Battery Charging and Management Solutions

High Performance Analog ICs

LINEAR TECHNOLOGY

Linear Technology's high performance battery charging and management ICs enable long battery life and run time, while providing precision charging control, constant status monitoring and stringent battery protection. Our proprietary design techniques seamlessly manage multiple input sources while providing small solution footprints, faster charging and 100% standalone operation. Battery and circuit protection features enable improved thermal performance and high reliability operation.

Each battery chemistry has unique charging requirements. Selecting the correct battery charger increases the operational run time of the end product, ensuring that the battery is optimally charged. This guide contains the essential technical criteria to identify the optimum battery charging IC for 1-cell to multiple-cell configurations, regardless of chemistry. Data sheets for our complete battery management product portfolio, including our latest product releases, are available at **www.linear.com**.

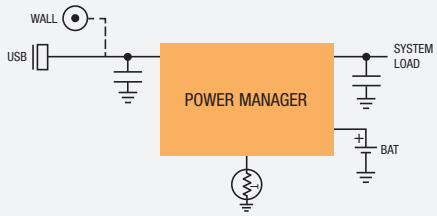
Battery Charging and Management Solutions

Battery Charging Products

Battery Charging Products (continued)

TYPE	PAGE	TOPOLOGY	BATTERY CHEMISTRY

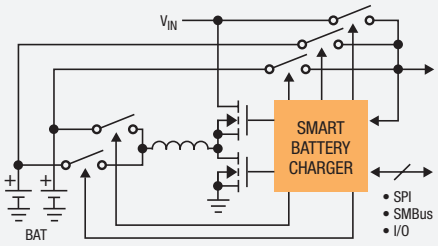
Power Managers (BAT Decoupled from V_{OUT})



Lithium-Ion/Polymer

LiFePO$_4$

Switch Mode – Smart Battery



Lithium-Ion/Polymer

LiFePO$_4$

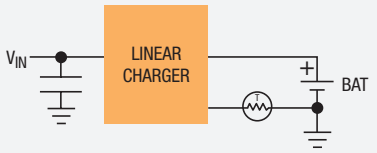
NiMH/NiCd

Lead-Acid

Multichemistry

Supercapacitor

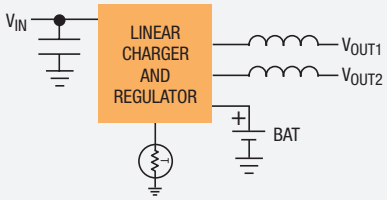
Linear Chargers



Lithium-Ion/Polymer

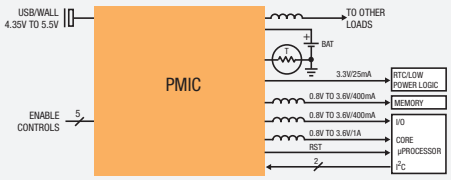
NiMH/NiCd

Linear Charger + Regulators



Lithium-Ion/Polymer

Power Management Integrated Circuits (PMICs) with Integrated Chargers



Lithium-Ion/Polymer

Battery Management Products

Wireless Power Receiver & Buck Battery Charger

LTC4120

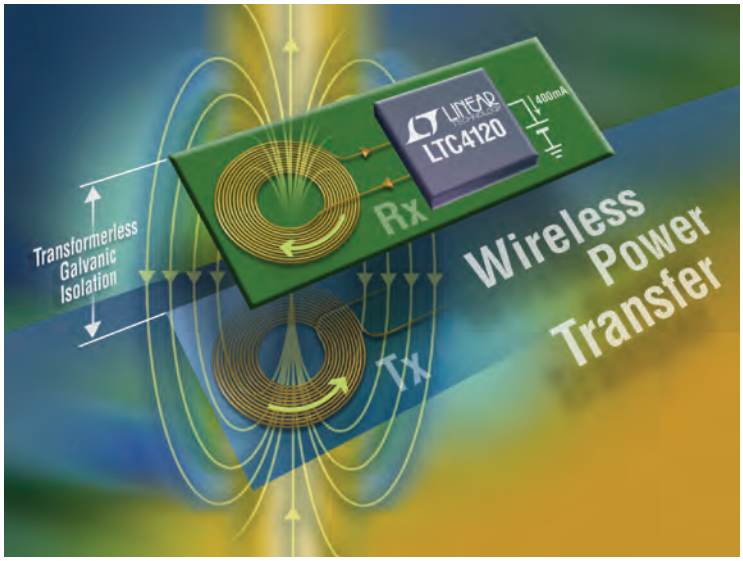
The LTC4120, a high performance wireless receiver and battery charger, serves as the central component of the receiver electronics in a wireless battery charging system. The Linear Technology wireless power system is designed to transmit up to 2W to a battery with a maximum charge current of 400mA. The programmable float voltage of the device accommodates several battery chemistries and configurations. The IC utilizes a patented dynamic harmonization control (DHC) technique that enables high efficiency contactless charging with maximum T_X to R_X coil distance and misalignment without any of the thermal or overvoltage issues typically associated with wireless power systems. Wireless charging with the LTC4120 enables or improves many different applications. For instance, expensive connectors which become failure-prone in harsh environments can be eliminated. Similarly, wireless charging allows for a completely sealed enclosure for applications that require sterilization. Elimination of wires enables rechargeable batteries to be placed in moving or rotating equipment. Some applications are simply too small to use a conventional connector. Wireless charging can also provide transformerless galvanic isolation for high reliability isolated applications. The LTC4120 provides the ability to charge batteries in applications where it is difficult or impossible to use a connector. Unlike consumer-oriented solutions following the Qi standard, the LTC4120-based solution addresses the needs of high reliability industrial, military and medical applications.

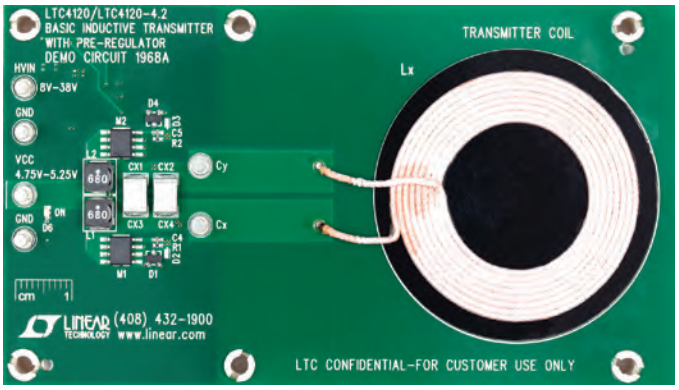
LTC4120 — Key Technical Features

- Dynamic Harmonization Control Reduces Alignment Sensitivity and Extends Power Transmission Range
- Enables Up to 2W Wireless Charging at Up to a 1.2cm Gap
- Adjustable Battery Charge Voltage: 3.5V to 11V
- 50mA to 400mA Charge Current, Programmed with a Single Resistor
- No Microprocessor or Firmware Required
- No Transformer Core
- Wide Rectified Input Voltage Range: 4.3V to 40V
- Thermally Enhanced 16-Lead 3mm × 3mm QFN Package

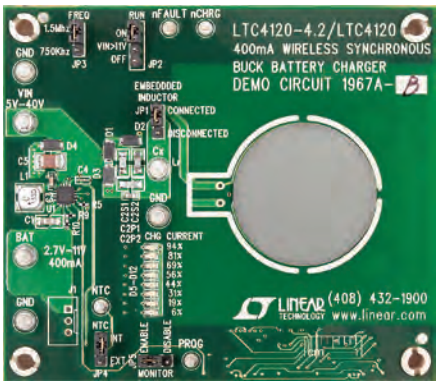
Applications

- Industrial/Military Sensors and Devices
- Portable Medical Devices
- Physically Small Devices
- Electrically Isolated Devices
- Devices for Harsh Environments





LTC4120
75% Size Demo Circuit
Basic Transmitter Board

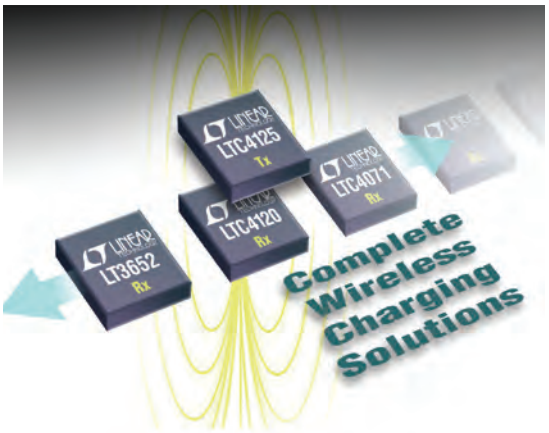


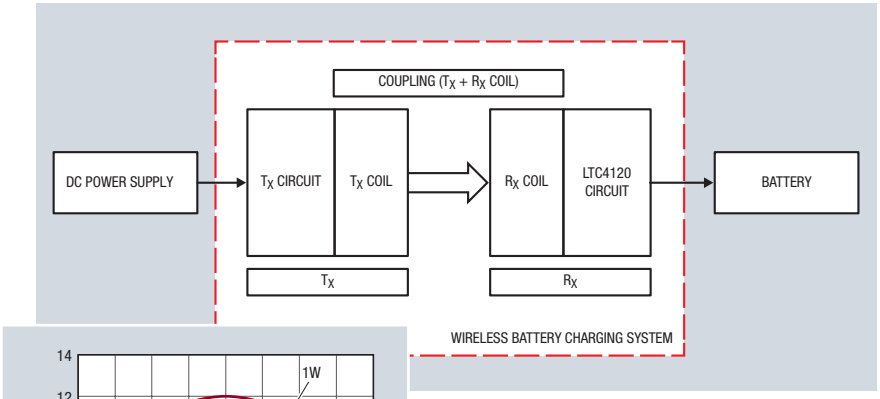
LTC4120
75% Size
Receiver/Charger Demo Board

Wireless Power Transfer (WPT)

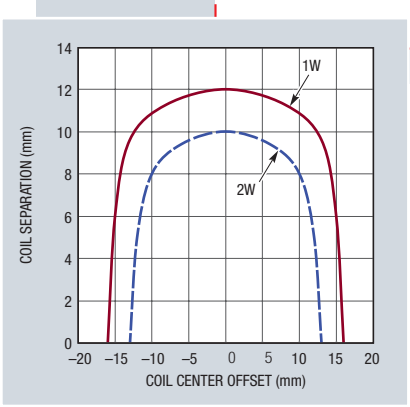
An inductive wireless power system consists of transmitter electronics, transmit coil, receive coil and receiver electronics. The LTC4120-based resonant coupled system uses dynamic harmonization control (DHC) to optimize power transfer and provide overvoltage protection. This eliminates the need for precise mechanical alignment between the transmit and receive coils as well as the need for a coupling core. The LTC4120 wireless buck charger forms the basis for the receiver electronics. The receive coil can be integrated into the receiver electronics circuit board. Linear Technology offers several transmitter electronics options. The LTC4125 is the power controller for a simple but versatile wireless power transmitter. The LTC4125 enhances a basic wireless power transmitter by providing three key features: an AutoResonant function that maximizes available receiver power, an Optimum Power Search algorithm that maximizes overall wireless power system efficiency and foreign object detection to ensure safe and reliable operation when working in the presence of conductive foreign objects.

LTC4120 Product Page: **www.linear.com/product/LTC4120**
LTC4120 Application Note: **www.linear.com/docs/43968**
LTC4125 Product Page: **www.linear.com/product/LTC4125**





Wireless Power Transfer System Block Diagram Charging



Battery Charge Power vs R_X-T_X Coil Location

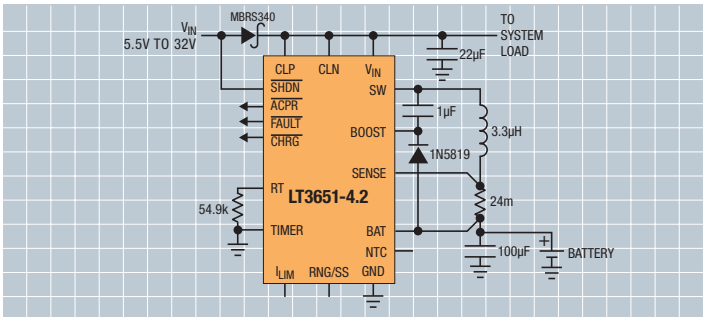
Part Number	Device Architecture	Vin Range (V)	Power Level (W)	Auto Resonant Drive	Foreign Object Detection	Optimum Power Transfer	Practical Coupling Distance (mm)	Package (mmxmm)
Wireless Power Transmitters								
LTC4125	Wireless Transmitter	3 to 5.5	5	Yes	Yes	Yes	13 Full Power 16 Half Power	4x5 QFN-20

Part Number	Device Architecture	Vin Range (V)	Power Level (W)	Charge Current (mA)	Practical Coupling Distance (mm)	Cell (s) Chemistry	Charge Termination Method	Package (mmxmm)
Battery Chargers								
LTC4120	Wireless Receiver & Battery Charger	4.25 to 40	2	50 to 400	12	1 to 3 Lithium	Adj. Timer	3x3 QFN-16
LTC4123	Wireless Receiver & Battery Charger	2.2 to 5	.038	25	12	1 Nickle	Adj. Timer	2x2 DFN-6
LTC4071	Shunt Battery Charger	N/A Shunt	.21	50	12	1 Lithium	Thermal NTC	2x3 DFN-8
LT3652HV	High Power Battery Charger	4.95 to 34 (40V abs max)	2	2A	12	1 to 5 Lithium Lead Acid	Adj. Timer or C/10	3x3 DFN-12, MSOP-12E

Switch Battery Chargers

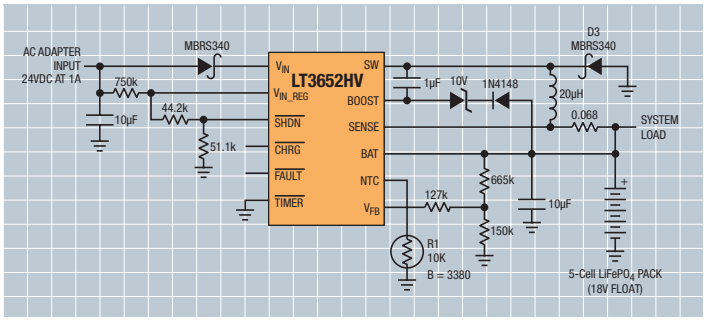
Our step-down (buck) battery chargers enable high efficiency charging from a wide input voltage range for a variety of battery chemistries.

LT®3651: Monolithic 4A High Voltage Li-Ion Battery Charger



7.5V to 32V Single Cell 4A Charger

LT3652HV: Power Tracking 2A Battery Charger



24V 5-Cell $LiFePO_4$ Charger (18V at 1.5A) with C/10 Termination

Part Number	Maximum Charge Current (A)	V_{BAT} Range (V)	Battery Chemistry	Number of Battery Cells (Series)	Input Voltage (V)	Integrated Power Transistor	Synchronous	Charge Termination	Package (mmxmm)
Switch Mode Multi-Chemistry Buck (Step-Down) Battery Chargers									
LTC4121	0.4	3.6 to 18	Li-Ion, $LiFePO_4$ SLA	SLA, 1-5 $LiFePO_4$ 1-4 Li-Ion	4.3 to 40	✓	–	Timer	3x3 QFN-16
LT1510	1	2.5 to 26	NiMH NiCd SLA Li-Ion	1-12 Ni, SLA 1-4 Li-Ion	7 to 29	✓	–	External µC or LTC1729	SO-8, SSOP-16, SO-16
LT3652	2	3.3 to 14.4	SLA, $LiFePO_4$ Li-Ion	SLA , 1-4 $LiFePO_4$ 1-3 Li-Ion	4.9 to 32†	✓	–	Timer or C/10	3x3 DFN-12, MSOP-12E
LT3652HV	2	3.3 to 18	SLA, $LiFePO_4$ Li-Ion	SLA, 1-5 $LiFePO_4$ 1-4 Li-Ion	4.9 to 34†	✓	–	Timer or C/10	3x3 DFN-12, MSOP-12E
LT1769	2	2.5 to 26	NiMH NiCd SLA Li-Ion	1-12 Ni, SLA 1-4 Li-Ion	7 to 29	✓	–	External µC or LTC1729	TSSOP-20, SSOP-28
LT1511	3	2.5 to 26	NiMH NiCd SLA Li-Ion	1-12 Ni, SLA 1-4 Li-Ion	7 to 29	–	–	External µC or LTC1729	SO-24
LTC4008	4	3 to 28	NiMH NiCd SLA Li-Ion	4-18 Ni, SLA 2-6 Li-Ion	6 to 28	–	✓	External µC	SSOP-20
LTC4009/-1*/-2	4	2 to 28	NiMH NiCd SLA Li-Ion	2-18 Ni, 1-4 Li-Ion	6 to 28	–	✓	External µC	4x4 QFN-20
LTC4012/-1*/-2/-3	4	2 to 28	NiMH NiCd SLA Li-Ion	2-18 Ni, 1-4 Li-Ion	6 to 28	–	✓	External µC	4x4 QFN-20
LT1505	8	2.5 to 23	NiMH NiCd SLA Li-Ion	1-12 Ni, SLA 1-4 Li-Ion	6.7 to 26	–	✓	External µC	SSOP-28
LTC1960	8	3.5 to 28	NiMH NiCd SLA Li-Ion	4-16 Ni, SLA 2-6 Li-Ion	6 to 28	–	✓	External µC	5x7 QFN-38, SSOP-36
LTC4015	20**	up to 35V	$LiFePO_4$ SLA Li-Ion	3/6/12 SLA, 1-9 $LiFePO_4$ 1-8 Li-Ion	4.5 to 35	–	✓	Timer, C/X	5x7 QFN-38
Switch Mode Li-Ion Buck Battery Chargers									
LT1571	1.5	2.5 to 26	Li-Ion	1-2, Adj	6.2 to 27	✓	–	External µC	SSOP-16, SSOP-28
LTC4001/-1*	2	4.2	Li-Ion	1	4 to 5.5	✓	✓	Timer	3x3 QFN-16
LT3650-4.1/-4.2	2	4.1, 4.2	Li-Ion	1	4.75 to 32† (40 Max)	✓	–	Timer + C/10	3x3 DFN-12, MSOP-12E
LT3650-8.2/-8.4	2	8.2, 8.4	Li-Ion	2	9 to 32† (40 Max)	✓	–	Timer + C/10	3x3 DFN-12, MSOP-12E
LT3651-4.1/4.2	4	4.1, 4.2	Li-Ion	1	4.8 to 32	✓	✓	Timer + C/10	5x6 QFN-36
LT3651-8.2/8.4	4	8.2, 8.4	Li-Ion	2	9 to 32	✓	✓	Timer + C/10	5x6 QFN-36
LTC4002-4.2/-8.4	4	4.2, 8.4	Li-Ion	1-2	4.7 to 22	–	–	Timer	3x3 DFN-10, SO-8
LTC4006-2/-4/-6	4	5 to 16.8	Li-Ion	2-4	6 to 28	–	✓	Timer	SSOP-16
LTC4007/-1	4	7.5 to 16.8	Li-Ion	3-4	6 to 28	–	✓	Timer	SSOP-24

*4.1V Cell Voltage, **Depends on external components, † Minimum Start-up Voltage is + 3.3V Above V_{BATMAX}

Buck-Boost Battery Chargers

Our buck-boost battery chargers seamlessly charge a battery as its voltage varies below, above or equal to the input voltage.

LTC4020: 55V Buck-Boost Multi-Chemistry Battery Charger with Maximum Power Point Control (MPPC)

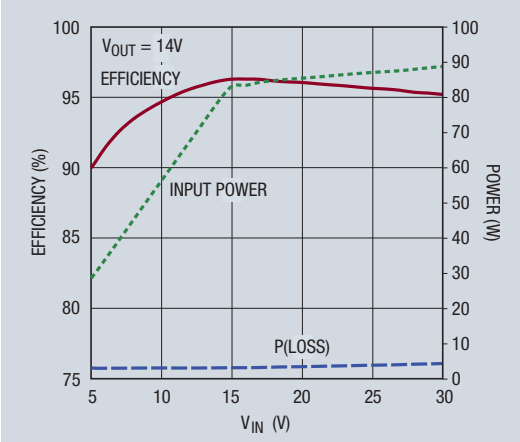
Features

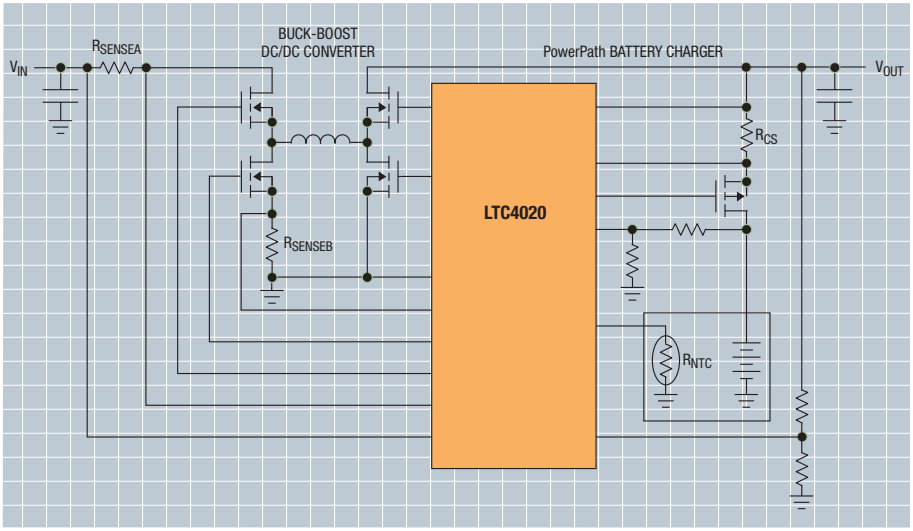
- Wide Voltage Range: 4.5V to 55V Input, Up to 55V Output (60V Absolute Maximums)
- Synchronous Buck-Boost DC/DC Controller
- Li-Ion and Lead-Acid Charge Algorithms
- ±0.5% Float Voltage Accuracy
- ±5% Charge Current Accuracy
- Instant-On for Heavily Discharged Batteries
- Ideal Diode Controller Provides Low Loss PowerPath when Input Power is Limited
- Input Voltage Regulation for High Impedance Input Supplies and Solar Panel Peak Power Operation
- Onboard Timer for Protection and Termination
- Bad Battery Detection with Auto-Reset
- NTC Input for Temperature Qualified Charging
- Low Profile (0.75mm) 38-Pin 5mm × 7mm QFN Package

Applications

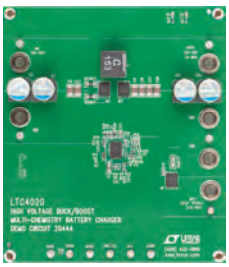
- Portable Industrial and Medical Equipment
- Solar-Powered Systems
- Military Communications Equipment
- 12V to 24V Embedded Automotive Systems

Maximum Power Efficiency vs V_{IN}





Buck-Boost DC/DC Converter Controller with PowerPath Battery Charger Accepts Inputs from 4.5V to 55V and Produces Output Voltages Up to 55V



DC2044A
30% of Actual Size
Demo Circuit

Part Number	Number of Battery Cells (Series)	Maximum Charge Current (A)	V_{BAT} Range (V)	Battery Chemistry	Input Voltage (V)	Integrated Power Transistor	Synchronous	Charge Termination	Package (mm×mm)
Switch Mode Buck-Boost (Step-Down/Step-Up) Battery Chargers									
LT1512	1-12 Ni	0.8	1.5 to 20	NiCd NiMH SLA	2.4 to 29	✓	–	External µC	SO-8
LT1513	1-12 Ni	1.6	1.5 to 20	NiCd NiMH SLA	2.4 to 29	✓	–	External µC	DD Pak, TO-220
LTC1980	1-2 Li-Ion	4	2.85 to 10	NiCd NiMH Li-Ion	4.1 to 12	–	–	External µC, Timer (Li-Ion)	SSOP-24
LTC4110 *†	Up to 10 Ni, 1-4 Li-Ion, Up to 6 SLA	4	3.5 to 18	NiCd NiMH SLA, Li-Ion	6 to 19	–	✓	Timer, C/10, SMBus	5x7 QFN-38
LTC4020	SLA, $LiFePO_4$, Li-Ion, SLA	20+**	2.5 to 55	$LiFePO_4$, 1-13 Li-Ion	4.5 to 55	–	✓	Timer, C/x	5x7 QFN-38

*Flyback Topology, **Depends on external components, † Supercapacitor Compatible

Solar Battery Charging ICs

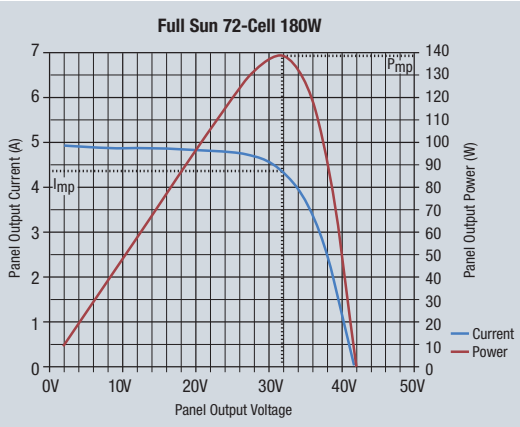
Batteries are often paired with solar panels to provide energy storage for the inherently intermittent power generation nature of solar panels. However, solar panels are non-ideal power sources, and the operating point at which maximum power is generated depends on many factors such as incident light (including any partial shading), temperature and panel aging. When discussing solar panels and power, terms such as maximum power point tracking (MPPT) and maximum power point control (MPPC) are often used.

As can be seen in Figure 1, the output current of a solar panel varies nonlinearly with the panel voltage. Under short-circuit conditions, the output power is zero since the output voltage is zero. Under open-circuit conditions, the output power is zero since the output current is zero. Most solar panel manufacturers specify the panel voltage at maximum power (Vmp). This voltage is typically around 70 – 80% of the panel's open circuit voltage (Voc). In Figure 1 the maximum power is just under 140W with Vmp just under 32V and Imp just under 4.5A. Ideally, any system using a solar panel would operate that panel at its maximum power output. This is particularly true of a solar powered battery charger, where the goal is to capture and store as much solar energy as possible, as quickly as possible. Put another way, since we cannot predict the availability or intensity of solar power, we need to harness as much energy as possible while energy is available.

