Easy to Use Power Bank Solution (EZPBS™) Integrated Chip with Switch Charger, ADC, and Load Switch

General Description

The RT9481 is a high integration and easy to use power solution for Li-ion power bank and other powered handheld applications. We call it EZPBS™ (Easy to Use Power Bank Solution). This single chip includes a Switching Charger with Boost function, Analog to Digital Converter (ADC), USBOUT Load Switch, Adapter Detection with BC1.2, DCP controller and LDO.

Applications

- Power Bank

Ordering Information

RT9481 □□

- Package Type
  QW : WQFN-24L 4x4 (W-Type)
  (Exposed Pad-Option 2)
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

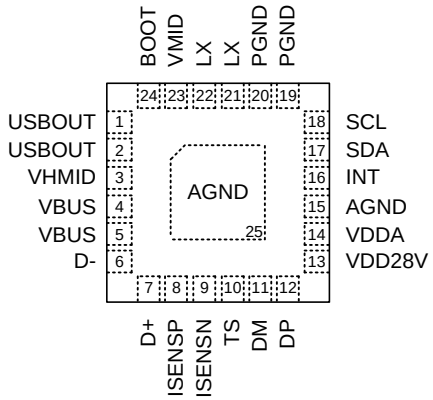
Note :

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-24L 4x4

Features

System

- **High Accuracy Voltage/Current Regulation**
  - **±1% Charge Voltage Regulation**
  - **±0.1A Charge Current Regulation**
  - **±3% Boost USBOUT Voltage Regulation**
- **Thermal Shutdown Protection**
- **Reverse Leakage Protection to Prevent Battery Drainage.**
- **Built-In USBOUT DCP Controller**
- **Built-In USBOUT Attach/Detach Detection**
- **Built-In USBOUT Light Load Detection**
- **Built-In Load Switch with Current Regulation Thermal Regulation and Output Short Current Protection**
- **Built-In Adapter Detection with BC1.2**
- **Built-In Accurate ADC to Measure VBAT, VBUS, TS, IBAT , USBOUT and IUSBOUT**
- **Built-In LDO**
- **Interrupt Output for Event Notification**
- **I^2C Interface with 400kHz**

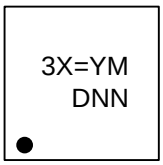
Charge Mode

- **Charge Voltage Regulation : 3.65V to 4.6V**
- **Charge Current Regulation : 0.7A to 2.7A**
- **Minimum Input Voltage Regulation (MIVR) : 4.2V to 4.8V**
- **Average Input Current Regulation (AICR) : 0.1A to 2A**
- **Charge Termination Current : 0.15A to 0.6A**
- **Pre-charge Threshold : 2.3V to 3.8V**
- **Pre-charge Current : 0.2A to 0.5A**
- **Thermal Regulation**
- **VMID Under Voltage Protection**
- **VBUS Over Voltage Protection**
- **Battery Over Voltage Protection**
- **Bad Adapter Detection**

Boost Mode

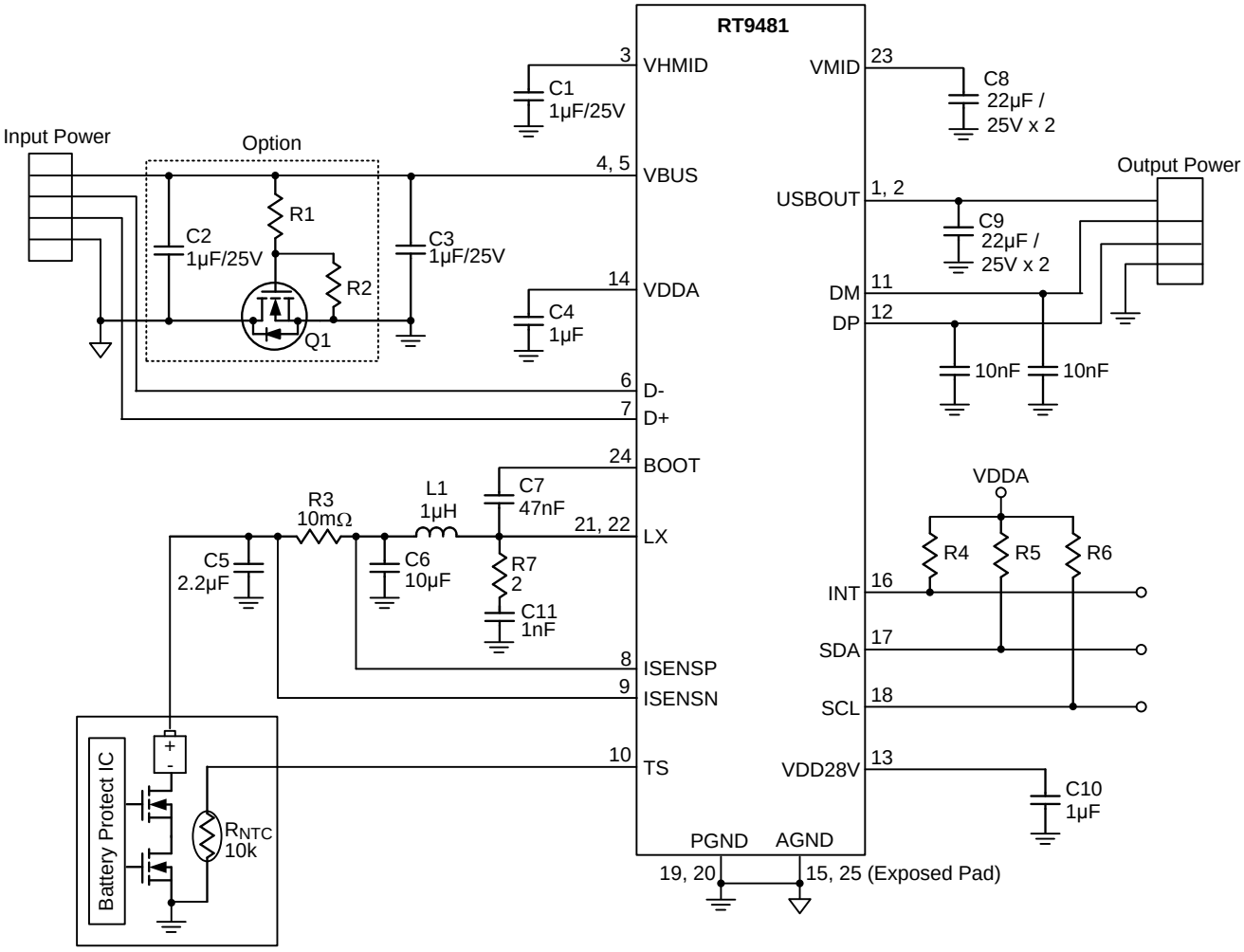
- **Boost Output Current Up to 3A**
- **Boost Output Voltage : 3.65V to 5.2V**
- **Battery Under Voltage Protection : 2.5V to 3.2V**
- **VMID Over Voltage Protection**

Marking Information



3X= : Product Code
YMDNN : Date Code

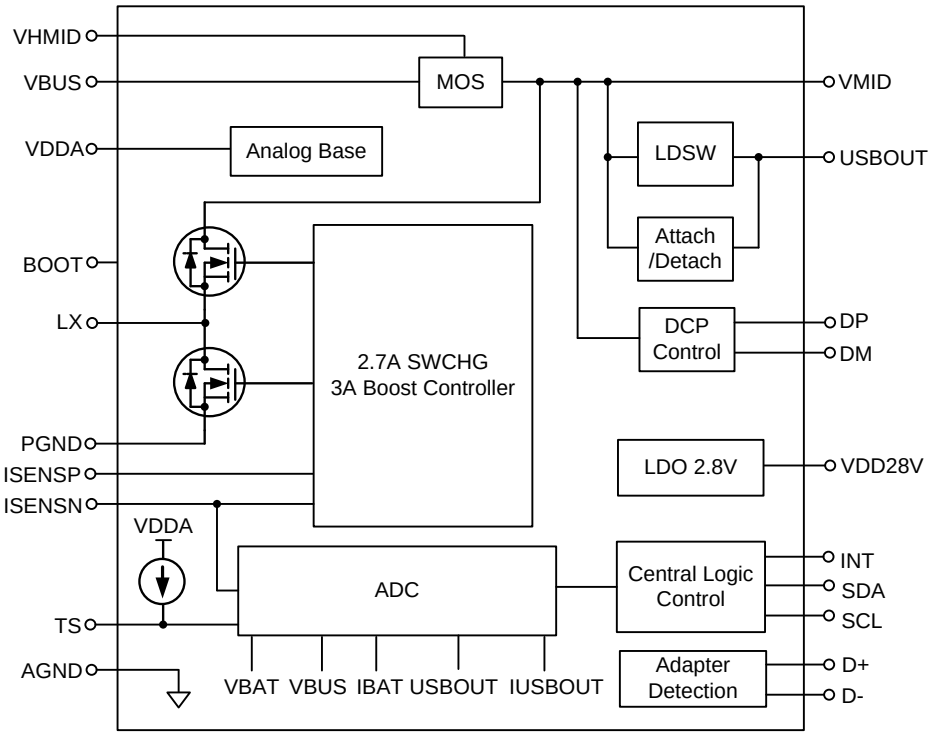
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 2	USBOUT	USB Power Output.
3	VHMID	Internal Use Only.
4, 5	VBUS	VBUS Power Supply.
6	D-	D- Input for Adapter Detection.
7	D+	D+ Input for Adapter Detection.
8	ISENSP	Charging Current Sensing Positive Node.
9	ISENSN	Charging Current Sensing Negative Node and Connect to Battery Plus Terminal.
10	TS	Battery Temperature Detection Pin.
11	DM	DCP Controller DM Output.
12	DP	DCP Controller DP Output.
13	VDD28V	Internal Use LDO Output.
14	VDDA	Internal Power for Analog Blocks, Put 1μF to GND.
15, 25 (Exposed Pad)	AGND	Analog Ground Node. The exposed pad must be soldered to a large PCB and connected to AGND for maximum power dissipation.
16	INT	Interrupter Signal. Connect an external pull-up resistor.
17	SDA	Data Input and Output for I^2C Serial Port. Connect an external pull-up resistor.
18	SCL	Clock Input for I^2C Serial Port. Connect an external pull-up resistor.
19, 20	PGND	Power Ground for Switching Charger.
21, 22	LX	Internal Switch Node to Output Inductor Connection.
23	VMID	Connection Point Between Reverse Blocking and High-Side.
24	BOOT	Bootstrap Power Node for Switching Charger.

Functional Blocks Diagram



Operation

The RT9481 is a high integrated IC for Li-Ion battery power bank. It includes a Switch charger 2.7A, a synchronous Boost 5V.

Charge Current

Base on thermal regulation function, the charging current can support up to 2.7A.

VBUS Over Voltage Protection

If the input voltage (VBUS) is higher than the threshold voltage V_{OVP}, the internal OVP signal will go high and the charger will stop charging until VIN is below V_{OVP} – hysteresis.

VMID Over Voltage Protection

If the internal voltage (VMID) is higher than the threshold voltage V_{OVP}, the internal OVP signal will go high and the charger will stop charging until VMID is below V_{OVP} – hysteresis.

VMID Under Voltage Protection

If the internal voltage (VMID) is lower than the threshold voltage VUVP, the internal VMID_UVP signal will go high and the system will disable LDSW function in order to protect system from short-to-ground current damages.

USBOUT SCP

The USBOUT short circuit protection (SCP) function will prevent system from burning out by monitoring the voltage drop between LDSW. If the USBOUT is short to ground, the inrush current will make the VDS voltage too large to damage chip. The SCP function also reports this condition to protect chip in time.

Boost OCP

The converter senses the current signal when the high-side P-MOSFET turns on. As a result, The OCP is cycle by-cycle current limitation. If the OCP occurs, the converter holds off the next on pulse until inductor current drops below the OCP limit.

OTP

The converter has an over-temperature protection.

When the junction temperature is higher than the thermal shutdown rising threshold, the system will be latched and the output voltage will no longer be

regulated until the junction temperature drops under the falling threshold.

CC/CV/TR Multi Loop Controller

There are constant current loop, constant voltage loop and thermal regulation loop to control the charging current.

