APÉNDICE

HOJAS TÉCNICAS DE COMPONENTES UTILIZADOS

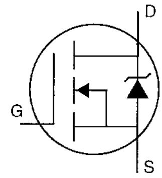
International IOR Rectifier

PD-9.509B

IRFZ34

HEXFET® Power MOSFET

- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements



V_{DSS} = 60V

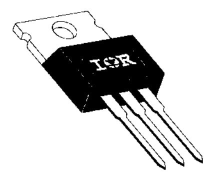
$R_{DS(on)}$ = 0.050Ω

I_D = 30A

Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220 package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.



TO-220AB

DATA SHEETS

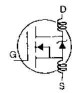
Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10 V	30	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10 V	21	
I_{DM}	Pulsed Drain Current ①	120	
P_D @ T_C = 25°C	Power Dissipation	88	W
	Linear Derating Factor	0.59	W/°C
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	200	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.5	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +175	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1 N•m)	

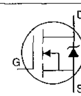
Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{θJC}$	Junction-to-Case	—	—	1.7	°C/W
$R_{θCS}$	Case-to-Sink, Flat, Greased Surface	—	0.50	—	
$R_{θJA}$	Junction-to-Ambient	—	—	62	

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	60	—	—	V	V_{GS}=0V, I_D= 250µA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.065	—	V/°C	Reference to 25°C, I_D= 1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	0.050	Ω	V_{GS}=10V, I_D=18A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D= 250µA
g_{fs}	Forward Transconductance	9.3	—	—	S	V_{DS}=25V, I_D=18A ④
I_{DSS}	Drain-to-Source Leakage Current	—	—	25	µA	V_{DS}=60V, V_{GS}=0V
		—	—	250		V_{DS}=48V, V_{GS}=0V, T_J=150°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS}=20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS}=-20V
Q_g	Total Gate Charge	—	—	46	nC	I_D=30A
Q_{gs}	Gate-to-Source Charge	—	—	11		V_{DS}=48V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	22		V_{GS}=10V See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	13	—	ns	V_{DD}=30V
t_r	Rise Time	—	100	—		I_D=30A
$t_{d(off)}$	Turn-Off Delay Time	—	29	—		R_G=12Ω
t_f	Fall Time	—	52	—		R_D=1.0Ω See Figure 10 ④
L_D	Internal Drain Inductance	—	4.5	—	nH	Between lead, 6 mm (0.25in.) from package and center of die contact 
L_S	Internal Source Inductance	—	7.5	—		
C_{iss}	Input Capacitance	—	1200	—	pF	V_{GS}=0V
C_{oss}	Output Capacitance	—	600	—		V_{DS}=25V
C_{rss}	Reverse Transfer Capacitance	—	100	—		f=1.0MHz See Figure 5

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	30	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	120		
V_{SD}	Diode Forward Voltage	—	—	1.6	V	T_J=25°C, I_S=30A, V_{GS}=0V ④
t_{rr}	Reverse Recovery Time	—	120	230	ns	T_J=25°C, I_F=30A
Q_{rr}	Reverse Recovery Charge	—	0.70	1.4	µC	di/dt=100A/µs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is neglegible (turn-on is dominated by L_S+L_D)				

Notes:

① Repetitive rating; pulse width limited by max. junction temperature (See Figure 11)

② V_{DD}=25V, starting T_J=25°C, L=259µH R_G=25Ω, I_{AS}=30A (See Figure 12)

③ I_{SD}≤30A, di/dt≤200A/µs, V_{DD}≤$V_{(BR)DSS}$, T_J≤175°C

④ Pulse width ≤ 300 µs; duty cycle ≤2%.

