Linear Single Cell Li-Ion Battery Charger with Input Over Voltage Protection

General Description

The RT9526A is a fully integrated low cost single cell Li-ion battery charger ideal for portable applications. The RT9526A is capable of being powered up from AC adapter and USB (Universal Serial Bus) port inputs. The RT9526A enters sleep mode when supplies are removed. The RT9526A optimizes the charging task by using a control algorithm including preconditioning mode, fast charge mode, and constant voltage mode. The charging task will remain in constant voltage mode to hold the battery in a full charge condition. The charge current can be programmed with an external resistor. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate under all ambient temperatures. The RT9526A features 28V maximum rating voltage for VIN. Under-voltage protection and over-voltage protection are provided for the AC adapter supply.

The RT9526A is available in the WDFN-8L 2x3 and SOT-23-6 package to achieve best solution for PCB space and total BOM cost saving considerations.

Applications

- Cellular Phones
- Digital Cameras
- PDAs and Smart Phones
- Portable Instruments

Features

- **28V Maximum Rating for AC Adapter with Over-Voltage Protection 7V**
- **Internal Integrated Power FETs**
- **AC Adapter Power Good Status Indicator**
- **Programmed Charging Current**
- **Charge Status Indicator**
- **Programmed End of Charge Current**
- **Under-Voltage Protection**
- **Thermal Feedback Optimizing Charge Rate**
- **RoHS Compliant and Halogen Free**

Ordering Information

RT9526A□□

Package Type
QW : WDFN-8L 2x3 (W-Type)
E : SOT-23-6

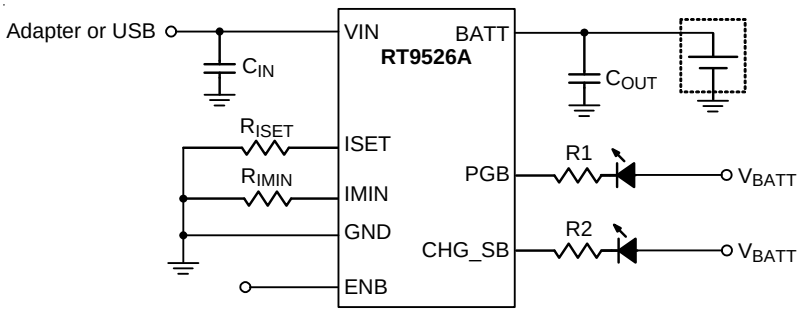
Lead Plating System
G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

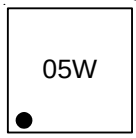
Simplified Application Circuit



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Marking Information

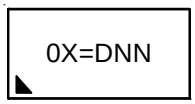
RT9526AGQW



05 : Product Code

W : Date Code

RT9526AGE

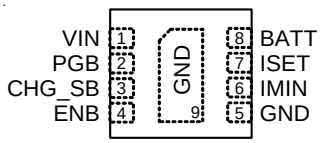


0X= : Product Code

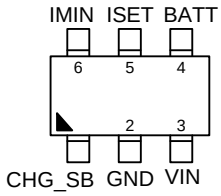
DNN : Date Code

Pin Configurations

(TOP VIEW)



