

600mA, Single Li-ion Battery Charger

Descriptions

The WS4508E is a complete constant-current / constant voltage linear charger for single cell Lithium-Ion batteries. 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 WS4508E automatically terminates the charge cycle when the charge current drops to 1/10 the programmed value after the final float voltage is reached.

When the input supply (wall adapter or USB supply) is removed, the WS4508E automatically enters a low current state, dropping the battery drain current to less than 0.5uA. The WS4508E can be put into shutdown mode, reducing supply current to 45uA (Typ.).

The WS4508E is available in a small package with SOT-23-5L. Standard product is Pb-Free.

Features

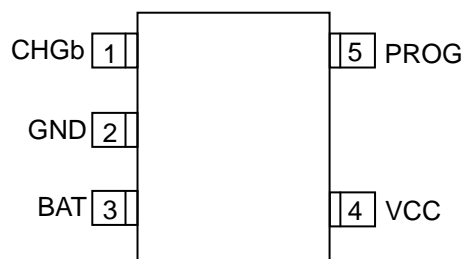
- Programmable Charge Current Up to 600mA
- Over-Temperature Protection
- Under Voltage Lockout Protection
- Automatic Recharge Threshold 4.05V(Typ.)
- Charge Status Output Pin
- 2.9V Trickle Charge Threshold
- Soft-Start Limits Inrush Current

Applications

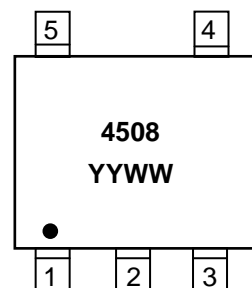
- Wireless phone
- MP3/MP4 Player
- Bluetooth device



SOT-23-5L



Pin configuration (Top view)