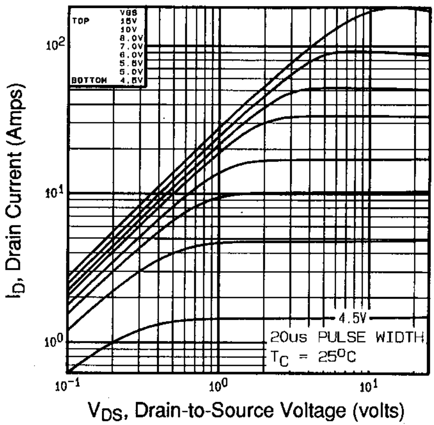


Fig 1. Typical Output Characteristics, Tc=25°C

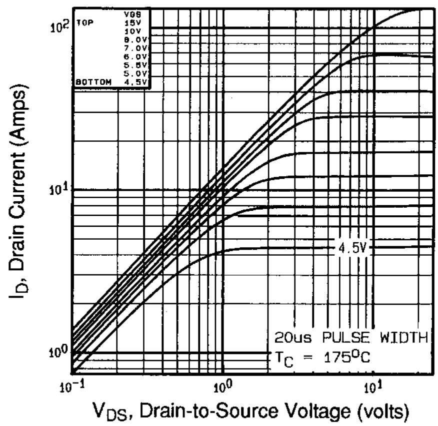


Fig 2. Typical Output Characteristics, Tc=175°C

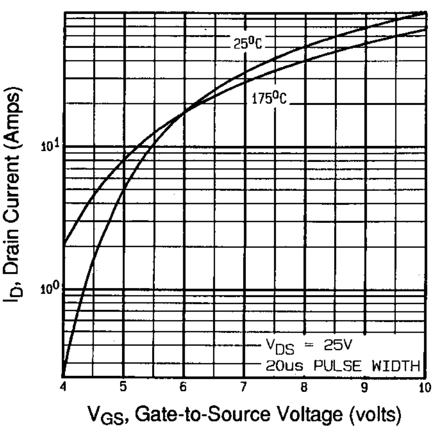


Fig 3. Typical Transfer Characteristics

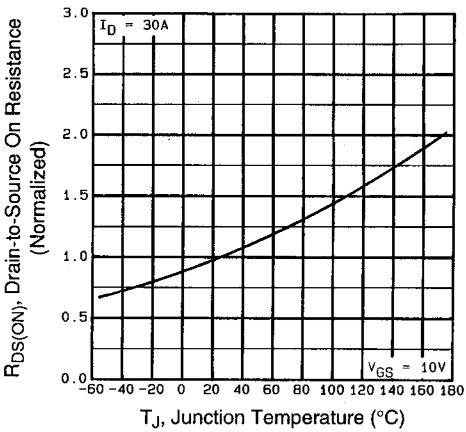


Fig 4. Normalized On-Resistance Vs. Temperature

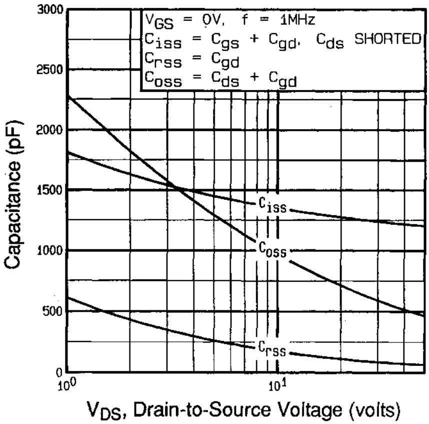


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

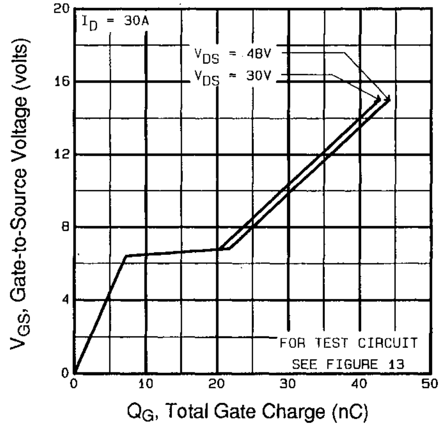


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

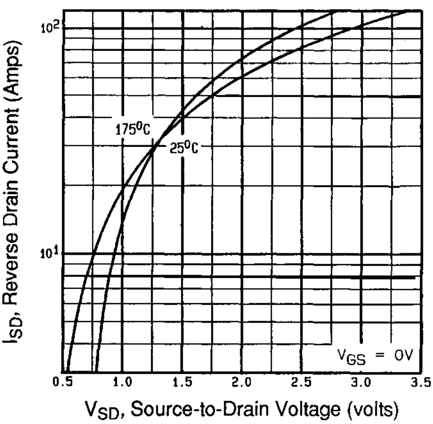


Fig 7. Typical Source-Drain Diode Forward Voltage

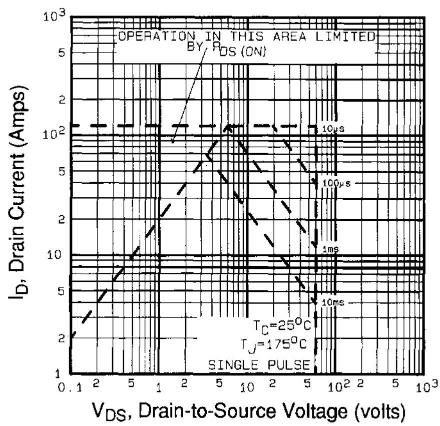


Fig 8. Maximum Safe Operating Area

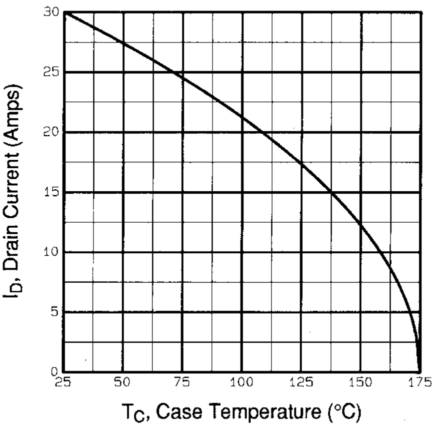


Fig 9. Maximum Drain Current Vs. Case Temperature

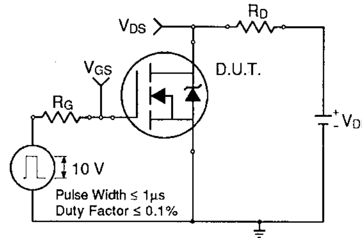


Fig 10a. Switching Time Test Circuit

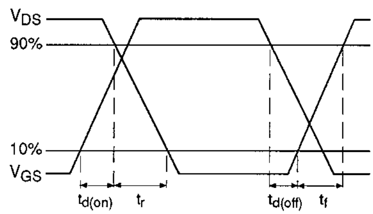


Fig 10b. Switching Time Waveforms

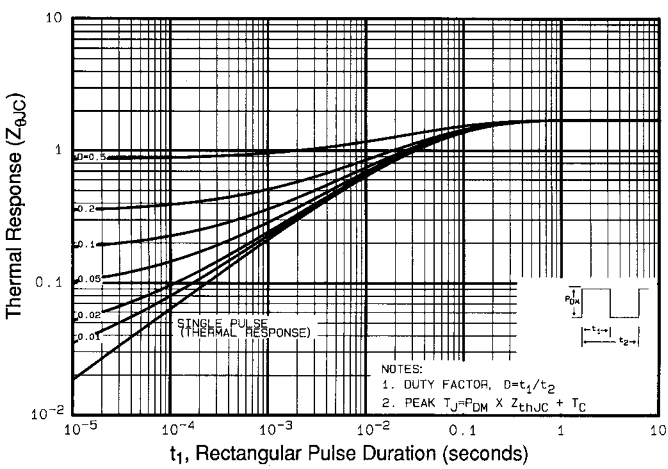


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

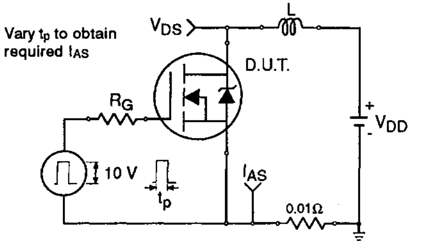


Fig 12a. Unclamped Inductive Test Circuit

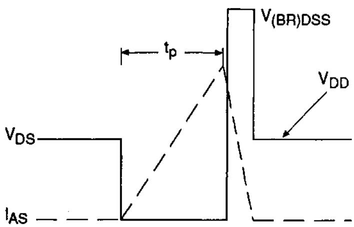


Fig 12b. Unclamped Inductive Waveforms

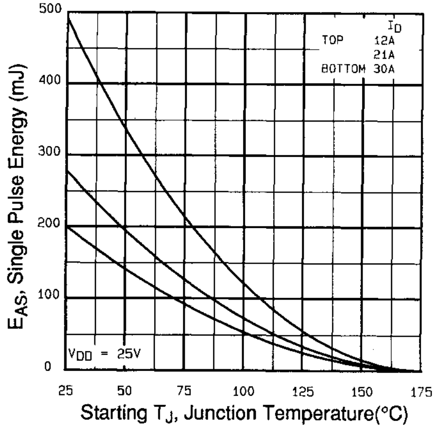


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

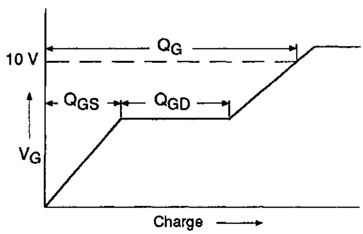


Fig 13a. Basic Gate Charge Waveform

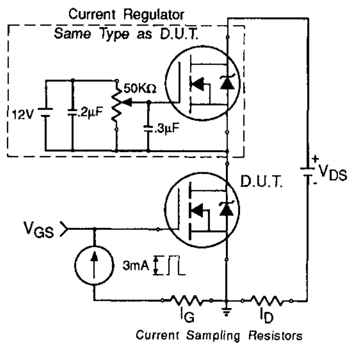


Fig 13b. Gate Charge Test Circuit

Appendix A: Figure 14, Peak Diode Recovery dv/dt Test Circuit – See page 1505

Appendix B: Package Outline Mechanical Drawing – See page 1509

Appendix C: Part Marking Information – See page 1516

Appendix E: Optional Leadforms– See page 1525

International
IOR Rectifier

19-0113; Rev. 2; 1/95

EVALUATION KIT MANUAL FOLLOWS DATA SHEET

MAXIM

3.3V/5V/Adjustable-Output, Step-Up DC-DC Converters

MAX756/MAX757

General Description

The MAX756/MAX757 are CMOS step-up DC-DC switching regulators for small, low input voltage or battery-powered systems. The MAX756 accepts a positive input voltage down to 0.7V and converts it to a higher pin-selectable output voltage of 3.3V or 5V. The MAX757 is an adjustable version that accepts an input voltage down to 0.7V and generates a higher adjustable output voltage in the range from 2.7V to 5.5V. Typical full-load efficiencies for the MAX756/MAX757 are greater than 87%.

The MAX756/MAX757 provide three improvements over previous devices. Physical size is reduced—the high switching frequencies (up to 0.5MHz) made possible by MOSFET power transistors allow for tiny (<5mm diameter) surface-mount magnetics. Efficiency is improved to 87% (10% better than with low-voltage regulators fabricated in bipolar technology). Supply current is reduced to 60µA by CMOS construction and a unique constant-off-time pulse-frequency modulation control scheme.

Applications

- 3.3V to 5V Step-Up Conversion
- Palmtop Computers
- Portable Data-Collection Equipment
- Personal Data Communicators/Computers
- Medical Instrumentation
- 2-Cell & 3-Cell Battery-Operated Equipment
- Glucose Meters

Features

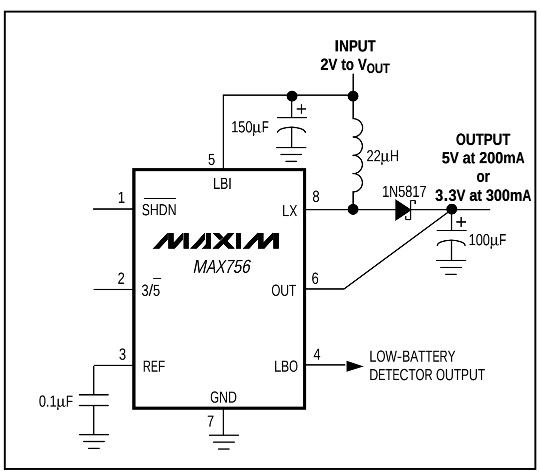
- ♦ **Operates Down to 0.7V Input Supply Voltage**
- ♦ **87% Efficiency at 200mA**
- ♦ **60µA Quiescent Current**
- ♦ **20µA Shutdown Mode with Active Reference and LBI Detector**
- ♦ **500kHz Maximum Switching Frequency**
- ♦ **±1.5% Reference Tolerance Over Temperature**
- ♦ **Low-Battery Detector (LBI/LBO)**
- ♦ **8-Pin DIP and SO Packages**

Ordering Information

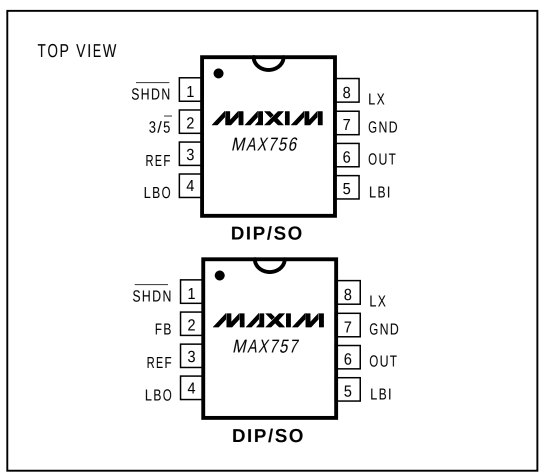
PART	TEMP. RANGE	PIN-PACKAGE
MAX756CPA	0°C to +70°C	8 Plastic DIP
MAX756CSA	0°C to +70°C	8 SO
MAX756C/D	0°C to +70°C	Dice*
MAX756EPA	-40°C to +85°C	8 Plastic DIP
MAX756ESA	-40°C to +85°C	8 SO
MAX757CPA	0°C to +70°C	8 Plastic DIP
MAX757CSA	0°C to +70°C	8 SO
MAX757C/D	0°C to +70°C	Dice*
MAX757EPA	-40°C to +85°C	8 Plastic DIP
MAX757ESA	-40°C to +85°C	8 SO

** Dice are tested at T_A = +25°C only.*

Typical Operating Circuit



Pin Configurations



3.3V/5V/Adjustable-Output, Step-Up DC-DC Converters

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (OUT to GND) ....-0.3V, +7V
Switch Voltage (LX to GND) ....-0.3V, +7V
Auxiliary Pin Voltages ($\overline{SHDN}$, LBI, LBO, REF,
3/$\overline{5}$, FB to GND) ....-0.3V, (V_{OUT} + 0.3V)
Reference Current (I_{REF}) 2.5mA
Continuous Power Dissipation (T_A = +70°C)
Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
SO (derate 5.88mW/°C above +70°C)..........................471mW

Operating Temperature Ranges:
MAX75_C_ _ ....0°C to +70°C
MAX75_E_ _..-40°C to +85°C
Junction Temperature...+150°C
Storage Temperature Range.............................. -65°to +160°C
Lead Temperature (soldering, 10sec) .... +300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(Circuits of Figure 1 and Typical Operating Circuit, V_{IN} = 2.5V, I_{LOAD} = 0mA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

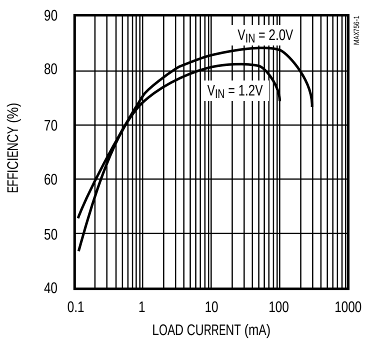
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage	2V < V_{IN} < 3V	MAX756, 3/$\overline{5}$ = 0V, 0mA < I_{LOAD} < 200mA	4.8	5.0	5.2	V
		MAX756, 3/$\overline{5}$ = 3V, 0mA < I_{LOAD} < 300mA	3.17	3.30	3.43	
		MAX757, V_{OUT} = 5V, 0mA < I_{LOAD} < 200mA	4.8	5.0	5.2	
Minimum Start-Up Supply Voltage	I_{LOAD} = 10mA			1.1	1.8	V
Minimum Operating Supply Voltage (once started)	I_{LOAD} = 20mA			0.7		V
Quiescent Supply Current in 3.3V Mode (Note 1)	I_{LOAD} = 0mA, 3/$\overline{5}$ = 3V, LBI = 1.25V, V_{OUT} = 3.47V, FB = 1.3V (MAX757 only)				60	µA
Battery Quiescent Current Measured at V_{IN} in Figure 1	Output set for 3.3V			60		µA
Shutdown Quiescent Current (Note 1)	$\overline{SHDN}$ = 0V, LBI = 1.25V, 3/$\overline{5}$ = 3V, V_{OUT} = 3.47V, FB = 1.3V (MAX757 only)			20	40	µA
Reference Voltage	No REF load, C_{REF} = 0.1µF		1.23	1.25	1.27	V
Reference-Voltage Regulation	3/$\overline{5}$ = 3V, -20µA < REF load < 250µA, C_{REF} = 0.22µF			0.8	2.0	%
LBI Input Threshold	With falling edge		1.22	1.25	1.28	V
LBI Input Hysteresis				25		mV
LBO Output Voltage Low	I_{SINK} = 2mA				0.4	V
LBO Output Leakage Current	LBO = 5V				1	µA
$\overline{SHDN}$, 3/$\overline{5}$ Input Voltage Low					0.4	V
$\overline{SHDN}$, 3/$\overline{5}$ Input Voltage High			1.6			V
$\overline{SHDN}$, 3/$\overline{5}$, FB, LBI Input Current	LBI = 1.25V, FB = 1.25V, $\overline{SHDN}$ = 0V or 3V, 3/$\overline{5}$ = 0V or 3V				±100	nA
FB Voltage	MAX757		1.22	1.25	1.28	V
Output Voltage Range	MAX757, I_{LOAD} = 0mA (Note 2)		2.7		5.5	V

Note 1: Supply current from the 3.3V output is measured with an ammeter between the 3.3V output and OUT pin. This current correlates directly with actual battery supply current, but is reduced in value according to the step-up ratio and efficiency.
Note 2: Minimum value is production tested. Maximum value is guaranteed by design and is not production tested.

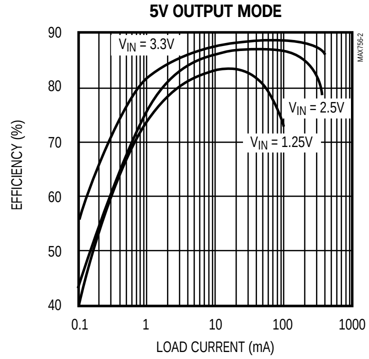
Typical Operating Characteristics

(Circuit of Figure 1, T_A = +25°C, unless otherwise noted.)

