Standalone Li-Lon Switch Mode Battery Charger ME4059

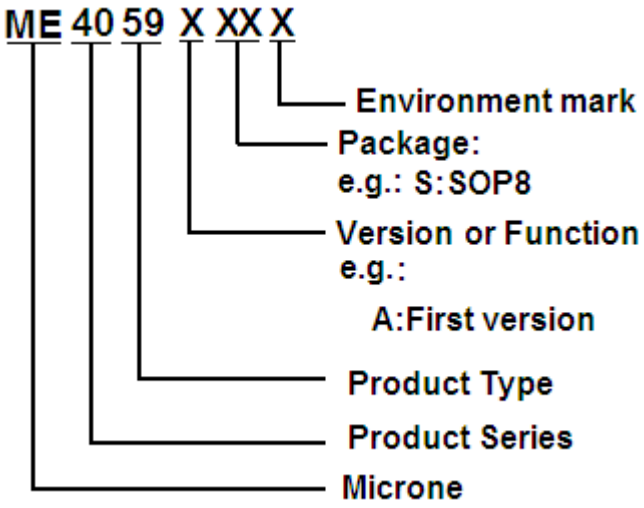
General Description

The ME4059 is a complete battery charger controller for one (4.2V) cell lithium-ion battery. The ME4059 provides a small, simple and efficient solution to fast charge Li-ion battery. An external sense resistor sets the charge current with high accuracy. An internal resistor divider and precision reference set the final float voltage to 4.22V per cell with ±1% accuracy. When the input supply is removed, the ME4059 automatically enters a low current sleep mode, dropping the battery drain current to 6μA. After the charge cycle ends, if the battery voltage drops below 4.1V per cell, a new charge cycle will automatically begin.

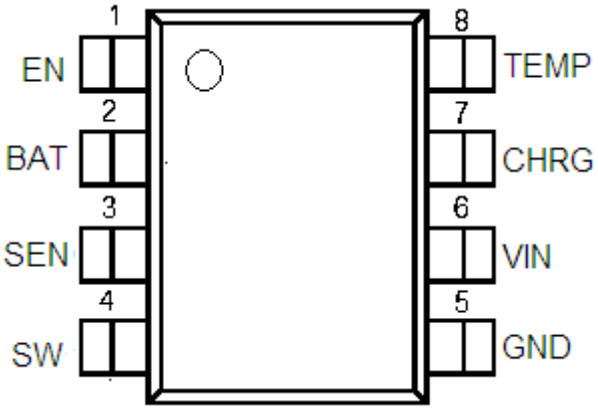
Features

- ●Input Supply Range: 4.7V-6V
- ●High Efficiency Current Mode PWM Controller
- ●End Charge Current Detection Output
- ●Constant Switching Frequency for Minimum Noise
- ● Preset 4.22V charge voltage with ±1% accuracy
- ● Automatic Recharge
- ●Automatic Shutdown When Input Supply is Removed
- ●Automatic Trickle Charging of Low Voltage
- ●Stable with Ceramic Output Capacitor
- ● Battery Temperature Sensing
- ● Available in SOP8 package