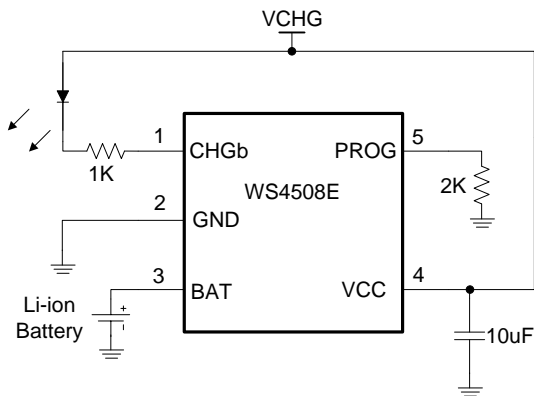


4508 = Device Code
YY = Year
WW = Week

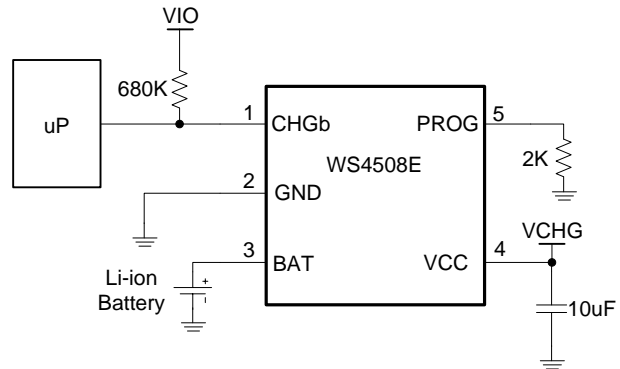
Order information

Device	Package	Shipping
WS4508E-5/TR	SOT-23-5L	3000/Reel&Tape

Typical applications



Typical applications W/T LED indicate

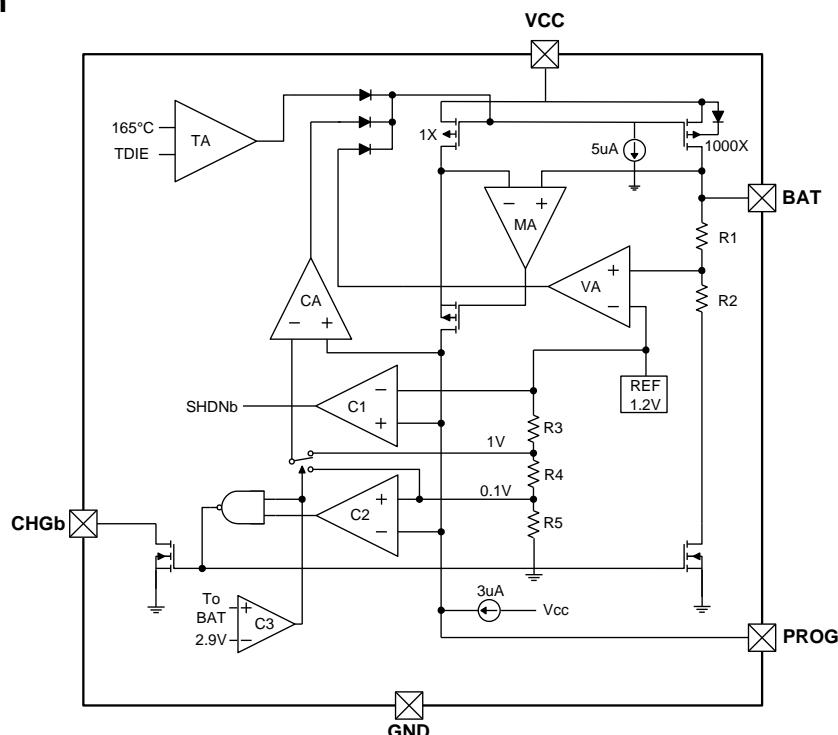


Typical applications W/T microprocessor detect

Pin descriptions

Pin Number	Pin Name	Function
1	CHGb	Open-Drain Charge Status Output. When the battery is charging, the CHGb pin is pulled low. When the charge cycle is completed or VCC is removed, the CHGb is forced high impedance.
2	GND	Ground
3	BAT	Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.2V.
4	VCC	Power Supply
5	PROG	Charge current setting, charge current monitor and shutdown pin. The charging current is given by $I_{BAT} = (1/R_{PROG}) * 1000$. The chip will be shutdown when PROG pin floating

Block Diagram



Absolute Maximum ratings

Parameter	Symbol	Rating	Unit
Supply Voltage	VCC	-0.3~8	V
PROG Voltage	V _{PROG}	-0.3~VCC	V
BAT Voltage	V _{BAT}	-0.3~8	V
CHGb Voltage	V _{CHGb}	-0.3~VCC	V
BAT Pin Current	I _{BAT}	600	mA
Power Dissipation – Note1	Pd	0.5	W
Power Dissipation – Note2	Pd	0.3	W
Junction Temperature	T _j	150	°C
Operation Temperature	T _{op}	-45~85	°C
Storage Temperature	T _{sg}	-65~125	°C
Lead Temperature (Soldering 10s)		260	°C

Thermal resistance characteristics

Symbol	Parameter	Max.	Unit
R _{θJA1}	Thermal Resistance, Junction to Ambient – Note1	125	°C/W
R _{θJA2}	Thermal Resistance, Junction to Ambient – Note2	415	°C/W

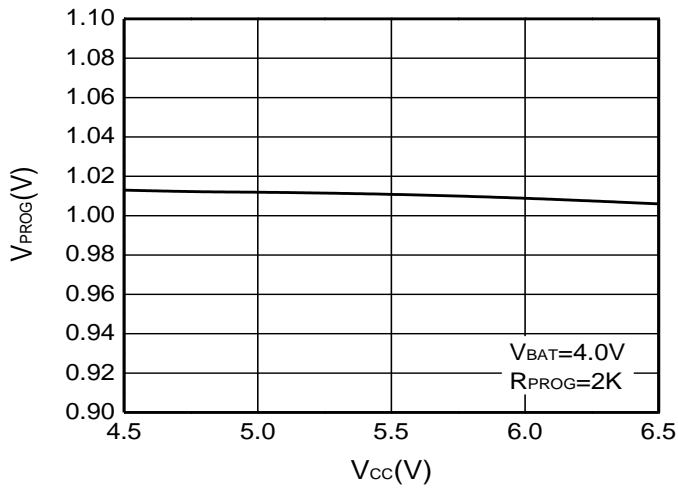
Note1: Surface mounted on FR4 Board using 1 in sq pad size, 2oz Cu.

Note2: Surface mounted on FR4 board using the minimum recommended pad size, 2oz Cu.

