High Efficiency 2A 1.5MHz Single Cell Li-ion Battery Switching Charger

Description

The MT2011 is a 4.5-20V input, 2A single-cell synchronous Li-Ion battery switching charger, suitable for portable application. The MT2011 integrates a synchronous PWM controller, 20V rating power MOSFETs, current sense resistor, high-accuracy current and voltage regulation, and charge termination, into a compact 8-pin SOP_EP package.

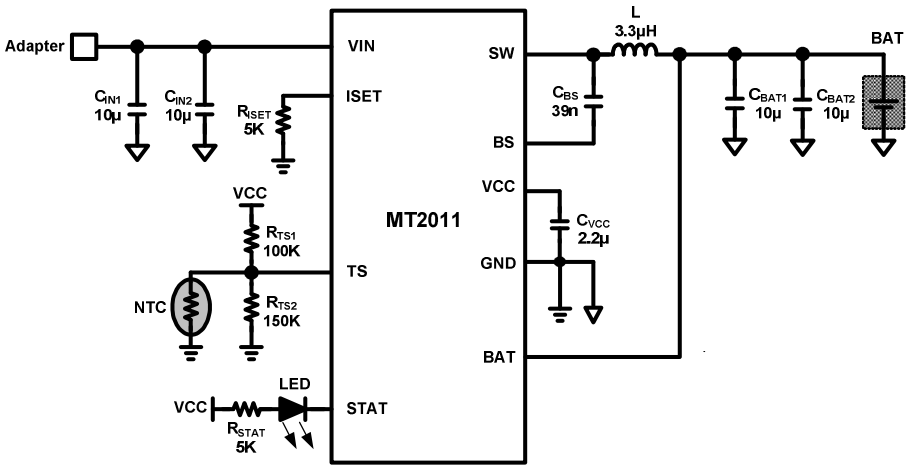
Features

- 1.5MHz Synchronous Switching Charger with Integrated Power FETs
- Up to 93% Efficiency
- 20V Input Rating with 6.7V OVP
- Programmable (2A Max) Charge Current
- Built-in Charge Current Soft Start
- Built-in Reverse Current Blocking Diode
- Built-in Charge Current Sense Resistor
- Output Short Circuit Protection
- Over Temperature Protection
- Pb-Free(ROHS compliant)
- Available in a SOP8_EP Package

Applications

- Tablet PC, Ebook and Netbook
- Handheld Portable Media Products
- Power Bank

Typical Application



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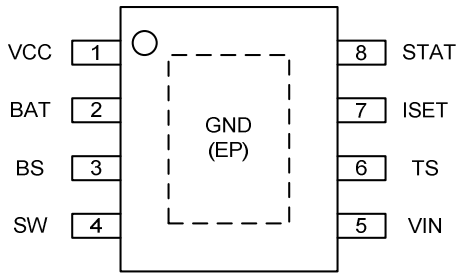
Ordering Information

Part No.	Marking	Temp. Range	Package	Remark	MOQ
MT2011XSPR	MT2011 YWWXX X	-40℃ ~85℃	SOP8L_EP	VBAT_REG=4.2V	2500/Tape & Reel
MT2011BSPR	MT2011 YWWXX B	-40℃ ~85℃	SOP8L_EP	VBAT_REG=4.35V	2500/Tape & Reel

Note: Y:Year, WW:Week, XX:Control Code

Pin Configuration



Top View

Pin Description

Pin NO.	Pin Name	Description		
1	VCC	5V linear regulator output. Bypass a 2.2uF ceramic capacitor from VCC to GND.		
2	BAT	Battery connection. Connect to the positive terminal of the battery. Bypass BAT to GND with a 20uF capacitor.		
3	BS	High Side MOSFET Gate Driver Supply. Connect a 0.1uF ceramic capacitor from BS to SW to supply the gate drive for the high side MOSFETs.		
4	SW	Switching node. Connect SW to the external inductor.		
5	VIN	IC power supply of internal bias and power devices. Bypass 20uF MLCC ceramic capacitor from VIN to GND.		
6	TS	Battery Pack NTC Monitor. Connect TS to the center tap of a resistor divider from VCC to GND. Pull TS to GND and disable charge function.		
7	ISET	Charge Current Programming Input. Connect a resistor R_{ISET} from ISET to GND to program the charge current. The charge current is programmable from 0.5A to 2A.		
8	STAT	Charge Status Open Drain Output. STAT is pulled low when a charge cycle starts and remains low while charging. STAT is high impedance when the charging terminates and when no supply exists. STAT is blinking when IC detect fault conditions.		
		HIGH	LOW	Blinking
		Charge complete	Charge in progress	Fault
EP	GND	The exposed thermal pad and the IC ground pin.		

