國立中央大學 111 學年度碩士班考試入學試題

所別： 光電類　　共4頁 第1頁

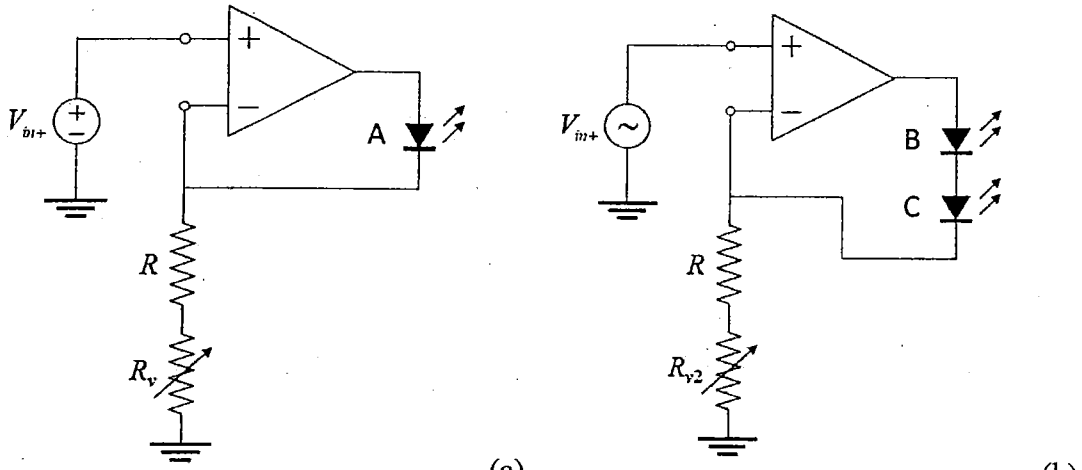
科目： 電子學

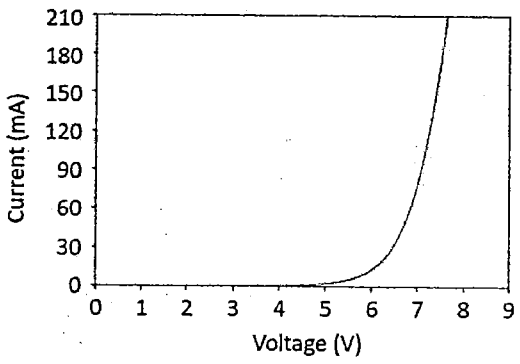
本試題共四大題計算題，無計算過程不予計分。答案請標示單位。

1. Driving circuit

The circuits in Fig. 1(a) and 1(b) show simple driving circuits for one LED and two LEDs. Figure 1(c) shows the I-V curve of the LED. The V_{in+} is 5 V dc voltage and the OP is driven by ±25-V V_{cc}. Please answer the following questions. (22%)

1) If R and R_v keep the same values, what will you observe about the brightness of the LEDs A, B, C? (hint: brighter, dimmer, or the same) (5%)
2) What is the major difference between this driving circuit and the circuit that directly connects LEDs and voltage source in series? Especially in the condition that there are more than 2 LEDs. (5%)
3) If the maximum driving current of the LED is 200 mA and the dynamic range of the LED is from 0 to 200 mA. Please give your design for R and R_v. (6%)
4) With a suitable combination of R and R_v, the driving current of two LEDs in Fig. 1(b) are set as 200 mA. If two more LEDs are now added to Fig. 1(b) and connected in series with other LEDs, what will happen to the brightness of these LEDs? Please explain your reason. (6%)





(c)

Fig. 1

注意:背面有試題

2. Amplifier and filter

1) For the circuit in Fig.2, please draw the time curve of the output voltage, where $V_{in-}(t) = 5\cos(250t)$. Please give all the details about this signal in your chart. (10%)

