SGM4054 Standalone Linear Li-Ion Battery Charger with Thermal Regulation

GENERAL DESCRIPTION

The SGM4054 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its SOT23-5 small package and low external component count make the SGM4054 ideally suited for portable applications. Besides wall adapter's 5V power supply, the SGM4054 is specifically designed to work within USB power specifications.

SGM4054 is high integrated charger, there is no external current sense resistor and MOSFET, 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 SGM4054 automatically terminates the 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 SGM4054 automatically enters a low current state, dropping the battery drain current to less than 3µA. The SGM4054 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.

The SGM4054 has lead (Pb) free SOT23-5 package and is rated over the -40°C to +85°C temperature range.

FEATURES

- **Programmable Charge Current Up to 800mA**
- **No External MOSFET, Sense Resistor or Blocking Diode Required**
- **Complete Linear Charger in SOT23-5 Package for Single Cell Li-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**
- **Charge Current Monitor Output for Gas Gauging**
- **Automatically Recharge**
- **Charge Status Indication Pin**
- **C/10 Charge Termination**
- **25µA Supply Current in Shutdown Mode**
- **2.9V Trickle Charge Threshold**
- **Soft-Start Limits Inrush Current**
- **Lead (Pb) Free SOT23-5 Package**

APPLICATIONS

Mobile Phones, PDA's, MP3 Players

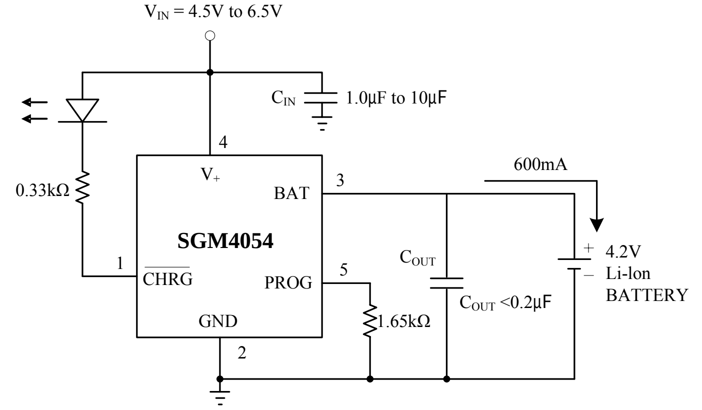
Charging Docks and Cradles

Bluetooth Applications

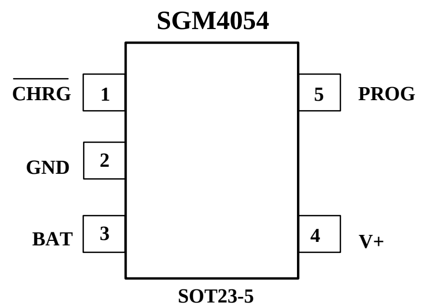
Other Handheld Devices

TYPICAL APPLICATION

600mA Single Cell Li-Ion Charger



PIN CONFIGURATION（TOP VIEW）



ELECTRICAL CHARACTERISTICS

(V_+ = 5V, full = -40°C to +85°C, room = 25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP(1)	MIN	TYP(1)	MAX	UNITS
Input Supply Voltage	V_+		full	4.3		6.5	V
Input Supply Current	I_+	Charge Mode (Note 1), R_{PROG} = 10kΩ	full		300	2000	μA
		Standby Mode (Charge Terminated)	full		250	500	
		Shutdown Mode (R_{PROG} Not Connected, V_+ < V_{BAT}, or V_+ < V_{UV})	full		25	50	
Regulated Output (Float) Voltage	V_{FLOAT}	T_A = 0°C to +85°C, I_{BAT} = 40mA		4.158	4.2	4.242	V
BAT Pin Current	I_{BAT}	R_{PROG} = 10kΩ, Current Mode	full	87	100	113	mA
		R_{PROG} = 2kΩ, Current Mode	full	465	500	535	
		Standby Mode, V_{BAT} = 4.2V	full	0	-2.5	-8	μA
		Shutdown Mode (R_{PROG} Not Connected)	room		±1	±3	
		Sleep Mode, V_+ = 0V	room		±1	±3	
Trickle Charge Current	I_{TRIKL}	V_{BAT} < V_{TRIKL}, R_{PROG} = 2kΩ	full	20	52	70	mA
Trickle Charge Threshold Voltage	V_{TRIKL}	R_{PROG} = 10kΩ, V_{BAT} Rising	room	2.8	2.9	3.0	V
Trickle Charge Hysteresis Voltage	V_{TRHYS}	R_{PROG} = 10kΩ	room	50	81	110	mV
V_+ Undervoltage Lockout Threshold	V_{UV}	V_+ from Low to High	full	3.7	3.81	4	V
V_+ Undervoltage Lockout Hysteresis	V_{UVHYS}		full	70	111	150	mV
Manual Shutdown Threshold Voltage	V_{MSD}	PROG Pin Rising	full	1.15	1.2	1.30	V
		PROG Pin Falling	full	0.9	1.09	1.2	
V_+ – V_{BAT} Lockout Threshold Voltage	V_{ASD}	V_+ from Low to High	room		98		mV
		V_+ from High to Low	room		54		
C/10 Termination Current Threshold	I_{TERM}	R_{PROG} = 10kΩ (Note 2)	full		0.1		mA/mA
		R_{PROG} = 2kΩ	full		0.1		
PROG Pin Voltage	V_{PROG}	R_{PROG} = 10kΩ, Current Mode	full	0.9	1	1.1	V
$\overline{CHRG}$ Pin Weak Pull-Down Current	$I_{\overline{CHRG}}$	$V_{\overline{CHRG}}$ = 5V	room	5	18	44	μA
$\overline{CHRG}$ Pin Output Low Voltage	$V_{\overline{CHRG}}$	$I_{\overline{CHRG}}$ = 5mA	room		0.34	0.6	V
Recharge Battery Threshold Voltage	ΔV_{RECHRG}	V_{FLOAT} - V_{RECHRG}	room		112		mV
Junction Temperature in Constant Temperature Mode	T_{LIM}		room		120		°C
Power FET "ON" Resistance (Between V_+ and BAT)	R_{ON}		room		600		mΩ
Soft-Start Time	t_{SS}	I_{BAT} = 0 to I_{BAT} =1000V/R_{PROG}	room		100		μs
Recharge Comparator Filter Time	$t_{RECHARGE}$	V_{BAT} High to Low	room		1.5		ms
Termination Comparator Filter Time	t_{TERM}	I_{BAT} Falling Below I_{CHG}/10	room		600		μs

