I²C Programmable Linear Single Cell Li-Ion Battery Charger with Auto Power-Path Management and USB/AV Switch

General Description

The RT9528 is a programmable single-cell Li-ion battery charger with I²C programmable control I/F, Auto Power-Path Management IC and USB/AV Switch. For the RT9528, there is no need to use external MOSFET. The RT9528 enters sleep mode when supplies are removed. The RT9528 optimizes the charging task by using a control algorithm including pre-charge mode, fast charge mode and constant voltage mode. The RT9528 includes termination, timer, charge current and V_{SYS} settings via a serial I²C control I/F.

The RT9528 provides protections for the battery pack, charger and input circuitry such as over current, under voltage, over voltage, thermal regulation and thermal protection. Status can be monitored via the serial port for charge state and fault conditions.

The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures.

The recommended junction temperature range is –40°C to 125°C, and the ambient temperature range is –40°C to 85°C.

Ordering Information

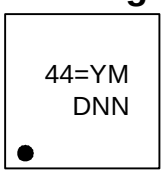
RT9528□□

- Package Type
  QW : WQFN-28L 4x4 (W-Type)
- Lead Plating System
  G : Richtek Green Policy Compliant

Note :

Richtek products are Richtek Green Policy compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.

Marking Information



44= : Product Code

YMDNN : Date Code

Features

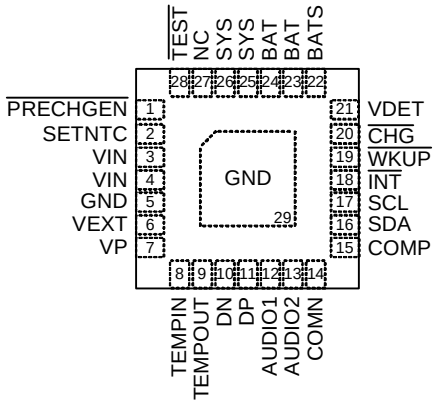
- **28V Maximum Rating for AC Adapter**
- **Auto Power Path Management (APPM)**
- **High-Speed USB Operation**
- **USB/Audio/Video Switches**
- **Negative Rail Audio Signal Path**
- **I²C controlled Interface**
- **Integrated 3.3V LDO for TS Circuitry**
- **Integrated Power MOSFETs**
- **Interrupt Status Indicator**
- **Power Good and Charge Status Indicators**
- **Under/Over Voltage Protection**
- **Thermal Feedback Optimizing Charge Rate**
- **28-Lead WQFN Package**
- **RoHS Compliant and Halogen Free**

Applications

- Digital Cameras
- PDAs and Smart Phones
- Portable Instruments

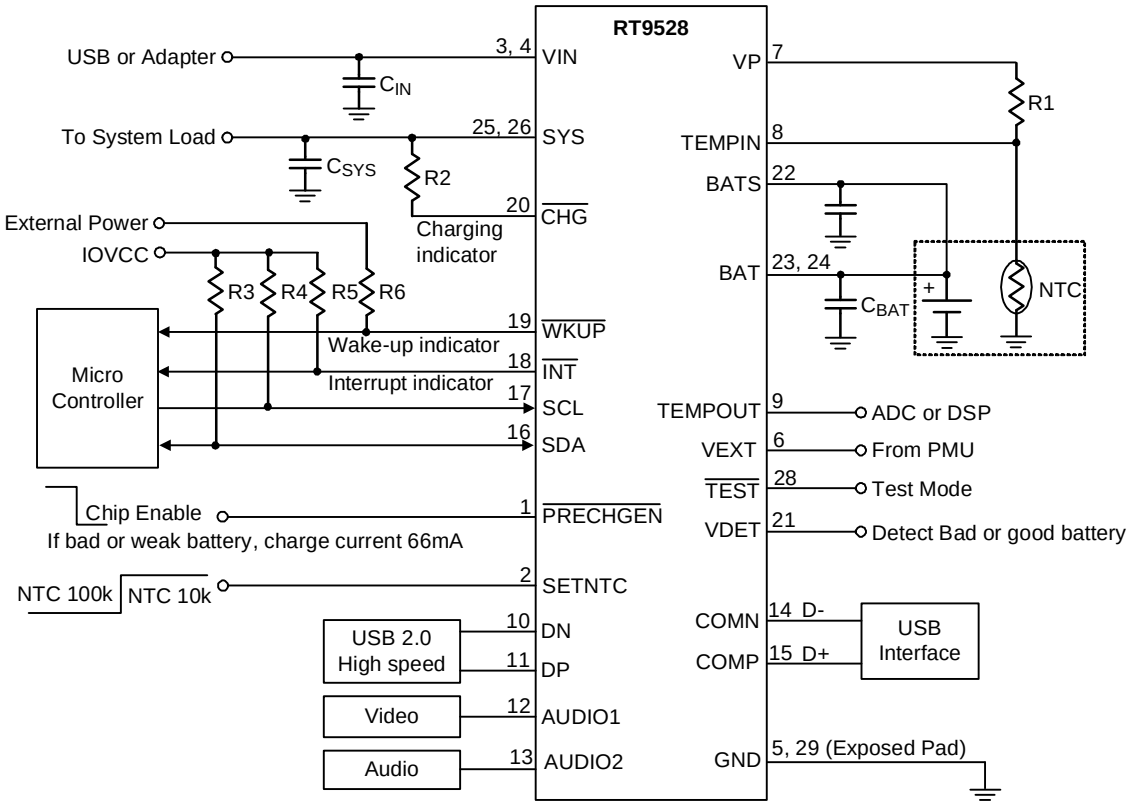
Pin Configuration

(TOP VIEW)



WQFN-28L 4x4

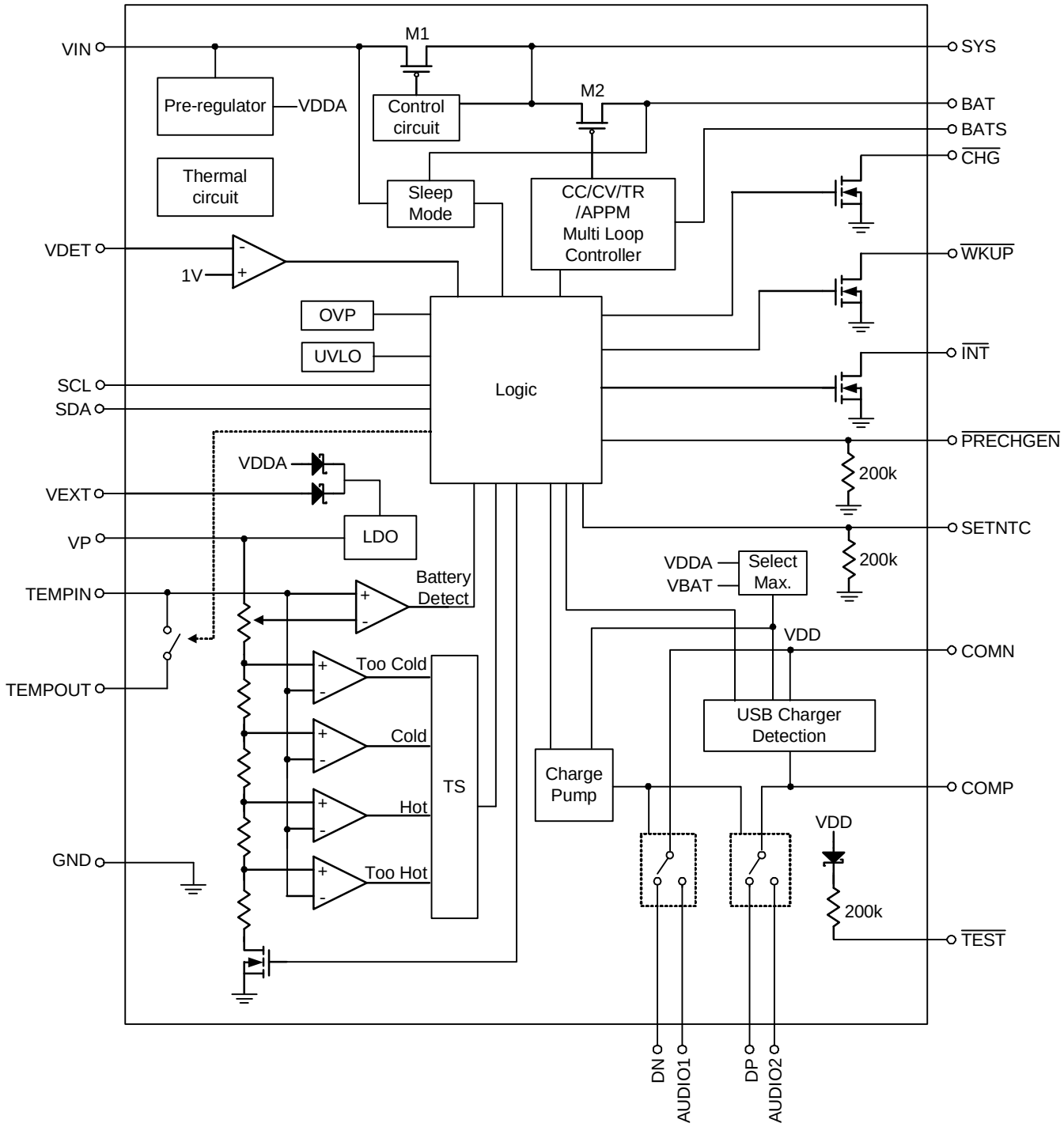
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	$\overline{\text{PRECHGEN}}$	66mA auto charging enable for weak and dead battery. H = disable, L = enable 200kΩ pull low.
2	SETNTC	Set NTC Initial Condition Input. H = NTC resistor 10kΩ, L = NTC resistor 100kΩ. 200kΩ pull low.
3, 4	VIN	Power Input.
5, 29 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
6	VEXT	External power for the power of TS LDO. Note the power of TS_LDO will choose maximum voltage between VEXT and VDDA.
7	VP	3.3V LDO Output. The regulator only provides thermistor with resistor power.
8	TEMPIN	Detect the Presence of Battery. Connect TEMPIN to NTC thermistor.
9	TEMPOUT	Connect to ADC of DSP.
10	DN	USB Input for D–.
11	DP	USB Input for D+.
12	AUDIO1	Audio or Video Input.
13	AUDIO2	Audio or Video Input.
14	COMN	Common Output N. Connect to D– on mini/micro USB connector.
15	COMP	Common Output P. Connect to D+ on min/micro USB connector.
16	SDA	I^2C Serial Data Input/Output. Connect an external pull up resistor.
17	SCL	I^2C Serial Clock Input. Connect an external pull up resistor.
18	$\overline{\text{INT}}$	Interrupt Status Open-Drain Output. Connect an external pull up resistor. Initial active low.
19	$\overline{\text{WKUP}}$	Power Good Status Open-Drain Output. Connect an external pull up resistor. Active low.
20	$\overline{\text{CHG}}$	Charging Status Open-Drain Output. Connect an external pull up resistor. Active low.
21	VDET	Voltage Detection Input.
22	BATS	Battery Sense. Connect battery.
23, 24	BAT	Battery Charge Current Output.
25, 26	SYS	Connect this pin to a system with a minimum 10μF ceramic capacitor to GND.
27	NC	No Internal Connection.
28	$\overline{\text{TEST}}$	Test Mode. Internal 200kΩ pull up. H : Normal, L : Test mode, USB switch turn on and set USB 500mA mode. If $\overline{\text{TEST}}$ = L, RT9528 will set $\overline{\text{PRECHGEN}}$ = 1 internally.

Functional Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, V_{IN} ---------- –0.3V to 28V
- SETNTC, $\overline{\text{PRECHGEN}}$ ---------- –0.3V to 28V
- Other Pins ---------- –0.3V to 6V
- BAT Continuous Current (between BAT and SYS pins) (Note 2) ---------- 2.5A
- Power Dissipation, P_D @ T_A = 25°C
  WQFN-28L 4x4 ---------- 1.923W
- Package Thermal Resistance (Note 3)
  WQFN-28L 4x4, θ_{JA} ---------- 52°C/W
  WQFN-28L 4x4, θ_{JC} ---------- 7°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 4)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 5)

- Supply Input Voltage Range, V_{IN} (ISETL = 1) ---------- 4.35V to 6V
- Supply Input Voltage Range, V_{IN} (ISETL = 0) ---------- 4.45V to 6V
- Supply Input Voltage Range, V_{EXT} (If VIN No Use) ---------- 4V to 5.5V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 5V, V_{BAT} = 4V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Input Voltage						
VIN Under Voltage Lockout Threshold	V_{UVLO}		3.1	3.3	3.5	V
VIN Under Voltage Lockout Hysteresis	V_{UVLO_HYS}		--	240	--	mV
VIN-BAT VOS Rising	V_{OS_H}		--	100	200	mV
VIN-BAT VOS Falling	V_{OS_L}		10	50	--	mV
Voltage Regulation						
Battery Regulation Voltage	V_{REG}	Set by I^2C, 20mV/step	3.5	--	4.26	V
Battery Regulation Voltage Accuracy	V_{REG2}	V_{REG} = 4.2V	4.16	4.2	4.23	V
System Regulation Voltage	V_{SYS1}	Set by I^2C , I_{SYS} = 800mA	4.3	4.4	4.5	V
System Regulation Voltage	V_{SYS2}	V_{IN} = 6V, Set by I^2C , I_{SYS} = 800mA	5.3	5.5	5.7	V
APPM Regulation Voltage	V_{APPM}	ISETL = 0, ISETU = 1	3.85	3.95	4.05	V
DPM Regulation Voltage	V_{DPM}	ISETL = 0, ISETU = X	4.3	4.4	4.5	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VIN to VSYS MOSFET Ron	$R_{DS(ON)}$	I_{VIN} = 1A, ISETL = 1	--	0.25	0.5	Ω
BAT to VSYS MOSFET Ron	$R_{DS(ON)}$	V_{BAT} = 4.2V, I_{SYS} = 1A	--	0.05	0.1	Ω
Re-charge Threshold	ΔV_{RECHG}	V_{REG} – Recharge level	60	100	140	mV
Current Regulation						
Charge Current Setting Range	I_{CHG}	Set by I^2C, 16 steps	66	--	1200	mA
Charge Current Setting Range 2	I_{CHG2}	I_{CHG} = 600mA	570	600	630	mA
VIN Current Limit	I_{VIN}	ISETL = 1, (1.5A mode)	1.2	1.5	1.8	A
		ISETL = 0, ISETU = 1 (500mA mode)	450	475	500	mA
		ISETL = 0, ISETU = 0 (100mA mode)	90	95	100	mA
Pre-Charge						
BAT Pre-Charge to Fast-Charge Threshold	$V_{PRECH-R}$	Set by I^2C, V_{BAT} Rising	2.4	--	3.1	V
BAT Pre-Charge to Fast-Charge Threshold 2	$V_{PRECH-R2}$	V_{BAT} = 3V, V_{BAT} Rising	2.9	3	3.1	V
BAT Pre-Charge Threshold Hysteresis	ΔV_{PRECH}	V_{BAT} Falling	--	200	--	mV
Pre-Charge Current	I_{PRECH}	Set by I^2C, V_{BAT} = 2V,	40	--	100	mA
Pre-Charge Current 2	I_{PRECH2}	I_{PRECH} = 60mA, V_{BAT} = 2V,	48	60	72	mA
Charge Termination Detection						
Termination Current Ratio to Fast Charge	I_{TERM}	Set by I^2C	0	--	35	%
Termination Current Ratio to Fast Charge 2	I_{TERM2}	I_{TERM} = 10%	5	10	15	%
Timer						
Time Out (Pre-Charge)	t_{PCHG}	Set by I^2C	30	--	60	Min.
Time Out (Fast-Charge)	t_{FCHG}	Set by I^2C	240	--	480	Min.
Time Out for Pre-Charge (Stand-alone)	t_{PCHG1}	Time (Pre) = 30min	22.5	30	37.5	Min.
Time Out for Fast-Charge (Stand-alone)	t_{FCHG1}	Time (Fast) = 240min	180	240	300	Min.
$\overline{WKUP}$ Deglitch Time	$t_{\overline{WKUP}}$	$\overline{PRECHGEN}$ = H	--	--	1	s
Input Over Voltage Blanking Time	t_{OVP}		--	50	--	µs
Pre-Charge to Fast-Charge Deglitch Time	t_{PF}		--	25	--	ms
Fast-Charge to Pre-Charge Deglitch Time	t_{FP}		--	25	--	ms
Termination Deglitch Time	t_{TERMI}		--	25	--	ms
Recharge Deglitch Time	t_{RECHG}		--	100	--	ms
Input Power Loss to SYS LDO Turn-Off Delay Time	t_{No-in}	V_{IN} > V_{UVLO}, V_{IN} falling until less than V_{BAT}	--	25	--	ms
Pack Temperature Fault Detection Deglitch Time	t_{TS}		--	25	--	ms

