VS6102

Standalone Linear Lithium Battery Charger

General Description

VS6102 is a complete constant-current & constant voltage linear charger for single cell lithium-ion batteries. Its SOT-23 package and low external component count make VS6102 ideally suited for portable applications. Furthermore, the VS6102 is specifically designed to work within USB power specification. At the same time, VS6102 can also be used in the standalone lithium-ion battery charger.

No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charger 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 VS6102 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 VS6102 automatically enters a low current stage, dropping the battery drain current to less than 2 μA. The VS6102 can be put into shutdown mode, reducing the supply current to 20 μA.

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

Features

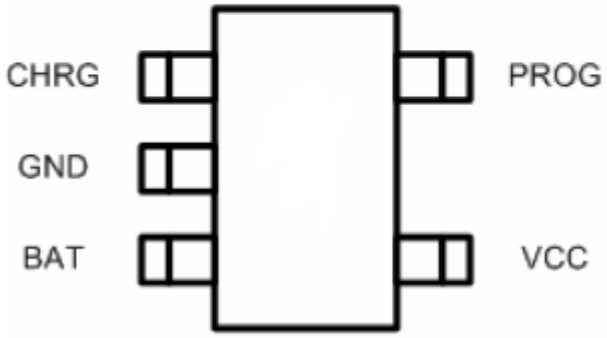
- Programmable Charge Current Up to 800mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Constant-Current/Constant-Voltage Operation with Thermal Protection to Maximize Charge Rate without Risk of Overheating
- Charges Single Cell Li-ion Batteries Directly from USB Port
- Preset 4.2V Charge Voltage with +-1% Accuracy
- 20 μA Supply Current in Shutdown
- 2.9V Trickle Charge Threshold
- Available Without Trickle Charge
- Soft-Start Limits Inrush Current
- Available in 5-Lead SOT-23 Package

Applications

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

Pin Configuration

SOT-23-5L
G-Pinout
(Top View)



Absolute Maximum Rating (1)

Parameter	Symbol	Value	Units
Input Supply Voltage	V_{CC}	7	V
PROG Voltage	V_{PROG}	VCC+0.3	V
BAT Voltage	V_{BAT}	7	V
CHRG Voltage	V_{CHRG}	10	V
BAT Short-Circuit Duration	-	Continuous	-
Thermal Resistance, Junction-to-Ambient	Θ_{JA}	250 (SOT-23-5)	°C/W
BAT Pin Current	I_{BAT}	800	mA
PROG Pin Current	I_{PROG}	800	μA
Maximum Junction Temperature	T_J	125	°C
Storage Temperature	T_S	-65 to +125	°C
Lead Temperature (Soldering, 10 sec)	-	300	°C

Recommended Operating Conditions (2)

Parameter	Symbol	Value	Units
Supply Input Voltage	V_{IN}	-0.3 to +7	V
Junction Temperature	T_J	-40 to +85	°C

Electrical Characteristics

V_{IN} = 5V; T_J = 25°C; unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	Input Supply Voltage		4.25		5.5	V
I_{CC}	Input Supply Current	Charge Mode(3), R_{PROG} = 10k		110	500	μA
		Standby Mode (Charge Terminated)		115	160	μA
		Shutdown Mode(R_{PROG} Not Connected, V_{CC} < V_{BAT}, or V_{CC} < V_{UV})		20	40	μA
V_{FLOAT}	Regulated Output (Float) Voltage	I_{BAT} = 30mA, I_{CHRG} = 5mA	4.158	4.2	4.242	V
I_{BAT}	BAT Pin Current	R_{PROG} = 10k, Current Mode	90	110	130	mA
		R_{PROG} = 2k, Current Mode		500		mA
		Standby Mode, VBAT = 4.2V	0	+/-1	+/-5	μA
		Shutdown Mode (R_{PROG} Not Connected)		+/-0.5	+/-5	μA
		Sleep Mode, V_{CC} = 0V		+/-1	+/-5	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{PROG} = 10k	12	18	25	mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG} = 10k, V_{BAT} Rising	2.8	2.9	3.8	V

