

Principles of Communications 7th Edition Solution Manual

Problem A.1

All parts of the problem are solved using the relation

$$V_{\text{rms}} = \sqrt{4kTRB}$$

where

$$\begin{aligned} k &= 1.38 \times 10^{-23} \text{ J/K} \\ B &= 30 \text{ MHz} = 3 \times 10^7 \text{ Hz} \end{aligned}$$

- a. For $R = 10,000$ ohms and $T = T_0 = 290$ K

$$\begin{aligned} V_{\text{rms}} &= \sqrt{4(1.38 \times 10^{-23})(290)(10^4)(3 \times 10^7)} \\ &= 6.93 \times 10^{-5} \text{ V rms} \\ &= 69.3 \text{ } \mu\text{V rms} \end{aligned}$$

- b. V_{rms} is smaller than the result in part (a) by a factor of $\sqrt{10} = 3.16$. Thus

$$V_{\text{rms}} = 21.9 \text{ } \mu\text{V rms}$$

- c. V_{rms} is smaller than the result in part (a) by a factor of $\sqrt{100} = 10$. Thus

$$V_{\text{rms}} = 6.93 \text{ } \mu\text{V rms}$$

- d. Each answer becomes smaller by factors of 2, $\sqrt{10} = 3.16$, and 10, respectively.

Problem A.2

Use

$$I = I_s \exp \frac{eV}{kT} - 1$$

We want $I > 20I_s$ or $\exp \frac{eV}{kT} - 1 > 20$.

- a. At $T = 290$ K, $\frac{e}{kT} = \frac{1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times 290} \approx 40$, so we have $\exp(40V) > 21$ giving

$$V > \frac{\ln(21)}{40} = 0.0761 \text{ volts}$$

$$I_{\text{rms}}^2 = 2eIB = 2eBI_s \exp \frac{eV}{kT}$$

$$\begin{aligned} \text{or } \frac{I_{\text{rms}}^2}{B} &= 2eI_s \exp \frac{eV}{kT} \\ &= 2 \frac{1.6 \times 10^{-19}}{1} \frac{1.5 \times 10^{-5}}{1} \exp(40 \times 0.0761) \\ &= 1.0075 \times 10^{-22} \text{ A}^2/\text{Hz} \end{aligned}$$

- b. If $T = 90$ K, then $\frac{e}{kT} = 129$, and for $I > 20I_s$, we need $\exp(129V) > 21$ or

$$V > \frac{\ln(21)}{129} = 2.36 \times 10^{-2} \text{ volts}$$

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