High Efficiency Switching Mode Battery Charger

General Description

The RT9538 is a PWM switch mode battery charger controller to fast charge single or multiple Li-ion, NiMH and NiCd batteries, using constant current or constant voltage control. Maximum current can be easily adjusted by an external resistor. The constant voltage output can support up to 30V with 0.5% accuracy.

A third control loop limits the input current drawing from the adapter during charging. This allows simultaneous operation of the equipment and fast battery charging without over loading to the adapter.

The RT9538 can charge batteries from 2.5V to 25V with dropout voltage as low as 2V. A diode is not required in series with the battery because the charger automatically enters a 10μA sleep mode when the adapter is unplugged.

A logic output indicates Li-ion full charge when current drops to 20% of the full-scale adjusted charge current.

Marking Information

1C=YM DNN	1C= : Product Code YMDNN : Date Code

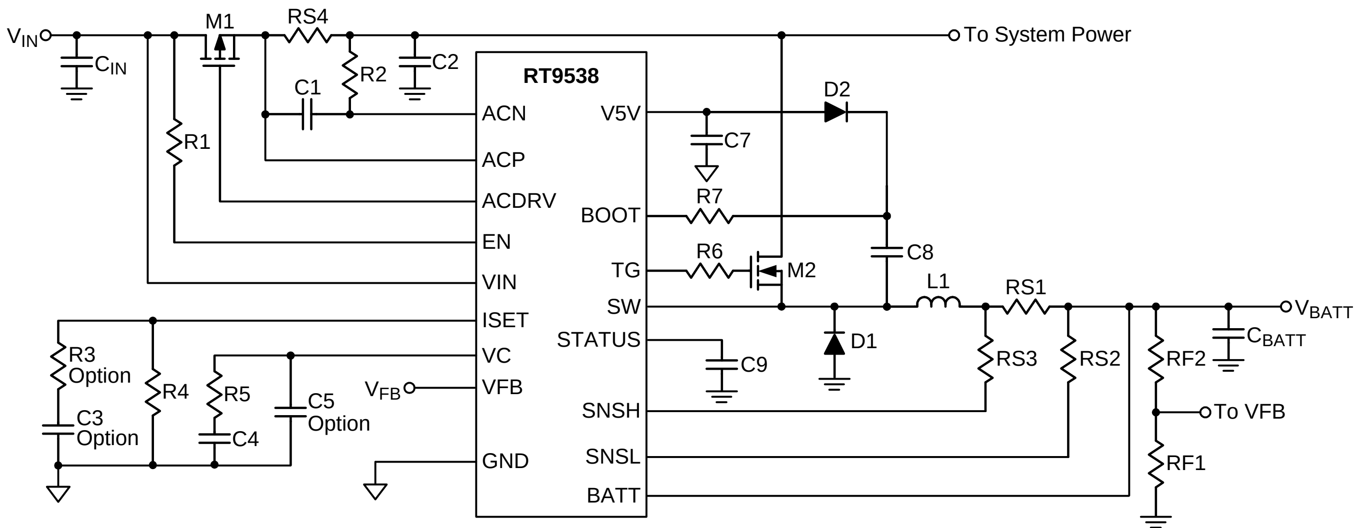
Features

- **Fast Charging for Li-ion, NiMH and NiCd Batteries**
- **Adjustable Battery Voltages from 2.5V to 25V**
- **High Efficiency : Up to 95%**
- **Charging Current Adjusted by Resistor**
- **Precision 0.5% Charging Voltage Accuracy**
- **Provide 5% Charging Current Accuracy**
- **Input Current Limit Maximizes Charging Rate**
- **475kHz Switching Frequency**
- **Flag Indicates Li-ion Charge Completion**
- **Auto Shutdown with Adapter Removal**
- **Only 10μA Battery Drain When Idle**
- **Available in an 16-Lead WQFN Package**
- **RoHS Compliant and Halogen Free**

Applications

- Notebook Computers
- Portable Instruments
- Chargers for Li-ion, NiMH, NiCd and Lead Acid
- Rechargeable Batteries

Simplified Application Circuit



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Ordering Information

RT9538 □ □
- Package Type
  QW : WQFN-16L 4x4 (W-Type)
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

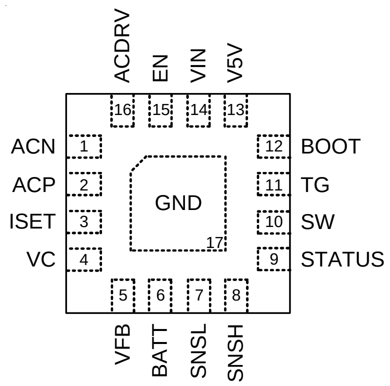
Note :

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.

Pin Configurations

(TOP VIEW)



WQFN-16L 4x4

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	ACN	Negative Terminal to Sense Input Current. A 0.1μF ceramic capacitor is placed from ACN to ACP to provide differential-mode filtering the switching noise.
2	ACP	Positive Terminal to Sense Input Current.
3	ISET	Charge Current Setting and System Loop Compensation Pin. Connect a resistor from this pin to ground to set the charge current. A capacitor of at least 0.1μF to GND filters out the current ripple.
4	VC	Control Signal of the Inner Loop of the Current Mode PWM. It provides the loop compensation and soft-start.
5	VFB	Charge Voltage Analog Feedback Adjustment. Connect a resistor divider from output to VFB to GND to adjust the output voltage. The internal regulation limit is 2.5V.
6	BATT	Battery Voltage Sense Input. A 10μF or larger X5R ceramic capacitor is recommended for filtering charge current ripple and stability purpose.
7	SNSL	Negative Terminal for Sensing Charge Current. A 0.1μF ceramic capacitor is placed from SRN to SRP to provide differential-mode filtering.
8	SNSH	Positive Terminal for Sensing Charge Current.
9	STATUS	Flag to Indicate Charge Completion. It turns to logic high when the charge current drops blew 20% of the setting charge current. A 0.1μF capacitor from STATUS to ground is needed to filter the sampled charge current ripple.
10	SW	Switch Node. This pin switches between ground and VIN with high dv/dt rates. Care needs to be taken in the PCB layout to keep this node from coupling to other sensitive nodes.
11	TG	Gate Driver Output for the External N-MOSFET.
12	BOOT	Bootstrap for High-Side Gate Driver. In normal operation, $V_{BOOT} \approx V_{SW} + 5V$.
13	V5V	Output of Internal 5V LDO. Connect a 1μF ceramic capacitor from this pin to GND for stability.

