

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.

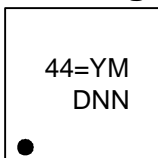
Ordering Information

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

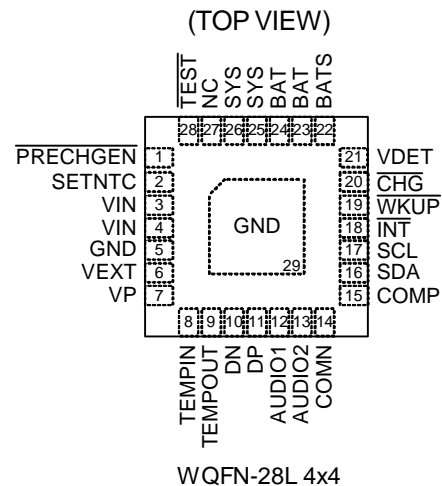
Features

- | 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

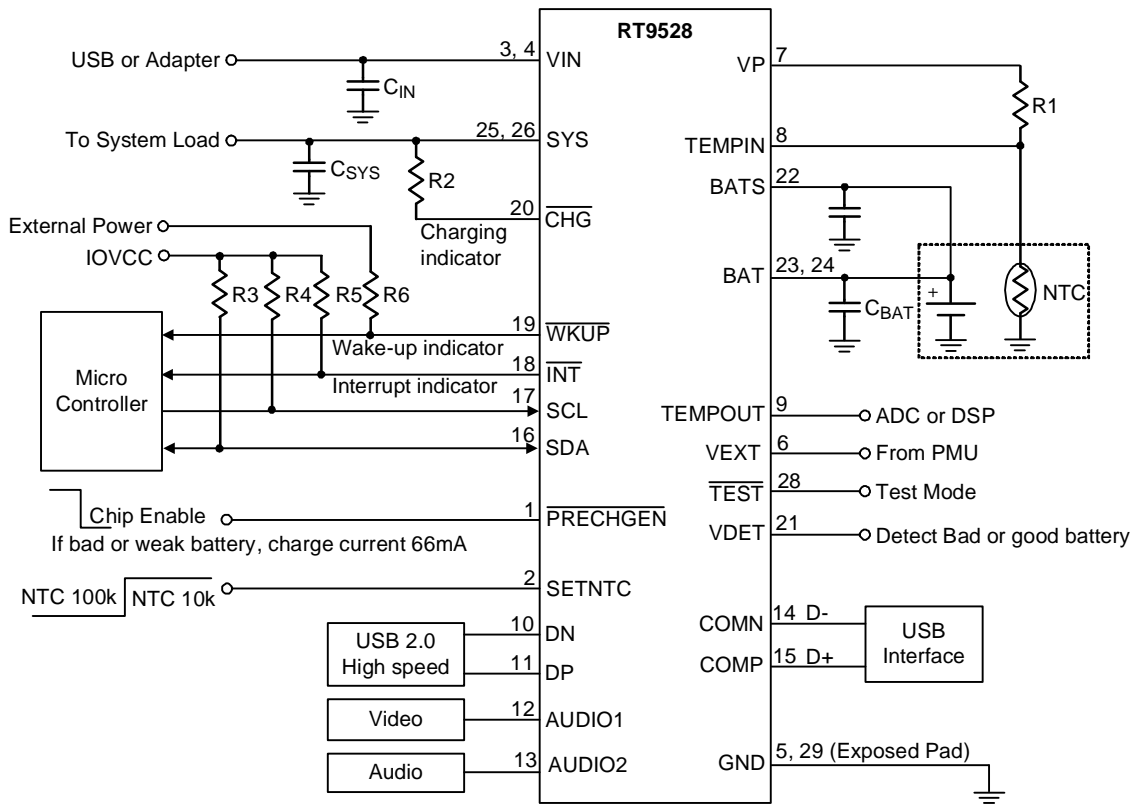
Applications

- | Digital Cameras
- | PDAs and Smart Phones
- | Portable Instruments

Pin Configuration



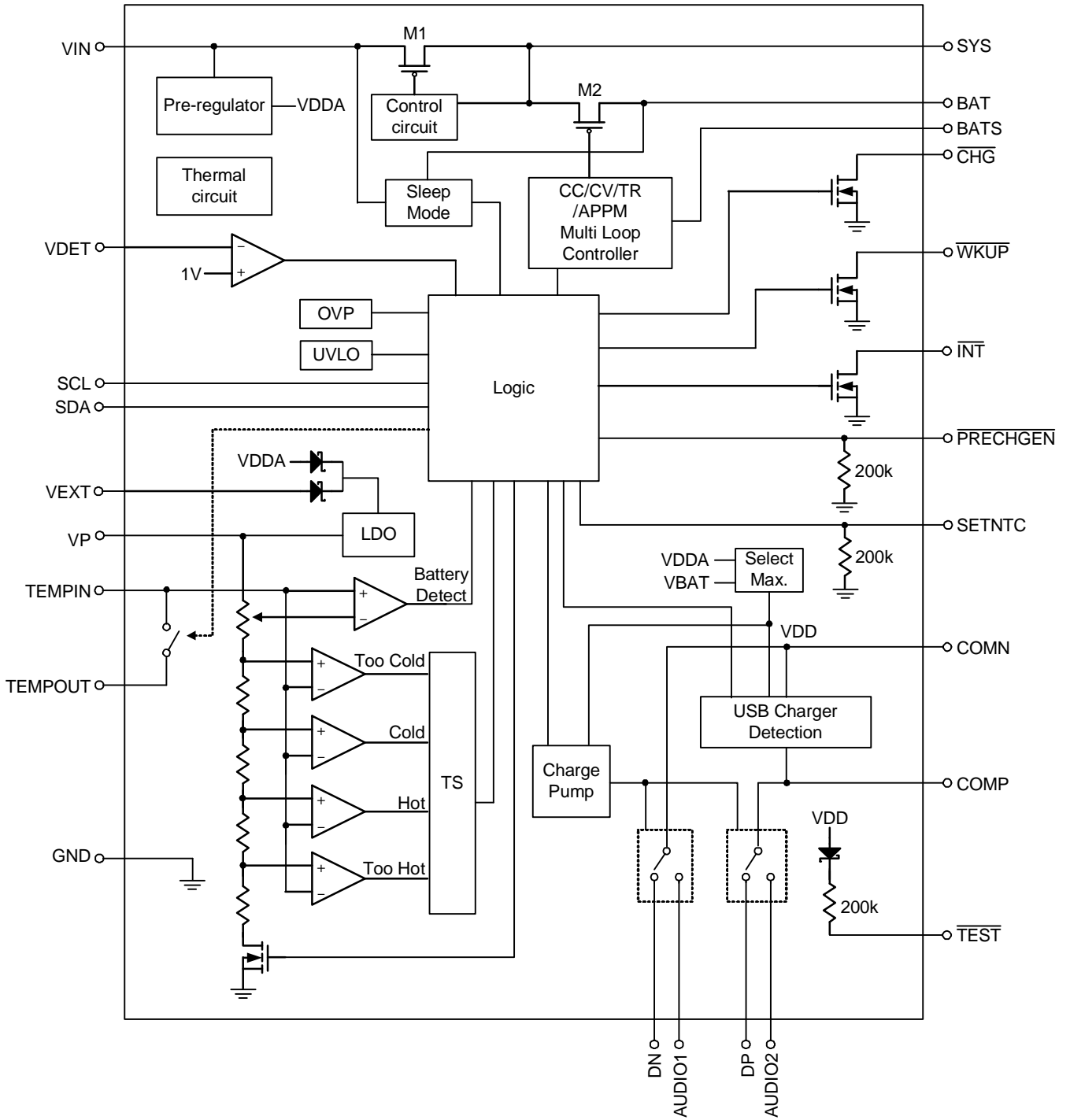
Typical Application Circuit



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 ² C Serial Data Input/Output. Connect an external pull up resistor. |
| 17 | SCL | I ² C 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, $\overline{\text{USB switch}}$ turn on and set USB 500mA mode. If $\overline{\text{TEST}} = \text{L}$, 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 @ $T_A = 25^\circ\text{C}$ | |
| 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 V_{IN} No Use) ----- | 4V to 5.5V |
| Junction Temperature Range ----- | -40°C to 125°C |
| Ambient Temperature Range ----- | -40°C to 85°C |

Electrical Characteristics

($V_{IN} = 5V$, $V_{BAT} = 4V$, $T_A = 25^\circ\text{C}$, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|--------------------------------------|-----------|---|------|------|------|------|
| Supply Input Voltage | | | | | | |
| VIN Under Voltage Lockout Threshold | VUVLO | | 3.1 | 3.3 | 3.5 | V |
| VIN Under Voltage Lockout Hysteresis | VUVLO_HYS | | -- | 240 | -- | mV |
| VIN-BAT VOS Rising | VOS_H | | -- | 100 | 200 | mV |
| VIN-BAT VOS Falling | VOS_L | | 10 | 50 | -- | mV |
| Voltage Regulation | | | | | | |
| Battery Regulation Voltage | VREG | Set by I ² C, 20mV/step | 3.5 | -- | 4.26 | V |
| Battery Regulation Voltage Accuracy | VREG2 | VREG = 4.2V | 4.16 | 4.2 | 4.23 | V |
| System Regulation Voltage | VSYS1 | Set by I ² C, I _{SYS} = 800mA | 4.3 | 4.4 | 4.5 | V |
| System Regulation Voltage | VSYS2 | V _{IN} = 6V, Set by I ² C, I _{SYS} = 800mA | 5.3 | 5.5 | 5.7 | V |
| APPM Regulation Voltage | VAPPM | ISETL = 0, ISETU = 1 | 3.85 | 3.95 | 4.05 | V |
| DPM Regulation Voltage | VDPM | 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 ² C, 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 ² C, 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 ² C, 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 ² C | 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 ² C | 30 | -- | 60 | Min. |
| Time Out (Fast-Charge) | t _{FCHG} | Set by I ² C | 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. |
| WKUP Deglitch Time | t _{WKUP} | 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 | tSHORT | | -- | 256 | -- | μs | |
| Short-Circuit, Recovery Time | tSHORT_R | | -- | 64 | -- | ms | |
| Session valid to connect for PD with Dead or Weak Battery | tSVLD_Con_WKB | | 15 | -- | 45 | Min. | |
| Login Input/Output | | | | | | | |
| $\overline{\text{INT}}$ Pull Down Voltage | V _{INT} | I _{INT} = 5mA | -- | 200 | -- | mV | |
| $\overline{\text{CHG}}$ Pull Down Voltage | V _{CHG} | I _{CHG} = 5mA | -- | 200 | -- | mV | |
| $\overline{\text{WKUP}}$ Pull Down Voltage | V _{WKUP} | I _{WKUP} = 5mA | -- | 200 | -- | mV | |
| $\overline{\text{PRECHGEN}}$, $\overline{\text{SETNTC}}$, $\overline{\text{TEST}}$ Threshold | V _{I_H} | | 1.5 | -- | -- | V | |
| | V _{I_L} | | -- | -- | 0.4 | V | |
| $\overline{\text{PRECHGEN}}$ Pull Low Resistor | R _{PRECHGEN} | | -- | 200 | -- | kΩ | |
| $\overline{\text{SETNTC}}$ Pull Low Resistor | R _{SETNTC} | | -- | 200 | -- | kΩ | |
| Digital Signals (SCL, SDA) for I²C | | | | | | | |
| 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 | |
| V _{DET} | V _{DET} | V _{DET} Falling | 0.98 | 1 | 1.02 | V | |
| BATON | V _{BATON} | V _{TEMPIN} 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 |
| V _{DAT_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 |
| V _{COMP_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 | ΔR _{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 ² C 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 ² C Stop to Switch On, R _L = 32Ω | -- | -- | 1 | ms |
| Analog Switch Turn Off Time | t _{OFF} | I ² C 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 |
| V _{DATA} _SRC ON Time | t _{DP_SRC_ON} | | 40 | -- | -- | ms |
| Off-Isolation(DN, DP) | V _{ISO} | R _L = 32Ω, f = 20kHz, V _{COM} = 2V _{p-p} , | -- | TBD | -- | dB |
| Off-Isolation(AUDIO1/2) | V _{ISO} | R _L = 32Ω, f = 20kHz, V _{COM} = 0.5V _{p-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} = 2V _{p-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 $T_A = 25^\circ\text{C}$ 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.

