Choosing a Voltage Regulator (LDO) for Battery Operated Products

Overview

Simplified block diagram of Linear Regulator

Types of Pass elements

Discharge curve of Li-ion battery

Let’s define a problem statement

Selected LDO’s

LTspice simulation of Dropout voltage

LTspice simulation of Quiescent current

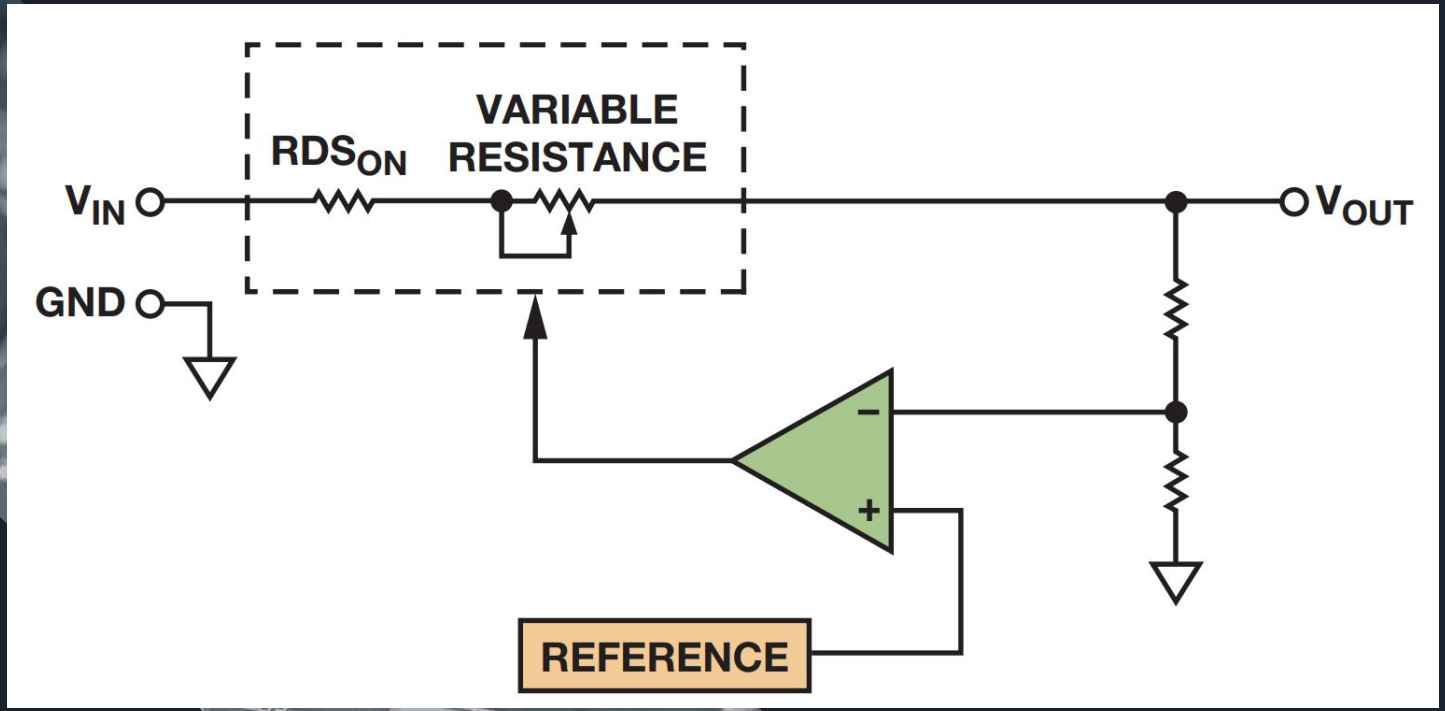
Overview

So the voltage regulators are used to provide a stable power supply voltage independent of load impedance or input voltage variations.