Selection Guide



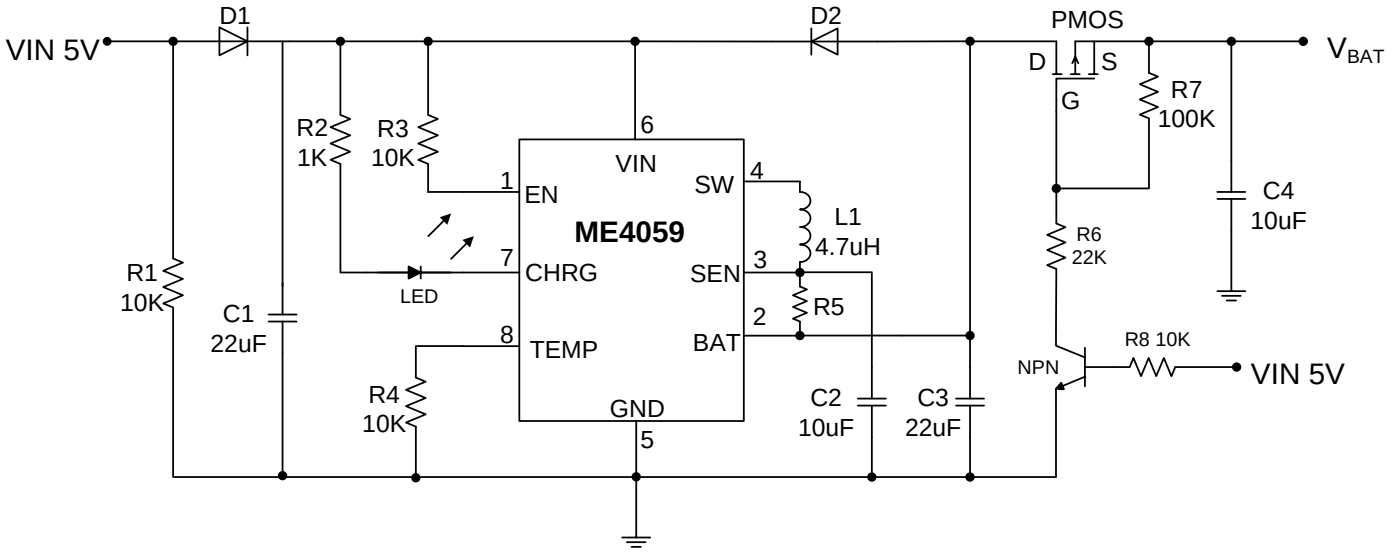
Pin Configuration



Applications

- ●Charging Docks
- ●Handheld InstrumenTEMP
- ●Portable Computers

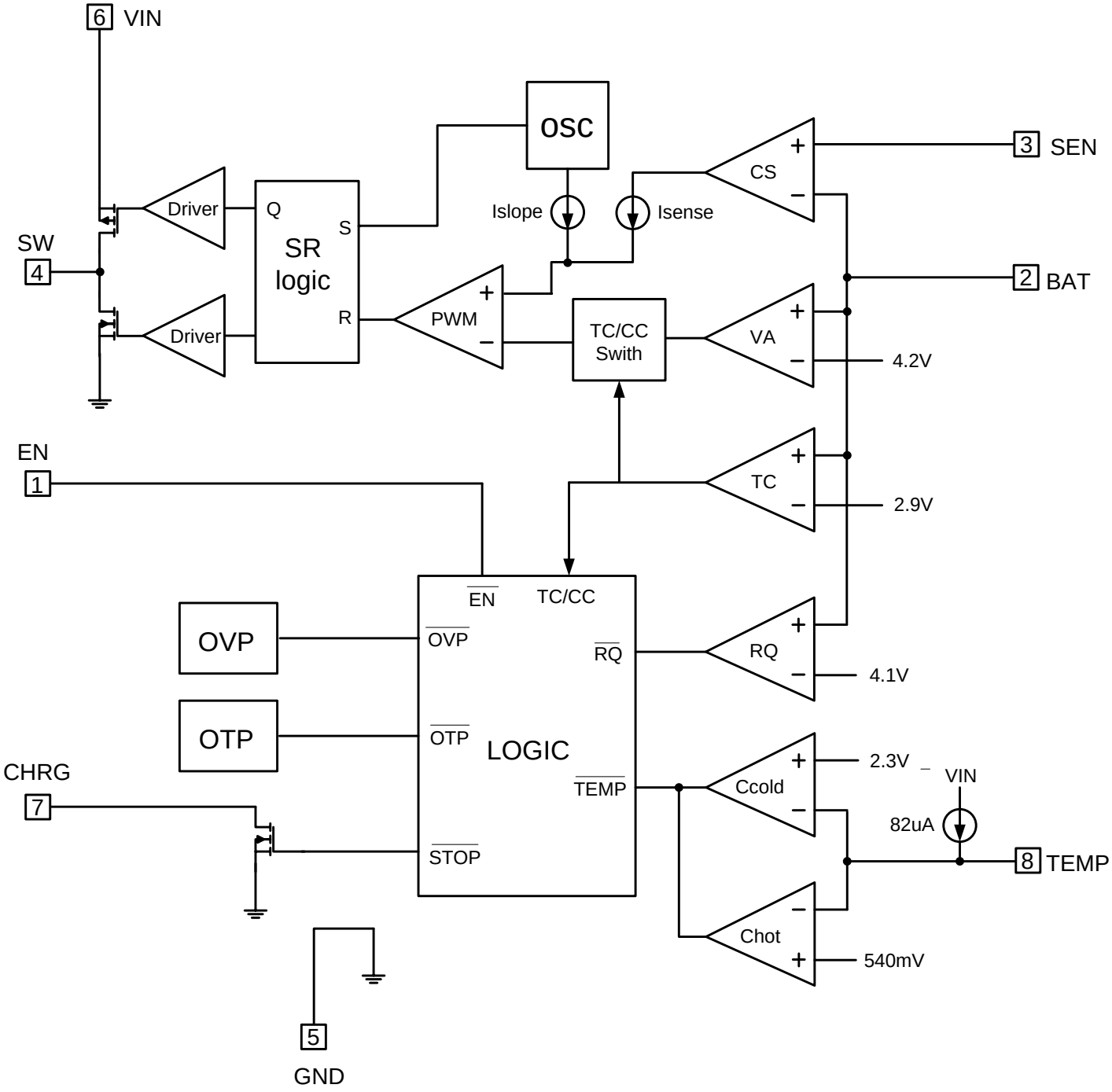
Typical Application



Pin Assignment

Pin Num.	Symbol	Function
1	EN	ON/OFF Control
2	BAT	Feedback Pin. Receives the feedback voltage from an external resistor across the output
3	SEN	Charge Current program. The output current is set by an external resistor according to the following formula: I_{OUT}= 0.19V/R5.
4	SW	Charge Current Output. It provides charge current to the battery and regulates the final float voltage to 4.22V.
5	GND	Ground
6	VIN	Positive Supply Voltage Input. VIN can range from 4.7V to 6V. A 10μF low ESR capacitor is required at the source pins of the power P-channel MOSFET.
7	CHRG	When the charge current drops below the End-of-Charge threshold for more than 120μs, the N-channel MOSFET turns off and a weak current source is connected from the CHRG pin to GND. When the input supply is removed, the weak current source is turned off and the CHRG pin becomes high impedance.
8	TEMP	Temperature sense. TEMP Thermistor Input. With an external 10KΩ, negative temperature coefficient thermistor to ground, this pin senses the temperature of the battery pack and stops the charger when the temperature is out of range. When the voltage at this pin drops below 540mV at hot temperature or rises above 2.3V at cold temperature, charging is suspended and the internal timer stops. The CHRG pin output is not affected during this hold state. To disable the temperature qualification function, ground the TEMP pin.

Block Diagram



Absolute Maximum Ratings

Parameter	Rating	Unit
VIN, CHRG, SW, SEN Voltage	-0.3～6.5	V
SW Pin Current	3.8	A
Operating Temperature Range	-40～85	℃
Maximum junction temperature	125	℃
Operating ambient temperature range	-40～85	℃
Storage temperature :range	-65～125	℃
Soldering temperature and time	+300（Recommended 10S）	℃

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage.

These values must therefore not be exceeded under any conditions.