WDFN-8L 2x3



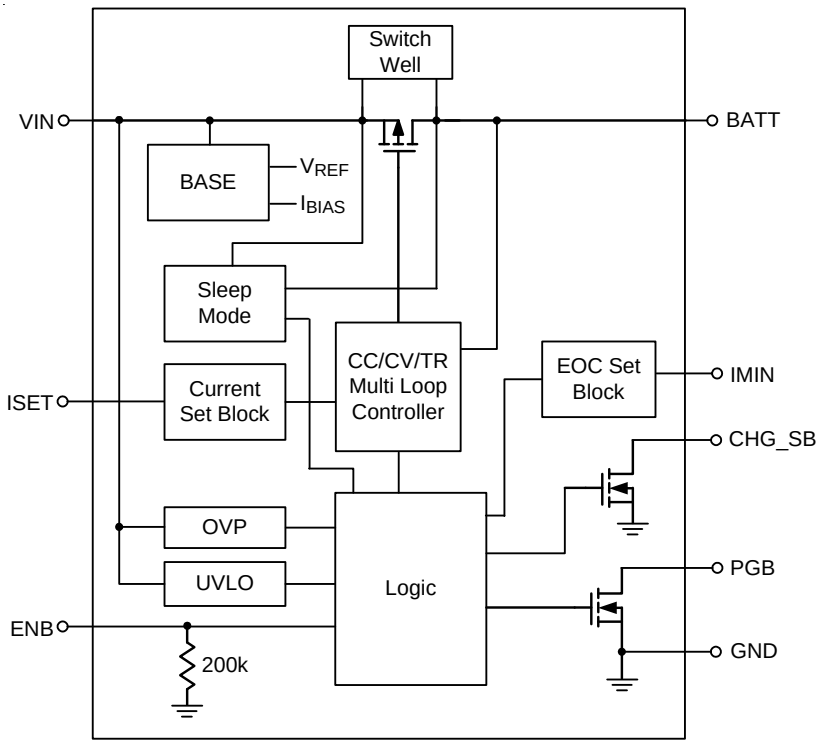
SOT-23-6

Function Pin Description

Pin No.		Pin Name	Pin Function
WDFN-8L 2x3	SOT-23-6		
1	3	VIN	Supply Voltage Input. VIN can withstand up to 28V input.
2	--	PGB	Power Good Indicator. This pin connects to VIN with 10SL N-MOSFET as power good condition.
3	1	CHG_SB	Charge Status Indicator Output (Open-Drain). Indicate low when battery is charging; indicate high when battery charging finished or any fault happened.
4	--	ENB	Enable Control Input (Active Low). Connect this pin with a 200kΩ pull-low resistor.
5, 9 (Exposed Pad)	2	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
6	6	IMIN	EOC Current Setting.
7	5	ISET	Charge Current Set Point.
8	4	BATT	Battery Charge Current Output.

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Function Block Diagram



Operation

The RT9526A is a fully integrated low cost single cell Li-ion charger. It provides a fast-charge current setting by resistor R_{IREF}. Pre-charge is 16.7% of fast charge current, while VBAT < 2.45V. The PGB pin is low, while VIN > POR, VIN < OVP, and VIN – VBAT > V_{OSH_H}. The CHG_SB pin is low, while RT9526A is charging. The CHG_SB pin will go high while end of charger happens. End of charge condition is set by R_{IMIN}. CHG_SB will go low again, while charge current is larger than 75% of fast-charge setting. The RT9526A charges continuously after end of charge happens. Li-ion battery will be full charged until CV = 4.2V. The RT9526A can be disabled by ENB = H.

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Absolute Maximum Ratings (Note 1)

- Supply Voltage, VIN ---------- –0.3V to 28V
- CHG_SB, PGB ---------- –0.3V to 7V
- Other Pins ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  - WDFN-8L 2x3 ---------- 3.17W
  - SOT-23-6 ---------- 0.48W
- Package Thermal Resistance (Note 2)
  - WDFN-8L 2x3, θ_{JA} ---------- 31.5°C/W
  - WDFN-8L 2x3, θ_{JC} ---------- 7.5°C/W
  - SOT-23-6, θ_{JA} ---------- 208.2°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C

Recommended Operating Conditions (Note 3)

- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 4.5V, T_A = 25°C unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
VIN POR Rising Threshold Voltage		V_{POR_H}		3.4	3.8	4.2	V
VIN POR Falling Threshold Voltage		V_{POR_L}		3.1	3.5	3.9	V
VIN – V_{BATT} VOS Rising		V_{OS_H}		--	90	150	mV
VIN – V_{BATT} VOS Falling		V_{OS_L}		10	50	--	mV
VIN Standby Current			V_{BATT} = 4.5V	--	400	600	μA
BATT Sleep Leakage Current		I_{SLEEP}		--	1	5	μA
Battery Regulation Voltage		V_{REG}		4.158	4.2	4.242	V
VIN Power MOSFET On-Resistance		$R_{DS(ON)}$	I_{BATT} = 0.5A	--	0.6	--	Ω
ISET Set Voltage (Fast Charge Phase)		V_{ISET}		--	1.22	--	V
Charge Current Accuracy			R_{ISET} = 24.3kΩ	450	500	550	mA
BATT Pre-Charge Threshold		V_{CHG_PRE}		2.45	2.55	2.65	V
BATT Pre-Charge Threshold Hysteresis		ΔV_{CHG_PRE}		40	100	150	mV
Pre-Charge Current		I_{CHG_PRE}		12	16.7	21.3	%
ENB Input Threshold Voltage	Logic-High	V_{IH}	V_{IN} = 4.2V to 24V	1.5	--	--	V
	Logic-Low	V_{IL}		--	--	0.4	
Thermal Regulation		T_{REG}		--	115	--	°C

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Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VIN Over-Voltage Protection Threshold	V_{OVP}		6.7	7	7.5	V
VIN OVP Hysteresis	ΔV_{OVP}		--	0.1	--	V
PGB Pull-Down Voltage		5mA	--	200	--	mV
CHG_SB Pull-Down Voltage		5mA	--	200	--	mV
EOC Current Setting	I_{IMIN}	R_{IMIN} = 243kΩ	--	45	--	mA
EOC Rising Threshold		R_{IREF} = 24.3kΩ	337.5	375	412.5	mA

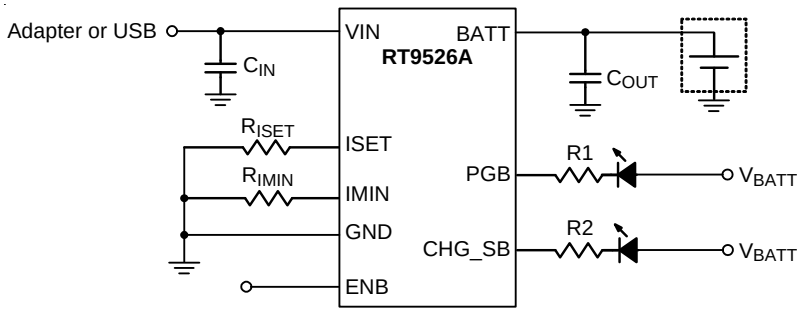
Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ_{JC} is measured at the exposed pad of the package.

Note 3. The device is not guaranteed to function outside its operating conditions.

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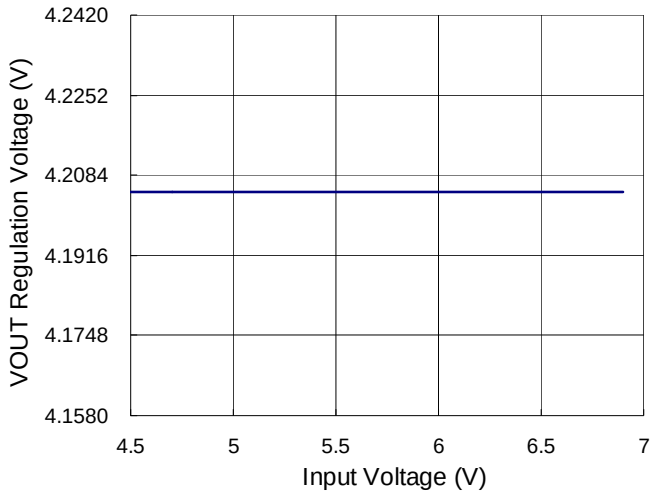
Typical Application Circuit



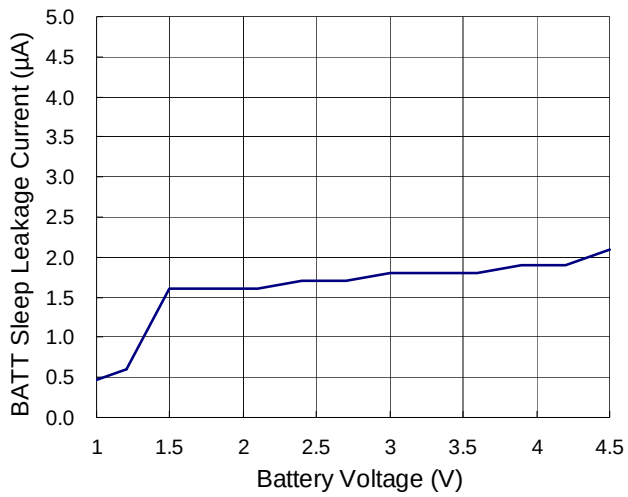
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Typical Operating Characteristics

