Standalone Linear Li-Ion Battery Charger in ThinSOT ME4054-4.2V

DESCRIPTION

ME4054 is a constant-current/constant-voltage linear charger for single cell lithium-ion batteries.Its ThinSOT package and low external component count make the ME4054 ideally suited for portable applications. Furthermore, the ME4054 is specifically designed to work within USB power specifications.

No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture.Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The ME4054 automatically terminates he charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

When the input supply (wall adapter or USB supply) is removed, the ME4054 automatically enters a low current state, dropping the battery drain current to less than 2μA.The ME4054 can be put into shutdown mode, reducing the supply current to 25μA.

Other features include charge current monitor, undervoltage lockout, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

FEATURES

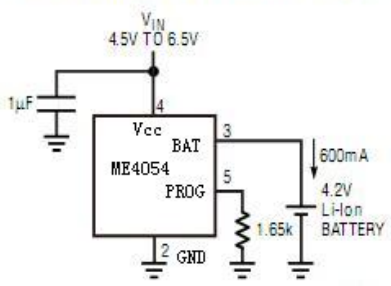
- Programmable Charge Current Up to 800mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger in ThinSOT Package for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset 4.2V Charge Voltage with ±1% Accuracy
- Automatic Recharge
- Charge Status Output Pin
- C/10 Charge Termination
- 25μA Supply Current in Shutdown
- 2.9V Trickle Charge Threshold
- Soft-Start Limits Inrush Current
- Available in 5-Lead SOT-23 Package

APPLICATIONS

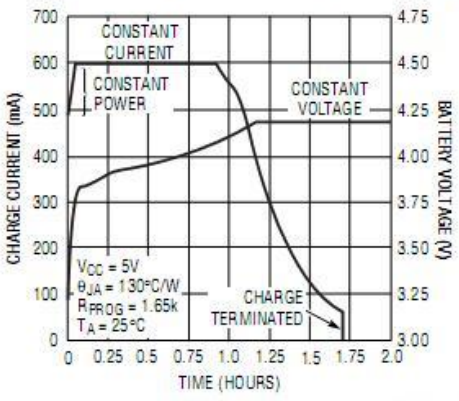
- Cellular Telephones, PDAs, MP3 Players
- Charging Docks and Cradles
- Bluetooth Applications

TYPICAL APPLICATION

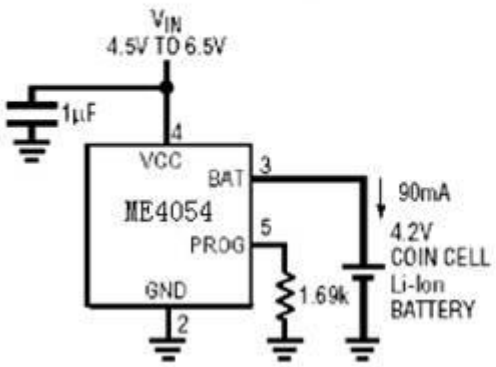
600mA Single Cell Li-Ion Charger



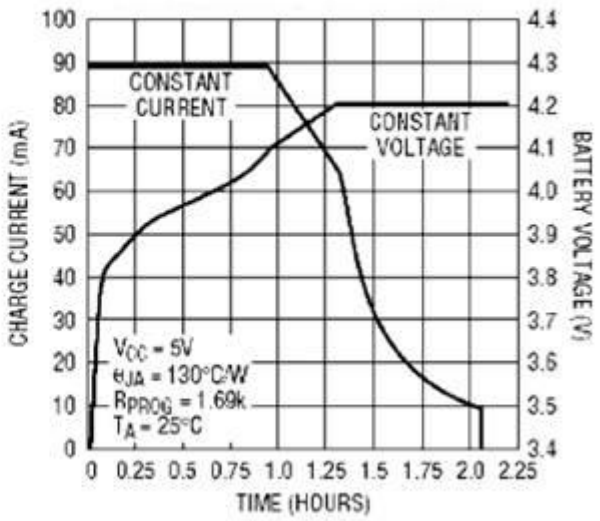
Complete Charge Cycle (750mAh Battery)



90mA Single Cell Li-Ion Charge



Complete Charge Cycle(130mAh Battery)



