TI-RSLK MAX

Texas Instruments Robotics System Learning Kit

Texas Instruments

Module 5

Lecture: Battery and voltage regulation

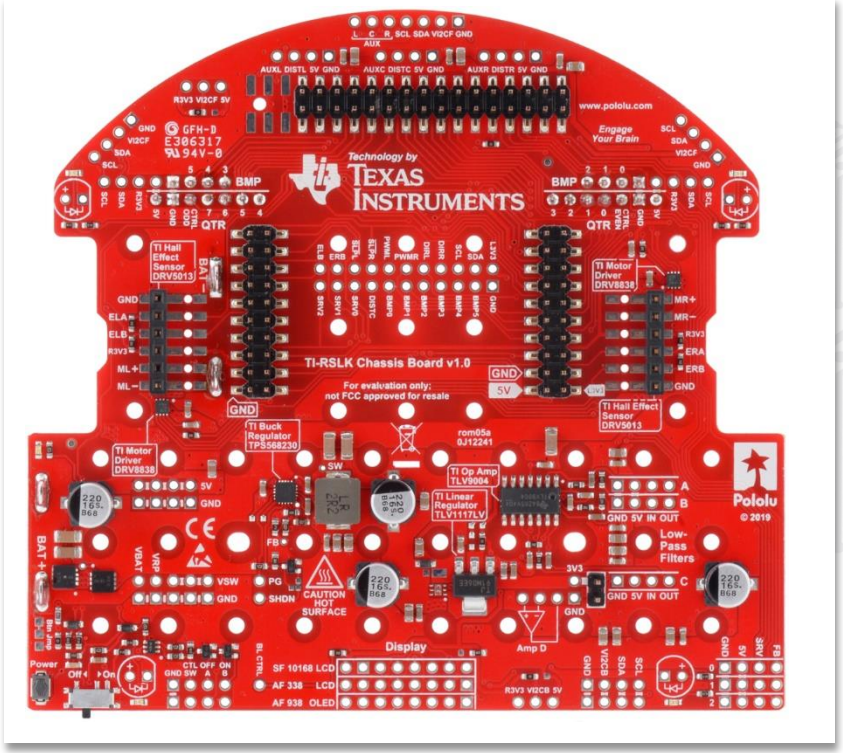
Battery and Voltage Regulation

You will learn in this module

- Power sources - Batteries
  - Voltage, V (volts)
  - Current, I (amps)
  - Energy, E (joules)

- Voltage regulation (Constant Voltage)
  - Purpose
  - Types
  - Circuits

- Performance measurements (Lab)
  - Monitoring Battery Voltage, Current, Storage
  - Voltage regulation (DC voltmeter)
  - Noise (AC voltmeter, oscilloscope)



TI-RSLK chassis board

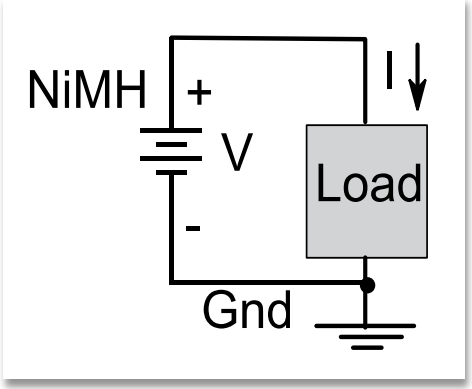
Power and Energy

Sources of Power

- 120/220 VAC 50/60 Hz
  - Needs an AC to DC converter
  - Needs a voltage regulator
- DC power supply (+5V on USB, +12V used in automotive)
  - USB power used to power TI‘s Launchpad (5V)
- Battery
  - Need to drive robot autonomously
  - Provide power to TI’s Launchpad, motors, sensors
  - Voltage, energy, size, weight
  - Needs a regulator for **constant voltage**

- Energy harvesting like solar or EM field pickup

Power = V*I (watts)
Energy = V*I*time (Joules)



Power Budget

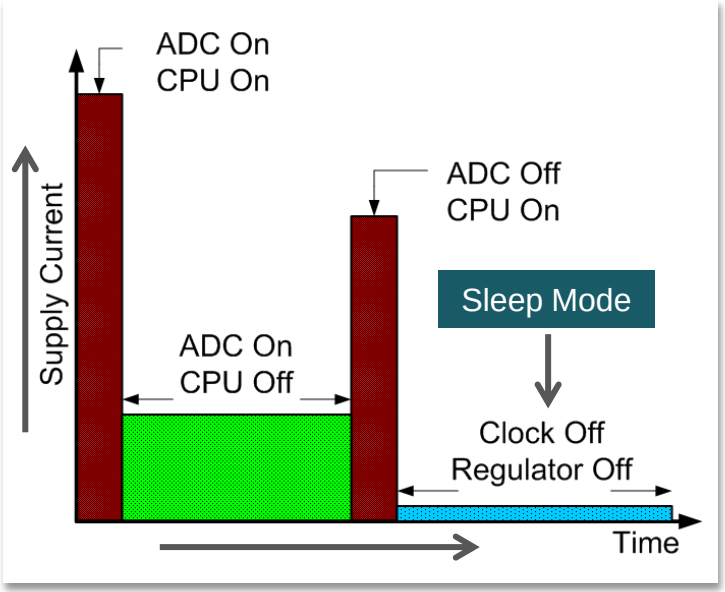
Energy = V*I*time (J)
Storage = I*time (amp-hr)

Battery-powered embedded system

- Power Budget => Battery Life
  Average Current < Energy Storage/t_{life}

- Save Power :
  Reduce voltage, Sleep modes, Clock, CPU,

TI's Launchpad MSP432 Low Power MCU



MSP432 : Supply current under different modes of operation

Batteries

Types of batteries

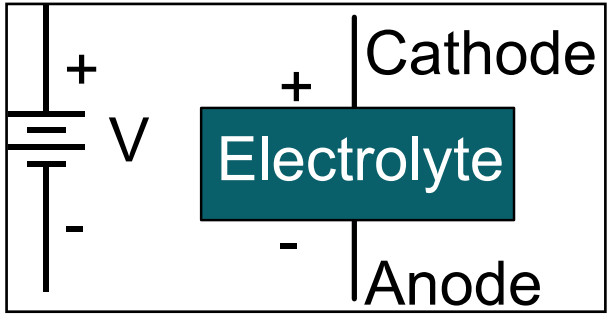
- Primary (not re-usable)
  - Heavy duty
  - Alkaline
  - Lead-acid
  - Lithium

