# EECS192 Lecture 5
Feb. 14, 2017

Notes:

1. Check off-
- 2/19: Motor drive/stall, steering servo from battery, schematics due (+ part location rats nest- no copper)
- PCB design due (Gerbers) Tues 2/21 midnight

2. 2/21 Quiz 3: switch mode power supply and regulator

3. CalDay Sat. April 22 @ UCB

Topics
- Wiring
- Battery cell balancing
- Power supplies
- Linear regulator
- Buck converter
- *Boost converter- switch mode power supply*

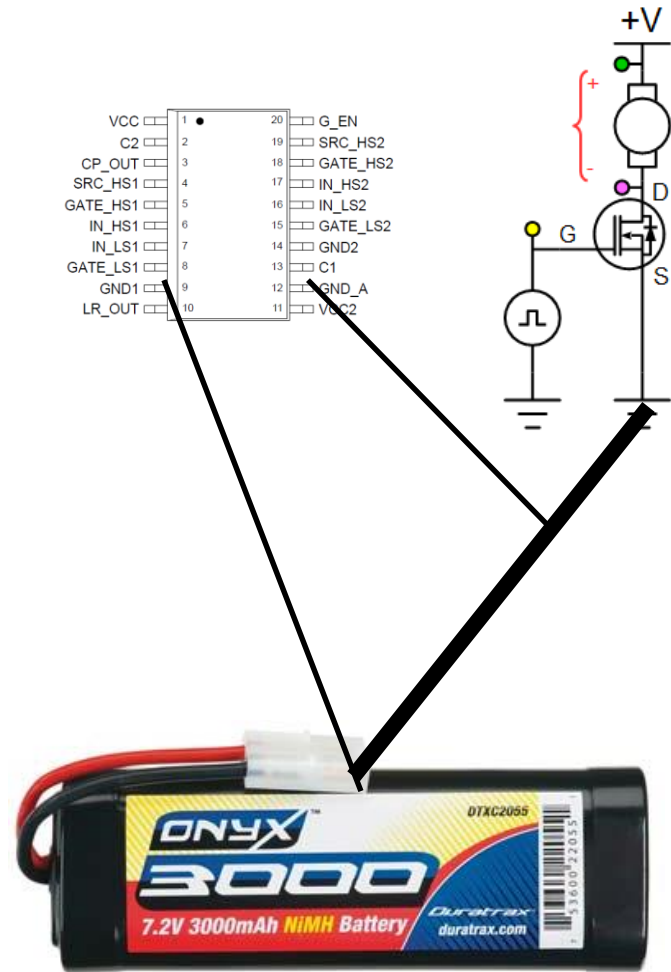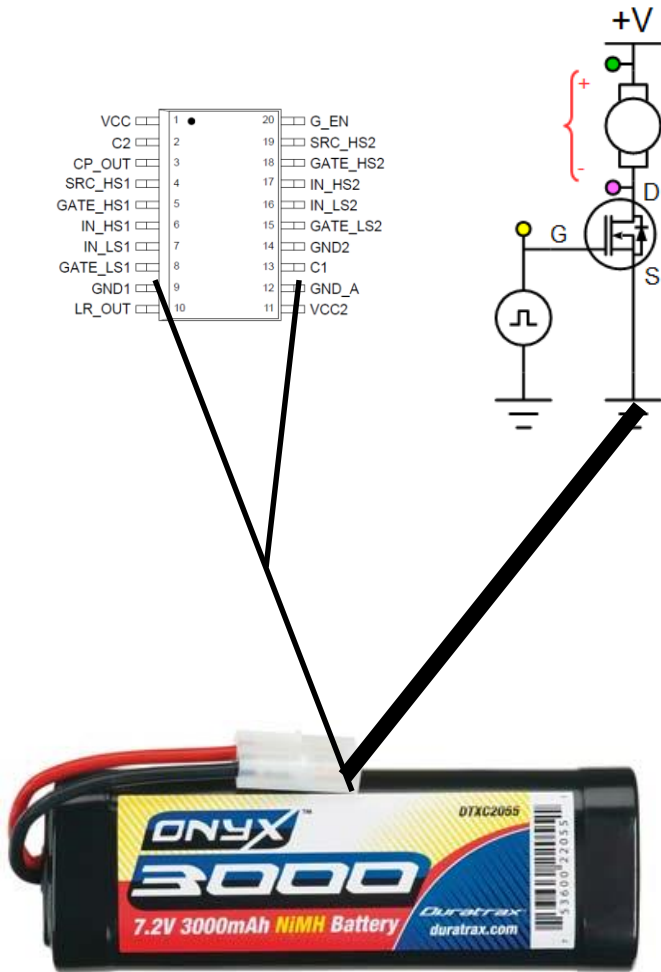# Power supply wiring- Star is better!
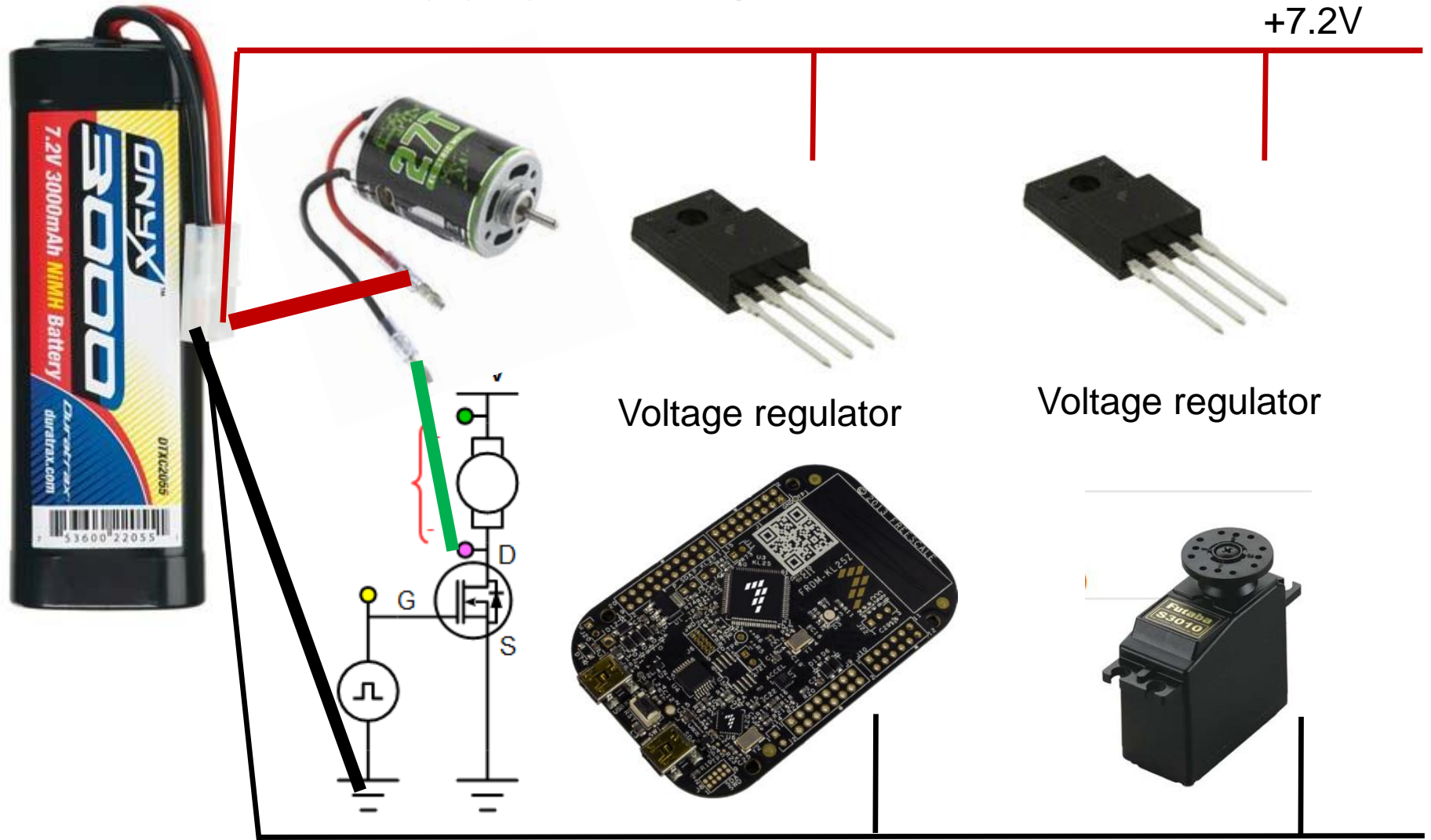
+7.2V

