EECS 16A Designing Information Devices and Systems I
Spring 2023 Exam Prep 8A

1. Stay Tuned (Fall 2020 Midterm 2 Question 5)

PG&E just announced another power outage and you desperately need a radio transmitter to battle the impending telecommunication doom! You need to build an antenna tuner, which is a variable resistor to control the power of the transmitter signal.

This tuner consists of two identical resistive bars (M_1 and M_2) of length L, and a cross-sectional area of A, as shown in Figure 1. The strips are made of a material with resistivity ρ. The resistive bars are connected with ideal electrical wires in the following configuration:

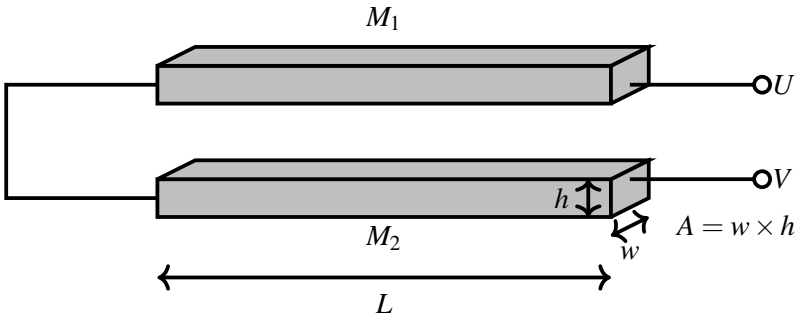


Figure 1: Resistive metal bars connected through ideal wires.

(a) Let R_{UV} be the equivalent resistance between nodes U and V in Figure 1. **Write an expression for R_{UV} in terms of L, A, ρ and other numerical values.** Show your work.

(b) The resistive bar M_1 is flexible, so if we press any point on it a contact is made between M_1 and M_2. As shown in Figure 2, a sliding contact is used to make a contact at position x_0.

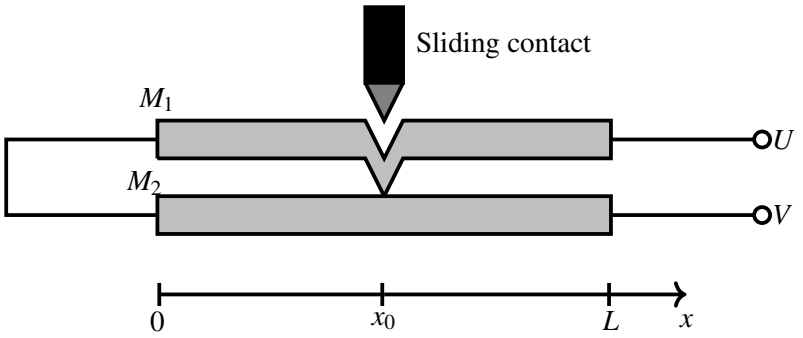


Figure 2: Sliding switch making a contact between M_1 and M_2.

(i) **Draw a circuit diagram that represents the scenario in Figure 2. The sliding contact has no resistance and acts like a wire when the contact is made.** *Hint: Your diagram should have four resistors.*

(ii) **Express the equivalent resistance between nodes U and V, i.e., R_{UV} in terms of L, x_0, A, ρ and other numerical values, when the sliding contact is present**.

(iii) Assume $x_0 = 8\text{cm}$, $L = 10\text{cm}$, $A = 10^{-3}\text{cm}^2$, and $\rho = 5 \times 10^{-3}\Omega\text{cm}$. **Find the value of R_{UV} when the sliding contact is present. Show your work.**

(c) (5 points) Now let us model the transmitter as a voltage source V_S, in series with a resistor R_S, while our antenna tuner is represented by R_{UV}. The circuit model is shown in Figure 3:

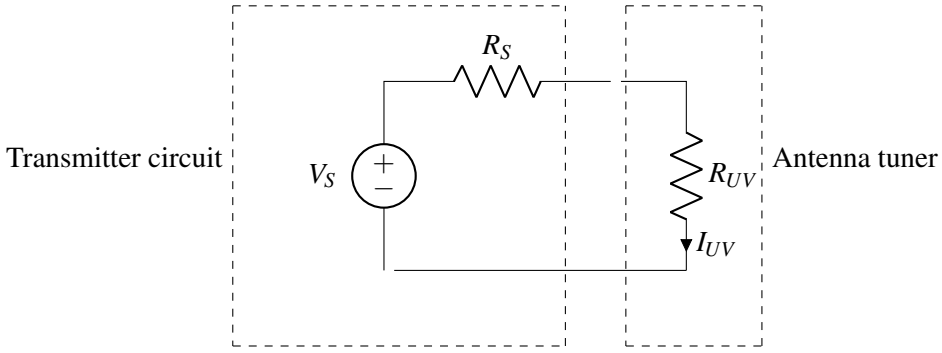
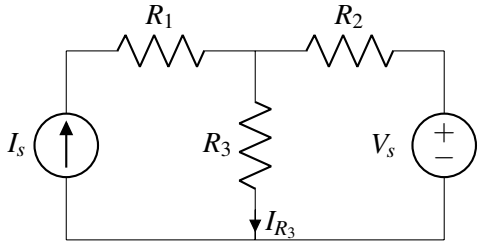


Figure 3: Circuit model for the radio transmitter.

In order to prevent damage to the tuner, we need to make sure that the current through R_{UV} never exceeds 0.1A. **Assuming** $20\Omega \leq R_{UV} \leq 80\Omega$ **and** $R_S = 50\Omega$**, find the maximum allowable value of** V_S**, so that** $I_{UV} \leq 0.1\text{A}$ **for the full range of** R_{UV}**. Show your work.**

2. Superposition

Consider the following circuit:



Let $R_1 = \alpha\Omega$, $R_2 = \beta\Omega$, $R_3 = \gamma\Omega$, $I_s = \delta$A, and $V_s = \varepsilon$V.

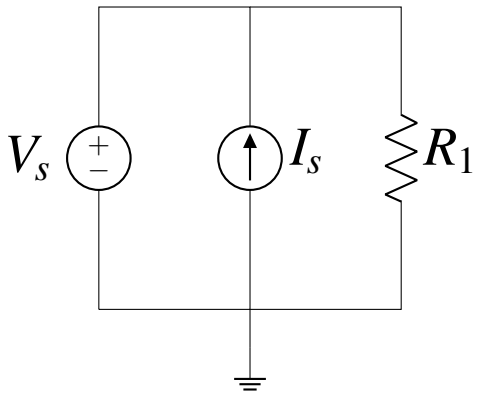
(a) With the current source turned on and the voltage source off, find the current I_{R_3}.

(b) With the voltage source turned on and the current source turned off, find the voltage V_{R_3}.

(c) Find the power dissipated across R_3.

3. Energy/Power (Fall 2021 Midterm 2 Question 19)

In the circuit below, $V_s = 4V$, $I_s = 1.5mA$, and $R_1 = 8000\,\Omega$



(a) What is the power dissipated by R_1?

(b) What is the power supplied by I_s?

(c) What is the power dissipated by V_s?