ABSOLUTE MAXIMUM RATINGS

Parameter	Ratings
Input Supply Voltage (Vcc)	－0.3V～10V
PROG	-0.3V～Vcc＋0.3V
BAT	-0.3V～7V
CHRG	-0.3V～10V
BAT Short-Circuit Duration	Continuous
BAT Pin Current	800mA
PROG Pin Current	800uA
Maximum Junction Temperature	125℃
Operating Ambient Temperature Range	-40℃～85℃
Storage Temperature Range	-65℃～125℃
Lead Temperature (Soldering, 10 sec)	260℃

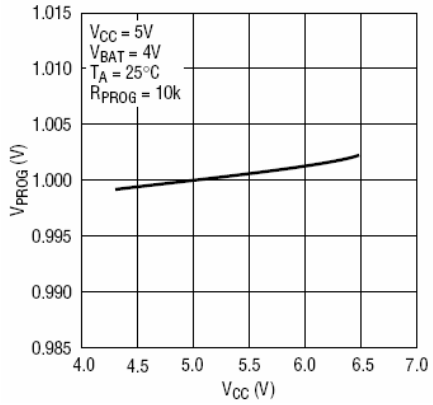
ELECTRICAL CHARACTERISTIC

The●denotes specifications which apply over the full operating temperature range,otherwise specifications are at TA = 25°C. VCC = 5V, unless otherwise noted.

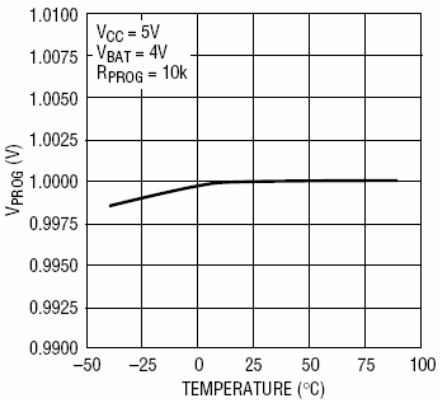
SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Vcc	Input Supply Voltage		●	4.25		6.5	V
Icc	Input Supply Current	Charge Mode， R_{PROG}=10K	●		300	2000	uA
		Standby Mode (Charge Terminated)	●		200	500	uA
		Shutdown Mode（R_{PROG} Not Connected，Vcc<V_{BAT}）	●		25	50	uA
V_{FLOAT}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃,I_{BAT}=40mA		4.158	4.2	4.242	V
I_{BAT}	BAT Pin Current	R_{PROG}=10K，Current Mode	●	93	100	107	mA
		R_{PROG}=2K，Current Mode	●	465	500	535	mA
		Standby Mode，V_{BAT}=4.2V	●	0	-2.5	-6	uA
		Shutdown Mode（R_{PROG} Not Connected）			±1	±2	uA
		Sleep Mode，Vcc=0V			±1	±2	uA
I_{TRILK}	Trickle Charge Current	V_{BAT}＜V_{TRILK}，R_{PROG}=2K	●	20	45	70	mA
V_{TRILK}	Trickle Charge Threshold Voltage	R_{PROG}=10K，V_{BAT} Rising		2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{PROG}=10K		60	80	110	mV
V_{UV}	VCC Undervoltage Lockout Threshold	From Vcc Low to High	●	3.7	3.8	3.92	V
V_{UVHYS}	VCC Undervoltage Lockout Hysteresis		●	150	200	300	mV
V_{MSD}	Manual Shutdown Threshold Voltage	PROG Pin Rising	●	1.15	1.21	1.30	V
		PROG Pin Falling	●	0.9	1.0	1.1	V
V_{ADS}	Vcc-V_{BAT} Lockout Threshold Voltage	Vcc from Low to High		70	100	140	mV
		Vcc from High to Low		5	30	50	mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG}=10K	●	0.085	0.10	0.115	mA /mA
		R_{PROG}=2K	●	0.085	0.10	0.115	mA /mA
V_{PROG}	PROG Pin Voltage	R_{PROG}=10K，Current Mode	●	0.93	1.0	1.07	V
I_{CHRG}	CHRG Pin Weak Pull-Down Current	V_{CHRG}=5V		8	20	35	uA
V_{CHRG}	CHRG Pin Output Low	I_{CHRG}=5mA			0.35	0.6	V
V_{RECHRG}	Recharge Battery Threshold Voltage	V_{FLOAT}－V_{RECHRG}		100	150	200	mV
T_{LIM}	Junction Temperature in Constant Temperature Mode				120		℃
R_{ON}	Power FET “ON” Resistance (Between VCC and BAT)				600		mΩ
T_{SS}	Soft-Start Time	I_{BAT}=0 to I_{BAT}=1000V/ R_{PROG}			100		uS
T_{RE}	Recharge Comparator Filter Time	V_{BAT} High to Low		0.75	2	4.5	mS
T_{TERM}	Termination Comparator Filter Time	I_{BAT} Falling Below I_{CHG}/10		400	1000	2500	uS
I_{PROG}	PROG Pin Pull-Up Current Current				3		uA