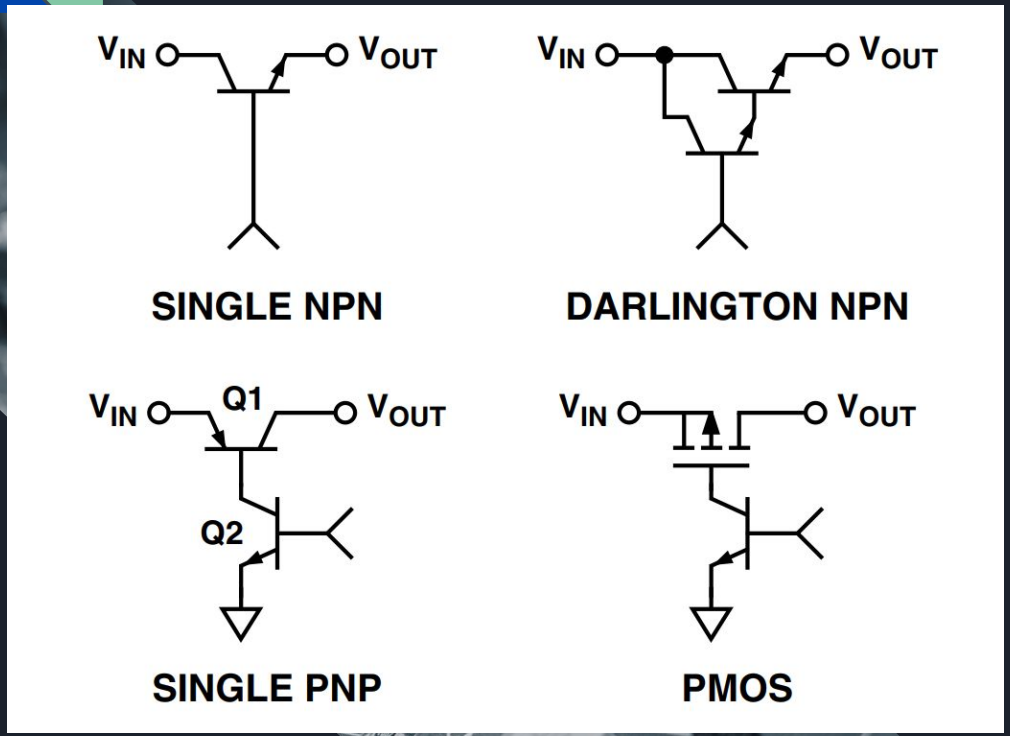
Low-dropout regulators have the ability to maintain regulation with small differences between supply voltage and load voltage.

Typical sensitive load circuitry such as radio frequency amplifiers, clock and timing ICs, SERDES, precision analog and image sensors choose LDO for low noise performance.

