國立臺灣大學99學年度碩士班招生考試試題

Q1. The displacement of a robot arm in a given direction is represented by a voltage signal $V_{in}(t)$. The voltage is proportional to displacement, and 1 V corresponds to a displacement of 0.01 m from the reference position. (a) Design a circuit that produces a voltage $V_o(t)$ that is proportional to the velocity of the robot arm such that 1 m/s corresponds to 1 V. **(10%)** (b) The conditions for choosing the component values in the circuit must be specified clearly. **(10%)**

Q2. Find the minimum CMRR for an electrocardiograph amplifier if the differential gain is 1000, the desired differential input signal has a peak amplitude of 1 mV, the common-mode signal is 50-V-peak 60-Hz sine wave, and it is desired that the output contains a peak common-mode contribution that is 0.1% or less of the peak output caused by the differential input signal. **(15%)**

Q3. The MOSFETs in the circuit of Figure 1 are matched, having the parameters as: $k_n^{'}(W/L)_1 = k_p^{'}(W/L)_2 = 2$ mA/V^2, and $|V_t| = 0.5$V. The resistance R = 500 kΩ. Please answer the following questions.

(a) What are the drain currents I_{D1} and I_{D2} ? **(5%)**

(b) For $r_o = \infty$, what is the voltage gain of the amplifier from G to D ? **(10%)**

(c) For finite r_o ($|V_A| = 20$V), what is the voltage gain and input resistance? **(10%)**

(d) For what range of output signals do Q_1 and Q_2 remain in saturation region? **(5%)**

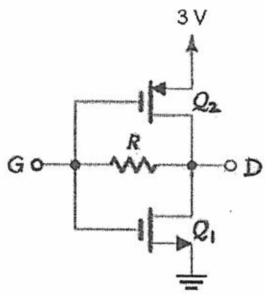

Fig. 1

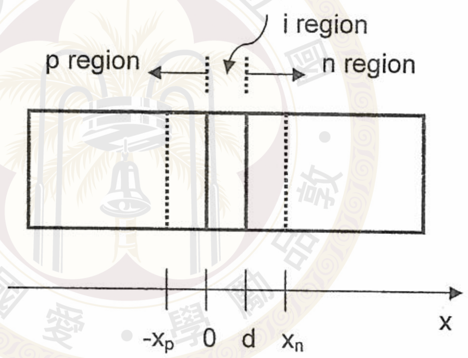

Fig. 2

Q4. In many modern VLSI devices, the devices are operated at very high electric fields within the depletion regions of some of their p-n junctions. In fact, the junction fields may be so high that detrimental high-field effects, such as avalanche multiplication and hot-carrier effects, would occur. To overcome such problems, device engineers sometimes introduce a thin and undoped region (i.e. an intrinsic i-layer) between the p-n junction. In the following let's analyze such a p-i-n structure, assuming a (uniform) p-doping concentration of N_A, a (uniform) n-doping concentration of N_D, and an i-layer thickness of d. Assume a total potential drop V_{bi}-V is across the junction (V_{bi} is built-in potential and V is the applied bias), and a total depletion width of $W_d = x_p + x_n$ is formed (see Figure 2).

(a) **(5%)** Draw the schematic energy-band diagram of the p-i-n structure under thermal equilibrium. Specify the p-, i-, n-regions and give your descriptions.

(b) **(9%)** Let's take the depletion approximation. Write down the Poisson's equations for the p-region ($-x_p \le x \le 0$), i-region ($0 \le x \le d$), and n-region ($d \le x \le x_n$) within the depletion region.

(c) **(12%)** With the depletion approximation and appropriate boundary conditions, solve the Poisson's equation to get the distribution of the electric field E(x) in $-x_p \le x \le x_n$. Then calculate W_d and the maximum electric field E_m (in $-x_p \le x \le x_n$) as a function of N_A, N_D, d and V_{bi}-V.

(d) **(5%)** Consider another p-n junction diode that has no i-layer but has the same p-side and n-side doping concentrations (i.e. N_A and N_D) and the same applied bias V. Give its depletion width W_{d0} and maximum electric field E_{m0} (as a function of N_A, N_D, and V_{bi}-V).

(e) **(4%)** Compare E_{m0} and E_m, and comment.

試題隨卷繳回