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 resistors.

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^2C interface. The junction temperature is monitored by I^2C.

Other features include under-voltage protection, over-voltage protection (including V_{BAT} and V_{BUS} side), thermal regulation and reverse leakage protection and MIVR.

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

Ordering Information

RT9465 □□

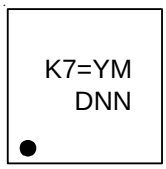
- Package Type
  QW : WQFN-16L 3x3 (W-Type)
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

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.

Marking Information



K7= : Product Code

YMDNN : Date Code

Features

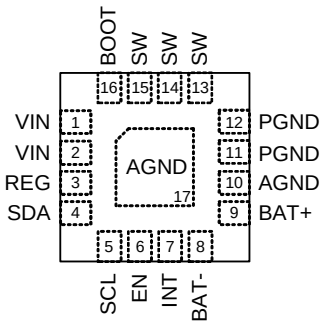
- **Input Voltage Range : 3.9V to 14V**
- **Synchronous 1.5MHz/0.75MHz Switching Frequency 95% Max. Duty**
- **Up to 92%/94% Peak Efficiency at VIN = 9V/5V**
- **VIN Over-Voltage Protection : 14.5V**
- **VIN Under-Voltage Protection : 3.8V**
- **VIN Under-Voltage-Lock-Out : 3.3V**
- **Fault Detection (VIN and VBAT Monitoring)**
- **INT Output for Communication with I^2C**
- **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)**
- **VIN Minimum Input Voltage Regulation (MIVR) : ±3%**
- **Battery CV (Constant Voltage) Regulation : ±1%**
- **Output CC (Constant Current) Regulation, Output Current < 1A : ±100mA (VBUS = 9V/12V)**
- **Output CC (Constant Current) Regulation, Output Current > 1A : ±10% (VBUS = 9V/12V)**
- **Junction Temperature Monitor : ±3°C**
- **Thermal Shutdown : 160°C**

Applications

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

Pin Configuration

(TOP VIEW)

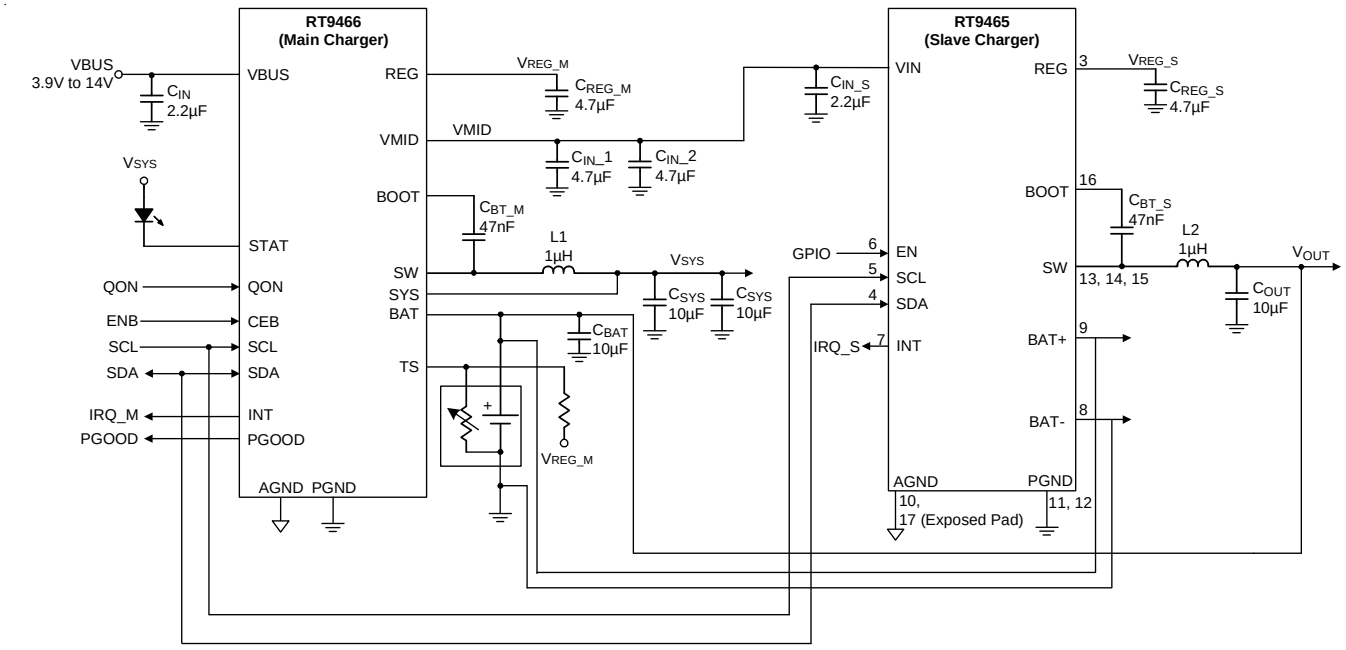


WQFN-16L 3x3

Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 2	VIN	Power input.
3	REG	PWM low side driver and bootstrap power supply.
4	SDA	Data input for I^2C.
5	SCL	Data input for I^2C.
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 a capacitor between BOOT and SW.

