

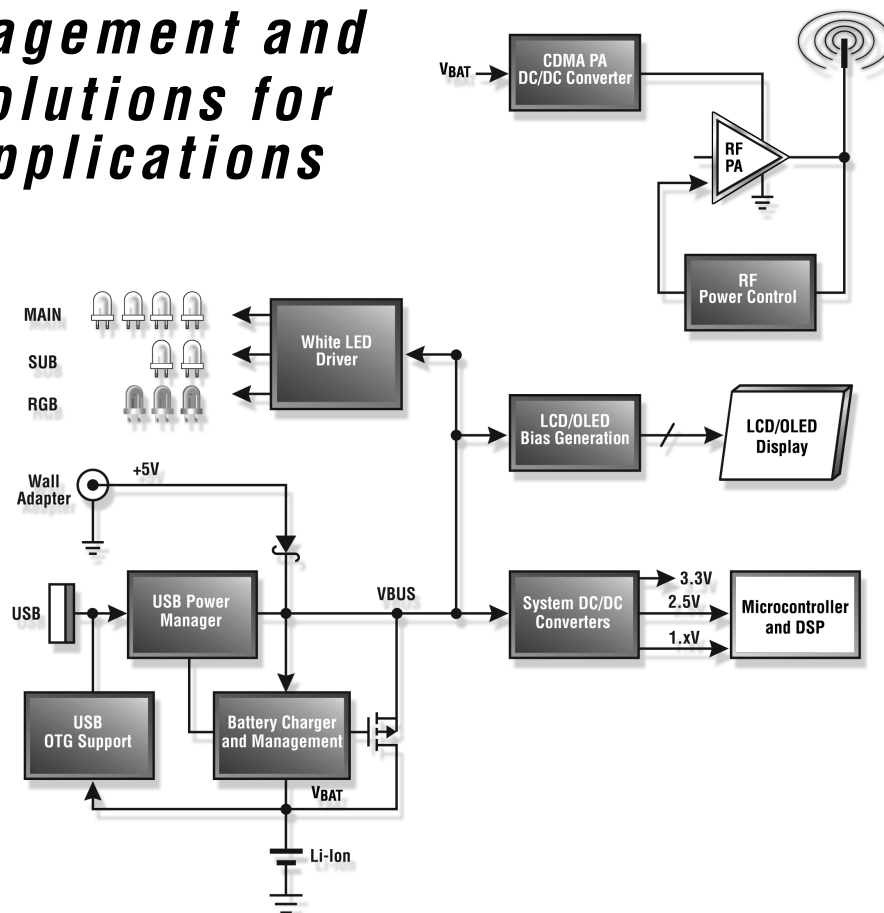
Linear Technology Chronicle

High Performance Analog Solutions from Linear Technology

Vol. 12 No. 6

Focus...

Power Management and Wireless Solutions for Handheld Applications



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From cell phones and PDAs to medical instruments and industrial test equipment, handheld electronic devices make up an ever increasing part of our world. We expect access to critical information wherever we go and communication with anyone at anytime. Linear Technology produces the high performance analog integrated circuits which make this possible.

Designing portable systems presents a myriad of design challenges. Today's handheld products require extremely small and low profile power management solutions. Consumers also expect long battery life, so maximum efficiency is essential. Sensitive wireless receivers in

close proximity to switching regulators pose potential interference issues.

Linear Technology's high performance analog ICs provide efficient system solutions for Li-Ion battery charging, battery management, USB support, system power regulation, display drivers, white LED drivers and RF power.

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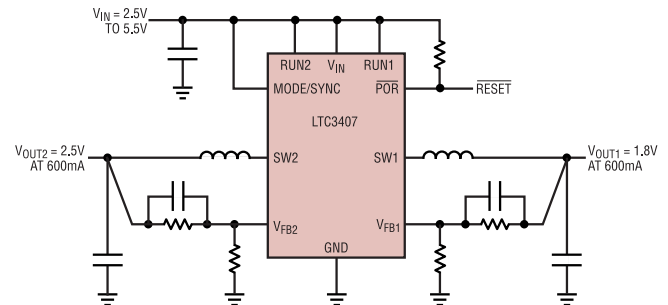
System Power: Step Down

Portable battery-powered devices present multiple challenges for designers. Consumers expect feature-rich devices with bright color displays while simultaneously demanding long battery life and small size. Linear Technology offers a wide range of high performance DC/DC converters ideal for today's challenging handheld applications.