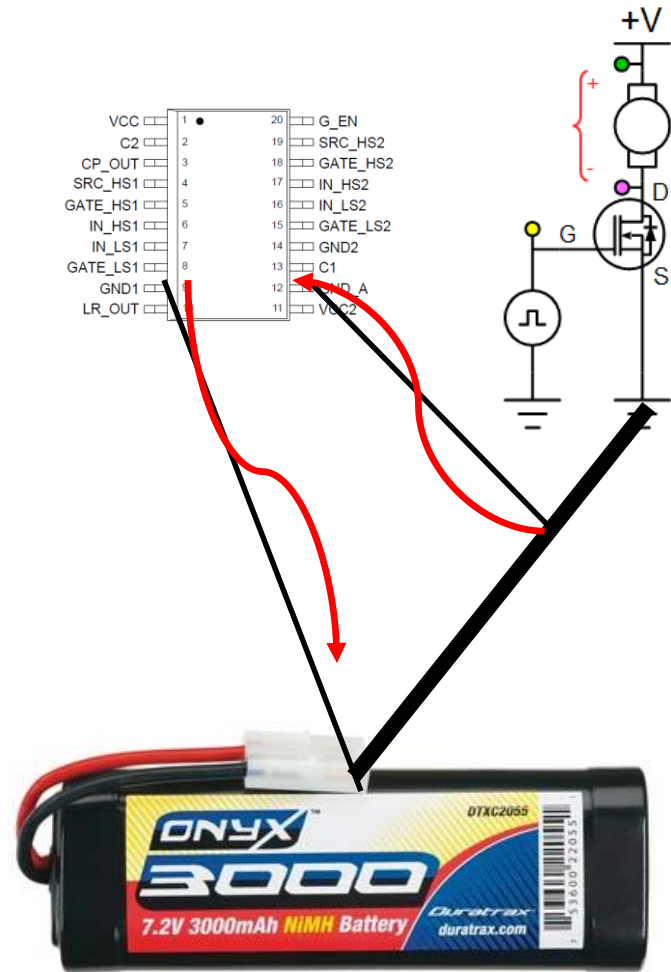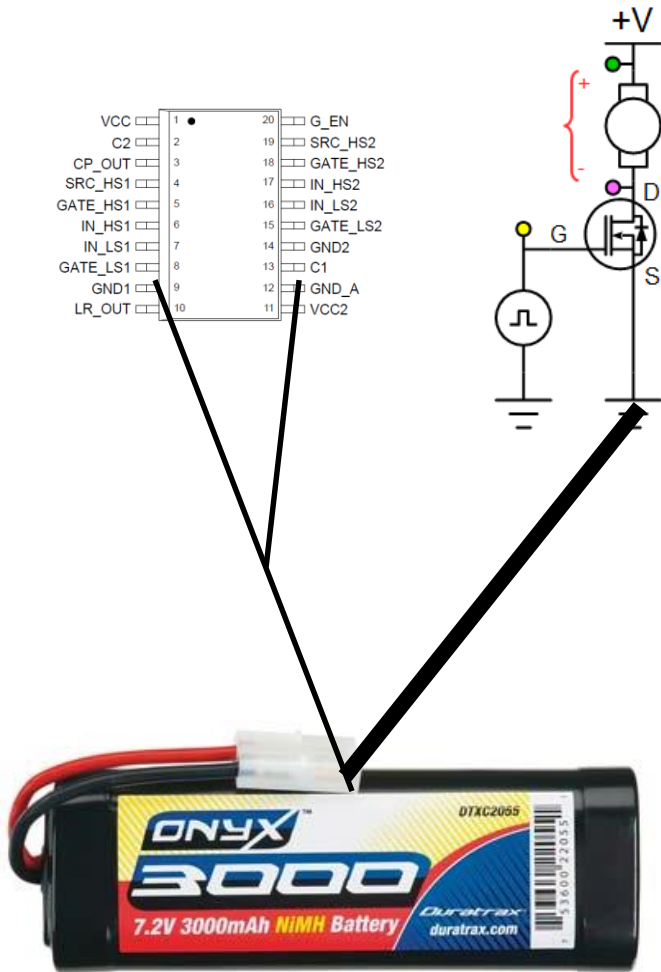Voltage regulator

