

APPLICATION NOTE

Voltage and Current Regulation and Power Distribution module

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Abstract

The components that are being used in the robot require power at different ratings. Instead of using separate battery pack each of the components, Power distribution module is to be made to provide power through only one battery pack.

Keyword: Step Down Voltage regulator, LM1117, LM2575S, LM317.

Introduction

Power is one of the main components of any electrical devices. And each component is rated at different voltage consumption and amp. Thus it is necessary to create a power distribution unit that is capable of supplying power to each component as per their requirements.

For the team project, the devices that require the power are Raspberry PI, GPS, Accelerometer, Motor Driver and multiple passive sensors.

Objective

This document contains information on how to produce a functioning multi-output power supply that is capable of delivering 9V, 5V, and 3.3V from a 11.1V Li-Po battery. The explanation on why a particular voltage regulator was selected to achieve the desired outcome.

Description

- **Voltage Regulator**

Voltage regulator is the device that acts as comparators. When excited through a power source, the output is constant at a rated voltage. There are two types of Voltage Regulators, Step-Up and Step-Down.

- Step-Up Voltage Regulator

The output voltage of a Step-Up regulator is higher than the input voltage.

For Example, the most common Step-Up Voltage regulator is LM1577 by Texas Instrument. It is a simple boost regulator with a 3A current limiter, that means

it will shut off if the current exceeds 3A thus creating a failsafe. Typical application of LM1577 is represented in fig 1 below.

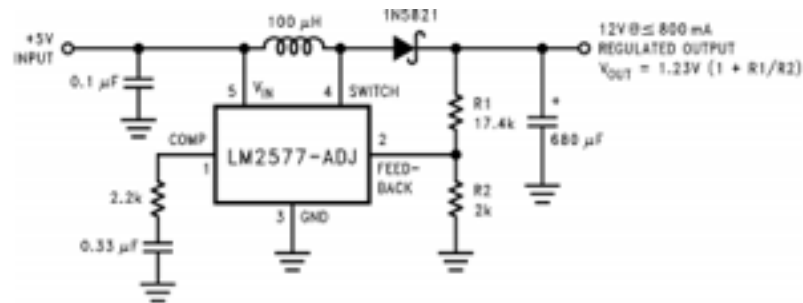


Figure 1. LM1577 Step-Up or Boost Voltage Regulator

The output can be varied based on the values of R_1 and R_2 in the circuit. With the provided vales the output of the circuit in fig 1 is $V_{OUT} = 12V$ when a +5V is supplied as an input.

- Step-Down Voltage Regulator

The output voltage is less than the input voltage.

For example, the simplest Step Down voltage regulator is LM117, shown in fig 2 below. Whenever the input voltage is higher than $(V_{DO} + 1.25)$ V, the output voltage will be constant at 1.25V.

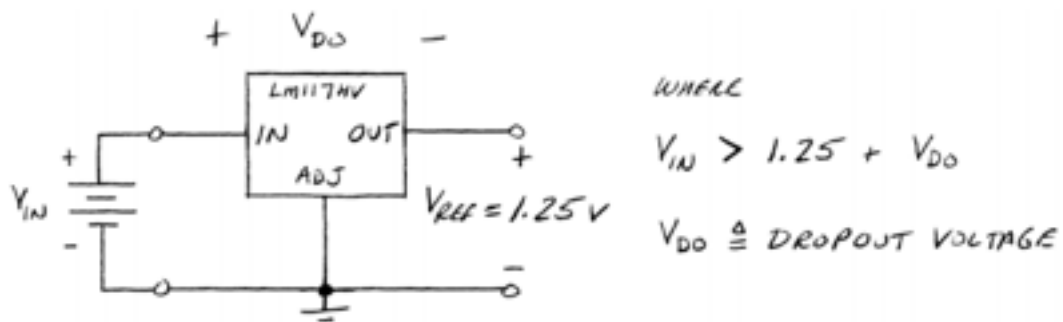


Figure 2. LM117 Step-Down or Buck Voltage Regulator

For our design we will be using a Step-Down regulator, not specifically LM117, since we need to draw lower voltage than power supply or a 11.1V battery pack.

Advantages of Voltage Regulator:

- Easily controllable.
- The output will be constant even when the input voltage is fluctuating.
- Has inbuilt cutoff capability to any overloads.

Disadvantages of Voltage Regulators:

- Generates tremendous amount of heat.
- Overheating will cause the regulator to thermal shutdown.

Since the heating is the main issues when using a voltage regulator, there is one type of voltage regulator that is capable of controlling heat generation, Switching Regulators. The switching regulator is increasing in popularity because it offers the advantages of higher power conversion efficiency and increased design flexibility.

- **Step Down Voltage Regulator used in the project**
 - LM317
 - LM2575S
 - LM1117

Procedure

- Requirement

The requirements for the power consumption are shown in table 1.

