Why is Your I_Q Too High?

nanoPower Boost Converter

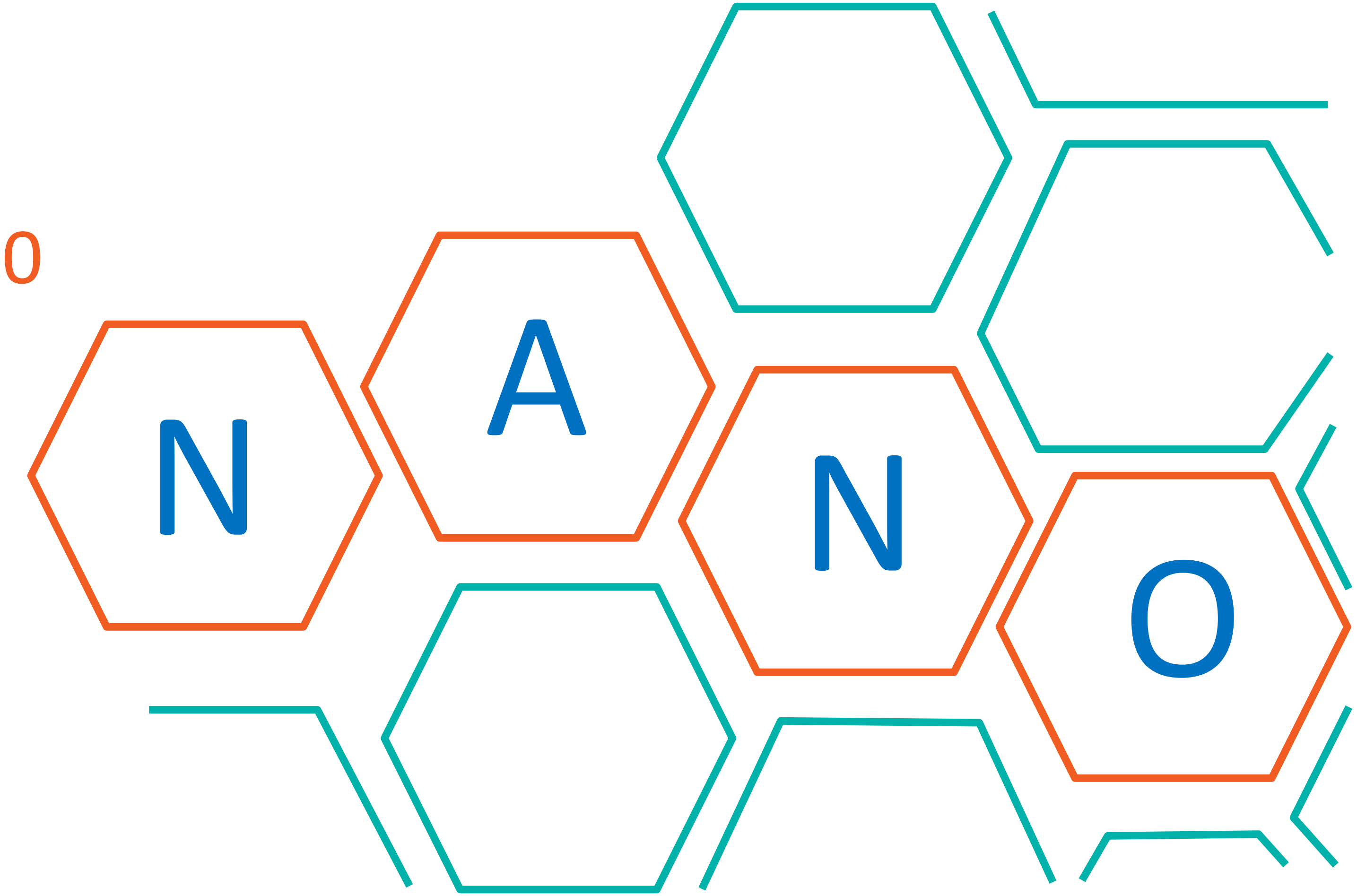
May, 2017

nano ; n

10^{-9}

1/ 1000 000 000

0.000 000 001



10^n	접두어	기호	배수	십진수
10^{24}	요타 (yotta)	Y	자	1 000 000 000 000 000 000 000 000
10^{21}	제타 (zetta)	Z	십해	1 000 000 000 000 000 000 000
10^{18}	엑사 (exa)	E	백경	1 000 000 000 000 000 000
10^{15}	페타 (peta)	P	천조	1 000 000 000 000 000
10^{12}	테라 (tera)	T	조	1 000 000 000 000
10^{9}	기가 (giga)	G	십억	1 000 000 000
10^{6}	메가 (mega)	M	백만	1 000 000
10^{3}	킬로 (kilo)	k	천	1 000
10^{2}	헥토 (hecto)	h	백	100
10^{1}	데카 (deca)	da	십	10
10^{0}			일	1
10^{-1}	데시 (deci)	d	십분의 일	0.1
10^{-2}	센티 (centi)	c	백분의 일	0.01
10^{-3}	밀리 (milli)	m	천분의 일	0.001
10^{-6}	마이크로 (micro)	µ	백만분의 일	0.000 001
10^{-9}	**나노** (nano)	n	십억분의 일	0.000 000 001
10^{-12}	피코 (pico)	p	일조분의 일	0.000 000 000 001
10^{-15}	펨토 (femto)	f	천조분의 일	0.000 000 000 000 001
10^{-18}	아토 (atto)	a	백경분의 일	0.000 000 000 000 000 001
10^{-21}	젭토 (zepto)	z	십해분의 일	0.000 000 000 000 000 000 001
10^{-24}	욕토 (yocto)	y	일자분의 일	0.000 000 000 000 000 000 000 001