Electrical Characteristics

Operating Conditions: T_A=25℃,V_{IN}=5V, R5 = 0.1Ω,unless otherwise specified

Symbol	Parameter	Condition	Min	Typ.	Max	Unit
VIN	Input supply voltage		4.7	5.0	6.0	V
I_{IN}	static current	Charge mode	-	300	-	μA
		Standby mode(charge end)	-	18	-	
		Sleep mode	-	6	-	
V_{FLOAL}	Battery Regulated Float voltage	0℃≤T_A≤85℃, I_{OUT}=1.2A	4.17	4.22	4.26	V
$V_{SNS(CHR)}$	Constant Current Sense Voltage	3V≤V_{BAT}≤4V	-	190	-	mV
$V_{SNS(TRKL)}$	Trickle Current Sense Voltage	V_{BAT}=2.5V	-	50	-	mV
V_{TRKL}	Trickle Charge Threshold voltage	V_{BAT} Rising	-	2.9	-	V
V_{ASD}	Automatic Shutdown Threshold voltage	VIN-V_{BAT}	-	100	-	mV
I_{TEMP}	TEMP Pin Output Current	V_{TEMP}=0.85V	-	82	-	μA
V_{TH-HOT}	TEMP Pin Threshold Voltage (Hot)	V_{TEMP} Falling	-	0.54	-	V
$V_{TH-COLD}$	TEMP Pin Threshold Voltage (Cold)	V_{NTC} Rising Hysteresis	-	2.3	-	V
OVP	Over voltage protection	VIN Rising	-	6.5	-	V
ΔV_{RECHRG}	Recharge battery voltage Offset from Full Charged Battery Voltage	V_{FLOAT} -V_{RECHRG}, V_{BAT} Falling	-	100	-	mV
f_{OSC}	Switching Frequency		-	1.1	-	MHz
DC	Maximum Duty Cycle		-	-	100	%

Description of the Principle

The ME4059 is a constant current, constant voltage Li-Ion battery charger controller that uses a current mode PWM step-down (buck) switching architecture. The charge current is set by an external sense resistor (R5) across the SEN and BAT pins. The final battery float voltage is internally set to 4.22V. For batteries like lithium-ion that require accurate final float voltage, the internal reference, voltage amplifier and the resistor divider provide regulation with high accuracy. A charge cycle begins when the voltage at the VIN pin is greater than the battery voltage 100mV. At the beginning of the charge cycle, if the battery voltage is less than the trickle charge threshold, the charger goes into trickle charge mode. The trickle charge current is internally set to 25% of the full-scale current. When the battery voltage exceeds the trickle charge threshold, the charger goes into the full-scale constant current charge mode. In constant current mode, the charge current is set by the external sense resistor R5 and an internal 190mV reference; I_{OUT}= 190mV/R5.

When the battery voltage approaches the programmed float voltage, the charge current will start to decrease. When the current drops to 25% of the full-scale charge current, an internal comparator turns off the internal pull-down N-channel MOSFET at the CHRG pin, and connects a weak current source to ground to indicate a end-of-charge condition and then the charge cycle is terminated and the CHRG pin is forced high impedance. To restart the charge cycle, remove and reapply the input voltage or momentarily shut the charger down. Also, a new charge cycle will begin if the battery voltage drops below the recharge threshold voltage. When the input voltage is present, the charger can be shut down. When the input voltage is not present, the charger goes into sleep mode. This will greatly reduce the current drain on the battery and increase the standby time. A 10KΩ TEMP (negative temperature coefficient) thermistor can be connected from the TEMP pin to ground for battery temperature qualification.

