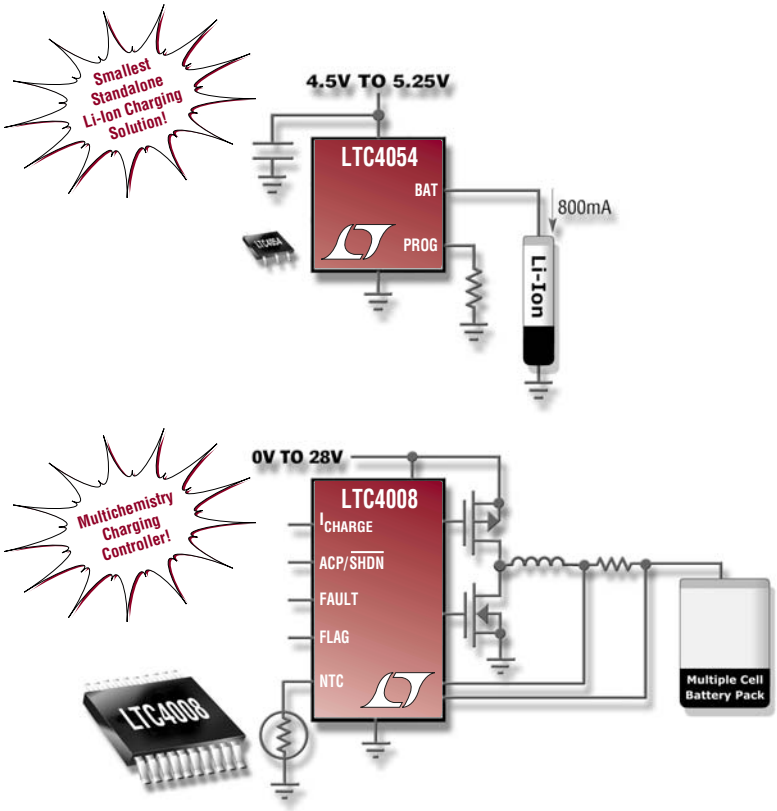
Linear Technology Chronicle

High Performance Analog Solutions from Linear Technology Vol. 12 No. 2

Focus...

Battery Chargers



Inside This Issue:

Battery charging applications present many challenges, particularly selecting the right charge current given the maze of batteries, battery capacities and battery chemistries. Heat dissipation must be considered as size and weight requirements of portable devices continue to shrink. Designing for adequate thermal management while still providing an acceptable charge rate is not a trivial task. Too much current presents thermal dissipation issues, which if not properly addressed, can damage not only the battery charger but also the portable device being charged. Too little current translates into excessively long charge times.

Linear Technology has a wide range of products to meet your charge current, input voltage, battery chemistry and heat dissipation requirements. From linear chargers at lower currents to pulse chargers and switching regulators at higher current levels, there is most likely a charger that is right for your application.

Single Cell Li-Ion Chargers

Not All Chargers Are Alike . . .

In addition to standard charging features, LTC's Li-Ion battery chargers provide an additional feature set of innovative enhancements that just aren't available anywhere else.

1. **Thermal regulation—if the die temperature rises and exceeds a preset value due to high charge current and/or elevated ambient temperature, the IC gradually reduces the charge current.**

   Key Benefits

   • Provides maximum charging current limited only by heat dissipation

   • Greatly simplifies thermal analysis design considerations

2. **A unique patented charge current monitor—converts the charge current to a voltage that appears at the PROG pin.**

   Key Benefits

   • Allows real-time monitoring of the charge current

   • Eliminates the need for an external current sense resistor

   • Ideal for gas gauging

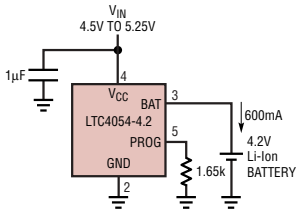
Combine these with internal current sense resistors, 0.6% preset charge voltage accuracy, small package sizes and internal/external pass transistor options and it's easy to see why LTC is a leader in battery charging products.