Base Circuits

Base circuits provide the internal power, VDDA and reference voltage and bias current.

Buck Regulator for Charging and Boost Regulator as BOOST

The multi-loop controller controls the operation of charging process and current supply to the system. It also controls the circuits as a Boost converter for BOOST applications.

USB Charger Detection

The RT9481 detects USB Charger (Standard Charger Port, Charging Downstream Port and Dedicated Charger Port) via D+ and D- pins.

USBOUT Attach/Detach Detection

RT9481 includes an auto attach detection for the power bank product. The attach detection has a current threshold which represent an attach condition. When the attach detection is enable, the USBOUT will generate a 1.6V to monitor the load current. Once load current is greater than 5μA, the attach flag will be reported until the load current is removed.

I^2C Controller

The key parameters of charging and BOOST are programmable through I^2C commands.

Absolute Maximum Ratings (Note 1)

- VBUS, VHMID Supply Input Voltage ---------- –0.3V to 18V
- VMID ---------- –0.3V to 6.7V
- LX, BOOT ---------- –0.3V to 6V
- VMID – VBUS, BOOT– LX ---------- –0.3V to 6V
- Others ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  WQFN-24L 4x4 ---------- 3.57W
- Package Thermal Resistance (Note 2)
  WQFN-24L 4x4, θ_{JA} ---------- 28°C/W
  WQFN-24L 4x4, θ_{JC} ---------- 7.1°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) ---------- 2kV
  MM (Machine Model) ---------- 200V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage ---------- 4.3V to 5.65V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{BUS} = 5V, V_{BATS} = 4.2V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Power Source						
VBUS Operation Range			4	--	5.65	V
VBUS Supply Current	I_Q	PWM switching, I_{CHG} = I_{BAT} = 0mA	--	10	--	mA
		High Impendence Mode	--	--	200	μA
Leakage Current from Battery	I_{BAT_LEAK}	V_{BAT} = 4.2V, V_{BUS} = 0V, Charger off. 1/80 ADC execution time duty	--	40	60	μA
Protection						
VBUS OVP Threshold Voltage	V_{BUS_OVP}	VBUS Rising	5.7	6	6.3	V
VBUS OVP Hysteresis	$V_{BUS\_OVP\_HYS}$	VBUS Falling	--	200	--	mV
VBUS UVLO	V_{BUS_UVLO}	VBUS Rising	3	3.25	3.5	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VBUS UVLO Hysteresis	$V_{BUS\_UVLO\_HYS}$	VBUS Falling	--	150	--	mV
ISENSN OVP	V_{BAT_OVP}	VISENSN Rising	103	107	114	%
ISENSN OVP Hysteresis	$V_{BAT\_OVP\_HYS}$	VISENSN Falling	--	5	--	%
Over Temperature Protection	T_{OTP}	(Note 5)	--	160	--	°C
OTP Hysteresis	T_{OTP_HYS}		--	20	--	°C
Thermal Regulation Threshold	T_{REG}	Optional 100/120/135°C by I^2C (Default value is 120°C)	--	120	--	°C
Input Power Source Detection						
Poor Source Detect Threshold	V_{BUS_pr}	Bad Voltage Source Detection	3.6	3.8	4	V
Poor Source Detect Deglitch	$t_{VBUS\_pr\_dg}$		--	30	--	ms
Poor Source Detect Hysteresis	$V_{BUS\_pr\_hys}$	VBUS Rising	100	--	200	mV
Current Sink to GND	I_{VBUS_pr}	During Poor Source Detection	--	50	--	mA
Detection Interval Time	$t_{VBUS\_pr\_int}$		--	2	--	s
Sleep Mode Comparator						
Sleep-Mode Entry Threshold VBUS – ISENSN	V_{SLP}	3V < V_{ISENSN} < V_{BATREG}, VBUS Falling	--	40	100	mV
Sleep-Mode Exit Hysteresis VBUS Symbol ISENSN	$V_{SLPEXIT}$	3V < V_{ISENSN} < V_{BATREG}, VBUS Rising	40	120	200	mV
Sleep-Mode Deglitch Time	t_{SLP}	VBUS Rising Above V_{SLP} + $V_{SLPEXIT}$	--	30	--	ms
Minimum Input Voltage Regulation (MIVR)						
Minimum Input Voltage Regulation	V_{MIVR}	Optional 4.2V to 4.8V by I^2C per 0.1V (Default value is 4.7V)	4.2	--	4.8	V
V_{MIVR} Accuracy			–5	--	5	%
Average Input Current Regulation (AICR) Accuracy	I_{AICR_100mA}	I_{AICR} = 100mA	80	90	100	mA
	I_{AICR_500mA}	I_{AICR} = 500mA	400	450	500	
	I_{AICR_700mA}	I_{AICR} = 700mA	560	630	700	
	I_{AICR_1000mA}	I_{AICR} = 1000mA	800	900	1000	
AICR Range	I_{AICR}	Optional 100mA to 2000mA by I^2C (Default value is 0.5A)	100	--	2000	mA
VDDA Regulator						
VDDA Voltage	VDDA	V_{VBUS} > 4.5V	--	4.5	--	V
		V_{VBUS} < V_{ISENSN}	--	V_{ISENSN}	--	
VDDA UVLO	V_{DDA_UV}	VDDA Risling	2.4	2.5	2.6	V
VDDA UVLO Hysteresis	$V_{DDA\_UV\_hys}$	VDDA Falling	--	150	--	mV

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Battery Voltage Regulation						
Battery Voltage Regulation	V_{BATREG}	Optional 3.65V to 4.6V by I^2C per 25mV (Default value is 4.2V)	3.65	--	4.6	V
V_{BATREG} Accuracy			–1	--	1	%
Re-Charge Threshold	ΔV_{REG}	V_{ISENSN} Falling, $\Delta V_{REG} = (V_{BATREG} - V_{REC})$	50	125	200	mV
Re-Charge Deglitch Time	t_{REC}		--	128	--	ms
Charging Current Regulation						
Output Charging Current	I_{CHG}	R_{SENSE} = 10mΩ, Optional 0.7A to 2.7A by I^2C per 0.25A (Default value is 0.7A)	0.7	--	2.7	A
I_{CHG} Accuracy	I_{CHG_ACC}	R_{SENSE} = 10mΩ	–100	--	100	mA
Pre-Charge Threshold	V_{PREC}	Rising, Optional 2.3V to 3.8V by I^2C per 0.1V (Default value is 3V)	2.3	--	3.8	V
V_{PREC} Accuracy			–5	--	5	%
Pre-Charge Current	I_{PREC}	Optional 200mA to 500mA by I^2C per 100mA (Default value is 300mA)	200	--	500	mA
I_{PREC} Accuracy			–20	--	20	%
Charge Termination Detection						
End of Charge Current	I_{EOC}	R_{SENSE} = 10mΩ, Optional 150mA to 600mA by I^2C (Default value is 200mA)	150	--	600	mA
I_{EOC} Accuracy		R_{SENSE} = 10mΩ	–100	--	100	mA
Deglitch Time for EOC	t_{EOC}	$I_{CHG} < I_{EOC}$, $V_{ISENSN} > (V_{BATREG} - \Delta V_{REG})$ Optional 4ms to 32ms by I^2C (Default value is 32ms)	4	--	32	ms
Charger Timer Protection						
Fast-Charge Time-Out		Optional 6Hrs to 20Hrs by I^2C per 2Hrs (Default value is 20Hrs)	6	--	20	Hrs
Pre-Charge Time-Out		Optional 30Mins to 60Mins by I^2C per 15Mins (Default value is 60Mins)	30	--	60	Mins
PWM Switching Charger						
VBUS to LX Resistance	$R_{DS(ON)\_VBUS\_LX}$	From VBUS to LX, as IAICR disable or I_{AICR} = 2A	--	97	--	mΩ
VBUS to USBOUT Resistance	$R_{DS(ON)\_VBUS\_USBOUT}$	From VBUS to USBOUT	--	98	--	mΩ
Low-Side On-Resistance	$R_{DS(ON)\_LS}$	From LX to PGND	--	35	--	mΩ

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Efficiency for Charge	EFF_CHG	V_{BUS} = 5V, V_{ISENSN} = 4V, and I_{CHG} = 2A	--	90	--	%
Oscillator Frequency	f_{OSC}		--	0.75	--	MHz
Frequency Accuracy			–10	--	10	%
Maximum Duty Cycle	D_{MAX}	At Minimum Voltage Input	--	95	--	%
Minimum Duty Cycle	$D_{(MIN)}$		0	--	--	%
Peak OCP as Charger Mode			--	4.5	--	A
Boost Mode Operation						
Output Voltage Level	V_{BOOST}	To VMID Optional 3.625V to 5.2V by I^2C per 25mV (Default value is 5.1V)	3.625	--	5.2	V
Output Voltage Accuracy			–3	--	3	%
Output Current On VMID	I_{BST}	V_{BAT} > 3V	3	--	--	A
Efficiency for Boost	EFF_BST	V_{MID} = 5V, V_{ISENSN} = 4V, and Loading = 2A	--	92	--	%
Peak OCP as Boost Mode	I_{OCP_BST}		--	6	--	A
VMID OVP as Reverse Boost	V_{OVP_BST}	VMID Rising	--	6	--	V
VMID OVP Hysteresis	$V_{OVP\_BST\_HYS}$	VMID Falling	--	200	--	mV
Battery UVP for Boost	V_{BATMIN}	Falling, I^2C Programmable Per 0.1V Optional 2.5V to 3.2V by I^2C per 0.1V (Default value is 3V)	2.5	--	3.2	V
NTC Function						
Current Source for NTC 10kΩ	ITS_10k		33	35	37	μA
Load Switch for USBOUT						
Supply Voltage	V_{SW}		2.5	5	5.5	V
Load Switch On Resistance of MOSFET	$R_{DS(ON)\_SW}$	V_{MID} = 5V, I_O = 1000mA	--	35	--	mΩ
Load Switch UVP Delta	$V_{SW\_UVP\_D}$	VMID – VUSBOUT	--	1.4	--	V
Light Load Detection Current	I_{DET_10mA}	Detection current	--	10	--	mA
Thermal Regulation Threshold of the Load Switch	T_{REG_LSW}	Optional 100°C to 135°C by I^2C (Default value is 100°C)	--	100	--	°C
Adapter Detection						
D+ Voltage Source	V_{D+_SRC}		0.5	--	0.7	V
VDAT_REF Voltage	V_{DAT_REF}		0.25	--	0.4	V
VLGC Voltage	V_{LGC}		0.8	--	2	V
D- Sink Current	I_{DN_SINK}		50	--	150	μA

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
USBOUT Attach/Detach Detection						
USBOUT Attach Voltage		I_{USBOUT} = 1.5μA	1.4	1.6	1.8	V
USBOUT Attach/Detach Threshold		C_{USBOUT} = 40μF, Note 6	1	5	10	μA
Detect Time 1		V_{BAT} = 3V, C_{OUT} = 30μF, 0X24[4:2] = 010	--	375	--	ms
Detect Time 2		V_{BAT} = 3V, C_{OUT} = 50μF, 0X24[4:2] = 100	--	600	--	ms
LDO 2.8V						
Output Voltage	$V_{OUT\_2.8V}$	C_{OUT} = 1μF	2.66	2.8	2.94	V
Output Current	$I_{OUT\_2.8V}$	VDDA > 3V	10	--	--	mA
The Time for VOUT Ready	$t_{RDY\_2.8V}$	C_{OUT} = 1μF	1	--	--	ms
ADC Characteristics						
Resolution			--	12	--	Bit
Measurement Error	V_{GERR}	VBAT, TS	–10	--	10	mV
		VBUS, USBOUT	–50	--	50	mV
		I_{BAT} < 1A	–100	--	100	mA
		I_{BAT} > 1A	–10	--	20	%
		I_{USBOUT} < 1A	–100	--	100	mA
		I_{USBOUT} > 1A	–10	--	10	%
Conversion Time	T_{CONV}		--	--	25	ms
Logic Inputs (SDA SCL)						
SDA, SCL Input Threshold Voltage — High-Level			1.5	--	--	V
SDA, SCL Input Threshold Voltage — Low-Level			--	--	0.4	V
Open Drain Low Voltage	VODL	I_{SINK} = 1mA	--	--	0.4	V
I²C Timing Characteristics						
SCL Clock Rate	f_{SCL}	VDDA = 3.3V	--	--	400	kHz
Hold Time (Repeated) START Condition. After this period, the first clock pulse is generated	$t_{HD;STA}$		0.6	--	--	ms
Input Power						
DCP Controller Power UVLO Threshold Voltage from VMID	$V_{UVLO\_R\_DCP\_CTRL}$	Rising	3.9	4.1	4.3	V
UVLO Hysteresis	$V_{UVLO\_F\_CP\_CTRL}$	Falling	100	200	300	mV
DCP Controller Supply Current	I_{DCP_CTRL}	4.5V < V_{UID} < 5V	--	150	200	μA
BC1.2 DCP Mode						
DP and DM Shorting Resistance	R_{DPM_SHORT}	V_{DP} = 0.8V, I_{DM} = 1mA	--	157	200	Ω