Electrical Characteristics (Continued)

V_{IN} = 5V; T_J = 25°C; unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{UV}	V_{CC} Undervoltage Lockout Threshold	From V_{CC} Low to High		3.4		V
V_{UVHYS}	V_{CC} Undervoltage Lockout Hysteresis			170		mV
V_{MSD}	Manual Shutdown Threshold Voltage	PROG Pin Rising		1.25		V
		PROG Pin Falling		1.2		V
V_{ASD}	V_{CC} – V_{BAT} Lockout Threshold Voltage	V_{CC} from Low to High		100		mV
		V_{CC} from High to Low		30		mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG} = 10k(4)		0.1		mA/mA
		R_{PROG} = 2k		0.1		mA/mA
V_{PROG}	PROG Pin Voltage	R_{PROG} = 10k, Current Mode	0.9	1.03	1.1	V
I_{CHRG}	CHRG Pin Weak Pull-Down Current	V_{CHRG} = 5V	8	20	40	μA
V_{CHRG}	CHRG Pin Output Low Voltage	I_{CHRG} = 5mA		0.35	0.8	V
$\triangle V_{RECHRG}$	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{RECHRG}		100		mV
T_{LIM}	Thermal Protection Temperature			120		°C
t_{SS}	Soft-Start Time	I_{BAT} = 0 to 1000V/R_{PROG}		100		μs
$t_{RECHARGE}$	Recharge Comparator Filter Time	V_{BAT} High to Low		2		ms
t_{TERM}	Termination Comparator Filter Time	I_{BAT} Falling Below I_{CHG}/10		1000		μs
I_{PROG}	PROG Pin Pull-Up Current			1		μA

Note 1: Exceeding the absolute maximum rating may damage the device.

Note 2: The device is not guaranteed to function outside its operating rating.

Note 3: 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 4: ITERM is expressed as a fraction of measured full charge current with indicated PROG resistor.

Typical Performance Characteristics

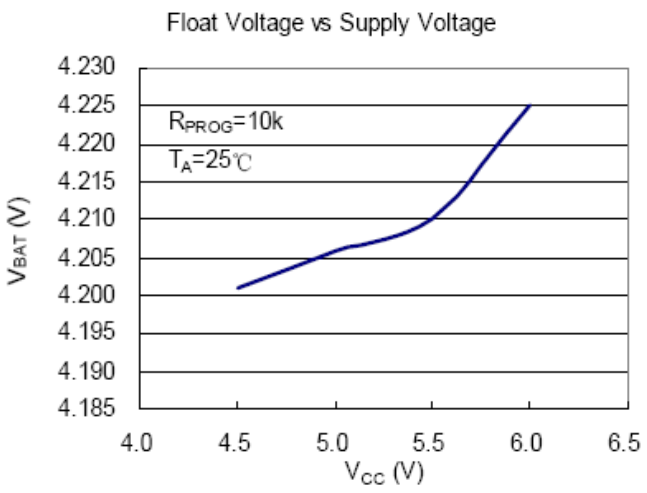


Figure 1.

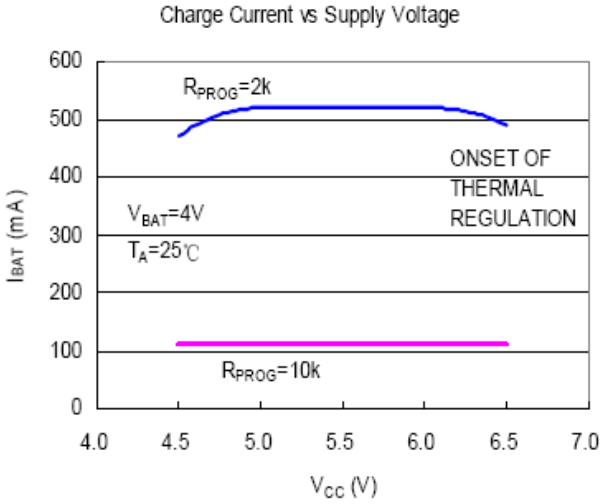


Figure 2.