Absolute Maximum Rating (Reference to GND) (Note1)

VIN, STAT to GND …….. -0.3V to 20V

BS to GND ……..…….. -0.3V to 26V

SW to GND ……..... -2 to 20V

VCC, ISET, TS, BAT to GND …….. -0.3V to 6V

Junction temperature range …..... 150℃

Storage temperature range ……. -55℃ to 150℃

Lead Temperature ……..…… 260℃

ESD Classification ……..…….. Class 2

Recommended Operating Conditions (Note2)

Input Voltage (V_{IN}) ……..…… 4.5V to 6.5V

Junction temperature range …….. 135℃

Ambient Temperature Range ……. -40℃ to 85℃

Thermal Information (Note3, 4)

Maximum Power Dissipation (TA=25℃) …2.15W

Thermal resistance θ_{JA} …….. 51℃/W

Thermal resistance θ_{JC} …….. 13℃/W

Note1: Stress exceeding those listed “Absolute Maximum Ratings” may damage the device.

Note2: The device is not guaranteed to function outside of the recommended operating conditions.

Note3: Measured on JESD51-7, 4-Layer PCB.

Note4: The maximum allowable power dissipation is a function of the maximum junction temperature T_{J_MAX}, the junction to ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D\_MAX}= (T_{J\_MAX}-T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

Electrical Characteristics (Note1)

Unless otherwise noted, all parameter limits are established over the recommended operating conditions:

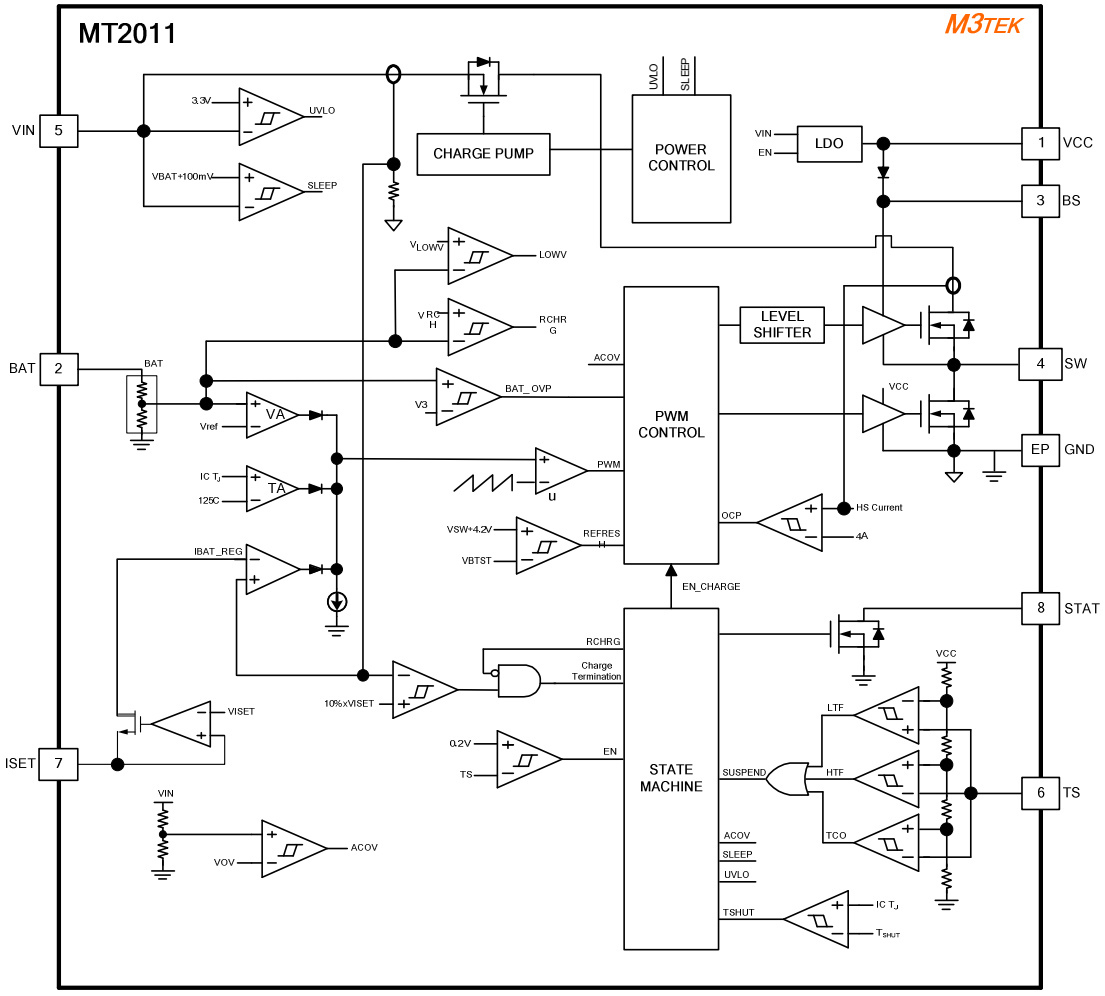
V_{IN}=5V, typical values are at T_A = 25℃, with respect to GND (unless otherwise note d)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNITS
INPUT VOLTAGE						
V_{IN}	Supply Operating Range		4.5		6.5	V
V_{UVLO}	Under-voltage lockout threshold	Measure on VIN 0V➔4V		3.3		V
V_{UVLO_HYS}	Hysteresis on UVLO	Measure on VIN 4V➔0V		300		mV
V_{OVP}	Over-Voltage Rising	VIN rising 5V➔7V	6.55	6.75	6.95	V
V_{OVP_HYS}	Hysteresis on OVP	VIN falling 7V➔5V		100		mV
AUTOMATIC SLEEP COMPARATOR (REVERSE DISCHARGING PROTECTION)						
V_{SLEEP}	SLEEP mode threshold	V_{IN} – V_{BAT} falling		100		mV
V_{SLEEP_HYS}	Hysteresis	V_{IN} – V_{BAT} rising		200		mV
QUIESCENT CURRENTS						
I_{BAT}	Battery discharge current	Pull TS to GND			25	μA
I_{AC}	Adapter supply current	V_{IN} > V_{UVLO}, V_{IN} > V_{BAT}, V_{BAT}>V_{BAT_REG}, Charge disabled		1.2	2.0	mA