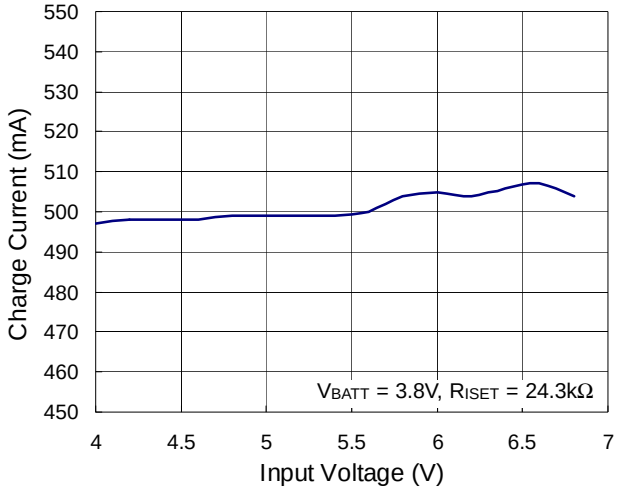
VOUT Regulation Voltage vs. Input Voltage



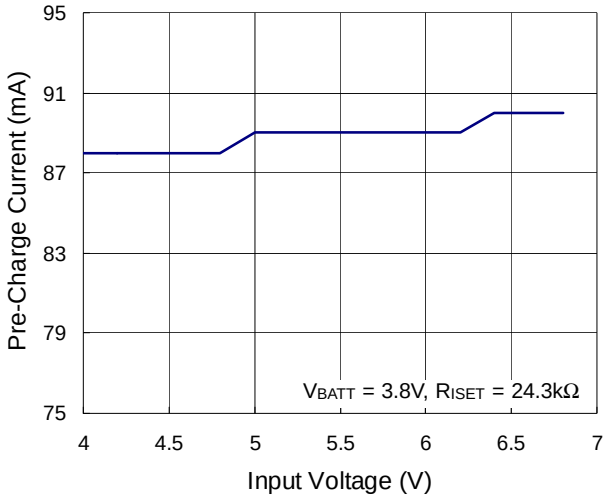
BATT Sleep Leakage Current vs. Battery Voltage