TYPICAL PERFORMANCE CHARACTERISTICS

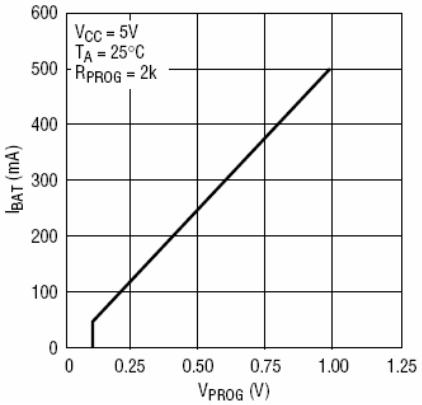
PROG Pin Voltage vs Supply Voltage(Constant Current Mode)



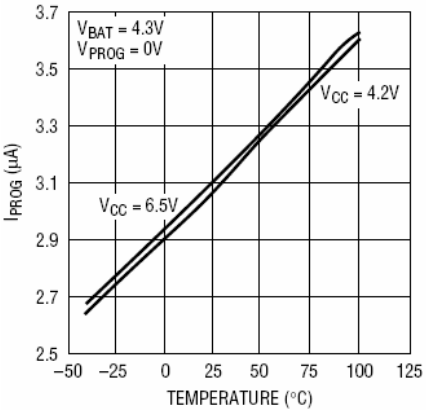
PROG Pin Voltage vs Temperature



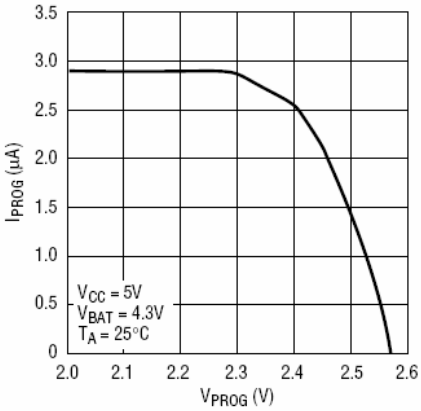
Charge Current vs PROG Pin Voltage



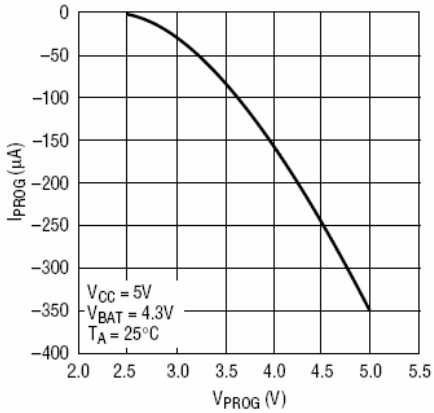
PROG Pin Pull-Up Current vs Temperature and Supply Voltage



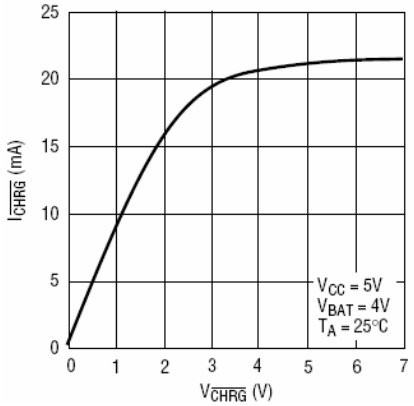
PROG Pin Current vs PROG Pin Voltage (Pull-Up Current)