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Short-Circuit, Deglitch Time		t_{SHORT}		--	256	--	μs
Short-Circuit, Recovery Time		t_{SHORT_R}		--	64	--	ms
Session valid to connect for PD with Dead or Week Battery		$t_{SVLD\_Con\_WKB}$		15	--	45	Min.
Login Input/Output							
$\overline{INT}$ Pull Down Voltage		$V_{\overline{INT}}$	$I_{\overline{INT}}$ = 5mA	--	200	--	mV
$\overline{CHG}$ Pull Down Voltage		$V_{\overline{CHG}}$	$I_{\overline{CHG}}$ = 5mA	--	200	--	mV
$\overline{WKUP}$ Pull Down Voltage		$V_{\overline{WKUP}}$	$I_{\overline{WKUP}}$ = 5mA	--	200	--	mV
$\overline{PRECHGEN}$, SETNTC, $\overline{TEST}$ Threshold		V_{I_H}		1.5	--	--	V
		V_{I_L}		--	--	0.4	V
$\overline{PRECHGEN}$ Pull Low Resistor		$R_{\overline{PRECHGEN}}$		--	200	--	kΩ
SETNTC Pull Low Resistor		R_{SETNTC}		--	200	--	kΩ
Digital Signals (SCL, SDA) for I^2C							
Logic Input Voltage	Logic-High	V_{IH}		1.5	--	--	V
	Logic-Low	V_{IL}		--	--	0.4	
Input Leakage Current		I_{INLEAK}		–1	--	1	μA
Open Drain Low for SDA		V_{ODLO}	I_{SINK} = 1mA	--	--	0.4	V
Protection							
Thermal Regulation		T_{REG}		--	125	--	°C
Thermal Shutdown Temperature		T_{SD}		--	155	--	°C
Thermal Shutdown Hysteresis		ΔT_{SD}		--	20	--	°C
OVP SET Voltage		V_{OVP}	V_{IN} Rising	6.25	6.5	6.75	V
OVP Hysteresis		V_{OVP_Hys}		--	100	--	mV
VDET		V_{DET}	V_{DET} Falling	0.98	1	1.02	V
BATON		V_{BATON}	VTEMPIN Rising	93	95	97	%VP
Output Short-Circuit Detection Threshold		V_{SHORT}	$V_{BAT} – V_{SYS}$	--	300	--	mV
VP							
VP (internal used only)		VP	V_{IN} = 5V or V_{IN} = 0V (V_{EXT} > 4V), I_{VP} = 1mA	3.2	3.3	3.4	V
RNTC = 100kW (0, 10, 45, 58°C) NCP15WF104F03RC							
Too Cold temperature Fault Threshold voltage		V_{Too_Cold}	Rising Threshold	--	78	--	%VP
			Hysteresis	--	1	--	
Cold temperature Fault Threshold voltage		V_{Cold}	Rising Threshold	--	67.5	--	%VP
			Hysteresis	--	1	--	
Hot temperature Fault Threshold voltage		V_{Hot}	Falling Threshold	--	29	--	%VP
			Hysteresis	--	1.5	--	
Too Hot temperature Fault Threshold voltage		V_{Too_Hot}	Falling Threshold	--	19.5	--	%VP
			Hysteresis	--	1.5	--	

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
RNTC = 10kW (0, 10, 45, 58°C) NCP15XH103F03RC						
Too Cold temperature Fault Threshold Voltage	V_{Too_Cold}	Rising Threshold	--	73	--	%VP
		Hysteresis	--	1	--	
Cold temperature Fault Threshold Voltage	V_{Cold}	Rising Threshold	--	64	--	%VP
		Hysteresis	--	1	--	
Hot temperature Fault Threshold Voltage	V_{Hot}	Falling Threshold	--	33	--	%VP
		Hysteresis	--	1.5	--	
Too Hot temperature Fault Threshold Voltage	V_{Too_Hot}	Falling Threshold	--	24.5	--	%VP
		Hysteresis	--	1.5	--	
USB/ Audio/ Video Switches and Charger Detect						
Internal Switch Supplies	V_{SWPOS}		--	3	--	V
Internal Switch Supplies	V_{SWNEG}		--	–2	--	V
VBAT UVLO	V_{BAT_UVLO}		1.3	1.8	2.3	V
VBAT Supply Current	I_{VBAT}	V_{BAT} = 4.2V, V_{IN} = 0V, CP_EN = 0, SDA = SCL = 0V	--	5	10	µA
	I_{VBAT2}	V_{BAT} = 4.2V, V_{IN} = 0V, CP_EN = 1, SDA = SCL = 0V	--	30	--	
VIN Supply Current by Suspend	I_{VIN_USUS}	V_{IN} = 5V, V_{BAT} = 0V, CP_EN = 1, USUS = 1, LDO_TS = 0, TS = 0	--	--	300	µA
VDP_SRC Voltage	V_{DP_SRC}	With I_{DAT_SRC} = 0 to 250µA	0.5	--	0.7	V
VDM_SRC Voltage	V_{DM_SRC}	With I_{DAT_SRC} = 0 to 250µA	0.5	--	0.7	V
VDAT_REF Voltage	V_{DAT_REF}		0.25	--	0.4	V
VLGC Voltage	V_{LGC}		0.8	--	2	V
IDM_SINK Current	I_{DM_SINK}	V_{COMN} = 0.6V	50	--	150	µA
IDP_SINK Current	I_{DP_SINK}	V_{COMP} = 0.6V	50	--	150	µA
RDM_DWN	R_{DM_DWN}		14.25	--	24.8	kΩ
IDP_SRC	I_{DP_SRC}	V_{COMP} = 0.8V	1	--	13	µA
VCOMP_DCD	V_{COMP_DCD}	In DCD flow, V_{COMP} = Float	2	--	--	V
USB Analog Switch (DN1, DP2)						
Analog Signal Range	V_{DN1}, V_{DP2}	CP_EN = 0	0	--	V_{SWPOS}	V
		CP_EN = 1	V_{SWNEG}	--	V_{SWPOS}	
On-Resistance	R_{ONUSB}	V_{IN} = 5V, V_{BAT} = 3V, CP_EN = 1, I_{COM} = 10mA, V_{COM} = 0V to 3V	--	4	--	Ω
On-Resistance Match Between Channels	ΔR_{ONUSB}	V_{IN} = 5V, V_{BAT} = 3V, CP_EN = 1, I_{COM} = 10mA, V_{COM} = 400mV	--	0.5	--	Ω
Off Leakage Current	$I_{USB(OFF)}$	V_{IN} = 5V, V_{BAT} = 4.2V, Switch open, V_{DN1} or V_{DP2} = 0.3V, 2.5V, V_{COM} = 2.5V, 0.3V	–360	--	360	nA
On Leakage Current	$I_{USB(ON)}$	V_{IN} = 5V, V_{BAT} = 4.2V,Switch closed, V_{DN1} or V_{DP2} = 0.3V, 2.5V, V_{COM} and V_{AUD} = Float	–360	--	360	nA

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Audio Analog Switch (AUD1, AUD2)						
Analog Signal Range	V_{AUDIO}	CP_EN = 0	0	--	V_{SWPOS}	Ω
		CP_EN = 1	V_{SWNEG}	--	V_{SWPOS}	
On-Resistance Match Between Channels	$\Delta R_{DS(ON)A}$	V_{IN} = 0V, V_{BAT} = 3V, CP_EN = 1, I_{COM} = 10mA, V_{COM} = 0V	--	0.2	--	Ω
On-Resistance Flatness	R_{FLATA}	V_{IN} = 0V, V_{BAT} = 3V, CP_EN = 1, I_{COM} = 10mA, V_{COM} = –2 to 2V	--	1.5	--	Ω
Off Leakage Current	$I_{LA(OFF)}$	V_{IN} = 0V, V_{BAT} = 4.2V, Switch open, V_{AUD} = –0.5V, 0.5V, V_{COM} = –0.5 to 0.5V	–360	--	360	nA
On Leakage Current	$I_{LA(ON)}$	V_{IN} = 0V, V_{BAT} = 4.2V, Switch closed, V_{AUD} = –2V, 2V, V_{COM} and V_{DX} = Float	–360	--	360	nA
Shunt Resistor	R_{SHUNT}		30	100	200	Ω
Dynamic						
I^2C Max Clock	F_{I2CCLK}		--	--	400	kHz
CP_EN delay time	t_{CP_EN}	Not production tested	--	--	1	ms
Analog Switch Turn On Time	t_{ON}	I^2C Stop to Switch On, R_L = 32Ω	--	--	1	ms
Analog Switch Turn Off Time	t_{Off}	I^2C Stop to Switch Off, R_L = 32Ω	--	--	1	ms
Break-Before-Make Delay Time	t_D	R_L = 32Ω	>0	--	--	μs
Data Contact Detect Debounce	t_{DCD_DBNC}		20	--	40	ms
DCD Time-OUT	t_{DCD_TO}		300	--	900	ms
VDAT_SRC ON Time	$t_{DP\_SRC\_ON}$		40	--	--	ms
Off-Isolation(DN, DP)	V_{ISO}	R_L = 32Ω, f = 20kHz, V_{COM} = 2Vp-p,	--	TBD	--	dB
Off-Isolation(AUDIO1/2)	V_{ISO}	R_L = 32Ω, f = 20kHz, V_{COM} = 0.5Vp-p,	--	TBD	--	dB
Cross-talk	V_{CT}	R_L = 32Ω, f = 20kHz, V_{COM} = 1V_{RMS}	--	–110	--	dB
Total Harmonic Distortion for Audio	T_{HD}	F = 20Hz to 20kHz, V_{COM} = 2Vp-p, R_L = 32Ω, DC bias = 0	--	0.1	--	%
Capacitance (Note 2)						
DP/Audio2 , DN/Audio1 ON Capacitance	C_{ON} (DP/Audio2, DN/Audio1)	USB on, f = 240MHz	--	4.5	--	pF
		Audio on, f = 1Mhz	--	9	--	pF
USB Input source OFF Capacitance	C_{OFF}(DP/DN)	f = 1MHz	--	1.5	--	pF
Audio(Audio2/Audio1)	C_{OFF} (Audio2/Audio1)	f = 1MHz	--	3	--	pF

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

Note 2. Guaranteed by design.

Note 3. 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.

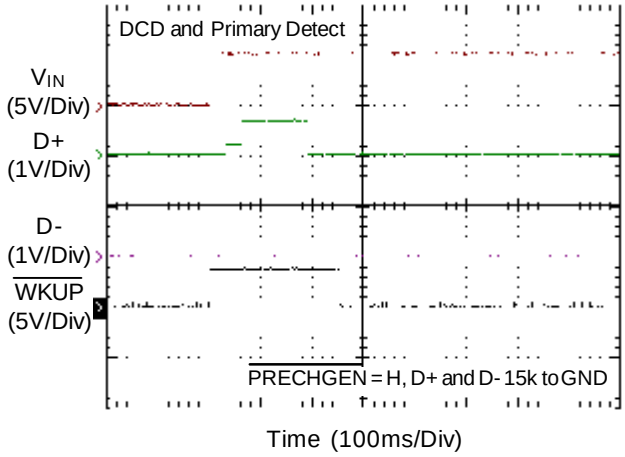
Note 4. Devices are ESD sensitive. Handling precautions are recommended.

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

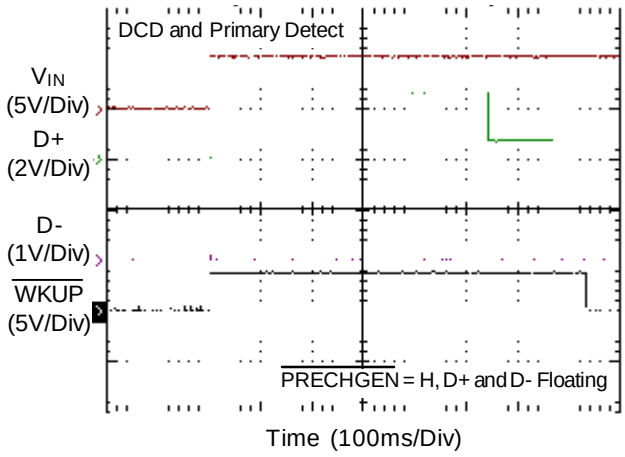
Typical Operating Characteristics

V_{IN} = 5V, unless otherwise specified.