LTC4054 Linear Charger

The new LTC4054 battery charger provides a complete lithium-ion charging solution in a small ThinSOT™ package. This makes it the smallest standalone battery charger available. No microprocessor intervention is required. Simply add a small bypass capacitor and a resistor to set the charge current and the circuit is complete. Features include:

- **An internal 800mA pass transistor**
- **An internal current sense resistor**
- **C/10 charge termination**
- **Thermal limit charging—elevated temperatures reduce the maximum charging current**
- **PROG pin for gas gauging**

LTC4054: Standalone Li-Ion Battery Charger in ThinSOT Package



Single Cell Li-Ion Battery Chargers

Part Number	Charger Type	Charge Current (A)	Input Voltage (V)	Microcontroller Needed?	Pass Element Internal/ External	Charge Termination	Ambient Temperature Monitor?	Package	Targeted Battery Capacities, mAh*
LTC1734L	Linear	0.05 to 0.18	4.55 to 8	Yes	Ext	µC Required	—	SOT-23-6	Up to 450
LTC4056	Linear	0.2 to 0.7	4.5 to 6.5	No	Ext	Timer	—	SOT-23-8	Up to 1,700
LTC1734	Linear	0.2 to 0.7	4.55 to 8	Yes	Ext	µC Required	—	SOT-23-6	Up to 1,700
LTC4054	Linear	to 0.8	4.25 to 6.5	No	Int	C/10	—	SOT-23-5	Up to 2,000
LTC4050	Linear	to 1	4.5 to 12	No	Ext	Timer	Yes	MSOP-10	Up to 2,500
LTC1730	Pulse	to 1	4.5 to 12	No	Ext	Timer	Yes	SSOP-16	Up to 2,500
LTC1731	Linear	to 1	4.5 to 12	No	Ext	Timer	—	MSOP-8	Up to 2,500
LTC1732	Linear	to 1	4.5 to 12	No	Ext	Timer	—	MSOP-10	Up to 2,500
LTC4053	Linear	1.25 (Wall Cube), 0.1 to 0.5 (USB)	4.25 to 6.5	No	Int	Timer	Yes	MSOP-10	Up to 3,000
LTC1733	Linear	0.5 to 1.5	4.5 to 6.5	No	Int	Timer	Yes	MSOP-10	Up to 3,750
LT1571-5	Switcher (500kHz)	to 1.5	6.2 to 28	Yes	Int	C/5 Flag, µC Required	—	SSOP-16	Up to 3,750
LTC4052	Pulse	to 2	4.5 to 12	No	Int	Timer	—	MSOP-8	Up to 5,000

*Assumes a charging rate in the range of 0.4C to 1C

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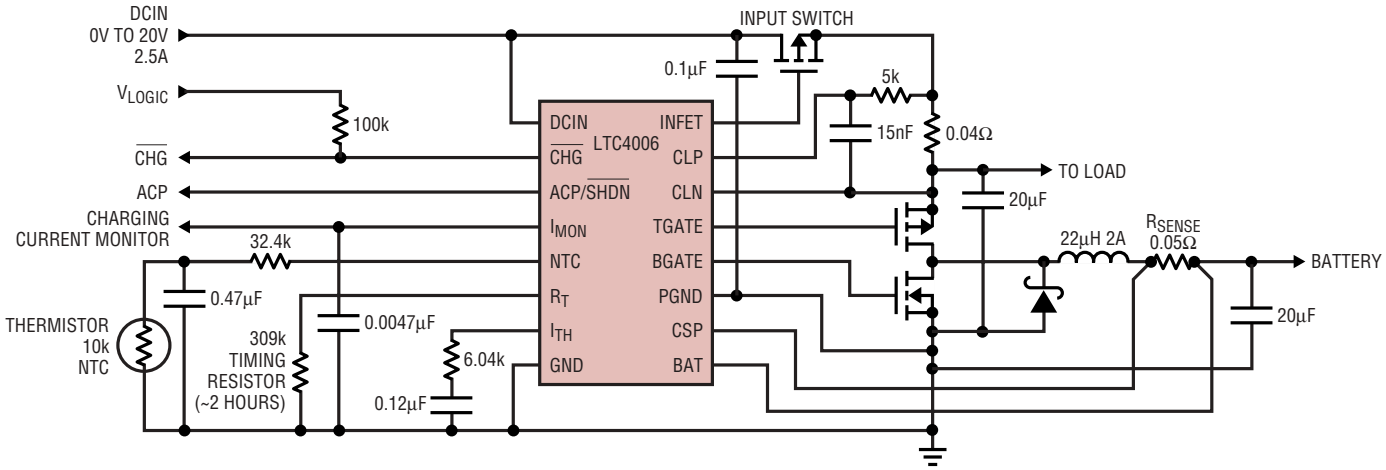
Chargers for Li-Ion Battery Packs

Battery packs often require high efficiency chargers due to the amount of heat generated when charging. This is why switching regulators typically displace linear chargers and pulse chargers at the higher charge currents.