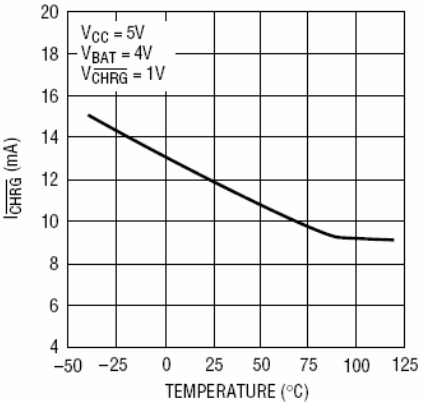
PROG Pin Current vs PROG Pin Voltage (Clamp Current)



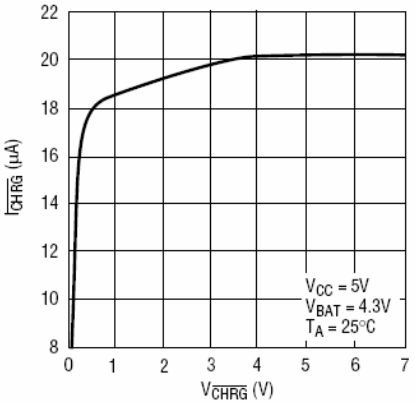
$\overline{CHRG}$ Pin I-V Curve (Strong Pull-Down State)



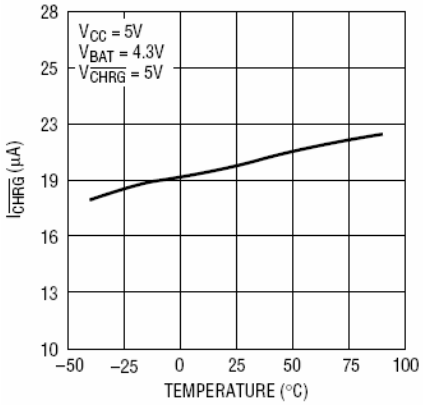
$\overline{CHRG}$ Pin Current vs Temperature (Strong Pull-Down State)



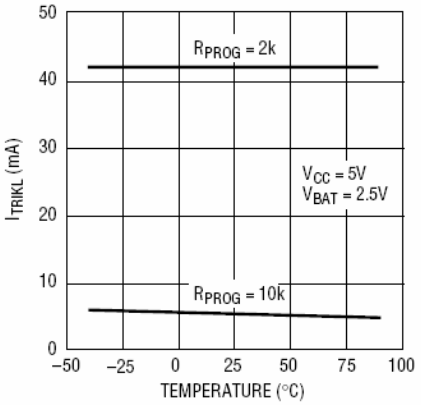
$\overline{CHRG}$ Pin I-V Curve (Weak Pull-Down State)



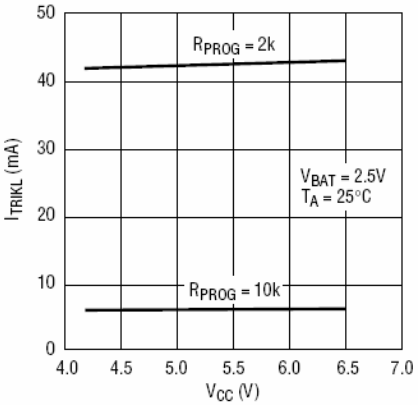
$\overline{CHRG}$ Pin Current vs Temperature (Weak Pull-Down State)



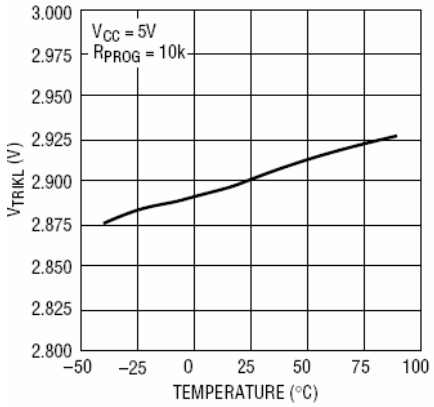
Trickle Charge Current vs Temperature



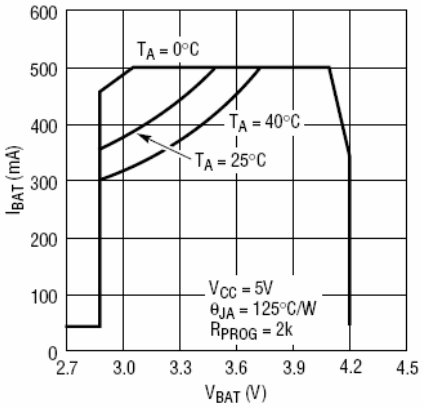
Trickle Charge Current vs Supply Voltage