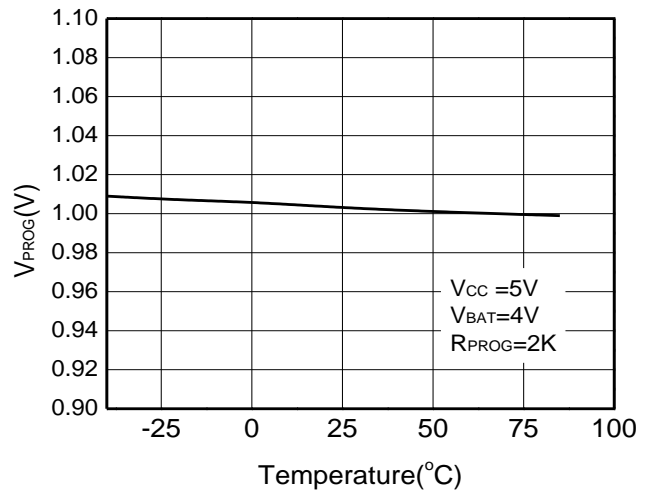
Electronics Characteristics (VCC=5V, Ta=25°C, unless otherwise noted)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
I _{SPLYCHRG}	Charge Mode Supply Current	R _{PROG} =2kΩ		650	2000	uA
		R _{PROG} =10kΩ		240	2000	uA
I _{BATCHRG}	Charge Mode Battery Current	R _{PROG} =2kΩ	450	500	550	mA
		R _{PROG} =10kΩ	80	93	110	mA
V _{PROGCHRG}	PROG Pin Voltage	R _{PROG} =2kΩ	0.93	1.00	1.07	V
		R _{PROG} =10kΩ	0.93	1.00	1.07	V
I _{SPLYSTBY}	Standby Mode Supply Current	Charge Terminated		140	500	uA
I _{BATSTBY}	Standby Mode Battery Current	Charge Terminated	0	-2.5	-6	uA
I _{SPLYASD}	Shutdown Mode Supply Current	V _{CC} <V _{BAT}	20	45	90	uA
I _{BATASD}	Shutdown Mode BAT Pin Current	V _{CC} <V _{BAT}		±0.05	±1	uA
I _{SPLYUVLO}	UVLO Mode Supply Current	V _{CC} <V _{UV}	20	45	90	uA
I _{BATUVLO}	UVLO Mode BAT Pin Current	V _{CC} <V _{UV}		±0.05	±1	uA
I _{SPLYSHUT}	Shutdown Mode Supply Current	R _{prog} not Connected	20	45	70	uA
I _{BATSHUT}	Shutdown Mode BAT Pin Current	R _{prog} not Connected		±0.05	±1	uA
I _{BATMSD}	Manual Shutdown BAT Pin Current	V _{prog} =1.3V		±0.05	±1	uA
I _{BATSLEEP}	Sleep Mode BAT Pin Current	V _{CC} =0V		±0.05	±1	uA
V _{FLOAT}	Float Voltage		4.158	4.2	4.242	V
I _{TRIKL}	Trickle Charge Current	R _{PROG} =2kΩ	20	50	70	mA
V _{TRIKL}	Trickle Charge Voltage Threshold	R _{PROG} =10kΩ	2.8	2.9	3.0	V
V _{TRIKL, HYS}	Trickle Charge Voltage Hysteresis	R _{PROG} =10kΩ		100		mV
V _{UVLO}	UVLO Threshold	From V _{CC} Low to High	3.6	3.8	4.0	V
V _{UVLO, HYS}	UVLO Hysteresis			250		mV
V _{MSD}	Manual Shutdown Threshold Voltage	PROG Pin Rising		1.2	1.3	V
		PROG Pin Falling		1.0		V
V _{ASD}	V _{CC} -V _{BAT} Lockout Threshold Voltage	V _{CC} from Low to High		120		mV
		V _{CC} from High to Low	5	50		mV
ΔV _{RECHRG}	Auto Recharge Battery Voltage		100	150	200	mV
V _{CHGb}	CHGb Pin Output Low Voltage	I _{CHGb} =5mA		0.3	0.6	V
T _{LIM}	Junction Temperature In Constant Temperature Mode			165		°C
R _{ON}	Power FET ON Resistance			200		mΩ
T _{SS}	Soft-Start Time	R _{PROG} =2kΩ		100		us
T _{RECHRG}	Recharge Comparator Filter Time			2		ms
T _{TERM}	Termination Comparator Filter Time			1		ms
I _{PROG}	PROG Pin Pull-up Current			3		uA

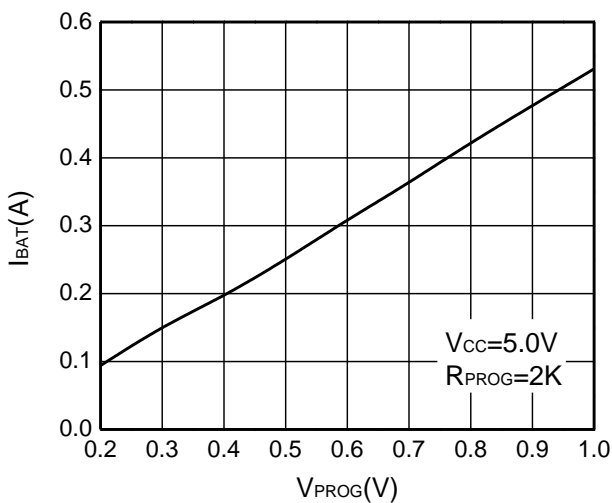
Typical Characteristics (Ta=25°C, unless otherwise noted)