The new LTC4006 switching regulator battery charger controller is loaded with features, yet is simple to design with. It can provide efficiencies up to 95%, requires only a few external components and provides very precise battery charging, maintaining optimal battery performance while keeping your system costs down.

- **High efficiency switching regulator battery charger**
- **Charges up to four Li-Ion cells**
- **Up to 4A of charge current**
- **Built-in charge termination allows standalone operation**
- **Automatic recharge at 3.9V/cell**

2A Li-Ion Battery Charger



Chargers for Li-Ion Battery Packs

Part Number	Charger Type	Charge Current (A)	Input Voltage (V)	Number of Cells	Microcontroller Needed?	Pass Element Internal/ External	Charge Termination	Package	Targeted Battery Capacities, mAh*
LTC1731	Linear	to 1	4.5 to 12	1 to 2	No	Ext	Timer	MSOP-8	Up to 2,500
LTC1732	Linear	to 1	4.5 to 12	1 to 2	No	Ext	Timer	MSOP-10	Up to 2,500
LT®1510-5	Switcher (500kHz)	to 1	6.2 to 29	1 to 4	Yes	Int	µC Required	SO-8, SO-16, SSOP-16	Up to 2,500
LT1571	Switcher (200kHz)	to 1.5	6.2 to 28	1 to 4	Yes	Int	µC Required	SSOP-28	Up to 3,000
LT1511	Switcher (200kHz)	to 3	6 to 28	1 to 4	Yes	Int	µC Required	SO-24	Up to 7,500
LTC4006	Sync Switcher Controller	to 4	6 to 28	2 to 4	No	Ext	Timer	SSOP-16	Up to 10,000
LTC4007	Sync Switcher Controller	to 4	6 to 28	3 to 4	No	Ext	Timer, Temp	SSOP-24	Up to 10,000
LTC4008	Sync Switcher Controller	to 4	6 to 28	2 to 6	Yes	Ext	µC Required	SSOP-20	Up to 10,000

*Assumes a charging rate in the range of 0.4C to 1C

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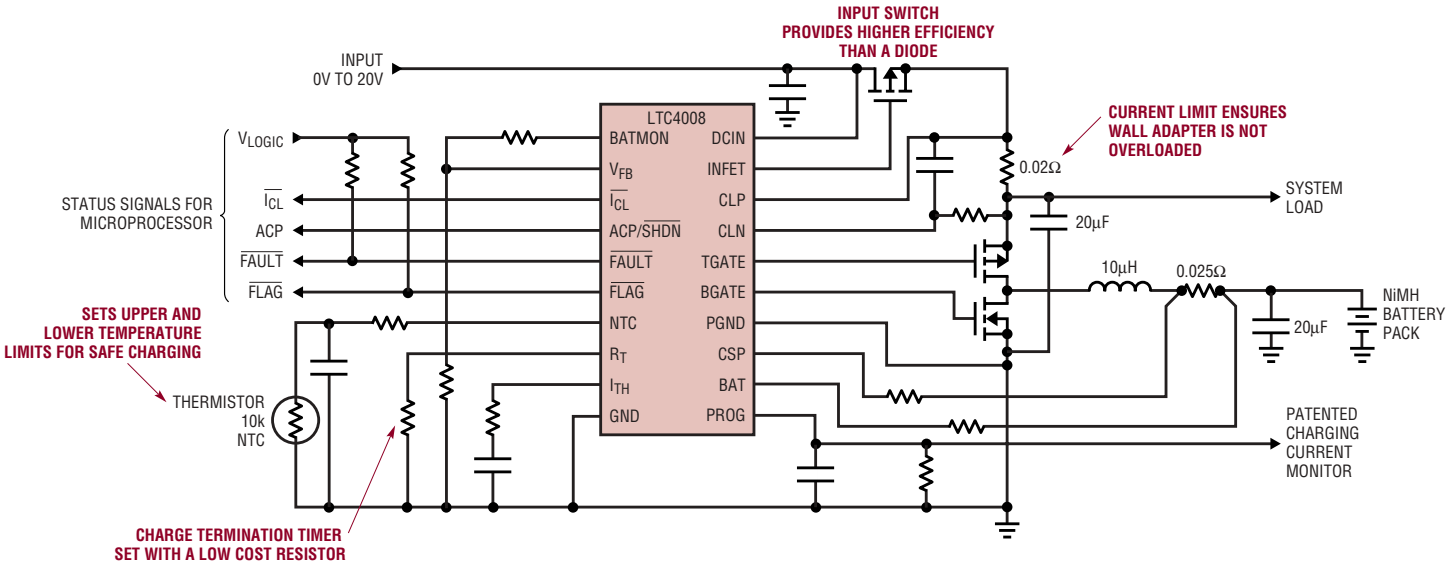
Nickel-Based Battery Packs (NiCd and NiMH)

