1. A modified version of differential amplifier is shown in Fig. 1. The gain may be set by varying the resistor R_G. Please compute the differential voltage gain when $R_G = 5$ kΩ, $R_1 = 100$ kΩ, and $R_2 = 500$ kΩ. (15%)

2. A feedback type of transconductance amplifier is depicted in Fig. 2. Find the input resistance of the one-port network. (10%)

3. Find I_p and I_n in a forward-biased diode with the forward conducting current $I = 1$ mA. The parameters for this diode are $N_A = 10^{18}/\text{cm}^3$, $N_D = 10^{16}/\text{cm}^3$, $L_p = 5$ μm, $L_n = 10$ μm, $D_p = 10$ cm^2/s, and $D_n = 20$ cm^2/s. (15%)

4. For a capacitively coupled common-emitter amplifier as depicted in Fig. 3, find the midband gain, and the value of R_L that reduces the midband gain to half. (10%) The parameters for this transistor are given as follows. $V_{CC} = V_{EE} = 10$ V, $I = 1$ mA, $R_B = 100$ kΩ, $R_C = 8$ kΩ, $R_{sig} = 5$ kΩ, $R_L = 5$ kΩ, $\beta_0 = 100$, $V_A = 100$ V, $C_\mu = 1$ pF, $f_T = 800$ MHz, and $r_x = 50$ Ω..

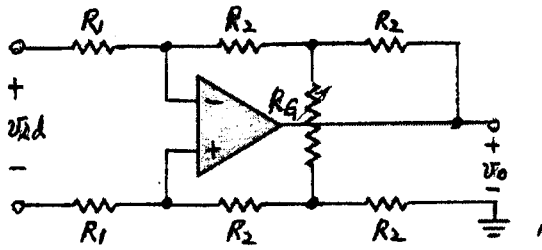


Fig. 1

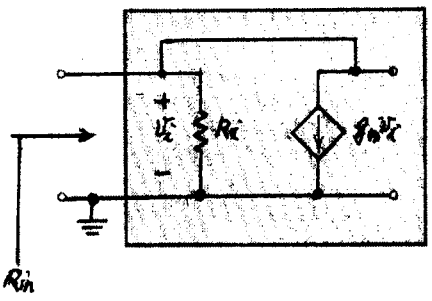


Fig. 2

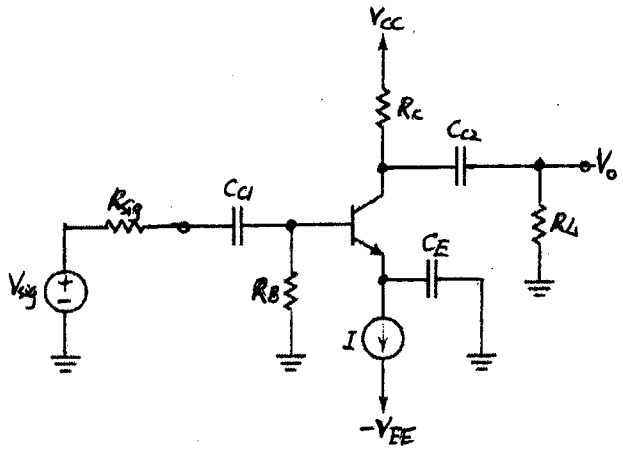
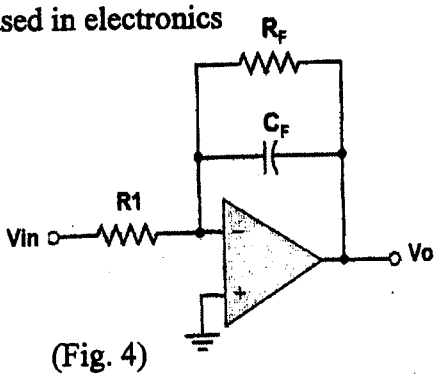


Fig. 3

(背面仍有題目,請繼續作答)

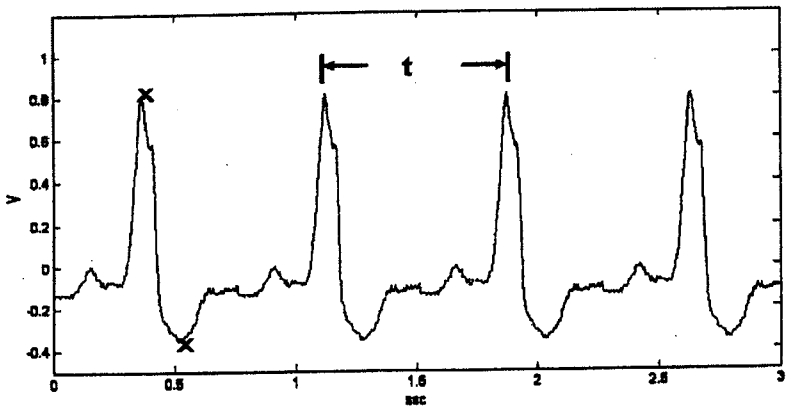
5. (15 %) Explain the following terminologies generally used in electronics
   (a) 1-line-to-8-line demultiplexer
   (b) Tristate buffer
   (c) Class E amplifier
   (d) Hardware description language (HDL)
   (e) Synchronous counter



(Fig. 4)

6. (20 %) Figure 4 is the one-pole low-pass filter.
   (a) Please derive the cutoff frequency and Vo(s)/Vin(s)
   (b) Please choose the values of components that it can filter out frequency beyond 100 Hz with gain of -1.
   (c) Draw the equivalent switched-capacitor filter of the same specifications of (b) giving the clock frequency (f_c) with equivalent resistance $R_{eq} = 1/f_c C$

7. (15 %) Figure 5 is an example trace of ECG waveform, an analogue signal recorded from human heart. You may make any assumptions in your designed circuit.
   (a) Could you design a hybrid circuit, combination of analogue and digital circuits, to determine the R-R interval, the t marked in the figure, up to the time resolution of ms? (Hint: comparator and counter might be a good combination)
   (b) Could you design a circuit to provide the analogue output of the peak-to-peak amplitude, marked with x's? (Hint: peak detectors, summer, inverter of OP-Amps might be needed)



(Fig. 5)