Welcome!
Texas Instruments New Product Update

- This webinar will be recorded and available at www.ti.com/npu
- Phone lines will be muted
- Please post questions in the chat or contact your sales person or field applications engineer

Low voltage, ultra-low I_Q buck-boost converter new product update

TPS63900: 75-nA I_Q buck-boost converter with input current limit and DVS

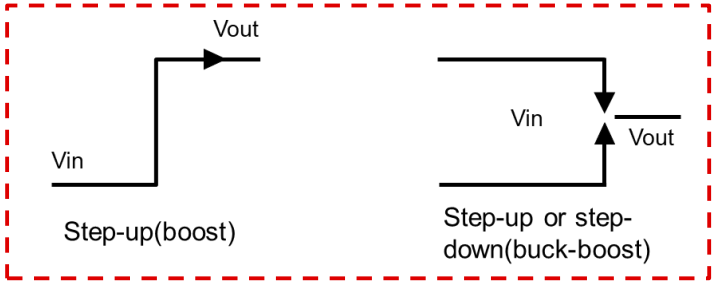
Julian Hagedorn

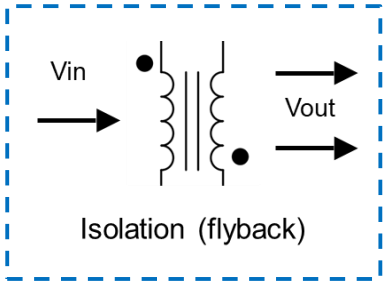
Agenda

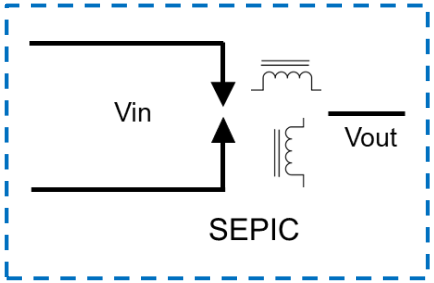
- Boost and Buck-Boost Converter and Controller Selection Card
- Ultra Low I_Q Boost and Buck-Boost converter Portfolio update
- Where are ultra-low I_Q DC/DCs typically needed?
- TPS63900 – Ultra low I_Q buck-boost converter with input current limit
  - Key benefits
  - Key Performance Charts
- System level examples:
  - Dynamic Voltage Scaling:
    - Application Example: Wireless Environmental Sensor
  - Input Current Limit: How to Extend Operating Time of a $LiSOCl_2$ Powered System
    - Application Example: Smart Meter with NB-IoT
  - Parallel TPS63900:
    - Application Example: Wireless security camera
- Collateral Overview

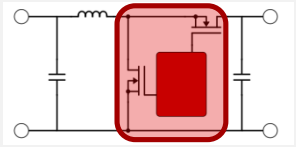
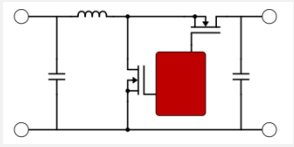
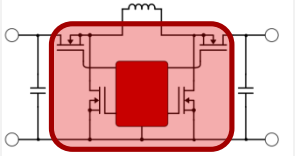
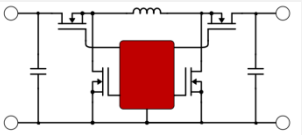
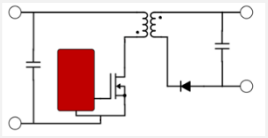
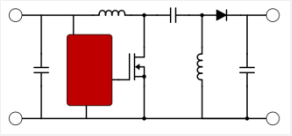
Boost & buck-boost converters & controllers:

Which solutions do we offer?







Product Families				Additional Topologies	
Boost Converter	**Boost Controller**	**Buck-Boost Converter**	**Buck-Boost Controller**	**Flyback**	**SEPIC**
Integrated FETs E.g. TPS61xxx, TLV61xxx, TPS55xxx, …	External FETs TPS43xxx, LM34xx, LM50xx, LM51xx	Integrated FETs E.g. TPS55xxx, TPS63xxx, TPIC741xx	External FETs E.g. TPS43xxx, LM25xxx, LM51xx	Isolated and/or multi-rail power with transformer	Step-up or step-down with boost and coupled inductor
					

Boost & buck-boost converters & controllers (BCS)

Simple selection table

I_{SW}	BOOST CONVERTERS				BUCK-BOOST CONVERTERS	
	V_{IN} <= 7V		V_{IN} > 7V		V_{IN} < 7V (single-cell battery)	V_{IN} > 7V (multi-cell/ 12/36V_{BAT})
	V_{OUT} < 6V	V_{OUT} > 6V	V_{OUT} < 20V	V_{OUT} > 20V		
< 1A	TLV61220 TPS61098x[1]	TLV61046A		LM5002[4]	TPS63050/1 TPS6303x	
1-3A	TPS61099[1] TPS61291 TPS61256A TPS61322	TPS61093 TPS61251/2 TPS61086	LMR61428 LM2731	LM5000 LM5001[4] TPS61170	TPS63900[1] TPS630242 TPS63010 TPS63020	TPS63060/1 TPIC74101 TPS55065
3-6A	TPS61021A TPS61280D TPS61023 TPS61253A	TPS61087 TLV61048 TPS61378	LM2700	TPS55330/2 TPS61175 TPS55340 LM5157 LM51571	TPS630250/2 TPS63021/7 TPS63802/6 TPS63810/1	TPS63070 TPS55165 TPS55160 TPS55162
6A+	TPS61022		TPS61088/9 TPS61178			TPS55288

Type	BOOST/SEPIC/FLYBACK CONTROLLERS		BUCK-BOOST CONTROL
	V_{IN} <= 55V	V_{IN} >55V	Wide Input V_{IN} >= 30V
SYNC	TPS43060/1 LM25122	LM5121 LM5122 LM5170[3]	LM5176 LM34936 LM5127[12] LM5170[3]
NON-SYNC	LM5150[1] LM51501[1] LM3481 TPS40210/1 LM5155 LM51551	LM5022 LM5156[12] LM51561[12] LM5020	LM5118 LM25118

