Welcome!
Texas Instruments New Product Update

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- Phone lines will be muted
- Please post questions in the chat or contact your TI sales contact or field applications engineer

New Product Update: Ultra-low I_Q boost and buck-boost converters

Adam Grula

November 18, 2021

Agenda

- TPS61094 Bidirectional buck/boost with integrated supercapacitor charging (60-nA I_q)
- TPS63900 buck-boost with 75-nA I_q and DVS (dual voltage scaling)
- LM5157/8 Wide V_{IN} integrated FET converters for boost/flyback/SEPIC
- LM5155/6 Wide V_{IN} External FET controller for boost/flyback/SEPIC

TPS61094

60 nA I_q bi-directional buck or boost converter with 4nA bypass mode

FEATURES

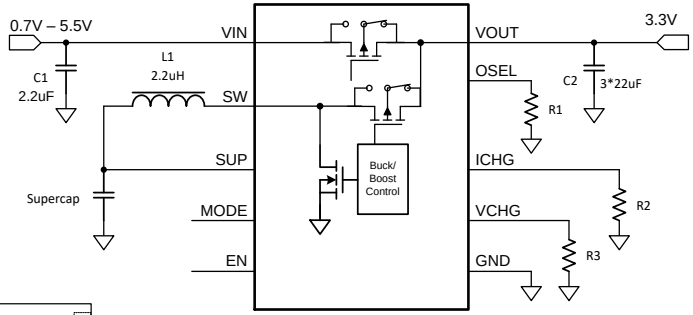
- Input voltage range: 0.7 V – 5.5 V, startup 1.8 V
- Programmable boost output voltage, from 2.7 V to 5.4 V
- Programmable buck output voltage, from 1.7 V to 5.4 V
  Programmable buck output current, from 2.5 mA to 600 mA
- Typical 2A valley current limit
- Pin selectable buck/boost/bypass/true shutdown mode
- 800mA Output Current @ 3.3 V_{out} from 1.8 V_{in}
- Bypass mode with less than 4 nA I_q (typical)
- Boost mode with less than 60 nA I_q (typical)
- Buck mode with less than 60 nA I_q (typical)
- Rdson: 60mΩ(LS),140mΩ (HS), 100mΩ Bypass switch
- 1 MHz switching frequency
- ±2% Reference voltage accuracy over -40℃ to +125℃
- Output short protection
- 3mm x 2mm QFN-12 pin package

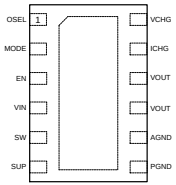
APPLICATIONS

- Gas meter, Water meter
- Smoke detector
- Energy Harvesting

BENEFITS

- 60 nA ultra low I_q: increase light load efficiency to extend battery running time.
- Bi-directional buck/boost is suitable for supercap backup power solution.
- Bypass switch: decrease power loss and improve load transient performance when $V_{in} > V_{out}$





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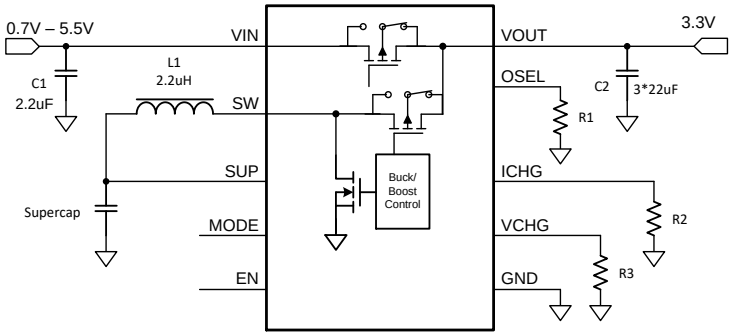
Operation Mode

	EN	MODE	Bypass	Boost	Buck	Function
Forced bypass	0	0	√	×	×	Shutdown. Bypass. VOUT = VIN
True shutdown	0	1	×	×	×	Shutdown. Bypass disconnect. VOUT = 0 V
Forced buck	1	0	√	×	√	Buck enabled. Bypass. VOUT = VIN while charging the supercap or backup battery
Auto buck or boost	1	1	√	×	√	When VIN > target VOUT +0.1 V, VOUT = VIN and supercap is charged by buck
	1	1	√	√	x	Boost enabled. When VOUT + 0.1 V > VIN > target VOUT, VOUT is from both VIN through bypass and supercap by boost.
	1	1	x	√	×	Boost enabled. When VIN < target VOUT, VOUT is from supercap by boost.