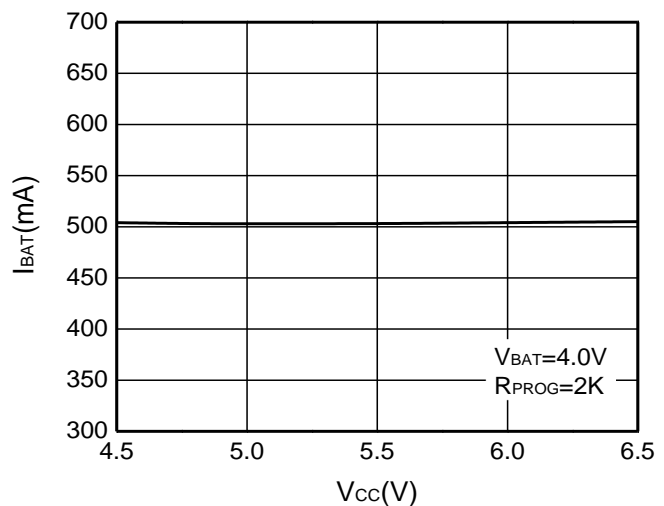
PROG Pin Voltage vs Supply Voltage



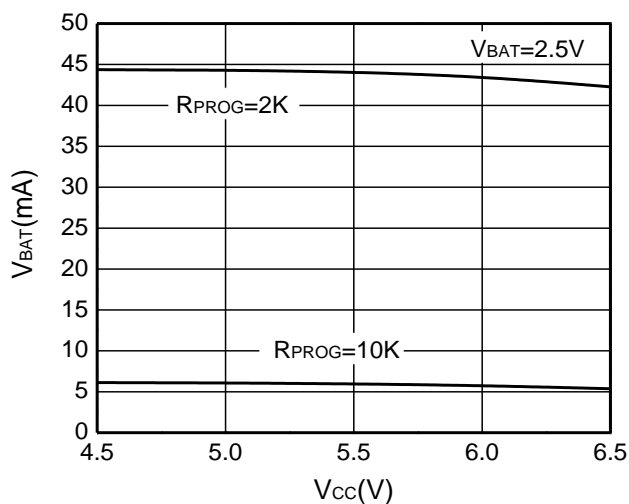
PROG Pin Voltage vs Ambient Temperature



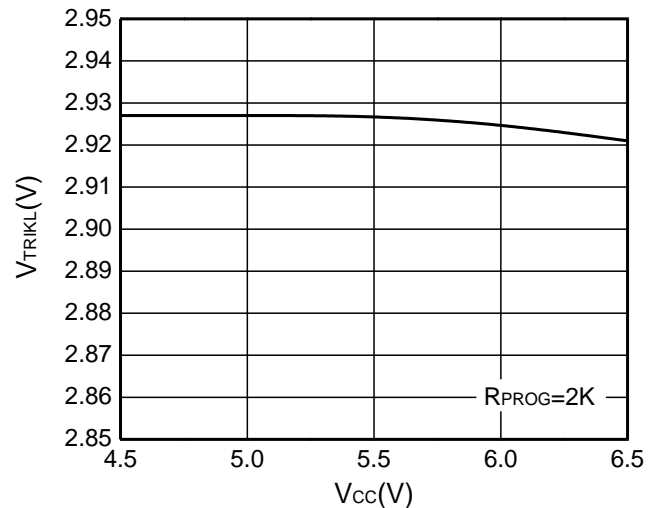
Charge Current vs PROG Pin Voltage



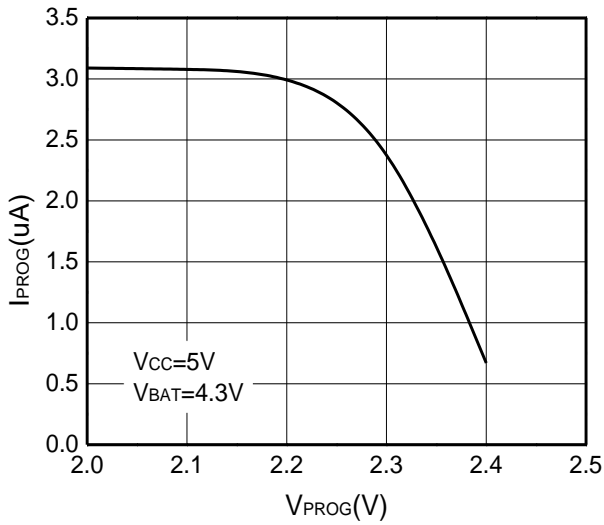
