Department of Avionics,
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AV491 – Advanced Sensors and Interface Electronics
Instructor: Anoop C. S., Tutorial – **3**

Q. 1. A piezoelectric crystal has an effective mass of 10 g, stiffness of 10^{10} N m^{-1} and damping constant of 200 Ns m^{-1}. Electrical capacitance of crystal is 1000 pF and its charge to force sensitivity is 2×10^{-10} C N^{-1}.
(a) Incorporate the crystal into a Closed-Loop Oscillator System (CLOS) which can oscillate at the crystal parallel resonant frequency.
(b) Design the specifications of the amplifier that should be used in the CLOS.
(c) Draw neatly labelled circuits/waveforms/responses of the CLOS system to explain your design methodology.

Q. 2. A piezoelectric transducer has a capacitance of 1200 pF and sensitivity of 100 pC/μm. The connecting cable has a capacitance of 250 pF, while the oscilloscope used for read-out has an input impedance of 2 MΩ // 75 pF.
(a) Compute the sensitivity (mV/μm) of the transducer alone.
(b) Compute the high-frequency sensitivity (mV/μm) of the entire measurement system.
(c) What is the lowest frequency that can be measured with 5 % amplitude error by the entire system?

Q. 3. An input, x(t) is applied to a piezoelectric transducer.

$$x(t) = \begin{matrix} At; 0 < t < T \\ 0; t > T \end{matrix}$$

Solve the differential equation and find the output of the transducer.

Q. 4. A transit time ultrasonic flowmeter is used to measure the velocity of a fluid in a pipe. Transit time during zero flow was found to be 1 ms. When there is a flow, the differential transit-time is found as 87 μs. The angle between the line connecting the transmitter/receiver and flow direction is 30º.
Find the velocity of the fluid. Velocity of the sound in the fluid is 500 m/s.

Q. 5. Consider the readout circuit of a piezoelectric sensor shown in the figure.

When the piezoelectric sensor generates a charge q_p, the resulting change in voltage Vx is −2 V. Then, find the corresponding change in the voltage V_{out}.