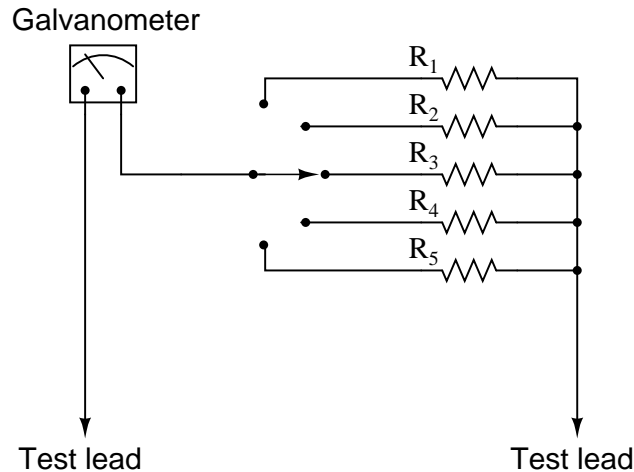


Design Project: Voltmeter

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Your project is to design and build a multi-range voltmeter, using a sensitive galvanometer movement and a set of external resistors. Here is a sample schematic diagram for you to follow when designing your system:



Of course, you are not restricted to using this exact design.

Deadlines (set by instructor):

- Project design completed:
- Components purchased:
- Working prototype:
- Finished system:
- Full documentation:

Question 1

The most important component of your voltmeter will be the galvanometer movement itself. Identify some of the ideal characteristics of this device. For example, what should its full-scale current rating be (very high or very low), and why?

file 01499

Answer 1

Look for a galvanometer with the lowest full-scale current rating possible (you should be able to obtain meter movements with I_{FS} ratings as low as $50\ \mu\text{A}$ with little difficulty). Ruggedness is another ideal characteristic, as is a mirrored scale to avoid parallax errors.

Notes 1

I have found a good source of meter movements for students' own voltmeter projects to be inexpensive analog multimeters. These may be obtained from most tool stores in the United States for \$30 or less (2004 prices), and come with multiple scales on the faces, plus mirror bands for anti-parallax reading. General-purpose galvanometer movements may be obtained through wholesale electronics suppliers, but generally not at the same (low) cost as these consumer-grade meters.

It may seem like a shame to purchase a multimeter only to tear it apart and re-build it as a simple voltmeter, but the purpose here is to learn how to design range resistor circuitry and calibrate a meter once it's built.

Question 2

Suppose you have found a sensitive meter movement to be the heart of your voltmeter project, but you don't know much about its electrical characteristics. How would you experimentally determine the two most important characteristics of the meter movement: its *full-scale current rating* and its *coil resistance*?

file 01500

Answer 2

A precise measurement of coil resistance may be obtained using a digital multimeter (ohmmeter) connected to the meter movement. Determining the meter movement's full-scale current rating, especially without danger of damaging the meter from accidental overcurrent, entails that you design a test circuit specifically for this purpose.

Notes 2

As the instructor, you may be called on for frequent assistance by students as they prepare to test their meter movements for full-scale current. You may be called upon by less thoughtful students as they ask you to explain why their galvanometer won't move anymore after being directly connected to a 6 volt battery.

The exercise of experimentally determining a meter's full-scale current rating is a great way to prepare students for the creative challenges of the workplace. Technicians are frequently asked to invent test jigs and other custom circuitry to measure quantities for which there are no "off-the-shelf" meters to measure, or to perform specialized tasks for which there are no ready-made devices to do it. This is where technicians really prove their worth to a business enterprise, and where competent technicians distinguish themselves from the incompetent.

Question 3

A common adage heard among instrument designers is the phrase, “*Don’t make it accurate; make it adjustable.*” Modify the example meter design to include independent adjustment for each of the voltage ranges.

file 01501

Answer 3

This is easy to do with potentiometers, connected as variable resistors. The real challenge, though, is to determine how to use available potentiometers to give adjustment ranges that are not too large or too small. In other words, you want your potentiometers to have fine enough adjustment to allow you to precisely “dial in” a calibrated range, yet not so fine that you “run out of adjustment” if your calculations happen to be off.

Notes 3

Some students may suggest using nothing but potentiometers (no fixed resistors) in their voltmeter circuits. While this is theoretically possible, it ends up being impractical due to the adjustments being too coarse. This becomes an excellent exercise in “bracketing” a potentiometer’s range through the judicious connection of fixed-value resistors in the circuit.

Something students might not be aware of when they begin this project is multi-turn potentiometers. If ever there was an application for them, this is it!