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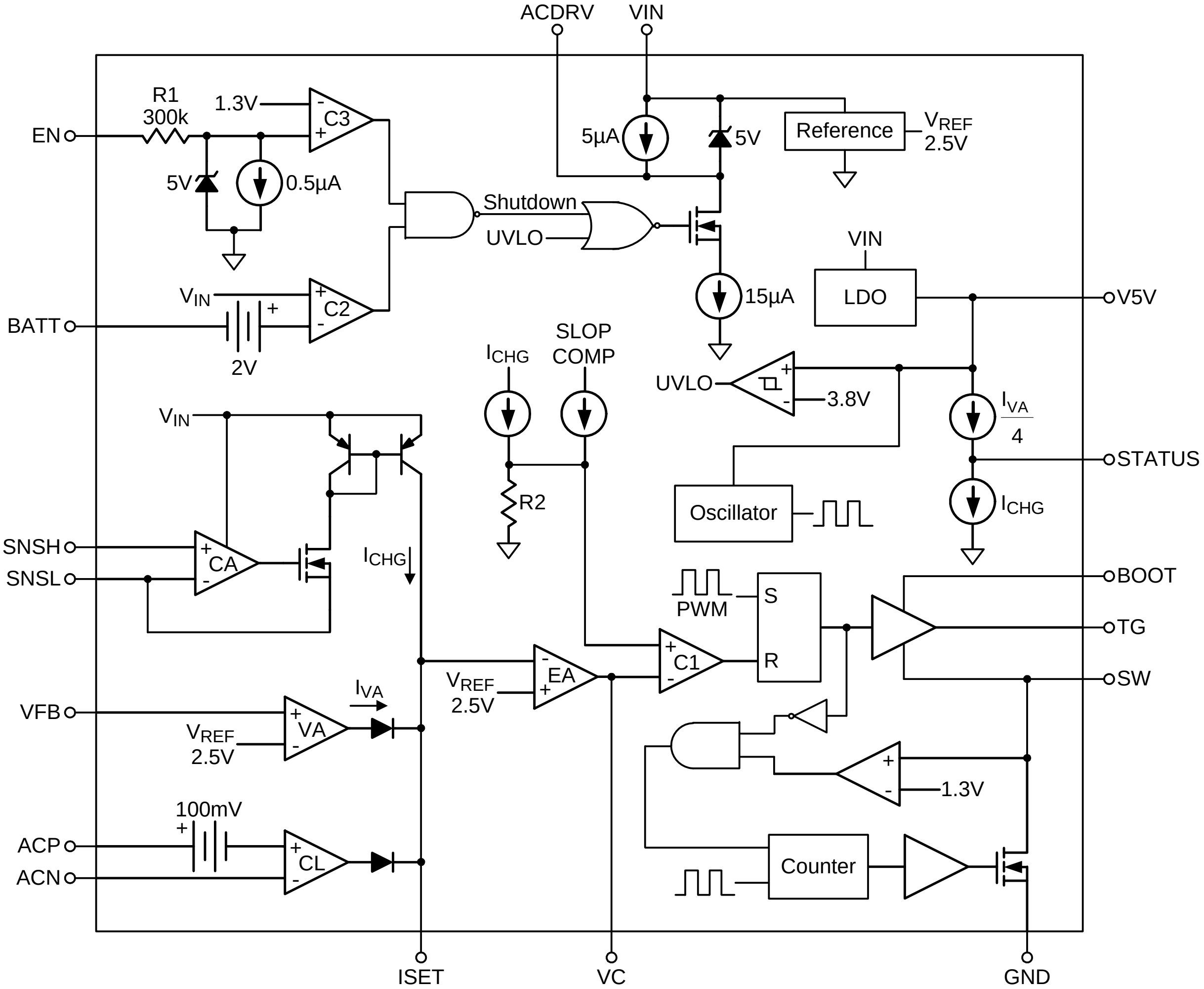
Pin No.	Pin Name	Pin Function
14	VIN	Input Power Supply. Connect a low ESR capacitor of 10μF or higher from this pin to ground for good bypass.
15	EN	Enable Control Input (Active High). It must be connected to a logic voltage or pulled up to VIN with a 100kΩ resistor.
16	ACDRV	Gate Driver Output for Input P-MOSFET.
17 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

Function Block Diagram



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Operation

The RT9538 is a current-mode PWM step-down switching charger controller. The battery DC charge current is adjusted by a resistor R4 at the ISET pin and the ratio of sense resistor RS2 over RS1 in the typical application circuit. Amplifier CA converts the charge current through RS1 to a much lower sampled current I_{CHG} ($I_{CHG} = I_{BATT}$ x RS1 / RS2) fed into the ISET pin. Amplifier EA compares the output of CA with 2.5V reference voltage and drives the PWM loop to force them to be equal. Note that I_{CHG} has both AC and DC components. High DC accuracy is achieved with averaging filter R3 and C3 at the ISET pin. I_{CHG} is mirrored to go through R4 and generates a ramp signal that is fed to the PWM control comparator, forming the current mode inner loop. An internal LDO generates a 5V to power high-side FET gate driver. For batteries like lithium that require both constant current and constant voltage charging, the 0.5% 2.5V reference and the voltage amplifier VA reduce the charge current when battery voltage reaches the normal charge voltage level. For NiMH and NiCd, VA can be used for over-voltage protection.

CL Amplifier

The amplifier CL monitors and limits the input current, normally from the AC adapter to a preset level (100mV/RS4). At input current limit, CL will supply the adjusted current at the ISET pin, thus reducing battery charging current.

Charge STATUS

When the charger is in voltage mode and the charge current level is reduced to 20%, the STATUS pin will turn to logic high. This charge completion signal can be used to start a timer for charge termination. A 0.1μF capacitor from STATUS to ground is needed to filter the sampled charging current ripple.

ACDRV Driver

The ACDRV pin drives an external P-MOSFET to avoid reverse current from battery to input supply. When input supply is removed, the RT9538 goes into a low current, 10μA maximum, sleep mode as VIN drops below the battery voltage.

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Absolute Maximum Ratings (Note 1)

- VIN, EN, ACN, BATT, SW to GND -- –0.3V to 36V
- ACDRV -- (ACN – 6V) to (ACN + 0.3V)
- ACP -- (ACN – 0.3V) to (ACN + 0.6V)
- ISET, VC, STATUS, VFB, V5V to GND -- –0.3V to 6V
- SNSL -- (BATT – 0.3V) to (BATT + 0.3V)
- SNSH -- (SNSL – 0.3V) to (SNSL + 0.3V)
- BOOT -- (SW – 0.3V) to (SW + 6V)
- TG -- (SW – 0.3V) to (BOOT + 0.3V)
- Power Dissipation, P_D @ T_A = 25°C
  WQFN-16L 4x4 -- 3.5W
- Package Thermal Resistance (Note 2)
  WQFN-16L 4x4, θ_{JA} -- 28.5°C/W
  WQFN-16L 4x4, θ_{JC} -- 7°C/W
- Junction Temperature -- 150°C
- Lead Temperature (Soldering, 10 sec.) -- 260°C
- Storage Temperature Range -- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) -- 2kV

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VIN -- 4.5V to 28V
- Junction Temperature Range -- –40°C to 125°C
- Ambient Temperature Range -- –40°C to 85°C