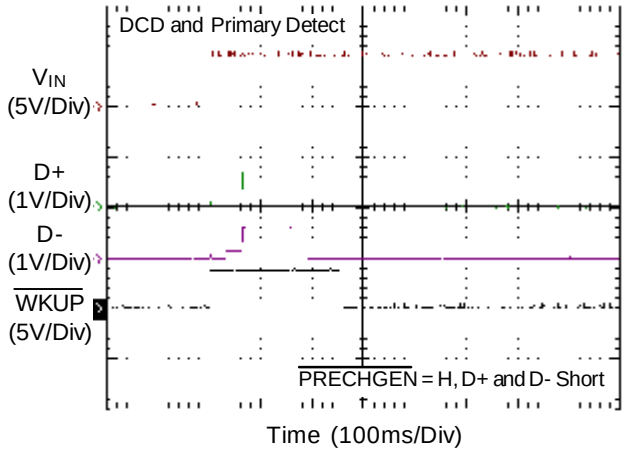
Standard Downstream Port



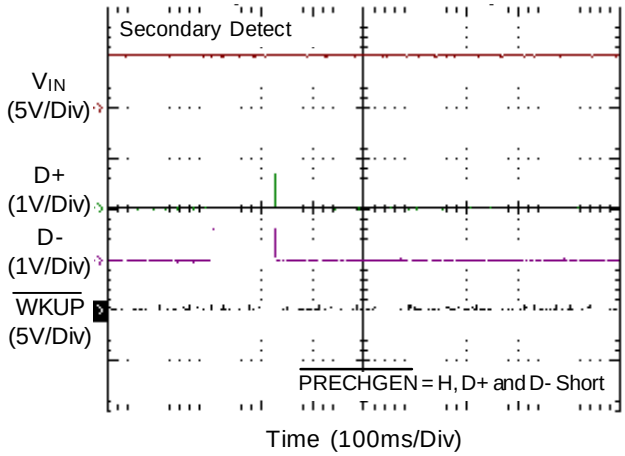
Floating



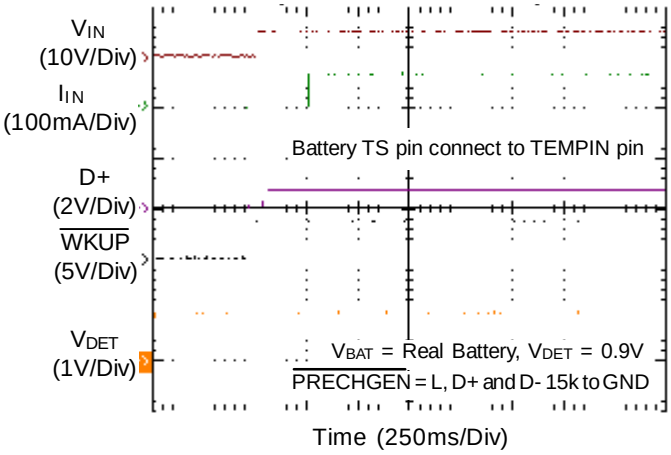
Dedicated Charging Port



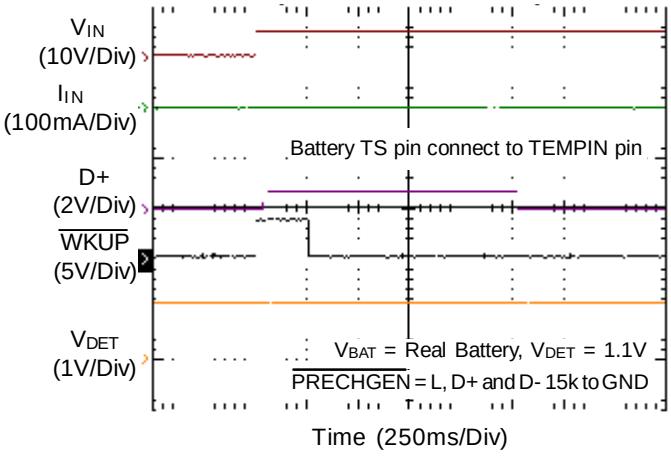
Dedicated Charging Port



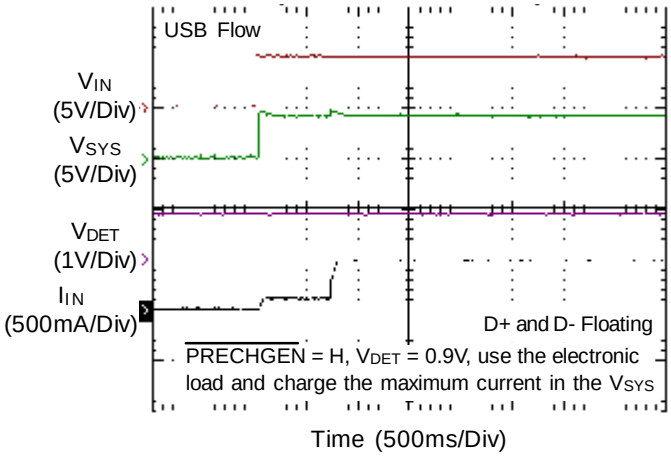
In The Dead Battery Flow



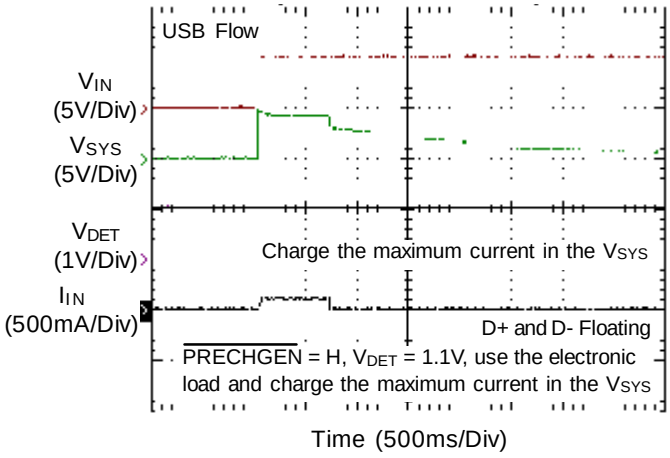
Finish Dead Battery Flow



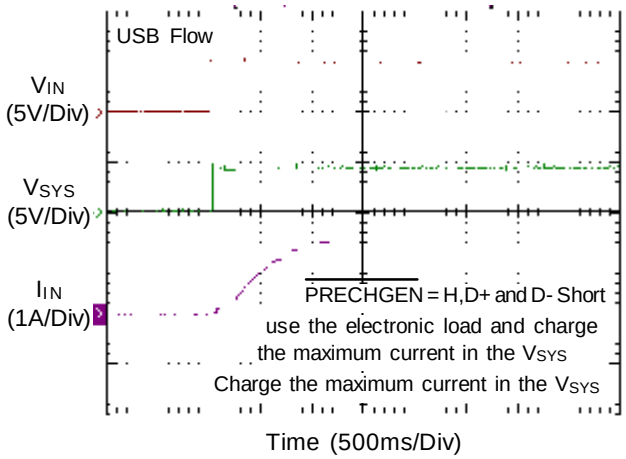
Standard 500mA Mode



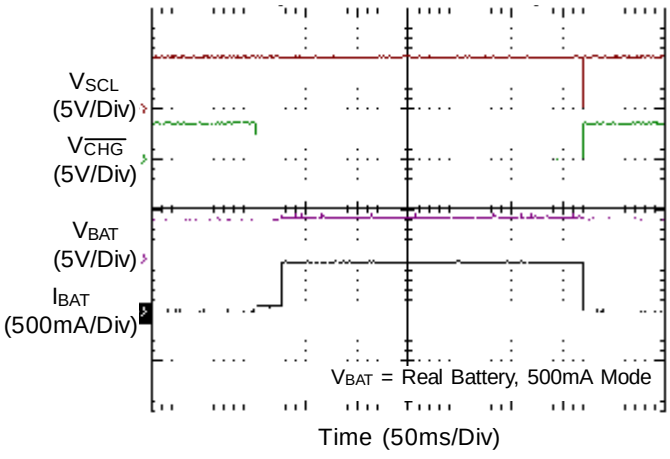
Standard USUS



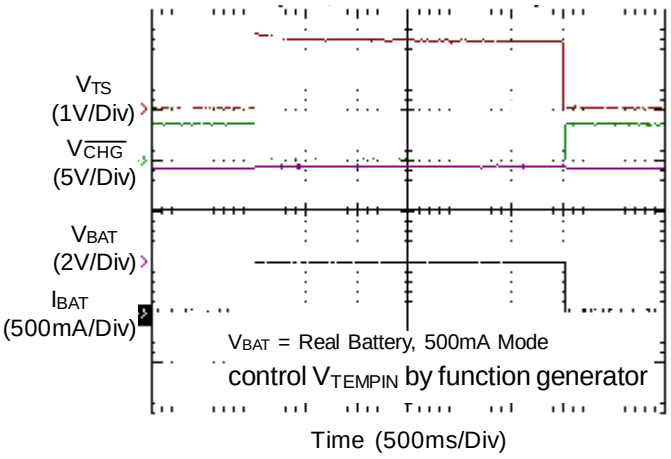
Dedicated Charging Port



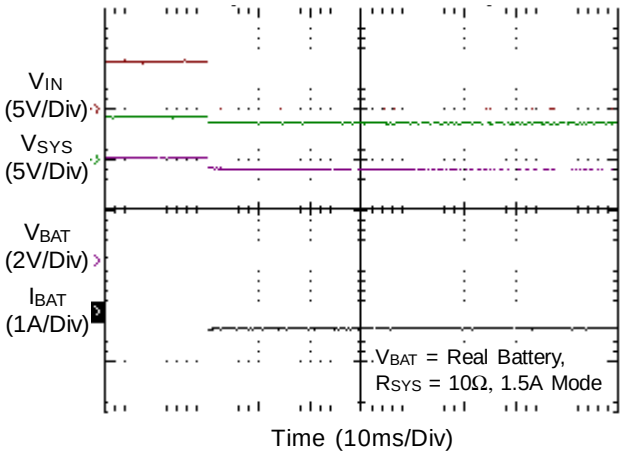
Charge on/Off Control by I²C



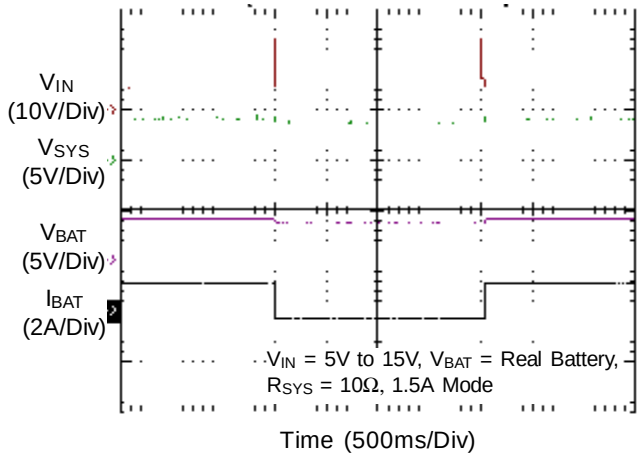
TEMPIN On/Off



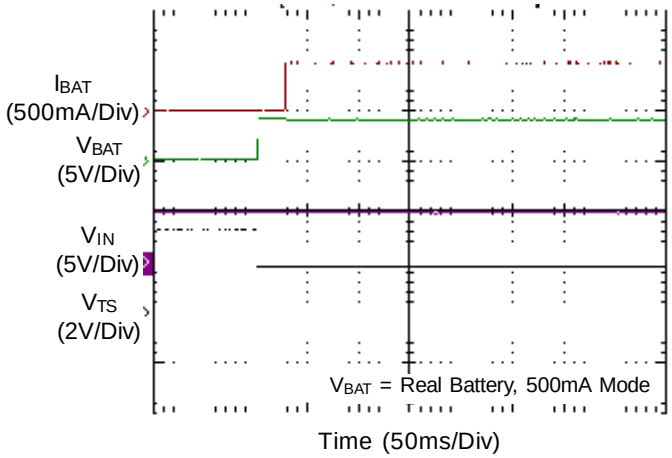
V_{IN} Removal



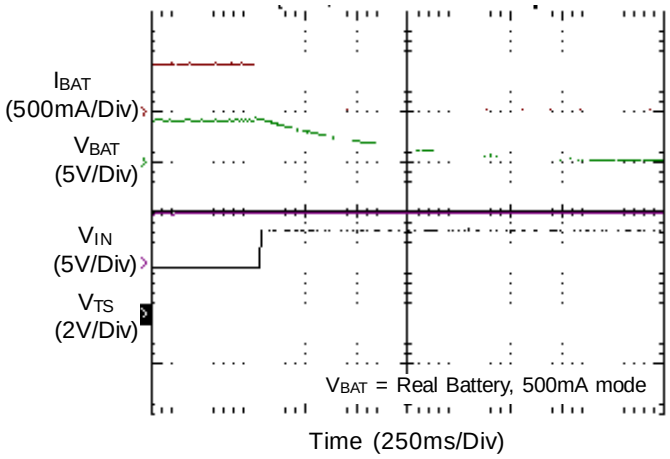
V_{IN} Over Voltage Protection



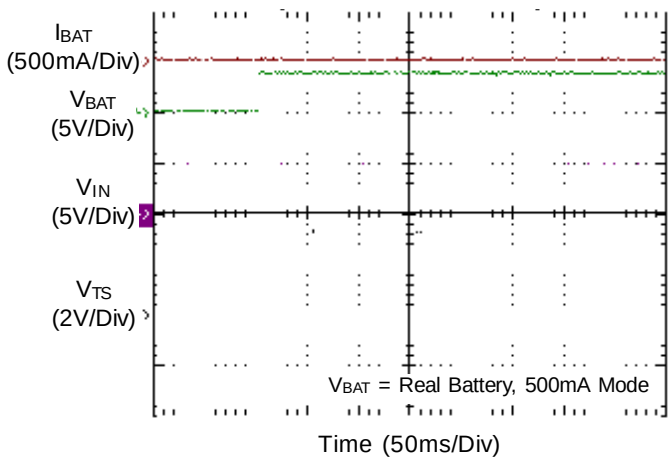
Battery with NTC Resistor Plug-In



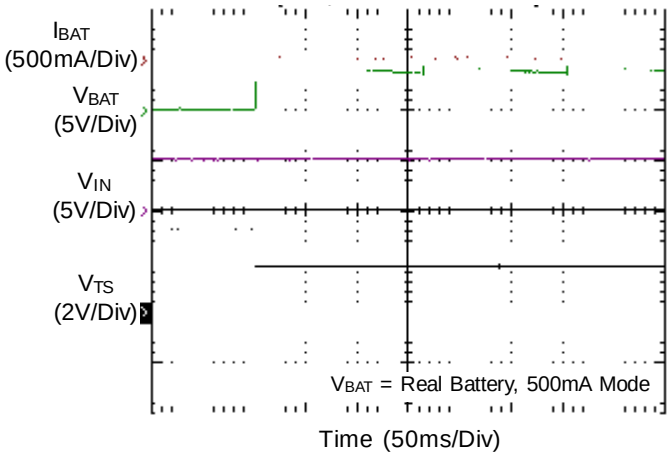
Battery with NTC Resistor Plug-Out



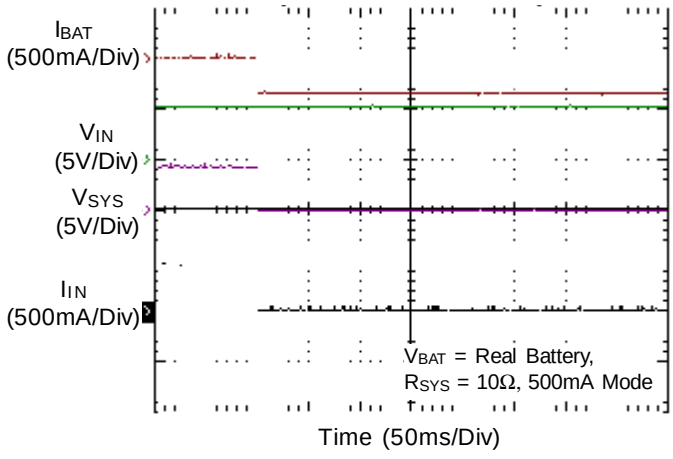
With Battery without NTC Resistor



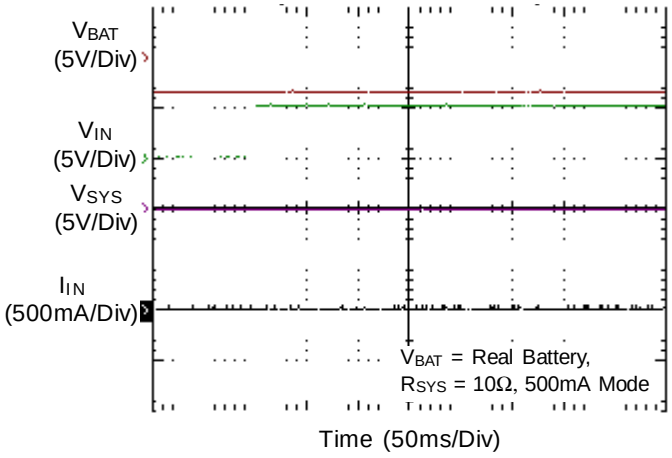
With NTC Resistor without Battery



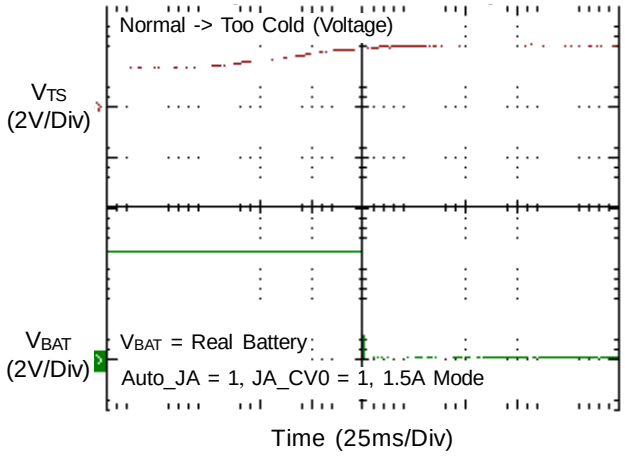
V_{IN} Exist then Negative Battery



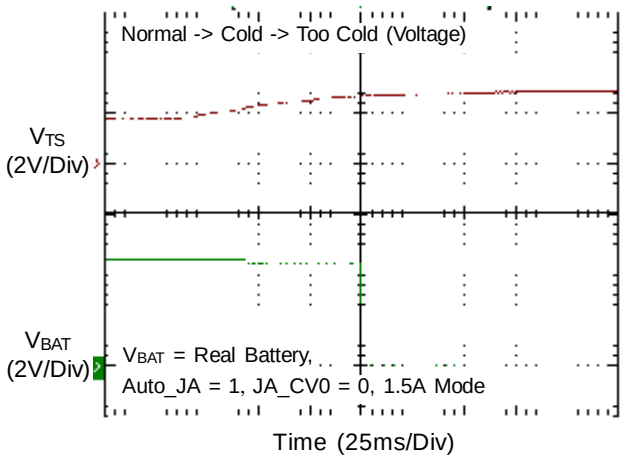
Negative Battery then V_{IN} Plug-In



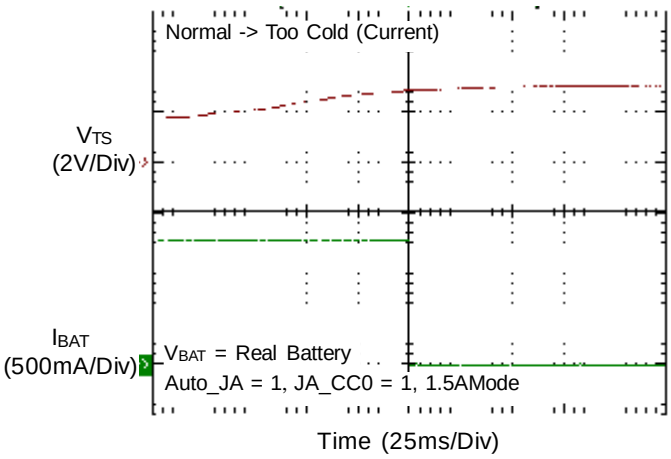
The Temperature of Battery Status



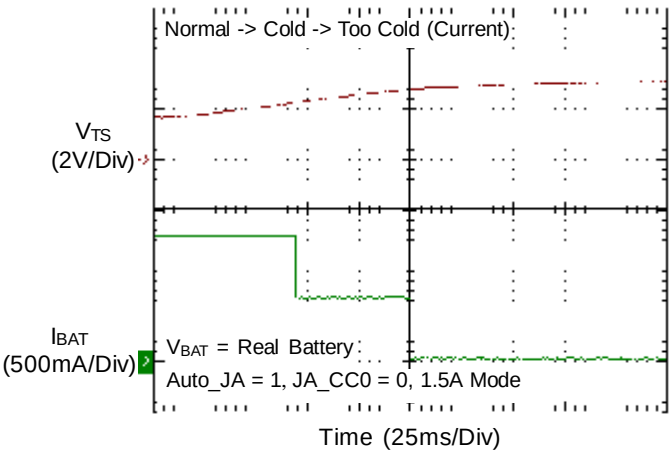
The Temperature of Battery Status



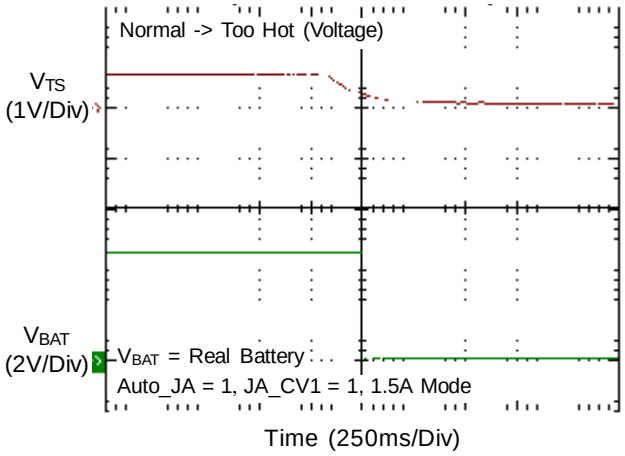
The Temperature of Battery Status



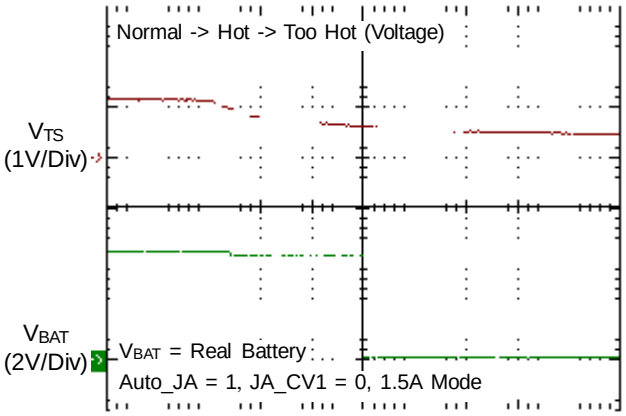
The Temperature of Battery Status



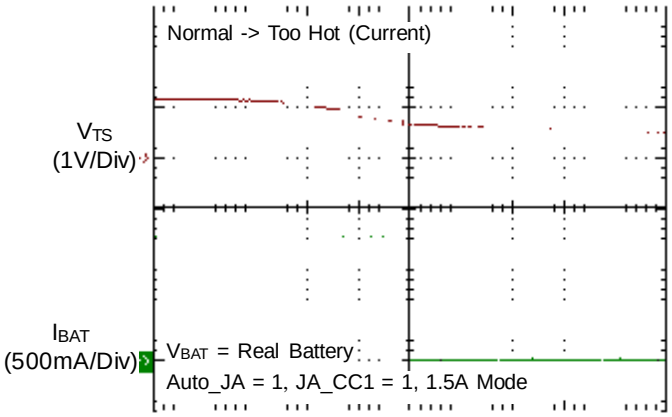
The Temperature of Battery Status



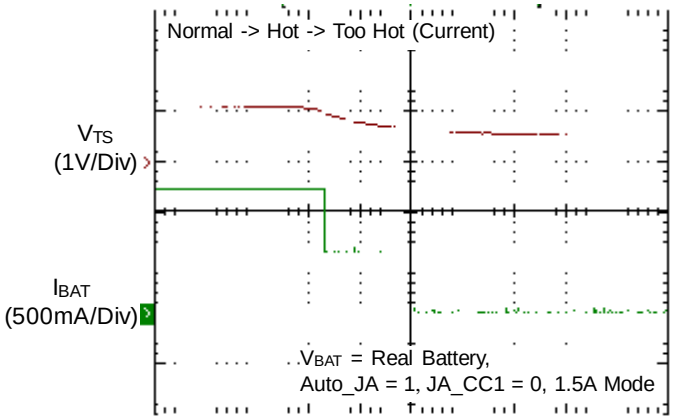
The Temperature of Battery Status



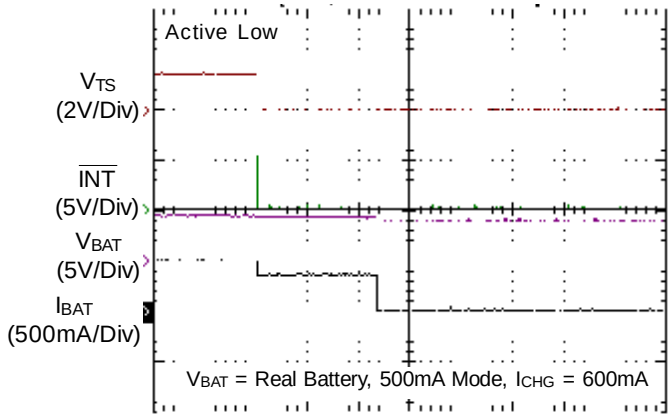
The Temperature of Battery Status



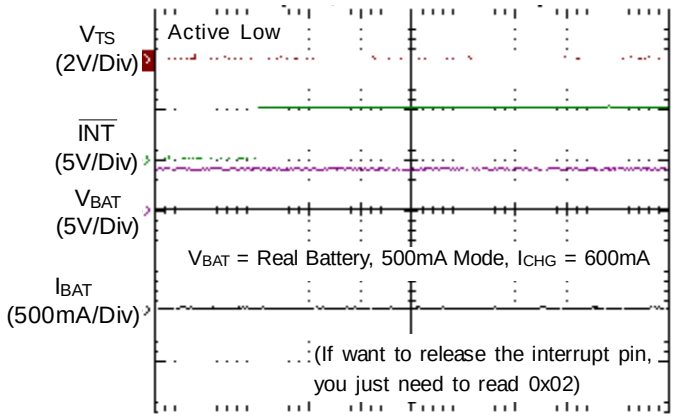
The Temperature of Battery Status



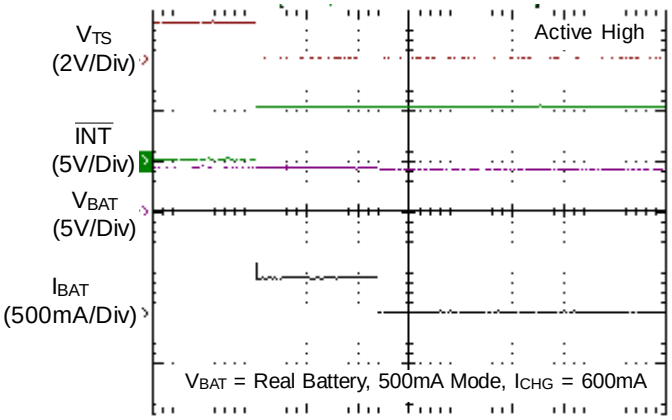
Interrupt Happen



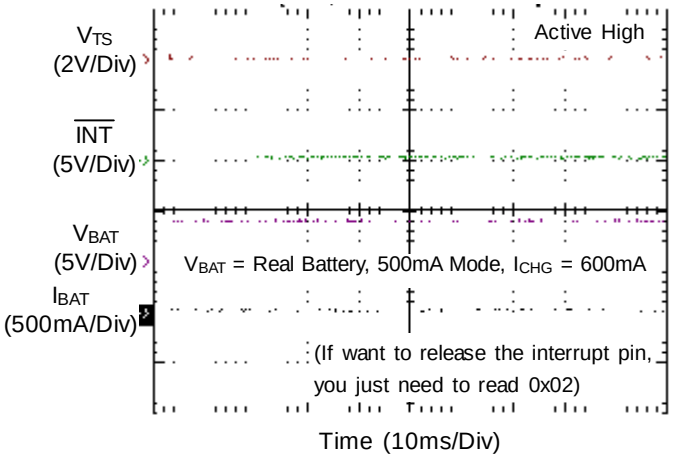
Interrupt Release



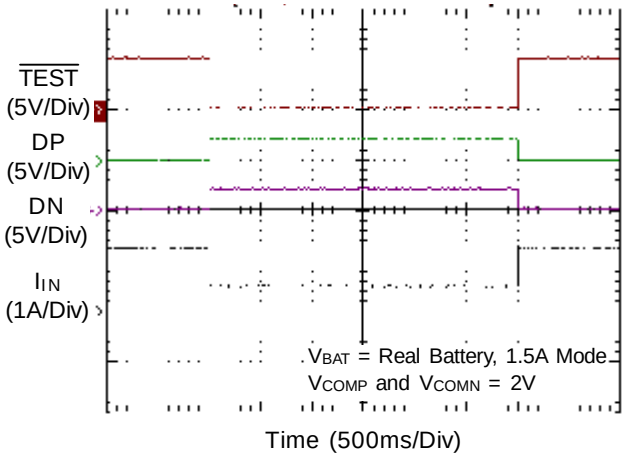
Interrupt Happen



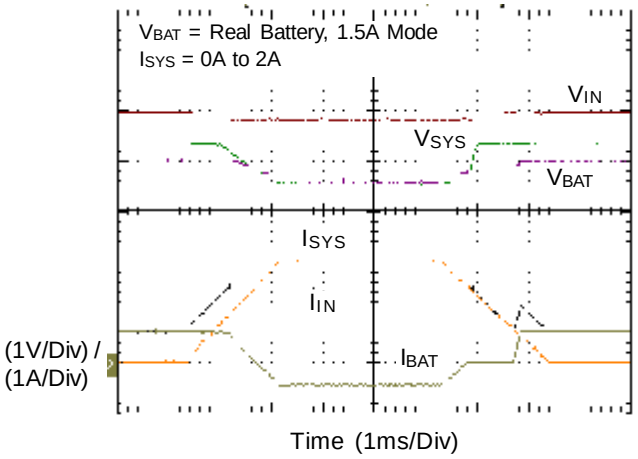
Interrupt Release



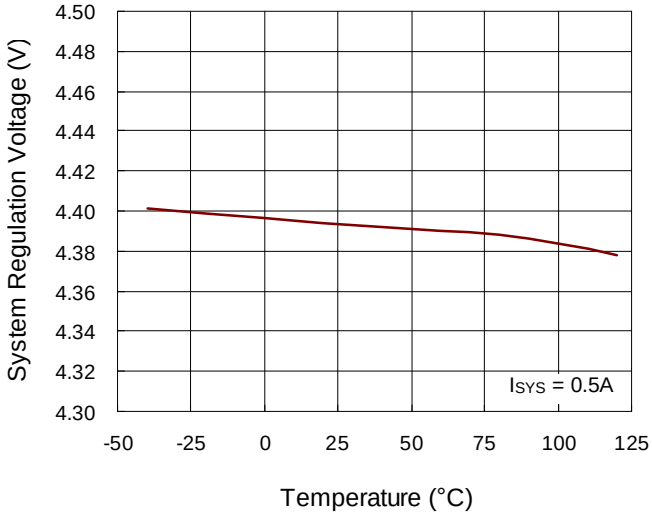
$\overline{\text{TEST}}$ Pin Function



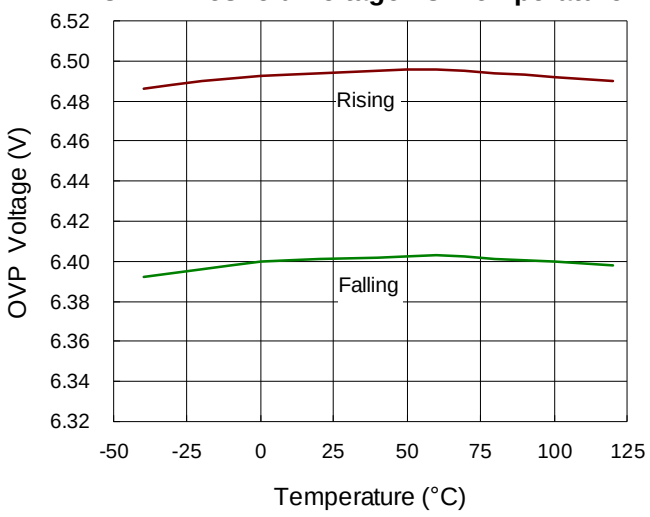
APPM