Preview products, Hero products

[1] Ultra low Iq (topology specific), [2] low EMI, [3] bidirectional (buck or boost) [4] 75V input

Boost & buck-boost converters & controllers (BCS)

Automotive simple selection table

I_{SW}	BOOST CONVERTERS				BUCK-BOOST CONVERTERS		Type	BOOST/SEPIC/FLYBACK CONTROLLERS		BUCK-BOOST CONTROL
	Backup batery or POL V_{IN} < 7V	$12V_{BAT}$ V_{IN} < 40V	$24V_{BAT}$ V_{IN} < 60V	$48V_{BAT}$ V_{IN} < 75V	$12V_{BAT}$ V_{IN} < 40V	$24V_{BAT}$ V_{IN} < 60V		$24V_{BAT}$ V_{IN} < 60V	$48V_{BAT}$ V_{IN} < 75V	Wide Input V_{IN} >= 30V
< 1A	TLV61046A			LM5002	TPS63050 TPS63030		SYNC	TPS43060/1 LM25122-Q1	LM5121-Q1 LM5122-Q1 LM5170-Q1[3]	LM5176-Q1 LM34936-Q1 LM5127-Q1[12] LM5170-Q1[3]
1-3A	TPS61099[1] TPS61029-Q1 TPS61251/2			LM5000 LM5001-Q1	TPS63020-Q1	TPIC74101-Q1 TPS55065-Q1	NON-SYNC	LM5150-Q1[1] LM51501-Q1[1] LM3481-Q1 LM3478/88-Q1 TPS40210-Q1 LM5155-Q1 LM51551-Q1	LM5022-Q1 LM5156-Q1[12] LM51561-Q1[12] LM5020	LM5118-Q1 LM25118-Q1
3-6A	TPS61021A TPS61230A TPS61087-Q1	LM2700-Q1 TPS61175-Q1 TPS55340-Q1 LM5157-Q1 LM51571-Q1 TPS61378-Q1	TPS55332-Q1		TPS63070 TPS630252 TPS55165-Q1 TPS55160-Q1 TPS55162-Q1					
6A+	TPS61236P	TPS61088-Q1				TPS55288				

Preview products, Hero products

[1] Ultra low Iq (topology specific), [2] low EMI, [3] bidirectional (buck or boost)

Texas Instruments

Boost & buck-boost converters & controllers (BCS)

Charge pump/PWM modulators simple selection table

I_{OUT}	CHARGE PUMPS (INDUCTORLESS) 5.5 V_{IN} unless specified			V_{IN}	PWM MODULATORS	
	Boost	Inverting	Buck-Boost		Single	Dual
<100mA	LM2665 LM2681 LM2765/6/7 TPS603x (3.3 V_{IN}) TPS60240/1/2/3 TPS60202/3 TPS60212/3	LM2664 LM2682 TL7660 (11 V_{IN})	REG711x REG710x	<20V	TPS43000 TL497A* TL499A	
100mA	MAX660 TPS60140/1 TPS60122/3 TPS60101 (3.3 V_{IN}) TPS60201/2/5 TPS60210/1	LM2660 LT1054		30-40V	MC3x063A* LM3578A* UCx572*	TL1453
150mA	TPS60151 TPS60132/3 TPS60111			>=50V		TL1451A
200 - 300mA	LM2775 TPS60120/1/4/5 (3.3 V_{IN})	LM2776x LM2662/3				

* Inverted output

Ultra low I_Q boost and buck-boost converter

Iq

10uA
1uA
500nA
100nA

TLV61220
2.0 x 1.2 SOT-6
February 5, 2009
- 0.7~5.5V
- Up to 6Vout
- 400mA Isw
- ~6uA Iq
- No true shutdown

TPS61096A
3 x 2 12-pin QFN
May 3, 2017
- 1.8~5.5Vin
- Up to 28Vout
- 0.25A / 0.5A Isw
- ~1.5uA Iq
- 2 level shifts

TPS61098x
1.5x1.5 QFN-6
August 10, 2016
- 0.7~4.5Vin
- Up to 4.3Vout
- 0.5A Isw
- 300nA Iq
- 200mA LDO / load SW
- Two mode: active mode; low power mode

TPS61291
2x2 QFN-6
September 26, 2014
- 0.9~5V rising:1.5V
- 2.5, 3.0, 3.3Vout
- 1A Isw
- 6uA Iq
- Force pass through with 15nA

TPS61099x
QFN & WCSP
September 19, 2016
- 0.7~5.5Vin
- Up to 5.5Vout
- 1A Isw
- 1uA Iq
- Down mode

TPS61322x
SOT23-3
January 20, 2018
- 0.9~5.5Vin
- 2.2, 3.3, 3.6, 5.0Vout
- 0.9 / 1.2A Isw
- 6.5uA Iq
- No EN pin

TPS63900
QFN-10
- 1.8~5.5Vin
- Vout up to 5V
- 1.45A Isw
- 75nA Iq
- Programmable input current limit (1mA to 100mA & unlimited)
- 2-level dynamic voltage scaling (DVS)

Red is key selling point and dividing point.

TPS6380x
QFN & WCSP
October 29, 2019
- 1.3~5.5V rising:1.8V
- Vout up to 5.2V
- 5A(peak) at boost and buck-boost
- 3.8A(peak) at buck
- 11uA Iq
- MODE pin: PFM/FPWM
- Reverse Current Limit: 900mA

TPS6380x
QFN & WCSP
October 29, 2019
- 1.3~5.5V rising:1.8V
- Vout up to 5.2V
- 5A(peak) at boost and buck-boost
- 3.8A(peak) at buck
- 11uA Iq
- MODE pin: PFM/FPWM
- Reverse Current Limit: 900mA

0.5A 1A 2A 3A 5A

I_{SW}

Device Type

Boost | Buck-boost

Where are ultra-low I_Q DC/DCs typically needed?