Simplified block diagram of Linear Regulator



Types of Pass elements

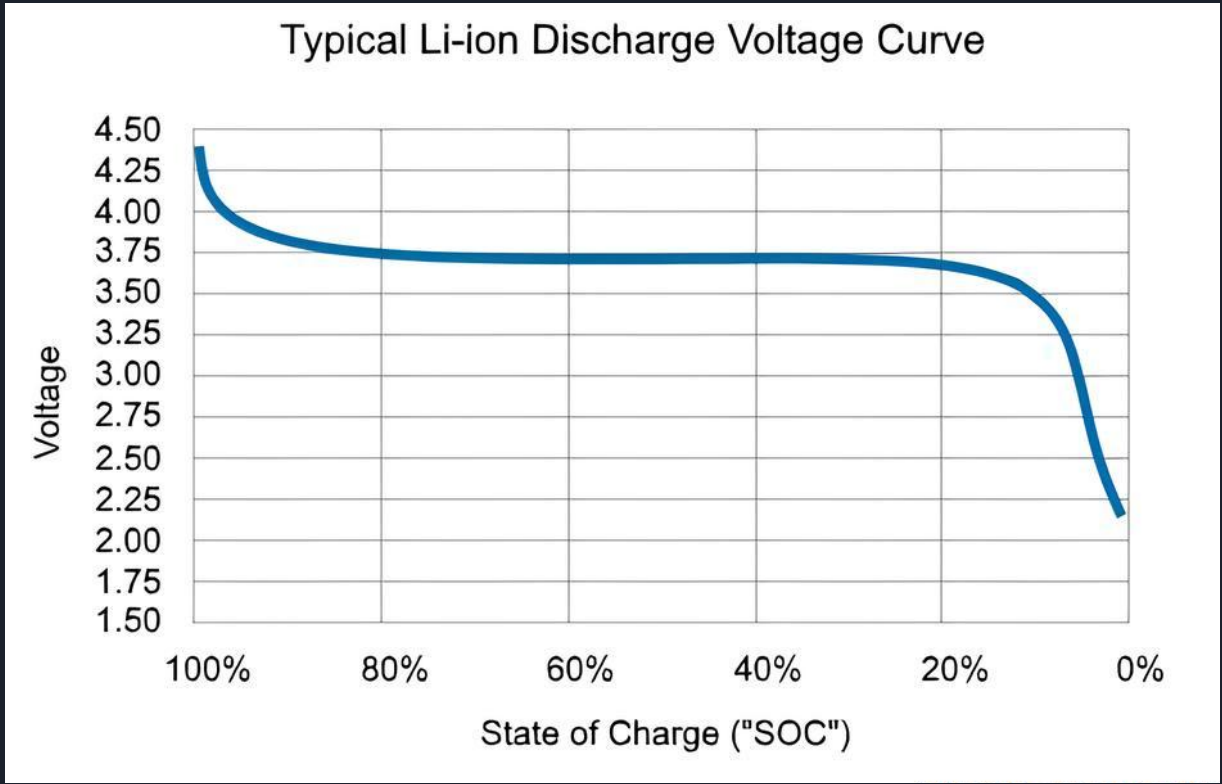


NPN and Darlington transistors are mostly used in standard linear regulators. Due to way NPN and Darlington transistors work, these pass elements cannot provide provide dropout voltages below 1 V.

PMOS and PNP transistors are mostly used in LDO regulators, these pass devices minimize the voltage loss and the power dissipation, thus allowing low dropout, high-efficiency voltage regulators.

PMOS pass devices can provide the lowest possible dropout voltage drop. They also allow the quiescent current flow to be minimized.

Discharge curve of Li-ion battery



Let's define a problem statement

- Device has to operate on Li-ion battery for as long as possible.
- Device consists of a microcontroller and sensor circuits.
- The microcontroller can operate from 2.5V to 3.3V.
- The sensor circuits can operate from 3V to 3.3V.
- Li-ion battery protection circuit cuts off the battery at 3V.
- The device has a peak current draw of 20mA.
- The device must use a LDO for voltage regulation.

LINEAR TECHNOLOGY

LT1117/LT1117-2.85
LT1117-3.3/LT1117-5

800mA Low Dropout Positive Regulators Adjustable and Fixed 2.85V, 3.3V, 5V

FEATURES

- Space Saving SOT-223 Surface Mount Package
- 3-Terminal Adjustable or Fixed 2.85V, 3.3V, 5V
- Output Current of 800mA
- Operates Down to 1V Dropout
- Guaranteed Dropout Voltage at Multiple Current Levels
- 0.2% Line Regulation Max
- 0.4% Load Regulation Max

APPLICATIONS

- Active SCSI Terminators
- High Efficiency Linear Regulators
- Post Regulators for Switching Supplies
- Battery Chargers
- 5V to 3.3V Linear Regulators

DESCRIPTION

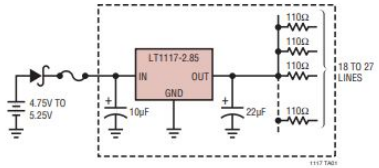
The LT®1117 is a positive low dropout regulator designed to provide up to 800mA of output current. The device is available in an adjustable version and fixed output voltages of 2.85V, 3.3V and 5V. The 2.85V version is designed specifically to be used in Active Terminators for the SCSI bus. All internal circuitry is designed to operate down to 1V input to output differential. Dropout voltage is guaranteed at a maximum of 1.2V at 800mA, decreasing at lower load currents. On chip trimming adjusts the reference/output voltage to within ±1%. Current limit is also trimmed in order to minimize the stress on both the regulator and the power source circuitry under overload conditions.

The low profile surface mount SOT-223 package allows the device to be used in applications where space is limited. The LT1117 requires a minimum of 10µF of output capacitance for stability. Output capacitors of this size or larger are normally included in most regulator designs.