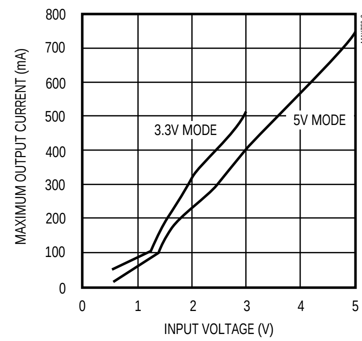
EFFICIENCY vs. LOAD CURRENT
3.3V OUTPUT MODE



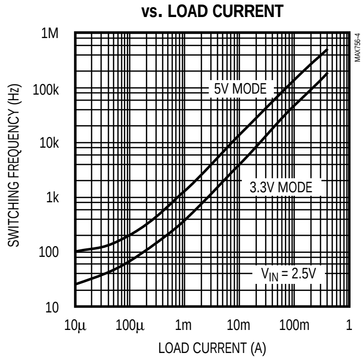
EFFICIENCY vs. LOAD CURRENT
5V OUTPUT MODE



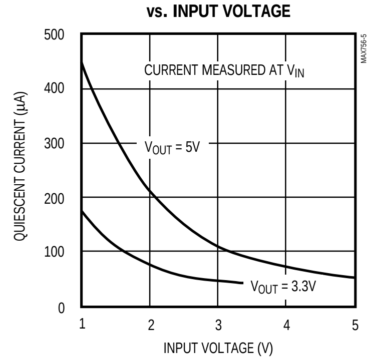
MAXIMUM OUTPUT CURRENT
vs. INPUT VOLTAGE



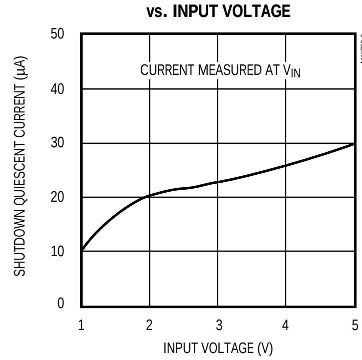
SWITCHING FREQUENCY
vs. LOAD CURRENT



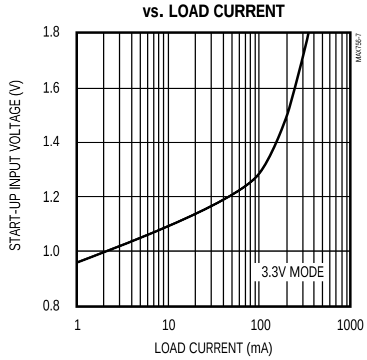
QUIESCENT CURRENT
vs. INPUT VOLTAGE



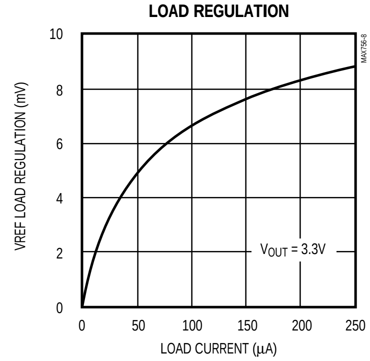
SHUTDOWN QUIESCENT CURRENT
vs. INPUT VOLTAGE



MINIMUM START-UP INPUT VOLTAGE
vs. LOAD CURRENT



REFERENCE VOLTAGE
LOAD REGULATION



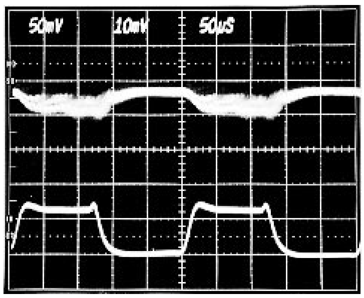
Typical Operating Characteristics (continued)

(Circuit of Figure 1, T_A = +25°C, unless otherwise noted.)

LOAD-TRANSIENT RESPONSE

OUTPUT VOLTAGE 50mV/div

OUTPUT CURRENT 0mA to 200mA

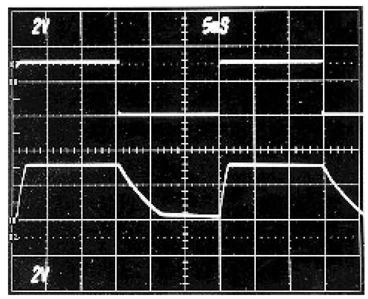


V_{IN} = 2.5V
HORIZONTAL = 50µs/div
5V Mode

START-UP DELAY

$V_{\overline{SHDN}}$ 2V/div

V_{OUT} 2V/div



3V
0V
5V
0V

V_{IN} = 2.5V
HORIZONTAL = 5ms/div
5V Mode

Pin Description

PIN		NAME	FUNCTION
MAX756	MAX757		
1	1	$\overline{SHDN}$	Shutdown Input disables SMPS when low, but the voltage reference and low-battery comparator remain active.
2	–	3/$\overline{5}$	Selects the main output voltage setting; 5V when low, 3.3V when high.
–	2	FB	Feedback Input for adjustable output operation. Connect to an external voltage divider between OUT and GND.
3	3	REF	1.25V Reference Voltage Output. Bypass with 0.22µF to GND (0.1µF if there is no external reference load). Maximum load capability is 250µA source, 20µA sink.
4	4	LBO	Low-Battery Output. An open-drain N-channel MOSFET sinks current when the voltage at LBI drops below +1.25V.
5	5	LBI	Low-Battery Input. When the voltage on LBI drops below +1.25V, LBO sinks current. Connect to V_{IN} if not used.
6	6	OUT	Connect OUT to the regulator output. It provides bootstrapped power to both devices, and also senses the output voltage for the MAX756.
7	7	GND	Power Ground. Must be low impedance; solder directly to ground plane.
8	8	LX	1A, 0.5Ω N-Channel Power MOSFET Drain

Detailed Description

Operating Principle

The MAX756/MAX757 combine a switch-mode regulator with an N-channel MOSFET, precision voltage reference, and power-fail detector in a single monolithic device. The MOSFET is a "sense-FET" type for best efficiency, and has a very low gate threshold voltage to ensure start-up under low-battery voltage conditions (1.1V typ).

Pulse-Frequency Modulation Control Scheme

A unique minimum off time, current-limited, pulse-frequency modulation (PFM) control scheme is a key feature of the MAX756/MAX757. This PFM scheme combines the advantages of pulse-width modulation (PWM) (high output power and efficiency) with those of a traditional PFM pulse-skipper (ultra-low quiescent currents). There is no oscillator; at heavy loads, switching is accomplished through a constant peak-current limit in the switch, which allows the inductor current to self-oscillate between this peak limit and some lesser value. At light loads, switching frequency is governed by a pair of one-shots, which set a minimum off-time (1µs) and a maximum on-time (4µs). The switching frequency depends on the load and the input voltage, and can range as high as 500kHz.

The peak switch current of the internal MOSFET power switch is fixed at 1A ±0.2A. The switch's on resistance is typically 0.5Ω, resulting in a switch voltage drop (V_{SW}) of about 500mV under high output loads. The value of V_{SW} decreases with light current loads.

Conventional PWM converters generate constant-frequency switching noise, whereas this architecture produces variable-frequency switching noise. However, the noise does not exceed the switch current limit times the filter-capacitor equivalent series resistance (ESR), unlike conventional pulse-skippers.

Voltage Reference

The precision voltage reference is suitable for driving external loads such as an analog-to-digital converter. It has guaranteed 250µA source-current and 20µA sink-current capability. The reference is kept alive even in shutdown mode. If the reference drives an external load, bypass it with 0.22µF to GND. If the reference is unloaded, bypass it with at least 0.1µF.

Control-Logic Inputs

The control inputs ($3/\overline{5}$, $\overline{SHDN}$) are high-impedance MOS gates protected against ESD damage by normally reverse-biased clamp diodes. If these inputs are driven from signal sources that exceed the main supply voltage, the diode current should be limited by a series resistor (1MΩ suggested). The logic input threshold level is the same (approximately 1V) in both 3.3V and 5V modes. Do not leave the control inputs floating.

Design Procedure

Output Voltage Selection

The MAX756 output voltage can be selected to 3.3V or 5V under logic control, or it can be left in one mode or the other by tying $3/\overline{5}$ to GND or OUT. Efficiency varies depending upon the battery and the load, and is typically better than 80% over a 2mA to 200mA load range. The device is internally bootstrapped, with power derived from the output voltage (via OUT). When the output is set at 5V instead of 3.3V, the higher internal supply voltage results in lower switch-transistor on resistance and slightly greater output power. Bootstrapping allows the battery voltage to sag to less than 1V once the system is started. Therefore, the battery voltage range is from $V_{OUT} + V_D$ to less than 1V (where V_D is the forward drop of the Schottky rectifier). If the battery voltage exceeds the programmed output voltage, the output will follow the battery voltage. In many systems this is acceptable; however, the output voltage must not be forced above 7V.

The output voltage of the MAX757 is set by two resistors, R1 and R2 (Figure 1), which form a voltage divider between the output and the FB pin. The output voltage is set by the equation:

$$V_{OUT} = (V_{REF}) [(R2 + R1) / R2]$$

where $V_{REF} = 1.25V$.

To simplify resistor selection:

$$R1 = (R2) [(V_{OUT} / V_{REF}) - 1]$$

Since the input bias current at FB has a maximum value of 100nA, large values (10kΩ to 200kΩ) can be used for R1 and R2 with no significant loss of accuracy. For 1% error, the current through R1 should be at least 100 times FB's bias current.

Low-Battery Detection

The MAX756/MAX757 contain on-chip circuitry for low-battery detection. If the voltage at LBI falls below the regulator's internal reference voltage (1.25V), LBO (an open-drain output) sinks current to GND. The low-battery monitor's threshold is set by two resistors, R3 and R4 (Figure 1), which forms a voltage divider between the input voltage and the LBI pin. The threshold voltage is set by R3 and R4 using the following equation:

$$R3 = [(V_{IN} / V_{REF}) - 1] (R4)$$

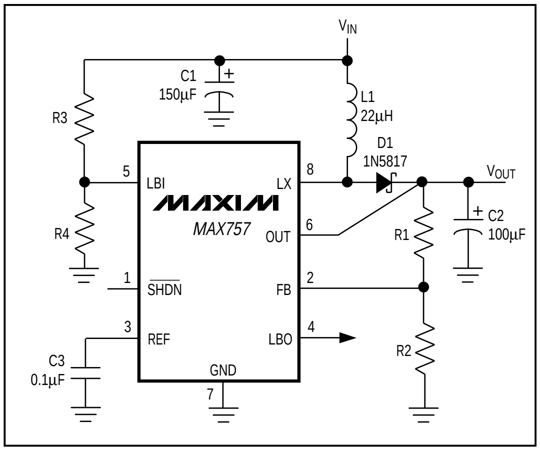


Figure 1. Standard Application Circuit

where V_{IN} is the desired threshold of the low-battery detector, R3 and R4 are the input divider resistors at LBI, and V_{REF} is the internal 1.25V reference.

Since the LBI current is less than 100nA, large resistor values (typically 10kΩ to 200kΩ) can be used for R3 and R4 to minimize loading of the input supply.

When the voltage at LBI is below the internal threshold, LBO sinks current to GND. A pull-up resistor of 10kΩ or more connected from LBO to V_{OUT} can be used when driving CMOS circuits. Any pull-up resistor connected to LBO should not be returned to a voltage source greater than V_{OUT}. When LBI is above the threshold, the LBO output is off. The low-battery comparator and reference voltage remain active when the MAX756/MAX757 is in shutdown mode.

If the low-battery comparator is not used, connect LBI to V_{IN} and leave LBO open.

Inductor Selection

The inductors should have a saturation (incremental) current rating equal to or greater than the peak switch-current limit, which is 1.2A worst-case. However, it's generally acceptable to bias the inductor into saturation by 20%, although this will reduce the efficiency.

The 22µH inductor shown in the typical applications circuit is sufficient for most MAX756/MAX757 application circuits. Higher input voltages increase the energy transferred with each cycle, due to the reduced input/output differential. Minimize excess ripple due to increased energy transfer by reducing the inductor value (10µH suggested).

The inductor's DC resistance significantly affects efficiency. For highest efficiency, limit L1's DC resistance to 0.03Ω or less. See Table 1 for a list of suggested inductor suppliers.

Table 1. Component Suppliers

PRODUCTION METHOD	INDUCTORS	CAPACITORS
Surface-Mount	Sumida CD54-220 (22µH) CoilCraft DT3316-223 Coiltronics CTX20-1	AVX TPS series Sprague 595D series
Miniature Through-Hole	Sumida RCH654-220	Sanyo OS-CON OS-CON series low-ESR organic semiconductor
Low-Cost Through-Hole	CoilCraft PCH-27-223	Nichicon PL series low-ESR electrolyic United Chemi-Con LXF series

AVX	USA:	(207) 282-5111, FAX (207) 283-1941 (800) 282-9975
CoilCraft	USA:	(708) 639-6400, FAX (708) 639-1969
Coiltronics	USA:	(407) 241-7876, FAX (407) 241-9339
Collmer Semiconductor	USA:	(214) 233-1589
Motorola	USA:	(602) 244-3576, FAX (602) 244-4015
Nichicon	USA:	(708) 843-7500, FAX (708) 843-2798
	Japan:	+81-7-5231-8461, FAX (+81-) 7-5256-4158
Nihon	USA:	(805) 867-2555, FAX (805) 867-2556
	Japan:	+81-3-3494-7411, FAX (+81-) 3-3494-7414
Sanyo OS-CON	USA:	(619) 661-6835
	Japan:	+81-720-70-1005, FAX (+81-720-) 70-1174
Sprague	USA:	(603) 224-1961, FAX (603) 224-1430
Sumida	USA:	(708) 956-0666
	Japan:	+81-3-3607-5111, FAX (+81-3-) 3607-5428
United Chemi-Con	USA:	(708) 696-2000, FAX (708) 640-6311

Capacitor Selection

A 100µF, 10V surface-mount (SMT) tantalum capacitor typically provides 50mV output ripple when stepping up from 2V to 5V at 200mA. Smaller capacitors, down to 10µF, are acceptable for light loads or in applications that can tolerate higher output ripple.