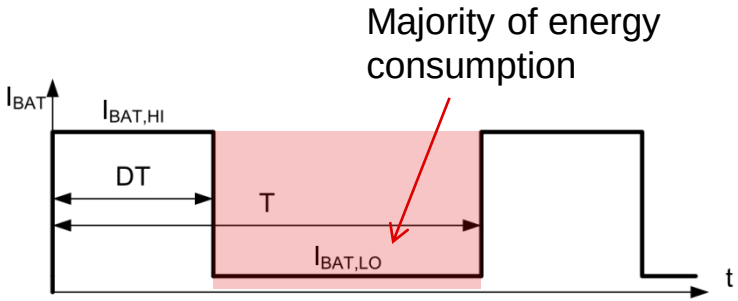
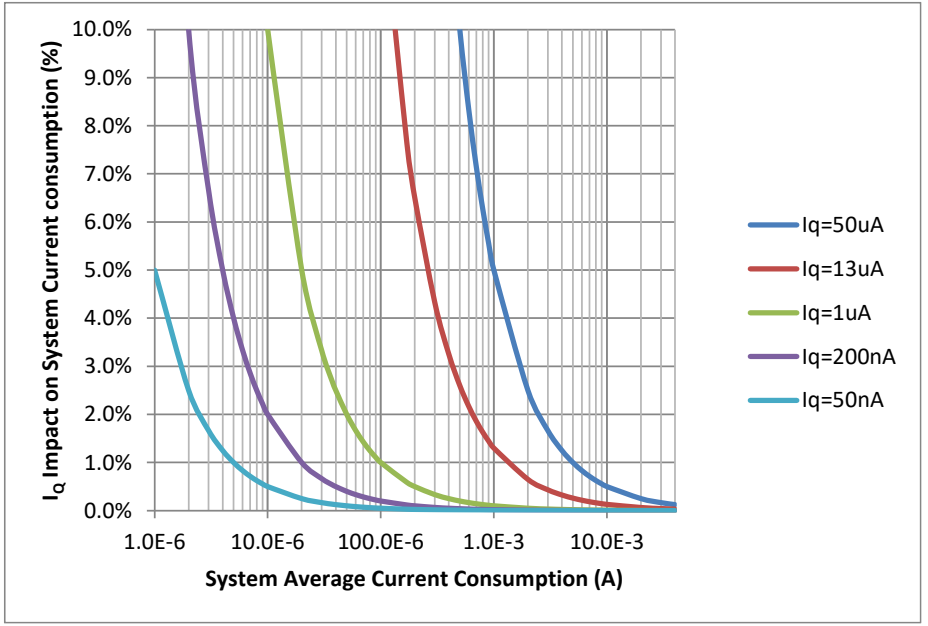


Figure 1. Battery Current Profile with a Pulsed Load

T>>DT, waveform not to scale



Case Study: Selecting a DC/DC Converter for Maximum Battery Life in Pulsed-Load Applications

TPS63900

75-nA I_Q buck-boost converter with input current limit and DVS

FEATURES

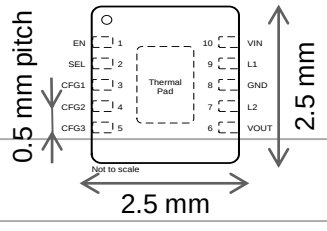
- Input voltage range: 1.8 V to 5.5 V
- Output voltage range: 1.8 V to 5 V ±1.5% (100-mV steps)
- **Output current: >400 mA for V_I≥2.0V, V_O=3.3V**
  - (typ. 1.4 A peak current limit)
- **> 90% Efficiency at 10-µA load current**
  - Quiescent current: 75nA typical
  - Shutdown current: 60nA typical
- <50mV Load transient response
- **2-level dynamic voltage scaling** (DVS)
- **Programmable input current limit** (1mA to 100mA & unlimited)
- Device enable pin
- Short-circuit protection, thermal shutdown

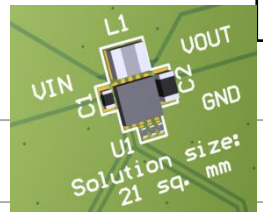
APPLICATIONS

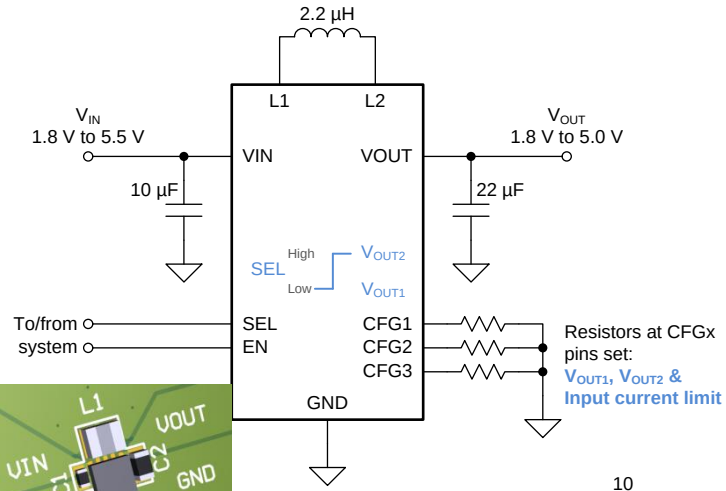
- IoT
- Smart Gas- and Water meters and sensor nodes
- Fitness trackers, smart watches and patient monitors
- Thermostats, Door locks

BENEFITS

- Input current limit **maximizes capacity of primary batteries** like LiSOCl2
- DVS allows for optimizing output voltages for heavy and light load operation which **reduces the total system power consumption**
- Output current **supports commonly-used RF standards like sub-1-GHz, BLE, LoRa, wM-Bus& NB-IoT**
- High efficiency over wide load range **prolongs battery life**