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Resistance Between DP/DM and GND	R_{DCHG_SHORT}	DP = 0.8V	350	656	1150	kΩ
Voltage Threshold on DP1 under which the Device Goes Back to Divider Mode	$V_{DPL\_TH\_DET}$	Falling	310	330	350	mV
Hysteresis	$V_{DPL\_TH\_DET\_HYS}$	Rising	--	50	--	mV
DIVIDER Mode						
DP Output Voltage for DIVIDER Mode	$V_{DP\_2.7V}$	V_{UID} = 5V	2.57	2.7	2.84	V
DM Output Voltage for DIVIDER Mode	$V_{DM\_2.7V}$	V_{UID} = 5V	2.57	2.7	2.84	V
DP Output Impedance for DIVIDER Mode	R_{DP_PAD1}	I_{DP} = –5μA	24	30	36	kΩ
DM Output Impedance for DIVIDER Mode	R_{DM_PAD1}	I_{DM} = –5μA	24	30	36	kΩ
DP and DM Shorting Resistance	R_{PM_short}		--	150	200	Ω
1.2V / 1.2V Mode						
DP Output Voltage for 1.2V Mode	$V_{DP\_1.2V}$		1.12	1.2	1.28	V
DP Output Impedance for 1.2V Mode	R_{DP_PAD}		80	102	130	kΩ

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 recommended.

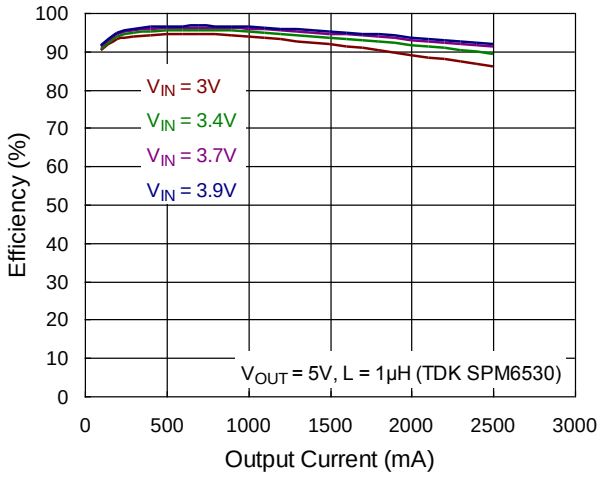
Note 4. The device is not guaranteed to function outside its operating conditions.

Note 5. Guarantee by design.

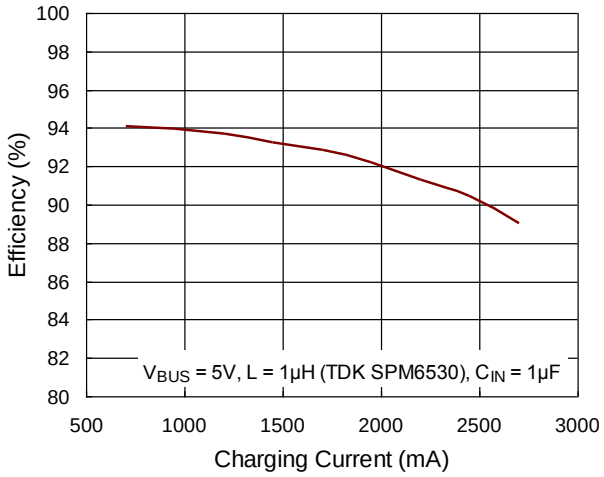
Note 6. It will attach when only plug-in APPLE charging line.

Typical Operating Characteristics

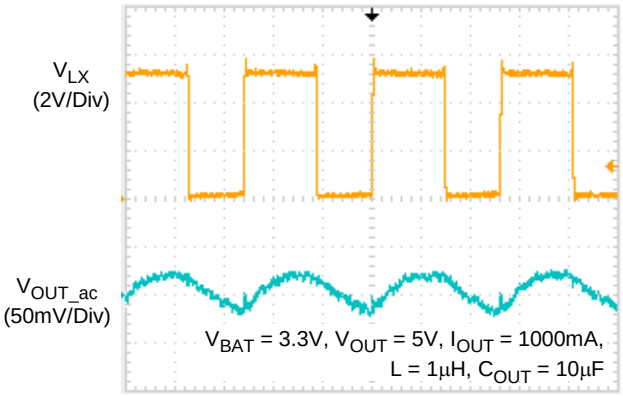
Boost Efficiency vs Output Current



Charging Efficiency vs. Charging Current



Steady State



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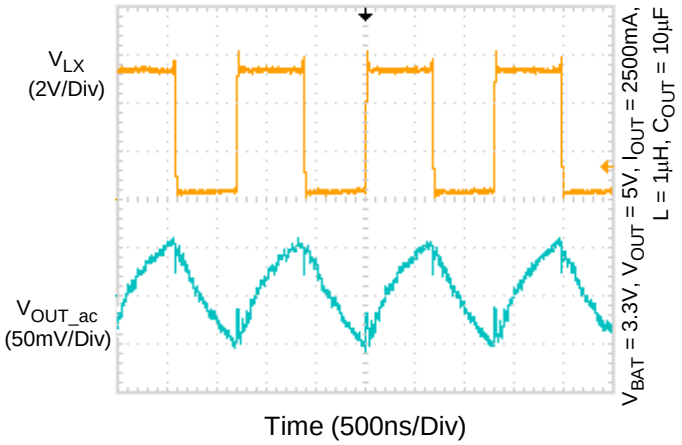

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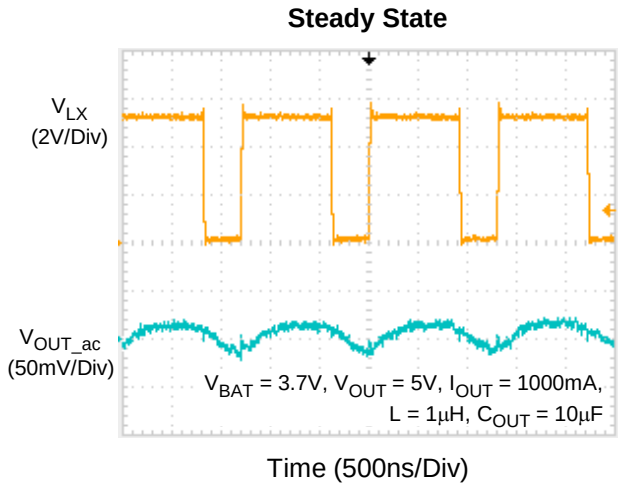
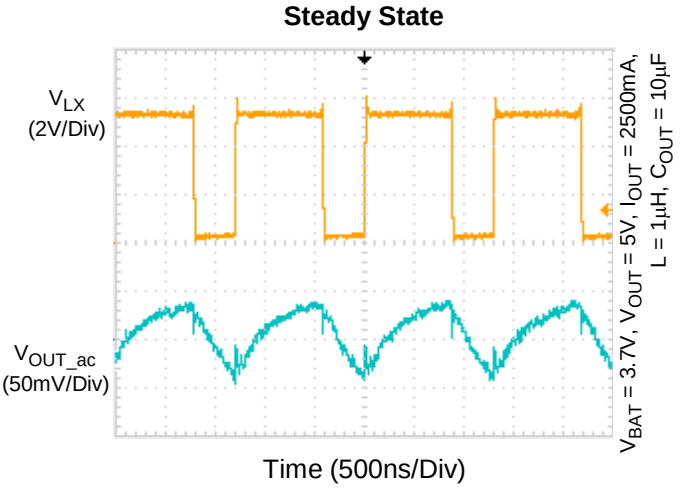


Steady State



Application Information

Switching Charger

The switching charger integrates a synchronous PWM controller with power MOSFETs to provide Minimum Input Voltage Regulation (MIVR), Average Input Current Regulation (AICR), high accuracy current and voltage regulation, and charge termination.

In charge mode, the switching charger supports a precision charging system for single cell. In boost mode, the switching charger works as the boost converter. And in high impedance mode, the switching charger stops charging or boosting and operates in a mode with low current from battery to reduce the power consumption when the portable device is in standby mode.

Notice that the switching charger does not integrate input power source (AC adapter or USB input) charging detection. Thus, the switching charger does not set the charge current automatically. The charge current needs to be set via I^2C interface by the host. The switching charger application mechanism and I^2C compatible interface are introduced in later sections.

Charge Mode Operation

Minimum Input Voltage Regulation (MIVR)

The switching charger features Minimum Input Voltage Regulation 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. VBUS is regulated at a predetermined voltage level which can be set as 4.2V to 4.8V per 0.1V by I^2C interface. At this time, the current drawn by the switching charger equals to the maximum current value that the input power can provide at the predetermined voltage level, instead of the set value.

Table 1. MIVR Register Setting Table

MIVR[2:0]	V_{MIVR}
000	Disable
001	4.2V
010	4.3V
011	4.4V
100	4.5V
101	4.6V
110	4.7V (default)
111	4.8V

Charge Profile

The switching charger provides a precision Li-ion or Li-polymer charging solution for single-cell applications. Input current limit, charge current, termination current, charge voltage and input voltage MIVR are all programmable via the I^2C interface. In charge mode, the switching charger has five control loops to regulate input current, charge current, charge voltage, input voltage MIVR and device junction temperature. During the charging process, all five loops (if MIVR is enabled) are enabled and the dominant one will take over the control.

For normal charging process, the Li-ion or Li-polymer battery is charged in three charging modes depending on the battery voltage. At the beginning of the charging process, the switching charger is in pre-charge mode. When the battery voltage rises above pre-charge threshold voltage (V_{PREC}), the switching charger enters fast-charge mode. Once the battery voltage is close to the regulation voltage (V_{BATREG}), the switching charger enters constant voltage mode.

Pre-Charge Mode

For life-cycle consideration, the battery cannot be charged with large current under low battery condition. When the ISENSN pin voltage is below pre-charge threshold voltage (V_{PREC}), the charger is in pre-charge mode with a weak charge current witch equals to the pre-charge current (I_{PREC}). In pre-charge mode, the charger basically works as a Linear Charger. The pre-charge current also acts as the current limit when the ISENSN pin is shorted.

The Pre-Charge current levels are 200mA to 500mA programmed by I^2C per 100mA.

Table 2. VPREC Register Setting Table

VPREC[2:0]	Pre-Charge Threshold
0000	2.3V
0001	2.4V
0010	2.5V
0011	2.6V
0100	2.7V
0101	2.8V
0110	2.9V
0111	3V (default)
1000	3.1V
1001	3.2V
1010	3.3V
1011	3.4V
1100	3.5V
1101	3.6V
1110	3.7V
1111	3.8V

Table 3. IPREC Register Setting Table

IPREC[1:0]	Pre-Charge Current
00	200mA
01	300mA (default)
10	400mA
11	500mA

Fast-Charge Mode and Settings

As the ISENSN pin rises above V_{PREC}, the charger enters fast-charge mode and starts switching. Notice that the switching charger does not integrate input power source (AC adapter or USB input) detection. Thus, the switching charger does not set the charge current automatically. Unlike the linear charger (LDO), the switching charger (Buck converter) is a current amplifier. The current drawn by the switching charger is different from the current into the battery. The user can set the Average Input Current Regulation (AICR) and output charge current (I_{CHRG}) respectively.