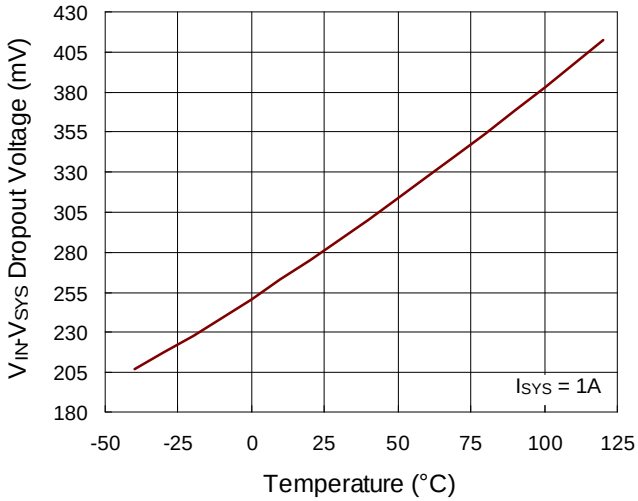
System Regulation Voltage vs. Temperature



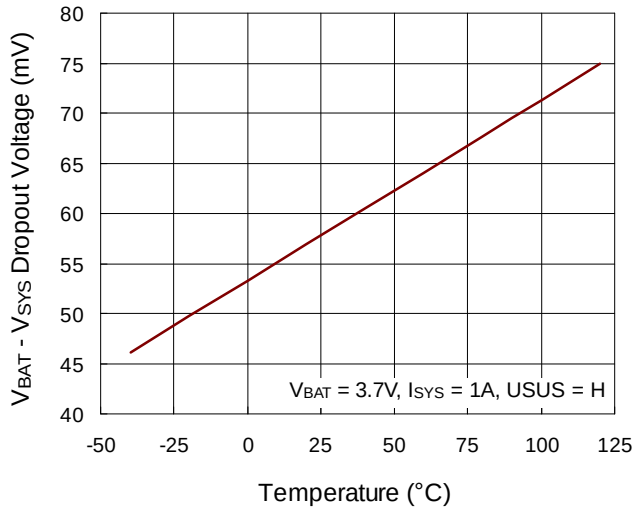
OVP Threshold Voltage vs. Temperature



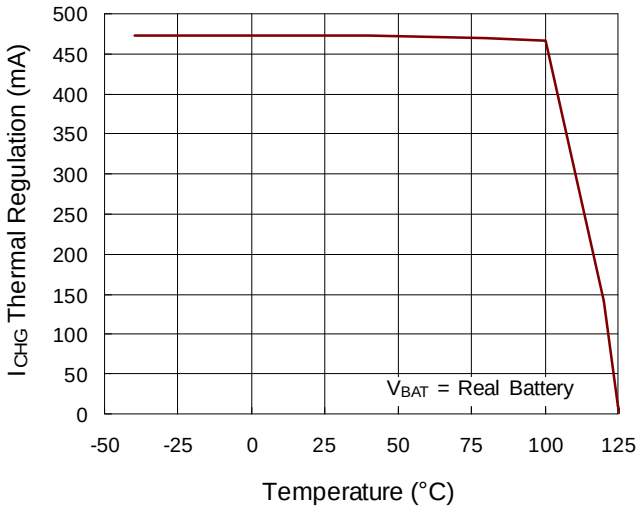
V_{IN} - V_{SYS} Dropout Voltage vs. Temperature



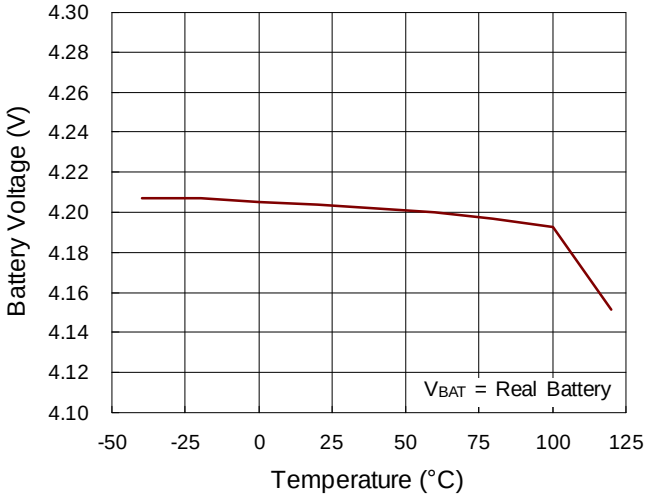
V_{BAT} - V_{SYS} Dropout Voltage vs. Temperature



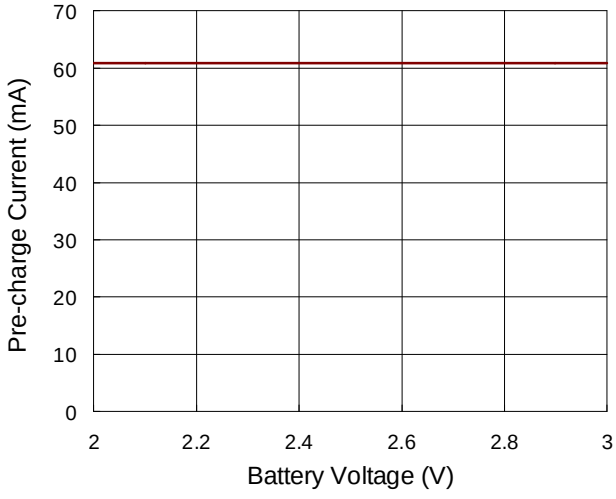
I_{CHG} Thermal Regulation vs. Temperature



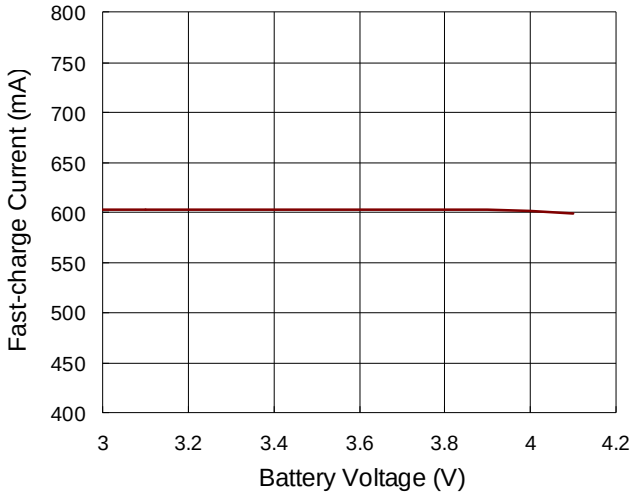
Battery Regulation Voltage vs. Temperature



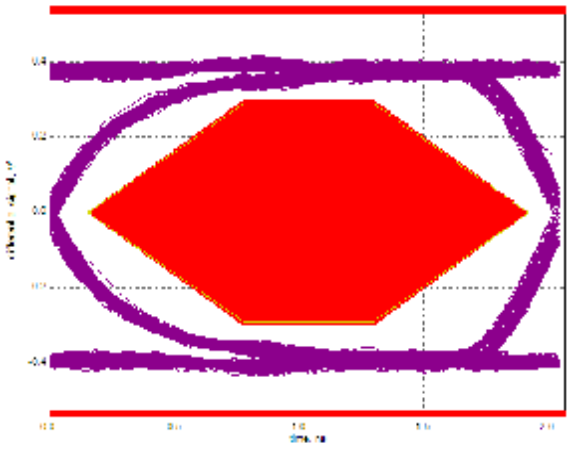
Pre-charge Current vs. Battery Voltage



Fast-charge Current vs. Battery Voltage



Eye Patten



I²C Register Information

Address : 1000101x

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x00	Base_SET1	USUS	ISETL	ISETU	VSYS_set	Reserved	CHG_EN	Reserved	Reserved
	Reset Value	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
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x01	Base_SET2	$\overline{\text{INT}}$_OUT	INT_EN	TS	LDO_TS	TS_switch	ISET	NC	Auto_JA
	Reset Value	0	0	1	1	0	1	1	1
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x02	INT_status	CHGDET	DCD_T	PG2	Termination	TS_change	Battery _absent	Time _fault	VDET _status
	Reset Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Read/Write	R	R	R	R	R	R	R	R
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x03	Status1	DCPORT	CHPORT	OVP	UVLO	SLEEP	NC	Pre_CHG	Fast_CHG
	Reset Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Read/Write	R	R	R	R	R	R	R	R
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x04	Status2	TS_flag			BAT_NEG	TS_fault	Reserved	Reserved	Reserved
	Reset Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Read/Write	R	R	R	R	R	R	R	R
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x05	CTR1	VREG						JA_CV1	JA_CV0
	Reset Value	1	0	0	0	1	1	0	1
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x06	CTR2	ICHG				IPRE_CHG		JA_CC1	JA_CC0
	Reset Value	0	0	0	0	0	0	1	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x07	CTR3	Itermi			VPRE			Time_out	
	Reset Value	0	0	1	1	1	0	0	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x08	CTR4	RNTC Type		Too Cold			Cold		
	Reset Value	0	0	1	0	0	1	0	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x09	CTR5	CHG_IND_DIS	I^2C_ctl	Hot			Too Hot		