nano ; n

10^{-9}

1/ 1000 000 000

0.000 000 001

Agenda

- Lower I_Q: nanoPower defined
- Emerging applications
- Unique requirements

nanoPower ICs

Very low power ICs that have quiescent current < 1µA

- Extending battery life

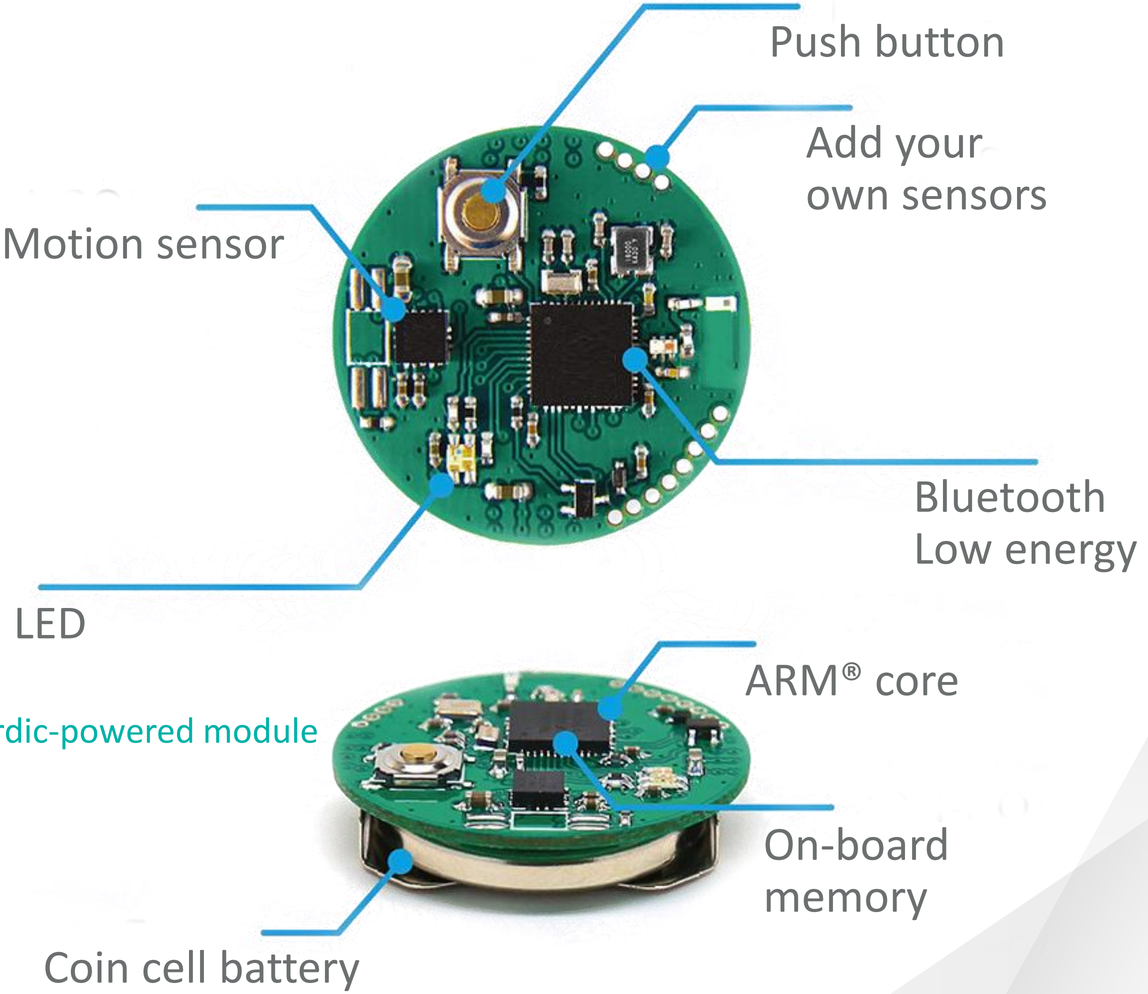
Key applications

- Wearable devices
- IoT sensors
- Battery-powered medical equipment
- Low-power wireless communication

Don’t Overlook the Regulated Supply!

A boost converter can extend battery life & reduce PCB size

- Every little bit counts
- Shrinking product size
  - > Small coin cell battery
  - > Small footprint
- Extended battery life
  - > Low quiescent boost converter (300nA)
  - > Minimized leakage loss
  - > True shutdown for long shelf life
  - > High/low load efficiency



MetaWear Nordic-powered module

Why nanoPower Regulators?

Smaller devices need smaller batteries

Lithium Coin Cell

- CR1216 lithium coin cell
  - > 34mAh from 3V to 2V terminal voltage
  - > 1% per year self-discharge
  - > That’s only 39nA self-discharge current!
  - > 10-year operating life is 390nA average load

Why nanoPower Regulators?

Smaller devices need smaller batteries

Specifications	Energizer CR1215
Nominal voltage	3.0 volts
Typical capacity	34 mAh (to 2.0 volts) Rated at 62K ohms at 21°C
Self discharge	~1% / year

- CR1216 lithium coin cell
  - > 34mAh from 3V to 2V voltage
  - > 1% per year self-discharge
  - > That's only 39nA self-discharge current!
  - > 10-year operating life is 390nA average load

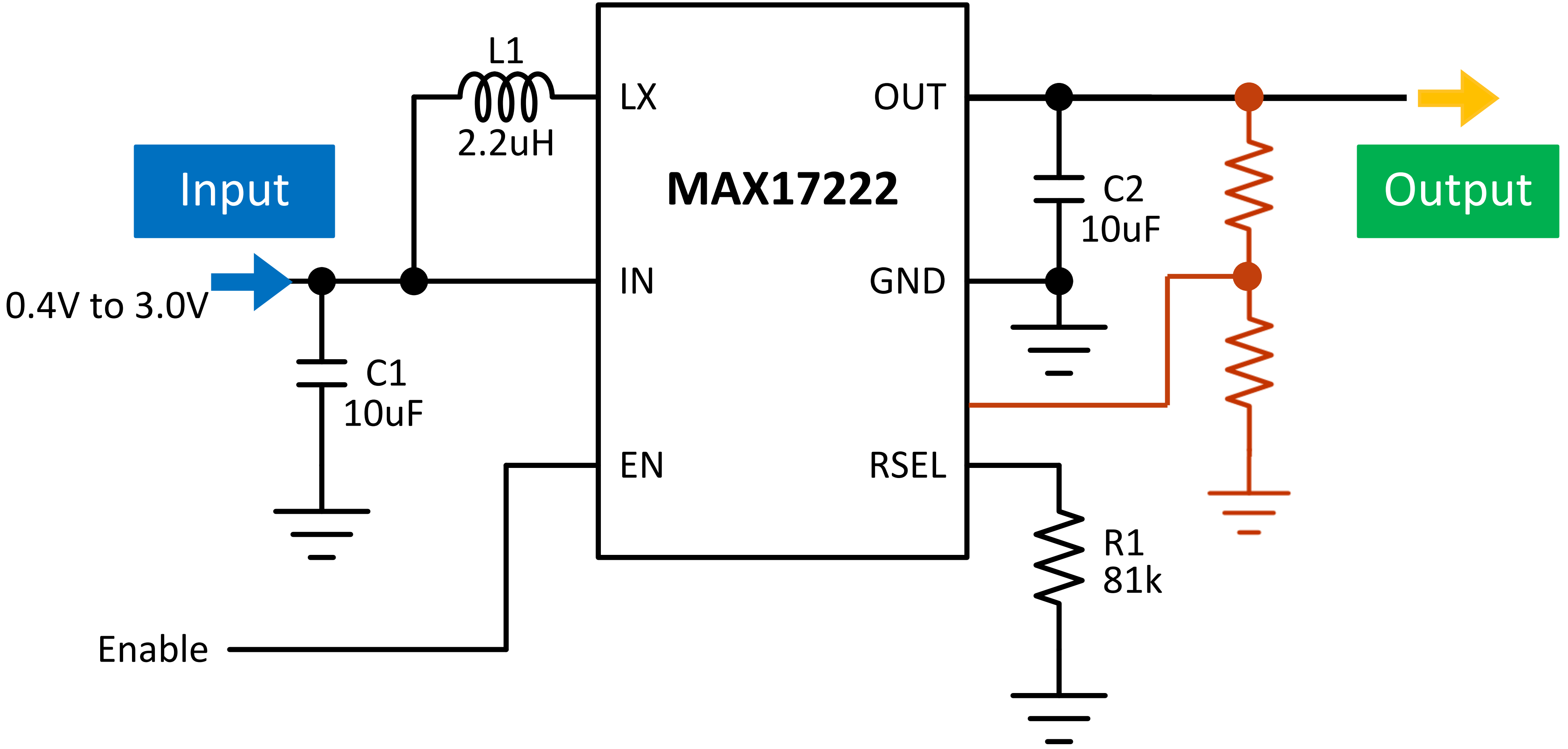
Why nanoPower Regulators?

nanoPower regulators

- Need to power circuitry with long idle states
  - > **15mA** for 10ms every minute = 2.5uA
  - > **300nA** (nanopower boost)/2.5uA = 12% loss
  - > 1uA (non-nano boost)/2.5uA = 50% loss

Regulator quiescent current should compete with battery self-discharge

nanoPower Boost with True Shutdown™



nanoPower Boost with True Shutdown™

Low I_Q architecture

- 300nA low-power mode optimizes quiescent current

Small external components

- 2MHz switching frequency, small inductor

True Shutdown

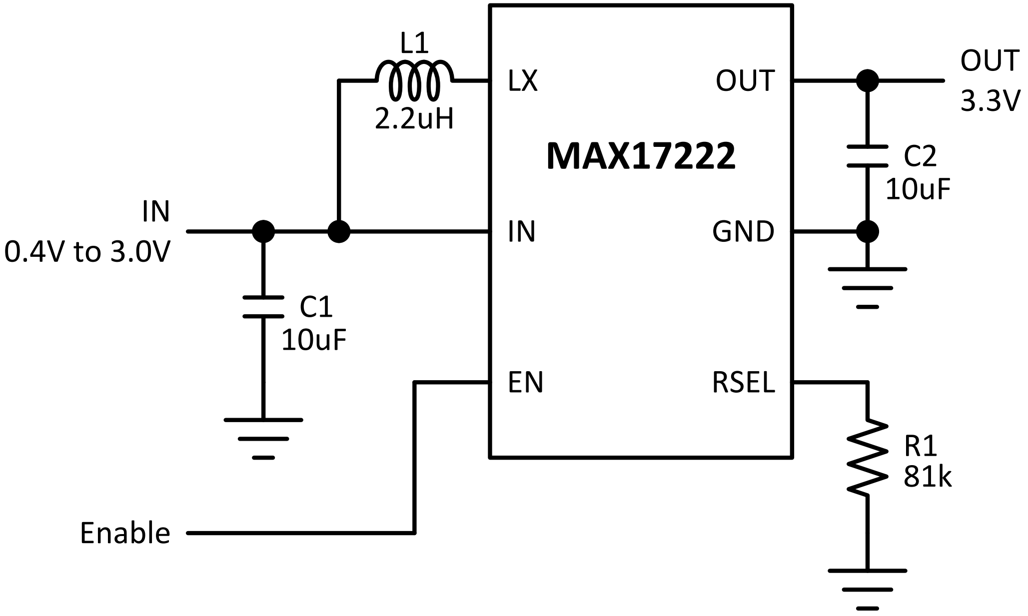
- No quiescent current, V_{OUT} from 0V to 5.5V