Cycle-by-Cycle Current Limit

The charger of the switching charger has an embedded cycle-by-cycle current limit for inductor. Once the inductor current touches the threshold, the charger stops charging immediately to prevent over current from damaging the device. Notice that, the mechanism cannot be disabled by any way.

Adapter Detection

RT9481 includes the VBUS detection function. When VBUS plugs in, CHGGOODADP_STAT will reset to 0 once VBUS not rising exceeds 3.8V after 16ms. Besides, if VBUS falling below 3.8V during the charging interval, CHGBADADP_ STAT is set as 1 to inform customer the poor adapter situation.

Average Input Current Regulation (AICR)

The AICR levels are 100mA to 2A programmed by I^2C per 50mA.

Charge Current (I_{CHRG})

The charge current into the battery is determined by the sense resistor (R_{SENSE}) and ICC setting by I^2C. The voltage between the ISENSP and ISENSN pins is regulated to the voltage control by ICC setting.

As the R_{SENSE} is 10mΩ, the Fast-Charge currents are 700mA to 2.7A programmed by I^2C per 250mA.

Table 4. ICHG Register Setting Table

ICHG[3:0]	VCC	ICHG R_{SENSE} is 10mΩ
0000	7mV	0.7A (default)
0001	9.5mV	0.95A
0010	12mV	1.2A
0011	14.5mV	1.45A
0100	17mV	1.7A
0101	1.95mV	1.95A
0110	2.2mV	2.2A
0111	2.45mV	2.45A
1000	2.7mV	2.7A

Constant Voltage Mode and Settings

The switching charger enters constant voltage mode when the VBAT voltage is close to the output-charge voltage (V_{BATREG}). Once in this mode, the charge current begins to decrease. For default settings (charge current termination is disabled), the switching charger does not turn off and always regulates the battery voltage at V_{BATREG}. However, once the charge current termination is enabled, the charger terminates if the charge current is below termination current (I_{EOC}) in constant-voltage mode. The charge current termination function is controlled by the I^2C interface.

After termination, a new charge cycle restarts when one of the following conditions is detected :

- The ISENSN pin voltage falls below the V_{BATREG} as V_{REC} threshold.
- VBUS Power On Reset (POR).
- Enable bit toggle or Charger reset (via I^2C interface)

Battery Charge Voltage (V_{BATREG})

The output-charge voltage is set by the I^2C interface. Its range is from 3.65V to 4.6V per 25mV.

Termination Current (I_{EOC})

If the charger current termination is enabled (TE bit = "1"), the end-of-charge current is determined by both the termination current sense voltage (V_{EOC}) and sense resistor (R_{SENSE}). As R_{SENSE} is 10mΩ, I_{EOC} is set by the I^2C interface from 150mA to 600mA.

Table 5. EOC Register Setting Table

EOC[2:0]	VEOC	IEOC R_{SENSE} is 10mΩ
000	Disable	Disable
001	1.5mV	150mA
010	2mV	200mA (default)
011	2.5mV	250mA
100	3mV	300mA
101	4mV	400mA
110	5mV	500mA
111	6mV	600mA

VBUS Voltage Protection in Charge Mode

During charge mode, there are two protection mechanisms against if input power source capability is less than the charging current setting. One is AICR and the other is minimum input voltage regulation. A suitable level of AICR can prevent VBUS drop by the insufficient capability. As the AICR setting is not suitable, MIVR will regulate the VBUS in the setting level and sink the maximum current of power source.

Sleep Mode ($V_{VBUS} - V_{VBAT} < V_{SLP}$)

The switching charger enters sleep mode if the voltage drop between the VBUS and ISENSN pins falls below V_{SLP}. In sleep mode, the reverse blocking switch and PWM are all turned off. This function prevents battery drain during poor or no input power source.

VBUS Over Voltage Protection

When VBUS rises above the input over voltage threshold, the switching charger stops charging and then sets fault status bits. The condition is released when VBUS falls below OVP threshold. The switching charger then resumes charging operation.

Reverse Boost Mode Operation Trigger and Operation

The switching charger features Boost support. When BOOST function is enabled, the synchronous boost control loop takes over the power MOSFETs. In boost mode, the VMID pin is regulated to 5V (typ.) to support other BOOST devices connected to the USB connector.

USBOUT Over-Voltage Protection

In boost mode, the output over voltage protection is triggered when the VMID voltage is above the output OVP threshold. When OVP occurs, the boost converter stops switching and turns off immediately.

Battery Protection

Battery Over-Voltage Protection in Charge Mode

The switching charger monitors the VBAT voltage for output over voltage protection. In charge mode, if the VBAT voltage rises above V_{OVP_BAT} x V_{BATREG}, such as when the battery is suddenly removed, the switching charger stops charging and then sets fault status bits and sends out fault pulse at the INT pin. The condition is released when the VBAT voltage falls below (V_{OVP_BAT} – ΔV_{OVP_BAT}) x V_{OVP_BAT}. The switching charger then resumes charging process with default settings and the fault is cleared.

Low Battery Voltage Protection (LBP)

When the Battery voltage is lower than a specified value, the converter will stop switching. Until the battery voltage rises above the low battery voltage protection threshold plus hysteresis voltage value, the converter resumes switching. The low battery voltage protection can be programmed with 8 different levels (2.5V to 3.2V).

Table 6. LBP Register Setting Table

LBP[2:0]	Low Battery Protection Level
000	2.5V
001	2.6V
010	2.7V
011	2.8V
100	2.9V
101	3V (default)
110	3.1V
111	3.2V

USB Battery Charging Specification

The RT9481 supports adapter detection for dedicated charging port, Charging downstream port and Standard downstream port by D- and D+.

USB Dedicated Charging Port Controller

The RT9481 supports an USB dedicated charging port (DCP) controller. The DCP controller detects USB data line voltage, and automatically provides the correct electrical signatures on the data lines (DM and DP) to charge compliant devices. D+ =2.7V and D- =2.0V. BC1.2 DCP, required to short the D+ Line to the D– Line and 1.2 V on both D+ and D– Lines.

IRQ and STA Operation

RT9481 summarize all IRQ items in the register table. All IRQ_status registers are implemented as reset after read. If IRQ_enable bit is Low, the IRQ_status bit will not update status. IRQ_enable will mask IRQ_status to trigger IRQ Low, so the system can decide which interrupt is necessary.

When STA low to high or high to low IRQ will be trigger but STA will keep situation and cannot be masked only mask IRQ.

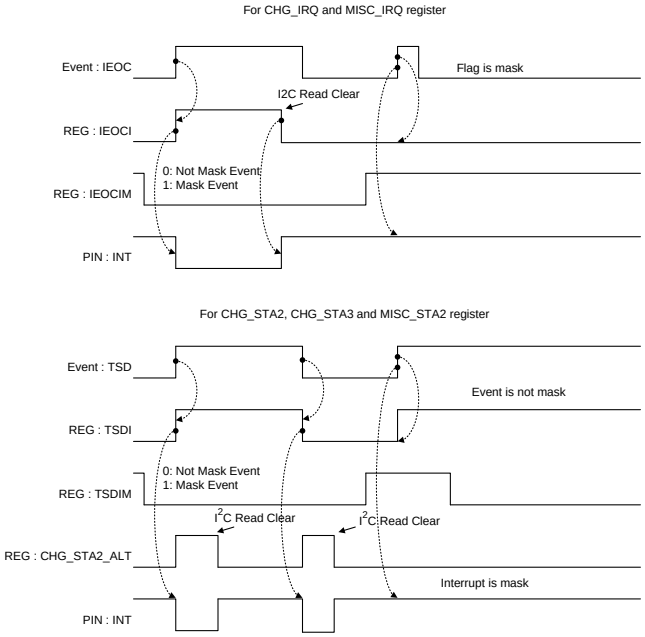


Figure 1. IRQ and STA Operation

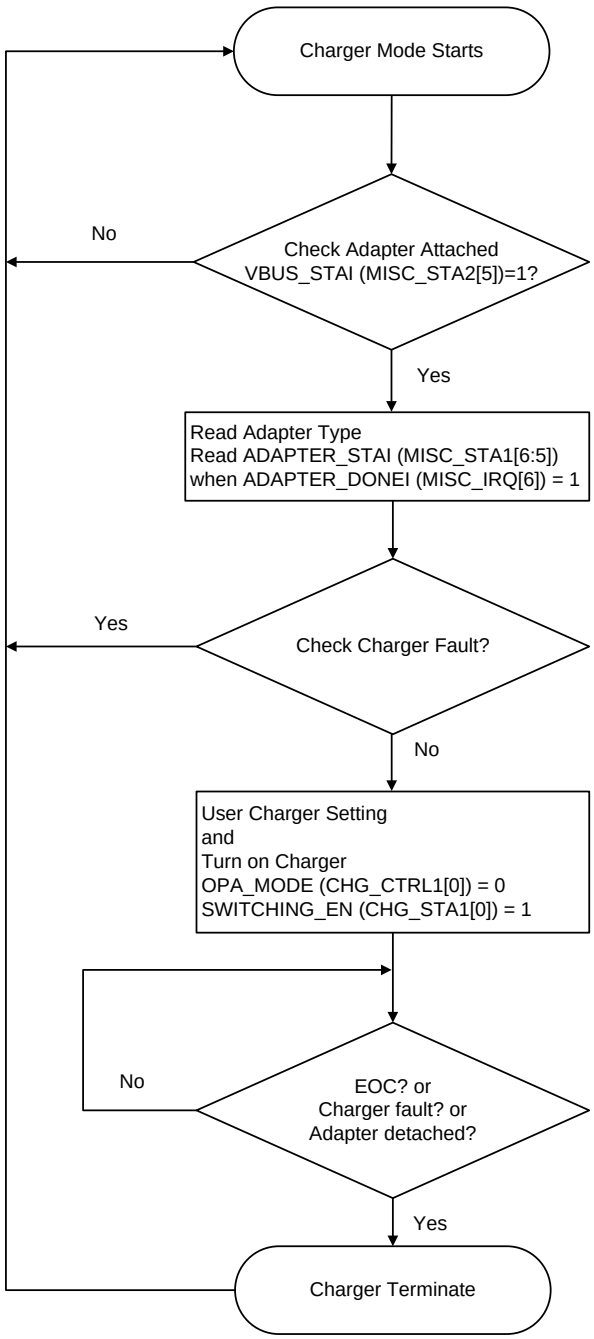


Figure 2. Charger Mode Flow

Charger Mode Flow

The Charger mode is start from adapter attached, the flag of VBUS_STAI (MISC_STA2[5]) will be set to high and the host can read this bit to check adapter attached or not. Then adapter type detection will auto start to detect the type of adapter with BC1.2 standard. Its detection result is show in the flag ADAPTER_STAI (MISC_STA1[6:5]) when ADAPTER_DONE (MISC_IRQ[6]) is set.

The host could decide the user Charger setting by adapter type, like AICR or ICHG etc… For example, set IAICR to 0.5A, if the adapter type is SDP. Set IAICR to 1.5A, if the adapter type is CDP or DCP.

If there is no Charger fault event triggered in registers CHG_STAT1 or CHG_STAT2, the host can decide to turn on Charger or not. Set user Charger setting from registers CHG_CTRL1 to CHG_CTRL6 before turn on Charger. Please refer to I2C register map for detailed functional setting. To enable Charger by setting OPA_MODE (CHG_CTRL1[0]) to low and setting SWITCHING_EN (CHG_STA1[0]) to high.

When charging is start the host can check CHG_STAT (CHG_STA1[5]) to make sure the charging is in progress.

If system want to implement the charge and bypass feature, the host can set EN_LDSW (USBOUT_CTL[6]) to high to turn on Load Switch and set EN_DCP (USBOUT_CTL[7]) to high to turn on DCP Controller, then the power of adapter could bypass to device when battery is under charging.

Charger Terminate

There are three conditions to terminate Charger and the host could set SWITCHING_EN (CHG_STA1[0]) to low to turn off Charger.