	Reset Value	0	0	1	0	0	1	0	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x0a	Bast_SET3	COMP		COMN		CP_EN	CP_AUD	CHG_TYP	USB_CHGDET
	Reset Value	1	1	1	1	0	0	0	1
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

I^2C Table (Detail)

Base_SET1

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x00	Base_SET1	USUS	ISETL	ISETU	VSYS_set	Reserved	CHG_EN	Reserved	Reserved
	Reset Value	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

USUS	VIN Suspend Control. Turn off M1 LDO and charger function 0 : Disable Suspend function. M1 LDO turn on 1 : Enable Suspend function. M1 LDO turn off
ISETL	VIN Current Limit Control. 0 : See ISETU set 1 : 1.5A current limit
ISETU	VIN Current Limit Control 0 : 95mA current limit 1 : 475mA current limit
VSYS_set	SYS Voltage regulation control 0 : V_{SYS} = 4.4V 1 : V_{SYS} = 5.5V
CHG_EN	Charger enable control 0 : Disable charger function 1 : Enable charger function

Base_SET2

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x01	Base_SET2	$\overline{\text{INT}}$_OUT	INT_EN	TS	LDO_TS	TS_switch	ISET	NC	Auto_JA
	Reset Value	0	0	1	1	0	1	1	1
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

$\overline{\text{INT}}$_OUT	This bit sets the interrupt polarity 0 : Active low 1 : Active High
INT_EN	Enables interrupt generation. When set to disabled, it will mask $\overline{\text{INT}}$ pin out. If $\overline{\text{INT}}$_OUT = 0 and INT_EN = 0, $\overline{\text{INT}}$ pin is high impedance. If $\overline{\text{INT}}$_OUT = 1 and INT_EN = 0, $\overline{\text{INT}}$ pin is low. 0 : Disable Interrupt 1 : Enable Interrupt
TS	Thermal Sense function and check battery absent function 0 : Disable TS function and check battery absent function 1 : Enable TS function and check battery absent function
LDO_TS	The LDO for Thermal Sense 0 : Disable LDO_TS 1 : Enable LDO_TS
TS_switch	The switch between TEMPIN and TEMPOUT 0 : Open 1 : Short
ISET	SET charge current (If Auto_JA = 1 , ISET can not control charge current) 0 : Half of charge current 1 : Full of charge current
Auto_JA	Auto control charge current and voltage by battery temperature 0 : Disable 1 : Enable

INT_Status

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x02	INT_status	CHGDET	DCD_T	PG2	Termination	TS _change	Battery _absent	Time_fault	VDET _status
	Reset Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Read/Write	R	R	R	R	R	R	R	R