Specifications subject to changes without notice.

Note 1: Supply current includes PROG pin current (approximately 100μA), but does not include any current delivered to the battery through the BAT pin (approximately 100mA).

Note 2: I_{TERM} is expressed as a fraction of measured full charge current with indicated PROG resistor.

PACKAGE/ORDERING INFORMATION

ORDER NUMBER	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ACCURACY VOLTAGE REFERENCE	MARKING INFORMATION	PACKAGE OPTION
SGM4054A-YN5/TR	SOT23-5	+25°C	-2% ~ -1%	4054A	Tape and Reel, 3000
SGM4054B-YN5/TR	SOT23-5	+25°C	±1%	4054B	Tape and Reel, 3000

ABSOLUTE MAXIMUM RATINGS

Storage Temperature Range.............. –65℃ to +150℃
Junction Temperature ....160℃
Operating Temperature Range ....–40℃ to +85℃
Lead Temperature Range (Soldering 10 sec) ....260℃
ESD Susceptibility
HBM...4000V
MM..400V

NOTES

1. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

CAUTION

This integrated circuit can be damaged by ESD. SG Micro-electronics recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

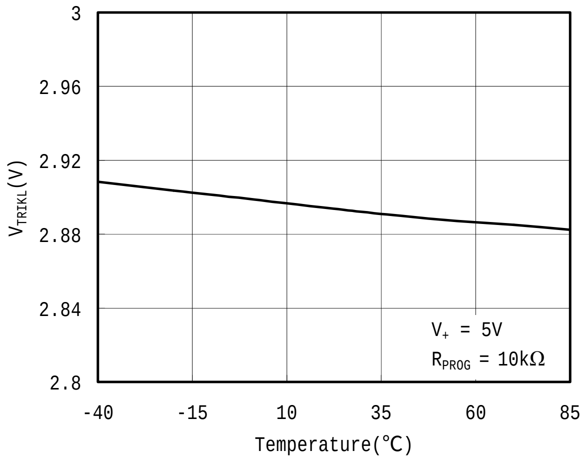
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PIN DESCRIPTION

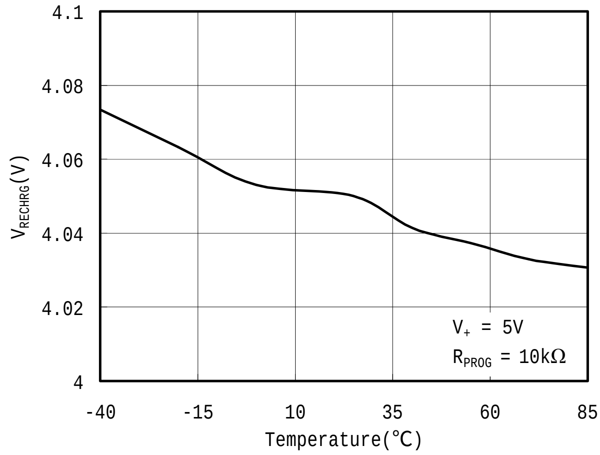
NAME	FUNCTION
$\overline{CHRG}$	Open-Drain Charger Status Indication Pin. When the battery is charging, the $\overline{CHRG}$ pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, a weak pull-down of approximately 18µA is connected to the $\overline{CHRG}$ pin, indicating an “AC present” condition. When the SGM4054 detects an undervoltage lockout condition, $\overline{CHRG}$ is forced high impedance.
GND	Ground
BAT	Charge Current Output Pin. Connecting with Li-ion Battery. Provides charge to 4.2V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shutdown mode.
V_+	Positive Input Supply Voltage. Provides power to the charger. V_+ can range from 4.3V to 6.5V and should be bypassed with at least a 1µF capacitor. When V_+ drops to within 54mV of the BAT pin voltage, the SGM4054 enters shutdown mode, dropping I_{BAT} to less than 3µA.
PROG	Charge Current Program, Charge Current Monitor and Shutdown Control Pin. The charge current is programmed by connecting a 1% resistor from RPROG pin 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: $I_{BAT} = (V_{PROG}/R_{PROG}) \bullet 1000$ The PROG pin can also be used to shut down the charger. Disconnecting the program resistor from ground allows a 1.5µA current to pull this pin to High. When it reaches the 1.2V shutdown threshold voltage, the charger enters shutdown mode, charging stops and the input supply current drops to 25µA.