Typical Application Circuit



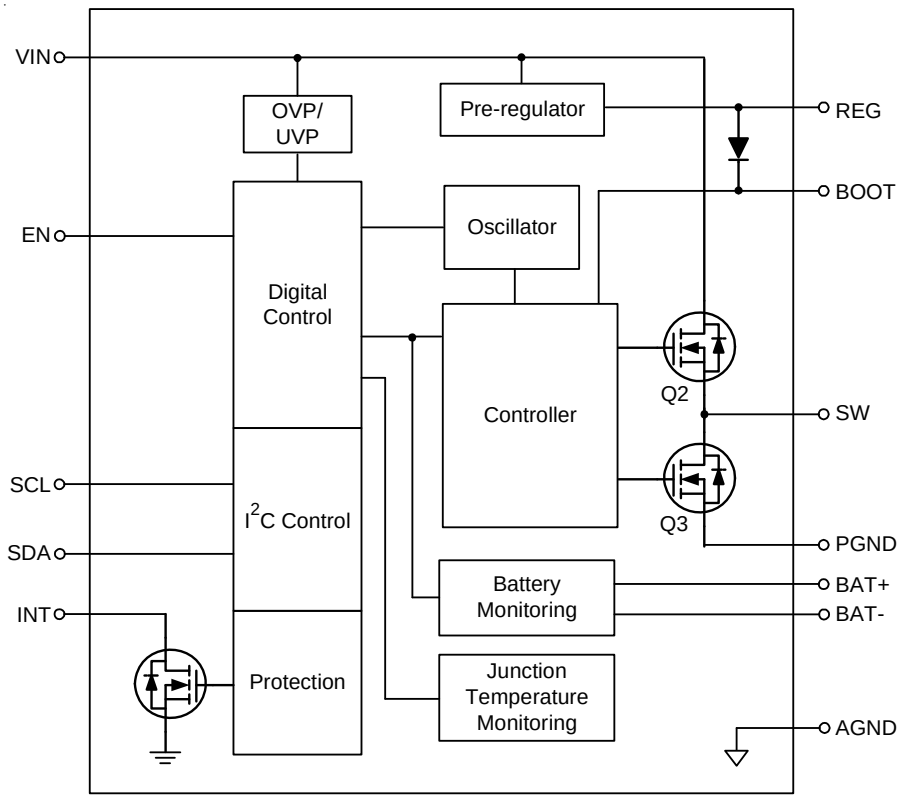
Note : The total C_{IN} of slave charger between PMID pin of main charger is 10µF at least.

Table 1. Component List of Evaluation Board

Reference	Q'ty	Part Number	Description	Package	Manufacturer
C_{IN_S}	1	GRM155R61E225KE11	2.2µF/25V/X5R	0402	muRata
C_{REG_S}	1	GRM155R60J475ME47	4.7µF/6.3V/X5R	0402	muRata
C_{BT_S}	1	GRM033R61C473KE84	47nF/16V/X5R	0201	muRata
C_{OUT}	1	GRM188R61A106KE69	10µF/10V/X5R	0603	muRata
L1	1	DFE252012F	1µH	2.5x2.0x1.2	TOKO
U1	1	RT9465	CHIP	WQFN-16L 3x3	RICHTEK

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

Functional Block Diagram



Absolute Maximum Ratings (Note 2)