CHGDET	Output of USB Charger detection comparator. This bit will set to one if COMP > VDAT_REF for longer than 20ms. Any change in this bit triggers an interrupt. 0 : COMN < VDAT_REF or COMN > VLGC (High-current charger not detected) 1 : VLGC > COMN > VDAT_REF (High-current charger detected
DCD_T	Data Contact Detect Time Wait. (Interrupt generated for 0 to 1 transition) 0 : Data Contact Detect timer not expired 1 : Data Contact Detect running for >512ms
PG2	PG2_status bit. Any change in this bit triggers an interrupt. 0 : No power good. 1 : Power good (no OVP & no UVLO & no SLEEP)
Termination	Charge termination bit (latch type, one time, use EN or USUS re-toggle reset) Any change in this bit triggers an interrupt. 0 : Normal 1 : Termination
TS_change	TS change bit. (Interrupt generated for 0 to 1 transition) TS_change = 1 triggers an interrupt. After 0x02 is read, TS_change will be set to 0. 0 : Normal 1 : When 0x04 register bit5 to bit7 (TS_flag) status have some changes.
Battery_absent	Battery absent bit. Any change in this bit triggers an interrupt. 0 : Normal 1 : Battery absent happen
Time_fault	Charger timer fault bit. Any change in this bit triggers an interrupt. 0 : Normal 1 : Time Fault
VDET_status	VDET state bit. Any change in this bit triggers an interrupt. 0 : VDET < 1V 1 : VDET > 1V

I²C_Status1

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x03	Status1	DCPORT	CHPORT	OVP	UVLO	SLEEP	NC	Pre_CHG	Fast_CHG
	Reset Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Read/Write	R	R	R	R	R	R	R	R
DCPORT	Indicates if a Dedicated USB Charger is Connected 0 : No dedicated Charger 1 : Dedicated Charger Detected								
CHPORT	Indicates if a High Current Host/Hub is Connected 0 : No dedicated HCHH 1 : HCHH Detected								
OVP	OVP_state bit 0 : VIN Voltage is lower than OVP Threshold Voltage 1 : VIN Voltage is higher than OVP Threshold Voltage								
UVLO	UVLO_state bit 0 : VIN Voltage is higher than UVLO Threshold Voltage 1 : VIN Voltage is lower than UVLO Threshold Voltage								
SLEEP	SLEEP_state bit 0 : No sleep , (VIN – 100mV) > V_{BAT} 1 : Sleep state, (VIN – 50mV) < V_{BAT}								
Pre_CHG	Pre-charge status. If CHG_EN is disabled, Pre_CHG = 0 0 : Not Pre-charge 1 : Pre-charge								
Fast_CHG	Fast-charge status. If CHG_EN is disabled, Fast_CHG = 0 0 : Not Fast-charge 1 : Fast-charge								

I²C_Status2

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x04	Status2	TS_flag			BAT_NEG	TS_fault	Reserved	Reserved	Reserved
	Reset Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Read/Write	R	R	R	R	R	R	R	R
TS_flag	TS_flag state bit 000 : < (Too Cold) 001 : (Too Cold) ~ (Cold) 010 : Normal 011 : (Hot) ~ (Too Hot) 100 : > (Too Hot) 101 ~ 111 : Reserved Note : Let (Too Cold) < (Cold) < (Hot) < (Too Hot)								
BAT_NEG	Battery negative status bit 0 : Normal 1 : BAT pin is negative voltage								
TS_fault	TS_fault 0 : Normal 1 : Too Cold or Too Hot								

I²C_CTR1

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x05	CTR1	VREG						JA_CV1	JA_CV0
	Reset Value	1	0	0	0	1	1	0	1
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
VREG		Setting of Battery Regulation Voltage (Range : 3.5V to 4.26V, Default = 4.2V) If Auto_JA = 1, these bits will not control.							
		000000	3.50V	010000	3.82V	100000	4.14V	110000	4.26V
		000001	3.52V	010001	3.84V	100001	4.16V	110001	4.26V
		000010	3.54V	010010	3.86V	100010	4.18V	110010	4.26V
		000011	3.56V	010011	3.88V	100011	4.20V	110011	4.26V
		000100	3.58V	010100	3.90V	100100	4.22V	110100	4.26V
		000101	3.60V	010101	3.92V	100101	4.24V	110101	4.26V
		000110	3.62V	010110	3.94V	100110	4.26V	110110	4.26V
		000111	3.64V	010111	3.96V	100111	4.26V	110111	4.26V
		001000	3.66V	011000	3.98V	101000	4.26V	111000	4.26V
		001001	3.68V	011001	4.00V	101001	4.26V	111001	4.26V
		001010	3.70V	011010	4.02V	101010	4.26V	111010	4.26V
		001011	3.72V	011011	4.04V	101011	4.26V	111011	4.26V
		001100	3.74V	011100	4.06V	101100	4.26V	111100	4.26V
		001101	3.76V	011101	4.08V	101101	4.26V	111101	4.26V
		001110	3.78V	011110	4.10V	101110	4.26V	111110	4.26V
		001111	3.80V	011111	4.12V	101111	4.26V	111111	4.26V
JA_CV1		If Auto_JA = 1, JA_CV1 controls charge voltage, Hot ~ Too Hot 0 : Hot ~ Too Hot : 4.06V 1 : Hot ~ Too Hot : 4.2V							
JA_CV0		If Auto_JA = 1, JA_CV0 controls charge voltage, Cold ~ Too Cold 0 : Cold ~ Too Cold : 4.06V 1: Cold ~ Too Cold : 4.2V							

I²C_CTR2

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x06	CTR2	ICHG				IPRE_CHG		JA_CC1	JA_CC0
	Reset Value	0	0	0	0	0	0	1	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ICHG		Setting of Fast Charge Current (Range : 66mA to 1000mA, Default = 66mA)							
		0000	66mA						
		0001	100mA						
		0010	200mA						
		0011	250mA						
		0100	300mA						
		0101	350mA						
		0110	400mA						
		0111	450mA						
		1000	500mA						
		1001	600mA						
		1010	700mA						
		1011	800mA						
		1100	900mA						
		1101	1000mA						
		1110	1100mA						
		1111	1200mA						
IPre_CHG		Setting of Pre-charge Current (Range : 40 to100mA, Default = 40mA)							
		00	40mA						
		01	60mA						
		10	80mA						
		11	100mA						
JA_CC1		If Auto_JA = 1, JA_CC1 controls the current , Hot ~ Too Hot 0 : Hot ~ Too Hot : 50% charge current 1 : Hot ~ Too Hot : 100% charge current							
JA_CC0		If Auto_JA = 1, JA_CC0 controls the current , Cold ~ Too Cold 0 : Cold ~ Too Cold : 50% charge current 1 : Cold ~ Too Cold : 100% charge current							

I²C_CTR3

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x07	CTR3	Itermi			VPRE			Time_out	
	Reset Value	0	0	1	1	1	0	0	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Itermi		Setting of charger termination Ratio (Range : 5 to 35%, Default = 10%)							
		000	5%						
		001	10%						
		010	15%						
		011	20%						
		100	25%						
		101	35%						
		110	Reserved						
		111	disable						
VPre to Fast		Setting of Pre to Fast charge (Range : 2.4 to 3.1V, Default = 3V)							
		000	2.4V						
		001	2.5V						
		010	2.6V						
		011	2.7V						
		100	2.8V						
		101	2.9V						
		110	3.0V						
		111	3.1V						
Time-out		Setting of Time out Pre/Fast (Range : 30min/240min to 60min/480min, Default = 30min/240min)							
		00	Pre / Fast = 30min / 240min						
		01	Pre / Fast= 45min / 360min						
		10	Pre / Fast = 60min / 480min						
		11	Disable						

I²C_CTR4

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x08	CTR4	RNTC Type		Too Cold			Cold		
	Reset Value	0	0	1	0	0	1	0	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
RNTC Type	RNTC Type set 00 : See SETNTC Pin 01 : RNTC = 100kΩ 10 : RNTC = 10kΩ 11 : Reserved(same as 00)								
Too Cold	Setting of charger Too Cold Temperature (Range : –10 to 15°C, Default = 0°C) 000 : –10°C 001 : –10°C 010 : –10°C 011 : –5°C 100 : 0°C 101 : 5°C 110 : 10°C 111 : 15°C								
Cold	Setting of charger Cold Temperature (Range : –10 to 25°C, Default = 10°C) 000 : –10°C 001 : –5°C 010 : 0°C 011 : 5°C 100 : 10°C 101 : 15°C 110 : 20°C 111 : 25°C								

I²C_CTR5

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x09	CTR5	CHG_IND_DIS	I²C_ctl	Hot			Too Hot		
	Reset Value	0	0	1	0	0	1	0	0
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CHG_IND_DIS	$\overline{CHG}$ pin control : 0 : $\overline{CHG}$ pin is normal. (Default) 1 : $\overline{CHG}$ pin is high impedance
I²C_ctl	When VIN is no power force RT9528 wake-up. 0 : Disable 1 : Enable
Hot	Setting of charger Hot Temperature (Range : 25 to 58°C, Default = 45°C) 000 : 25°C 001 : 30°C 010 : 35°C 011 : 40°C 100 : 45°C 101 : 50°C 110 : 55°C 111 : 58°C
Too Hot	Setting of charger Too Hot Temperature (Range : 40 to 58°C, Default = 58°C) 000 : 40°C 001 : 45°C 010 : 50°C 011 : 55°C 100 : 58°C 101 : 58°C 110 : 58°C 111 : 58°C

Base_SET3

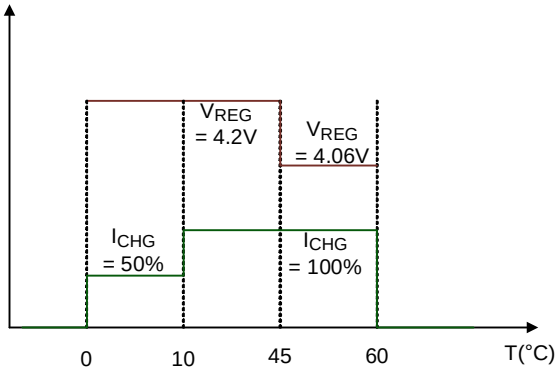
Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x0a	Base_SET3	COMP		COMN		CP_EN	CP_AUD	CHG_TYP	USB_CHGDET
	Reset Value	1	1	1	1	0	0	0	1
	Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

COMP	The bit sets the position of the mux switch connected to COMP 00 : COMP Connected to DP 01 : COMP Connected to AUDIO2 10 : High Impedance 11 : High Impedance
COMN	The bit sets the position of the mux switch connected to COMN 00 : COMN Connected to DN 01 : COMN Connected to AUDIO1 10 : High Impedance 11 : High Impedance
CP_EN	Enables the charge pump required for analog switch operation. Set to 1 when any signal is passed through the switch. When set to disable, there must be no signal connected to an audio input which goes below ground. 0 : Disabled 1 : Enabled
CP_AUD	The bit sets the position of the click/pop resistor on both AUDIO1 and AUDIO2 0 : Disabled 1 : Enabled
CHG_TYP	Enables Charger Type Detection. Set this bit to determine between Dedicated USB charger and High Current Host/Hub Chargers. 0 : Disabled 1 : Enabled
USB_CHGDET	Enables the USB Charger Detection. 0 : Disabled 1 : Enabled

Application Information

Richtek's component specification does not include the following information in the Application Information section. Thereby no warranty is given regarding its validity and accuracy. Customers should take responsibility to verify their own designs and reserve suitable design margin to ensure the functional suitability of their components and systems.

J_A Initial State



VDET

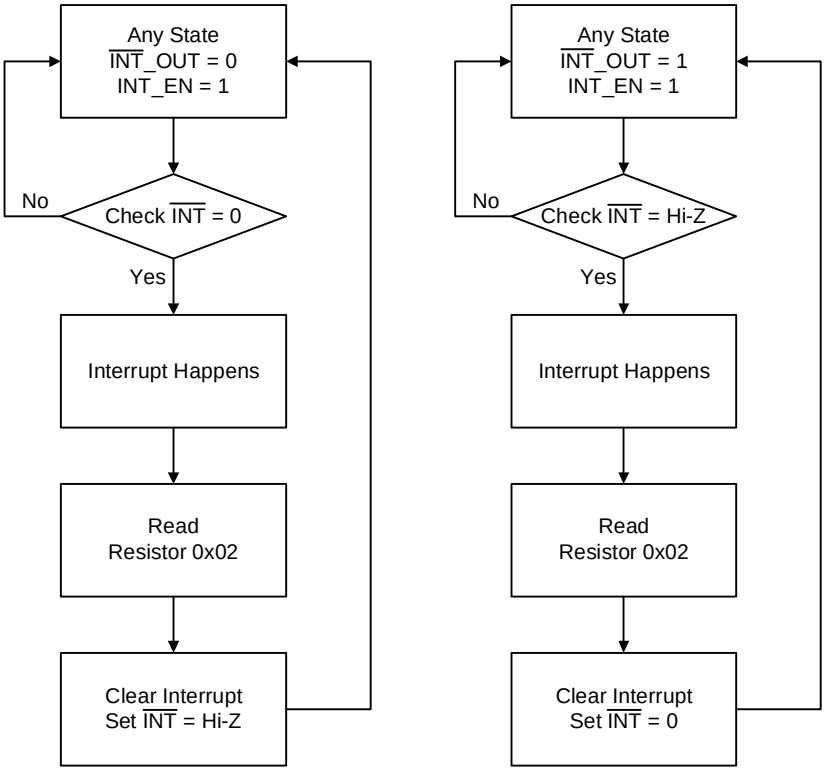
If VIN power is good, 0x02 VDET_status works normally.

If Only Battery plugs in, 0x02 VDET_status = 1

$\overline{\text{WKUP}}$

$\overline{\text{WKUP}}$ keeps Hi-Z without VIN.

Interrupt Chart flow



Note1 :

If Set INT_EN = 0, it just mask the $\overline{\text{INT}}$ signal.