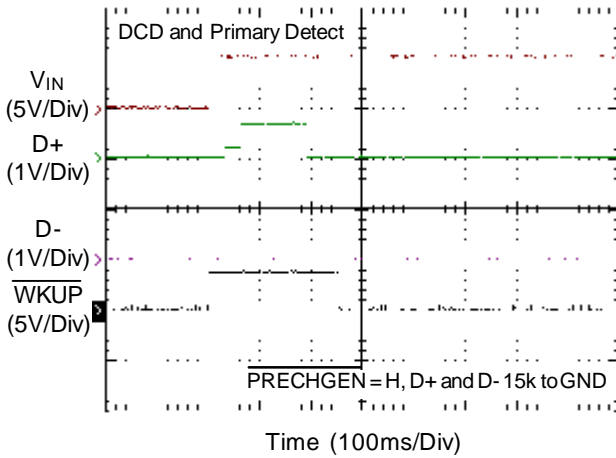
Note 4. Devices are ESD sensitive. Handling precautions are recommended.

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

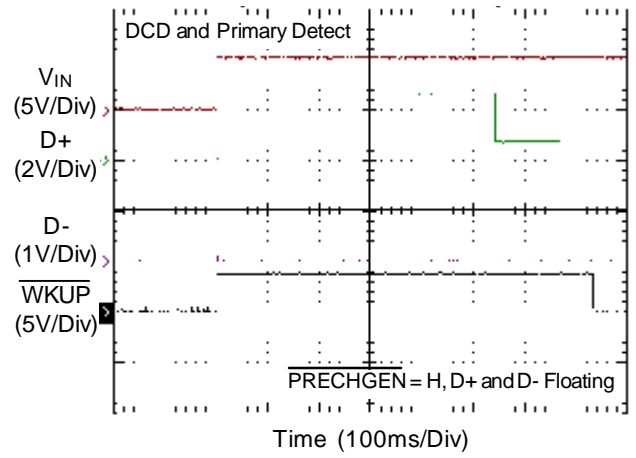
Typical Operating Characteristics

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

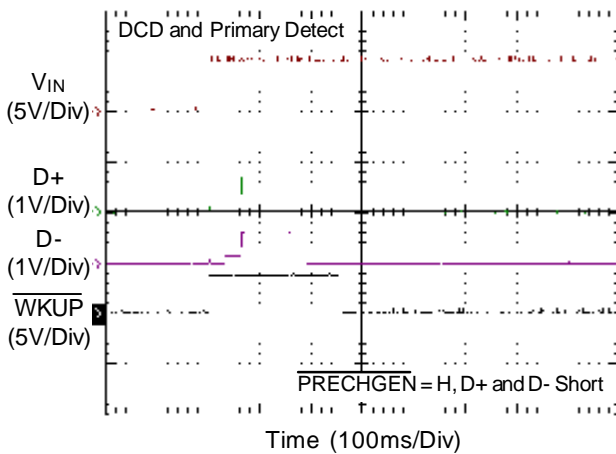
Standard Downstream Port



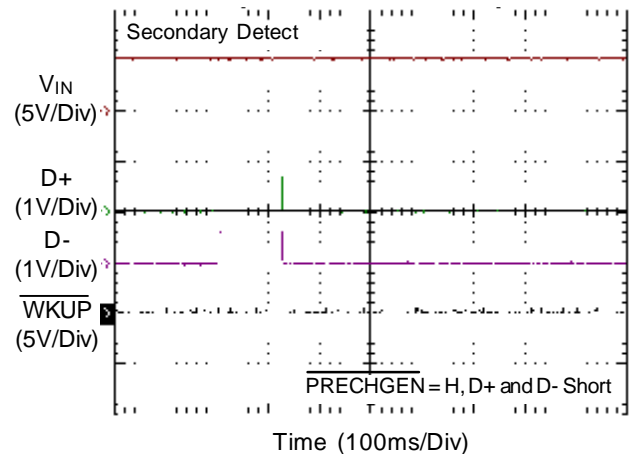
Floating



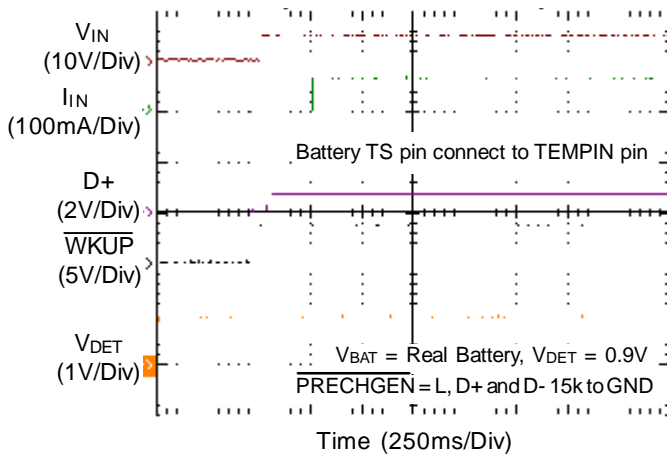
Dedicated Charging Port



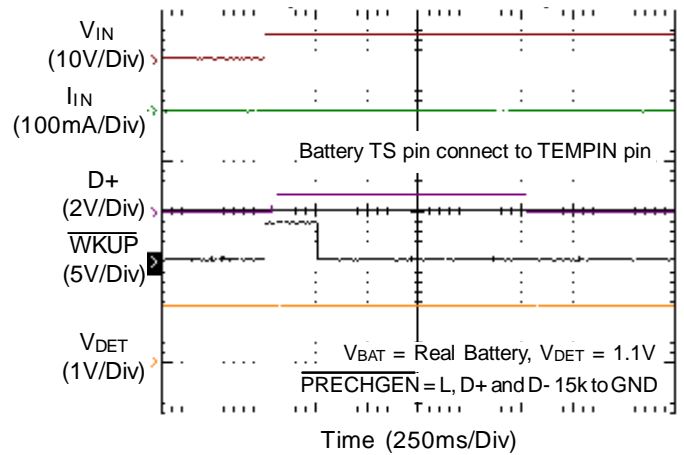
Dedicated Charging Port



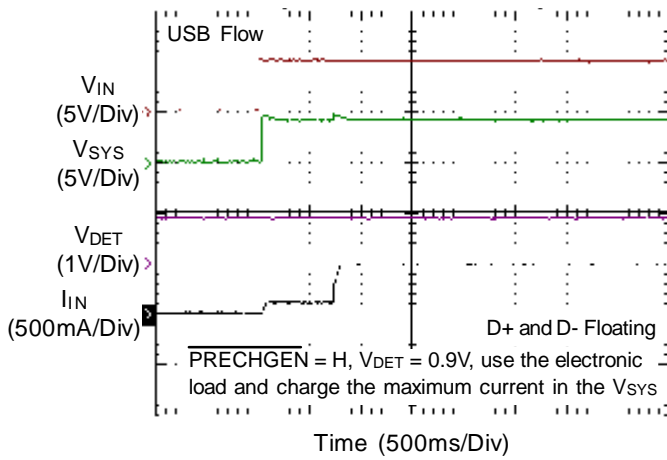
In The Dead Battery Flow



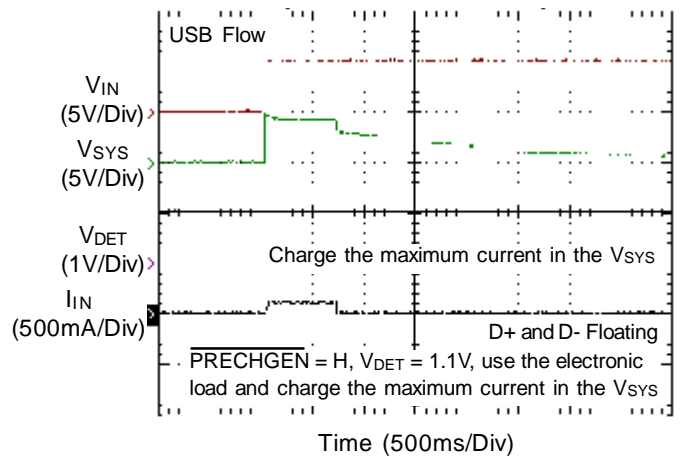