7.2V requires
6 batteries

- Secondary (rechargeable)
  - NiCad
  - NiMH
  - Li-ion
  - Supercap

Energy = V*I*time
Storage = I*time (amp-hr)

Inside a Battery



Batteries

AA Sized Batteries

Energy = V*I*time
Storage = I*time (amp-hr)

Battery	Voltage (V)	Energy Storage (Ah)	Type
Alkaline	1.5	2	Primary
Lithium	1.5	3	Primary
NiCad	1.2	1.2	Secondary
NiMH	1.2	1.8	Secondary
Li-ion	3.6	1.9	Secondary

Most energy for the same size battery

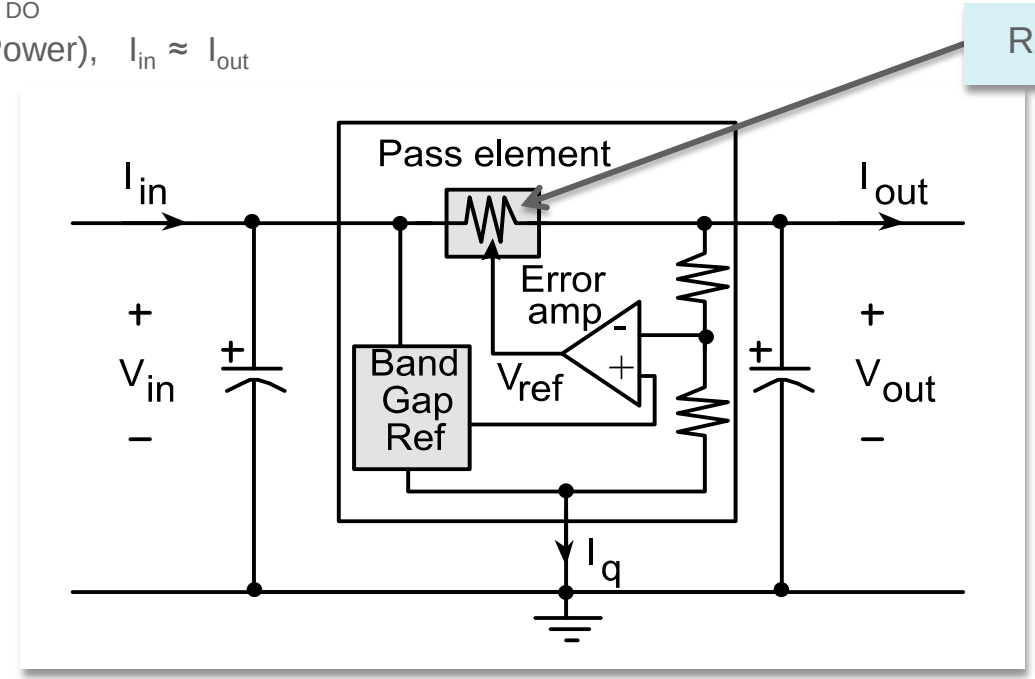
Running at a ½ amp, your robot will run for 3.6 hours

t_{life} = Energy Storage/ I
= 1.8/0.5 = 3.6 hr (NiMH)

Voltage regulation using a Linear Regulator

Properties

- Generates a constant output voltage V_{out} for varying, input voltage V_{in} & load I_{out}
- Dropout voltage, $V_{in} > V_{out} + V_{DO}$
- Inefficient (dissipating more Power), $I_{in} \approx I_{out}$
- Low noise



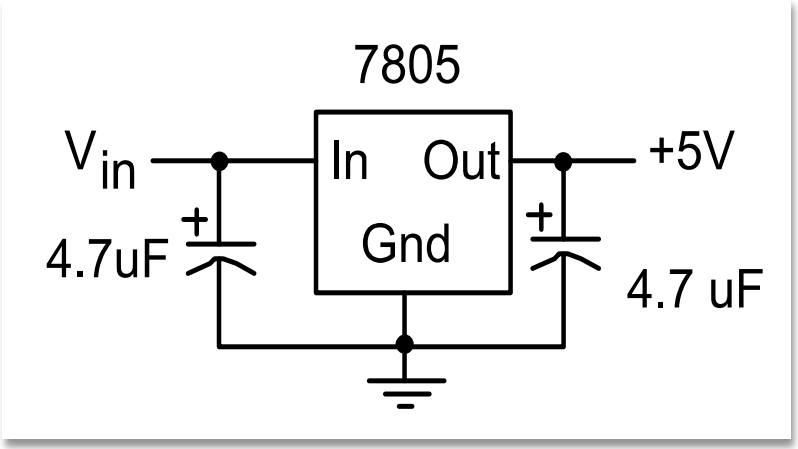
Input Power – Output Power = 7.2 V * 100 mA – 5 V * 100 mA = 0.22W of Power Loss !!!