Electrical Characteristics

(V_{IN} = V_{BATT} + 3V, V_{BATT} is the full charge voltage, pull-up EN to VIN with 100kΩ resistor, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Overall						
Supply Quiescent Current	I_Q	No Charge Current	0.5	1.3	2	mA
Supply Shutdown Current	I_{SD}	V_{EN} = 0	--	--	12	μA
Reverse Current from Battery	I_{REV}	V_{IN} Floating, Sleep Mode	--	--	10	μA
VIN Under-Voltage Falling Threshold	V_{UVLO_L}	Check ACDRV	3.6	3.8	4.2	V
VIN Under-Voltage Hysteresis	V_{UVLO_HYS}		--	300	--	mV
Reference						
Reference Voltage	V_{FB}		2.488	2.5	2.512	V
FB Leakage Current	I_{FB}		--	--	0.1	μA

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Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Charge Current							
Full-Scale Charge Current Sense Voltage		V_{ICHG}	Measure the Voltage Drop Across RS1	95	100	105	mV
ISET Output Current		I_{ISET}		0.5	--	--	mA
Termination Current Set Factor		V_{ITM}	1/5-Scale Charge Current when STATUS from Low to High	15	20	25	%
SNSH Bias Current		I_{SNSH}		–36	–12	–6	μA
SNSL Bias Current		I_{SNSH}	No Charge Current	–36	–12	–6	μA
Battery Voltage							
VIN Minimum Voltage with Respect to BATT		ΔV_{IN}	(Note 5)	--	2	--	V
BATT Bias Current		I_{BATT}		–30	–15	–5	μA
VC Pin Current		I_{VC}	V_{VC} = 0V	–25	–15	–8	μA
Input Current Limit							
Input Current Limit Sense Voltage		V_{ILMT}	Measure the Voltage Drop Across RS4	90	100	110	mV
ACN Input Current		I_{ACN}	$V_{ACP} - V_{ACN}$ = 0.1V	8	16	34	μA
ACP Input Current		I_{ACP}	$V_{ACP} - V_{ACN}$ = 0.1V	25	50	100	μA
ACDRV ON Voltage		V_{ACON}	Measure the Voltage ($V_{ACN} - V_{ACDRV}$)	4	5.4	6	V
ACDRV OFF Voltage		V_{ACOFF}	Measure the Voltage ($V_{ACN} - V_{ACDRV}$), V_{EN} = 0V	0	--	0.1	V
ACDRV Pull-Down Current		I_{ACPD}	$V_{ACN} - V_{ACDRV}$ = 3.8V	5	10	30	μA
ACDRV Pull-Up Current		I_{ACPU}	$V_{ACN} - V_{ACDRV}$ = 0.5V, V_{EN} = 0V	–10	–5	–2	μA
Switch Characteristics							
Switching Frequency		f_{OSC}		425	475	525	kHz
TG Rising Time		T_R	$V_{BOOT} - V_{SW}$ = 5V, 1nF Load at TG Pin	--	25	75	ns
TG Falling Time		T_F	$V_{BOOT} - V_{SW}$ = 5V, 1nF Load at TG Pin	--	25	75	ns
Maximum Duty			(Note 5)	95	--	--	%
TG ON Voltage		V_{TG}	$V_{TG} - V_{SW}$ (Note 5)	--	5	--	V
Regulator and Logic Characteristics							
LDO Output Voltage		V_{LDO}	40mA Load at V5V, V_{VC} = 0V	4	5.2	6	V
STATUS High Voltage			STATUS Cap = 0.1μF	--	5	--	V
EN Input Voltage	Logic-High	V_{ENH}		2.5	--	--	V
	Logic-Low	V_{ENL}		--	--	0.6	
EN Input Current		I_{EN}	0V ≤ V_{EN} ≤ 5V	--	--	10	μA

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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. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

Note 5. Design guarantee.

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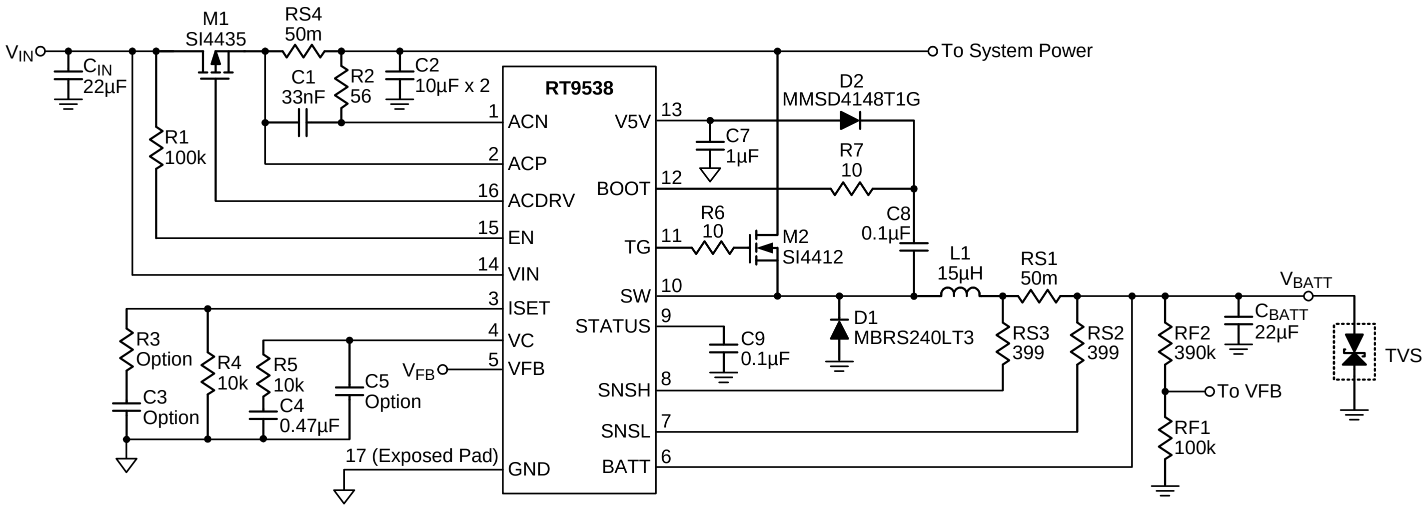
Typical Application Circuit



Note :

(1). For application with removable battery, a TVS with appropriate rating is required as shown above.