TEXAS INSTRUMENTS

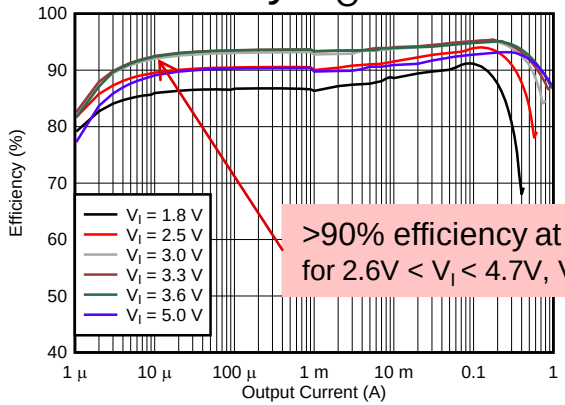
TPS63900

400-mA buck-boost converter with nanoampere quiescent current

Feature	Benefit
Buck-boost operation	Supports a wider range of battery chemistries than a buck or a boost converter
	Tolerates battery impedance IR drops better than a buck converter
	Supports dynamic voltage scaling better than a buck or a boost converter
> 400 mA output current	Supports all commonly-used RF standards like sub-1-GHz, BLE, LoRa, wM-Bus & NB-IoT
	High enough to be used as a preregulator for small battery charging systems (e.g. Earpods)
84% efficiency at I_O = 5 µA (V_I = 3.6 V, V_O = 2.5 V)	Maximizes battery lifetime in standby mode
Dynamic voltage scaling	Allows customers to reduce system power consumption by operating at different supply voltages during standby and high-power (Tx/Rx) modes
Input current limiting	Simplifies the use of current-limited battery types such as lithium coin cells
Single-mode operation	Does not interfere with sensitive loads, because there are no output voltage perturbations caused by mode switching
Innovative switching control scheme	Improves dynamic performance (better transient response with no reduction in stability)

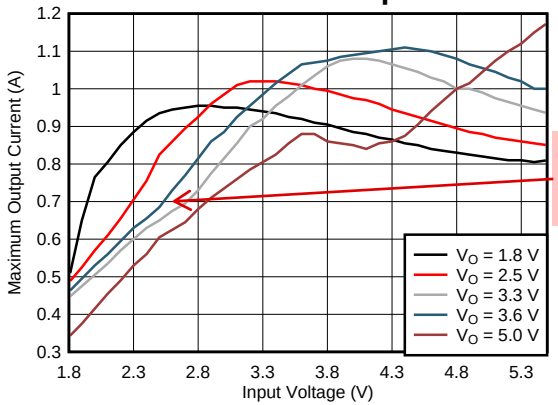
Typical performance graphs of TPS63900

Efficiency V_O = 3.3V



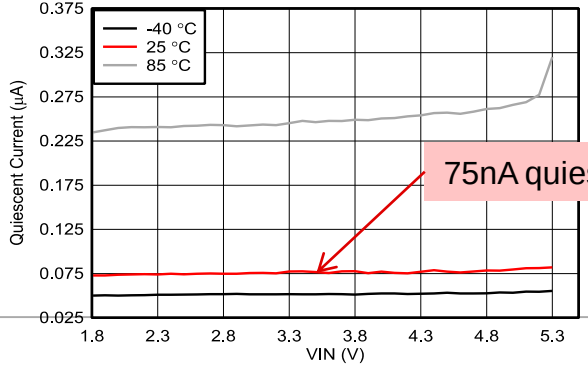
>90% efficiency at 10µA load
for 2.6V < V_I < 4.7V, V_O = 3.3V

Maximum Output Current T_A = 25ºC



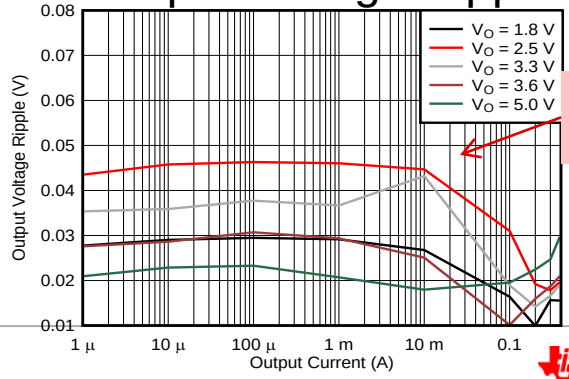
>650mA output current
for V_I > 2.5V, V_O = 3.3V

Quiescent Current into VIN



75nA quiescent current

Output Voltage Ripple V_I = 3.3V



<50mV voltage ripple
with 1x 22µF (0603)

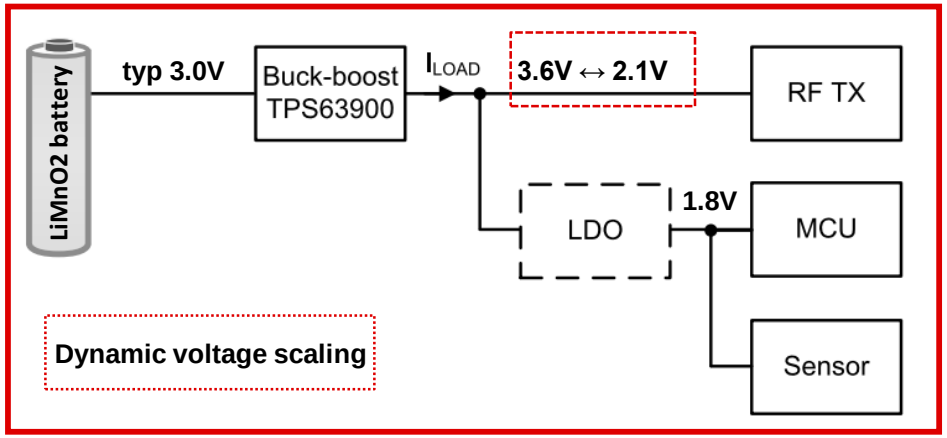
Key features

DVS

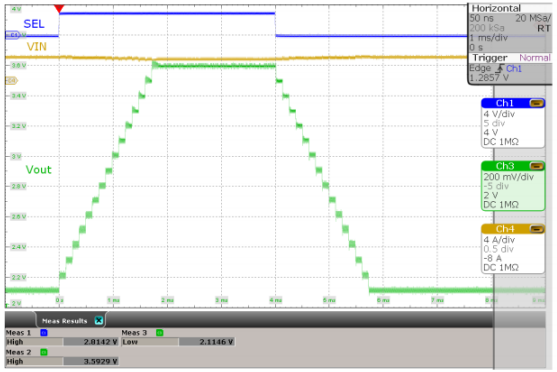
TPS63900 dynamic voltage scaling (DVS)