End of Charge (EOC)

Set TE (CHG_CTRL1[1]) to high to enable Termination function, then the Charger will terminate automatically and CHTERMI (CHG_IRQ[7]) is set to high when the charging current is below IEOC (CHG_CTRL5[2:0]) and charging voltage is above re-charge threshold. The host could turn on Charger again when CHRCHGI (CHG_IRQ[5]) is set.

Charger Fault

The Charger automatically terminates when Charger fault event be triggered in Table 7.

Table 7. Charger Fault Event

Charger Fault Event	Flag	Register
Power Status	PWR_Rdy = 0	CHG_STA1[2]
Thermal Shutdown	TSD_STAT = 1	CHG_STA2[7]
VBUS OVP	VBUSOVP_STAT = 1	CHG_STA2[6]
Reverse Protection	CHRVP_STAT = 1	CHG_STA2[5]
Battery OVP	CHBATOV_STAT = 1	CHG_STA2[4]
Good Adaptor Detection	CHGGOODADP_STAT = 0	CHG_STA2[1]
Bad Adaptor Detection	CHGBADADP_STAT = 1	CHG_STA2[0]

Adapter Detach

The flag of VBUS_STAI will be set to low when adapter detached and it will terminate Charger directly.

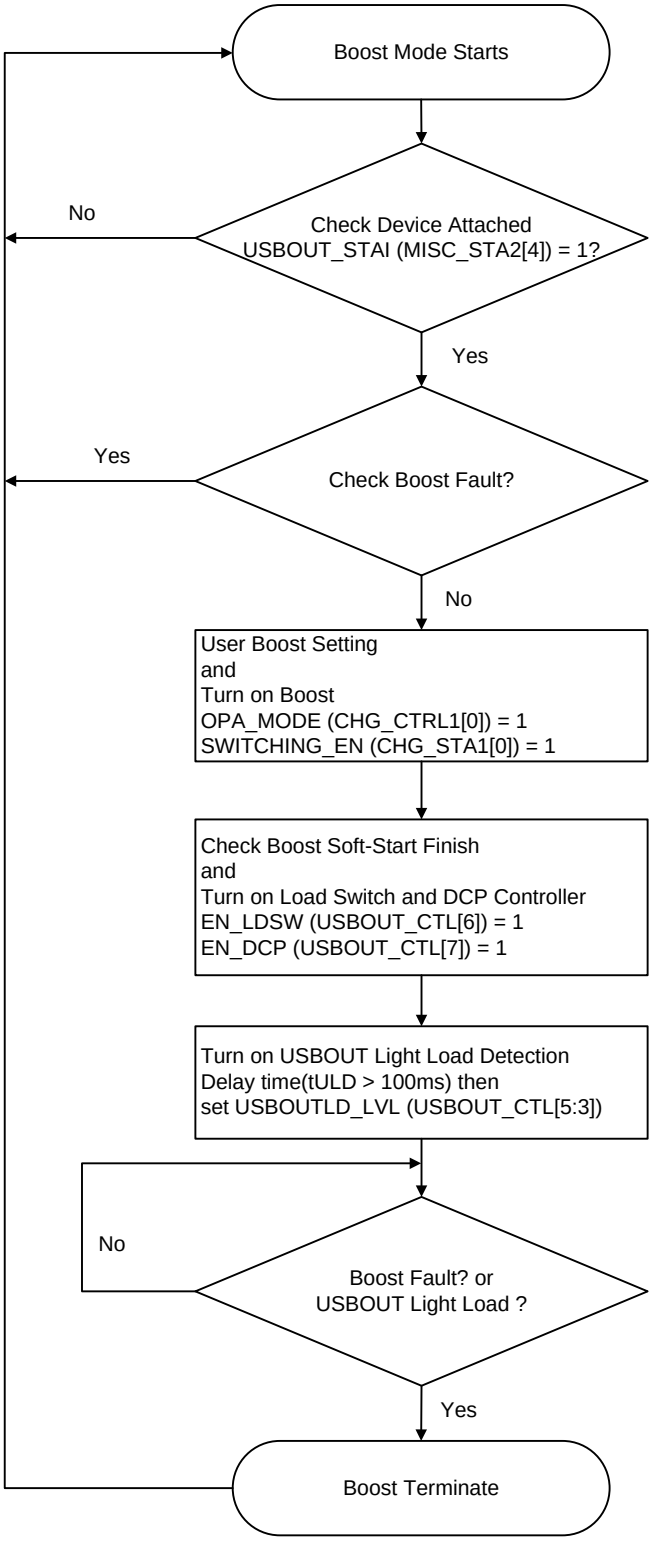


Figure 3. Boost Mode Flow

Boost Mode Flow

The Boost mode could start from device attached, and the flag of USBOUT_STAI (MISC_STA2[4]) will be set to high for indicate the device attached. The USBOUT attach detection is control by register ATTACH_CTL[5].

If there is no any Boost fault triggered in registers CHG_STAT2 or BST_IRQ or MISC_IRQ, the host can decide to turn on Boost or not. The host can set user Boost setting before turn on the Boost from registers CHG_CTRL1 to CHG_CTRL6 and please refer to I2C register map for detailed functional setting.

The Boost could be enable by set OPA_MODE (CHG_CTRL1[0]) to high and setting SWITCHING_EN (CHG_STA1[0]) to high.

Before enable the Load Switch suggest to wait Boost soft start (CHG_IRQ[3]) finish, it can guarantee the Boost ready for output.

Then the host could set EN_LDSW (USBOUT_CTL[6]) to high to turn on Load Switch and the Boost would start output current to device. For let device identify the power bank is a powerful adapter, to set EN_DCP (USBOUT_CTL[7]) to high to turn on DCP controller at the same time.

USBOUT light load detection (USBOUTLD_CTL[5:3]) can help the host to check the device charging full or device detached by the condition of USBOUT current is under the threshold or not. But according to USB standard, the device will start charging after it connect to adapter 100 millisecond. We suggest to add delay time t_{ULD} over 100 millisecond before enable USBOUT light load detection after Load Switch turn on. It could avoid USBOUT light load detection trigger early.

The host could read BOOST_STAT (CHG_STA1) to make sure the Boost is in progress.

Discharging Terminate

There are two conditions to terminate discharging.

Boost Fault

The Boost automatically terminates when Boost fault event be triggered in Table 8.

Table 8. Boost Fault Event

Boost Fault Event	Flag	Register
Thermal Shutdown	TSD_STAT	CHG_STA2[2]
Boost Thermal Shutdown	BSTTSDI	BST_IRQ[7]
VMID Over Voltage Protect	BSTVMIDVPI	BST_IRQ[6]
Battery Voltage is too Low	BSTLOWVI	BST_IRQ[5]
Load Switch Short Current Protect	LDSW_SCPI	MISC_IRQ[5]
VMID Short Current Protect	VMIDSCPI	MISC_IRQ[1]
VMID Under Voltage Protect	VMIDUVPI	MISC_IRQ[0]

USBOUT Light Load

It means device charging full or device detached when USBOUTLD_STAT (MISC_STA2) set to high. According to USBOUTLD_STAT, the host could decide to turn off Boost or not.

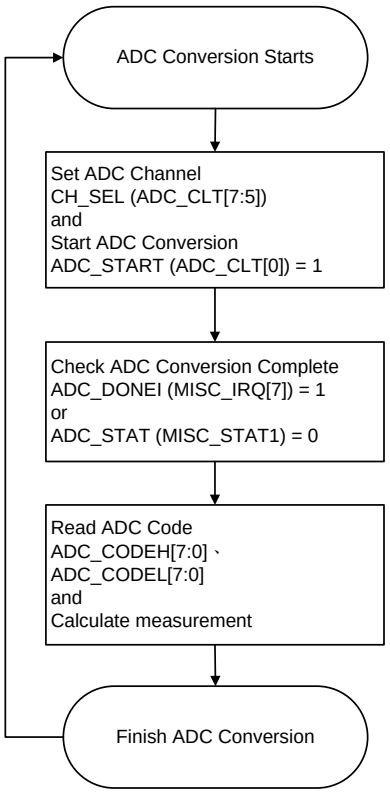


Figure 4. ADC Conversion Operation Flow

ADC Conversion Operation Flow

Figure 4 shows ADC conversion operation flow. ADC conversion starts from set ADC channel CH_SEL (ADC_CLT[7:5]) and set ADC_START (ADC_CLT[0]) to high. ADC conversion time is 25ms and ADC_DONEI (MISC_IRQ[7]) will set to high and ADC_STAT (MISC_STAT1) will set to low also, the host could read them to make sure ADC conversion completes.

The host could read ADC code high byte (ADC_CODEH[7:0]) and low byte (ADC_CODEL[7:0]) to calculate the voltage or current measurement relative to ADC channel.

Table 9 shows the every measurement equation of ADC channel. Please pay attention to the calculation of IBAT, it need to consider the setting of ICHG (CHG_CTRL6[7:4]).

ADC code format is unsigned. If operation is Charger mode, IBAT means battery charging current. If operation is boost mode, IBAT means battery discharging current.

The code of IBAT is invalid if SWITCHING_EN (CHG_STA1[0]) is set to low. And the code of IUSBOUT is invalid if EN_LDSW (USBOUT_CTL[6]) is set to low.

The TS pin will automatic output 35uA during ADC TS channel under conversion. It will cause the IR drop on NTC thermistor and then ADC measure the voltage on TS pin. The host could get the temperature by mapping the voltage. We suggest to use 10kΩ NTC which the beta (B25/85) is 3435k, like SEMITEC 103AT.

Table 9. Calculate Voltage or Current Measurement

ADC Channel	Measurement Equation	Measurement Range
VBAT	VBAT = ((ADC_CODEH x 256) + ADC_CODEL) x 1.25 mV	0V to VDDA
VBUS	VBUS = ((ADC_CODEH x 256) + ADC_CODEL) x 6.25 mV	1V to 18V
USBOUT	USBOUT = ((ADC_CODEH x 256) + ADC_CODEL) x 6.25 mV	1V to 6V
TS	TS = ((ADC_CODEH x 256) + ADC_CODEL) x 1.25 mV	0V to VDDA
IBAT	IBAT = ((ADC_CODEH x 256) + ADC_CODEL) x ICHG x 1.25 mA	0A to 6A
IUSBOUT	IUSBOUT = ((ADC_CODEH x 256) + ADC_CODEL) x 2.5 mA	0A to 6A

Table 10. Protection Items

	Protection Type	Threshold (typical) Refer to Electrical Spec.	Protection Methods	IC Shutdown Delay Time	Reset Method
VBAT	LBP	VBAT < LPB setting	Exist boost mode	None	VDDA power reset
	OVP	VBAT > 1.07 x CHG_CV	Stop charging	None	VDDA power reset or VBAT falling to 1.02 x CHG_CV
VDDA	UVP	VDDA < 2.35V	analog circuit disable	None	VDDA >2.5V
VBUS	OVP	VBUS > 6V	Stop charging, UUG disable	None	VDDA power reset or VBUS falling to VBUSOVP-hysteresis
	Bad adapter	VBUS < 3.8V	None	None	VDDA power reset or VBUS rising to VBUS_BAD + hysteresis
	Good adapter	None	None	None	None
	RVP	VBUS < VBAT	Stop charging, UUG disable	None	VDDA power reset or VBUS rising above VBAT
	TREG	Temp. ≒ Thermal regulation setting	None	None	VDDA power reset or thermal loop release
	MIVR	VBUS ≒ MIVR setting	None	None	VDDA power reset or MIVR loop release
	AICR	IBUS ≒ AICR setting	None	None	VDDA power reset or AICR loop release
VMID	OVP	N/A	N/A		N/A
	UVP	3.5V	Absolute voltage below threshold		sEn_VMIDUVP
	SCP	3.5V	Absolute voltage below threshold		sEn_VMIDUVP
USBOUT	LDSWREG	1.5A/2A/2.5A/3A	Load current is above current limit		sEn_LDSW
	LDSWSCP	VDS~1.4V	VDS voltage is too high		sEn_LDSW
	Current limit	1.5A/2A/2.5A/3A	Load current reach to limit-point		sEn_LDSW
Boost	Current limit	Inductor current > 6A	cycle by cycle, inductor current limit	None	Inductor current < 6A
OTP	Thermal Shutdown	Temp > 160°C	Stop charging, UUG disable	None	Temp < 160°C

