

## 3A Single Cell Li-on Battery Slave Switching Charger

### General Description

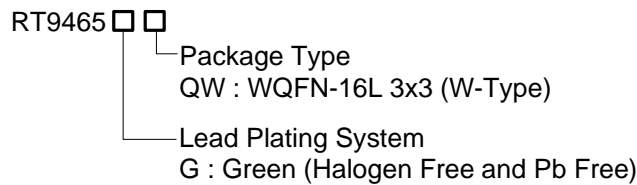
The RT9465 is a switch-mode single cell li-Ion/Li-Polymer battery charger for portable applications. It integrates a synchronous PWM controller and high accuracy voltage regulation. Besides, the charging current is regulated through the integrated sensing MOSFET.

The RT9465 optimizes the charging task by using a control algorithm to vary the charge rate via different modes, including fast charge mode and constant voltage mode. The key charge parameters are programmable via the I<sup>2</sup>C interface. The junction temperature is monitored by ADC.

Other features include under-voltage protection, over-voltage protection (including V<sub>BAT</sub> and V<sub>IN</sub> side), thermal regulation and MIVR.

The RT9465 is available in a WQFN-16L 3x3 package.

### Ordering Information

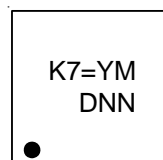


Note :

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.

### Marking Information



K7= : Product Code  
YMDNN : Date Code

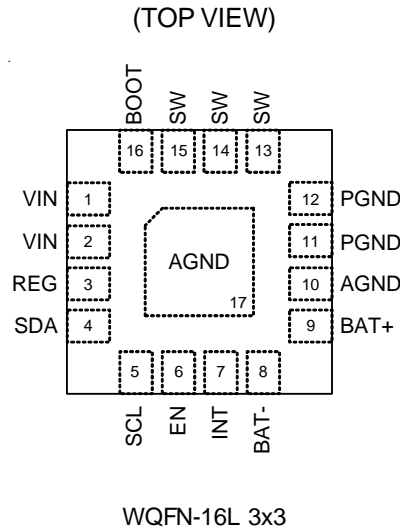
### Features

- Input Voltage Range : 3.9V to 14V
- Synchronous 1.5MHz/0.75MHz Switching Frequency 95% Max. Duty
- Up to 92%/94% Peak Efficiency at V<sub>IN</sub> = 9V/5V
- V<sub>IN</sub> Over-Voltage Protection : 14.5V
- V<sub>IN</sub> Under-Voltage Protection : 3.8V
- V<sub>IN</sub> Under-Voltage-Lock-Out : 3.3V
- Fault Detection (V<sub>IN</sub> and V<sub>BAT</sub> Monitoring)
- Programmable Minimum Input Voltage Range : 3.9V to 13.4V (0.1V/Step)
- Programmable Battery Voltage Regulation Range : 3.8V to 5.06V (0.02V/Step)
- Programmable End of Charge Range : 0.6A to 1.6A (0.1A/Step)
- Programmable Average Output Current Regulation Range : 0.6A to 3A (0.1A/Step)
- Junction Temperature Monitor : 60°C to 116°C (4°C/Step)
- V<sub>IN</sub> Minimum Input Voltage Regulation (MIVR) : ±3%
- Battery CV (Constant Voltage) Regulation : ±1%
- Output CC (Constant Current) Regulation, Output Current < 1A : ±100mA (V<sub>IN</sub> = 9V/12V)
- Output CC (Constant Current) Regulation, Output Current > 1A : ±10% (V<sub>IN</sub> = 9V/12V)
- Junction Temperature Monitor Accuracy : ±3°C
- Thermal Shutdown : 160°C

### Applications

- Cellular Telephones
- Personal Information Appliances
- Tablet PC, Power Bank
- Portable Instruments

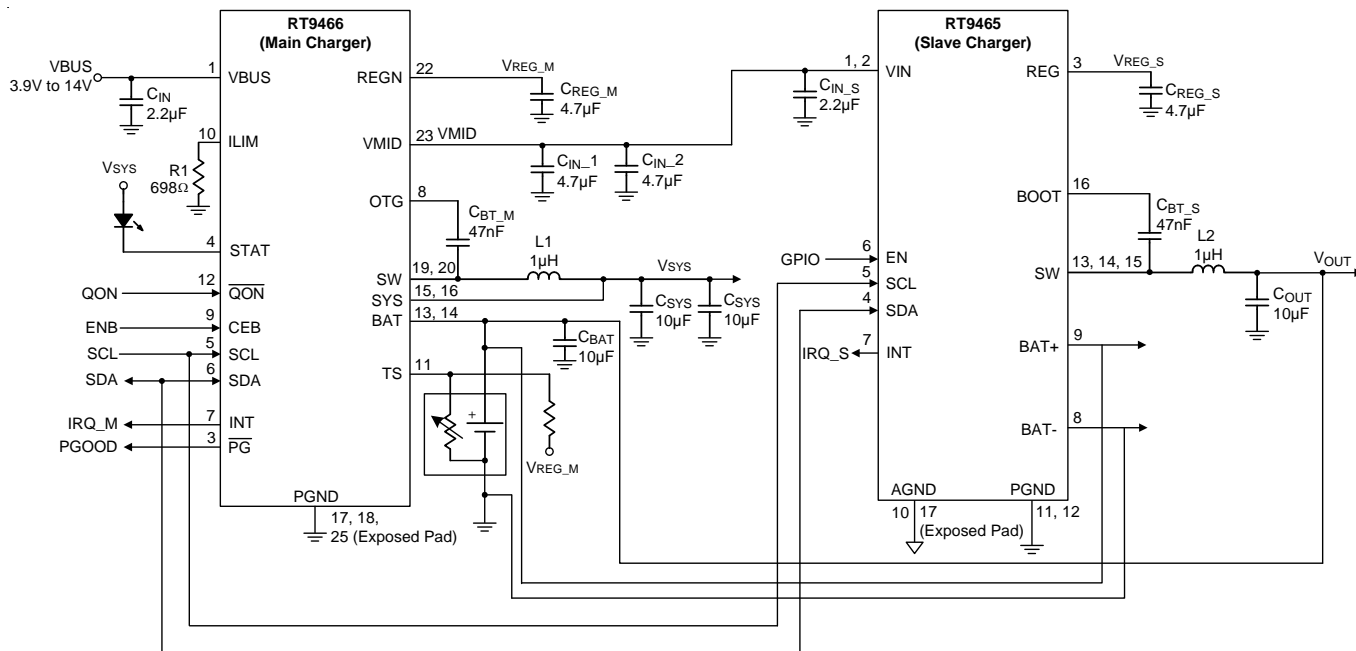
Pin Configuration



Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 2	VIN	Power input. Bypass VIN to GND with a 2.2μF/25V ceramic capacitor.
3	REG	PWM low-side driver and bootstrap power supply. Bypass REGN to GND with a 4.7μF/6.3V ceramic capacitor.
4	SDA	I <sup>2</sup> C interface serial clock input. Open-drain. An external pull-up resistor 10kΩ is required.
5	SCL	I <sup>2</sup> C interface serial data input/output. Open-drain. An external pull-up resistor 10kΩ is required.
6	EN	Device enable control pin. Pull low to disable device.
7	INT	Open-drain. Interrupt signal to Host.
8	BAT-	Negative battery voltage sense.
9	BAT+	Positive battery voltage sense.
10, 17 (Exposed Pad)	AGND	Analog ground. The exposed pad must be soldered to a large PCB and connected to AGND for maximum thermal dissipation.
11, 12	PGND	Power ground.
13, 14, 15	SW	Switch node. Connect to an external inductor.
16	BOOT	Bootstrap supply for high-side MOSFET. Connect 47nF/16V ceramic capacitor across BOOT and SW.