The LTC[®]3407 is a dual output, high efficiency synchronous step-down regulator that can deliver up to 600mA of continuous current from each output. It operates from an input voltage range of 2.5V to 5.5V making it ideal for single-cell Li-Ion, multicell alkaline or NiMH/NiCd applications. Its switching frequency of 1.5MHz allows the utilization of tiny low cost capacitors and inductors less than 1mm in height. The combination of tiny externals and small MSOP-10 package makes the LTC3407 ideal for space-constrained applications. Features of the part include:

- High efficiency up to 95%
- V_{IN} from 2.5V to 5.5V
- V_{OUT} down to 0.6V
- Low I_Q : as low as 20 μ A/channel, $I_{SD} < 1\mu$ A
- 1.5MHz switching frequency

2.5V/1.8V at 600mA from Li-Ion Battery



Tiny, Synchronous Step-Down DC/DC Converter Family

Part No.	V_{IN} (V)	V_{OUT} (V)	I_{OUT} (A)	Frequency	Efficiency	I_Q (μ A)	I_{SD} (μ A)	Package	Comments
LTC3405A	2.5 to 5.5	0.8 to 5.5	0.30	1.5MHz	96%	20	<1	ThinSOT™	Low Noise
LTC3404	2.5 to 6.0	0.8 to 5.5	0.60	1.4MHz	95%	10	<1	MSOP-8	$\pm 2\%$ V_{OUT} Accuracy
LTC3406/B	2.5 to 5.5	0.6 to 5.5	0.60	1.5MHz	95%	20	<1	ThinSOT	Current Mode
LTC3407	2.5 to 5.5	0.6 to 5.5	2 x 0.60	1.5MHz	95%	40	<1	MSOP-10	Power-On Reset Output
LTC3411	2.5 to 5.5	0.8 to 5.5	1.25	4MHz	95%	60	<1	DFN, MSOP-10	100% Duty Cycle
LTC3412	2.5 to 5.5	0.8 to 5.5	2.50	4MHz	95%	60	<1	TSSOP-16	Low $R_{DS(ON)}$ Internal Switches 85m Ω

For low power applications that cannot use magnetics or require a lower profile solution, inductorless step-down converters provide a high efficiency alternative to linear regulators. Linear Technology offers a family of inductorless step-down converters that offer low noise outputs at up to 500mA output current.

Very Low Noise, High Efficiency Inductorless Step-Down DC/DC Converter Family

Part No.	V_{IN} (V)	V_{OUT} (V)	I_{OUT} (mA)	Frequency	I_Q (μ A)	Package	Comments
LTC1911	2.7 to 5.5	1.5/1.8	250	1.5MHz	180	MSOP-8	Wide V_{IN} , High Efficiency
LTC3250	3.1 to 5.5	1.5	250	1.5MHz	35	ThinSOT	Ultralow Noise, Dual Phase Switching
LTC3251	2.7 to 5.5	0.9 to 1.6 or 1.5 Fixed	500	1MHz to 1.6MHz	8	MSOP-10	Ultralow Noise, Dual Phase Spread Spectrum Switching
LTC3252	2.7 to 5.5	Dual 0.9 to 1.2	250 x 2	1MHz	50	DFN-12	Dual Outputs, Ultralow Noise, Spread Spectrum Switching, Output Disconnect

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System Power: Step Up

Powering handheld devices from single or dual cell alkaline batteries can be difficult. With input voltages as low as 0.8V, powering the system supply of up to 5V while maintaining high efficiency and small size requires the use of high performance boost regulators.

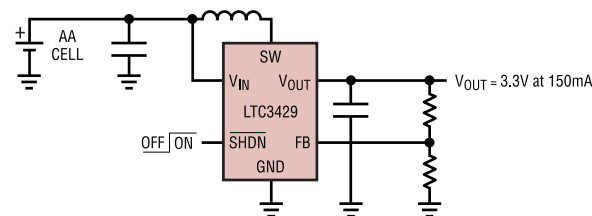
The LTC3429 is a synchronous step-up DC/DC converter delivering high efficiency in a ThinSOT package. With a 600mA switch

and an input voltage range that extends from 0.85V to 4V, the LTC3429 is capable of supplying 3.3V at 150mA from a single AA cell. The 1.2MHz fixed switching frequency minimizes the total solution footprint by allowing the use of tiny, low profile inductors and ceramic capacitors. An integrated output disconnect ensures no leakage from battery to load during shutdown.