No resistive feedback

- Current loses

Efficiency

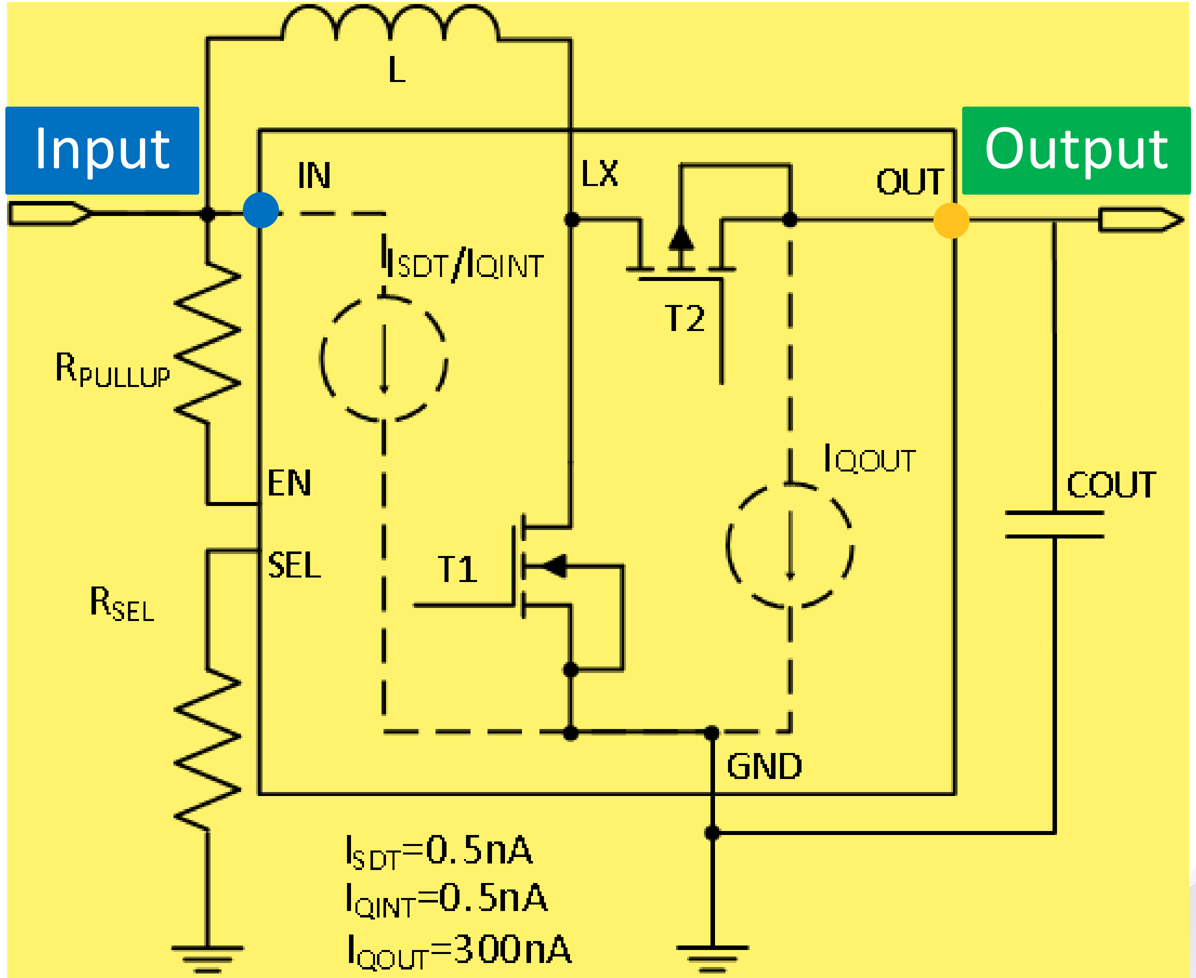
- High/low load efficiency



nanoPower Boost with True Shutdown

True Shutdown

- Storables (medical patches)
- Long shelf life
- Only 0.5nA leakage in shutdown
- Battery self-discharge dominates



Extending Usable Battery

Battery voltage drops
as stored energy is drained

How do we get more usable power

- operates down to 0.4V input
- How do we keep the device enabled?

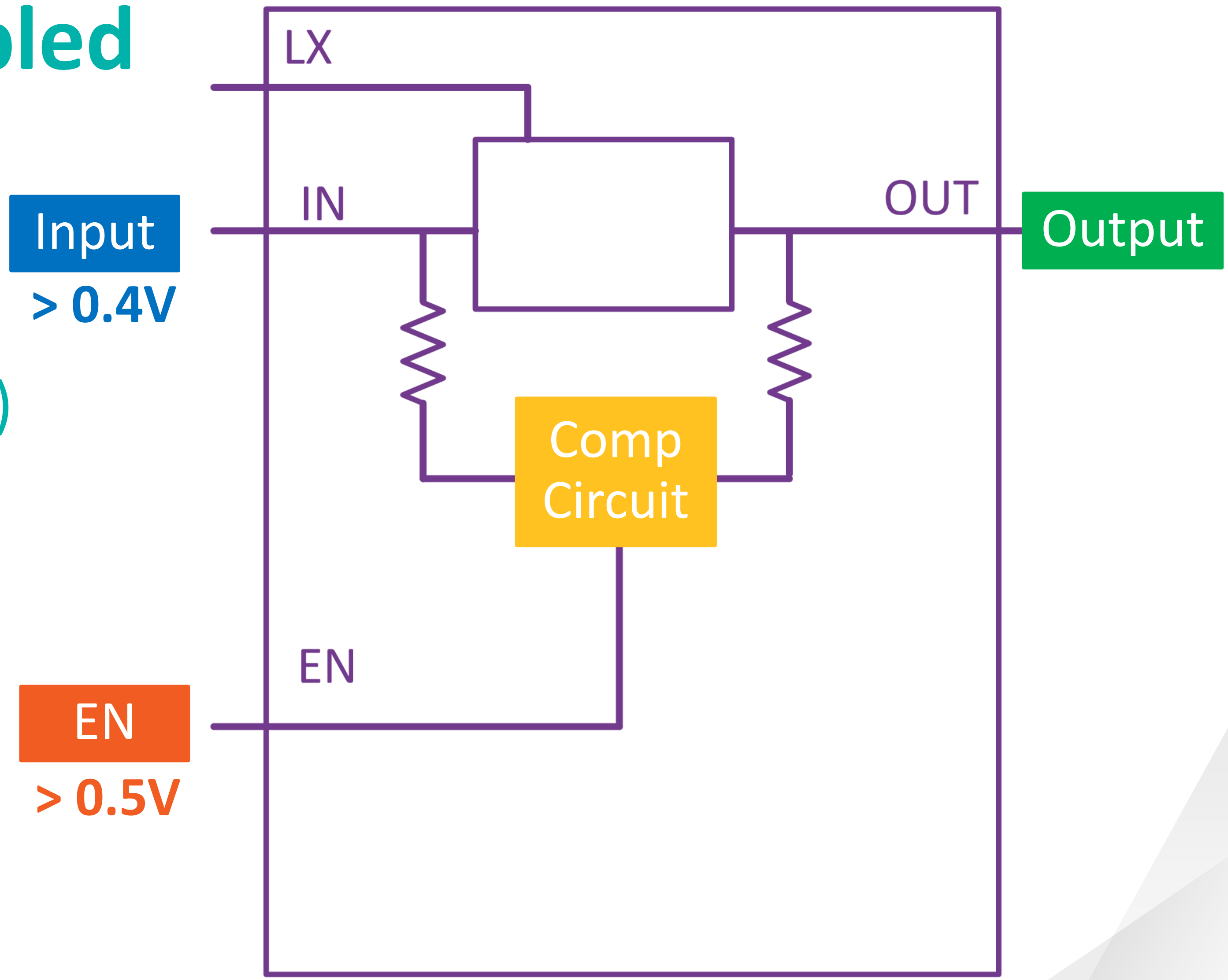
0.4V operation

Keeping the Boost Enabled

How do we keep the circuit alive?