The ESR of both bypass and filter capacitors affects efficiency. Best performance is obtained by using specialized low-ESR capacitors, or connecting two or more filter capacitors in parallel. The smallest low-ESR SMT tantalum capacitors currently available are Sprague 595D series, which are about half the size of competing products. Sanyo OS-CON organic semiconductor through-hole capacitors also exhibit very low ESR, and are especially useful for operation at cold temperatures. Table 1 lists suggested capacitor suppliers.

Rectifier Diode

For optimum performance, a switching Schottky diode, such as the 1N5817, is recommended. 1N5817 equivalent diodes are also available in surface-mount packages from Collmer Semiconductor in Dallas, TX, phone (214) 233-1589. The part numbers are SE014 or SE024. For low output power applications, a pn junction switching diode, such as the 1N4148, will also work well, although efficiency will suffer due to the greater forward voltage drop of the pn junction diode.

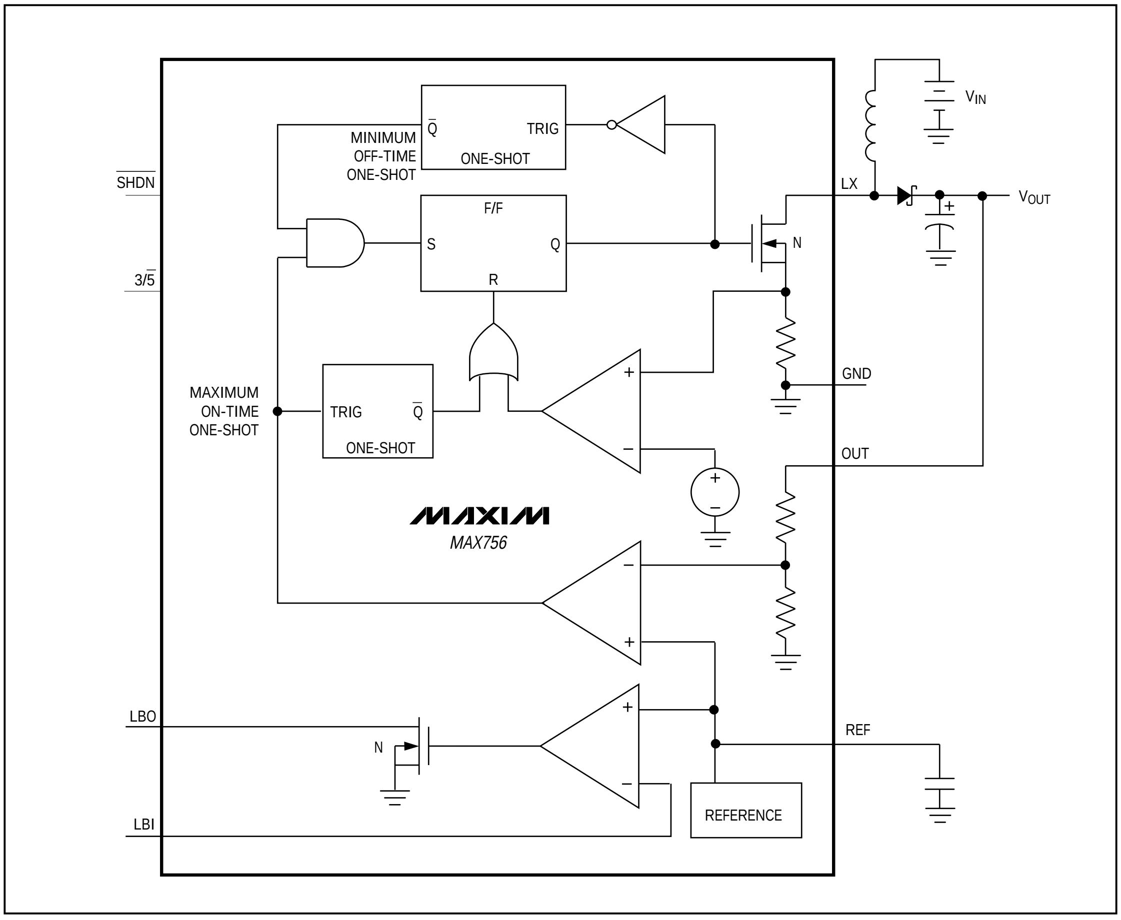
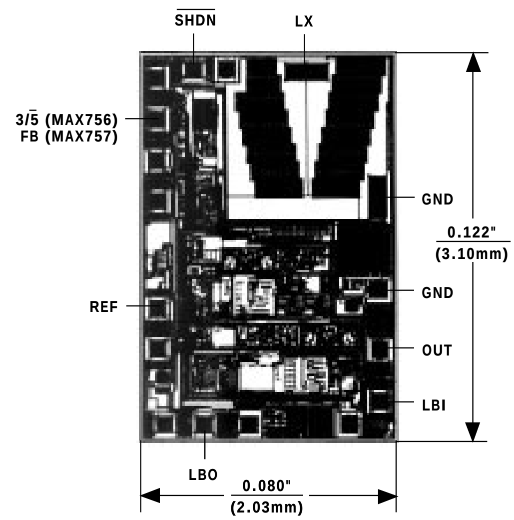


Figure 2. MAX756 Block Diagram

PC Layout and Grounding

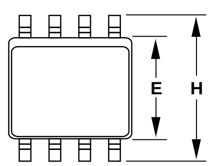
The MAX756/MAX757 high peak currents and high-frequency operation make PC layout important for minimizing ground bounce and noise. The distance between the MAX756/MAX757's GND pin and the ground leads of C1 and C2 in Figure 1 must be kept to less than 0.2" (5mm). All connections to the FB and LX pins should also be kept as short as possible. To obtain maximum output power and efficiency and minimum output ripple voltage, use a ground plane and solder the MAX756/MAX757 GND (pin 7) directly to the ground plane.

Chip Topography



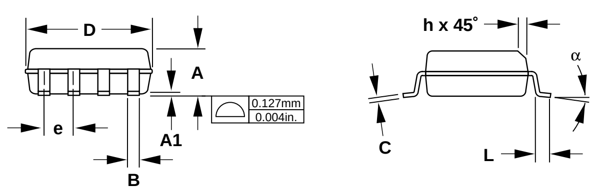
TRANSISTOR COUNT: 758
SUBSTRATE CONNECTED TO OUT

Package Information



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
D	0.189	0.197	4.80	5.00
E	0.150	0.157	3.80	4.00
e	0.050 BSC		1.27 BSC	
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27
α	0°	8°	0°	8°

21-325A



8-PIN PLASTIC SMALL-OUTLINE PACKAGE

19-2902; Rev 0; 7/03

SOT23 Dual-Input USB/AC Adapter 1-Cell Li+ Battery Chargers

General Description

The MAX1551/MAX1555 charge a single-cell lithium-ion (Li+) battery from both USB* and AC adapter sources. They operate with no external FETs or diodes, and accept operating input voltages up to 7V.

On-chip thermal limiting simplifies PC board layout and allows optimum charging rate without the thermal limits imposed by worst-case battery and input voltage. When the MAX1551/MAX1555 thermal limits are reached, the chargers do not shut down, but progressively reduce charging current.

The MAX1551 includes a $\overline{POK}$ output to indicate when input power is present. If either charging source is active, $\overline{POK}$ goes low. The MAX1555 instead features a $\overline{CHG}$ output to indicate charging status.

With USB connected, but without DC power, charge current is set to 100mA (max). This allows charging from both powered and unpowered USB hubs with no port communication required. When DC power is connected, charging current is set at 280mA (typ). No input-blocking diodes are required to prevent battery drain.

The MAX1551/MAX1555 are available in 5-pin thin SOT23 packages and operate over a -40°C to +85°C range.

Applications

PDAs

Wireless Appliances

Cell Phones

Digital Cameras

Features

- ♦ **Charge from USB or AC Adapter**
- ♦ **Automatic Switchover when AC Adapter is Plugged In**
- ♦ **On-Chip Thermal Limiting Simplifies Board Design**
- ♦ **Charge Status Indicator**
- ♦ **5-Pin Thin SOT23 Package**
- ♦ **Protected by U.S. Patent #6,507,172**

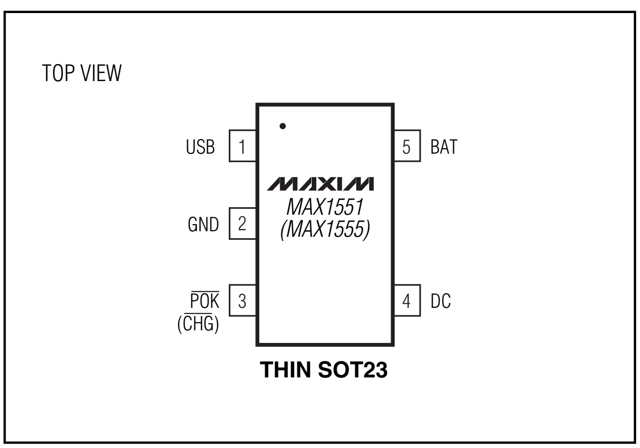
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX1551EZK-T	-40°C to +85°C	5 Thin SOT23-5
MAX1555EZK-T	-40°C to +85°C	5 Thin SOT23-5

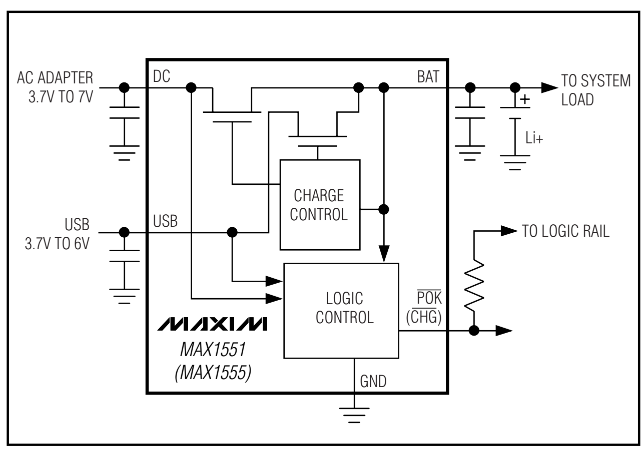
Selector Guide

PART	TOP MARK	FEATURES
MAX1551EZK	ADRT	$\overline{POK}$ Output
MAX1555EZK	ADRU	$\overline{CHG}$ Output

Pin Configuration



Typical Operating Circuit



*Protected by U.S. Patent #6,507,172.