(2). V_{IN} = 15V to 30V, 3-cell , $I_{adapter\_limit}$ = 2.5A, I_{charge} = 2A

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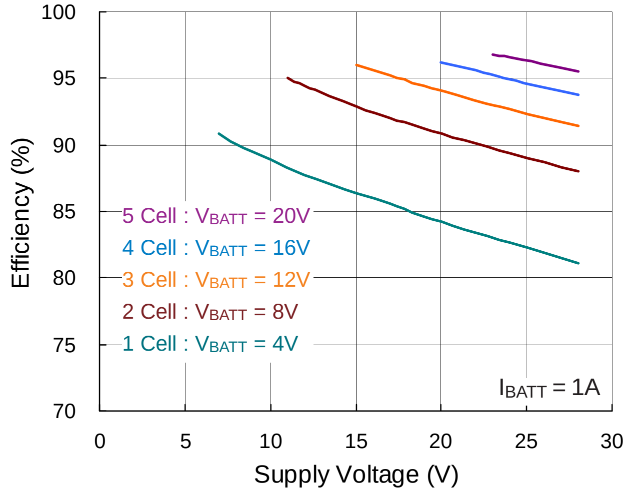
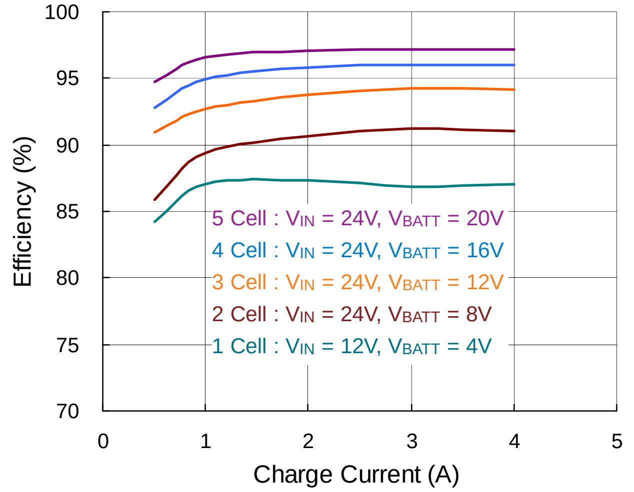
Typical Operating Characteristics

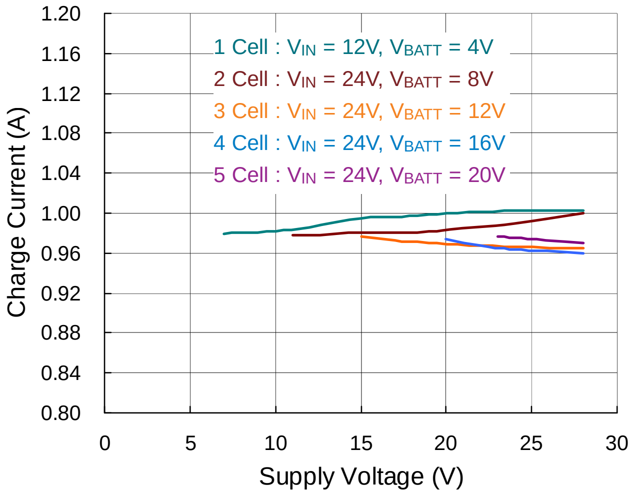
Efficiency vs. Supply Voltage



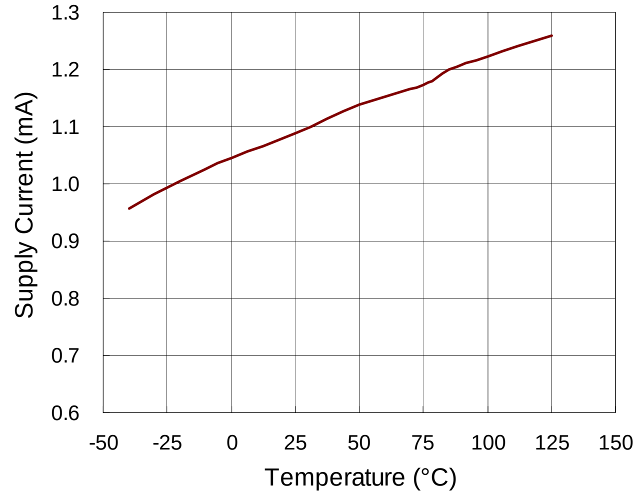
Efficiency vs. Charge Current



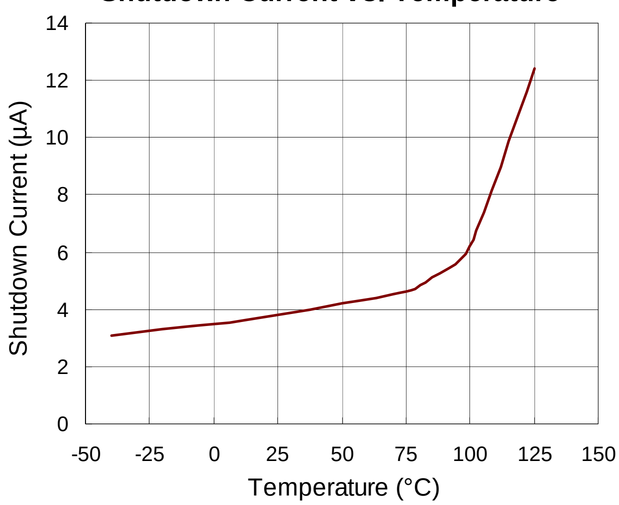
Charge Current vs. Supply Voltage



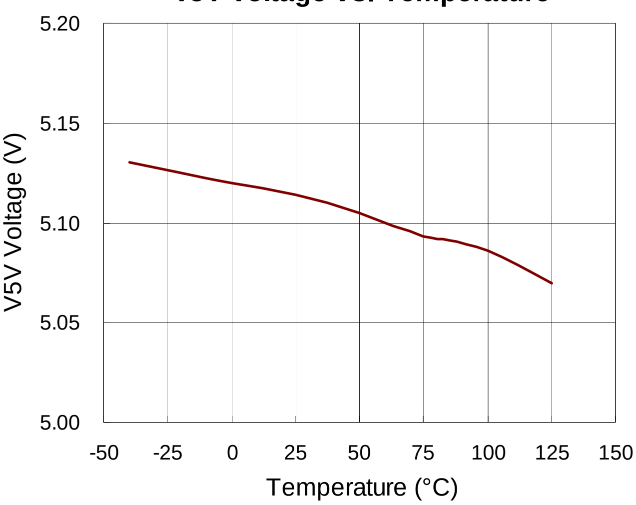
Supply Current vs. Temperature



Shutdown Current vs. Temperature



V5V Voltage vs. Temperature



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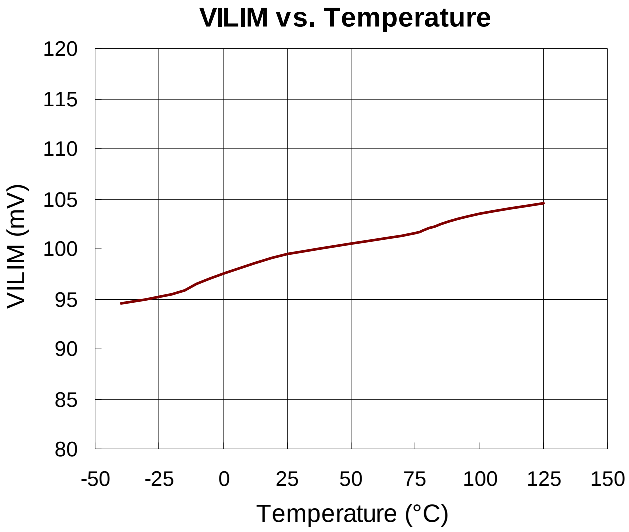

