

## 6 + 3 Channels DC-DC PMU with Li-ion Battery Charger for CMOS DSC/DV

### General Description

The RT5021 is a complete power supply solution for digital still cameras and other hand held devices. The RT5021 is composed of a multi-channel DC-DC power converter unit, a single-cell linear Li-ion battery charger, a charger type detector, and an I<sup>2</sup>C control interface.

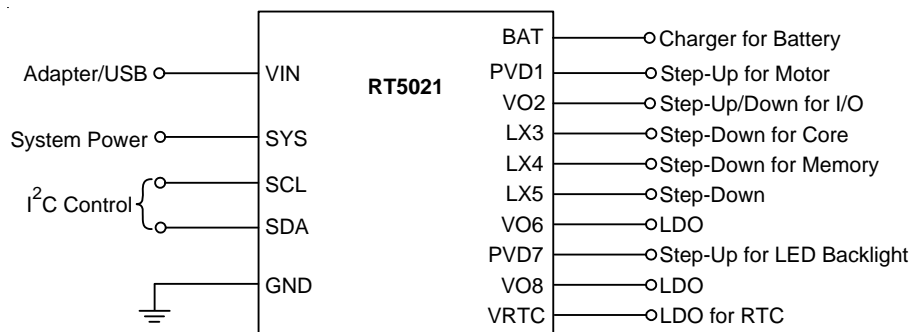
The power converter unit includes one synchronous step-up converter (CH1), one synchronous step-up/down converter (CH2), three synchronous step-down converters (CH3/4/5), two LDOs with input power as low as 1.5V (CH6/8), one WLED driver in synchronous high-voltage step-up mode or low-voltage current regulator mode (CH7), and a keep-alive LDO (CH9) for RTC application. All converters are internally frequency compensated and integrate power MOSFETs. The power converter unit provides complete protection functions : over current, thermal shutdown, over voltage, and under voltage protection. RT5021 has a WAKEUP impulse generation circuitry to monitor VIN or BAT installation event. To fulfill most of applications, RT5021 has six preset power on/off sequences.

The battery charger includes Auto Power Path Management (APPM). No external MOSFETs are required. The charger can enter sleep mode when power is removed.

Charging tasks are optimized by using a control algorithm to vary the charge rate, including pre-charge mode, fast charge mode and constant voltage mode. The charge current can also be programmed via the I<sup>2</sup>C control interface. The battery regulation voltage and current can be adjusted by JEITA standard temperature control or other schemes set via the I<sup>2</sup>C interface. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures. The charging task will always be terminated in constant voltage mode when the charging current reduces to the termination current of 10% x I<sub>CHG\_FAST</sub>. The charger includes under voltage and over voltage protection for the supply input voltage, VIN. The charger includes USB charger detection circuitry via D+ and D- pins of USB interface to detect USB standard downstream ports (SDP), USB charging downstream port (CDP), dedicated charger port (DCP), or Apple/Sony charger ports. RT5021 uses some indicators to show charger states : two open drain ports  $\overline{\text{CHG}}$  and  $\overline{\text{CHG2}}$ , and an interrupt ( $\overline{\text{INT}}$ ) to immediately notify the state change.

RT5021 has I<sup>2</sup>C interface to control rich functions of Power Converter Unit and Charger Unit. The RT5021 is available in the WQFN-40L 5x5 package.

### Simplified Application Circuit



## Features

### Power Converter Unit

- CH1 LV Sync Step-Up
  - ▶ Support Up to 1A Loading, DVS (Dynamic Voltage Scaling), Load-Disconnect, Up to 95% Efficiency, PSM/PWM Selectable
- CH2 LV Sync Step-Up/Down
  - ▶ Support Up to 1A Loading, DVS, Up to 95% Efficiency, PSM/PWM Selectable
- CH3/4 LV Sync Step-Down
  - ▶ Support Up to 1.3A Loading, DVS, Up to 95% Efficiency, 100% (MAX) Duty Cycle, PSM/PWM Selectable
- CH5 LV Sync Step-Down
  - ▶ Support Up to 0.6A Loading, Up to 95% Efficiency, 100% (MAX) Duty Cycle
  - ▶ Output Voltage can be Selected from Preset List or Set by External Feedback Network
- CH6 Low Input Power LDO
  - ▶  $V_{IN}$  Range 1.5V to 5.5V
  - ▶ Output Voltage Level Selectable in I<sup>2</sup>C Register
- CH7 WLED Driver in Either Sync Step-Up Operation or Current Regulator Operation
  - ▶ Step-Up Mode with LED Open Protection (OVP7 16V or 25V, Selectable in I<sup>2</sup>C Register)
  - ▶ Step-Up Mode Support Series 2 to 6 WLED and Load Disconnect Function
  - ▶ Current Regulator Mode for 1 WLED
  - ▶ 31 WLED Dimming Levels
  - ▶ Automatic Mode Selection by External Circuit Topology
- CH8 Generic LDO
  - ▶  $V_{IN}$  Range 1.5V to 5.5V
  - ▶ Output Voltage Level Selectable in I<sup>2</sup>C Register
- CH9 Low Quiescent LDO with Reverse Leakage Prevention for RTC Power Supply
  - ▶ Fixed 3.05V Output
- Six Preset Power On/Off Sequences by One Pin SEQ
  - ▶ SEQ # 0 : CH2→CH3→CH4
  - ▶ SEQ # 1 : CH1→CH3→CH2→CH4
  - ▶ SEQ # 2 : CH1→CH3→CH4→CH2
  - ▶ SEQ # 3 : CH1→CH2→CH4→CH3

- ▶ SEQ # 4 : CH1→CH4→CH3→CH2
- ▶ SEQ # 5 : CH1→CH4→CH2→CH3
- All Power Switches Integrated with Internal Compensation
- Discharge Output of Every Channels when Turning Off
- Wake Up Impulse to Monitor BAT and VIN Plug-In
- Fixed 2MHz Switching Frequency for CH1/3/4/5, Fixed 1MHz Switching Frequency for CH2/7

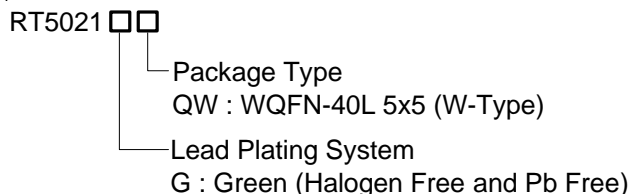
### Charger Unit

- 28V Maximum Rating for  $V_{IN}$  Power
- Selectable Power Input Current Limit (0.1A / 0.5A / 1A / 1.5A)
- Auto Power Path Management (APPM) with Integrated Power MOSFETs
- Battery Charging Current Control and Regulation Voltage Control
- Programmable Charging Current and Safe Charge Timer
- Optimized Charge Rate Via Thermal Feedback
- Under Voltage Protection, Over Voltage Protection
- Charger Status and VIN Power GOOD Indicators
- Interrupt Indicator to JEITA Temperature/Fault/Status Events when PMU is Enabled
  - ▶ Battery Temperature Events
  - ▶ Battery Removing Event
  - ▶ Charger in Thermal Regulation Control
  - ▶ Safety Timer Timeout
  - ▶ End of Charging
  - ▶ VIN Power Good
  - ▶ VIN < DPM Threshold 4.35V
  - ▶ Charger Type Detection Finishing
- Charger Type Detection
  - ▶ Dedicated Charger : Support Apple and Sony Charger
  - ▶ Secondary Charger Detection to Distinguish CDP and DCP
- I<sup>2</sup>C Control Interface : Support Fast Mode up to 400kb/s
- Small 40-Lead WQFN Package
- RoHS Compliant and Halogen Free

### Applications

- DSC Power Supply System
- CMOS-Sensor DV
- Portable Instruments

### Ordering Information

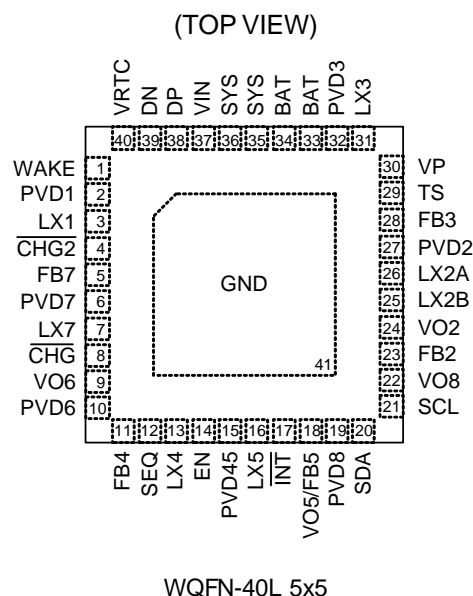


Note :

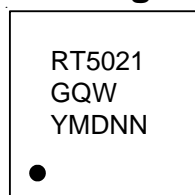
Richtek products are :

- ▶ RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- ▶ Suitable for use in SnPb or Pb-free soldering processes.

### Pin Configuration



### Marking Information



RT5021GQW : Product Code  
YMDNN : Date Code

### Part Status

| Part No.  | Status | Package Type | Lead Plating System              |
|-----------|--------|--------------|----------------------------------|
| RT5021GQW | EOL    | WQFN-40L 5x5 | Green (Halogen Free and Pb Free) |

The part status values are defined as below :

**Active** : Device is in production and is recommended for new designs.

**Lifebuy** : The device will be discontinued, and a lifetime-buy period is in effect.

**NRND** : Not recommended for new designs.

**Preview** : Device has been announced but is not in production.

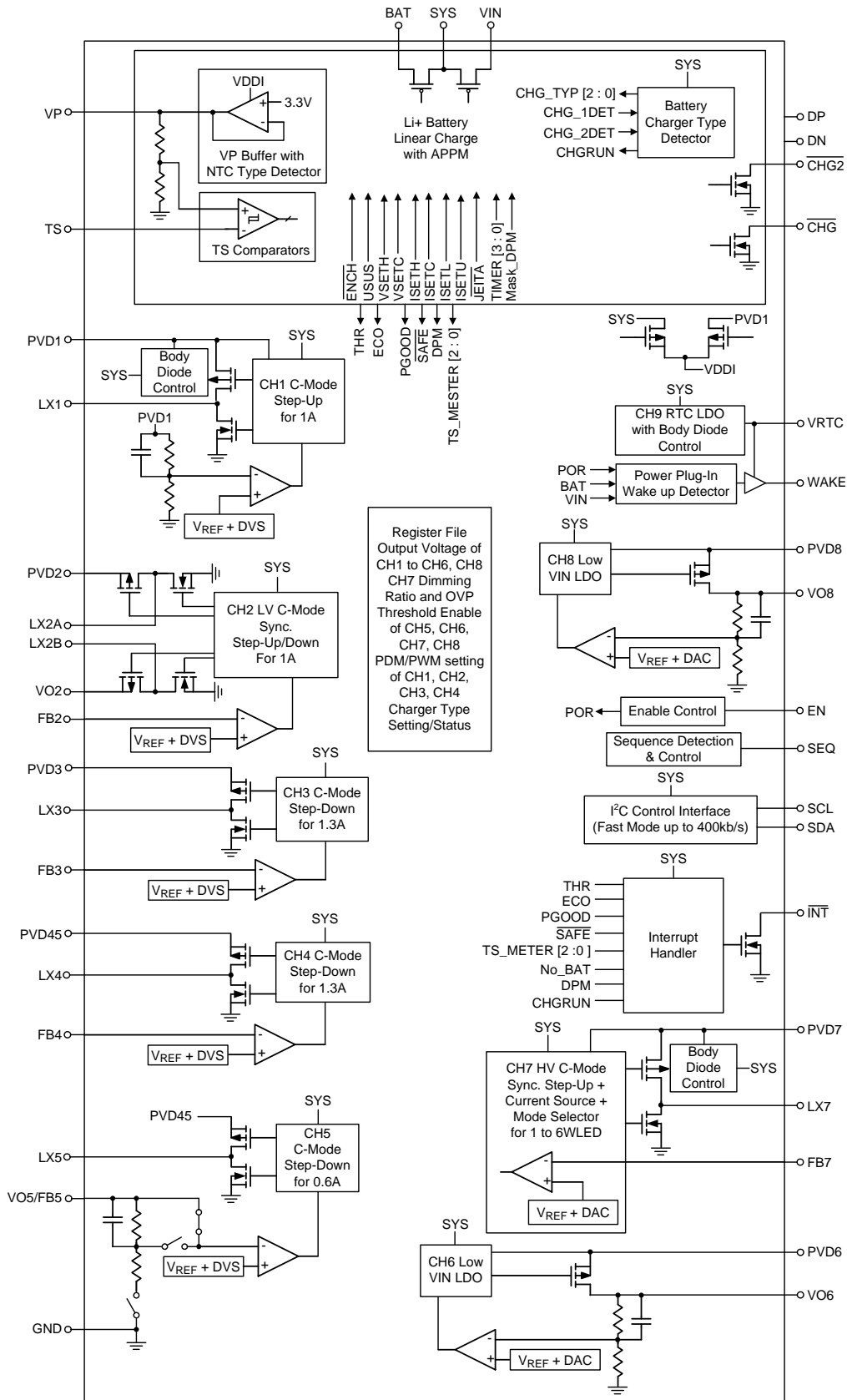
**EOL** : Richtek has discontinued the production of the device.

**Functional Pin Description**

| Pin No. | Pin Name                 | Pin Function  |
|---------|--------------------------|---|
| 1       | WAKE                     | Wake-Up Impulse Push Pull Output. If VIN or BAT plug in, WAKE pin generates one 90ms-width high pulse to notify micro processor.  |
| 2       | PVD1                     | Power Output pin of CH1. To make CH1 stable, the power path from the pin PVD1 to its output capacitors must be as short ( $\leq 1\text{mm}$ is better) and wide as possible to reduce its parasitic inductance. The output capacitor must be ceramic capacitor ( $\geq 20\mu\text{F}$ ).  |
| 3       | LX1                      | Switch Node of CH1.   |
| 4       | $\overline{\text{CHG2}}$ | 2nd Charger Status Indicator (Open Drain Output).   |
| 5       | FB7                      | Feedback Input Pin of CH7 in Step-Up Mode or Current Regulator Mode   |
| 6       | PVD7                     | Power Output Pin of CH7 in Step-Up or Power Input Pin of CH7 in Current Regulator Mode.   |
| 7       | LX7                      | Switch Node of CH7 in Step-Up Mode.<br>LX7 initial voltage determine CH7 operation mode.  |
| 8       | $\overline{\text{CHG}}$  | Charger Status Indicator (Open Drain Output).   |
| 9       | VO6                      | Power Output Pin of CH6.  |
| 10      | PVD6                     | Power Input Pin of CH6.   |
| 11      | FB4                      | Feedback Input Pin of CH4.  |
| 12      | SEQ                      | Power Sequence Selection for CH1 to CH4.  |
| 13      | LX4                      | Switch Node of CH4.   |
| 14      | EN                       | Enable Pin of Power Converter Unit.   |
| 15      | PVD45                    | Power Input Pin of CH4 and CH5. To avoid the crosstalk between CH4 and CH5, the power path from the pin PVD45 to its input capacitors must be as short ( $\leq 1\text{mm}$ is better) and wide as possible to reduce its parasitic inductance. The input capacitance must be $\geq 10\mu\text{F}$ with low ESR.   |
| 16      | LX5                      | Switch Node of CH5.   |
| 17      | $\overline{\text{INT}}$  | Interrupt Indicator Open Drain Output. If events of NoBAT, THR, EOC, Battery Temperature Change (TS_METER), PGOOD, $\overline{\text{SAFE}}$ , VIN DPM, or Charge Type Detection Finishing (CHGRUN) happen, the output $\overline{\text{INT}}$ goes low and the INT bit in I <sup>2</sup> C register bank 0x9 is set to be "1". After INT bit is written to be "0", $\overline{\text{INT}}$ goes high. |
| 18      | VO5/FB5                  | Output Voltage Sense Pin or feedback network input pin of CH5. The function is selected by I <sup>2</sup> C register.   |
| 19      | PVD8                     | Power Input Pin of CH8.   |
| 20      | SDA                      | Data Signal Pin of I <sup>2</sup> C Interface.  |
| 21      | SCL                      | Clock Signal Pin of I <sup>2</sup> C Interface.   |
| 22      | VO8                      | Power Output Pin of CH8.  |
| 23      | FB2                      | Feedback Input Pin of CH2.  |
| 24      | VO2                      | Power Output Pin of CH2.  |
| 25      | LX2B                     | Switch Node B of CH2.   |
| 26      | LX2A                     | Switch Node A of CH2.   |
| 27      | PVD2                     | Power Input Pin of CH2.   |

| Pin No.          | Pin Name | Pin Function  |
|------------------|----------|---|
| 28               | FB3      | Feedback Input Pin of CH3.  |
| 29               | TS       | Temperature Sense Input. The TS pin connects to a battery's thermistor to determine if the battery is too hot or too cold to charge. If the battery's temperature is out of range, charging is paused until it re-enters the valid range. TS also detects whether the battery (with NTC) is present or not. |
| 30               | VP       | Power Output Pin of 3.3V Buffer for Battery Temperature Sensing.  |
| 31               | LX3      | Switch Node of CH3.   |
| 32               | PVD3     | Power Input Pin of CH3.   |
| 33, 34           | BAT      | Charger Output for Battery.   |
| 35, 36           | SYS      | Power Output for System. Connect this pin to System with a minimum 10 $\mu$ F ceramic capacitor to GND.   |
| 37               | VIN      | Supply Voltage Input.   |
| 38               | DP       | USB D+ Input for Charger Type Detection.  |
| 39               | DN       | USB D- Input for Charger Type Detection.  |
| 40               | VRTC     | RTC LDO Power Output Pin.   |
| 41 (Exposed pad) | GND      | Exposed PAD Should be Soldered to PCB and Connected to GND.   |

## Functional Block Diagram



## Operation

The RT5021 is an integrated power solution for digital still cameras and other small handheld devices. It includes six DC-DC converters, a WLED driver, a RTC LDO, and a fully integrated single-cell Li-ion battery charger.

### CH1 : Step-Up DC-DC Converter

CH1 is a step-up converter for motor driver power. The converter operates at PFM or PWM current mode which can be set by I<sup>2</sup>C interface.

### CH2 : Step-Up/Down DC-DC Converter

CH2 is a step-up/down converter for I/O power. The converter operates at PFM or PWM current mode which can be set by I<sup>2</sup>C interface.

### CH3 : Step-Down DC-DC Converter

CH3 is a step-down converter for core power. The converter operates at PFM or PWM current mode which can be set by I<sup>2</sup>C interface.

### CH4 : Step-Down DC-DC Converter

CH4 is a step-down converter for memory power. The converter operates at PFM or PWM current mode which can be set by I<sup>2</sup>C interface.

### CH5 : Step-Down DC-DC Converter

CH5 is a step-down converter. The converter operates at PFM/PWM current mode.

### CH6 : Generic LDO

CH6 is a generic low voltage LDO for multiple purpose power.

### CH7 : WLED Driver

CH7 is a WLED driver that can operate in either current source mode or synchronous step-up mode which is determined by I<sup>2</sup>C interface control signal.

### CH8 : Generic LDO

CH8 is a generic low voltage LDO for multiple purpose power.

### CH9 : Keep Alive LDO and RTC

CH9 is a LDO providing a 3.05V output for real time clock.

### Charger Unit

A Li-ion battery charger with automatic power path management is designed to operate in below modes.

### Pre-Charge Mode

When the output voltage is lower than 2.8V, the charging current will be reduced to a ratio of fast-charge current set by A8.ISETA [3:0] to protect the battery life-time.

### Fast-Charge Mode

When the output voltage is higher than 3V, the charging current will be equal to the fast-charge current set by A8.ISETA [3:0].

### Constant Voltage Mode

When the output voltage is near 4.2V and the charging current falls below the termination current for a deglitch time of 25ms, the charger will be turned off and CHG will go to high.

### Re-Charge Mode

When the chip is in charge termination mode, the charging current gradually goes down to zero. Once the battery voltage drops to below 4.1V for 100ms, the charger will resume charging operation.



## Absolute Maximum Ratings (Note 1)

- Supply Voltages, SYS ----- -0.3V to 6V
- Supply Input Voltage, VIN ----- -0.3V to 28V
- Switch Node Voltage, LX1, LX2, LX3, LX4, LX5 ----- -0.3V to 6V
- PVD7, LX7 ----- -0.3V to 25V
- $\overline{\text{CHG}}$  ----- -0.3V to 28V
- $\overline{\text{CHG2}}$  ----- -0.3V to 6V
- Other Pins ----- -0.3V to 6V
- $\overline{\text{INT}}$ ,  $\overline{\text{CHG}}$ ,  $\overline{\text{CHG2}}$  Continuous Current ----- 20mA
- BAT Continuous Current (Total in two pins) ----- 2.5A
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ\text{C}$   
 WQFN-40L 5x5 ----- 3.64W
- Package Thermal Resistance (Note 2)  
 WQFN-40L 5x5,  $\theta_{JA}$  ----- 27.5°C/W  
 WQFN-40L 5x5,  $\theta_{JC}$  ----- 6°C/W
- Junction Temperature ----- 150°C
- Lead Temperature (Soldering, 10 sec.) ----- 260°C
- Storage Temperature Range ----- -65°C to 125°C
- ESD Susceptibility (Note 3)  
 HBM (Human Body Model) ----- 2kV  
 MM (Machine Model) ----- 200V

## Recommended Operating Conditions (Note 4)

- Supply Input Voltage, BAT ----- 1.8V to 5.5V
- Supply Input Voltage Range, VIN (A7.ISETL = 1) ----- 4.4V to 6V
- Supply Input Voltage Range, VIN (A7.ISETL = 0) ----- 4.5V to 6V
- Junction Temperature Range ----- -40°C to 125°C
- Ambient Temperature Range ----- -40°C to 85°C

## Electrical Characteristics

### Power Converter Unit :

( $V_{\text{SYS}} = 3.3\text{V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified)

| Parameter  | Symbol           | Test Conditions                                   | Min  | Typ   | Max  | Unit |
|--|------------------|---|------|-------|------|------|
| <b>Supply Voltage</b>                                |                  |   |      |       |      |      |
| PMU Startup Voltage at SYS                           | $V_{\text{ST}}$  | For bootstrap                                     | 1.5  | --    | --   | V    |
| SYS Operating Voltage for PMU                        | $V_{\text{SYS}}$ |   | 2.7  | --    | 5.5  | V    |
| VDDI Over Voltage Protection (OVP) (Hysteresis High) |                  |   | 5.82 | 6     | 6.18 | V    |
| VDDI OVP Hysteresis (Gap)                            |                  |   | --   | -0.25 | --   | V    |
| VDDI UVLO (Hysteresis High)                          |                  | VDDI UVLO takes effect once CH2 soft-start finish | 2.2  | 2.4   | 2.6  | V    |
| VDDI UVLO Hysteresis (Gap)                           |                  |   | --   | -0.3  | --   | V    |



| Parameter  | Symbol                 | Test Conditions                             | Min   | Typ          | Max   | Unit |
|--|------------------------|---|-------|--------------|-------|------|
| <b>Supply Current</b>  |                        |   |       |              |       |      |
| Shutdown Supply Current into BAT (Include I <sub>DDQ</sub> of RTC LDO) | I <sub>OFF-BAT</sub>   | EN = L, and PMU off, BAT = 4.2V             | --    | 10           | 20    | μA   |
| CH1 + CH2 + CH3 + CH4 Supply Current                                   | I <sub>Q1234</sub>     | Non switching, EN = 3.3V                    | --    | --           | 2000  | μA   |
| CH5 Supply Current   | I <sub>Q5</sub>        | Non switching, A2.EN5 = 1                   | --    | --           | 500   | μA   |
| CH6 Supply Current   | I <sub>Q6</sub>        | A2.EN6 = 1                                  | --    | --           | 100   | μA   |
| CH7 in Step-Up Mode Supply Current                                     | I <sub>Q7b</sub>       | Non switching, A2.EN7_DIM7 [4:0] = 5'b11111 | --    | --           | 500   | μA   |
| CH7 in Current Source mode Supply Current                              | I <sub>Q7c</sub>       | A2.EN7_DIM7 [4:0] = 5'b11111<br>PVD7 = 5V   | --    | --           | 400   | μA   |
| CH8 Supply Current   | I <sub>Q8</sub>        | A2.EN8 = 1                                  | --    | --           | 100   | μA   |
| <b>Oscillator</b>  |                        |   |       |              |       |      |
| CH1, 3, 4, 5 Operation Frequency                                       | f <sub>OSC_1345</sub>  |   | 1800  | 2000         | 2200  | kHz  |
| CH2, 7 Operation Frequency   | f <sub>OSC_27</sub>    | CH7 in Step-Up mode                         | 900   | 1000         | 1100  | kHz  |
| <b>CH1 LV Sync Step-Up</b>   |                        |   |       |              |       |      |
| Output Voltage Accuracy at PVD1  |                        | Target voltage defined at A4.VOUT1 [3:0]    | -1.5  | --           | 1.5   | %    |
| Minimum On Time for PSM  |                        |   | --    | 100          | --    | ns   |
| Soft-Start Time  |                        | PVD1 = 0 to 5V                              | --    | 4            | --    | ms   |
| Maximum Duty Cycle (Step-Up)   |                        | PVD1 < Target defined in A4.VOUT1 [3:0]     | 80    | 83           | 86    | %    |
| On Resistance of MOSFET  | R <sub>DS(ON)_P</sub>  | P-MOSFET, PVD1 = 3.3V                       | --    | 200          | 300   | mΩ   |
|  | R <sub>DS(ON)_N</sub>  | N-MOSFET, PVD1 = 3.3V                       | --    | 150          | 250   | mΩ   |
| Current Limitation (Step-Up)   | I <sub>LIM_1</sub>     |   | 2.2   | 3            | 4     | A    |
| Over Voltage Protection at PVD1  |                        |   | 5.82  | 6            | 6.18  | V    |
| Under Voltage Protection -1 at PVD1                                    |                        |   | --    | SYS - 0.8    | --    | V    |
| Under Voltage Protection -2 at PVD1                                    |                        | Target Voltage is defined in A4.VOUT1 [3:0] | --    | Target x 0.5 | --    | V    |
| Over Load Protection at PVD1   |                        | Target Voltage is defined in A4.VOUT1 [3:0] | --    | Target - 0.6 | --    | V    |
| Off Discharge Current at PVD1  |                        | PVD1 = 5V, SYS = 3.3V                       | --    | 20           | --    | mA   |
| Discharge Finishing Threshold at PVD1                                  |                        |   | --    | 0.6          | --    | V    |
| <b>CH2 LV Sync Step-Up/Down</b>  |                        |   |       |              |       |      |
| Feedback Regulation Voltage at FB2                                     |                        | A4.FB2 [2:0] = 3'b100                       | 0.788 | 0.8          | 0.812 | V    |
| Soft-Start Time  |                        | FB2 = 0 to 0.8V                             | --    | 4            | --    | ms   |
| Maximum Duty Cycle   |                        | LX2B  | --    | 55           | --    | %    |
|  |                        | LX2A  | --    | --           | 100   | %    |
| On Resistance of MOSFET  | R <sub>DS(ON)_2A</sub> | LX2A - GND, N-MOSFET PVD2 = 3.3V            | --    | 200          | 300   | mΩ   |
|  |                        | PVD2 - LX2A, P-MOSFET PVD2 = 3.3V           | --    | 150          | 250   | mΩ   |

| Parameter                            | Symbol                 | Test Conditions  | Min   | Typ             | Max   | Unit |
|--------------------------------------|------------------------|--|-------|-----------------|-------|------|
| On Resistance of MOSFET              | R <sub>DS(ON)_2B</sub> | VO2-LX2B,<br>P-MOSFET, VO2 = 3.3V                        | --    | 200             | 300   | mΩ   |
|                                      |                        | LX2B – GND,<br>N-MOSFET VO2 = 3.3V                       | --    | 150             | 250   | mΩ   |
| Current Limitation                   | I <sub>LIM_2</sub>     | Both P-MOSFET (PVD2 – LX2A)<br>and N-MOSFET (LX2B – GND) | 2     | 2.5             | 3     | A    |
| Over Voltage Protection at VO2       |                        |  | 5.82  | 6               | 6.18  | V    |
| Under Voltage Protection at FB2      |                        | Target voltage is the chosen one<br>in A4.FB2 [2:0]      | --    | 0.4             | --    | V    |
| Over Load Protection at FB2          |                        |  | --    | Target<br>– 0.1 | --    | V    |
| Off Discharge Current at VO2         |                        | VO2 = 3.3V, SYS = 3.3V                                   | --    | 20              | --    | mA   |
| Discharge Finishing Threshold at VO2 |                        |  | --    | 0.1             | --    | V    |
| <b>CH3 LV Sync Step-Down</b>         |                        |  |       |                 |       |      |
| Feedback Regulation Voltage at FB3   |                        | A5.FB3 [2:0] = 3'b100                                    | 0.788 | 0.8             | 0.812 | V    |
| Minimum On Time for PSM              |                        |  | --    | 50              | --    | ns   |
| Maximum Duty Cycle                   |                        | FB3 = 0.75V  | --    | --              | 100   | %    |
| Soft-Start Time                      |                        | FB3 = 0 to 0.8V  | --    | 4               | --    | ms   |
| On Resistance of MOSFET              | R <sub>DS(ON)_P</sub>  | P-MOSFET, PVD3 = 3.3V                                    | --    | 200             | 300   | mΩ   |
|                                      | R <sub>DS(ON)_N</sub>  | N-MOSFET, PVD3 = 3.3V                                    | --    | 150             | 250   | mΩ   |
| Current Limitation                   | I <sub>LIM_3</sub>     |  | 1.3   | 1.8             | 2.4   | A    |
| Under Voltage Protection at FB3      |                        |  | 0.35  | 0.4             | 0.45  | V    |
| Over Load Protection at FB3          |                        | Target voltage is the chosen one<br>in A5.FB3 [2:0]      | --    | Target<br>– 0.1 | --    | V    |
| Off Discharge Current at LX3         |                        | LX3 = 1V, SYS = 3.3V                                     | --    | 20              | --    | mA   |
| Discharge Finishing Threshold at FB3 |                        |  | --    | 0.1             | --    | V    |
| <b>CH4 LV Sync Step-Down</b>         |                        |  |       |                 |       |      |
| Feedback Regulation Voltage at FB4   |                        | A5.FB4 [2:0] = 3'b100                                    | 0.788 | 0.8             | 0.812 | V    |
| Minimum On Time for PSM              |                        |  | --    | 50              | --    | ns   |
| Maximum Duty Cycle                   |                        | FB4 = 0.75V  | --    | --              | 100   | %    |
| Soft-Start Time                      |                        | FB4 = 0 to 0.8V  | --    | 4               | --    | ms   |
| On Resistance of MOSFET              | R <sub>DS(ON)_P</sub>  | P-MOSFET, PVD4 = 3.3V                                    | --    | 300             | 400   | mΩ   |
|                                      | R <sub>DS(ON)_N</sub>  | N-MOSFET, PVD4 = 3.3V                                    | --    | 200             | 300   | mΩ   |
| Current Limitation                   | I <sub>LIM_4</sub>     |  | 1.3   | 1.8             | 2.4   | A    |
| Under Voltage Protection at FB4      |                        |  | 0.35  | 0.4             | 0.45  | V    |
| Over Load Protection at FB4          |                        | Target voltage is the chosen one<br>in A5.FB4 [2:0]      | --    | Target<br>– 0.1 | --    | V    |
| Off Discharge Current at LX4         |                        | LX4 = 1V, SYS = 3.3V                                     | --    | 20              | --    | mA   |
| Discharge Finishing Threshold at FB4 |                        |  | --    | 0.1             | --    | V    |