There are many different ways to operate a solar panel at its maximum power point. One of the simplest is to connect a battery to the solar panel through a diode. This technique is described in the Linear Technology article "Energy Harvesting with Low Power Solar Panels" (www.linear.com/solutions/1786). It relies on matching the maximum output voltage of the panel to the relatively narrow voltage range of the battery. When available power levels are very low (approximately less than a few tens of milliwatts), this may be the best approach. The article describes using the LTC4071 with a single-cell Li-Ion/polymer battery. However, the same basic approach can be used with the LTC4079 (without the diode). The LTC4079 dramatically increases the flexibility of this approach by allowing any battery voltage from 1.2V to 60V. Therefore, a specified solar panel can be matched to a battery or a specified battery can be matched to a panel.

An alternate approach is to implement a complete maximum power point tracking (MPPT) algorithm. There are a variety of MPPT algorithms, but most have the ability to sweep the entire operating range of the solar panel to determine where maximum power is produced. The LT8490 is an example of an integrated circuit that performs this function. The advantage of a full MPPT algorithm is that it can differentiate a local power peak from a global power maximum. In multicell solar panels, it is possible to have more than one power peak during partial shading conditions (see Figure 2). The difference in available power between operating at the true global maximum power point and a false local maximum can be very large. Typically, a full MPPT algorithm is required to find the true maximum power operating point. It does so by periodically sweeping the entire output range of the solar panel and remembering the operating conditions where maximum power was achieved. When the sweep is complete, the circuitry forces the panel to return to its maximum power point. In between these periodic sweeps, the MPPT algorithm will continuously dither the operating point to ensure that it operates at the peak.

Figure 1
Solar Panel I-V Curve Showing Maximum Power

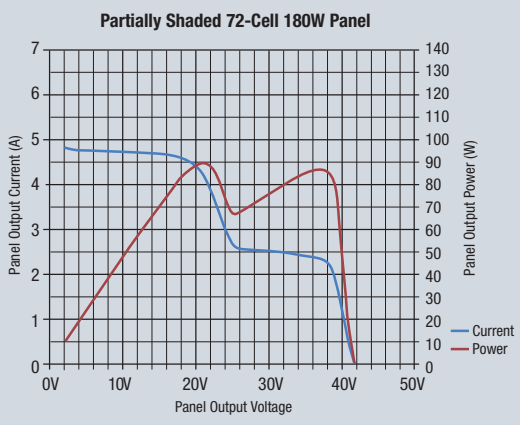


An intermediate approach is something that Linear Technology calls maximum power point control (MPPC). This technique takes advantage of the fact that the maximum power voltage (V_{MP}) of a solar panel does not, typically, vary much as the amount of incident light changes (see "Solar Battery Charger Maintains High Efficiency in Low Light" for more information). Therefore, a simple circuit can force the panel to operate at a fixed voltage and approximate maximum power operation. A voltage divider is used to measure the panel voltage and if the input voltage falls below the programmed level, the load on the panel is reduced until it can maintain the programmed voltage level. Products with this functionality include the LTC3105, LTC3129, LT3652(HV), LTC4000-1, and the LTC4020. Depending on solar panel construction, shading conditions and incident light levels, a full MPPT algorithm can extract considerably more power from a solar panel than an MPPC algorithm. However, under some circumstances, the simplicity of an MPPC approach may be a better choice.

A recent Linear Technology product introduction provides yet another technique to extract maximum power from a limited source. The new approach is a blend of a full MPPT algorithm and an MPPC function. The LTC4121 employs an MPPT algorithm that compares a stored open-circuit input voltage measurement against the instantaneous input voltage while charging. The LTC4121 automatically reduces the charge current if the input voltage falls below the user-defined percentage of the open-circuit voltage. This algorithm lets the LTC4121 optimize power transfer for a variety of different input sources including first order temperature compensation of a solar panel. While this technique will not differentiate between local and global maxima, it will adjust its operating conditions as temperature varies, and it can accommodate a variety of solar panels without hardware changes assuming the ratio of V_{MP} to V_{OC} remains approximately constant.

In summary, there are many different ways of operating a solar panel at its maximum output operating condition. The panel can be connected to a battery (through a diode) whose voltage range is close to the maximum power voltage of the panel. A full MPPT algorithm, including periodic global sweeps to find the global maximum and a continuous dither to remain at that maximum can be used (an example is the LT8490). Other products implement an input voltage regulation technique (MPPC) to operate a solar panel at a fixed operating voltage, including the energy harvesting switching regulator devices LTC3105, LTC3129, the charge controller LTC4000-1, plus the battery chargers LT3652(HV), and the LTC4020. Finally, the LTC4121 blends two approaches.

Figure 2
Partially Shaded Solar Panel Showing Multiple Power Maxima



Solar Battery Chargers: Switch Mode Buck / Buck-Boost, Linear and Shunt

LT8490 - High Voltage, High Current Buck-Boost Battery Charge Controller with Maximum Power Point Tracking (MPPT)

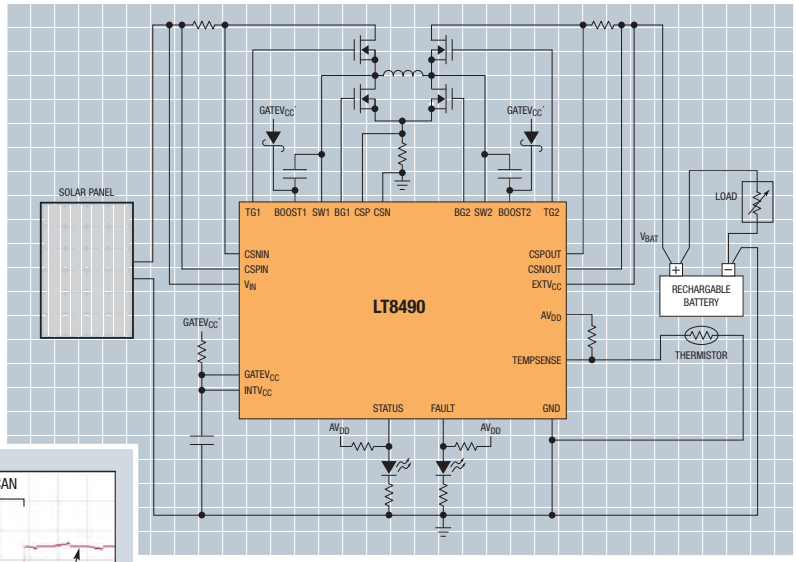
Features

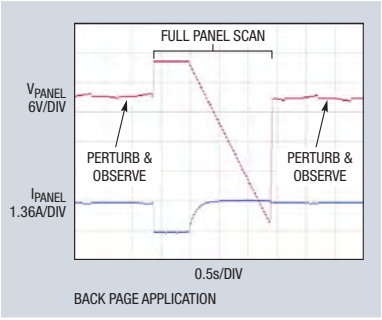
- V_{IN} Range: 6V to 80V
- V_{BAT} Range: 1.3V to 80V
- Single Inductor Allows V_{IN} Above, Below or Equal to V_{BAT}
- Automatic MPPT for Solar Powered Charging
- Automatic Temperature Compensation
- No Software or Firmware Development Required
- Operation from Solar Panel or DC Supply
- Input and Output Current Monitor Pins
- Four Integrated Feedback Loops
- Synchronizable Fixed Frequency: 100kHz to 400kHz
- 64-Lead (7mm × 11mm × 0.75mm) QFN Package

Applications

- Solar Powered Battery Chargers
- Multiple Types of Lead-Acid Battery Charging
- Li-Ion Battery Charger
- Battery Equipped Industrial or Portable Military Equipment

Typical Application Circuit





Maximum Power Point Tracking

Part Number	Maximum Charge Current (A)	V_{BAT} Range (V)	Battery Chemistry	Number of Battery Cells (Series)	Input Voltage (V)	Integrated Power Transistor	Synchronous	Charge Termination	MPPx	Package (mmxmm)
Switch Mode Multi-Chemistry Buck and Buck-Boost (Step-Down/Step-Up) Solar Battery Chargers										
LT3652	2	3.3 to 14.4	SLA, $LiFePO_4$ Li-Ion	SLA , 1-4 $LiFePO_4$, 1-3 Li-Ion	4.9 to 32†	✓	–	Timer or C/10	MPPC	3x3 DFN-12, MSOP-12E
LT3652HV	2	3.3 to 18	SLA, $LiFePO_4$ Li-Ion	SLA, 1-5 $LiFePO_4$, 1-4 Li-Ion	4.9 to 34†	✓	–	Timer or C/10	MPPC	3x3 DFN-12, MSOP-12E
LTC4121	400mA	3.5V to 18V	SLA $LiFePO_4$ Li-Ion	SLA 1-5 $LiFePO_4$, 1-4 Li-Ion	4.4V to 40V	✓	✓	Timer	MPPT	3x3 QFN-16
LTC4020	20+*	2.5V to 55V	SLA, $LiFePO_4$, Li-Ion	SLA, 1-15 $LiFePO_4$, 1-13 Li-Ion	4.5V to 55V	–	✓	Timer, C/x	MPPC	5x7 QFN-38
LT8490	20+*	1.3V to 80V	SLA, Li-Ion	SLA, 1-19 Li-Ion	2.8V to 80V	–	✓	Timer, C/10	MPPT	5x7 QFN-38, TSSOP-38
Linear Multi-Chemistry Solar Battery Chargers										
LTC4079	250mA	1.2V to 60V	SLA Li-Ion, Ni	SLA, 1-14 Li-Ion, 1-50 Ni	2.7V to 60V	✓	n/a	C/10, Timer	DVReg^	3x3 DFN-10
Shunt Solar Battery Chargers										
LTC4070	50mA	2.7V to 4.2V	Li-Ion	1, unlimited	✓	–	n/a	n/a	n/a	2x3 DFN-8, MSOP-8
LTC4071	50mA ^^	2.7V to 4.2V	Li-Ion	1, unlimited	✓	–	n/a	n/a	n/a	2x3 DFN-8, MSOP-8

* Depends on external components
^ Differential voltage regulation
^^ 500mA with external PFET

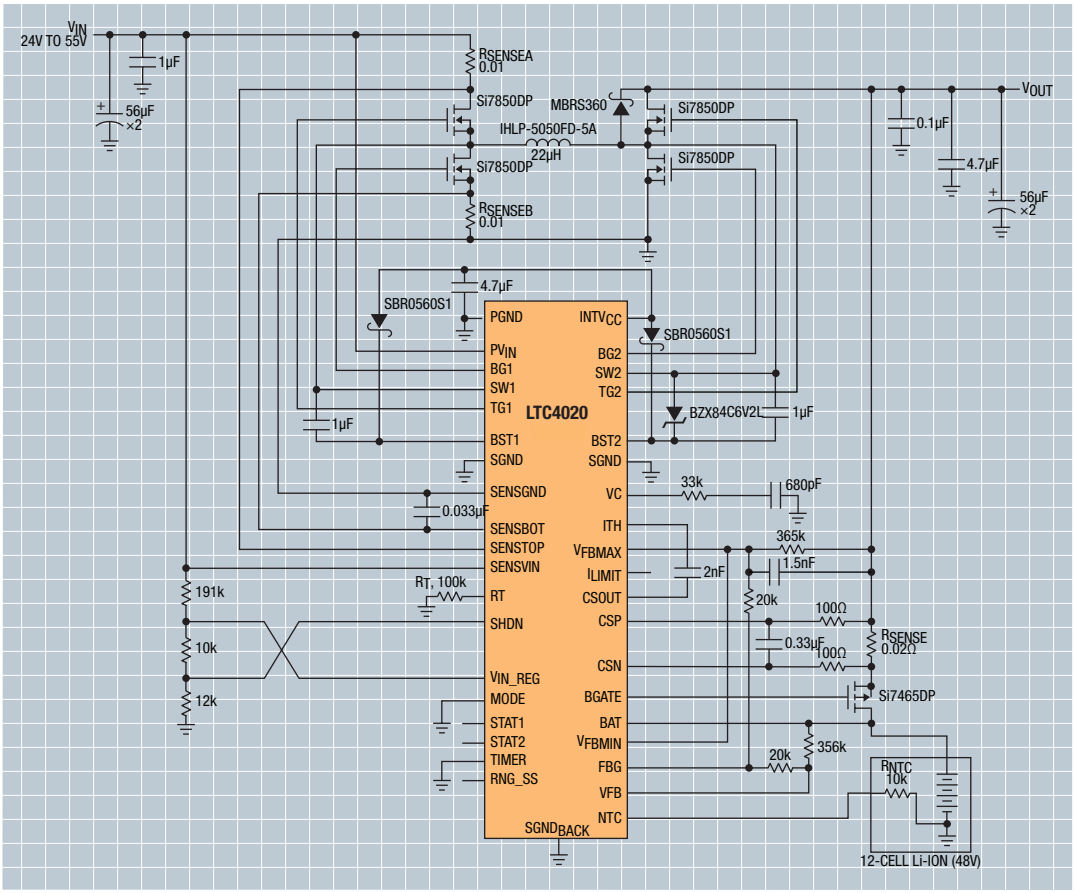
LTC4020 - 55V Buck-Boost Multi-Chemistry Battery Charger with Maximum Power Point Control (MPPC)

Features

- Wide Voltage Range: 4.5V to 55V Input, Up to 55V Output (60V Absolute Maximums)
- Synchronous Buck-Boost DC/DC Controller
- Li-Ion and Lead-Acid Charge Algorithms
- Input Voltage Regulation for High Impedance Input Supplies and Solar Panel Peak Power Operation
- ±0.5% Float Voltage Accuracy
- ±5% Charge Current Accuracy
- Instant-On for Heavily Discharged Batteries
- Ideal Diode Controller Provides Low Loss PowerPath when Input Power is Limited
- Onboard Timer for Protection and Termination
- Bad Battery Detection with Auto-Reset
- NTC Input for Temperature Qualified Charging
- Low Profile (0.75mm) 38-Pin 5mm × 7mm QFN Package

Applications

- Solar-Powered Systems
- Portable Industrial and Medical Equipment
- Military Communications Equipment
- 12V to 24V Embedded Automotive Systems



Application Schematic:

Remote 24V to 55V (48V System) Input to 12-Cell Li-Ion (48V) PowerPath Charger/System Supply. 5A Inductor Current Limit with 2.5A Battery Charge Current Limit. Minimum V_{IN} is 24V as Input Regulation Limits Voltage Loss Due to Line Impedance. Battery Termination Voltage Is 48V with Maximum Output Voltage of 52.8V. Instant-On Functionality Limits Minimum Regulated Output Voltage to 40.8V.

The Power and Flexibility of the LTC4000 / LTC4000-1

The LTC4000 is a high voltage controller and power manager which, when paired with an externally compensated DC/DC converter, becomes a full-featured battery charger solution. The LTC4000 is capable of driving virtually any topology, including buck, boost, buck-boost, SEPIC and flyback converters. Its intelligent PowerPath manager provides power to the system load when input power is available, enabling instant-on operation even with a deeply discharged battery. A full-featured controller, the LTC4000 can charge a variety of battery types including lithium, nickel and lead-acid based chemistries. Highly accurate charge current and float voltage, as well as onboard termination, ensure safe and accurate charging.

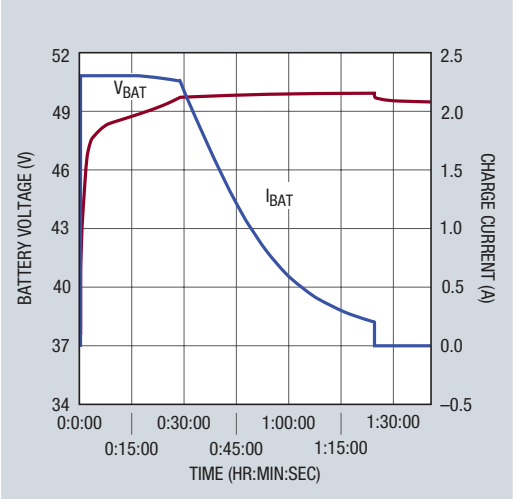
Complete Solution: PowerPath™ Control & Termination, No Software

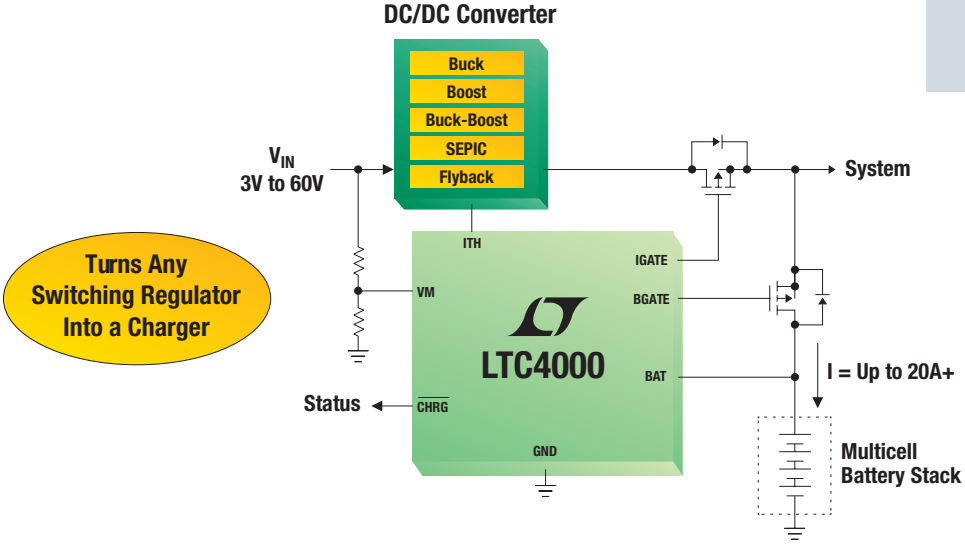
60V, 20A+ Battery Charging Controller

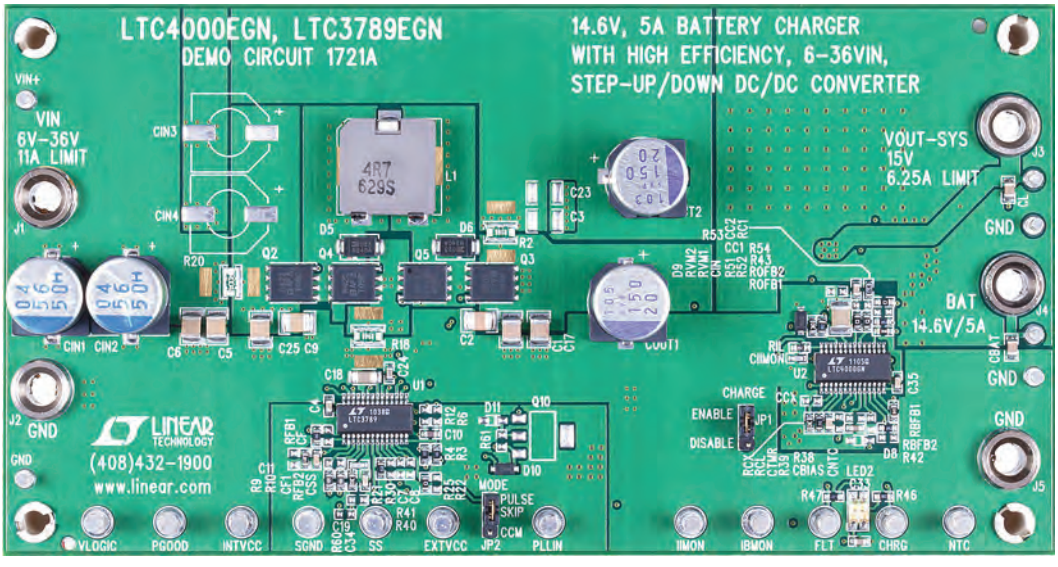
Features

- Input/Output Voltage: 3V to 60V
- Charge Currents up to 20A+
- Input Ideal Diode for Low Loss Reverse Blocking and Load Sharing
- Programmable Input and Charge Current: ±1% Accuracy
- ±0.1% Accurate Programmable Float Voltage
- Programmable C/X or Timer-Based Charge Termination
- NTC Input for Temperature-Qualified Charging
- LTC4000-1 for Solar Panel Input Applications

12S 2.2Ah Li-Ion Charge Curves



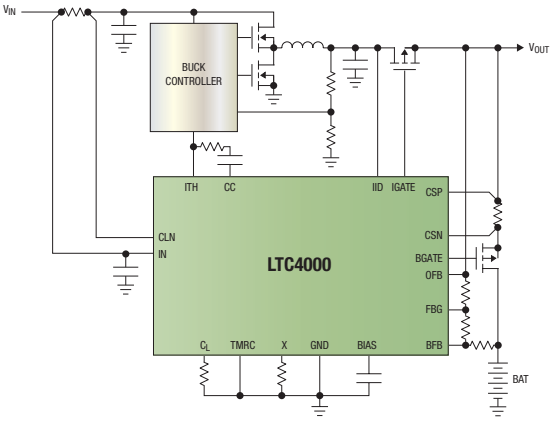




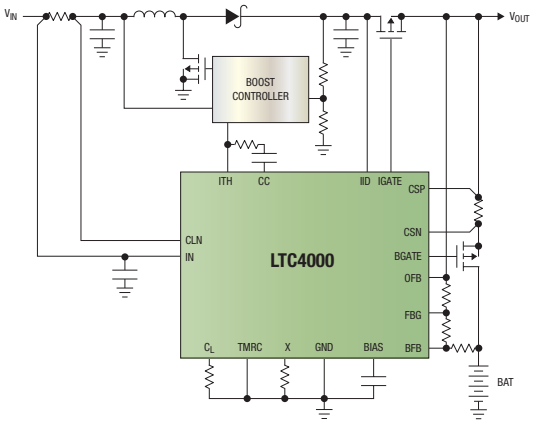
LTC4000 Buck-Boost Configuration
Actual Size
Demo Circuit

LTC4000, LTC4000-1 Paired with Example Companion Switching Regulators

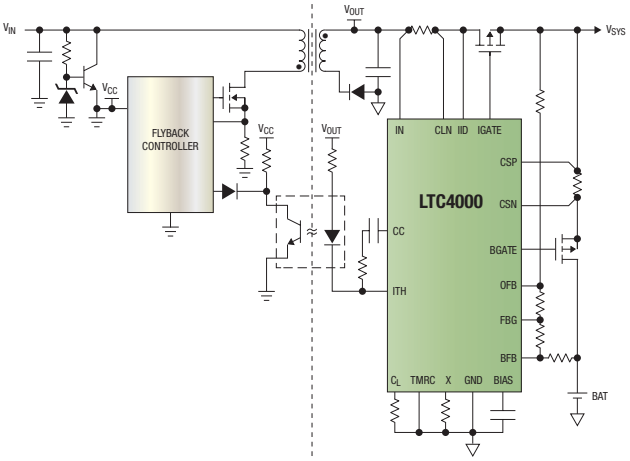
15V to 60V Buck 10A Charger for 3-Cell $LiFePO_4$



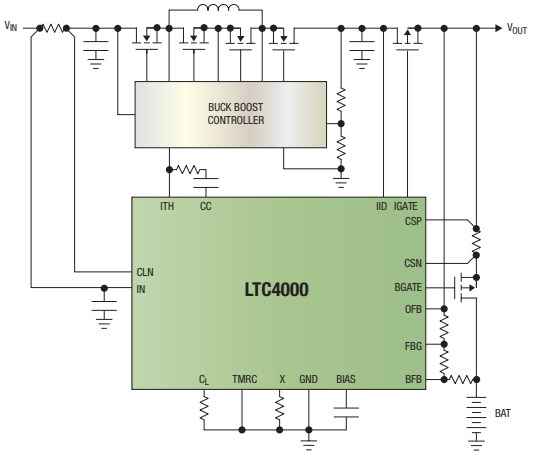
12V to 21V Boost 10A Charger for 24V Lead-Acid



18V to 72V Flyback 2A Charger for 1-Cell Li-Ion



6V to 36V Buck-Boost 5A Charger for 4-Cell $LiFePO_4$



Topology	LTC4000 + Switcher	Input Voltage (V)	Output Voltage (V)	Charge Current (A)	Battery
Lab-Tested LTC4000 Applications					
Buck-Boost	LTC3789	5-30	14.4	10	4 Cell $LiFePO_4$
Buck-Boost	LTC3789	6-36	14.6	5	4 Cell $LiFePO_4$
Buck-Boost	LTC3789	9-30	16.8	5	4 Cell Li-Ion
Buck-Boost	LTC3789	10-27	24	4	12 Cell Lead-Acid
Buck-Boost	LTC3789	11-13	13.6	4	6 Cell Lead-Acid
Buck-Boost	LTC3789	11-13	38	2.5	18 Cell Lead-Acid
Buck-Boost	LT3790	6-60	14.5	6.5	4 Cell $LiFePO_4$
Buck-Boost	LT8705 (+ LTC4000-1)	15-60	29.4	6.25	7 Cell Li-Ion
Boost	LTC3787	12-21	30	10	12 Cell Lead-Acid
Boost	LTC3862	19-24	42.5	5	11 Cell Li-Ion
Boost	LTC3862	19-24	53.3	5	13 Cell Li-Ion
Boost	LTC3786	6-21	21	5	5 Cell Li-Ion
Buck	LT3845A	24-60	16.8	10	4 Cell Li-Ion
Buck	LT3845A	15-60	10.8	10	3 Cell $LiFePO_4$
Active Clamp Forward	LTC3765, LTC3766	12-36	28	7	Lead-Acid
AC / DC	NCP1012	110/220 (AC)	14.4	0.33	4 Cell $LiFePO_4$
Flyback	LTC3805	18-72	4.2	2	1 Cell Li-Ion

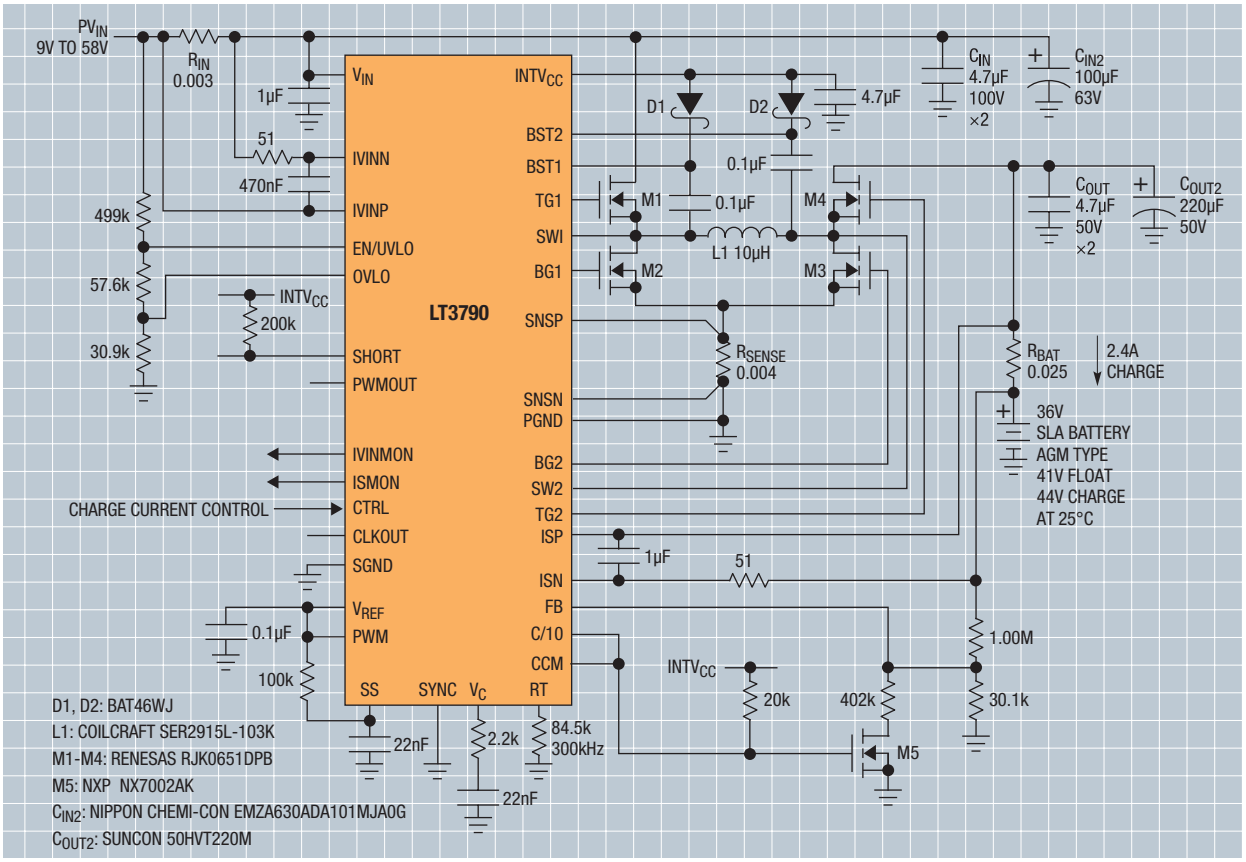
CC/CV Switching Regulators as Battery Chargers

In some battery powered applications, a system microcontroller already exists that can assume some, if not all, of the functions required to safely manage the charging of the battery. In other cases, an integrated battery charger IC that meets the design requirements may not exist. While the LTC4000 can help in many of these scenarios, a switching regulator with the ability to accurately control both its output voltage and its output current may be sufficient. This section describes a variety of Linear Technology products that meet this requirement. Typically, these products can be used in several different power topologies with extremely wide voltage operating ranges.