Finish Dead Battery Flow



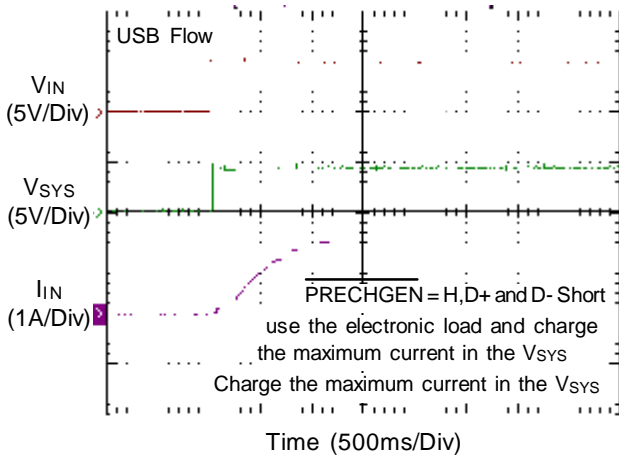
Standard 500mA Mode



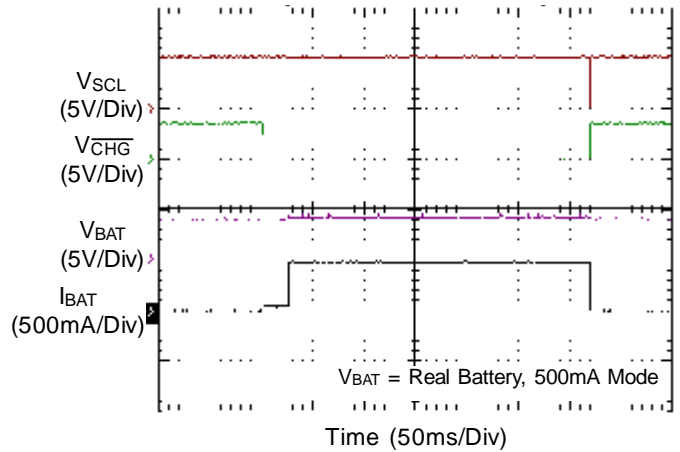
Standard USUS



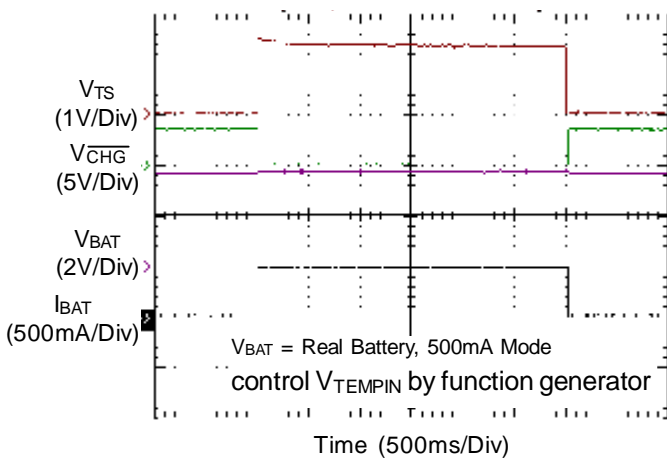
Dedicated Charging Port



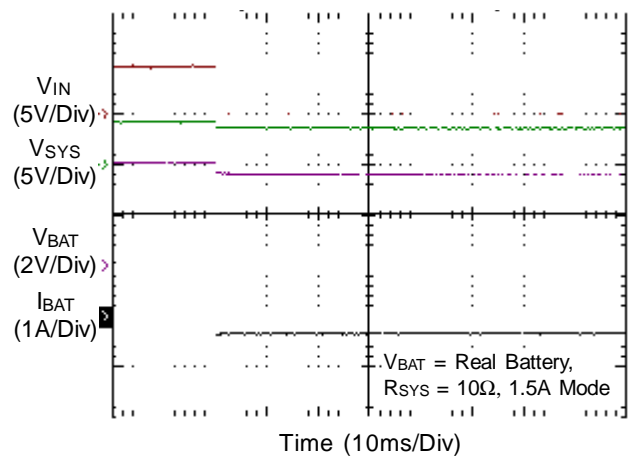
Charge on/Off Control by I²C



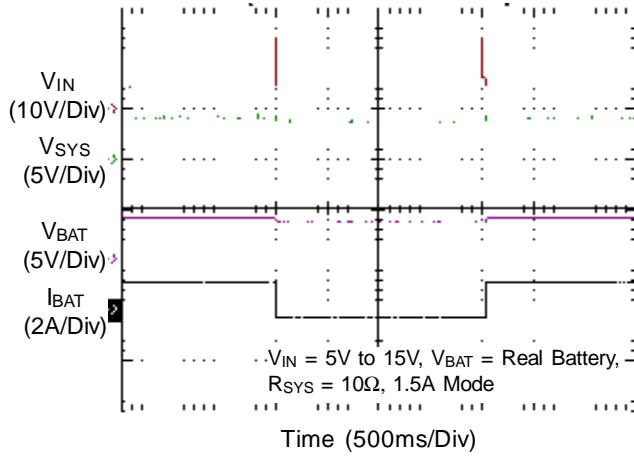
TEMPIN On/Off



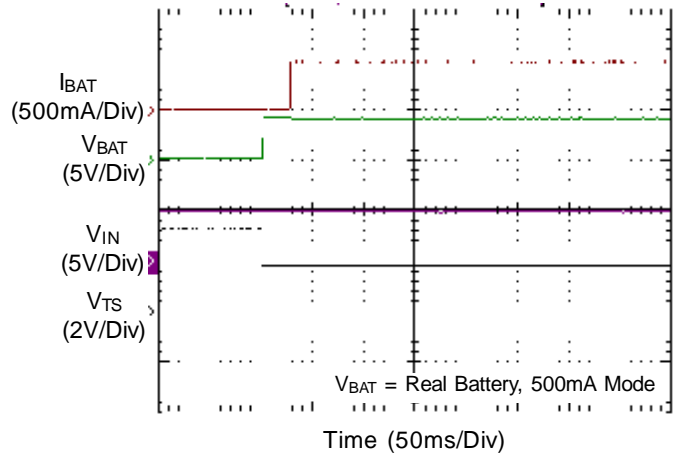
V_{IN} Removal



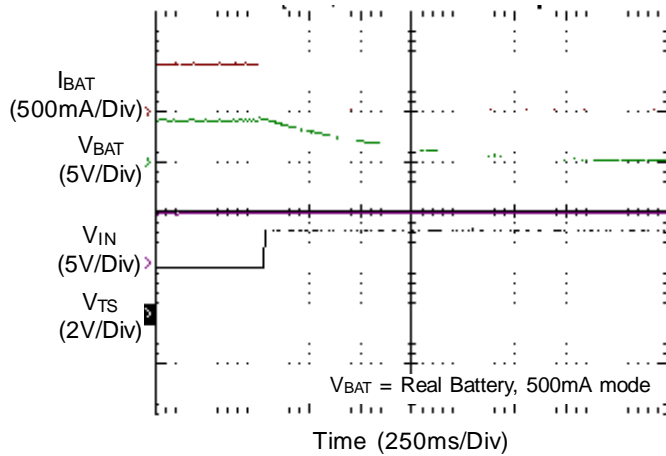
V_{IN} Over Voltage Protection



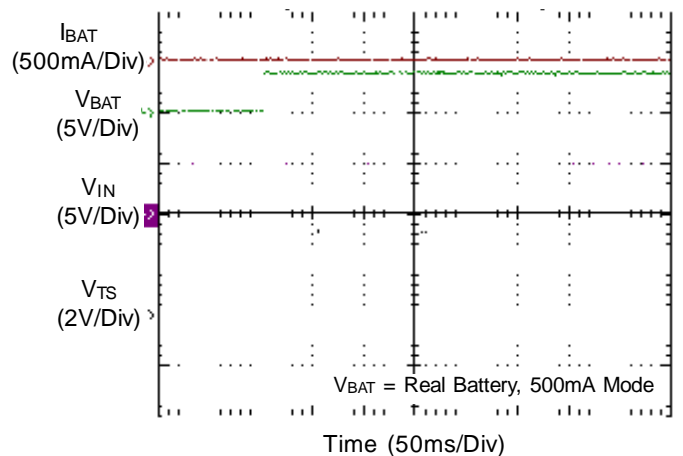
Battery with NTC Resistor Plug-In



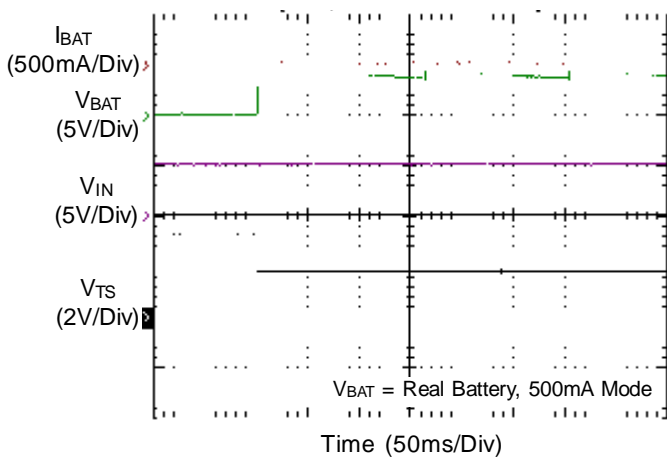
Battery with NTC Resistor Plug-Out



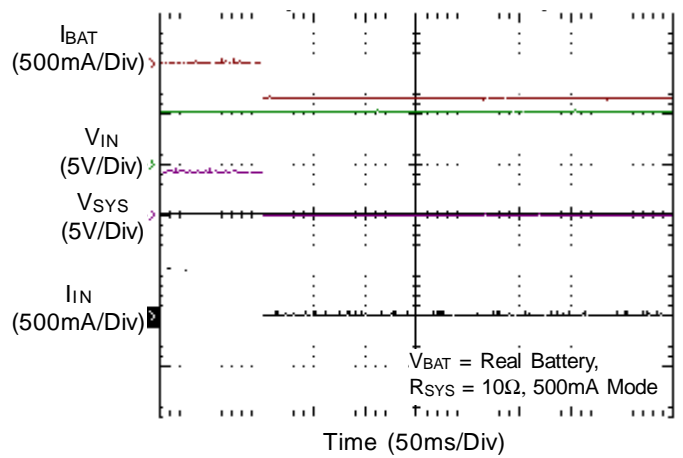