Functional Description

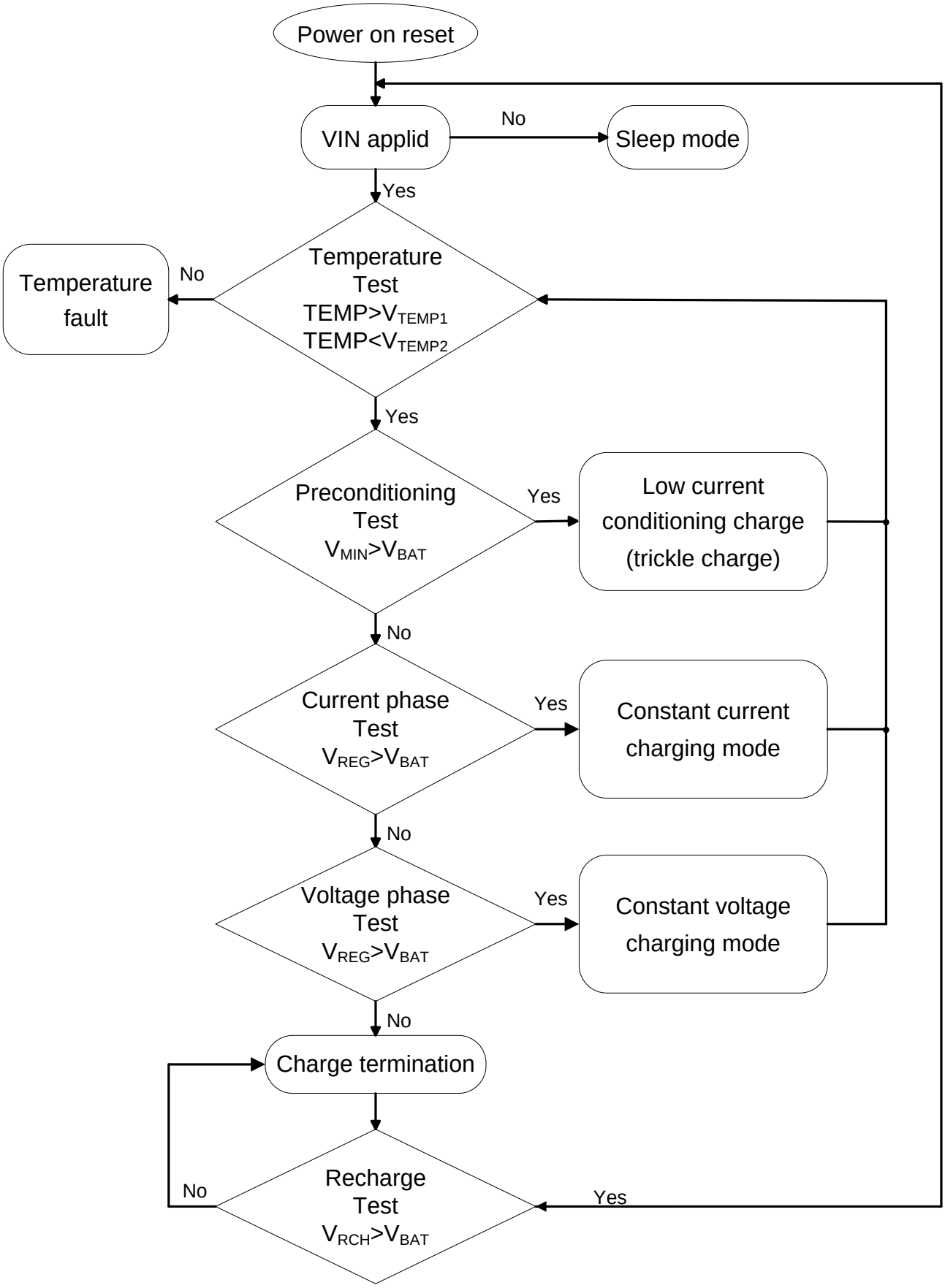


Fig. 1: Operation Flow Chart

Qualification and Precharge

The ME4059 suspends charge if the battery temperature is outside the V_{TEMP1} to V_{TEMP2} range and suspends charge until the battery temperature is within the allowed range. The ME4059 also checks the battery voltage. If the battery voltage is below the precharge threshold V(min) , the ME4059 uses precharge to condition the battery. The conditioning charge rate $I_{(PRECHG)}$ is set at approximately 25% of the regulation current. See Fig.2 for a typical charge-profile.