TYPICAL PERFORMANCE CHARACTERISTICS

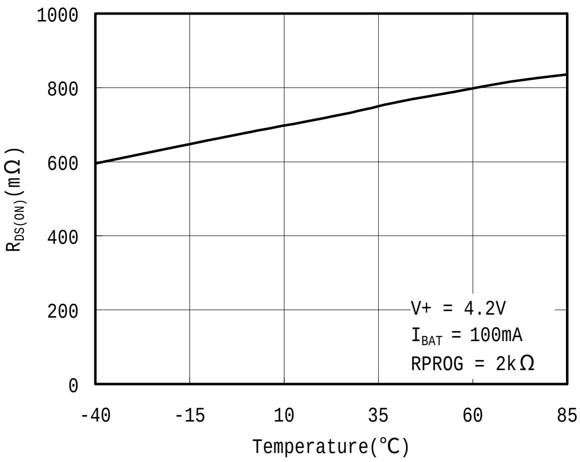
Trickle Charge Threshold vs.Temperature



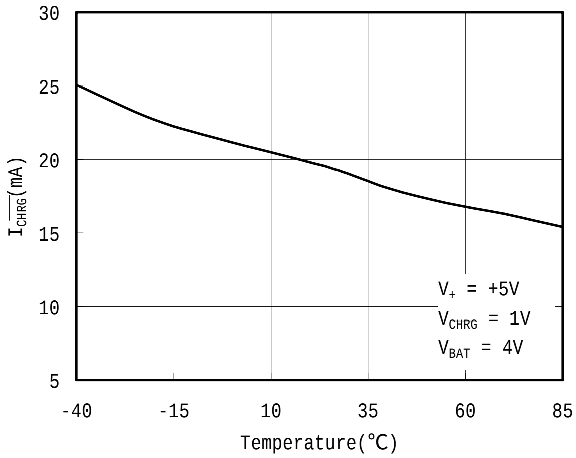
Recharge Voltage Threshold vs.Temperature



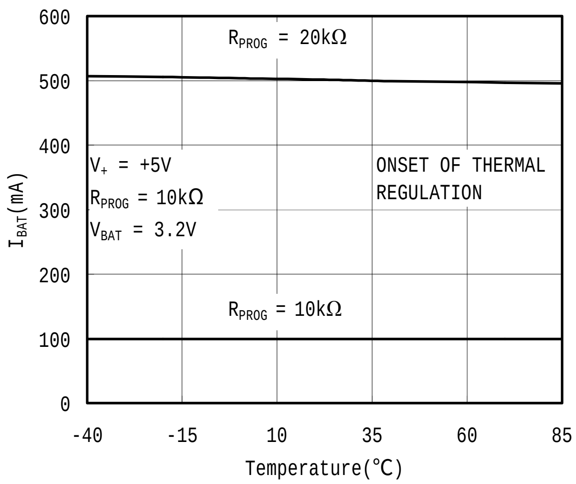
Power FET "ON" Resistance vs.Temperature



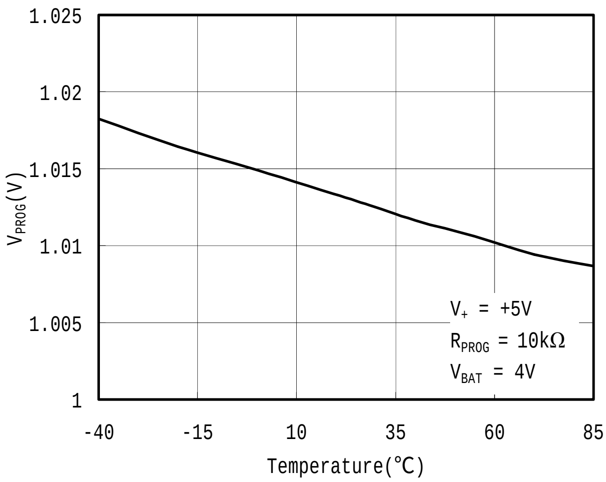
$\overline{CHRG}$ Pin Current vs.Temperature (Strong Pull-Down State)