Voltage regulation using a Linear Regulator

Example +5V regulator

Specifications:

- V_{in} > 7V (V_{DO} = 2V)
- I_{out} < 1 amp



Build this circuit if you do not have the TI-RSLK MAX chassis board from Pololu

WEBENCH® is a free design tool from Texas Instruments you can use to design power supply circuits (link to **WEBENCH Power Designer**)

Voltage Regulation using Switching regulators

Properties

- Buck: Step-down (Vin > Vout)
- Boost: Step-up (Vin < Vout)
- Buck-boost: either/both
- Noisy due to switching

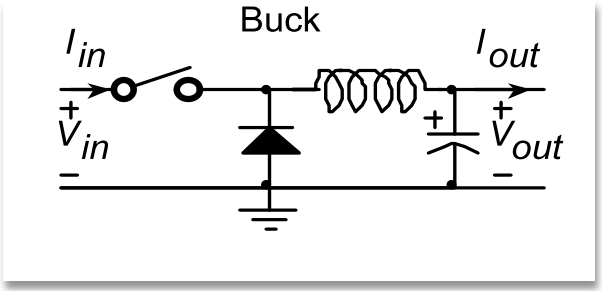
Power In ≈ Power Out

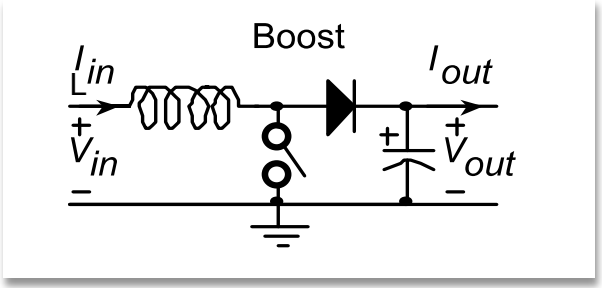
$V_{in} * I_{in} \approx V_{out} * I_{out}$

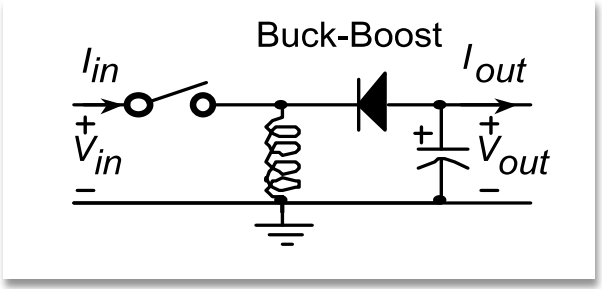
Efficiency = $(V_{out} * I_{out})/(V_{in} * I_{in})$

Or P_{out} / P_{in}

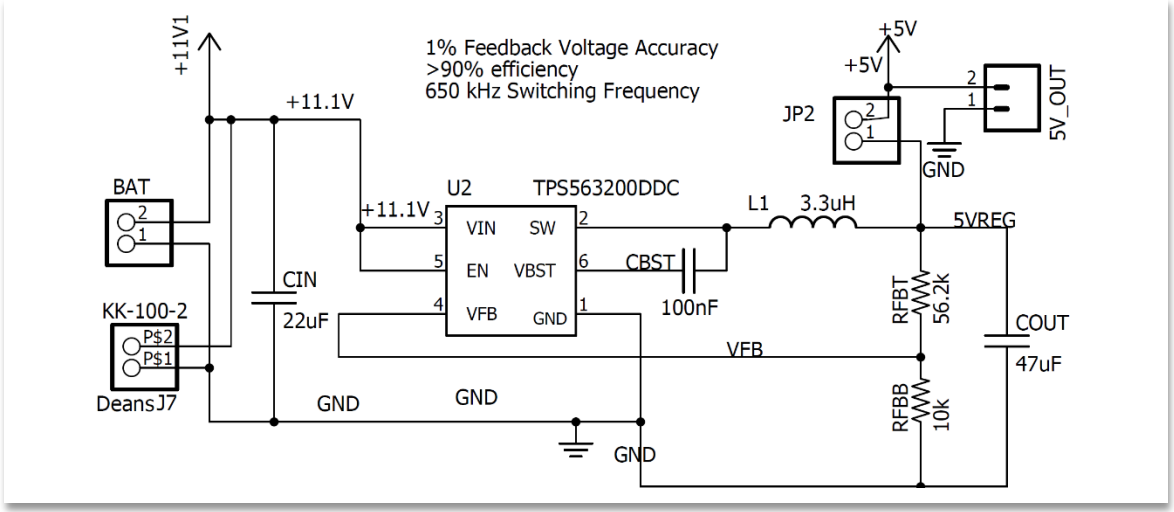
To learn more about regulators go to ti.com/PMLK



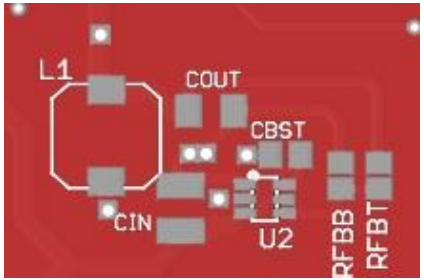




Switching Regulator Circuit : An Example



Warning :
Pay careful attention not to connect the wire from output of the regulator to ground.!!



Switching Regulator schematic & PCB using TI TPS563200 17-V Input, 2- A Synchronous Step-Down Voltage Regulator

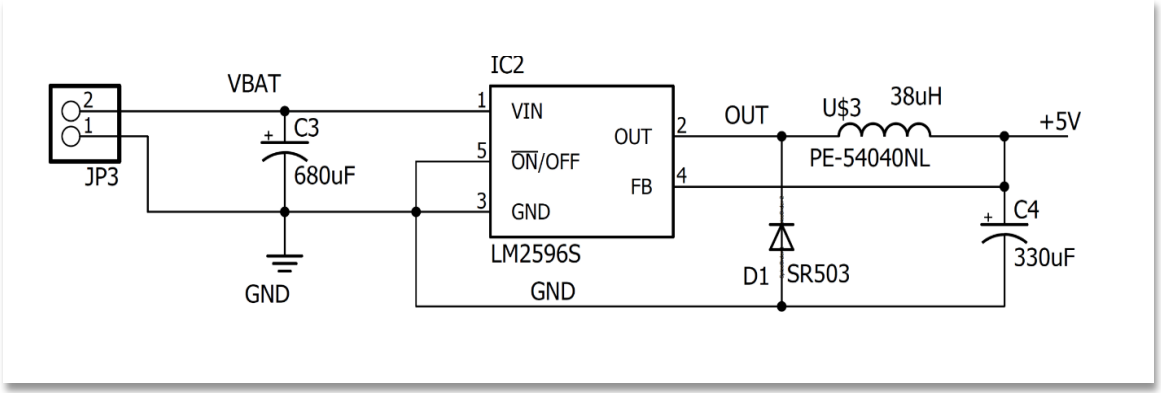
The TI-RSLK Chassis board uses a similar regulator