Features and benefits	
75nA I_Q	**Extends battery operating time** in low power mode
1.4A switch current limit	**3x more output current** than the closest competitor
Dynamic voltage scaling	**Minimizes supply voltage** for each operating state – **50% more battery life**

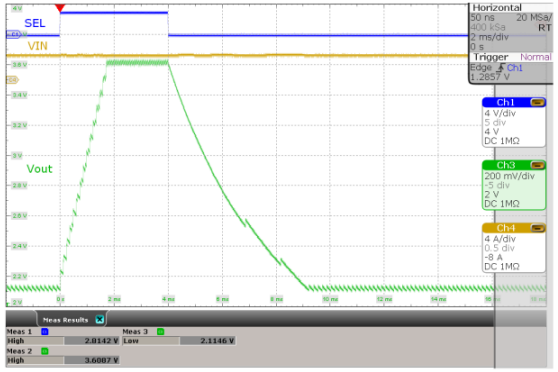
Wireless environmental sensor with $LiMnO_2$ battery



DVS behavior at high load



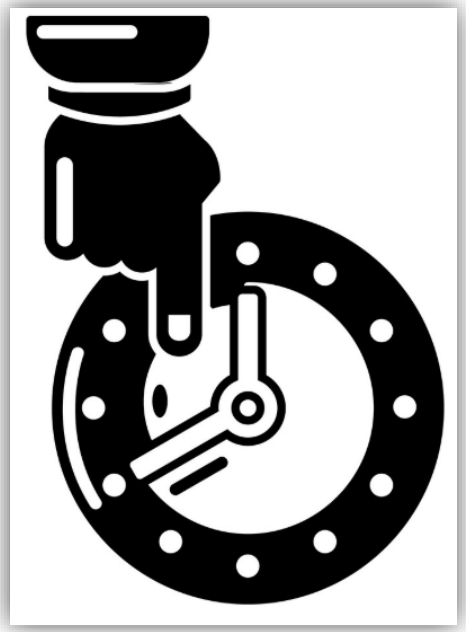
DVS behavior at light load



What about operating time…?

Load Profile			TPS63900			Competitor		
I_{OUT} [mA]	t [s]	V_{OUT} [V]	Eff [%]	I_{IN} [mA]	Q_{IN} [As]	Eff [%]	I_{IN} [mA]	Q_{IN} [As]
0.01	21600	3.6	92.5	$1.3x10^{-5}$	0.281	82.1	$1.46x10^{-5}$	0.316
250	0.4	3.6	92.3	0.325	0.130	91.7	0.327	0.131
			Total Q_{IN} [As]		0.411			0.447
			Battery life extended [%]		9			

Load Profile			TPS63900		
I_{OUT} [mA]	t [s]	V_{OUT} [V]	Eff [%]	I_{IN} [mA]	Q_{IN} [As]
0.01	21600	2.1	90.8	$7.71x10^{-6}$	0.167
250	0.4	3.6	92.3	0.325	0.130
			Total Q_{IN} [As]		0.297
			Battery life extended [%]		51

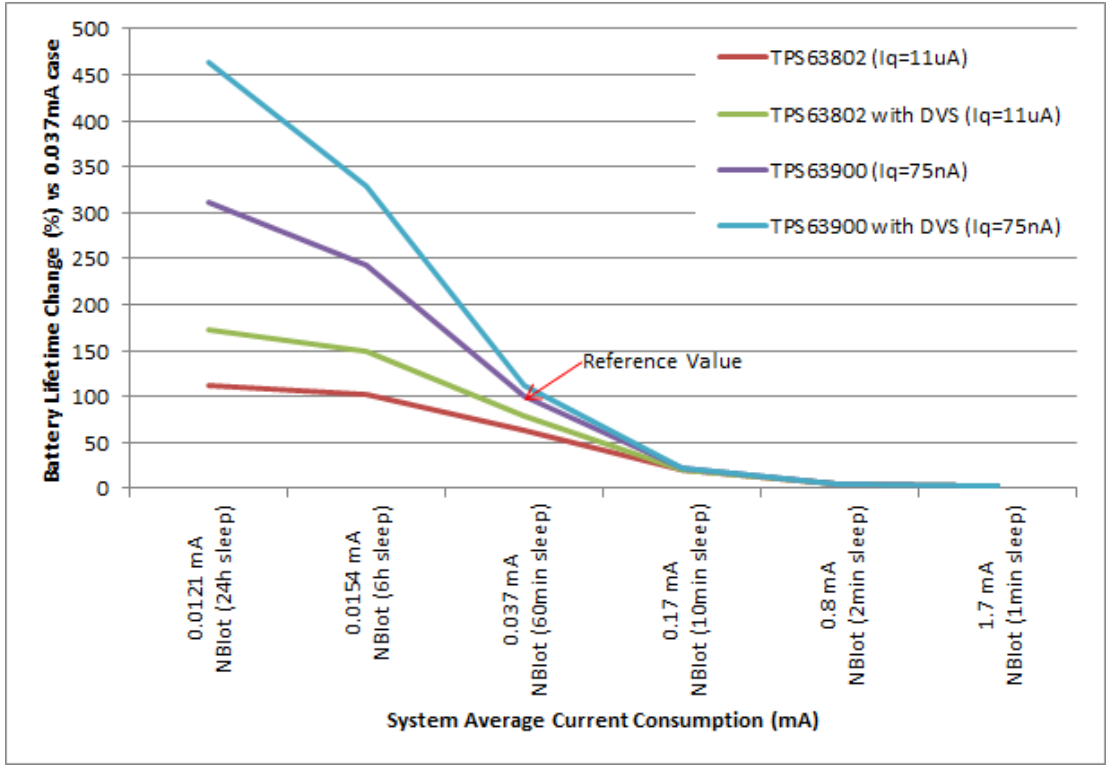


50% Battery life extended vs competition non-DVS solution.