Electrical Characteristics (continued)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
CHARGE VOLTAGE REGULATION					
V_{BAT_REG} BAT regulation voltage	MT2011X, measured on BAT 0℃ ≤ T_A ≤+70℃	4.158	4.200	4.242	V
	MT2011B, measured on BAT 0℃ ≤T_A ≤+70℃	4.306	4.350	4393	V
V_{RCHG} Recharge Threshold, below regulation voltage limit	1 cell, measured on BAT V_{BAT_REG}-V_{BAT}		100		mV
V_{LOWV} Trickle Charge to fast charge transition threshold	measured on BAT		2.9		V
V_{OV_BAT} BAT Over-voltage Threshold	As percentage of V_{BAT_REG}		104%		
CHARGE CURRENT REGULATION					
I_{OUT} Charge Current Limit	$V_{BAT(REG)} > V_{BAT} > V_{LOWV}$; $I_{OUT} = K_{ISET}/R_{ISET}$: R_{ISET} = 40kΩ to 200kΩ	0.5		2	A
K_{ISET} Fast charge current factor	$R_{ISET} = K_{ISET}/I_{OUT}$; 0.5A<$I_{OUT}$< 2A		100		A·kΩ
%I_{TRICHG} Trickle Charge Current	$V_{BAT} < V_{LOWV}$		10		%I_{OUT}
%I_{TERM} Termination Current	$V_{BAT} > V_{RCHG}$		10		%I_{OUT}
THERMISTOR COMPARATOR					
V_{COLD} Cold Temperature, TS pin Voltage Rising Threshold	Charger suspends charge. As percentage to V_{CC} Hysteresis 0.4%	70.5%	73.5%	76.5%	
V_{HOT} Hot Temperature TS pin voltage rising Threshold	As percentage to V_{CC} Hysteresis 2.5%		47.2%		
V_{OFF} Charging Disable Threshold TS pin voltage falling edge	Hysteresis 0.15V			0.15	V
INTERNAL THERMAL REGULATION					
T_{J_REG} Temperature Regulation Limit	Charging		125		℃
$T_{J(OFF)}$ Thermal Shutdown Temperature			160		℃
$T_{J(OFF-HYS)}$ Thermal Shutdown Hysteresis			20		℃
INTERNAL PWM Driver					
fsw PWM Switching Frequency		1200	1500	1700	kHz
I_{OCP_HSFET} Peak Current limit	Measure on High Side FET		4		A
R_{DS_HI}	High Side MOSFET On Resistance		150		mΩ
R_{DS_LO}	Low Side MOSFET On Resistance		75		mΩ
VCC REGULATOR					
V_{CC_REG} V_{CC} regulator voltage	V_{IN} > 6 V,	4.0	5.0	5.5	V
I_{VCC_LIM} V_{CC} current limit	V_{CC} = 0 V		50		mA