- Supply Input Voltage ---------- –0.3V to 22V
- BOOT ---------- –0.3V to 22V
- SW ---------- –0.3V to 20V
- MID – VIN, BOOT – SW ---------- –0.3V to 6V
- Others ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  WQFN-16L 3x3 ---------- 3.33W
- Package Thermal Resistance (Note 3)
  WQFN-16L 3x3, θ_{JA} ---------- 30°C/W
  WQFN-16L 3x3, θ_{JC} ---------- 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 ---------- 3.9V to 14V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 5V, V_{BAT} = 4.2V, L = 1µH, C_{IN} = 10µF, C_{BATS} = 10µF, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Quiescent Current						
VIN Supply Current	$I_{(VIN)\_SW}$	PWM is switching, V_{IN} = 5V, V_{BAT+} = 3.8V	--	8	--	mA
	$I_{(VIN)\_SW}$	PWM is switching, V_{IN} = 9V, V_{BAT+} = 3.8V	--	28	--	
	$I_{(VIN)\_no\_SW}$	PWM is non-switching, V_{IN} = 5V, V_{BAT+} = 4.4V	--	--	2	
Leakage Current from Battery	I_{BAT_leak}	Charger disable, V_{BAT} = 3.8V	--	--	1	µA
VIN/VBAT Power up						
VIN Under-Voltage Protection	V_{UVP}		--	3.8	--	V
VIN Under-Voltage Protection Hysteresis	V_{UVP_HYS}		--	150	--	mV
Input Power Regulation						
Input Voltage Regulation Range	V_{MIVR}	I^2C programmable per 0.1V	3.9	--	13.4	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
V_{MIVR} Accuracy	V_{MIVR_acc}	MIVR = 4.4V, 9V	–3	--	3	%
Protection						
V_{IN}						
IC Active Threshold Voltage	V_{UVLO}	V_{IN} rising	3.05	3.3	3.55	V
IC Active Hysteresis	V_{UVLO_HYS}	V_{IN} falling from UVLO	--	150	--	mV
V_{IN} OVP Threshold Voltage	V_{INOVP}	V_{IN} rising	13.5	14.5	15.5	V
VIN OVP Hysteresis	V_{INOVP_HYS}		--	350	--	mV
V_{BAT}						
Battery OVP	V_{BATOVP}	(V_{BATOVP_Rising} - V_{CV})/V_{CV}	102	104	106	%
Battery UVP	V_{BATUVP}	V_{BAT} falling	2.3	2.4	2.5	V
Thermal Protection						
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
Battery Charging Interval						
End of Charge						
Battery Voltage Regulation	V_{OREG}	I^2C programmable per 20mV	3.8	--	5.06	V
Battery Voltage Accuracy	V_{OREG_ACC}	Temperature = 0 to 85°C	–1	--	1	%
Fast Charge						
Charging Current	I_{CHRG}	I^2C programmable per 0.1A	0.6	--	3	A
I_{CHG} Accuracy	I_{CHRG_ACC}	V_{IN} = 5V, charge current > 1A	–15	--	15	%
		V_{IN} = 9V, 12V, charge current > 1A	–10	--	10	
		V_{IN} = 5V, charge current < 1A	–150	--	150	mA
		V_{IN} = 9V, 12V, charge current < 1A	–100	--	100	
End of Charging Current	I_{EOC}	I^2C Programmable Per 0.1A	0.6	--	1.6	A
I_{EOC} Accuracy	I_{EOC_ACC}	V_{IN} = 5V, 9V, 12V, I_{EOC} setting > 1A	–15	--	15	%
		V_{IN} = 5V, 9V, 12V, I_{EOC} setting < 1A	–150	--	150	mA
Battery charger						
High Side On-Resistance	$R_{ON(UUG+UG)}$	From V_{IN} to SW	--	30	--	mΩ
Low Side On-Resistance	$R_{ON(LG)}$	From SW to PGND	--	30	--	mΩ
Charging Efficiency		V_{IN} = 9V, V_{BAT} = 3.8V, and I_{CHG2} = 2.5A	--	89.5	--	%
Switching Frequency (1.5MHz)	f_{OSC1}	I^2C Programmable 1.5 MHz	--	1.5	--	MHz
Switching Frequency (750kHz)	f_{OSC2}	I^2C Programmable 0.75MHz	--	0.75	--	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_{REG} Regulation	V_{REG}	V_{IN} = 5V	--	4.9	--	V
EN Pull Low	R_{EN}		--	500	--	kΩ
I^2C Characteristics						
Output Low Voltage	V_{OL}	I_{DS} = 10mA	--	--	0.4	V
SCL, SDA Input Logic High Threshold Voltage	V_{IH}		1.3	--	--	V
SCL, SDA Input Logic Low Threshold Voltage	V_{IL}		--	--	0.4	V
SCL Clock			--	--	400	kHz
Load Capacitance	C_{LOAD}	V_{PULL_UP} = 1.8V	--	--	1	pF
Control I/O Pin						
EN Input Threshold Voltage	V_{IH}	Logic high threshold	1.2	--	--	V
EN Input Threshold Voltage	V_{IL}	Logic low threshold	--	--	0.4	V
Device Turn-On Delay Time After EN Pull-High			--	--	500	μS

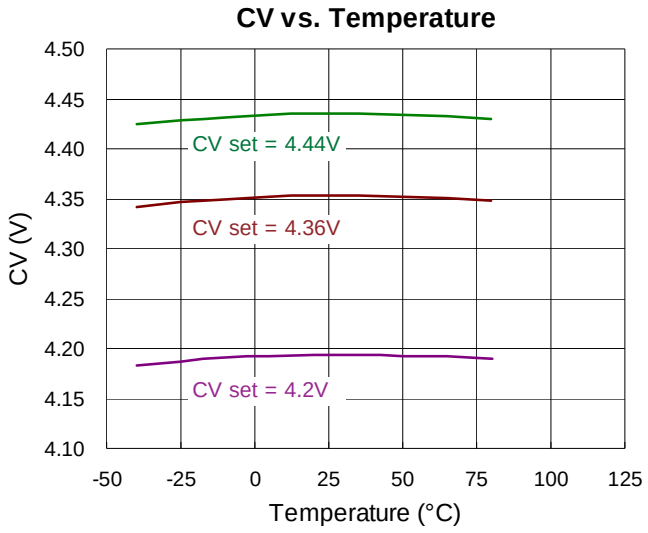
Note 2. Stresses beyond those listed “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

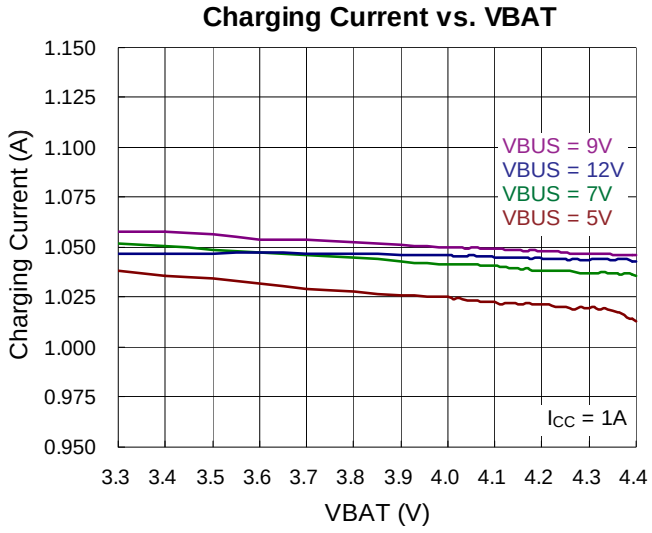
Note 3. θ_{JA} is measured under natural convection (still air) at T_A = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. θ_{JC} is measured at the exposed pad of the package.