Typical Application Circuit



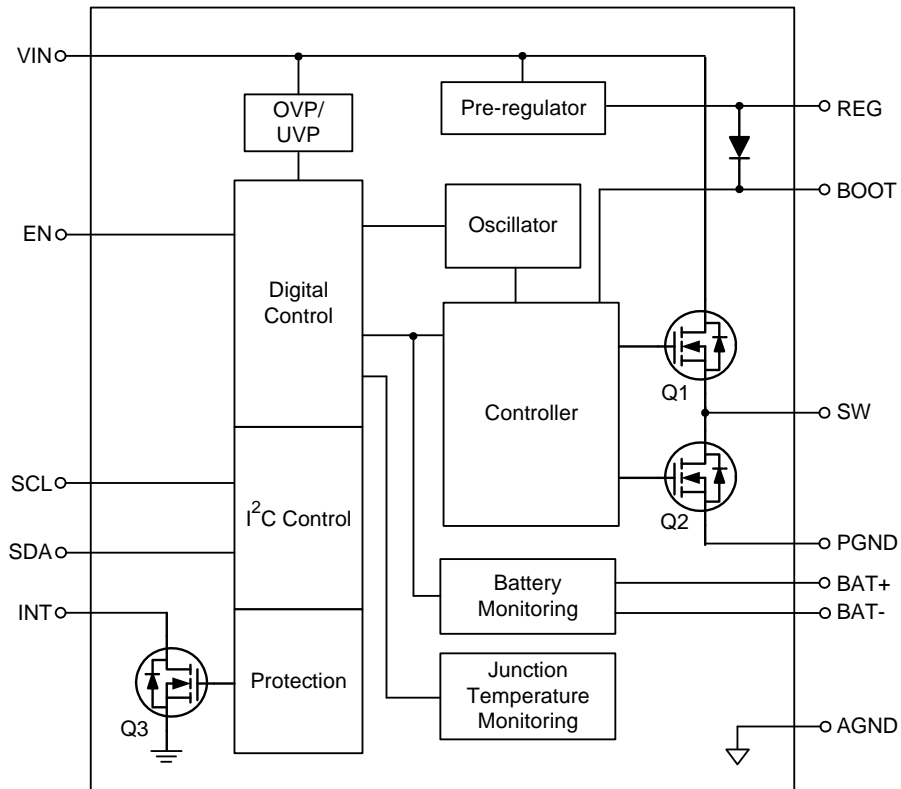
Note : The total  $C_{IN}$  of slave charger between PMID pin of main charger is  $10\mu F$  at least.

Table 1. Component List of Evaluation Board

Reference	Qty	Part Number	Description	Package	Manufacturer
$C_{IN\_S}$	1	GRM155R61E225KE11	2.2 $\mu F$ /25V/X5R	0402	muRata
$C_{REG\_S}$	1	GRM155R60J475ME47	4.7 $\mu F$ /6.3V/X5R	0402	muRata
$C_{BT\_S}$	1	GRM033R61C473KE84	47nF/16V/X5R	0201	muRata
$C_{OUT}$	1	GRM188R61A106KE69	10 $\mu F$ /10V/X5R	0603	muRata
L2	1	DFE252012F-1R0M	1 $\mu H$	2.5x2.0x1.2	muRata
U1	1	RT9465GQW	Chip	WQFN-16L 3x3	RICHTEK

Note 1. The total  $C_{IN}$  of slave charger between PMID pin of main charger is  $10\mu F$  at least.

## Functional Block Diagram



**Absolute Maximum Ratings** (Note 2)

- Supply Input Voltage, VIN ----- -0.3V to 22V
- BOOT ----- -0.3V to 22V
- SW ----- -0.3V to 20V
- REG, SCL, SDA, EN, INT, BAT+, BAT- ----- -0.3V to 6V
- Power Dissipation, PD @ TA = 25°C  
 WQFN-16L 3x3 ----- 3.33W
- Package Thermal Resistance (Note 3)  
 WQFN-16L 3x3, θJA ----- 30°C/W  
 WQFN-16L 3x3, θJC ----- 7.5°C/W
- Lead Temperature (Soldering, 10sec.) ----- 260°C
- Junction Temperature ----- 150°C
- Storage Temperature Range ----- -65°C to 150°C
- ESD Susceptibility (Note 4)  
 HBM (Human Body Model) ----- 2kV

**Recommended Operating Conditions** (Note 5)

- Supply Input Voltage, VIN ----- 3.9V to 14V
- Charge Current, IBAT ----- 0.6A to 3A
- Battery Voltage, VBAT ----- 3.8V to 5.06V
- Junction Temperature Range ----- -40°C to 125°C
- Ambient Temperature Range ----- -40°C to 85°C