Switching Regulator Circuit : An Example

- 3.3V, 5V, 12V, and Adjustable Output Versions
- Step-down (buck) switching regulator
- Available in TO-220 and TO-263 Packages
- Ensured 3A Output Load Current version.
- Requires Only 4 External Components
- 150 kHz Fixed Frequency Internal Oscillator
- High Efficiency
- Thermal Shutdown and Current Limit Protection

TO-220-5 package

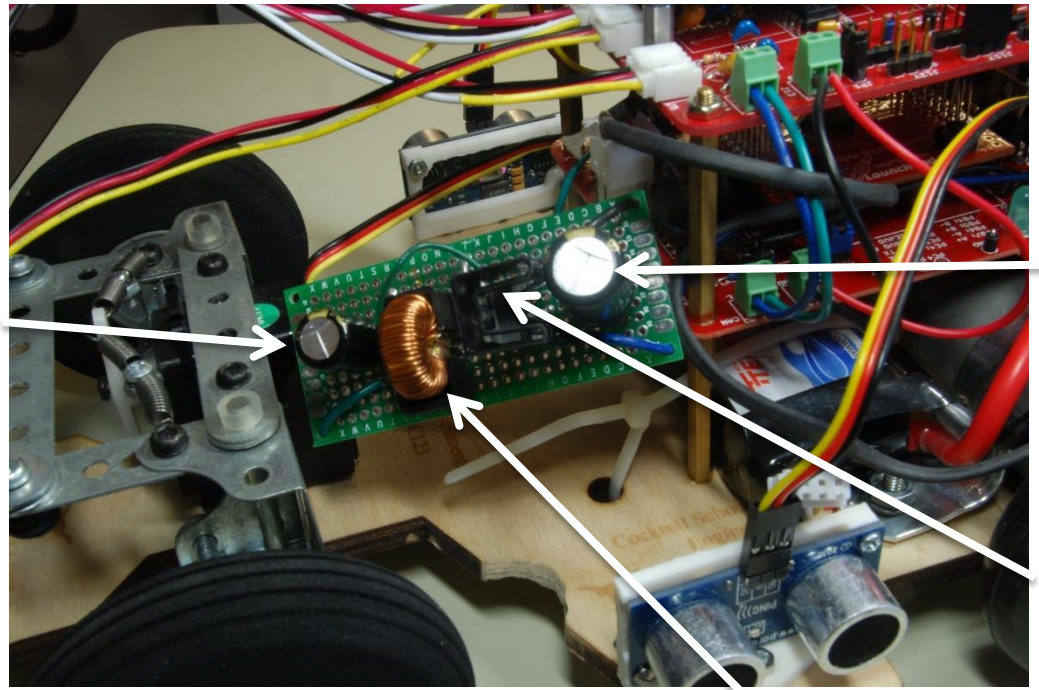
These features provide circuit protection!



Build this circuit (or 7805) if you do not have the TI-RSLK chassis board
For more information on the power supply design go to **http://www.ti.com/tool/lm2596s-adjevm**

Switching regulator circuit board using TI's LM2596

- LM2596T-5.0
- All through-hole parts
- Student-proof



Build this circuit if you do not have the TI-RSLK chassis board

Batteries and Voltage Regulation

Summary

- Power Sources - Battery
  - Primary versus secondary
  - Power budget and Energy Storage

- Voltage Regulation - Linear Regulator
  - Low noise
  - Wasted power = $(V_{in}-V_{out})*I_{out}$
  - Dropout voltage, $V_{in} > V_{out}+V_{do}$

- Voltage Regulation - Switching Regulator
  - Large voltage drop
  - Voltage increase
  - Higher Efficiency

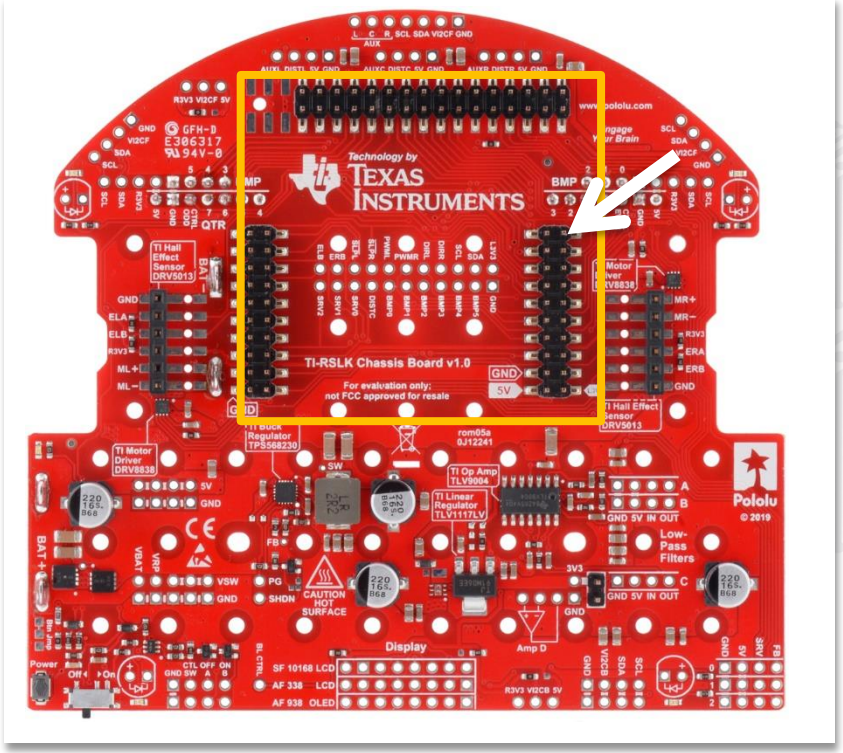
Power = V*I
Energy = V*I*time
Energy Storage = I*time
Power Budget:
Average Current < Energy Storage/t_{life}

