นายโสภณ สุวสมบูรณ์
6201011631188 Measurement

PIV

11.12 An RTD fabricated from platinum exhibits a temperature coefficient of resistivity $\gamma_1 = 0.003902/°C$. Assume that γ_2 is negligible. If the resistance of the sensor is 100 Ω at 0°C, find the resistance at

(a) −240°C
(b) −120°C
(c) 90°C
(d) 260°C
(e) 600°C
(f) 900°C

Formula : $R = R_0(1 + \gamma_1 T + \gamma_2 T^2 + \cdots \gamma_n T^n)$

(a) $T = -240°C$

$R = (100\,\Omega)(1 + [0.003902/°C][-240°C])$

$R = 6.352\ \Omega$

(b) $T = -120°C$

$R = (100\,\Omega)(1 + [0.003902/°C][-120°C])$

$R = 53.176\ \Omega$

(c) $T = 90°C$

$R = (100\,\Omega)(1 + [0.003902/°C][90°C])$

$R = 135.118\ \Omega$

(d) $T = 260°C$

$R = (100\,\Omega)(1 + [0.003902/°C][90°C])$

$R = 201.452\ \Omega$

(e) $T = 600°C$

$R = (100\,\Omega)(1 + [0.003902/°C][600°C])$

$R = 334.12\ \Omega$

(f) $T = 900°C$

$R = (100\,\Omega)(1 + [0.003902/°C][900°C])$

$R = 451.18\ \Omega$

11.16 A platinum RTD with a resistance of 100 Ω at 0°C is used in the constant-current potentiometer circuit shown in Fig. 11.8. If the current i equals 5 mA, determine the output voltage v_o at the following temperatures:

(a) −240°C (b) −120°C (c) 90°C (d) 260°C (e) 600°C (f) 900°C

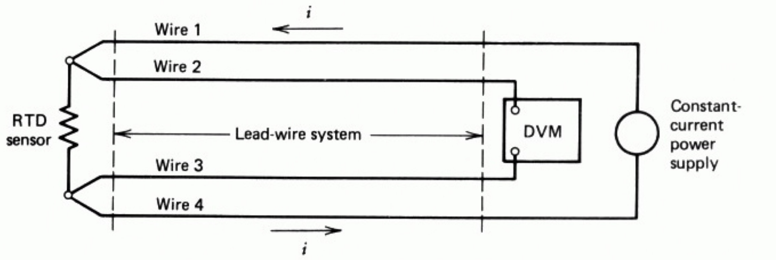

Figure 11.8 Constant-current potentiometer circuit with lead-wire compensation and automatic reading of the output from an RTD sensor.