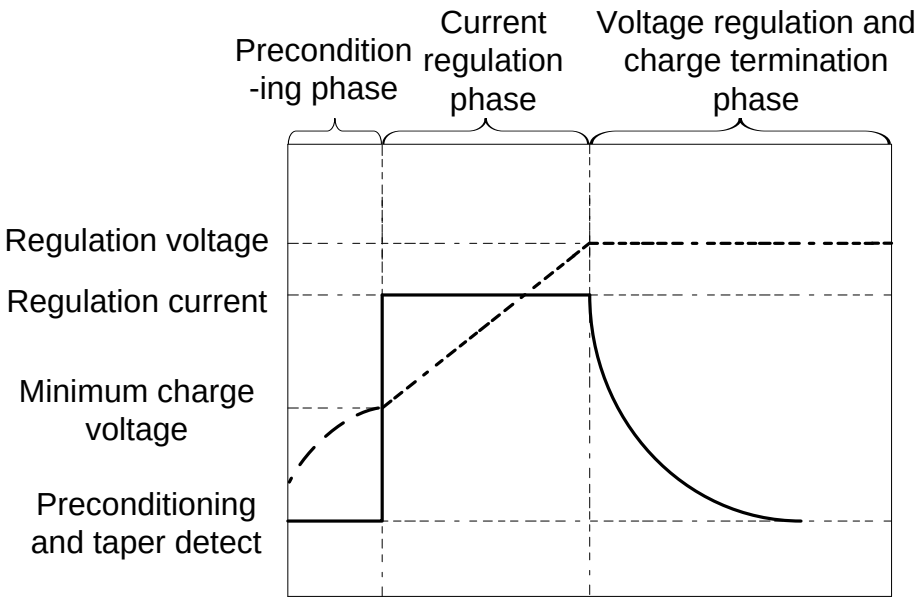


Fig. 2: Typical Charge Profile

Charge Termination Recharge

The ME4059 monitors the charging current during the voltage-regulation phase. The ME4059 declares a done condition and terminates charge when the current drops to the charge termination threshold A new charge cycle begins when the battery voltage falls below 4.1V.

Battery Temperature Monitoring

A negative temperature coefficient (NTC) thermistor located close to the battery pack can be used to monitor battery temperature and will not allow charging unless the battery temperature is within an acceptable range. Connect a 10KΩ thermistor from the TEMP pin to ground. With the 82μA pull-up current source, the Hot temperature voltage threshold is 540mV. For Cold temperature, the voltage threshold is set at 2.3V with 82μA of pull-up current. The charge cycle begins or resumes once the temperature is within the acceptable range.

Charge Status Indication

The ME4059 reports the status of the charge on the CHRG pin. The following Table 1 summarized the operation of the CHRG pin. The CHRG pin can be used to drive a chip LED.

Condition	CHRG pin
Battery conditioning and charging	Low
Charge complete(done)	Hi-Z
Temperature fault or sleep mode	Hi-Z

Table 1

Automatic Shutdown Voltage (V_{ASD})

Differential input voltage and V_{BAT} is less than 100 mV, IC will enter shutdown mode.

Trickle Charge

At the beginning of a charge cycle, if the battery voltage is below the trickle charge threshold, the charger goes into trickle charge mode with the charge current reduced to 25% of the full-scale current.

Shutdown

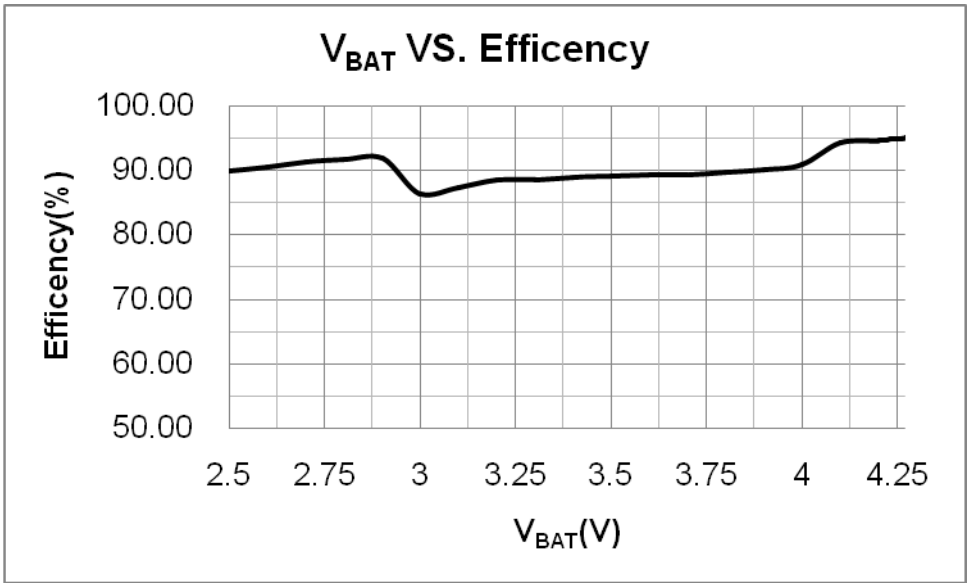
The ME4059 can be shut down by pulling the EN pin to ground. In shutdown, the output of the CHRG pin is high impedance and the quiescent current remains at 18μA.