https://www.ti.com/lit/an/slvaer8/slvaer8.pdf

LiMnO2 battery with 3120mAh capacity (FDK CR17500EP)

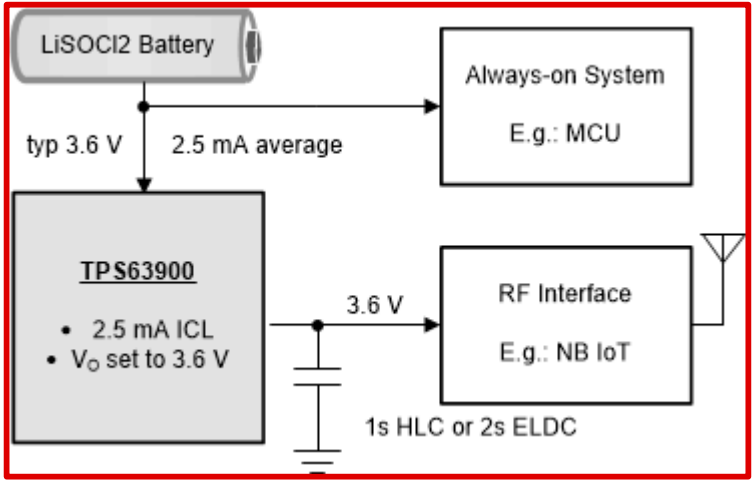
Operating time – DVS vs non-DVS

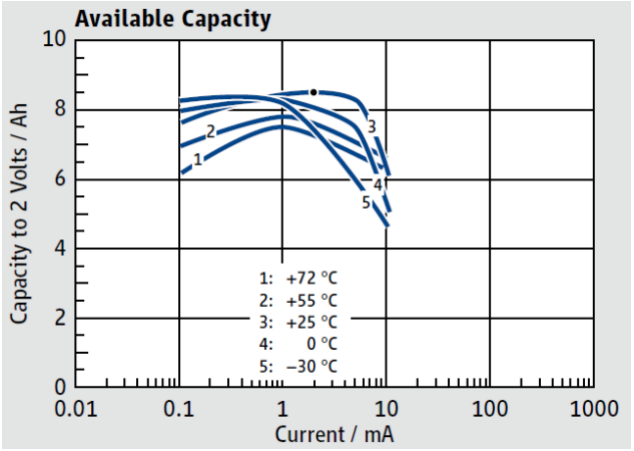


Input current limit

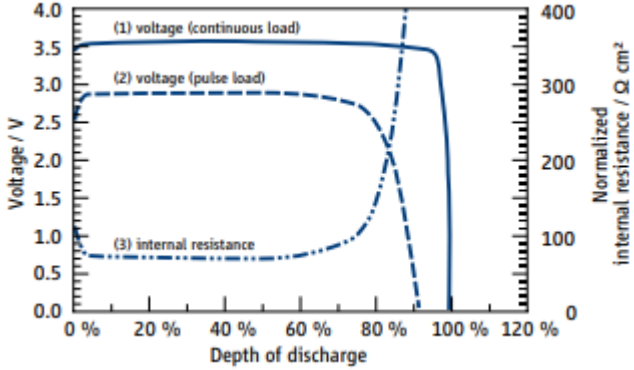
Why input current limit?