OSEL, VCHG and ICHG Configuration TPS61094 version

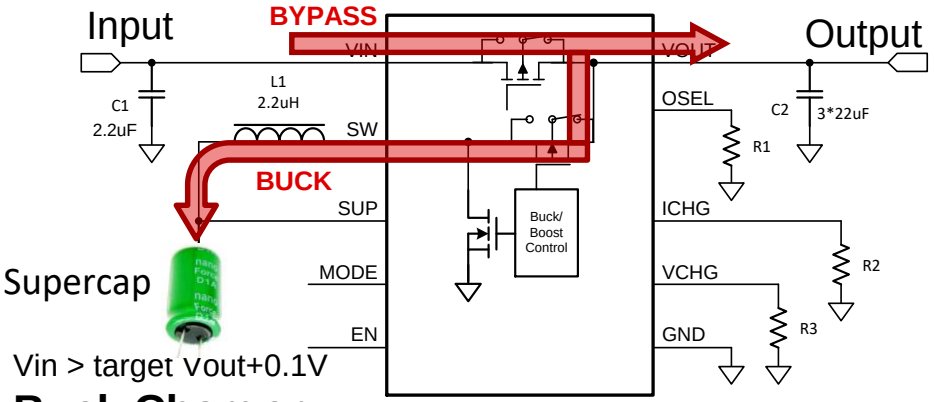
Output Voltage Options(OSEL)							
Resistance (kΩ)	V_{OUT_REG} (V)	Resistance (kΩ)	V_{OUT_REG} (V)	Resistance (kΩ)	V_{OUT_REG} (V)	Resistance (kΩ)	V_{OUT_REG} (V)
0	2.7	9.53	3.45	28.7	3.8	150	4.8
3.09	3.0	13.0	3.5	49.9	4.0	205	5.0
4.75	3.3	17.4	3.6	75.0	4.2	274	5.2
6.65	3.4	22.1	3.7	107	4.5	open	5.4

Charging Current Options(ICHG)							
Resistance (kΩ)	I_{CHG} (mA)	Resistance (kΩ)	I_{CHG} (mA)	Resistance (kΩ)	I_{CHG} (mA)	Resistance (kΩ)	I_{CHG} (mA)
0	0 (disabled)	9.53	25	28.7	150	150	350
3.09	2.5	13.0	50	49.9	200	205	400
4.75	5	17.4	75	75.0	250	274	500
6.65	10	22.1	100	107	300	open	600

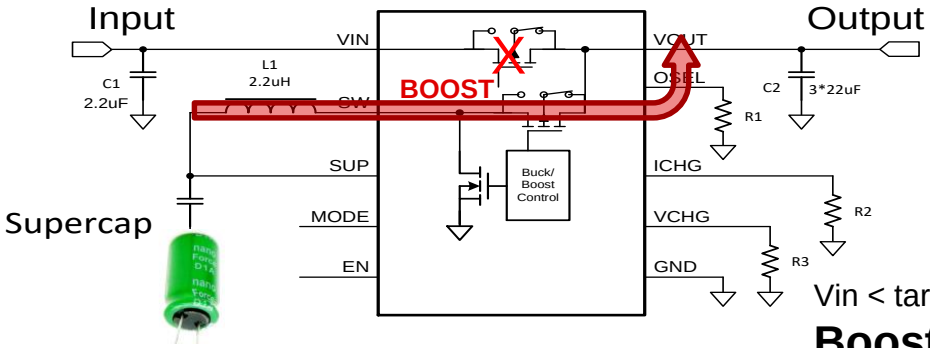
Charging Termination Voltage Options(VCHG)							
Resistance (kΩ)	V_{CHG_REG} (V)	Resistance (kΩ)	V_{CHG_REG} (V)	Resistance (kΩ)	V_{CHG_REG} (V)	Resistance (kΩ)	V_{CHG_REG} (V)
0	1.7	9.53	2.6	28.7	3.7	150	4.9
3.09	2.0	13.0	2.7	49.9	4.1	205	5
4.75	2.2	17.4	3.6	75.0	4.15	274	5.1
6.65	2.5	22.1	3.65	107	4.2	open	5.4

Note: TPS61094 detects and latches OSEL, VCHG and ICHG configuration during the start-up. Changing the resistor during operation can't change configuration. Toggling EN pin will refresh the setting.