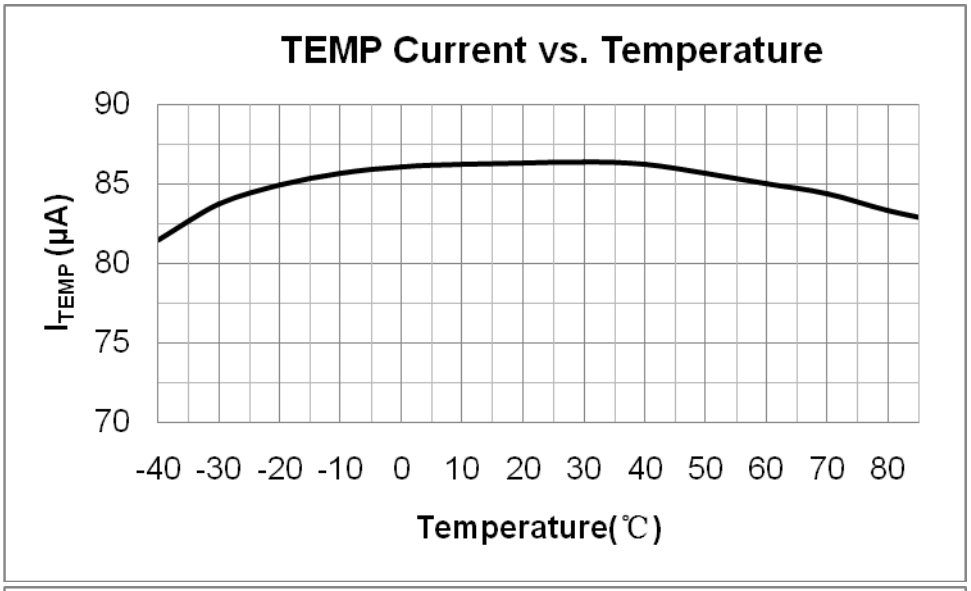
Input and Output Capacitors

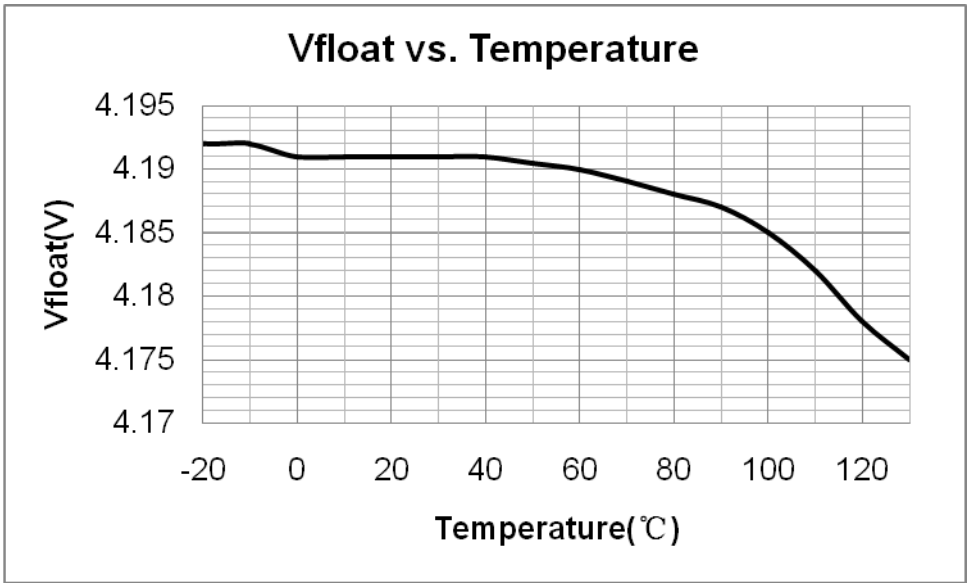
Since the input capacitor is assumed to absorb all input switching ripple current in the converter, it must have an adequate ripple current rating. Worst-case RMS ripple current is approximately one-half of output charge current. Actual capacitance value is not critical. Solid tantalum capacitors have a high ripple current rating in a relatively small surface mount package, but caution must be used when tantalum capacitors are used for input bypass. High input surge currents can be created when the adapter is hot-plugged to the charger and solid tantalum capacitors have a known failure mechanism when subjected to very high turn-on surge currents. Selecting the highest possible voltage rating on the capacitor will minimize problems. Consult with the manufacturer before use. The selection of output capacitor C_{OUT} is primarily determined by the ESR required to minimize ripple voltage and load step transients. The output ripple ΔV_{OUT} is approximately bounded by: $\Delta V_{OUT} \leqq \Delta I_L (ESR + \frac{1}{8 f_{OSC} C_{OUT}})$