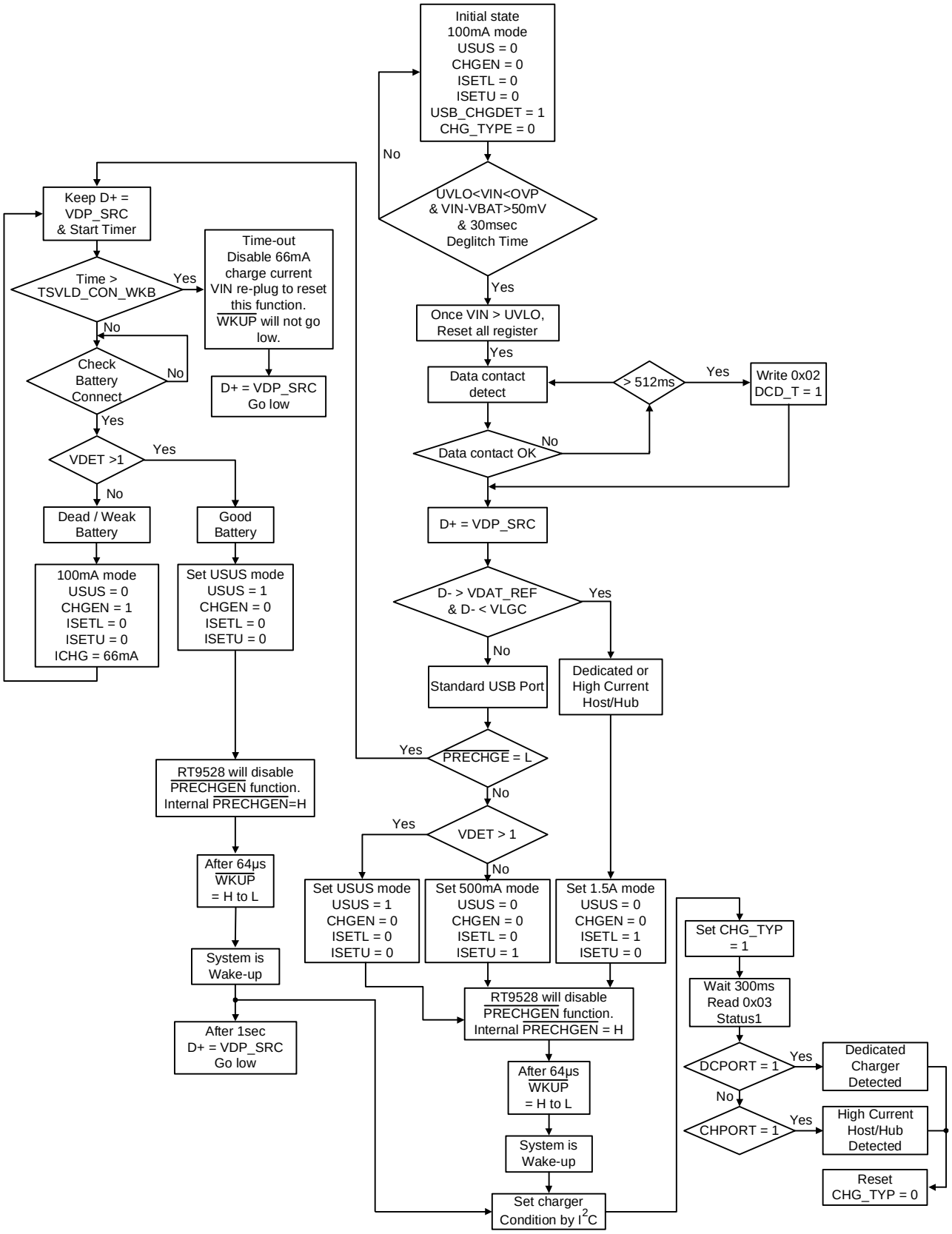
When INT_EN = 1, interrupt still happens.

Note 2 :

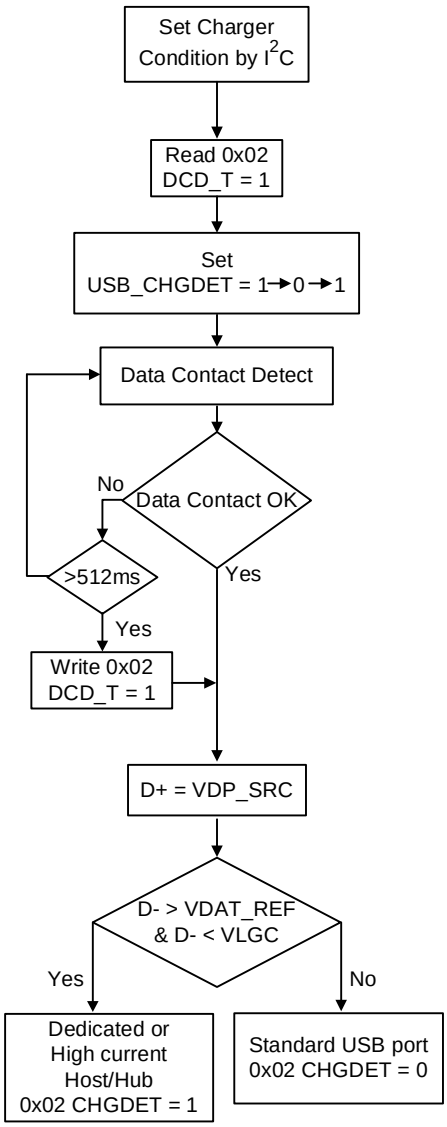
If $\overline{\text{INT}}$_OUT = 0 and $\overline{\text{INT}}$_EN = 0, INT pin is high impedance.

If $\overline{\text{INT}}$_OUT = 1 and $\overline{\text{INT}}$_EN = 0, INT pin is low.

Charger Initial Flow Chart



After $\overline{\text{WKUP}}$ from H go L, system can do DCD and CHGDET again as below



NTC Ratio

NCP15WF104F03RC_100kΩ

T (°C)	R1 (kW)	RNTC (kW)	Ratio (%)
–10	100	528.988	84
–5	100	471.632	82.5
0	100	357.012	78
5	100	272.5	73
10	100	209.71	67.5
15	100	162.651	62
20	100	127.08	56
25	100	100	50
30	100	79.222	44
35	100	63.167	38.5
40	100	50.677	33.5
45	100	40.904	29
50	100	33.195	25
55	100	27.091	21.5
58	100	24.1708	19.5

NCP15XH103F03RC_10kΩ

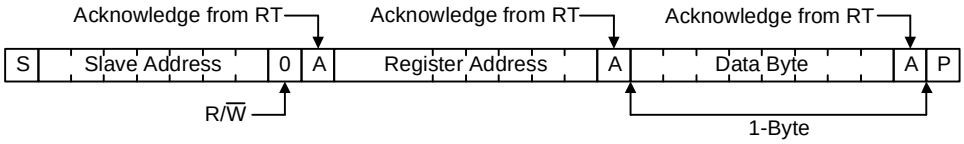
T (°C)	R1 (kW)	RNTC (kW)	Ratio (%)
–10	10	42.5062	81
–5	10	33.8922	77
0	10	27.2186	73
5	10	22.0211	69
10	10	17.9255	64
15	10	14.6735	59.5
20	10	12.0805	54.5
25	10	10	50
30	10	8.3145	45.5
35	10	6.9479	41
40	10	5.8336	37
45	10	4.9169	33
50	10	4.1609	29.5
55	10	3.535	26
58	10	3.22258	24.5

I²C Write and Read

Write

RT9528 1 support byte writing as below. If you want to write another data byte, you must follow as below again.

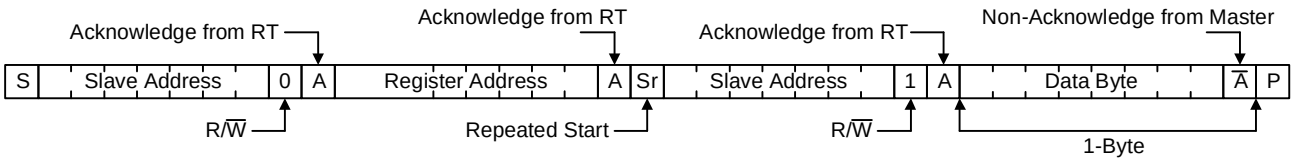
ı Writing 1 Byte of Data to RT



Read

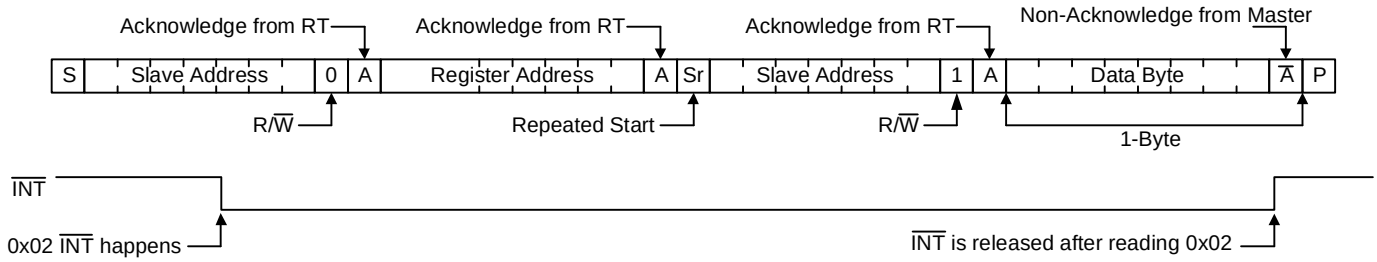
RT9528 1 support byte reading as below. If you want to read another data byte, you must follow as below again.

ı Reading 1 Byte of Data from RT



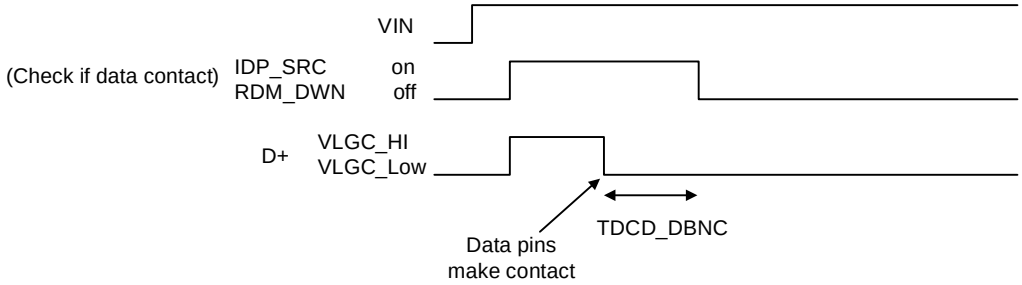
$\overline{\text{INT}}$ Release

- $\overline{\text{INT}}$ release , $\overline{\text{INT}}$_OUT = 0 and INT_EN = 1

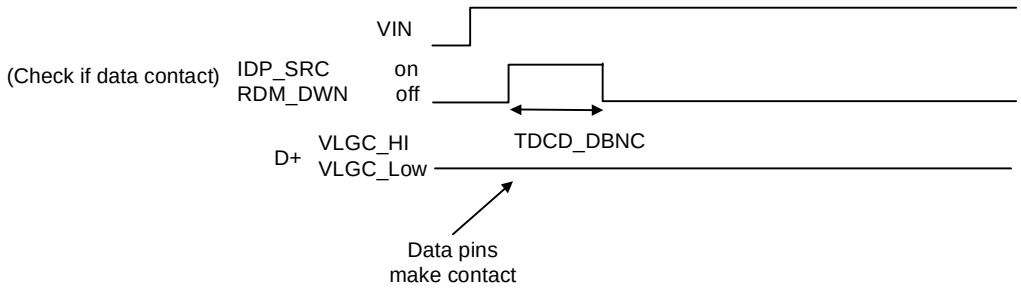


Data Pin Contact Timing

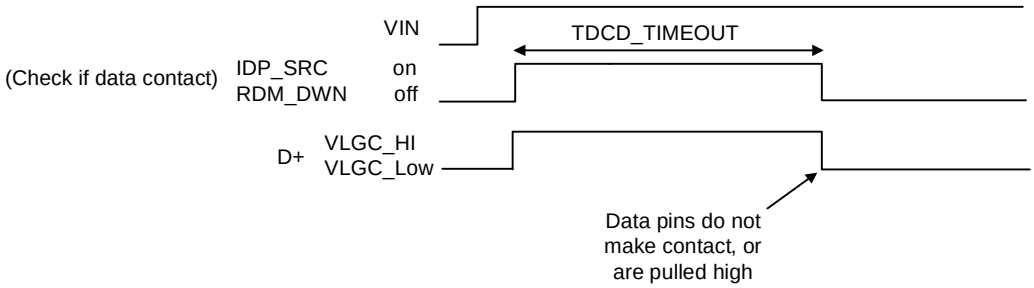
DCD Timing, Contact After Start



DCD Timing, Contact Before Start

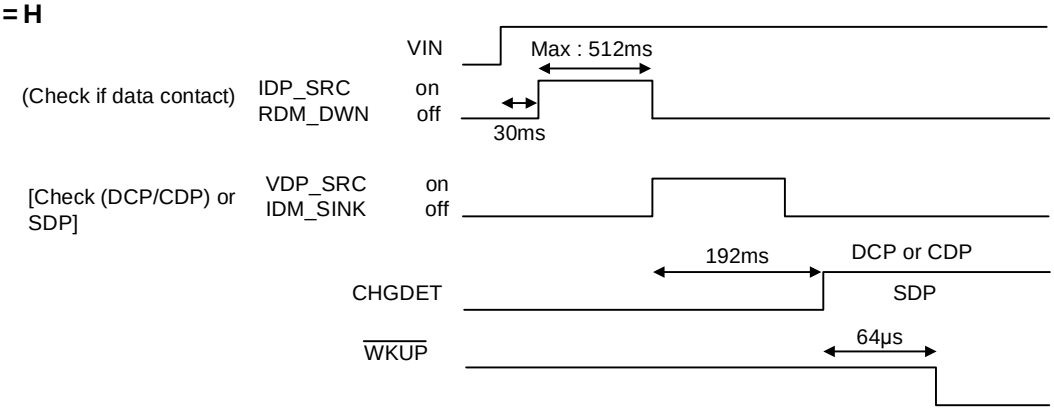


DCD Timing, non Contact



Waveform for $\overline{\text{PRECHGEN}}$

$\overline{\text{PRECHGEN}}$ = H

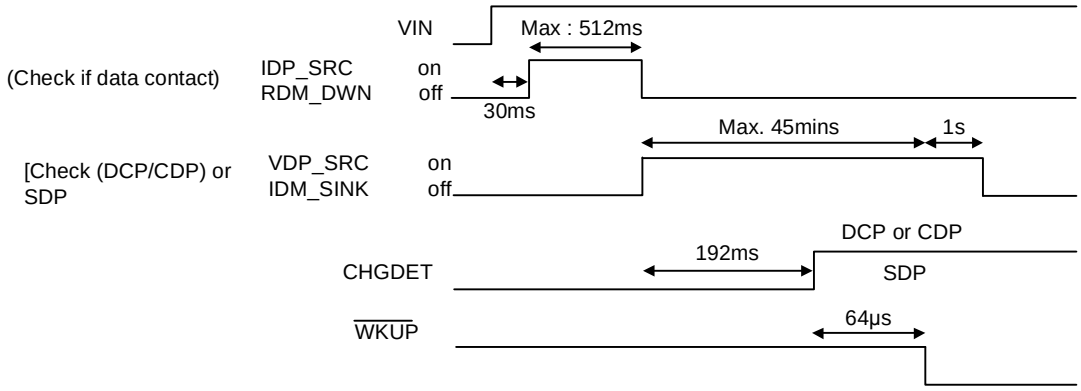


SDP : Standard Downstream Port

CDP : Charging Downstream Port

DCP : Dedicated Charging Port

$\overline{\text{PRECHGEN}}$ = L



SDP : Standard Downstream Port

CDP : Charging Downstream Port

DCP : Dedicated Charging Port

ISET

For dead battery flow or pre-charge flow, charge current will not be half, even if 0x01 ISET = 0.