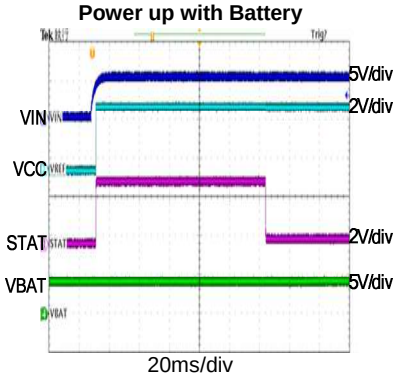
Functional Block Diagram



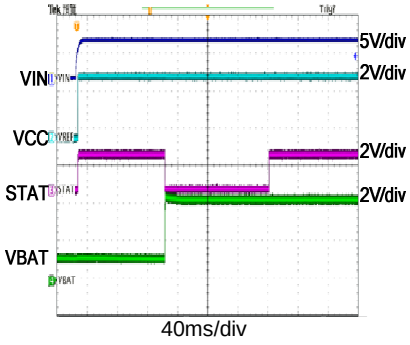
Typical Performance Characteristics

VIN = 5V, R_{ISET}=50kΩ, Typical Application Circuit Figure 1, T_A = +25℃, unless otherwise noted.

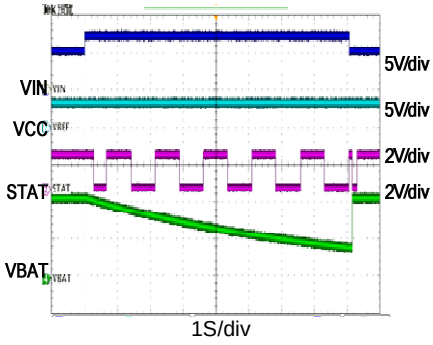
Power up with Battery



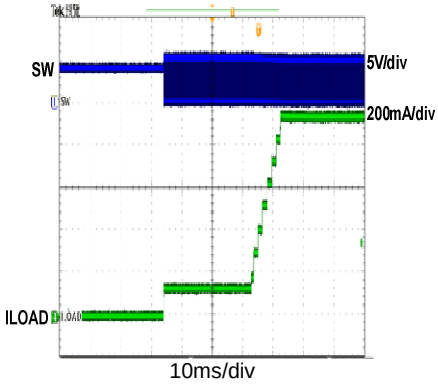
Power up without Battery



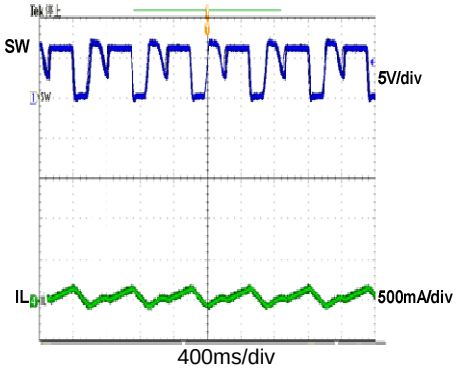
Input Over-voltage Protection



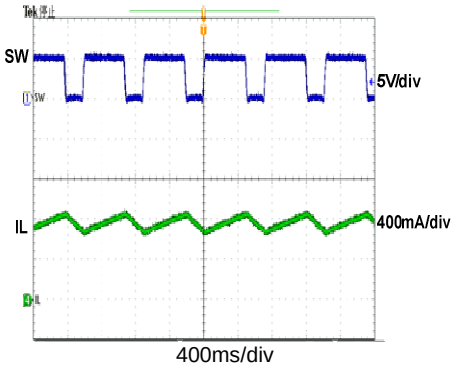
Charge Current Soft Start



