Design Documentation

Jerry Tian

Requirements

Input: 18-27 Vdc, reverse polarity protection
Output: 11.9 Vdc -12.1 Vdc, 2A max, Indicator LED

Result

18-27 Vdc to 12 Vdc 2A power supply

Assumptions

DC input and DC output
Molex connector input and output
Input <= 27 Vdc

Research Notes

I started with brainstorming the options to step down the voltage, after talking to my professor, I narrowed it down to three options.

	Pros	Cons	Examples
Shunt Regulator	Very quiet Easy to understand	Max output current is very low Power inefficient	https://www.digikey.ca/en/products/detail/diodes-incorporated/ZTL432BQFTA/16547392
Switch Mode Power Supply	Very power Efficient	Very hard to understand	https://www.analog.com/media/en/technical-documentation/data-sheets/3481fc.pdf
Low Dropout Regulator	Relatively quiet and power efficient	Create some heat	https://www.digikey.ca/en/products/detail/stmicroelectronics/LD1085D2T-R/669201

After doing research on all three types, I decided to use a Switch Mode Power Supply ic. However, after reading the datasheet, I realized even though I could replicate the design in the datasheet, I don't understand how the ic works at all. As a result, I moved to the other option, the Low Dropout Voltage Regulator. Below is my design process.

1. Understand Low Dropout Regulator: powered by a MOSFET and differential amplifier
2. Choose Low Dropout Regulator ic on digikey, filter by input voltage range, max output voltage and output current.
3. Read the datasheet, verify max drop voltage is within acceptable range (6V), check output voltage formula sheet

   ## Calculation of voltage divider:

   Given: Vout = 12V, Vref is defined as the voltage difference between Vout and Adj pin, and from the datasheet, Vout = Vref(1+R2/R1), Imin = 10mA, Vref = 1.25V

   Solve for: R1, R2

   Solution:

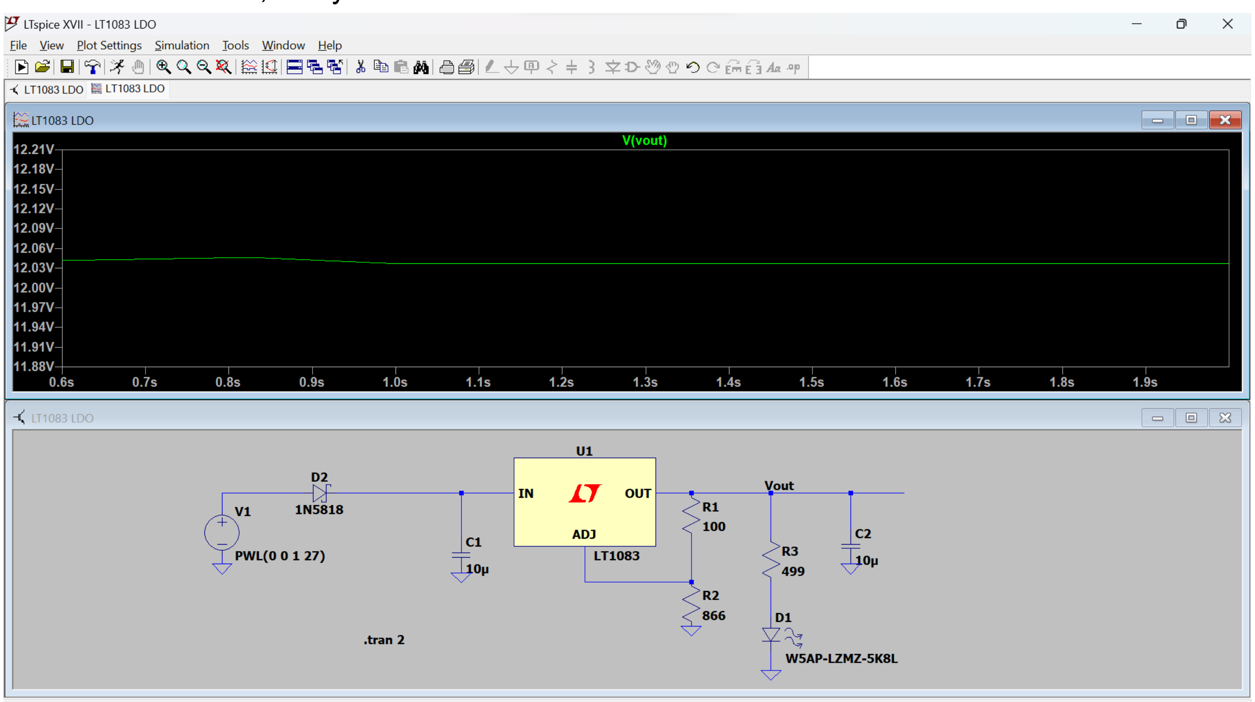
   $12 = 1.25(1+R2/R1)$

   $R2/R1 = 8.6 \quad \Rightarrow \quad R1/R2 = 0.116$

   $\max(R1 + R2) = Vout / Imin = 12V / 10mA = 1200$ ohm

   Select R1 as 100 ohm, the closest R2 we can select is 866 ohm

   Therefore R1 = 100 ohm, R2 = 866 ohm
4. LTSPICE simulation, verify calculation is correct



5. Schematic Design and component selection
   a) Indicator LED calculation:

      Given: Vout = 12 V, forward voltage = 2.2 V, forward current = 20 mA

      Solve for: Resistor

      Solution:

      $Vr = 12-2.2 = 9.8V$

      $R = Vr / Ir = 9.8V / 20mA = 490$ ohm

      The closest resistance is 499 ohm so I selected a 499 ohm resistor.

    b) I selected a Schottky diode for input reverse polarity protection since the Schottky diode’s voltage drop is very low. There is another option that uses a regular diode if finance is a concern.
    c) I believe there are better ways to regulate max output current but the design is very complicated. I chose the fuse since I understand it better.
6. Create PCB layout
    a) I implemented the ground plane in my design after considering these benefits:
       Reduce air wiring on the pcb.
       Since this is a power supply circuit, ground plane would reduce noise in both input and output connections
    b) I divided the board into 2 regions, input region and output region. The power traces are set to 20 mils wide to handle 2A current. The power traces are lined up on a straight line since the board prioritizes 12 VDC output.
    c) Since the low drop regulator IC steps down the voltage by dissipating heat, I added some holes under it to allow some air flow to lower the temperature.