Though not as high in energy density, NiMH and NiCd batteries are still used in many portable applications, as they provide lower cost alternatives to Li-Ion batteries. With NiMH and NiCd batteries, microcontroller intervention is often required for proper charger termination.

The new LTC4008 is the latest multichemistry battery charger targeted for nickel-based and Li-Ion batteries. Its features include:

- **Charge currents to 4A**
- **Synchronous switching for highest efficiency**
- **Small footprint (SSOP-20)**
- **Fewest external components for a switcher-based solution**

4A NiMH Charger



Multichemistry Battery Chargers for NiCd and NiMH Batteries

Part Number	Charger Type	Charge Current (A)	Input Voltage (V)	Number of Cells	Pass Element Internal/ External	Charge Termination	Package	Targeted Battery Capacities, mAh*
LTC1734	Linear	0.2 to 0.7	4.55 to 8	4	Ext	µC Required	SOT-23-6	Up to 1,700
LTC1734L	Linear	0.05 to 0.18	4.55 to 8	4	Ext	µC Required	SOT-23-6	Up to 450
LTC1731	Linear	to 1	4.5 to 12	6	Ext	µC Required	MSOP-8	Up to 2,500
LTC1732	Linear	to 1	4.5 to 12	6	Ext	µC Required	MSOP-10	Up to 2,500
LT1510-5	Switcher 500kHz	to 1	6.2 to 29	18	Int	µC Required	SO-8, SO-16, SSOP-16	Up to 2,500
LTC4008	Sync Switcher Controller	to 4	6 to 28	16	Ext	µC Required	SSOP-20	Up to 10,000

*Assumes a charging rate in the range of 0.4C to 1C.

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Battery Chemistries

With a host of different battery types, sizes and capacities and variations between different manufacturers, it can be difficult keeping up with the key attributes of different battery chemistries. The following table provides a relative guide to some of the key characteristics of Li-Ion, NiMH and NiCd batteries.

Relative Battery Chemistry Comparison

	NiCd	NiMH	Li-Ion
Nominal Cell Voltage (V)	1.2	1.2	3.6
Full Charge Voltage (V)	1.55	1.55	4.1 or 4.2
Nominal End of Life Voltage (V)	1	1	2.7
Battery Cost ($)	Low	Moderate	High
Self-Discharge per Month	10%	10%	6%
Current Capacity (mAh)	Lowest	Middle	Highest
Weight (for Identical Capacity)	Heavy	Moderate	Light
Mass Charge Density (mWh/gm)	Lowest	Midrange	Highest
Memory Effect	Yes	Some	No
Internal Resistance	Lowest	Low	Low (Lower than NiMH)
Continuous High Current Discharge	Excellent	Very Good	Good
Intermittent High Current Discharge	Good	Good	Excellent
End of Life Disposal Concerns	High, Cadmium Is a Toxic Metal	Low	Low