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-24L 4x4 package, the thermal resistance, θ_{JA}, is 28°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°C /W) = 3.57W for WQFN-24L 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 5 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

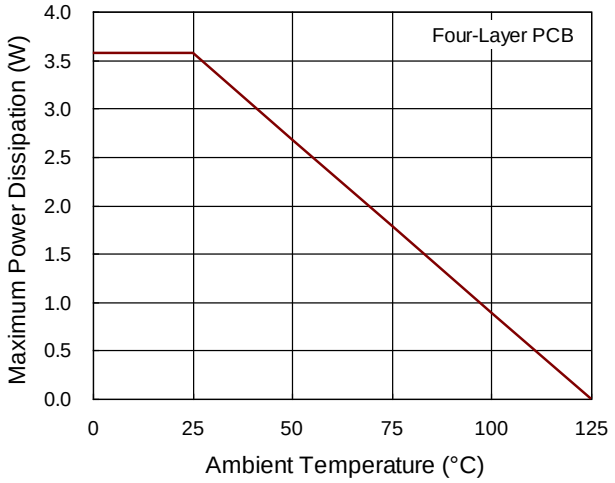


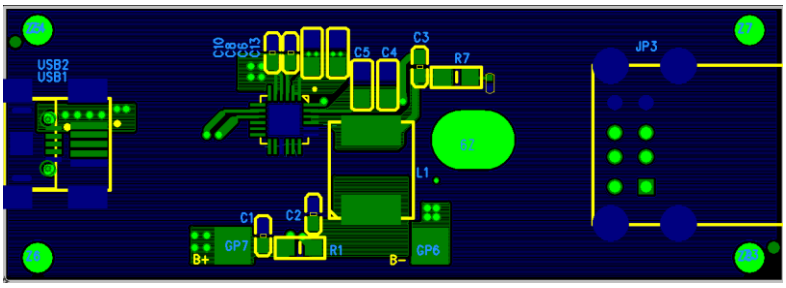
Figure 5. Derating Curve of Maximum Power Dissipation

Layout Considerations

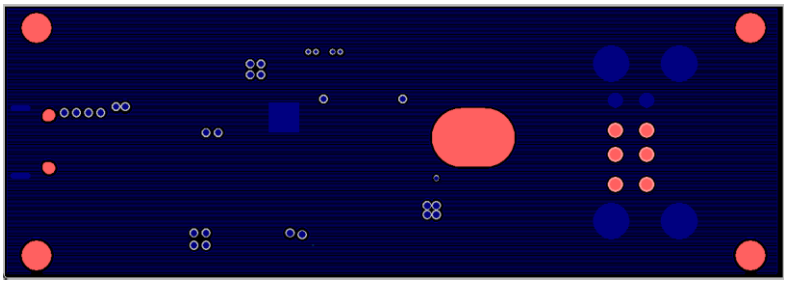
Some PCB layout guidelines for optimal performance of RT9481 list as following. Following figure shows the real PCB layout considerations and it is based on the real component size whose unit is millimeter (mm).

- 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 boot capacitor should be placed close to the chip and LX pins.
- The battery voltage sensing point should be placed after the output capacitor.
- To optimize current sense accuracy, connect the traces to RSENSE with Kelvin sense connection by ISENSN and ISENSP.
- LX node is with high frequency voltage swing and should be kept small area. Keep analog components away from LX node to prevent stray capacitive noise pick-up.
- Add Snubber in LX: 2Ω resister 0805 package and 1nF capacitor.

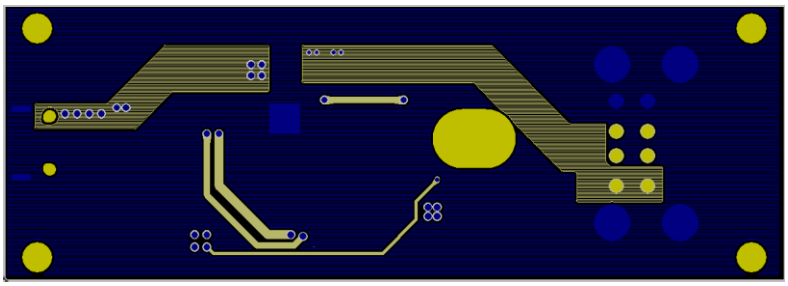
Top :



Iayer2 :



Layer3 :



Bottom :

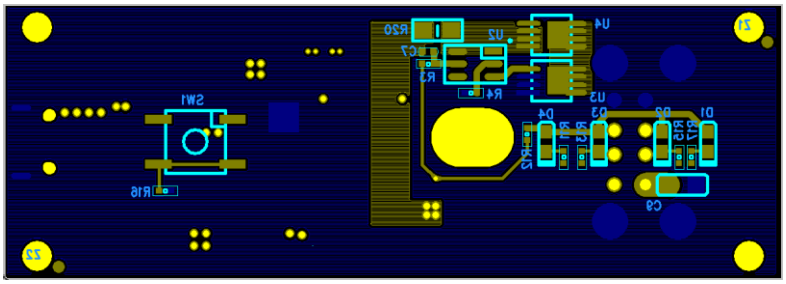
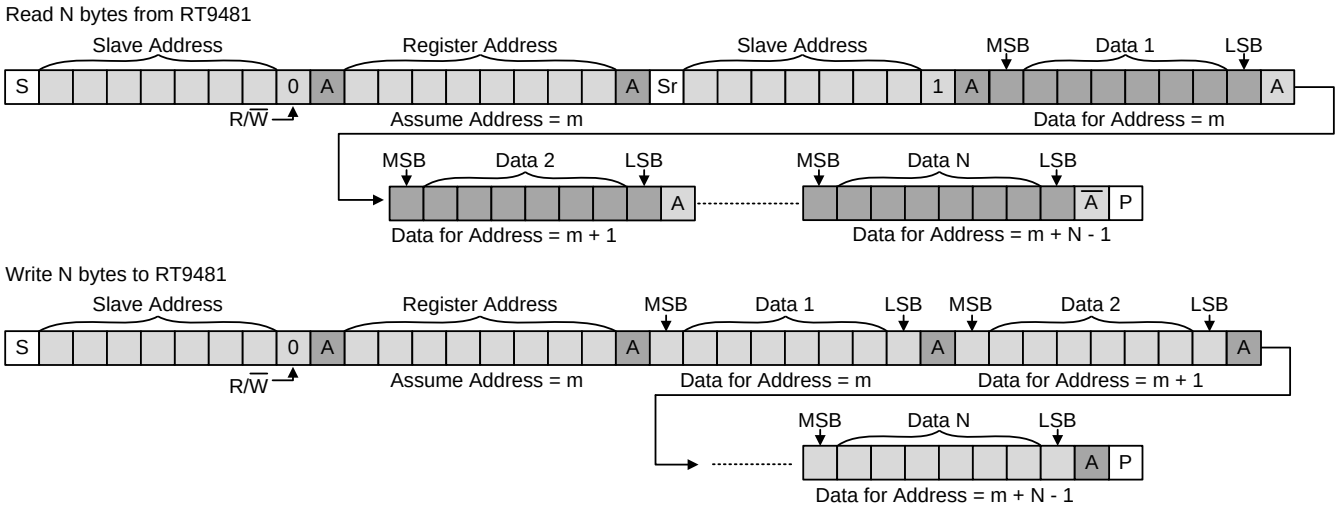


Figure 6. PCB Layout Guide

I²C Interface

RT9481 I²C slave address = 7'b1101100.

I²C interface support fast mode (bit rate up to 400kb/s). The write or read bit stream (N ≥ 1) is shown below :



I²C Register Map

Register of the SWCHG

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Low BAT CTRL	0X00	Meaning	Fix_ Freq	Sel_ SWFreq	Higher_ OCP	HZ	LBP Enable	LBP[2:0]		
		Default	1	1	0	0	1	1	0	1
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Fix_Freq			Control the switching frequency to be dynamic or fix 0 : Auto-change frequency 1 : Fixed frequency (default)							
Sel_ SWFreq			The switching frequency selection bit (Charger/ Boost) 0 : The switching frequency is 1.5MHz 1 : The switching frequency is 0.75MHz (default)							
Higher_ OCP			Higher_OCP enable 0 : Disable (default) 1 : Higher IL OCP level selection of buck mode and boost mode							
HZ			0 : Not high impedance mode (default) 1 : High impedance							
LBP Enable			Low Battery Protection Enable 0 : Disable 1 : Enable (default)							
LBP[2:0]			Define Low Battery Protection Level. The default voltage is 3V.							
			Code	Voltage	Code	Voltage	Code	Voltage	Code	Voltage
			000	2.5V	010	2.7V	100	2.9V	110	3.1V
			001	2.6V	011	2.8V	101	3V (default)	111	3.2V

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 1	0X01	Meaning	IAICR[5:0]						TE	OPA_ MODE
		Default	0	0	1	0	1	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
IAICR[5:0]			Define AICR current. The default current is 0.5A.							
			Code	Current	Code	Current	Code	Current	Code	Current
			000000	Disable	010000	0.8A	100000	1.6A	110000	2A
			000001	0.1A	010001	0.85A	100001	1.65A	110001	2A
			000010	0.1A	010010	0.9A	100010	1.7A	110010	2A
			000011	0.15A	010011	0.95A	100011	1.75A	110011	2A
			000100	0.2A	010100	1A	100100	1.8A	110100	2A
			000101	0.25A	010101	1.05A	100101	1.85A	110101	2A
			000110	0.3A	010110	1.1A	100110	1.9A	110110	2A
			000111	0.35A	010111	1.15A	100111	1.95A	110111	2A
			001000	0.4A	011000	1.2A	101000	2A	111000	2A
			001001	0.45A	011001	1.25A	101001	2A	111001	2A
			001010	0.5A (default)	011010	1.3A	101010	2A	111010	2A
			001011	0.55A	011011	1.35A	101011	2A	111011	2A
			001100	0.6A	011100	1.4A	101100	2A	111100	2A
			001101	0.65A	011101	1.45A	101101	2A	111101	2A
			001110	0.7A	011110	1.5A	101110	2A	111110	2A
			001111	0.75A	011111	1.55A	101111	2A	111111	2A
TE			Termination enable 0 : Disable charge current termination (default) 1 : Enable charge current termination							
OPA_MODE			0 : Charger mode (default) 1 : Boost mode							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 2	0X02	Meaning	CHG_CV[5:0]						Reserved	Reserved
		Default	0	1	0	1	1	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
CHG_CV[5:0]			Define battery regulation voltage. The delta-V of the Battery regulation voltage is 25mV. The default voltage is 4.2V.							
			Code	Voltage	Code	Voltage	Code	Voltage	Code	Voltage
			000000	3.65V	010000	4.05V	100000	4.45V	110000	4.6V
			000001	3.675V	010001	4.075V	100001	4.475V	110001	4.6V
			000010	3.7V	010010	4.1V	100010	4.5V	110010	4.6V
			000011	3.725V	010011	4.125V	100011	4.525V	110011	4.6V
			000100	3.75V	010100	4.15V	100100	4.55V	110100	4.6V
			000101	3.775V	010101	4.175V	100101	4.575V	110101	4.6V
			000110	3.8V	010110	4.2V (default)	100110	4.6V	110110	4.6V
			000111	3.825V	010111	4.225V	100111	4.6V	110111	4.6V
			001000	3.85V	011000	4.25V	101000	4.6V	111000	4.6V
			001001	3.875V	011001	4.275V	101001	4.6V	111001	4.6V
			001010	3.9V	011010	4.3V	101010	4.6V	111010	4.6V
			001011	3.925V	011011	4.325V	101011	4.6V	111011	4.6V
			001100	3.95V	011100	4.35V	101100	4.6V	111100	4.6V
			001101	3.975V	011101	4.375V	101101	4.6V	111101	4.6V
			001110	4V	011110	4.4V	101110	4.6V	111110	4.6V
			001111	4.025V	011111	4.425V	101111	4.6V	111111	4.6V
			CHG : 3.65V + CHG_CV x 0.025V, max. : 4.6V							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 3	0X03	Meaning	Boost _CV[5:0]						TREG_SEL[1:0]	
		Default	1	1	1	0	1	1	0	1
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Boost _CV[5:0]			Define Boost regulation voltage. The delta-V of the **Boost v**oltage is 25mV. The default voltage is 5.1V.							
			Code	Voltage	Code	Voltage	Code	Voltage	Code	Voltage
			000000	3.625V	010000	4.025V	100000	4.425V	110000	4.825V
			000001	3.65V	010001	4.05V	100001	4.45V	110001	4.85V
			000010	3.675V	010010	4.075V	100010	4.475V	110010	4.875V
			000011	3.7V	010011	4.1V	100011	4.5V	110011	4.9V
			000100	3.725V	010100	4.125V	100100	4.525V	110100	4.925V
			000101	3.75V	010101	4.15V	100101	4.55V	110101	4.95V
			000110	3.775V	010110	4.175V	100110	4.575V	110110	4.975V
			000111	3.8V	010111	4.2V	100111	4.6V	110111	5V
			001000	3.825V	011000	4.225V	101000	4.625V	111000	5.025V
			001001	3.85V	011001	4.25V	101001	4.65V	111001	5.05V
			001010	3.875V	011010	4.275V	101010	4.675V	111010	5.075V
			001011	3.9V	011011	4.3V	101011	4.7V	111011	5.1V (default)
			001100	3.925V	011100	4.325V	101100	4.725V	111100	5.125V
			001101	3.95V	011101	4.35V	101101	4.75V	111101	5.15V
			001110	3.975V	011110	4.375V	101110	4.775V	111110	5.175V
			001111	4V	011111	4.4V	101111	4.8V	111111	5.2V
			Boost : 3.625 + Boost _CV x 0.025V, Boost max.: 5.2V							
TREG_SEL[1:0]			Define thermal regulation level 00 : 100°C 01 : 120°C (default) 10 : 135°C 11 : 135°C							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 4	0X04	Meaning	TMR2X_EN	JEITA	WT_FC			WT_PRC		EN_TMR
		Default	1	0	1	1	1	1	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
TMR2X_EN	Run charge timer in half clock rate during MIVR, AICR and thermal regulation. 0 : Disable 2X extended charger timer 1 : Enable 2X extended charger timer (default)									
JEITA	JEITA function 0 : Charging regulation current is ICHG (default) 1 : Charging regulation current is ICHG/2									
WT_FC	Define Fast charge Timer. The default time is 20 hours.									
	Code	Hours	Code	Hours	Code	Hours	Code	Hours		
	000	6 hours	010	10 hours	100	14 hours	110	18 hours		
	001	8 hours	011	12 hours	101	16 hours	111	20 hours (default)		
WT_PRC	Define Pre-charge charge Timer 00 : 30mins 01 : 45mins 10 : 60mins (default) 11 : 60mins									
EN_TMR	0 : Disable internal timer function (default) 1 : Enable internal timer function									