With Battery without NTC Resistor



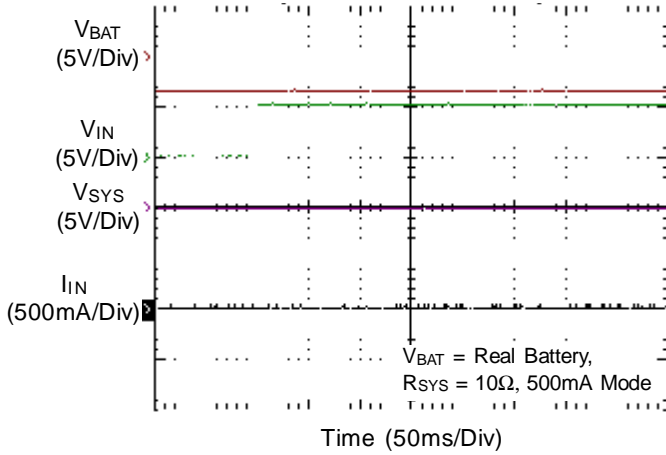
With NTC Resistor without Battery



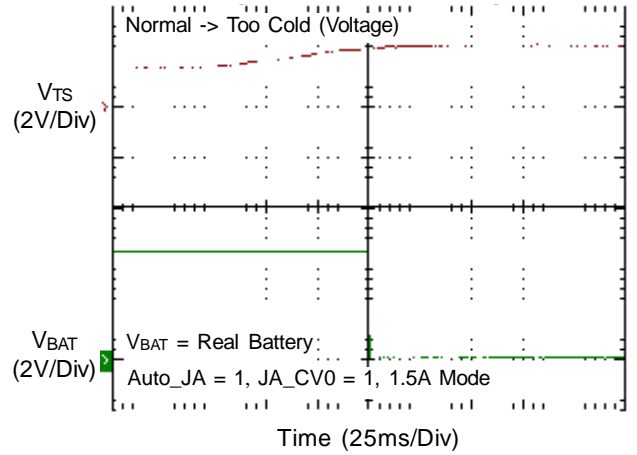
V_{IN} Exist then Negative Battery



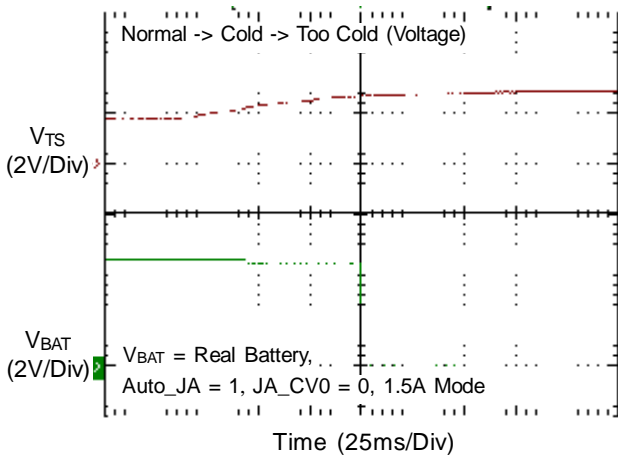
Negative Battery then V_{IN} Plug-In



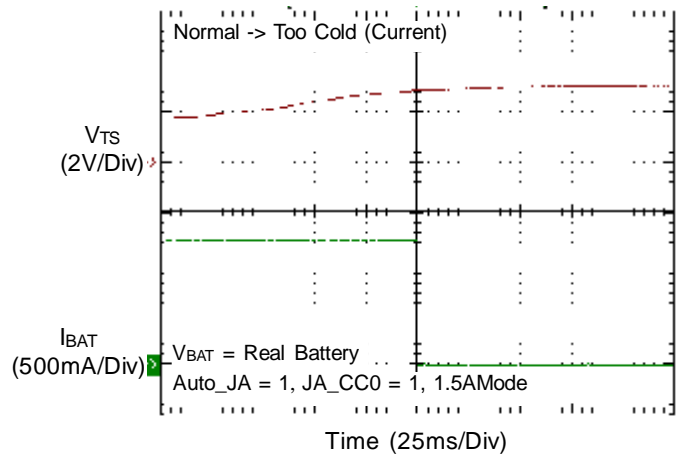
The Temperature of Battery Status



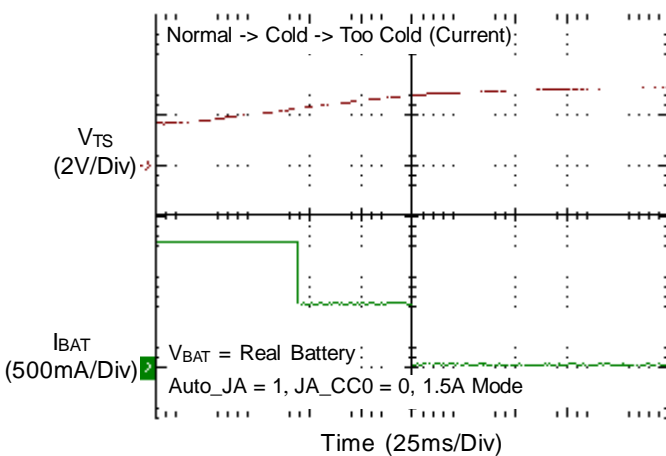
The Temperature of Battery Status



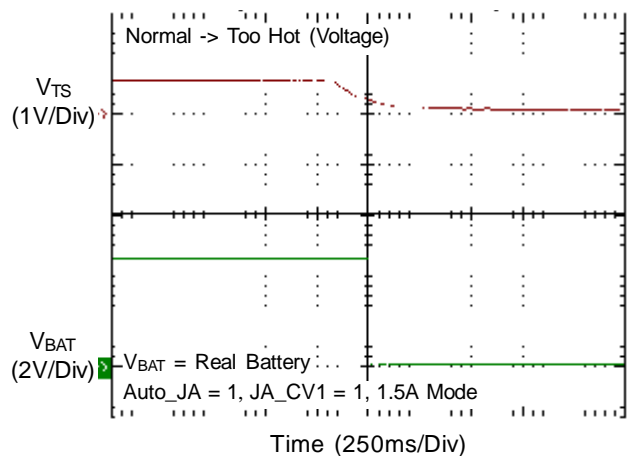
The Temperature of Battery Status



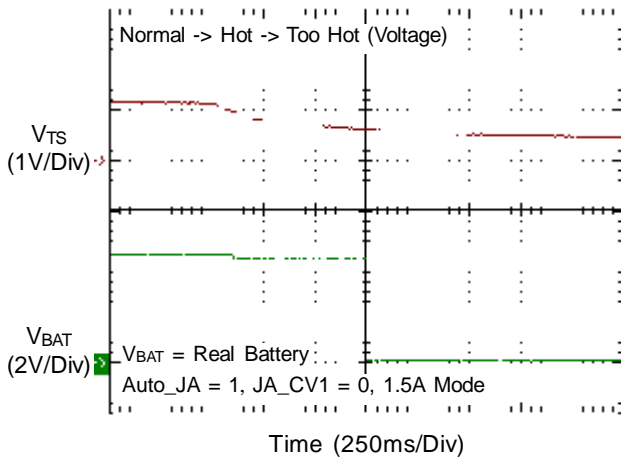
The Temperature of Battery Status



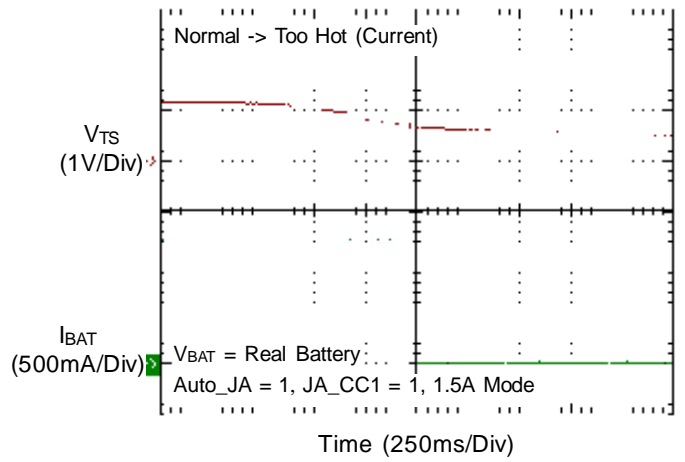
The Temperature of Battery Status