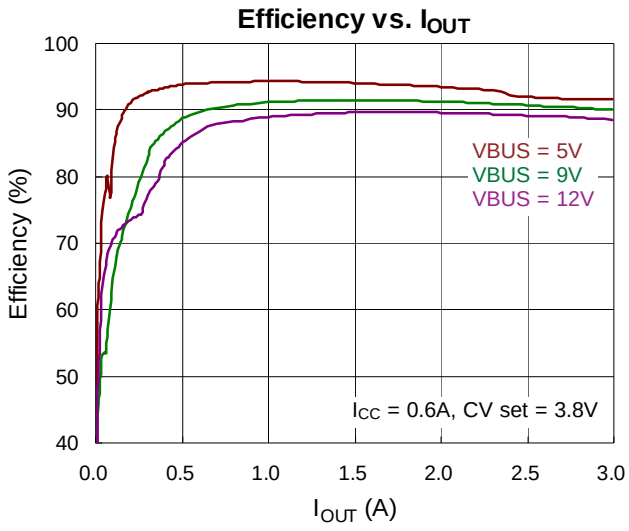
Note 4. Devices are ESD sensitive. Handling precaution is recommended.

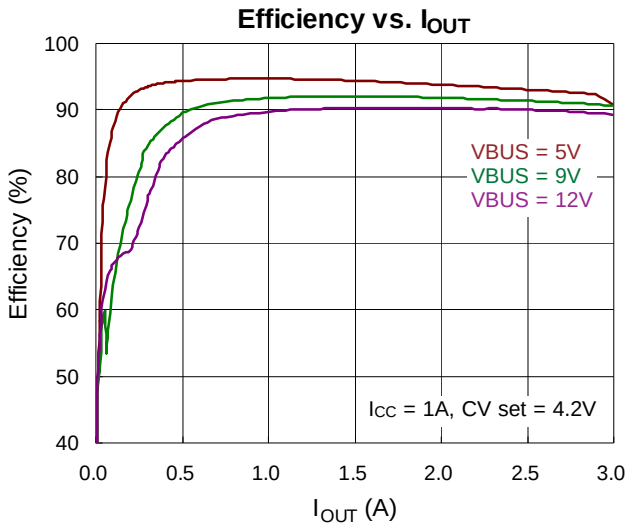
Note 5. The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics









Application Information

Junction Temperature Monitor

The RT9465 supports a junction temperature monitor to optimize the charge current for applications. The monitoring is split in to 16 levels from a 4-bit ADC to I^2C register as shown in Table 2. In addition, the RT9465 provides two programmable monitoring levels by I^2C serial interface to report the temperature warning and release flags, $T_{J\_WARNING}$ and $T_{J\_RELEASE}$ as shown in Table 2. If the junction temperature rises above the warning threshold ($T_{J\_WARNING}$), the event is asserted to an interrupt. If the junction temperature falls under the release threshold ($T_{J\_RELEASE}$), the event is asserted to an interrupt.

Table 2.

Reported Register	Temperature
0000	< 60 degree ($T_{J\_RELEASE}$ default)
0001	> 60 degree
0010	> 64 degree
0011	> 68 degree ($T_{J\_WARNING}$ default)
0100	> 72 degree
0101	> 76 degree
0110	> 80 degree
0111	> 84 degree
1000	> 88 degree
1001	> 92 degree
1010	> 96 degree
1111	> 100 degree
1100	> 104 degree
1101	> 108 degree
1110	> 112 degree
1111	> 116 degree

Minimum Input Voltage Regulation (MIVR) :

The RT9465 features input voltage MIVR function to prevent input voltage drop due to insufficient current provided by the adaptor or USB input. If MIVR function is enabled, the input voltage decreases when the over-current of the input power source occurs and is regulated at a predetermined voltage level which can be set from 3.9V to 13.4V with the step of 100mV by I^2C interface to MIVR register.

Average Output Current Regulation (AOCR) :

The RT9465 proposed output current AOCR function to limit charge current. The AOCR senses and averages the inductor current in to the regulation loop for constant current charge. If AOCR function is enabled, the output current increase when the over-current of the charge occurs and is regulated at a predetermined current level which can be set from 0.6A to 3A with the step of 100mA by I^2C interface to AOCR register.

I²C Register Information

I²C Slave Address : 1001011 (4BH)

Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X00	System1	RST_REG	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X01	System2	CHG_EN	Reserved	Reserved	Reserved	IRQ_pulse	Reserved	Reserved	Reserved
	Reset Value	0	1	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X02	Clock	Sel_SWFreq	FixFrq	OSCSS_EN	Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X03	CV	VOREG[5:0]						Reserved	Reserved
	Reset Value	0	1	0	1	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X04	TH	THREG[1:0]		Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	1	1	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X05	MIVR	VMIVR[6:0]							VMIVR_EN
	Reset Value	0	0	0	0	1	0	1	1
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X06	CC	ICHG[4:0]					Reserved	Reserved	Reserved
	Reset Value	1	0	1	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X07	EOC1	IEOC[3:0]				EOC_EN	CHG_TDEG_EOC[2:0]		
	Reset Value	0	1	0	1	1	1	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X08	EOC2	TE	EOC_TIMER[1:0]		Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X09	Timing	WT_FC[2:0]			TMR2X_ EN	TMR_EN	TMR_ PAUSE	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X0A	WDT	WDT_EN	WDT_TRST	WDT[1:0]		Reserved	Reserved	Reserved	Reserved
	Reset Value	0	1	0	1	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X0C	ADC1	ADC_RPT[3:0]				TEMP_EN	TEMP_AVG	Reserved	Reserved
	Reset Value	0	0	0	0	1	0	0	0
	Read/ Write/ Clear	R	R	R	R	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X0D	ADC2	ADC_HIGH[3:0]				ADC_OFFSET[3:0]			
	Reset Value	0	0	1	1	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X20	CHG1	CHG_STAT		Reserved	Reserved	VERSION[2:0]			TRIMDONE
	Reset Value	1	1	0	0	0	0	0	0
	Read/ Write/ Clear	R	R	R/W	R/W	R	R	R	R

Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X30	CHG1	PWR_ RDY	CHG_ MIVR	CHG_ TREG	Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R	R	R	R	R	R	R	R
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X31	CHG2	CHG_ VINOV	CHG_ VBATUV	CHG_ VBATOV	Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/C	R/C	R/C	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X32	IRQ1	OTPI	CHG_ ADPBADI	CHG_ TMRI	TEMP_H	TEMP_L	Reserved	CHG_ STATCI	CHG_ FAULTI
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/C	R/C	R/C	R/C	R/C	R/W	R/C	R/C
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X33	IRQ2	CHG_ IEOCI	CHG_ TERMI	SSFINISHI	WDTMRI	Reserved	Reserved	Reserved	Reserved
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/C	R/C	R/C	R/C	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X40	CHG MASK1	PWR_ RDYM	CHG_ MIVRM	CHG_ TREGM	OTPIM	CHG_sV BUSOVM	CHG_sV BUSUVM	CHG_sV BATOVM	CHG_sV BATUVM
	Reset Value	0	0	0	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X41	CHG MASK2	CHG_ VINOV M	CHG_ VBATUV M	CHG_ VBATOV M	Reserved	Reserved	Reserved	Reserved	Reserved
	Reset Value	1	1	1	0	0	0	0	0
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X42	IRQMASK 1	OTPM	CHG_ ADPBA DM	CHG_ TMRM	TEMP_ HM	TEMP_ LM	Reserved	CHG_ STATCM	CHG_ FAULTM
	Reset Value	1	1	1	1	1	1	1	1
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Register Address	Description	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0X43	IRQMASK 2	CHG_ IEOCIM	CHG_ TERMIM	SSFINISH IM	WDTMRIM	Reserved	Reserved	Reserved	Reserved
	Reset Value	1	1	1	1	1	1	1	1
	Read/ Write/ Clear	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Name		Function	Addr	Reset
CHG_CTRL0		System1	0x00	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	RST_REG	0	All registers reset bit. 0 : Don't reset all registers. 1 : Reset all registers. (Notice : This bit will be reset to "0" after reset procedure finish)
[6:0]	R/W	Reserved	0000000	Reserved

Name		Function	Addr	Reset
CHG_CTRL1		System2	0x01	0x40
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	CHG_EN	0	Charging enable 0 : CHG is disabled (default) 1 : CHG is enabled
[6:4]	R/W	Reserved	100	Reserved
3	R/W	IRQ_pulse	0	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]	R/W	Reserved	000	Reserved

Name		Function	Addr	Reset
CHG_CTRL2		Clock	0x02	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	Sel_SWFreq	0	The switching frequency selection bit (Charger) 0 : The switching frequency is 1.5MHz. (Default) 1 : The switching frequency is 0.75MHz.
6	R/W	FixFreq	0	Charger switching frequency 0 : Charger switching frequency is varied (default) 1 : Charger switching frequency is fixed
5	R/W	OSCSS_EN	0	Charger spread spectrum enable 0 : Disabled (default) 1 : Enabled
[4:0]	R/W	Reserved	00000	Reserved

Name		Function	Addr	Reset
CHG_CTRL3		CV	0x03	0x50
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:2]	R/W	VOREG<5:0>	010100	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]	R/W	Reserved	00	Reserved

Name		Function	Addr	Reset
CHG_CTRL4		TH	0x04	0xC0
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:6]	R/W	THREG <1:0>	11	Charger thermal regulation threshold 00 : 60°C 11 : 80°C 10 : 100°C 11 : 120°C (default)
[5:0]	R/W	Reserved	000000	Reserved

Name		Function	Addr	Reset
CHG_CTRL5		MIVR	0x05	0x0B
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:1]	R/W	VMIVR[6:0]	0000101	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	R/W	MIVR_EN	1	MIVR loop enable 0 : MIVR loop disable 1 : MIVR loop enable (default)

Name		Function	Addr	Reset
CHG_CTRL6		CC	0x06	0xA0
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:3]	R/W	ICHG[4:0]	10100	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 11110 to 11111 : 3A
[2:0]	R/W	Reserved	000	Reserved

Name		Function	Addr	Reset
CHG_CTRL7		EOC1	0x07	0x5C
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:4]	R/W	IEOC[3:0]	0101	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	R/W	EOC_EN	1	IEOC enable/disable 0: Disable 1: Enable (default)
[2:0]	R/W	CHG_TDEG_EOC [2:0]	100	EOC deglitch time 000 : 120us 001 : 180us 010 : 240us 011 : 360us 100 : 2ms (default) 101 : 4ms 110 : 8ms 111 : 16ms