Charge Current vs.Temperature

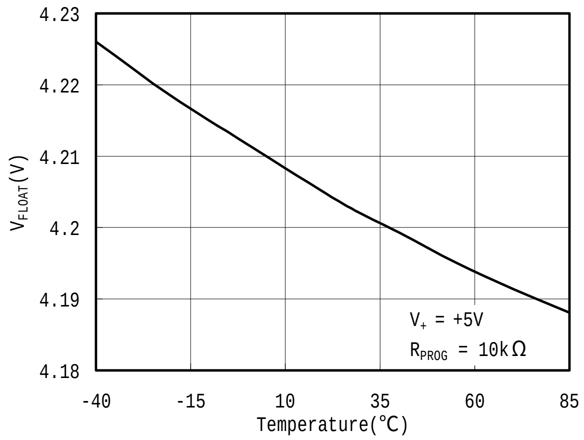


PROG Pin Voltage vs.Temperature

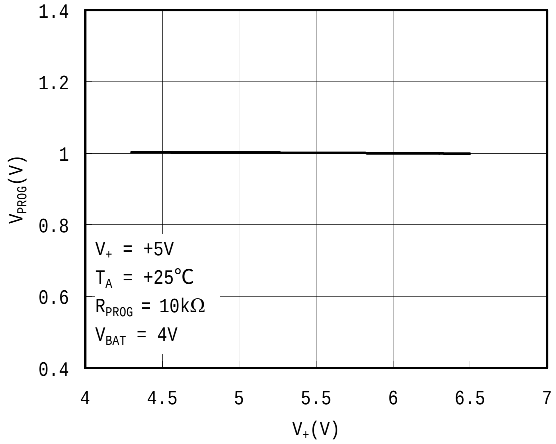


TYPICAL PERFORMANCE CHARACTERISTICS

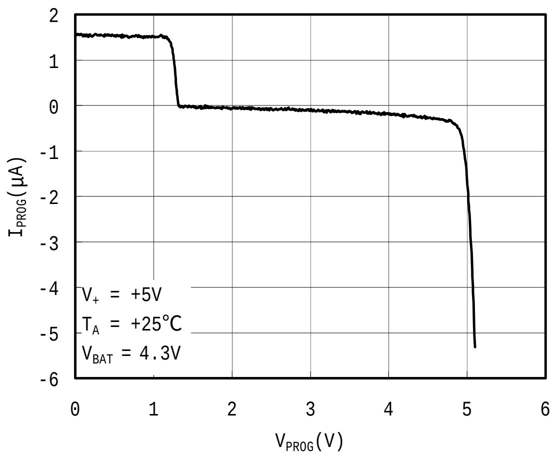
Regulated Output(Float)Voltage vs.Temperature



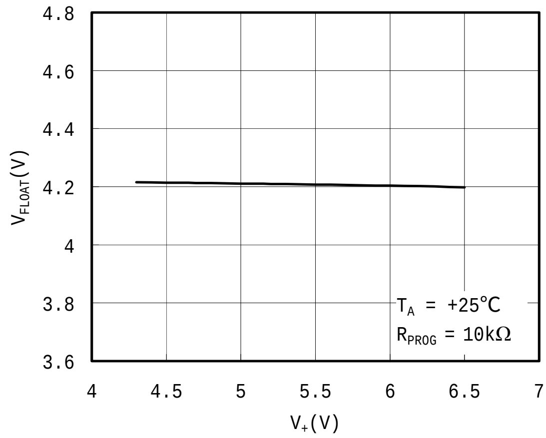
PROG Pin Voltage vs.Supply Voltage
(Constant Current Mode)



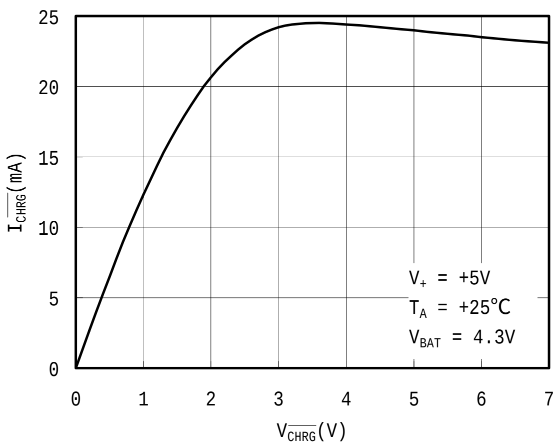
PROG Pin Current vs.PROG Pin Voltage
(Pull-Up Current)



Regulated Output (Float) Voltage
vs.Supply Voltage



$\overline{CHRG}$ Pin 1-V Curve(Strong Pull-Down State)