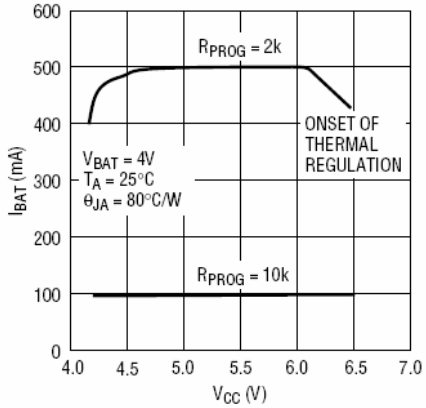
Trickle Charge Threshold vs Temperature



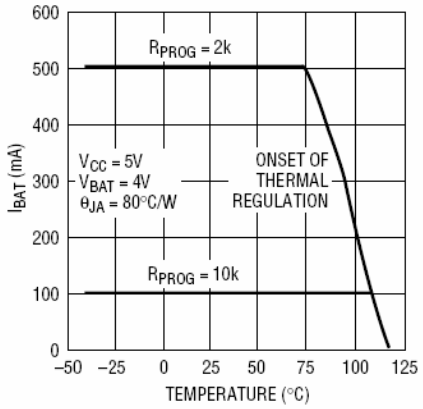
Charge Current vs Battery Voltage



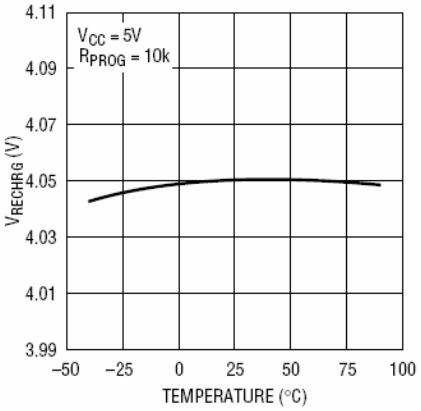
Charge Current vs Supply Voltage



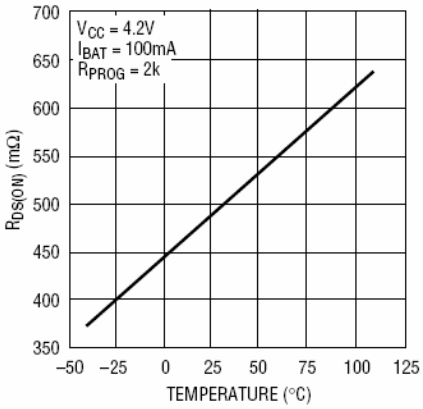
Charge Current vs Ambient Temperature



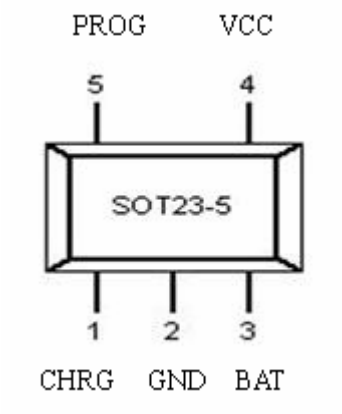
Recharge Voltage Threshold vs Temperature



Power FET "ON" Resistance vs Temperature



PIN ASSIGNMENT



Pin	Symbol	Description
SOT23-5		
1	CHRG	Open-Drain Charge Status Output
2	GND	Ground
3	BAT	Charge Current Output
4	VCC	Positive Input Supply Voltage
5	PROG	Charge Current Program

PIN FUNCTIONS

CHRG (Pin 1): Open-Drain Charge Status Output. When the battery is charging, the CHRG pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, a weak pull-down of approximately 20uA is connected to the CHRG pin, indicating an "AC present"condition. When the ME4054 detects an undervoltage lockout condition, CHRG is forced high impedance.

GND (Pin 2): Ground.

BAT (Pin 3): Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.2V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shutdown mode.

VCC (Pin 4): Positive Input Supply Voltage. Provides power to the charger. VCC can range from 4.25V to 6.5V and should be bypassed with at least a 1uF capacitor.When VCC drops to within 30mV of the BAT pin voltage, the ME4054 enters shutdown mode, dropping IBAT to less than 2mA.