SOT23 Dual-Input USB/AC Adapter 1-Cell Li+ Battery Chargers

ABSOLUTE MAXIMUM RATINGS

DC to GND..0 to +8V
DC to BAT...0 to +7V
BAT, $\overline{CHG}$, $\overline{POK}$, USB to GND ....-0.3V to +7V
Continuous Power Dissipation (T_A = +70°C)
5-Pin Thin SOT23 (derate 9.1mW/°C above +70°C)....727mW
Operating Temperature Range ....-40°C to +85°C
Junction Temperature Range ....-40°C to +150°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{DC} = 5V, V_{USB} = 0, I_{BAT} = 0, C_{BAT} = 1µF, **T_A = 0°C to +85°C**, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC					
DC Voltage Range	(Note 1)	3.7		7.0	V
DC to BAT Voltage Range		0.1		6.0	V
DC Undervoltage Lockout Threshold	Input rising, 430mV hysteresis, V_{BAT} = 3V (Note 1)	3.75	3.95	4.15	V
DC Supply Current			1.75	3	mA
DC to BAT On-Resistance	V_{DC} = 3.7V, V_{BAT} = 3.6V		1	2	Ω
DC to BAT Dropout Voltage	When charging stops, V_{BAT} = 4V, DC falling, 200mV hysteresis	30	60	90	mV
USB					
USB Voltage Range	(Note 1)	3.7		6.0	V
USB Undervoltage Threshold	Input rising, 430mV hysteresis, V_{DC} = 0, V_{BAT} = 3V (Note 1)	3.75	3.95	4.15	V
USB Supply Current	V_{USB} = 5V, V_{DC} = 0		1.65	3	mA
USB to BAT On-Resistance	V_{USB} = 3.7V, V_{BAT} = 3.6V, V_{DC} = 0		2	4	Ω
USB to BAT Dropout Voltage	When charging stops, V_{BAT} = 4V, USB falling, 200mV hysteresis, V_{DC} = 0	30	60	90	mV
BAT					
BAT Regulation Voltage	V_{DC} or V_{USB} = 5V	4.158	4.2	4.242	V
DC Charging Current	V_{BAT} = 3.3V, V_{USB} = 0, V_{DC} = 5V	220	280	340	mA
USB Charging Current	V_{BAT} = 3.3V, V_{DC} = 0, V_{USB} = 5V	80	90	100	mA
BAT Prequal Threshold	V_{BAT} rising, 100mV hysteresis	2.9	3	3.1	V
Prequalification Charging Current	V_{BAT} = 2.8V	20	40	80	mA
BAT Leakage Current	V_{DC} = V_{USB} = 0, V_{BAT} = 4.2V			5	µA
$\overline{POK}$, $\overline{CHG}$, AND THERMAL LIMIT					
$\overline{CHG}$ Threshold	Charge current where $\overline{CHG}$ goes high, I_{BAT} falling, 50mA hysteresis	25	50	100	mA
$\overline{CHG}$, $\overline{POK}$ Logic-Low Output	$I_{\overline{CHG}}$, $I_{\overline{POK}}$ = 10mA		150	300	mV
$\overline{CHG}$, $\overline{POK}$ Leakage Current	$V_{\overline{CHG}}$, $V_{\overline{POK}}$ = 6V, T_A = +25°C		0.001	1	µA
Thermal-Limit Temperature	Charge current reduced by 17mA/°C above this temperature		+110		°C

ELECTRICAL CHARACTERISTICS

(V_{DC} = 5V, V_{USB} = 0, I_{BAT} = 0, C_{BAT} = 1µF, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note 2)

PARAMETER	CONDITIONS	MIN	MAX	UNITS
DC				
DC Voltage Range	(Note 1)	3.7	7.0	V
DC to BAT Voltage Range		0.1	6.0	V
DC Undervoltage Lockout Threshold	Input rising, 430mV hysteresis, V_{BAT} = 3V (Note 1)	3.75	4.15	V
DC Supply Current			3	mA
DC to BAT On-Resistance	V_{DC} = 3.7V, V_{BAT} = 3.6V		2	Ω
DC to BAT Dropout Voltage	When charging stops, V_{BAT} = 4V, DC falling, 200mV hysteresis	30	95	mV
USB				
USB Voltage Range	(Note 1)	3.7	6.0	V
USB Undervoltage Lockout Threshold	Input rising, 430mV hysteresis, V_{DC} = 0, V_{BAT} = 3V (Note 1)	3.75	4.15	V
USB Supply Current	V_{USB} = 5V, V_{DC} = 0		3	mA
USB to BAT On-Resistance	V_{USB} = 3.7V, V_{BAT} = 3.6V, V_{DC} = 0		4	Ω
USB to BAT Dropout Voltage	When charging stops, V_{BAT} = 4V, USB falling, 200mV hysteresis, V_{DC} = 0	30	95	mV
BAT				
BAT Regulation Voltage	V_{DC} or V_{USB} = 5V	4.141	4.259	V
DC Charging Current	V_{BAT} = 3.3V, V_{USB} = 0, V_{DC} = 5V	220	340	mA
USB Charging Current	V_{BAT} = 3.3V, V_{DC} = 0, V_{USB} = 5V	80	100	mA
BAT Prequal Threshold	V_{BAT} rising, 100mV hysteresis	2.9	3.1	V
Prequalification Charging Current	V_{BAT} = 2.8V	20	80	mA
BAT Leakage Current	V_{DC} = V_{USB} = 0, V_{BAT} = 4.2V		5	µA
$\overline{POK}$, $\overline{CHG}$				
$\overline{CHG}$ Threshold	Charge current where $\overline{CHG}$ goes high, I_{BAT} falling, 50mA hysteresis	25	100	mA
$\overline{CHG}$, $\overline{POK}$ Logic-Low Output	$I_{\overline{CHG}}$, $I_{\overline{POK}}$ = 10mA		300	mV
$\overline{CHG}$, $\overline{POK}$ Leakage Current	$V_{\overline{CHG}}$, $V_{\overline{POK}}$ = 6V, T_A = +25°C		1	µA

Note 1: The input undervoltage lockout has 430mV of hysteresis. The charger turns on when an input rises to 3.95V (typ), and turns off when it falls below 3.52V.

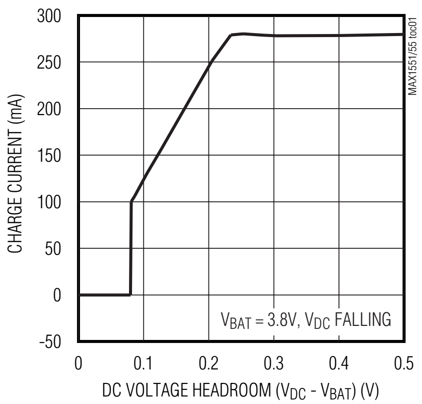
Note 2: Specifications to -40°C are guaranteed by design, not production tested.

SOT23 Dual-Input USB/AC Adapter 1-Cell Li+ Battery Chargers

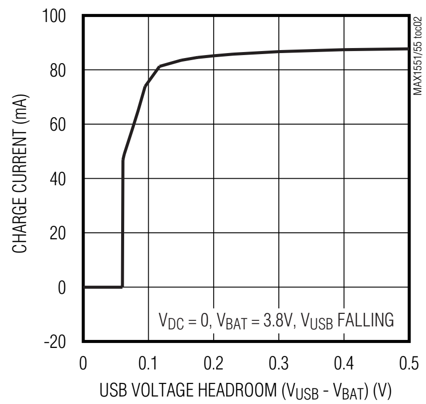
Typical Operating Characteristics

(V_{DC} = 5V, V_{USB} = 0, I_{BAT} = 0, C_{BAT} = 1µF, T_A = +25°C, unless otherwise noted.)

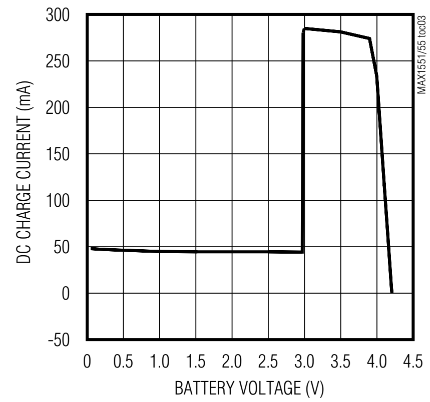
CHARGE CURRENT vs. DC VOLTAGE HEADROOM



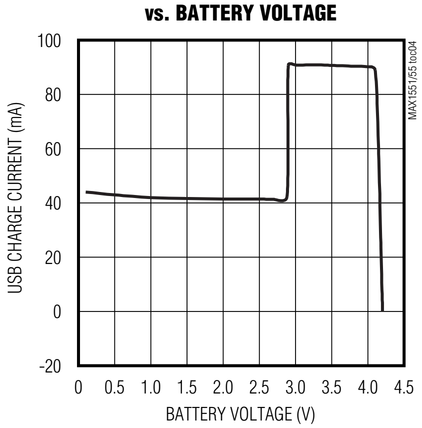
CHARGE CURRENT vs. USB VOLTAGE HEADROOM



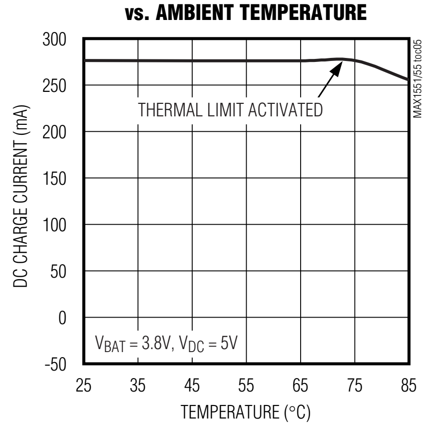
DC CHARGE CURRENT vs. BATTERY VOLTAGE



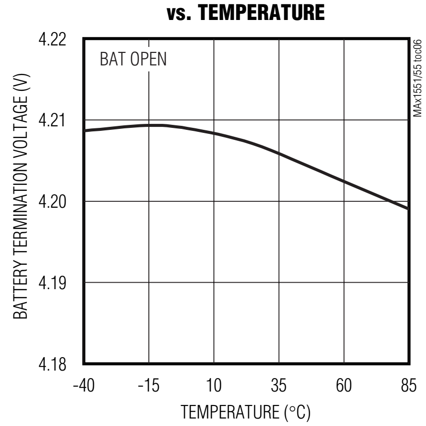
USB CHARGE CURRENT vs. BATTERY VOLTAGE



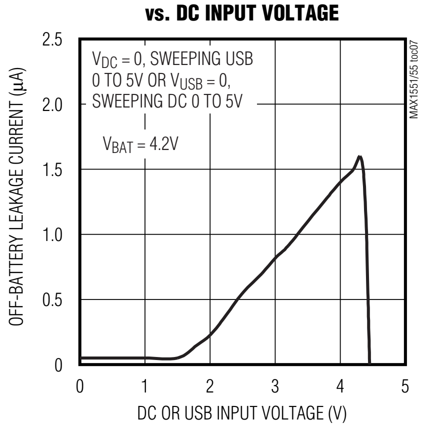
DC CHARGE CURRENT vs. AMBIENT TEMPERATURE



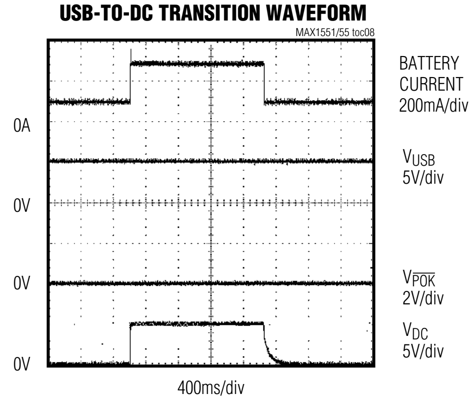
BATTERY TERMINATION VOLTAGE vs. TEMPERATURE



OFF-BATTERY LEAKAGE CURRENT vs. DC INPUT VOLTAGE



USB-TO-DC TRANSITION WAVEFORM



Pin Description

PIN	NAME	FUNCTION
1	USB	USB Port Charger Supply Input. USB draws up to 100mA to charge the battery. Decouple USB with a 1µF ceramic capacitor to GND.
2	GND	Ground
3	$\overline{POK}$	Power-OK Active-Low Open-Drain Charger Status Indicator. $\overline{POK}$ pulls low when either charger source is present (MAX1551 only).
	$\overline{CHG}$	Active-Low Open-Drain Charge Status Indicator. $\overline{CHG}$ pulls low when the battery is charging. $\overline{CHG}$ goes to a high-impedance state, indicating the battery is fully charged, when the charger is in voltage mode and charge current falls below 50mA. $\overline{CHG}$ is high impedance when both input sources are low (MAX1555 only).
4	DC	DC Charger Supply Input for an AC Adapter. DC draws 280mA to charge the battery. Decouple DC with a 1µF ceramic capacitor to GND.
5	BAT	Battery Connection. Decouple BAT with a 1µF ceramic capacitor to GND.

Detailed Description

The MAX1551/MAX1555 charge a single-cell Li+ battery from both USB and AC adapter sources, enabling portable users to forgo carrying a wall cube. These devices operate with no external FETs or diodes, and accept operating input voltages up to 7V.