Voltage regulator

D

G

S

Low power ground

On board: what does this look like electrically (as a schematic)?
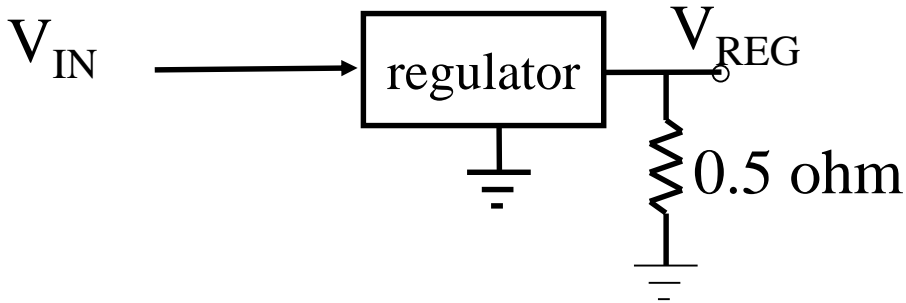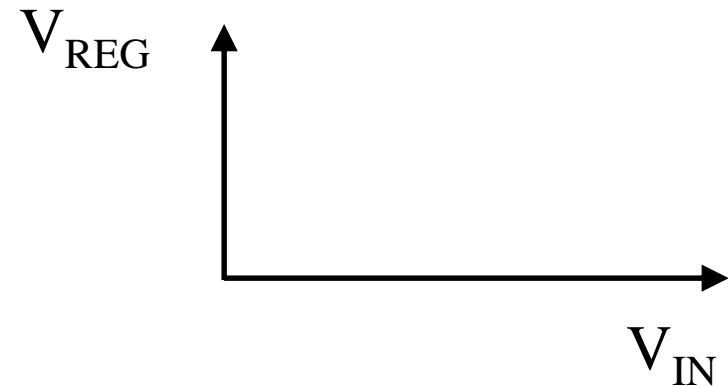
Which is ``Star'' config?

Which is ``Star'' config?
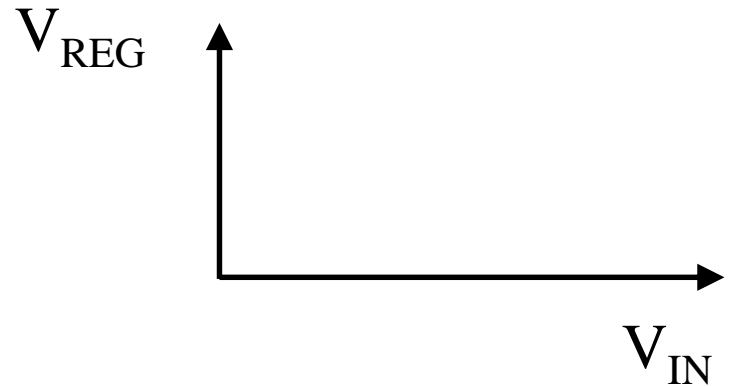
➔ supply waveforms with motor PWM

- Battery model
- Waveforms on board
- Wiring to reduce voltage resistance effects of wiring

