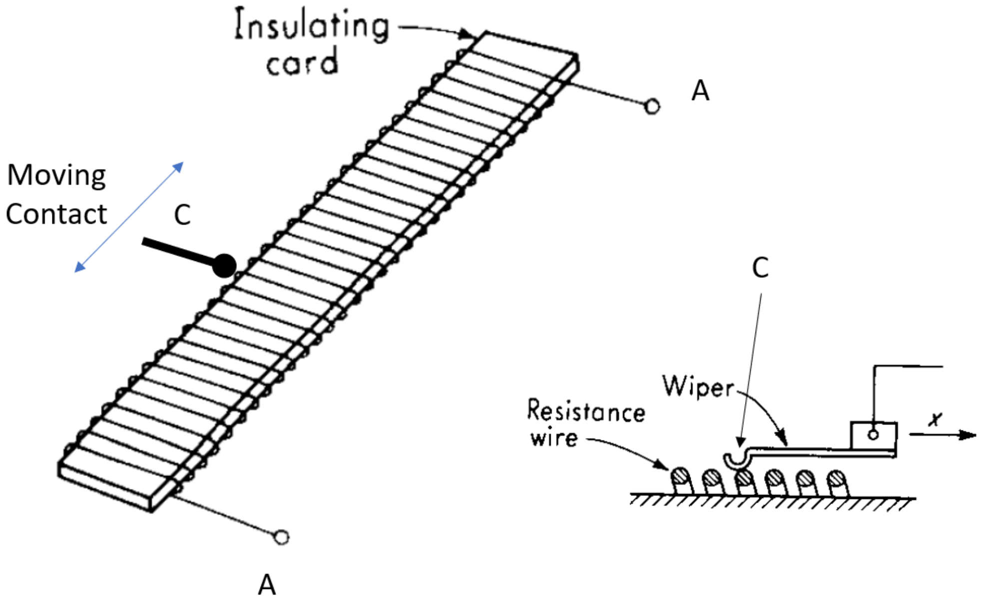
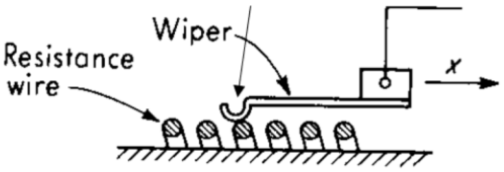
Transducer and Instrumentation – Assignment 04

Measuring Movements

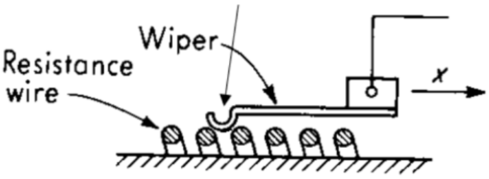
1) A wire-wound potentiometer is constructed by winding a conductive wire around a cuboidal insulate card, with the two ends of the wires forming the two ends of the potentiometer. The moving contact is formed by a third contact that slides over the wound wire as shown in the picture below.



Assuming that the total length of the wire wound on the insulated card is L, and the width and breadth of its cross-section are w and b, respectively. The diameter of the wire is d, and it is wrapped around with a gap of g between two successive loops. Assume that the wire is tightly wound around the insulating cord. The wiper or moving contact can contact one or two adjacent coils of the resistance wire as shown in the following figure.



Wiper contacting one coil of the resistance wire.

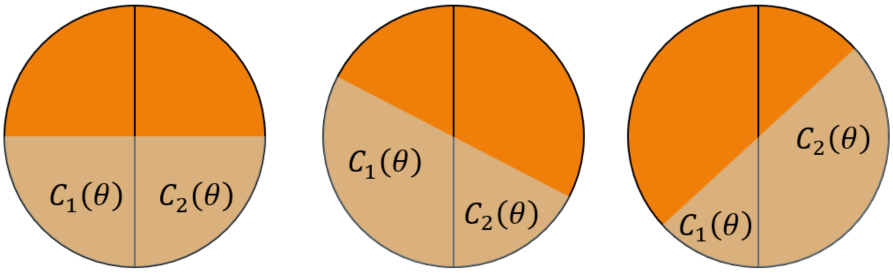


Wiper contacting two adjacent coils of the resistance wire.