Unique internal enable circuit (EN)

- Internal pull-up resistors
- Choose between IN and OUT

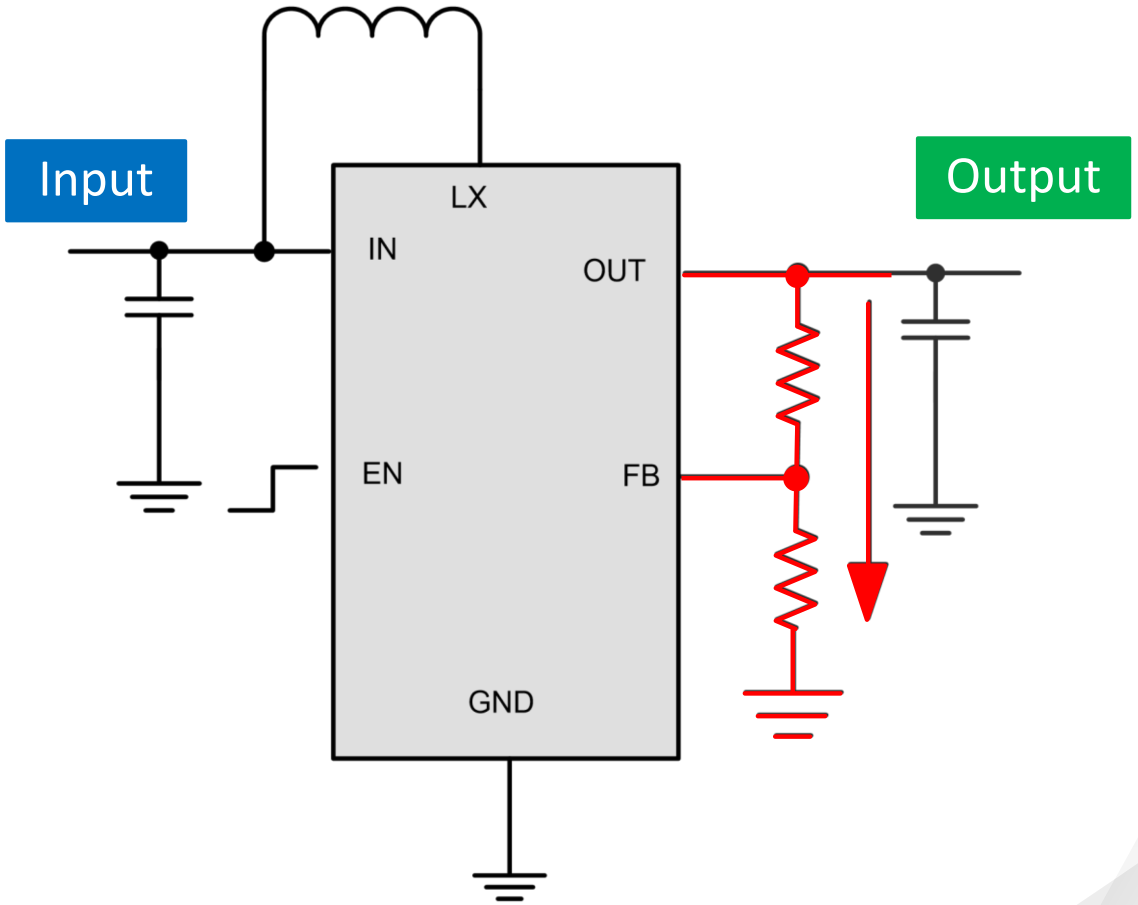


Losses Through the Feedback

Feedback network

- Setting output voltage
- High impedance resistor
- 10MΩ to 30MΩ = 125 nA
- 10kΩ to 30kΩ = 125 000 nA