LT3790 - 60V Synchronous 4-Switch Buck-Boost Controller

Features

- 4-Switch Single Inductor Architecture Allows V_{IN} Above, Below or Equal to V_{OUT}
- Synchronous Switching: Up to 98.5% Efficiency
- Wide V_{IN} Range: 4.7V to 60V
- 2% Output Voltage Accuracy: 1.2V ≤ V_{OUT} < 60V
- 6% Output Current Accuracy: 0V ≤ V_{OUT} < 60V
- 38-Lead TSSOP Package



LT3790: 2.4A Buck-Boost 36V SLA Battery Charger

Part #	Input Voltage (V)	Output Voltage (V)	Topology	I_{OUT} Accuracy	V_{OUT} Accuracy	Charger Features	Package (mm x mm)
CC/CV Switching Regulators as Battery Chargers							
LT3741	6 to 36	Up to 34	Buck	±6%	±1.5%	-	4x4 QFN-20, TSSOP-20
LT3763	6 to 60	Up to 55	Buck	±6%	±1.5%	C/10	TSSOP-28
LT3761	4.5 to 60	Up to 80	Boost/SEPIC	±3%	±2%	C/10	MSOP-16E
LT3796	6 to 100	Up to 100	Boost/SEPIC	±3%	±2%	C/10	TSSOP-28
LT3955	4.5V to 60	Up to 80	Boost/SEPIC	±3%	±2%	C/10	5x6 QFN-36
LT3790	4.7 to 60	Up to 60	Buck-Boost	±6%	±2%	C/10	TSSOP-38
LT8705	2.8 to 80	Up to 80	Buck-Boost	±9%	±1.8%	-	5x7 QFN-38, TSSOP-38

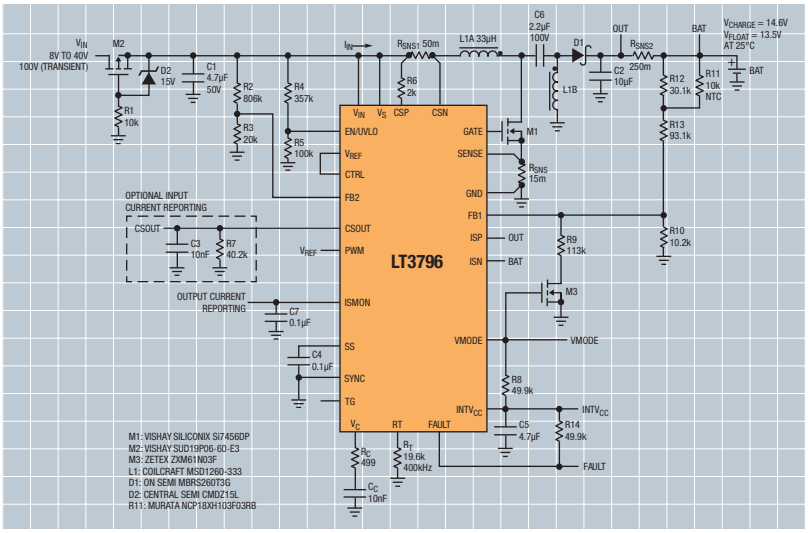
CC/CV Switching Regulators as Battery Chargers (continued)

LT3796: 100V Constant-Current and Constant-Voltage Controller with Dual Current Sense

Features

- Wide Input Voltage Range: 6V to 100V
- Current Monitoring Up to 100V
- High Side PMOS Disconnect and PWM Switch Driver
- Constant-Current and Constant-Voltage Regulation
- 28-Lead TSSOP Package

LT3796: SEPIC Sealed Lead-Acid (SLA) Battery Charger

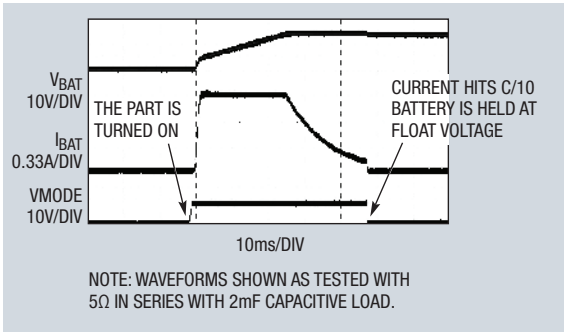


LT3955: 60V_{IN} LED Converter with Internal PWM Generator

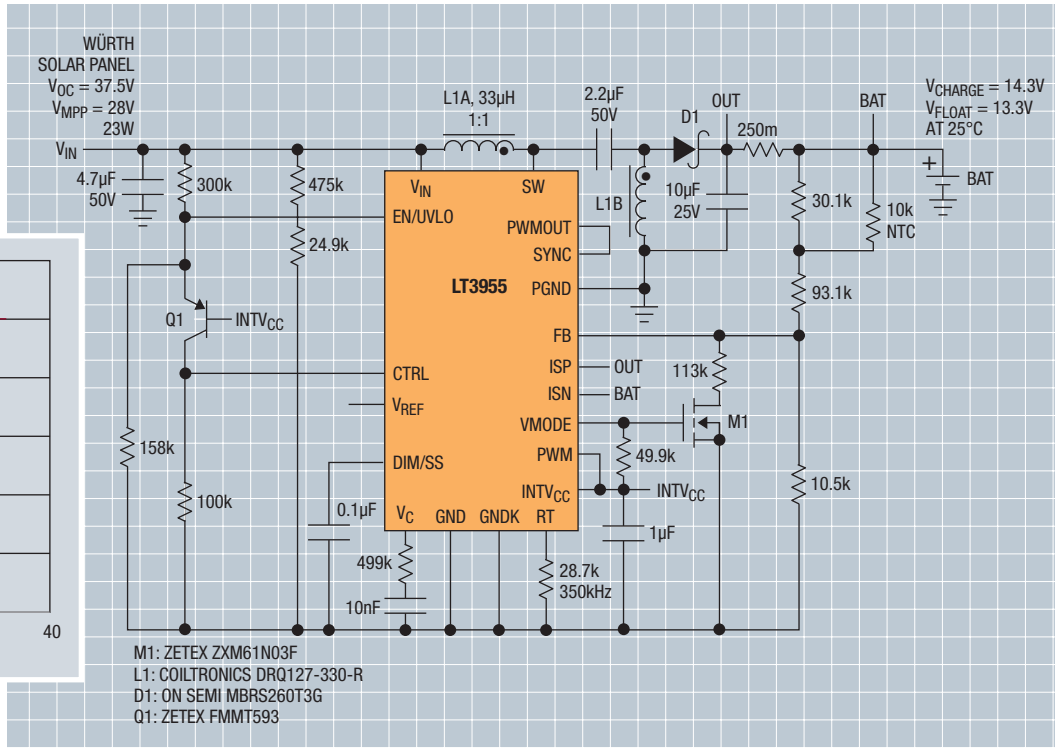
Features

- Wide V_{IN} Range: 4.5V to 60V
- Rail-to-Rail Current Sense Range: 0V to 80V
- Internal 80V/3.5A Switch
- Programmable PWM Dimming Signal Generator
- Constant Current (±3%) and Constant-Voltage (±2%) Regulation
- Accurate Analog Dimming
- 5mm x 6mm QFN-36 Package

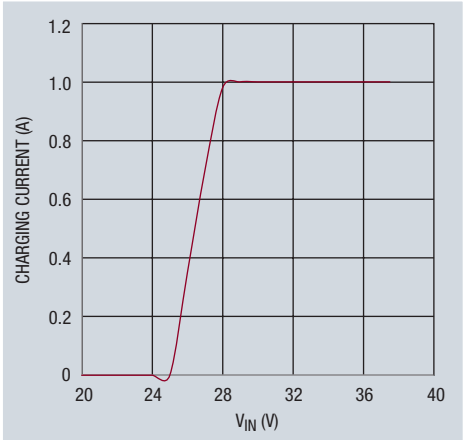
LT3955: Battery Charger Waveforms



LT3955: Solar Panel SEPIC Battery Charger



I_{BAT} vs V_{IN}



Tutorial: PowerPath Control

Battery-Fed (Charger-Fed) Systems

First generation USB system applications incorporated a current-limited battery charger directly between the USB port and the battery (see Figure 1). In this battery-fed topology, the battery directly powers the system and the power available to the system from the USB can be expressed as:

$$P_{SYS} = I_{USB} \bullet V_{BAT}$$

because V_{BAT} is the only voltage available to the system load. For linear chargers, input current approximately equals charge current, so a simple current limit is sufficient. Connecting the system load directly to the battery eliminates the need for a load sharing diode. Disadvantages of this topology include low efficiency, 500mA maximum charge current from the USB, no system power when the battery voltage is low (i.e., a dead or missing battery), and loss of nearly half of the available power within the linear battery charger element as heat. Furthermore, an additional resistor and signal transistor are required to increase charge current when a wall adapter is present.

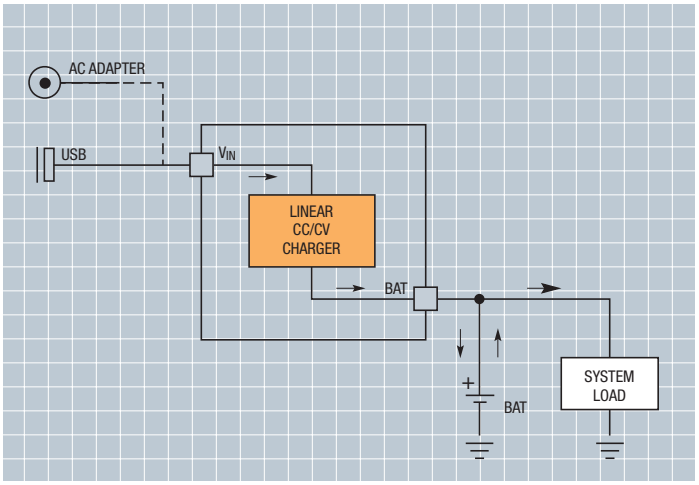


Figure 1: Simplified Battery-Fed Control Circuit

Linear PowerPath Power Managers

Second generation USB charging systems, commonly referred to as PowerPath systems, develop an intermediate voltage between the USB port and the battery (see Figure 2). In PowerPath systems, the USB port supplies current to an intermediate voltage, V_{OUT}, via a current-limited switch. V_{OUT} powers both the linear battery charger and the system load with priority going to the system load. By decoupling the battery from the system load, charging can be carried out opportunistically. PowerPath systems also offer instant-on operation because the intermediate voltage is available for system loads as soon as power is applied to the circuit—this allows the end product to operate immediately when plugged in, regardless of the battery's state of charge. In a linear PowerPath system, nearly all of the 2.5W available from the USB port is accessible to the system load provided the system load does not exceed the input current limit. Furthermore, if the system requires more power than is available from the input, an ideal diode also supplies current to the load from the battery. Thus, a linear PowerPath system offers significant advantages over a battery-fed system. But significant power may still be lost, especially if the system load exceeds the input current limit and the battery voltage is low, resulting in a large differential between the input voltage and both the system voltage and the battery voltage. An optional external PFET can reduce the ideal diode voltage drop during heavy load conditions.

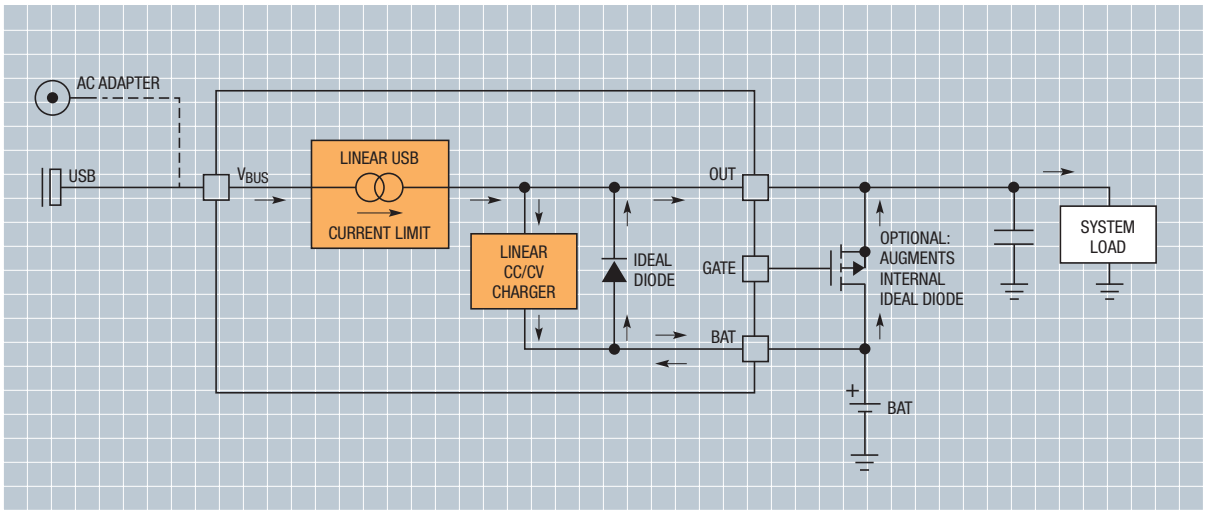


Figure 2: Simplified Linear Power Manager Circuit

Switch Mode PowerPath Power Managers

Third generation USB charging systems feature a switch mode-based topology (see Figure 3). This type of PowerPath device produces an intermediate bus voltage from a USB-compliant step-down switching regulator that regulates a small differential voltage above the battery voltage. Linear Technology refers to this as Bat-Track™ adaptive output control because the output voltage tracks the battery voltage. The differential voltage between the battery and the system is large enough to allow full charging through the linear charger, but small enough to minimize power lost in the charger, thereby increasing system efficiency and maximizing power available to the load. The switching average input current limit allows the use of nearly all of the 2.5W available from the USB port, independent of operating conditions. By ensuring that the Bat-Track regulation loop does not allow the output voltage to drop below 3.5V (even with severely discharged batteries) this topology also provides instant-on functionality. As in linear PowerPath systems, an ideal diode allows the battery to supplement input power during heavy load transients. An optional external PFET can reduce the ideal diode voltage drop. This architecture is suitable for systems with large (>1.5AHr) batteries and high (>2W) system power.

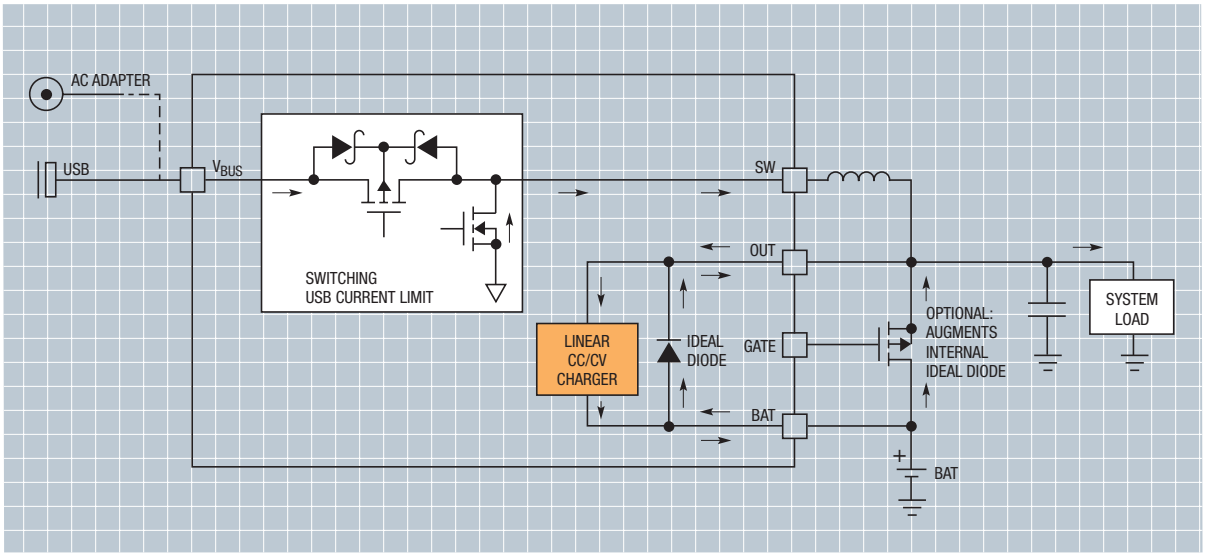


Figure 3: Simplified Switch Mode Power Manager Circuit

External High Voltage Switching Regulator Control

Several Linear Technology power manager ICs (both linear and switching) provide the ability to adaptively control the output of an external high voltage switching regulator (see Figure 4). The WALL pin detects the presence of a high voltage supply (e.g., car battery, 12V wall adapter, FireWire input) and enables Bat-Track adaptive output control via the buck regulator's V_C pin. Similar to a switching PowerPath system, the output of the high voltage buck is regulated to a small differential voltage above the battery voltage with a minimum output voltage of approximately 3.5V. This functionality maximizes charger efficiency while still allowing instant-on operation even when the battery is deeply discharged. Compared to the traditional approach of converting a high voltage input to 5V to power the system, this technique can reduce system power dissipation by over 50%. By choosing an LT3653 as the high voltage regulator, further system improvements can be made (see Figure 5). The LT3653 accurately controls its maximum output current, which eliminates the potential for localized heating, reduces the required current rating of the power components and provides a robust solution to withstand harsh overload and short-circuit conditions. In addition, the unique LT3653 architecture eliminates a power PFET and output capacitor from the application schematic.

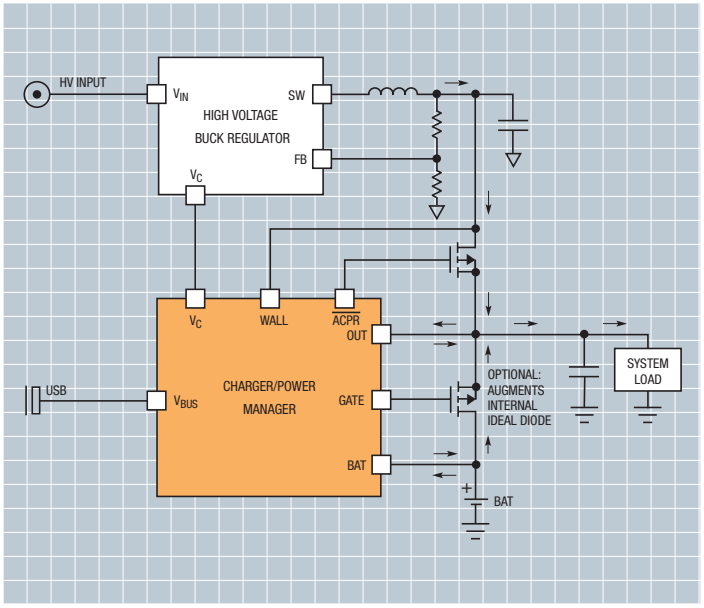


Figure 4: Simplified HV Switching Regulator Control Circuit

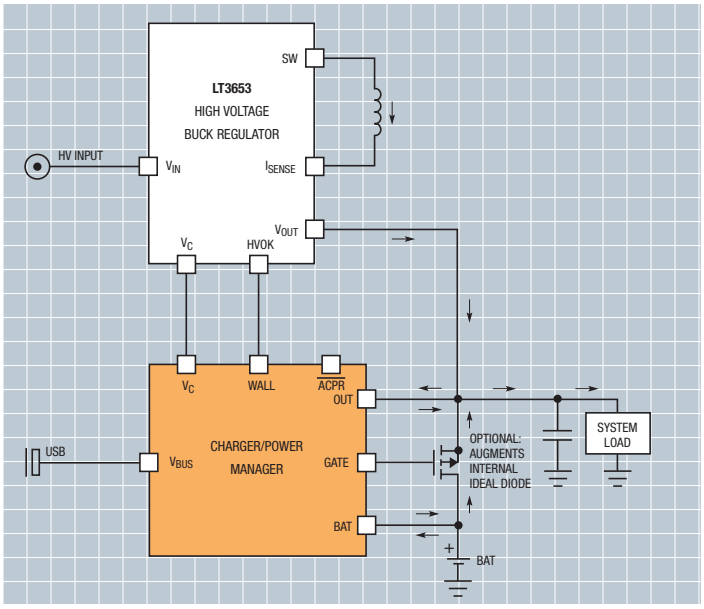


Figure 5: Simplified LT3653 Control Circuit

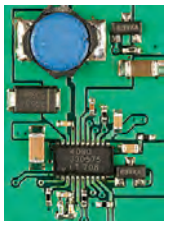
Attribute	Battery-Fed	Linear PowerPath	Switch Mode PowerPath
Table 1: Comparison of USB-Compliant Battery Charging System Topologies			
Size	Small	Moderate	Larger
Complexity	Simple	Moderate	More Complex
Solution Cost	Low	Moderate	Higher
USB Charge Current	Limited to 500mA	Limited to 500mA	500mA and Higher (~2.3W)
Autonomous Control of Input Power Sources	No	Yes	Yes
Instant-On Operation	No	Yes	Yes
System Load Efficiency (I_{BUS}<USB Limit)	Good (V_{BAT}/V_{BUS})	Exceptional (>90%)	Excellent (~90%)
System Load Efficiency (I_{SYS}>USB Limit)	Good (V_{BAT}/V_{BUS})	Good (V_{BAT}/V_{BUS})	Excellent (~90%)
Battery Charger Efficiency	Good (V_{BAT}/V_{BUS})	Good (V_{BAT}/V_{BUS})	Excellent (~90%)
Power Dissipation	High	Moderate	Low
Bat-Track Adaptive Output Control/ Interface to HV Buck	No	Yes	Yes

USB Power Managers: Battery Chargers with PowerPath Control

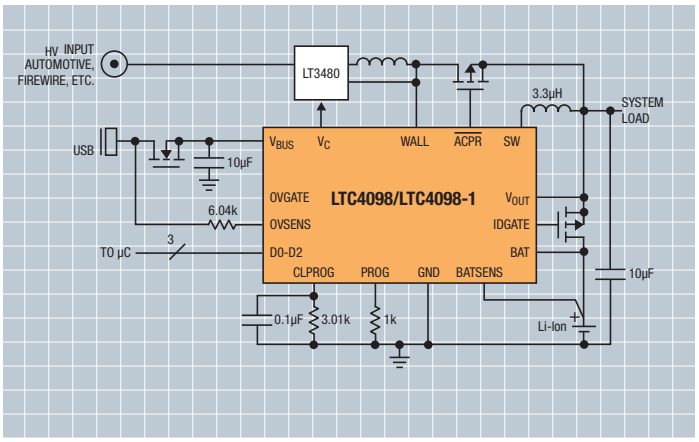
PowerPath products and architectures permit the load to be powered from both V_{IN} and the battery, enabling shorter charge time, instant-on operation (even with a dead or missing battery) and more flexibility for the portable device designer. Other key features include standalone operation and thermal regulation.