| Parameter   | Symbol                | Test Conditions   | Min   | Typ            | Max   | Unit |
|---|-----------------------|---|-------|----------------|-------|------|
| <b>CH5 LV Sync Step-Down</b>                                  |                       |   |       |                |       |      |
| Output Voltage Accuracy at VO5                                |                       | Target voltage defined at A6.VOUT5 [3:0] = 4'b1000 to 4'b1111         | -1.5  | --             | 1.5   | %    |
|   |                       | Target voltage defined at A6.VOUT5 [3:0] = 4'b0001 to 4'b0111         | -2    | --             | 2     | %    |
| Feedback Regulation Voltage at FB5                            |                       | A6.VOUT5 [3:0] = 4'b0000  | 0.788 | 0.8            | 0.812 | V    |
| Maximum Duty Cycle  |                       |   | --    | --             | 100   | %    |
| Soft-Start Time   |                       | VO5 = 0V to Target  | --    | 4              | --    | ms   |
| On Resistance of MOSFET                                       | R <sub>DS(ON)_P</sub> | P-MOSFET, PVD5 = 3.3V   | --    | 400            | 550   | mΩ   |
|   | R <sub>DS(ON)_N</sub> | N-MOSFET, PVD5 = 3.3V   | --    | 250            | 400   | mΩ   |
| Current Limitation  | I <sub>LIM_5</sub>    |   | 1     | 1.5            | 2     | A    |
| Under Voltage Protection at VO5                               |                       |   | --    | Target x 0.5   | --    | V    |
| Over Load Protection at VO5                                   |                       | Target voltage is the chosen one in A6.VOUT5 [3:0] = 0000 (FB5 = 0.8) | --    | Target - 0.1   | --    |      |
|   |                       | Target voltage is the chosen one in A6.VOUT5 [3:0] = 0001 to 0111     | --    | Target - 0.167 | --    |      |
|   |                       | Target voltage is the chosen one in A6.VOUT5 [3:0] = 0111 to 1111     | --    | Target - 0.25  | --    |      |
| Off Discharge Current at VO5                                  |                       | VO5 = 1.8V, SYS = 3.3V  | --    | 30             | --    | mA   |
| Discharge Finishing Threshold at VO5                          |                       |   | --    | 0.1            | --    | V    |
| <b>CH6 LDO</b>  |                       |   |       |                |       |      |
| Input Voltage Range (PVD6)                                    |                       |   | 1.5   | --             | 5.5   | V    |
| Quiescent Current into PVD6                                   |                       | PVD6 = 3.3V, I <sub>OUT</sub> = 0mA                                   | --    | --             | 75    | μA   |
| Regulation Voltage Accuracy at VO6                            |                       | A6.VOUT6 [3:0] = 4'b1000 to 4'b1111                                   | -1.5  | --             | 1.5   | %    |
|   |                       | A6.VOUT6 [3:0] = 4'b0000 to 4'b0111                                   | -2    | --             | 2     | %    |
| Drop Out Voltage (PVD6-VO6)                                   |                       | I <sub>OUT</sub> = 300mA, VO6 = 1.3V                                  | --    | --             | 0.15  | V    |
| PSRR+   |                       | I <sub>OUT</sub> = 10mA, PVD6 = 3.3V at 1kHz                          | --    | -60            | --    | dB   |
| Max Output Current (Current Limit)                            |                       | PVD6 = 1.5V, VO6 = 1.3V   | 300   | 450            | 600   | mA   |
| Off Discharge Current at VO6                                  |                       | SYS = 3.3V  | --    | --             | 10    | mA   |
| <b>CH7 WLED Driver</b>  |                       |   |       |                |       |      |
| Feedback Regulation Voltage at FB7 (Both Step-Up and Current) |                       | A2.EN7_DIM7 [4:0] = 5'b11111  | 0.237 | 0.25           | 0.263 | V    |
| Minimum On Time for PSM (Step-Up)                             |                       |   | --    | 300            | --    | ns   |
| Maximum Duty Cycle (Step-Up mode)                             |                       | FB7 = 0.15V   | 91    | 93             | 97    | %    |

| Parameter                                      | Symbol                | Test Conditions   | Min  | Typ         | Max  | Unit |
|--|-----------------------|---|------|-------------|------|------|
| On Resistance of MOSFET                        | R <sub>DS(ON)_P</sub> | P-MOSFET, PVD7 = 10V  | --   | 2           | 3    | Ω    |
|  | R <sub>DS(ON)_N</sub> | N-MOSFET, SYS = 3.3V  | --   | 0.9         | 1.1  | Ω    |
| Current Limitation (Step-Up mode)              |                       | N-MOSFET, SYS = 3.3V  | 0.6  | 0.8         | 1    | A    |
| Over Voltage Protection at PVD7 (Step-Up mode) |                       | A0.OVP7 = 0   | 15   | 16          | 17   | V    |
|  |                       | A0.OVP7 = 1   | 24   | 25          | 26   | V    |
| Off Discharge Current at PVD7 (Step-Up mode)   |                       | PVD7 = 10V, SYS = 3.3V  | --   | 20          | --   | mA   |
| Discharge Finishing Threshold at PVD7          |                       | (Step-Up Mode)  | --   | SYS - 0.4   | --   | V    |
| <b>CH8 LDO</b>                                 |                       |   |      |             |      |      |
| Input Voltage Range (PVD8)                     |                       |   | 1.5  | --          | 5.5  | V    |
| Quiescent Current into PVD8                    | I <sub>Q_PVD8</sub>   | PVD8 = 3.3V, I <sub>OUT</sub> = 0mA                                   | --   | --          | 75   | μA   |
| Regulation Voltage Accuracy at VO8             |                       | A3.VOUT8 [3:0] = 4'b1000 to 4'b1111                                   | -1.5 | --          | 1.5  | %    |
|  |                       | A3.VOUT8 [3:0] = 4'b0000 to 4'b0111                                   | -2   | --          | 2    | %    |
| Drop Out Voltage (PVD8-VO8)                    |                       | I <sub>OUT</sub> = 300mA, VO8 = 2.5V                                  | --   | --          | 0.2  | V    |
| PSRR+  |                       | I <sub>OUT</sub> = 10mA, PVD8 = 3.3V at 1kHz                          | --   | -60         | --   | dB   |
| Max Output Current (Current Limit)             |                       | PVD8 = 3V, VO8 = 2.5V   | 300  | 450         | 600  | mA   |
| Off Discharge Current at VO8                   |                       | SYS = 3.3V  | --   | --          | 10   | mA   |
| <b>CH9 RTC LDO</b>                             |                       |   |      |             |      |      |
| Standby Quiescent Current                      |                       | BAT = 4.2V  | --   | 3           | 6    | μA   |
| Lockout Current into VRTC                      | I <sub>LO-VRTC</sub>  | EN = L, and PMU off, BAT = 0V, VRTC = 3.05V, SYS = 0V                 | --   | --          | 1    | μA   |
| Regulation Voltage at VRTC                     |                       | I <sub>OUT</sub> = 0mA  | 3    | 3.05        | 3.1  | V    |
| Max Output Current (Current Limit)             |                       | BAT = 4.2V  | 60   | 130         | 200  | mA   |
| Dropout Voltage at (BAT-VRTC)                  |                       | I <sub>OUT</sub> = 50mA   | --   | --          | 1000 | mV   |
|  |                       | I <sub>OUT</sub> = 10mA   | --   | --          | 150  | mV   |
|  |                       | I <sub>OUT</sub> = 3mA  | --   | --          | 60   | mV   |
| <b>Wake Up Detector</b>                        |                       |   |      |             |      |      |
| WAKE Impulse High Duration                     | t <sub>WAKEUP</sub>   | VIN or BAT plug in, VRTC = 3.05V                                      | 60   | 90          | 120  | ms   |
| WAKE UP High Level                             | V <sub>WAKE_H</sub>   | Source Current 0.5mA, VRTC = 3.05V                                    | --   | VRTC - 0.3V | VRTC | V    |
| WAKE UP Low Level                              | V <sub>WAKE_L</sub>   | Sink Current 0.5mA, VRTC = 3.05V                                      | 0    | 0.3         | --   | V    |
| WAKE UP Rising Time                            | t <sub>WAKE_R</sub>   | C <sub>LOAD</sub> 100pF at WAKE pin, 10% to 90% of VRTC, VRTC = 3.05V | --   | --          | 1    | μs   |
| BAT Wake Up Threshold Voltage                  |                       | VRTC = 3.05V  | 3    | 3.1         | 3.2  | V    |
| BAT Wake Up Threshold Hysteresis Gap           |                       | VRTC = 3.05V  | --   | -0.28       | --   | V    |

| Parameter                                      | Symbol           | Test Conditions   | Min  | Typ   | Max | Unit |
|--|------------------|---|------|-------|-----|------|
| VIN Wake Up Threshold Voltage                  |                  | VRTC = 3.05V  | 3.55 | 3.75  | 4   | V    |
| VIN Wake Up Threshold Gap                      |                  | VRTC = 3.05V  | --   | -0.24 | --  | V    |
| <b>Control</b>                                 |                  |   |      |       |     |      |
| EN Input High Level Threshold                  |                  |   | 1.3  | --    | --  | V    |
| EN Input Low Level Threshold                   |                  |   | --   | --    | 0.4 | V    |
| EN Pull Down Current                           |                  |   | --   | 1     | 3   | μA   |
| SEQ Pull High Threshold for Power Sequence #0  |                  |   | 0.2  | --    | --  | V    |
| SEQ Pull Down Resistance for Power Sequence #1 |                  | BAT = SYS = 2.7V  | 25   | 40    | 64  | kΩ   |
| SEQ Pull Down Resistance for Power Sequence #2 |                  | BAT = SYS = 2.7V  | 6.25 | 10    | 16  | kΩ   |
| SEQ Pull Down Resistance for Power Sequence #3 |                  | BAT = SYS = 2.7V  | 1.56 | 2.5   | 4   | kΩ   |
| SEQ Pull Down Resistance for Power Sequence #4 |                  | BAT = SYS = 2.7V  | --   | 0.63  | 1   | kΩ   |
| SEQ Pull Low Threshold for Power Sequence #4   |                  |   | --   | --    | 0.2 | V    |
| SEQ Pull Down Resistance for Power Sequence #5 |                  | BAT = SYS = 2.7V  | 100  | 160   | --  | kΩ   |
| Power Sequence Time Gap                        |                  | From previous channel starting to next channel starting | 9    | 10    | 11  | ms   |
| <b>Protection</b>                              |                  |   |      |       |     |      |
| Protection Fault Delay                         |                  |   | --   | 100   | --  | ms   |
| Thermal Shutdown                               | T <sub>SD</sub>  |   | 125  | 155   | --  | °C   |
| Thermal Shutdown Hysteresis                    | ΔT <sub>SD</sub> |   | --   | 20    | --  | °C   |

### Charger Unit :

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

| Parameter                            | Symbol              | Test Conditions  | Min  | Typ   | Max  | Unit     |
|--------------------------------------|---------------------|--|------|-------|------|----------|
| <b>Supply Input</b>                  |                     |  |      |       |      |          |
| VIN Under Voltage Lockout Threshold  | $V_{UVLO}$          | $V_{IN} = 0V$ to 4.5V  | 3.1  | 3.3   | 3.5  | V        |
| VIN Under Voltage Lockout Hysteresis | $\Delta V_{UVLO}$   | $V_{IN} = 4.5V$ to 0V  | --   | 240   | --   | mV       |
| VIN Supply Current                   | $I_{SUPPLY}$        | $I_{SYS} = I_{BAT} = 0mA$ , A7.ENCH = 0 ( $V_{BAT} > V_{REGx}$ ) | --   | 1     | 2    | mA       |
|                                      |                     | $I_{SYS} = I_{BAT} = 0mA$ , A7.ENCH = 1 ( $V_{BAT} > V_{REGx}$ ) | --   | 0.8   | 1.5  | mA       |
| VIN Suspend Current                  | $I_{USUS}$          | $V_{IN} = 5V$ , A7.USUS = 1                                      | --   | 195   | 300  | $\mu A$  |
| VIN-BAT VOS Rising                   | $V_{OS\_H}$         |  | --   | 200   | 300  | mV       |
| VIN-BAT VOS Falling                  | $V_{OS\_L}$         |  | 10   | 50    | --   | mV       |
| <b>Voltage Regulation</b>            |                     |  |      |       |      |          |
| System Regulation Voltage            | $V_{SYS}$           | $I_{SYS} = 800mA$  | 4.9  | 5     | 5.1  | V        |
| Battery Regulation Voltage           | $V_{REG1}$          | 0 to 85°C, Loading = 20mA, When A9.VSETH = 1 and A9.VSETC = 1    | 4.16 | 4.2   | 4.23 | V        |
| Battery Regulation Voltage           | $V_{REG2}$          | 0 to 85°C, Loading = 20mA, When A9.VSETH = 0 and A9.VSETC = 0    | 4.01 | 4.05  | 4.08 | V        |
| APPM Regulation Voltage              | $V_{APPM}$          |  | 4.05 | 4.15  | 4.25 | V        |
| DPM Regulation Voltage               | $V_{DPM}$           |  | 4.25 | 4.35  | 4.45 | V        |
| VIN to VSYS MOSFET Ron               | $R_{DS(ON)}$        | $I_{VIN} = 1000mA$   | --   | 0.2   | 0.35 | $\Omega$ |
| BAT to VSYS MOSFET Ron               | $R_{DS(ON)}$        | $V_{BAT} = 4.2V$ , $I_{SYS} = 1A$                                | --   | 0.05  | 0.1  | $\Omega$ |
| Re-Charge Threshold                  | $\Delta V_{REGCHG}$ | Battery Regulation - Recharge level                              | 60   | 100   | 140  | mV       |
| <b>Current Regulation</b>            |                     |  |      |       |      |          |
| Charge Current Setting Range         | $I_{CHG}$           |  | 100  | --    | 1200 | mA       |
| Charge Current Accuracy1             | $I_{CHG1}$          | $V_{BAT} = 4V$ , A8.ISETA [3 : 0] = 4'b0101                      | 570  | 600   | 630  | mA       |
| Charge Current Accuracy2             | $I_{CHG2}$          | $V_{BAT} = 3.8V$ , A8.ISETA [3 : 0] = 4'b0010                    | 285  | 300   | 315  | mA       |
| VIN Current Limit                    | $I_{LIM\_VIN}$      | A7.ISETL = 1, A7.ISETU = 1 (1.5A Mode)                           | 1.5  | 1.8   | 2.1  | A        |
|                                      |                     | A7.ISETL = 1, A7.ISETU = 0 (1A Mode)                             | 0.85 | 0.925 | 1.0  | A        |
|                                      |                     | A7.ISETL = 0, A7.ISETU = 1 (500mA mode)                          | 450  | 475   | 500  | mA       |
|                                      |                     | A7.ISETL = 0, A7.ISETU = 0 (100mA Mode)                          | 80   | 90    | 100  | mA       |
| <b>Pre-Charge</b>                    |                     |  |      |       |      |          |
| BAT Pre-Charge Threshold             | $V_{PRECH}$         | BAT Falling  | 2.7  | 2.8   | 2.9  | V        |
| BAT Pre-Charge Threshold Hysteresis  | $\Delta V_{PRECH}$  |  | --   | 200   | --   | mV       |
| Pre-Charge Current                   | $I_{CHG\_PRE}$      | $V_{BAT} = 2V$   | 5    | 10    | 15   | %        |

| Parameter  | Symbol                | Test Conditions   | Min   | Typ | Max   | Unit    |
|--|-----------------------|---|-------|-----|-------|---------|
| <b>Charge Termination Detection</b>                            |                       |   |       |     |       |         |
| Termination Current Ratio to Fast Charge (Except USB 100 Mode) | $I_{TERM}$            | A7.ISETL = 0, A7.ISETU = 1<br>Or A7.ISETL = 1, A7.ISETU = X | 5     | 10  | 15    | %       |
| Termination Current Ratio to Fast Charge (USB100 Mode)         | $I_{TERM2}$           | A7.ISETL = 0, A7.ISETU = 0                                  | --    | 3.3 | --    | %       |
| <b>Login Input/Output</b>                                      |                       |   |       |     |       |         |
| $\overline{CHG}$ Pull Down Voltage                             | $V_{\overline{CHG}}$  | $I_{\overline{CHG}} = 5mA$                                  | --    | 200 | --    | mV      |
| $\overline{CHG2}$ Pull Down Voltage                            | $V_{\overline{CHG2}}$ | $I_{\overline{CHG2}} = 5mA$                                 | --    | 200 | --    | mV      |
| $\overline{INT}$ Pull Down Voltage                             | $V_{\overline{INT}}$  | $I_{\overline{INT}} = 5mA$                                  | --    | 200 | --    | mV      |
| <b>Protection</b>  |                       |   |       |     |       |         |
| Thermal Regulation Point                                       | $T_{REG}$             |   | --    | 125 | --    | °C      |
| Thermal Shutdown Temperature                                   | $T_{SD}$              |   | --    | 155 | --    | °C      |
| Thermal Shutdown Hysteresis                                    | $\Delta T_{SD}$       |   | --    | 20  | --    | °C      |
| Over Voltage Protection  | $V_{OVP}$             | $V_{IN}$ Rising   | 6.25  | 6.5 | 6.75  | V       |
| Over Voltage Protection Hysteresis                             | $\Delta V_{OVP}$      | $V_{IN} = 7V$ to $5V$ , $V_{OVP} - \Delta V_{OVP}$          | --    | 100 | --    | mV      |
| Output Short Circuit Detection Threshold                       | $V_{SHORT}$           | $V_{BAT} - V_{SYS}$   | --    | 300 | --    | mV      |
| Battery Installation Detection Threshold at TS                 |                       | EN = H (PMU enabled), report at A10. NoBAT bit              | --    | 90  | --    | % of VP |
| <b>Time</b>  |                       |   |       |     |       |         |
| Input Over Voltage Blanking Time                               | $t_{OVP}$             |   | --    | 50  | --    | $\mu s$ |
| 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                | $t_{NO\_IN}$          |   | --    | 25  | --    | ms      |
| Pack Temperature Fault Detection Deglitch Time                 | $t_{TS}$              |   | --    | 25  | --    | ms      |
| Short Circuit Deglitch Time                                    | $t_{SHORT}$           |   | --    | 250 | --    | $\mu s$ |
| Short Circuit Recovery Time                                    | $t_{SHORT-R}$         |   | --    | 64  | --    | ms      |
| <b>Other</b>   |                       |   |       |     |       |         |
| VP Regulation Voltage  | $V_{VP}$              | $V_{SYS} = 4.2V$  | 3.234 | 3.3 | 3.366 | V       |
| VP Load Regulation   | $V_{VP}$              | VP source out 2mA   | --    | --  | -0.1  | V       |



| Parameter  | Symbol                 | Test Conditions                    | Min   | Typ  | Max  | Unit    |
|--|------------------------|------------------------------------|-------|------|------|---------|
| VP Under Voltage Lockout Threshold               |                        | Falling Threshold                  | --    | 0.8  | --   | V       |
| TS Battery Detect Threshold                      | V <sub>TS</sub>        |                                    | 2.75  | 2.85 | 2.95 | V       |
| <b>NTC Temperature Sense</b>                     |                        |                                    |       |      |      |         |
| Low Temperature Trip Point (0°C)                 | V <sub>TOO_COLD</sub>  | NTC = 100kΩ                        | 73    | 74   | 75   | % of VP |
|  | V <sub>TOO_COLD</sub>  | NTC = 10kΩ                         | 59    | 60   | 61   | % of VP |
| Low Temperature Trip Point (10°C) for JEITA      | V <sub>COLD</sub>      | NTC = 100kΩ                        | 63    | 64   | 65   | % of VP |
|  | V <sub>COLD</sub>      | NTC = 10kΩ                         | 51    | 52   | 53   | % of VP |
| High Temperature Trip Point (45°C) for JEITA     | V <sub>HOT</sub>       | NTC = 100kΩ                        | 34    | 35   | 36   | % of VP |
|  | V <sub>HOT</sub>       | NTC = 10kΩ                         | 31    | 32   | 33   | % of VP |
| High Temperature Trip Point (60°C)               | V <sub>TOO_HOT</sub>   | NTC = 100kΩ, A8.TSHT [1:0] = 2'b00 | 27    | 28   | 29   | % of VP |
|  | V <sub>TOO_HOT</sub>   | NTC = 10kΩ, A8.TSHT [1:0] = 2'b00  | 27    | 28   | 29   | % of VP |
| High Temperature Trip Point Hysteresis for JEITA |                        |                                    | --    | 1    | --   | % of VP |
| <b>Charger Detection</b>                         |                        |                                    |       |      |      |         |
| VDP_SRC Voltage                                  | VDP_SRC                | With IDAT_SRC = 0 to 200μA         | 0.5   | --   | 0.7  | V       |
| VDAT_REF Voltage                                 | VDAT_REF               |                                    | 0.25  | --   | 0.4  | V       |
| VLGC Voltage                                     | VLGC                   |                                    | 0.8   | --   | 2.0  | V       |
| IDP_SRC Current                                  | IDP_SRC                |                                    | 6.6   | --   | 11   | μA      |
| D+ and D- Sink Current                           | ICD+_SINK<br>ICD-_SINK |                                    | 50    | --   | 150  | μA      |
| D- Pull down Resistor                            | RD-_DWN                |                                    | 14.25 | --   | 24.8 | kΩ      |
| Data Contact Detect Debounce                     | TDCD_DBNC              |                                    | 20    | 30   | 40   | ms      |
| DCD Time OUT                                     | TDCD_TO                |                                    | 300   | --   | 900  | ms      |
| VDAT_SRC ON Time                                 | TDP_SRC_ON             |                                    | 100   | --   | 200  | ms      |

(V<sub>sys</sub> = 3.3V, T<sub>A</sub> = 25°C, unless otherwise specified)

| Parameter   | Symbol              | Test Conditions           | Min | Typ | Max | Unit |
|---|---------------------|---------------------------|-----|-----|-----|------|
| <b>I<sup>2</sup>C</b>   |                     |                           |     |     |     |      |
| SDA, SCLK Input High Level Threshold  |                     |                           | 1.4 | --  | --  | V    |
| SDA, SCLK Input Low Level Threshold   |                     |                           | -   | --  | 0.6 | V    |
| SCLK Clock Rate   | f <sub>SCL</sub>    |                           | --  | --  | 400 | kHz  |
| Hold Time (repeated) START Condition.<br>After this period, the first clock pulse is generated. | t <sub>HD,STA</sub> |                           | 0.6 | --  | --  | μs   |
| LOW Period of the SCL Clock   | t <sub>LOW</sub>    |                           | 1.3 | --  | --  | μs   |
| HIGH Period of the SCL Clock  | t <sub>HIGH</sub>   |                           | 0.6 | --  | --  | μs   |
| Set-Up Time for a Repeated START Condition  | t <sub>SU,STA</sub> |                           | 0.6 | --  | --  | μs   |
| Data Hold Time  | t <sub>HD,DAT</sub> |                           | 0   | --  | 0.9 | μs   |
| Data Set-Up Time  | t <sub>SU,DAT</sub> |                           | 100 | --  | --  | ns   |
| Set-Up Time for STOP Condition  | t <sub>SU,STO</sub> |                           | 0.6 | --  | --  | μs   |
| Bus Free Time between a STOP and START condition  | t <sub>BUF</sub>    |                           | 1.3 | --  | --  | μs   |
| Rise time of both SDA and SCL signals   | t <sub>R</sub>      |                           | 20  | --  | 300 | ns   |
| Fall Time of Both SDA and SCL Signals   | t <sub>F</sub>      |                           | 20  | --  | 300 | ns   |
| SDA and SCL Output Low Sink Current   | I <sub>OL</sub>     | SDA or SCL voltage = 0.4V | 2   | --  | --  | mA   |

**Note 1.** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device.

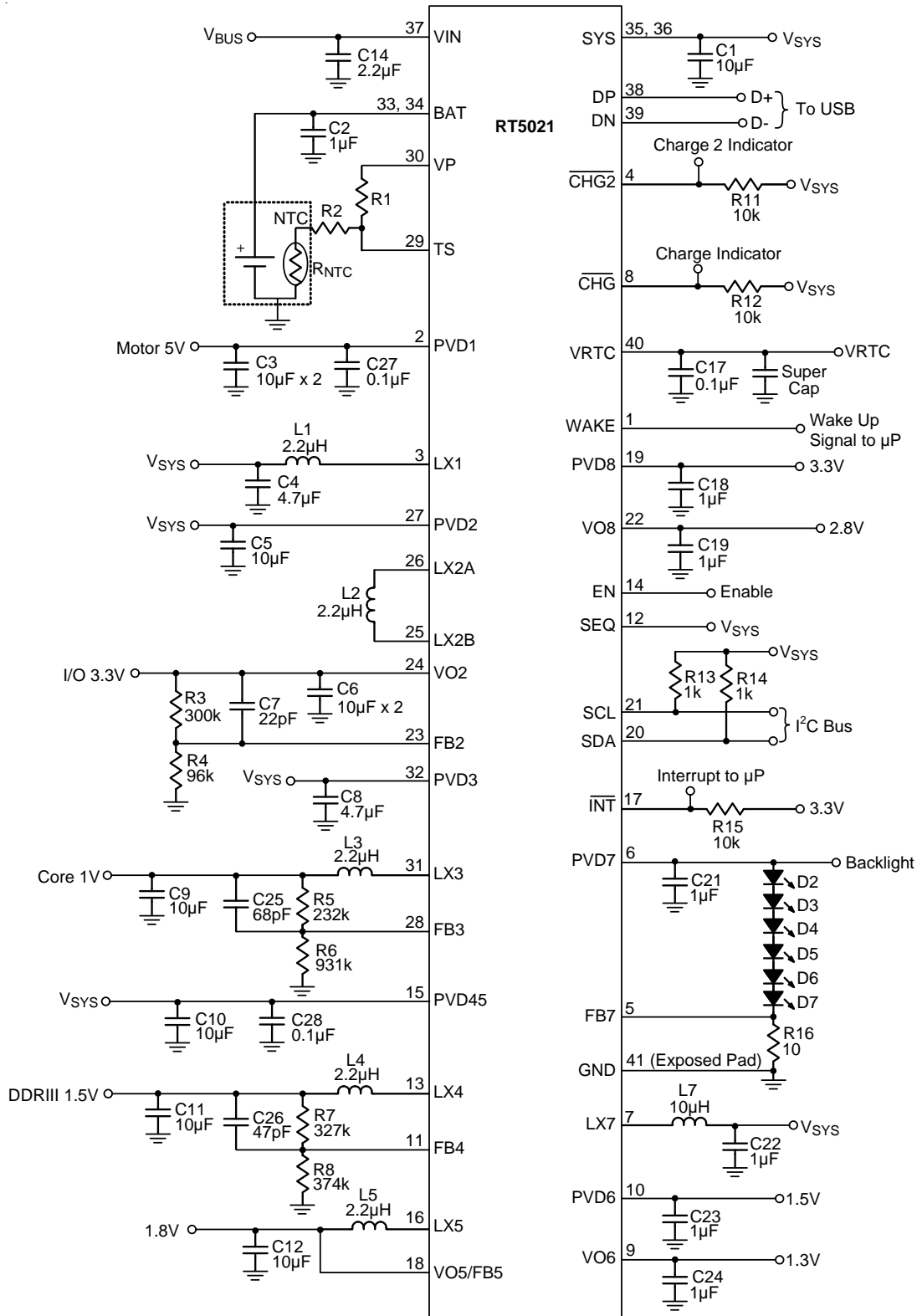
These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

**Note 2.** θ<sub>JA</sub> is measured at T<sub>A</sub> = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ<sub>JC</sub> is measured at the exposed pad of the package.

**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

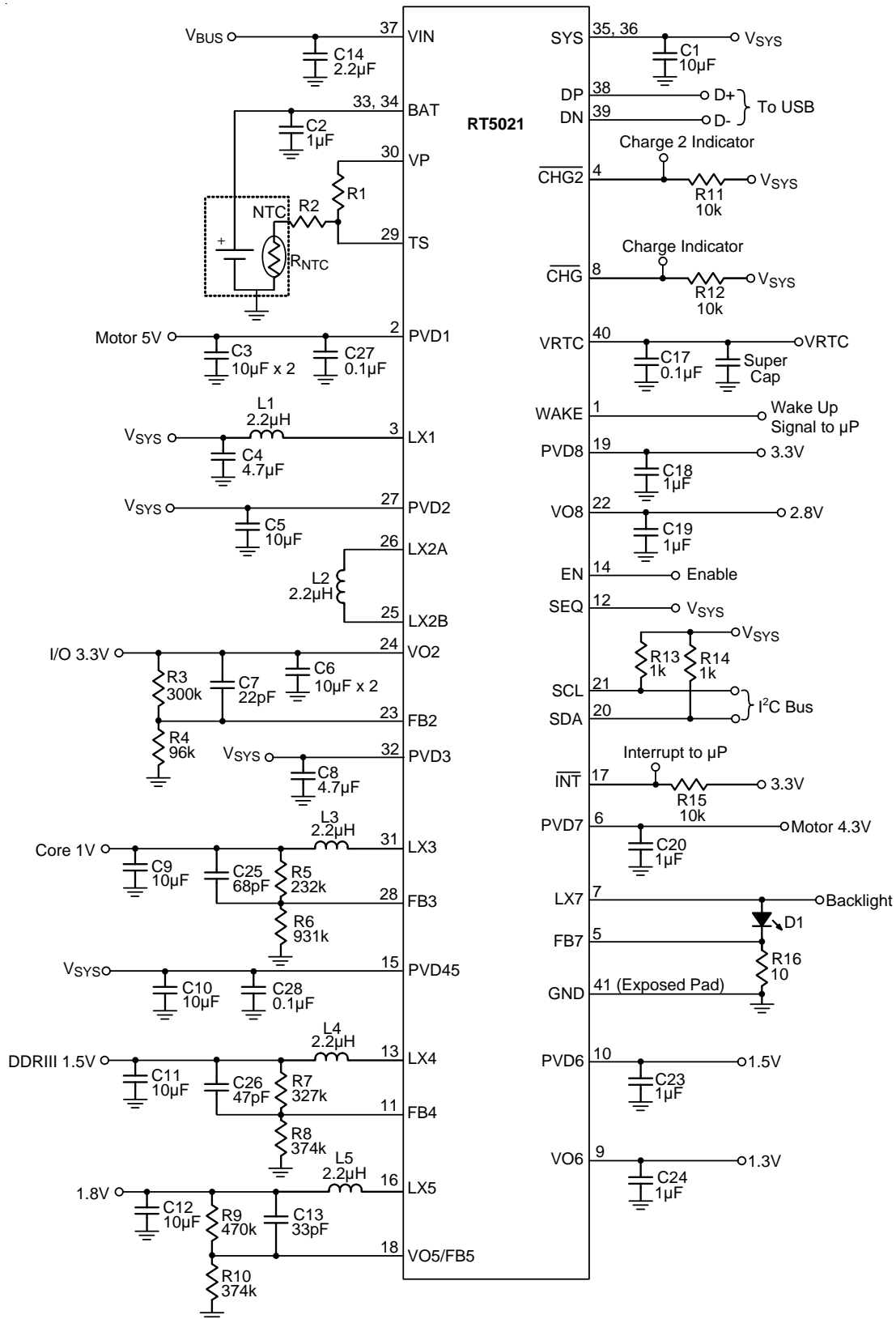
**Note 4.** The device is not guaranteed to function outside its operating conditions.

