
SECTION FIVE

MOSFETs: Discharging Filter Capacitors

SECTION OVERVIEW

You may have noticed that the power LED on your power supply stays on for a long time, even after you turn off the power switch. This is a result of large filter capacitors, which slowly discharge through the LED, but still retain large amounts of energy long after the power is turned off. In this section, you will be improving the safety of your power supply by designing a circuit that will discharge these capacitors to a safe voltage, within moments of the power being turned off.

Objectives

- Design a circuit to discharge the filter capacitors to a safe voltage, after the power is turned off.

Materials

- Your lab kit and power supply.
- Test leads and oscilloscope probes.

Design Constraints

Error! Reference source not found. lists some of the design constraints for the capacitor discharge circuit. The best source for these constraints is the *Project Specification Document*. Keep these in mind as you complete this lab. Each criterion must be met.

- Discharges the filter capacitor on each channel to under 3V in five seconds or less, when the main power switch is turned to off, and when there is no load present on the output of the supply.
- Design using one (or more) MOSFETs.
- Does not increase the ripple voltage of the capacitor when the power supply is turned on beyond the requirements outlined for the power supply in earlier sections.
- Safely assembled.

Box 5: Filter capacitor discharge circuit design constraints

PRE-LAB

For the pre-lab in this section, implement the following:

1. Using PSPICE, design and simulate a circuit that will discharge the filter capacitors, as per the design constraints of Box 5.
2. Use the following hints to help you with the design simulation.

- Hints:**
- (a) You may find it useful to think of this design as having two parts.
 - (b) The first part is how to use the MOSFET drain and source, in order to create a path to discharge the filter capacitors.
 - (c) The second part is to decide as to how to turn this path on and off, when the power switch is turned off (and on) respectively.
 - (d) Once you turn off your power switch, the voltage across your rectifier capacitors does not change quickly. What happens to the voltage across the secondary of your transformer once you turn off your power switch?

3. Bring a printed copy of the datasheets for the parts used in your design, to lab.

LAB

There is only one part/ task for the lab portion in Section Five, which is the **filter discharge circuit**. In order to build a circuit that quickly discharges the filter capacitors, when the power is turned off, follow these steps:

1. Build your design on solder-less bread board.



A common and simple way to discharge filter capacitors is to place a resistor across the capacitors. However, bear in mind that this increases the voltage ripple and therefore, it can still take up to a minute to discharge these large capacitors.

2. Test your design, making sure all the design constraints are met.
3. Add the circuit to your power supply.
4. Demonstrate your working design to the TA.

TURN-IN

The following need to be turned in, **at the beginning of the next lab.**

Student Name: _____

Lab Section Time: _____

| <u>Test (from Project Specification)</u> | <u>Measurements</u> | <u>TA Signature</u> |
|---|---------------------|---------------------|
| <u>7.1.18 - CAPACITOR DISCHARGE BLOCK - THE FILTER CAPACITOR FOR THE POSITIVE CHANNEL DISCHARGES TO UNDER 3 VOLTS IN 5 SECONDS OR LESS WHEN THE MAIN POWER SWITCH IS TURNED TO OFF AND NO LOAD PRESENTS ON THE OUTPUT OF THE SUPPLY</u> | | ✓ _____ |
| <u>7.1.19 CAPACITOR DISCHARGE BLOCK - THE FILTER CAPACITOR FOR THE NEGATIVE CHANNEL DISCHARGES TO UNDER MAGNITUDE OF -3 VOLTS IN 5 SECONDS OR LESS WHEN THE MAIN POWER SWITCH IS TURNED TO OFF AND NO LOAD PRESENTS ON THE OUTPUT OF THE SUPPLY</u> | | ✓ _____ |
| <u>7.1.20 - CAPACITOR DISCHARGE BLOCK - DESIGN USED ONE (OR MORE) MOSFETS</u> | | ✓ _____ |
| <u>7.1.21 - CAPACITOR DISCHARGE BLOCK - CAPACITOR RIPPLE VOLTAGE STILL MEETS SPEC OUTLINED IN EARLIER SECTIONS</u> | | ✓ _____ |

The **written project specification** to be turned in next week includes:

- Project Specification Sections for this lab's circuits:
 - Block Diagram
 - Interface Definition
 - Schematic and theory of operations
 - Parts List Changes and Testing Results

Lastly, turn in your **answers to the study questions** below.

1. The voltage of the capacitors discharges quickly at first, then more slowly after a second or two, and then finally it seems to stop discharging. Explain the following:
 - (a) Why is the discharge rate not constant?
 - (b) Why does the discharge stop, when a voltage still remains across the capacitors?
 - (c) How could you cause the voltage to continue to drop all the way to 0V?
(Hint: You should know the answer to this, using the knowledge from many earlier courses.)

2. Provide a clear description of the current and voltages of each component in your discharge circuit, when:
 - (a) The power switch is on.
 - (b) In the seconds following the switch being turned off.
 - (c) Also, justify why you are able to exceed the component limits, even if your circuit does exceed any limits at any time.

3. Calculate the time it takes for your circuit to discharge the filter capacitors to 37% of the operating voltage.

CHALLENGES

1. Your power supply does not warn you of over-current conditions. Design and build a circuit to sound a buzzer, (or light an LED), if either channel exceeds a current limit, (as defined by the power supply design constraints in earlier sections).
2. Even with a circuit to discharge the filter capacitors, your power LED may glow dimly long after the power supply is turned off. Design and implement a modification that will cause the power LED to turn off immediately after the power switch is turned off