Application Circuit: Boost with Buck Charger



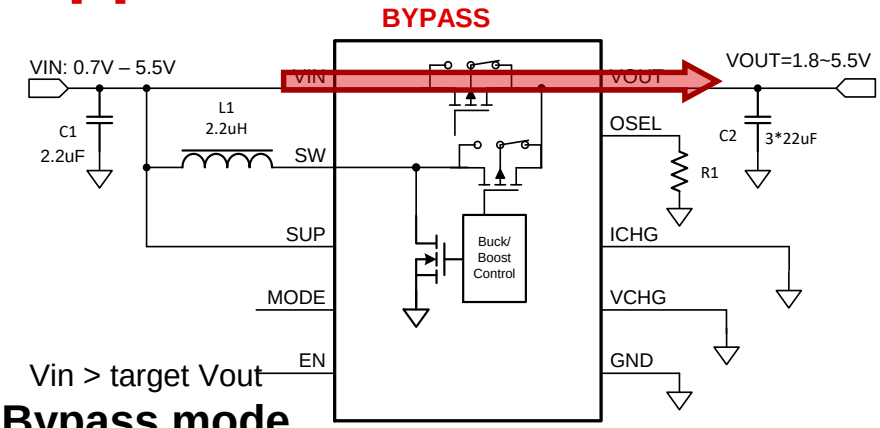
Buck Charger

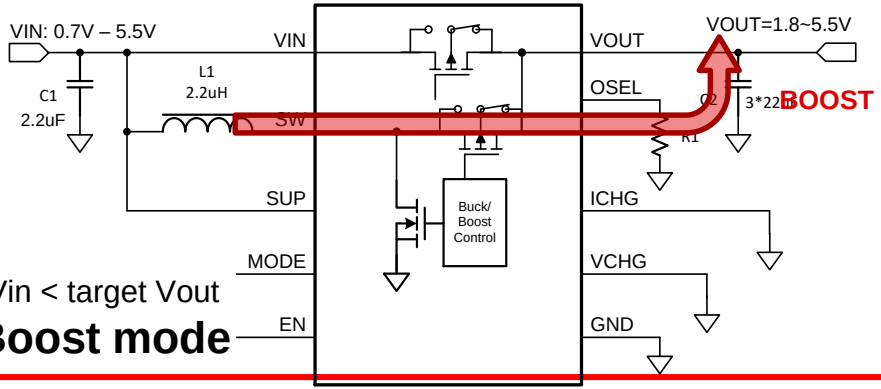


Boost Converter

- Key features
  - One chip solution for supercap charging and discharging
  - Programmable charging current and voltage
  - Fast and auto response to keep Vout no undershoot when input is power off
  - 60nA I_q at boost or buck mode
- Applications
  - Smart meter(water/gas meter)
  - Fault indicator
  - Patient monitor
  - E-POS

Application Circuit: Pure Boost with Bypass





- Key features
  - 94.57% efficiency at 10uA load (V_{in}= 3 V V_{out} = 3.6 V)
  - 96.68% efficiency at 100mA load (V_{in}= 3 V V_{out} = 3.6V)
  - 60nA I_q at boost mode
  - 4nA I_q at forced bypass mode
  - Bypass switch: decrease power loss and improve load transient performance when V_{in} > V_{out}

- Applications
  - Smoke detector
  - Door/window sensor

Visit

www.ti.com/TPS61094

For more information about this new device

TPS63900

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

FEATURES

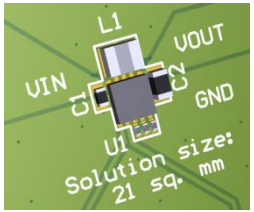
- Input voltage range: 1.8 V to 5.5 V
- Output voltage range: 1.8 V to 5 V ±1.5% (100-mV steps)
- **Output current: >400 mA for V_I≥2.0V, V_O=3.3V**
  - (typ. 1.4 A peak current limit)
- **> 90% Efficiency at 10-µA load current**
  - Quiescent current: 75nA typical
  - Shutdown current: 60nA typical
- <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

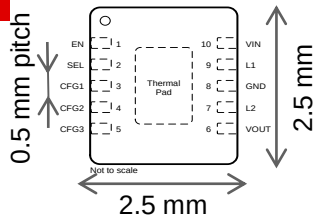
APPLICATIONS

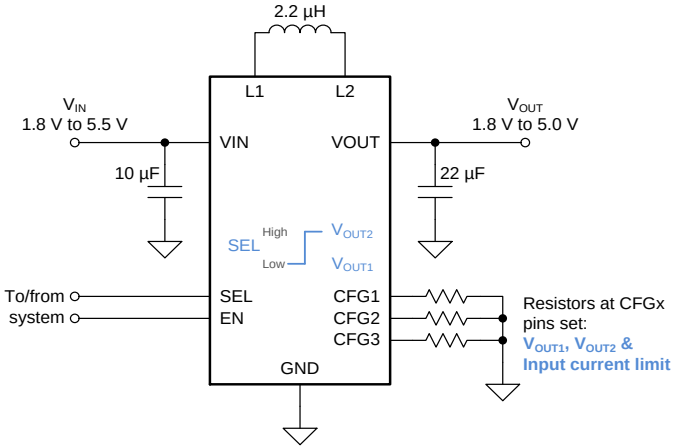
- IoT
- Smart Gas- and Water meters and sensor nodes
- Fitness trackers, smart watches and patient monitors
- Thermostats, Door locks