LTC4098:
Actual Size
Demo Circuit

LTC4090:
Actual Size
Demo Circuit

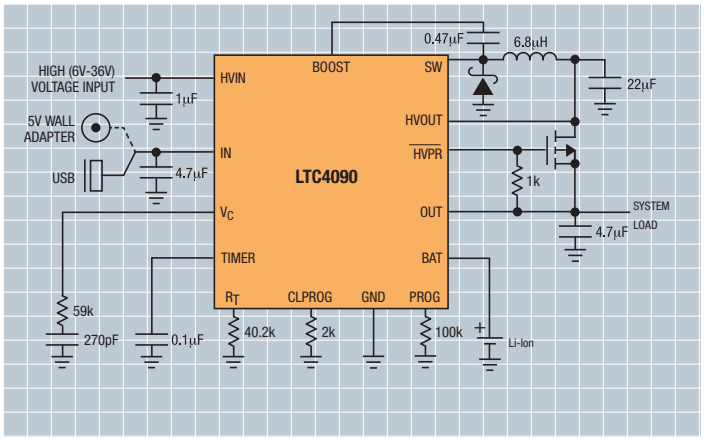


LTC4098/-1: USB Power Manager with Overvoltage Protection



High Efficiency USB/Automotive Power Manager with Overvoltage Protection

LTC4090: USB Power Manager with 2A High Voltage Bat-Track Buck Regulator



High Voltage USB Power Manager with Bat-Track Adaptive Output Control

Part Number	Number of Battery Cells (Series)	Max Charge Current from Wall (A)	Max Charge Current from USB (mA)	Input Voltage (V)	Power Manager Topology	Charge Termination (Plus Indication)	Ideal Diode $R_{DS(ON)}$	Package (mm x mm)
USB Power Managers and Li-Ion/Polymer Linear Battery Chargers with PowerPath Control								
LTC4055/-1*	1	1	500	4.35 to 5.5	Linear	Timer	200mΩ	4x4 QFN-16
LTC4089*	1	1.2	500	4.35 to 5.5 USB, 6-36, 40 Max Wall	Linear	Timer + C/10	215mΩ, (<50mΩ Opt.)	3x6 DFN-22
LTC4089-5	1	1.2	500	4.35 to 5.5 USB, 6-36, 40 Max Wall	Linear	Timer + C/10	215mΩ, (<50mΩ Opt.)	3x6 DFN-22
LTC4089-1*† /-3*^	1	1.2	500	4.35 to 5.5 USB, 6-36, 40 Max Wall	Linear	Timer + C/10	215mΩ, (<50mΩ Opt.)	3x6 DFN-22
LTC4090*	1	1.2	500	4.35 to 5.5 USB, 6-38, 60 Max Wall	Linear	Timer + C/10	215mΩ, (<50mΩ Opt.)	3x6 DFN-22
LTC4090-5	1	1.2	500	4.35 to 5.5 USB, 6-36, 60 Max Wall	Linear	Timer + C/10	215mΩ, (50mΩ Opt.)	3x6 DFN-22
LTC4067	1	1.25	500	4.35 to 5.5, 13 OVP	Linear	Timer + C/10	200mΩ, (<50mΩ Opt.)	3x4 DFN-12
LTC4066/-1†	1	1.5	500	4.35 to 5.5, USB + Wall Inputs	Linear	Timer + C/x	50mΩ	4x4 QFN-24
LTC4085 /-1†/-3^/-4^	1	1.5	500	4.35 to 5.5, USB + Wall Inputs	Linear	Timer + C/10	215mΩ, (<50mΩ Opt.)	3x4 DFN-14
LTC4088/-1/-2*	1	1.5	700	4.35 to 5.5	Switch Mode	Timer + C/x	180mΩ, (<50mΩ Opt.)	3x4 DFN-14
LTC4098/-1*†	1	1.5	700	4.35 to 5.5 USB, 66 OVP, Wall = 5V Adapter or Buck High-V	Switch Mode	Timer + C/x	180mΩ, (<50mΩ Opt.)	3x4 QFN-20
LTC4098-3.6*#	1	1.5	700	4.35 to 5.5 USB, 66 OVP, Wall = 5V Adapter or Buck High-V	Switch Mode	Timer + C/x	180mΩ, (<50mΩ Opt.)	3x4 QFN-20
LTC4160/-1*†§	1	1.5	700	4.35 to 5.5 USB, 66 OVP	Switch Mode	Timer + C/x	180mΩ, (<50mΩ Opt.)	3x4 QFN-20
LTC4099*‡	1	1.5	700	4.35 to 5.5 USB, 66 OVP	Switch Mode	Timer + C/x	180mΩ, (<50mΩ Opt.)	3x4 QFN-20
LTC4155*§**	1	3.5	700	4.35 to 5.5 USB, 77 OVP	Switch Mode	Timer + C/x	180mΩ	4x5 QFN-28
LTC4156*§**#	1	3.5	700	4.35 to 5.5 USB, 77 OVP	Switch Mode	Timer + C/x	180mΩ	4x5 QFN-28

* Bat-Track Adaptive Output Control, ^ 3.95V Cell Voltage, † 4.1V Cell Voltage, ‡ I²C Controlled, Selectable 4.1V/4.2V Float Voltage, § USB On-The-Go, # For 1-cell Lithium Iron Phosphate ($LiFePO_4$) Batteries

Supercapacitor/Capacitor Chargers and Backup Power ICs

Supercapacitors, capacitors with up to 100s of farads in value, are emerging as an alternative to batteries in applications where the importance of power delivery trumps that of total energy storage. Supercapacitors have a number of advantages over batteries that make them a superior solution when short-term high power is needed, such as in power ride-through applications. These advantages include lower effective series resistance (ESR) and enhanced durability in the face of repeated charging.

Linear Technology offers a portfolio of linear, switching and switched-capacitor ICs designed to charge supercapacitors (also known as ultracapacitors) and capacitors. These devices offer input or output current limiting, automatic cell balancing and a range of protection features that make them uniquely suited to supercap charging.

LTC3350: High Current Supercapacitor Backup Controller and System Monitor

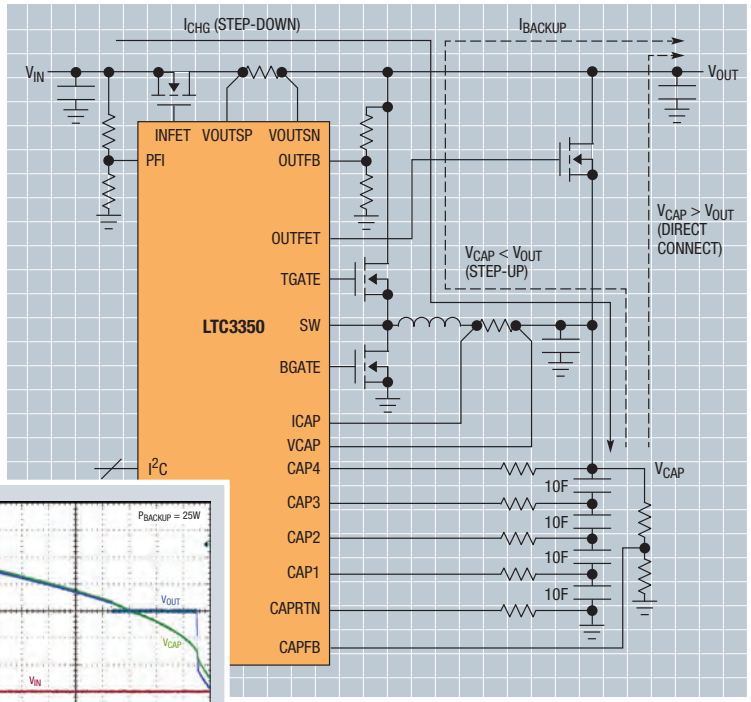
Features

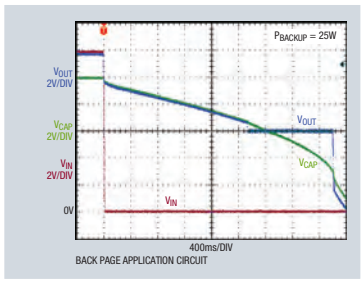
- High Efficiency Synchronous Step-Down CC/CV Charging of One to Four Series Supercapacitors
- Step-Up Mode in Backup Provides Greater Utilization of Stored Energy in Supercapacitors
- 14-Bit ADC for Monitoring System Voltages/Currents, Capacitance and ESR
- Active Overvoltage Protection Shunts
- Internal Active Balancers—No Balance Resistors
- V_{IN}: 4.5V to 35V, $V_{CAP(n)}$: Up to 5V per Capacitor, Charge/Backup Current: 10+A
- Programmable Input Current Limit Prioritizes System Load Over Capacitor Charge Current
- Dual Ideal Diode PowerPath Controller
- All NFET Charger Controller and PowerPath Controller
- Compact 38-Lead 5mm × 7mm QFN Package

Applications

- High Current 12V Ride-Through UPS
- Servers/Mass Storage/High Availability Systems

High Current Supercapacitor Charger and Backup Supply





Backup Application

Part Number	Topology	Input Voltage (V)	V_{OUT} VCAP (max) (V)	Storage Element	Quiescent Current (µA)	Charge Current	PowerPath Control	Automatic Balancing	Supercap Overvoltage Protection	Package
Supercapacitor Chargers										
LTC3225/-1	Charge Pump - Boost	2.8-5.5	5.5	2 SCap	20	150mA	–	✓***	✓	2x3 DFN-10
LTC3226	Charge Pump - Boost + 2 LDOs	2.5-5.5	5.5	2 SCap	20	360mA	✓	✓***	✓	3x3 QFN-16
LTC3625/-1	Switching Buck & Boost	2.7-5.5	5.5	2 SCap	23	1A*	–	✓***	✓	3x4 DFN-12
LTC4225	Linear	2.7-5.5	5.5	2 SCap	20	1A	–	✓	✓	3x3 DFN-12 MSOP-12
LTC3355	Buck + LDO + Charger + Boost Backup	3-20	5	1 SCap	120	1A	✓	✓	✓	4x4 QFN-29
LTC3110	Bi-Dir Buck-Boost	1.71-5.25	5.5	1-2 SCap	48	2A	–	✓	✓	4x4 QFN-20, TSSOP-24
LTC3128	Buck-Boost	1.73-5.5	5.5	1-2 SCap	600	3A	–	✓	✓	4x5 QFN-20, TSSOP-24
LTC3350	Buck Charger, Boost Backup, Balancer + OVP, Health Monitor	4.5-35	V_{IN}	1-4 SCap	4mA	10A+	✓	✓	✓	5x7 QFN-38
LTC3643	Bi-Dir Boost Charger/ Buck Backup	3-17	up to 40V	Electrical Cap	400	2A	✓	n/a	–	3x5 QFN-24
LTC4040	Buck Charger + Boost Backup	3.5-5.5	5	Li-Ion $LiFePO_4$	40	2.5A	✓	n/a	✓	4x5 QFN-24

* in 2-inductor circuit; 500mA in 1-inductor configuration ** ideal diode V_{IN} to V_{OUT} *** while charging

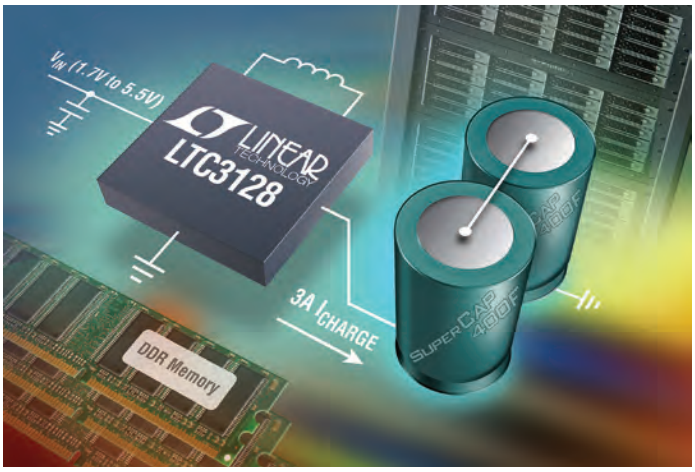
LTC3128: 3A Monolithic Buck-Boost Supercapacitor Charger and Balancer with Accurate Input Current Limit

Features

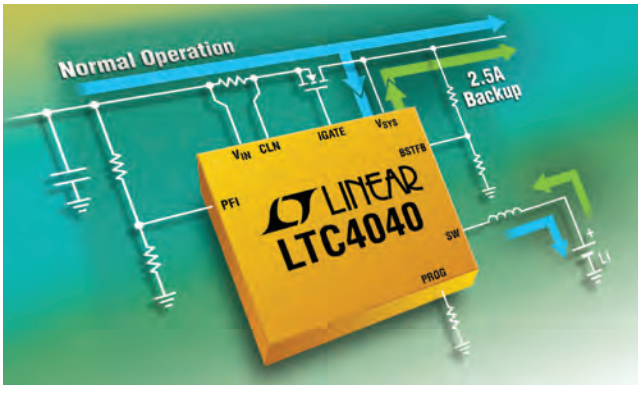
- ±2% Accurate Average Input Current Limit Programmable Up to 3A
- Programmable Maximum Capacitor Voltage Limit
- Active Charge Balancing for Fast Charging of Unmatched Capacitors
- Charges Single or Stacked Capacitors
- V_{IN} Range: 1.73V to 5.5V
- V_{OUT} Range: 1.8V to 5.5V
- <2µA Quiescent Current from V_{OUT} When Charged
- Output Disconnect in Shutdown: <1µA I_Q Shutdown
- Power Good Comparator
- Power Failure Indicator
- Thermally Enhanced 20-Lead (4mm × 5mm × 0.75mm) QFN and 24-Lead TSSOP Package

Applications

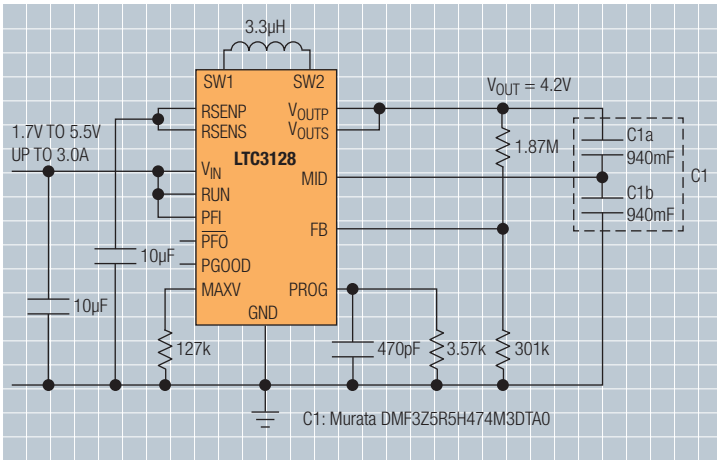
- Supercapacitor Based Backup Power
- Memory Backup
- Servers, RAID, RF Systems
- Industrial, Communications, Computing



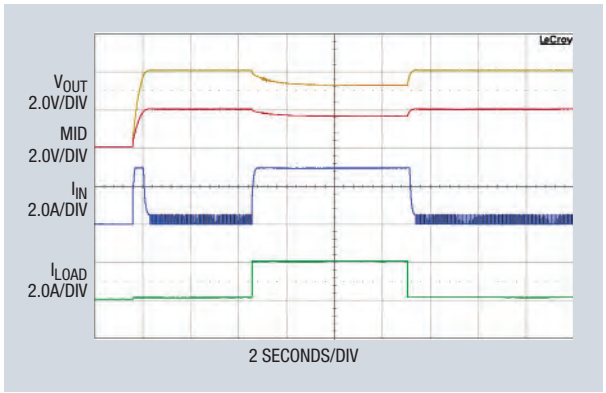
LTC4040: Buck Charger and Boost Backup



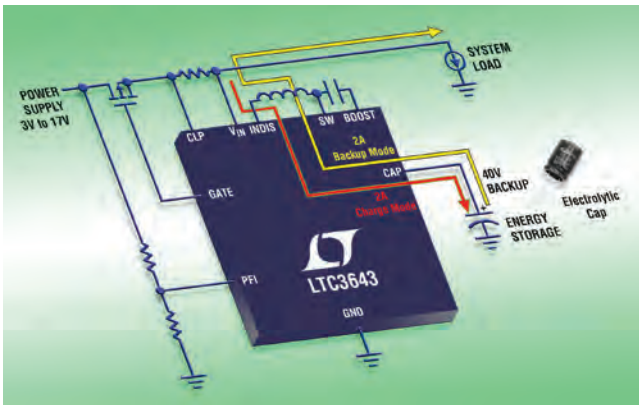
Wide V_{IN} (3A Programmed Input Current) to 4.2V



Stacked Output Capacitors Charging Waveform

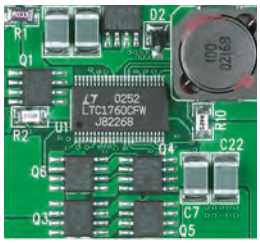


LTC3643: Bi-Directional Boost Charger/Buck Backup



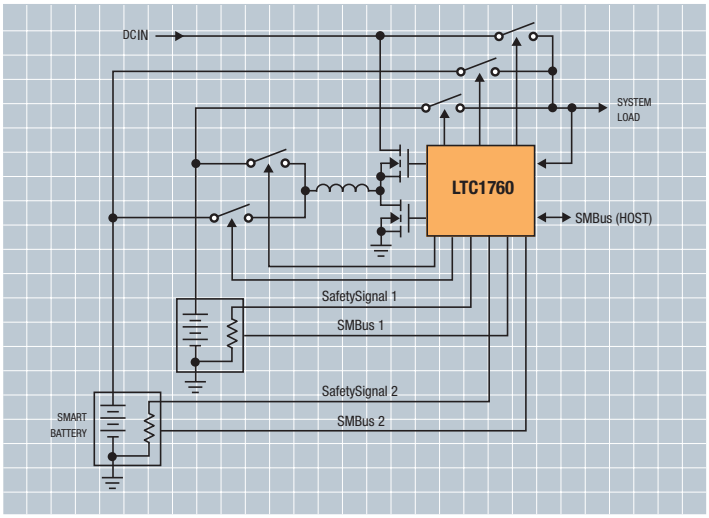
Smart Battery Chargers

Our smart battery chargers offer true plug-and-play operation, independent of chemistry and cell configuration, built-in safety features, reliable battery detection and automatic charge management.



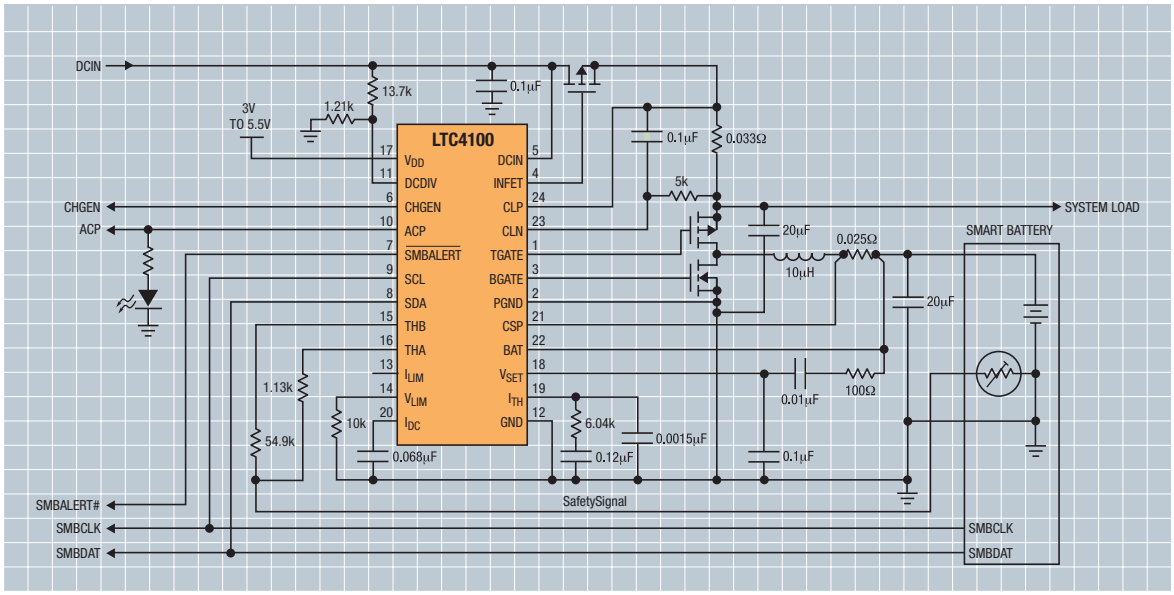
LTC1760:
Actual Size
Demo Circuit

LTC1760: Dual Smart Battery System Manager



Dual Battery Charger/Selector System Architecture

LTC4100: Smart Battery Charger Controller



SMBus Smart Battery Charger Controller

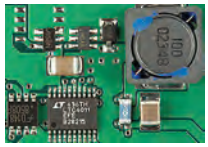
Part Number	Maximum Charge Current (A)	V_{BAT} Range (V)	Standalone	Serial Bus Type	Single or Dual Battery Pack	Float Voltage Accuracy	Safety Limits	AC Present Output	Charger On Status	Thermistor Interface	Package
SMBus/SPI Battery Chargers (Controllers)											
LTC4110	3	3.5 to 18	✓	SMBus 1.1	Single *	0.5%	–	✓	✓	✓	5x7 QFN-38
LTC4100	4	3.5 to 26	✓	SMBus 1.1	Single	0.8%	✓	✓	✓	✓	SSOP-24
LTC4101	4	2.7 to 4.2	✓	SMBus 1.1	Single	0.8%	✓	✓	✓	✓	SSOP-24
LTC1760	4	3.5 to 28	✓	SMBus 1.1	Dual	0.2%	✓	✓	✓	✓	TSSOP-48
LTC1759	8	3 to 23	✓	SMBus 1.0	Single	1%	✓	–	✓	✓	SSOP-36
LTC1960	8	6 to 28	–	SPI	Dual	0.8%	–	–	–	–	5x7 QFN-38, SSOP-36

* Scalable

NiMH and NiCd Battery Chargers

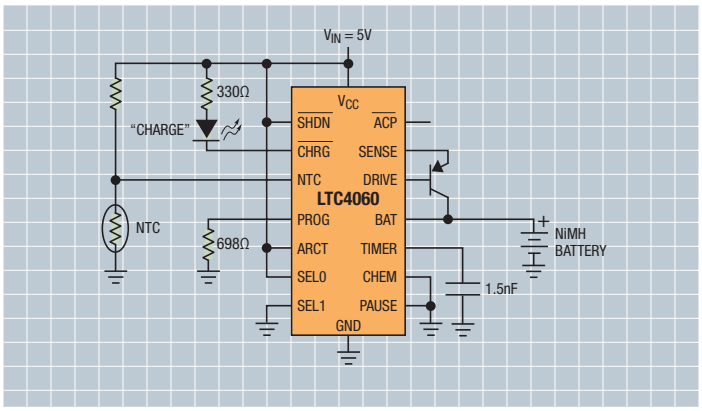
Our nickel battery chargers reduce component count, speed design and allow fast, accurate and reliable charging of both NiMH and NiCd cells.