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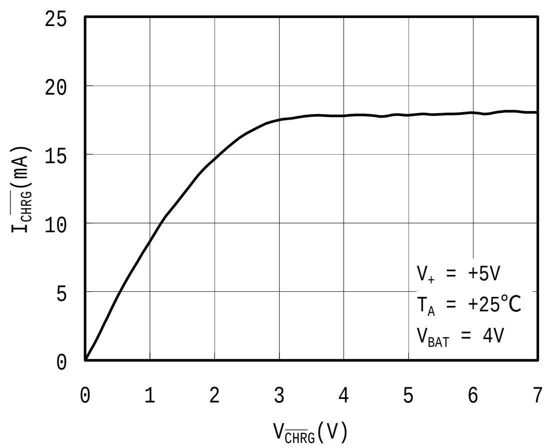
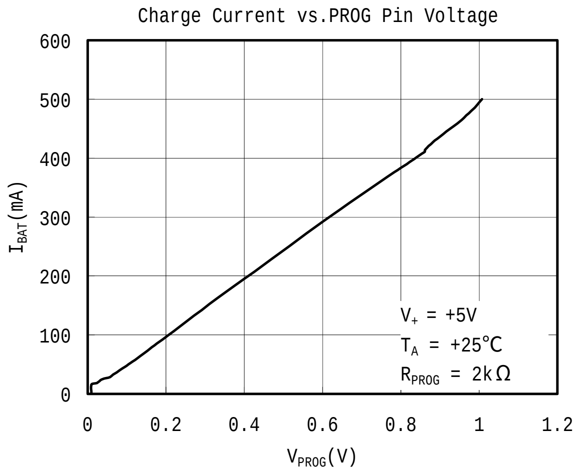
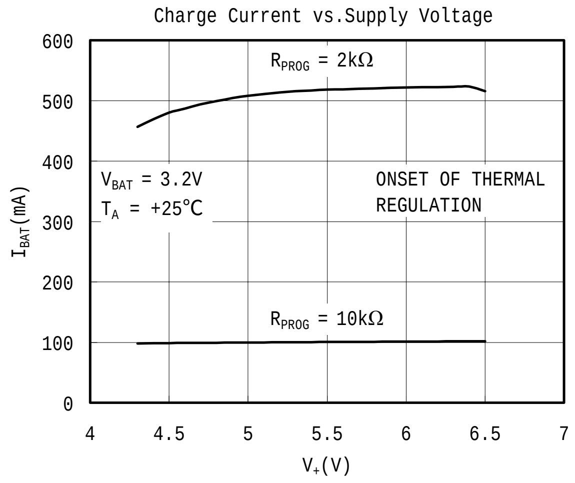
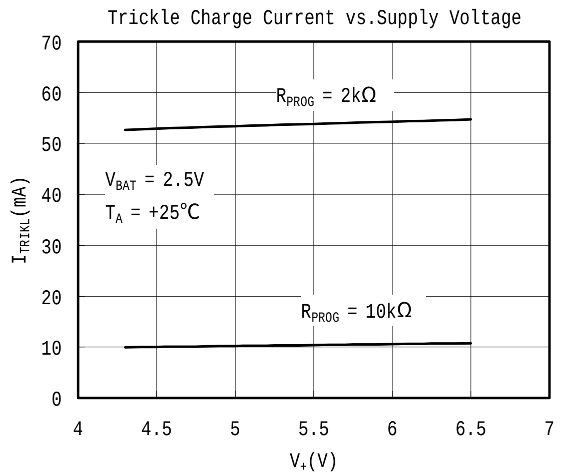


TYPICAL PERFORMANCE CHARACTERISTICS







OPERATION

The SGM4054 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 SGM4054 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 SGM4054 is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the V_+ 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 SGM4054 supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging.

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 SGM4054 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:

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

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

$$R_{PROG} = \frac{V_{PROG}}{R_{PROG}} \cdot 1000$$

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[1] for longer than t_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and the SGM4054 enters standby mode, where the input supply current drops to 250μA. (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 (t_{TERM}) 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 SGM4054 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 SGM4054 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.098V recharge threshold (V_{RECHRG}), 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 ($\overline{CHRG}$)

The charge status output has three different states: strong pull-down (~10mA), weak pull-down (~18μA) and high impedance. The strong pull-down state indicates that the SGM4054 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 V_+ meets the UVLO conditions and the SGM4054 is ready to charge. High impedance indicates that the SGM4054 is in undervoltage lockout mode: either V_+ is less than 98mV above the BAT pin voltage or insufficient voltage is applied to the V_+ pin. A microprocessor can be used to distinguish between these three states—this method is discussed in the Applications Information section.

OPERATION

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℃.This feature protects the SGM4054 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 SGM4054. 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 V_+ rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 111mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if V_+ falls to within 54mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until V_+ rises 98mV above the battery voltage.

Manual Shutdown

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At any point in the charge cycle, the SGM4054 can be put into shutdown mode by removing R_{PROG} thus floating the PROG pin. This reduces the battery drain current to less than 3μA and the supply current to less than 50μA. A new charge cycle can be initiated by reconnecting the program resistor.

In manual shutdown, the $\overline{CHRG}$ pin is in a weak pull-down state as long as V_+ is high enough to exceed the UVLO conditions. The $\overline{CHRG}$ pin is in a high impedance state if the SGM4054 is in undervoltage lockout mode: either V_+ is within 100mV of the BAT pin voltage or insufficient voltage is applied to the V_+ pin.

Automatic Recharge

Once the charge cycle is terminated, the SGM4054 continuously monitors the voltage on the BAT pin using a comparator with a 1.5ms filter time ($t_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 4.098V. This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. $\overline{CHRG}$ output enters a strong pull down state during recharge cycles.