An internal thermal control loop simplifies PC board layout and allows optimum charging rate without the thermal limits imposed by worst-case battery and input voltage. When the MAX1551/MAX1555 thermal limits are reached, the chargers do not shut down, but simply reduce charging current by 17mA/°C above a die temperature of +110°C.

With USB connected, but without DC power, the charge current is set to 100mA (max). This allows charging from both powered and unpowered USB hubs with no port communication required. When DC power is connected, charging current is set at 280mA (typ). The MAX1551/MAX1555 do not feature an enable input. Once power is connected to USB and/or DC, the charger is on.

When input power is removed, battery leakage current is less than 5µA. No input-blocking diodes are required to prevent battery drain. Insert a diode at DC (the adapter input) if protection from negative voltage inputs (reversed-polarity adapter plugs) is required.

USB to Adapter Power Handoff

The MAX1551/MAX1555 can charge from either the USB input or the DC input. The battery does not charge from both sources at the same time. The MAX1551/MAX1555 automatically detect the active input and charge from that. If both power sources are active, the DC input takes precedence. The switchover between DC and USB is detailed in Table 1.

MAX1551 Power-OK ($\overline{POK}$)

The MAX1551's $\overline{POK}$ is an active-low, open-drain output that goes low when V_{DC} or V_{USB} is above 3.95V. $\overline{POK}$ can be used as a logic output or can drive an LED. $\overline{POK}$ indicates the charger is connected to input power and is charging.

MAX1555 Charge Status ($\overline{CHG}$)

The MAX1555's $\overline{CHG}$ is an active-low, open-drain charge status indicator. $\overline{CHG}$ pulls low when the battery is charging (whenever USB or DC are powered) and charge current is greater than 50mA. $\overline{CHG}$ indicates when the battery is fully charged by going high impedance when the charger is in voltage mode *and* charge current falls below 50mA. Charging does not stop when $\overline{CHG}$ goes high. $\overline{CHG}$ is low in precharge mode.

Table 1. USB and DC Input Selection

V_{DC} > 7V OR V_{USB} > 6V	V_{DC} > 3.95V AND V_{USB} DON'T CARE	V_{DC} < 3.52V AND 3.95V < V_{USB} < 6V	V_{DC} AND V_{USB} < 3.52V
Exceeds operating input range. Not allowed. See the *Absolute Maximum Ratings* section.	280mA (typ) charging from DC	100mA (max) charging from USB	Undervoltage lockout

(V_{DC} takes precedence when both inputs are present.)

Precharge Current

The MAX1551/MAX1555 feature a precharge current to protect deeply discharged cells. If V_{BAT} is less than 3V, the device enters precharge mode where charging current is limited to 40mA.

Package Thermal Limiting

On-chip thermal limiting in the MAX1551/MAX1555 simplifies PC board layout and allows charging rates to be optimized without the limits imposed by worst-case battery and input voltages. The device reduces the power dissipation at BAT to prevent overheating. This allows the board design to be optimized for compact size and typical thermal conditions. When the MAX1551/MAX1555 thermal limits are reached, the chargers do not shut down, but progressively reduce charging current by 17mA/°C above a die temperature of +110°C. Solder the MAX1551/MAX1555s' GND to a large ground plane to help dissipate power and keep the die temperature below the thermal limit. The USB charge current of 100mA is unlikely to induce thermal limiting.

Bypass Capacitors

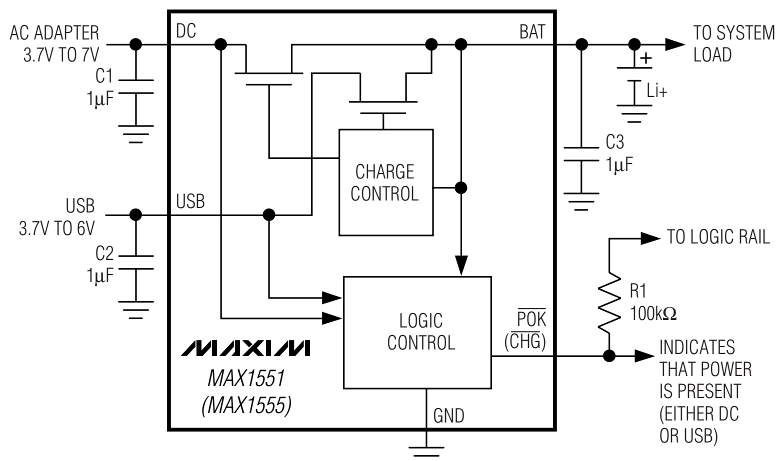
Use ceramic bypass capacitors at DC, USB, and BAT. Mount these capacitors within 1cm of their respective pins. X7R and X5R dielectrics are recommended.

Chip Information

TRANSISTOR COUNT: 541

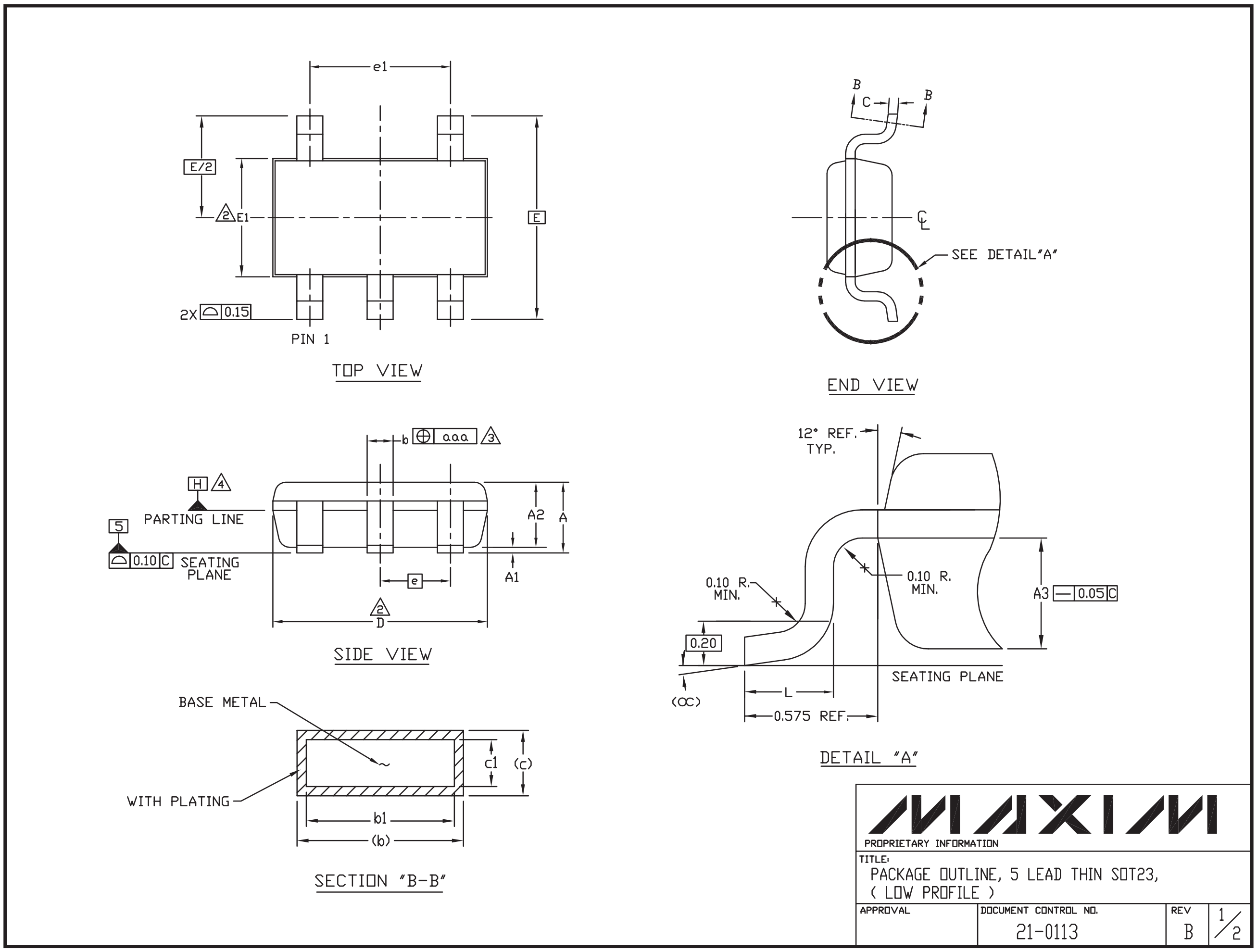
PROCESS: BiCMOS

Typical Application Circuit



Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. "D" AND "E1" ARE REFERENCE DATUM AND DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS, AND ARE MEASURED AT THE BOTTOM PARTING LINE. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15mm ON "D" AND 0.25mm ON "E" PER SIDE.
3. THE LEAD WIDTH DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.07mm TOTAL IN EXCESS OF THE LEAD WIDTH DIMENSION AT MAXIMUM MATERIAL CONDITION.
4. DATUM PLANE "H" LOCATED AT MOLD PARTING LINE AND COINCIDENT WITH LEAD, WHERE LEAD EXITS PLASTIC BODY AT THE BOTTOM OF PARTING LINE.
5. THE LEAD TIPS MUST LINE WITHIN A SPECIFIED TOLERANCE ZONE. THIS TOLERANCE ZONE IS DEFINED BY TWO PARALLEL LINES. ONE PLANE IS THE SEATING PLANE, DATUM [-C-]; AND THE OTHER PLANE IS AT THE SPECIFIED DISTANCE FROM [-C-] IN THE DIRECTION INDICATED. FORMED LEADS SHALL BE PLANAR WITH RESPECT TO ONE ANOTHER WITH 0.10mm AT SEATING PLANE.
6. THIS PART IS COMPLIANT WITH JEDEC SPECIFICATION MO-193 EXCEPT FOR THE "e" DIMENSION WHICH IS 0.95Mmm INSTEAD OF 1.00mm. THIS PART IS IN FULL COMPLIANCE TO EIAJ SPECIFICATION SC-74.

SYMBOLS			
	MIN	NOM	MAX
A	-	-	1.10
A1	0.05	0.075	0.10
A2	0.85	0.88	0.90
A3	0.50 BSC		
b	0.30	-	0.45
b1	0.25	0.35	0.40
c	0.15	-	0.20
c1	0.12	0.127	0.15
D	2.80	2.90	3.00
E	2.75 BSC		
E1	1.55	1.60	1.65
L	0.30	0.40	0.50
e1	1.90 BSC		
e	0.95 BSC		
α	0°	4°	8°
aaa	0.20		

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 5 LEAD THIN SOT23, (LOW PROFILE)

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0113	B	2/2

19-2024; Rev 2; 6/03

USB-Powered Li+ Charger

MAX1811

General Description

The MAX1811 is a single-cell lithium-ion (Li+) battery charger that can be powered directly from a USB port* or from an external supply up to 6.5V. It has a 0.5% overall battery regulation voltage accuracy to allow maximum utilization of the battery capacity.

The charger uses an internal FET to deliver up to 500mA charging current to the battery. The device can be configured for either a 4.1V or 4.2V battery, using the SELV input. The SELI input sets the charge current to either 100mA or 500mA. An open-drain output ($\overline{CHG}$) indicates charge status.

The MAX1811 has preconditioning that soft-starts a near-dead battery cell before charging. Other safety features include continuous monitoring of voltage and current and initial checking for fault conditions before charging.

The MAX1811 is available in a small 1.4W thermally enhanced 8-pin SO package.