LTC4060:
Actual Size
Demo Circuit



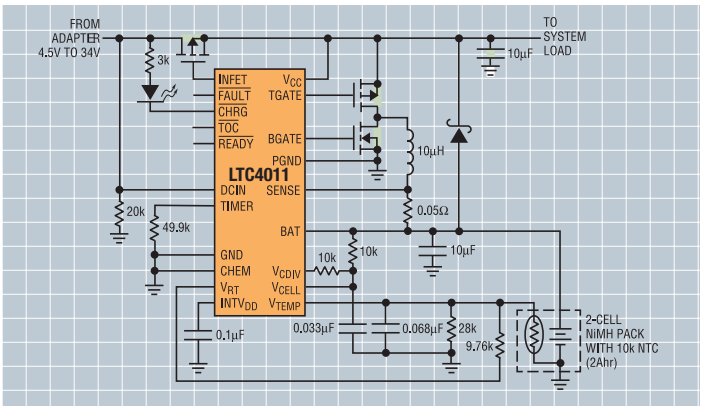
LTC4011:
Actual Size
Demo Circuit

LTC4060: Standalone 2A Linear NiMH/NiCd Fast Battery Charger



2-Cell, 2A Standalone NiMH Fast Charger with Optional Thermistor and Charge Indicator

LTC4011: High Efficiency 4A Standalone Switch Mode Battery Charger with Analog INFET Control



2A NiMH Battery Charger

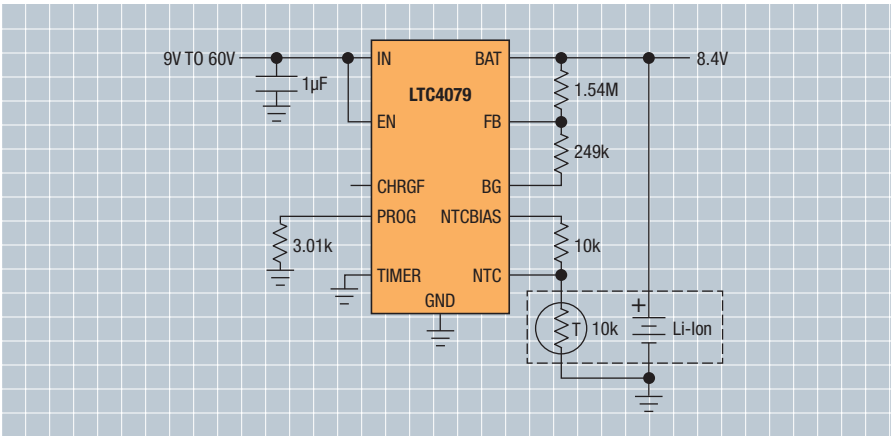
Part Number	Topology	Number of Battery Cells* (Series)	Maximum Charge Current (A)	Input Voltage (V)	Charge Termination	Integrated Power Transistor	End-of-Charge Signal	AC Present Signal	Thermistor Interface	Package (mm x mm)
NiMH/NiCd Battery Chargers – Standalone										
LTC4060	Linear	1–4	2	4.5 to 10	-dV, t, V, T	–	✓	✓	✓	3x5 DFN-16, TSSOP-16
LTC4010	Synchronous Step-Down	1–16	4	4.5 to 34	-dV, dT/dt, T, t	–	✓	✓	✓	TSSOP-16E
LTC4011†	Synchronous Step-Down	1–16	4	4.5 to 34	-dV, dT/dt, T, t	–	✓	✓	✓	TSSOP-20E
NiMH/NiCd Battery Chargers – Non-Standalone										
LT1512	SEPIC	1–12	0.8	2.4 to 29	External µC	✓	–	–	–	SO-8
LT1510	Step-Down	1–12	1	7 to 29	External µC	✓	–	–	–	SO-8, SSOP-16, SO-16
LT1513	SEPIC	1–12	1.6	2.4 to 29	External µC	✓	–	–	–	DD Pak, TO-220
LT1769	Step-Down	1–12	2	7 to 29	External µC	✓	–	–	–	TSSOP-20, SSOP-28
LT1511	Step-Down	1–12	3	7 to 29	External µC	✓	–	–	–	SO-24
LTC4008	Synchronous Step-Down	4–14	4	6 to 28	External µC	–	✓	✓	✓	SSOP-28
LTC4009/ -1/-2	Synchronous Step-Down	2–14	4	6 to 28	External µC	–	✓	✓	–	4x4 QFN-20
LTC4012/ -1/-2/-3†	Synchronous Step-Down	2–14	4	6 to 28	External µC	–	✓	✓	–	4x4 QFN-20
LT1505	Synchronous Step-Down	1–12	8	6.7 to 26	External µC	–	✓	–	–	SSOP-28
LTC1960	Step-Down	4–16	8	6 to 28	External µC, SPI	–	–	–	–	5x7 QFN-38, SSOP-36
NiMH/NiCd Battery Chargers – Smart Chargers (SMBus)										
LTC4110	Synchronous Flyback	up to 10	3	6 to 20	Smart Battery, External µC	–	–	✓	✓	5x7 QFN-38
LTC4100	Step-Down	1–13	4	6 to 28	Smart Battery, External µC	–	–	✓	✓	SSOP-24
LTC4101	Step-Down	2–3	4	6 to 28	Smart Battery, External µC	–	–	✓	✓	SSOP-24
LTC1759	Step-Down	1–13	8	11 to 24	Smart Battery, External µC	–	–	✓	✓	SSOP-36
LTC4079	Linear	up to 60V	.25	2.7 to 60V	Adj. Timer or C/10	✓	✓	–	✓	3x3 DFN-10

*Based on Maximum Cell Voltage of 1.8V, † Includes PowerPath Control

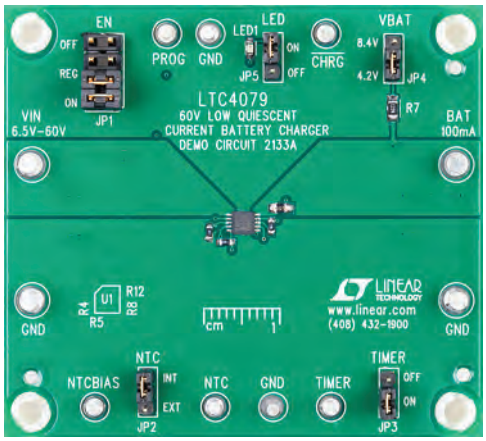
Linear Li-Ion/Polymer Battery Chargers

We produce a comprehensive line of high performance battery chargers for any rechargeable battery chemistry, including lithium-ion, lithium-polymer, lead-acid and nickel-based. Our linear battery charger ICs are completely autonomous in operation and offer many standard features for battery safety and management, including on-chip battery preconditioning, status signaling, thermal regulation and NTC thermistor interface.

LTC4079: 60V, 250mA Linear Charger with Low Quiescent Current

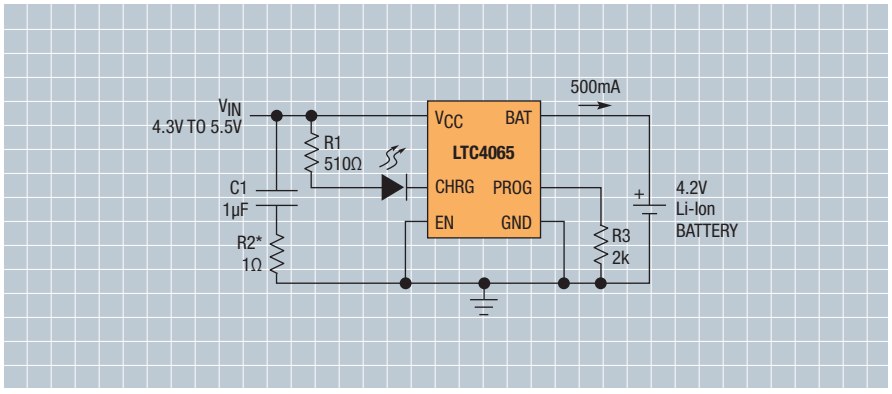


Charging a Backup Battery

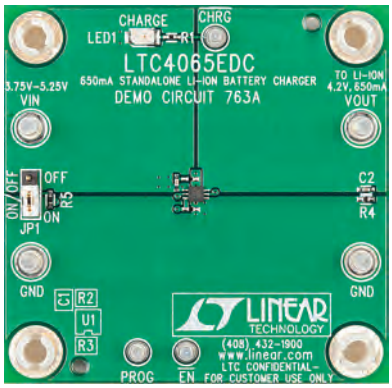


LTC4079:
Actual Size Demo Circuit

LTC4065/A: Standalone 750mA Li-Ion Battery Charger in 2x2 DFN



Standalone Li-Ion Charger



LTC4065:
Actual Size Demo Circuit

Linear Li-Ion/Polymer Battery Chargers (continued)

Part Number	Number of Battery Cells (Series)	Maximum Charge Current (A)	Input Voltage (V)	Cell Type	Integrated Power Transistor	Charge Termination (Plus Indication)	Package (mm x mm)
Linear Li-Ion/Polymer Battery Chargers							
LTC4054L	1	0.15	4.25 to 6.5	Li-Ion/Poly	✓	C/10	ThinSOT™
LTC1734L	1	0.18	4.55 to 8	Li-Ion/Poly	External	External µC	ThinSOT
LTC4065L/X	1	0.25	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-6
LTC4079	14	0.25	2.7 to 60	Li-Ion/Poly, Ni, SLA	✓	Timer	3x3 DFN-10
LTC4080*/X* ¶	1	0.5	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	3x3 DFN-10, MSOP-10E
LTC4081*	1	0.5	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	3x3 DFN-10
LTC4056*	1	0.7	4.5 to 6.5	Li-Ion/Poly	External	Timer	ThinSOT
LTC1734	1	0.7	4.55 to 8	Li-Ion/Poly	External	External µC	ThinSOT
LTC4065*	1	0.75	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-6
LTC4065-4.4*	1	0.75	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-6
LTC4065A*	1	0.75	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-6
LTC4069*	1	0.75	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-6
LTC4069-4.4*	1	0.75	3.75 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-6
LTC4054*/X* ¶	1	0.8	4.25 to 6.5	Li-Ion/Poly	✓	C/10	ThinSOT
LTC4057*	1	0.8	4.25 to 6.5	Li-Ion/Poly	✓	External µC	ThinSOT
LTC4059*	1	0.9	3.75 to 8	Li-Ion/Poly, Ni ‡	✓	External µC	2x2 DFN-6
LTC4059A*	1	0.9	3.75 to 8	Li-Ion/Poly, Ni ‡	✓	External µC	2x2 DFN-6
LTC4058*/X* ¶	1	0.95	4.25 to 6.5	Li-Ion/Poly	✓	C/10	3x3 DFN-8
LTC4068*/X* ¶	1	0.95	4.25 to 6.5	Li-Ion/Poly	✓	C/x	3x3 DFN-8
LTC4075*/X* ¶	1	0.95	4.3 to 8	Li-Ion/Poly	✓	C/x	3x3 DFN-10
LTC4075HVX* ¶	1	0.95	4.3 to 6, 22 max	Li-Ion/Poly	✓	C/x	3x3 DFN-10
LTC4078*/X* ¶	1	0.95	4.3 to 6, 22 max	Li-Ion/Poly	✓	C/x	3x3 DFN-10
LTC4076*	1	0.95	4.3 to 8	Li-Ion/Poly	✓	C/x	3x3 DFN-10
LTC4077*	1	0.95	4.3 to 8	Li-Ion/Poly	✓	C/10	3x3 DFN-10
LTC3550-1*	1	0.95	4.3 to 8	Li-Ion/Poly	✓	C/x	3x5 DFN-16
LTC3550*	1	0.95	4.3 to 8	Li-Ion/Poly	✓	C/x	3x5 DFN-16
LTC3552-1*	1	0.95	4.25 to 8	Li-Ion/Poly	✓	C/x	3x5 DFN-16
LTC3552*	1	0.95	4.25 to 8	Li-Ion/Poly	✓	C/x	3x5 DFN-16
LTC4095*	1	0.95	4.3 to 5.5	Li-Ion/Poly	✓	Timer + C/10	2x2 DFN-8
LTC4064*	1	1.0	4.25 to 6.5	Li-Ion/Poly	✓	Timer + C/10	MSOP-10E
LTC4061*	1	1.0	4.5 to 8	Li-Ion/Poly	✓	Timer + C/x	3x3 DFN-10
LTC4061-4.4*	1	1.0	4.5 to 8	Li-Ion/Poly	✓	Timer + C/x	3x3 DFN-10
LTC4062* †	1	1.0	4.3 to 8	Li-Ion/Poly	✓	Timer + C/x	3x3 DFN-10
LTC4063* §	1	1.0	4.3 to 8	Li-Ion/Poly	✓	Timer + C/x	3x3 DFN-10
LTC4096*/X* ¶	1	1.2	4.25 to 5.5	Li-Ion/Poly	✓	C/x	3x3 DFN-10
LTC4097*	1	1.2	4.25 to 5.5	Li-Ion/Poly	✓	C/x	2x3 DFN-12
LTC4053*	1	1.25	4.25 to 6.5	Li-Ion/Poly	✓	Timer + C/10	3x3 DFN-10, MSOP-10E
LTC4052 #	1	1.3	4.5 to 10	Li-Ion/Poly	✓	Timer + C/10	MSOP-8E
LTC1733	1	1.5	4.5 to 6.5	Li-Ion/Poly	✓	Timer + C/10	MSOP-10E
LTC1731	1, 2	1.5	4.5 to 12	Li-Ion/Poly	External	Timer + C/10	MSOP-8, SO-8
LTC1732	1, 2	1.5	4.5 to 12	Li-Ion/Poly, Ni ‡	External	Timer + C/10	MSOP-10

* USB 2.0 Compatible, † Onboard Comparator, ‡ Constant-Current Mode (Voltage Mode Disabled), § Onboard LDO, ¶ "X" (No Trickle Charge) Versions Useful when the System Load Exceeds the Trickle Charge Current at Very Low Battery Voltages
# Pulse Charger

4.1V/Cell Battery Float Voltage

Our 4.1V per cell float voltage chargers improve battery life and high temperature safety margin by accurately charging the battery to a level slightly below full charge.

Part Number	Number of Battery Cells (Series)	Maximum Charge Current (A)	Input Voltage (V)	Battery Charger Type	USB 2.0 Compatible	Interface to High Voltage Buck	PowerPath Control	Integrated DC/DC Converters	Package (mm x mm)
Linear and Switch Mode Battery Chargers, Power Managers, Smart Battery Chargers and PMICs—4.1V/Cell Float Voltage									
LTC4070/71◉	1	0.05¶	Unlimited	Shunt	–	–	–	–	2x3 DFN-8, MSOP-8E
LTC4079	SLA, 1-14 Li-Ion, 1-50 Ni	0.25	2.7 to 60	Linear	–	–	–	–	3x3 DFN-10
LTC4065L-4.1	1	0.25	3.7 to 5.5	Linear	–	–	–	–	2x2 DFN-6
LTC4121	SLA, 1-5 $LiFePO_4$ 1-4 Li-Ion	0.4	4.3 to 40	Switch Mode	–	–	–	–	3x3 QFN-16
LTC3455-1	1	0.5	2.7 to 5.5	Linear	✓	–	✓	2 Bucks	4x4 QFN-24
LTC1734-4.1	1	0.7	4.55 to 8	Linear	✓	–	–	–	ThinSOT
LTC3559-1	1	0.95	4.3 to 5.5	Linear	✓	–	–	2 Bucks	3x3 QFN-16
LTC4055-1	1	1	4.3 to 5.5	Linear	✓	–	✓	–	4x4 QFN-16
LTC4064 (4.0V)	1	1	4.25 to 6.5	Linear	✓	–	–	–	MSOP-10E
LTC4089-1	1	1.2	6 to 36	Linear	✓	–	✓	–	3x6 DFN-22
LTC1733‡	1	1.5	4.5 to 6.5	Linear	✓	–	–	–	MSOP-10E
LTC4066-1	1	1.5	4.3 to 5.5	Linear	✓	–	✓	–	4x4 QFN-24, 4x4 QFN-24
LTC4085-1	1	1.5	4.35 to 5.5	Linear	✓	–	✓	–	3x4 DFN-14
LTC3557-1	1	1.5	4.35 to 5.5	Linear	✓	✓	✓	3 Bucks, 1 LDO	4x4 QFN-28
LTC3577-1/-4	1	1.5	4.35 to 5.5	Linear	✓	✓	✓	3 Bucks, 2 LDOs, 10-LED Boost	4x7 QFN-44
LTC3576-1	1	1.5	4.35 to 5.5	Bat-Track Linear	✓	✓	✓	3 Bucks, 1 LDO	4x6 QFN-38
LTC3555-3	1	1.5	4.35 to 5.5	Bat-Track Linear	✓	–	✓	3 Bucks, 1 LDO	4x5 QFN-28
LTC3586-1	1	1.5	4.35 to 5.5	Bat-Track Linear	✓	–	✓	1 Boost, 1 Buck-Boost, 2 Bucks, 1 LDO	4x6 QFN-38
LTC4098-1	1	1.5	4.35 to 5.5	Bat-Track Linear	✓	✓	✓	–	3x4 QFN-20
LTC4099+	1	1.5	4.35 to 5.5	Bat-Track Linear	✓	✓	✓	–	3x4 QFN-20
LTC4160-1	1	1.5	4.35 to 5.5	Bat-Track Linear	✓	–	✓	–	3x4 QFN-20
LTC1731-4.1/-8.2	1/2	2	4.5 to 12	Linear	–	–	–	–	MSOP-8/SO-8
LTC1732-4	1, 2	2	4.5 to 12	Linear	–	–	–	–	MSOP-10
LTC4050-4.1/8.2	1	2	4.5 to 12	Linear	–	–	–	–	MSOP-10
LTC4001-1	1	2	4 to 5.5	Switch Mode	–	–	–	–	4x4 QFN-16
LT3650-4.1§/8.2#	1, 2	2	4.75 to 32	Switch Mode	–	–	–	–	3x3 DFN-12, MSOP-12E
LTC1980†	1, 2	2	4.1 to 12	Switch Mode	–	–	–	–	SSOP-24
LTC4110† *	1–4	3	6 to 20	Switch Mode/ Flyback	–	–	✓	–	5x7 QFN-38
LT3651-4.1/8.2	1/2	4	4.8/9 to 32	Switch Mode	–	–	–	–	5x6 QFN-36
LT3652/HV	1–3/1–4	2	4.95 to 32§	Switch Mode	–	–	–	–	3x4 DFN-12, MSOP-12E
LTC4007/-1	3, 4	4	6 to 28	Switch Mode	–	–	✓	–	SSOP-24
LTC4100† *	2–6	4	6 to 28	Switch Mode	–	–	✓	–	SSOP-24
LTC4101† *	1	4	6 to 28	Switch Mode	–	–	✓	–	SSOP-24
LTC4008†	2–6	4	6 to 28	Switch Mode	–	–	✓	–	SSOP-20
LTC4009† /-1	1–4	4	6 to 28	Switch Mode	–	–	–	–	4x4 QFN-20
LTC4012† /-1/-3	1–4	4	6 to 28	Switch Mode	–	–	✓	–	4x4 QFN-20
LTC1760† *	2–6	4	6 to 28	Switch Mode	–	–	✓	–	TSSOP-48
LTC1960† *	2–6	8	6 to 28	Switch Mode	–	–	✓	–	5x7 QFN-38, SSOP-36
LTC4020	SLA, 1-15 $LiFePO_4$, 1-13 Li-Ion	20+	4.5 to 55	Switch Mode	–	–	✓	–	5x7 QFN-38

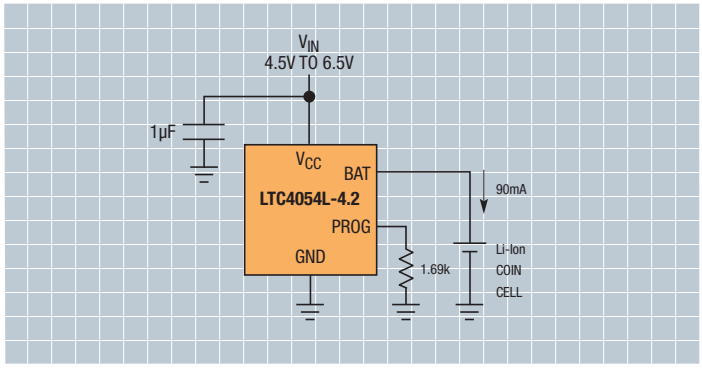
* I^2C Controlled, † Programmable, ‡ SEL Pin = 0V Programs for 4.1V or 4.2V, § 7.5V Start-up Voltage for 1-Cell Operation, # 11.5V Start-up Voltage, ¶ 500mA with External PFET, ◉ Battery Pack Protection

Low Current/Coin Cell Battery Chargers

Our coin cell battery chargers enable highly accurate charging of low capacity, charge-sensitive coin cells used in thin, compact devices such as Bluetooth headsets and hearing aids.

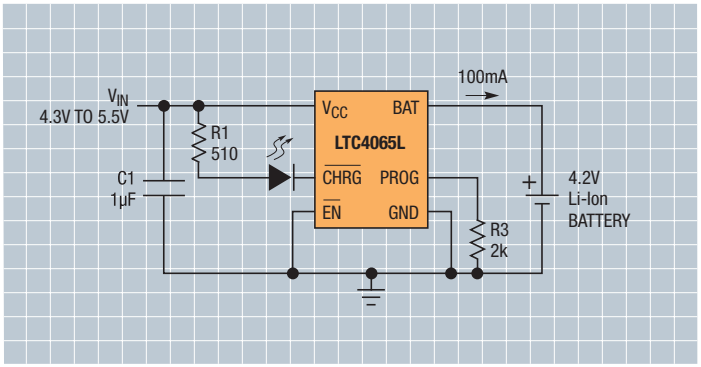
LTC4054L:
Actual Size
Demo Circuit

LTC4054L: 150mA Standalone Li-Ion Battery Charger for Coin Cells

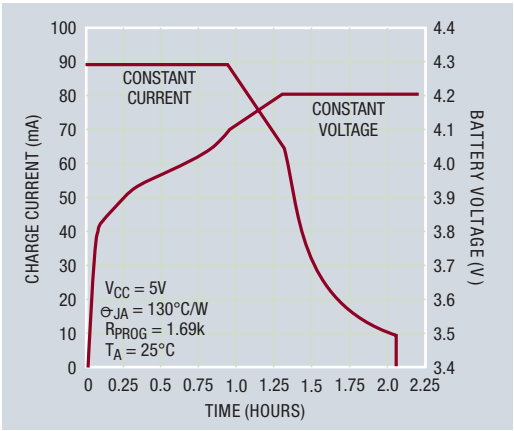


90mA Li-Ion Coin Cell Charger

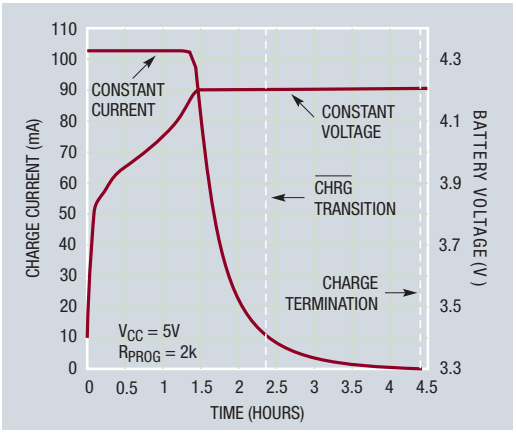
LTC4065L: 250mA Standalone Linear Li-Ion Battery Charger in 2mm x 2mm DFN



Standalone Li-Ion Charger



LTC4054L Complete Charge Cycle



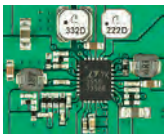
LTC4065L Complete Charge Cycle

Part Number	Charge Current Range (mA)	Input Voltage (V)	Battery Charger Type	Standalone	Charge Termination (Plus Indication)	Thermal Regulation	Integrated Power Transistor	Package (mmxmm)
Coin Cell Li-Ion Battery Chargers								
LTC4070	0.001-50†	Unlimited	Shunt	✓	✓	–	✓	2x3 DFN-8 MSOP-8E
LTC4071	0.001-50	Unlimited	Shunt	✓	✓	–	✓	2x3 DFN-8 MSOP-8E
LTC4054L	10-150	4.25 to 6.5	Linear	✓	C/10	✓	✓	ThinSOT
LTC1734L	10-180	4.55 to 8	Linear	–	–	–	External	ThinSOT
LTC4079	10-250	2.7 to 60	Linear	–	Timer	–	–	3x3 DFN-10
LTC4065L/LX*	15-250	3.75 to 5.5	Linear	✓	Timer + C/10	✓	✓	2x2 DFN-6
LTC4059/A	90-900	3.75 to 8	Linear	–	–	✓	✓	2x2 DFN-6

* "X" (No Trickle Charge) Versions Useful when the System Load Exceeds the Trickle Charge Current at Very Low Battery Voltages, † 500mA with ext PFET

PMICs: Switch Mode Power Manager-Based

Our power management integrated circuits (PMICs) address battery charging and multiple system power rail needs for single-cell lithium-ion/polymer portable products. Switch mode power management enables higher efficiency charging, less heat dissipation and compatibility with wall adapter, USB and high voltage power sources.



LTC3556:
Actual Size
Demo Circuit

LTC3556: High Efficiency Switch Mode USB Power Manager + Battery Charger + Dual Step-Down DC/DC + Buck-Boost + LDO

Features

Power Manager

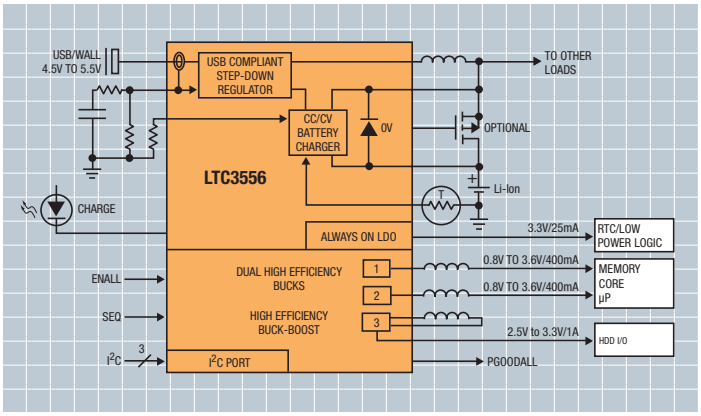
- High Efficiency Switching PowerPath Controller with Bat-Track Adaptive Output Control
- Programmable USB or Wall Current Limit (100mA/500mA/1A)
- Full Featured Li-Ion/Polymer Battery Charger
- 1.2A Maximum Charge Current
- Internal 180mΩ Ideal Diode + External Ideal Diode Controller Powers Load in Battery Mode
- Low No-Load Quiescent Current when Powered from BAT (<30µA)

DC/DCs

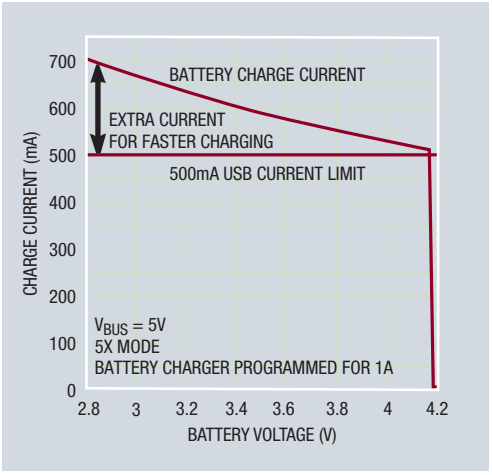
- Dual High Efficiency Step-Down DC/DCs (400mA/400mA I_{OUT})
- High Efficiency Buck-Boost DC/DC (1A I_{OUT})
- All Regulators Operate at 2.25MHz
- Dynamic Voltage Scaling on Two Buck Outputs
- I^2C Control of Enables, MODE, Two V_{OUT} Settings
- Low No-Load Quiescent Current: 20µA
- Always-On, 3.3V/25mA LDO
- Low Profile 4mm × 5mm 28-Pin QFN Package

Applications

- HDD-Based MP3 Players, PMPs
- PNDs, DMB/DVB-H; Digital/Satellite Radio
- Portable Industrial/Medical Products
- Universal Remotes, Photo Viewers
- Other USB-Based Handheld Products



High Efficiency PowerPath Manager, Dual Buck, Buck-Boost and LDO



Battery Charge Current from USB

Part Number	Number of Regulators	Input Voltage (V)	Buck(s) (I_{OUT})	Buck-Boost (I_{OUT})	Boost (I_{OUT})	LDO(s) (I_{OUT})	Li-Ion/ Polymer Charger	Max Charge Current (A)	Ideal Diode	Interface	Package (mm x mm)
Switch Mode PowerPath Management Integrated Circuits (PMICs)											
LTC3566	2	4.35 to 5.5	–	1A	–	3.3V/25mA	✓	1.5	Int + Ext (Opt.)	Simple	4x4 QFN-24
LTC3567	2	4.35 to 5.5	–	1A	–	3.3V/25mA	✓	1.5	Int + Ext (Opt.)	I^2C	4x4 QFN-24
LTC3555/-1/-3*	4	4.35 to 5.5	1A, 400mA x 2	–	–	3.3V/25mA	✓	1.5	Int + Ext (Opt.)	I^2C	4x5 QFN-28
LTC3556	4	4.35 to 5.5	400mA x 2	1A	–	3.3V/25mA	✓	1.5	Int + Ext (Opt.)	I^2C	4x5 QFN-28
LTC3576/-1*†	4	4.35 to 5.5, High-V, OVP	1A, 400mA x 2	–	–	3.3V/20mA	✓	1.5	Int + Ext (Opt.)	I^2C	4x6 QFN-38
LTC3586/-1*	5	4.35 to 5.5	400mA x 2	1A	0.8A	3.3V/20mA	✓	1.5	Int + Ext (Opt.)	Simple	4x6 QFN-38

* 4.1V Battery Float Voltage, † See Page 27 for Compatible High Voltage Buck Regulators

PMICs: Linear Power Manager-Based

Our power management integrated circuits (PMICs) address battery charging and multiple system power rail needs in single-cell lithium-ion/polymer portable products. Linear power management allows seamless transition and manages power flow between input power sources such as a wall adapter, USB port, lithium battery and the system load.

