Q1

(a): mismatch of the input transistors and components during fabrication of the silicon die and stresses placed on the die during the packaging process

(b):

$$V = -\int \frac{V_{\text{os}}}{RC} dt$$

(c)

- $V_{\text{out}} = R_2 I_{B(-)} - I_{B(+)} R_P \left(1 + \frac{R_2}{R_1}\right)$
- $R_P = \frac{R_1 R_2}{R_1 + R_2}$

(d)

- $\text{CMRR} = \frac{A_{\text{dm}}}{A_{\text{cm}}}$ In high-precision circuits, such as instrumentation amplifiers, even small common-mode voltages can lead to significant output errors when the CMRR is finite.

(e)

- $V_{\text{out}} = 105 \text{ nA} \times 10^6 = 105 \text{ mV}$
- $R_3 = R_1 \parallel R_2 = 9901\Omega$
- -45.096mV

(f)? 滤除电源噪声

Q2

(a)

$$v_o = v_{\text{in(-)}} - v_{\text{in(+)}}$$

(b)

(c)

$$v_{\text{out}} = v_{\text{in(-)}} - v_{\text{in(+)}} + v_{\text{os}} + I_{\text{os}} R$$

$$\text{RTO} = v_{\text{os}} + I_{\text{os}} R; R = 10k\Omega$$

(d)

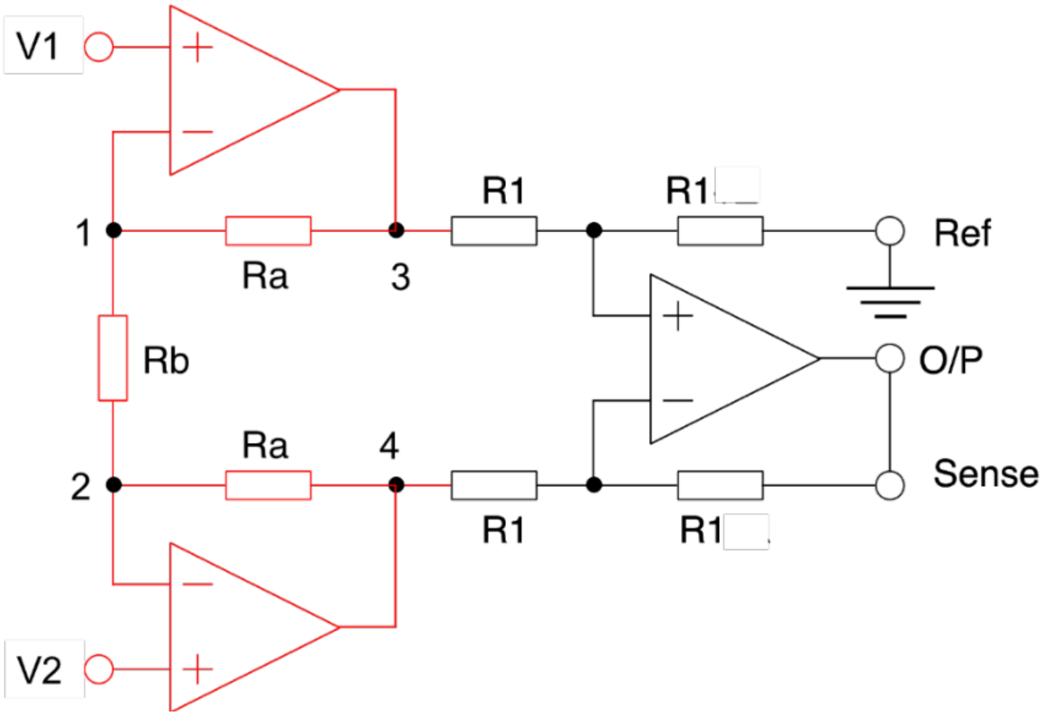
$$F = V_{\text{os}} + I_{\text{os}} R$$

Q3

(a)

To achieve a high CMRR.

(b)

- 

- $A_{\text{dm}} = \frac{R_b+2R_a}{R_b}$

(c)

Twisted pair advantage: Common mode noise.

- The idea of a twisted pair cable is that the currents induced in each of the two wires are very nearly equal.
  - The twisting ensures that the two wires are on average the same distance from the interfering source and are, therefore, affected equally.
  - The “noise” then produces a common-mode signal which can be cancelled due to the very high CMRR of the differential amplifier.
  - This helps ensure that only the wanted difference signal is processed.

- 高输入阻抗:确保从源设备（如传感器）获取信号时不会对其造成负载影响。
- 高 CMRR:能够有效抑制与信号无关的共模干扰，如电源线噪声和环境干扰。

- 可调增益:可以通过外部电阻简单调整增益，以适应不同的测量需求。

Q4

(a)

Summarize possible strategies for improving the Signal to Noise ratio (SNR) when using operational amplifiers:

1. Select a Low-Noise Op-Amp:减少输入的电流与电压噪声
2. Optimize Gain Settings(增加信号增益,抑制噪声增益)
3. Optimize Gain Settings(减少电阻所产生的热噪声)
4. Minimize Bandwidth(在输出端添加一个滤波器)
5. Shielding(屏蔽, 比如用双绞线)

(b):

见 App.typ (c)

- $\text{NEB} = n \times \frac{\text{GBW}}{\text{Noise Gain}} = 1.57 \times \frac{5.2\text{MHz}}{101} = 80.8\ \text{kHz}$ thermal:1.159×10^{-5} and 1.159×10^{-6}
- $E_{\text{opamp}} = e_{\text{nw}} \cdot \sqrt{\text{NEB}} = 4.55 \times 10^{-6}$
  $R_3 = R_1 \parallel R_2 = 1k\Omega$
  $E_{R_1} = G_n \cdot 1.16 \times 10^{-6} = 117.16\mu V$
  $E_{R_2} = G_n \cdot 1.16 \times 10^{-5} = 1170.59\mu V$
  $E_{\text{opamp}} = G_n \cdot 4.55\mu V = 459.55\mu V$
  $E_{R_3} = G_n \cdot 1.15\mu V = 116.15\mu V$
  $E_{\text{tot}} = \sqrt{117.16^2 + 1170.59^2 + 116.15^2 + 459.55^2} = 1.262\ \text{mV}$
  $V_{\text{sig}} = \frac{2}{\sqrt{2}} = 1.414V$
  $\text{SNR} = 20 \log_{10}\left(\frac{1.414}{1.262\ \text{mV}}\right) = 60.98\ \text{dB}$