Introduction to Time-Varying Electrical Networks: Assignment Week

In the problems that follow, assume that the opamps are ideal, but are associated with a noise voltage at their inputs denoted by $v_{n,a}$ (the corresponding spectral density is denoted by $S_{va}(f)$.)

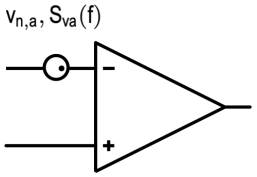

Figure 1: Noise model for an opamp, which is otherwise ideal.

Problem 1

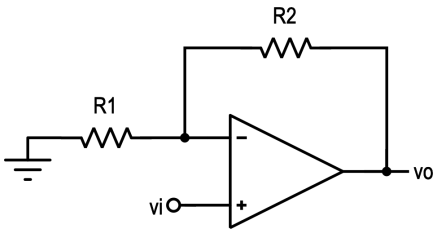

Figure 2: Circuit for problem 1.

For the circuit of Fig. 2 determine the equivalent input-referred noise voltage spectral density.

Problem 2

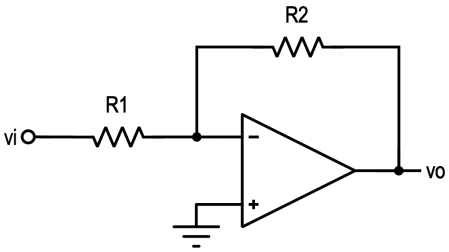

Figure 3: Circuit for problem 2.

Repeat problem 1 for the circuit of Fig. 3.

Problem 3

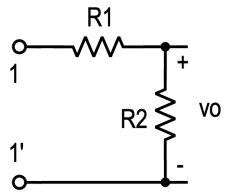

Figure 4: Network for problem 3.

In the network of Fig. 4, determine the spectral densities of the equivalent input-referred equivalent noise voltage and current spectral densities.

Problem 4

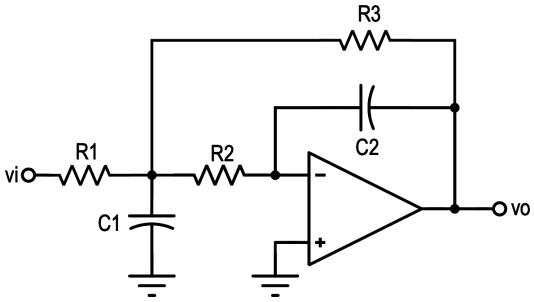

Figure 5: Network for problem 4.

Determine the output noise spectral density of the lowpass filter circuit shown in Fig. 5. The opamp is noisy, as mentioned at the beginning of this tutorial.

Problem 5

Consider a network consisting of resistors, capacitors, and voltage-controlled current sources. The transconductance of the i^{th} VCCS is denoted by $g_{m,i}$. Every resistor is accompanied by its noise source, as usual, and every transconductance is accompanied by a noise current in parallel with the output, with a spectral density is given by $4kT/g_{m,i}$.

Denote the output noise voltage spectral density of the network by $S_{v,out}(f)$. Now, all the resistors in the network are doubled, and transconductors are halved. Determine the output voltage spectral density of the network now.

Problem 6

Consider a network consisting of resistors, capacitors, and voltage-controlled current sources. The transconductance of the i^{th} VCCS is denoted by $g_{m,i}$. Every resistor is accompanied by its noise source, as usual, and every transconductance is accompanied by a noise current in parallel with the output, with a spectral density is given by $4kT/g_{m,i}$.

Denote the output noise voltage spectral density of the network by $S_{v,out}(f)$. Now, all the capacitors in the network are doubled. Determine the output voltage spectral density of the network now.