Since ΔI_L increases with input voltage, the output ripple is highest at maximum input voltage. Typically, once the ESR requirement is satisfied, the capacitance is adequate for filtering and has the necessary RMS current rating. Switching ripple current splits between the battery and the output capacitor depending on the ESR of the output capacitor and the battery impedance. EMI considerations usually make it desirable to minimize ripple current in the battery leads. Ferrite beads or an inductor may be added to increase battery impedance at the 500KHz switching frequency. If the ESR of the output capacitor is 0.2Ω and the battery impedance is raised to 4Ω with a bead or inductor, only 5% of the current ripple will flow in the battery.

Typical Performance Characteristics

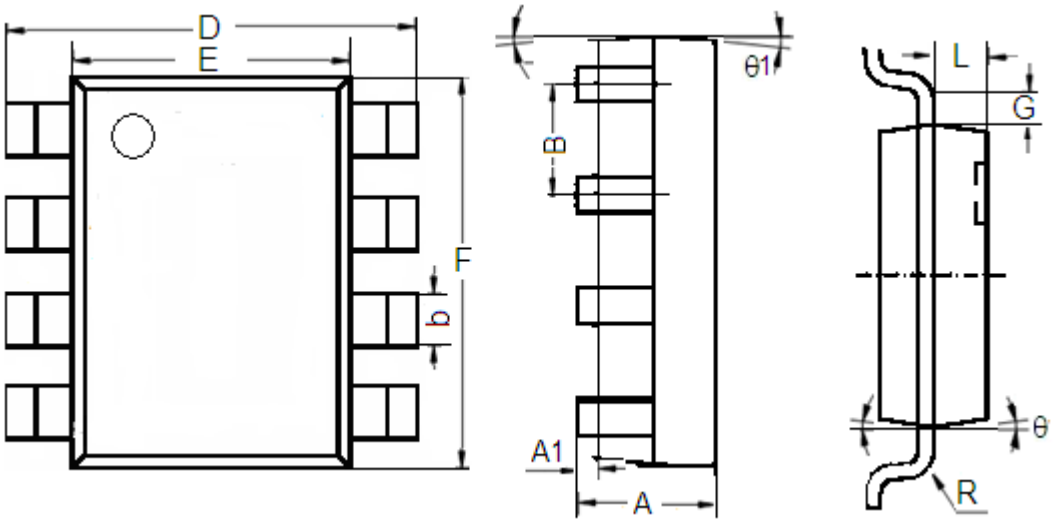






Packaging Information:

Packaging Type: SOP8 Unit:mm(inch)



Character	Dimension (mm)		Dimension (Inches)	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.1	0.3	0.004	0.012
B	1.27(Typ.)		0.05(Typ.)	
b	0.330	0.510	0.013	0.020
D	5.8	6.2	0.228	0.244
E	3.800	4.000	0.150	0.157
F	4.7	5.1	0.185	0.201
L	0.675	0.725	0.027	0.029
G	0.32(Typ.)		0.013(Typ.)	
R	0.15(Typ.)		0.006(Typ.)	
θ1	7°		7°	
θ	8°		8°	

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