Name		Function	Addr	Reset
CHG_CTRL8		EOC2	0x08	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	TE	0	Termination enable 0 : Disable charge current termination (default) 1 : Enable charge current termination
[6:5]	R/W	EOC_TIMER[1:0]	00	EOC back-charging time 00 : 0mins (default) 01 : 30mins 10 : 45mins 11 : 60mins
[4:0]	R/W	Reserved	00000	Reserved

Name		Function	Addr	Reset
CHG_CTRL9		Timing	0x09	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:5]	R/W	WT_FC[2:0]	000	Fast charge Timer 000 : 4hrs (default) 001 : 6hrs 010 : 8hrs 011 : 10hrs 100 : 12hrs 101 : 14hrs 110 : 16hrs 111 : 20hrs
4	R/W	TMR2X_EN	0	Double charger timer during MIVR, AICR, and thermal regulation 0 : Disable 2x extended charger timer (default) 1 : Enable 2x extended charger timer
3	R/W	TMR_EN	0	Charger timer enable/disable 0 : Disable 1 : Enable (default)
2	R/W	TMR_PAUSE	0	Timer control bit 0: Timer is active (default) 1: Timer is pause
[1:0]	R/W	Reserved	00	Reserved

Name		Function	Addr	Reset
CHG_CTRL10		WDT	0x0A	0x50
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	WDT_EN	0	Watch dog timer enable/disable 0 : Disable (default) 1 : Enable
6	R/W	WDT_TRST	1	Waiting timer to reset I^2C setup after watchdog is asserted 0 : 200ms 1 : 500ms (default)
[5:4]	R/W	WDT[1:0]	01	Watch dog timer, from WDTEN is enabled to watchdog IRQ, clear timmer by I^2C access 00 : 8s 01 : 40s (default) 10 : 80s 11 : 160s
[3:0]	R/W	Reserved	0000	Reserved

Name		Function	Addr	Reset
CHG_CTRL12		ADC1	0x0C	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:4]	R	ADC_RPT[3:0]	0000	Report the TEMP_ADC result, sampling every 64T (22μs) and average times (352μs if TEMP_ANG = 0) 0000 : <60 degree 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	R/W	TEMP_EN	1	Temperature ADC measurement function enable/disable 0 : Disable 1 : Enable (default)
2	R/W	TEMP_AVG	0	Choose the average times for TEMP_ADC code calculate 0 : 16times 1 : 32times
[1:0]	R/W	Reserved	00	Reserved

Name		Function	Addr	Reset
CHG_CTRL13		ADC2	0x0D	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:4]	R/W	ADC_HIGH [3:0]	0011	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]	R/W	ADC_OFFSET [3:0]	0000	Temperature sensor threshold set. The IRQ "TEMP_L" will be trigger when ADC code is smaller than ADC_HIGH_RST before "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

Name		Function	Addr	Reset
SYSTEM1		CHG1	0x20	0xC0
Bit	**Type**	**Name**	**Reset Value**	**Description**
[7:6]	R	CHG_STAT	11	Charger status bit 00 : Ready 01 : Charge in progress 10 : Charge done 11 : Fault
[5:4]	R/W	Reserved	00	Reserved
[3:1]	R	VERSION[2:0]	000	Version Code
0	R	TRIMDONE	0	TRIMDONE

Name		Function	Addr	Reset
CHG_STATC		CHG1	0x30	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R	PWR_RDY	0	Power ready status bit 0 : Input power is bad, VIN < VDDAUVLO2 1 : Input power is good, VIN > VDDAUVLO2
6	R	CHG_MIVR	0	Charger warning. Input voltage MIVR loop active. 0 : MIVR loop is not active 1 : MIVR loop is active
5	R	CHG_TREG	0	Charger warning. Thermal regulation loop active. 0 : Thermal regulation loop is not active 1 : Thermal regulation loop is active
[4:0]	R/W	Reserved	00000	Reserved

Name		Function	Addr	Reset
CHG_FAULT		CHG2	0x31	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R	CHG_VBUSOV	0	VBUS over-voltage protection. Set when VBUS > VIN_OVP is detected. 0 : VBUS is not over-voltage 1 : VBUS is over-voltage
6	R	CHG_VBATOV	0	Charger fault. Battery OVP. 0 : Battery is not OVP 1 : Battery is OVP
4	R	CHG_VBATSUV	0	Charger fault. Battery UVP. 0 : Battery is not UVP 1 : Battery is UVP
[4:0]	R/W	Reserved	00000	Reserved

Name		Function	Addr	Reset
CHG_IRQ1		IRQ1	0x32	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/C	OTPI	0	Thermal shutdown fault 0 : No operation 1 : Event occurs
6	R/C	CHG_ADPBADI	0	Charger bad adaptor fault 0 : No event occurs 1 : Event occurs
5	R/C	CHG_TMRI	0	Charger timer time-out fault 0 : No event occurs 1 : Event occurs
4	R/C	TEMP_H	0	Temperature too high fault 0 : No event occurs 1 : Event occurs
3	R/C	TEMP_L	0	Temperature back to low fault 0 : No event occurs 1 : Event occurs
2	R/W	Reserved	0	Reserved
1	R/C	CHG_STATCI	0	Status of each CHG_STATC register (Reg0x30) is changed 0 : No event occurs 1 : Event occurs
0	R/C	CHG_FAULTI	0	Status of each CHG_FAULT register (Reg0x31) is changed 0 : No event occurs 1 : Event occurs