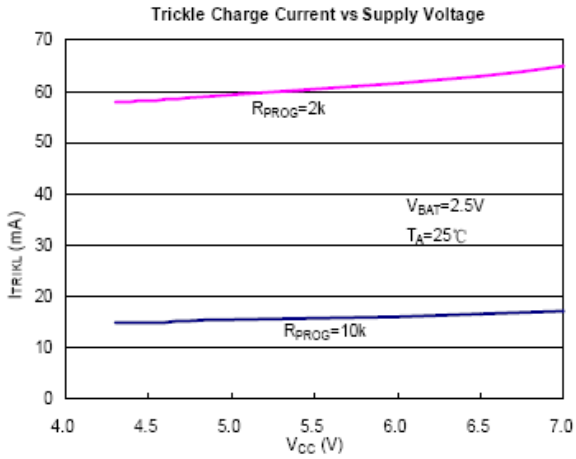


Figure 3.

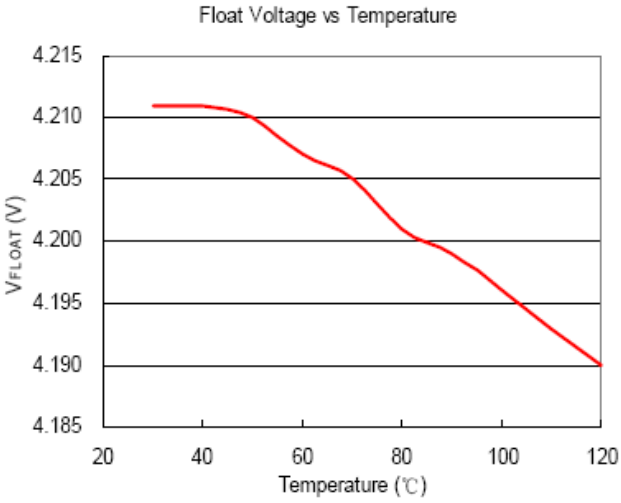
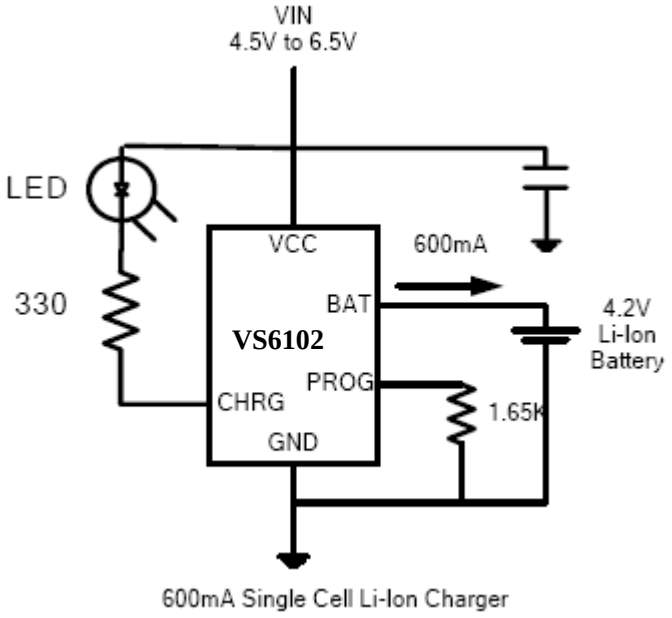


Figure 4.

Application Diagram



600mA Single Cell Li-Ion Charger

Operation

The VS6102 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 VS6102 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 VS6102 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 2.8V, the charger enters trickle charge mode. In this mode, the VS6102 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 2.8V, 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 VS6102 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 1100 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R_{PROG} = \frac{1100V}{I_{CHG}}, I_{CHG} = \frac{1100V}{R_{PROG}},$$

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

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \bullet 1100$$

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 VS6102 enters standby mode, where the input supply current drops to 200mA. (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 VS6102 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 VS6102 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 (~20μA) and high impedance. The strong pull-down state indicates that the VS6102 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 VS6102 is ready to charge. High impedance indicates that the VS6102 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.