**Electrical Characteristics**

(VIN = 5V, VBAT = 4.2V, L = 1μH, CIN\_S = 2.2μF, COUT = 10μF, TA = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>Quiescent Current</b>						
VIN Supply Current	I(VIN)_SW	PWM is switching, VIN = 5V, VBAT+ = 3.8V	--	8	--	mA
	I(VIN)_SW	PWM is switching, VIN = 9V, VBAT+ = 3.8V	--	28	--	
	I(VIN)_no_SW	PWM is non-switching, VIN = 5V, VBAT+ = 4.4V	--	--	2	
Leakage Current from Battery	IBAT_leak	Charger disable, VBAT = 3.8V	--	--	1	μA
<b>VIN/VBAT Power up</b>						
VIN Under-Voltage Protection	VUVP		3.67	3.8	3.93	V
VIN Under-Voltage Protection Hysteresis	VUVP_HYS		120	200	280	mV
<b>Input Power Regulation</b>						
Input Voltage Regulation Range	VMIVR	I <sup>2</sup> C programmable per 0.1V	3.9	--	13.4	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
V <sub>MIVR</sub> Accuracy	V <sub>MIVR_ACC</sub>	MIVR = 4.4V, 9V	-3	--	3	%
<b>Protection</b>						
<b>V<sub>IN</sub></b>						
IC Active Threshold Voltage	V <sub>UVLO</sub>	V <sub>IN</sub> rising	3.05	3.3	3.55	V
IC Active Hysteresis	V <sub>UVLO_HYS</sub>	V <sub>IN</sub> falling from UVLO	--	150	--	mV
V <sub>IN</sub> OVP Threshold Voltage	V <sub>INOVP</sub>	V <sub>IN</sub> rising	13.5	14.5	15.5	V
V <sub>IN</sub> OVP Hysteresis	V <sub>INOVP_HYS</sub>		--	350	--	mV
<b>V<sub>BAT</sub></b>						
Battery OVP	V <sub>BATOVP</sub>	(V <sub>BATOVP_Rising</sub> - V <sub>CV</sub> )/V <sub>CV</sub>	102	104	106	%
Battery UVP	V <sub>BATUVP</sub>	V <sub>BAT</sub> falling	2.3	2.4	2.5	V
<b>Thermal Protection</b>						
Over-Temperature Protection	OTP	Thermal shutdown	--	160	--	°C
OTP Hysteresis	OTP_HYS		--	10	--	°C
Thermal Regulation Threshold	TR	Charge current begins to reduce	--	120	--	°C
<b>Battery Charging Interval</b>						
<b>End of Charge</b>						
Battery Voltage Regulation	V <sub>OREG</sub>	I <sup>2</sup> C programmable per 20mV	3.8	--	5.06	V
Battery Voltage Accuracy	V <sub>OREG_ACC</sub>	Temperature = 0 to 85°C	-1	--	1	%
<b>Fast Charge</b>						
Charging Current	I <sub>CHG</sub>	I <sup>2</sup> C programmable per 0.1A	0.6	--	3	A
I <sub>CHG</sub> Accuracy	I <sub>CHG_ACC</sub>	V <sub>IN</sub> = 5V, charge current > 1A	-15	--	15	%
		V <sub>IN</sub> = 9V, 12V, charge current > 1A	-10	--	10	
		V <sub>IN</sub> = 5V, charge current < 1A	-150	--	150	mA
		V <sub>IN</sub> = 9V, 12V, charge current < 1A	-100	--	100	
End of Charging Current	I <sub>EOC</sub>	I <sup>2</sup> C programmable per 0.1A	0.6	--	1.6	A
I <sub>EOC</sub> Accuracy	I <sub>EOC_ACC</sub>	V <sub>IN</sub> = 5V, 9V, 12V, I <sub>EOC</sub> setting > 1A	-15	--	15	%
		V <sub>IN</sub> = 5V, 9V, 12V, I <sub>EOC</sub> setting < 1A	-150	--	150	mA
<b>Battery Charger</b>						
High-Side On-Resistance	R <sub>ON(Q1)</sub>	From V <sub>IN</sub> to SW	17	21.5	26	mΩ
Low-Side On-Resistance	R <sub>ON(Q2)</sub>	From SW to PGND	17	21.5	26	mΩ
Charging Efficiency		V <sub>IN</sub> = 9V, V <sub>BAT</sub> = 3.8V, and I <sub>CHG</sub> = 2.5A	--	89.5	--	%
Switching Frequency (1.5MHz)	f <sub>OSC1</sub>	I <sup>2</sup> C programmable 1.5 MHz	1.35	1.5	1.65	MHz
Switching Frequency (750kHz)	f <sub>OSC2</sub>	I <sup>2</sup> C programmable 0.75MHz	0.675	0.75	0.825	MHz

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Frequency Accuracy			10	--	10	%
Maximum Duty Cycle		At minimum voltage input	--	95	--	%
Minimum Duty Cycle			0	--	--	%
V <sub>REG</sub> Regulation	V <sub>REG</sub>	V <sub>IN</sub> = 5V	4.74	4.9	5.06	V
EN Pull Low	R <sub>EN</sub>		180	500	820	kΩ
<b>I<sup>2</sup>C Characteristics</b>						
Output Low Voltage	V <sub>OL</sub>	I <sub>DS</sub> = 10mA	--	--	0.4	V
SCL, SDA Input Logic High Threshold Voltage	V <sub>IH</sub>		1.3	--	--	V
SCL, SDA Input Logic Low Threshold Voltage	V <sub>IL</sub>		--	--	0.4	V
SCL Clock			--	--	400	kHz
Load Capacitance	C <sub>LOAD</sub>	V <sub>PULL_UP</sub> = 1.8V	--	--	1	pF
Junction Temperature Monitor Accuracy			-3	--	3	°C
<b>Control I/O Pin</b>						
EN Input Threshold Voltage	V <sub>IH</sub>	Logic high threshold	1.2	--	--	V
EN Input Threshold Voltage	V <sub>IL</sub>	Logic low threshold	--	--	0.4	V
Device Turn-On Delay Time After EN Pull-High			--	--	500	μS

**Note 2.** Stresses beyond those listed under “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.

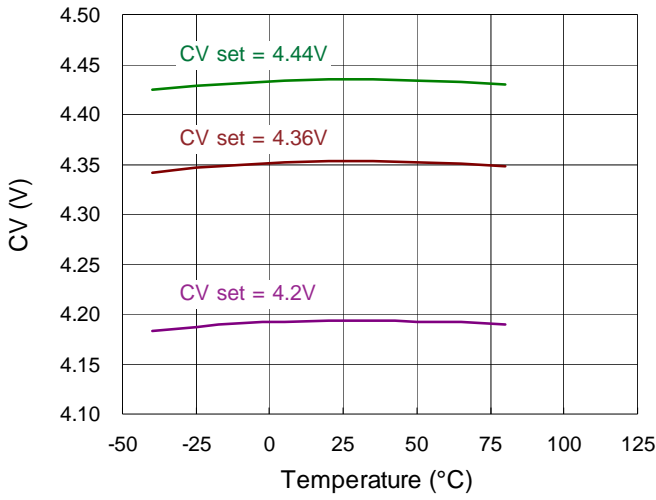
**Note 3.** θ<sub>JA</sub> is measured under natural convection (still air) at T<sub>A</sub> = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. θ<sub>JC</sub> is measured at the exposed pad of the package.

**Note 4.** Devices are ESD sensitive. Handling precaution is recommended.

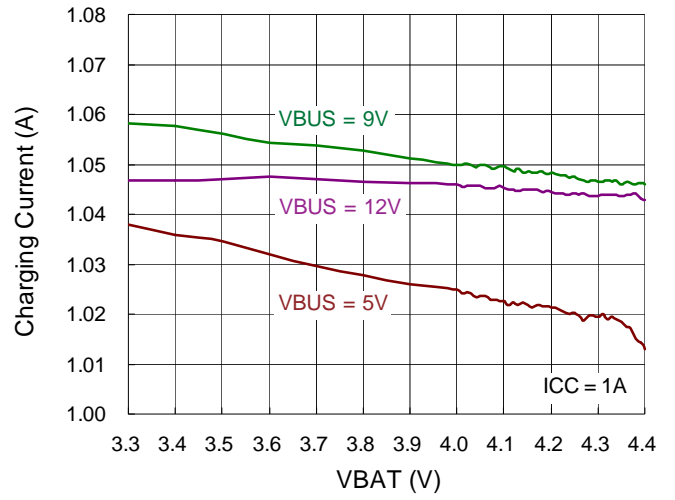
**Note 5.** The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics

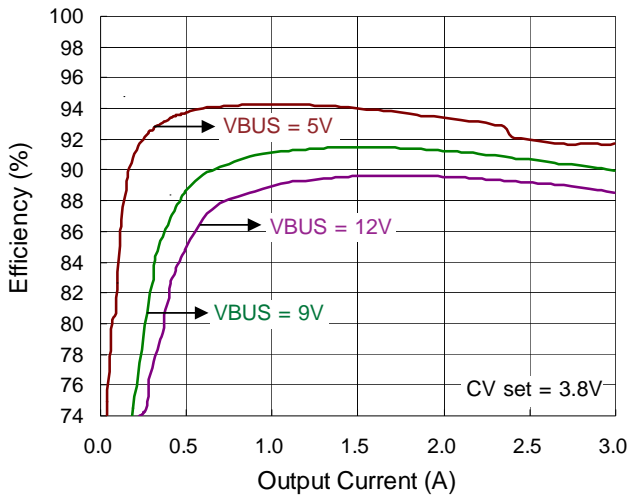
CV vs. Temperature



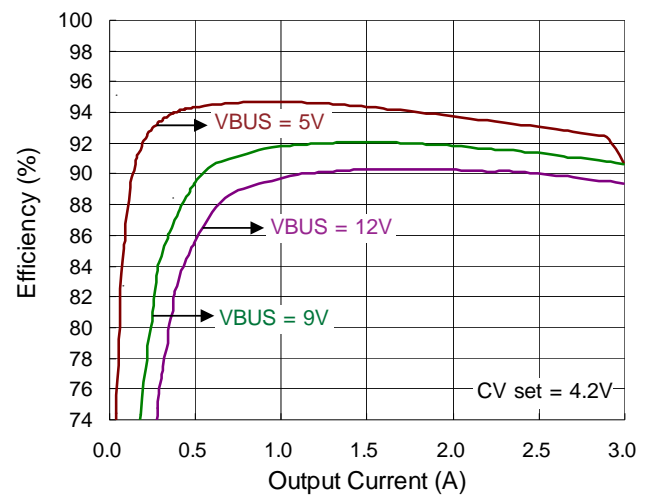
Charging Current vs. VBAT



Efficiency vs. Output Current



Efficiency vs. Output Current





## I<sup>2</sup>C Register Information

I<sup>2</sup>C Slave Address : 1001011 (4BH)

R : Read only

R/W : Read and write

R/C : Read automatically clear

Register Address : 0x00, Register Name : CHG\_CTRL0

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	RST_REG	0	Y	Y	R/W	All registers reset bit. 0 : No action. (default) 1 : Reset all registers. (Notice : This bit will be reset to "0" after reset procedure finish)
6:0	Reserved	0000000	Y	Y	R/W	Reserved

Register Address : 0x01, Register Name : CHG\_CTRL1

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	CHG_EN	0	Y	Y	R/W	Charging enable 0 : CHG is disabled (default) 1 : CHG is enabled
6:4	Reserved	100	Y	Y	R/W	Reserved
3	IRQ_pulse	0	Y	Y	R/W	IRQ remind function 0 : IRQ reminding is disabled (default) 1 : IRQ reminding is enabled. If IRQ is triggered and no check action, IRQ pin will be released with every 2s interval and be triggered again.
2:0	Reserved	000	Y	Y	R/W	Reserved

Register Address : 0x02, Register Name : CHG\_CTRL2

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	Sel_SWFreq	0	Y	Y	R/W	The switching frequency selection bit 0 : The switching frequency is 1.5MHz. (default) 1 : The switching frequency is 0.75MHz.
6	FixFreq	0	Y	Y	R/W	Charger switching frequency 0 : Charger switching frequency is varied (default) 1 : Charger switching frequency is fixed
5	OSCSS_EN	0	Y	Y	R/W	Charger spread spectrum enable 0 : Disabled (default) 1 : Enabled
4:0	Reserved	00000	Y	Y	R/W	Reserved

Register Address : 0x03, Register Name : CHG\_CTRL3

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:2	VOREG<5:0>	010100	Y	Y	R/W	Battery regulation voltage. The delta-V of the battery regulation voltage is 20mV. 000000 : 3.8V 000001 : 3.82V 000010 : 3.84V ... 010100 : 4.2V (default) 010101 : 4.22V ... 101001 : 4.62V 101010 : 4.64V 101011 : 4.66V ... 111111 : 5.06V
1:0	Reserved	00	Y	Y	R/W	Reserved

Register Address : 0x04, Register Name : CHG\_CTRL4

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:6	THREG <1:0>	11	Y	Y	R/W	Charger thermal regulation threshold 00 : 60°C 11 : 80°C 10 : 100°C 11 : 120°C (default)
5:0	Reserved	000000	Y	Y	R/W	Reserved

Register Address : 0x05, Register Name : CHG\_CTRL5

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:1	VMIVR[6:0]	0000101	Y	Y	R/W	Input MIVR threshold setting 0000000 : 3.9V 0000001 : 4V 0000010 : 4.1V 0000011 : 4.2V 0000100 : 4.3V 0000101 : 4.4V (default) 0000110 : 4.5V ... 0011110 : 6.9V 0011111 : 7V ... 0110010 : 8.9V 0110011 : 9V ... 1010000 : 11.9V 1010001 : 12V ... 1011111 : 13.4V 1100000 to 1111111 : 13.4V
0	MIVR_EN	1	Y	Y	R/W	MIVR loop enable 0 : MIVR loop disable 1 : MIVR loop enable (default)

Register Address : 0x06, Register Name : CHG\_CTRL6

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:3	ICHG[4:0]	10100	Y	Y	R/W	Charging regulation current 00000 to 00110 : 0.6A ... 01001 : 0.9A 01010 : 1A 01011 : 1.1A ... 10011 : 1.9A 10100 : 2A (default) ... 11001 : 2.5A 11010 : 2.6A ... 11101 : 2.9A 11110 to 11111 : 3A
2:0	Reserved	000	Y	Y	R/W	Reserved

Register Address : 0x07, Register Name : CHG\_CTRL7

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:4	IEOC[3:0]	0101	Y	Y	R/W	EOC current setting 0000 to 0100 : 600mA 0101 : 600mA (default) 0110 : 700mA 0111 : 800mA 1000 : 900mA 1001 : 1000mA 1010 : 1100mA 1011 : 1200mA 1100 : 1300mA 1101 : 1400mA 1110 : 1500mA 1111 : 1600mA
3	EOC_EN	1	Y	Y	R/W	IEOC enable/disable 0 : Disable 1 : Enable (default)
2:0	CHG_TDEG_ EOC[2:0]	100	Y	Y	R/W	EOC deglitch time 000 : 120µs 001 : 180µs 010 : 240µs 011 : 360µs 100 : 2ms (default) 101 : 4ms 110 : 8ms 111 : 16ms

Register Address : 0x08, Register Name : CHG\_CTRL8

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	TE	1	Y	Y	R/W	Termination enable 0 : Disable charge current termination 1 : Enable charge current termination (default)
6:5	EOC_TIMER[1 :0]	00	Y	Y	R/W	EOC back-charging time 00 : 0mins (default) 01 : 30mins 10 : 45mins 11 : 60mins
4:0	Reserved	00000	Y	Y	R/W	Reserved

Register Address : 0x09, Register Name : CHG\_CTRL9

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:5	WT_FC[2:0]	000	Y	Y	R/W	Fast charge timer 000 : 4hrs (default) 001 : 6hrs 010 : 8hrs 011 : 10hrs 100 : 12hrs 101 : 14hrs 110 : 16hrs 111 : 20hrs
4	TMR2X_EN	0	Y	Y	R/W	Double charger timer during MIVR, and thermal regulation 0 : Disable 2x extended charger timer (default) 1 : Enable 2x extended charger timer
3	TMR_EN	0	Y	Y	R/W	Charger timer enable/disable 0 : Disable (default) 1 : Enable
2	TMR_PAUSE	0	Y	Y	R/W	Timer control bit 0 : Timer is active (default) 1 : Timer is pause
1:0	Reserved	00	Y	Y	R/W	Reserved