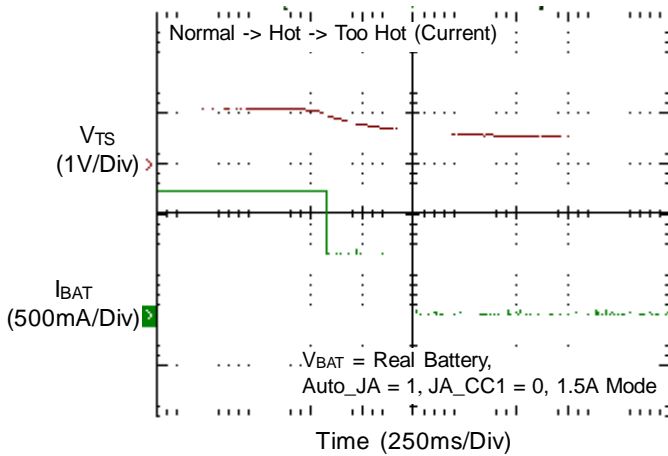
The Temperature of Battery Status



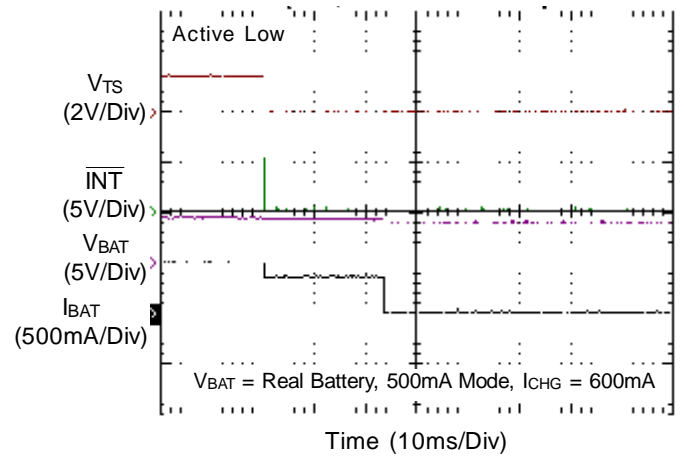
The Temperature of Battery Status



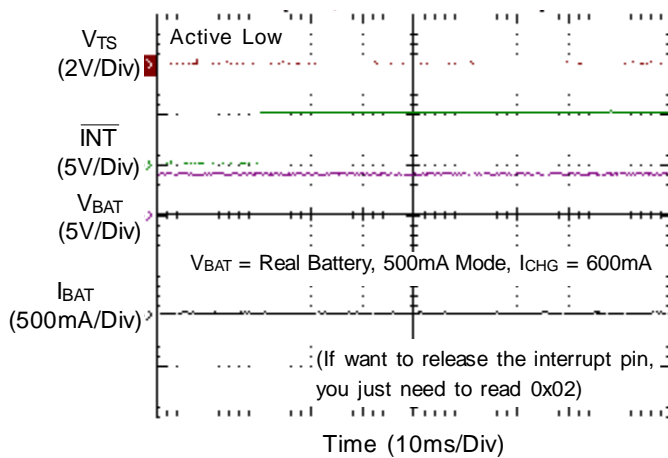
The Temperature of Battery Status



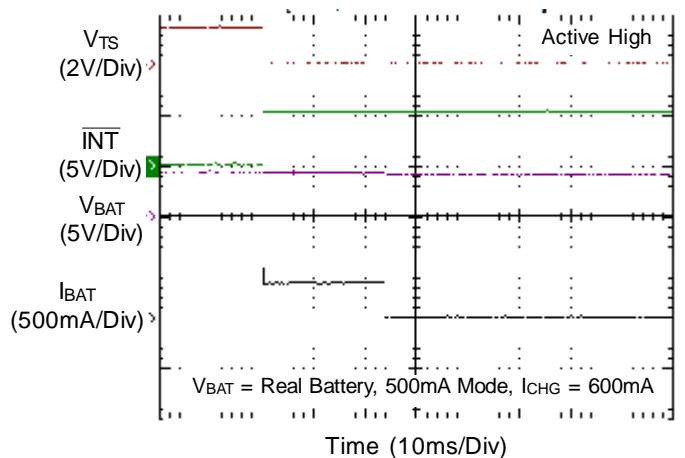
Interrupt Happen



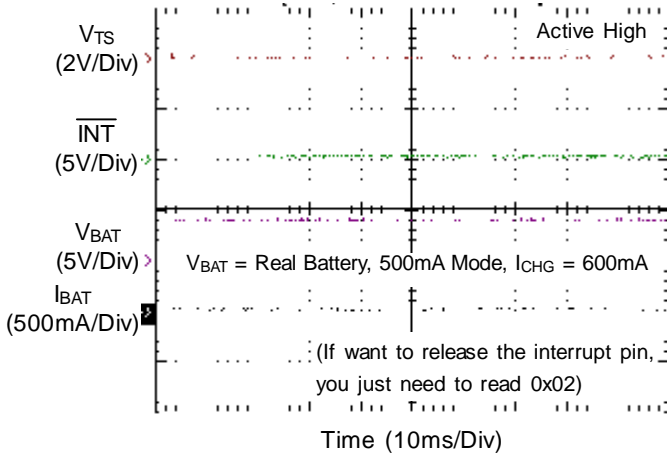
Interrupt Release



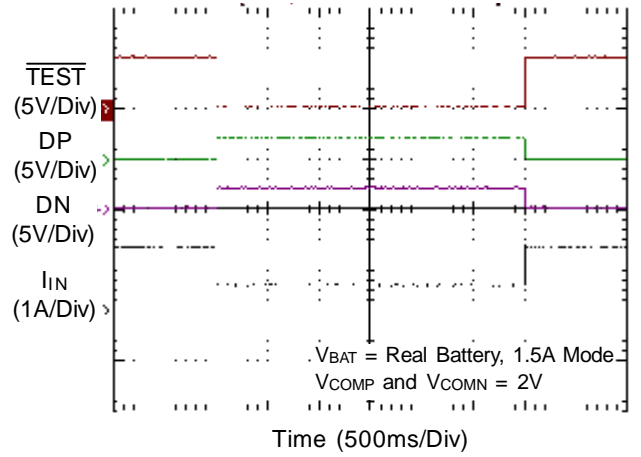
Interrupt Happen



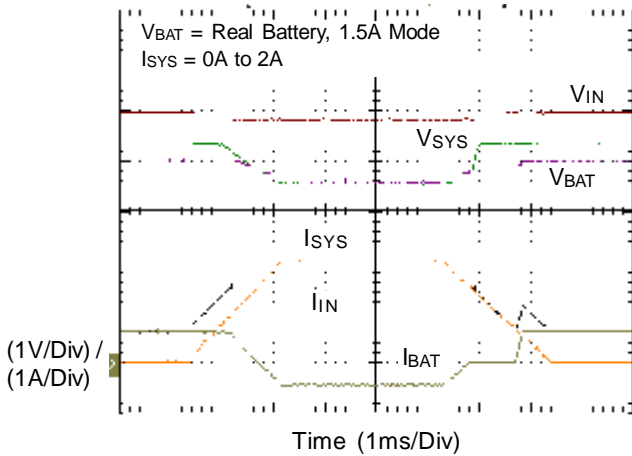
Interrupt Release



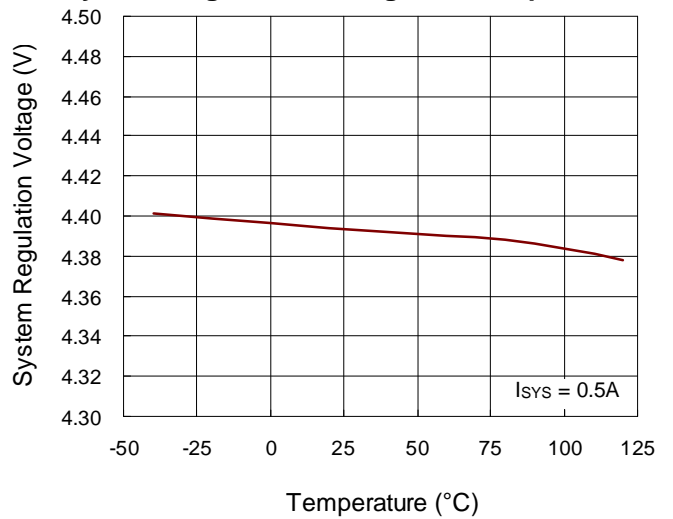
TEST Pin Function



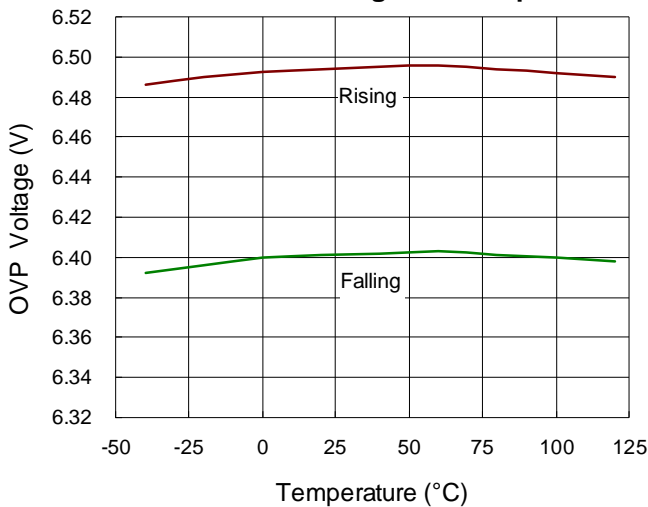
APPM



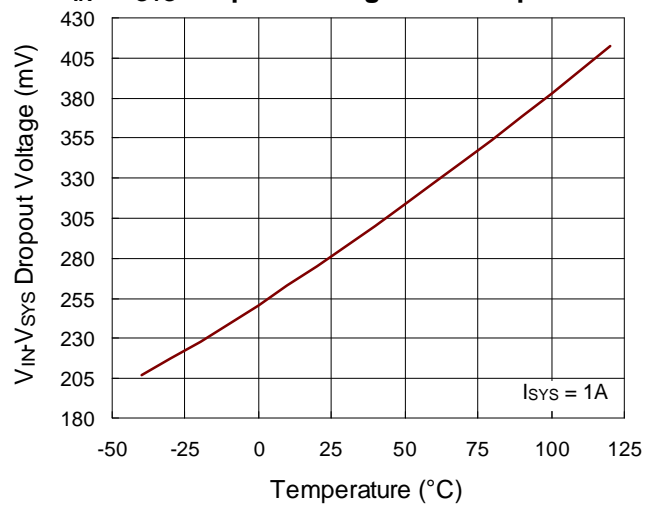
System Regulation Voltage vs. Temperature