Module 5

Lecture: TI-RSLK chassis board

TI-RSLK Chassis Board features

- **Male-pinned connectors for the TI LaunchPad**
- Battery input section with on/off switch and latching button
- TI 5V Switching Regulator TPS568230
- TI 3.3V Linear Regulator TLV1117
- TI Op Amp TLV9004
- TI Motor Drivers DRV8838
- TI Hall Effect Sensors on the Motors themselves, DRV5013



TI-RSLK chassis board

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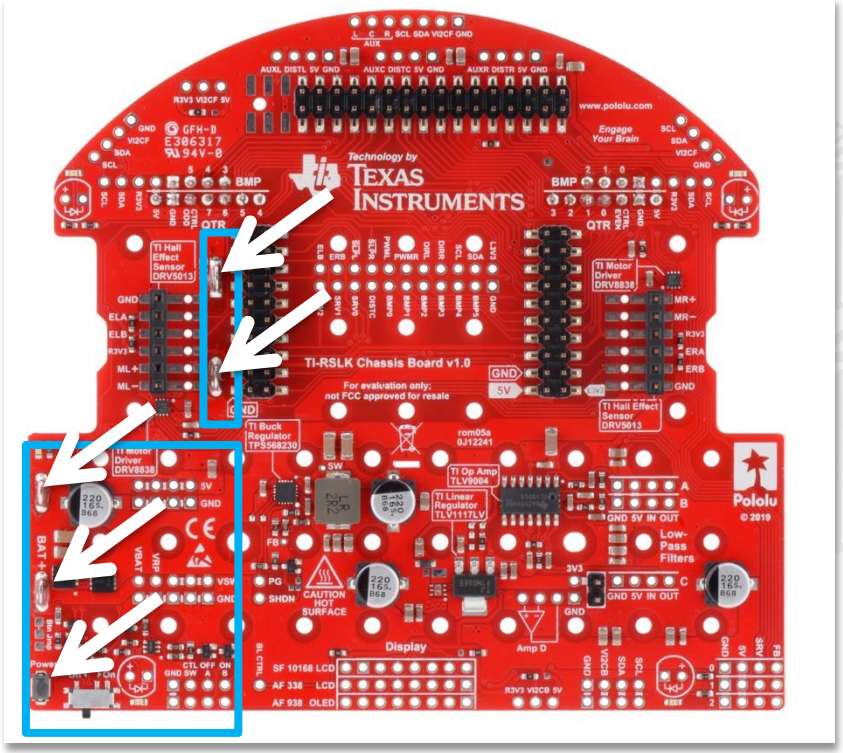

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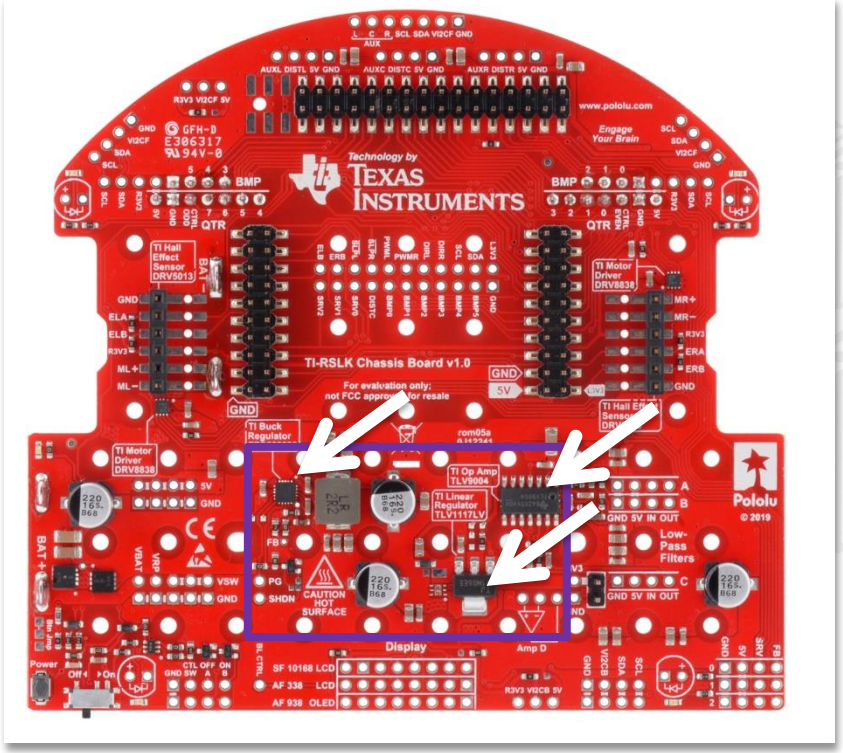

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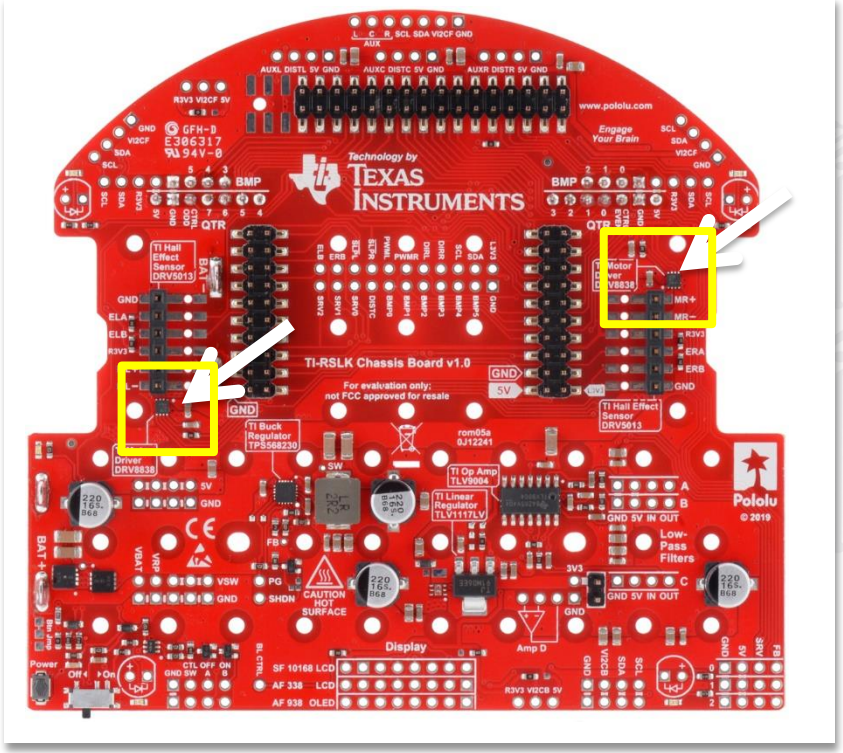