Features of the part include:

- **High efficiency up to 92%**
- **V_{IN} from 0.85V to 4V**
- **V_{OUT} up to 5V**
- **Integrated 600mA switch**
- **Low I_Q: as low as 19μA, I_{SD} < 1μA**
- **Output disconnect**
- **ThinSOT package**

Single AA Cell to 3.3V Synchronous Step-Up Converter



Low Noise, High Efficiency Step-Up DC/DC Converter Family

Part No.	V _{IN} (V)	V _{OUT} (V)	I _{SW} (A)	Frequency	I _Q (μA)	Package	Comments
LT [®] 3464	2.3 to 10	34	0.085	Constant Off-Time	25	ThinSOT	Integrated Schottky, Output Disconnect
LT3460	2.5 to 16	36	0.3	1.3MHz	2mA	SC70, ThinSOT	Tiny SC70 Package
LT1615/-1	1 to 15	34	0.3/0.075	Constant Off-Time	20	ThinSOT	Operates with V _{IN} to 1V
LT1613	0.9 to 10	34	0.55	1.4MHz	3mA	ThinSOT	Operates with V _{IN} to 0.9V
LTC3400/B	0.85 to 5	5	0.6	1.2MHz	19/300	ThinSOT	"B" Version Disables Burst Mode [®] Operation
LTC3429	0.85 to 4	5	0.6	500kHz	20	ThinSOT	Output Disconnect
LTC3401	0.5 to 5	5	1.0	3MHz	38	MSOP-10	Up to 97% Efficiency
LTC3423	0.5 to 5	5.5	1.0	3MHz	38	MSOP-10	For V _{OUT} from 1.5V to 2.6V
LT3467	2.4 to 16	40	1.1	1.3MHz	1mA	ThinSOT	Integrated Soft-Start
LTC3402	0.5 to 5	5	2.0	3MHz	38	MSOP-10	Up to 97% Efficiency
LTC3424	0.5 to 5	5.5	2.0	3MHz	38	MSOP-10	For V _{OUT} from 1.5V to 2.6V
LTC3425	0.5 to 4.5	5.25	5.0	8MHz	16	QFN-32	4-Phase Synchronous Boost Converter

High Efficiency Inductorless Step-Up DC/DC Converter Family

Part No.	V _{IN} (V)	V _{OUT} (V)	I _{OUT} (mA)	Frequency	I _Q	Package	Comments
LTC3200	2.7 to 4.5	4.8 to 5.2	100	2MHz	8mA	MSOP-10	Low Noise, 2/1 Conv. Ratio
LTC3201	2.7 to 4.5	4.8 to 5.2	100	1.5MHz	6.5mA	MSOP-10	Low Noise, 2/1 Conv. Ratio
LTC3202	2.7 to 4.5	4.8 to 5.2	125	1.8MHz	5mA	MSOP-10	Low Noise, 3/2 Conv. Ratio
LTC1514	2 to 10	3.3/5	50	650kHz	60μA	SO-8	Step-Up/Step-Down
LTC1754	2.2 to 5.5	3.3/5	50	650kHz	13μA	ThinSOT	Very Low Standby Current

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System Power: Buck-Boost

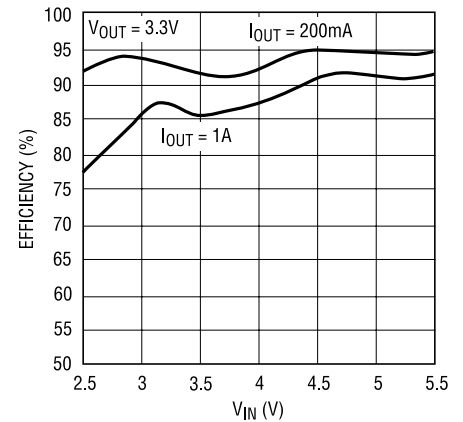
Generating 3.3V from a single cell Li-Ion battery poses a unique set of problems. With a voltage range from ~4.2V fully charged down to ~2.7V fully discharged, the Li-Ion battery voltage can be either above or below the desired output voltage, making standard DC/DC converter topologies less than ideal.