LTC3577/-1: Highly Integrated 6-Channel PMIC

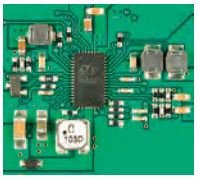
Features

- Full Featured Li-Ion Charger/PowerPath Controller with Instant-On Operation
- High Temperature Battery Voltage Reduction Improves Safety and Reliability
- 1.5A Maximum Charge Current with Thermal Limiting
- Pushbutton On/Off Control with System Reset
- Dual 150mA Current Limited LDOs
- Triple Adjustable High Efficiency Step-Down Switching Regulators (600mA, 400mA, 400mA I_{OUT})
- 200mΩ Internal Ideal Diode Plus External Ideal Diode Controller Provides Low Loss PowerPath from Battery
- Bat-Track Control for External HV Buck DC/DCs
- I^2C Adjustable SW Slew Rates for EMI Reduction
- Overvoltage Protection for USB (VBUS)/Wall Input
- Integrated 40V Series LED Driver with 60dB Brightness and Gradation Control via I^2C
- Small 4mm × 7mm 44-Pin QFN Package

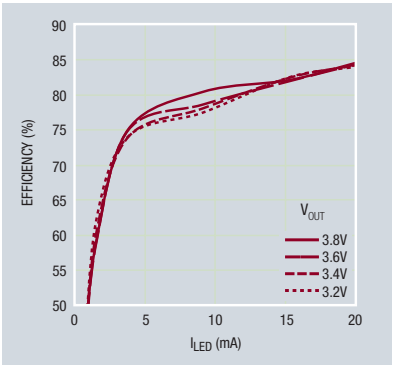
Applications

- PNDs, DMB/DVB-H; Digital/Satellite Radio
- Portable Industrial/Medical Products
- Universal Remotes, Photo Viewers
- Other USB-Based Handheld Products

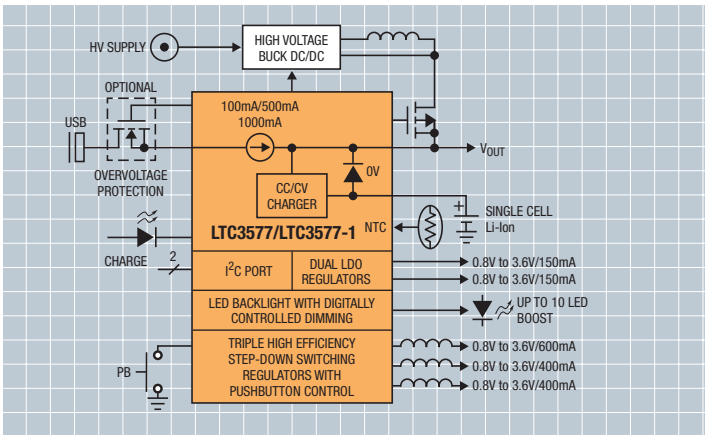
LTC3577: Actual Size, Complete Solution



Solution Size = 22mm x 15mm



LED Driver Efficiency (10 LEDs)



USB Plus HV Input Charger and Multichannel PMIC

Part Number	Number of Regulators	Input Voltage (V)	Buck(s) (I_{OUT})	LDO(s)	Li-Ion/ Polymer Charger	Max Charge Current	PowerPath	Ideal Diode	Interface	Package (mm x mm)
Linear PowerPath Management Integrated Circuits (PMICs)										
LTC3553	2	4.35 to 5.5	200mA	150mA	✓	500mA	✓	✓	–	3x3 QFN-20
LTC3554	2	4.35 to 5.5	200mA x 2	–	✓	500mA	✓	✓	–	3x3 QFN-20
LTC3455	3	2.7 to 5.5, USB + Wall Inputs	400mA, 600mA‡	Controller	✓	500mA	✓	–	–	4x4 QFN-24
LTC3557/-1§	4	2.7 to 5.5, USB, High-V Bat-Track (*)	600mA, 400mA x 2	3.3V/25mA	✓	1.5A	✓	Int + Ext (Opt.)	–	4x4 QFN-28
LTC3577/-3 LTC3577-1/-4§	6#	2.7 to 5.5, USB, High-V Bat-Track (*), OVP	800mA, 500mA x 2	2x150mA	✓	1.5A	✓	Int + Ext (Opt.)	–	4x7 QFN-44
LTC3677-3¶	6	2.7 to 5.5, USB, High-V Bat-Track (*), OVP	800mA, 500mA x 2	2x150mA	✓	1.5A	✓	Int + Ext (Opt.)	–	4x7 QFN-44

* See Table Below for Compatible High Voltage Buck Regulators, † Includes 50mA Hot Swap™ Controller, ‡ May be Increased to 1A with Additional Components, § 4.1V Battery Float Voltage, # Includes 10-LED Boost, ¶ No LED Driver

Part Number	Input Voltage, Maximum (V)	Efficiency (%)	I_{SW}/I_{OUT} (A)	Switching Frequency	Reference Voltage (V)	Inductor (µH)	Output Capacitor (µF)	Quiescent Current	I_{SD} (µA)	Package (mm x mm)
***High Voltage Buck Regulators (Compatible with LTC3557, LTC3576 and LTC3577)**										
LT3505	3.6-36, 40	>85	1.75 / 1.2	300k-3MHz	0.78	6.8	10-Ceramic	2mA	<2	3x3 DFN-8, MSOP-8E
LT3480	3.6-38, 60	>85	3 / 2	200k-2MHz	0.79	4.7	22-Ceramic	70µA	<1	3x3 DFN-10, MSOP-10E
LT3481	3.6-34, 36	>85	3.2 / 2	300k-2.8MHz	1.26	4.7	22-Ceramic	50µA	<1	3x3 DFN-10, MSOP-10E
LT3653	7.5-30, 60	>85	2 / 1.2	1.5MHz	n/a	4.7	10-Ceramic	2.8mA	n/a	2x3 DFN-8

PMICs: Linear Battery Charger (Battery-Fed)

Our power management integrated circuits (PMICs) address battery charging and multiple system power rail needs in single-cell lithium portable products. A high level of integration is offered in a small footprint for a compact total solution size and ease-of-use.

LTC3558: Linear USB Battery Charger with Buck-Boost and Buck Regulators

Features

Power Manager

- Standalone USB Charger
- Up to 950mA Charge Current Programmable via Single Resistor
- HPWR Input Selects 20% or 100% of Programmed Charge Current
- NTC Input for Temperature Qualified Charging
- Internal Timer Termination
- Bad Battery Detection

Switching Regulators

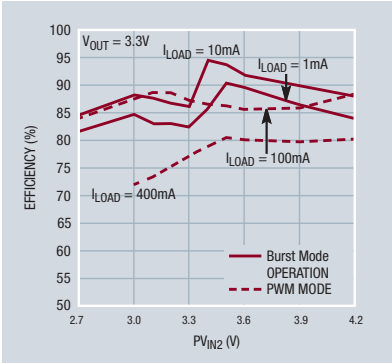
- 400mA Output Current per Regulator
- 2.25MHz Constant Frequency Operation
- Power Saving Burst Mode® Operation
- Low Profile 3mm × 3mm 20-Pin QFN Package

Applications

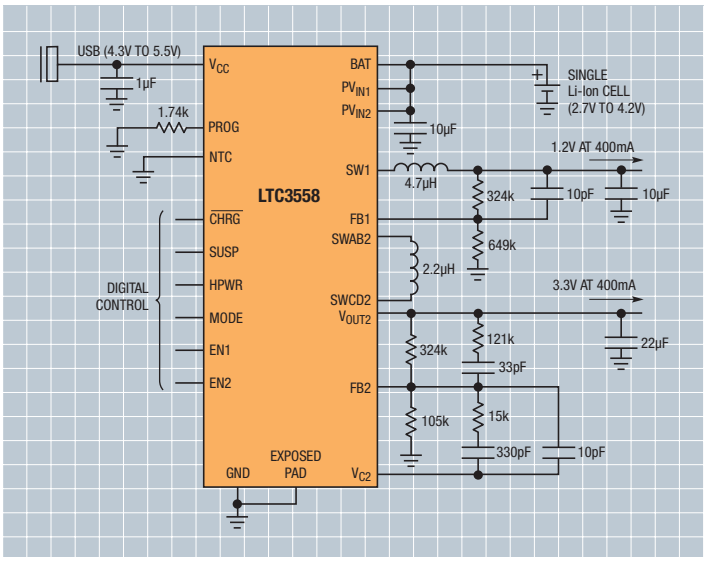
- PNDs, DMB/DVB-H; Digital/Satellite Radio
- SD/Flash-Based MP3 Players
- Portable Industrial/Medical Products
- Universal Remotes, Photo Viewers
- Other USB-Based Handheld Products
- Low Power Handheld Applications

LTC3558:
Actual Size
Complete Solution

Solution Size = 12mm x 11mm



Buck-Boost Regulator Efficiency vs Input Voltage



USB Charger Plus Buck Regulator and Buck-Boost Regulator

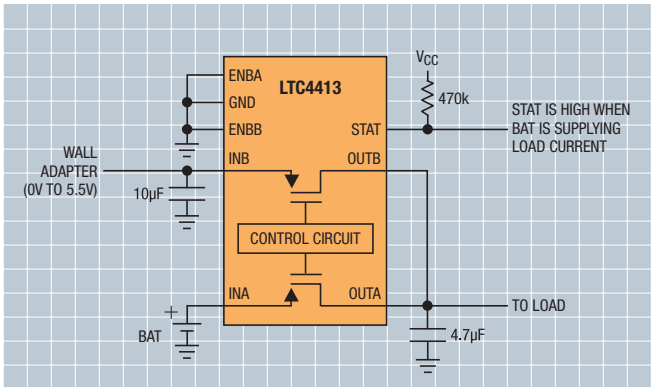
Part Number	Number of Regulators	Maximum Charge Current (mA)	Input Voltage (V)	Buck(s) (I_{OUT})	Buck-Boost(s) (I_{OUT})	Li-Ion/Polymer Charger	PowerPath Topology	Package (mm x mm)
Power Management Integrated Circuits (PMICs), Charger-Fed								
LTC4080	1	500	2.7 - 4.5	300mA	–	✓	–	3x3 DFN-10, MSOP-10E
LTC4081	1	500	2.7 - 4.5	300mA	–	✓	–	3x3 DFN-10
LTC3550/-1	1	950	2.5 - 5.5	600mA	–	✓	–	3x5 DFN-16
LTC3552/-1	2	950	2.5 - 5.5	400mA/800mA	–	✓	–	3x5 DFN-16
LTC3558	2	950	3.0 - 4.2	400mA	400mA	✓	–	3x3 QFN-20
LTC3559	2	950	3.0 - 4.2	400mA x 2	–	✓	–	3x3 QFN-16

Ideal Diodes/PowerPath Controllers

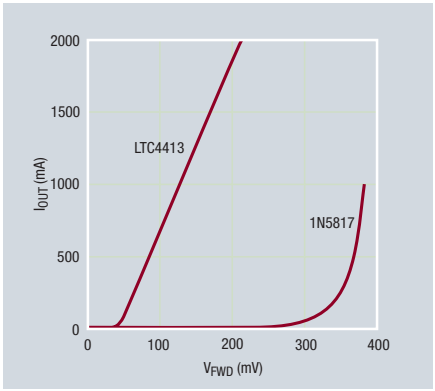
Our ideal diode devices provide a low loss, near "ideal" diode function. They feature much lower forward voltage drop and reverse leakage current than conventional Schottky diodes. This reduces power loss and eases thermal management while extending battery run time.

LTC4413:
Actual Size
Demo Circuit

LTC4413: Dual 2.6A, 2.5V to 5.5V Ideal Diodes in 3mm x 3mm DFN



Monolithic Dual Ideal Diode

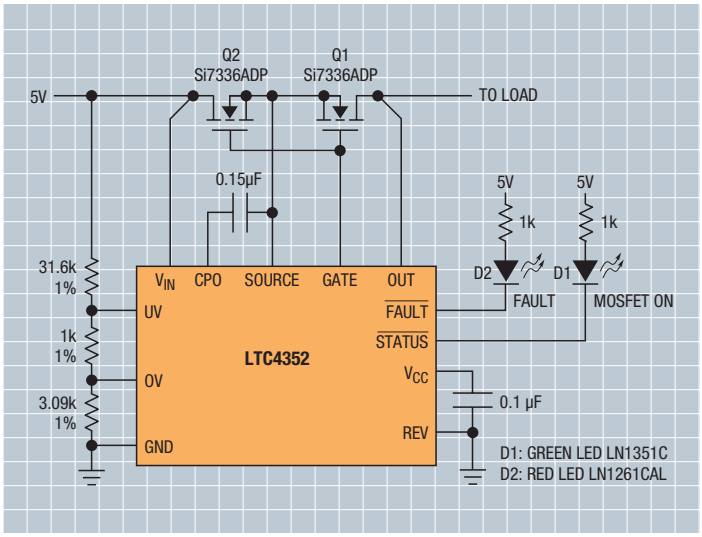


LTC4413 vs 1N5817 Schottky

Part Number	Ideal Diode	External MOSFET	Integrated MOSFET	Maximum Current (A)	Input Voltage (V)	Forward Voltage (mV)	Forward ON Resistance	Reverse Leakage Current (µA)	Supply Current (µA)	Package (mmxmm)
P-Channel PowerPath/Ideal Diode Controllers										
LTC4411	Single	P-Channel	✓	1	2.6 to 5.5	28	140mΩ	1	35	ThinSOT
LTC4412	Single	P-Channel	–	2*	2.5 to 28	20	Controller	3	13	ThinSOT
LTC4412HV	Single	P-Channel	–	2*	2.5 to 36	20	Controller	3	13	ThinSOT
LTC4413/-1†	Dual	P-Channel	✓	2.6	2.5 to 5.5	28	100mΩ	1	20	3x3 DFN-10
LTC4413-2†	Dual	P-Channel	✓	2.6	2.5 to 5.5,13, OVP	28	100mΩ	1	20	3x3 DFN-10
LTC4414	Single	P-Channel	–	5-75*	3 to 36	22	Controller	3	33	MSOP-8
LTC4415	Dual	P-Channel	✓	4	1.7 to 5.5	15	50mΩ	1	44	3x5 DFN-16, MSOP-16
LTC4416/-1	Dual	P-Channel	–	5-75*	3.6 to 36	22	Controller	3	70	MSOP-10
LTC4417	Triple	P-Channel	–	5-75*	2.5 to 36	*	Controller	n/a	28	4x4 QFN-24, SSOP-24

* Depends on MOSFET Selection, † High Speed Version

LTC4352: MOSFET Diode-OR Controller



5V Ideal Diode Circuit with Input Undervoltage and Overvoltage Protection

Part No.	Ideal Diode	External MOSFET	Maximum Current (A)	Input Voltage (V)	Package (mmxmm)
N-Channel Power PowerPath/Ideal Diode Controllers					
LTC4352	Single	N-Channel	≥5*	0 to 18	3x3 DFN-12, MSOP-12
LTC4357	Single	N-Channel	≥5*	9 to 80	2x3 DFN-6, MSOP-8
LTC4358	Single	N-Channel (Internal)	5	9 to 26.5	4x3 DFN-14, TSSOP-16
LTC4359	Single	N-Channel	≥5*	4 to 80	2x3 DFN-6, MSOP-8
LTC1473	Dual	N-Channel	≥5*	4.75 to 30	SSOP-16
LTC1473L	Dual	N-Channel	≥5*	2.8 to 9	SSOP-16
LTC2952†	Dual	N-Channel	≥5*	2.7 to 28	TSSOP-20, 4x4 QFN-20
LTC4353	Dual	N-Channel	≥5*	0 to 18	4x3 DFN-16, MSOP-16
LTC4371	Dual	N-Channel	≥5*	–4.5 to >–100 (Floating)	3x3 DFN-10, MSOP-10
LTC4355	Dual	N-Channel	≥5*	9 to 80	4x3 DFN-14, SOIC-16
LTC1479	Triple	N-Channel	≥5*	6 to 28	SSOP-36

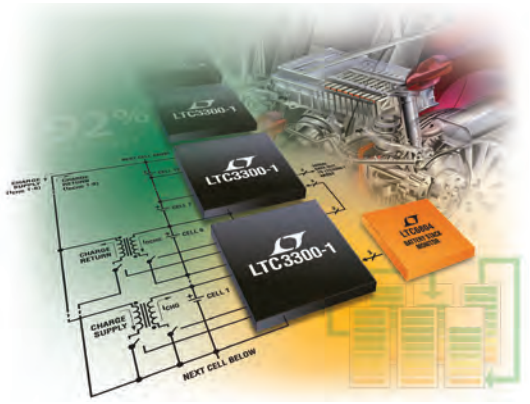
* Depends on MOSFET Selection, † Pushbutton PowerPath Controller with Supervisor

Active Balancing ICs

Emerging electric vehicles (EV) and plug-in hybrid vehicles (PHEV) are demanding longer usable run time from their battery stacks. These stacks of batteries are typically made of battery modules, each with as many as 12 Li-Ion cells stacked in series, offering a 400V battery module. As the battery run time defines the very feasibility of these vehicles, maximizing battery capacity is of primary importance. Batteries can always be made larger to improve driving range but this increases the weight, size and cost of the vehicle. So the goal for automotive EV designers is to find ways to make the existing battery run longer. One effective method is to employ active balancing. Because EV batteries are stacked in series, the lowest capacity cell will limit the entire battery stack's run time. Ideally, the batteries would be perfectly matched, but this is often not the case, and generally gets worse as the batteries age. Passive energy balancing offers no improved run time, as it dissipates the extra energy of the higher capacity batteries as heat to match the lowest one. Conversely, high efficiency active balancing redistributes the charge from the stronger cells (higher voltage) to the weaker cells. This enables the weaker cells to continue to supply the load during stack discharge, extending the vehicle's range. It may also be beneficial to have onboard diagnostics for each cell within these modules to monitor temperature, voltage (state of charge) and internal impedance both for safety and long term reliability.

Practical Example

- Big batteries are expensive—they all degrade over time and lose capacity
- Low cost/refurbished cells have greater capacity mismatch
- Increasing stack capacity with mismatched cells done in 2 ways:
  - Use bigger batteries (solution cost ~ $1–$2 per A-hr per cell)
  - Use active balancing
    - LTC3300-1 solution cost ~ $2–$3 per cell, depending on IBAL
    - LT8584 solution cost ~ $3.50–$4.50 per cell, depending on IBAL
- Example, adding 10A-hrs of capacity costs:
  - Bigger batteries: ~ $10–$20 per cell
  - Active balancing: ~ $2–$3 per cell
- Active balancing maximizes run time and allows fastest charge rates



LTC3300-1/-2 - High Efficiency/Addressable Bidirectional Multicell Battery Balancer

The LTC3300-1 is a fault-protected controller IC for transformer-based bidirectional active balancing of multicell battery stacks. All associated gate drive circuitry, precision current sensing, fault detection circuitry and a robust serial interface with built-in watchdog timer are integrated. Each LTC3300-1 can balance up to six series-connected battery cells with an input common mode voltage up to 36V. Charge from any selected cell can be transferred at high efficiency to or from 12 or more adjacent cells.

LTC3300-1 Offers

- Highest energy recovery (max run time)
- 92% transfer efficiency, bidirectional operation
- Fastest balancing time (min charge time)
- Up to 10A charge/discharge current, external power switches
- Numerous safety features
- Cost efficiency – 6-cell integration

Features

- Bidirectional Synchronous Flyback Balancing of Up to Six Li-Ion or $LiFePO_4$ Cells in Series
- Up to 10A Balancing Current (Set by External Components)
- Bidirectional Architecture Minimizes Balancing Time and Power Dissipation
- Up to 92% Charge Transfer Efficiency
- Stackable Architecture Enables >1000V Systems
- Integrates Seamlessly with LTC6804-X Family of Battery Cell Monitor ICs
- Uses Simple 2-Winding Transformers
- 1MHz Daisy-Chainable Serial Interface with 4-Bit CRC Packet Error Checking
- High Noise Margin Serial Communication
- Numerous Fault Protection Features
- 48-Lead Exposed Pad QFN & LQFP Packages

Applications

- Electric Vehicles/Plug-in HEVs
- High Power UPS/Grid Energy Storage Systems
- General Purpose Multicell Battery Stacks

LT8584 - 2.5A Monolithic Active Cell Balancer with Telemetry Interface

The LT8584 is a monolithic flyback DC/DC designed to actively balance high voltage stacks of batteries. The high efficiency of a switching regulator significantly increases the achievable balancing current while reducing heat generation. The LT8584 includes an integrated 6A/50V power switch, reducing the complexity of the application circuit. The device runs completely off the cell it is discharging, eliminating complicated biasing schemes. The LT8584 provides system telemetry including current, temperature and cell voltage when used with the LTC680x family of battery monitors.

LT8584 Offers

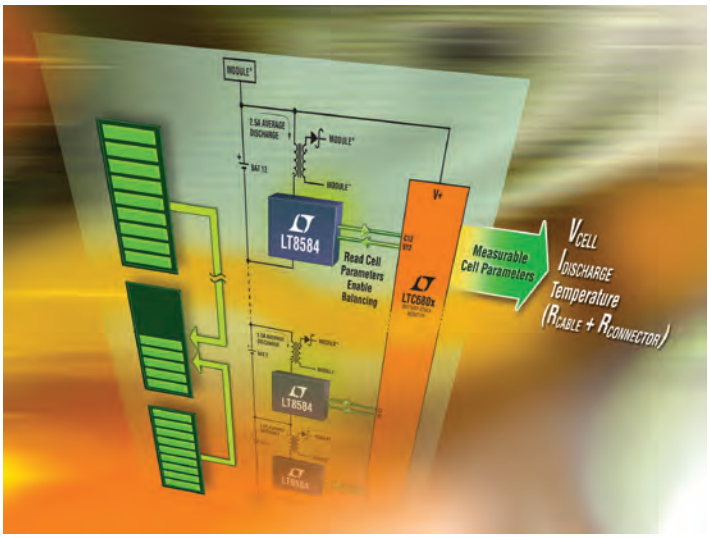
- High level of integration
- Numerous safety features, additional system monitoring MUX
  - Measure IBAL for calculating “IR Drop Compensation,” “Coulomb tracking”
  - Measure internal reference for BMS self-testing per channel
- Simple to use: no additional software required for “Simple Mode” operation
- High energy recovery
  - 82% charge transfer efficiency
- Fast balancing time
  - 2.5A discharge current, internal power switch

Features

- 2.5A Typical Average Cell Discharge Current
- Integrated 6A/50V Power Switch
- Integrates Seamlessly with LTC680x Family
- Selectable Current and Temperature Monitors
- Ultralow Quiescent Current in Shutdown
- Engineered for ISO 26262 Compliant Systems
- Isolated Balancing:
  - Can Return Charge to Top of Stack
  - Can Return Charge to Any Combination of Cells in Stack
  - Can Return Charge to 12V Battery for Alternator Replacement
- Can Be Paralleled for Greater Discharge Capability

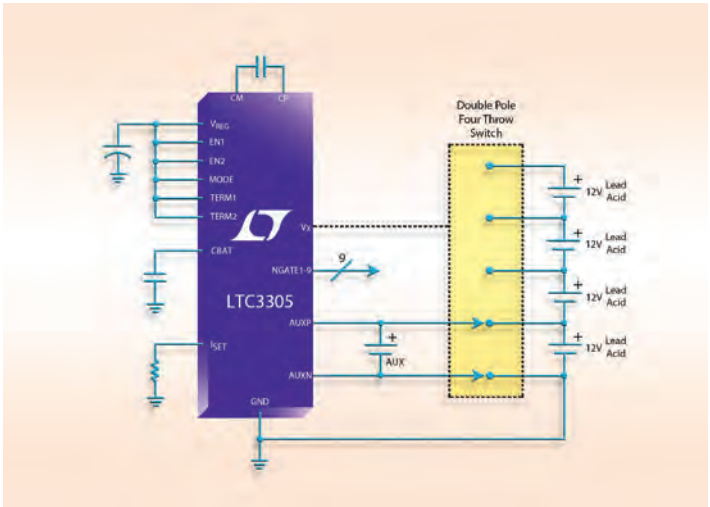
Applications

- Active Battery Stack Balancing
- Electric and Hybrid Electric Vehicles
- Failsafe Power Supplies
- Energy Storage Systems



LTC3305 Lead-Acid Battery Balancer

The LTC3305 balances up to four lead-acid batteries connected in series. All voltage monitoring, gate drive and fault detection circuitry is integrated. The LTC3305 is designed for standalone operation and does not require any external control circuitry.