## Typical Application Circuit



Note : To make CH1 stable, C27 must be close to PVD1. To make CH4 and CH5 stable, C28 must be close to PVD45.

Figure 1. Typical Application Circuit for DSC with 6-LED Backlight



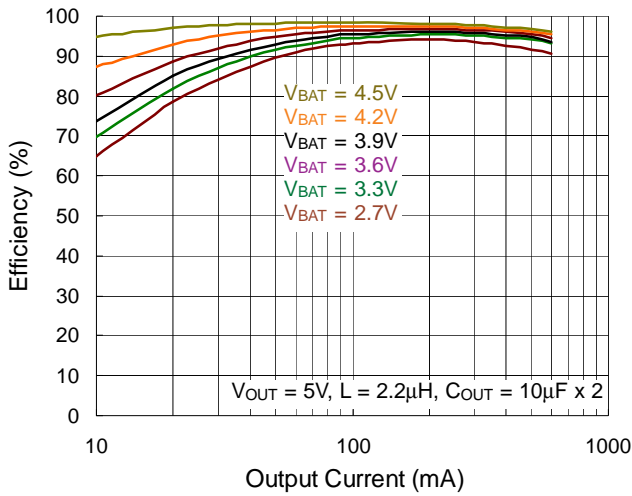
Note : To make CH1 stable, C27 must be close to PVD1. To make CH4 and CH5 stable, C28 must be close to PVD45.

Figure 2. Typical Application Circuit for DSC with One LED Backlight

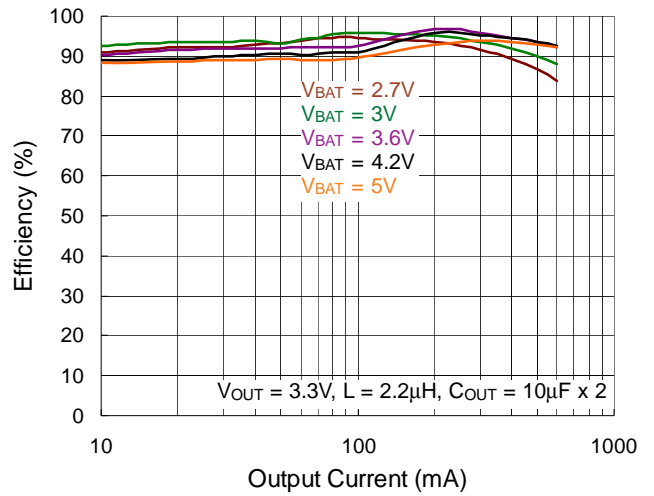
## Typical Operating Characteristics

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

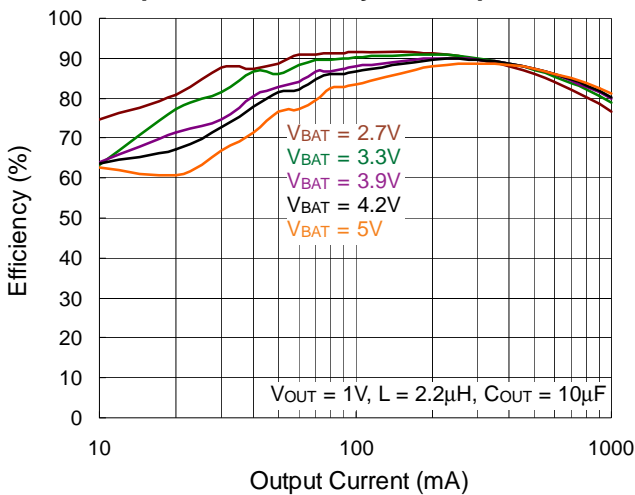
### CH1 Step-Up Efficiency vs. Output Current



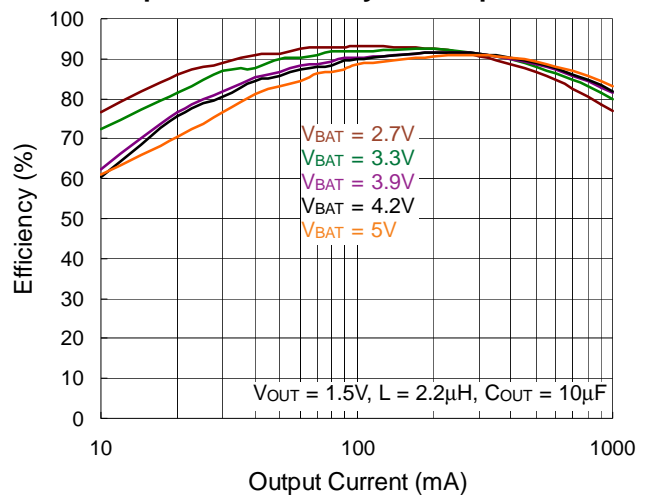
### CH2 Step-Up/Down Efficiency vs. Output Current



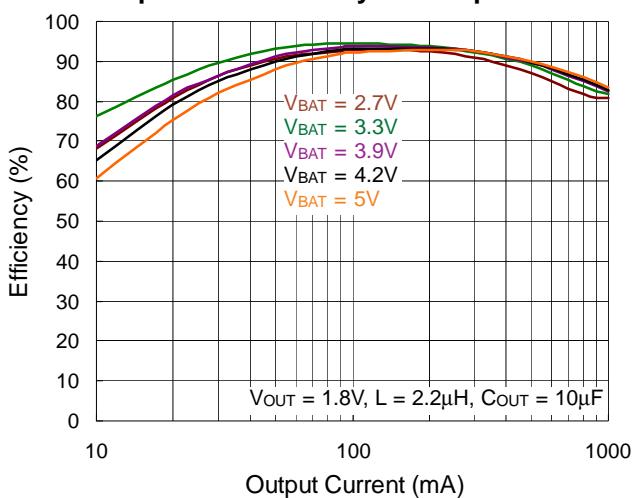
### CH3 Step-Down Efficiency vs. Output Current



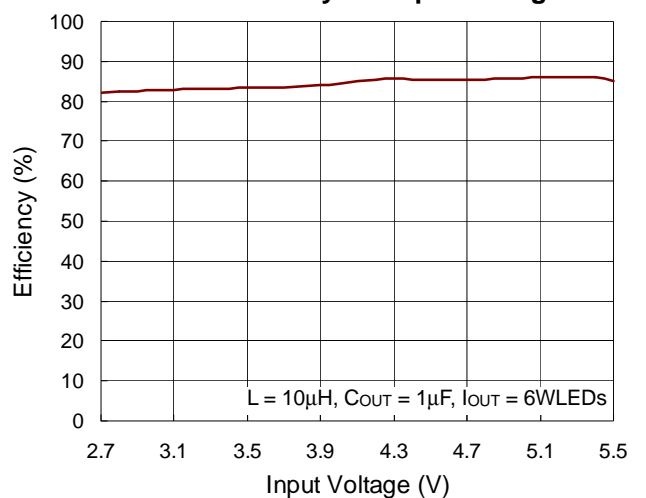
### CH4 Step-Down Efficiency vs. Output Current



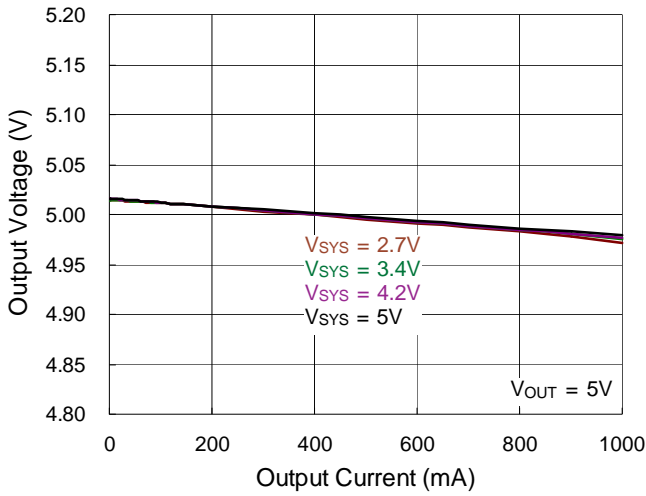
### CH5 Step-Down Efficiency vs. Output Current



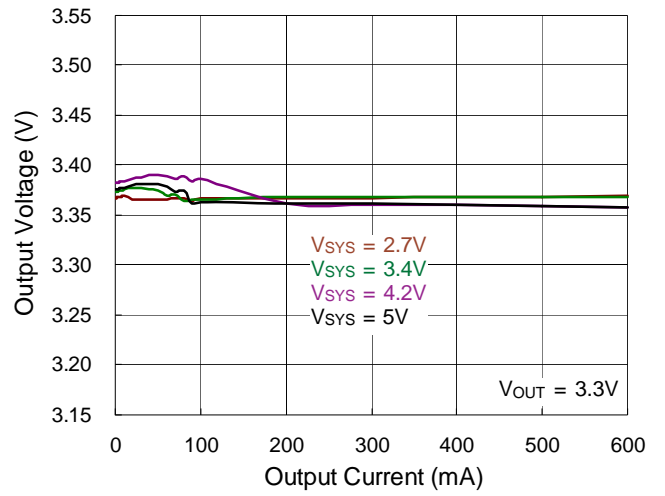
### CH7 Efficiency vs. Input Voltage



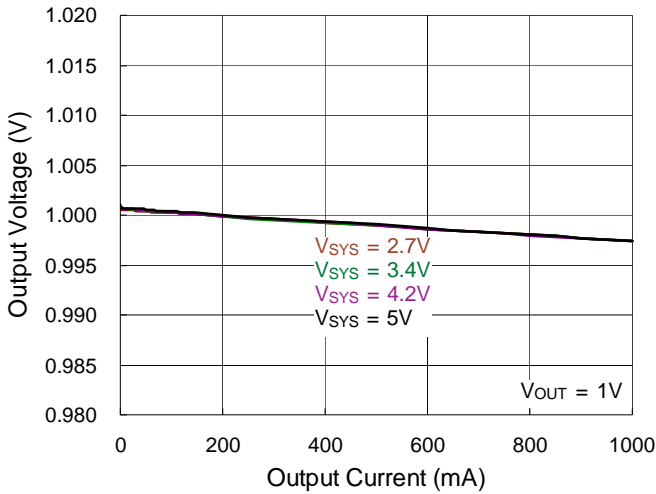
**CH1 Step-Up Output Voltage vs. Output Current**



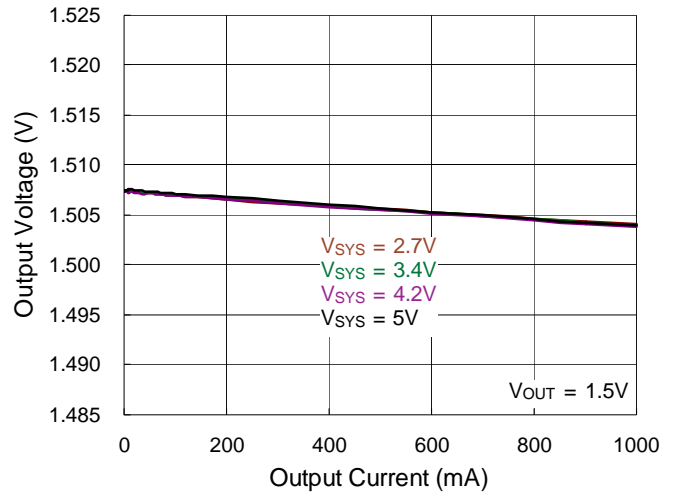
**CH2 Step-Up/Down Output Voltage vs. Output Current**



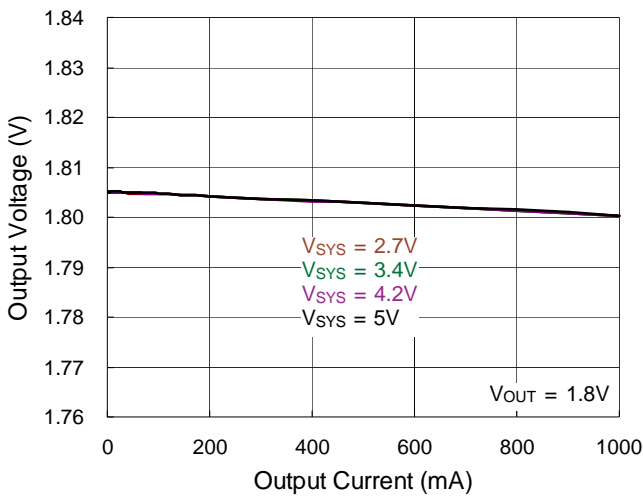
**CH3 Step-Down Output Voltage vs. Output Current**



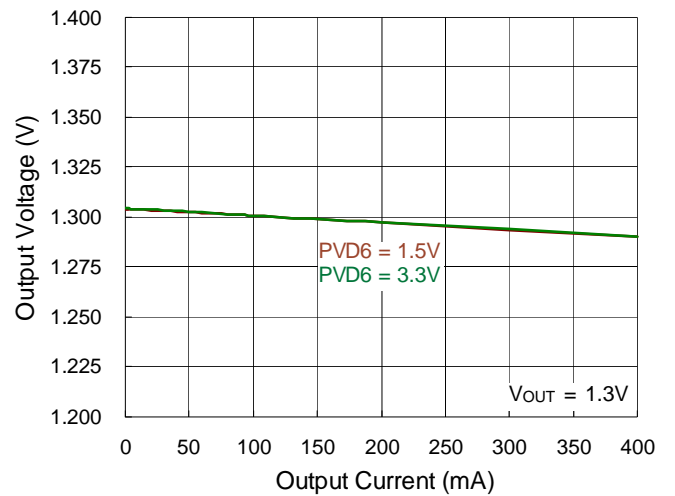
**CH4 Step-Down Output Voltage vs. Output Current**



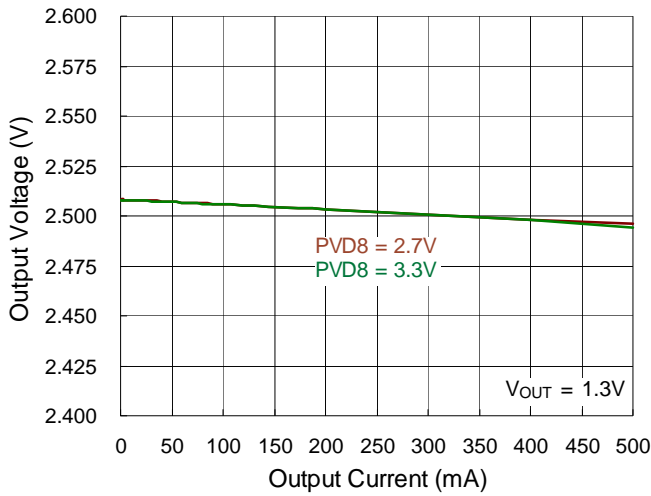
**CH5 Step-Down Output Voltage vs. Output Current**



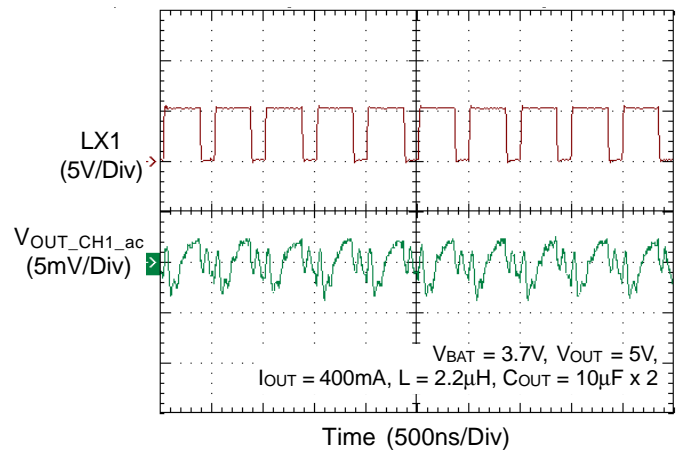
**CH6 LDO Output Voltage vs. Output Current**



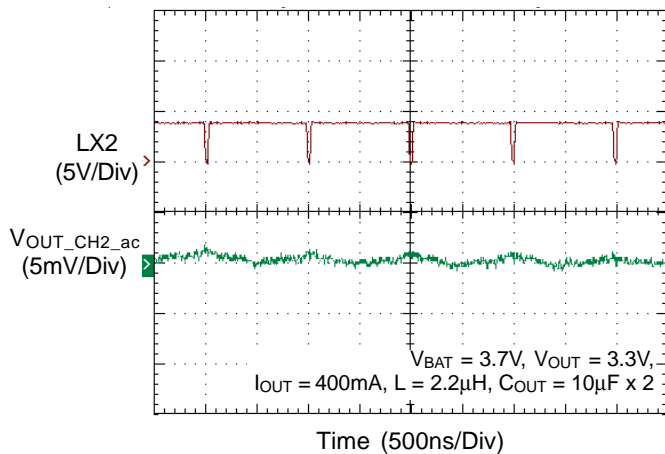
### CH8 LDO Output Voltage vs. Output Current