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 VS6102 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 VS6102. 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. Thin SOT 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 raises 100mV above the battery voltage.

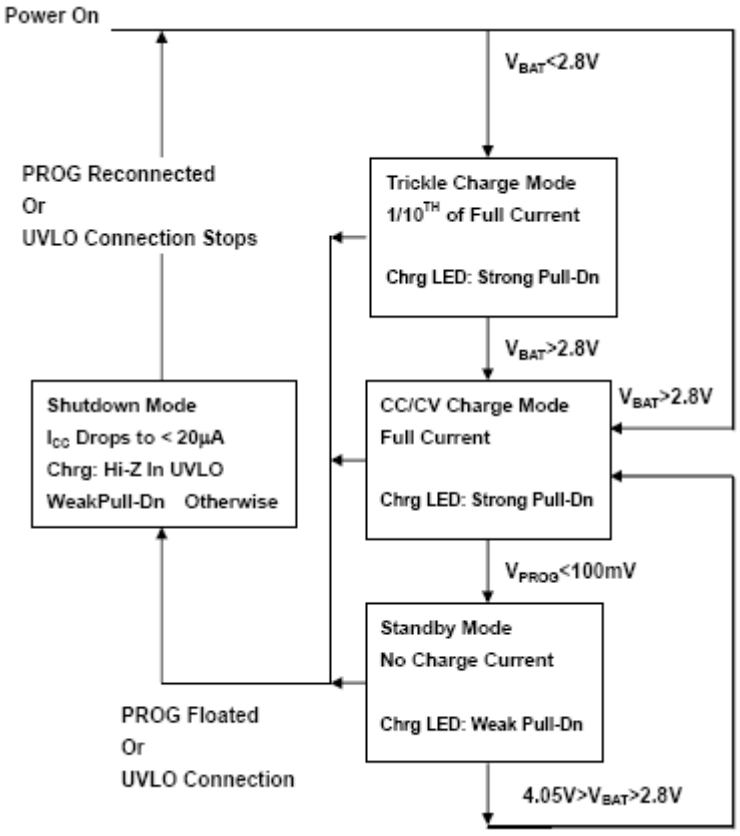
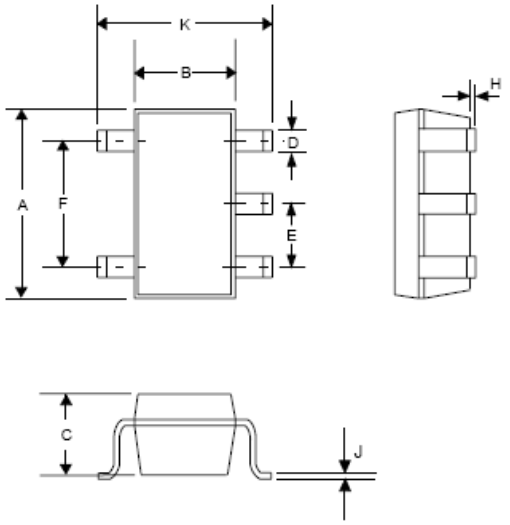


Figure5. State Diagram of a Typical Charge Cycle

OUTLINE DRAWING SOT-23-5L



DIMENSIONS				
DIMN	INCHES		MM	
	MIN	MAX	MIN	MAX
A	0.110	0.120	2.80	3.05
B	0.059	0.070	1.50	1.75
C	0.036	0.051	0.90	1.30
D	0.014	0.020	0.35	0.50
E	–	0.037	–	0.95
F	–	0.075	–	1.90
H	–	0.006	–	0.15
J	0.0035	0.008	0.090	0.20
K	0.102	0.118	2.60	3.00