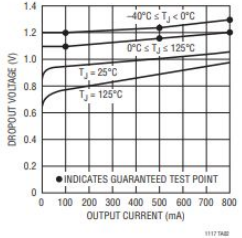
Unlike PNP type regulators where up to 10% of the output current is wasted as quiescent current, the quiescent current of the LT1117 flows into the load, increasing efficiency.

TYPICAL APPLICATION

Active Terminator for SCSI-2 Bus



Dropout Voltage ($V_{IN} - V_{OUT}$)



ANALOG DEVICES

Ultralow Quiescent Current, 150 mA, CMOS Linear Regulators

Data Sheet **ADP160/ADP161/ADP162/ADP163**

FEATURES

Ultralow quiescent current
I_Q = 560 nA with 0 µA load
I_Q = 860 nA with 1 µA load
Stable with 1 µF ceramic input and output capacitors
Maximum output current: 150 mA
Input voltage range: 2.2 V to 5.5 V
Low shutdown current: <50 nA typical
Low dropout voltage: 195 mV at 150 mA load
Initial accuracy: ±1%
Accuracy over line, load, and temperature: ±3.5%
15 fixed output voltage options: 1.2 V to 4.2 V
Adjustable output available
PSRR performance of 72 dB at 100 Hz
Current limit and thermal overload protection
Logic-control enable
Integrated output discharge resistor
5-lead TSOT package
4-ball, 0.5 mm pitch WLCSP

APPLICATIONS

Mobile phones
Digital cameras and audio devices
Portable and battery-powered equipment
Post dc-to-dc regulation
Portable medical devices

TYPICAL APPLICATION CIRCUITS

ADP160/ADP162

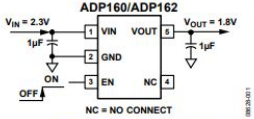


Figure 1. 5-Lead TSOT ADP160/ADP162 with Fixed Output Voltage, 1.8 V

ADP161/ADP163

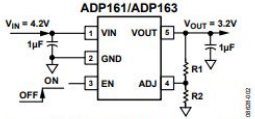


Figure 2. 5-Lead TSOT ADP161/ADP163 with Adjustable Output Voltage, 3.2 V

ADP160/ADP162

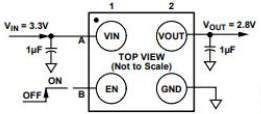


Figure 3. 4-Ball WLCSP ADP160/ADP162 with Fixed Output Voltage, 2.8 V

GENERAL DESCRIPTION

The ADP160/ADP161/ADP162/ADP163 are ultralow quiescent current, low dropout, linear regulators that operate from 2.2 V to 5.5 V and provide up to 150 mA of output current. The low 195 mV dropout voltage at 150 mA load improves efficiency and allows operation over a wide input voltage range.

The ADP16x are specifically designed for stable operation with a tiny 1 µF ± 30% ceramic input and output capacitors to meet the requirements of high performance, space-constrained applications.

The ADP160 is available in 15 fixed output voltage options, ranging from 1.2 V to 4.2 V. The ADP160/ADP161 also include a switched resistor to discharge the output automatically when the LDO is disabled. The ADP162 is identical to the ADP160 but does not include the output discharge function.

The ADP161 and ADP163 are available as adjustable output voltage regulators. They are only available in a 5-lead TSOT package. The ADP163 is identical to the ADP161 but does not include the output discharge function.

Short-circuit and thermal overload protection circuits prevent damage in adverse conditions. The ADP160 and ADP162 are available in a tiny 5-lead TSOT and a 4-ball, 0.5 mm pitch WLCSP package for the smallest footprint solution to meet a variety of portable power applications.

LTspice simulation of Dropout voltage

Dropout voltage determines the range of operation of a device for a battery.

LTspice simulation of Quiescent Current

Quiescent current determines the battery life of device.

Thank you!

For help or to learn more about **Choosing correct LDO for battery operations**, you can visit the DevHeads GitHub repo where the contents of this demo will be stored or find me in the DevHeads Discord server at ***@shreeshan97*** where I'm available to answer questions based on electronics and embedded issues.