Register Address : 0x0A, Register Name : CHG\_CTRL10

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	WDT_EN	0	Y	Y	R/W	Watchdog timer enable/disable 0 : Disable (default) 1 : Enable
6	WDT_TRST	1	Y	Y	R/W	Waiting timer to reset I <sup>2</sup> C setup after watchdog is asserted 0 : 200ms 1 : 500ms (default)
5:4	WDT[1:0]	01	Y	Y	R/W	Watchdog timer, from WDTEN is enabled to watchdog IRQ, clear timer by I <sup>2</sup> C access 00 : 8s 01 : 40s (default) 10 : 80s 11 : 160s
3:0	Reserved	0000	Y	Y	R/W	Reserved

Register Address : 0x0C, Register Name : CHG\_CTRL12

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:4	ADC_RPT[3:0]	0000	Y	Y	R	Report the TEMP_ADC result, sampling every 64T (22μs) and average times (352μs if TEMP_AVG = 0) 0000 : <60 degree (default) 0001 : >60 degree 0010 : >64 degree 0011 : >68 degree 0100 : >72 degree 0101 : >76 degree 0110 : >80 degree 0111 : >84 degree 1000 : >88 degree 1001 : >92 degree 1010 : >96 degree 1011 : >100 degree 1100 : >104 degree 1101 : >108 degree 1110 : >112 degree 1111 : >116 degree
3	TEMP_EN	1	Y	Y	R/W	Temperature ADC measurement function enable/disable 0 : Disable 1 : Enable (default)
2	TEMP_AVG	0	Y	Y	R/W	Choose the average times for TEMP_ADC code calculate 0 : 16times (default) 1 : 32times
1:0	Reserved	00	Y	Y	R/W	Reserved

Register Address : 0x0D, Register Name : CHG\_CTRL13

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:4	ADC_HIGH [3:0]	0011	Y	Y	R/W	Temperature sensor threshold set. The IRQ "TEMP_H" will be trigger when the ADC code is larger than ADC_HIGH. 0000 : <60 degree 0001 : >60 degree 0010 : >64 degree 0011 : >68 degree (default) 0100 : >72 degree 0101 : >76 degree 0110 : >80 degree 0111 : >84 degree 1000 : >88 degree 1001 : >92 degree 1010 : >96 degree 1011 : >100 degree 1100 : >104 degree 1101 : >108 degree 1110 : >112 degree 1111 : >116 degree
3:0	ADC_OFFSET [3:0]	0000	Y	Y	R/W	Temperature sensor threshold set. The IRQ "TEMP_L" will be trigger when ADC code is smaller than (ADC_HIGH - ADC_OFFSET) after "TEMP_H" trigged. 0000 : 4 degree (default) 0001 : 4 degree 0010 : 8 degree 0011 : 12 degree 0100 : 16 degree 0101 : 20 degree 0110 : 24 degree 0111 : 28 degree 1000 : 32 degree 1001 : 36 degree 1010 : 40 degree 1011 : 44 degree 1100 : 48 degree 1101 : 52 degree 1110 : 56 degree 1111 : 60 degree

Register Address : 0x20, Register Name : SYSTEM1

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7:6	CHG_STAT	00	Y	Y	R	Charger status bit 00 : Ready (default) 01 : Charge in progress 10 : Charge done 11 : Fault
5:4	Reserved	00	Y	Y	R/W	Reserved
3:1	VERSION[2:0]	000	N	N	R	Version code
0	TRIMDONE	0	N	N	R	Trim done

Register Address : 0x30, Register Name : CHG\_STATC

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	PWR_RDY	0	Y	Y	R	Power ready status bit 0 : Input power is bad, $V_{IN} < V_{UVP}$ (default) 1 : Input power is good, $V_{IN} > V_{UVP}$
6	CHG_MIVR	0	Y	Y	R	Charger warning. Input voltage MIVR loop active. 0 : MIVR loop is not active (default) 1 : MIVR loop is active
5	CHG_TREG	0	Y	Y	R	Charger warning. Thermal regulation loop active. 0 : Thermal regulation loop is not active (default) 1 : Thermal regulation loop is active
4:0	Reserved	00000	Y	Y	R/W	Reserved

Register Address : 0x31, Register Name : CHG\_FAULT

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	CHG_VBUSOV	0	Y	Y	R	VBUS over-voltage protection. Set when $VBUS > VIN\_OVP$ is detected. 0 : VBUS is not over-voltage (default) 1 : VBUS is over-voltage
6	CHG_VBATSUV	0	Y	Y	R	Charger fault. Battery UVP. 0 : Battery is not UVP (default) 1 : Battery is UVP
5	CHG_VBATOV	0	Y	Y	R	Charger fault. Battery OVP. 0 : Battery is not OVP (default) 1 : Battery is OVP
4:0	Reserved	00000	Y	Y	R/W	Reserved



Register Address : 0x32, Register Name : CHG\_IRQ1

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	OTPI	0	Y	Y	R/C	Thermal shutdown fault 0 : No event occurs (default) 1 : Event occurs
6	CHG_ADPBADI	0	Y	Y	R/C	Charger bad adaptor fault 0 : No event occurs (default) 1 : Event occurs
5	CHG_TMRI	0	Y	Y	R/C	Charger timer time-out fault 0 : No event occurs (default) 1 : Event occurs
4	TEMP_H	0	Y	Y	R/C	Temperature too high fault 0 : No event occurs (default) 1 : Event occurs
3	TEMP_L	0	Y	Y	R/C	Temperature too low fault 0 : No event occurs (default) 1 : Event occurs
2	Reserved	0	Y	Y	R/W	Reserved
1	CHG_STATCI	0	Y	Y	R/C	Status of each CHG_STATC register (Reg0x30) is changed 0 : No event occurs (default) 1 : Event occurs
0	CHG_FAULTI	0	Y	Y	R/C	Status of each CHG_FAULT register (Reg0x31) is changed 0 : No event occurs (default) 1 : Event occurs

Register Address : 0x33, Register Name : CHG\_IRQ2

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	CHG_IEOCI	0	Y	Y	R/C	Charging current is lower than EOC current ever occurs 0 : No event occurs (default) 1 : Event occurs
6	CHG_TERMI	0	Y	Y	R/C	Charge terminated event 0 : No event occurs (default) 1 : Event occurs
5	SSFINISHI	0	Y	Y	R/C	Charger soft-start finishes event 0 : No event occurs (default) 1 : Event occurs
4	WDTMRI	0	Y	Y	R/C	Watch dog timer timeout fault 0 : No event occurs (default) 1 : Event occurs
3:0	Reserved	0000	Y	Y	R/W	Reserved

Register Address : 0x40, Register Name : CHG\_STATC\_Mask

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	PWR_RDYM	0	Y	Y	R/W	Power ready interrupt mask 0 : Interrupt is not masked (default) 1 : Interrupt is masked
6	CHG_MIVRM	0	Y	Y	R/W	Input voltage MIVR loop active interrupt mask 0 : Interrupt is not masked (default) 1 : Interrupt is masked
5	CHG_TREGM	0	Y	Y	R/W	Thermal regulation loop active interrupt mask 0 : Interrupt is not masked (default) 1 : Interrupt is masked
4:0	Reserved	00000	Y	Y	R/W	Reserved