The LTC3441 is a synchronous, fixed frequency, Buck-Boost DC/DC converter designed to optimize battery run time for single cell Li-Ion, multicell alkaline or NiMH/NiCd battery-powered applications. It operates from input voltage range of 2.5V to 5.5V and can provide up to 1A of output current. The unique Buck-Boost

topology allows it to operate above, below and equal to the output voltage with a single inductor. The LTC3441's switching frequency is programmable up to 1MHz allowing the use of tiny, surface mount components. Features of the part include:

- **True Buck-Boost topology with one inductor**
- **Up to 96% efficient at Li-Ion to 3.3V**
- **I_{OUT} up to 1A**
- **V_{IN} 2.5V to 5.5V**
- **True output disconnect**

LTC3441 Efficiency Curve



Synchronous Buck-Boost DC/DC Converters

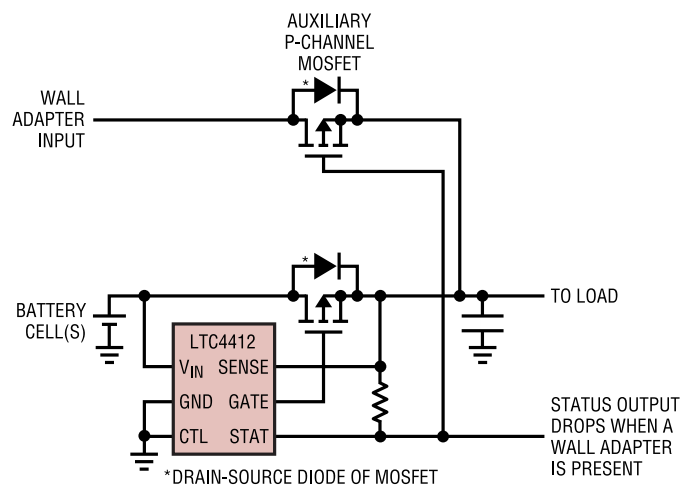
Part No.	V _{IN} (V)	V _{OUT} (V)	I _{OUT} (A)	Frequency	I _Q (μA)	I _{SD} (μA)	Package	Comments
LTC3440	2.5 to 5.5	2.5 to 5.5	0.60	2MHz	25	<1	MSOP-10	Single Inductor Buck-Boost Topology; No Schottky Diode, 95% Efficiency
LTC3441	2.4 to 5.5	1.5 to 5.25	1.0	1MHz	25	<1	DFN-12	Single Inductor Buck-Boost Topology; No Schottky Diode, 95% Efficiency

LTC4412 Ideal Diode

Using the LTC4412 low loss PowerPath™ controller instead of OR'ing diodes extends the run time of battery operated devices. The LTC4412 automatically switches between a wall adapter and battery power with a fraction of the power loss a diode exhibits. This device controls an external FET to provide the lowest dropout voltage available and also protects batteries by preventing reverse current flow. Features of the part include:

- **Lowest dropout voltage of 0.02V (compared to 0.7V for a diode)**
- **Ideal for switching between wall adapter to battery power**
- **Low 11μA supply current**
- **Small 6-lead ThinSOT package for space-constrained portable applications**

Automatic Switchover of Load Between a Battery and a Wall Adapter with Auxiliary P-Channel MOSFET for Lowest Loss



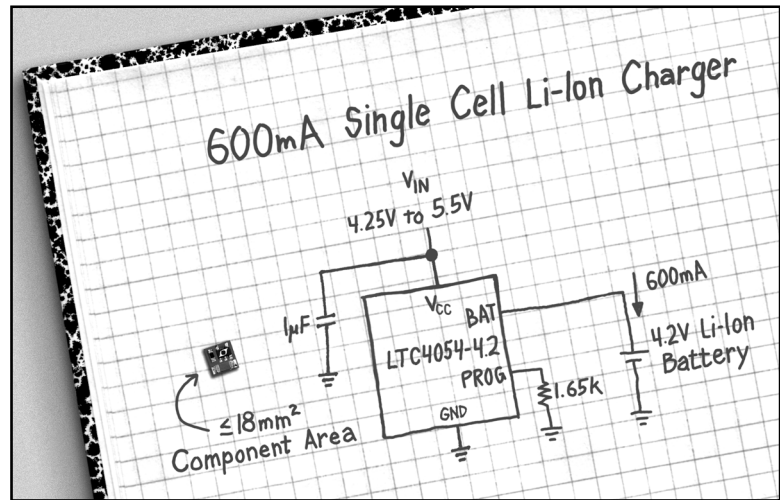
Battery Chargers

Choosing the right battery charger is challenging, given the myriad of batteries, battery capacities and battery chemistries. A designer must strike a balance between the desire for compact size and fast charge times, given the realities of heat dissipation and termination requirements.