Plot the resistance R_{AC} – the resistance between points A and C as a function of x as it varies from 0 to L. Assume that the resistance of the wiper is zero. The value of $x = 0$ when the wiper is at one end of the insulating card (point A), and its value is $x = L$ when it is at the other end. Assuming there is no noise in the system, what is the minimum change in position and resistance that can be detected with this sensor?

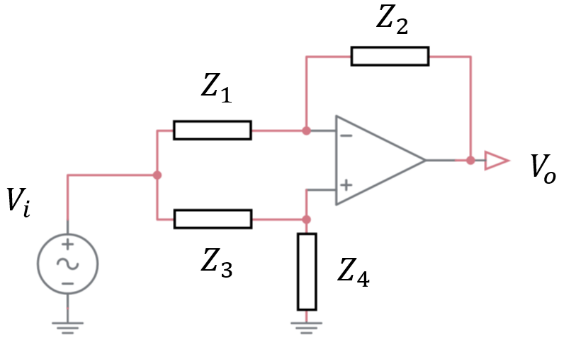
2) Find the output impedance of an LVDT sensor using the equivalent circuit discussed in the lecture. The output of a LVDT sensor is given by $v_o(t) = k \cdot x \cdot \sin(\omega_p t + \varphi)$ when the input is $v_p(t) = \sin(\omega_p t)$. If $L_p = 4mH$, $L_s = 2mH$, $R_p = 100\Omega$, and $R_s = 50\Omega$, find the frequency ω_p at which $\varphi < 0.1\pi$.

3) Compute the expression for the capacitances $C_1(\theta)$ and $C_2(\theta)$, and plot them as function of θ for the following sensor. Note that these are parallel plate capacitors.



$C_1(\theta) = C_2(\theta)$ $C_1(\theta) > C_2(\theta)$ $C_1(\theta) < C_2(\theta)$

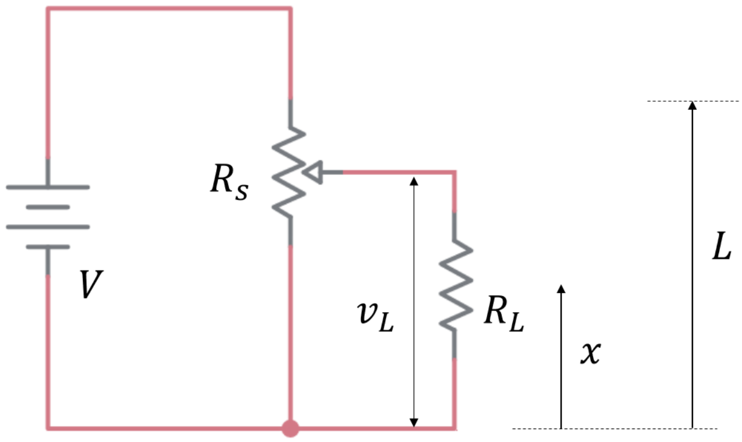
Derive the transfer function of the following bridge amplifier circuit.



$$V_o = \frac{\left(\frac{Z_4}{Z_3} - \frac{Z_2}{Z_1}\right)}{1 + \frac{Z_4}{Z_3}} V_i$$

Assign $C_1(\theta)$ and $C_2(\theta)$ to be two of these impedances, and appropriately choose the remaining two impedances such that the transfer function is proportional to the angle θ. Assuming that the input voltage $v_i(t) = \cos(\omega t)$, come up with a scheme for demodulating the output signal $v_o(t)$ to extract information about $\theta(t)$.

4) Consider the following potentiometer circuit for sensing linear displacement, where a load resistance R_L is connected across the output potentiometer.



Find the expression for the load voltage as a function of the displacement x. When is the sensitivity of this sensor maximum, assuming v_L as the sensor output and x as the sensor input?