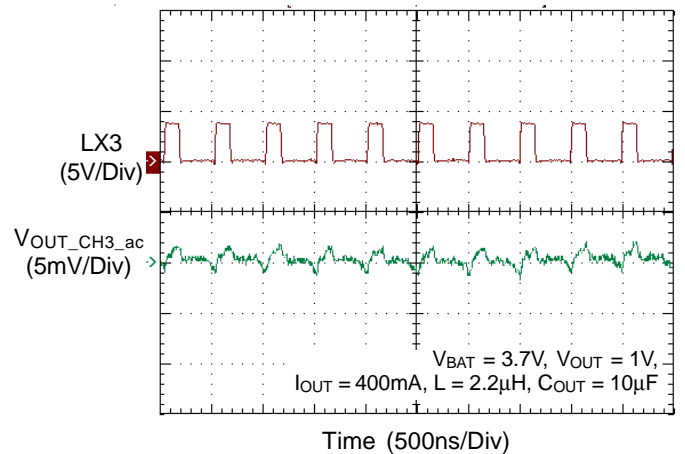
### CH1 Output Voltage Ripple



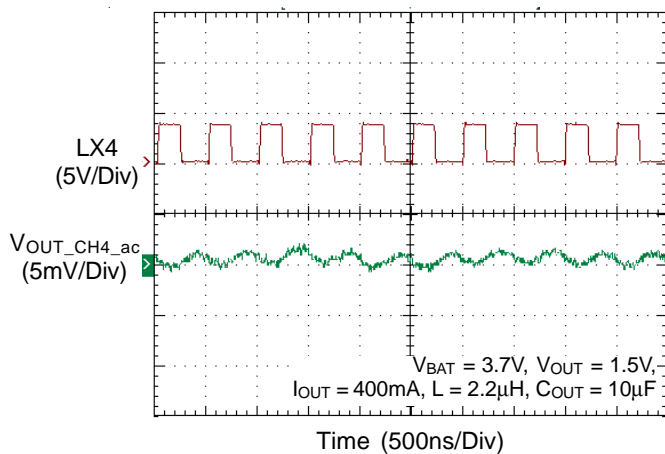
### CH2 Output Voltage Ripple



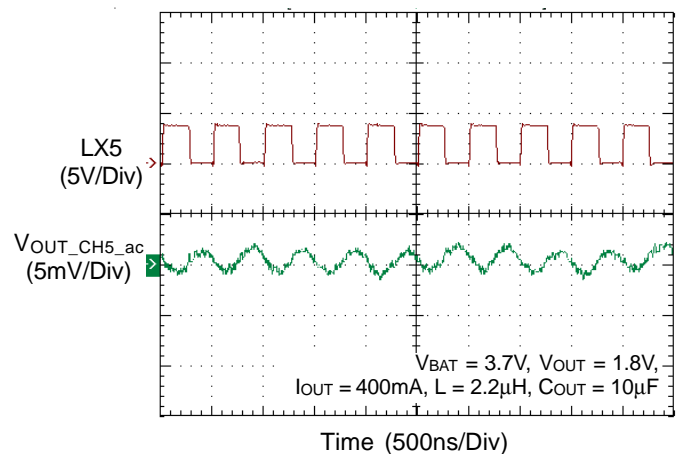
### CH3 Output Voltage Ripple



### CH4 Output Voltage Ripple

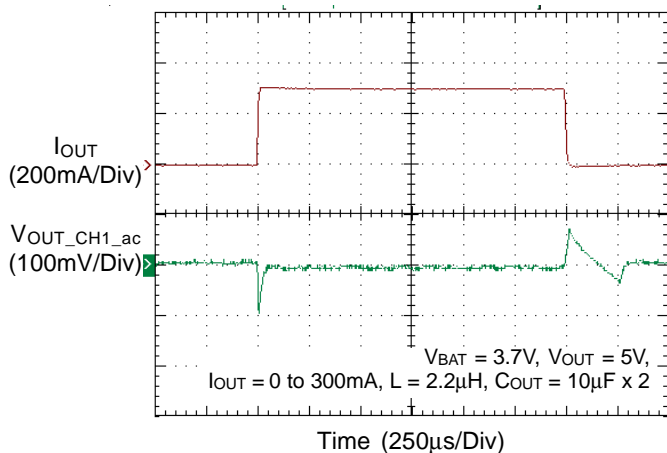


### CH5 Output Voltage Ripple

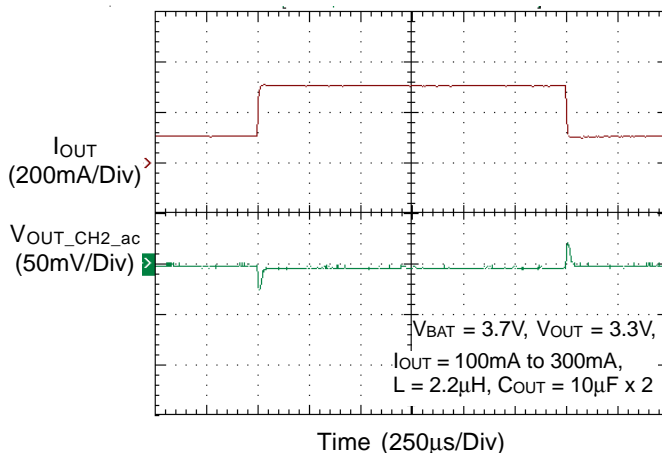




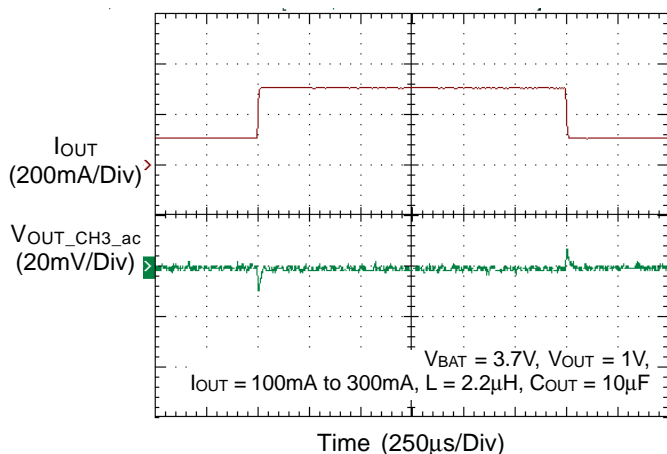
**CH1 Load Transient Response**



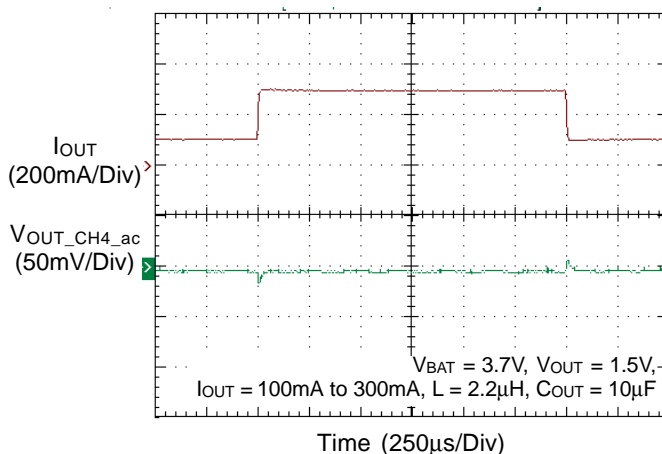
**CH2 Load Transient Response**



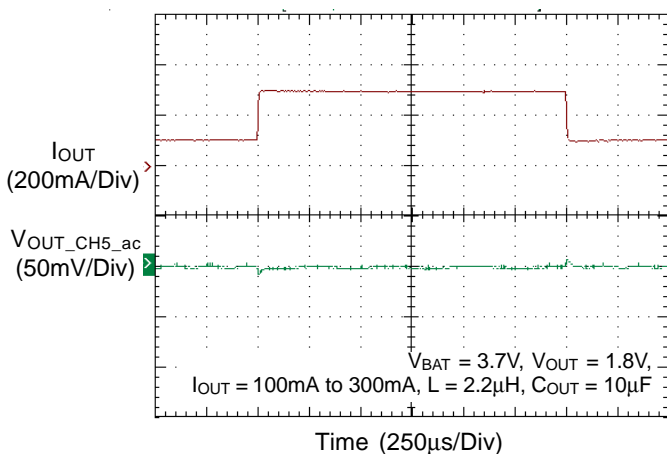
**CH3 Load Transient Response**



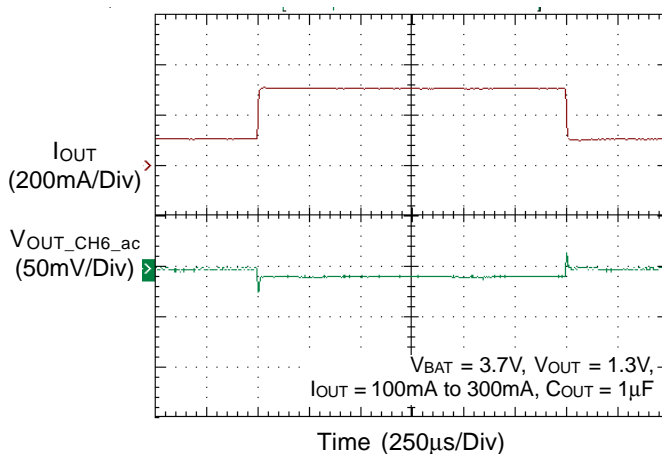
**CH4 Load Transient Response**



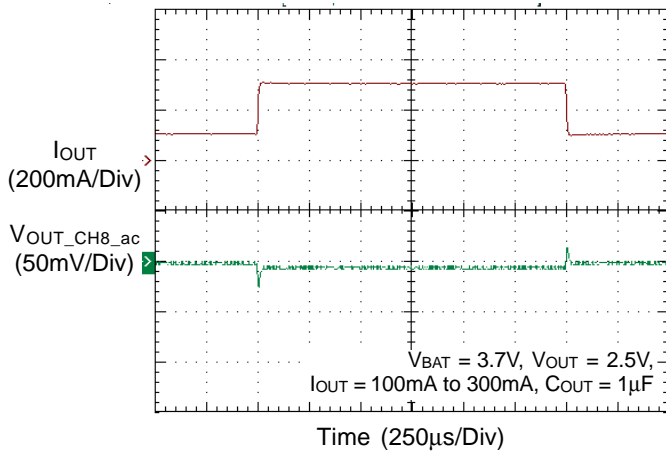
**CH5 Load Transient Response**



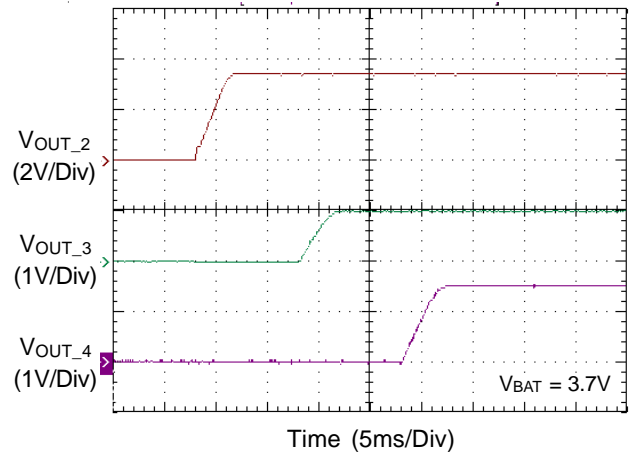
**CH6 Load Transient Response**



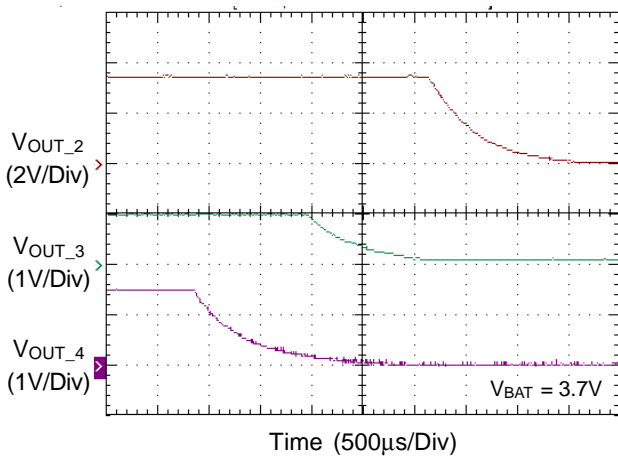
### CH8 Load Transient Response



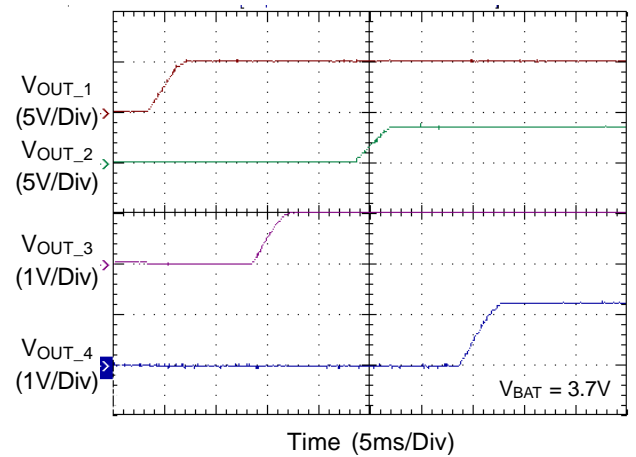
### Power On Sequence 0



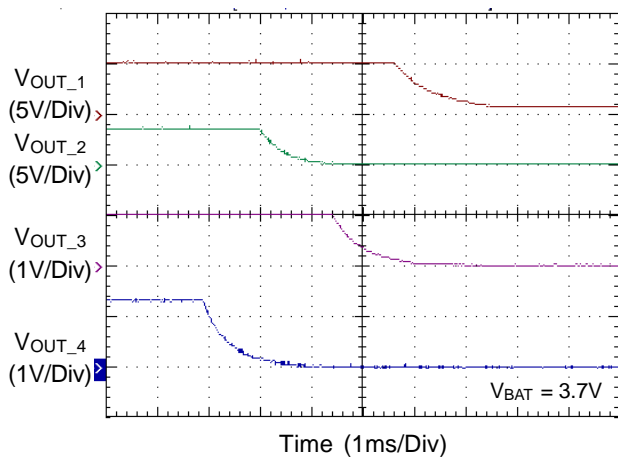
### Power Off Sequence 0



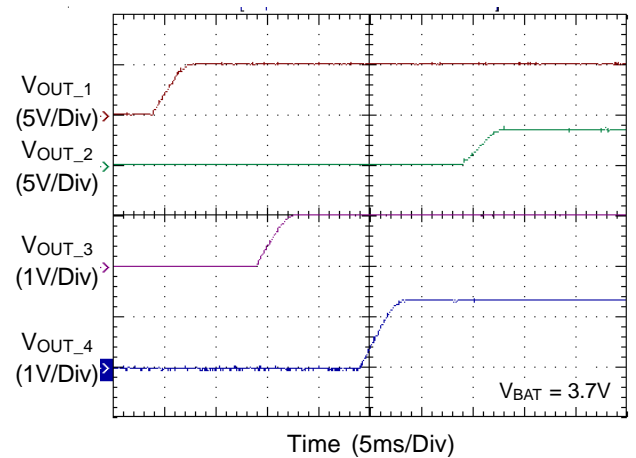
### Power On Sequence 1



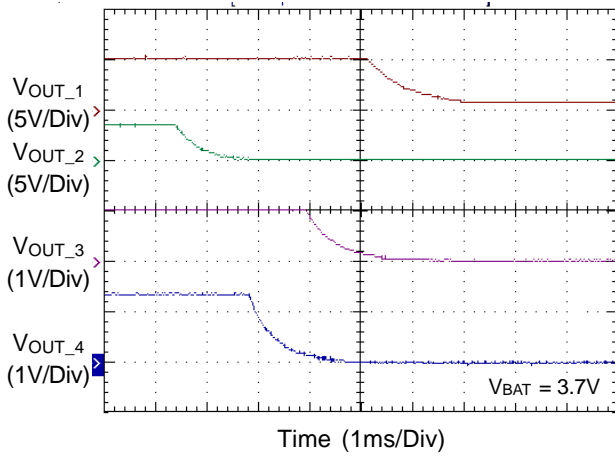
### Power Off Sequence 1



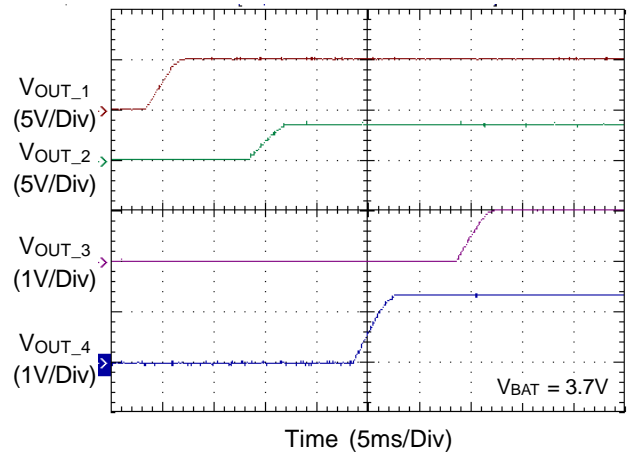
### Power On Sequence 2



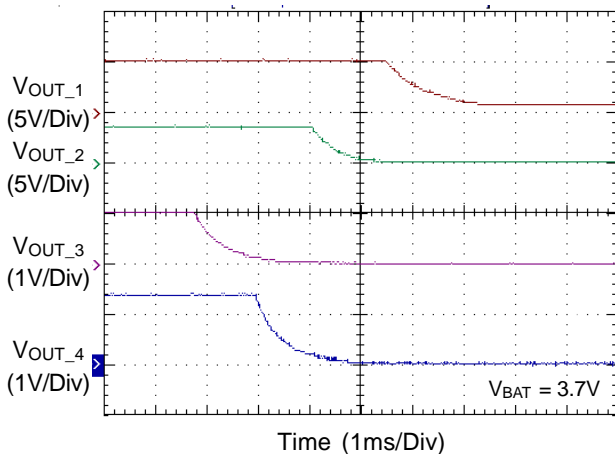
**Power Off Sequence 2**



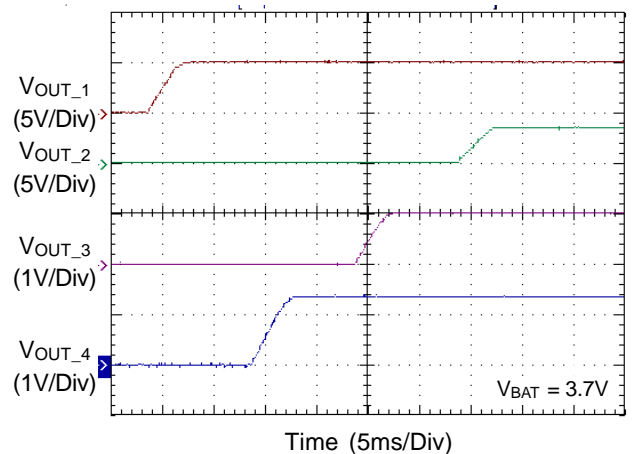
**Power On Sequence 3**



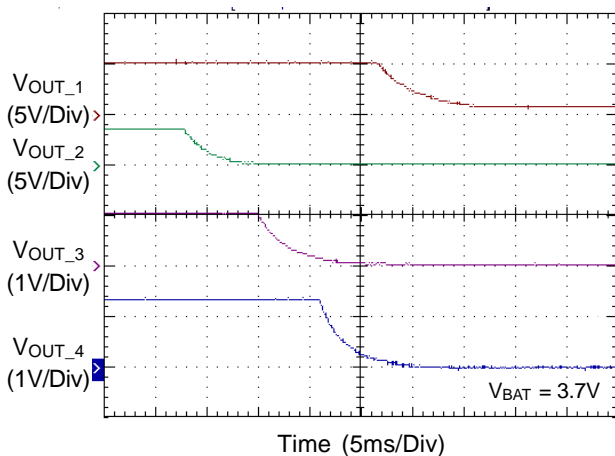
**Power Off Sequence 3**



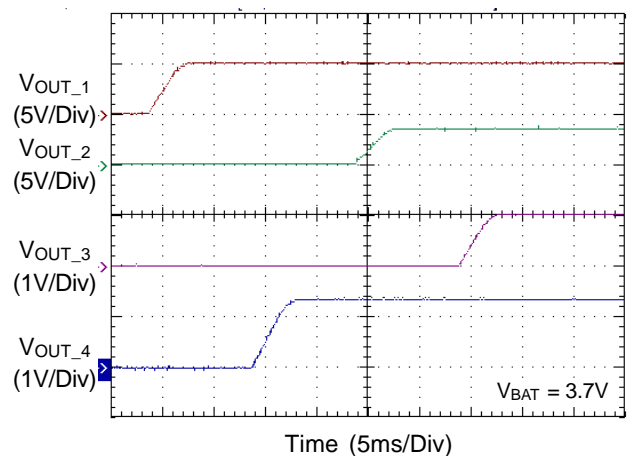
**Power On Sequence 4**



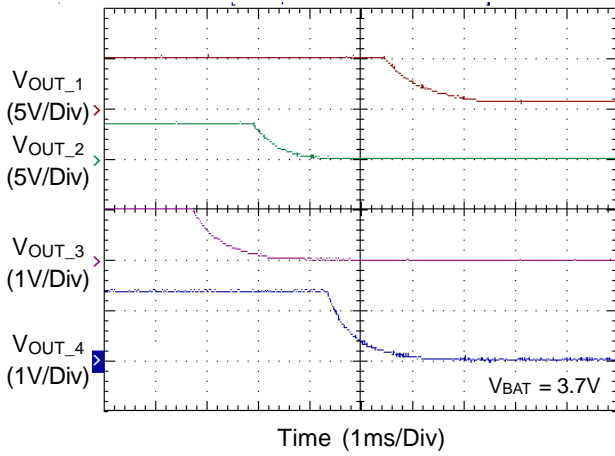
**Power Off Sequence 4**



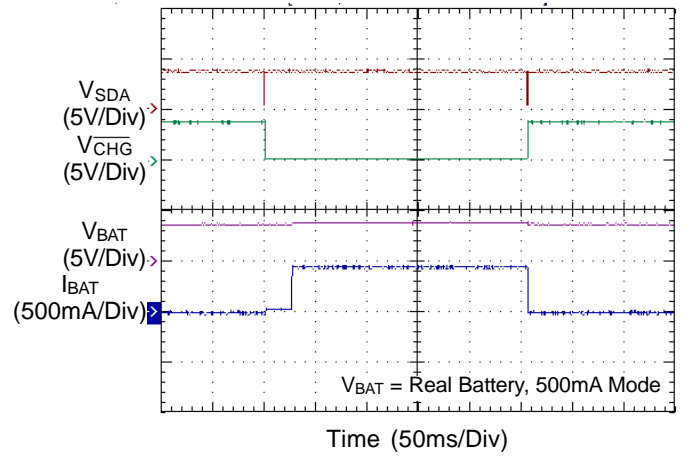
**Power On Sequence 5**



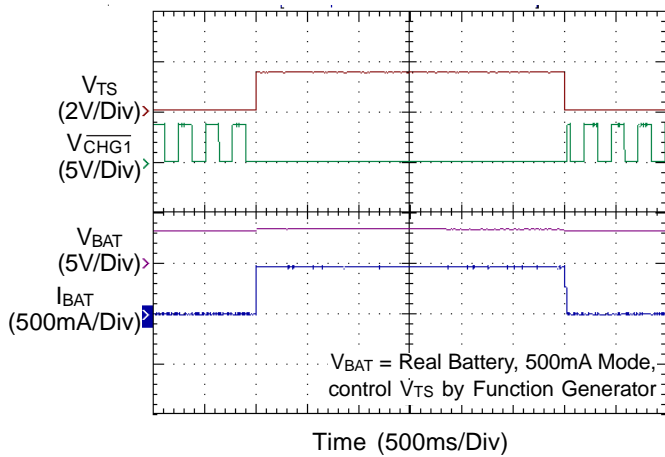
Power Off Sequence 5



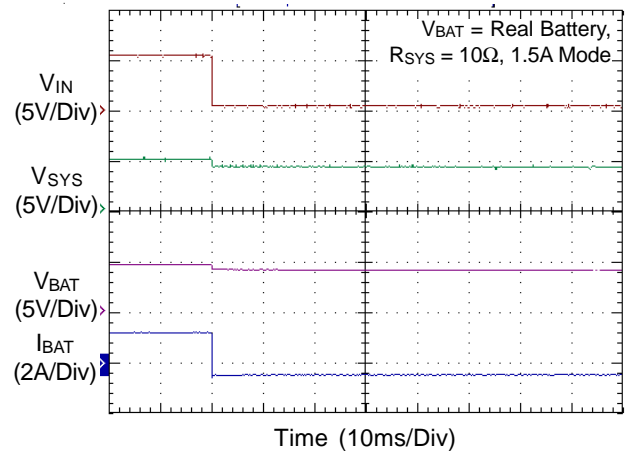
Charge On/Off Control by I<sup>2</sup>C



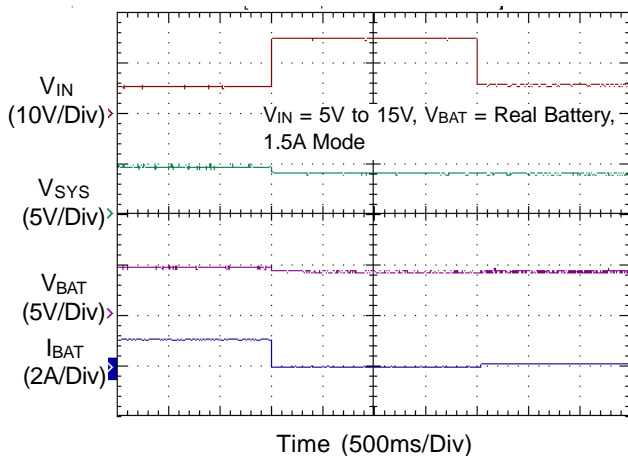
V<sub>TS</sub> On/Off



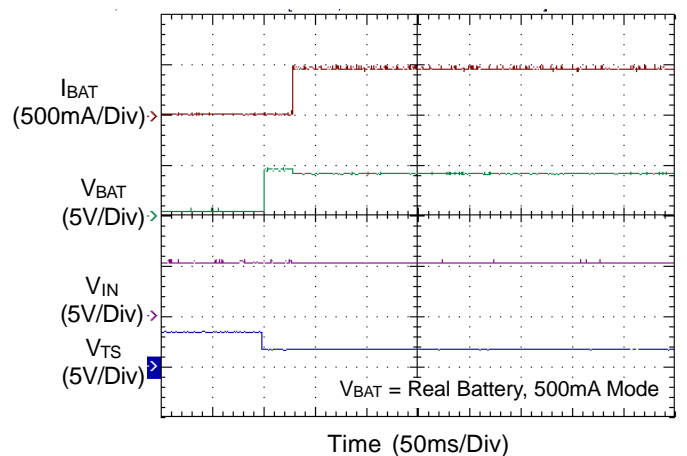
V<sub>IN</sub> Removal



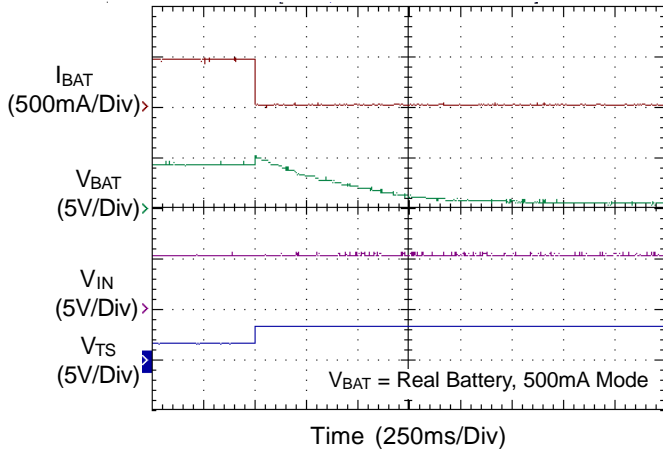
V<sub>IN</sub> Over Voltage Protection



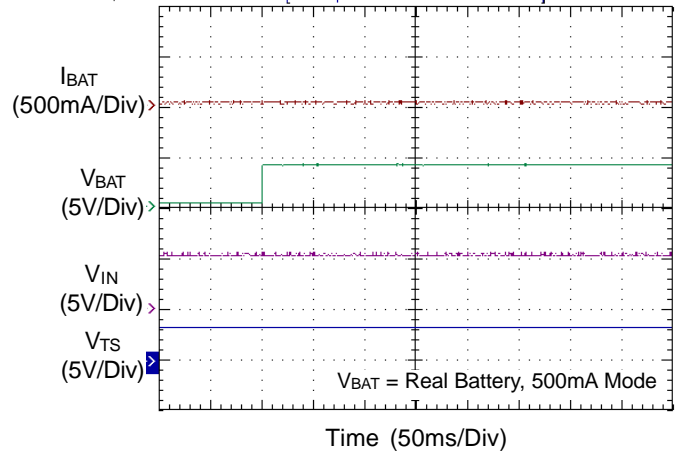
Battery with NTC Resistor Plug-In



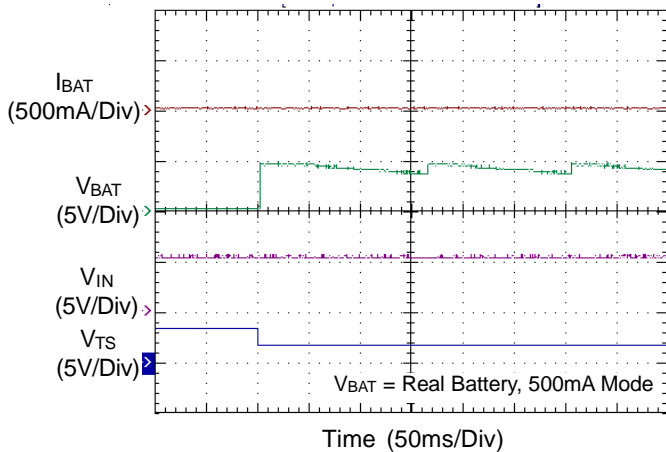
**Battery with NTC Resistor Plug-Out**



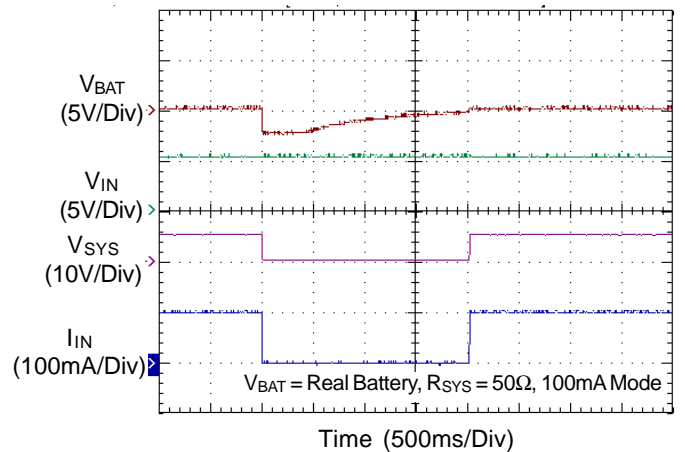
**With Battery without NTC Resistor**



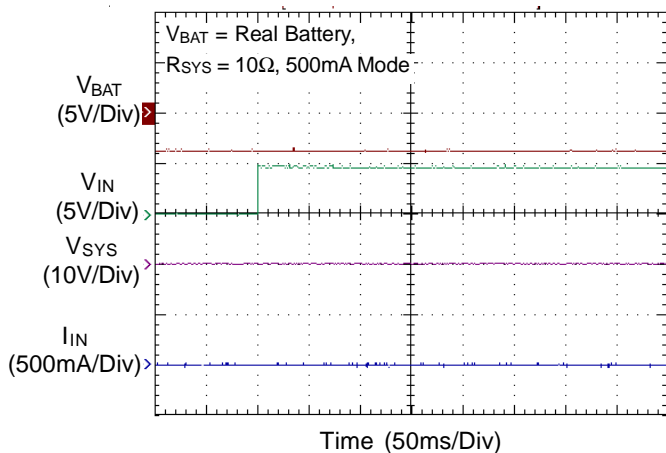
**With NTC Resistor without Battery**



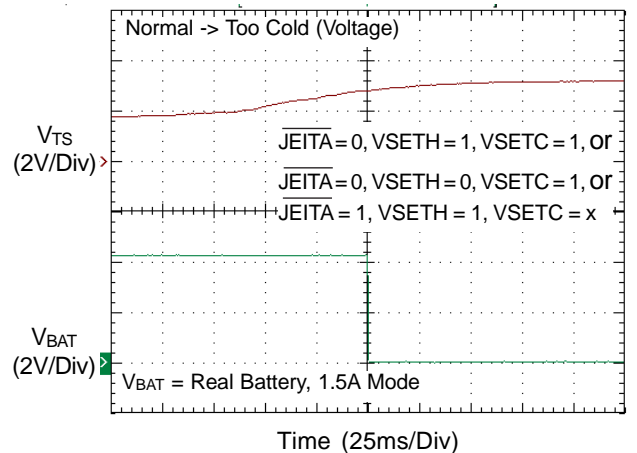
**V\_IN Exist then Negative Battery and Plug-out**



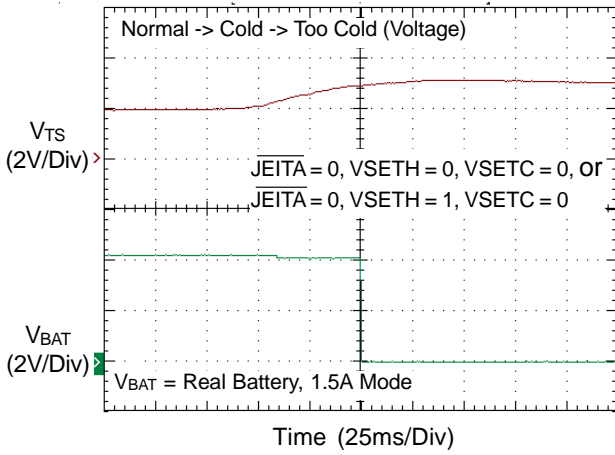
**Negative Battery then V\_IN Plug-In**



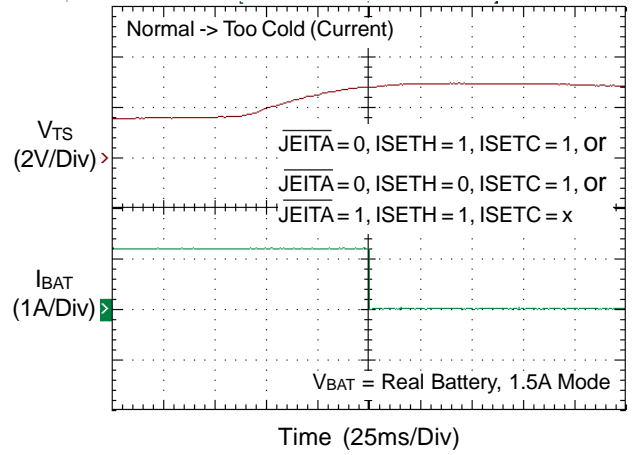
**The Temperature of Battery Status**



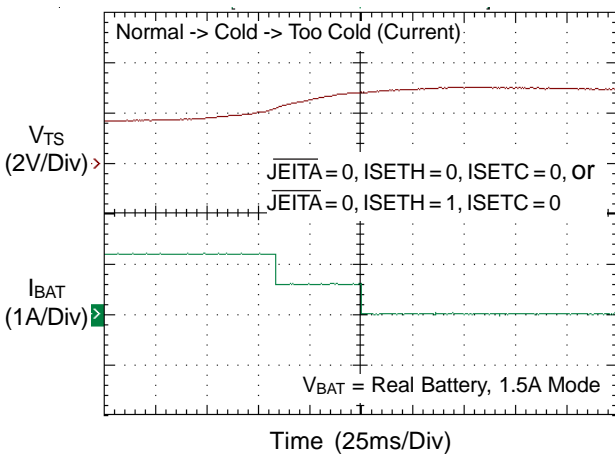
The Temperature of Battery Status



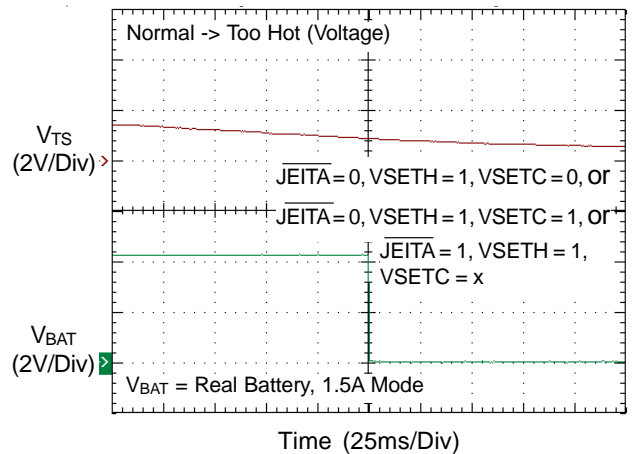
The Temperature of Battery Status



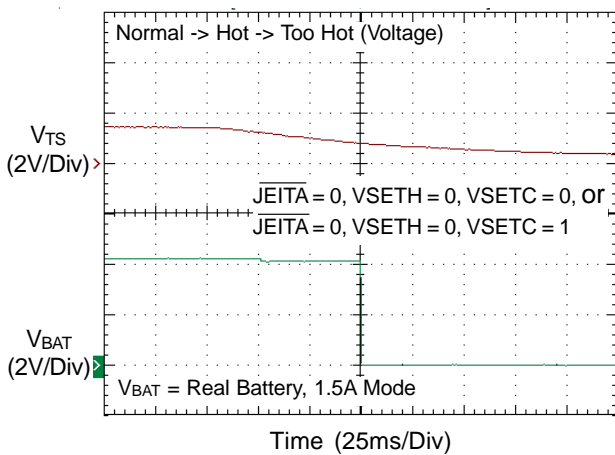
The Temperature of Battery Status



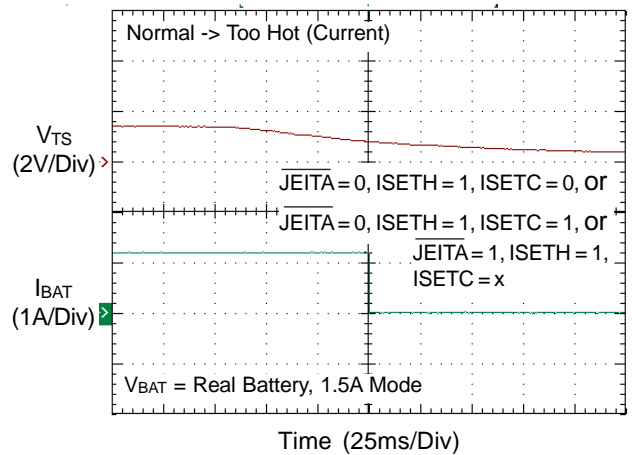
The Temperature of Battery Status



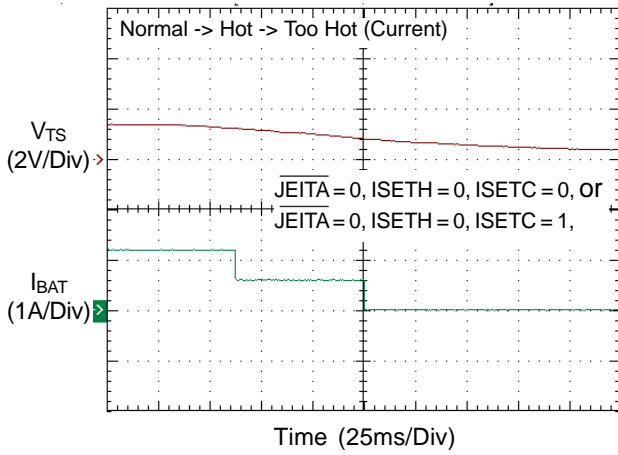
The Temperature of Battery Status



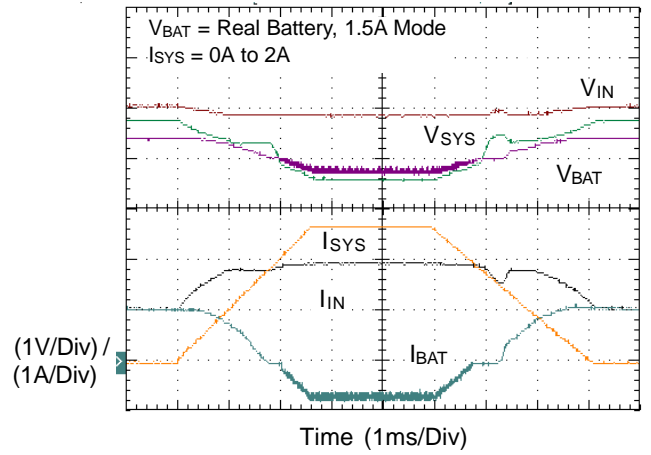
The Temperature of Battery Status



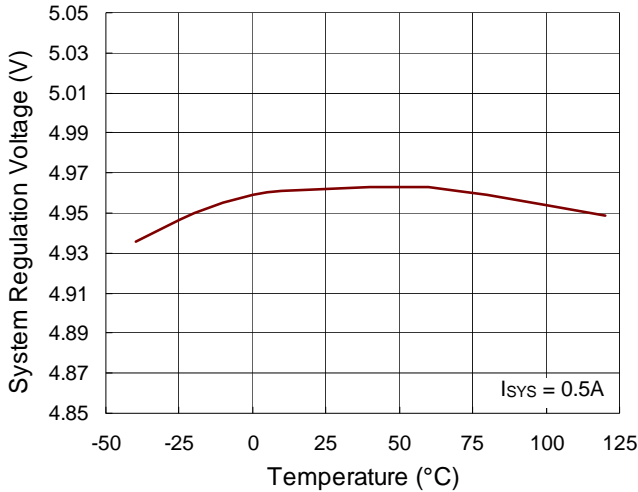
**The Temperature of Battery Status**



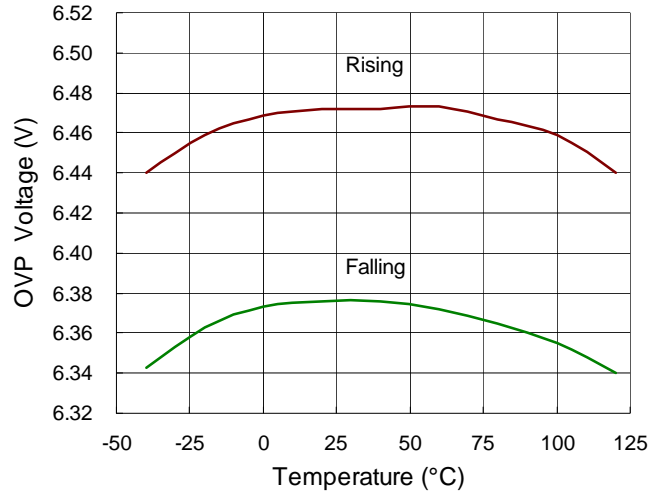
**APPM**



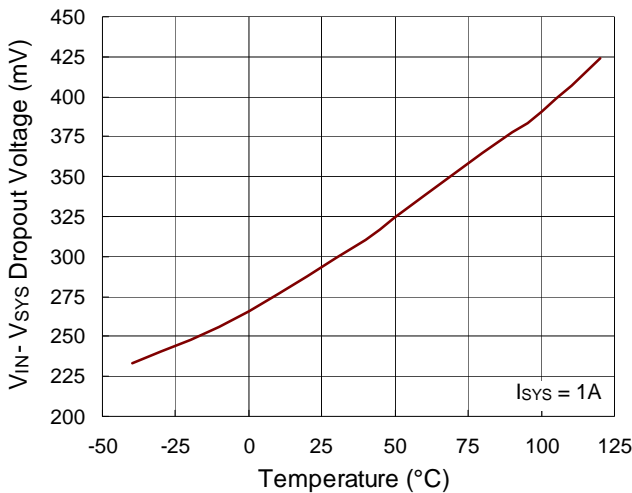
**System Regulation Voltage vs. Temperature**