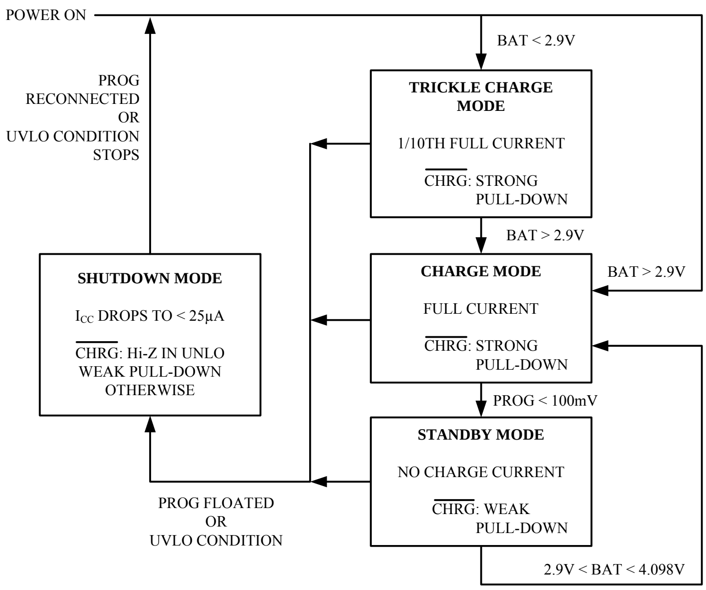


Figure 1. State Diagram of a Typical Charge Cycle

APPLICATIONS INFORMATION

Stability Considerations

The constant-voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charger output. With no battery present, an output capacitor is recommended to reduce ripple voltage. When using high value, low ESR ceramic capacitors, it is recommended to add a 1Ω resistor in series with the capacitor. No series resistor is needed if tantalum capacitors are used.

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 20k. However, additional capacitance on this node reduces the maximum allowed program resistor. The pole frequency at the PROG pin should be kept above 100kHz. Therefore, if the PROG pin is loaded with a capacitance, C_{PROG}, the following equation can be used to calculate the maximum resistance value for R_{PROG}:

$$R_{PROG} \leq \frac{1}{2\pi \cdot 10^5 \cdot C_{PROG}}$$

Average, rather than instantaneous, charge current may be of interest to the user. For example, if a switching power supply operating in low current mode is connected in parallel with the battery, the average current being pulled out of the BAT pin is typically of more interest than the instantaneous current pulses. In such a case, a simple RC filter can be used on the PROG pin to measure the average battery current as shown in Figure 2. A 10k resistor has been added between the PROG pin and the filter capacitor to ensure stability.

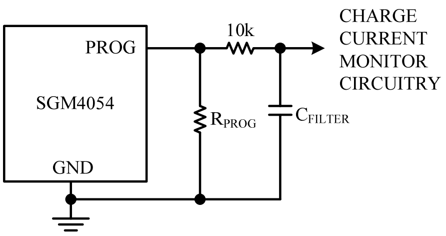


Figure 2. Isolating Capacitive Load on PROG Pin and Filtering

Power Dissipation

The conditions that cause the SGM4054 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET—this is calculated to be approximately:

$$P_D = (V_+ - V_{BAT}) \cdot I_{BAT}$$

where P_D is the power dissipated, V_+ is the input supply voltage, V_{BAT} is the battery voltage and IBAT is the charge current. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 120°C - P_D\theta_{JA}$$
$$T_A = 120°C - (V_+ - V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA}$$

Example: An SGM4054 operating from a 5V USB supply is programmed to supply 400mA full-scale current to a discharged Li-Ion battery with a voltage of 3.75V. Assuming θ_{JA} is 150°C /W (see Board Layout Considerations), the ambient temperature at which the SGM4054 will begin to reduce the charge current is approximately:

$$T_A = 120°C - (5V - 3.75V) \cdot (400mA) \cdot 150°C/W$$
$$T_A = 120°C - 0.5W \cdot 150°C/W = 120°C - 75°C$$
$$T_A = 45°C$$

The SGM4054 can be used above 45°C ambient, but the charge current will be reduced from 400mA. The approximate current at a given ambient temperature can be approximated by:

$$I_{BAT} = \frac{120C° - T_A}{(V_+ - V_{BAT}) \cdot \theta_{JA}}$$

Using the previous example with an ambient temperature of 60°C, the charge current will be reduced to approximately:

$$I_{BAT} = \frac{120C° - 60C°}{(5V - 3.75V) \bullet 150C°/W} = \frac{60C°}{187.5C°/A}$$

$$I_{BAT} = 320mA$$

APPLICATIONS INFORMATION

Moreover, when thermal feedback reduces the charge current, the voltage at the PROG pin is also reduced proportionally as discussed in the Operation section.
It is important to remember that SGM4054 applications do not need to be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 120℃.