Features

- ♦ **Charges Single-Cell Li+ Batteries Directly from USB Port**
- ♦ **0.5% Overall Charging Accuracy**
- ♦ **Minimal External Components**
- ♦ **Input Diode Not Required**
- ♦ **Automatic IC Thermal Regulation**
- ♦ **Preconditions Near-Depleted Cells**
- ♦ **Convenient Power SO-8 Package (1.4W)**
- ♦ **Protected by U.S. Patent # 6,507,172**

Applications

PDAs and Palmtops

Digital Still Cameras

MP3 Players

Cell Phones

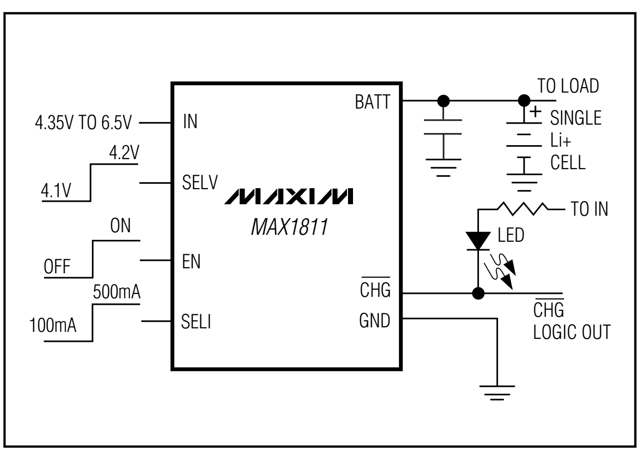
Two-Way Pagers

Hand-Held Computers

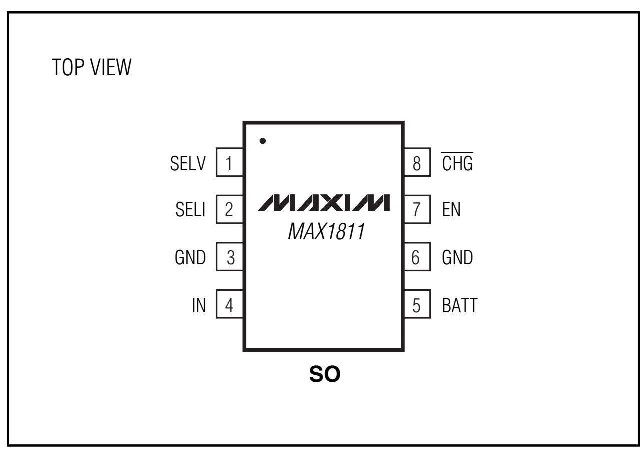
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX1811ESA	-40°C to +85°C	8 SO

Typical Operating Circuit



Pin Configuration



* *Protected by U.S. Patent # 6,507,172*

ABSOLUTE MAXIMUM RATINGS

IN, BATT, SELI, $\overline{CHG}$, EN to GND ....-0.3V to 7V
SELV to GND ....-0.3V to (V_{IN} + 0.3V)
Continuous Power Dissipation (T_A = +70°C)
8-Pin SO (derate 17.5mW/°C above +70°C)....................1.4W
Short-Circuit Duration..Continuous
Operating Temperature Range ....-40°C to +85°C
Storage Temperature Range ....-65°C to +150°C
Maximum Die Temperature...+150°C
Lead Temperature (soldering, 10s) ....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 4.5V, EN = IN, **T_A = 0°C to +85°C**, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Supply Voltage		4.35		6.50	V
Input Undervoltage Lockout	I_{IN} rising	3.75		4.05	V
Input Undervoltage Lockout Hysteresis			50		mV
Input Supply Current	Operating, EN = IN, no load		0.9	2.0	mA
	Shutdown, EN = GND		2.5	5.0	µA
Charging Headroom	SELI = GND (100mA mode), V_{IN} = 4.35V		100		mV
	SELI = IN (500mA mode)		200		
Precondition Threshold	BATT rising, transition from precondition to charge mode	2.3	2.5	2.7	V
Precondition Threshold Hysteresis			80		mV
$\overline{CHG}$ Output Leakage Current	$V_{IN} = V_{\overline{CHG}}$ = 6.5V		0.1	1.0	µA
$\overline{CHG}$ Output Low Voltage	I_{SINK} = 10mA			0.4	V
Charging Current	$V_{SELI} = V_{IN}$ = 5.5V, V_{BATT} = 2.7V		455	500	mA
	SELI = GND, V_{IN} = 5.5V, V_{BATT} = 2.7V		85	100	
	V_{BATT} = 2V, SELI = GND or IN	20	43	70	
BATT Regulation Voltage	SELV = GND, I_{BATT} = 0	4.08	4.10	4.12	V
	SELV = IN, I_{BATT} = 0	4.18	4.20	4.22	
BATT Leakage Current (Input Power Removed)	V_{BATT} = 4.2V, EN = IN = GND		1	5	µA
BATT Shutdown Current	EN = GND, V_{BATT} = 4.2V		0.1	2	µA
Logic Input Low Voltage (EN, SELI, SELV)	V_{IN} = 4.35V to 6.5V			0.8	V
Logic Input High Voltage (EN, SELI, SELV)	V_{IN} = 4.35V to 6.5V	2.0			V
Logic Input Leakage Current (EN, SELI)	V_{IN} = 0 to 6.5V; V_{SELI}, V_{EN} = 6.5V or GND			1	µA
Logic Input Leakage Current (SELV)	V_{IN} = 0 to 6.5V, V_{SELV} = V_{IN} or GND			1	µA
Thermal Regulation	Die temperature beyond which charging current is reduced		125		°C

ELECTRICAL CHARACTERISTICS

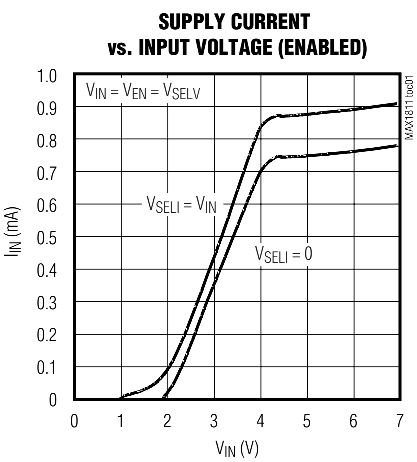
(V_{IN} = 4.5V, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note1)

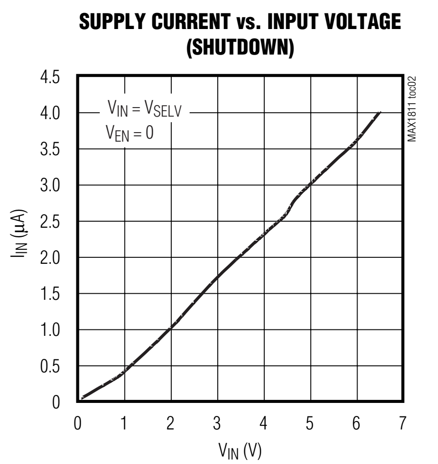
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Supply Voltage		4.35		6.50	V
Input Undervoltage Lockout	I_{IN} rising	3.75		4.05	V
Input Supply Current	Operating, EN = IN, no load			3	mA
	Shutdown, EN = GND			6	µA
Precondition Threshold	BATT rising, transition from precondition to charge mode	2.3		2.7	V
BATT Regulation Voltage	SELV = GND, I_{BATT} = 0	4.06		4.14	V
	SELV = IN, I_{BATT} = 0	4.16		4.24	
BATT Leakage Current (Input Power Removed)	V_{BATT} = 4.2V, IN = GND			10	µA
BATT Shutdown Current	EN = GND, V_{BATT} = 4.2V			3	µA

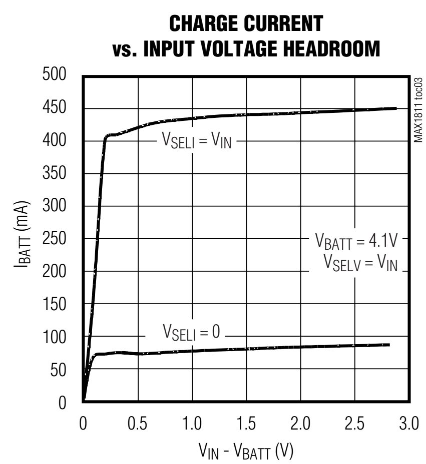
Note 1: Specifications to -40°C are guaranteed by design and not production tested.

Typical Operating Characteristics

($\overline{CHG}$ unconnected, C_{BATT} = 2.2µF, T_A = +25°C, unless otherwise noted.)

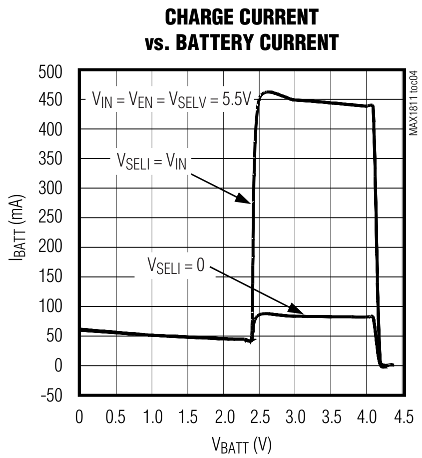


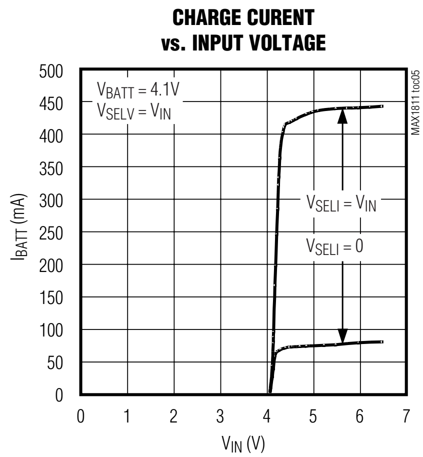


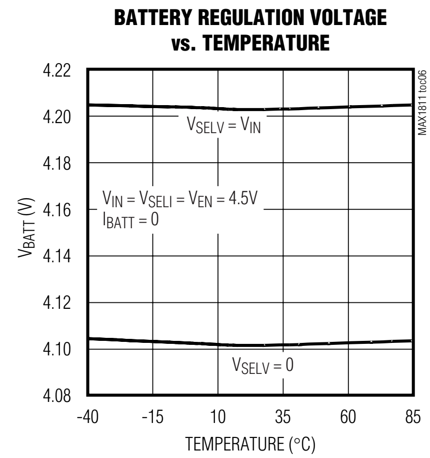


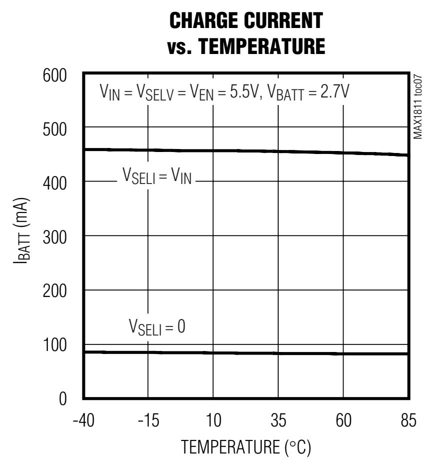
Typical Operating Characteristics (continued)

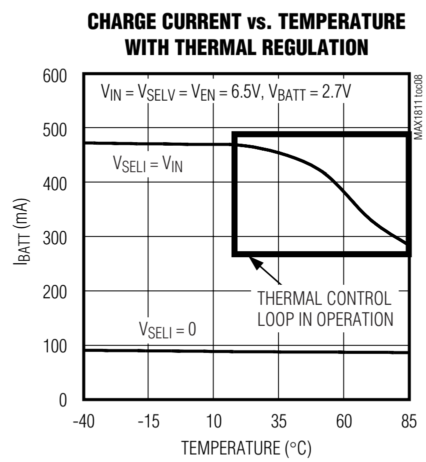
($\overline{CHG}$ unconnected, C_{BATT} = 2.2µF, T_A = +25°C, unless otherwise noted.)











Pin Description

PIN	NAME	DESCRIPTION
1	SELV	Battery Regulation Voltage-Select Input. A low (< 0.8V) selects a 4.1V battery regulation set point. A high (> 2.0V) selects a 4.2V battery regulation set point.
2	SELI	Battery Regulation Current-Select Input. A low (< 0.8V) selects a 100mA maximum battery regulation current. A high (> 2.0V) selects a 500mA maximum battery regulation current. SELI is not diode clamped to IN, and the voltage at V_{SELI} can exceed the voltage at V_{IN}.
3, 6	GND	Ground. Connect pins 3 and 6 to a large copper trace for maximum power dissipation.
4	IN	Input Supply Voltage. Bypass with a 4.7µF capacitor to GND.
5	BATT	Li+ Battery Connection. Bypass with a capacitor no less than 2.2µF to GND. High impedance in shutdown.
7	EN	Enable Input. A high (> 2.0V) enables the device. A low (< 0.8V) disables the device and places it into shutdown mode. BATT is high impedance when disabled.
8	$\overline{CHG}$	Charging Indicator Open-Drain Output. $\overline{CHG}$ pulls low while the device is in charge mode (2.5V < V_{BATT} < BATT Regulation Voltage).