For fast charge flow, if ISET = 1, charge current = 1 x (I^2C set); if ISET = 0, charge current = 0.5 x (I^2C set).

Time-Out

(1) For dead battery flow : (regardless of Auto-JA)

If 0x01 ISET = 1 (default)

Timeout = 30min, even if too cold or too hot.

If 0x01 ISET = 0

Timeout = 30min, even if too cold or too hot.

During the timeout period, the $\overline{\text{CHG}}$ pin is high impedance.

(2) For pre-charge flow : (regardless of Auto-JA)

If 0x01 ISET = 1 (default)

Timeout = 1 x (I^2C set), even if too cold or too hot.

If 0x01 ISET = 0

Timeout = 1 x (I^2C set), even if too cold or too hot.

During the timeout period, the $\overline{\text{CHG}}$ pin is flashed by 2Hz.

(3) For fast-charge flow :

(3_1) 0x01 Auto-JA = 0

If 0x01 ISET = 1 (default)

Timeout = 1 x (I^2C set), even if too cold or too hot.

If 0x01 ISET = 0

Timeout = 2 x (I^2C set), even if too cold or too hot.

(3_2) 0x01 Auto-JA = 1

The charge current is set according to 0x06 JA_CC1 and JA_CC0 setting.

If Auto-JA makes charge current to be half for cold or hot condition, Timeout = 2 x (I^2C set), and timeout will be still the same (= 2 x (I^2C set)) if too cold or too hot.

During the timeout period, the $\overline{CHG}$ pin is flashed by 2Hz.

$\overline{CHG}$ Indicator

In dead battery or normal charge flow, the following cases make the $\overline{CHG}$ pin to be high impedance : no battery, too hot too cold, 0x00 USUS = 1, 0x00 CHG_EN = 0, charge termination, time-out in dead battery flow, 0x09 CHG_IND_DIS = 1, or 0x02 PG2 = 0 in normal charge flow.

Battery absent function and TS function

If VIN plugs in, 0x01 TS = 1 and 0x01 LDO_TS = 1, battery absent function and TS function will work normally.

If only battery plugs in, battery absent function and TS function will not work due to battery leakage current request (IBAT < 5μA). And 0x02 Battery absent = 1 even if battery plugs in. 0x04 TS_flag [bit7, bit6, bit5] = [010] even if battery temperature changes. If you need battery absent function and TS function, you can set 0x09 I^2C_ctl = 1, VEXT pin > 3.8V, 0x01 TS = 1, and 0x01 LDO_TS = 1. However, these functions will sink current from battery. If you want to suspend battery current, you can set 0x09 I^2C_ctl = 0 and VEXT pin = 0V.

By the way, if VIN and battery plug in and 0x02 USUS = 1 or CHG_EN = 0, the 0x04 TS_fault bit will be set at 1. After setting USUS = 0 and CHG_EN = 1, the 0x04 TS_fault bit can work normally. When 0x09 I^2C_ctl = 1, the 0x04 TS_fault bit will work normally even if USUS = 1 or CHG_EN = 0.

Upside Down Battery Function

If battery is inserted upside down, it causes that the voltage of BAT pin is negative. RT9528 will disable charger function until battery voltage is normal. If battery is inserted upside down, 0x04 bit4 BAT_NEG will be 1.

USB Switch

If VIN is not good power (VIN > OVP, VIN < UNLO, or VIN–VBA < 50mV), USB switch will be turned off even if set 0x0a COMP = (0,0) COMN = (0,0).

I^2C Register Reset

If VIN plugs in, all I^2C register will reset.

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-28L 4x4 package, the thermal resistance, θ_{JA}, is 52°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 :

$P_{D(MAX)} = (125°C - 25°C) / (52°C/W) = 1.923W$ for

WQFN-28L 4x4 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

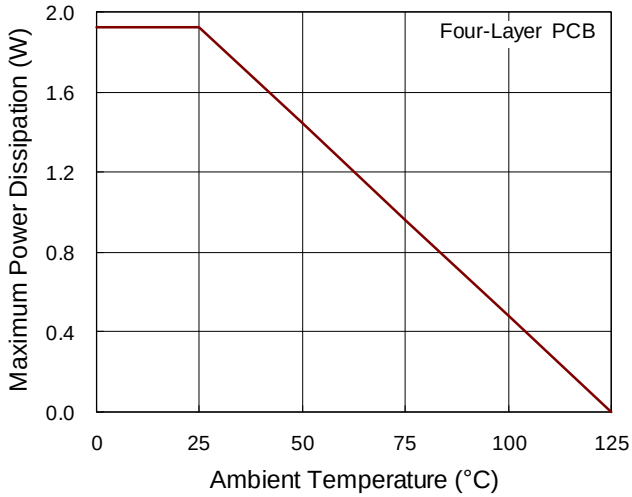


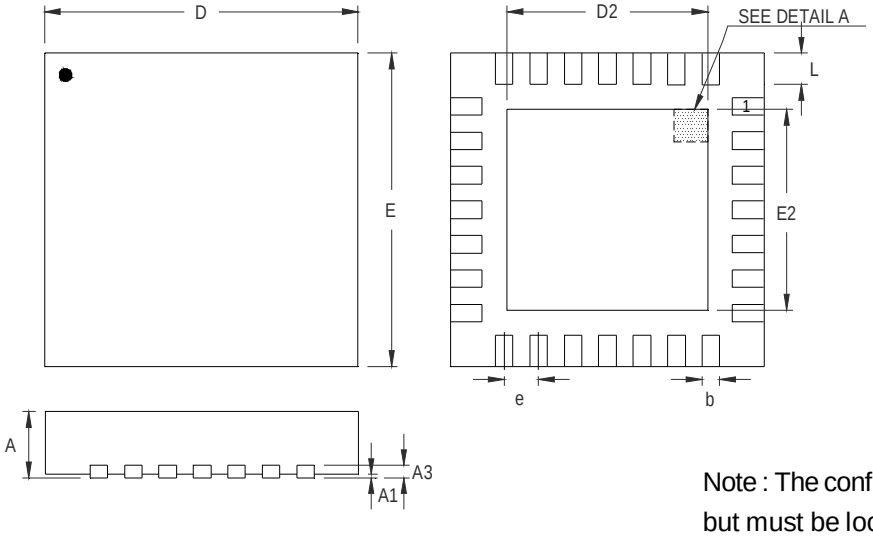
Figure 1. Derating Curve of Maximum Power Dissipation

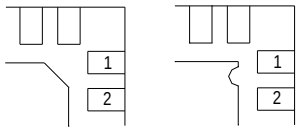
Layout Considerations

The RT9528 is a fully integrated low cost single cell Li-ion battery charger ideal for portable applications. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. A short connection is highly recommended. The following guidelines should be strictly followed when designing a PCB layout for the RT9528.

- Input and output capacitor should be placed as close to the IC as possible and connected to ground plane. The input trace on the PCB should be placed far away from sensitive devices and shielded by the ground.
- The GND and exposed pad should be connected to a strong ground plane for heat sinking and noise protection.
- DN pin and DP pin should be placed as close to the USB controller as possible. Distance of the DN/DP pin to USB controller must be less than 25mm. A short wire is recommended to prevent EMI and noise coupling.
- The trace of DN pin and DP pin avoids using via for low impedance of the transmission line.
- The trace of DN pin and DP pin is as symmetrical as possible to improve performance.
- The trace of USB function avoids using cross line for noise coupling.

Outline Dimension





DETAIL A

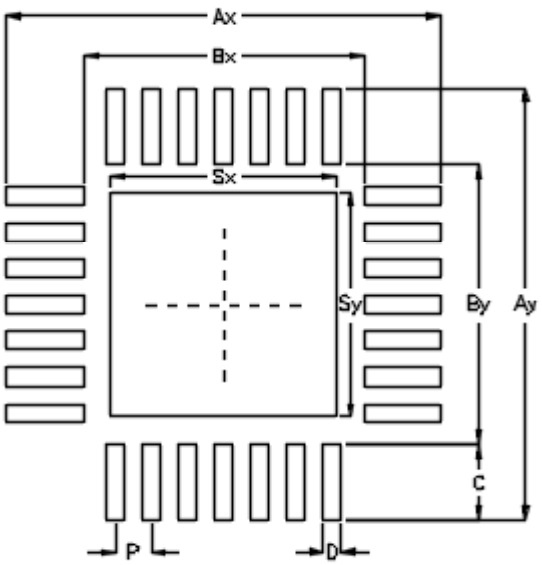
Pin #1 ID and Tie Bar Mark Options

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	0.150	0.250	0.006	0.010
D	3.900	4.100	0.154	0.161
D2	2.350	2.450	0.093	0.096
E	3.900	4.100	0.154	0.161
E2	2.350	2.450	0.093	0.096
e	0.400		0.016	
L	0.350	0.450	0.014	0.018

W-Type 28L QFN 4x4 Package

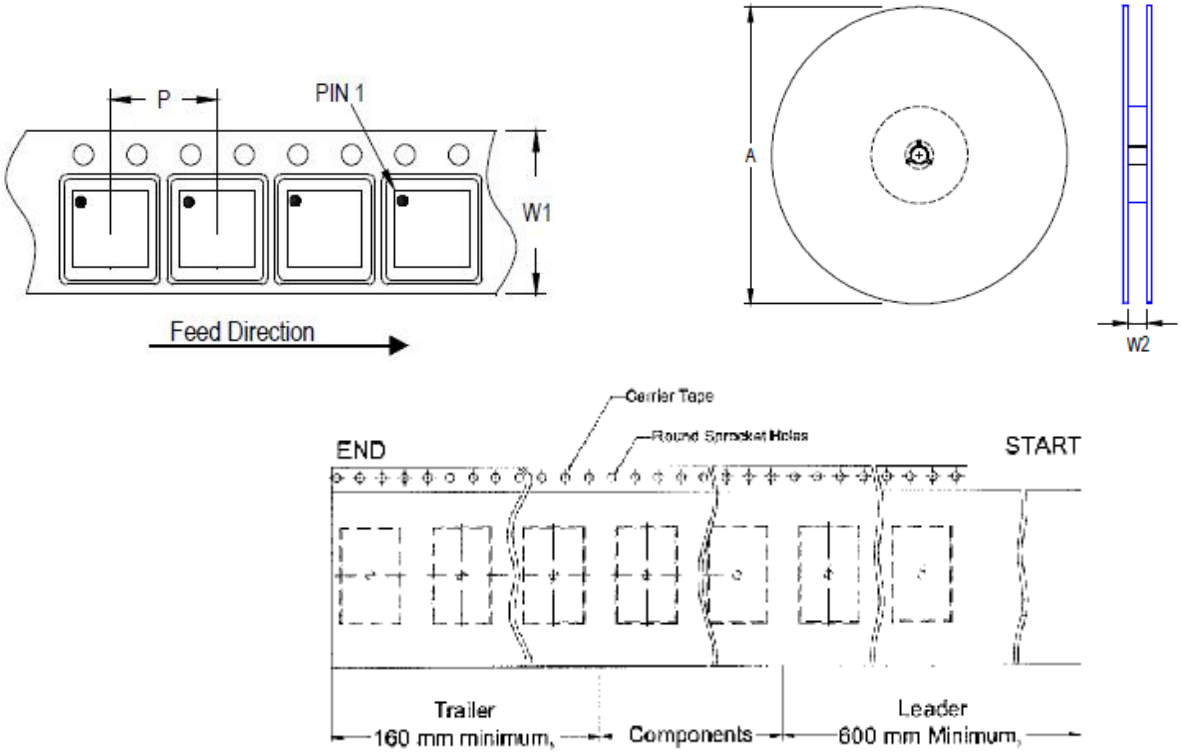
Footprint Information



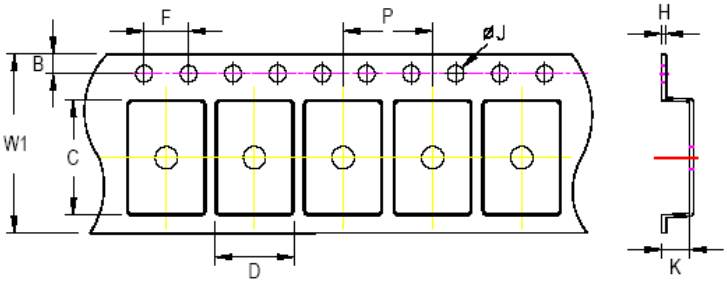
Package	Number of Pin	Footprint Dimension (mm)									Tolerance
		P	Ax	Ay	Bx	By	C	D	Sx	Sy	
V/W/U/XQFN4*4-28	28	0.40	4.80	4.80	3.10	3.10	0.85	0.20	2.50	2.50	±0.05

Packing Information

Tape and Reel Data



Package Type	Tape Size (W1) (mm)	Pocket Pitch (P) (mm)	Reel Size (A)		Units per Reel	Trailer (mm)	Leader (mm)	Reel Width (W2) Min./Max. (mm)
			(mm)	(in)				
QFN/DFN 4x4	12	8	180	7	1,500	160	600	12.4/14.4



C, D and K are determined by component size. The clearance between the components and the cavity is as follows:

- For 12mm carrier tape: 0.5mm max.

Tape Size	W1	P		B		F		ØJ		H
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.
12mm	12.3mm	7.9mm	8.1mm	1.65mm	1.85mm	3.9mm	4.1mm	1.5mm	1.6mm	0.6mm

Tape and Reel Packing

Step	Photo/Description	Step	Photo/Description
1	 Reel 7”	4	 3 reels per inner box **Box A**
2	 HIC & Desiccant (1 Unit) inside	5	 12 inner boxes per outer box
3	 Caution label is on backside of Al bag	6	 Outer box **Carton A**

Container / Package	Reel		Box				Carton			
	Size	Units	Item	Size(cm)	Reels	Units	Item	Size(cm)	Boxes	Unit
QFN/DFN 4x4	7”	1,500	Box A	18.3*18.3*8.0	3	4,500	Carton A	38.3*27.2*38.3	12	54,000
			Box E	18.6*18.6*3.5	1	1,500	For Combined or Partial Reel.			

Packing Material Anti-ESD Property

Surface Resistance	Aluminum Bag	Reel	Cover tape	Carrier tape	Tube	Protection Band
Ω/cm^2	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**	**10^4 to 10^{11}**

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Datasheet Revision History

Version	Date	Description	Item
02	2023/9/13	Modify	General Description on P1 Ordering Information on P1 Electrical Characteristics on P5, 7 Application Information on P29 Footprint Information on P38 Packing Information on P39, 40, 41