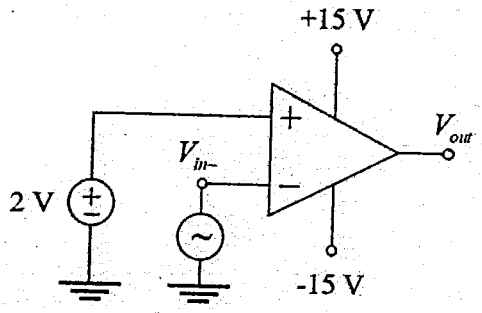


Fig. 2

2) Figure 3 shows a signal synthesizer combined with an active filter. Set $V_1(t) = 0.4\cos(1000t\text{-}60°)$, $V_2(t) = 0.3\cos(1600t + 30°)$, and $V_3(t) = 0.1\cos(5000t)$. Please give the function of the output signal. (18%)

$$V_{out}(t) = \boxed{(a)} \times \cos\left(200t + \boxed{(b)}\right) + \boxed{(c)} \times \cos\left(500t + \boxed{(d)}\right) + \boxed{(e)} \times \cos\left(2000t + \boxed{(f)}\right)$$

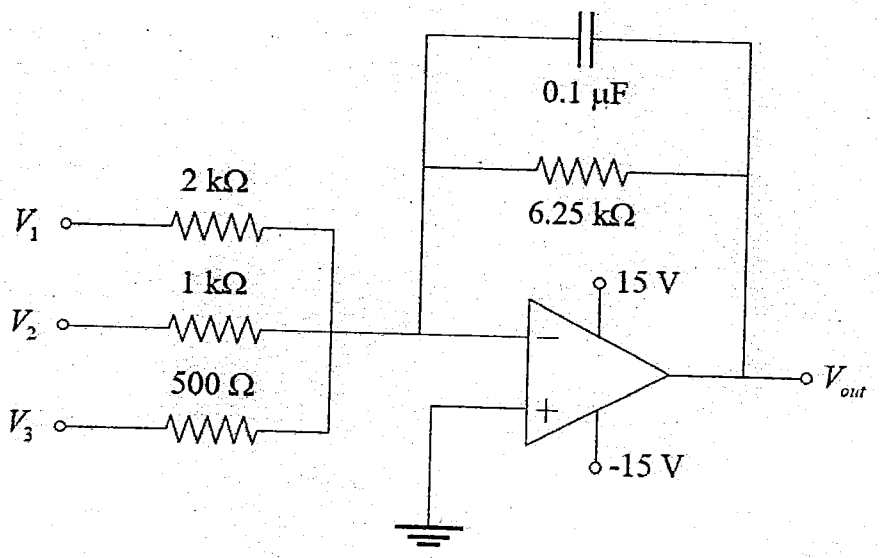


Fig. 3

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3. (25%) For the following circuit, n-MOSFET Q1 works as a common source (CS) amplifier while Q2 and Q3 work as a current mirror. These transistors are identical with $V_t = 2$ V, $k_n = \mu_n C_{ox}(W/L) = 2$ mA/V^2, $V_A = 100$ V, and $V_{DD} = Vss = 5$ V.

(5%) (a) To make sure the resistance of the current mirror is large enough, we would like to have the output resistance (for Q_3) $r_o = V_A/I_D = 100$ kΩ. Please find the corresponding R_{ref}.

(15%) (b) Followed by (a), if the open-circuit gain (A_{vo} without R_L) of the CS amplifier is designed to be $A_{vo} = -10$. What is R_D? What are the corresponding V_D and V_S for Q1?

(5%) (c) Followed by (b), if now the load R_L is connected at the drain with a capacitor C_L=100 nF, what is the minimal R_L to operate this circuit at low frequency $f_{L(3dB)} < 500$ Hz.