PROG (Pin 5): Charge Current Program, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a 1% resistor, RPROG, to ground.When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula:

IBAT = (VPROG/RPROG) • 1000

The PROG pin can also be used to shut down the charger.Disconnecting the program resistor from ground allows a 3uA current to pull the PROG pin high. When it reaches the 1.21V shutdown threshold voltage, the charger enters shutdown mode, charging stops and the input supply current drops to 25uA. This pin is also clamped to approximately 2.4V. Driving this pin to voltages beyond the clamp voltage will draw currents as high as 1.5mA.Reconnecting RPROG to ground will return the charger to normal operation.

OPERATION

The ME4054 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 800mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of±1%. The ME4054 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus,the basic charger circuit requires only two external components.Furthermore, the ME4054 is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the VCC pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode.In this mode, the ME4054 supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging. (Note: The ME4054X does not include this trickle charge feature).

When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the ME4054 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value, the charge cycle ends.

Programming Charge Current

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current is 1000 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R_{PROG}=1000V/I_{CHG}\ ,\ I_{CHG}=1000V/\ R_{PROG}$$

The charge current out of the BAT pin can be determined at any time by monitoring the PROG pin voltage using the following equation:

$$I_{BAT}=1000*\ V_{PROG}/\ R_{PROG}$$

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal,filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV for longer than tTERM (typically 1ms), charging is terminated. The charge current is latched off and the ME4054 enters standby mode, where the input supply current drops to 200uA.(Note: C/10 termination is disabled in trickle charging and thermal limiting modes).

When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10th the programmed value. The 1ms filter time (tTERM) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination.Once the average charge current drops below 1/10th the programmed value, the ME4054 terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.

The ME4054 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V recharge threshold (VRECHRG), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the PROG pin. Figure 1 shows the state diagram of a typical charge cycle.

Charge Status Indicator (CHRG)

The charge status output has three different states: strong pull-down (~10mA), weak pull-down (~20uA) and high impedance. The strong pull-down state indicates that the ME4054 is in a charge cycle. Once the charge cycle has terminated, the pin state is determined by undervoltage lockout conditions. A weak pull-down indicates that VCC meets the UVLO conditions and the ME4054 is ready to charge. High impedance indicates that the ME4054 is in undervoltage lockout mode: either VCC is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the VCC pin. A microprocessor can be used to distinguish between these three states—this method is discussed in the Applications Information section.

Thermal Limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120°C. This feature protects the ME4054 from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the ME4054. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions. ThinSOT power considerations are discussed further in the Applications Information
section.

Undervoltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if VCC falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 100mV above the battery voltage.

Manual Shutdown

At any point in the charge cycle, the ME4054 can be put into shutdown mode by removing RPROG thus floating the PROG pin. This reduces the battery drain current to less than 2uA and the supply current to less than 50uA. A new charge cycle can be initiated by reconnecting the program resistor.In manual shutdown, the CHRG pin is in a weak pull-down state as long as VCC is high enough to exceed the UVLO
conditions. The CHRG pin is in a high impedance state if the ME4054 is in undervoltage lockout mode: either VCC is within 100mV of the BAT pin voltage or insufficient voltage is applied to the VCC pin.

Automatic Recharge

Once the charge cycle is terminated, the ME4054 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (tRECHARGE). A charge cycle restarts when the battery voltage falls below 4.05V (which corresponds to approximately 80% to 90% battery capacity).This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. CHRG output enters a strong pulldown state during recharge cycles.