The new LTC4054 battery charger provides a complete lithium-ion charging solution with an integrated 600mA transistor in a small ThinSOT package. No microprocessor intervention is required—simply add a small bypass capacitor and a resistor to set the charge current and the circuit is complete. Internal C/10 charge termination and unique thermal management features make this a small, simple and complete battery charging solution. Features include:

- **Integrated 600mA transistor**
- **Internal C/10 charge termination**
- **Very simple: No external MOSFET, sense resistor, blocking diode or microcontroller**
- **USB compatible**
- **ThinSOT package**

600mA Single Cell Li-Ion Charger



Li-Ion Battery Chargers for Handheld Applications

Part Number	Li-Ion Cells	Max. Charge Current	Max. Input Voltage	On Board Charge Termination	Integrated Transistor	USB 2.0 Compliant	Charger Type	Package
LTC4054L	1-Cell	180mA	8V			☑	Linear	ThinSOT
LTC1734		700mA	8V					ThinSOT
LTC4057		800mA	6.5V	☑		☑		ThinSOT
LTC4056		700mA	6.5V	☑	☑	☑		ThinSOT
LTC4054		800mA	6.5V	☑	☑	☑		ThinSOT
LTC4058		800mA	6.5V	☑				DFN
LTC4050		1.5A	10V	☑	☑			MSOP-10
LTC1733		1.5A	6.5V	☑	☑			MSOP-10
LTC4053		1.5A	6.5V	☑	☑	☑		MSOP-10
LTC4052		1.5A	10V	☑				Pulse
LTC1732-8.4	2-Cell	1.5A	12V	☑			Linear	MSOP-10
LTC4006	2-4-Cell	4A	28V	☑			Switching	SSOP-16
LTC4007	3-4-Cell	4A	28V	☑				SSOP-24
LTC4008	2-6-Cell	4A	28V					SSOP-20
LTC4002	1-2-Cell	4A	28V	☑				SO-8, DFN

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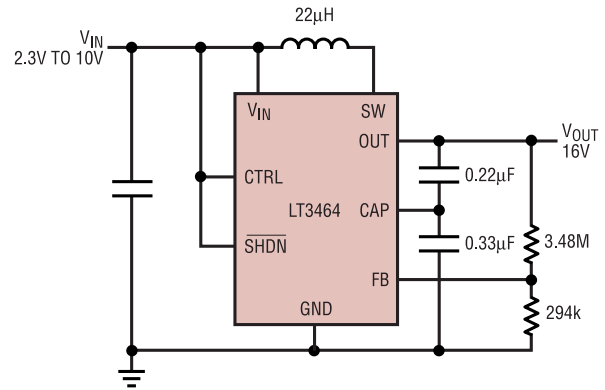
LCD/OLED Biasing

LCD and OLED displays typically require multiple bias supplies: a pair of low current, high voltage positive and negative voltages and one or more high current, low voltage main supplies. Linear Technology offers a range of boost and inverting switching regulators to meet the needs of LCDs or OLEDs of any size or type.

The LT3464 is ideal for applications that require up to 34V in the smallest possible form factor. An 85mA switch, Schottky diode and output disconnect transistor are all integrated in a tiny ThinSOT package, providing a complete biasing solution in less than 40mm². Burst Mode operation enables an ultralow supply current of 25μA, while shutdown current is typically less than 0.5μA. Features of the part include:

- **V_{IN} from 2.3V to 10V**
- **V_{OUT} up to 34V**
- **Integrated 85mA switch**
- **Integrated Schottky diode**
- **Output disconnect**
- **ThinSOT package**