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**

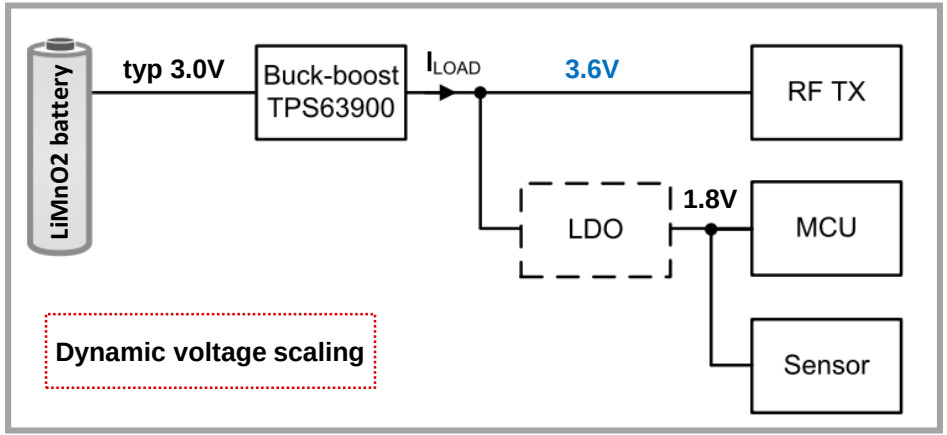


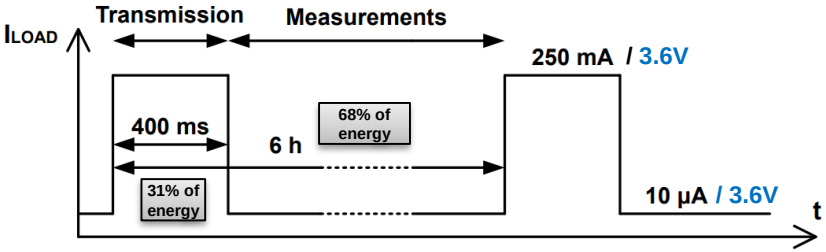




Ultra-low power sensor example

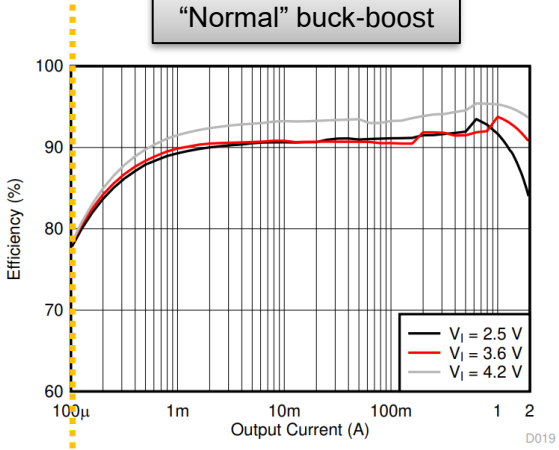
Wireless Environmental Sensor with $LiMnO_2$ battery





slvaer8a: Extending Battery Life With Low Quiescent Current and Dynamic Voltage Scaling

