Diode Temperature Sensor

Experiment: Procedure/Observation

(I) Current source

1. Design the current source circuit shown in Fig. 1 for $I_{DUT} = 1\,\text{mA}$.
2. Use a resistor $R_L = 1\,\text{k}$ as the DUT and verify that $I_{DUT} \approx 1\,\text{mA}$.
3. Use $R_L = 470\,\Omega$, and verify that the DUT current remains the same.
4. Replace R_L with the diode to be used for sensing temperature, i.e., a diode-connected transistor 2N2222. Measure I_{DUT} and V_L.

(II) Difference amplifier

1. Wire up the difference amplifier circuit shown in Fig. 2 (c). Use $R_1 = R_3 = 10\,\text{k}$, $R_2 = 47\,\text{k}$. In order to make $R_4 = R_2$, use the pot arrangement shown in the figure.
2. Apply a large common-mode sinusoidal voltage (e.g., amplitude 6 V, frequency 1 kHz). Adjust the pot such that the output voltage is zero (as small as possible). Leave the pot setting unchanged for the rest of the experiment.
3. Find the gain of the difference amplifier by making $V_2 = 0\,\text{V}$ and applying $V_1 = \hat{V}_1 \sin\omega t$ (say, $\hat{V}_1 = 100\,\text{mV}$, $f = 1\,\text{kHz}$).

(III) Complete sensor circuit

1. Wire up the voltage divider circuit shown in Fig. 2 (b). Record the minimum and maximum achievable values of V_{ref} by adjusting the pot. Verify that they are consistent with your calculations.
2. Wire up the complete sensor circuit (Fig. 2 (a)). Adjust V_{ref} to make the output voltage V_o equal to the LM-35 output voltage at room temperature, i.e., without any heating. Measure the diode voltage V_D as well. All voltages should be measured with a multi-meter with a resolution of 1 mV.

   Do not change V_{ref} hereafter.
3. Apply $V_R = 0.5\,\text{V}$ to the heating element. Wait for five minutes for the temperature to settle. Measure V_D, V_o, V_{LM35}. The diode temperature in °C is given by $V_{LM35}/10$ where V_{LM35} is in mV.
4. Repeat for V_R equal to 1 V, 1.5 V, $\cdots$, 5 V.
5. Plot $V_o(T)$ and $V_D(T)$, and estimate $\dfrac{dV_D}{dT}$ and $\dfrac{dV_o}{dT}$.

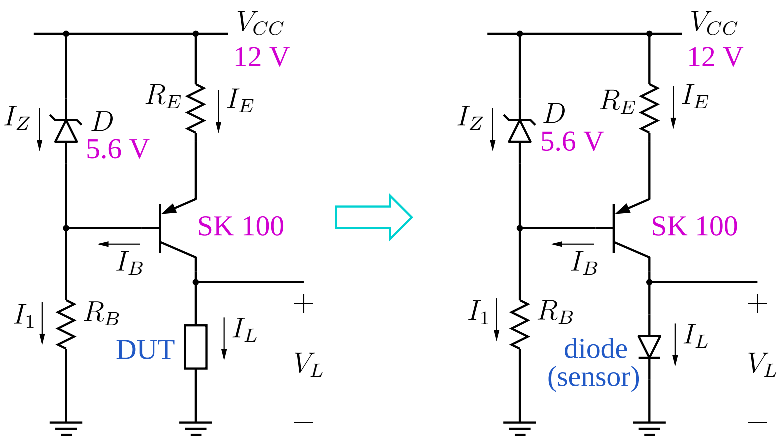

Figure 1: Implementation of a constant current source. DUT stands for "device under test" which is a diode-connected transistor in our experiment.

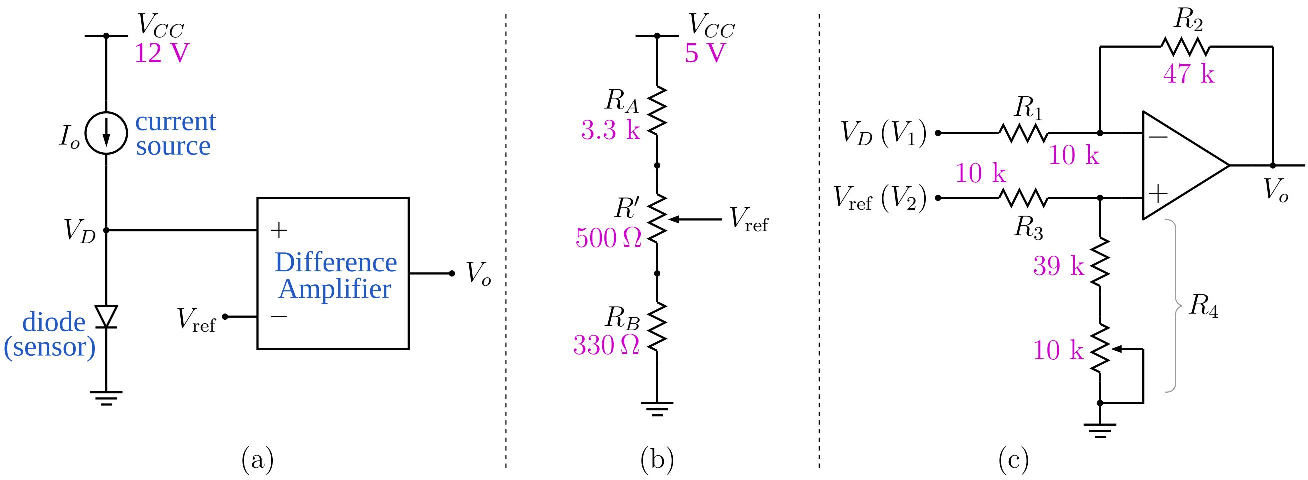

Figure 2: (a) Overall sensor circuit, (b) potential divider to obtain $V_{\rm ref}$, (c) difference amplifier.