Physics S123: Homework 1, Passive Devices I

Total points: 22.

1 Dividers & Their Thevenin Models (12 points, total of points shown below)

Suppose you are given a +100V (DC) power supply, and you are asked to design circuits to deliver two output voltages, 50V and 10V, subject to the specifications shown below:

50V output: should droop no more than 10% when 100µA is drawn from the output into a “load” returned to ground.

10V output: should droop no more than 10% when loaded by a 100k resistor to ground.

'What are we asking?', you ask Students sometimes complain that they’re not sure what we’re asking, on some problem-set questions. If you find yourself puzzled in this way, don’t suffer in silence: send an email.

Figure 1: The two outputs you are to produce
1.1 Thevenin Models (4 points)

Show Thevenin models for the voltage sources you are asked to produce. Show numbers for $V_{\text{Thev}}$ and $R_{\text{Thev}}$. You may use exact values, even these would not be practical to implement in a circuit. (We hope you’ll discover that this model provides the best way to solve the problem posed in problem 2, below. We’re promoting Thevenin, here.)

**Design the Circuits**, in two ways, detailed below:

1.2 Circuits (8 points)

Design the two circuits, minimizing power dissipation, given the constraints stated above. Show your circuit’s resistor values in two ways:

- exact values (‘textbook’ values: e.g., “17k” is OK)
- 10% values (that is, values you would use in a lab equipped with the usual resistor values, which keep incrementing by 10%: not “17k” but “18k”)

Here are the 10% values, as a reminder:

10 12 15 18 22 27 33 39 47 56 68 82 100

You can scale these, of course: 10k, 12k...etc.

1.3 Power dissipation optional: (2 points)

How much power is dissipated by the divider you designed to drive the 100k load? (With no load attached.)

How much power would that divider dissipate (no load attached), if it had been designed so that it “should droop no more than 10% when loaded by a 1k resistor to ground.”
2 Effect of Loading by Instruments (6 points, total of points shown below)

What happens to $V_{out}$ for each of the two circuits of problem 1 (a,b), above, when that circuit drives each of the following instruments (give answers to roughly 1%, this time)–DVM, VOM, and your home-made voltmeter of Lab 1. (Labor-saving HINT: use your Thevenin models. Doing this should keep the arithmetic easy; don’t overwork yourself by calculating performance of the actual circuits you designed, with their non-ideal resistors.)

2.1 A DVM with (constant-) $R_{in}$ of 10MΩ? (2 points)

![Figure 2: 50V](image)

(50V output (your answer, here))

![Figure 3: 10V](image)

(10V output (your answer, here))
2.2 A VOM whose front panel shows the specification, “20,000 Ω/V” (2 points)

(This is a little harder\textsuperscript{1}). Assume that the meter can be switched to any of the following full-scale ranges: 1V, 10V, 50V, 1000V. Choose the single most appropriate range.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure4.png}
\caption{50V (50V output (your answer, here))}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure5.png}
\caption{10V (10V output (your answer, here))}
\end{figure}

\footnote{If you’re not yet clear on what “20,000 Ω/V” means, see the Manual’s worked example at pp. 22-23 for help.}
3 Accidental Filters *(4 points)*

![Two accidental filters](image)

Figure 6: Two accidental filters

3.1 *Which is which? (2 pts)*

Which is the low-pass, which the high-pass? Which might work as differentiator, which might work as integrator? (Explain your answer, briefly.)

3.2 *... How Would you Test to find the answer ’which is which?’ (2 pts)*

If you suspect you’ve got one of these accidental filters, what’s the quickest way to check whether in fact you do? (Use your instruments, not just your eyeballs!)