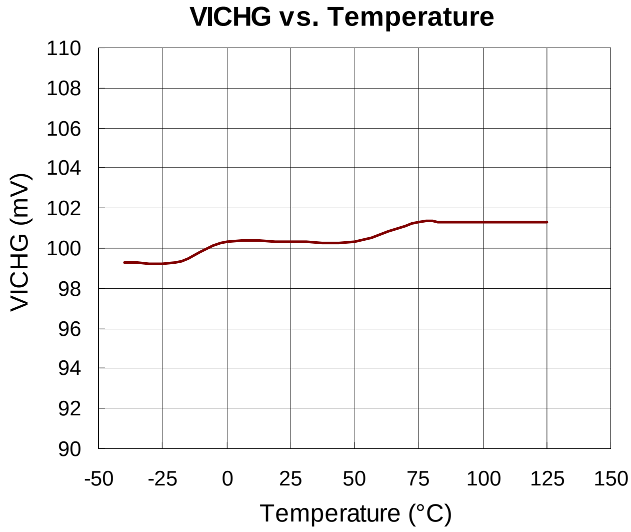

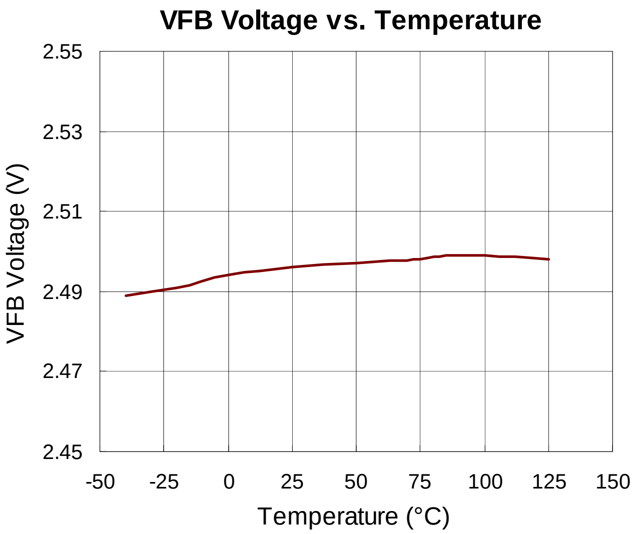

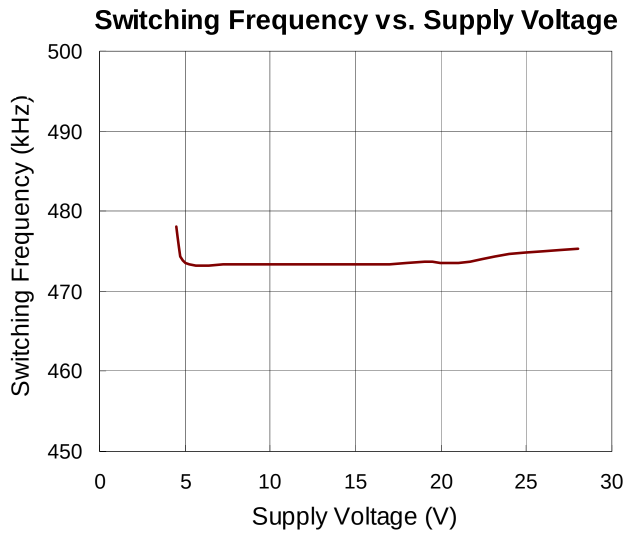

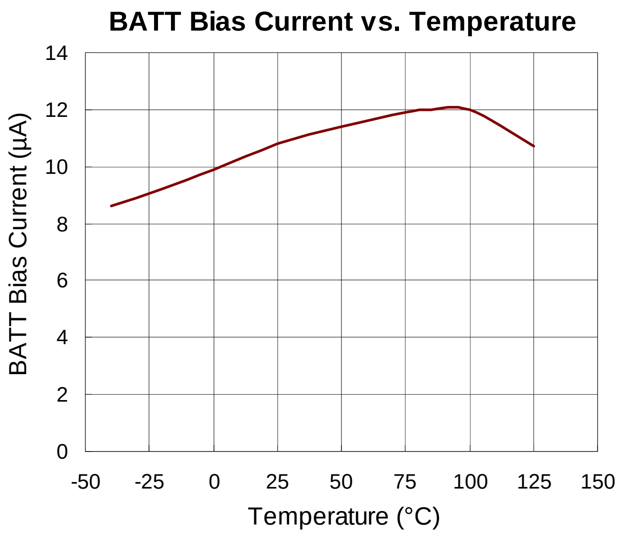

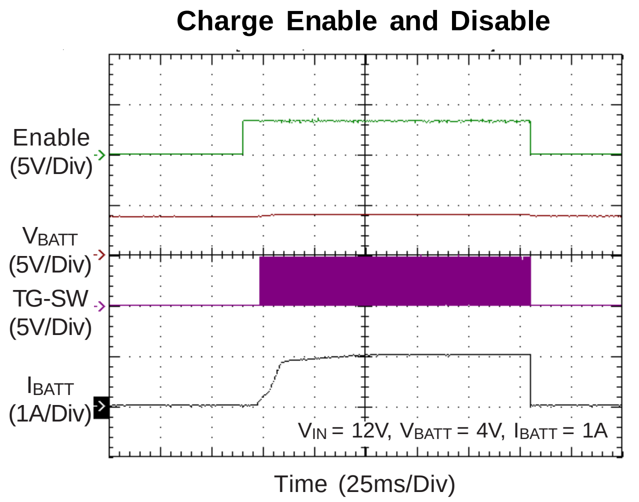

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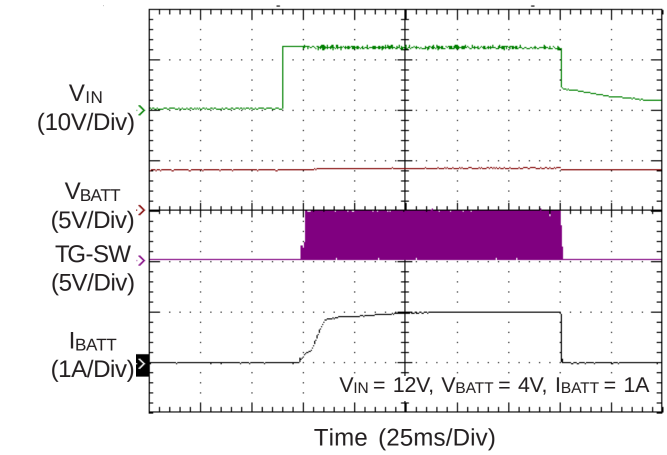
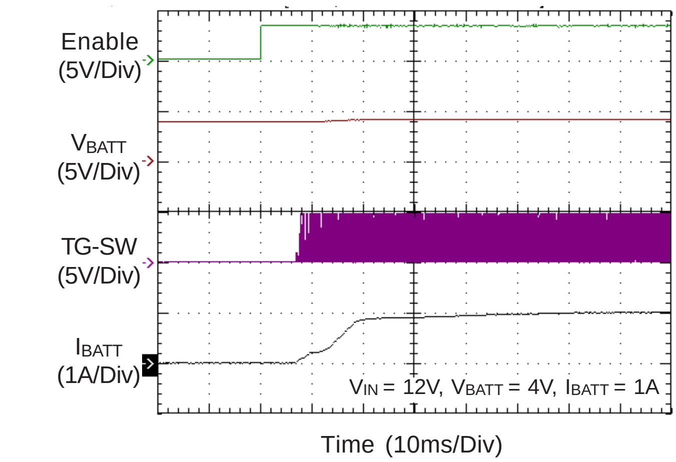
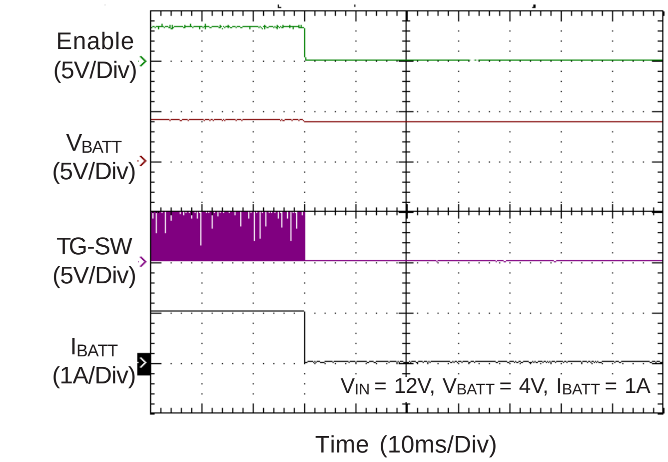
Adapter Insert and Remove



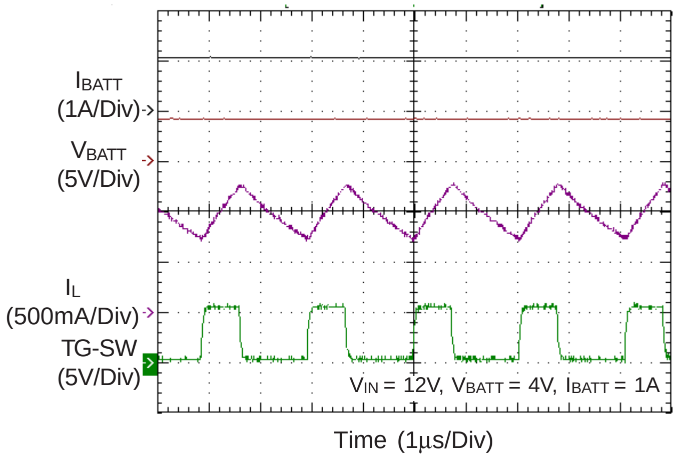
Charge Enable



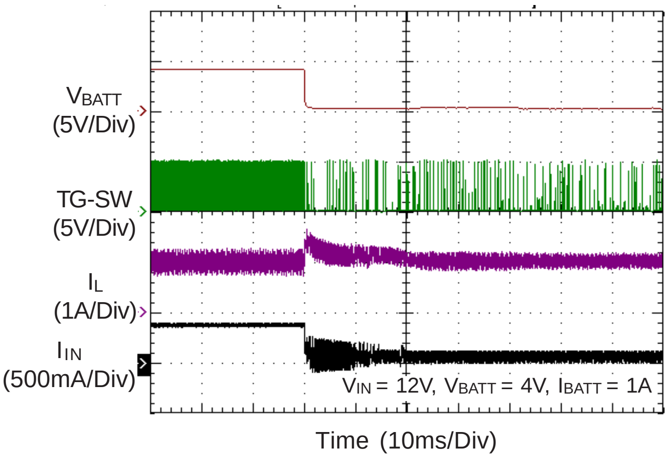
Charge Disable



Switching



Battery to GND Short Response



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Applications Information

Input and Output Capacitors

In the typical application circuit, the input capacitor (C2) is assumed to absorb all input switching ripple current in the converter, so it must have adequate ripple current rating. Typically, at high charging currents, the converter will operate in continuous conduction mode. In this case, the RMS current I_{RMSIN} of the input capacitor C2 can be estimated by the equation :

$$I_{RMSIN} = I_{BATT} \times \sqrt{D - D^2}$$

Where I_{BATT} is the battery charge current and D is the duty cycle. In worst case, the I_{RMSIN} ripple current will be equal to one half of output charging current at 50% duty cycle. For example, I_{BATT} = 2A, the maximum I_{RMSIN} current will be 1A. A low-ESR ceramic capacitor such as X7R or X5R is preferred for the input-decoupling capacitor and should be placed to the Drain of the high-side MOSFET and Source of the low-side MOSFET as close as possible. The voltage rating of the capacitor must be higher than the normal input voltage level. 22μF capacitance is suggested for typical of 2A charging current.

The output capacitor (C_{BATT}) is also assumed to absorb output switching current ripple. The general formula for capacitor current I_{RMSCB} is :