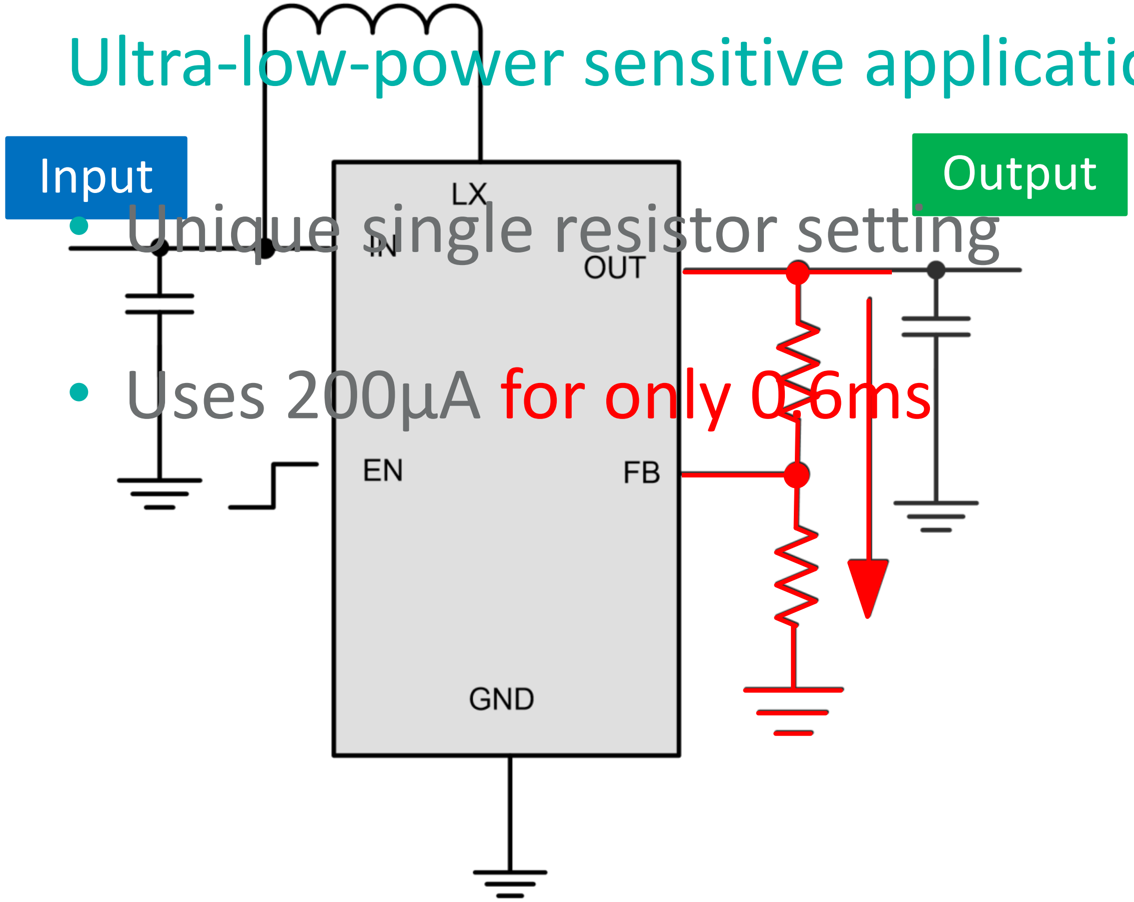
= 125uA @always

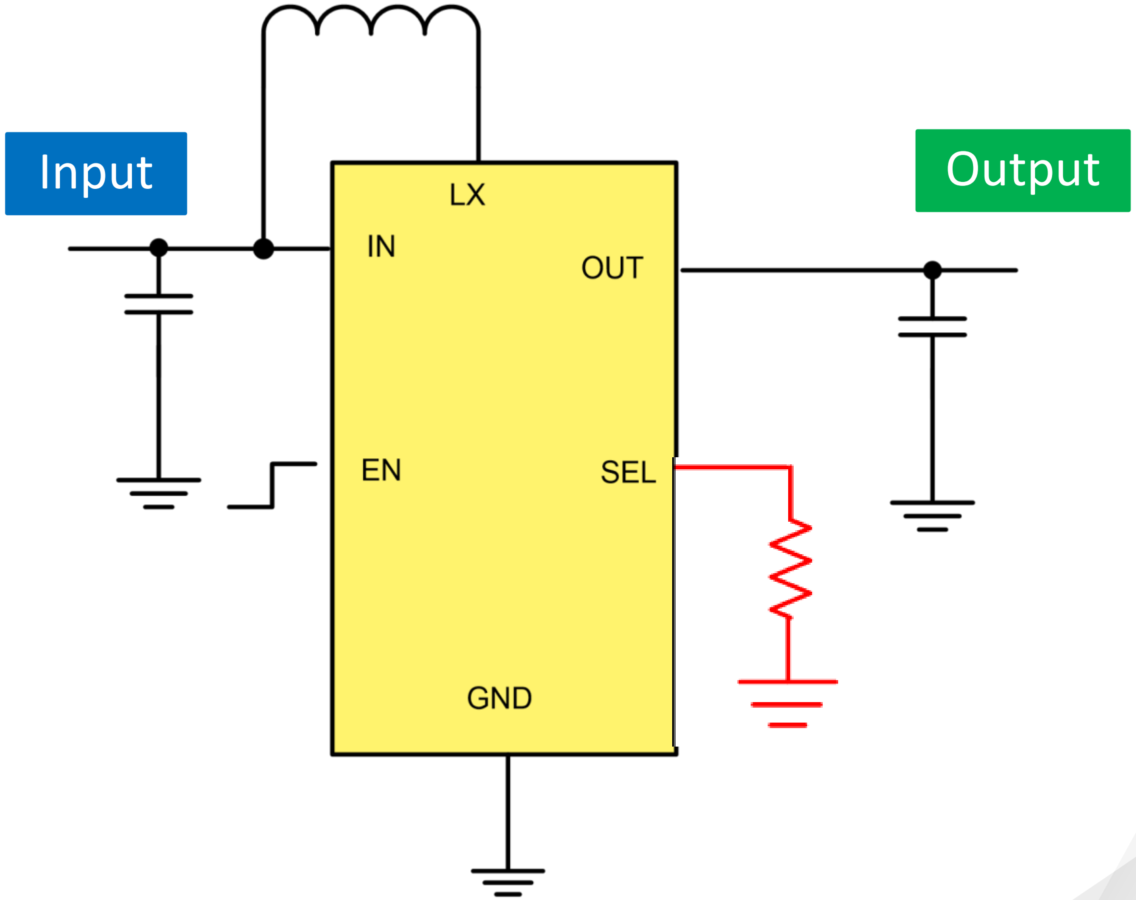


Losses Through the Feedback

Ultra-low-power sensitive applications

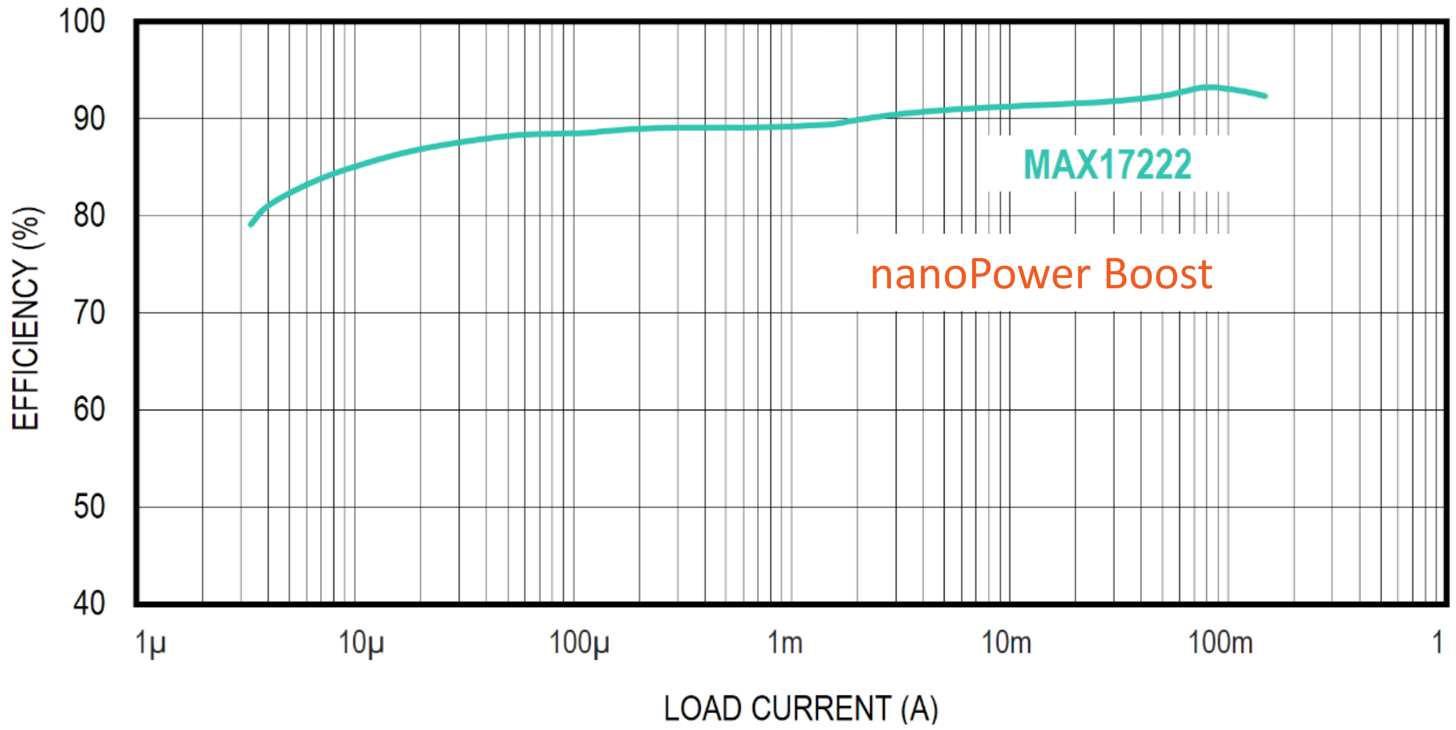
- Unique single resistor setting
- Uses 200µA for only 0.6ms



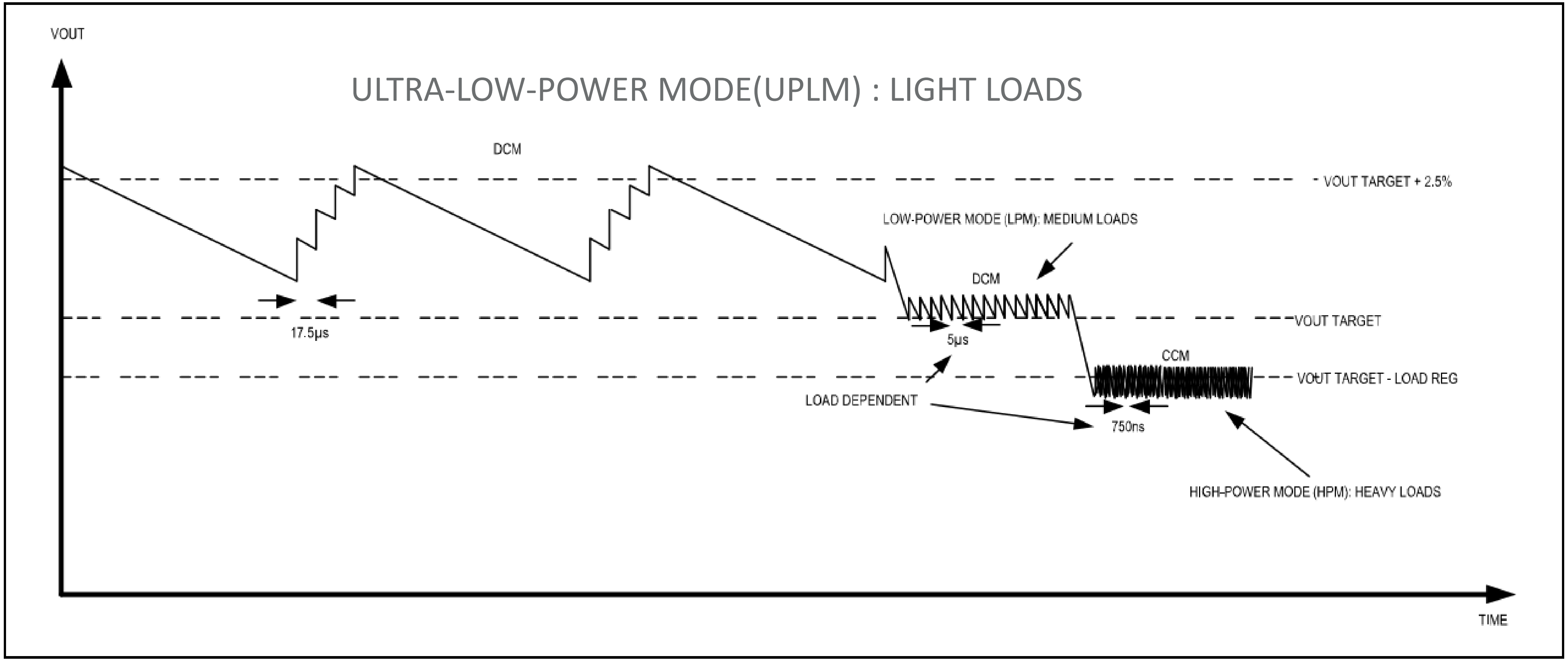


High Efficiency Throughout the Load Range

- Key contributor to power loss
- High losses at low output
- Many long-life IoT applications run on ultra-low power