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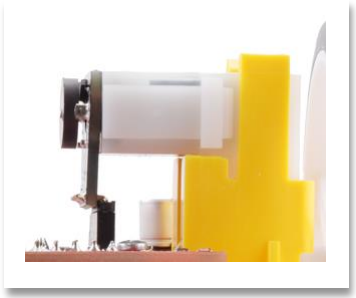


Gearmotor and Encoder Assembly for Romi/TI-RSLK MAX robot kit

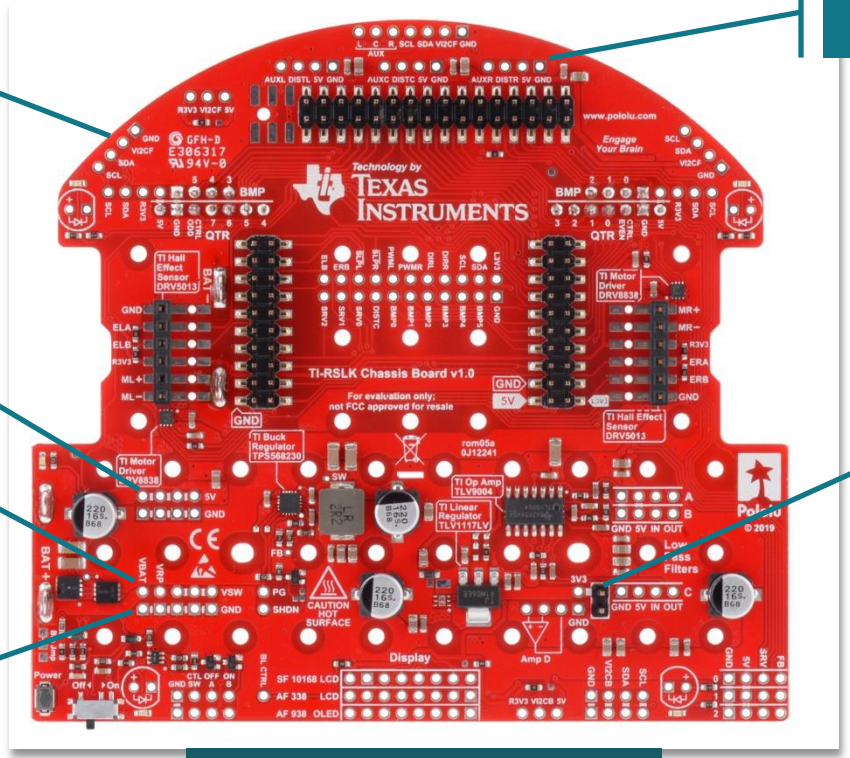
TI-RSLK Chassis Board features – Power and Gnd

