Design Project: DC voltage regulator

Your project is to design and build a DC voltage regulator capable of regulating 24 volts DC (input) to an adjustable output with a range of *at least* 3 to 20 volts, with a maximum continuous current rating of 2 amps. Your circuit must be built entirely from discrete components (no integrated circuits), and regulate voltage to within 10%, from no load to full load. Your team is responsible for selecting and testing the circuit design.

A circuit such as this would typically follow an AC-DC power supply (transformer, rectifier, and filter).

Deadlines (set by instructor):

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

Question 1

It may seem difficult to even start on a project such as this, with no schematic diagram provided. Identify a few different sources of information where you might find sample voltage regulator circuits, to begin your design from.

Why do you suppose your instructor decided to challenge you with a project such as this, with no schematic diagram to follow and plenty of things to potentially go wrong?

file 01520

Answer 1

I'll let you determine where sample voltage regulator circuit designs may be found.

As to the question of why the instructor would challenge you in this way, the answer is quite simple: to prepare you for the realities of a challenging career in electronics. Think of this project as being a small-scale example of the work world, where you will be required to overcome technical obstacles on a routine basis, often with little or no assistance.

Challenges are a fact of life. It would be unrealistic to expect you to have immediate answers to every challenge you will ever face. What *is* expected of you, however, is a positive attitude and the skillful persistence to *find* those answers in due time.

Notes 1

Not much needs to be said here!

Question 2

When designing a project such as this, it is a good idea to "prototype" the circuit before soldering components together, where they will be more difficult to replace, exchange, and reconfigure. Explain how you intend to prototype your circuit prior to assembling it in its final form.

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Answer 2

I'll let you determine the answer to this question!

Notes 2

Students are typically loathe to prototype *anything* for fear of "wasting time" when they could be building something in its final form. What most students fail to realize, though, is that they will waste far more time by re-doing their "final" build than they would have spent prototyping the circuit in less permanent form.

Prototyping is an essential part of the design and build process. You may elect to hold your students accountable to this process as part of their grade, or let them choose not to prototype (and allow them to discover firsthand why they should have prototyped their circuit).

Question 3

Your circuit will no doubt use a zener diode to establish the reference voltage. The zener diode circuit itself (including the series "dropping" resistor) is incapable of supplying high current to a load. How, then, does your circuit manage to supply at least *2 amps* to the load, when using a zener voltage reference?

file 01516

Answer 3

The zener reference circuit will have to be "followed" by a transistor amplifier of some sort.

Notes 3

Student designs will vary on this point, exactly how they boost the zener's low current output up to 2 amps. Indeed, this is the real challenge of the design, to make a good amplifier for the task.

Question 4

Make a rough calculation of the power your circuit's final output transistor(s) must dissipate when carrying the full 2 amps of current. Will the power dissipation be greatest at maximum voltage (20 volts) output or minimum voltage (3 volts) output? Explain why.

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Answer 4

The answer to this question may surprise you, being somewhat nonintuitive. You may find that power dissipation is the most significant technical challenge to overcome in this circuit design: how to ensure your circuit will not be damaged by excessive heat.

Notes 4

Having students recognize this design problem and engineer solutions to it is very important part of this project, and it will greatly enhance their practical understanding of transistor circuits as well!

Question 5

The best regulator designs use *feedback* to ensure "tight" regulation of voltage over a wide range of load currents. Explain what this "feedback" is, and how it works to improve voltage regulation.

file 01519

Answer 5

With "feedback," the output voltage is sampled and "fed back" to a prior stage in the transistor circuit, so that any load-induced change in output voltage elicits a response from the amplifier to counter-act that change. In other words, feedback makes the circuit "aware" of its own output.

Notes 5

Many voltage regulator circuits employ operational amplifiers (using negative feedback) to accomplish this very design goal: improved voltage regulation. Your students may find a perusal of an op-amp based design helpful when considering how to build their regulator circuits out of discrete components.