V_{IN} ⟶ [regulator] V_{REG}

0.5 ohm

Linear Regulator $V_{IN} > V_{REG}$

V_{REG}

V_{IN}

Boost Converter $V_{IN} < V_{REG}$

V_{REG}
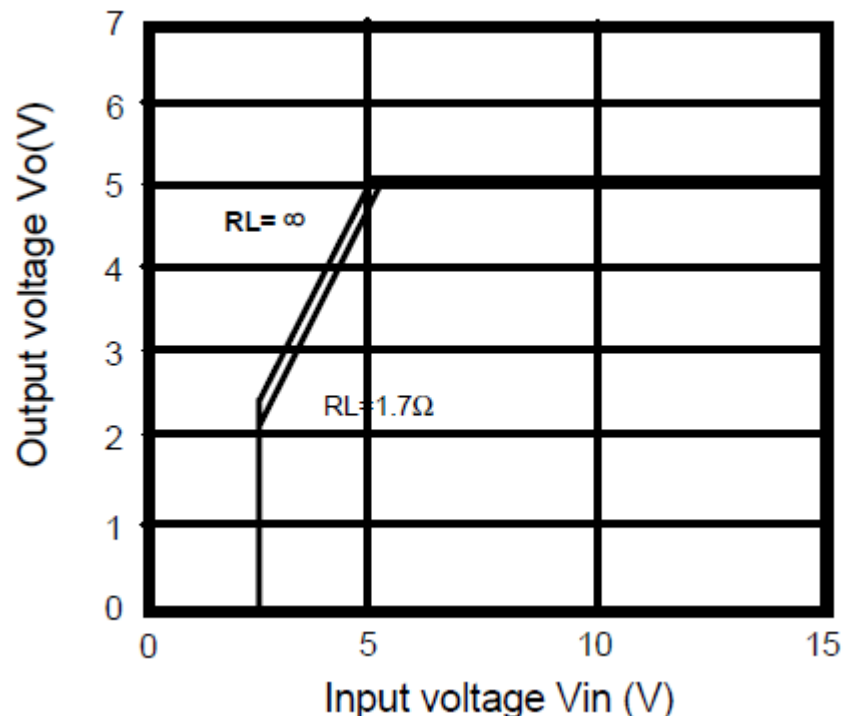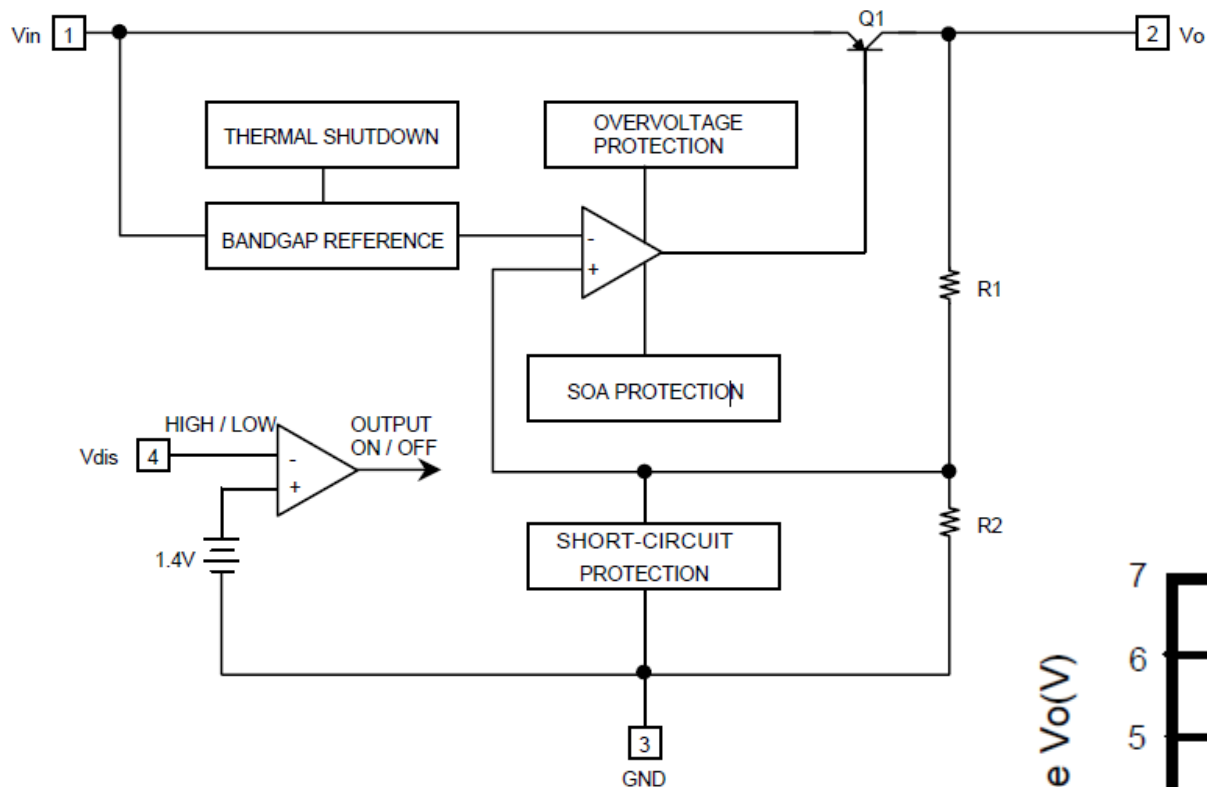
V_{IN}

Buck Converter $V_{IN} < V_{REG}$
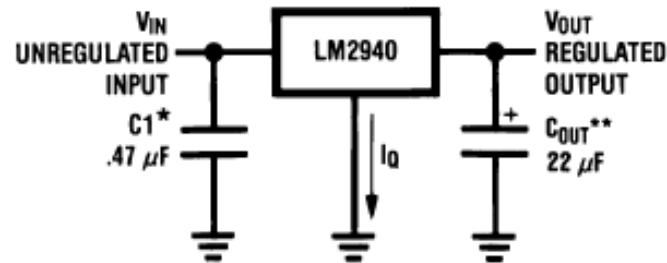
V_{REG}