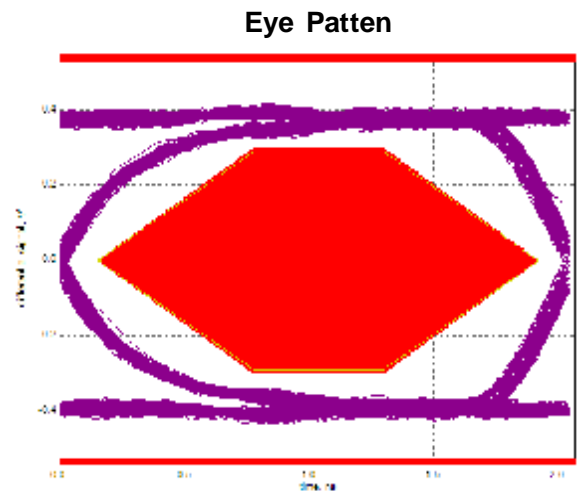
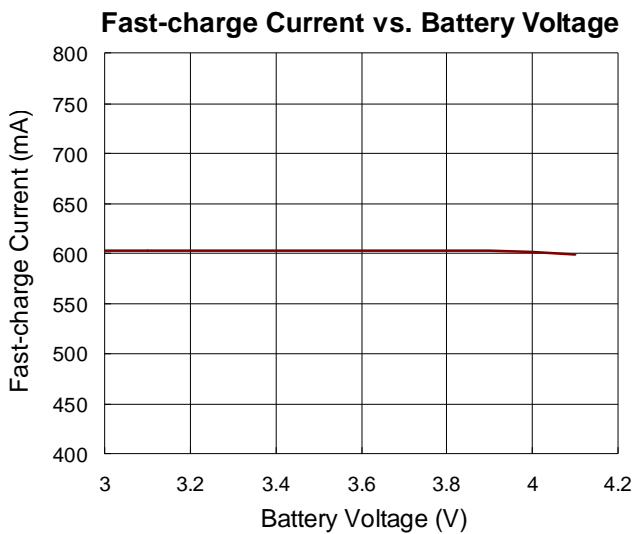
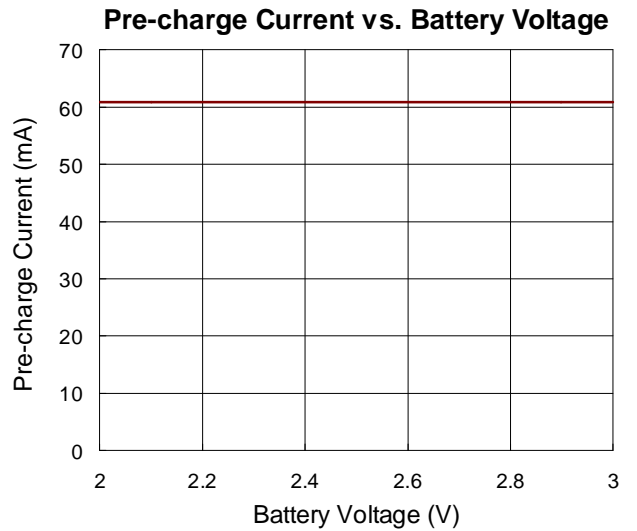
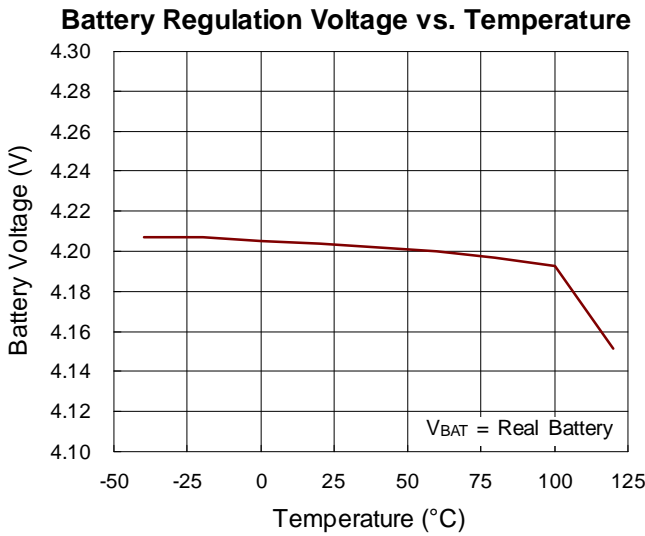
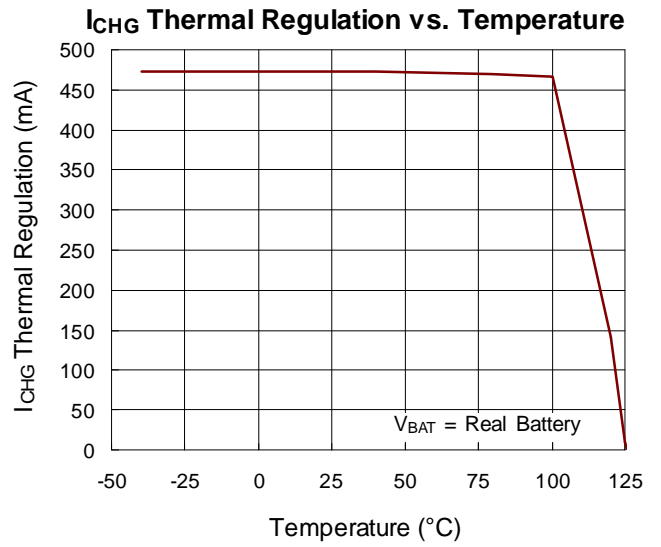
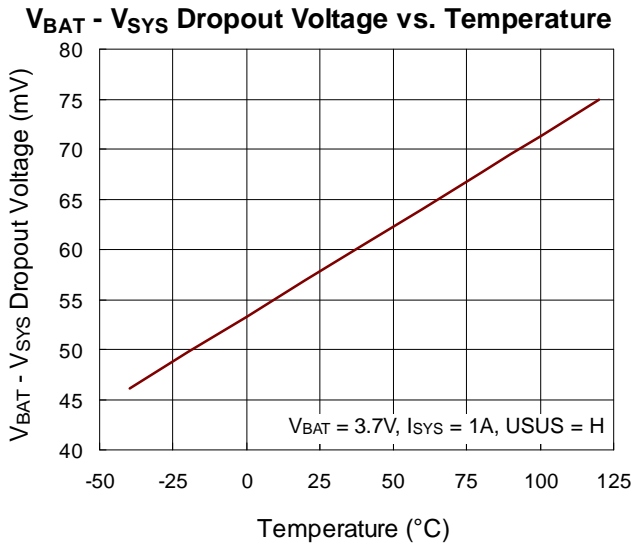


OVP Threshold Voltage vs. Temperature



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





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 | ISSET | 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 ² C_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 |

I²C 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, 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 to 100mA, 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 SETNNTC 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 | I ² C_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 | CHG pin control : 0 : CHG pin is normal. (Default) 1 : CHG pin is high impedance | | | | | | | |
| | I ² C_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 | | | | | | | |

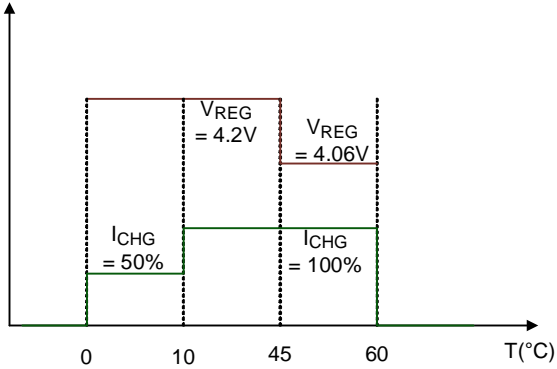
Base_SET3

| 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



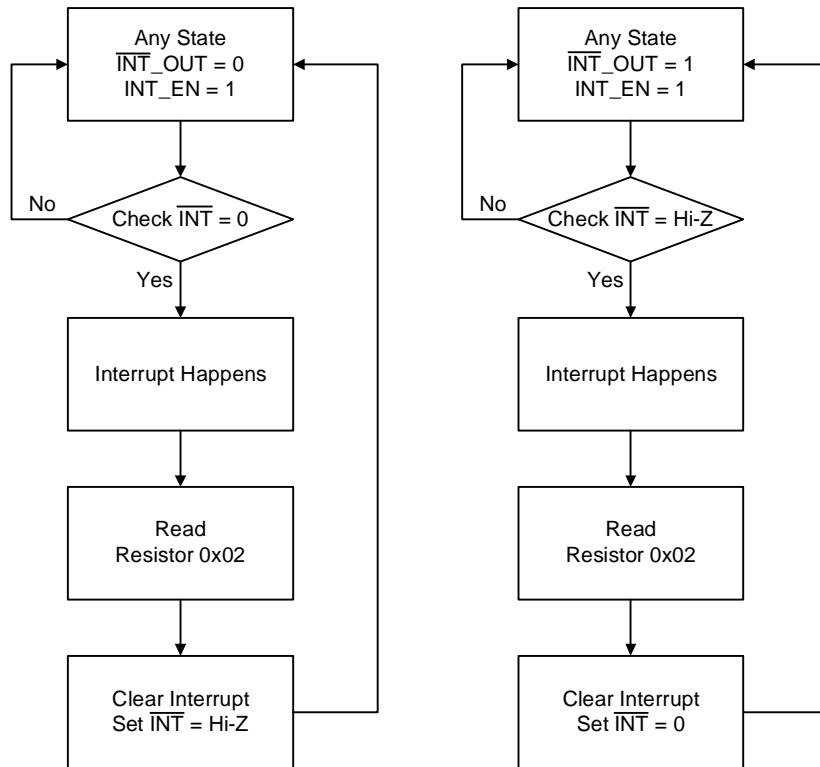
VDET

If VIN power is good, 0x02 VDET_status works normally.
If Only Battery plugs in, 0x02 VDET_status = 1

WKUP

WKUP keeps Hi-Z without VIN.

Interrupt Chart flow



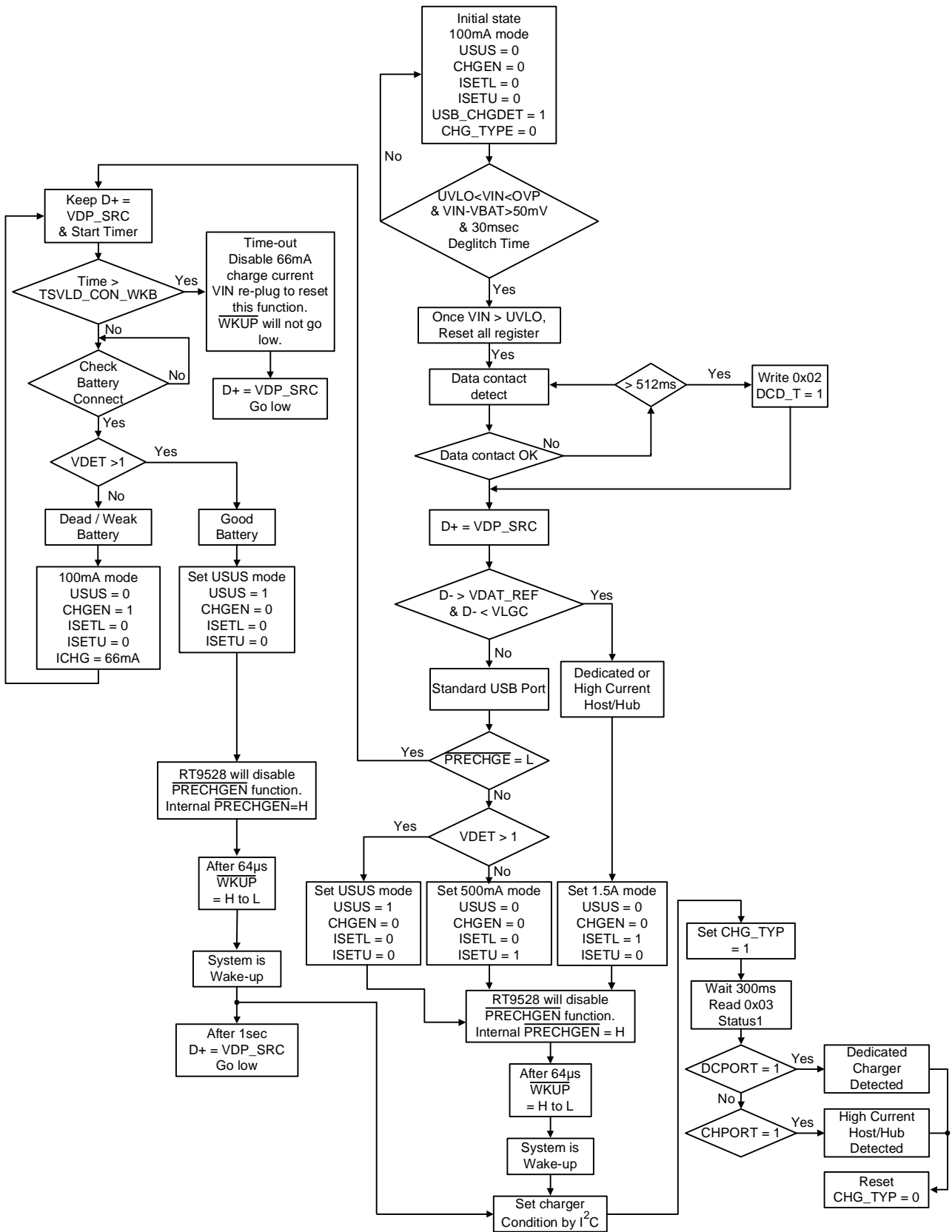
Note1 :