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 5	0X05	Meaning	MIVR[2:0]			IPREC[1:0]		EOC[2:0]		
		Default	1	1	0	0	1	0	1	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
MIVR[2:0]	Define VMIVR voltage. The default voltage is 4.7V.									
	Code	Voltage	Code	Voltage	Code	Voltage	Code	Voltage		
	000	Disable	010	4.3V	100	4.5V	110	4.7V (default)		
	001	4.2V	011	4.4V	101	4.6V	111	4.8V		
IPREC[1:0]	Define Pre-Charge Current 00 : 200mA 01 : 300mA (default) 10 : 400mA 11 : 500mA									
EOC[2:0]	Define Termination Current (IEOC RSENSE is 10mΩ). The default current is 200mA.									
	Code	Current	Code	Current	Code	Current	Code	Current		
	000	Disable	010	200mA (default)	100	300mA	110	500mA		
	001	150mA	011	250mA	101	400mA	111	600mA		

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 6	0X06	Meaning	ICHG[3:0]				VPREC[3:0]			
		Default	0	0	0	0	0	1	1	1
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ICHG[3:0]			Define charging regulation current. The default current is 7mV (0.7A).							
			Code	Current	Code	Current	Code	Current	Code	Current
			0000	7mV (0.7A) (default)	0100	17mV (1.7A)	1000	27mV (2.7A)	1100	27mV (2.7A)
			0001	9.5mV (0.95A)	0101	19.5mV (1.95A)	1001	27mV (2.7A)	1101	27mV (2.7A)
			0010	12mV (1.2A)	0110	22mV (2.2A)	1010	27mV (2.7A)	1110	27mV (2.7A)
			0011	14.5mV (1.45A)	0111	24.5mV (2.45A)	1011	27mV (2.7A)	1111	27mV (2.7A)
			External Sensing R : Charge current sense voltage (current equivalent for 10mΩ sense resistor)							
VPREC[3:0]			Define Pre-Charge Threshold. The default voltage is 3V.							
			Code	Voltage	Code	Voltage	Code	Voltage	Code	Voltage
			0000	2.3V	0100	2.7V	1000	3.1V	1100	3.5V
			0001	2.4V	0101	2.8V	1001	3.2V	1101	3.6V
			0010	2.5V	0110	2.9V	1010	3.3V	1110	3.7V
			0011	2.6V	0111	3V (default)	1011	3.4V	1111	3.8V

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Control 7	0X07	Meaning	Reserved	Reserved	Reserved	Reserved	Reserved	TDEG_EOC		
		Default	0	0	0	0	0	1	1	1
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
TDEG_EOC[2:0]			EOC de-glitch time							
			Code	Time	Code	Time	Code	Time	Code	Time
			000	32µs	010	128µs	100	4ms	110	16ms
			001	64µs	011	256µs	101	8ms	111	32ms (default

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Status1	0X08	Meaning	UUGPUMP_ STAT	VBAT_ LVL	CHG_ STAT	CHG_ Done	BOOST_ STAT	PWR_ Rdy	SWBASE_EN	SWITCHING_ EN
		Default	0	1	0	0	0	0	1	0
		Read/ Write	R	R	R	R	R	R	R/W	R/W
UUGPUMP_STAT			UUG pump enable status 0 : UUG pump is disable 1 : UUG pump is enable							
VBAT_LVL			Battery voltage level detect under charging 0 : Battert voltage is lower than pre-charge level 1 : Battery voltage is higher than fast-charge level							
CHG_STAT			Charging Status 0 : Charging is not in progress 1 : Charging is in progress							
CHG_Done			Charger Done indication bit 0 : Charging is not done 1 : Charging is done							
BOOST_STAT			0 : Not in Boost mode 1 : Boost mode							
PWR_Rdy			Power status bit 0 : VBUS > VBUS_OVP or VBUS < VBUS_UVLO or VBUS < ISENSN + VSLP (Power Fault) 1 : VBUS_UVLO < VBUS < VBUS_OVP & VBUS > ISENSN + VSLP (Power Ready)							
SWBASE_EN			Switching charger base circuit enable 0 : Disabled 1 : Enabled							
SWITCHING_EN			Charger/ Boost enable 0 : Charger/ Boost is disabled 1 : Charger/ Boost is enabled							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Status 2	0X09	Meaning	TSD_ STAT	VBUSOVP_STAT	CHRVP_ STAT	CHBATOV_ STAT	Reserved	Reserved	CHGGOODADP_ STAT	CHGBADADP_ STAT
		Default	0	0	0	0	0	0	1	0
		Read/ Write	R	R	R	R	R	R	R	R
TSD_STAT			Thermal shutdown fault. Set when the die temperature exceeds thermal shutdown threshold. 0 : Thermal shutdown is not on going 1 : Thermal shutdown is on going							
VBUSOVP_STAT			VBUS over voltage protection. Set when VBUS > VIN_OVP is detected. 0 : VBUS is not over voltage 1 : VBUS is over voltage							
CHRVP_STAT			Charger fault. Reverse protection fault (VBUS < ISENSN + VSLP) 0 : Reverse protection is not occur 1 : Reverse protection is occur							
CHBATOV_STAT			Charger fault. Battery OVP. 0 : Battery is not OVP 1 : Battery is OVP							
CHGGOODADP_STAT			Good adaptor detection. It is only enabled in the VBUS plug-in. Once it pass the detection, it will always high and enable charging. 0 : Adaptor is not good adaptor 1 : Adaptor is good adaptor							
CHGBADADP_STAT			Bad adaptor detection. It is used to indicate the adaptor input voltage is lower than 3.8V during the charging 0 : Adaptor is not bad adaptor 1 : Adaptor is bad adaptor							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Status 3	0X0A	Meaning	CHTREG_ STAT	CHMIVR_ STAT	CHAICR_ STAT	CHRCHG_ STAT	Reserved	Reserved	Reserved	Reserved
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R	R	R	R	R/W	R/W	R/W	R/W
CHTREG_STAT			Charger warning. Thermal regulation loop active. 0 : Thermal regulation loop is not active 1 : Thermal regulation loop is active							
CHMIVR_STAT			Charger warning. Input voltage MIVR loop active. 0 : MIVR loop is not active 1 : MIVR loop is active							
CHAICR_STAT			Charger warning. Input current AICR loop active. 0 : AICR loop is not active 1 : AICR loop is active							
CHRCHG_STAT			Indicate battery voltage is below re-charge level under charging 0: Battery voltage higher re-charge level 1 : Battery voltage lower re-charge level							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
CHG_ IRQ	0X0B	Meaning	CHTER MI	IEOC	CHRC HGI	CHTM RFI	SOFTSTA RTI	Reserved	CHG_ STAT2_ALT	CHG_ STAT3_ALT
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/C	R/C	R/C	R/C	R/C	R/W	R/C	R/C
CHTERMI			Charge terminated.							
IEOC			Charge current is lower than EOC current.							
CHRCHGI			Re-Charge request.							
CHTMRFI			Charger fault. time-out (fault).							
SOFTSTARTI			Charger or Boost soft-start finish							
CHG_STAT2_ALT			The status of CHG_STAT2 register is change							
CHG_STAT3_ALT			The status of CHG_STAT3 register is change							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
BST_ IRQ	0X0C	Meaning	BSTTSDI	BSTVMID OVPI	CHRC HGI	Reserved	Reserved	Reserved	Reserved	Reserved
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/C	R/C	R/C	R/W	R/W	R/W	R/W	R/W
BSTTSDI			Boost fault. Thermal shutdown; auto set OPA_MODE and SWITCHING_EN to low.							
BSTVMIDOVPI			Boost fault. VMID OVP; auto set OPA_MODE and SWITCHING_EN to low.							
BSTLOWVI			Boost fault. Battery voltage is too low; auto set OPA_MODE and SWITCHING_EN to low.							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Status 2 Control	0X0D	Meaning	TSDI_ STATM	VBUSOVP_STATM	CHRVP_ STATM	CHBATOV_ STATM	Reserved	Reserved	CHGGOODADP_STATM	CHGBADADP_STATM
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
TSDI_ STATM			Thermal shutdown interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
VBUSOVP_STATM			VBUS over voltage protection interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHRVP_STATM			Reverse protection interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHBATOV_STATM			Battery OVP interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHGGOODADP_STATM			Good adaptor detection interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHGBADADP_STATM			Bad adaptor detection interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger Status 3 Control	0X0E	Meaning	CHTREG_ STATM	CHMIVR_ STATM	CHAICR_ STATM	CHGRCHG_STATM	Reserved	Reserved	Reserved	Reserved
		Default	0	0	0	1	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
CHTREG_STATM			Thermal regulation loop active interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHMIVR_STATM			Input voltage MIVR loop active interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHAICR_STATM			Input current AICR loop active interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHGRCHG_STATM			Battery voltage re-charge level interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
Charger IRQ Control	0X0F	Meaning	CHTERMIM	IEOCM	CHRCHGIM	CHTMRFIM	SOFTSTARTIM	Reserved	CHG_ STAT2_ALTM	CHG_ STAT3_ALTM
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
CHTERMIM			Charge terminated interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
IEOCM			Charge current is lower than EOC current interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHRCHGIM			Charger Re-Charge request interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHTMRFIM			CHTMRFI interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
SOFTSTARTIM			SOFTSTARTI interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHG_ STAT2_ALTM			CHG_ STAT2_ALT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
CHG_ STAT3_ALTM			CHG_ STAT3_ALT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
Function	**Register Address**		**b[7] (MSB)**	**b[6]**	**b[5]**	**b[4]**	**b[3]**	**b[2]**	**b[1]**	**b[0] (LSB)**
Boost IRQ Control	0X10	Meaning	BSTTSDIM	BSTVMIDOVPIM	BSTLOWVIM	Reserved	Reserved	Reserved	Reserved	Reserved
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
BSTTSDIM			Boost fault. Thermal shutdown interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
BSTVMIDOVPIM			Boost fault. VMID OVP interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
BSTLOWVIM			Boost fault. Battery voltage is too low interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							