Thermal Considerations

Because of the small size of the ThinSOT package, it is very important to use a good thermal PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package leads, (especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

The following table lists thermal resistance for several different board sizes and copper areas. All measurements were taken in still air on 3/32" FR-4 board with the device mounted on topside.

Table 1. Measured Thermal Resistance (2-Layer Board*)

COPPER AREA		BOARD AREA	THERMAL RESISTANCE JUNCTION-TO-AMBIENT
TOPSIDE	BACKSIDE		
2500mm^2	2500mm^2	2500 mm^2	125℃/W
1000 mm^2	2500 mm^2	2500 mm^2	125℃/W
225 mm^2	2500 mm^2	2500 mm^2	130℃/W
100 mm^2	2500 mm^2	2500 mm^2	135℃/W
50 mm^2	2500 mm^2	2500 mm^2	150℃/W

*Each layer uses one ounce copper

Table 2. Measured Thermal Resistance (4-Layer Board)**

COPPER AREA (EACH SIDE)	BOARD AREA	THERMAL RESISTANCE JUNCTION-TO-AMBIENT
2500 mm^2	2500 mm^2	80℃/W

*Top and bottom layers use two ounce copper, inner layers use one ounce copper.
**10,000mm^2 total copper area

Increasing Thermal Regulation Current

Reducing the voltage drop across the internal MOSFET can significantly decrease the power dissipation in the IC. This has the effect of increasing the current delivered to the battery during thermal regulation. One method is by dissipating some of the power through an external component, such as a resistor or diode.

Example: An SGM4054 operating from a 5V wall adapter is programmed to supply 800mA full-scale current to a discharged Li-Ion battery with a voltage of 3.75V. Assuming θ_{JA} is 125°C/W, the approximate charge current at an ambient temperature of 25°C is:

$$I_{BAT} = \frac{120C^\circ - 25C^\circ}{(5V - 3.75V) \bullet 125C^\circ / W} = 608mA$$

By dropping voltage across a resistor in series with a 5V wall adapter (shown in Figure 3), the on-chip power dissipation can be decreased, thus increasing the thermally regulated charge current：

$$I_{BAT} = \frac{120C^\circ - 25C^\circ}{(V_S - I_{BAT}R_{CC} - V_{BAT}) \bullet \theta_{JA}}$$

APPLICATIONS INFORMATION

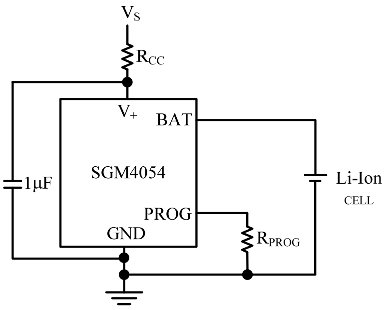


Figure 3. A Circuit to Maximize Thermal Mode Charge Current

Solving for I_{BAT} using the quadratic formula[2].

I_{BAT} =

$$\frac{(V_S - V_{BAT}) - \sqrt{\left\{(V_S - V_{BAT})^2 \; \frac{4R_{CC}(120C^\circ - T_A)}{\theta_{JA}}\right\}}\,120C^\circ}{2R_{CC}}$$

Using R_{CC} = 0.25W, V_S = 5V, V_{BAT} = 3.75V, T_A = 25°C and θ_{JA} = 125°C/W we can calculate the thermally regulated charge current to be:

I_{BAT} = 708.4mA

While this application delivers more energy to the battery and reduces charge time in thermal mode, it may actually lengthen charge time in voltage mode if V_+ becomes low enough to put the SGM4054 into dropout. Figure 4 shows how this circuit can result in dropout as R_{CC} becomes large.

This technique works best when R_{CC} values are minimized to keep component size small and avoid dropout. Remember to choose a resistor with adequate power handling capability.

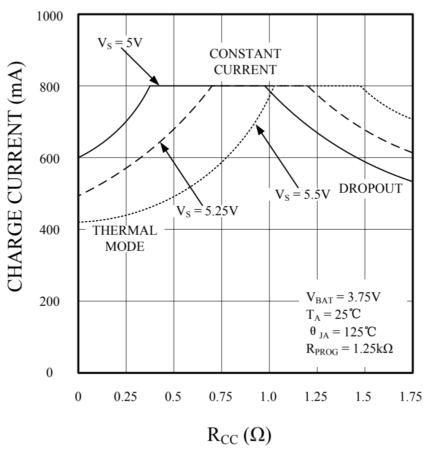


Figure 4. Charge Current vs. R_{CC}

V_+ Bypass Capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5W resistor in series with an X5R ceramic capacitor will minimize start-up voltage transients. For more information, refer to Application Note 88.

Charge Current Soft-Start

The SGM4054 includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When a charge cycle is initiated, the charge current ramps from zero to the full-scale current over a period of approximately 100µs. This has the effect of minimizing the transient current load on the power supply during start-up.