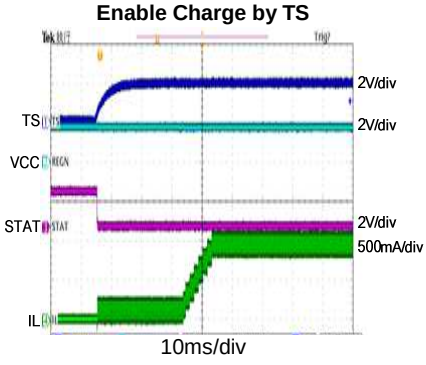
Charge Current Discontinuous Conduction Mode



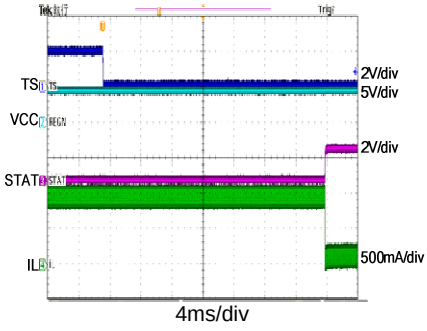
Charge Current Continuous Conduction Mode



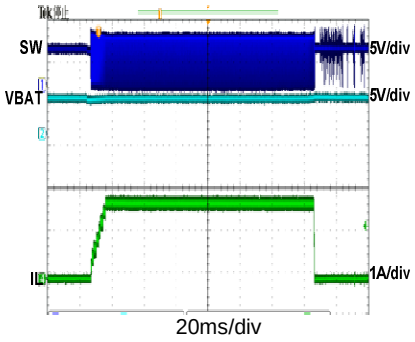
Enable Charge by TS



Disable Charge by TS



Battery Insertion and Removal



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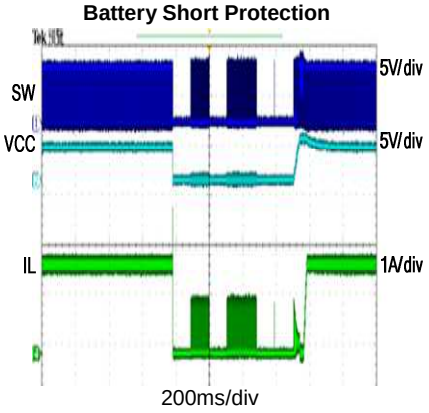
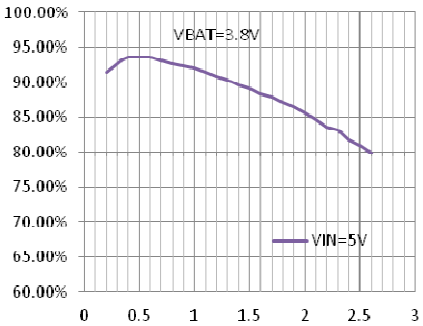
Typical Performance Characteristics

VIN = 5V, R_{ISET}=50kΩ, Typical Application Circuit Figure 1, T_A = +25℃, unless otherwise noted