Register of the ADC & LDSW & DCP Control & Adapter Detection & Attach Control & Reset

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
ADC_CTL	0X20	Meaning	CH_SEL			Reserved	Reserved	Reserved	Reserved	ADC_START
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
CH_SEL			ADC channel selection.							
			Code	Chanel	Code	Chanel	Code	Chanel	Code	Chanel
			000	VBAT (default)	010	USBOUT	100	IBAT	110	Reserved
			001	VBUS	011	TS	101	IUSBOUT	111	Reserved
ADC_START			ADC start control 0 : ADC conversion not active (default) 1 : Start ADC conversion (auto clear when conversion done)							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
ADC CODEH	0X21	Meaning	ADC_CODEH							
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R	R	R	R	R	R	R	R
ADC_CODEH			ADC code high byte							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
ADC CODEL	0X22	Meaning	ADC_CODEL							
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R	R	R	R	R	R	R	R
ADC_CODEL			ADC code low byte							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
USBOUT Control	0X23	Meaning	EN_ DCP	EN_ LDSW	USBOUTLDI_LVL			Reserved	LDSW_ TREG[1:0]	
		Default	0	0	0	0	0	1	0	1
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

EN_DCP	DCP controller Enable 0 : DCP controller disable (default) 1 : DCP controller enable
EN_LDSW	Load Switch Enable 0 : Load switch disable (default) 1 : Load switch enable
USBOUTLDI_LVL	USBOUTLDI_LVL

Code	Current	Code	Current
000	Disable	100	50mA
001	NA	101	100mA
010	10mA	110	150mA
011	30mA	111	150mA

LDSW_TREG[1:0]	Thermal regulation level 00 : Disable 01 : 100°C (default) 10 : 120°C 11 : 135°C

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
ATTACH Control	0X24	Meaning	EN_ ADAPTERDET	EN_ VBUSAT	EN_ USBOUTAT	USBOUTAT_TIME			USBOUTAT_ Mode	Reserved
		Default	1	1	1	0	1	1	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

EN_ADAPTERDET	Adapter type detect enable 0 : Adapter detect disable 1 : Adapter detect enable (default)
EN_VBUSAT	VBUS attach/detach detect enable 0 : VBUS attach/detach detect disable 1 : VBUS attach/detach detect enable (default)
EN_USBOUTAT	USBOUT attach/detach detect enable 0 : USBOUT attach/detach detect disable 1 : USBOUT attach/detach detect enable (default)
USBOUTAT_TIME	USBOUT attach/detach detection time.

Code	Time	Code	Time
000	Detection time 150ms	100	Detection time 600ms
001	Detection time 250ms	101	Detection time 700ms
010	Detection time 375ms	110	Detection time 925ms
011	Detection time 475ms	111	Detection time 1125ms

USBOUTAT_Mode	USBOUT attach detect mode 0 : Normal Mode 1 : Power Saving Mode, power save 50% and detection time increase 100%

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
MISC_ STA1	0X25	Meaning	ADC_ STA	ADAPTER_STA		Reserved	Reserved	Reserved	Reserved	Reserved
		Default	0	1	1	0	0	0	0	0
		Read/ Write	R	R	R	R/W	R/W	R/W	R/W	R/W
ADC_STA			ADC status 0 : ADC is idle 1 : ADC conversion is on going							
ADAPTER_STA			VBUS adapter type 00 : SDP with D+ / D- floating 01 : SDP 10 : CDP 11 : DCP							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
MISC_ STA2	0X26	Meaning	LDSWREG _STAT	USBOUTLD _STAT	VBUS_STAT	USBOUT_ STAT	VDDAUVP_ STAT	LDSW_ STAT	Reserved	Reserved
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R	R	R	R	R	R	R/W	R/W
LDSWREG_STAT			Load switch warning. LDSW output current regulation loop active 0 : LDSW output current regulation loop is not active 1 : LDSW output current regulation loop is active							
USBOUTLD_STAT			USBOUT light load indicator 0 : USBOUT loading > USBOUTLC_LVL or disable 1 : USBOUT loading < USBOUTLC_LVL							
VBUS_STAT			VBUS connection status 0 : VBUS has no adapter connect (VBUS < VBUS_POR) 1 : VBUS has adapter connect (VBUS > UVLO & VBUS > ISENSN + VSLP)							
USBOUT_STAT			USBOUT device connection status 0 : USBOUT has no device connect 1 : USBOUT has device connect							
VDDAUVP_STAT			VDDA under voltage protect, disable SWCHG, LDSW, DCP Control, Adapter Detection, ADC and TS driver when VDDAUVP is occur. 0 : VDDA UVP is not trigger 1 : VDDA UVP is trigger							
LDSW_STAT			Load switch status 0 : Load switch is turn off 1 : Load switch is turn on							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
MISC_ IRQ	0X27	Meaning	ADC_ DONEI	ADAPTER_ DONEI	LDSW_ SCPI	LDSWRDYI	MISC_ STA2_ALT	WDTI	VMIDSCPI	VMIDUV PI
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/C	R/C	R/C	R/C	R/C	R/C	R/C	R/W
ADC_DONEI			ADC conversion done interrupt							
ADAPTER_DONEI			Adapter detection done interrupt							
LDSW_SCPI			Load switch short current protect interrupt							
LDSWRDYI			Load switch turn on ready							
MISC_ STA2_ALT			The status of MISC_ STA2_ALT register is change							
WDTI			WDT interrupt							
VMIDSCPI			VMID short current protect interrupt, auto set EN_LDSW to 0							
VMIDUV PI			VMID under voltage protect interrupt, auto set EN_LDSW to 0							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
MISC_ STA2 Control	0X28	Meaning	LDSWREG_S TATM	USBOUTLD _STATM	VBUS_ STATM	USBOUT_ STATM	VDDAUVP_ STATM	LDSW_ STATM	Reserved	Reserved
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
LDSWREG_STATM			LDSWREG_STAT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
USBOUTLD_STATM			USBOUTLD_STAT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
VBUS_STATM			VBUS_STATI interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
USBOUT_STATM			USBOUT_STAT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
VDDAUVP_STATM			VDDAUVP_STAT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
LDSW_STATM			LDSWM_STAT interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
MISC_ IRQ_ CTRL	0X29	Meaning	ADC_ DONEIM	ADAPTER_ DONEIM	LDSW_ SCPIM	LDSWR DYIM	MISC_ STA2_ ALTM	Reserved	VMIDSC PIM	VMIDUV PIM
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ADC_DONEIM			ADC_DONEI interrupt mask 0 : Interrupt is not masked 1 : Interrupt is masked							
ADAPTER_DONEIM			ADAPTER_DONEI mask 0 : Interrupt is not masked 1 : Interrupt is masked							
LDSW_SCPIM			LDSW_SCPI mask 0 : Interrupt is not masked 1 : Interrupt is masked							
LDSWRDYIM			LDSWRDYIM mask 0 : Interrupt is not masked 1 : Interrupt is masked							
MISC_ STA2_ALTM			MISC_ STA2_ALT mask 0 : Interrupt is not masked 1 : Interrupt is masked							
VMIDSCPIM			VMIDSCPI mask 0 : Interrupt is not masked 1 : Interrupt is masked							
VMIDUVPIM			VMIDUVPI mask 0 : Interrupt is not masked 1 : Interrupt is masked							

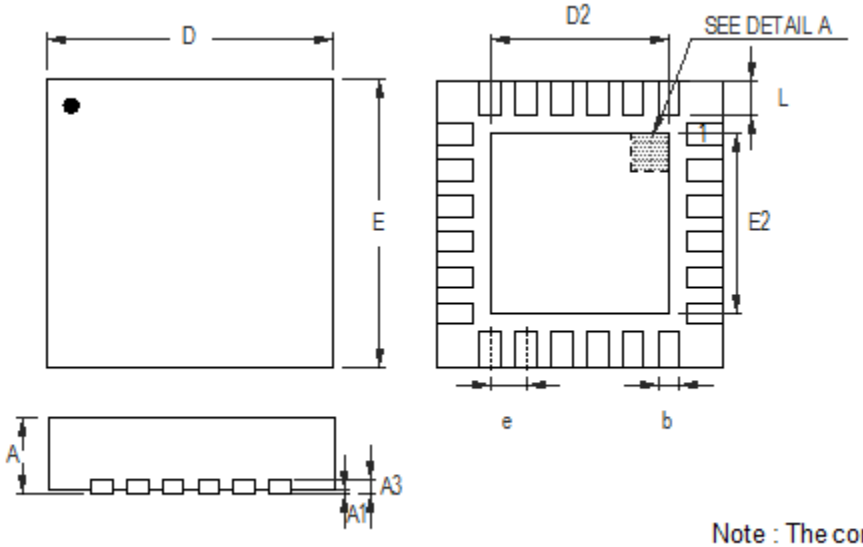
Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
RESET	0X2A	Meaning	RESET							
		Default	0	0	0	0	0	0	0	0
		Read/ Write	W	W	W	W	W	W	W	W
RESET			Reset control register 0X96 : RESET, reset whole chip include register and circuit 0X3C : REG_RST, reset whole register setting to default only							

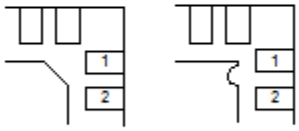
Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
WDT_ CTRL	0X2B	Meaning	WDT_ EN	Reserved	WDT		Reserved	Reserved	Reserved	WDT_ REFR ESH
		Default	0	0	0	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	W
WDT_EN			WDT enable control 0 : WDT disable (default) 1 : WDT enable							
WDT			Watch Dog Timer, it will reset whole chip when time out 00 : 8 second (default) 01 : 16 second 10 : 32 second 11 : 64 second							
WDT_REFRESH			Watch Dog Timer refresh 0 : No action 1 : Refresh watch dog timer							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
LDSW_ ILIM_FUSE	0X2C	Meaning	Reserved	Reserved	LDSW_ILIM_FUSE					
		Default	0	0	0	0	0	0	0	0
		Read	R	R	R	R	R	R	R	R
LDSW_ILIM_FUSE			Report the fuse setting of LDSW current regulation							

Function	Register Address		b[7] (MSB)	b[6]	b[5]	b[4]	b[3]	b[2]	b[1]	b[0] (LSB)
LDSW_ ILIM_CTRL	0X2D	Meaning	LDSW_ILIM_LVL		LDSW_ILIM_CTRL					
		Default	0	1	1	0	0	0	0	0
		Read/ Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
LDSW_ILIM_LVL			LDSW current regulation 00 : Min = 1.0A, TYP = 2.0A, MAX = 3.0A 01 : Min = 1.5A, TYP = 2.5A, MAX = 3.5A 10 : Min = 2.0A, TYP = 3.0A, MAX = 4.0A							
LDSW_ILIM_CTRL			LDSW_ILIM_CTRL = LDSW_ILIM_FUSE-[2500-TARGET+(LDSW_ILIM_LVL-1)x567]/35 Target = the target USBOUT current regulation setting, the unit is mA.							

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		3.950	4.050	0.156	0.159
D2	Option 1	2.400	2.500	0.094	0.098
	Option 2	2.650	2.750	0.104	0.108
E		3.950	4.050	0.156	0.159
E2	Option 1	2.400	2.500	0.094	0.098
	Option 2	2.650	2.750	0.104	0.108
e		0.500		0.020	
L		0.350	0.450	0.014	0.018

W-Type 24L QFN 4x4 Package

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