Charge Current vs Supply Voltage



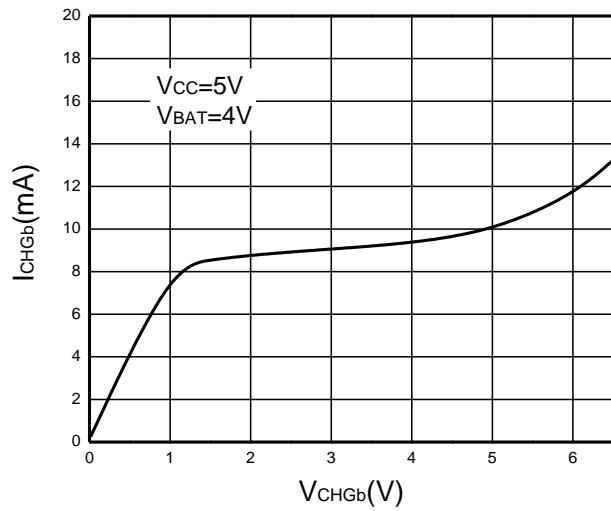
Trickle Charge Current vs Supply Voltage



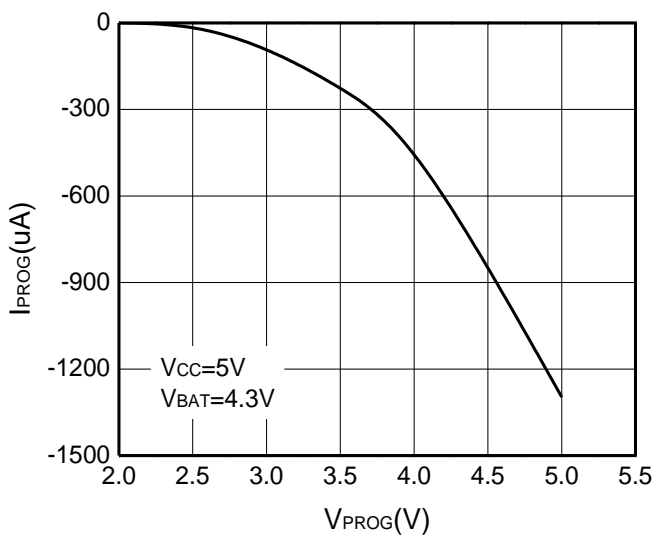
Trickle Voltage vs Supply Voltage



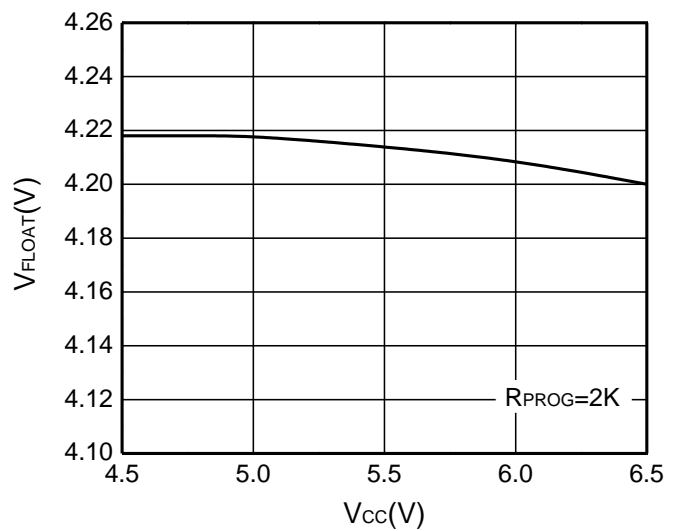
PROG Pin Pull-Up Current vs PROG Pin Voltage