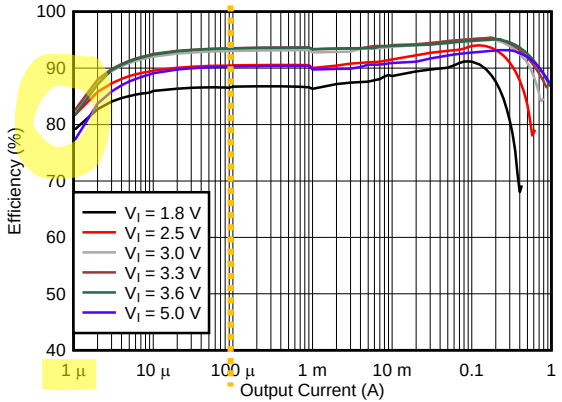
"Normal" buck-boost



TPS63900

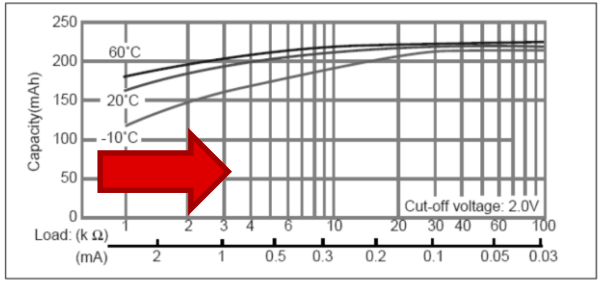
V_O = 3.3 V

MODE = Low



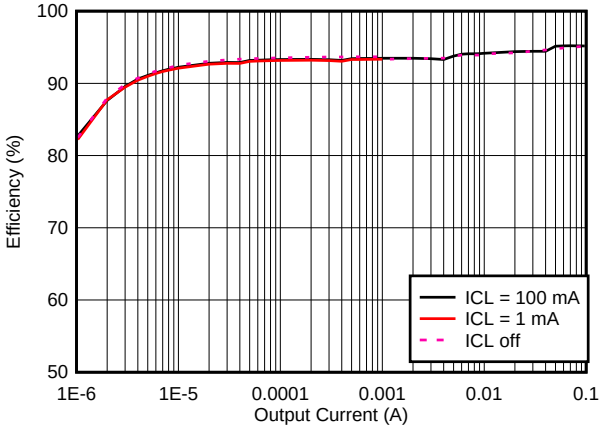
TPS63900 – Input current limit performance