$$I_{RMSCB} = \frac{V_{BATT} \times \left(1 - \frac{V_{BATT}}{V_{VIN}}\right)}{2 \times \sqrt{3} \times L1 \times f_{OSC}}$$

For example, V_{VIN} = 19V, V_{BATT} = 8.4V, L1= 10μH, and f_{OSC} = 475kHz, I_{RMSCB} = 0.15A.

EMI considerations usually make it desirable to minimize ripple current in the battery leads. Beads or inductors may be added to increase battery impedance at the 475kHz switching frequency. Switching ripple current splits between the battery and the output capacitor depending on the ESR of the output capacitor and the battery impedance. If the ESR of C_{OUT} is 0.2Ω and the battery impedance is raised to 4Ω with a bead or inductor, only 5% of the ripple current will flow in the battery.

Inductor

The inductor value will be changed for more or less current ripple. The higher the inductance, the lower the current ripple will be. As the physical size is kept the same, typically, higher inductance will result in higher series resistance and lower saturation current. A good tradeoff is to choose the inductor so that the current ripple is approximately 30% to 50% of the full-scale charge current. The inductor value is calculated as :

$$L1 = \frac{V_{BATT} \times (V_{VIN} - V_{BATT})}{V_{VIN} \times f_{OSC} \times \Delta I_L}$$

Where ΔI_L is the inductor current ripple. For example, V_{VIN} = 19V, choose the inductor current ripple to be 40% of the full-scale charge current in the typical application circuit for 2A, 2-cell battery charger, ΔI_L = 0.8A, V_{BATT} = 8.4V, calculate L1 to be 12.3μH. So choose L1 to be 15μH which is close to 12.3μH.

Soft-Start and Under-Voltage Lockout

The soft-start is controlled by the voltage rising time at VC pin. There is external soft-start in the RT9538. With a 0.47μF capacitor, time to reach full charge current is about 25ms and it is assumed that input voltage to the charger will reach full value in less than 25ms. The capacitor can be increased if longer input start-up time is needed.