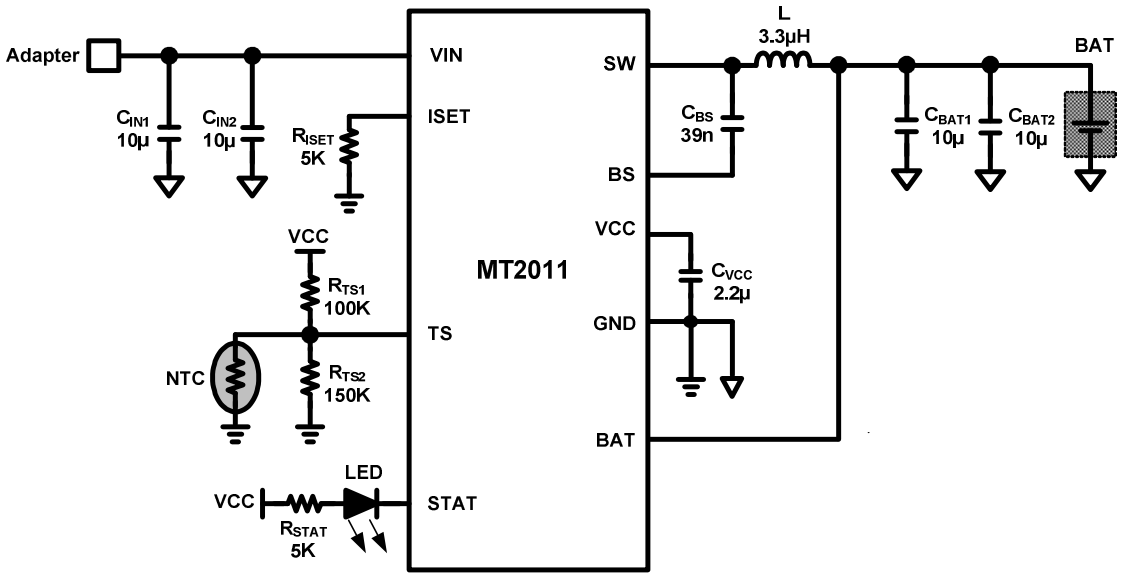
Battery Short Protection



Efficiency vs. ICHG(A)



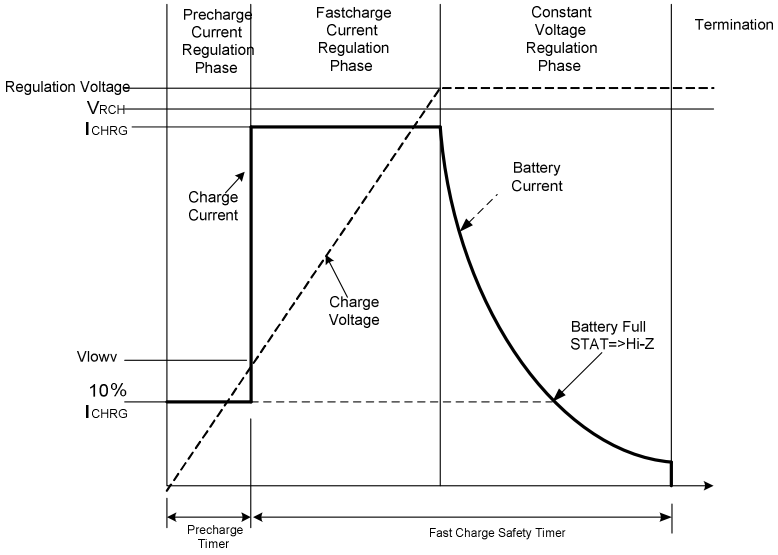
Typical Application Circuit



MT2011 Typical Application Circuit, ICHG=2A

Detailed Description

The MT2011 family is an integrated charger optimized for charging 1-cell Li-ion or Li-polymer batteries. It charges a battery with constant current (CC) and constant voltage (CV) profile. The typical charge profile is illustrated in below figure.



MT2011 Typical Charge Profile

Battery Charge Current Regulation

The charge current up to 2A is programmed by a resistor R_{ISET} from ISET to ground. The charge current is calculated by the following equation:

$$I_{CHG} = \frac{K_{ISET}}{R_{ISET}} = \frac{100\ A \cdot k\Omega}{R_{ISET}}$$

The valid resistor range is 40kΩ to 200kΩ (See Table 1.) Under high ambient temperature, the charge current will be fold back to keep IC junction temperature not exceeding +125℃.

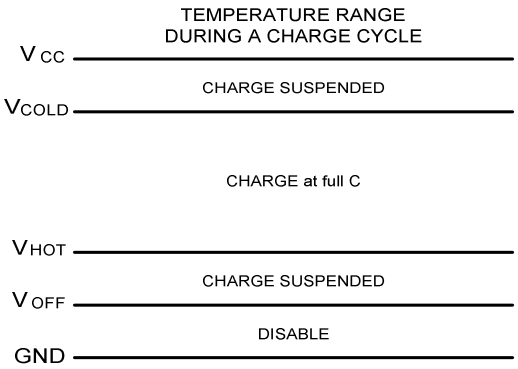
Table 1. Charge Current Settings

R_{ISET} (kΩ)	Charge Current (A)
50	2.0
66.7	1.5
100	1.0
200	0.5

The Thermistor Input TS

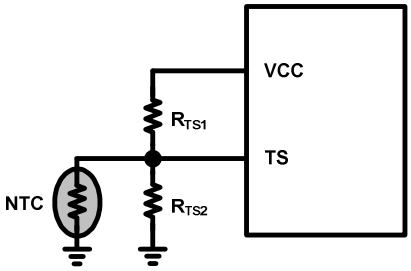
The MT2011 continuously monitors battery temperature by measuring the voltage between the TS pin and GND. A negative temperature coefficient thermistor (NTC) and an external voltage divider typically develop this voltage. The MT2011 compares this voltage against its internal thresholds to determine if charging is

allowed. To initiate a charge cycle, the battery temperature must be within the VCOLD to VHOT thresholds. If battery temperature is outside of this range, the MT2011 suspends charge and waits until the battery temperature is within the VCOLD to VHOT range. During the charge cycle the battery temperature must be within the VCOLD to VHOT threshold.