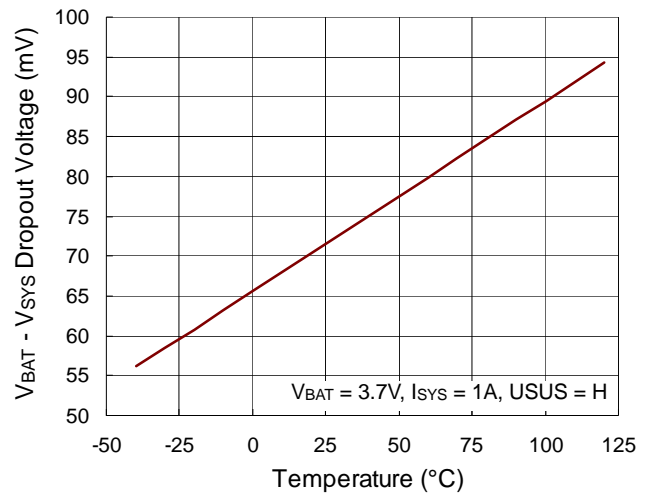
**OVP Threshold Voltage vs. Temperature**



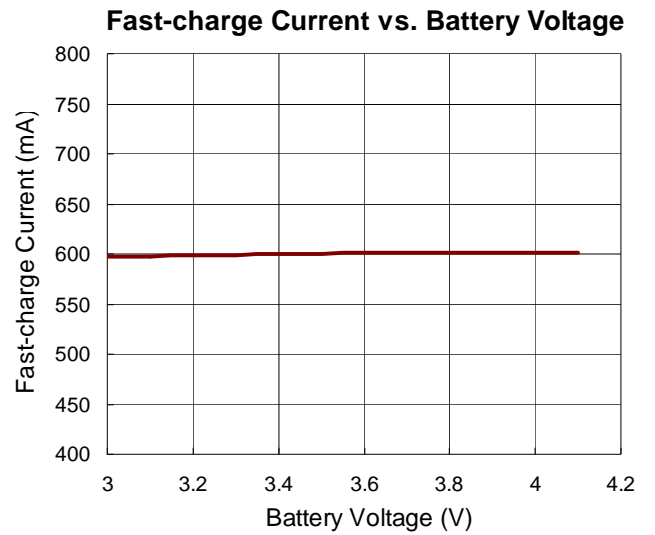
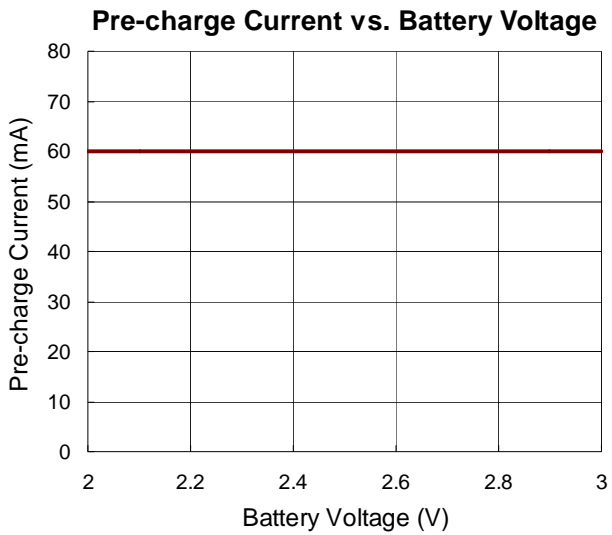
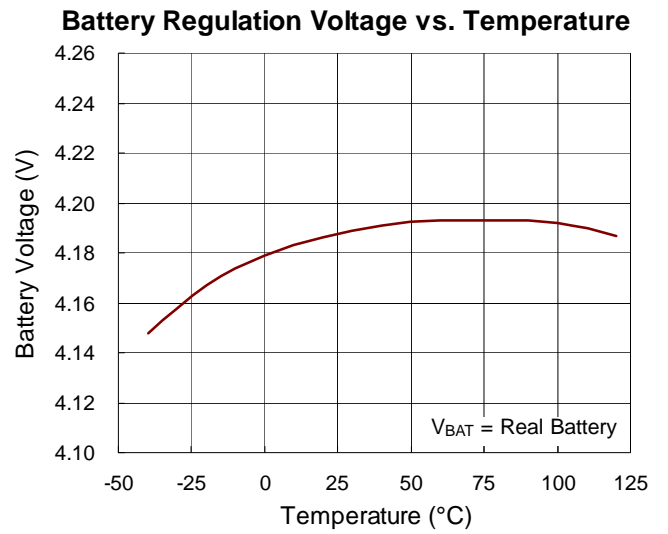
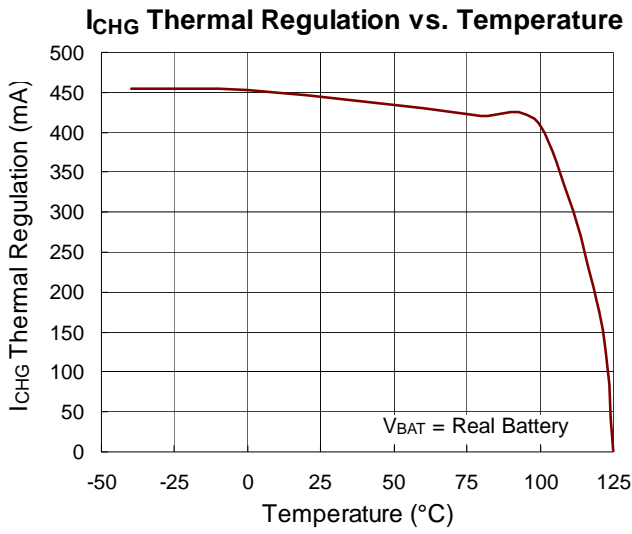
**$V_{IN} - V_{SYS}$  Dropout Voltage vs. Temperature**



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







## Application Information

### Power Converter Unit

The RT5021 is an integrated power solution for digital still cameras and other small handheld devices. It includes six DC-DC converters, a WLED driver, two low output LDO, a RTC LDO, and a fully integrated single-cell Li-ion battery charger that is ideal for portable applications.

### CH1 : Synchronous Step-Up DC-DC Converter

The synchronous step-up DC-DC converter can be operated in either PFM or Sync-PWM mode by setting I<sup>2</sup>C. It includes internal power MOSFETs, compensation network and feedback resistors. The P-MOSFET can be controlled to disconnect output loading. It is suitable for providing power to the motor. The output voltage of CH1 can be adjusted by the I<sup>2</sup>C interface in the range of 3.6V to 5.5V.

| VOUT1 [3:0] | CH1 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 5V. |         |      |         |      |         |      |         |
|-------------|--|---------|------|---------|------|---------|------|---------|
|             | Code   | Voltage | Code | Voltage | Code | Voltage | Code | Voltage |
|             | 0000   | 3.6V    | 0001 | 3.7V    | 0010 | 3.8V    | 0011 | 3.9V    |
|             | 0100   | 4V      | 0101 | 4.5V    | 0110 | 4.6V    | 0111 | 4.7V    |
|             | 1000   | 4.8V    | 1001 | 4.9V    | 1010 | 5V      | 1011 | 5.1V    |
|             | 1100   | 5.2V    | 1101 | 5.3V    | 1110 | 5.4V    | 1111 | 5.5V    |

### CH2 : Synchronous Step-Up/Down (Buck-Boost) DC-DC Converter

The synchronous step-up/down (Buck-Boost) DC-DC converter can be operated in either PFM or Sync-PWM mode by setting I<sup>2</sup>C. It includes internal power MOSFETs, compensation network and feedback resistors. This channel supplies the power for I/O. The FB voltage of CH2 can be adjusted by the I<sup>2</sup>C interface in the range of 0.72V to 0.86V.

| FB2 [2:0] | FB2 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 0.8V. |       |                  |                |                  |
|-----------|--|-------|------------------|----------------|------------------|
|           | Code   | VREF  | If Target = 1.8V | If Target = 1V | If Target = 3.3V |
|           | 000  | 0.72V | 1.62V            | 0.9V           | 2.97V            |
|           | 001  | 0.74V | 1.665V           | 0.925V         | 3.0525V          |
|           | 010  | 0.76V | 1.71V            | 0.95V          | 3.135V           |
|           | 011  | 0.78V | 1.755V           | 0.975V         | 3.2175V          |
|           | 100  | 0.8V  | 1.8V             | 1V             | 3.3V             |
|           | 101  | 0.82V | 1.845V           | 1.025V         | 3.3825V          |
|           | 110  | 0.84V | 1.89V            | 1.05V          | 3.465V           |
|           | 111  | 0.86V | 1.935V           | 1.075V         | 3.5475V          |

## CH3 to CH4 : Step-Down Synchronous DC/ DC Converter

The step-down synchronous DC/DC converters include internal power MOSFETs and compensation network. It support PFM or Sync-PWM mode by setting I<sup>2</sup>C. These channels supply the power for core and DRAM. They can be operated at 100% maximum duty cycle to extend battery operating voltage range. When the input voltage is close to the output voltage, the converter enters low dropout mode with low output ripple. The FB voltage of CH3 and CH4 can be adjusted by the I<sup>2</sup>C interface in the range of 0.72V to 0.86V.

| FB3 [2:0] | FB3 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 0.8V. |       |                  |                |                  |
|-----------|--|-------|------------------|----------------|------------------|
|           | Code   | VREF  | If Target = 1.8V | If Target = 1V | If Target = 3.3V |
|           | 000  | 0.72V | 1.62V            | 0.9V           | 2.97V            |
|           | 001  | 0.74V | 1.665V           | 0.925V         | 3.0525V          |
|           | 010  | 0.76V | 1.71V            | 0.95V          | 3.135V           |
|           | 011  | 0.78V | 1.755V           | 0.975V         | 3.2175V          |
|           | 100  | 0.8V  | 1.8V             | 1V             | 3.3V             |
|           | 101  | 0.82V | 1.845V           | 1.025V         | 3.3825V          |
|           | 110  | 0.84V | 1.89V            | 1.05V          | 3.465V           |
|           | 111  | 0.86V | 1.935V           | 1.075V         | 3.5475V          |

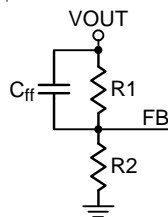
| FB4 [2:0] | FB4 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 0.8V. |       |                  |                |                  |
|-----------|--|-------|------------------|----------------|------------------|
|           | Code   | VREF  | If Target = 1.8V | If Target = 1V | If Target = 3.3V |
|           | 000  | 0.72V | 1.62V            | 0.9V           | 2.97V            |
|           | 001  | 0.74V | 1.665V           | 0.925V         | 3.0525V          |
|           | 010  | 0.76V | 1.71V            | 0.95V          | 3.135V           |
|           | 011  | 0.78V | 1.755V           | 0.975V         | 3.2175V          |
|           | 100  | 0.8V  | 1.8V             | 1V             | 3.3V             |
|           | 101  | 0.82V | 1.845V           | 1.025V         | 3.3825V          |
|           | 110  | 0.84V | 1.89V            | 1.05V          | 3.465V           |
|           | 111  | 0.86V | 1.935V           | 1.075V         | 3.5475V          |

If CH3/CH4 input voltage (PVD3/PVD45) is higher than 4.2V and the output voltage is lower than 1.5V, a feed forward capacitor can be added improve the transient response.

The capacitance can be estimated by the following equation.

$$C_{ff} = \frac{15.5 \times 10^{-6}}{R1}$$

For example, when R1 is 470kΩ, the available feed-forward capacitor is 33pF.



**CH5 : Step-Down Synchronous DC/DC Converter**

The step-down synchronous DC/DC converter includes internal power MOSFETs and compensation network. They can be operated at 100% maximum duty cycle to extend battery operating voltage range. When the input voltage is close to the output voltage, the converter enters low dropout mode with low output ripple. The output voltage can be selected as the following list or set by external feedback network.

|  |  |                |             |                |             |                |             |                |
|--|--|----------------|-------------|----------------|-------------|----------------|-------------|----------------|
| VOUT5 [3:0]  | CH5 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 1.8V. |                |             |                |             |                |             |                |
|  | <b>Code</b>  | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> |
|  | 0000   | REF            | 0001        | 1.1V           | 0010        | 1.2V           | 0011        | 1.3V           |
|  | 0100   | 1.4V           | 0101        | 1.5V           | 0110        | 1.6V           | 0111        | 1.7V           |
|  | 1000   | 1.8V           | 1001        | 2V             | 1010        | 2.2V           | 1011        | 2.3V           |
|  | 1100   | 2.5V           | 1101        | 2.6V           | 1110        | 2.7V           | 1111        | 2.8V           |
| Note : VOUT5 [3:0] = 0000 (REF) means using external feedback network and FB5 regulation target is 0.8V ± 1.5% |  |                |             |                |             |                |             |                |

**CH6 : Low Voltage LDO**

CH6 is a low voltage LDO and its output voltage is controlled by I<sup>2</sup>C interface. This supplies the multiple purpose power. The output voltage of CH6 can be adjusted by the I<sup>2</sup>C interface in the range of 1.1V to 3.3V.

|             |  |                |             |                |             |                |             |                |
|-------------|--|----------------|-------------|----------------|-------------|----------------|-------------|----------------|
| VOUT6 [3:0] | CH6 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 1.3V. |                |             |                |             |                |             |                |
|             | <b>Code</b>  | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> |
|             | 0000   | Switch         | 0001        | 1.1V           | 0010        | 1.2V           | 0011        | 1.3V           |
|             | 0100   | 1.4V           | 0101        | 1.5V           | 0110        | 1.6V           | 0111        | 1.7V           |
|             | 1000   | 1.8V           | 1001        | 2V             | 1010        | 2.2V           | 1011        | 2.5V           |
|             | 1100   | 2.8V           | 1101        | 3.1V           | 1110        | 3.2V           | 1111        | 3.3V           |

**CH7 : Current Source/Step-Up WLED Driver**

The WLED drivers operating in either current source mode or synchronous step-up mode include internal power MOSFET and compensation network. The operation mode is determined by setting I<sup>2</sup>C. The P-MOSFET in step-up mode can be controlled to disconnect the output loading.

When CH7 works in current source mode, it likes a LDO and regulates the current by FB7 voltage. The LED current is defined by the FB7 voltage as well as the external resistor between FB7 and GND. The FB7 regulation voltage can be set in 31 steps from 8mV to 250mV. If CH7 works in synchronous step-up mode, it can support an output voltage up to 15V or 21V controlled by I<sup>2</sup>C interface. The LED current is also set via an external resistor and FB7 regulation voltage.

The WLED current can be set by the following equation :

$$I_{LED} \text{ (mA)} = [250\text{mV} / R \text{ (}\Omega\text{)}] \times \text{EN7\_DIM7 [4:0]} / 31$$

Where R is the current sense resistor from FB7 to GND and EN7\_DIM7 [4:0] / 31 ratio refers to the I<sup>2</sup>C control register file.

## CH8 : Low Voltage LDO

CH8 is a low voltage LDO and its output voltage is controlled by I<sup>2</sup>C interface. It supplies for multiple purpose power. The output voltage of CH8 can be adjusted by the I<sup>2</sup>C interface in the range of 1.1V to 3.3V.

| VOUT8 [3:0] | CH8 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 2.8V. |         |      |         |      |         |      |         |
|-------------|--|---------|------|---------|------|---------|------|---------|
|             | Code   | Voltage | Code | Voltage | Code | Voltage | Code | Voltage |
|             | 0000   | Switch  | 0001 | 1.1V    | 0010 | 1.2V    | 0011 | 1.3V    |
|             | 0100   | 1.4V    | 0101 | 1.5V    | 0110 | 1.6V    | 0111 | 1.7V    |
|             | 1000   | 1.8V    | 1001 | 2V      | 1010 | 2.2V    | 1011 | 2.5V    |
| 1100        | 2.8V   | 1101    | 3.1V | 1110    | 3.2V | 1111    | 3.3V |         |

## RTC\_LDO : Accuracy 3.05V LDO Output.

The RT5021 provides a 3.05V output LDO for real-time clock. The LDO features low quiescent current (3μA), reverse leakage prevention from output node and high output voltage accuracy. This LDO is always on, even when the system is shut down. For better stability, it is recommended to connect a 0.1μF capacitor to the RTCPWR pin. The RTC LDO includes pass transistor body diode control to avoid the RTCPWR node from back-charging into the input node VDDI.

## Switching Frequency

The converters of CH1, CH3, CH4 and CH5 operate in PWM mode with 2MHz switching frequency. The converters of CH2 and CH7 operates in PWM mode with 1MHz switching frequency.

## Power On/Off Sequence and deglitch function for CH1 to CH4

SEQ pull down resistance R<sub>SEQ</sub> Defines power on/off sequence.

| SEQ#   | R <sub>SEQ</sub> (kΩ) Range |      |     |
|--------|-----------------------------|------|-----|
|        | Min                         | Typ  | Max |
| SEQ #0 | Short to Power (>0.2V)      |      |     |
| SEQ #1 | 25                          | 40   | 64  |
| SEQ #2 | 6.25                        | 10   | 16  |
| SEQ #3 | 1.56                        | 2.5  | 4   |
| SEQ #4 | --                          | 0.63 | 1   |
| SEQ #5 | 100                         | 160  | --  |

**SEQ # 0 : CH2 CH3 CH4**

**(CH1 is decided by register A4 bit3.)**

**SEQ # 1 : CH1 → CH3 → CH2 → CH4**

**SEQ # 2 : CH1 → CH3 → CH4 → CH2**

**SEQ # 3 : CH1 → CH2 → CH4 → CH3**

**SEQ # 4 : CH1 → CH4 → CH3 → CH2**

**SEQ # 5 : CH1 → CH4 → CH2 → CH3**

**Floating = resistance greater than 160kΩ = SEQ#5**

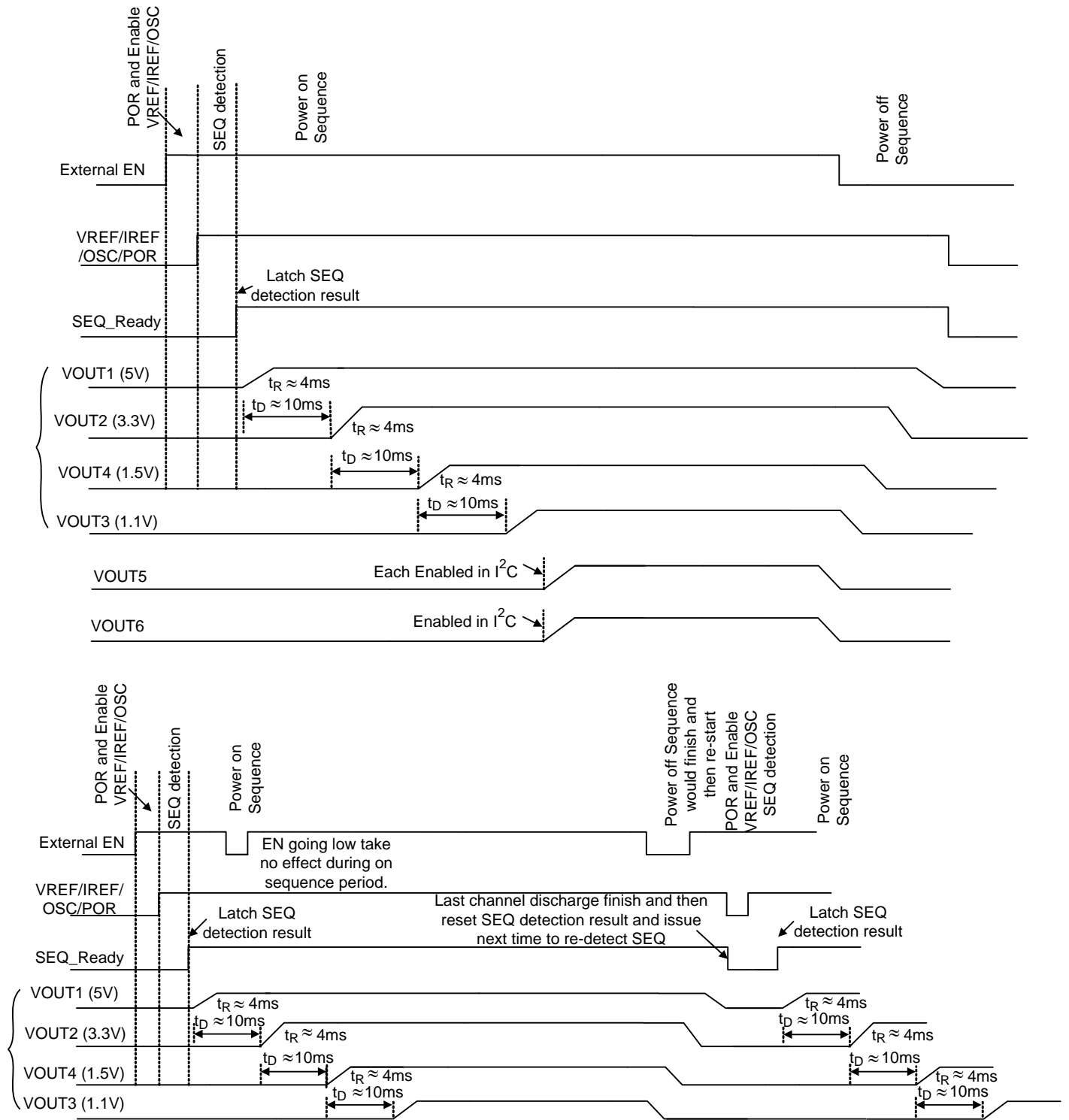
The power on sequence of CH1 to CH4 is shown below :

(Using SEQ #3 : CH1 → CH2 → CH4 → CH3 to explain)

When EN1234 goes high, CH1 will be turned on first then CH2 will be turned on after CH1 turn on for 10msec, likewise, CH4 will be turned on after CH2 turns on for 10msec. Finally, CH3 is turned on after CH4 turns on for 10msec. The soft-start time is 4msec for each channel.

The power off sequence of CH1 to CH4 is :

When EN1234 goes low, CH3 will turn off first and internally discharge output via LX3 pin. When FB3 < 0.1V, CH4 will turn off and also internally discharge output via the LX4 pin. When FB4 < 0.1V, CH2 will turn off and internally discharge output via the LX2 pin. Likewise, when FB2 < 0.1V, CH1 will turn off and discharge output. After FB1 < 0.1V, CH1 to CH4 shutdown sequence is completed.

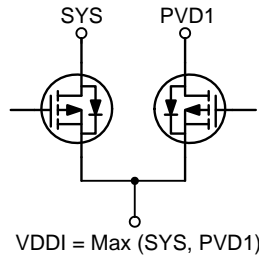


During On sequence period, EN going low would not take effect. After the sequence finish, EN state would be re-checked and decide to keep on or start off sequence.

During Off sequence period, EN going high would not take effect. After the sequence finish, EN state would be re-checked and decide to keep off or start on sequence.

## VDDM Bootstrap

To support bootstrap function, the RT5021 provides a power selection circuit which selects the maximum voltage between SYS and PVD1 to support the power requirement at node VDDI. The RT5021 includes UVLO circuits to monitor VDDI and SYS voltage status.



## Charger Unit

The RT5021 includes a Li-ion battery charger with Automatic Power Path Management. The charger is designed to operate in below modes :

### ► Pre-Charge Mode

When the output voltage is lower than 2.8V, the charging current will be reduced to a ratio of the fast-charge current set by A8.ISETA [3:0] to protect the battery life-time. The timing diagram is showed in Figure 3.

### ► Fast-Charge Mode

When the output voltage is higher than 3V, the charging current will be equal to the fast-charge current set by A8.ISETA [3:0] shown as Figure 3.

### ► Constant Voltage Mode

When the output voltage is near 4.2V and the charging current falls below the termination current for a deglitch time of 25ms, the charger will be disabled and CHG will go high. The timing diagram is showed in Figure 3.

### ► Re-Charge Mode

When the chip is in charge termination mode, the charging current gradually goes down to zero. Once the battery voltage drops to below 4.1V for a deglitch time of 100ms, the charger will resume charging shown as Figure 3.

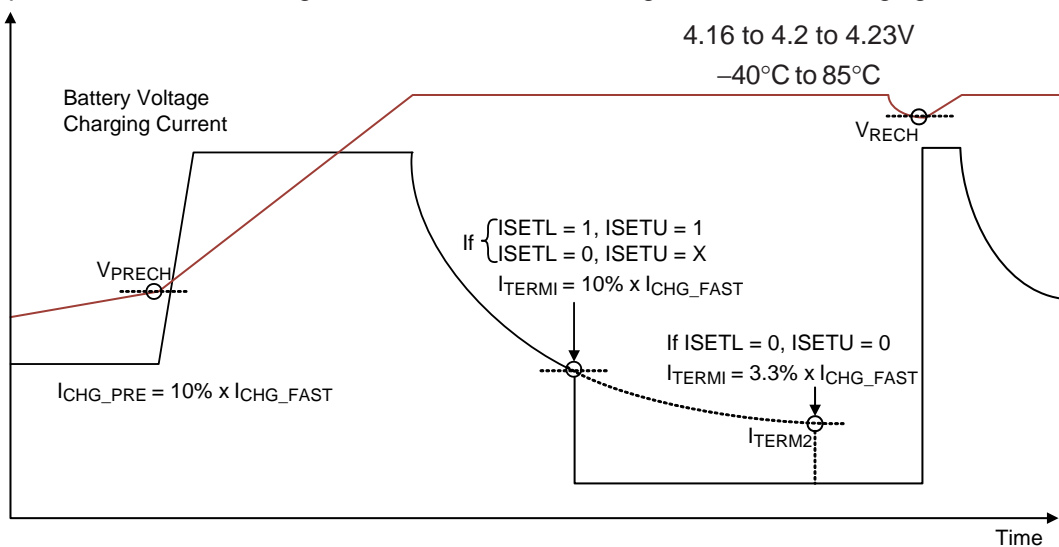


Figure 3



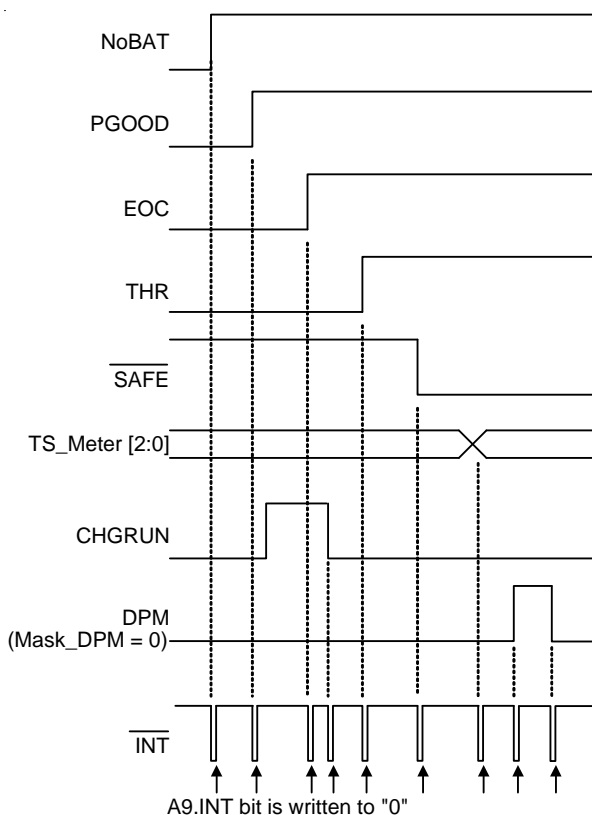
**Interrupt Indicator**

The RT5021 provides an interrupt indicator output pin ( $\overline{\text{INT}}$ ).  $\overline{\text{INT}}$  is an open drain output which is controlled by A9.INT bit. When the PGOOD, TS\_Meter [2:0], EOC, THR,  $\overline{\text{SAFE}}$ , NoBAT, CHGRUN, DPM status bits toggle, the A9.INT bit will be set to high. In order to reset the interrupt status, a "0" must be written to the A9.INT bit or power on the PMU again. The timing diagram is shown below :

**Interrupt vs. Events (I<sup>2</sup>C Status Bits)**

| $\overline{\text{INT}}$ assert<br>(Turn to low)                    | When PMU turns on with event condition |                        | During PMU on        |                         |
|--|--|------------------------|----------------------|-------------------------|
|  | No Event (0)                           | Event has occurred (1) | Event appear (0 → 1) | Event disappear (1 → 0) |
| PGOOD  | No                                     | Yes                    | Yes                  | Yes                     |
| NoBAT  | No                                     | Yes                    | Yes                  | Yes                     |
| TS_METER [2:0] = 000<br>(Event may be cold or hot, VP UVLO, NoBAT) | No                                     | Yes                    | Yes                  | Yes                     |
| EOC  | No                                     | Yes                    | Yes                  | Yes                     |
| THR  | No                                     | Yes                    | Yes                  | Yes                     |
| $\overline{\text{SAFE}}$   | No                                     | Yes                    | Yes                  | Yes                     |
| DPM  | No                                     | Yes                    | Yes                  | Yes                     |
| CHGRUN   | No                                     | No                     | No                   | Yes                     |

**$\overline{\text{INT}}$  vs. Fault/Status Timing Diagram**



When the A9.INT bit is written to "0", the  $\overline{\text{INT}}$  will be set to high.  
 When Mask\_DPM = 1 and DPM event change, the  $\overline{\text{INT}}$  would not be asserted.

