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BOOST REGULATORS (STEP-UP)

A boost regulator raises a lower voltage to a higher one, so a single 3.7 V cell can drive a 5 V rail. The topology, how duty cycle sets the output, and why input current is higher.

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A boost regulator does what a buck cannot: it raises a lower voltage to a higher one. That is how a single 3.7 V lithium cell can drive a 5 V rail. It uses the same switching idea as a buck, with the parts rearranged so the inductor comes first.

WHY YOU NEED A BOOST

Sometimes the battery sits below the rail you need. A single lithium cell is about 3.7 V, but plenty of parts want 5 V. You cannot make 5 V from 3.7 V by dropping voltage, because there is nothing to drop. A boost adds voltage by switching, so the cell can feed a higher rail.

THE BASIC BOOST

A boost puts the inductor across the input first. When the switch closes, current builds in the inductor and stores energy in its magnetic field. When the switch opens, that stored energy has nowhere to go but forward, through a diode into the output capacitor, and it arrives at a voltage higher than the input. Repeat fast and the output holds above the input.

DUTY CYCLE SETS THE STEP-UP

As with a buck, the duty cycle sets the output, but the relationship inverts: the longer the switch stays on each cycle, the higher the output climbs above the input. A larger duty cycle means a bigger step-up.

$$V_{out} = V_{in} / (1 - D)$$

INPUT CURRENT IS HIGHER THAN OUTPUT

Energy is conserved, so a boost cannot make power from nothing. Raising the voltage means the input must supply more current than the output delivers. Push 3.7 V up to 5 V and the cell hands over more amps than the 5 V rail draws, plus a little lost to the switching. A boost trades battery current for rail voltage.

$$I_{in} \times V_{in} = I_{out} \times V_{out}$$

INDUCTOR FIRST: STORED ENERGY IS RELEASED FORWARD AT A VOLTAGE ABOVE THE INPUT.

DEEP DIVE · THE LIMIT OF A BOOST, AND WHY A DYING CELL STRAINS IT

A boost has a ceiling. As the input falls, the duty cycle must rise to hold the same output, and the input current climbs to deliver the same power from a smaller voltage. Near a dead cell, with 3.0 V trying to hold 5 V at a real load, the inductor current can get very large and the efficiency sags. That is why a boost-fed board often browns out before the cell is truly empty, and why the battery, the boost, and the load have to be sized together rather than in isolation.

- Texas Instruments. Basic Calculation of a Boost Converter's Power Stage (SLVA372). ti.com

CHECKPOINT

1. What does a boost regulator let a 3.7 V cell do?

a. Power a 1.8 V chip more efficiently

b. Drive a higher rail, such as 5 V

c. Recharge without a charger IC

ANSWER · B

A boost steps the cell's voltage up so it can feed a rail above its own voltage.

2. In a boost, how does the input current compare to the output current?

a. It is higher, because raising the voltage conserves power

b. It is exactly equal

c. It is always zero

ANSWER · A

Iin x Vin = Iout x Vout: a higher output voltage means the input must supply more current.

3. Which part stores the energy that a boost releases at a higher voltage?

a. The output capacitor

b. The Schottky diode

c. The inductor

ANSWER · C

The inductor builds current while the switch is closed and releases it forward when the switch opens.

- Prerequisite: buck regulators (step-down)
- Next: LDO vs switcher, picking one