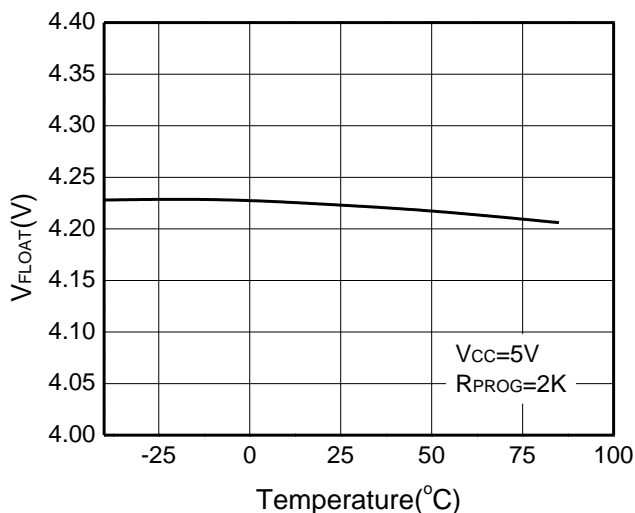
CHGb Pin Current vs CHGb Pin Voltage



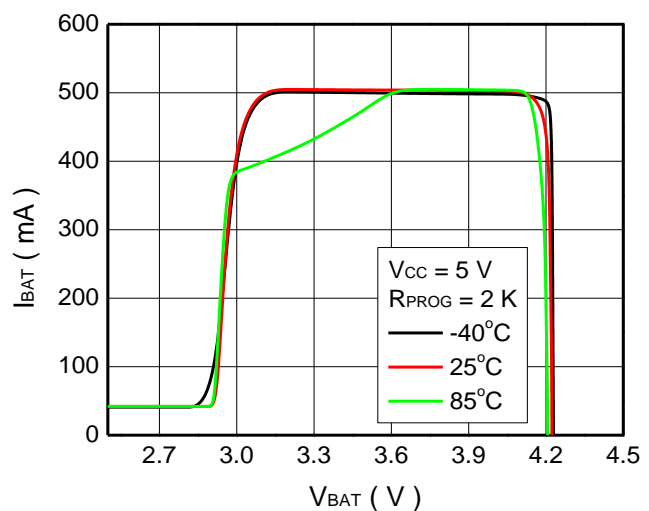
PROG Pin Clamp Current vs PROG Pin Voltage



Float Voltage vs Supply Voltage

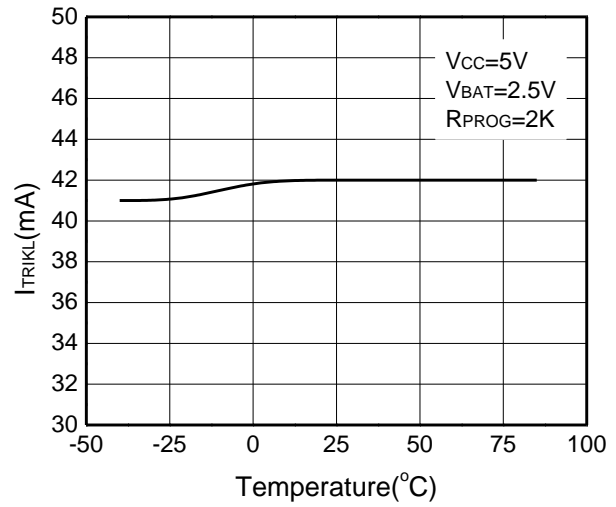
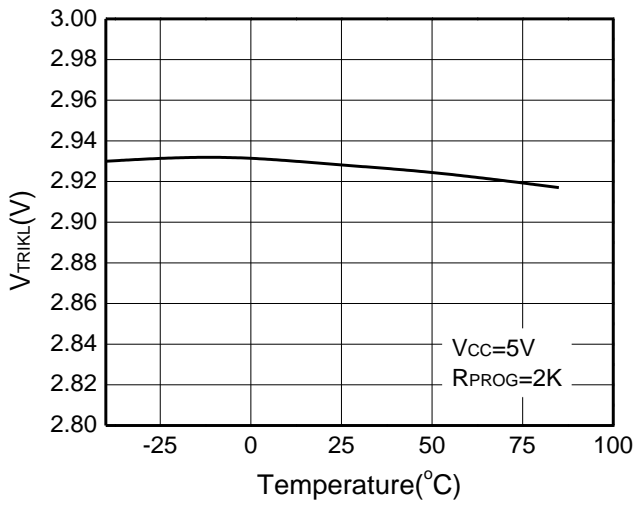