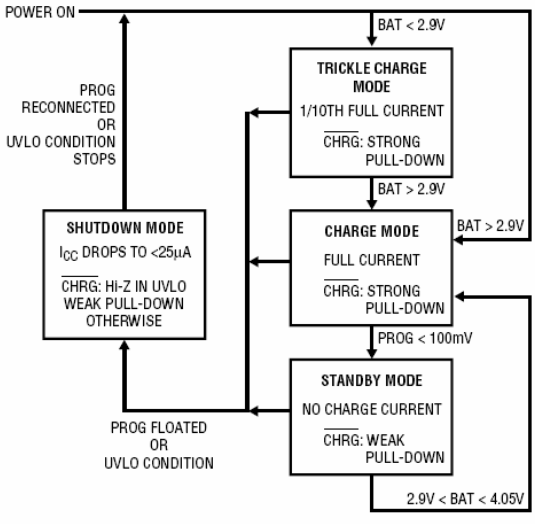
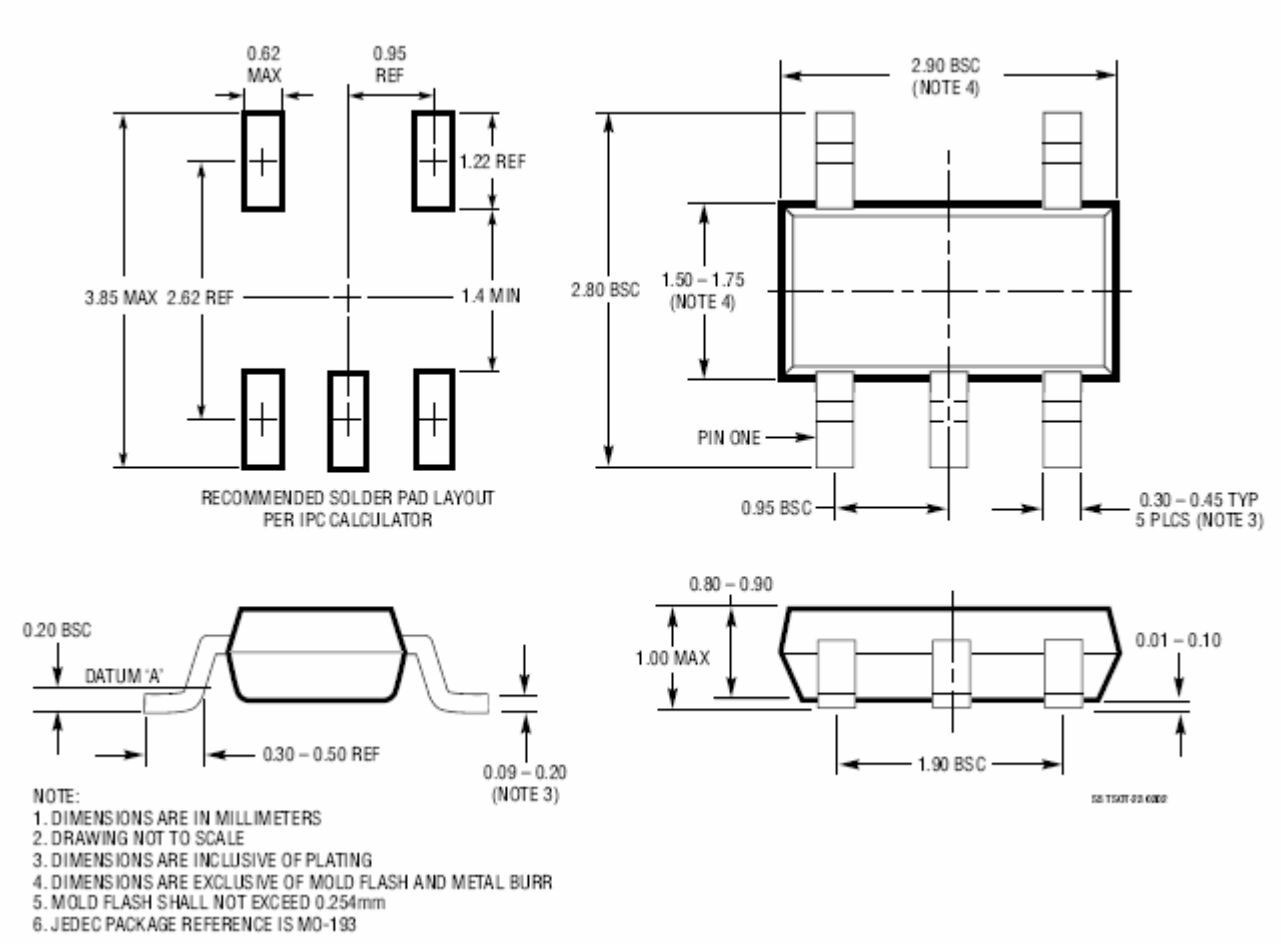


Figure 1. State Diagram of a Typical Charge Cycle

PACKAGE DESCRIPTION



NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
2. DRAWING NOT TO SCALE
3. DIMENSIONS ARE INCLUSIVE OF PLATING
4. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
5. MOLD FLASH SHALL NOT EXCEED 0.254mm
6. JEDEC PACKAGE REFERENCE IS MO-193

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