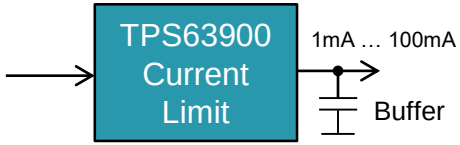
- **Capacity vs. load resistance**



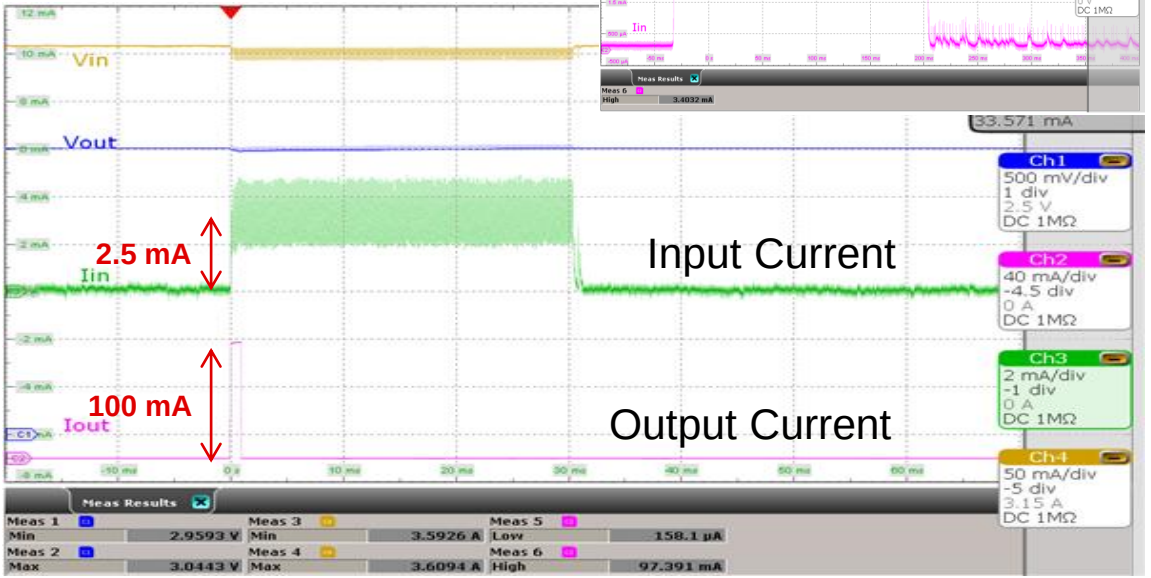
Source: Varta CR2032 battery datasheet

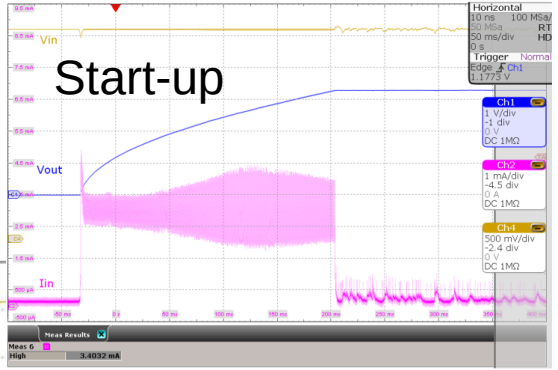
TPS63900 efficiency V_O = 3.3V





During Operation





New BCS WV Boost Controllers/Converters

	Boost Controllers		Boost Converters	
Parameter	LM5155 / LM51551	LM5156 / LM51561	LM5157 / LM51571	LM5158 / LM51581
Vin Range (V)	3.5 - 45V Min 1.5V (BIAS>3.5V)	3.5 - 60V Min 1.5V (BIAS>3.5V)	2.9 - 45V Min 1.5V (BIAS>2.9V)	3.2 - 60V Min 1.5V (BIAS>3.2V)
Vsw max (V)	External MOSFET	External MOSFET	50V	85V
Isw limit (A) (min. peak current limit)	Programmable by Rsense	Programmable by Rsense	6.5A (LM5157) 4.3A (LM51571)	3.2A (LM5158) 1.6A (LM51581)
Current limit Hiccup Mode	Yes (LM51551)	Yes (LM51561)	Yes (Mode pin)	Yes (Mode pin)
Spread Spectrum	-	Yes (DRSS, Selectable)	Yes (DRSS, Selectable)	Yes (DRSS, Selectable)
Package	WSON-12	WSON-12 (LM5156) HTSSOP-14	WQFN-16	WQFN-16
P2P	-	Drop in to replace LM5155 (with spread spectrum enabled)	Almost P2P compatible for different voltage/current specs	
To Replace Legacy Part#	TPS40210 LM3481 / LM3478	TPS40210 LM3481 / LM3478 LM5022	TPS55340 TPS55332	LM5000 LM5001 LM5002
Topologies	Boost, Flyback, SEPIC PSR Flyback, Negative-to-positive conversion, Multi-output Flyback, Dual-output SEPIC, Non-synchronous buck			

LM5158/581

2.2-MHz Wide V_{IN} non-sync Boost/SEPIC/Flyback Converter with Dual Random Spread Spectrum

Features

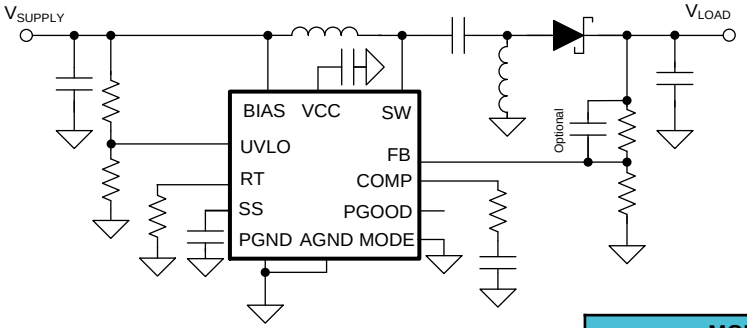
- Wide input range : **3.2** – **60 V (Abs Max 65 V)**
- **Maximum output voltage up to 83 V** in Boost (SW Abs Max 85 V)
- Shutdown I_Q ≤ 3 µA
- Non-switching I_Q ≤690 µA
- Programmable frequency 100 kHz - **2.2 MHz**
- 150-mΩ FET (TBD)
- Constant peak current limit **(LM5158: Min. 3.2 A, LM51581: Min. 1.6 A)**
- **Selectable internal spread spectrum**
- **Selectable hiccup mode protection**
- Optional clock synchronization
- Programmable output with **1.0 V +/-1% reference**
- Adjustable soft-start
- OVP protection
- Thermal shutdown
- **QFN-16 Package (3 mm x 3 mm)**

Applications

- General purpose Boost, Flyback, SEPIC applications
- Hold-up capacitor charger
- Audio amplifier power supply
- Piezo driver / Motor driver bias supply
- Portable speaker application
- Power Module

Benefits

- Boost/Sepic/Flyback(Non-isolated/isolated) configurable
- Wide V_{IN} for a variety of power rails
- Switching frequency out of AM band
- Reduced EMI using spread spectrum
- Small solution size at 2.2 MHz
- Low shutdown I_Q reduces battery drain in battery-powered application
- Selectable hiccup mode for sustained overload / short-circuit protection