ULPM, LPM, and HPM Waveforms

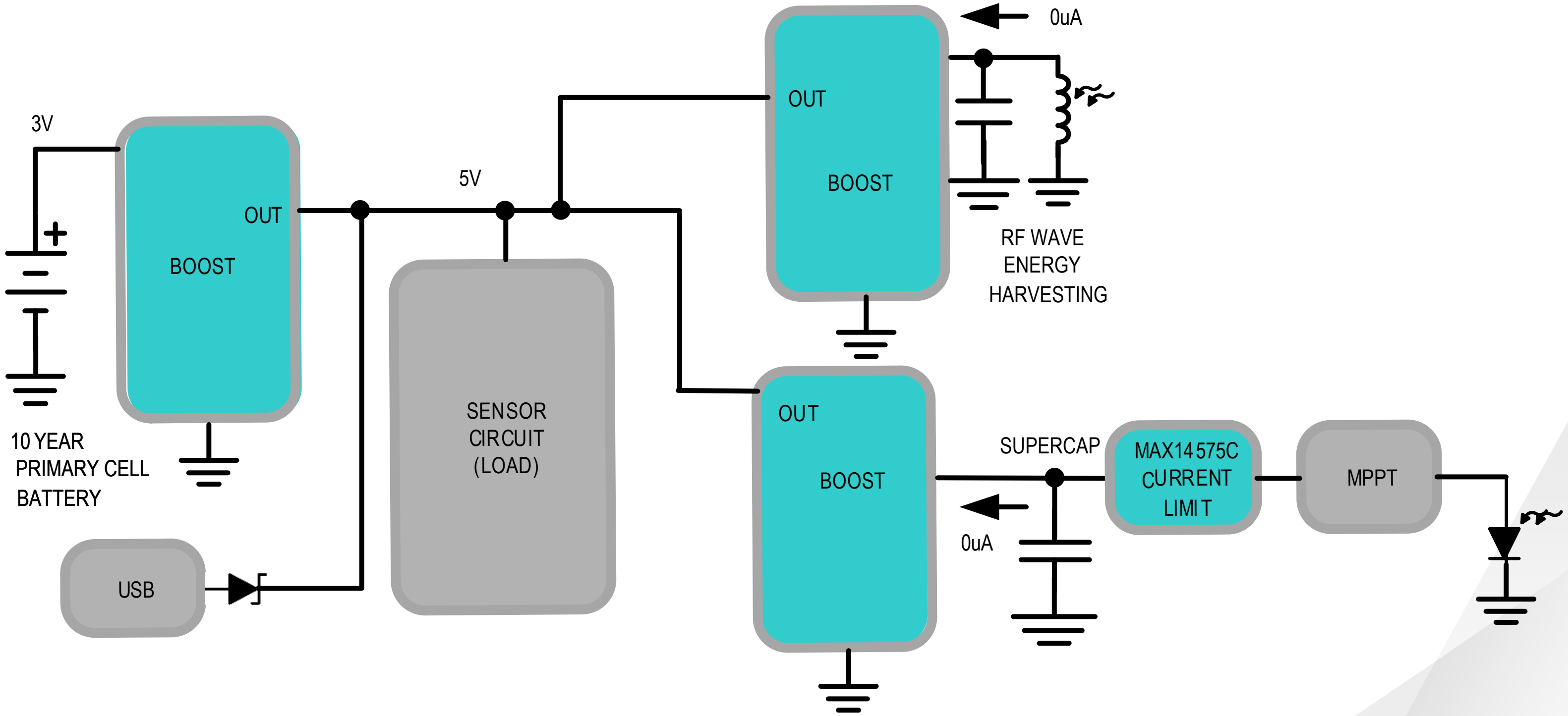


Multi-Source Systems

Working with Multiple Power Sources

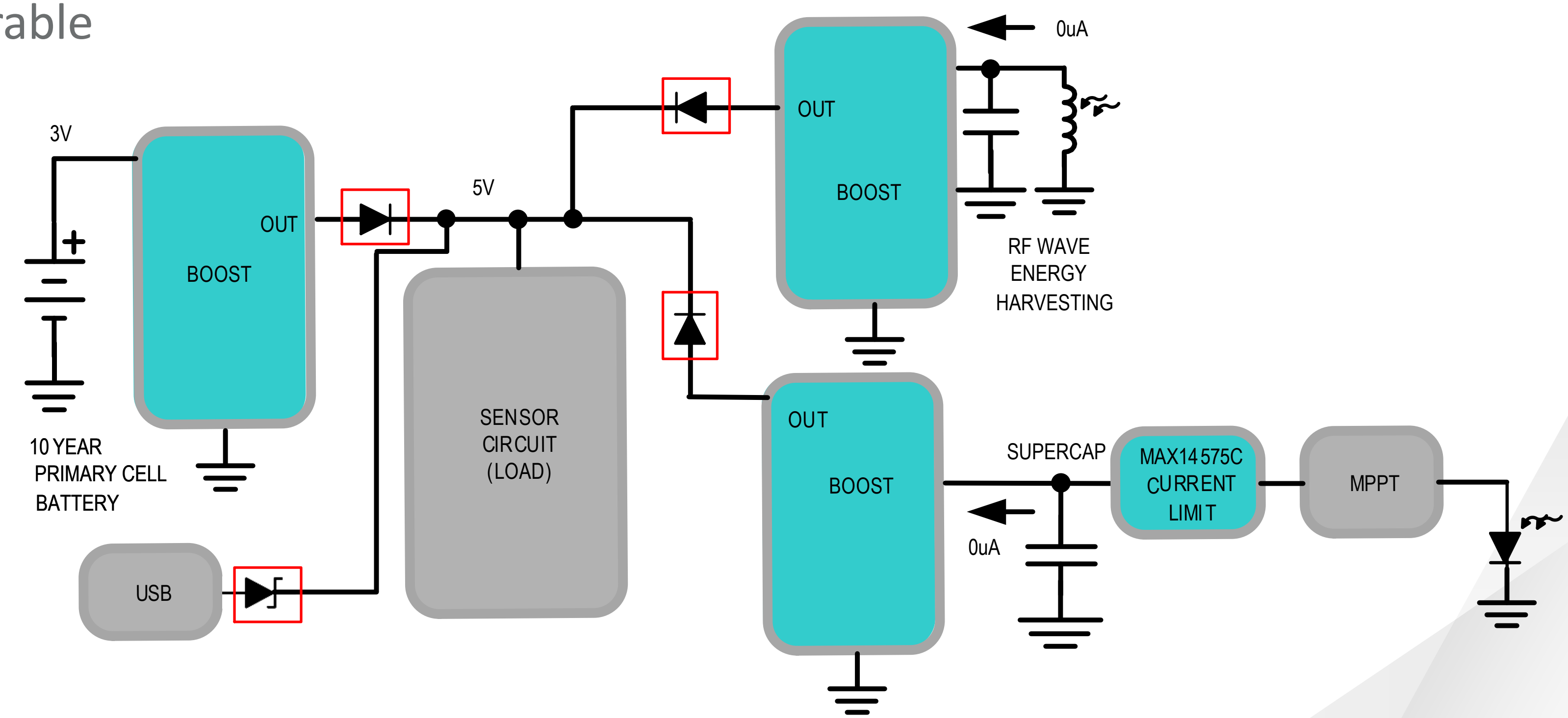
- Battery detection
- Disconnects body diode
- Soft start slowly ramps output
- No overvoltage oscillations