## Battery Installation Detection

RT5021 also detects TS voltage to monitor the battery status. If PMU is enabled but TS voltage > 90% of VP node voltage, RT5021 sets the bit

NoBAT = 1 an I<sup>2</sup>C register A10.NoBAT and sets A9.INT bit to "1".

|       |   |                                       |
|-------|---|---------------------------------------|
| NoBAT | 1 | No Battery Installed (TS > 90% of VP) |
|       | 0 | BAT Installed                         |

## VIN Power Good Status

|       |   |                            |
|-------|---|----------------------------|
| PGOOD | 0 | VIN < VUVLO                |
|       | 0 | VUVLO < VIN < VBAT + VOS_L |
|       | 1 | VBAT + VOS_H < VIN < VOVP  |
|       | 0 | VIN > VOVP                 |

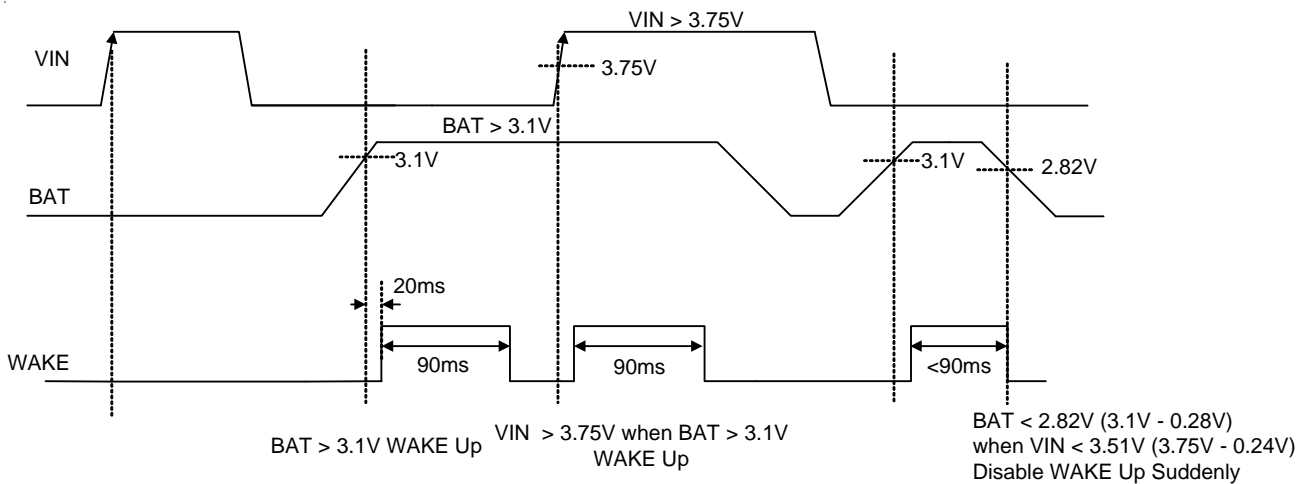
## End\_Of\_Charge (EOC) Status

The bit EOC in I<sup>2</sup>C register A10.EOC can show the EOC status. If EOC = 1, the charger is in EOC state and A9.INT bit is set to "1"

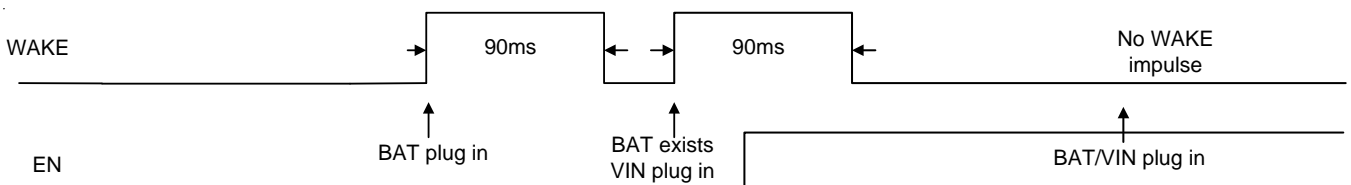
|     |   |   |
|-----|---|---|
| EOC | 1 | Charging Done or Recharging after Termination |
|     | 0 | During Charging                               |

## Wake-Up Detector

Wake-Up Detector detects VIN or BAT plug-in events. Once BAT plugs in or VIN plugs in for a 19msec deglitch time, the WAKE pin will provide a 90ms width high pulse. The timing diagram shows as below.



When PMU is enabled, WAKE UP impulse would be masked off. WAKE impulse width 90ms can not be cut by EN = H



**Suspend Mode**

When USUS = 1, the charger will enter Suspend Mode. In Suspend Mode,  $\overline{\text{CHG}}$  pin is high impedance and  $\text{IUSUS}(\text{MAX}) < 300\mu\text{A}$ .

**Charging Current Decision**

The charge current can be set according to the I<sup>2</sup>C register A8.ISETA [3:0] setting :

| ISETA [3:0] | RT5021 allows user to set the battery charge current level and the list as below. The default value is 0.5A. |                    |      |                    |      |                    |      |                    |
|-------------|--|--------------------|------|--------------------|------|--------------------|------|--------------------|
|             | Code   | BAT Charge Current | Code | BAT Charge Current | Code | BAT Charge Current | Code | BAT Charge Current |
|             | 0000   | 0.1A               | 0001 | 0.2A               | 0010 | 0.3A               | 0011 | 0.4A               |
|             | 0100   | 0.5A               | 0101 | 0.6A               | 0110 | 0.7A               | 0111 | 0.8A               |
|             | 1000   | 0.9A               | 1001 | 1A                 | 1010 | 1.1A               | 1011 | 1.2A               |
|             | 1100   | 1.2A               | 1101 | 1.2A               | 1110 | 1.2A               | 1111 | 1.2A               |

**Fault-Time**

During the fast charge phase, several events may increase the charging time.

For example, the system load current may have activated the APPM loop which reduces the available charging current or the device has entered thermal regulation because the IC junction temperature has exceeded T<sub>REG</sub>.

However, once the duration exceeds the fault-time, the  $\overline{\text{CHG}}$  output pin will flash at approximately 4Hz to indicate a fault condition and the charge current will be reduced to about 1mA.

There are four methods to release the Fault-time :

- ▶ Re-plug power
- ▶ Toggle EN
- ▶ Enter/exit suspend mode
- ▶ Remove Battery
- ▶ OVP

The fault-time is inverse proportional to the charger current.

$$\text{Fault-Time} \propto \frac{1}{\text{Icharge}}$$

Example :

If the sensing battery temperature is hot or cold, the charge current will reduce to half charge current. So, the fault-time will increase to be double.

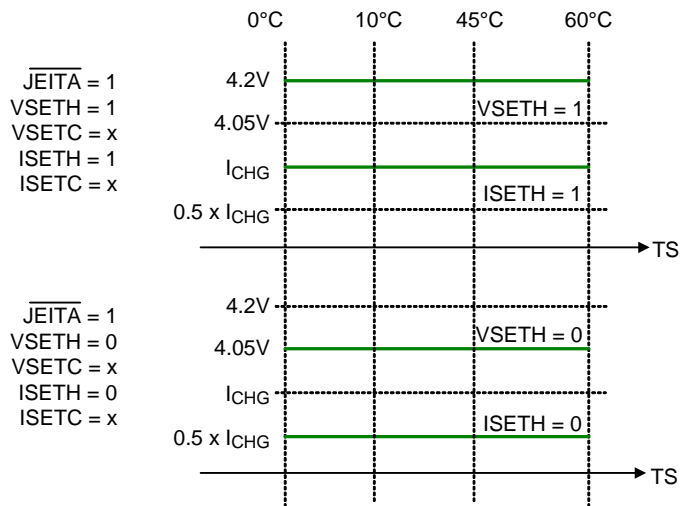
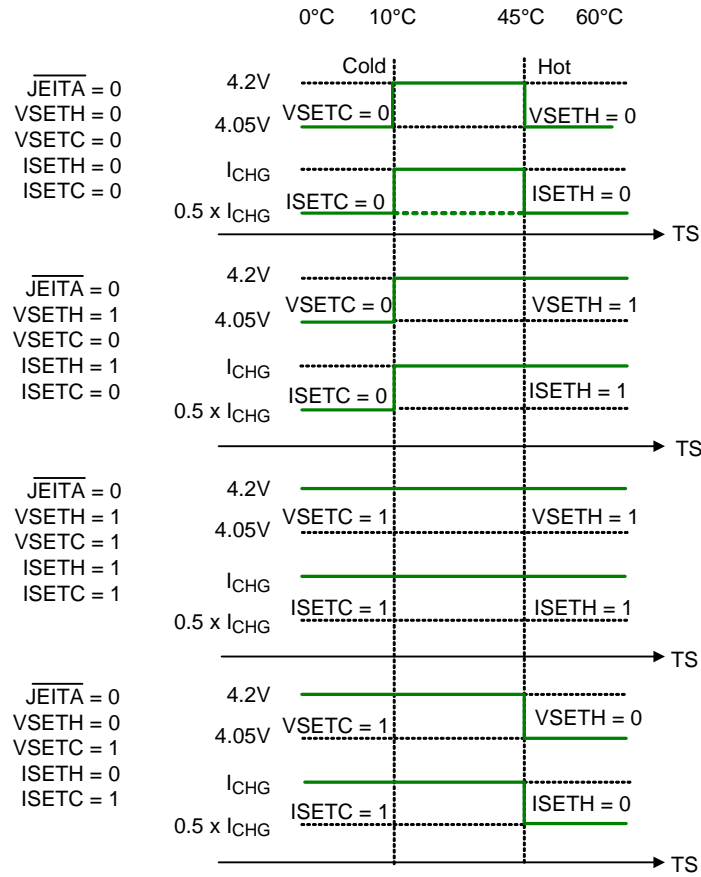
**JEITA Battery Temperature Standard**

CV regulation voltage will be changed in the following battery temperature ranges : 0°C to 10°C and 45°C to 60°C.

This function can be disabled by A9.VSETH and A9.VSETC.

CC regulation current will be changed in the following battery temperature ranges : 0°C to 10°C and 45°C to 60°C.

This function can be disabled by A9.ISETH and A9.ISETC.



**Battery Pack Temperature Monitoring**

The battery pack temperature monitoring function can be realized by connecting the TS pin to an external Negative Temperature Coefficient (NTC) thermal resistor to prevent over temperature condition. Charging is suspended when the voltage at the TS pin is out of normal operating range. The internal timer is then paused, but the value is maintained.

When the TS pin voltage returns to normal operating range, charging will resume and the safe charge timer will continue to count down from the point where it was suspended. Note that although charging is suspended due to the battery pack temperature fault, the  $\overline{\text{CHG}}$  pin will flash at 0.5Hz and indicate charging.

The 3.3V at VP pin is buffered by the RT5021 once it is in charging state or its PMU part is enabled. If a 100kΩ NTC thermal resistor is used, the A0.TSSEL bit should be set to "1". If a 10kΩ NTC thermal resistor is used, the A0.TSSEL bit should be set to "0". The TSSEL bit determines the TS threshold levels for 0°C and 60°C. It also defines the TS threshold levels used in JEITA operation. The choosing method of R1 and R2 to meet battery temperature monitoring shows as below.

Case 1 : TSSEL = H (For 100kΩ NTC) :

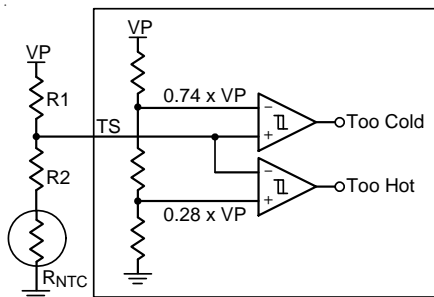


Figure 4

Case 2 : TSSEL = L (For 10kΩ NTC) :

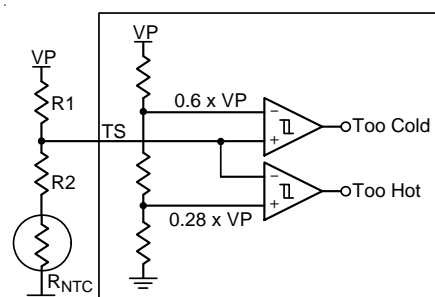


Figure 5

Too Cold Temperature

$$R_{\text{COLD}} = R_{\text{NTC}}$$

Too Hot Temperature

$$R_{\text{HOT}} = R_{\text{NTC}}$$

$$\frac{R_2 + R_{\text{COLD}}}{R_{\text{COLD}} + R_1 + R_2} = 0.74 \text{ ----- (1)}$$

$$\frac{R_2 + R_{\text{HOT}}}{R_{\text{HOT}} + R_1 + R_2} = 0.28 \text{ ----- (2)}$$

Form (1), (2)

$$R_1 = \frac{R_{\text{COLD}} - R_{\text{HOT}}}{2.457}$$

$$R_2 = 0.389 \times R_1 - R_{\text{HOT}}$$

If  $R_2 < 0$

$$\frac{R_{\text{COLD}}}{R_{\text{COLD}} + R_1} = 0.74 \text{ ----- (3)}$$

Form (3)

$$R_1 = \frac{R_{\text{COLD}}}{0.74} - R_{\text{COLD}}$$

Too Cold Temperature

$$R_{\text{COLD}} = R_{\text{NTC}}$$

Too Hot Temperature

$$R_{\text{HOT}} = R_{\text{NTC}}$$

$$\frac{R_2 + R_{\text{COLD}}}{R_{\text{COLD}} + R_1 + R_2} = 0.6 \text{ ----- (1)}$$

$$\frac{R_2 + R_{\text{HOT}}}{R_{\text{HOT}} + R_1 + R_2} = 0.28 \text{ ----- (2)}$$

Form (1), (2)

$$R_1 = 0.9 \times (R_{\text{COLD}} - R_{\text{HOT}})$$

$$R_2 = 0.388 \times R_1 - R_{\text{HOT}}$$

If  $R_2 < 0$

$$\frac{R_{\text{COLD}}}{R_{\text{COLD}} + R_1} = 0.6 \text{ ----- (3)}$$

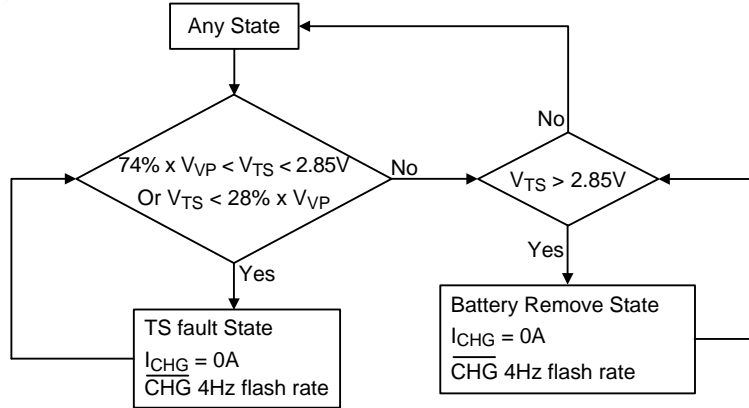
Form (3)

$$R_1 = \frac{R_{\text{COLD}}}{0.6} - R_{\text{COLD}}$$

**The Control Temperature Used in JEITA Operation**

The above calculation gives R1 and R2. JEITA control thresholds for full charging current and 4.2V regulation voltage are at TS/VP ratio = 32% and 52% (for TSSEL = L), 35% and 64% (for TSSEL = H). With the ratio, the corresponding NTC thermistor resistances from the resistors in the voltage divider circuit can be obtained. According to the NTC resistances, the corresponding temperatures can be found. The two temperatures are the control temperatures used in JEITA operation.

**Operation State Diagram for TS Pin (TSSEL = H)**



**Power Switch**

For the charger, there are three power scenarios :

- ▶ When a battery and an external power supply (USB or adapter) are connected simultaneously
 

If the system required load exceeds the input current limit, the battery will be used to supplement the current to the load. However, if the system load is less than the input current limit, the excess power from the external power supply will be used to charge the battery.
- ▶ When only the battery is connected to the system
 

The battery provides the power to the system.
- ▶ When only an external power supply is connected to the system
 

The external power supply provides the power to the system.

**Input DPM Mode**

For the charger, the input voltage is monitored when USB100 or USB500 is selected. If the input voltage is lower than VDPM, the input current limit will be reduced to stop the input voltage from dropping further. This can prevent the IC from damaging improperly configured or inadequately designed USB sources.

If VIN charger type is detected as SDP, the DPM function always is enabled.

For other types, the DPM function always is disabled but user can set A0.ENDPM to turn on the DPM function.

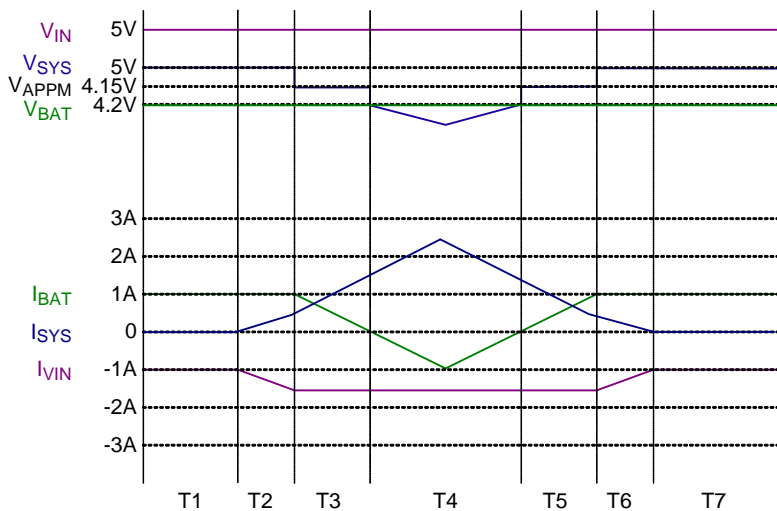
|       |  |
|-------|--|
| ENDPM | Enable the charger VIN DPM function. But if VIN charger type is detected as SDP (CHG_TYP [2:0] = 000), the DPM function always is enabled. |
|       | 0 : VIN DPM function disabled.   |
|       | 1 : VIN DPM function enabled.  |

**APPM Mode**

Once the sum of the charging current and system load current is higher than the maximum input current limit, the SYS pin voltage will be reduced. When the SYS pin voltage is reduced to  $V_{APPM}$ , the RT5021 will automatically operate in APPM mode. In this mode, the charging current is reduced while the SYS current is increased to maintain system output. In APPM mode, the battery termination function is disabled.

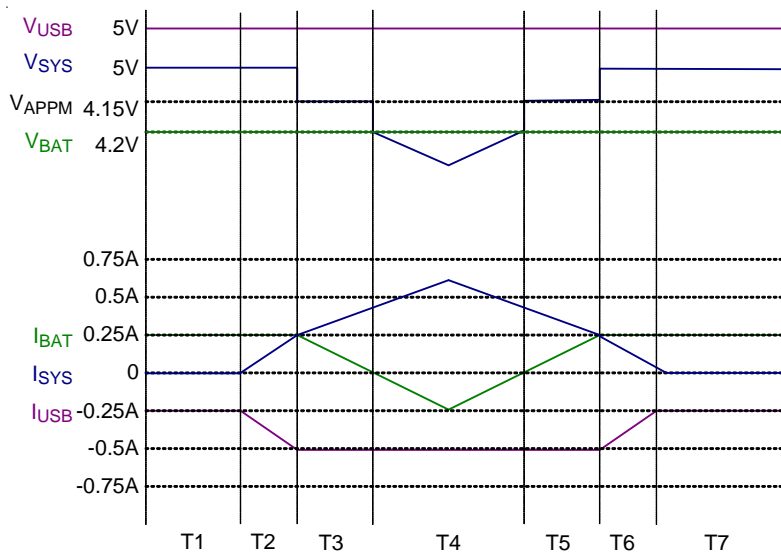
**APPM Profile**

1.5A Mode :



|        | $I_{SYS}$                                | $V_{SYS}$                             | $I_{VIN}$            | $I_{BAT}$               |
|--------|--|---------------------------------------|----------------------|-------------------------|
| T1, T7 | 0  | SYS Regulation Voltage                | CHG_MAX              | CHG_MAX                 |
| T2, T6 | $< I_{VIN\_OC} - CHG\_MAX$               | SYS Regulation Voltage                | $I_{SYS} + CHG\_MAX$ | CHG_MAX                 |
| T3, T5 | $> I_{VIN\_OC} - CHG\_MAX < I_{VIN\_OC}$ | Auto Charge Voltage Threshold         | $V_{IN\_OC}$         | $V_{IN\_OC} - I_{SYS}$  |
| T4     | $> I_{VIN\_OC}$                          | $V_{BAT} - I_{BAT} \times R_{DS(ON)}$ | $V_{IN\_OC}$         | $I_{SYS} - I_{VIN\_OC}$ |

500mA Mode :



|        | I <sub>sys</sub>   | V <sub>sys</sub>  | I <sub>usb</sub>           | I <sub>BAT</sub>                             |
|--------|--|---|----------------------------|--|
| T1, T7 | 0  | SYS Regulation Voltage                                    | CHG_MAX                    | CHG_MAX                                      |
| T2, T6 | < I <sub>VIN_OC</sub> (USB) – CHG_MAX                                | SYS Regulation Voltage                                    | I <sub>sys</sub> + CHG_MAX | CHG_MAX                                      |
| T3, T5 | > I <sub>VIN_OC</sub> (USB) – CHG_MAX<br>< I <sub>VIN_OC</sub> (USB) | Auto Charge Voltage Threshold                             | I <sub>VIN_OC</sub> (USB)  | I <sub>VIN_OC</sub> (USB) – I <sub>sys</sub> |
| T4     | > I <sub>VIN_OC</sub> (USB)  | V <sub>BAT</sub> – I <sub>BAT</sub> × R <sub>DS(ON)</sub> | I <sub>VIN_OC</sub> (USB)  | I <sub>sys</sub> – I <sub>VIN_OC</sub> (USB) |

### Battery Supplement Mode Short Circuit Protect

In APPM mode, the SYS voltage will continue to drop if the charge current is zero and the system load increases beyond the input current limit. When the SYS voltage decreases below the battery voltage, the battery will kick in to supplement the system load until the SYS voltage rises above the battery voltage.

While in supplement mode, there is no battery supplement current regulation. However, a built-in short circuit protection feature is available to prevent any abnormal current situation. While the battery is supplementing the load, if the difference between the battery and SYS voltage exceeds the short circuit threshold voltage, SYS will be disabled. After a short circuit recovery time, t<sub>SHORT\_R</sub>, the counter will be restarted. In supplement mode, the battery termination function is disabled. Note that the battery supply mode exiting condition is V<sub>BAT</sub> – V<sub>SYS</sub> < 0V.

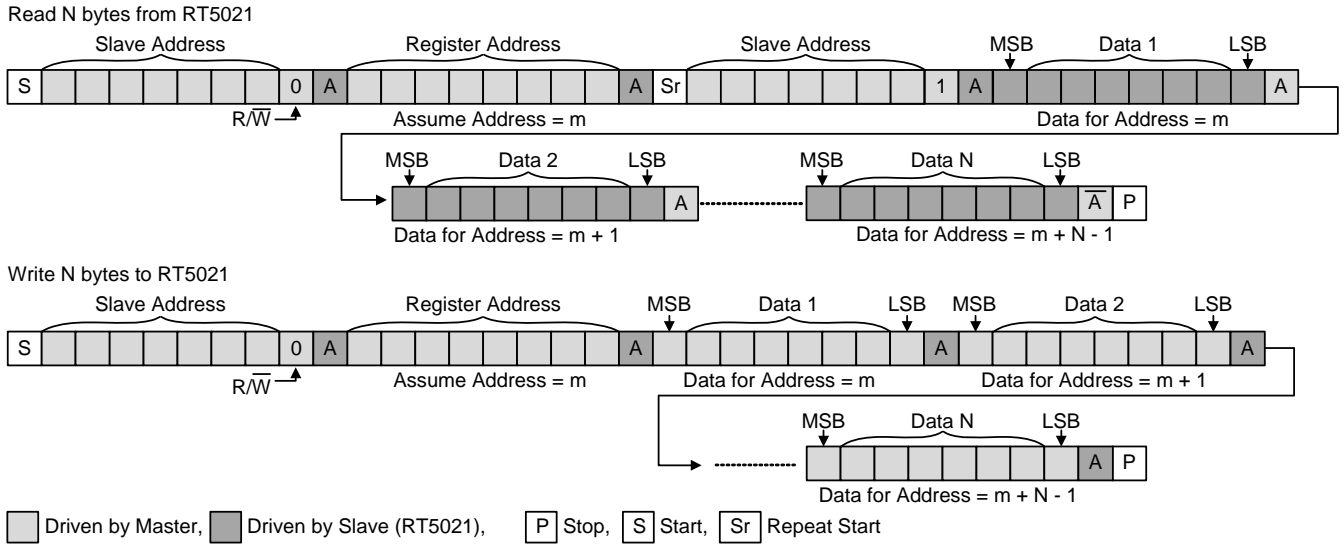
### Thermal Regulation and Thermal Shutdown

The charger provides a thermal regulation loop function to monitor the device temperature. If the die temperature rises above the regulation temperature, T<sub>REG</sub>, the charge current will automatically be reduced to lower the die temperature. However, in certain circumstances (such as high VIN, heavy system load, etc) even with the thermal loop in place, the die temperature may still continue to increase. In this case, if the temperature rises above the thermal shutdown threshold, T<sub>SD</sub>, the internal switch between VIN and SYS will be turned off. The switch between the battery and SYS will remain on, however, to allow continuous battery power to the load. Once the die temperature decreases by ΔT<sub>SD</sub>, the internal switch between VIN and SYS will be turned on again and the device returns to normal thermal regulation. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures.

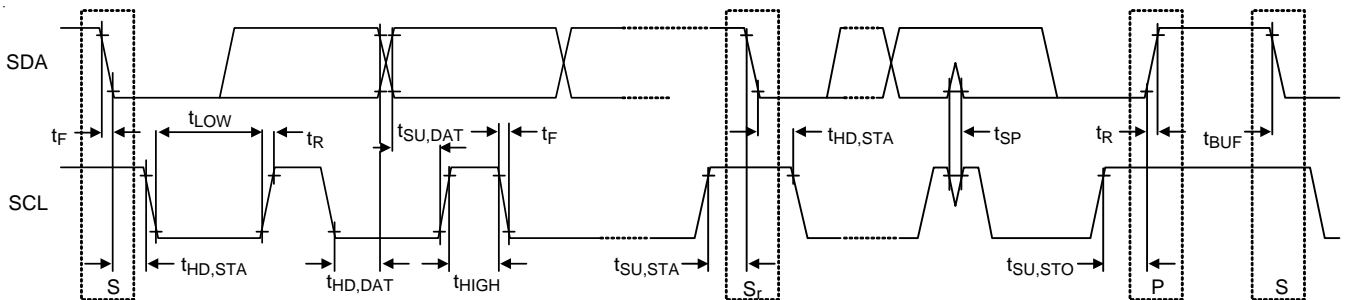


**I<sup>2</sup>C Interface**

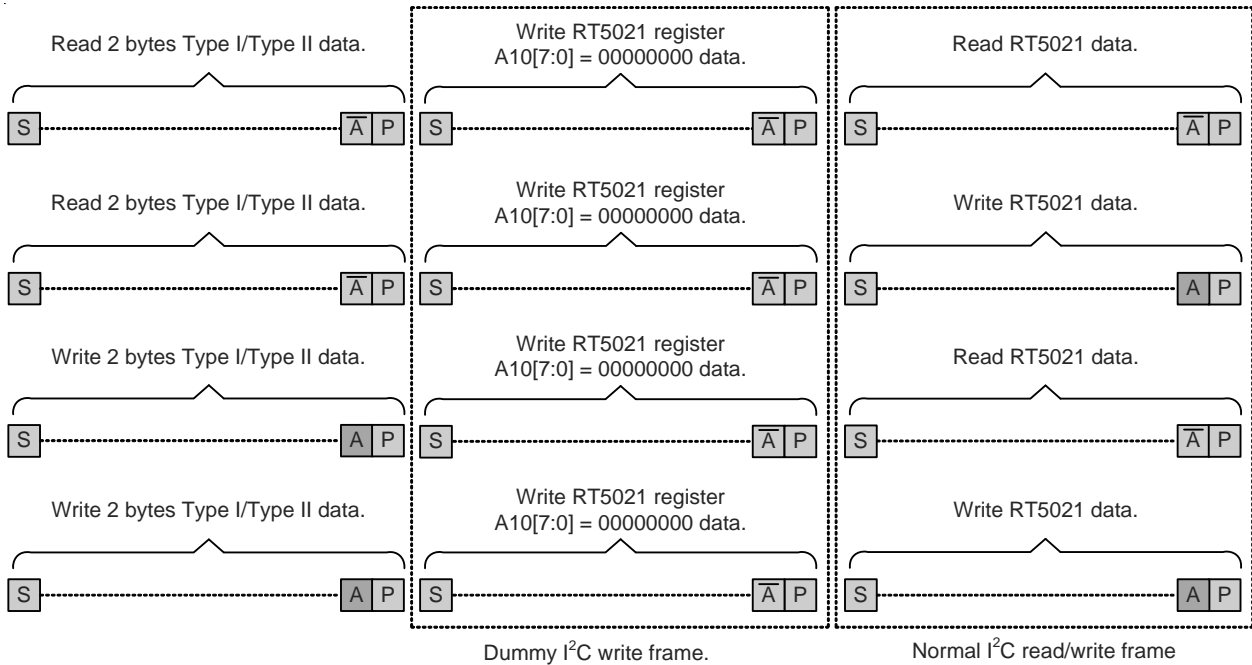
RT5021 I<sup>2</sup>C slave address = 0010010 (7 bits). I<sup>2</sup>C interface supports fast mode (bit rate up to 400kb/s). The write or read bit stream (N ≥ 1) is shown below :



**I<sup>2</sup>C Waveform Information**

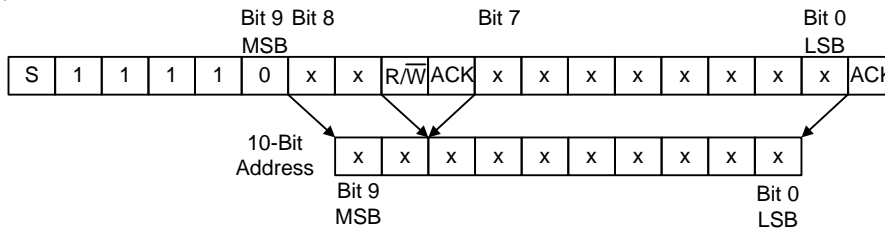


When RT5021 and other I<sup>2</sup>C devices with 10-bit slave addressing (type I) or two-byte register addressing (type II) coexist in one I<sup>2</sup>C bus, RT5021 need one dummy I<sup>2</sup>C write frame to reset the RT5021 internal I<sup>2</sup>C operation state. The below shows a dummy write frame example, that is to write RT5021 register A10 [7:0] = 00000000. Master should ignore the write operation (This operation is invalid). After the dummy frame, the master can read/write formal I<sup>2</sup>C frame for RT5021 to get right operation.



### Type I : 10-bit slave address data format

In 10-bit addressing, the slave address is sent in the first two bytes. The first byte begins with the special reserved address of 11110XX which indicates that 10-bit addressing is being used.



### Type II : 2-byte register address data format

The register address is combined with 2-byte as below.