Name		Function	Addr	Reset
CHG_IRQ2		IRQ2	0x33	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/C	CHG_IEOCI	0	Charging current is lower than EOC current ever occurs 0 : No event occurs 1 : Event occurs
6	R/C	CHG_TERMI	0	Charge terminated event 0 : No event occurs 1 : Event occurs
5	R/C	SSFINISHI	0	Charger or Boost soft-start finishes event 0 : No event occurs 1 : Event occurs
4	R/C	WDTMRI	0	Watch dog timer timeout fault 0 : No event occurs 1 : Event occurs
[3:0]	R/W	Reserved	0000	Reserved

Name		Function	Addr	Reset
CHG_STATC_Mask		CHGMASK1	0x40	0x00
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	PWR_RDYM	0	Power ready interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
6	R/W	CHG_MIVRM	0	Input voltage MIVR loop active interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
5	R/W	CHG_TREGM	0	Thermal regulation loop active interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
[4:0]	R/W	Reserved	00000	Reserved

Name		Function	Addr	Reset
CHG_FAULT_Mask		CHGMASK2	0x41	0xE0
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	CHG_VBUSOVM	1	VBUS over-voltage protection interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
6	R/W	CHG_VBATOVM	1	Battery OVP interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
4	R/W	CHG_VBATSUVM	1	System UVP interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
[4:0]	R/W	Reserved	00000	Reserved

Name		Function	Addr	Reset
CHG_IRQ1_Mask		IRQMASK1	0x42	0xFF
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/W	OTPM	1	Thermal shutdown fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
6	R/W	CHG_ADPBADM	1	Charger bad adaptor fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
5	R/W	CHG_TMRM	1	Charger timer time-out fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
4	R/W	TEMP_HM	1	Temperature too high fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
3	R/W	TEMP_LM	1	Temperature back to low fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
2	R/W	Reserved	1	Reserved
1	R/W	CHG_STATCM	1	Status of each CHG_STATC register (Reg0x30) changed interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
0	R/W	CHG_FAULTM	1	Status of each CHG_FAULT register (Reg0x31) changed interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked

Name		Function	Addr	Reset
CHG_IRQ2_Mask		IRQMASK2	0x43	0xFF
Bit	**Type**	**Name**	**Reset Value**	**Description**
7	R/C	CHG_IEOCM	1	Charging current is lower than EOC current interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
6	R/C	CHG_TERMM	1	Charge terminated event interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
5	R/C	SSFINISHM	1	Charger or Boost soft-start finishes event interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
4	R/C	WDTMRM	1	Watch dog timer timeout fault interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked
[3:0]	R/W	Reserved	1111	Reserved

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 θ_{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, θ_{JA}, is highly package dependent. For a WQFN-16L 3x3 package, the thermal resistance, θ_{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°C can be calculated as below :

$P_{D(MAX)}$ = (125°C – 25°C) / (30°C/W) = 3.33W 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, θ_{JA}. The derating curves in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

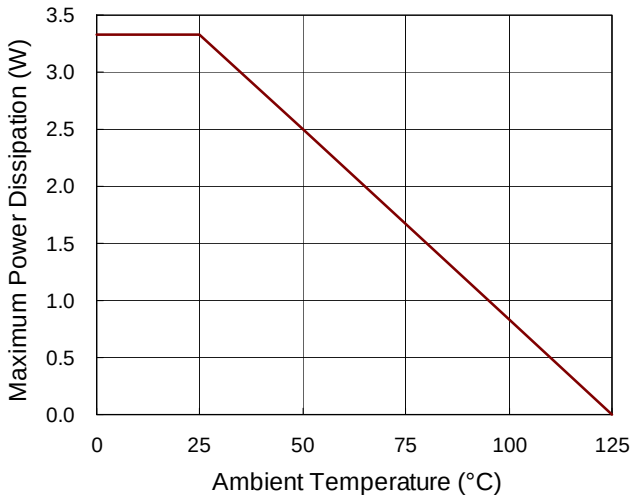


Figure 1. Derating Curve of Maximum Power Dissipation

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.