Battery Charger Architectures

Battery Charger Type Comparison

Switching	Linear	Pulse
Pros: • Low Heat Dissipation • Wide Input Voltage Range • Can Easily Provide Several Amps of Charge Current	**Pros:** • Few External Components • Very Low Noise • Small Footprint	**Pros:** • Very Low Heat Dissipation • Few External Components • Small Footprint
Cons: • More External Components • Larger Footprint • Potential Switching Noise	**Cons:** • Limited Input Supply Range • Requires Regulated Input • Usually Confined to Charge Currents ≤ 1A	**Cons:** • Requires Current Limited Source • Battery Voltage Fluctuates with Charge Pulses • Usually Confined to Charge Currents ≤ 1A

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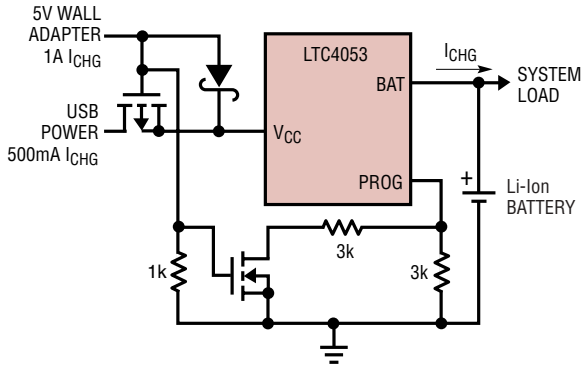
LTC4053 USB Battery Charger

The universal serial bus (USB) allows 100mA or 500mA to be drawn from the bus to power other peripherals. The innovative LTC4053 USB charger can charge a battery directly off the USB bus or alternatively can be used in a wall cube based charger.

- **Single cell linear Li-Ion charger**
- **User-selectable USB charge current of 100mA or 500mA**
- **Internal FET allows charger currents up to 1.25A for non-USB applications**
- **Small 10-pin MSOP package**
- **Thermal regulation—charge current is reduced if die temperature limit is exceeded**
- **Charge termination by time**

Combining Wall Adapter and USB Power

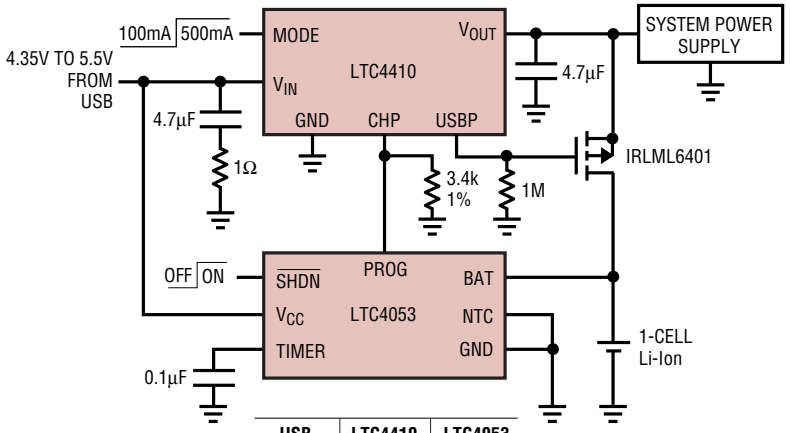


LTC4410 USB Power Manager

The LTC4410 USB power manager simultaneously manages a USB peripheral's system current and its battery charge current. It dynamically adjusts the battery charge current based on the needs of the peripheral. This guarantees that the system is compliant with the USB overcurrent specification and also provides for faster charging of the batteries when compared with conventional charging configurations.

- **System power comes directly from USB, providing more efficient power management and more charging current than conventional solutions**
- **Priority management—can manage charging two batteries**
- **Ideally suited to work with battery chargers like the LTC4053 and LTC1733**
- **Integrated reverse current protection**
- **Available in a very small 6-lead ThinSOT package**

USB Powered Battery Charger (LTC4053) with Power Manager (LTC4410)



USB MODE	LTC4410 MODE	LTC4053 SHDN
500mA	1	1
100mA	0	1
SUSPEND	1	0

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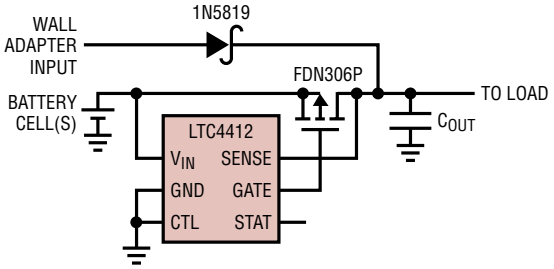
LTC4412 Ideal Diode