V_{IN}
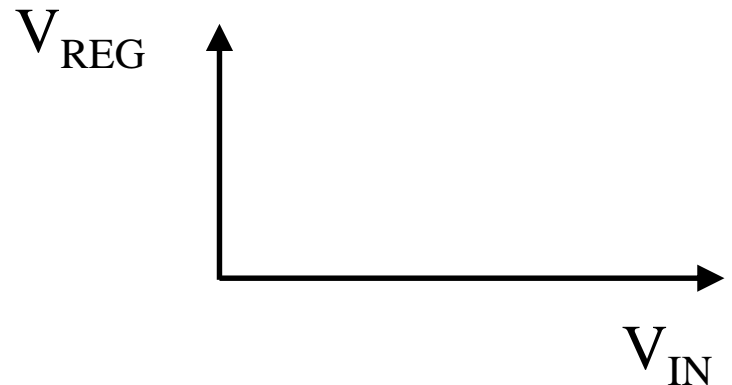
Linear Regulator, e.g. KA378R05

LDO = low drop out
Caution: not all are low drop out

LDO linear regulator LM2940

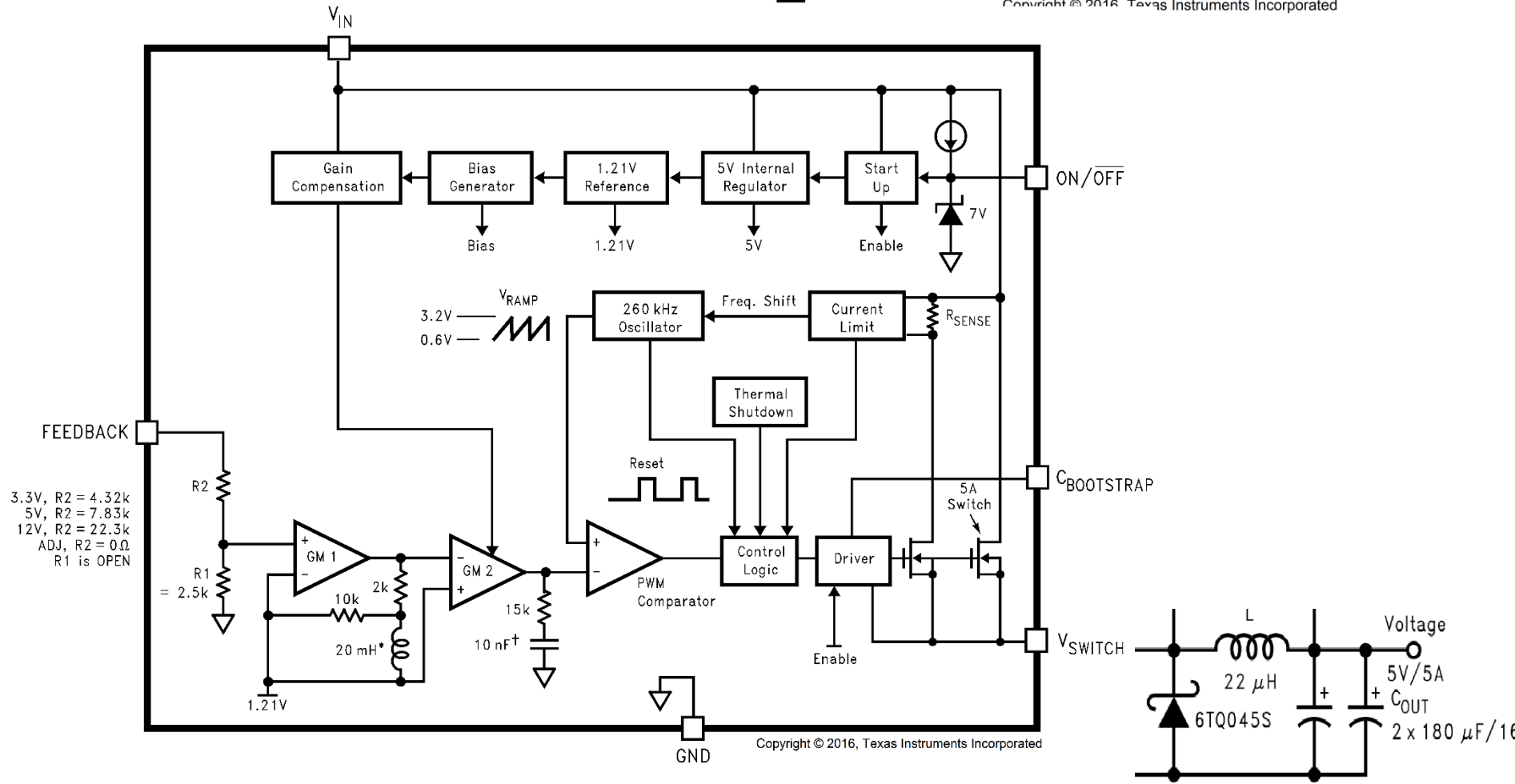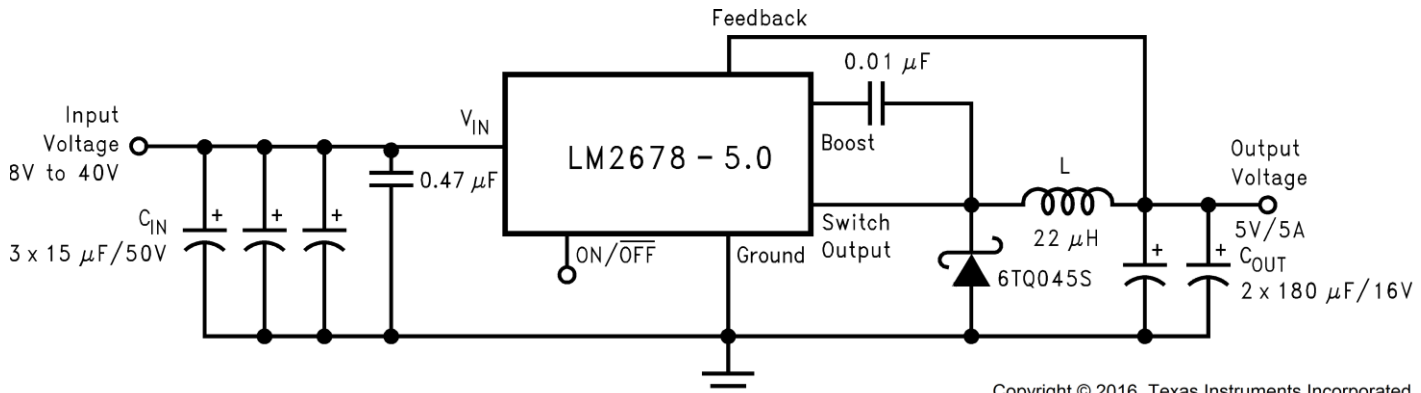**Typical Application**