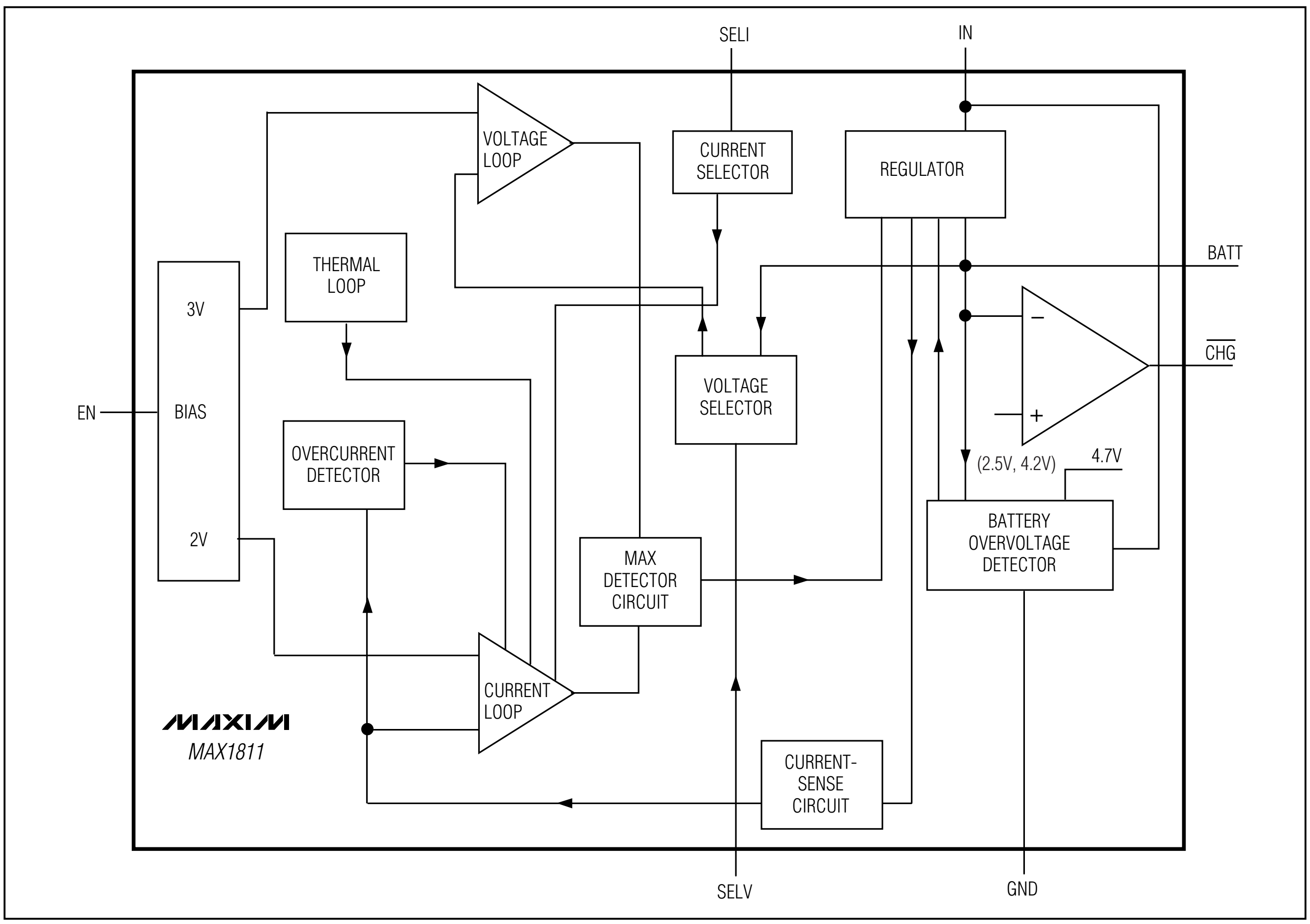


Figure 1. Functional Diagram

Detailed Description

Charger-Control Circuitry

The voltage/current regulator consists of a voltage control loop, a current control loop, and a thermal control loop (Figure 1). Use the SELV input to set the battery regulation voltage to a 4.1V or 4.2V single Li+ cell. The current and thermal loops are internally compensated and require no external compensation. The outputs from all loops drive an internal linear regulator. The thermal loop modulates the current loop by limiting the charge current if the die temperature exceeds +125°C. The MAX1811 is in current mode when the BATT voltage is below the regulation set point and in voltage mode when the BATT voltage is near the regulation set point. The $\overline{CHG}$ output indicates whether the part is in current mode ($\overline{CHG}$ = low) or voltage mode ($\overline{CHG}$ = high impedance). Battery voltages less than 2.5V activate a 43mA preconditioning mode ($\overline{CHG}$ = high impedance). Normal charging resumes when the battery voltage exceeds 2.5V.

System Configuration

The MAX1811 is designed to operate seamlessly with a universal serial bus (USB) port. In a typical design, the USB connects to the MAX1811 input, and the MAX1811 drives the load and charges the battery when enabled.

Charge-Current Selection

The MAX1811 charges a single cell Li+ battery in either 100mA or 500mA modes. The MAX1811 expects the system to poll the USB host to determine if the USB is capable of providing 100mA or 500mA and regulates the charging current accordingly (Figure 2). This is to maintain compatibility with both powered and unpowered USB hosts. A powered USB host is capable of providing 500mA, and an unpowered USB hub is limited to only 100mA.

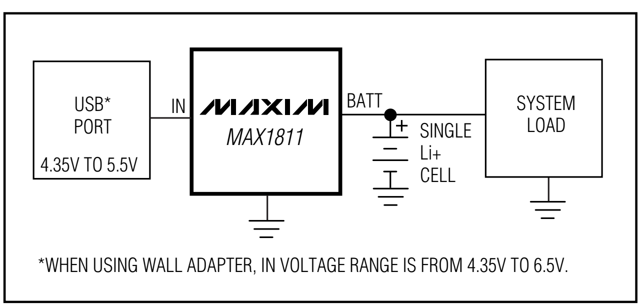


Figure 2. System Configuration

Drive SELI low to set the charge current to the 100mA mode. Use a 10kΩ pulldown resistor to ground on SELI, if necessary, to ensure that the MAX1811 defaults to the 100mA mode in the event that no logic signal is present. Drive SELI high to increase the charge current to the 500mA mode only if the polled USB port can provide the required current.

Thermal-Control Circuitry

The thermal loop limits the MAX1811 die temperature to +125°C by reducing the charging current as necessary. The MAX1811 can operate normally with the thermal loop active. This is not a fault condition and can be used continuously. The power dissipated by the internal power FET is determined by (V_{IN} - V_{BATT}) × I_{CHG}. The power dissipation rating for the thermally enhanced 8-pin SO package is 1.4W at +50°C ambient (assuming a 1in^2 PC board radiating area), which is the maximum ambient temperature at which most Li+ battery manufacturers allow charging. The 1.4W power dissipation may never be reached due to the MAX1811's thermal regulation loop.

Applications Information

USB Output Voltage

The minimum voltage to a USB-powered device may be as low as 4.35V when cable and connector drops are considered (Figure 3). The MAX1811 is optimized for operation at these low input voltage levels. USB hubs may also provide as much as 5.5V. At high input voltages (5.5V) and low cell voltages (2.7V), the MAX1811's thermal loop may limit the charge current until the cell voltage rises.

Charging from AC Adapters

The MAX1811 also operates from sources other than USB ports. The full charging input voltage range is 4.35V to 6.5V. When charging in the 500mA mode with an AC adapter, rely on the thermal loop to limit the power dissipation by limiting the charge current at higher input voltages if limited PC board area is available to dissipate heat.

Capacitor Selection

Use a minimum of 2.2µF placed close to BATT for proper stability. Bypass IN to GND with a 4.7µF capacitor. Use a larger input bypass capacitor for high input voltages or high charging current to reduce supply noise.

Chip Information

TRANSISTOR COUNT: 1907

PROCESS: BiCMOS

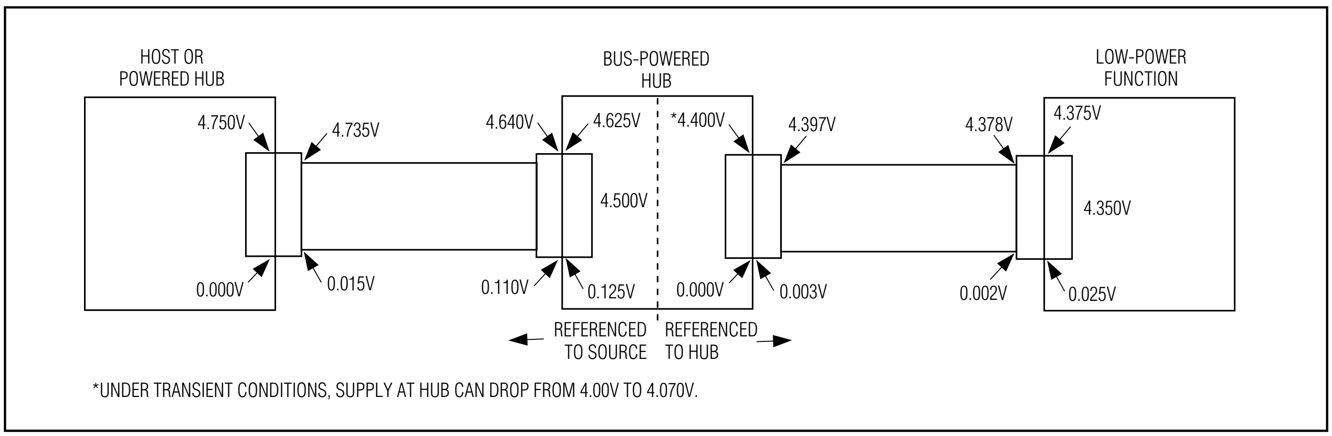


Figure 3. USB Voltage Specification

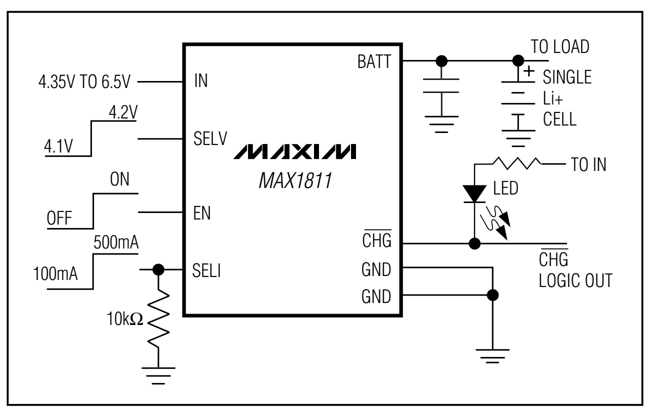


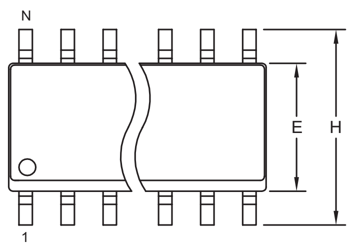
Figure 4. Charging from a USB Port

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

SOICN .EPS

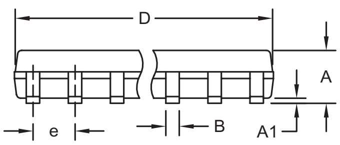
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27



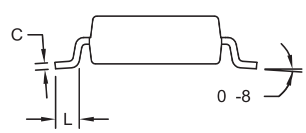
TOP VIEW

VARIATIONS:

	INCHES		MILLIMETERS			
DIM	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE:

PACKAGE OUTLINE, .150" SOIC

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0041	B	1/1