$\overline{CHGR}$ Status Output Pin

The $\overline{CHGR}$ pin can provide an indication that the input voltage is greater than the undervoltage lockout threshold level. A weak pull-down current of approximately 20µA indicates that sufficient voltage is applied to V_+ to begin charging. When a discharged battery is connected to the charger, the constant current portion of the charge cycle begins and the $\overline{CHGR}$ pin pulls to ground. The $\overline{CHGR}$ pin can sink up to 10mA to drive an LED that indicates that a charge cycle is in progress.

When the battery is nearing full charge, the charger enters the constant-voltage portion of the charge cycle and the charge current begins to drop. When the charge current drops below 1/10 of the programmed current, the charge cycle ends and the strong pull-down is replaced by the 18µA pull-down, indicating that the charge cycle has ended. If the input voltage is removed or drops below the undervoltage lockout threshold, the $\overline{CHGR}$ pin becomes high impedance. Figure 5 shows that by using two different value pull-up resistors, a microprocessor can detect all three states from this pin.

APPLICATIONS INFORMATION

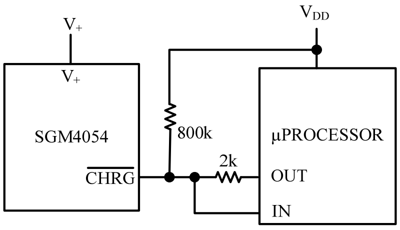


Figure 5. Using a Microprocessor to Determine $\overline{CHGR}$ State

To detect when the SGM4054 is in charge mode, force the digital output pin (OUT) high and measure the voltage at the $\overline{CHGR}$ pin. The N-channel MOSFET will pull the pin voltage low even with the 2k pull-up resistor. Once the charge cycle terminates, the N-channel MOSFET is turned off and a 18µA current source is connected to the $\overline{CHGR}$ pin. The IN pin will then be pulled high by the 2k pull-up resistor. To determine if there is a weak pull-down current, the OUT pin should be forced to a high impedance state. The weak current source will pull the IN pin low through the 800k resistor; if $\overline{CHGR}$ is high impedance, the IN pin will be pulled high, indicating that the part is in a UVLO state.

Reverse Polarity Input Voltage Protection

In some applications, protection from reverse polarity voltage on V+ is desired. If the supply voltage is high enough, a series blocking diode can be used. In other cases, where the voltage drop must be kept low a P-channel MOSFET can be used (as shown in Figure 6).

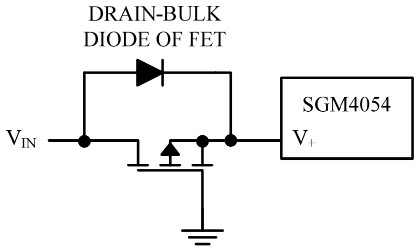


Figure 6. Low Loss Input Reverse Polarity Protection

USB and Wall Adapter Power

The SGM4054 allows charging from both a wall adapter and a USB port. Figure 7 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, MP1, is used to prevent back conducting into the USB port when a wall adapter is present and a Schottky diode, D1, is used to prevent USB power loss through the 1k pull-down resistor.

Typically a wall adapter can supply more current than the 500mA-limited USB port. Therefore, an N-channel MOSFET, MN1, and an extra 10k program resistor are used to increase the charge current to 600mA when the wall adapter is present.

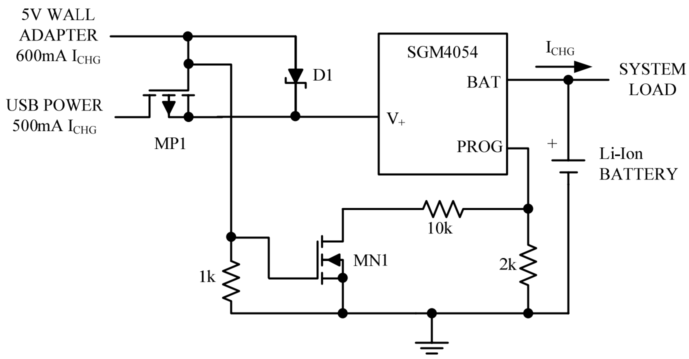
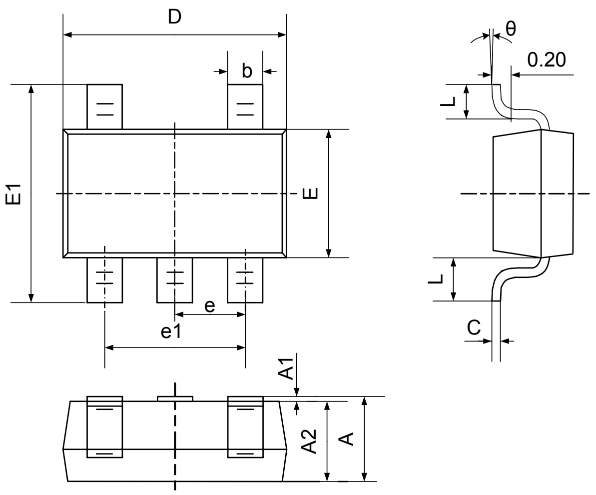


Figure 7. Combining Wall Adapter and USB Power

PACKAGE OUTLINE DIMENSIONS

SOT23-5



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

REVISION HISTORY

Location	Page

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