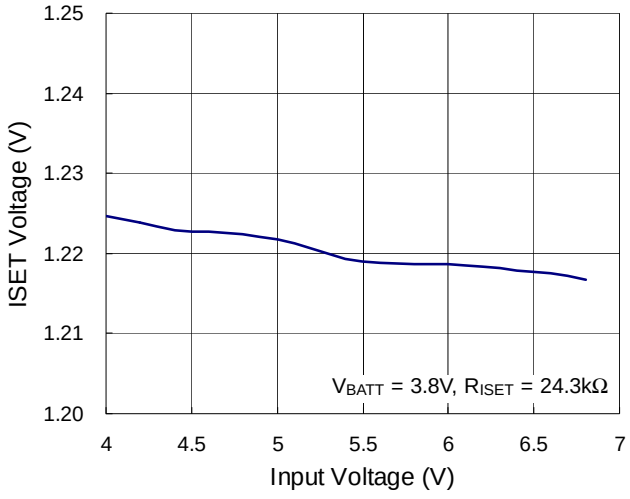
Charge Current vs. Input Voltage



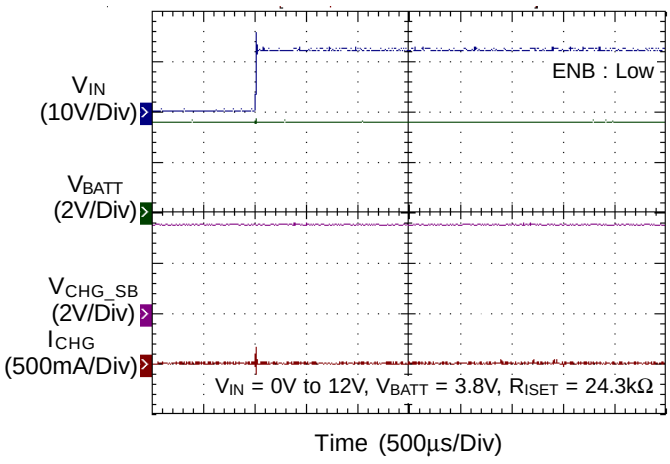
Pre-Charge Current vs. Input Voltage



ISET Voltage vs. Input Voltage

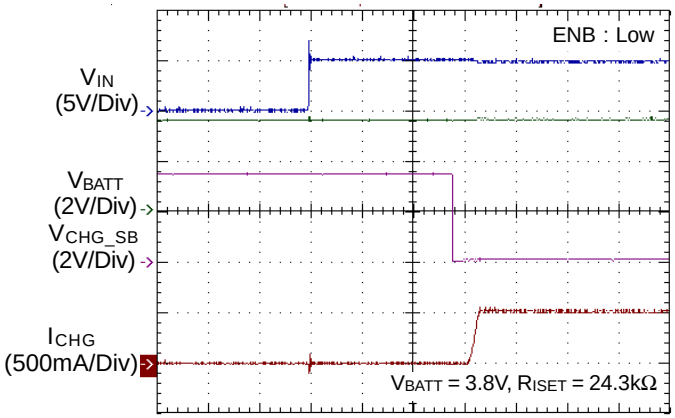


OVP

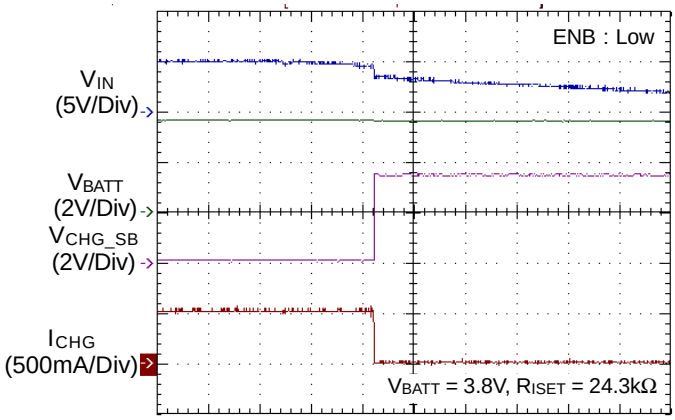


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Power On



Shutdown



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Application Information

The RT9526A is a fully integrated low cost single cell Li-ion battery charger operable in Constant Current (CC) mode or Constant Voltage (CV) mode. The CC mode current is set with the external resistor, R_{ISET}, and the CV mode voltage is fixed at 4.2V. If the battery voltage is below a typical 2.55V pre-charge threshold, the RT9526A charges the battery with a trickle current until the battery voltage rises above the pre-charge threshold. The RT9526A is capable of being powered up from AC adapter and USB (Universal Serial Bus) port inputs.

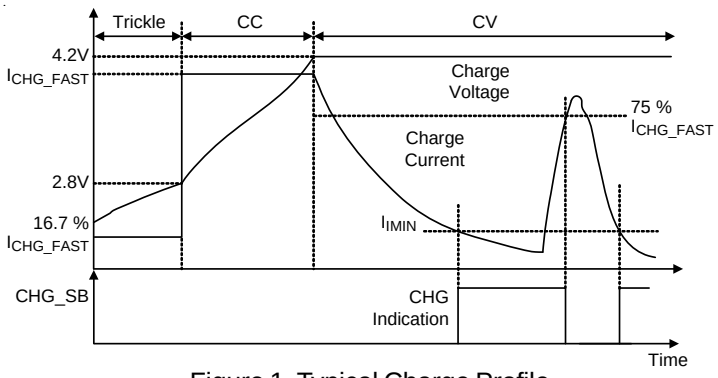


Figure 1. Typical Charge Profile

VIN Over-Voltage Protection

The input voltage is monitored by the internal comparator. The OVP threshold is set at 7V (typ.). When the input voltage exceeds the threshold, the controller outputs a logic signal to turn off the power P-MOSFET to prevent the electronics in the handheld system from damaging due to high input voltage. Nevertheless, an AC input voltage over 28V will still damage the RT9526A. When the input over-voltage condition is removed, the controller will enable the output again by running through soft-start.