00882203

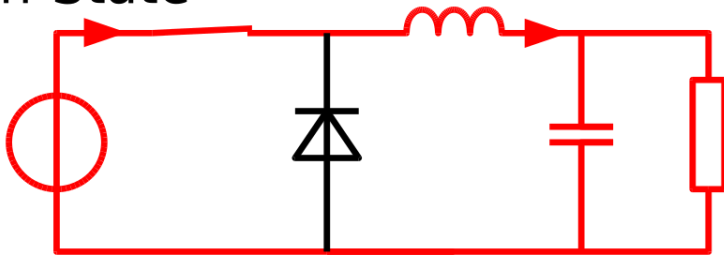*Required if regulator is located far from power supply filter.

**C_{OUT} must be at least 22 µF to maintain stability. May be increased without bound to maintain regulation during transients. Locate as close as possible to the regulator. This capacitor must be rated over the same operating temperature range as the regulator and the ESR is critical; see curve.
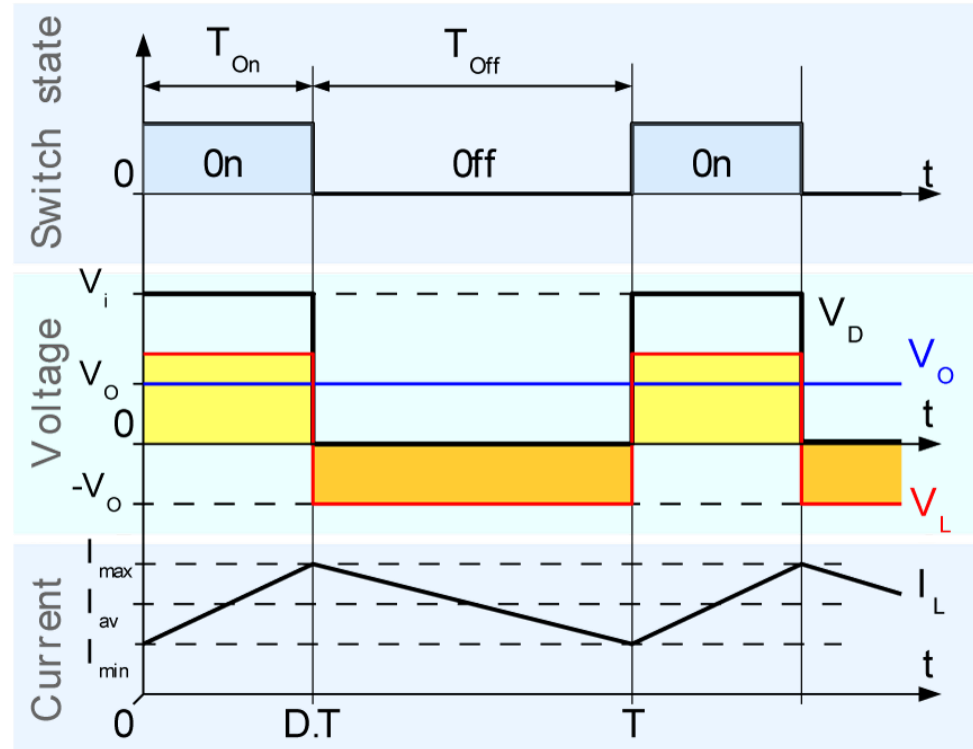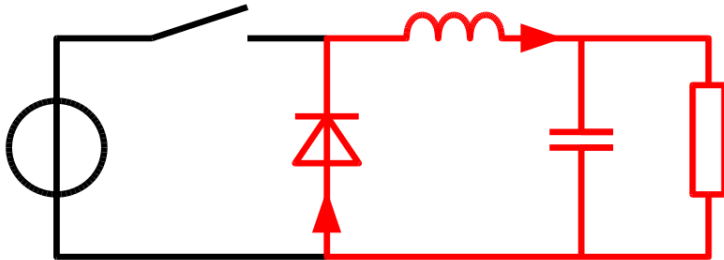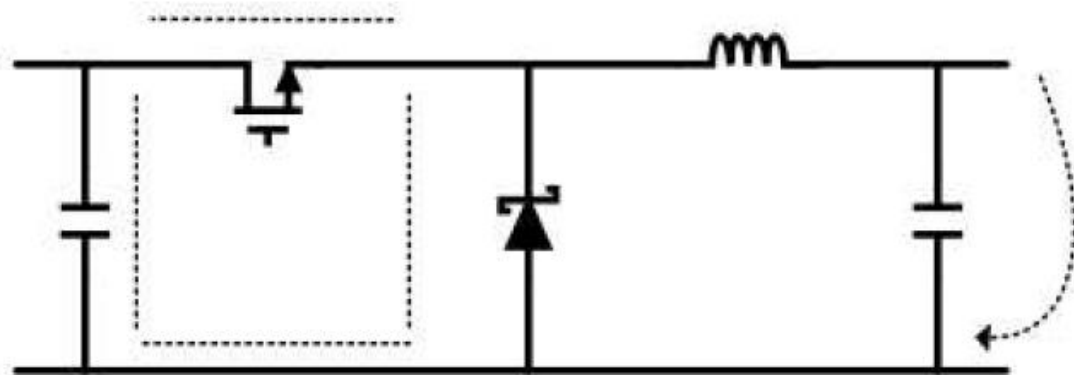
Feedback