Register Address : 0x41, Register Name : CHG\_FAULT\_Mask

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	CHG_VBUSOVM	1	Y	Y	R/W	VBUS over-voltage protection interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
6	CHG_VBATSUVM	1	Y	Y	R/W	Battery UVP interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
5	CHG_VBATOVM	1	Y	Y	R/W	Battery OVP interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
4:0	Reserved	00000	Y	Y	R/W	Reserved

Register Address : 0x42, Register Name : CHG\_IRQ1\_Mask

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	OTPM	1	Y	Y	R/W	Thermal shutdown fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
6	CHG_ADPBADM	1	Y	Y	R/W	Charger bad adaptor fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
5	CHG_TMRM	1	Y	Y	R/W	Charger timer time-out fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
4	TEMP_HM	1	Y	Y	R/W	Temperature too high fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
3	TEMP_LM	1	Y	Y	R/W	Temperature too low fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
2	Reserved	1	Y	Y	R/W	Reserved
1	CHG_STATCM	1	Y	Y	R/W	Status of each CHG_STATC register (Reg0x30) changed interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
0	CHG_FAULTM	1	Y	Y	R/W	Status of each CHG_FAULT register (Reg0x31) changed interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)

Register Address : 0x43, Register Name : CHG\_IRQ2\_Mask

Bit	Bit Name	Default	WDT RST	REG RST	Type	Description
7	CHG_IEOCM	1	Y	Y	R/C	Charging current is lower than EOC current interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
6	CHG_TERMM	1	Y	Y	R/C	Charge terminated event interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
5	SSFINISHM	1	Y	Y	R/C	Charger soft-start finishes event interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
4	WDTMRM	1	Y	Y	R/C	Watch dog timer timeout fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked (default)
3:0	Reserved	1111	Y	Y	R/W	Reserved

## Application Information

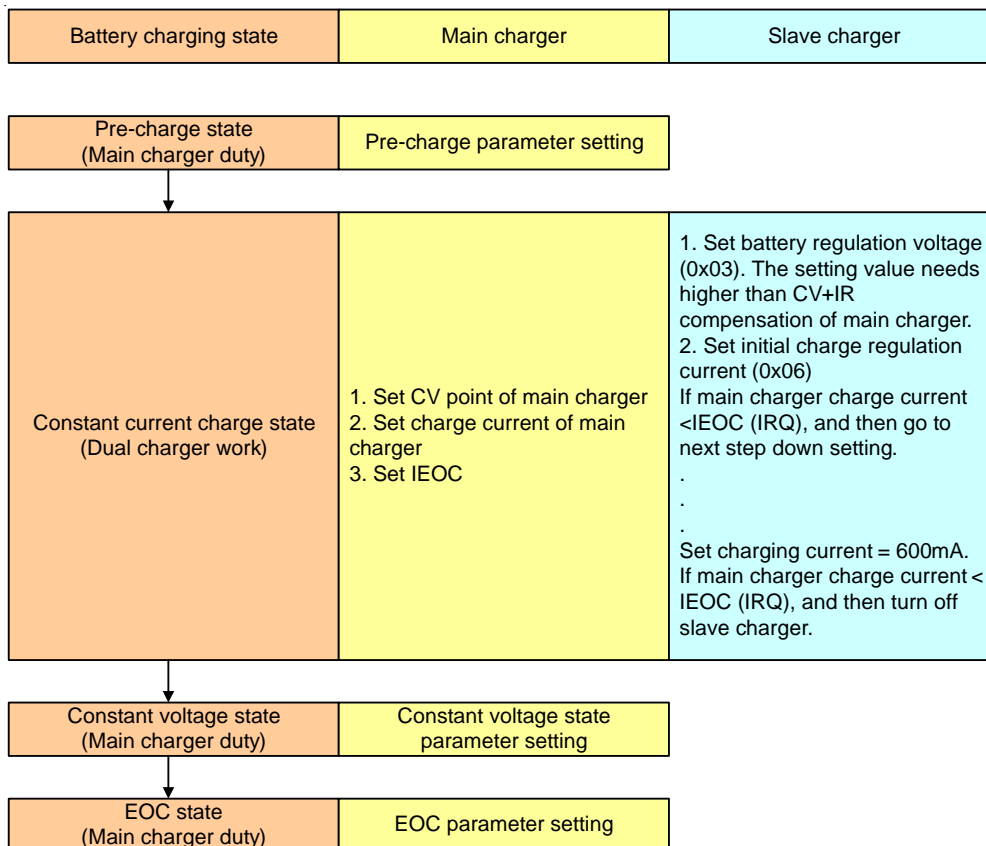
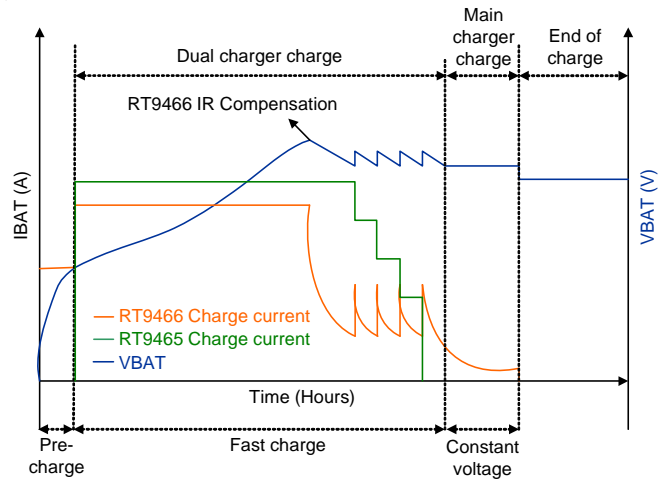
### Device Power On

The internal bias circuit is powered from  $V_{IN}$ . The device will be powered on when the  $V_{IN}$  is higher than  $V_{UVLO}$  threshold and EN pin is higher than 1.2V. In  $V_{IN} > V_{UVLO}$  and EN pin from low logic to high logic condition, the device requires maximum 500 $\mu$ s turn on delay time.

### Dual Charger Program Flow

A main charger (RT9466) is required in the system to manage pre-charge, fast-charge and constant voltage state. Below charge profile and program flow show the dual charge interactions. Once battery voltage higher than pre-charge voltage, system needs to enable slave charger (RT9465) to increase charge current and reduce fast charge period. The CV setting of slave charger needs to higher than main charger (include main charger's IR compensation). If main charger triggers IEOC event, the

system needs to reduce the slave charger's charge current to next step. When the main charger triggers the IEOC event and slave charger's ICHG is at 600mA, the system needs to turn off slave charger and main charger takes over the constant voltage state period.



**Charge Current (I<sub>CHG</sub>)**

The RT9465 senses and averages the inductor current to the regulation loop for constant current charge. Users can set the charge current from 0.6A to 3A by I<sup>2</sup>C interface.

**Protection Features**

When below events are triggered, the device turns off buck converter and pulls low INT pin to inform host. The device sets CHG\_EN bit to 0 when buck converter turns off.