โจทย์กำหนดให้ $I = 5\text{ mA}$, $R = R$ ในข้อที่ ก.2

(a) $T = -240^\circ C \Rightarrow R = 6.253\,\Omega$

จาก $V = IR$

$= (5\times10^{-3}\text{ A})(6.253\,\Omega)$

$\therefore V = 0.031265\text{ V} = 31.265\text{ mV}$

(b) $T = -120^\circ C \Rightarrow R = 53.176\,\Omega$

จาก $V = IR$

$= (5\times10^{-3}\text{ A})(53.176\,\Omega)$

$\therefore V = 0.26588\text{ V} = 265.88\text{ mV}$

(c) $T = 90^\circ C \Rightarrow R = 135.188\,\Omega$

จาก $V = IR$

$= (5\times10^{-3}\text{ A})(135.188\,\Omega)$

$\therefore V = 0.67594\text{ V} = 675.94\text{ mV}$

(d) $T = 260^\circ C \Rightarrow R = 201.452\,\Omega$

จาก $V = IR$

$= (5\times10^{-3}\text{ A})(201.452\,\Omega)$

$\therefore V = 1.00726\text{ V}$

(e) $T = 600^\circ C \Rightarrow 334.12\,\Omega$

จาก $V = IR$

$= (5\times10^{-3}\text{ A})(334.12\,\Omega)$

$\therefore V = 1.6706\text{ V}$

(f) $T = 900^\circ C \Rightarrow 451.18\,\Omega$

จาก $V = IR$

$= (5\times10^{-3}\text{ A})(451.18\,\Omega)$

$\therefore V = 2.2559\text{ V}$

11.20 Verify Eq. 11.13.

11.21 If $\beta = 4350$ K and $R_0 = 3000\ \Omega$ at $T_0 = 298$ K, determine the resistance of a thermistor at

(a) −80°C
(b) −40°C
(c) 0°C
(d) 50°C
(e) 75°C
(f) 150°C

Formula: $$R = R_0 e^{\beta(1/\theta - 1/\theta_0)}$$

and $K = 273 + C$

(a) $-80^\circ C$, $K = 273 - 80$

$K = 193\ K$

; $R = (3000\,\Omega)\, e^{(4350K)\left(\frac{1}{193K} - \frac{1}{298K}\right)}$

$= 8{,}435{,}100.892\ \Omega \approx 8.4351\ M\Omega$ #

(b) $-40^\circ C$, $K = 273 - 40$

$K = 233\ K$

; $R = (3000\,\Omega)\, e^{(4350K)\left(\frac{1}{233K} - \frac{1}{298K}\right)}$

$= 176{,}059.983\ \Omega \approx 176.059\ k\Omega$ #

(c) $0^\circ C$, $K = 273 - 0$

$K = 273\ K$

; $R = (3000\,\Omega)\, e^{(4350K)\left(\frac{1}{273K} - \frac{1}{298K}\right)}$

$= 11419.96097\ \Omega \approx 11.419.961\ k\Omega$ #

(d) $50^\circ C$, $K = 273 + 50$

$K = 323\ K$

; $R = (3000\,\Omega)\, e^{(4350K)\left(\frac{1}{323K} - \frac{1}{298K}\right)}$

$= 969.271\ \Omega$ #

(e) $75^\circ C$, $K = 273 + 75$

$K = 348\ K$

$R = (3000\,\Omega)\, e^{(4350K)\left(\frac{1}{348K} - \frac{1}{298K}\right)}$

$= 368.3568\ \Omega$ #

(f) $150^\circ C$, $K = 273 + 150$

$= 423\ K$

; $R = (3000\,\Omega)\, e^{(4350K)\left(\frac{1}{423K} - \frac{1}{298K}\right)}$

$R = 40.1547\ \Omega$ #

11.30 A DVM is being used to measure the output voltage v_o from a copper-constantan thermocouple, as shown in Fig. E11.30.

(a) Determine the output voltage v_o indicated by the DVM.

(b) If the DVM reading changes to 2.078 mV, what is the new temperature T_1?

(c) Do temperatures T_2 or T_3 influence the measurement? Why?

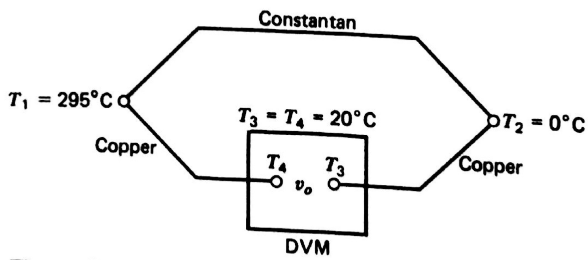

Figure E11.30

(a) $V_0 = S_{copper/constantan}(T_1 - T_2)$

$V_0 = (6.5 - (-35))(295 - 0)$

$= 12242.5\ \mu V = 12.2425\ mV$ #

(b) $(2.078 \times 10^{-3}) = (41.5 \times 10^{-6})(T_1 - 0)$

; $T_1 = 50.072\ ^\circ C$ #

(c) T_2 เนื่องจาก formula : $V_0 = C_1(T_1 - T_2) + C_2(T_1^2 - T_2^2)$

จะสังเกตว่า Temerature ที่มีผลกับ แรงดันมีแค่ 2 T คือ T_1 และ T_2 นั่นเอง

other (a) or (b)?

11.33 A DVM is being used to measure the output voltage v_o from an iron-constantan thermocouple, as shown in Fig. E11.33.

(a) Determine the temperature T_1 associated with a DVM reading of 14.123 mV.

(b) Does the separation at junction 1 influence the measurement of T_1? List any assumptions made in reaching your answer.

(c) How far can the junctions be separated before errors will develop? Explain.

(a) $V_0 = S_{iron/constantan}(T_1 - T_2)$

$(14.123 \times 10^{-3}) = (53.5 \times 10^{-6})(T_1 - 0)$

$T_1 = 263.9813\ ^\circ C$

(b) ในการวัดอุณหภูมิที่จุด T_1 ต้องใช้ Thermo Junction effect

(c) น้อยมากๆ