Float Voltage vs Ambient Temperature



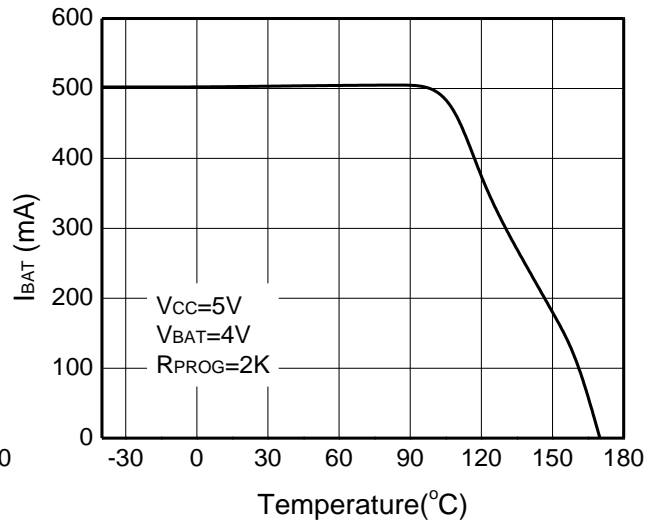
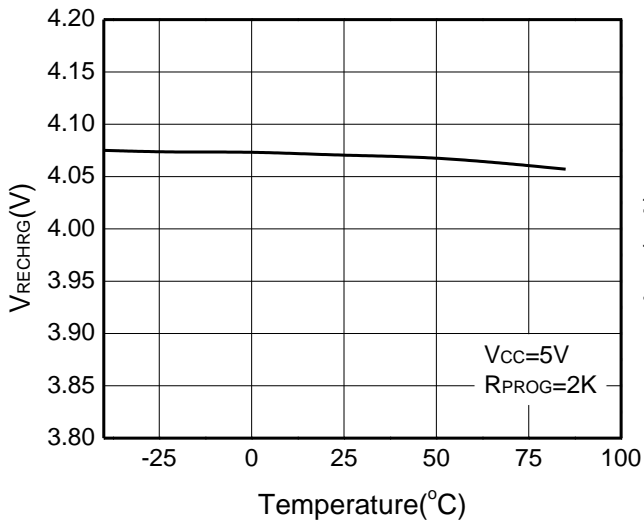
Charge Current vs Battery Voltage

WS4508E



Trickle Charge Threshold vs Ambient Temperature

Trickle Charge Current vs Ambient Temperature



Recharge Voltage Threshold vs Ambient Temperature

Charge Current vs Ambient Temperature

WS4508E

Charge status indicator (CHGb)

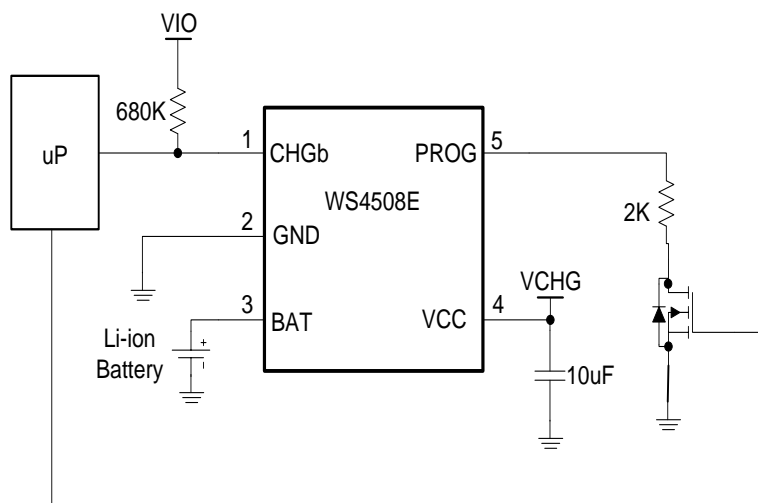
The charge status output indicator is an open drain circuit. The indicator has two different states: pull-down (~10mA), and high impedance. The pull-down state indicates that the WS4508E is in a charge cycle. High impedance indicates that the charge cycle is complete. The CHGb also can be used to detect the charge states by a microprocessor with a pull-up resistor.

Shutdown mode

At any point in the charge cycle, the WS4508E can be put into shutdown mode by removing RPROG thus floating the PROG pin. This reduces the battery drain current to less than 0.5uA and the supply current to less than 70uA. A new charge cycle can be initiated by reconnecting the program resistor. Below is a recommend application.

Automatic recharge

Once the charge cycle is terminated, the WS4508E continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (T_{RECHRG}). 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. CHGb output enters a pull-down state during recharge cycles.



The WS4508E also be put into shutdown mode when VCC voltage down to UVLO Threshold. In this state, the CHGb pin is high impedance state. The CHGb pin is also in a high impedance state if the charge cycle is completed.

Application informations

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 10KΩ. However, additional capacitance on this node reduces the maximum allowed program resistor thus it should be avoided.

Thermal limit

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 150°C. This feature protects the WS4508E 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 WS4508E. 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.

Power dissipation

The conditions that cause the WS4508E to reduce charge current through thermal feed-back 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:

$$P_D = (V_{CC} - V_{BAT}) * I_{BAT}$$

It is important to remember that WS4508E applications do not be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 150°C (Constant temperature mode).