Summary of Features: LTC3305

- Single IC Balances Up to Four 12V Lead-Acid Batteries in Series
- All NFET Design
- Stackable to Balance Larger Series Battery Packs
- Standalone Operation Requires no External µP or Control Circuitry
- Balancing Current Limited by External PTC Thermistor
- Continuous Mode and Timer Mode
- Programmable UV and OV Fault Thresholds
- Programmable Termination Time and Termination Voltage
- 38-Lead TSSOP and 7mm × 7mm 48-Lead LQFP Packages

High Voltage Battery Stack Monitors for Battery Management Systems

Applications

- Passenger Automobiles (EV, HEV)
- Electric Bicycles (Motorcycles, Scooters)
- Commercial Vehicles (Buses, Trains)
- Industrial Equipment (Forklifts, Trucks)
- Marine (Boats, Submarines)
- Mil/Aero (Planes, Satellites, Unmanned Vehicles)
- Energy Storage Systems

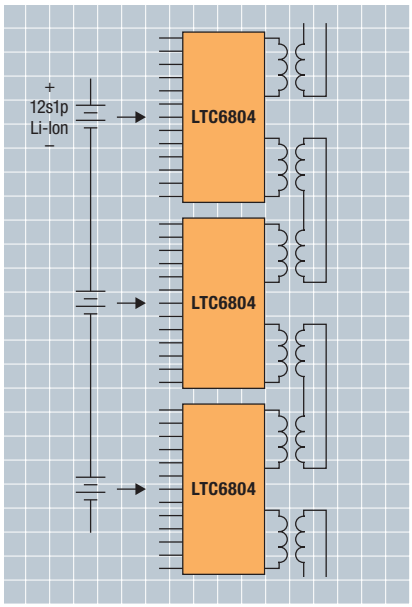
Part Number	Primary Function	Measurement Error Max	Multichip Interface	Package	Comments
LTC6804-1	12 Cell Measurements	0.10%	isoSPI, Daisy-Chain	SSOP-48	3rd Generation: High Noise Immunity High Accuracy, 240µsec Conversion
LTC6804-2	12 Cell Measurements	0.10%	isoSPI, Addressable	SSOP-48	3rd Generation: High Noise Immunity High Accuracy, 240µsec Conversion
LTC6803-1/3	12 Cell Measurements	0.25%	SPI, Daisy-Chain	SSOP-44	2nd Generation: High Noise Immunity, 0µA shutdown
LTC6803-2/4	12 Cell Measurements	0.25%	SPI, Addressable	SSOP-44	2nd Generation: High Noise Immunity, 0µA shutdown
LTC6802-1	12 Cell Measurements	0.25%	SPI, Daisy-Chain	SSOP-44	1st Generation: Superseded by the LTC6804 and LTC6803 for new designs
LTC6802-2	12 Cell Measurements	0.25%	SPI, Addressable	SSOP-44	1st Generation: Superseded by the LTC6804 and LTC6803 for new designs
LTC6801	12 Cell Fault Monitor	0.50%	Differential Clock Signals, Daisy-Chain	SSOP-36	Standalone Undervoltage/Overvoltage Monitor, Provides Redundancy

LTC6804: Next Generation Battery Stack Monitor

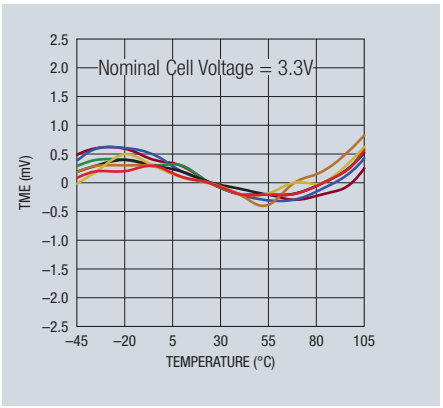
Features

- Measures Up to 12 Battery Cells in Series
- Stackable Architecture Supports 100s of Cells
- Built-in isoSPI™ Interface
- Delta-Sigma ADC With Frequency Programmable 3rd Order Noise Filter
- 1.2mV Maximum Total Measurement Error
- 240µs to Measure All Cells in a System
- Synchronized Voltage and Current Measurement
- Engineered for ISO26262 Compliant Systems
- Passive Cell Balancing with Programmable Timer
- General Purpose I/O for Digital or Analog Inputs, also Configurable for I²C Interface
- 4µA Sleep Mode Supply Current
- 48-Lead SSOP Package

Stackable BMS Architecture



Total Measurement Error vs Temperature

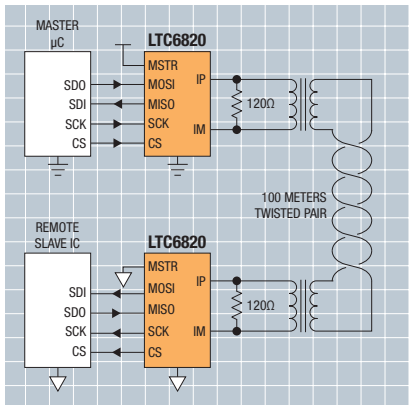


LTC6820: Noise Immune, Isolated, Bidirectional SPI Communications (isoSPI)

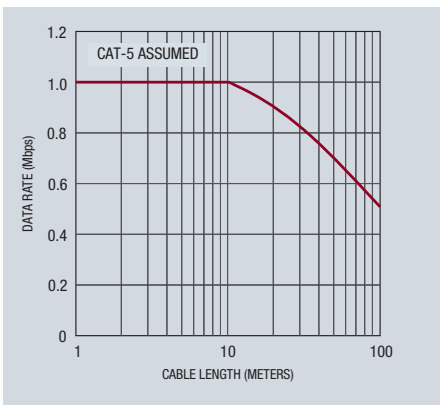
Features

- Supports LTC6804 High Voltage Battery Monitor
- 1Mbps Isolated SPI Using Standard Transformers
- Bidirectional Interface Over a Single Twisted Pair
- Supports Cable Lengths Up to 100 Meters
- Configurable for High Noise Immunity or Low Power
- Ultralow, 2.5µA Idle Current
- Interfaces with 1.8V to 5V Logic
- 16-Lead QFN and MSOP Packages

Isolated 2-Wire Communication



Data Rate vs Cable Length

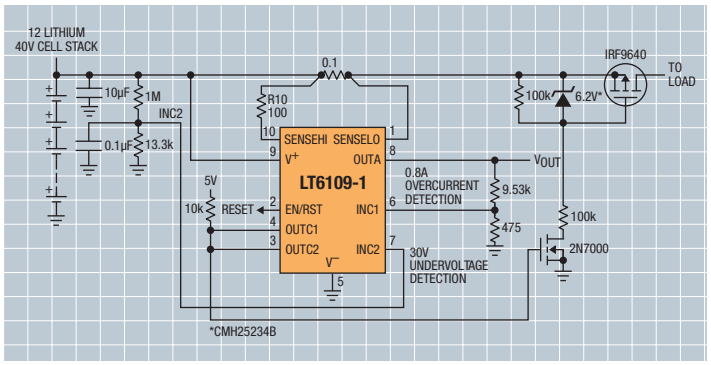


Battery Monitoring Devices

By combining a voltage reference with a comparator, it is easy to create accurate battery monitors. Linear Technology offers a number of combination devices with very low power and high accuracy voltage references. These products are available in many pin configurations to support a wide range of designs with minimum package footprint and pin count.

LT6109: High Side Current Sense Amplifier with Reference and Dual Comparator

The LT6109 is an ideal choice for monitoring batteries. It includes a precision high side current sense amplifier, a dual comparator for monitoring current and/or voltage, and a voltage reference. As shown, it is simple to implement battery fault protection. In this example, the comparators monitor for overcurrent and undervoltage conditions. If either fault is detected, the battery will be immediately disconnected from the load. The latching comparator outputs ensure the battery stays disconnected until an outside source resets the LT6109 comparator output.



Overcurrent and Undervoltage Battery Fault Protection

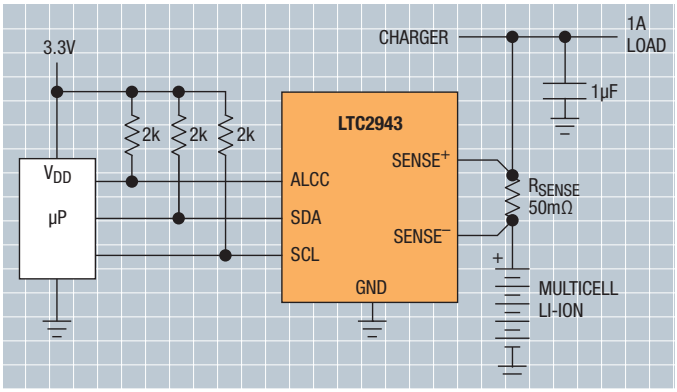
Part Number	Description	Supply Voltage (V)	Prop Delay (µs) Typ	Hysteresis (mV)	Supply Current (µA)	Package (mm x mm)
Comparator and Reference Combinations						
LT6700	Dual Comparators with 400mV Reference	1.4 to 18	18	6.5	10	SOT-23, 2x3 DFN-6
LT6700HV	36V Input/Output Dual Comparators and Reference	1.4 to 18	18	6.5	10	SOT-23
LT6700MP	Dual Comparators and Reference for –55°C to 150°C	1.4 to 18	18	6.5	10	2x3 DFN-6
LT6703	Single Comparator and Internal Reference	1.4 to 18	18	6.5	10	SOT-23, 2x2 DFN-3
LT6703HV	36V Input/Output Comparator and Reference	1.4 to 18	18	6.5	10	SOT-23
LTC1440	Ultralow Power Comparator with Reference	2 to 11	8	Adj	4	MSOP-8,SO-8, DIP-8, 3x3 DFN-8
LTC1441	Dual Ultralow Power Comparators with Reference	2 to 11	8	None	5.7	DIP-8, SO-8
LTC1442	Dual Ultralow Power Comparators with Reference	2 to 11	8	Adj	5.7	DIP-8, SO-8
LTC1443	Quad Ultralow Power Comparators with Reference	2 to 11	4	None	8.5	DIP-16, SO-16, 4x5 DFN-16
LTC1444	Quad Ultralow Power Comparators with Reference	2 to 11	4	Adj	8.5	DIP-16, SO-16, 4x5 DFN-16
LTC1445	Quad Ultralow Power Comparators with Reference	2 to 11	4	Adj	8.5	DIP-16, SO-16, 4x5 DFN-16
LTC1540	Nanopower Comparator with Reference	2 to 11	50	Adj	0.7	MSOP-8, SO-8, 3x3 DFN-8
LTC1541	Combined Amplifier, Comparator and Reference	2.5 to 12.6	8	2.25	7.5	MSOP-8, SO-8, 3x3 DFN-8
LTC1542	Micropower Amplifier and Comparator	2.5 to 12.6	8	2.25	5	MSOP-8, SO-8, 3x3 DFN-8
LTC1842	Dual Ultralow Power Comparators with Reference	2.5 to 11	4	Adj	5.7	SO-8
LTC1843	Dual Ultralow Power Comparators with Reference	2.5 to 11	4	Adj	5.7	SO-8
LTC1998	High Accuracy Comparator with 1.2V Reference	1.5 to 5.5	150	Adj	3.5	SOT-23
LT6108	High Side Current Sense Amplifier with Reference and Comparator	2.7 to 60	3	10	650	MSOP-8, 2x3 DFN-8
LT6109	High Side Current Sense Amplifier with Reference and 2 Comparators	2.7 to 60	3	10	700	MSOP
LT6118	Current Sense Amplifier, Reference, and Comparator with POR	2.7 to 60	3	10	650	MSOP-8, 2x3 DFN-8
LT6119	Current Sense Amplifier, Reference, and 2 Comparators with POR	2.7 to 60	3	10	700	MSOP

Special Functions/Battery Charger Support Devices

LTC2943: Multicell Battery Gas Gauge with Temperature, Voltage and Current Measurement

Features

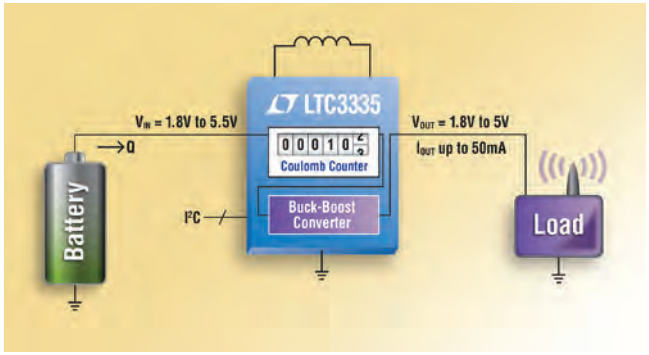
- Measures Accumulated Battery Charge and Discharge
- 3.6V to 20V Operating Range
- 14-Bit ADC Measures Voltage, Current and Temperature
- 1% Voltage, Current and Charge Accuracy
- 3mm x 3mm DFN-8 Package



LTC3335: Nanopower Buck-Boost DC/DC with Integrated Coulomb Counter

Features

- 680nA Input Quiescent Current (Output in Regulation at No Load)
- 1.8V to 5.5V Input Operationg Range
- Selectable Output Voltages of 1.8V, 2.5V, 2.8V, 3V, 3.3V, 3.6V, 4.5V, 5V
- Integrated Coulomb Counter Measures Accumulated Battery Discharge
- ±5% Battery Discharge Measurement Accuracy



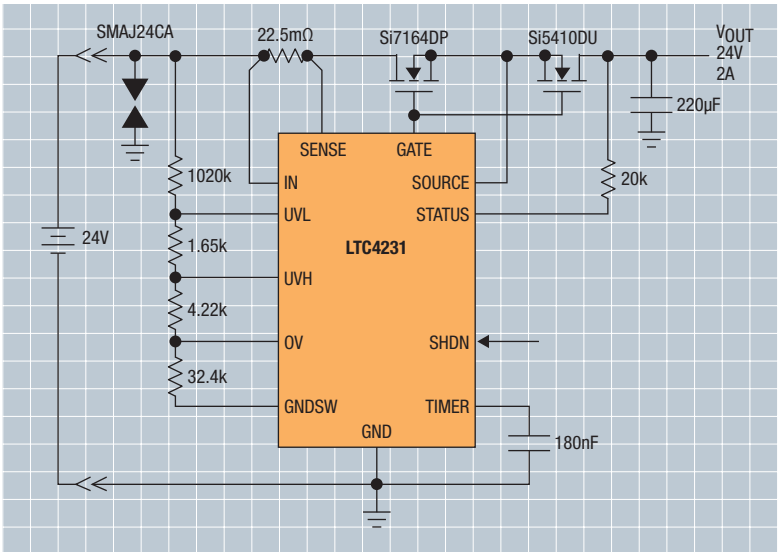
Part Number	Supply Voltage (V)	Max Shutdown Current (µA)	Measures Accumulated Charge & Discharge	Charge Accuracy (%)	Integrated R_{SENSE}	Measures Current	Integrated Temperature Sensor	Interface	Package (mm x mm)
Battery Gas Gauges (Coulomb Counters)									
LTC4150	2.7 to 8.5	1.5	✓	No Spec	–	–	–	2 µC I/O Pins	MSOP-10
LTC2941/-1	2.7 to 5.5	2	✓	1	– / ✓	–	–	I²C/SMBus	2x3 DFN-6, MSOP-8
LTC2942/-1	2.7 to 5.5	2	✓	1	– / ✓	✓	✓	I²C/SMBus	2x3 DFN-6
LTC2943/-1	3.6 to 20	25	✓	1	– / ✓	✓	✓	I²C/SMBus	3x3 DFN-8
LTC2944	3.6 to 60	50	✓	1	–	✓	✓	I²C/SMBus	3x3 DFN-8

LTC4231: Micropower Hot Swap Controller

Features

- Enables Safe Battery or Board Insertion and Removal
- Low 4µA Quiescent Current, 0.3µA in Shutdown
- Filtered Circuit Breaker with 1µs Fast Current Limit
- Overvoltage and Undervoltage Protection
  - Adjustable Undervoltage Hysteresis
  - Divider Strobed Ground for Reduced Current
- 2.7V to 36V Operating Range
- Reverse Battery Protection to –40V
- Controls Single or Back-to-Back N-Channel MOSFETs
- MOSFET On Status Output
- 3mm x 3mm QFN-12 and MSOP-12 Packages

Battery Hot Swap with Reverse Protection



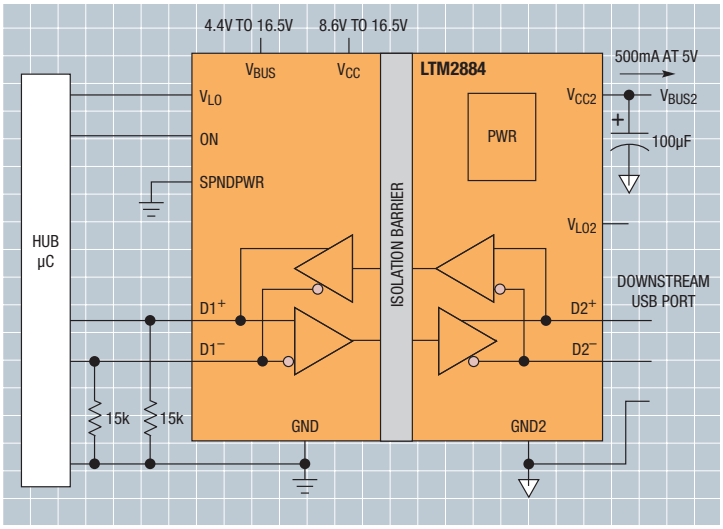
Special Functions/Battery Charger Support Devices

LTM®2884: Isolated USB Transceiver with Isolated Power

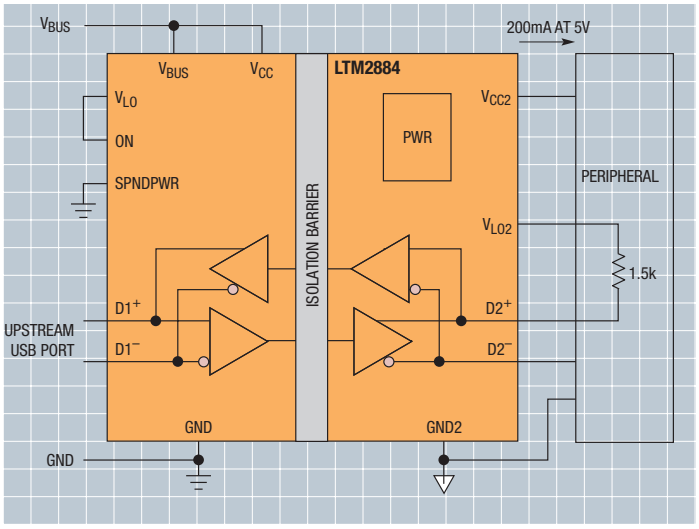
Features

- Isolated USB Transceiver: 2500V_{RMS} for 1 Minute
- USB 2.0 Full Speed and Low Speed compatible
- Integrated Isolated DC/DC Converter, External or Bus Powered
- Auto-Configuration of Bus Speed
- 15mm x 15mm BGA-44 Package

Powered 2.5W Isolated Hub Port

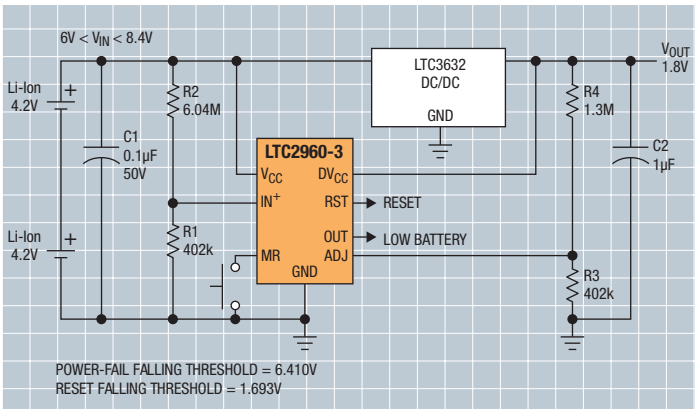


Bus Powered 1W Isolated Peripheral Device



Nano-Current Supervisors

Portable applications will appreciate the low power consumption of our nano-current supervisors, which can directly monitor voltages up to 36V. Resistor-programmable or pin-selectable thresholds provide flexibility in small footprints.



LTC2960 36V Nano-Current 2-Input Voltage Monitor

Features

- 850nA Quiescent Current
- Operating Range: 2.5V < V_{CC} < 36V
- 1.5% (Max) Accuracy Over Temperature
- Adjustable Reset Threshold
- Adjustable IN+/IN– Threshold
- 2mm × 2mm DFN-8 and TSOT-8 Packages

Part Number	# of Voltage Monitors (# of Adj Inputs)	Monitor Voltages (V)	Threshold Accuracy	Reset Pulse Width	Supply Current (µA)	Power Fail Warning	Manual Reset	Comments	Package (mm x mm)
Nano-Current Supervisors									
LTC2960	2 (2)	Adj	1.5%	15ms/ 200ms	0.85	✓	✓	Resistor Programmable Reset and UV/OV Thresholds	TSOT-8, 2x2 DFN-8
LTC2934	1 (1)	Adj	1.5%	15ms/ 200ms	0.5	✓	✓	Resistor Programmable Reset and Power-Fail Thresholds	TSOT-8, 2x2 DFN-8
LTC2935	1 (1)	1.6 to 6	1.5%	200ms	0.5	✓	✓	8 Pin-Selectable Reset and Power-Fail Thresholds	TSOT-8, 2x2 DFN-8

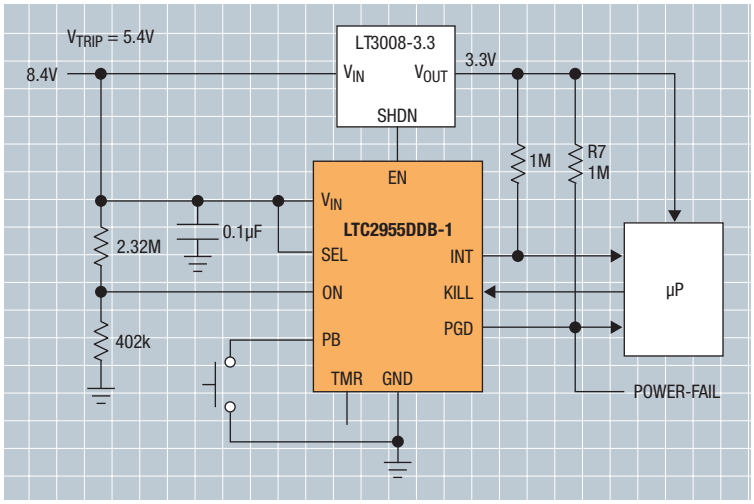
Pushbutton Controllers

Our pushbutton controllers solve the inherent bounce problem associated with all mechanical contacts, while also enabling power supply converters and releasing a processor once the supply is fully powered up. Wide voltage operation, rugged ESD protection, small size, low quiescent current and ease of design distinguish these pushbutton controllers from discrete implementations.

LTC2955: Pushbutton On/Off Controller with Automatic Turn-On

Features

- Automatic Turn-On via Voltage Monitor Input
- Wide Input Supply Range: 1.5V to 36V
- Low Supply Current: 1.2µA
- ±25kV ESD HBM on PB Input
- ±36V Wide Input Voltage for PB Input
- 3mm x 2mm DFN-10 and TSOT-8 Packages



Part Number	Description	Supply Voltage	Supply Current	Turn-On Debounce Time	System OK Response Time	Interrupt Debounce Time	Turn-Off Debounce Time	Turn-Off Delay	ESD	Package
Pushbutton Controllers										
LTC2950	Basic Pushbutton Controller	2.7V to 26V	6µA	Adj	512ms	Adj	n/a	1024ms	10kV	TSOT-8, DFN-8
LTC2951	Basic Pushbutton Controller	2.7V to 26V	6µA	128ms	512ms	Adj	n/a	Adj	10kV	TSOT-8, DFN-8
LTC2952	Pushbutton Controller with 2 Ideal Diode-OR Controllers for Load Sharing or Automatic Switchover Applications	2.7V to 28V	25µA	Adj	400ms	26ms	Adj	400ms	8kV	TSSOP-20, QFN-20
LTC2953	Pushbutton Controller with Supply Monitor, UVLO and Power Fail Comparators for Supervisory Applications	2.7V to 27V	12µA	32ms	512ms	32ms	Adj	n/a	10kV	DFN-12
LTC2954	Pushbutton Controller with Interrupt Logic for Menu-Driven Applications	2.7V to 26V	6µA	Adj	512ms	32ms	Adj	n/a	10kV	TSOT-8, DFN-8
LTC2955	Pushbutton Controller with Automatic Turn-On and Interrupt Logic for Menu-Driven Applications	1.5V to 36V	1.2µA	32ms	512ms	32ms	Adj	n/a	25kV	TSOT-8, DFN-10
LTC2956	Wake-Up Timer with Pushbutton Controller	1.5V to 36V	0.3µA	32ms	n/a	n/a	Adj	n/a	25kV	MSOP-12, DFN-12

High Side and Low Side Current Sensing

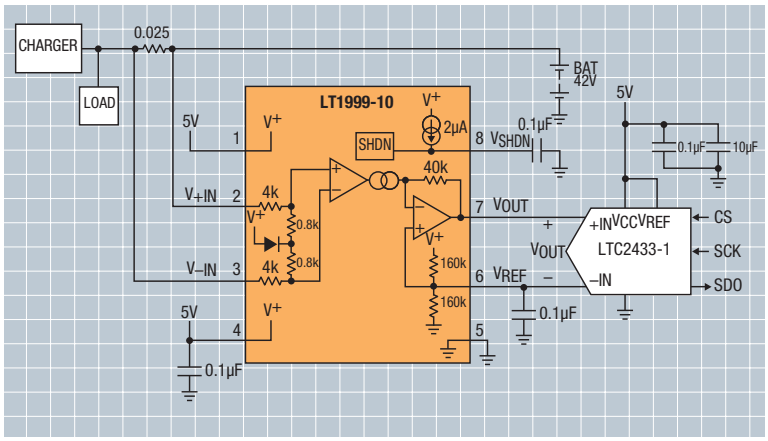
Sensing and controlling current flow is a fundamental requirement in many battery charger and monitor applications.

High side current sense amplifiers extract small differential voltages from high common mode voltages. This is used to measure the voltage on a small sense resistor placed in series between a power supply and load, providing a direct measurement of current flowing into the load.

In some applications, low side current sensing can be used, where a sense resistor is placed between load and ground. The best solutions for low side sensing are micropower, rail-to-rail input amplifiers with low input bias current and low offset voltage.