Smart meter with $LiSOCl_2$ battery





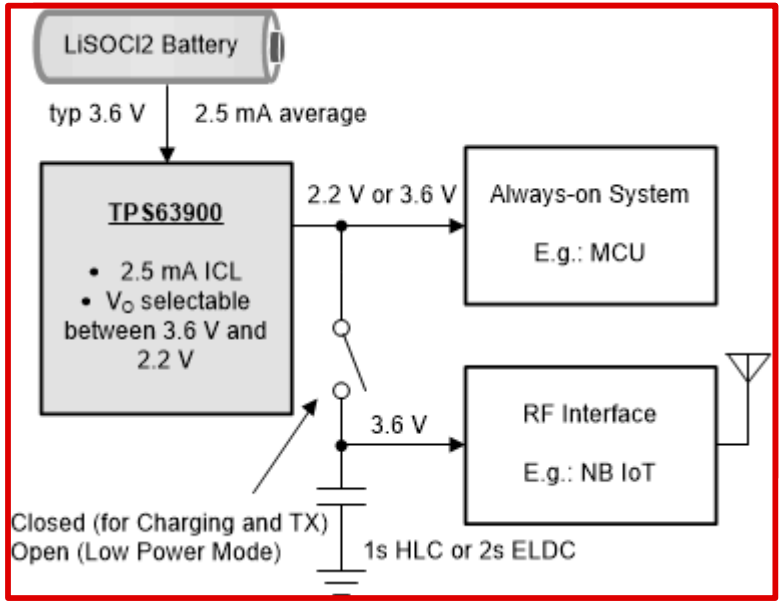
Tadiran SL-2870 Capacity

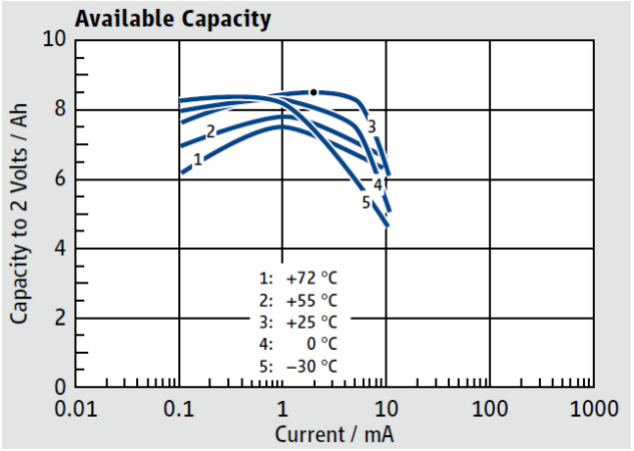


https://www.ti.com/lit/pdf/slvaev9

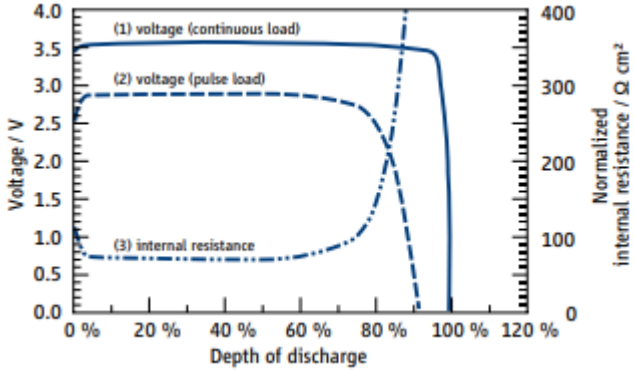
Why input current limit?