If Set INT_EN = 0, it just mask the INT signal.
When INT_EN = 1, interrupt still happens.

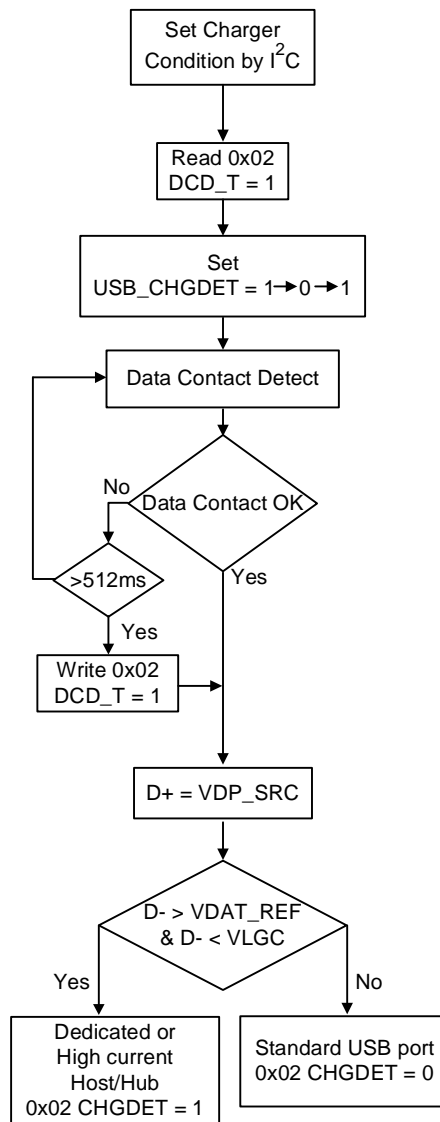
Note 2 :

If INT_OUT = 0 and INT_EN = 0, INT pin is high impedance.
If INT_OUT = 1 and INT_EN = 0, INT pin is low.

Charger Initial Flow Chart



After \overline{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

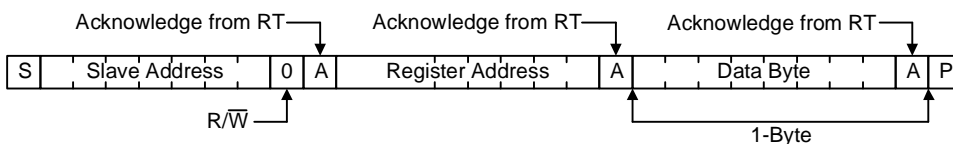
| T (°C) | R1 (kW) | RNTC (kW) | Ratio (%) |
|--------|---------|-----------|-----------|
| -10 | 10 | 42.5062 | 81 |
| -5 | 10 | 33.8922 | 77 |
| 0 | 10 | 27.2186 | 73 |
| 5 | 10 | 22.0211 | 69 |
| 10 | 10 | 17.9255 | 64 |
| 15 | 10 | 14.6735 | 59.5 |
| 20 | 10 | 12.0805 | 54.5 |
| 25 | 10 | 10 | 50 |
| 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.

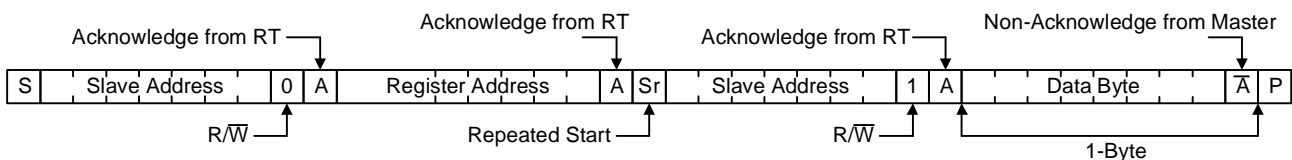
Writing 1 Byte of Data to RT



Read

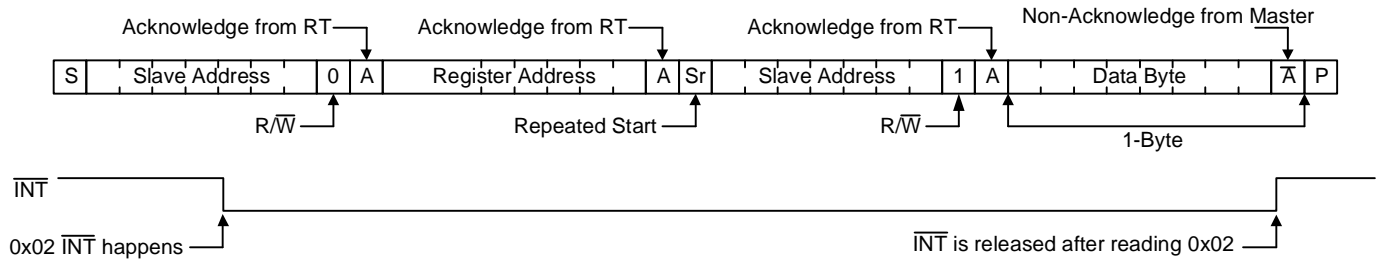
RT9528 1 support byte reading as below. If you want to read another data byte, you must follow as below again.

Reading 1 Byte of Data from RT



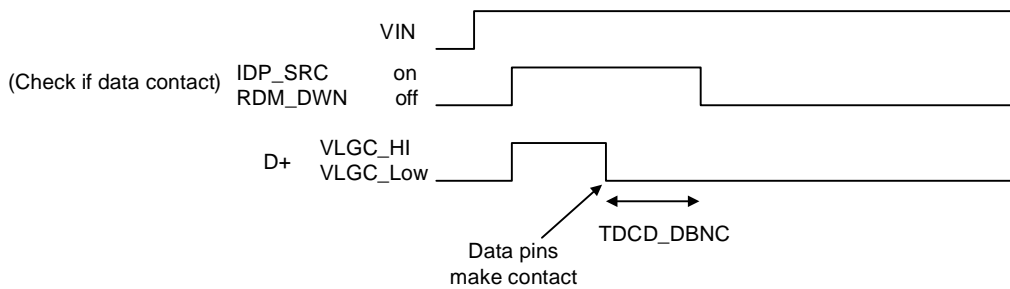
$\overline{\text{INT}}$ Release

1. $\overline{\text{INT}}$ release, $\overline{\text{INT_OUT}} = 0$ and $\text{INT_EN} = 1$