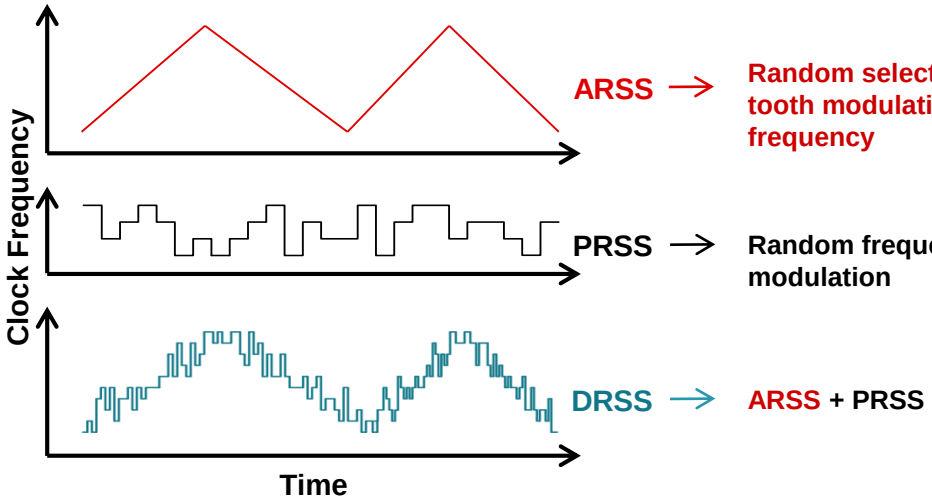


Peak current limit	
3.2 A min	**1.6 A min**
LM5158	LM51581

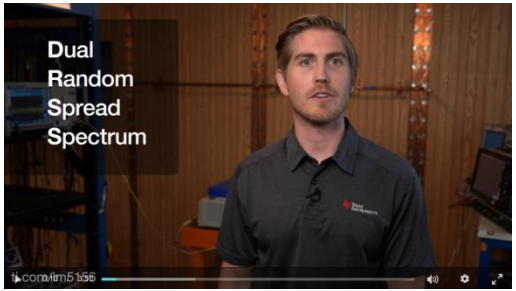
MODE		
	Spread Spectrum	**Hiccup Protection**
GND	Disabled	Disabled
R_{MODE}#1	Enabled	Enabled
R_{MODE}#2	Disabled	Enabled
R_{MODE}#3	Enabled	Disabled

What is Dual Random Spread Spectrum (DRSS)?

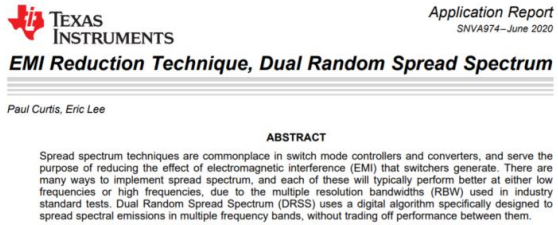
- **DRSS** is a digital spread spectrum technique that spreads energy in **multiple** bands of interest using two random frequency generators.



- Please watch TI Training Video : https://training.ti.com/node/1147013



- Please download TI's Application Note for more details https://www.ti.com/lit/an/snva974/snva974.pdf



Texas Instruments

Application Report
SNVA974–June 2020

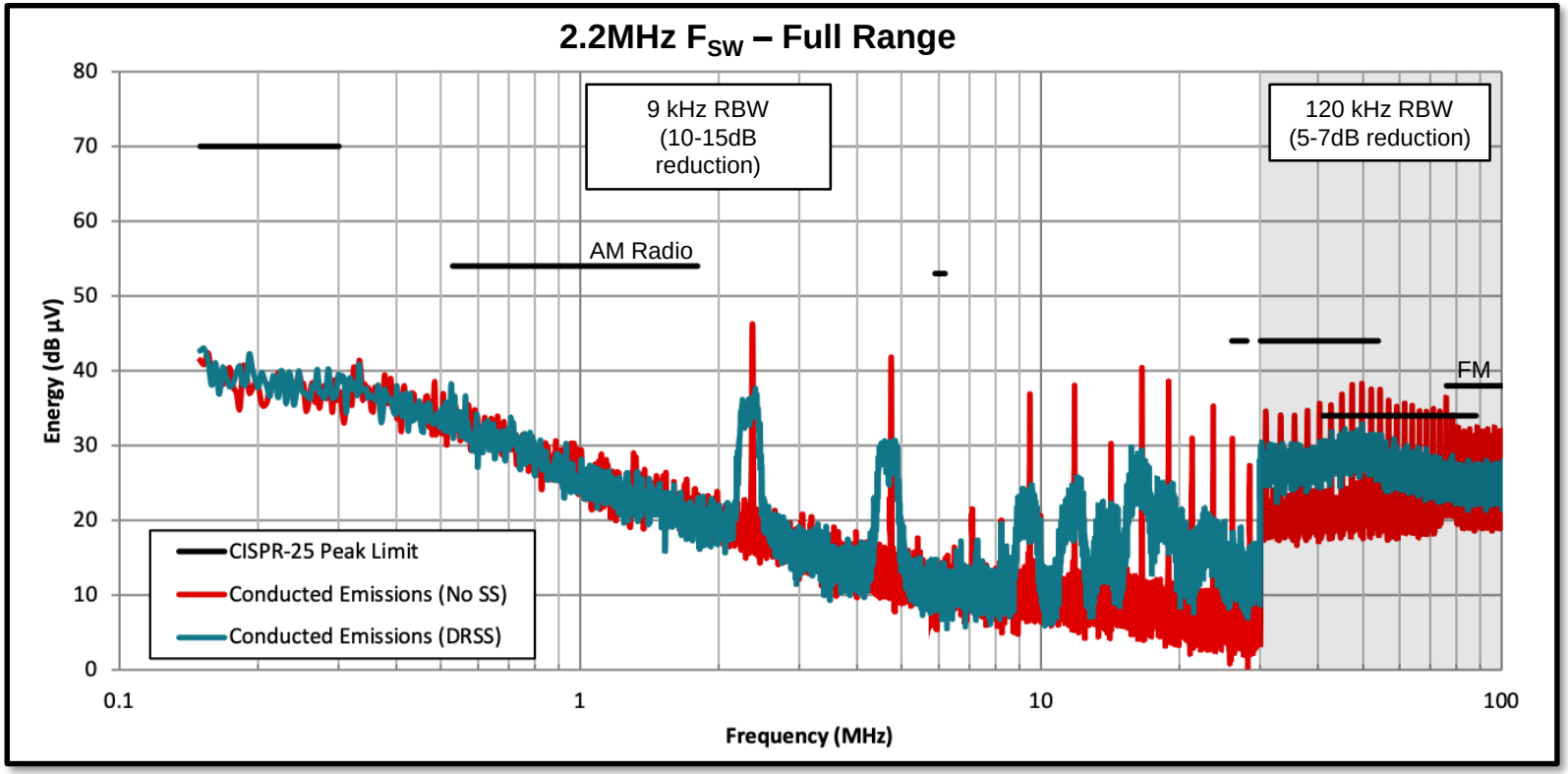
EMI Reduction Technique, Dual Random Spread Spectrum