High Voltage Boost Regulator in ThinSOT Package



Boost/Inverting Regulators for LCD/OLED Bias

Part No.	V _{IN} (V)	V _{OUT} (V)	I _{SW} (A)	Frequency	I _Q (mA)	I _{SD} (μA)	Package	Comments
LT3464	2.3 to 10	34	0.085	Constant Off-Time	25μA	<1	ThinSOT	Integrated Schottky, Output Disconnect
LT3460	2.5 to 16	36	0.3	1.3MHz	2	<1	SC70, ThinSOT	Tiny SC70 Package
LT1617/-1	1.2 to 15	-34	0.35/0.10	Constant Off-Time	20μA	<1	ThinSOT	For Inverting Applications
LT1611	1.1 to 10	-34	0.55	1.4MHz	3	<1	ThinSOT	For Inverting Applications
LT1930/A	2.6 to 16	34	1.00	1.2/2.2MHz	4.2	<1	ThinSOT	Operates with V _{IN} to 2.6V, V _{OUT} to 34V, Ideal for SEPIC
LT1931/A	2.6 to 16	-34	1.00	1.2/2.2MHz	4.2	<1	ThinSOT	For Inverting Applications
LT3467	2.4 to 16	40	1.1	1.3MHz	1	<1	ThinSOT	Integrated Soft-Start
LT1618	1.6 to 18	35	1.50	1.4MHz	1.8	<1	MSOP-10	Constant Current/Voltage Control

For even further integration, Linear Technology offers several dual or triple output switching regulators, providing all the necessary voltage supplies for an LCD or OLED in one simple package.

Multiple Output Regulators for LCD/OLED Bias

Part No.	V _{IN} (V)	V _{OUT} (V)	I _{SW} (A)	Frequency	I _Q (μA)	I _{SD} (μA)	Package	Comments
LT1944-1	1.2 to 15	34	0.18	Off-Time	20	< 1	MSOP-10	350mA and 150mA Boost Converters in Single Package
LT1944	1.2 to 15	34	0.35	Off-Time	20	< 1	MSOP-10	Dual 350mA Boost Converters in Single Package
LT1945	1.2 to 15	±34	0.25	Off-Time	20	< 1	MSOP-10	Dual 250mA, ±34V Boost Converters in Single Package
LT1947	2.6 to 6	34	1.10	3MHz	9.5mA	< 1	MSOP-10	Triple Output for TFT-LCD Applications

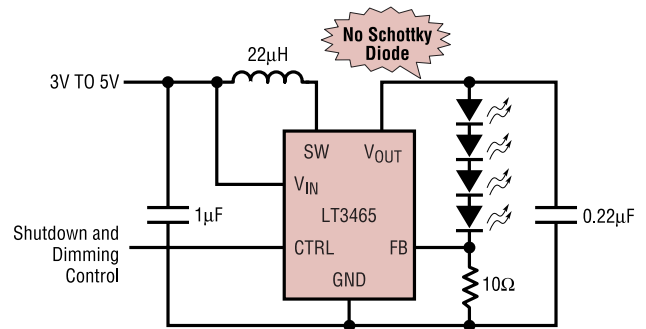
White LED Backlight

Bright, color LCD displays are quickly becoming the norm for handheld devices. These displays typically use white LEDs to provide backlighting, with larger displays requiring 4 or more LEDs to achieve the desired brightness. Linear Technology offers a wide range of low noise, high-efficiency switching regulators and inductorless DC/DC converters designed specifically for driving white LEDs.

The LT3465 is a switching regulator designed to drive up to 6 LEDs in series, providing inherently matched LED current and brightness. With an integrated switch and Schottky diode and housed in the ThinSOT package, the LT3465 offers a compact solution for handheld applications. Features of the part include:

- **Integrated 400mA switch and Schottky diode**
- **High efficiency: up to 81%**
- **Drives up to 6 LEDs**
- **1.2MHz switching frequency**

Li-Ion-Powered Driver for Four White LEDs



High Voltage, High Current White LED Drivers

Part Number	V _{IN} (V)	V _{OUT} (V)	Max. Switch Current (mA)	Max No. of White LEDs	Dimming Control	Frequency (MHz)	I _Q (µA)	I _{SD} (µA)	Package	Comments
LT1615	1.2 to 15	34	300	8	PWM	PFM	20	<1	ThinSOT	Constant-Current/Off Time
LT1932	1.0 to 10	34	400	8	PWM	1.2	1.2	<1	ThinSOT	Low Noise, 80% Efficiency, Ideal for 4-8 LEDs
LT1937	2.5 to 10	34	400	4	PWM	1.2	1.9	<1	ThinSOT, SC70	Low Noise, 84% Efficiency, Ideal for 2-4 LEDs
LT3465/A	2.7 to 16	30	400	6	PWM	1.2/2.2	2	<1	ThinSOT	Low Noise, 80% Efficiency, Ideal for 2-6 LEDs
LT1618	1.6 to 18	34	1.5A	20	PWM	1.4	1.8	<1	MSOP-10	Constant-Current/Voltage, Ideal for 8+ LEDs