Charger Enable Input

ENB is an active-low logic input to enable the charger. Drive the ENB pin low or leave it floating to enable the charger. This pin has a 200kΩ internal pull-down resistor. So when left floating, the input is equivalent to logic-low. Drive this pin high to disable the charger.

Battery Charge Profile

The RT9526A charges a Li-ion battery under Constant Current (CC) mode or Constant Voltage (CV) mode. The constant current of ISET is set via the external resistor, R_{ISET}, and the constant voltage is fixed at 4.2V. If the battery voltage is below a typical 2.55V pre-charge threshold, the RT9526A charges the battery with a trickle current until the battery voltage rises above the pre-charge threshold. When the battery voltage reaches 4.2V, the charger enters CV mode and regulates the battery voltage at 4.2V to fully charge the battery without the risk of over charge.

a. Battery Pre-Charge Current

During a charge cycle, if the battery voltage is below the pre-charge threshold, the RT9526A applies a pre-charge mode to the battery. This feature revives deeply discharged cells and protects battery life. The internally determined pre-charge rate of the RT9526A is 16.7% of the constant charge current.

b. Battery Fast-Charge Current (CC Mode)

The RT9526A offers ISET pin to determine the fast-charge current via an external resistor, R_{ISET}, connected between ISET and GND. The fast-charge current can be calculated by the following equation :

$$I_{CHG_FAST} = K_{ISET} \times \frac{V_{ISET}}{R_{ISET}} \quad (mA)$$

K_{SET} = 9959; V_{SET} = 1.22 (typ.)

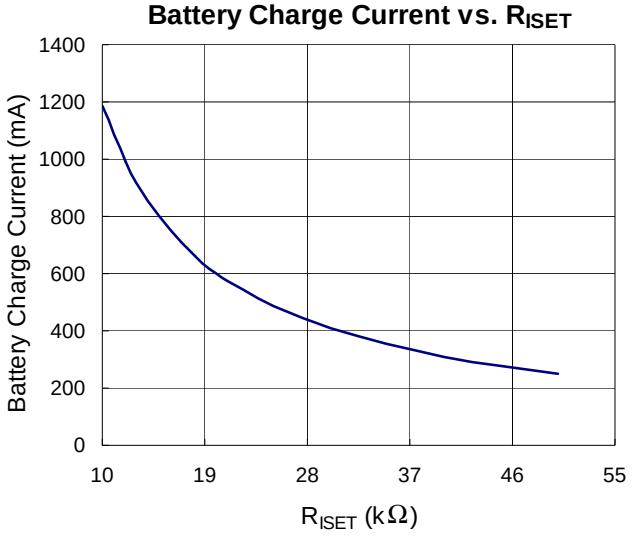


Figure 2

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c. Battery Voltage Regulation (CV Mode)

The battery voltage regulation feedback is through the BATT pin. The RT9526A monitors the battery voltage between the BATT and GND pins. When battery voltage is close to battery regulation voltage threshold, the voltage regulation phase begins and the charging current begins to taper down. When battery voltage is over battery regulation voltage threshold and charge mode stops, the RT9526A still monitors the battery voltage. Charge current is resumed when the battery voltage falls under battery regulation voltage threshold.

Sleep Mode

The RT9526A enters sleep mode if both AC and USB are removed from the input. This feature prevents draining the battery during the absence of input supply.