#### 2-Byte Register Address



**I<sup>2</sup>C Register File**

| Address Name | Register Address | Bit7 (MSB)   | Bit6  | Bit5  | Bit4 | Bit3     | Bit2  | Bit1 | Bit0 (LSB) |       |
|--------------|------------------|--|-------|-------|------|----------|-------|------|------------|-------|
| A0           | 0x00             | Meaning  | RST_P | RST_C | OVP7 | Reserved | ENDPM | TSD  | MOD7       | TSSEL |
|              |                  | Default  | 1     | 0     | 0    | X        | 0     | 0    | 0          | 1     |
|              |                  | Read/Write   | R/W   | R/W   | R/W  | --       | R/W   | R/W  | R          | R/W   |
| RST_P        |                  | RT5021 would reset PMU-related registers under any one of the below two conditions :<br>1) VDDI < 1.3V<br>2) (EN pin = low and A0.RST_P = 1)<br>In the 2 <sup>nd</sup> condition, RT5021 uses the register bit A0.RST_P to decide whether the PMU-related registers are reset or not when EN pin goes low.<br>0 : Don't reset register (0x3 to 0x6)<br>1 : Reset register (0x3 to 0x6).                  |       |       |      |          |       |      |            |       |
| RST_C        |                  | RT5021 would reset Charge-related register under any one of the below three conditions :<br>1) VIN < 4V<br>2) VDDI < 1.3V<br>3) (BAT < 3.1V) and (A0.RST_C = 1)<br>In the 3 <sup>rd</sup> condition, RT5021 uses the register bit A0.RST_C to decide whether the Charge-related registers are reset or not when BAT < 3.1V.<br>0 : Don't reset register (0x7 to 0x9).<br>1 : Reset register (0x7 to 0x9) |       |       |      |          |       |      |            |       |
| OVP7         |                  | CH7 allow user to select the OVP level by I <sup>2</sup> C interface<br>0 : 16V OVP<br>1 : 25V OVP   |       |       |      |          |       |      |            |       |
| ENDPM        |                  | Enable the charger VIN DPM function. But if VIN charger type is detected as SDP (CHG_TYP [2:0] = 000), the DPM function always is enabled.<br>0 : VIN DPM function disabled<br>1 : VIN DPM function enabled.   |       |       |      |          |       |      |            |       |
| TSD          |                  | Report whether thermal shutdown of PMU ever occurs. Reset it by writing 0 into the bit or (VDDI < 1.3V).<br>0 : Thermal Shutdown has not occurred.<br>1 : Thermal Shutdown event ever occurs.  |       |       |      |          |       |      |            |       |
| MOD7         |                  | Report the result of CH7 mode detection.<br>0 : Current Source.<br>1 : Boost.  |       |       |      |          |       |      |            |       |
| TSSEL        |                  | TS/VP ratio setting for battery temperature.<br>0 : TS/VP = 60% (0°C), 28% (60°C)<br>1 : TS/VP = 74% (0°C), 28% (60°C)   |       |       |      |          |       |      |            |       |

| Address Name | Register Address | Bit7 (MSB)   | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 (LSB) |      |
|--------------|------------------|--|------|------|------|------|------|------|------------|------|
| A1           | 0x01             | Meaning  | ERR1 | ERR2 | ERR3 | ERR4 | ERR5 | ERR6 | ERR7       | ERR8 |
|              |                  | Default  | 0    | 0    | 0    | 0    | 0    | 0    | 0          | 0    |
|              |                  | Read/Write   | R/W  | R/W  | R/W  | R/W  | R/W  | R/W  | R/W        | R/W  |
| ERR1 to ERR8 |                  | Report whether the protection event of CH1 to CH8 ever occurs respectively. Reset it by writing 0 into the bit or (VRTC < 1.6V).<br>0 : No protection event occurs.<br>1 : Protection event ever occurs. |      |      |      |      |      |      |            |      |

| Address Name   | Register Address | Bit7 (MSB)  | Bit6 | Bit5 | Bit4 | Bit3           | Bit2 | Bit1 | Bit0 (LSB) |  |
|----------------|------------------|---|------|------|------|----------------|------|------|------------|--|
| A2             | 0x02             | Meaning   | EN5  | EN6  | EN8  | EN7_DIM7 [4:0] |      |      |            |  |
|                |                  | Default   | 0    | 0    | 0    | 0              | 0    | 0    | 0          |  |
|                |                  | Read/Write  | R/W  | R/W  | R/W  | R/W            | R/W  | R/W  | R/W        |  |
| EN5            |                  | Enable/disable CH5<br>0 : Disable<br>1 : Enable   |      |      |      |                |      |      |            |  |
| EN6            |                  | Enable/disable CH6<br>0 : Disable<br>1 : Enable   |      |      |      |                |      |      |            |  |
| EN8            |                  | Enable/disable CH8<br>0 : Disable<br>1 : Enable   |      |      |      |                |      |      |            |  |
| EN7_DIM7 [4:0] |                  | Enable CH7 and define FB7 regulation voltage<br>00000 : CH7 turn off<br>00001 to 11111 : CH7 turn on and dimming ratio : VFB7 = EN7_DIM7 [4 : 0] / 31 x 0.25V |      |      |      |                |      |      |            |  |

| Address Name | Register Address |            | Bit7 (MSB)  | Bit6           | Bit5        | Bit4           | Bit3        | Bit2           | Bit1        | Bit0 (LSB)     |
|--------------|------------------|------------|---|----------------|-------------|----------------|-------------|----------------|-------------|----------------|
| A3           | 0x03             | Meaning    | PSM1  | PSM2           | PSM3        | PSM4           | VOUT8 [3:0] |                |             |                |
|              |                  | Default    | 1   | 1              | 1           | 1              | 1           | 0              | 0           |                |
|              |                  | Read/Write | R/W   | R/W            | R/W         | R/W            | R/W         | R/W            | R/W         | R/W            |
| PSM1 to PSM4 |                  |            | Define the CH1/2/3/4 CCM or PWM/PSM switching operation.<br>0 : Force PWM<br>1 : Automatic PWM/PSM switch operation |                |             |                |             |                |             |                |
| VOUT8 [3:0]  |                  |            | CH8 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 2.8V.                  |                |             |                |             |                |             |                |
|              |                  |            | <b>Code</b>   | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> |
|              |                  |            | 0000  | Switch         | 0001        | 1.1V           | 0010        | 1.2V           | 0011        | 1.3V           |
|              |                  |            | 0100  | 1.4V           | 0101        | 1.5V           | 0110        | 1.6V           | 0111        | 1.7V           |
|              |                  |            | 1000  | 1.8V           | 1001        | 2V             | 1010        | 2.2V           | 1011        | 2.5V           |
|              |                  |            | 1100  | 2.8V           | 1101        | 3.1V           | 1110        | 3.2V           | 1111        | 3.3V           |

| Address Name | Register Address |            | Bit7 (MSB)  | Bit6           | Bit5                    | Bit4                  | Bit3                    | Bit2           | Bit1        | Bit0 (LSB)     |
|--------------|------------------|------------|---|----------------|-------------------------|-----------------------|-------------------------|----------------|-------------|----------------|
| A4           | 0x04             | Meaning    | VOUT1 [3:0]   |                |                         |                       | EN1                     | FB2 [2:0]      |             |                |
|              |                  | Default    | 1   | 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            |
| VOUT1 [3:0]  |                  |            | CH1 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 5V.  |                |                         |                       |                         |                |             |                |
|              |                  |            | <b>Code</b>   | <b>Voltage</b> | <b>Code</b>             | <b>Voltage</b>        | <b>Code</b>             | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> |
|              |                  |            | 0000  | 3.6V           | 0001                    | 3.7V                  | 0010                    | 3.8V           | 0011        | 3.9V           |
|              |                  |            | 0100  | 4V             | 0101                    | 4.5V                  | 0110                    | 4.6V           | 0111        | 4.7V           |
|              |                  |            | 1000  | 4.8V           | 1001                    | 4.9V                  | 1010                    | 5V             | 1011        | 5.1V           |
|              |                  |            | 1100  | 5.2V           | 1101                    | 5.3V                  | 1110                    | 5.4V           | 1111        | 5.5V           |
| EN1          |                  |            | Enable/Disable CH1 when sequence ID is SEO#0.<br>In SEO#0, CH1 is not the power on/off sequence.<br>In other sequence, CH1 is in sequence control and on/off by the pin EN, not by the register bit EN1.<br>0 : Disable<br>1 : Enable |                |                         |                       |                         |                |             |                |
| FB2 [2:0]    |                  |            | FB2 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 0.8V.  |                |                         |                       |                         |                |             |                |
|              |                  |            | <b>Code</b>   | <b>VREF</b>    | <b>If Target = 1.8V</b> | <b>If Target = 1V</b> | <b>If Target = 3.3V</b> |                |             |                |
|              |                  |            | 000   | 0.72V          | 1.62V                   | 0.9V                  | 2.97V                   |                |             |                |
|              |                  |            | 001   | 0.74V          | 1.665V                  | 0.925V                | 3.0525V                 |                |             |                |
|              |                  |            | 010   | 0.76V          | 1.71V                   | 0.95V                 | 3.135V                  |                |             |                |
|              |                  |            | 011   | 0.78V          | 1.755V                  | 0.975V                | 3.2175V                 |                |             |                |
|              |                  |            | 100   | 0.8V           | 1.8V                    | 1V                    | 3.3V                    |                |             |                |
|              |                  |            | 101   | 0.82V          | 1.845V                  | 1.025V                | 3.3825V                 |                |             |                |
|              |                  |            | 110   | 0.84V          | 1.89V                   | 1.05V                 | 3.465V                  |                |             |                |
|              |                  |            | 111   | 0.86V          | 1.935V                  | 1.075V                | 3.5475V                 |                |             |                |

| Address Name | Register Address |  | Bit7 (MSB)  | Bit6                    | Bit5                  | Bit4                    | Bit3  | Bit2      | Bit1 | Bit0 (LSB) |
|--------------|------------------|--|-------------|-------------------------|-----------------------|-------------------------|-------|-----------|------|------------|
| A5           | 0x05             | Meaning  | FLST        | FB3 [2:0]               |                       |                         | FLST2 | FB4 [2:0] |      |            |
|              |                  | Default  | 1           | 1                       | 0                     | 0                       | 1     | 1         | 0    | 0          |
|              |                  | Read/Write   | R/W         | R/W                     | R/W                   | R/W                     | R/W   | R/W       | R/W  | R/W        |
| FLST         |                  | Used to control the $\overline{\text{CHG}}$ pin status when the register bit A9. CHG2STEN = 0.<br>1 : $\overline{\text{CHG}}$ = High impedance.<br>0 : $\overline{\text{CHG}}$ = Low.    |             |                         |                       |                         |       |           |      |            |
| FB3 [2:0]    |                  | FB3 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 0.8V.   |             |                         |                       |                         |       |           |      |            |
|              |                  | <b>Code</b>  | <b>VREF</b> | <b>If Target = 1.8V</b> | <b>If Target = 1V</b> | <b>If Target = 3.3V</b> |       |           |      |            |
|              |                  | 000  | 0.72V       | 1.62V                   | 0.9V                  | 2.97V                   |       |           |      |            |
|              |                  | 001  | 0.74V       | 1.665V                  | 0.925V                | 3.0525V                 |       |           |      |            |
|              |                  | 010  | 0.76V       | 1.71V                   | 0.95V                 | 3.135V                  |       |           |      |            |
|              |                  | 011  | 0.78V       | 1.755V                  | 0.975V                | 3.2175V                 |       |           |      |            |
|              |                  | 100  | 0.8V        | 1.8V                    | 1V                    | 3.3V                    |       |           |      |            |
|              |                  | 101  | 0.82V       | 1.845V                  | 1.025V                | 3.3825V                 |       |           |      |            |
|              |                  | 110  | 0.84V       | 1.89V                   | 1.05V                 | 3.465V                  |       |           |      |            |
|              |                  | 111  | 0.86V       | 1.935V                  | 1.075V                | 3.5475V                 |       |           |      |            |
| FLST2        |                  | Used to control the $\overline{\text{CHG2}}$ pin status when the register bit A8. CHG2STEN = 0.<br>1 : $\overline{\text{CHG2}}$ = High impedance.<br>0 : $\overline{\text{CHG2}}$ = Low. |             |                         |                       |                         |       |           |      |            |
| FB4 [2:0]    |                  | FB4 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 0.8V.   |             |                         |                       |                         |       |           |      |            |
|              |                  | <b>Code</b>  | <b>VREF</b> | <b>If Target = 1.8V</b> | <b>If Target = 1V</b> | <b>If Target = 3.3V</b> |       |           |      |            |
|              |                  | 000  | 0.72V       | 1.62V                   | 0.9V                  | 2.97V                   |       |           |      |            |
|              |                  | 001  | 0.74V       | 1.665V                  | 0.925V                | 3.0525V                 |       |           |      |            |
|              |                  | 010  | 0.76V       | 1.71V                   | 0.95V                 | 3.135V                  |       |           |      |            |
|              |                  | 011  | 0.78V       | 1.755V                  | 0.975V                | 3.2175V                 |       |           |      |            |
|              |                  | 100  | 0.8V        | 1.8V                    | 1V                    | 3.3V                    |       |           |      |            |
|              |                  | 101  | 0.82V       | 1.845V                  | 1.025V                | 3.3825V                 |       |           |      |            |
|              |                  | 110  | 0.84V       | 1.89V                   | 1.05V                 | 3.465V                  |       |           |      |            |
|              |                  | 111  | 0.86V       | 1.935V                  | 1.075V                | 3.5475V                 |       |           |      |            |

| Address Name | Register Address | Bit7 (MSB)   | Bit6           | Bit5        | Bit4           | Bit3        | Bit2           | Bit1        | Bit0 (LSB)     |             |                |
|--------------|------------------|--|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|
| A6           | 0x06             | Meaning  | VOUT5 [3:0]    |             |                |             | VOUT6 [3:0]    |             |                |             |                |
|              |                  | Default  | 1              | 0           | 0              | 0           | 0              | 0           | 1              | 1           |                |
|              |                  | Read/Write   | R/W            | R/W         | R/W            | R/W         | R/W            | R/W         | R/W            | R/W         |                |
| VOUT5 [3:0]  |                  | CH5 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 1.8V. |                |             |                |             |                |             |                |             |                |
|              |                  | <b>Code</b>  | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> |
|              |                  | 0000   | REF            | 0001        | 1.1V           | 0010        | 1.2V           | 0011        | 1.3V           |             |                |
|              |                  | 0100   | 1.4V           | 0101        | 1.5V           | 0110        | 1.6V           | 0111        | 1.7V           |             |                |
|              |                  | 1000   | 1.8V           | 1001        | 2V             | 1010        | 2.2V           | 1011        | 2.3V           |             |                |
|              |                  | 1100   | 2.5V           | 1101        | 2.6V           | 1110        | 2.7V           | 1111        | 2.8V           |             |                |
| VOUT6 [3:0]  |                  | CH6 regulation voltage can be selected by I <sup>2</sup> C interface. The default voltage is 1.3V. |                |             |                |             |                |             |                |             |                |
|              |                  | <b>Code</b>  | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> | <b>Code</b> | <b>Voltage</b> |
|              |                  | 0000   | Switch         | 0001        | 1.1V           | 0010        | 1.2V           | 0011        | 1.3V           |             |                |
|              |                  | 0100   | 1.4V           | 0101        | 1.5V           | 0110        | 1.6V           | 0111        | 1.7V           |             |                |
|              |                  | 1000   | 1.8V           | 1001        | 2V             | 1010        | 2.2V           | 1011        | 2.5V           |             |                |
|              |                  | 1100   | 2.8V           | 1101        | 3.1V           | 1110        | 3.2V           | 1111        | 3.3V           |             |                |

| Address Name    | Register Address | Bit7 (MSB)   | Bit6        | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 (LSB) |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
|-----------------|------------------|--|-------------|------|------|------|------|------|------------|-------|-------|-------------------------|---|---|----------------|---|---|-------|---|---|----|---|---|------|
| A7              | 0x07             | Meaning  | TIMER [3:0] |      |      |      | ENCH | USUS | ISETU      | ISETL |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
|                 |                  | Default  | 0           | 1    | 0    | 0    | 0    | 0    | 0          | 0     |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
|                 |                  | Read/Write   | R/W         | R/W  | R/W  | R/W  | R/W  | R/W  | R/W        | R/W   |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| TIMER [3:0]     |                  | Define fast charger safe charging time.<br>Fast charging timeout time = (TIMER [3:0] + 1) hours. The default voltage is 5 hours.<br>Note : pre-charge timeout time = fast charge time/8.   |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| ENCH            |                  | Enable charger<br>0 : Enable charger<br>1 : Disable charger  |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| USUS            |                  | VIN Suspend control<br>0 : No suspend<br>1 : Suspend   |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| ISETU and ISETL |                  | VIN Current limit setting : <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>ISETL</th> <th>ISETU</th> <th>VIN Input Current Limit</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>95mA (default)</td> </tr> <tr> <td>0</td> <td>1</td> <td>475mA</td> </tr> <tr> <td>1</td> <td>0</td> <td>1A</td> </tr> <tr> <td>1</td> <td>1</td> <td>1.5A</td> </tr> </tbody> </table> Note: When Charger Type Detection finds the charger is Dedicated Charging Port (Sony or Apple Charger), ISETU/ISETL would set to be 475mA automatically. |             |      |      |      |      |      |            | ISETL | ISETU | VIN Input Current Limit | 0 | 0 | 95mA (default) | 0 | 1 | 475mA | 1 | 0 | 1A | 1 | 1 | 1.5A |
| ISETL           | ISETU            | VIN Input Current Limit  |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| 0               | 0                | 95mA (default)   |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| 0               | 1                | 475mA  |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| 1               | 0                | 1A   |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |
| 1               | 1                | 1.5A   |             |      |      |      |      |      |            |       |       |                         |   |   |                |   |   |       |   |   |    |   |   |      |



| Address Name  | Register Address                | Bit7 (MSB)  | Bit6                          | Bit5                           | Bit4                       | Bit3     | Bit2               | Bit1 | Bit0 (LSB)         |     |
|---|---------------------------------|---|-------------------------------|--------------------------------|----------------------------|----------|--------------------|------|--------------------|-----|
| A8  | 0x08                            | Meaning   | TSHT[1:0]                     |                                | Mask_DPM                   | CHG2STEN | ISETA [3:0]        |      |                    |     |
|   |                                 | Default   | 0                             | 0                              | 0                          | 1        | 0                  | 1    | 0                  | 0   |
|   |                                 | Read/Write  | R/W                           | R/W                            | R/W                        | R/W      | R/W                | R/W  | R/W                | R/W |
| TSHT [1:0]  |                                 | Set TS/VP threshold to monitor battery temperature for HOT boundary.  |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | Code  | TS/VP ratio                   | Equivalent Battery Temperature |                            |          |                    |      |                    |     |
|   |                                 |   |                               | 10k NTC                        |                            | 100k NTC |                    |      |                    |     |
|   |                                 | 00  | 28%                           | 60°C                           |                            | 60°C     |                    |      |                    |     |
|   |                                 | 01  | 28.5%                         | 58°C                           |                            | 59°C     |                    |      |                    |     |
| 10  | 29%                             | 56°C  |                               | 57°C                           |                            |          |                    |      |                    |     |
| 11  | 29.5%                           | 54°C  |                               | 56°C                           |                            |          |                    |      |                    |     |
| Mask_DPM  |                                 | Mask DPM function   |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | 0 : When DPM event change, $\overline{\text{INT}}$ would be asserted.   |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | 1 : When DPM event change, $\overline{\text{INT}}$ would not be asserted.                                       |                               |                                |                            |          |                    |      |                    |     |
| CHG2STEN  |                                 | Used to control $\overline{\text{CHG2}}$ pin status.  |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | 0 : See FLSH2 set.  |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | 1 : Base on charging status.  |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | Charging Status   | CHG2STEN = 1<br>(A8.bit4 = 1) | CHG2STEN = 0 (A8.bit4 = 0)     |                            |          |                    |      |                    |     |
|   |                                 |   |                               | FLST2 = 1<br>(A5.bit3 = 1)     | FLST2 = 0<br>(A5.bit3 = 0) |          |                    |      |                    |     |
| No Charging/<br>Charging Finish   | High impedance<br>(No flashing) |   | High Impedance                |                                |                            | Low      |                    |      |                    |     |
| Pre-Charge/<br>Fast Charge  | Low                             |   |                               |                                |                            |          |                    |      |                    |     |
| Abnormal (Fault timer<br>timeout, in thermal<br>regulation, battery too<br>cold or too hot) | 4Hz (0.25s)                     |   |                               |                                |                            |          |                    |      |                    |     |
| ISETA [3:0]   |                                 | RT5021 allows user to set the battery charge current level and the list as below.<br>The default value is 0.5A. |                               |                                |                            |          |                    |      |                    |     |
|   |                                 | Code  | BAT Charge Current            | Code                           | BAT Charge Current         | Code     | BAT Charge Current | Code | BAT Charge Current |     |
|   |                                 | 0000  | 0.1A                          | 0001                           | 0.2A                       | 0010     | 0.3A               | 0011 | 0.4A               |     |
|   |                                 | 0100  | 0.5A                          | 0101                           | 0.6A                       | 0110     | 0.7A               | 0111 | 0.8A               |     |
|   |                                 | 1000  | 0.9A                          | 1001                           | 1A                         | 1010     | 1.1A               | 1011 | 1.2A               |     |
|   |                                 | 1100  | 1.2A                          | 1101                           | 1.2A                       | 1110     | 1.2A               | 1111 | 1.2A               |     |

| Address Name   | Register Address | Bit7 (MSB)  | Bit6               | Bit5                         | Bit4  | Bit3                      | Bit2  | Bit1                   | Bit0 (LSB) |                        |  |
|--|------------------|---|--------------------|------------------------------|-------|---------------------------|-------|------------------------|------------|------------------------|--|
| A9   | 0x09             | Meaning   | $\overline{JEITA}$ | VSETH                        | VSETC | ISETH                     | ISETC | CHGSTEN                | INT        | DPM                    |  |
|  |                  | Default   | 0                  | 0                            | 0     | 0                         | 0     | 1                      | 0          | 0                      |  |
|  |                  | Read/Write  | R/W                | R/W                          | R/W   | R/W                       | R/W   | R/W                    | R/W        | R                      |  |
| $\overline{JEITA}$ , VSETH, VSETC, ISETH, ISETC                                    |                  | BAT charge current and regulation voltage control scheme.   |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | $\overline{JEITA} = 0$ , it means the charger operation is automatic ( $\overline{JEITA}$ rule).  |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | $\overline{JEITA} = 1$ , User can set the VSETH/VSETC to decide the BAT regulate voltage and set ISETH/ISETC to decide the BAT charge current level. The control scheme is listed as below.   |                    |                              |       |                           |       |                        |            |                        |  |
| CHGSTEN  |                  | Used to control CHG pin status.   |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | 0 : See FLSH set.   |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | 1 : Base on charging status.  |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | Charging Status   |                    | CHGSTEN = 1 (A9.bit2 = 1)    |       | CHGSTEN = 0 (A9.bit2 = 0) |       | FLST = 1 (A5.bit7 = 1) |            | FLST = 0 (A5.bit7 = 0) |  |
|  |                  | No Charging/ Charging Finish  |                    | High impedance (No flashing) |       | High Impedance            |       | Low                    |            |                        |  |
| Pre-Charge/ Fast Charge  |                  | 0.5Hz (2s)  |                    |                              |       |                           |       |                        |            |                        |  |
| Abnormal (Fault timer timeout, in thermal regulation, battery too cold or too hot) |                  | 4Hz (0.25s)   |                    |                              |       |                           |       |                        |            |                        |  |
| INT  |                  | Control the output of $\overline{INT}$ open drain port. The bit value is inverted of $\overline{INT}$ output. When interrupt events happen, $\overline{INT}$ port goes low and this bit A9. INT would be triggered to 1. Micro-processor must write this bit to be 0 for making $\overline{INT}$ go high. |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | 0 : $\overline{INT} = \text{High}$  |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | 1 : $\overline{INT} = \text{Low}$   |                    |                              |       |                           |       |                        |            |                        |  |
| DPM  |                  | The DPM bit is the charger VIN DPM status bit. It means the charger DPM (VIN falls and regulates at 4.35V) is activated or not.   |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | 0 : VIN DPM not activated.  |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | 1 : VIN DPM activated (working).  |                    |                              |       |                           |       |                        |            |                        |  |
|  |                  | Note : when PMU turns on, it would check the bit DPM and compare to the value 0. If it is different, $\overline{INT}$ would be asserted. After PMU is on, once DPM bit toggles, $\overline{INT}$ also asserts again.  |                    |                              |       |                           |       |                        |            |                        |  |

| Address Name               | Register Address | Bit7 (MSB)   | Bit6           | Bit5 | Bit4 | Bit3  | Bit2 | Bit1  | Bit0 (LSB) |      |              |                  |             |   |                            |   |                           |   |            |   |
|----------------------------|------------------|--|----------------|------|------|-------|------|-------|------------|------|--------------|------------------|-------------|---|----------------------------|---|---------------------------|---|------------|---|
| A10                        | 0x0A             | Meaning  | TS_METER [2:0] |      |      | NoBAT | EOC  | PGOOD | THR        | SAFE |              |                  |             |   |                            |   |                           |   |            |   |
|                            |                  | Default  | 0              | 0    | 0    | 0     | 0    | 0     | 0          | 0    |              |                  |             |   |                            |   |                           |   |            |   |
|                            |                  | Read/Write   | R              | R    | R    | R     | R    | R     | R          | R    |              |                  |             |   |                            |   |                           |   |            |   |
| TS_METER [2:0]             |                  | <p>Reports the battery temperature and VP status by detecting the TS pin voltage.</p> <div style="text-align: center;"> <p>TS Meter [2:0]</p> <p>0°C      10°C      45°C      60°C      VP &lt; 0.8V (VP UVLO)</p> <p>TS Meter [2:0] = 110    TS Meter [2:0] = 100    TS Meter [2:0] = 000    TS Meter [2:0] = 001    TS Meter [2:0] = 011    TS Meter [2:0] = 010</p> <p style="text-align: right;">→ TS</p> </div> <p>Note : when PMU turns on, it would check TS_Meter [2:0] and compare to the value 000. If it is different, <math>\overline{INT}</math> would be asserted. After PMU is on, once any bits of TS_Meter [2:0] toggles, INT also asserts again.</p>                               |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| NoBAT                      |                  | <p>Means the battery installed or not.</p> <p>0 : BAT Installed</p> <p>1 : No Battery Installed (TS &gt; 90% of VP)</p> <p>Note : when PMU turns on, it would check the bit NoBAT and compare to the value 0. If it is different, <math>\overline{INT}</math> would be asserted. After PMU is on, once NoBAT bit toggles, <math>\overline{INT}</math> also asserts again.</p>  |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| EOC                        |                  | <p>End of charge (EOC) bit show the charge status. If EOC = 1 means the charger is in EOC status.</p> <p>0 : During Charging</p> <p>1 : Charging Done or Recharging after Termination</p> <p>Note: when PMU turns on, it would check the bit EOC and compare to the value 0. If it is different, <math>\overline{INT}</math> would be asserted. After PMU is on, once EOC bit toggles, <math>\overline{INT}</math> also asserts again.</p>   |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| PGOOD                      |                  | <p>PGOOD bit means the VIN power status.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Input Status</th> <th>PGOOD Bit Status</th> </tr> </thead> <tbody> <tr> <td>VIN &lt; VUVLO</td> <td>0</td> </tr> <tr> <td>VUVLO &lt; VIN &lt; VBAT + VOS_L</td> <td>0</td> </tr> <tr> <td>VBAT + VOS_H &lt; VIN &lt; VOVP</td> <td>1</td> </tr> <tr> <td>VIN &gt; VOVP</td> <td>0</td> </tr> </tbody> </table> <p>Note : when PMU turns on, it would check the bit PGOOD and compare to the value 0. If it is different, <math>\overline{INT}</math> would be asserted. After PMU is on, once PGOOD bit toggles, <math>\overline{INT}</math> also asserts again.</p> |                |      |      |       |      |       |            |      | Input Status | PGOOD Bit Status | VIN < VUVLO | 0 | VUVLO < VIN < VBAT + VOS_L | 0 | VBAT + VOS_H < VIN < VOVP | 1 | VIN > VOVP | 0 |
| Input Status               | PGOOD Bit Status |  |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| VIN < VUVLO                | 0                |  |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| VUVLO < VIN < VBAT + VOS_L | 0                |  |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| VBAT + VOS_H < VIN < VOVP  | 1                |  |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |
| VIN > VOVP                 | 0                |  |                |      |      |       |      |       |            |      |              |                  |             |   |                            |   |                           |   |            |   |

|                   |   |
|-------------------|---|
| THR               | THR bit can be let user to monitor the thermal regulation function is working or not.   |
|                   | 0 : thermal Regulation is not working   |
|                   | 1 : thermal Regulation is working   |
|                   | Note : when PMU turn on, it would check the bit THR and compare to the value 0. If it is different, $\overline{INT}$ would be asserted. After PMU is on, once THR bit toggles, $\overline{INT}$ also asserts again.                             |
| $\overline{SAFE}$ | Charger safety timer status.  |
|                   | 0 : charger in charging or suspended by thermal loop  |
|                   | 1 : safety timer expired  |
|                   | Note : when PMU turn on, it would check the bit $\overline{SAFE}$ and compare to the value 0. If it is different, $\overline{INT}$ would be asserted. After PMU is on, once $\overline{SAFE}$ bit toggles, $\overline{INT}$ also asserts again. |

| Address Names | Register Address   | Bit7 (MSB)                 | Bit6          | Bit5 | Bit4        | Bit3   | Bit2     | Bit1     | Bit0 (LSB) |        |
|---------------|--|----------------------------|---------------|------|-------------|--|----------|----------|------------|--------|
| A11           | 0x0B   | Meaning                    | CHG_TYP [2:0] |      |             | Reserved   | Reserved | CHG_2DET | CHG_1DET   | CHGRUN |
|               |  | Default                    | 0             | 0    | 0           | x  | x        | 0        | 1          | 0      |
|               |  | Read/Write                 | R             | R    | R           | --   | --       | R/W      | R/W        | R      |
| CHG_TYP [2:0] | The CHG_TYP [2:0] is used to recode the charger type.  |                            |               |      |             |  |          |          |            |        |
|               | <b>Code</b>  | <b>Charger Type</b>        |               |      | <b>Code</b> | <b>Charger Type</b>                                    |          |          |            |        |
|               | 000  | Standard USB CHARGER (SDP) |               |      | 100         | APPLE CHARGER (1A)                                     |          |          |            |        |
|               | 001  | Sony CHARGER -1            |               |      | 111         | DEDICATED CHARGER (DCP)                                |          |          |            |        |
|               | 010  | Sony CHARGER -2            |               |      | 110         | Charging Downstream Port (CDP) (High current Host/Hub) |          |          |            |        |
| 011           | APPLE CHARGER (0.5A)   |                            |               |      |             |  |          |          |            |        |
| CHG_2DET      | The CHG_2DET bit is used to enable the secondary charger detection (to distinguish CDP and DCP). Default value is 0. Set this bit value to 1 in order to enable charger detection.   |                            |               |      |             |  |          |          |            |        |
|               | 0 : Secondary CHARGER DETECTION DISABLED   |                            |               |      |             |  |          |          |            |        |
|               | 1 : Secondary CHARGER DETECTION ENABLE.  |                            |               |      |             |  |          |          |            |        |
| CHG_1DET      | The CHG_1DET bit is used to enable the primary charger detection. Default value is 1 (auto-detect charger type when VIN plug in). Toggle this bit value (set to 0 and then set 1) to re-enable charger detection.                    |                            |               |      |             |  |          |          |            |        |
|               | 0 : Primary CHARGER DETECTION DISABLED.  |                            |               |      |             |  |          |          |            |        |
|               | 1 : Primary CHARGER DETECTION ENABLE.  |                            |               |      |             |  |          |          |            |        |
| CHGRUN        | The CHGRUN bit is the charger detector status bit. It means the charger detection is running or not.   |                            |               |      |             |  |          |          |            |        |
|               | 0 : CHARGER DETECTION NOT RUNNING.   |                            |               |      |             |  |          |          |            |        |
|               | 1 : CHARGER DETECTION RUNNING.   |                            |               |      |             |  |          |          |            |        |
|               | Note : when PMU turn on, it would check the bit CHGRUN and compare to the value 1. If it is different, $\overline{INT}$ would be asserted. After PMU is on, once CHGRUN bit change from 1 to 0, $\overline{INT}$ also asserts again. |                            |               |      |             |  |          |          |            |        |