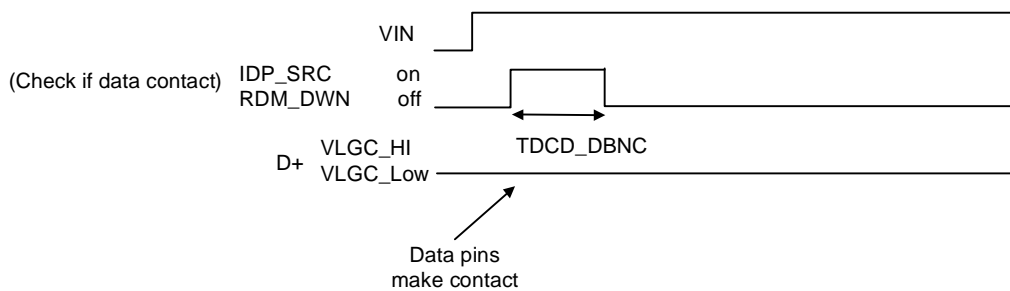


Data Pin Contact Timing

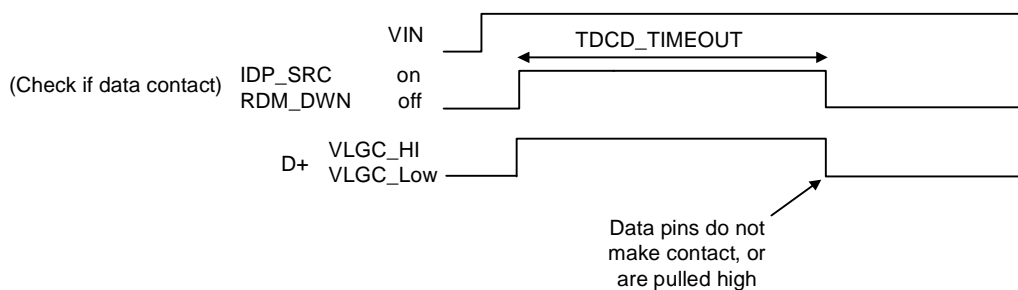
DCD Timing, Contact After Start



DCD Timing, Contact Before Start

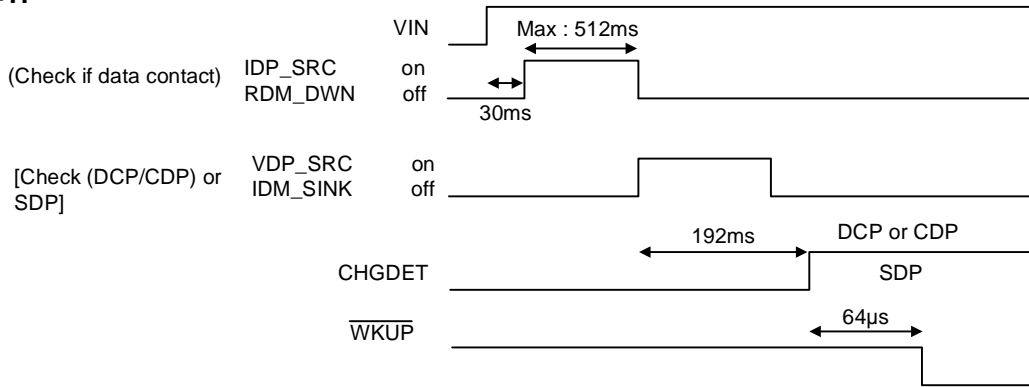


DCD Timing, non Contact



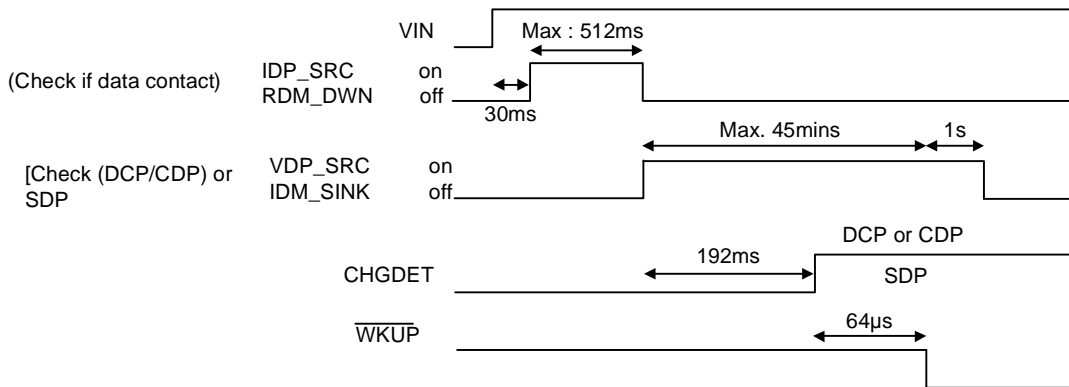
Waveform for PRECHGEN

PRECHGEN = H



SDP : Standard Downstream Port
 CDP : Charging Downstream Port
 DCP : Dedicated Charging Port

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 (I²C set); if ISET = 0, charge current = 0.5 x (I²C 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 (I²C set), even if too cold or too hot.

If 0x01 ISET = 0

Timeout = 1 x (I²C 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 (I²C set), even if too cold or too hot.

If 0x01 ISET = 0

Timeout = 2 x (I²C 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 (I²C set), and timeout will be still the same (= 2 x (I²C set)) if too cold or too hot.

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

CHG Indicator

In dead battery or normal charge flow, the following cases make the $\overline{\text{CHG}}$ 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 I²C_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 I²C_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 I²C_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).

I²C Register Reset

If VIN plugs in, all I²C 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 :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (52^\circ\text{C/W}) = 1.923\text{W for}$$

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.

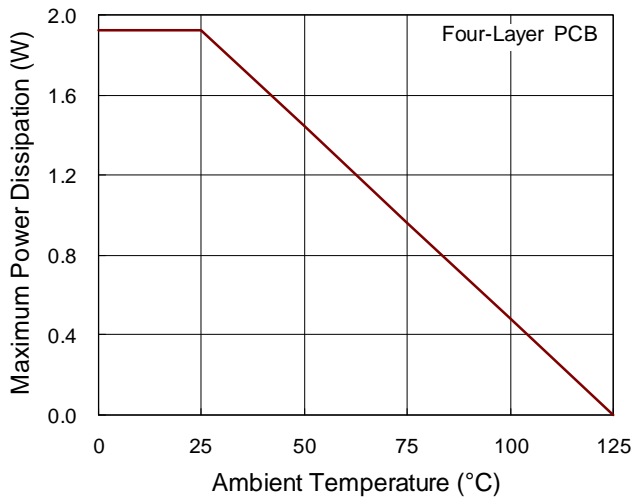


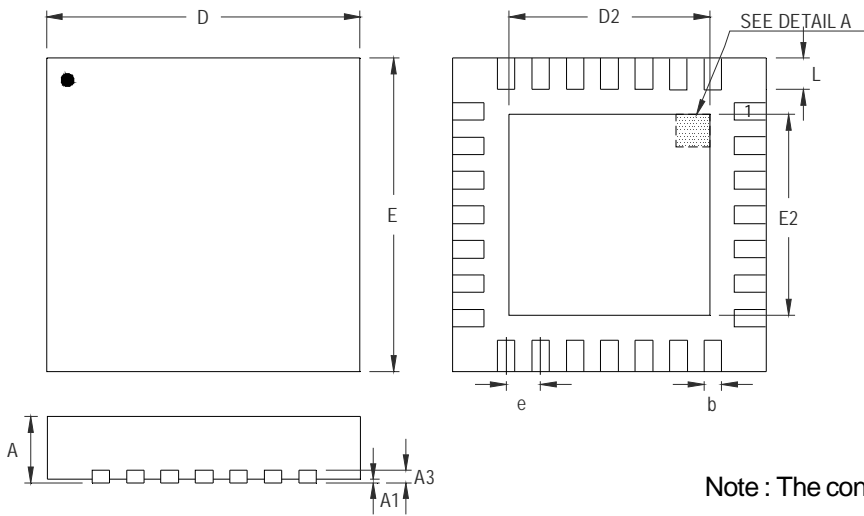
Figure 1. Derating Curve of Maximum Power Dissipation

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



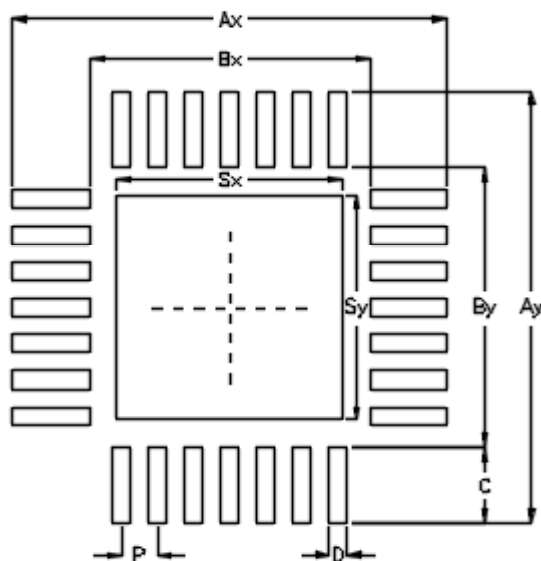
DETAIL A
Pin #1 ID and Tie Bar Mark Options

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

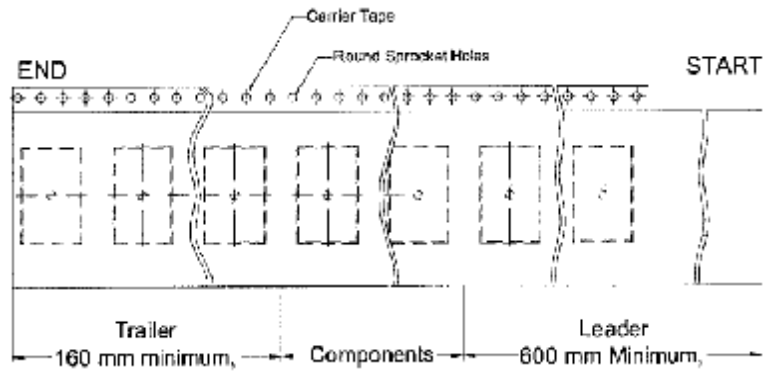
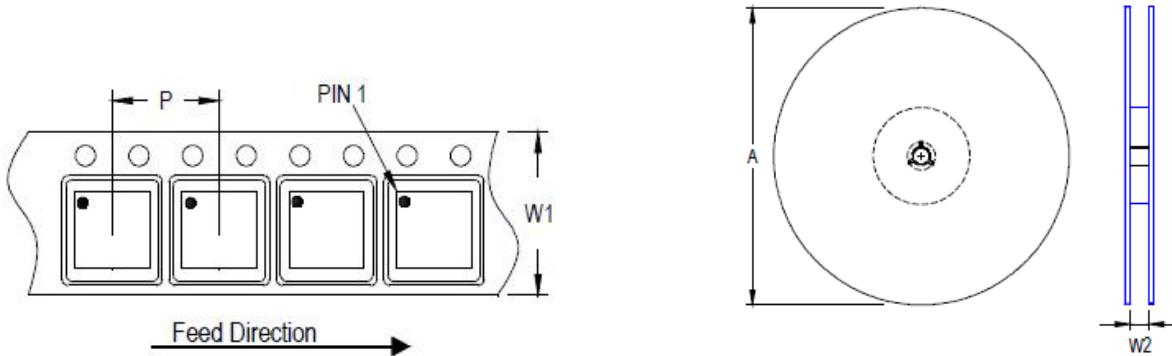
Footprint Information



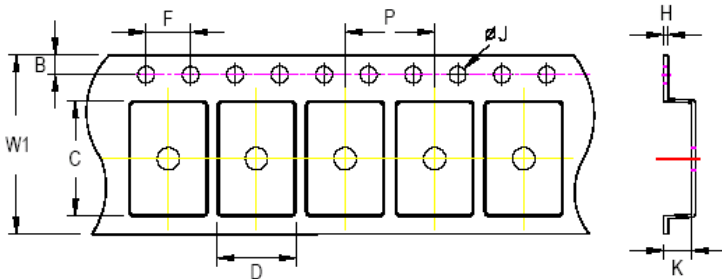
| Package | Number of Pin | Footprint Dimension (mm) | | | | | | | | | Tolerance |
|------------------|---------------|--------------------------|------|------|------|------|------|------|------|------|-----------|
| | | P | Ax | Ay | Bx | By | C | D | Sx | Sy | |
| V/W/U/XQFN4*4-28 | 28 | 0.40 | 4.80 | 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 |  <p>Reel 7"</p> | 4 |  <p>3 reels per inner box Box A</p> |
| 2 |  <p>HIC & Desiccant (1 Unit) inside</p> | 5 |  <p>12 inner boxes per outer box</p> |
| 3 |  <p>Caution label is on backside of AI bag</p> | 6 |  <p>Outer box Carton A</p> |

| 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 |