IOT SENSING SYSTEM WITH MULTIPLE ENERGY SOURCES



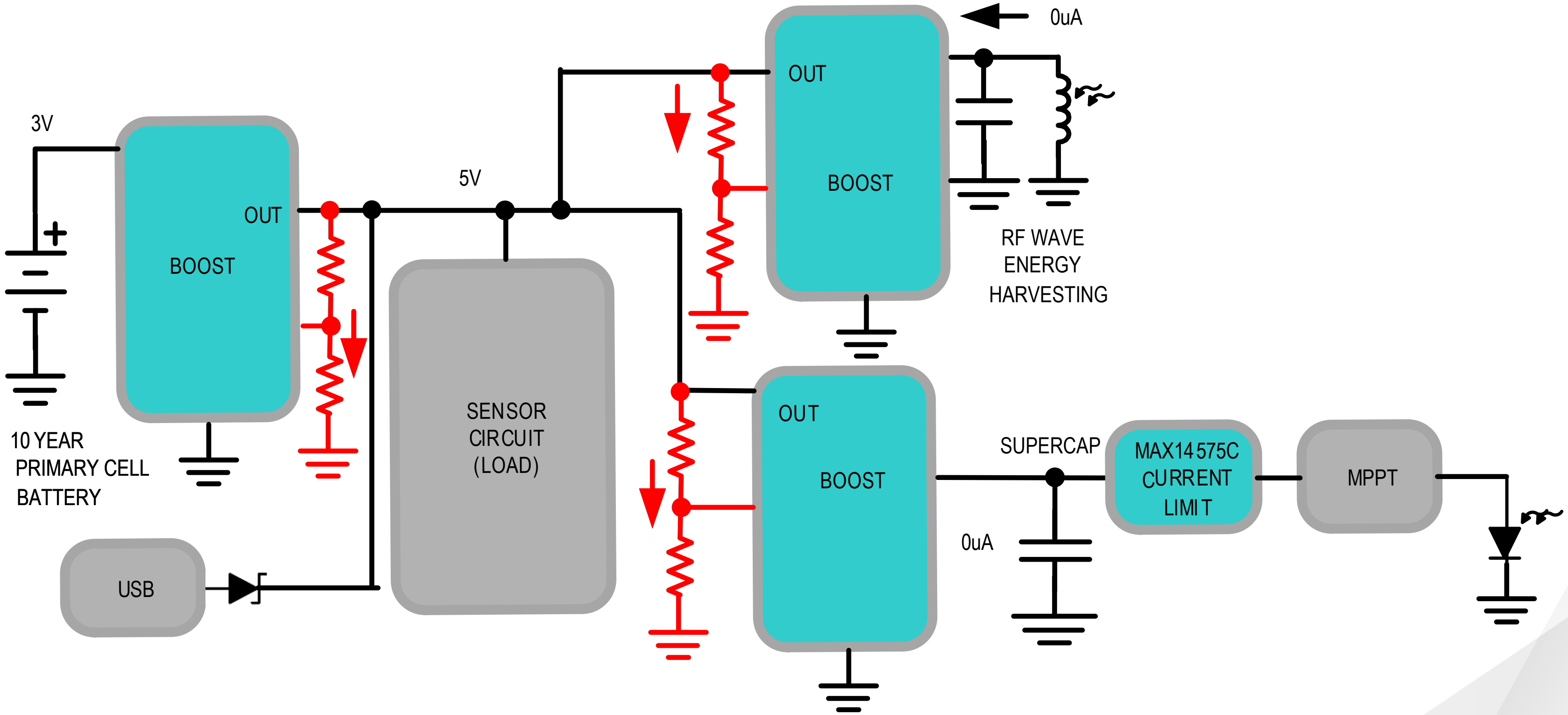
Isolate Each Power Source

- Eliminating reverse current leakage
- Diodes are commonly used in higher power systems
  - > Large voltage drops are undesirable
- Ideal diodes
  - > Need power
  - > Take up board space
  - > Need to be controlled