For the RT9538, it provides Under-Voltage Lockout (UVLO) protection. If LDO output voltage is lower than 3.8V, high-side power FET M2 and input power FET M1 will be cut off. This will protect the adapter from entering a quasi "latch" state where the adapter output stays in a current limited state at reduced output voltage.

Adapter Current Limiting

An important feature of RT9538 is the ability to automatically adjust charge current to a level which avoids overloading the wall adapter. This allows the product to operate, and at the same time batteries are being charged without complex load management algorithms. Additionally, batteries will automatically be charged at the maximum possible rate of which the adapter is capable.

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This is accomplished by sensing total adapter output current and adjusting charge current downward if a preset adapter current limit is exceeded. Amplifier CL in typical application circuit senses the voltage across RS4, connected between the ACP and ACN pins. When this voltage exceeds 100mV, the amplifier will override adjusted charge current to limit adapter current to 100mV/RS4. A low pass filter formed by 56Ω and 33nF is required to eliminate switching noise.

Full-Scale Charge Current Programming

The basic formula for full-scale charge current is (see Block Diagram) :

$$I_{BATT} = \left(\frac{V_{REF}}{R4}\right) \times \left(\frac{RS2}{RS1}\right);\ V_{REF} = V_{FB} = 2.5V\ (typ.)$$

where R4 is the total resistance from ISET pin to ground. For the sense amplifier CA biasing purpose, RS3 should have the same value as RS2 with 1% accuracy. For example, 2A full-scale charging current is needed. For low power dissipation on RS1 and enough signal to drive the amplifier CA, let RS1 = 100mV / 2A = 50mΩ. This limits RS1 power to 0.2W. Let R4 = 10kΩ, then :

$$RS2 = RS3 = \frac{I_{BATT} \times R4 \times RS1}{V_{REF}} = \frac{2A \times 10k \times 0.05}{2.5V} = 400\Omega$$

Note that for charge current accuracy and noise immunity, 100mV full scale level across the sense resistor RS1 is required. Consequently, both RS2 and RS3 should be 400Ω. Select 399Ω for real application.

It is critical to have a good Kelvin connection on the current sense resistor RS1 to minimize stray resistive and inductive pickup. RS1 should have low parasitic inductance (typical 3nH or less). The layout path from RS2 and RS3 to RS1 should be kept away from the fast switching SW node. A 10pF ceramic capacitor can be used across SNSH and SNSL should be kept away from the fast switching SW node.

Battery Voltage Regulation

The RT9538 uses a high-accuracy voltage bandgap and regulator for the high charging-voltage accuracy. The charge voltage is programmed via a resistor divider from the battery to ground, with the midpoint tied to the VFB pin. The voltage at the VFB pin is regulated to 2.5V, giving the following equation for the regulation voltage :

$$V_{BATT} = 2.5 \times \left(1 + \frac{RF2}{RF1}\right)$$

where RF2 is connected from VFB pin to the battery and RF1 is connected from VFB pin to GND.

Charging

The 2A Battery Charger (typical application circuit) charges lithium-ion batteries at a constant 2A until battery voltage reaches the setting value. The charger will then automatically go into a constant voltage mode with current decreasing to near zero over time as the battery reaches full charge.

Charging Completion

Some battery manufacturers recommend termination of constant voltage float mode after charge current has dropped below a specified level (typically around 20% of the full-scale charge current) and a further time-out period of 30 minutes to 90 minutes has elapsed. Check with manufacturers for details. The RT9538 provides a signal at the STATUS pin when charging is in voltage mode and charge current is reduced to 20% of full-scale charge current, assuming full-scale charge current is programmed to have 100mV across the current sense resistor (V_{RS1}).

The charge current sample I_{CHG} is compared with the output current I_{VA} of voltage amplifier VA. When the charge current drops to 20% of full-scale charge current, ICHG will be equal to 20% of I_{VA} and the STATUS pin voltage will go logic high and can be used to start an external timer. When this feature is used, a capacitor of at least 0.1μF is required at the STATUS pin to filter out the switching noise. If this feature is not used, the capacitor is not needed.

Dropout Operation

The RT9538 can charge the battery even when VIN goes as low as 2V above the combined voltages of the battery and the drops on the sense resistor as well as parasitic wiring. This low VIN sometimes forces 100% duty cycle and TG stays on for many switching cycles. While TG stays on, the voltage V_{BOOT} across the capacitor C8 drops down slowly because the current sink at BOOT pin. C8 needs to be recharged before V_{BOOT} drops too low to keep the high-side switch on.

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A unique design allows the RT9538 to operate under these conditions. If the SW pin voltage keeps larger than 1.3V for 32 oscillation periods, high-side power FET will be turned off and an internal FET will be turned on to pull the SW pin down. This function refreshes VBOOT voltage to a higher value.

It is important to use 0.1μF to hold V_{BOOT} up for a sufficient amount of time. The P-MOSFET M1 is optional and can be replaced with a diode if VIN is at least 2.5V higher than V_{BATT}. The gate control pin ACDRV turns on M1 when V5V gets up above the under-voltage lockout level and is clamped internally to 5V below V_{ACN}. In sleep mode when VIN is removed, ACDRV will clamp M1 V_{SG} to less than 0.1V.

Shutdown

When adapter power is removed, VIN will drift down. As soon as VIN goes down to 0.1V above V_{BATT}, the RT9538 will go into sleep mode drawing only ~10μA from the battery. There are two ways to stop switching : pulling the EN pin low or pulling the VC pin low. Pulling the EN pin low will shut down the whole chip. Pulling the VC pin low will only stop switching and LDO stays work. Make sure there is a pull-up resistor on the EN pin even if the EN pin is not used; otherwise, internal pull-down current will keep the EN pin low to shut down mode when power turns on.

Charger Protection

If the VIN connector of typical application circuit can be instantaneously shorted to ground, the P-MOSFET M1 must be quickly turned off; otherwise, high reverse surge current might damage M1. An internal transient enhancement circuit is designed to quickly charge the ACDRV pin voltage to the ACN pin voltage.

Note that the RT9538 will operate even when V_{BATT} is grounded. If V_{BATT} of typical application circuit charger gets shorted to ground very quickly from a high battery voltage, slow loop response may allow charge current to build up and damage the high-side N-MOSFET M2. A small diode from the EN pin to V_{BATT} will shut down switching and protect the charger.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For WQFN-16L 4x4 package, the thermal resistance, θ_{JA}, is 28.5°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 :

$P_{D(MAX)}$ = (125°C − 25°C) / (28.5°C/W) = 3.5W for WQFN-16L 4x4 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 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

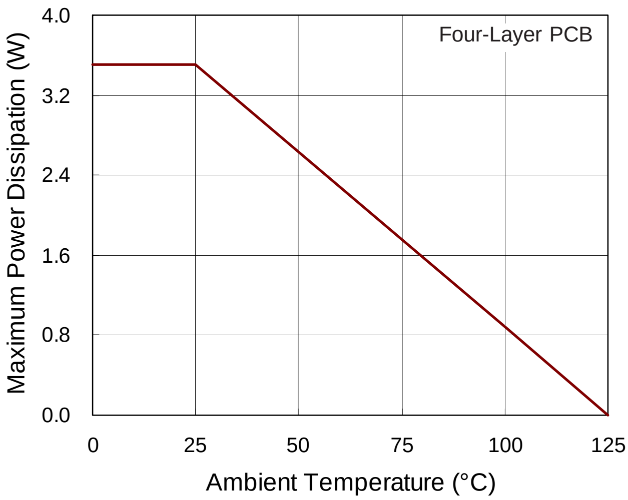

Figure 1. Derating Curve of Maximum Power Dissipation

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Layout Considerations

Switch rise and fall times are under 20ns for maximum efficiency. To prevent radiation, the power MOSFETs, the SW pin, the rectifier Schottky diode D1 and input bypass capacitor leads should be kept as short as possible. A ground plane should be used under the switching circuitry to prevent inter-plane coupling and to act as a thermal spreading path. Note that the rectifier Schottky diode D1 is probably the most heat dissipating device in the charging system.