0.01 μF

LM2678 − 5.0

Input
Voltage
8V to 40V

V_{IN}

Boost

C_{IN}
3 x 15 μF/50V

0.47 μF

ON/OFF

Switch
Output

Ground

L
22 μH

6TQ045S

Output
Voltage

5V/5A
C_{OUT}
2 x 180 μF/16V

Copyright © 2016, Texas Instruments Incorporated

V_{IN}

ON/OFF

Gain
Compensation

Bias
Generator

1.21V
Reference

5V Internal
Regulator

Start
Up

7V

Bias

1.21V

5V

Enable

V_{RAMP}

3.2V

0.6V

260 kHz
Oscillator

Freq. Shift

Current
Limit

R_{SENSE}

Thermal
Shutdown

FEEDBACK

3.3V, R2 = 4.32k
5V, R2 = 7.83k
12V, R2 = 22.3k
ADJ, R2 = 0Ω
R1 is OPEN

R2

R1
= 2.5k

GM 1

10k

2k

20 mH*

1.21V

GM 2

15k

10 nF†

Reset

PWM
Comparator

Control
Logic

Driver

Enable

$C_{BOOTSTRAP}$

5A
Switch

V_{SWITCH}

GND

Copyright © 2016, Texas Instruments Incorporated

L
22 μH

6TQ045S

Voltage

5V/5A
C_{OUT}
2 x 180 μF/16

Buck Converter

On-State

Off-State

Switch state

T_{On} T_{Off}

0 On Off On t

Voltage

V_i

V_D

V_O

V_O

0 t

$-V_O$

V_L

Current

I_{max}

I_{av}

I_L

I_{min}

0 D.T T t

https://en.wikipedia.org/wiki/Buck_converter
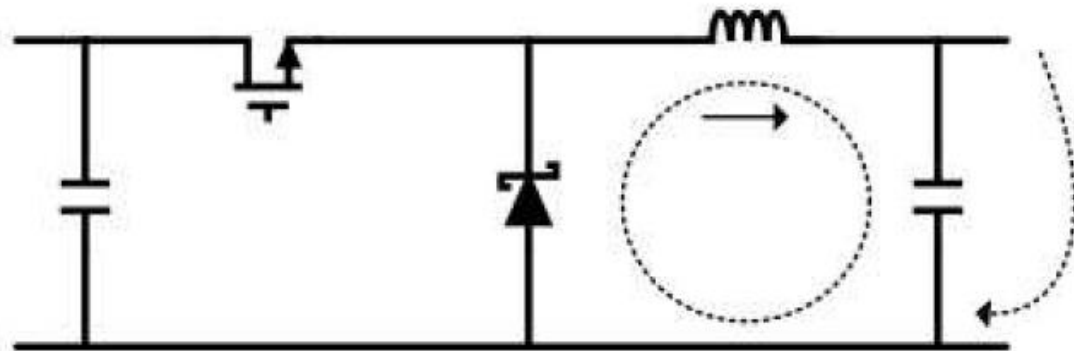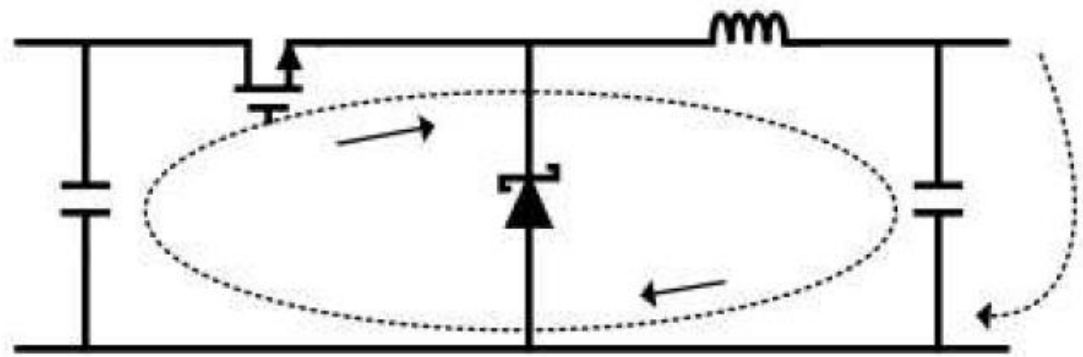
Buck Converter
LM2678