+3.3V

+5V

+7.2V

Gnd

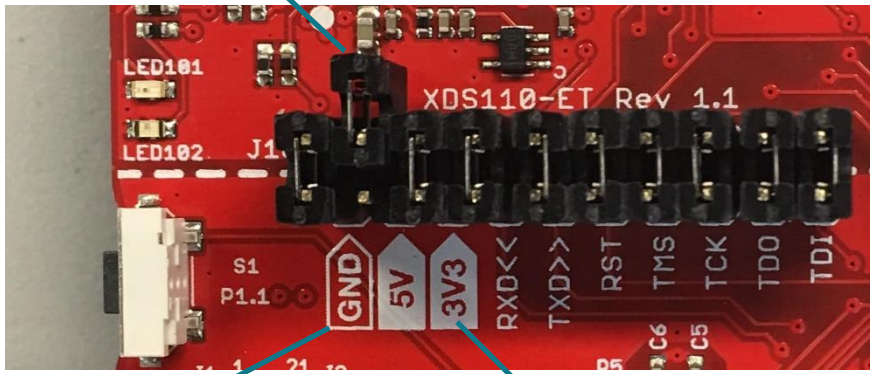


TI-RSLK chassis board

Power to sensor

Important safety feature

TI-RSLK Chassis Board features – Power and Gnd



+5V

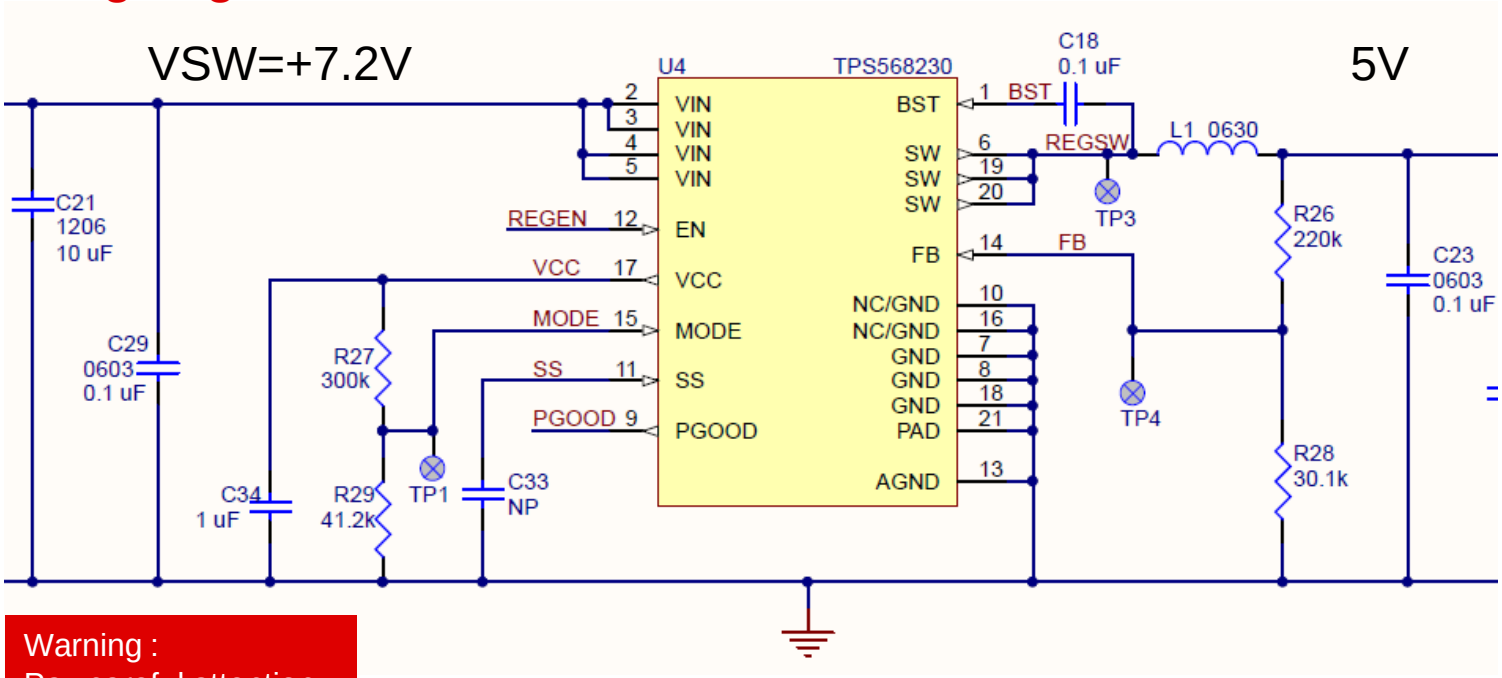
Important safety feature

Gnd

+3.3V

MSP432 LaunchPad

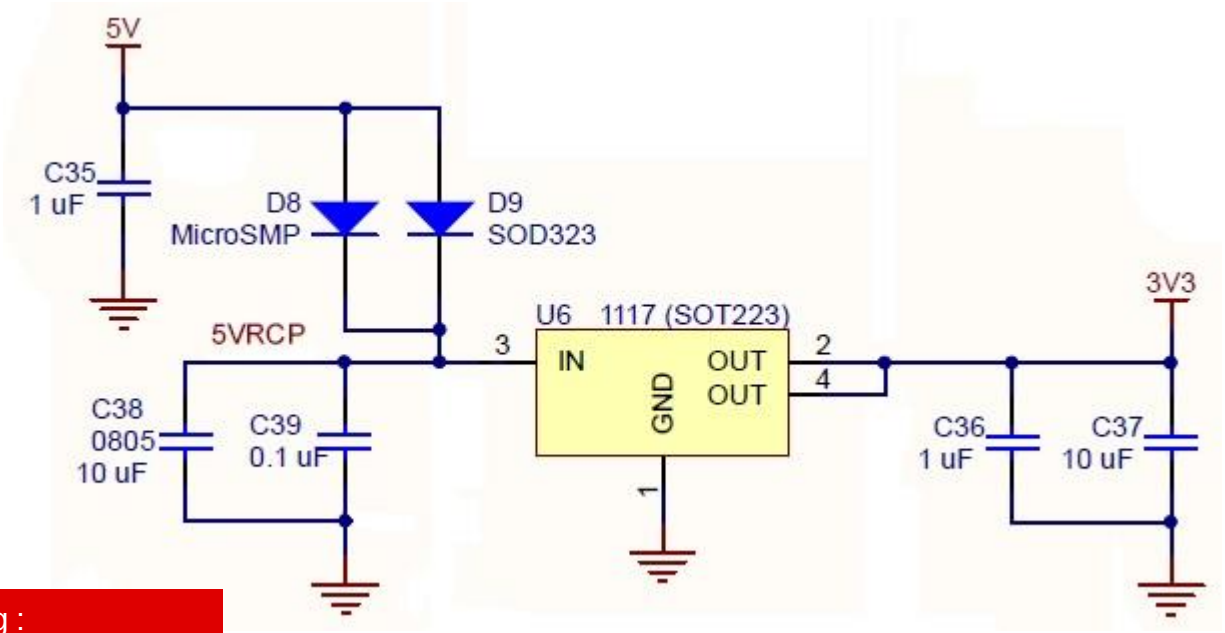
Switching Regulator Circuit : TI-RSLK MAX chassis board



Warning :
Pay careful attention not to connect the wire from output of the regulator to ground.!!

TI-RSLK chassis board uses a TI TPS568230 4.5 to 18-V input, 5V 8-A output, synchronous step-down voltage regulator