Thermistor Input TS Pin Threshold

Refer to MT2011 typical operating circuit. RTHHOT is the expected thermistor resistance at the programmed hot threshold, and RTHCOLD is the expected thermistor resistance at the programmed cold threshold. The values of R_{TS1} and R_{TS2} can be determined by using below equations.



$$R_{TS2} = \frac{V_{CC} \times RTH_{COLD} \times RTH_{HOT} \times \left(\frac{1}{V_{COLD}} - \frac{1}{V_{HOT}}\right)}{RTH_{HOT} \times \left(\frac{V_{CC}}{V_{HOT}} - 1\right) - RTH_{COLD} \times \left(\frac{V_{CC}}{V_{COLD}} - 1\right)}$$

$$R_{TS1} = \frac{\frac{V_{CC}}{V_{COLD}} - 1}{\frac{1}{R_{TS2}} + \frac{1}{RTH_{COLD}}}$$

Where V_{COLD} = 0.735 X V_{CC} and V_{HOT} = 0.447 X V_{CC}

Charge Current Soft Start

The MT2011 soft starts the charge current to ensure no overshoot or stress on the output capacitors or the power converter.

Battery Trickle Charge Current Regulation

During power-up, if the battery voltage is below the VLOWV threshold, the MT2011 only applies the trickle charge current into the battery. This trickle charge feature is intended to revive deeply discharged cells. If the V_{LOWV} threshold is not reached within 30 minutes of initiating trickle charge, the charger is turned off, and STAT pin blinks to indicate a FAULT condition.
For MT2011 series, the trickle charge current is set as 10% of the full charge current.

Charge Termination

The MT2011 monitor the charge current during the battery voltage regulation phase. Charge termination is set when the battery voltage is higher than recharge threshold V_{RCH} and the charge current is less than 10% of the full charge current.

Recharge

A new charge cycle is initiated when one of the following conditions occurs:

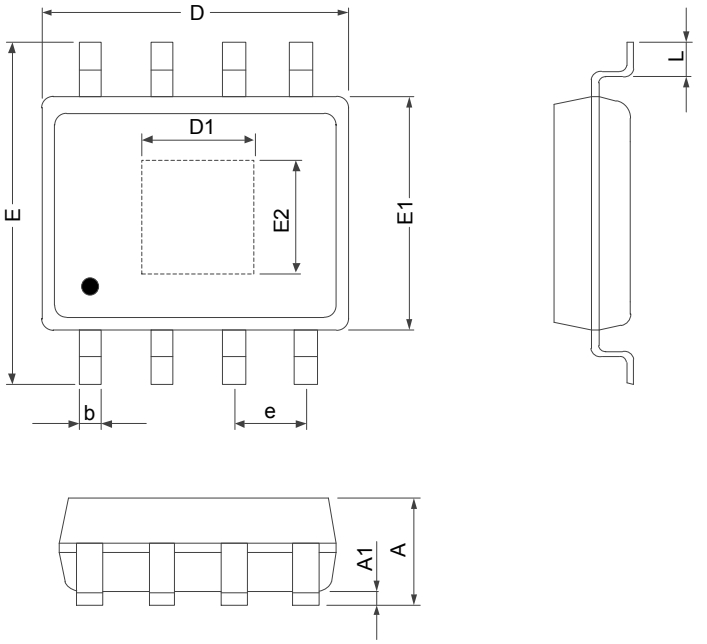
- The battery voltage falls below the recharge threshold
- Input supply V_{IN} power-on-reset (POR) event occurs
- TS pin is toggled below 0.15V (disable charging) and above 0.3V (enable charging)

PCB Layout Consideration

For the best efficiency and minimum noise problem, Place C_{IN}, C6, C7, C2, L, R_{ISET}, R3 and R4 close to the IC. Maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable. C_{IN} must be close to Pins IN and GND. The loop area formed by C_{IN} and GND must be minimized. The PCB copper area associated with SW pin must be minimized to avoid the potential noise problem.