Paul Curtis, Eric Lee

ABSTRACT

Spread spectrum techniques are commonplace in switch mode controllers and converters, and serve the purpose of reducing the effect of electromagnetic interference (EMI) that switchers generate. There are many ways to implement spread spectrum, and each of these will typically perform better at either low frequencies or high frequencies, due to the multiple resolution bandwidths (RBW) used in industry standard tests. Dual Random Spread Spectrum (DRSS) uses a digital algorithm specifically designed to spread spectral emissions in multiple frequency bands, without trading off performance between them.

Spread Spectrum (TI-Patented DRSS)



LM5155x

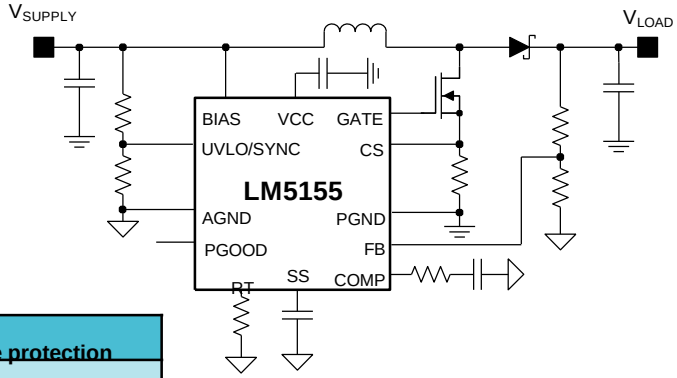
2.2-MHz Wide V_{IN} Non-synchronous Boost Controller

Features

- AEC-Q100 grade 1 qualified (T_A = -40ºC to 125ºC, T_J = -40ºC to 150ºC)
- Wide input range : **3.5 V~ 45 V**
  (2.97 V ~ 16 V when BIAS=VCC, 1.5 V~45 V when BIAS≥2.97 V)
- Programmable frequency 100 kHz to **2.2 MHz** with clock synchronization
- Shutdown I_Q ≤ 5 µA
- Non-switching I_Q ≤ 450 µA
- 1.5-A peak gate driver
- 100-mV current limit threshold with optional hiccup mode protection
- 1.0-V +/-1% reference
- Adjustable slope compensation
- Programmable line UVLO
- Adjustable soft-start
- PGOOD indicator
- OVP protection
- Thermal shutdown
- 12-pin-WSON package (3 mm x 2 mm) with Wettable Flank

Benefits

- Boost/Sepic/Flyback(Non-isolated/isolated) configurable
- Wide V_{IN} for a variety of power rails including 1-cell battery
- Switching frequency out of AM band
- Small solution size at 2.2 MHz
- Low shutdown I_Q reduces battery drain in battery-powered application
- Low current limit threshold minimizes power loss
- Optional hiccup mode for sustained overload / short-circuit protection
- Allows high step-up ratio using SYNC



Applications

- General purpose Boost / Sepic
- Battery powered application
- Automotive LED headlights
- Industrial Flyback power supply/ Primary side controlled Flyback

Hiccup mode protection	
Disabled	**Enabled**
LM5155-Q1	LM51551-Q1

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