- ▶ V<sub>IN</sub> Over-Voltage Protection (V<sub>INOVP</sub>)
- ▶ V<sub>IN</sub> Under-Voltage Protection (V<sub>INUVP</sub>)
- ▶ Battery Over-Voltage Protection (V<sub>BATOVP</sub>)
- ▶ Battery Under-Voltage Protection (V<sub>BATUVP</sub>)
- ▶ Over-Temperature Protection (OTP)

**Interrupt**

The RT9465 reports status to host (CPU, MCU, EC, or...etc.) by the INT (interrupt to host) pin, which is an

open-drain output. The INT pin goes low when any fault occurs. It will be automatically reset when all the fault flags are cleared. The IRQ\_Pulse (0x01, bit3) provides a reminder function. If the system interrupts by the interrupt signal but does not take any action to check the registers, the INT pin will be released with every 2 seconds and be triggered again.

**I<sup>2</sup>C Interface Timing Diagram**

The RT9465 acts as an I<sup>2</sup>C -bus slave. The I<sup>2</sup>C -bus master configures the settings for charge mode command bytes to the RT9465 via the 2-wire I<sup>2</sup>C -bus. After the START condition, the I<sup>2</sup>C master sends a chip address. This address is seven bits long followed by an eighth bit which is a data direction bit (R/W). The second byte selects the register to which the data will be written. The third byte contains data to the selected register.

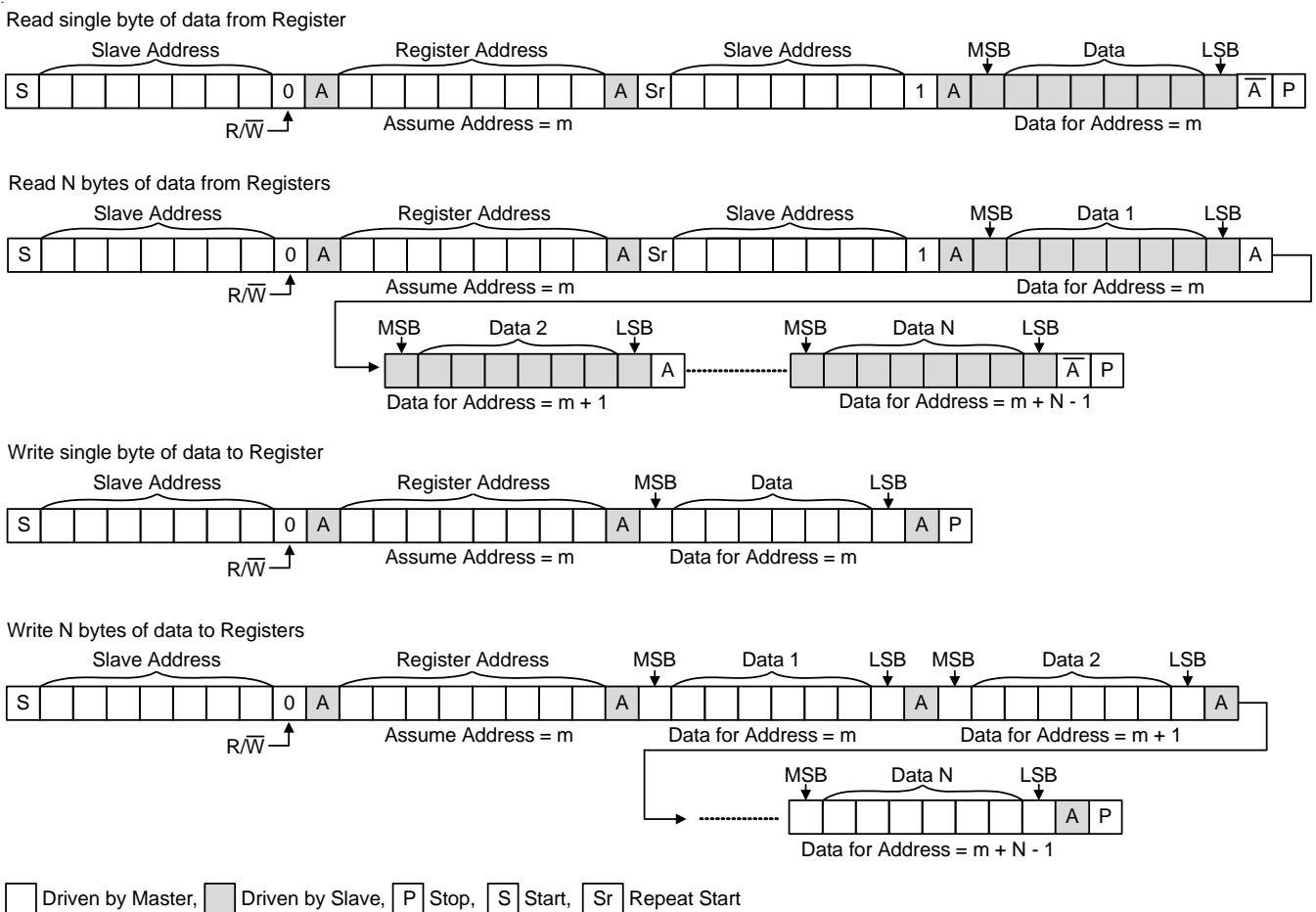


Figure 1. Read and Write Function

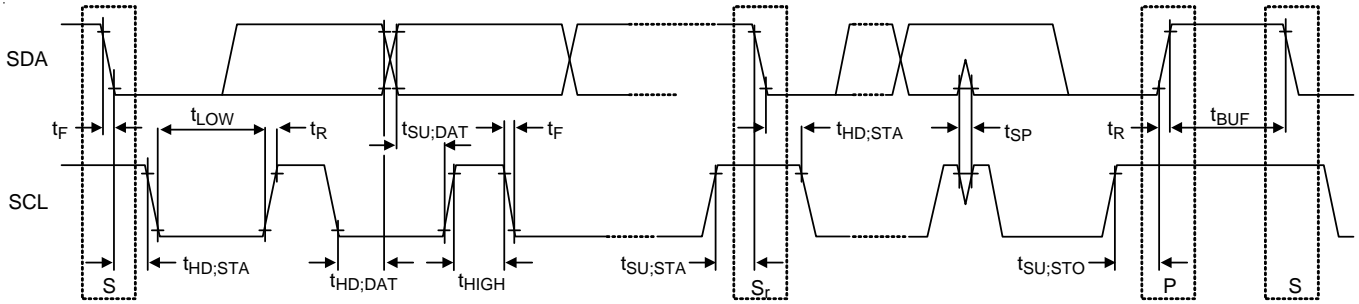


Figure 2. I<sup>2</sup>C Waveform Information

**Thermal Considerations**

The junction temperature should never exceed the absolute maximum junction temperature  $T_{J(MAX)}$ , listed under Absolute Maximum Ratings, to avoid permanent damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using 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  $\theta_{JA}$  is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 125°C. The junction-to-ambient thermal resistance,  $\theta_{JA}$ , is highly package dependent. For a WQFN-16L 3x3 package, the thermal resistance,  $\theta_{JA}$ , is 30°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated as below :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (30^\circ\text{C/W}) = 3.33\text{W for a WQFN-16L 3x3 package.}$$

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

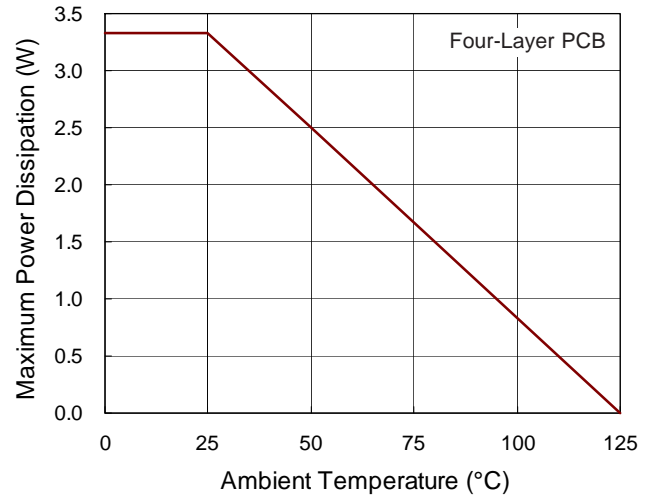


Figure 3. Derating Curve of Maximum Power Dissipation

**Layout Considerations**

- ▶ Place the input and output capacitors as close to the input and output pins as possible.
- ▶ Keep the main power traces as wide and short as possible.
- ▶ The output inductor and bootstrap capacitor should be placed close to the chip and SW pins.