Smart meter with $LiSOCl_2$ battery





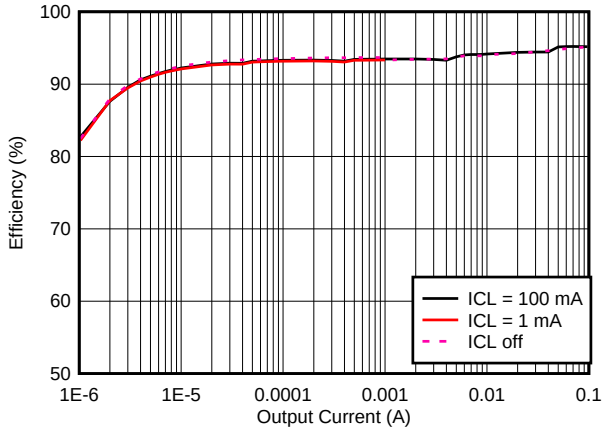
Tadiran SL-2870 Capacity



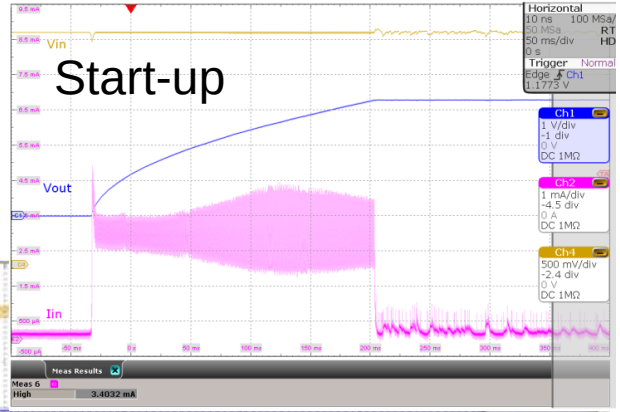
https://www.ti.com/lit/pdf/slvaev9

TPS63900 – Input current limit performance

Efficiency V_O = 3.3V



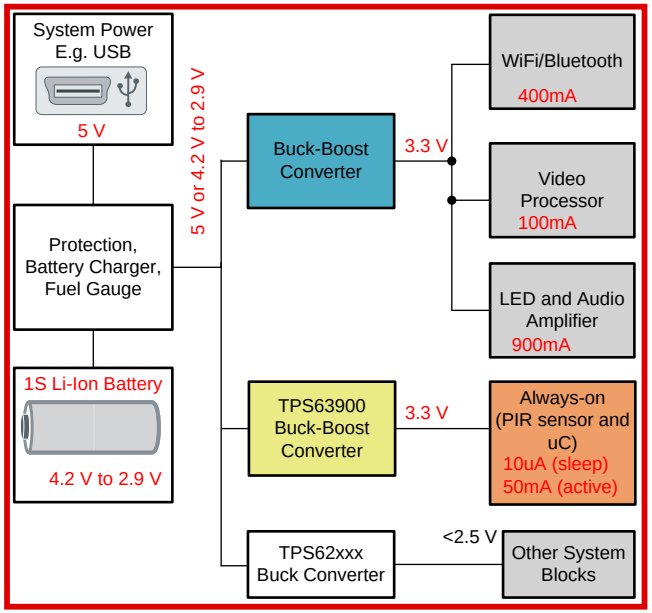
During Operation



Parallel TPS63900

Parallel TPS63900

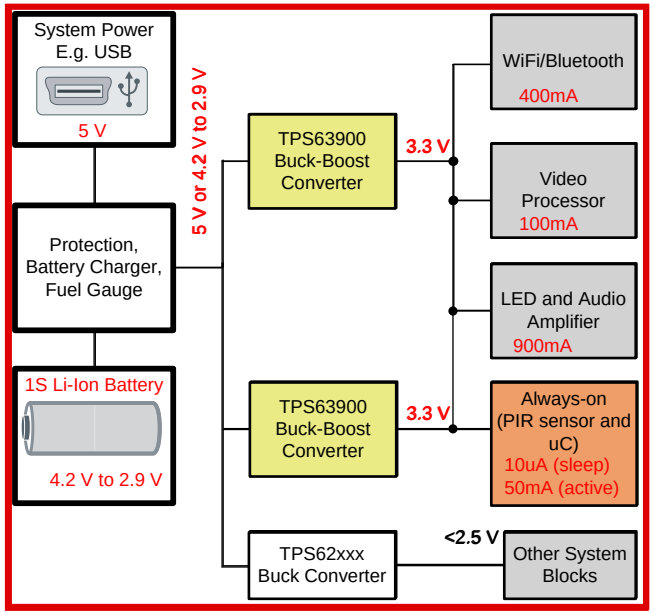
Wireless network camera



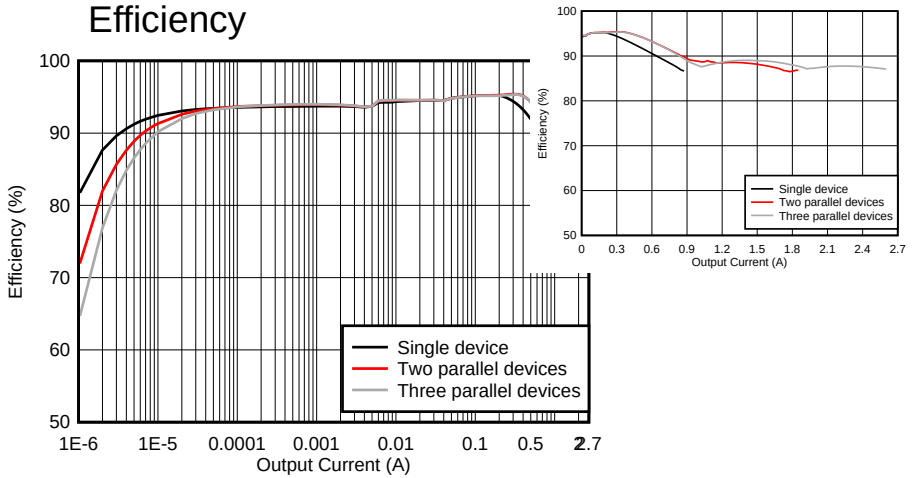
https://www.ti.com/lit/pdf/slvaew2

Parallel TPS63900

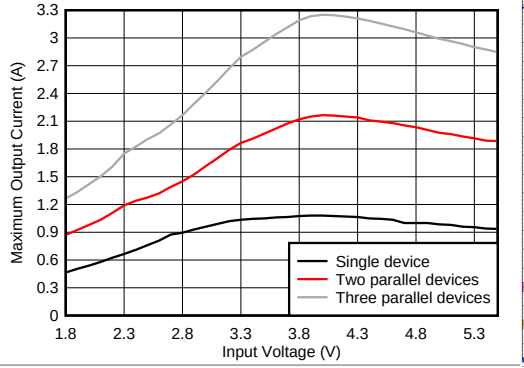
Wireless network camera



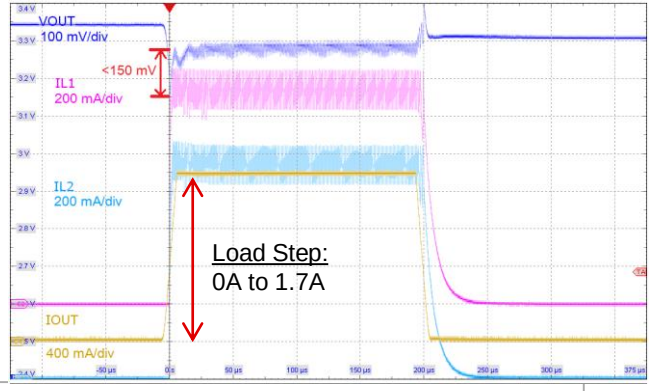
Efficiency



Output current



Load transient



https://www.ti.com/lit/pdf/slvaew2

Texas Instruments

TPS63900 collateral

Videos

Key functionality and features – 3 minutes
https://training.ti.com/node/1147249
Dynamic voltage scaling and input current limit – 3 minutes
https://training.ti.com/node/1147248

Technical Article

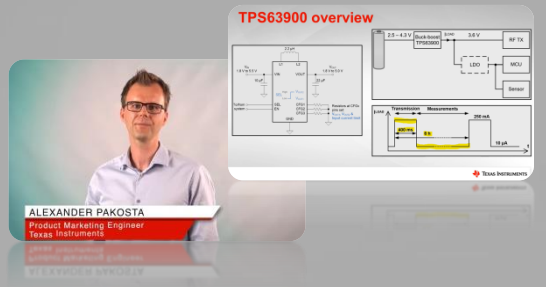
5 best practices to extend battery life in flow meters
https://e2e.ti.com/blogs_/b/powerhouse/archive/2020/08/28/5-best-practices-to-extend-battery-life-in-flow-meters

Application notes

How to Extend Operating Time of a $LiSOCl_2$ Powered System
https://www.ti.com/lit/pdf/slvaev9
Using Input Current Limiting to Extend Battery Life
https://www.ti.com/lit/pdf/slvaes7
Extending Battery Life with Low-Iq and Dynamic Voltage Scaling
https://www.ti.com/lit/pdf/slvaer8
How to Implement Multi-Level Dynamic Voltage Scaling With TPS63900
https://www.ti.com/lit/pdf/slvaew1
75-nA IQ Buck-Boost Converter in Parallel for Increased Output Current (≥ 2 A)
https://www.ti.com/lit/pdf/slvaew2

Reference designs

Low-power options for smart meter wireless modules using primary cells reference design
https://www.ti.com/tool/TIDA-010053
ECG, SpO2, PPT and heart rate sensors
https://www.ti.com/tool/TIDA-01580
https://www.ti.com/tool/TIDA-010029



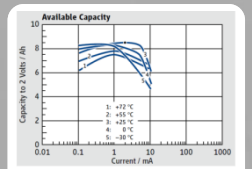


Figure 1. Tadiran SL-2870 Capacity

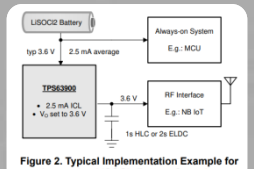


Figure 2. Typical Implementation Example for Increasing $LiSOCl_2$ Battery Capacity

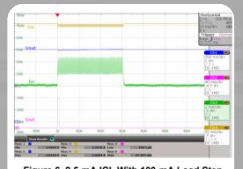
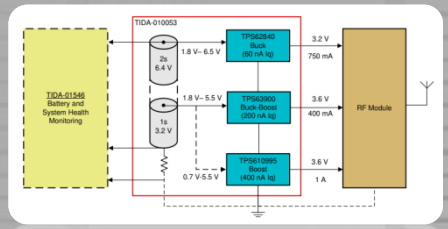


Figure 6. 2.5-mA ICL With 100-mA Load Step



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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265