Power Good

This open-drain output pin is used to indicate the input voltage status. The PGB output asserts low when

1. $V_{IN} > V_{POR}$
2. $V_{IN} – V_{BATT} > V_{OS}$
3. $V_{IN} < V_{OVP}$

It can be used to drive an LED or communicate to the host processor. Note that ON indicates the open-drain transistor is turned on and LED is bright.

CHG_SB Indication

The CHG_SB pin is an open-drain output capable to at least 10mA current when the charger starts to charge and turns off when the EOC current is reached. The CHG_SB signal is interfaced either with a micro processor GPIO or an LED for indication.

End-Of-Charge Current (EOC)

Connect a resistor between the IMIN pin and GND to set the EOC current. The EOC current level, I_{IMIN}, is programmable via the external resistor, R_{IMIN} (kΩ), as shown in the following equation :

$$I_{IMIN} = \frac{10935}{R_{IMIN}} \quad (mA)$$

Upon reaching the End-Of-Charge (EOC) current, the charger indicates charge completion via the CHG_SB pin, but the charger continues to output 4.2V voltage. Figure 1 shows the typical charge profile and the EOC/reset event. The CHG_SB signal asserts low when the trickle charge starts and changes to high at EOC. After EOC is reached, the charge current has to rise above 75% of I_{CHG_FAST} before the CHG_SB signal is allowed to turn on again. A current surge after EOC may occur due to a load connected to the battery.

Temperature Regulation and Thermal Protection

In order to maximize charge rate, the RT9526A features a junction temperature regulation loop. If the power dissipation of the IC results in junction temperature greater than the thermal regulation threshold (115°C), the RT9526A will cut back on the charge current and disconnect the battery in order to maintain thermal regulation at around 115°C. This operation continues until the junction temperature falls below thermal regulation threshold (115°C) by the hysteresis level. This feature prevents the maximum power dissipation from exceeding typical design conditions.

Selecting the Input and Output Capacitors

In most applications, a 1μF high frequency decoupling capacitor placed in close proximity to the input is sufficient. However, depending on the power supply characteristics and cable length, it may be necessary to add an additional 10μF ceramic capacitor to the input. For the RT9526A, a small output capacitor is required for loop stability. A 1μF ceramic capacitor placed between the BATT pin and GND is typically sufficient.

Thermal Considerations

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For WDFN-8L 2x3 package, the thermal resistance, θ_{JA}, is 31.5°C/W on a standard JEDEC 51-7 four-layer thermal test board. For SOT-23-6 package, the thermal resistance, θ_{JA}, is 208.2°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

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$P_{D(MAX)}$ = (125°C – 25°C) / (31.5°C/W) = 3.17W for WDFN-8L 2x3 package

$P_{D(MAX)}$ = (125°C – 25°C) / (208.2°C/W) = 0.48W for SOT-23-6 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 3 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.

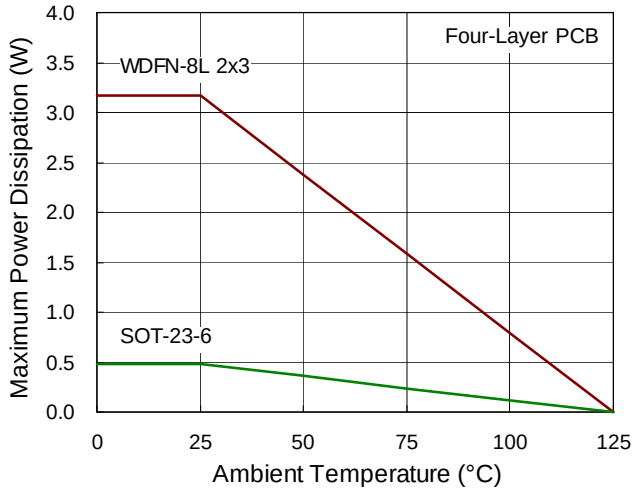


Figure 3. Derating Curve of Maximum Power Dissipation

Layout Consideration

The RT9526A is a fully integrated low cost single-cell Li-ion battery charger ideal for portable applications. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. A short connection is highly recommended. The following guidelines should be strictly followed when designing a PCB layout for the RT9526A.