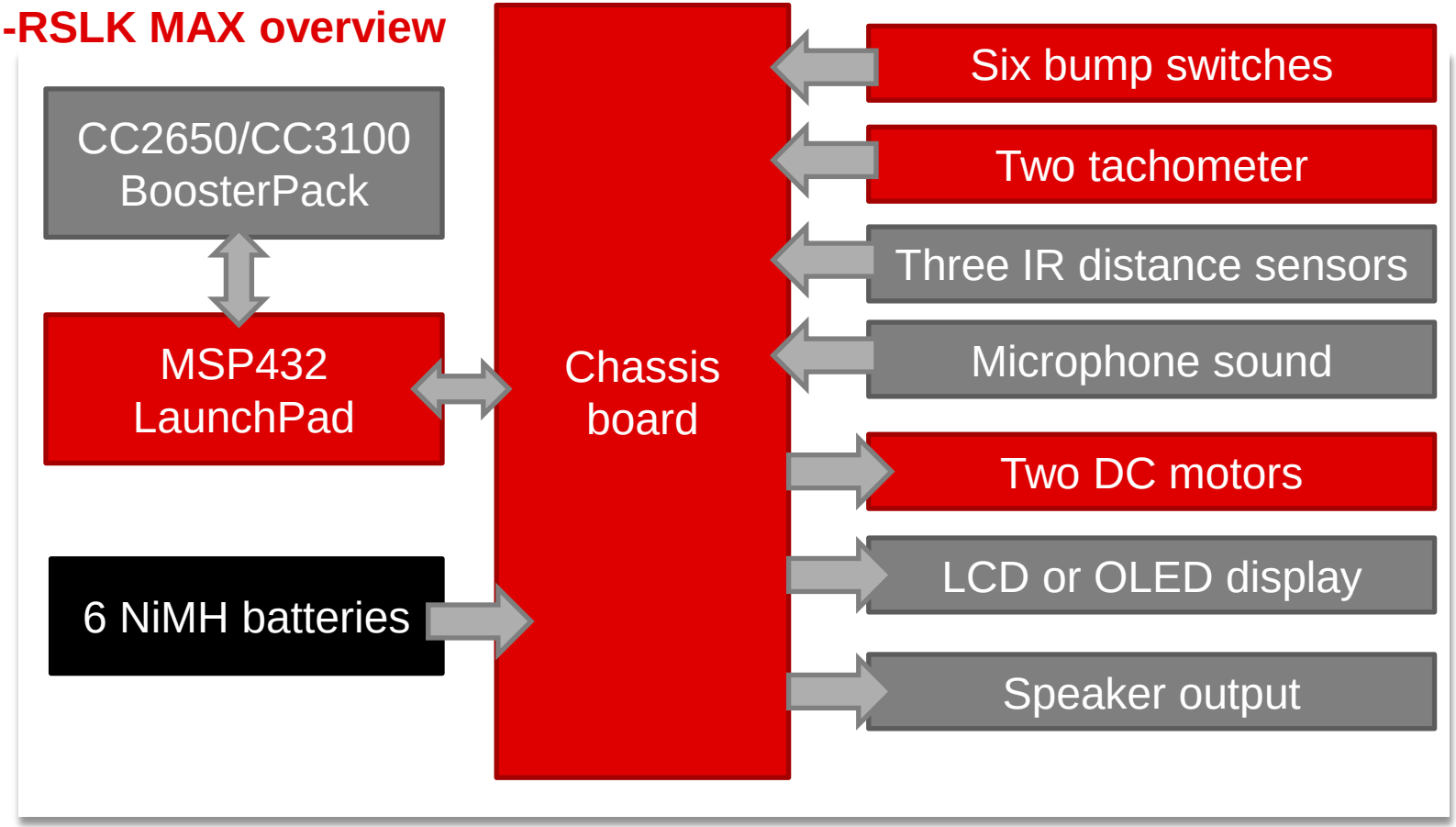
Linear regulator circuit: TI-RSLK MAX chassis board



Warning :
Pay careful attention not to connect the wire from output of the regulator to ground.!!

TI-RSLK chassis board uses a TI TLV1117 4.7 to 15-V input, 3.3V 800 mA output, linear regulator

TI-RSLK MAX overview

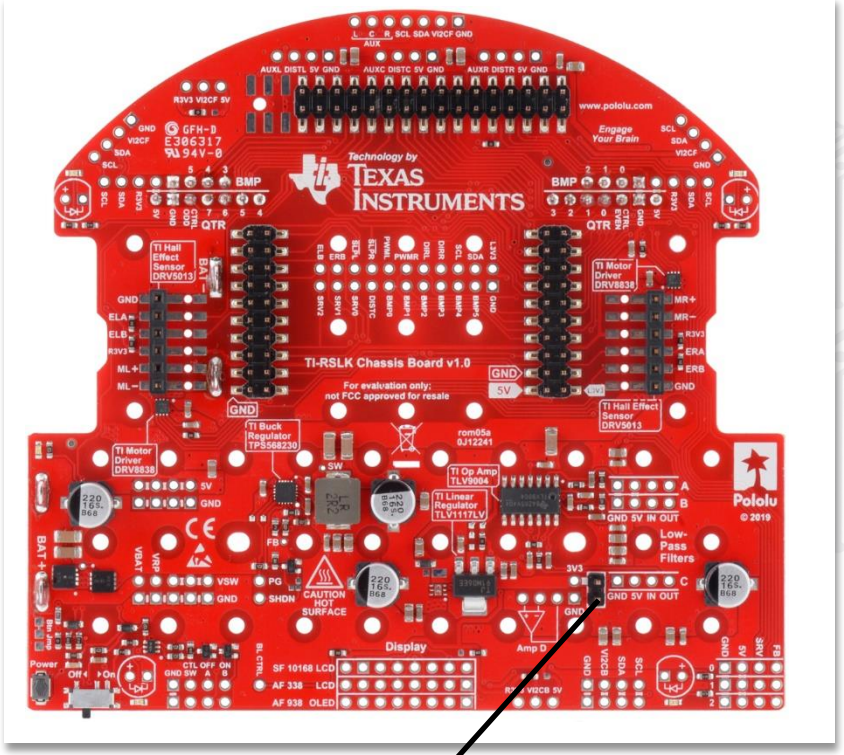


TI-RSLK MAX kit | Not in kit | Optional purchase

TI-RSLK Chassis Board

Summary

- Power
  - Battery
  - +5V and +3.3V regulators
- Interfaces
  - 2 DC motor drivers
  - 2 tachometer interfaces
  - 3 analog log pass filters
  - Extra analog op amp
  - I2C connectors
  - LCD/LED connectors
- Systems approach to robotics
  - Power and interface board
  - MSP432 LaunchPad and software
  - BoosterPacks for wireless communication



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