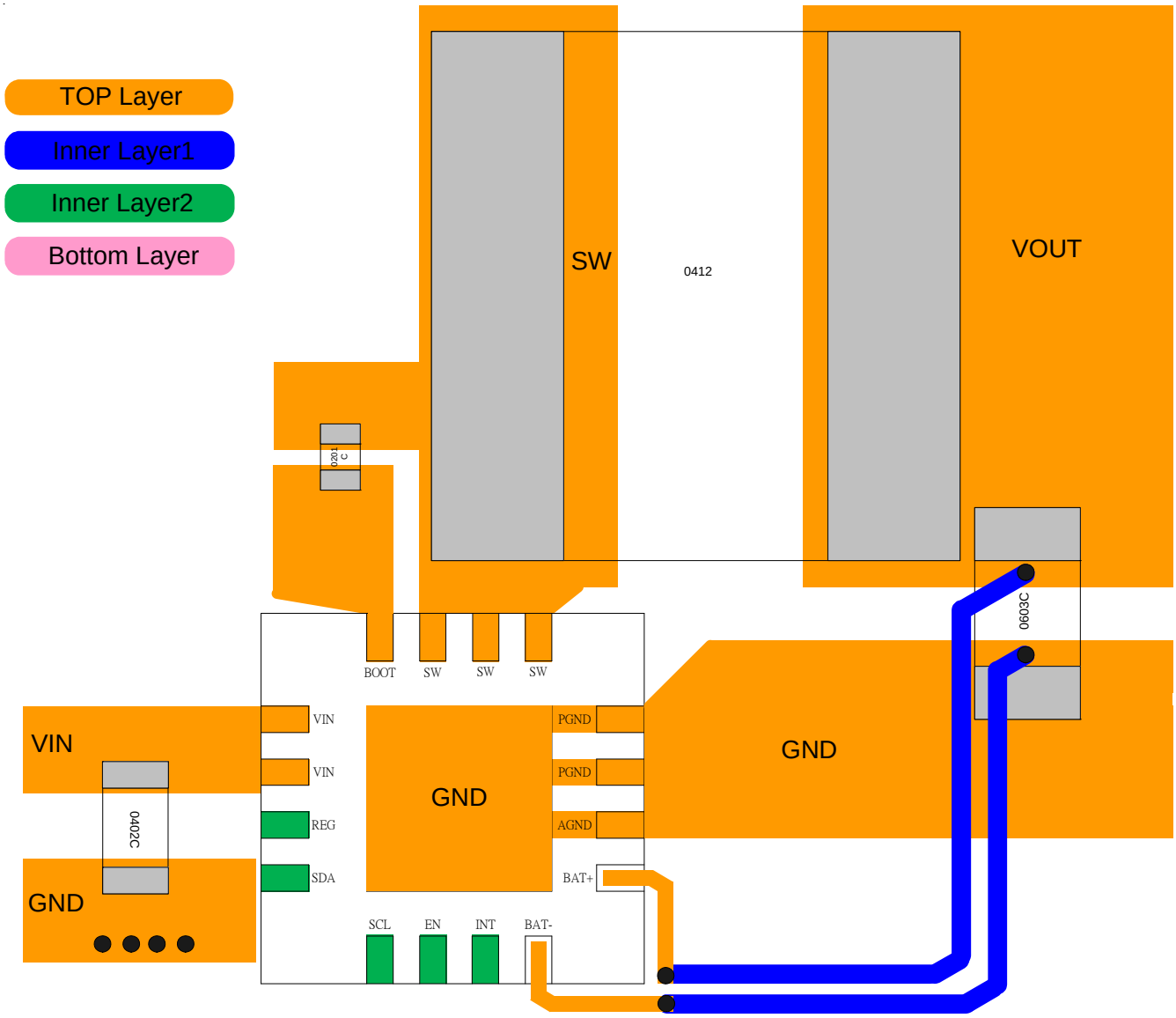
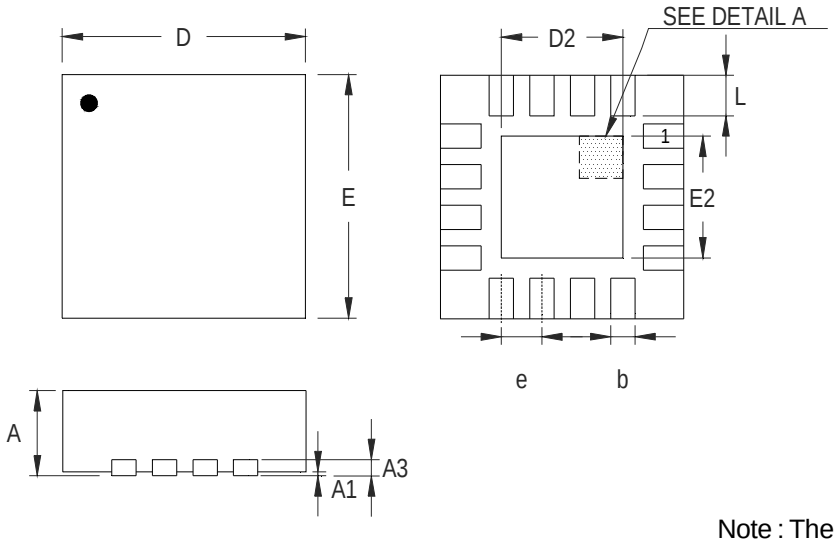
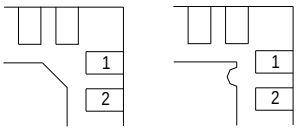


Figure 2. PCB Layout Guide

Outline Dimension





DETAIL A

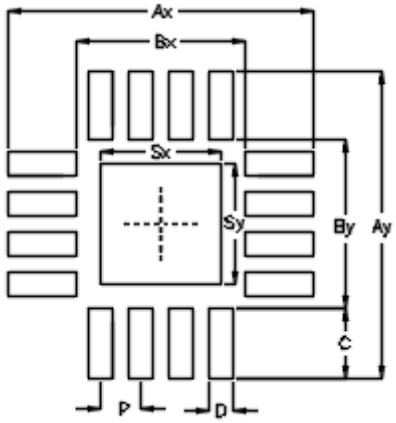
Pin #1 ID and Tie Bar Mark Options

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	0.180	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

Footprint Information



Package	Number of Pin	Footprint Dimension (mm)									Tolerance
		P	Ax	Ay	Bx	By	C	D	Sx	Sy	
V/W/U/XQFN3*3-16	16	0.50	3.50	3.50	2.10	2.10	0.70	0.30	1.50	1.50	±0.05

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