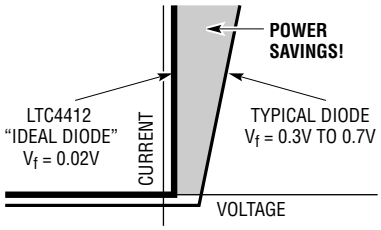
To squeeze the most life out of your battery, use the LTC4412 low loss PowerPath™ controller in place of OR'ing diodes. The LTC4412 automatically switches between a wall adapter and battery power with a fraction of the power loss a diode exhibits. This device controls an external FET to provide the lowest dropout voltage available and also protects batteries by preventing reverse current flow.

- **Maximizes battery life by providing the lowest dropout voltage of 0.02V (compared to 0.7V for a diode)**
- **Small 6-lead ThinSOT package for space-constrained portable applications**
- **Ideal for switching between two battery power supplies**
- **Low 11µA supply current**

LTC4412 PowerPath Controller



Power Savings Using the LTC4412

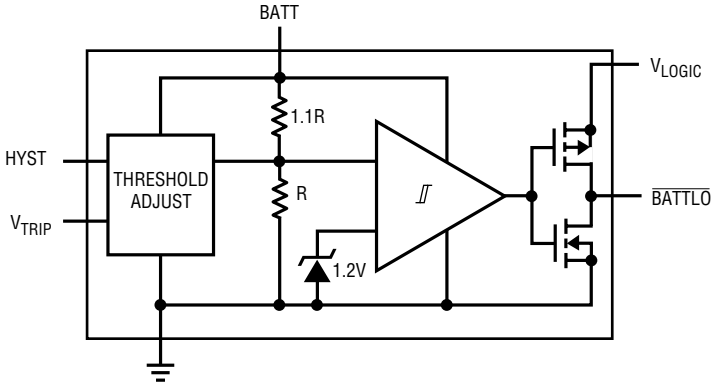


LTC1998 Li-Ion Low-Battery Detector

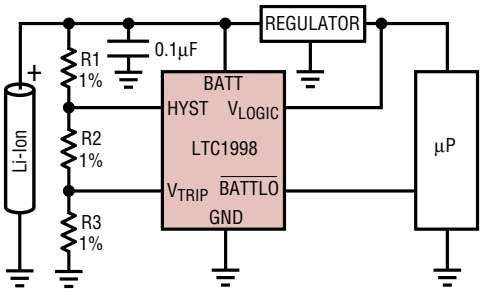
For accurate battery voltage monitoring, consider the LTC1998 comparator/reference IC. With its 1% threshold voltage accuracy over temperature (using 1% resistors), miserly 2.5µA supply current and small 6-pin ThinSOT package, it is ideal for lithium-ion battery monitoring circuits.

- **Programmable threshold voltage of 2.5V to 3.25V**
- **Rail-to-rail comparator output swing**
- **1% threshold voltage accuracy when using external 1% resistors**
- **Add hysteresis by simply adding one additional resistor**

LTC1998 Block Diagram



Low-Battery Threshold Detector with Hysteresis



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LT1787 Precision Current Sense Amplifier

Current sense amplifiers are used to monitor discrete battery chargers and to provide accurate power management in portable applications. The LT1787 high side current sense amplifier is ideal for fuel gauge applications and for monitoring proprietary charging algorithms. Its 2.5V minimum supply voltage means it can operate from a single Li-Ion cell and its 60µA quiescent current minimizes overall system power usage. The user-selectable sense resistor means the circuit can be uniquely tailored to optimize your system's performance.

- **2.5V to 60V supply voltage, 60µA quiescent current**
- **Unidirectional or bidirectional (charge/discharge) operation**
- **Small MSOP-8 package**
- **–40ºC to 125ºC temperature range**
- **Precise—only ±40µV input offset voltage with 12 bits of dynamic range**
- **Provides circuitry for input signal filtering**

LT1787 Unidirectional Current Sensing Mode