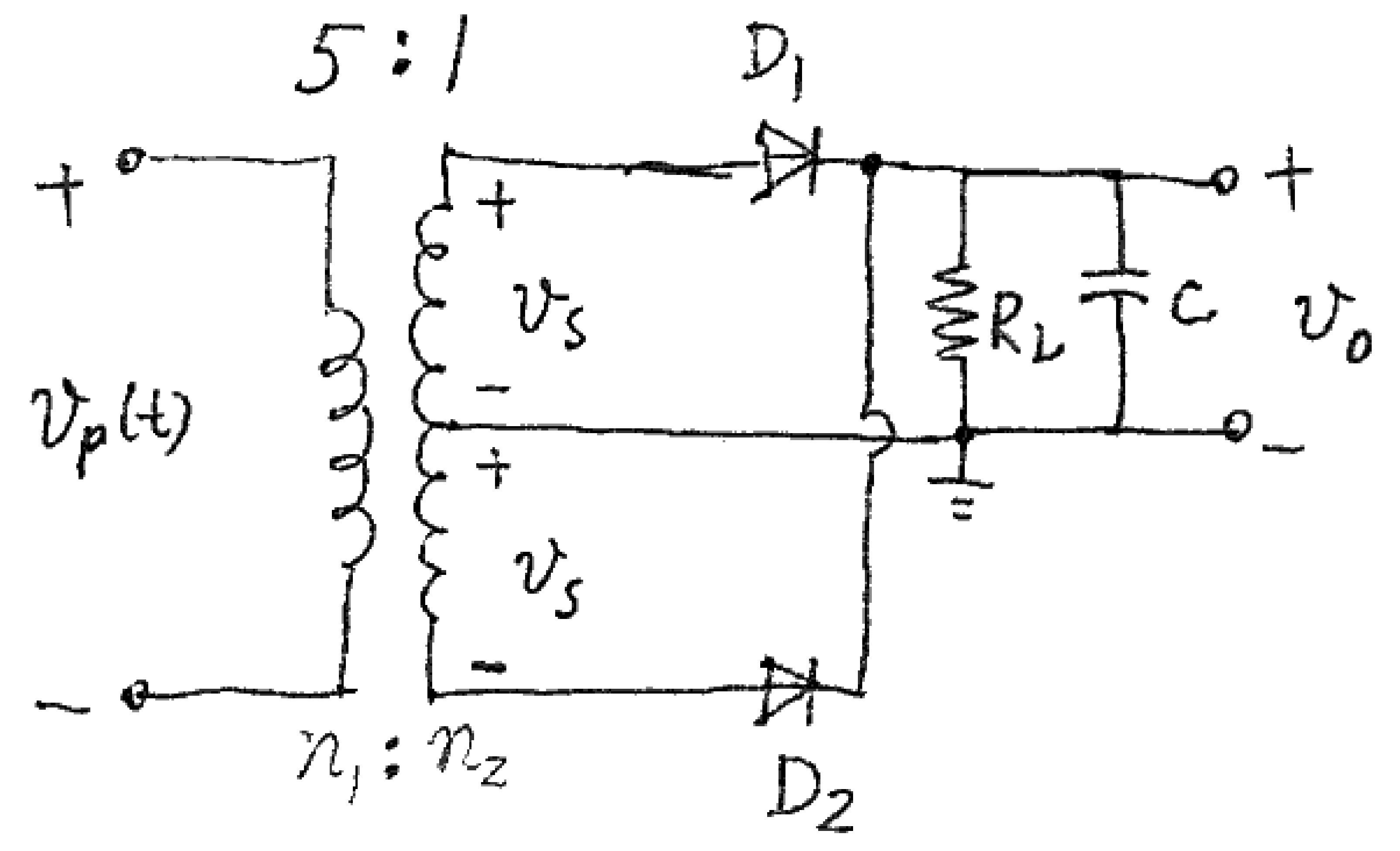
$$W = \sqrt{\frac{2\varepsilon_s(V_0 + V_R)}{qN_D}}$$

where $\varepsilon_s$ is the dielectric constant, $V_0$ is the built-in voltage, q is the unit charge, and $V_R$ is the reverse bias voltage. Show that the depletion capacitance per unit area $C_j$ is

$$C_j = \frac{\varepsilon_s}{W}$$

Hint: the charge stored in the depletion region is $q_j \approx qN_DW$ and use the definition of small signal capacitance, i. e., the capacitance is the slope of the $q_j$-$V_R$ curve. (15%)

6.




For the full-wave peak rectifier circuit, $V_p(t) = 100\sin(2\pi \times 60t)$ volts, the turns ratio is 5:1, diodes $D_1$, $D_2$ have forward voltage 0.7 V, forward resistance $r_D$ = 0 Ω and reverse resistance $r_R = \infty$, Also, we have $R_L = 10K\Omega$

(a) What is the peak inverse voltage (PIV) experienced by $D_1$ and $D_2$? (5%)

(b) Find the value of C such that the peak-to-peak ripple voltage at $v_o$ is 0.2 V. (10%)

(c) Find the conducting angle during which either $D_1$ or $D_2$ is conducting. (10%)

(360°= one period of 60Hz Sinusoidal wave )

(d) Find the average and peak current through $D_1$ and $D_2$ during their conduction time. (5%)