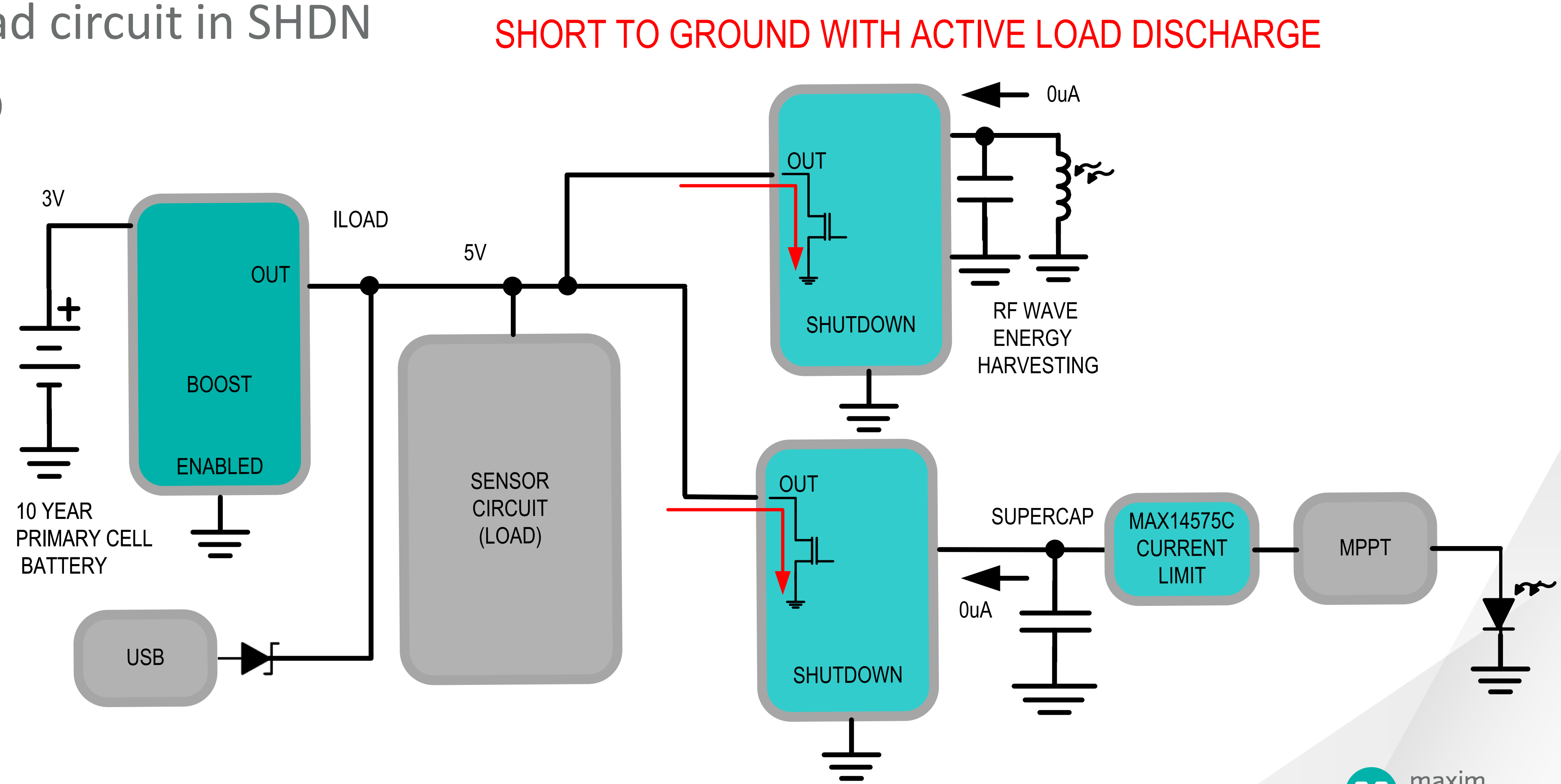
Other Hidden Loses

- Leakage through the divider network
- Costly loss of power for IoT devices



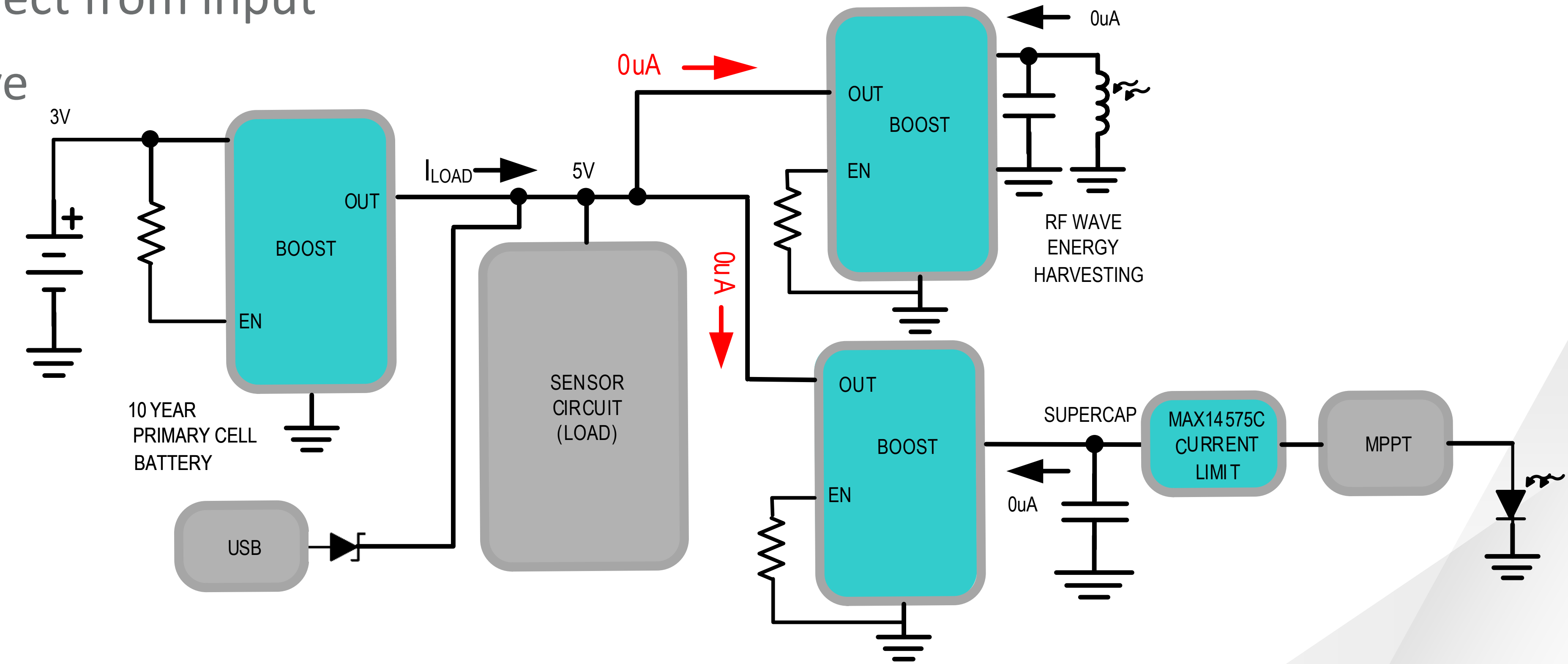
Watch Out for Active Load Discharge

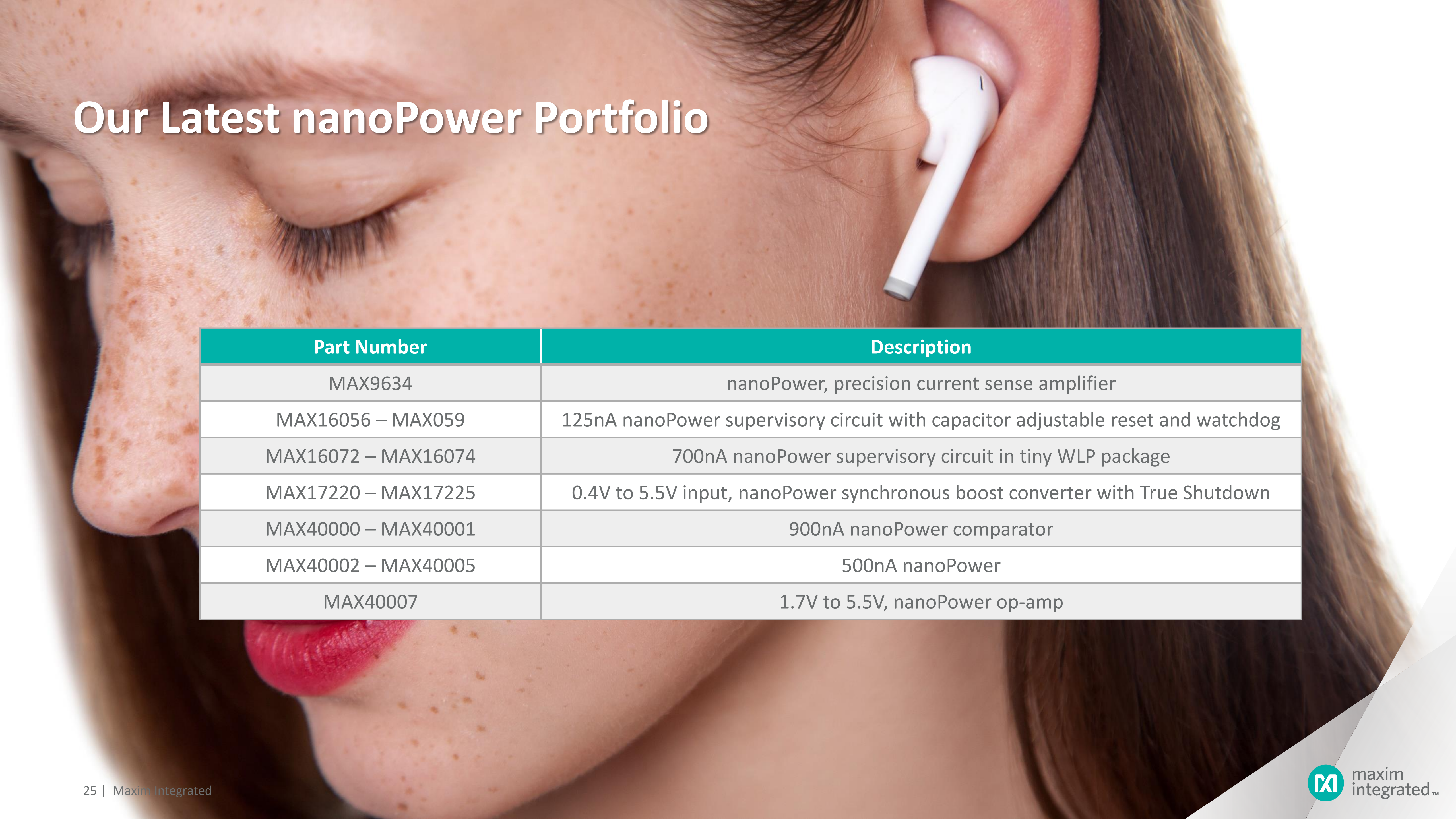
- Feature found on many boost converters
- To discharge the load circuit in SHDN
- Direct short to GND



Working with Multiple Power Sources

- MAX17222 ideal for multiple source applications
- 0.5nA True Shutdown
- True output disconnect from input
- No feedback resistive network leak





Our Latest nanoPower Portfolio

Part Number	Description
MAX9634	nanoPower, precision current sense amplifier
MAX16056 – MAX059	125nA nanoPower supervisory circuit with capacitor adjustable reset and watchdog
MAX16072 – MAX16074	700nA nanoPower supervisory circuit in tiny WLP package
MAX17220 – MAX17225	0.4V to 5.5V input, nanoPower synchronous boost converter with True Shutdown
MAX40000 – MAX40001	900nA nanoPower comparator
MAX40002 – MAX40005	500nA nanoPower
MAX40007	1.7V to 5.5V, nanoPower op-amp

Take Action Now

Order your Eval Kit from Digi-Key:
https://www.digikey.com/products/en/development-boards-kits-programmers/evaluation-boards-dc-dc-ac-dc-off-line-smps/792?k=max17222

Visit the product landing page to learn more about the product:
https://www.maximintegrated.com/en/products/power/switching-regulators/MAX17222.html/tb_tab0

Conclusion

- Consumer products are getting smaller and smaller
- Battery size determines product size
- New nanoPower boost converters solve the need for lower I_Q requirements
- A good boost converter reduces unwanted current losses
- The MAX17222 is ideal for ultra-low-power, multi-source applications

Questions and Answers

Thank You