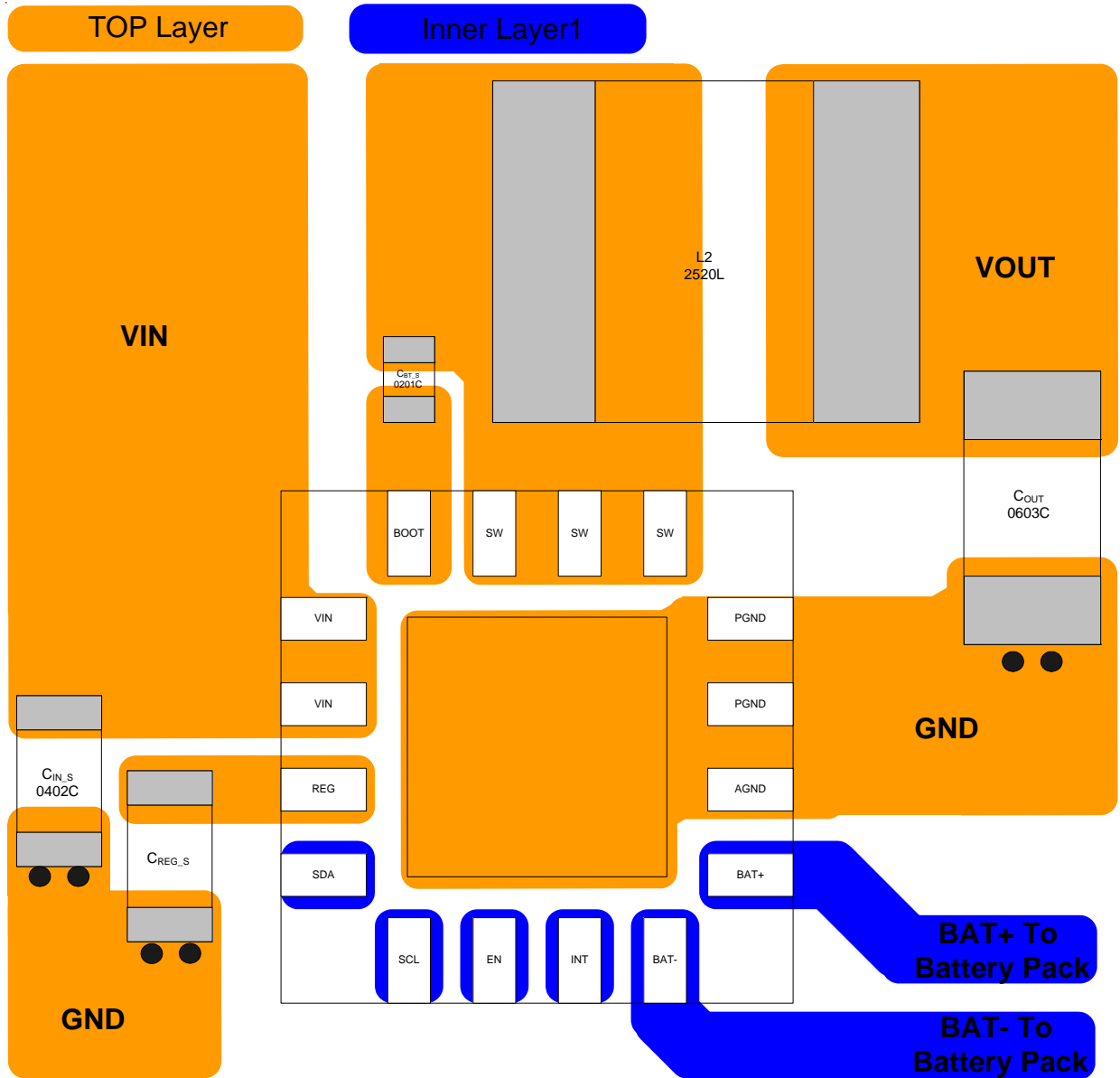
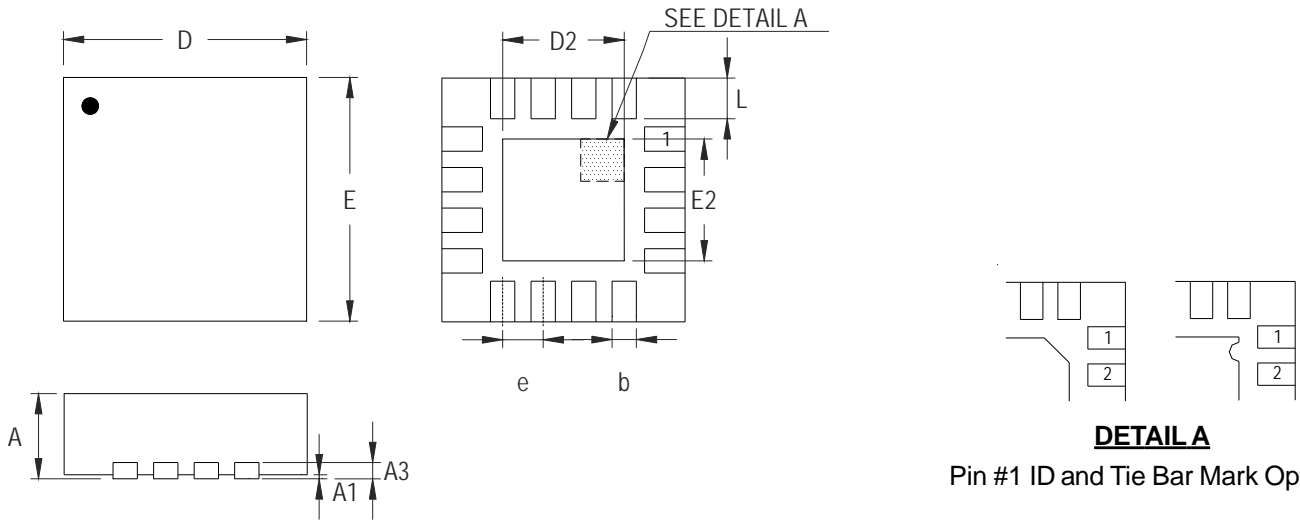


Figure 4. PCB Layout Guide

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	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	1.300	1.750	0.051	0.069
E	2.950	3.050	0.116	0.120
E2	1.300	1.750	0.051	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

W-Type 16L QFN 3x3 Package