Answer on Question #50911, Physics, Computational Physics

2. b) Noise voltage from a 50 Ω resistor obtained after amplification by an amplifier with 60 dB voltage gain is 100 mV at 27º C. Calculate the bandwidth of the amplifier. What will be the noise voltage if the temperature is increased to 57º C?

Answer:

Noise voltage from a 50 Ω resistor

$$U = \sqrt{4k_B TR\Delta f} \tag{1}$$

where $k_B = 1.38 \cdot 10^{-23} J/K$ is the Boltzmann constant; $R = 50\Omega$ is the resistor value in ohms; T is the resistor's absolute temperature in kelvin.

So according to condition of the problem

$$60dB = 20\lg\frac{100mV}{U_1} \Rightarrow U_1 = 100/1000 = 0.1mV\,. \tag{2}$$

From Eq. (1) – Eq.(2)

$$\Delta f = U_1^2/\left(4k_B T_1 R\right) = \left(0.1\cdot 10^{-3}\right)^2/\left(4\cdot 1.38\cdot 10^{-23}\cdot 300\cdot 50\right) = 1.2\cdot 10^{10} Hz \tag{3}$$

where $T_1 = 27 + 273 = 300K$

If the temperature is increased to 57ºC, the noise voltage will be

$$U_2 = \sqrt{4k_B T_2 R\Delta f} = \sqrt{4k_B T_1 R\Delta f\cdot\left(T_2/T_1\right)} = U_1\sqrt{\left(T_2/T_1\right)} = 0.1mV\sqrt{330/300} \approx 0.105mV$$

where $T_2 = 57 + 273 = 330K$