- Input capacitor should be placed close to the IC and connected to the ground plane. The trace of input on the PCB should be placed far away from the sensitive devices and shielded by the ground.
- The GND and exposed pad should be connected to a strong ground plane for heat sinking and noise protection.
- The connection of R_{ISET} should be isolated from other noisy traces.
- Output capacitor should be placed close to the IC and connected to the ground plane to reduce noise coupling.

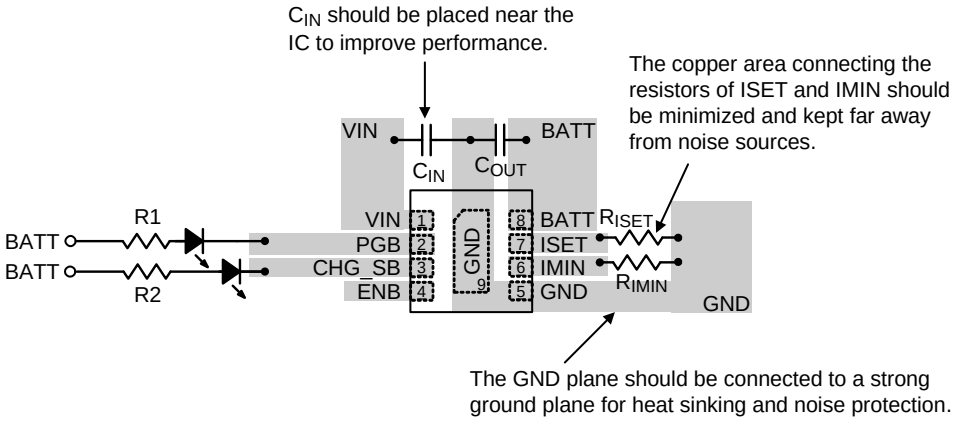
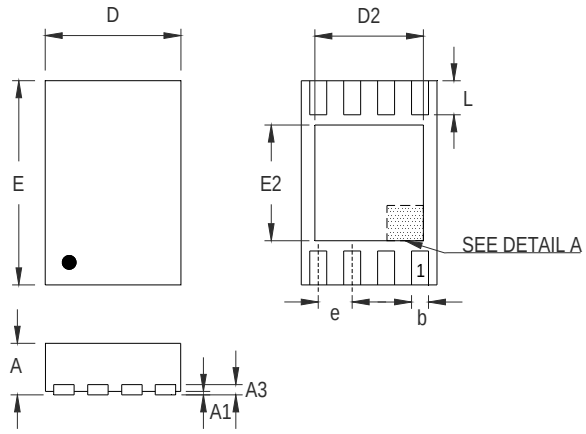
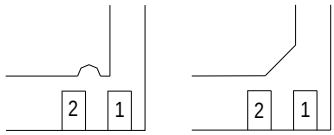


Figure 4. PCB Layout Guide

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Outline Dimension





DETAIL A

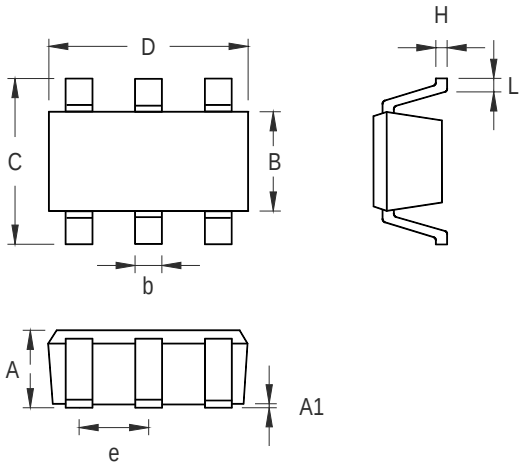
Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.200	0.300	0.008	0.012
D	1.900	2.100	0.075	0.083
D2	1.550	1.650	0.061	0.065
E	2.900	3.100	0.114	0.122
E2	1.650	1.750	0.065	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

W-Type 8L DFN 2x3 Package

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Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.031	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

SOT-23-6 Surface Mount Package

Richtek Technology Corporation

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Hsinchu, Taiwan, R.O.C.

Tel: (8863)5526789

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