Device	Power Rating
Motors	9V @ 1A
Raspberry-PI	5V @ 1A
GPS, Accelerometer, and Passive Sensors	3.3V @ 650mA

Table 1. Power Consumption

- The first step is to Step-Down the voltage from 11.1 V to 9V and LM 317 was used to Step-down the voltage. The circuit for the conversion is shown in fig 3. LM317 is rated at 1A output.

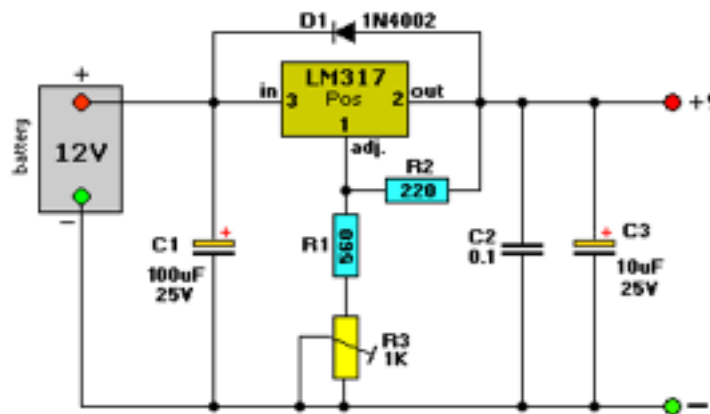


Figure 3. LM317 12V to 9V conversion

The Potentiometer R_3 will vary the output voltage. The capacitor C_2 improves the frequency response. The Formula that determines the output voltage is given by,

$$((R_2/R_1)+1)*1.25 = V_{OUT}$$

Thus, in order to get 9V output, R_3 needs to a 820Ω.

- From 9V to 5V.

Instead of stepping down the voltage from 11.1V to 5V, 9V can be used to step it down to 5V. LM2575S is the switching voltage regulator, by Texas Instrument, that will be used as buck converter. LM2575S is rated at 1A.

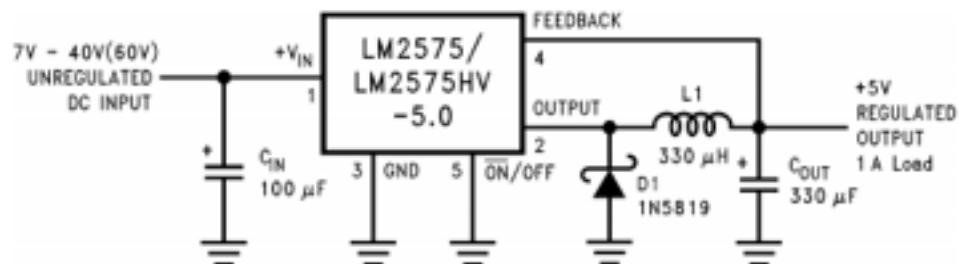


Figure 4. LM2575, 9V to 5V regulator

In the circuit, shown in fig 4, C_{IN} and C_{OUT} acts as a filter for any attenuation in noise.

- From 5V to 3.3V

LM1117 is a low-dropout voltage regulator which will be used to step-down from 5V to 3.3V. A simple application is shown in fig 5.

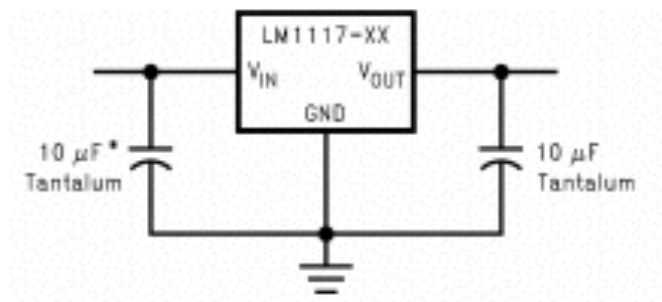


Figure 5. LM1117, 5 V to 3.3V regulator

The two capacitors used in figure 5 are the filtration capacitors. Since the LM1117 is rated at 650mA, there is no need to regulate the current through an inductor and resistors.

- The final circuit is given in figure 6. The final circuit is manipulated to make connections directly to the devices.

Conclusion

As shown above, switching step down voltage regulators can be used to suffice the power requirement. Heat will be a major issue when dealing with the power and that is why a switching regulator is used in the power modulation unit.

Reference

LM2577 Datasheet- <http://www.ti.com/lit/ds/symlink/lm2577.pdf>

Switching Regulator- <http://www.ti.com/lit/an/snva559/snva559.pdf>

LM2575 Datasheet- <http://www.ti.com/lit/ds/symlink/lm1575.pdf>

LM317 Datasheet- <http://www.ti.com/lit/ds/symlink/lm317.pdf>

LM1117 Datasheet- <http://www.ti.com/lit/ds/symlink/lm1117-n.pdf>