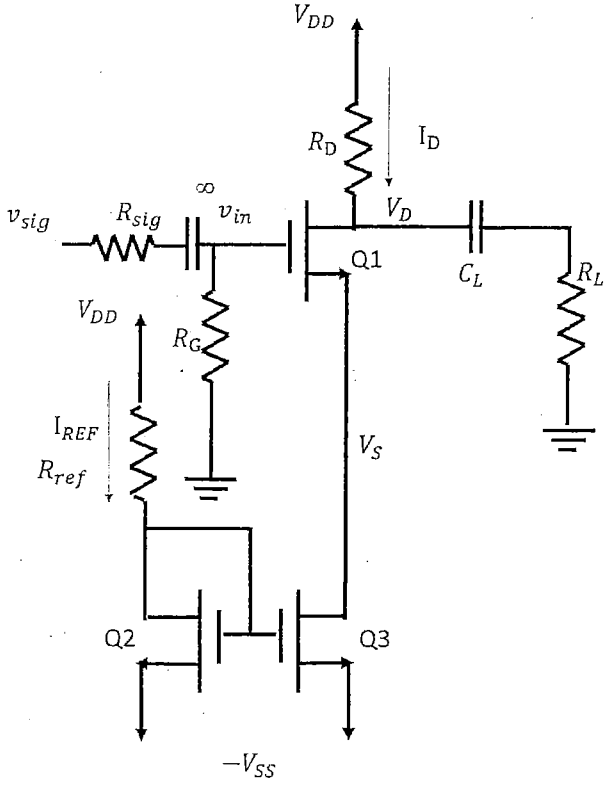

Figure 3

注意:背面有試題

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本科考試可使用計算器，廠牌、功能不拘　　＊請在答案卷(卡)內作答

4. (25%) A BJT differential pair is shown as below. All BJTs are assumed to be the same with β=100 and Early voltage $V_A=\infty$. V_{CC} = 5 V. Please evaluate the following at room temperature (V_T=25mV):

(10%) (a) If the R_{id} is designed to be 100 kΩ, what is the current source I needed for the BJT differential pair? What is the biasing voltage at collector (V_{c1} / V_{c2})?

(5%) (b) What is the differential voltage gain ($A_d=v_{od}/v_{id}$)?

(10%) (c) If we want to design the amplifier with common-mode rejection ratio

(CMRR=$\frac{v_{od}/v_{id}}{v_{od}/v_{icm}}$) > 1000 (or 60 dB) for R_{c1}/R_{c2} mismatch=1% (worst case dR_c/R_c =0.01), what is the maximal common-mode gain (A_{cm})? What is the minimal resistance for the current source ($R_{\text{current source}}$)?

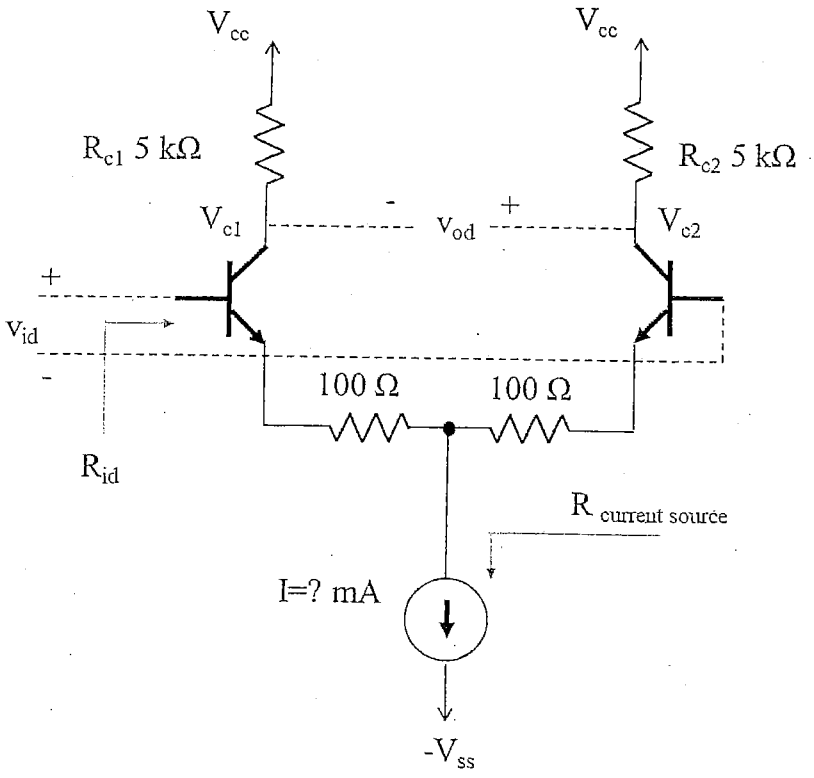

Figure 4

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