EE4341 TUTORIAL 1 SOLUTION

1. Only consider thermal noise as there is no flicker noise.

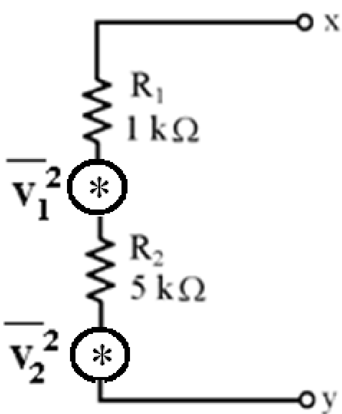
$$\overline{v^2} = 4kTR \quad \mathrm{V^2/Hz}$$

$$4kT = 4\times1.38\times10^{-23}\times290 \approx 1.6\times10^{-20}$$

$$\mathrm{V_{rms}} = \sqrt{4kTR\Delta f} = \sqrt{1.6\times10^{-20}\times50k\times\Delta f} = 28.29\sqrt{\Delta f} \quad \mathrm{nV}$$

Δf	$\mathrm{V_{rms}}$
50 kHz	6.33 μV
1 MHz	28.29 μV
20 MHz	126.52 μV

2.



$$\overline{v_1^2} = 4kTR_1$$

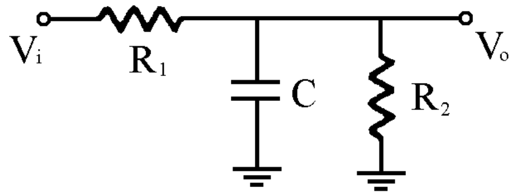
$$\overline{v_2^2} = 4kTR_2$$

$$\overline{v_T^2} = \overline{v_1^2} + \overline{v_2^2} = 4kT(R_1+R_2) = 1.656\times10^{-20}(1k+5k)$$

$$= 9.936\times10^{-17} \quad \mathrm{V^2/Hz}$$

$$V_{T,\mathrm{rms}} = \sqrt{\overline{v_T^2}\Delta f} = \sqrt{9.936\times10^{-17}\times\Delta f} = \sqrt{9.936\times10^{-17}\times10M} = 31.52\ \mu\mathrm{V}$$

3.



$$\frac{V_o}{V_1} = \frac{R_2 // \left(\frac{1}{j\omega C}\right)}{R_1 + R_2 // \left(\frac{1}{j\omega C}\right)} =$$

$$R_2 // \left(\frac{1}{j\omega C}\right) = \frac{R_2\left(\frac{1}{j\omega C}\right)}{R_2 + \frac{1}{j\omega C}} = \frac{R_2}{1 + j\omega C R_2}$$

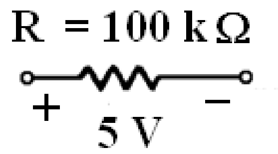
$$\therefore \frac{V_o}{V_1} = \frac{\frac{R_2}{1 + j\omega C R_2}}{R_1 + \frac{R_2}{1 + j\omega C R_2}} = \frac{R_2}{R_1 + R_2 + j\omega C R_1 R_2}$$

$$= \left(\frac{R_2}{R_1 + R_2}\right)\left(\frac{1}{1 + \frac{j\omega C R_1 R_2}{R_1 + R_2}}\right) = \left(\frac{R_2}{R_1 + R_2}\right)\left(\frac{1}{1 + \frac{j\omega}{\omega_o}}\right)$$

$$\omega_o = \frac{1}{C\left(\frac{R_1 R_2}{R_1 + R_2}\right)} \Rightarrow f_o = \frac{1}{2\pi C\left(\frac{R_1 R_2}{R_1 + R_2}\right)}$$

$$\Delta f = \frac{\pi}{2} f_o = \frac{\pi}{2} \times \frac{1}{2\pi C\left(\frac{R_1 R_2}{R_1 + R_2}\right)} = \frac{1}{4C\left(\frac{R_1 R_2}{R_1 + R_2}\right)}$$

4.



$$\overline{v_{ex}}^{\,2} = \frac{m^2 V_{DC}{}^2}{f} \quad \text{V}^2/\text{Hz}$$

$$V_{ex} = \sqrt{\int_{f_1}^{f_2} \overline{v_{ex}}^{\,2} df} = \sqrt{\int_{f_1}^{f_2} \frac{m^2 V_{DC}{}^2}{f} df} = mV_{DC}\sqrt{\ln\frac{f_2}{f_1}} \quad \text{V}$$

$$\because NI = \frac{V_{ex}}{V_{DC}} \quad \text{V/V per decade}$$

$$NI = \frac{mV_{DC}\sqrt{\ln 10}}{V_{DC}} = m\sqrt{\ln 10} \Rightarrow m = \frac{NI}{\sqrt{\ln 10}}$$

$$V_{ex} = \frac{NI}{\sqrt{\ln 10}} V_{DC}\sqrt{\ln\frac{f_2}{f_1}} = V_{DC} NI \sqrt{\frac{\ln f_2/f_1}{\ln 10}} = V_{DC} NI \sqrt{Log\,\frac{f_2}{f_1}} \quad \text{V}$$

$$V_{ex} = (5\text{V})(5\times 10^{-6}\ \text{V/V})\sqrt{Log\,\frac{200k}{20}} = 50\mu\text{V}$$

$$V_t = \sqrt{4kTR\Delta f} = \sqrt{1.656\times 10^{-20}\times 100k(200k - 200)} = 18.2\mu\text{V}$$

$$V_{rms} = \sqrt{V_{ex}{}^2 + V_t{}^2} = \sqrt{50^2 + 18.2^2} = 53.21\mu\text{V}$$