# 國立臺灣大學 102 學年度碩士班招生考試試題



1. (a) Sketch $V_{out}(t)$ of the circuit shown in Fig. 1 given a sinusoidal $V_{in}(t) = 5\sin(2\pi t/T)$ V, over t = 0 – 2T where T is the period of $V_{in}(t)$. Assume $V_{in} = 0$ when t<0, the offset voltage of the diode is 0.6 V, and $R_L$ is large enough to be considered infinite. ( 5 %) (b) What is the effect of a finite $R_L$ to $V_{out}(t)$? Sketch two curves of $V_{out}(t)$, one with a larger $R_L$ and the other with a smaller $R_L$ to demonstrate the effect of $R_L$. (10%)

2. Fig. 2 shows a differential amplifier. (a) Derive an expression for the differential gain $A_d = V_{out}/(V_2 - V_1)$, assuming $R_3 = R_1$ and $R_4 = R_2$. ( 5 %)

(b) What is the input impedance of the differential amplifier to a common-mode signal (e.g. interference caused by 60 Hz power lines)? Again, assume $R_3 = R_1$ and $R_4 = R_2$. (10%)

(c) Next, consider mismatched resistors R2 = 100 kΩ, R4 = 101 kΩ, and matched resistors R1 = R3 = 1 kΩ. Following the definition of common-mode signal, $V_{cm} = (V_2+V_1)/2$, and definition of differential-mode signal, $V_d = V_2 - V_1$, find the common-mode rejection ratio (CMRR) in decibels. Hint: derive expressions for differential-mode gain $A_d$ and common-mode gain $A_{cm}$ such that $V_{out} = A_{cm}V_{cm} + A_dV_d$, and CMRR = $A_d/A_{cm}$. (10%)

3. Fig. 3 shows an instrumentation amplifier for highly sensitive AC signal detection. (a) Derive an expression for the differential-mode gain $A_d = V_{out}/(V_2 - V_1)$, assuming $R_3 = R_1$ and $R_4 = R_2$. (10%)

(b) Assume $R_{gain} = R_1 = R_2 = R_3 = 1$ kΩ, $R_4 = 1.01$ kΩ, and R = 49.5 kΩ, find the CMRR in decibels. You may use the results of Question 2(c) to simplify the problem. (10%)

(c) Describe the advantages of the instrumentation amplifier (Fig. 3) compared with the differential amplifier (Fig. 2), in terms of input impedance and CMRR. (10%)

4. (a) Derive an expression for the frequency response (as a function of angular frequency ω) of the filter shown in Fig. 4. (10%) (b) Find out the cut off frequency. (10%) (c) What is the physical meaning of the phase of the frequency response? (10%)

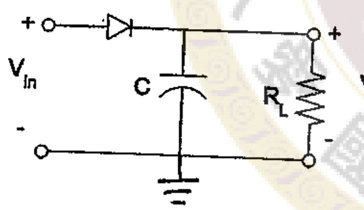


Fig. 1

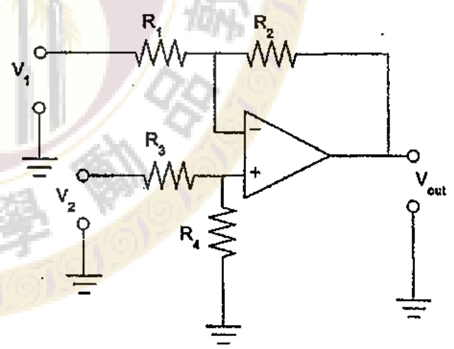


Fig. 2

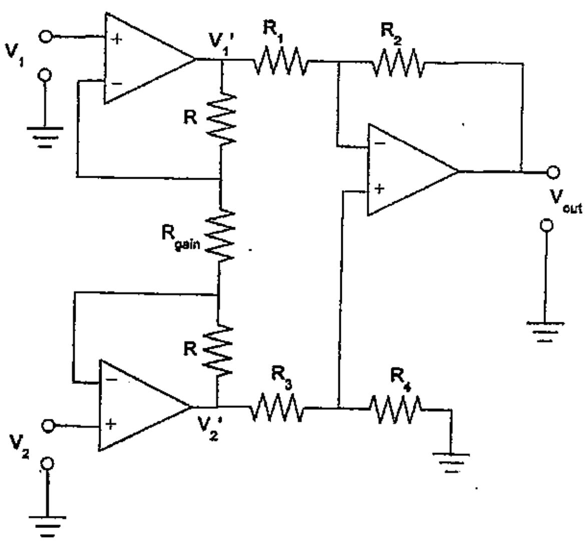


Fig. 3

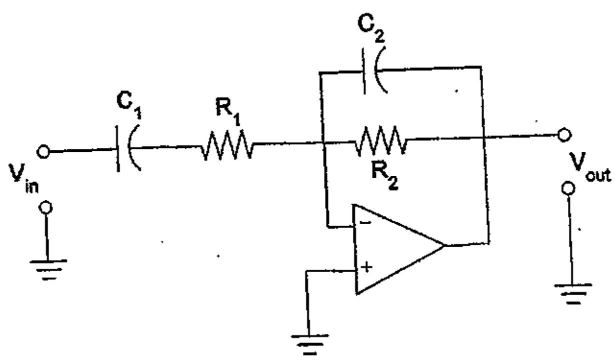


Fig. 4