DC-DC Gotchas

- Switch stuck on ➔ 11V LiPo burns out everything
- High peak currents ➔ big conductors, short leads
- 200 kHz radiation into sensor circuits or A/D
- Filter caps: low ESR, low inductance
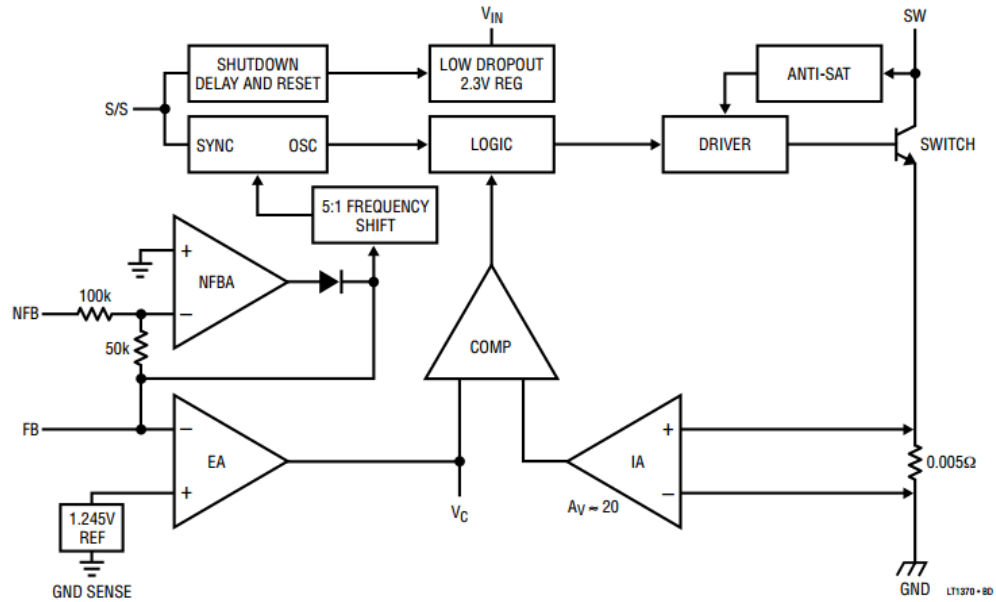- Feedback disconnect, noise on feedback line

Lin Reg Gotchas

- Inefficient: need heat sink
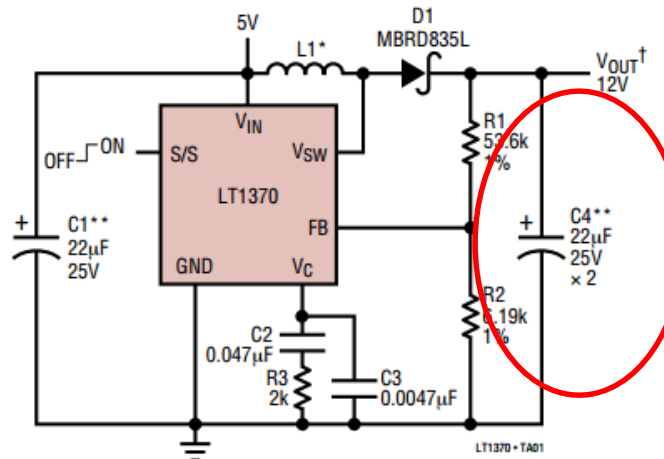- Filter caps: low ESR, low inductance possible instability!

Boost Converter- LT1370
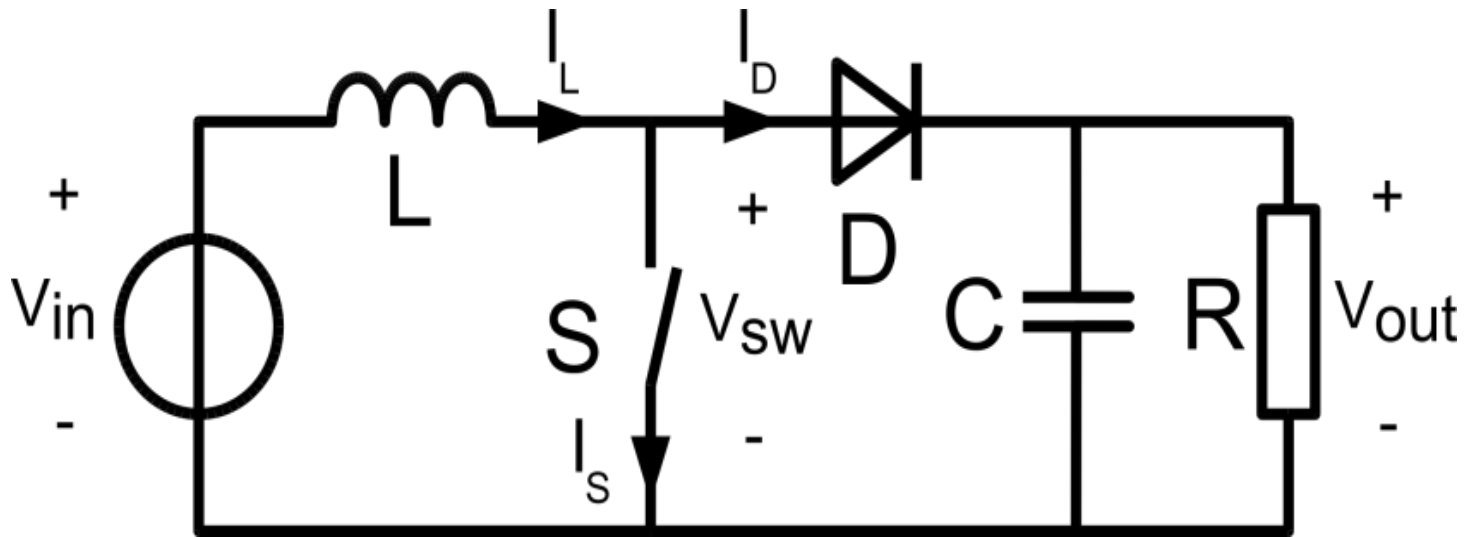
LT1370

BLOCK DIAGRAM

5V to 12V Boost Converter

Caution: ESR!
Need special cap

Boost Converter

Waveforms on board
(also see boost
converter notes)