For driving LEDs in parallel, Linear Technology offers a range of low noise inductorless DC/DC converters. The LTC3202 is a 125mA inductorless DC/DC designed to drive up to 8 white LEDs in parallel from a single cell Li-Ion battery. Features of the part include:

- **Drives up to 8 white LEDs**
- **Low noise**
- **Dimming control through an integrated 2-bit DAC**
- **MSOP-10 package**

Low Noise, Inductorless White LED Drivers

Part Number	V _{IN} (V)	Conversion Ratio	Max. Switch Current (mA)	Max. No. of White LEDs	Dimming Control	Frequency (MHz)	I _Q (mA)	I _{SD} (µA)	Package
LTC3200-5	2.7 to 4.5	1:2	100	6	PWM	2	8	<1	ThinSOT
LTC3200	2.7 to 4.5	1:2	100	6	PWM	2	8	<1	MSOP-10
LTC3201	2.7 to 4.5	1:2	100	6	DAC	1.7	6.5	<1	MSOP-10
LTC3202	2.7 to 4.5	1:1.5	125	8	DAC	1.5	5	<1	DFN, MSOP-10
LTC3205	2.7 to 4.5	1:1.5	250	6 + 3 RGB	SPI*	1	50	<1	QFN-24

* Serial Peripheral Interface

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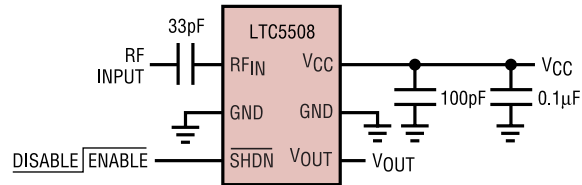
RF PA Power and Control

Portable communications devices of all types require the ability to accurately monitor the RF power emitted by the Power Amplifier (PA). The LTC5508 is a temperature compensated RF power detector with >40dB dynamic range for 300MHz to 3GHz applications. Available in the tiny SC70 package, it requires a fraction of the PCB space needed by a discrete design and consumes 9 times less supply current. Features of the part include:

- **Wide frequency range up to 7GHz**
- **40dB dynamic range**
- **Low power: 550µA**
- **SC70 package**

For GSM and GPRS applications, Linear Technology manufactures a range of dual band RF PA power detect and control ICs designed to operate over a wide range of frequencies (800MHz to 2.7GHz) and to control any RF PA.

300MHz to 7GHz RF Power Detector



RF PA Power Controllers

Part No.	Package	RF PA Compatible/Comments
LTC1757A	8-, 10-Lead MSOP	Legacy RF PA such as RF3103
LTC1758	8-, 10-Lead MSOP	Slow Turn on RF PAs such as PF08123, RF3160, CX77304, RF3160
LTC1957	8-, 10-Lead MSOP	Fast Turn on RF PAs such as RF3108, PF0819B, RF2138/RF2140
LTC4400	ThinSOT	Fast Turn on RF PAs such as RF3108, PF0819B, RF2138/RF2140
LTC4401	ThinSOT	Slow Turn on RF PAs such as PF08123, RF3160, CX77304, RF3160
LTC4402/3	8-, 10-Lead MSOP	EDGE/TDMA (ANSI-136), AM Modulation

RF Power Detector/Demodulators

Part Number	Main Application	Frequency Range	Sensitivity at 900MHz	V _{SUPPLY}	I _{SUPPLY}	Package
LTC5508	802.11a, b, g, 802.15, ISM CDMA, WCDMA, GSM, WLAN	300MHz to 7GHz	23mV/dB at P _{IN} = -16dBm	2.7V to 6V	550µA	SC70
LTC5505	ISM, CDMA, WCDMA, GSM, WLAN	300MHz to 3.5GHz	9mV/dB at P _{IN} = -16dBm	2.7V to 6V	550µA	ThinSOT
LTC5507	Lower Frequency Detection	100kHz to 1GHz	17mV/dB at P _{IN} = -16dBm	2.7V to 6V	550µA	ThinSOT

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