PACKAGING INFORMATION

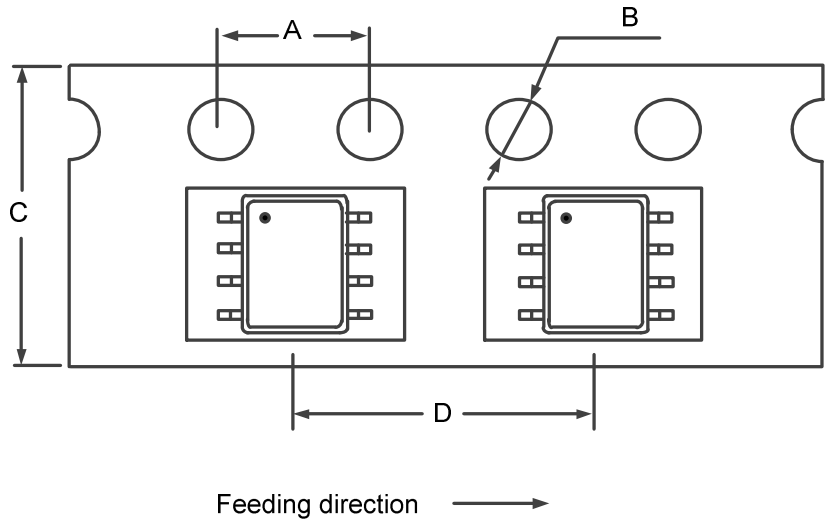
SOP_8L (EP) PACKAGE OUTLINE DIMENSONS



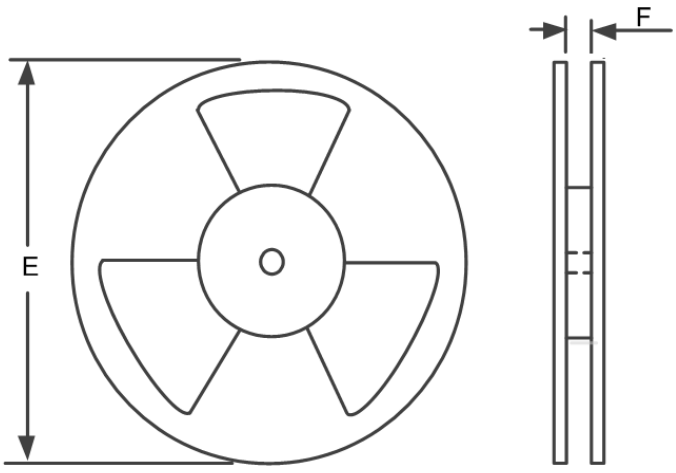
SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MIN.
A	1.35	1.75	0.053	0.069
A1	0.00	0.25	0.000	0.010
D	4.90		0.193	
E1	3.90		0.153	
D1	3.30		0.130	
E2	2.40		0.095	
E	5.80	6.20	0.228	0.244
L	0.40	1.27	0.016	0.050
b	0.31	0.51	0.012	0.020
e	1.27		0.050	

Carrier Tape & Reel Dimensions

1. Orientation / Carrier Tape Information :



2. Rokreel Information :



3. Dimension Details :

PKG Type	A	B	C	D	E	F	Q'ty/Reel
SOP 8L 150 mils	4.0 mm	1.5 mm	12.0 mm	8.0 mm	13 inches	13.0 mm	2,500

Reflow Profile

Classification of Reflow Profile

Reflow Profile	Green Assembly
Average Ramp-Up Rate (Ts_{min} to Tp)	1~2℃/second
Preheat -Temperature Min(Ts_{min}) -Temperature Max(Ts_{max}) -Time(ts_{min} to ts ts_{max})	 150℃ 200℃ 60~180 seconds
Time maintained above: -Temperature(T_L) -Time(t_L)	217℃ 40~50 seconds
Peak Temperature(Tp)	250 +0/-5 ℃
Time within 5℃ of actual Peak Temperature(tp)	15 seconds max.
Ramp-Down Rate	3℃/second
Time 25℃ to Peak Temperature	8 minutes max.

Note: For all temperature information, please refer to topside of the package, measured on the package body surface.