For more information, see our complete current sense solutions guide at **www.linear.com/currentsense**

LT1999: High Voltage, Bidirectional Current Sense Amplifier



Dual Current Sensor for Charge/Discharge Monitoring

Part Number	Directional Sense	Input Voltage Range (V)	Response Time (µs)	V_{OS} Max (µV)	V_{OS} Offset Drift	I_{BIAS} Max	Gain Settings	Package
High Side Current Sense Amplifiers								
LT1787	Bidirectional	2.5 to 65	10	75	0.5µV/°C	20µA	Fixed Gain=8	SO-8, MSOP-8
LT1787HV	Bidirectional	2.5 to 65	10	75	0.5µV/°C	20µA	Fixed Av=8	SO-8, MSOP-8
LTC4151	Unidirectional	7 to 80	n/a	4000	n/a	n/a	n/a	DFN-10, MSOP-10
LT6100	Unidirectional	4.1 to 48	40	300	0.5µV/°C	10µA	10,12.5,20,25,40,50V/V	DFN-8, MSOP-8
LTC6101	Unidirectional	4 to 105	1	300	1µV/°C	170nA	Adj w/ 2 Resistors	SOT-23, MSOP-8
LTC6101HV	Unidirectional	5 to 105	1	300	1µV/°C	170nA	Adj w/ 2 Resistors	SOT-23, MSOP-8
LTC6102	Unidirectional	4 to 105	1	10	25nV/°C	3nA	Adj w/ 2 Resistors	DFN-8, MSOP-8
LTC6102HV	Unidirectional	5 to 105	1	10	50nV/°C	3nA	Adj w/ 2 Resistors	DFN-8, MSOP-8
LTC6103	Unidirectional	4 to 70	1	450	1.5µV/°C	170nA	Adj w/ 2 Resistors/amp	MSOP-8
LTC6104	Bidirectional	4 to 70	1	450	1.5µV/°C	170nA	Adj w/ 3 Resistors	MSOP-8
LT6105	Unidirectional	-0.3 to 44	3.5	300	0.5µV/°C	25µA	Adj w/ 2 Resistors	DFN-6, MSOP-8
LT6106	Unidirectional	2.7 to 44	3.5	250	1µV/°C	40nA	Adj w/ 2 Resistors	SOT-23
LT6107	Unidirectional	2.7 to 44	3.5	250	1µV/°C	40nA	Adj w/ 2 Resistors	SOT-23
LT1999	Bidirectional	-5 to 80	2.5	750	5µV/ºC	2.5µA	10, 20, 50 V/V	MSOP-8, SO-8
LT6108	Undirectional	2.7 to 60	3	125	0.8µV/ºC	300µA	Adj w/ 2 Resistors	MSOP-8, DFN-8
LT6109	Undirectional	2.7 to 60	3	125	0.8µV/ºC	300µA	Adj w/ 2 Resistors	MSOP-8
LT6118	Undirectional	2.7 to 60	3	125	0.8µV/ºC	300µA	Adj w/ 2 Resistors	MSOP-8, DFN-8
LT6119	Undirectional	2.7 to 60	3	125	0.8µV/ºC	300µA	Adj w/ 2 Resistors	MSOP-8

Part Number	Description	Rail-to-Rail	Direction Sense	Input Voltage Range (V)	V_{OS} Max (µV)	V_{OS} Drift	I_{BIAS} Max	Gain	Package
Low Side Current Sense Amplifiers									
LT6015/6/7	Single/Dual/Quad Precision Over-the-Top Op Amps	In/Out	Bidirectional	0 to 76	50	0.75µV/°C	5nA	Adj w/ 2 Resistors	ThinSOT, MSOP-8, DFN-22
LT1490A/91A	Dual/Quad Over-The-Top® µPower Rail-to-Rail Op Amps	In/Out	Bidirectional	0 to 44	500	4µV/°C	8nA	Adj w/ 2 Resistors	DFN-8, DIP-8, MSOP-8, SO-8, DIP-14, SO-14
LT1636	Over-The-Top Micropower , Rail-to-Rail Single Supply Op Amp	In/Out	Bidirectional	0 to 44	225	5µV/°C	8nA	Adj w/ 2 Resistors	DFN-8, DIP-8, MSOP-8, SO-8
LT1638/39	1.2MHz, Over-The-Top Micropower Rail-to-Rail Op Amp	In/Out	Bidirectional	0 to 44	600	6µV/°C	50nA	Adj w/ 2 Resistors	DFN-8, DIP-8, MSOP-8, SO-8, DIP-14, SO-14
LTC2054/55	Single/Dual Low Power, Zero-Drift, 3V, 5V, ±5V Op Amps	Out	Bidirectional	0 to V±0.7	3	0.05µV/ºC	3nA	Adj w/ 2 Resistors	ThinSOT, DFN-8, MSOP-8
LT6105	Precision, High Side or Low Side, Current Sense Amplifier	In	Unidirectional	-0.3 to 44	300	1µV/°C	25µA	Adj w/ 2 Resistors	DFN-6, MSOP-8
LTC2057	High Voltage Low Noise Zero-Drift Op Amp	Out	Bidirectional	-0.1 to V±1.5	5	0.225µV/ºC	200µA	Adj w/ 2 Resistors	DFN-8, MSOP-8, MSOP-10, SO-8

MASTER SELECTOR GUIDES—Power Managers and Linear Battery Chargers

Battery		Charge Termination & Integration			Status Signals			Temperature Control		Package (mm x mm)	Part Number				
											Integration/Features				
Number of Battery Cells (Series)	Battery Charge Current (Max), A	Standalone	Charge Termination	Integrated Pass Transistor	I_{CHARGE} Monitor #	End-of-Charge Signal	AC Present Signal	Thermal Regulation	Thermistor Interface		Most ←				→ Least
Li-Ion/Polymer 4.2V/Cell & 4.1V/Cell Linear Battery Chargers with PowerPath Control (Power Managers)															
1	1.5	✓	✓¶	✓	✓	✓	–	✓	✓	QFN-20	LTC4099				
1	1.5	✓	✓¶	✓	✓	✓	–	✓	✓	QFN-20	LTC4160				
1	1.5	✓	✓¶	✓	✓	✓	–	✓	✓	QFN-20	LTC4098				
1	1.5	✓	✓¶	✓	✓	✓	–	✓	✓	QFN-20	LTC4098-3.6 ††				
1	1.5	✓	✓¶	✓	✓	✓	–	✓	✓	DFN-14	LTC4088				
1	1.2	✓	✓¶	✓	✓	✓	✓	✓	✓	DFN-22	LTC4090				
1	1.2	✓	✓¶	✓	–	✓	✓	✓	✓	DFN-22	LTC4089				
1	1.5	✓	✓‡	✓	✓**	✓	✓	✓	✓	QFN-24	LTC4066				
1	1.25	✓	✓‡	✓	–	✓	✓	✓	✓	QFN-16		LTC4055			
1	1.25	✓	✓‡	✓	✓	✓	–	✓	✓	DFN-12		LTC4067			
1	1.5	✓	✓‡	✓	–	✓	✓	✓	✓	DFN-14		LTC4085			
Li-Ion/Polymer 4.2V/Cell & 4.1V/Cell Linear Battery Chargers															
1	1	✓	✓¶	✓	✓	✓	✓	✓	✓	DFN-10			LTC4061		
1	1	✓	✓¶	✓	✓	✓	–	✓	–	DFN-10			LTC4062		
1	1	✓	✓¶	✓	✓	✓	–	✓	–	DFN-10			LTC4063		
1	2	✓	✓‡	–	–	✓	✓	–	✓	MSOP-10			LTC4050		
1	1.25	✓	✓‡	✓	✓	✓	✓	✓	✓	DFN-10 MSOP-10			LTC4053		
1-14	0.25	✓	✓‡	✓	✓	✓	–	✓	✓	DFN-10			LTC4079		
1	0.95	✓	✓†	✓	✓	✓	✓	✓	–	DFN-10			LTC4078/X		
1	0.95	✓	✓†	✓	✓	✓	✓	✓	–	DFN-10			LTC4075/X		
1	1.2	✓	✓†	✓	✓	✓	✓	✓	–	DFN-10			LTC4096/X		

* Current C/10, † Current C/x, ‡ Timer, § µC, ¶Timer + Current Indication, # PROG Pin Tracks Charge Current, ** Gas Gauge Capability, †† For 1-Cell $LiFePO_4$

MASTER SELECTOR GUIDES—Power Managers and Linear Battery Chargers (continued)

Battery		Charge Termination & Integration			Status Signals			Temperature Control		Package (mm x mm)	Part Number				
											Integration/Features				
											Most ←				→ Least
Number of Battery Cells (Series)	Battery Charge Current (Max), A	Standalone	Charge Termination	Integrated Pass Transistor	I_{CHARGE} Monitor #	End-of-Charge Signal	AC Present Signal	Thermal Regulation	Thermistor Interface						
Li-Ion/Polymer 4.2V/Cell & 4.1V/Cell Linear Battery Chargers															
1	0.95	✓	✓†	✓	✓	✓	✓	✓	–	DFN-10			**LTC4077**		
1	0.95	✓	✓†	✓	✓	✓	✓	✓	–	DFN-10			**LTC4076**		
1	0.95	✓	✓¶	✓	✓	✓	–	✓	✓	DFN-8			**LTC4095**		
1	0.95	✓	✓†	✓	✓	✓	✓	✓	–	DFN-8			**LTC4068/X**		
1	0.95	✓	✓*	✓	✓	✓	✓	✓	–	DFN-8			**LTC4058/X**		
1, 2	2	✓	✓‡	–	–	✓	✓	–	–	MSOP-10				**LTC1732**	
1, 2	2	✓	✓‡	–	–	✓	–	–	–	MSOP-8				**LTC1731**	
1	1.5	✓	✓‡	✓	✓	✓	✓	✓	✓	MSOP-10E				**LTC1733**	
1	0.8	✓	✓*	✓	✓	✓	–	✓	–	ThinSOT				**LTC4054/X**	
1	0.75	✓	✓¶	✓	✓	✓	–	✓	✓	DFN-6				**LTC4070**	
1	0.75	✓	✓‡	✓	✓	✓	✓	✓	–	DFN-6				**LTC4065/A**	
1	0.7	✓	✓‡	–	–	✓	–	–	–	ThinSOT				**LTC4056**	
1	0.9	–	✓§	✓	✓	–	✓	✓	–	DFN-6				**LTC4059/A**	
1	0.8	–	✓§	✓	✓	–	–	✓	–	ThinSOT				**LTC4057**	
1	1	✓	✓‡	✓	✓	✓	✓	✓	✓	MSOP-10E				**LTC4064**	
1	0.7	–	✓§	–	✓	–	–	–	–	ThinSOT					**LTC1734**
Li-Ion/Polymer Coin Cell Battery Chargers															
1	0.15	✓	✓*	✓	✓	✓	–	✓	–	ThinSOT				**LTC4054L**	
1	0.9	–	✓§	✓	✓	–	✓	✓	–	DFN-6				**LTC4059/A**	
1	0.25	✓	✓‡	✓	✓	✓	✓	✓	–	DFN-6				**LTC4065L/LX**	
1	50mA††	✓	✓	✓	–	–	–	–	✓	2x3 DFN-8, MSOP-8E				**LTC4070**	
1	50mA	✓	✓	✓	–	–	–	–	✓	2x3 DFN-8, MSOP-8E				**LTC4071**	
1	0.18	–	✓§	–	✓	–	–	–	–	ThinSOT					**LTC1734L**

* Current C/10, † Current C/x, ‡ Timer, § µC, ¶ Timer + Current Indication, # PROG Pin Tracks Charge Current, ** Gas Gauge Capability, †† 500mA With External PFET

MASTER SELECTOR GUIDES—Switch Mode Battery Chargers

Battery		Charge Termination & Integration			Status Signals			Temperature Control		Package (mm x mm)	Part Number
Number of Battery Cells (Series)	Battery Charge Current (Max), A	Standalone	Charge Termination	Integrated Power Transistor	I_{CHARGE} Monitor‡‡	End-of-Charge Signal	AC Present Signal	Thermal Regulation	Thermistor Interface		Integration/Features: Most ⟵ ⟶ Least
NiMH/NiCd Battery Chargers											
1-16	4	✓	✓#	–	–	✓	✓	–	✓	TSSOP-20E	**LTC4011 Switch Mode**
1-16	4	✓	✓#	–	–	✓	✓	–	✓	TSSOP-16E	**LTC4010 Switch Mode**
1-4	2	✓	✓§	–	–	✓	✓	–	✓	DFN-16 TSSOP-16	**LTC4060 Linear**
Li-Ion/Polymer Switch Mode Battery Chargers											
1	4	✓	✓**	✓	–	✓	✓	✓	✓	QFN-36	**LT3651-4.x**
2	4	✓	✓**	✓	–	✓	✓	✓	✓	QFN-36	**LT3651-8.x**
1	2	✓	✓‡	✓	–	–	✓	–	✓	SSOP-24	**LTC4001/-1**
1-2	2	✓	✓**	✓	–	–	✓	✓	✓	DFN-12	**LT3650**
3-4	4	✓	✓‡	–	✓	✓	✓	–	✓	SSOP-24	**LTC4007**
1-4	0.4	✓	✓‡	✓	✓	✓	–	✓	✓	QFN-16	**LTC4121**
2-4	4	✓	✓‡	–	✓	✓	✓	–	✓	SSOP-16	**LTC4006**
1-2	2	✓	✓‡	–	–	–	–	–	–	SSOP-24	**LTC1980**
1-2, adj	1.5	–	✓¶,††	✓	–	✓	–	–	–	SSOP-16 SSOP-28	**LT1571**
1-2	4	✓	✓‡	–	–	✓	–	–	✓	DFN-10 SO-8	**LTC4002**

* Current C/10, † Current C/x, ‡ Timer, ¶ µC, § T, t, -dV , # T, t, -dV, dT/dt, ** Timer + Current, †† for Li-Ion Termination, use LTC1729, ‡‡ PROG Pin Tracks Charge Current

MASTER SELECTOR GUIDES—Switch Mode Battery Chargers (continued)

Battery		Charge Termination & Integration			Status Signals			Temperature Control		Package (mm x mm)	Part Number				
V_{BAT} Range, V	Battery Charge Current (Max), A	Standalone	Charge Termination Method(s)	Integrated Pass Transistor	I_{CHARGE} Monitor‡‡	End-of-Charge Signal	AC Present Signal	Thermal Regulation	Thermistor Interface		Integration/Features: Most ⟵				⟶ Least
Smart Battery Chargers															
3.5-18	3	✓	SMBus‡,¶	–	–	–	✓	–	✓	QFN-38	**LTC4110**				
3.5-28	4	✓	SMBus¶	–	–	–	–	–	✓	TSSOP-48	**LTC1760**				
3-21	8	✓	SMBus¶	–	–	–	✓	–	✓	SSOP-36	**LTC1759**				
3.5-26	4	✓	SMBus¶	–	–	–	✓	–	✓	SSOP-24		**LTC4100**			
3.0-5.5	4	✓	SMBus¶	–	–	–	✓	–	✓	SSOP-24		**LTC4101**			
Lead-Acid, Li-Ion/Polymer, NiMH/NiCd Switch Mode Battery Chargers															
2.5-55	20A+	✓	**	✓	✓	✓	–	✓	✓	5x7 QFN-38	**LTC4020**				
1-4	0.4	✓	✓‡	✓	✓	✓	–	✓	✓	QFN-16		**LTC4121**			
1-14	0.25	✓	✓‡	✓	✓	✓	–	✓	✓	DFN-10			**LTC4079**		
3.5-28	8	–	SPI¶	–	–	–	–	–	–	SSOP-36, QFN-38	**LTC1960**				
2.5-23	8	–	✓¶,††	–	–	✓	–	–	–	SSOP-28		**LT1505**			
3.3-18	2	✓	✓**	✓	–	✓	–	✓	✓	3x3 DFN-12, MSOP-12E		**LT3652HV**			
3.3-14.4	2	✓	✓**	✓	–	✓	–	✓	✓	3x3 DFN-12, MSOP-12E		**LT3652**			
2-28	4	–	✓¶	–	✓	–	✓	✓	–	QFN-20			**LTC4012/-1/-2/-3**		
2-28	4	–	✓¶	–	✓	–	✓	✓	–	QFN-20			**LTC4009/-1/-2**		
3-28	4		✓¶	–	–	✓	✓	–	✓	SSOP-20			**LTC4008**		
2.5-26	3	–	✓¶,††	✓	–	–	–	–	–	SO-24				**LT1511**	
1.5-20	0.75	–	✓¶,††	✓	–	–	–	–	–	SO-8				**LT1512**	
1.5-20	2	–	✓¶,††	✓	–	–	–	–	–	DD Pak, TO-220				**LT1513**	
2.5-26	2	–	✓¶,††	✓	–	–	–	–	–	TSSOP-20, SSOP-28				**LT1769**	
2.5-26	1.5	–	✓¶,††	✓	–	–	–	–	–	TSSOP-16, SSOP-28				**LT1571**	
2.5-26	1	–	✓¶,††	✓	–	–	–	–	–	SO-8, SSOP-16, SO-16				**LT1510**	

* Current C/10, † Current C/x, ‡ Timer, ¶ µC , § T, t, -dV , # T, t, -dV, dT/dt, ** Timer + Current, †† for Li-Ion Termination, use LTC1729 , ‡‡ PROG Pin Tracks Charge Current

MASTER SELECTOR GUIDES—Multifunction PMICs

Onboard Regulators				Battery Charger/Power Manager				Other Features		Package (mm x mm)	Part Number (Most ⟷ Integration/Features ⟷ Least)					Page #
Number of Regulators	Buck(s) (I_{OUT})	Buck-Boost (BB)/ Boost (I_{OUT})	LDO(s) (I_{OUT})	Li-Ion/Polymer Charger	Maximum Charge Current (A)	PowerPath Topology	Ideal Diode	Input Voltage (V)	Interface							
Li-Ion/Polymer Multifunction Power Management Integrated Circuits (PMICs)																
5	400mA x 2	1A BB, 0.8A Boost	3.3V, 20mA	Sync Buck + Linear	1.5	Switch Mode	Int + Ext (opt.)	5, USB, Li Ion	–	4x6 QFN-38	**LTC3586/-1**					7, 11
5	600mA, 400mA x 2	10-LED Boost	2 x 150mA	Linear	1.5	Linear	Int + Ext (opt.)	5, USB, Li Ion, Hi-V Bat-Track, OVP	–	4x7 QFN-44	**LTC3577/-1/-3/-4**					7, 12
4	600mA, 400mA x 2	–	2 x 150mA	Linear	1.5	Linear	Int + Ext (opt.)	5, USB, Li Ion, Hi-V Bat-Track, OVP	–	4x7 QFN-44	**LTC3677/-3**					12
4	400mA x 2, 1A	–	3.3V, 20mA	Sync Buck + Linear	1.5	Switch Mode	Int + Ext (opt.)	5, USB, Li-Ion, Hi-V 38V with 60V transients; OVP: 68V	I^2C	4x6 QFN-38		**LTC3576/-1**				7, 11
4	400mA x 2	1A BB	3.3V, 25mA	Sync Buck + Linear	1.5	Switch Mode	Int + Ext (opt.)	5, USB, Li Ion	I^2C	4x5 QFN-28		**LTC3556**				11
4	600mA, 400mA x 2	–	3.3V, 25mA	Linear	1.5	Linear	Int + Ext (opt.)	5, USB, Li Ion, Hi-V 38V max	–	4x4 QFN-28		**LTC3557/-1**				7, 12
4	1A, 400mA x 2	–	3.3V, 25mA	Sync Buck + Linear	1.5	Switch Mode	Int + Ext (opt.)	5, USB, Li Ion	I^2C	4x5 QFN-24		**LTC3555/-1/-3**				7, 11
3	400mA, 600mA	–	Flexible Gain Block for LDO Controller	Linear	0.5	Linear	–	5, USB, Li Ion	–	4x4 QFN-24			**LTC3455/-1**			7, 12
2	–	1A BB	3.3V, 25mA	Sync Buck + Linear	1.5	Switch Mode	Int + Ext (opt.)	4.25 to 5.5	–	4x4 QFN-24				**LTC3566**		11
2	–	1A BB	3.3V, 25mA	Sync Buck + Linear	1.5	Switch Mode	Int + Ext (opt.)	4.25 to 5.5	I^2C	4x4 QFN-24				**LTC3567**		11
2	200mA x 2	–	–	Linear	0.5	Linear	–	4.35V to 5.5V	–	3x3 QFN-20				**LTC3554**		12
2	200mA	–	150mA	Linear	0.5	Linear	–	4.35V to 5.5V	–	3x3 QFN-20				**LTC3553**		12
2	400mA	0.4A BB	–	Linear	0.95	–	–	5, USB	–	3x3 QFN-20				**LTC3558**		13
2	400mA x 2	–	–	Linear	0.95	–	–	5, USB	–	3x3 QFN-16				**LTC3559/-1**		7, 13
2	400mA, 800mA	–	–	Linear	0.95	–	–	4.25 to 8	–	3x5 DFN-16				**LTC3552/-1**		13
1	600mA	–	–	Linear	0.95	–	–	4.3 to 8	–	3x5 DFN-16					**LTC3550/-1**	13
1	300mA	–	–	Linear	0.5	–	–	2.7 to 4.5	–	3x3 DFN-10, MSOP-10E					**LTC4080**	13
1	300mA	–	–	Linear	0.5	–	–	2.7 to 4.5	–	3x3 DFN-10					**LTC4081**	13

µModule Battery Chargers

A µModule Power Product simplifies implementation, verification, and manufacturing of complex power circuits by integrating the power function in a compact molded plastic package.

LTM8062/A: 32V_{IN}, 2A µModule Power Tracking Battery Charger

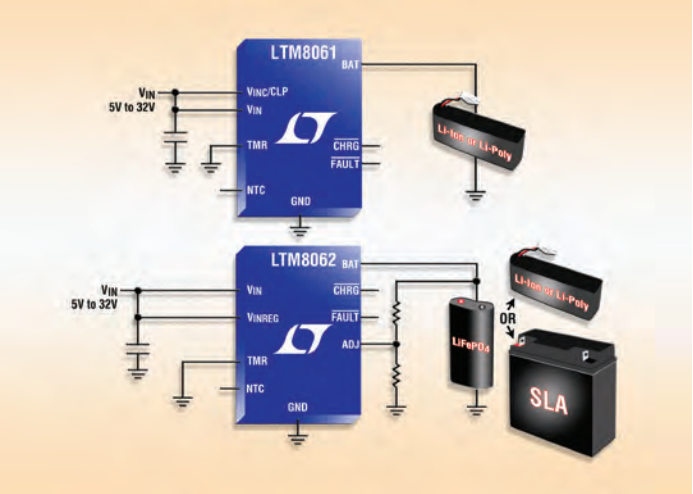
Features

- Complete Battery Charger System
- Input Supply Voltage Regulation Loop for Peak Power Tracking in MPPT (Maximum Peak Power Tracking) Solar Applications
- Resistor Programmable Float Voltage Up to 14.4V on the LTM8062 and 18.8V on the LTM8062A
- Wide Input Voltage Range: 4.95V to 32V (40V Abs Max)
- 9mm × 15mm × 4.32mm LGA Package

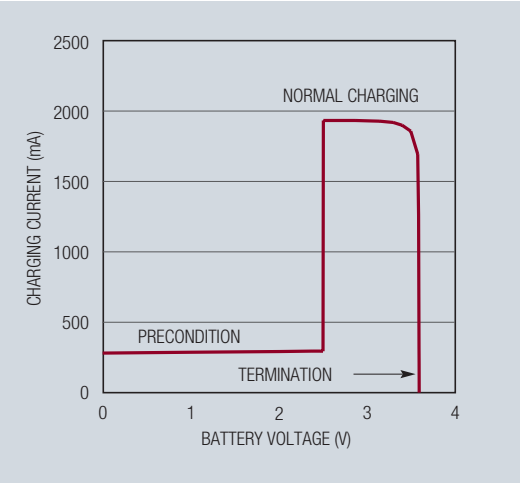
Applications

- Industrial Handheld Instruments
- 12V to 24V Automotive and Heavy Equipment
- Desktop Cradle Chargers
- Solar Power Battery Charging

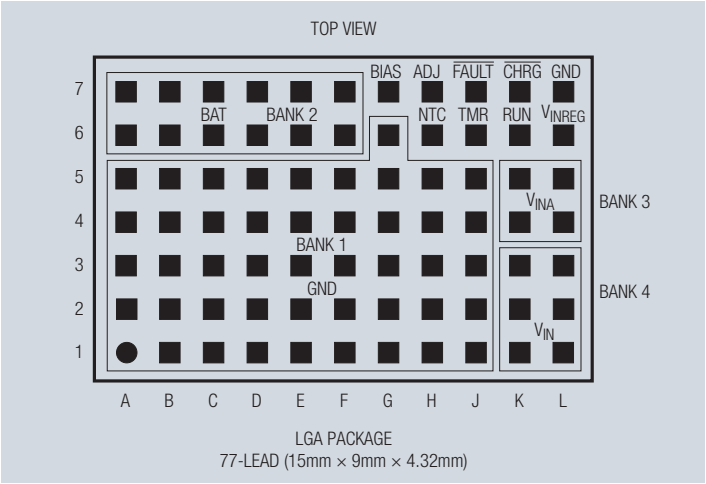
2A µModule Battery Chargers



Charge Current vs Battery Voltage



Pin Configuration



Part Number	Battery Float Voltage (V)	Input Voltage (V)	Charge Current (A)	Battery Chemistry	Package Type	Package Dimensions (mm)
µModule Battery Chargers						
LTM8061	4.1 - 8.4	4.95 - 32	2	Li-Ion, Li-Poly	LGA	9 x 15 x 4.3
LTM8062	3.3 - 14.4	4.95 - 32	2	Li-Ion, Li-Poly, Lead Acid, $LiFePO_4$	LGA	9 x 15 x 4.3
LTM8062A	3.3 - 18.8	4.95 - 32	2	Li-Ion, Li-Poly, Lead Acid, $LiFePO_4$	LGA	9 x 15 x 4.3

Notes:

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