Department of Avionics,
Indian Institute of Space Science & Technology, Trivandrum

AV491 – Advanced Sensors and Interface Electronics

Instructor: Anoop C. S.

Tutorial – **Noise**

Q. 1. Estimate the RMS input voltage noise of 741 OPAMP over the following frequency bands. (a) instrumentation range (0.1 Hz to 100 Hz), (b) audio range (20 Hz to 20 kHz), (c) wide-band range (0.1 Hz to 1 MHz)

Q. 2. Find the thermal noise associated with 1 kΩ resistor for a noise bandwidth of 1 Hz at below temperatures: (a) 25°C, (b) 77 K (liquid nitrogen), (c) 4.2 K (liquid helium)

Q. 3. Calculate the voltage noise produced by shot noise (at 27°C) in the base-emitter junction of a transistor biased in active region. Assume emitter current = 10 mA and noise bandwidth of 10 kHz.

Q. 4. Calculate the thermal noise of a conductor with same resistance and same noise bandwidth as the forward-biased junction in Q. 3.

Q. 5. Consider a 10 kΩ resistor at room temperature. Find (a) its voltage and current spectral densities, and (b) RMS noise voltage over the audio-range

Q. 6. Find the SNR for a diode over a bandwidth of 1 MHz if diode-current is 1μA and 1 nA.

Q. 7. Find the noise-bandwidth of a second-order low-pass filter having (i) natural frequency f_C and damping factor = 1, (i) natural frequency f_C and damping factor = 2

Q. 8. Study the noise models of BJT, JFET and MOSFET.

Q. 9. An inverting amplifier is configured to have a gain of 2 using 100 kΩ and 200 kΩ resistor. A resistor of 75 kΩ is also inserted for bias current compensation in the circuit. Find the total output-noise at the amplifier output above 0.1 Hz when OPAMP used is 741 IC (e_{nw} = 20 nV/√Hz, f_{CE} = 200 Hz, i_{nw} = 500 fA/√Hz, f_{CI} = 2 kHz, A = 10^6, f_T = 1 MHz). What is the SNR of this circuit if amplitude is 1V.

Q. 10. What values of resistors should be chosen so that the RMS output noise gets reduced to 50 μV and effect of bias current becomes negligible. Compute the SNR for this case as well.

Q. 11. Find the total output noise and SNR of the inverting amplifier circuit if OP07 (e_{nw} =10 nV/√Hz, f_{CE} = 10 Hz, i_{nw} = 170 fA/√Hz, f_{CI} = 50 Hz, A=5*10^5, f_T = 0.6 MHz) was used, instead of 741 IC in Question 9. Is it possible to reduce the noise by 50 %.

Q. 12. Noise (e_n) associated with an IC was measured at two frequencies (f_1 and f_2) and $e_n(f_1)$ = 20 nV/√Hz and $e_n(f_2)$ = 6 nV/√Hz. Assume f_1 = 10 Hz, $f_2 >> f_{CE}$. Find the RMS output noise from 1 mHz to 1 MHz.

Q. 13. Find the Noise-equivalent bandwidth of a two-stage composite amplifier consisting of 2 identical stages of gain $A(jf) = A_0/(1+jf/f_B)$.

Q. 14. Develop a circuit that can accept 3 inputs v_1, v_2 and v_3 and give an output $v_o = 2(v_1-v_2-v_3)$. Derive the expression for RMS output noise in the band (f_L, f_H). Assume noiseless resistors.

Q. 15. Derive the output-noise expressions for (i) a difference amplifier made of 4 resistors R_1 to R_4, (ii) a voltage buffer, (iii) trans-impedance amplifier with feedback resistor R.