The voltage drop on a 2A Schottky diode can be 0.5V. With 50% duty cycle, the power dissipation can go as high as 0.5W. Expanded traces should be used for the diode leads for low thermal resistance. Another large heat dissipating device is probably the inductor. The fast switching high current ground path including the MOSFETs, D1 and input bypass capacitor C2 should be kept very short. Another smaller input bypass (1μF ceramic or larger paralleled with C_{IN}) should be placed to VIN pin and GND pin as close as possible.

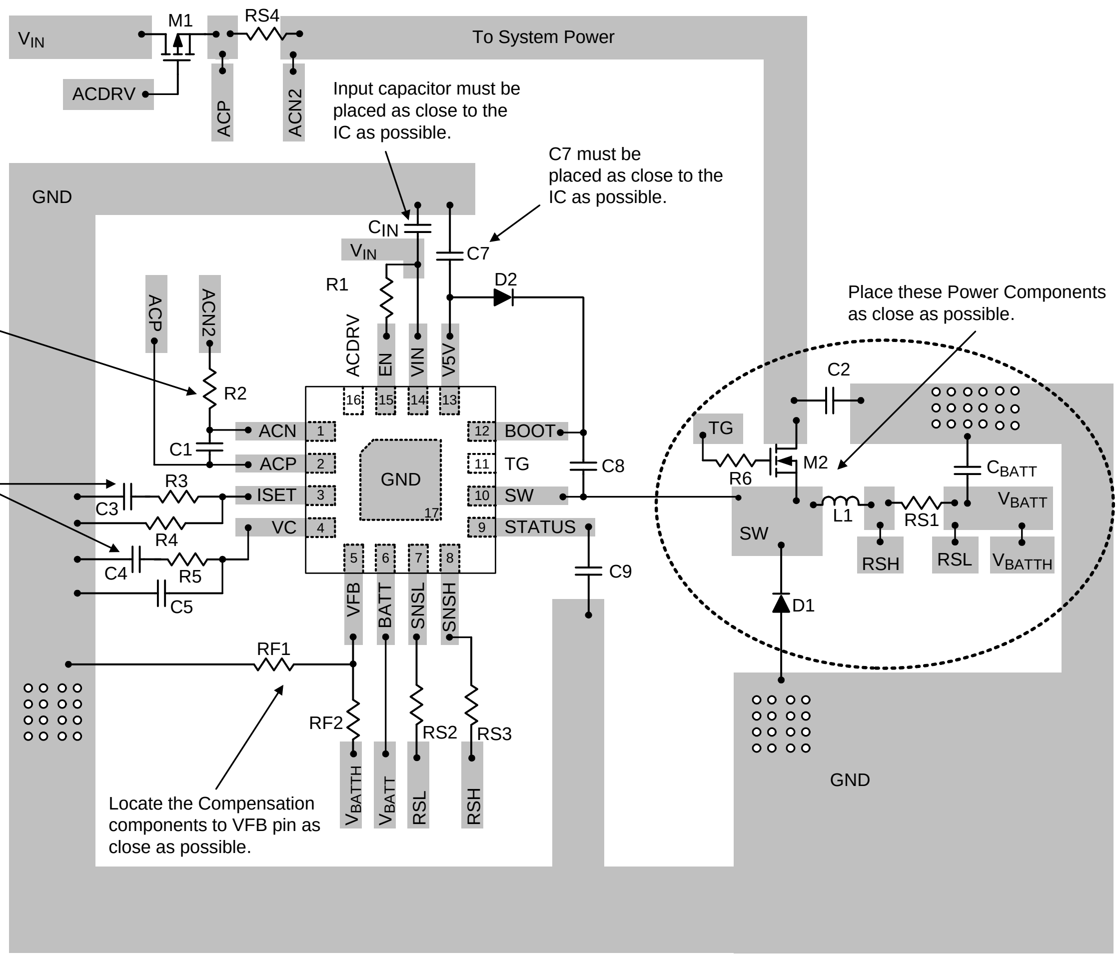
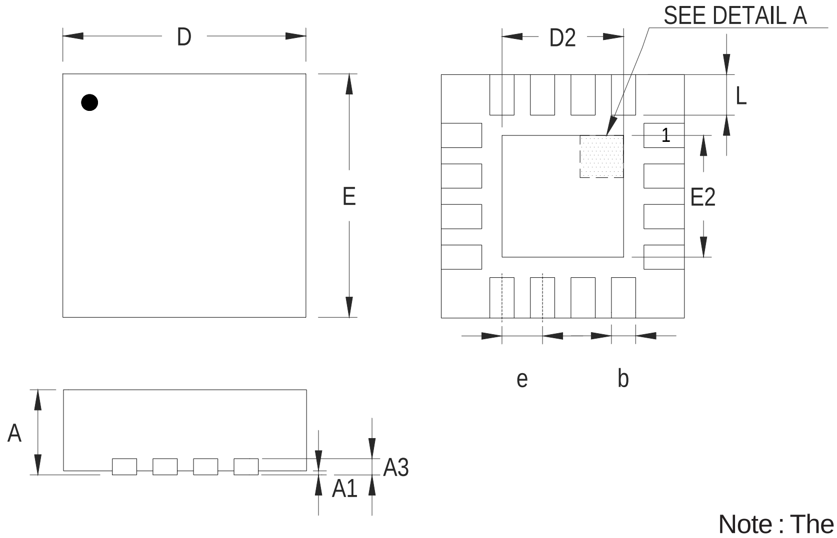
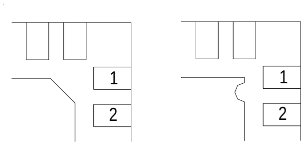


Figure 2. PCB Layout Guide

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	0.250	0.380	0.010	0.015
D	3.950	4.050	0.156	0.159
D2	2.000	2.450	0.079	0.096
E	3.950	4.050	0.156	0.159
E2	2.000	2.450	0.079	0.096
e	0.650		0.026	
L	0.500	0.600	0.020	0.024

W-Type 16L QFN 4x4 Package

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