VCC bypass capacitor

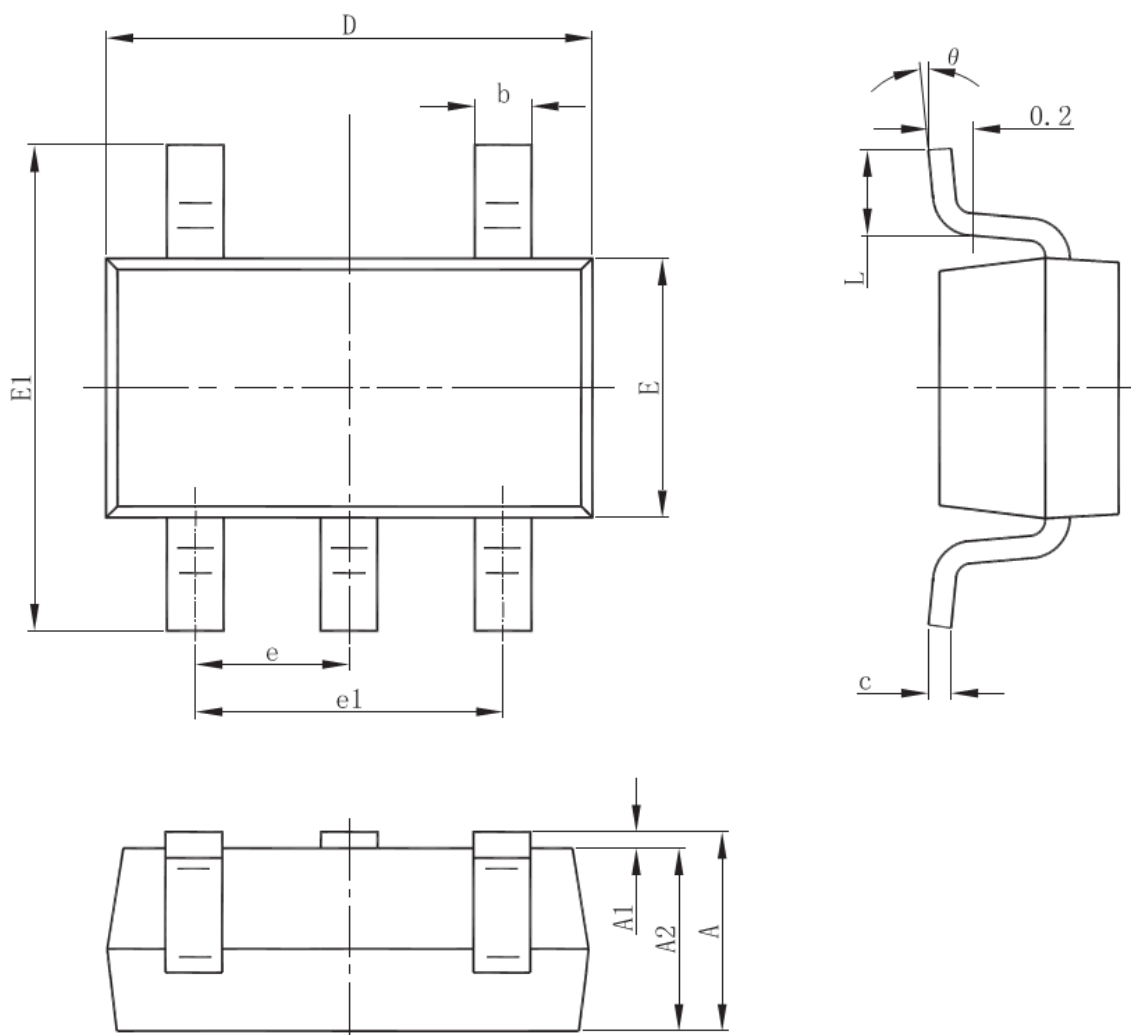
Many types of capacitors can be used for input bypass, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, a 1uF/16V ceramic capacitor is recommended for this bypass capacitor. Due to a high voltage transient will be generated under some start-up conditions, such as connecting the charger input to a live power source.

Charge current soft-start

The WS4508E 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 50s. This has the effect of minimizing the transient current load on the power supply during start-up.

Package outline dimensions

SOT-23-5L



Symbol	Dimensions In Millimeters	
	Min.	Max.
A	1.050	1.250
A1	0.000	0.100
A2	1.050	1.150
b	0.300	0.500
c	0.100	0.200
D	2.820	3.020
E	1.500	1.700
E1	2.650	2.950
e	0.950(Basic)	
e1	1.800	2.000
L	0.300	0.600
θ	0°	8°