| Address Name | Register Address | Bit7            | Bit6        | Bit5     | Bit4 | Bit3                     | Bit2        | Bit1  | Bit0  |       |
|--------------|------------------|-----------------|-------------|----------|------|--------------------------|-------------|-------|-------|-------|
| A0           | 0x00             | Meaning         | RST_P       | RST_C    | OVP7 | Reserved                 | ENDPM       | TSD   | MOD7  | TSSEL |
|              |                  | Default         | 1           | 0        | 0    | x                        | 0           | 0     | 0     | 1     |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | --                       | R/W         | R/W   | R     | R/W   |
|              |                  | Reset Condition | A           | A        | A    | G                        | A           | A     | H     | A     |
| A1           | 0x01             | Meaning         | ERR1        | ERR2     | ERR3 | ERR4                     | ERR5        | ERR6  | ERR7  | ERR8  |
|              |                  | Default         | 0           | 0        | 0    | 0                        | 0           | 0     | 0     | 0     |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | R/W                      | R/W         | R/W   | R/W   | R/W   |
|              |                  | Reset Condition | A           | A        | A    | A                        | A           | A     | A     | A     |
| A2           | 0x02             | Meaning         | EN5         | EN6      | EN8  | EN7_DIM7 [4:0]           |             |       |       |       |
|              |                  | Default         | 0           | 0        | 0    | 0                        | 0           | 0     | 0     | 0     |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | R/W                      | R/W         | R/W   | R/W   | R/W   |
|              |                  | Reset Condition | B           | B        | B    | B                        | B           | B     | B     | B     |
| A3           | 0x03             | Meaning         | PSM1        | PSM2     | PSM3 | PSM4                     | VOUT8 [3:0] |       |       |       |
|              |                  | Default         | 1           | 1        | 1    | 1                        | 1           | 1     | 0     | 0     |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | R/W                      | R/W         | R/W   | R/W   | R/W   |
|              |                  | Reset Condition | C           | C        | C    | C                        | C           | C     | C     | C     |
| A4           | 0x04             | Meaning         | VOUT1 [3:0] |          |      | EN1                      | FB2 [2:0]   |       |       |       |
|              |                  | Default         | 1           | 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   |
|              |                  | Reset Condition | C           | C        | C    | C                        | B           | C     | C     | C     |
| A5           | 0x05             | Meaning         | FLST        | FB3[2:0] |      | FLST2                    | FB4[2:0]    |       |       |       |
|              |                  | Default         | 1           | 1        | 0    | 0                        | 1           | 1     | 0     | 0     |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | R/W                      | R/W         | R/W   | R/W   | R/W   |
|              |                  | Reset Condition | C           | C        | C    | C                        | C           | C     | C     | C     |
| A6           | 0x06             | Meaning         | VOUT5 [3:0] |          |      | VOUT6 [3:0]              |             |       |       |       |
|              |                  | Default         | 1           | 0        | 0    | 0                        | 0           | 0     | 1     | 1     |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | R/W                      | R/W         | R/W   | R/W   | R/W   |
|              |                  | Reset Condition | C           | C        | C    | C                        | C           | C     | C     | C     |
| A7           | 0x07             | Meaning         | TIMER [3:0] |          |      | $\overline{\text{ENCH}}$ | USUS        | ISetu | ISetL |       |
|              |                  | Default         | 0           | 1        | 0    | 0                        | 0           | 0     | 0     |       |
|              |                  | Read/Write      | R/W         | R/W      | R/W  | R/W                      | R/W         | R/W   | R/W   |       |
|              |                  | Reset Condition | D           | D        | D    | D                        | D           | D     | D     |       |

| Address Name | Register Address | Bit7            | Bit6               | Bit5  | Bit4     | Bit3     | Bit2        | Bit1     | Bit0     |        |
|--------------|------------------|-----------------|--------------------|-------|----------|----------|-------------|----------|----------|--------|
| A8           | 0x08             | Meaning         | TSHT [1:0]         |       | Mask_DPM | CHG2STEN | ISETA [3:0] |          |          |        |
|              |                  | Default         | 0                  | 0     | 0        | 1        | 0           | 1        | 0        | 0      |
|              |                  | Read/Write      | R/W                | R/W   | R/W      | R/W      | R/W         | R/W      | R/W      | R/W    |
|              |                  | Reset Condition | D                  | D     | D        | D        | D           | D        | D        | D      |
| A9           | 0x09             | Meaning         | $\overline{JEITA}$ | VSETH | VSETC    | ISETH    | ISETC       | CHGSTEN  | INT      | DPM    |
|              |                  | Default         | 0                  | 0     | 0        | 0        | 0           | 1        | 0        | 0      |
|              |                  | Read/Write      | R/W                | R/W   | R/W      | R/W      | R/W         | R/W      | R/W      | R      |
|              |                  | Reset Condition | D                  | D     | D        | D        | D           | D        | D        | E      |
| A10          | 0x0A             | Meaning         | TS_METER [2:0]     |       |          | NoBAT    | EOC         | PGOOD    | THR      | SAFE   |
|              |                  | Default         | 0                  | 0     | 0        | 0        | 0           | 0        | 0        | 0      |
|              |                  | Read/Write      | R                  | R     | R        | R        | R           | R        | R        | R      |
|              |                  | Reset Condition | I                  | I     | I        | I        | J           | J        | J        | J      |
| A11          | 0x0B             | Meaning         | CHG_TYP [2:0]      |       |          | Reserved | Reserved    | CHG_2DET | CHG_1DET | CHGRUN |
|              |                  | Default         | 0                  | 0     | 0        | x        | x           | 0        | 1        | 0      |
|              |                  | Read/Write      | R                  | R     | R        | --       | --          | R/W      | R/W      | R      |
|              |                  | Reset Condition | K                  | K     | K        | G        | G           | F        | F        | L      |

I<sup>2</sup>C register reset condition :

- A. In addition to A0.bit 1 and A0.bit4, the bits of A0 and A1 (register 0x0, 0x1) reset only when (VRTC < 1.6V).
- B. The bits of A2 (register 0x2) and A4.bit3 reset when (EN pin = low) or (VDDI < 2.4V) or (BAT < 1.3V) or (Temperature > 125°C)
- C. In addition to A4.bit3, PMU settings (A3 to A6, register 0x3 to 0x6) reset when (EN pin = low and A0.RST\_P = 1) or (VDDI < 1.3V)

| VDDI < 1.3V         | EN pin | A0.RST_P bit   | ==> | Reset PMU Setting |
|---------------------|--------|----------------|-----|-------------------|
| TRUE                | x      | x (don't care) |     | Reset             |
| False (VDDI > 1.3V) | Low    | 1              |     | Reset             |
|                     | High   | 1              |     | Not reset         |
|                     | Low    | 0              |     | Not reset         |
|                     | High   | 0              |     | Not reset         |

- D. In addition to A9.bit 1, charger settings (A7 to A9, registers (0x7 to 0x9) reset when (VIN < 4V) or (VDDI < 1.3V) or ((BAT < 3.1V) and (A0.RST\_C = 1))

| VDDI < 1.3V         | VIN > 4V         | A0.RST_C bit | (BAT < 3.1V) | ==> | Reset Charger Setting |
|---------------------|------------------|--------------|--------------|-----|-----------------------|
| true (VDDI < 1.3V)  | x                | x            | x            |     | Reset                 |
| false (VDDI > 1.3V) | False (VIN < 4V) | x            | x            |     | Reset                 |
| false (VDDI > 1.3V) | True (VIN > 4V)  | 1            | TRUE         |     | Reset                 |
| false (VDDI > 1.3V) | True (VIN > 4V)  | 1            | FALSE        |     | Not reset             |
| false (VDDI > 1.3V) | True (VIN > 4V)  | 0            | TRUE         |     | Not reset             |
| false (VDDI > 1.3V) | True (VIN > 4V)  | 0            | FALSE        |     | Not reset             |

E. (EN pin = low) or (VDDI < 1.3V)

F. Charger type detection A11 (registers 0xB) reset when (VIN < 4V) or (VDDI < 1.3V)

G. Always reset.

H. A0.bit1 will be reset when (EN pin = low) or (VDDI < 2.4V) or (BAT < 1.3V) or (PMU protection occur) or (Temperature < 125°C).

I. A0.bit1 will be reset when (EN pin = low) or (VDDI < 2.4V) or (BAT < 1.3V) or (In addition to CH7 OVP, PMU protection occur) or (Temperature < 125°C).

J. Reference page-54 A10 explanation.

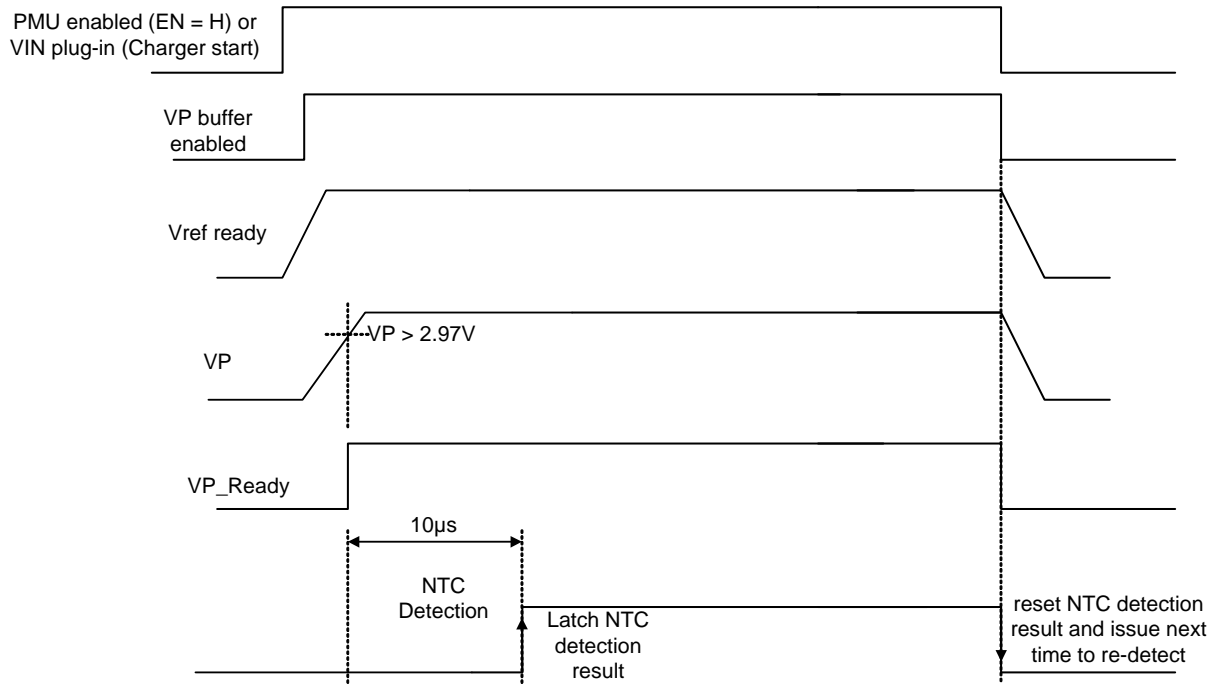
K. A11.bit7 to bit5 will be rewritten after charging type detects finish.

L. A11.bit0 keeps high during charging type detecting.

**CHG Signal Status**

| Charging Status  | CHG                          |                |              | CHG2                         |                |              |
|--|------------------------------|----------------|--------------|------------------------------|----------------|--------------|
|  | CHGSTEN = 1                  | CHGSTEN = 0    |              | CHG2STEN = 1                 | CHG2STEN = 0   |              |
|  |                              | A5. bit7 = 1   | A5. bit7 = 0 |                              | A5. bit3 = 1   | A5. bit3 = 0 |
| No Charging/Charging Finish  | High impedance (No flashing) | High impedance | Low          | High impedance (No flashing) | High impedance | Low          |
| Pre-Charge/Fast Charge   | 0.5Hz (2s)                   |                |              | Low                          |                |              |
| Abnormal (Fault timer timeout, in thermal regulation, battery too cold or too hot) | 4Hz (0.25s)                  |                |              | 4Hz(0.25s)                   |                |              |

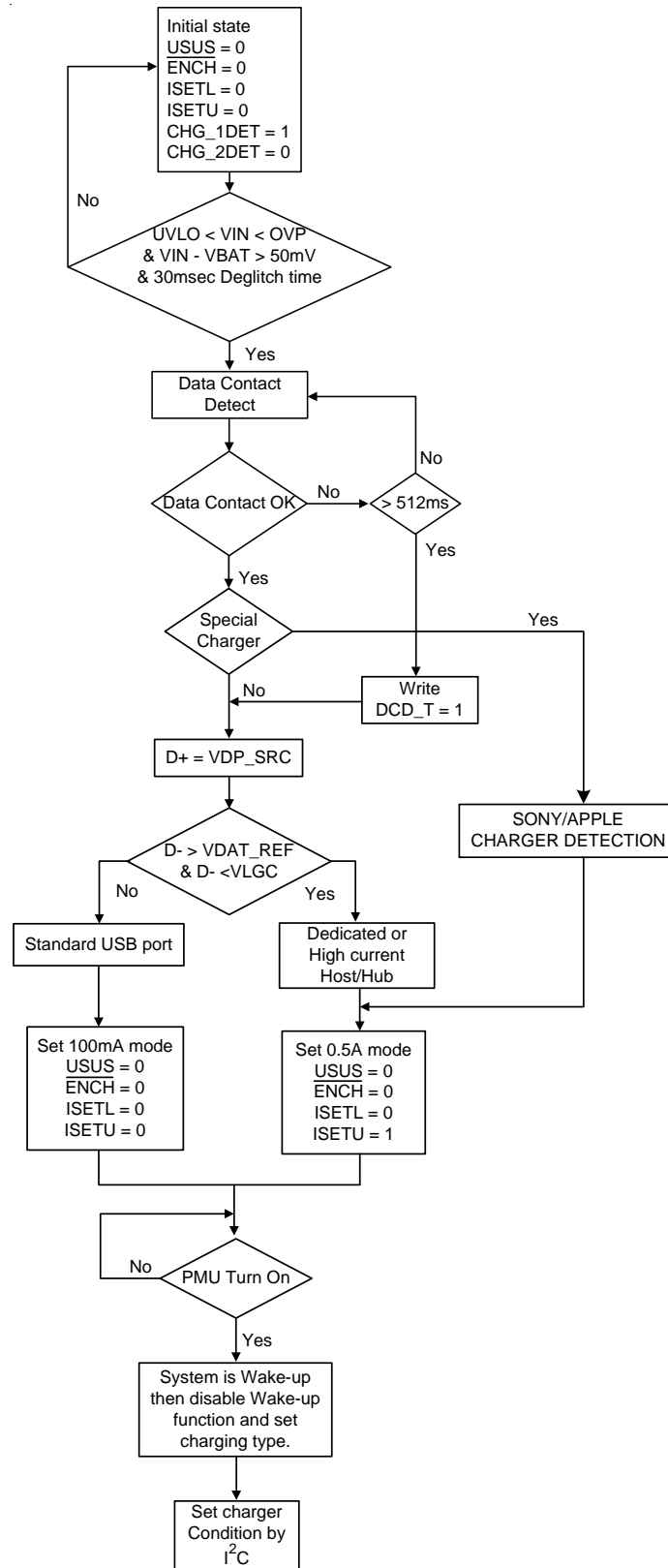
## NTC Thermistor Order Detection



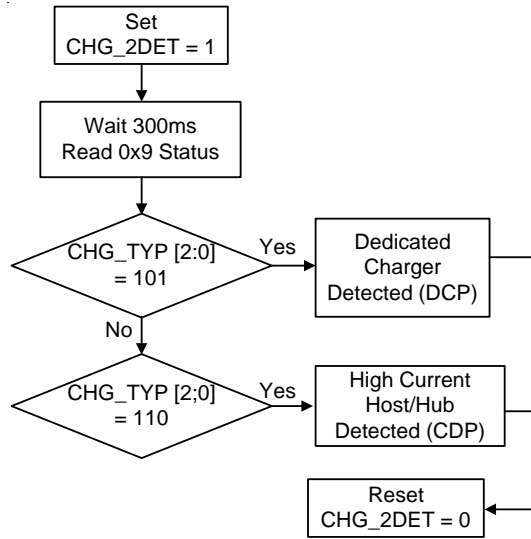


**USB Charger Detection**

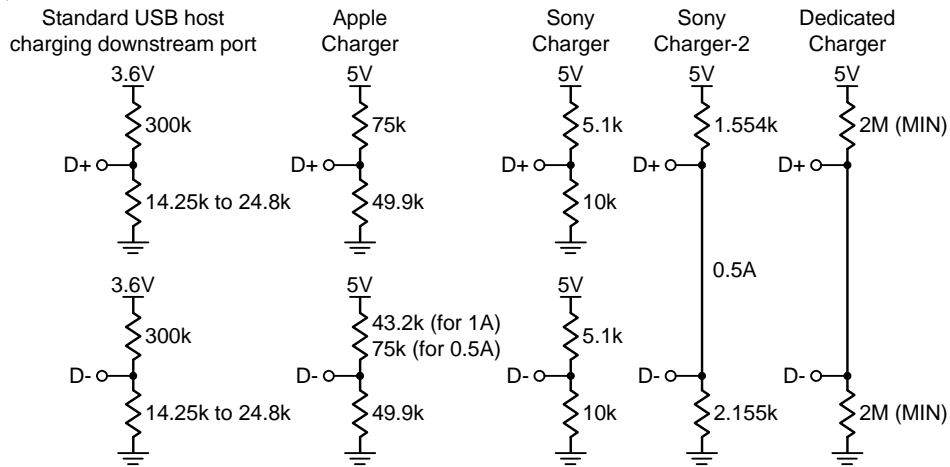
**Primary Charger Type Detection (CHG\_1DET) : Detection Time ≤ 200ms**



## Secondary Charger Type Detection (CHG\_2DET)



D+/D- impedance of Standard USB Host/Charging Downstream Port. Apple Charger, Sony Charger, and Dedicated Charger :



**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  $\theta_{JA}$  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,  $\theta_{JA}$ , is layout dependent. For WQFN-40L 5x5 package, the thermal resistance,  $\theta_{JA}$ , is 27.5°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by the following formula :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (27.5^\circ\text{C/W}) = 3.64\text{W for WQFN-40L 5x5 package}$$

The maximum power dissipation depends on the operating ambient temperature for fixed  $T_{J(MAX)}$  and thermal resistance,  $\theta_{JA}$ . The derating curve in Figure 6 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

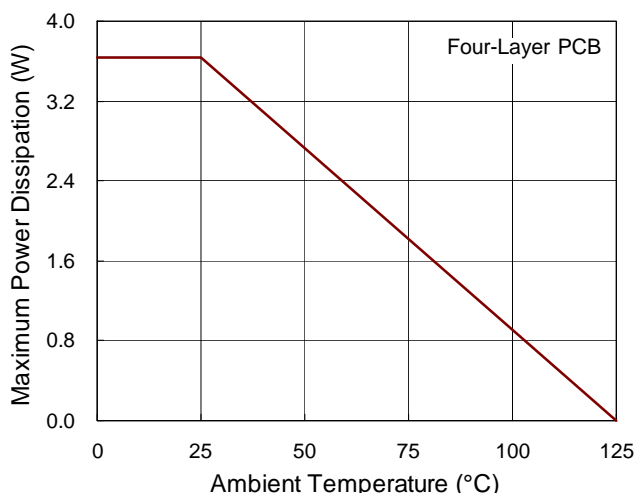


Figure 6. Derating Curve of Maximum Power Dissipation

**Layout Consideration**

For the best performance of the RT5021, the following PCB layout guidelines must be strictly followed.

- ▶ Place the input and output capacitors as close as possible to the input and output pins respectively for good filtering.
- ▶ Keep the main power traces as wide and short as possible.
- ▶ The switching node area connected to LX and inductor should be minimized for lower EMI.
- ▶ Place the feedback components as close as possible to the FB pin and keep these components away from the noisy devices.
- ▶ Connect the GND and Exposed Pad to a strong ground plane for maximum thermal dissipation and noise protection.
- ▶ To make CH1 and whole chip stable, the power path from the PVD1 pin to its output capacitors must be as short ( $\leq 1\text{mm}$  is better) and wide as possible.
- ▶ To make CH4 and CH5 stable, the power path from the PVD45 pin to its input capacitors must be as short ( $\leq 1\text{mm}$  is better) and wide as possible.

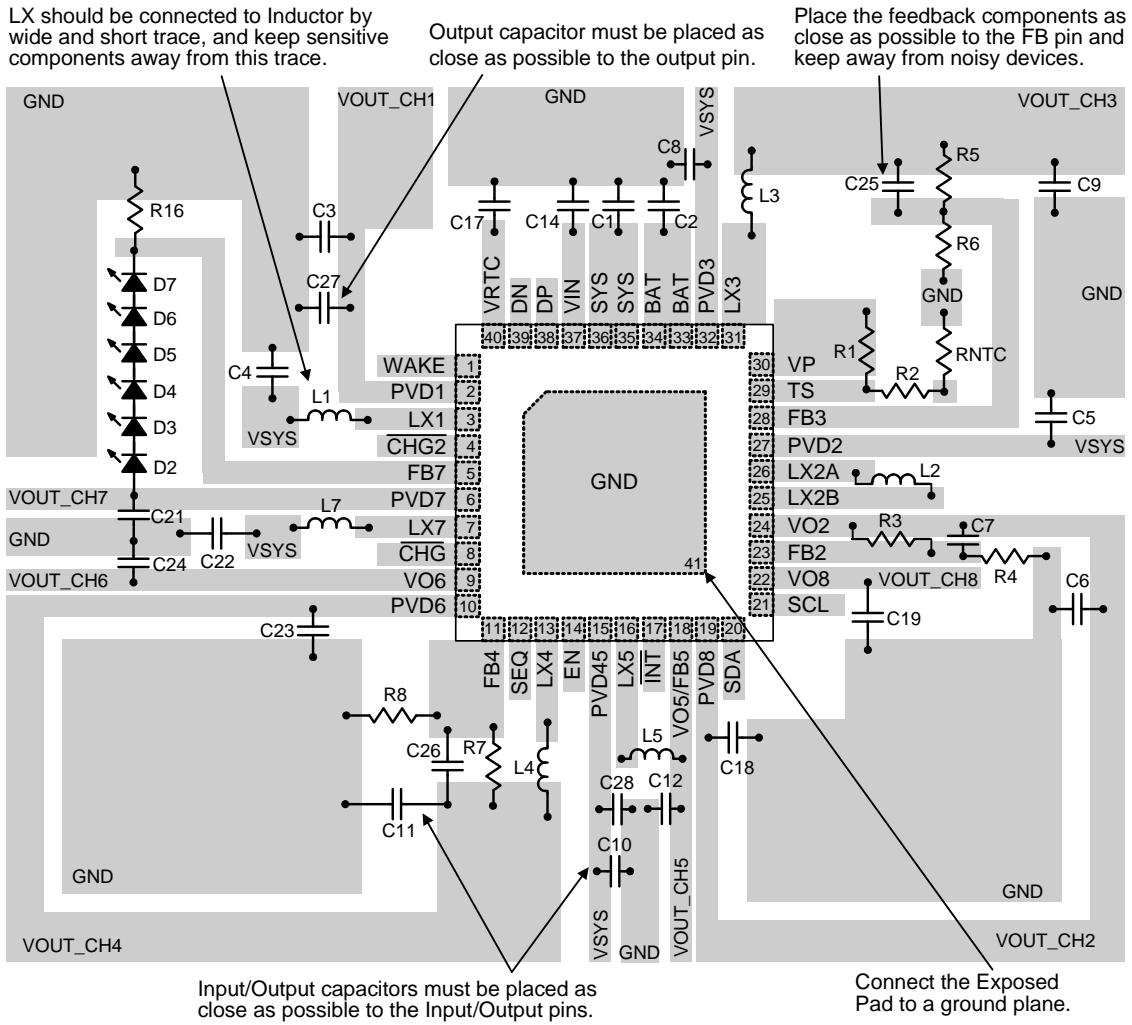
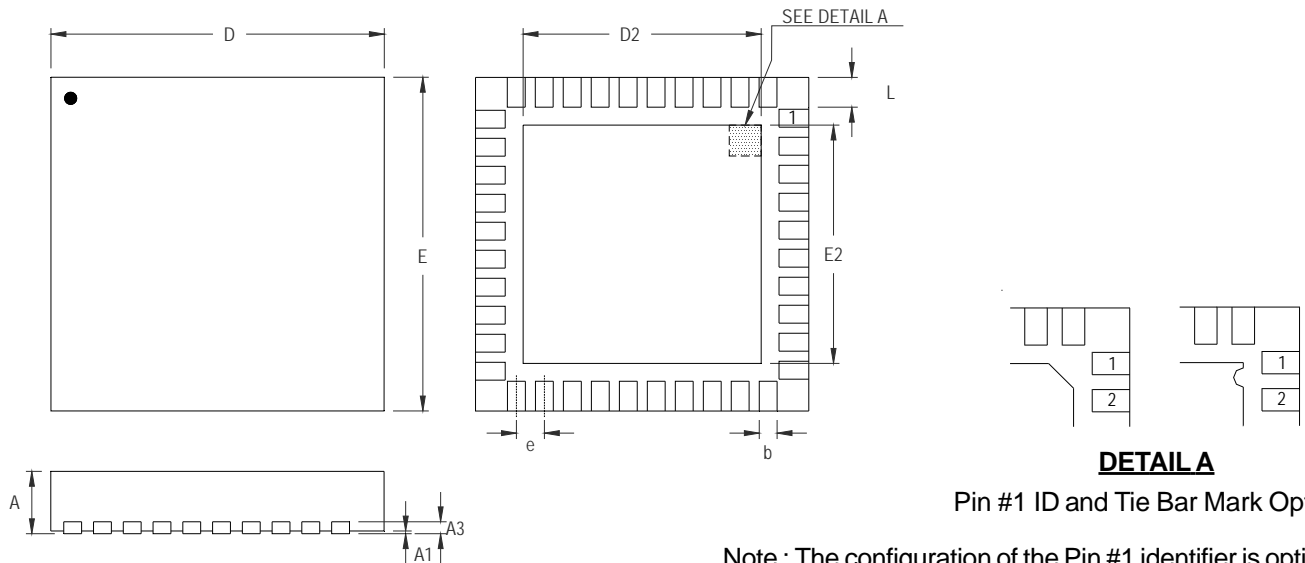


Figure 7. PCB Layout Guide

|                  | Protection Type     | Threshold (Typical) Refer to Electrical Spec.                           | Protection Methods   | PMU Shutdown Delay Time | Reset Method                              |
|------------------|---------------------|---|--|-------------------------|---|
| SYS              | UVLO                | SYS < 1.5V  | PMU Shutdown.  | No-delay                | EN1234 pin set to low or SYS > 2.1V       |
| VDDI             | OVP                 | VDDM > 6V   | Automatic reset at VDDM < 5.85V                                  | 100ms                   | VDDI power reset or EN1234 pin set to low |
|                  | UVLO                | VDDM < 2.4V   | PMU Shutdown.  | No-delay                | VDDI power reset or EN1234 pin set to low |
| CH1 Step-Up      | Current Limit       | N-MOSFET peak current > 3A  | N-MOSFET off, P-MOSFET off. Automatic reset at next clock cycle. | 100ms                   | VDDI power reset or EN1234 pin set to low |
|                  | PVD1 OVP            | PVDD1 > 6V  | N-MOSFET off, P-MOSFET off.                                      | No-delay                | VDDI power reset or EN1234 pin set to low |
|                  | PVD1 UVP --1        | PVDD1 < (VSYS – 0.8V) or PVDD1 < 1.28V after soft-start end.            | N-MOSFET off, P-MOSFET off.                                      | 100ms                   | VDDI power reset or EN1234 pin set to low |
|                  | PVD1 UVP --2        | After pre-charge (PVD1 UVP-2 : FB1 < 0.4V after pre-charge)             | N-MOSFET off, P-MOSFET off                                       | No-delay                | VDDI power reset or EN1234 pin set to low |
|                  | PVD1 Over Load (OL) | Target – 0.6V Target Voltage is defined in A4.VOUT1 [3:0]               | PMU Shutdown when OL occur each cycle until 100ms.               | 100ms                   | VDDI power reset or EN1234 pin set to low |
| CH2 Step-Up/Down | Current limit       | Both P-MOSFET (PVD2 – LX2A) and N-MOSFET (LX2B – GND) peak current > 2A | N-MOSFET off, P-MOSFET off. Automatic reset at next clock cycle. | 100ms                   | VDDI power reset or EN1234 pin set to low |
|                  | VO2 OVP             | PVDD1 > 6V  | N-MOSFET off, P-MOSFET off.                                      | No-delay                | VDDI power reset or EN1234 pin set to low |
|                  | FB2 UVP             | FB2 < 0.4V after soft-start end.  | N-MOSFET off, P-MOSFET off.                                      | No-delay                | VDDI power reset or EN1234 pin set to low |
|                  | FB2 Over Load       | Target – 0.1V (Target voltage is the chosen one in A4.FB2 [2:0])        | PMU Shutdown when OL occur each cycle until 100ms.               | 100ms                   | VDDI power reset or EN1234 pin set to low |
| CH3 Step-Down    | Current limit       | P-MOSFET peak current > 1.8A  | N-MOSFET off, P-MOSFET off. Automatic reset at next clock cycle. | 100ms                   | VDDI power reset or EN1234 pin set to low |
|                  | FB3 UVP             | FB3 < 0.4V after soft-start end.  | N-MOSFET off, P-MOSFET off.                                      | No-delay                | VDDI power reset or EN1234 pin set to low |
|                  | FB3 Over Load       | Target – 0.1V (Target voltage is the chosen one in A5.FB3 [2:0])        | PMU Shutdown when OL occur each cycle until 100ms.               | 100ms                   | VDDI power reset or EN1234 pin set to low |

|   | Protection Type                     | Threshold (Typical)<br>Refer to Electrical Spec.                       | Protection Methods   | PMU Shutdown Delay Time | Reset Method  |
|---|-------------------------------------|--|--|-------------------------|---|
| CH4<br>Step-Down  | Current limit                       | P-MOSFET peak current > 1.8A   | N-MOSFET off, P-MOSFET off. Automatic reset at next clock cycle. | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
|   | FB4 UVP                             | FB4 < 0.4V after soft-start end.                                       | N-MOSFET off, P-MOSFET off.                                      | No-delay                | VDDI power reset or EN1234 pin set to low                             |
|   | FB4 Over Load                       | Target – 0.1V (Target voltage is the chosen one in A5.FB4 [2:0])       | PMU Shutdown when OL occur each cycle until 100ms.               | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
| CH5<br>Step-Down  | Current limit                       | P-MOSFET peak current > 1.5A   | N-MOSFET off, P-MOSFET off. Automatic reset at next clock cycle. | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
|   | VO5 UVP                             | PVD5 UVP : FB5 < 0.4V after soft-start end                             | N-MOSFET off, P-MOSFET off.                                      | No-delay                | VDDI power reset or EN1234 pin set to low                             |
|   | VO5 Over Load                       | Target voltage is the chosen one in A6.VOUT5 [3:0] = 0000 (FB5 = 0.8V) | PMU Shutdown when OL occur each cycle until 100ms.               | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
| Target voltage is the chosen one in A6.VOUT5 [3:0] = 0001 to 0111 |                                     |  |  |                         |   |
| Target voltage is the chosen one in A6.VOUT5 [3:0] = 0111 to 1111 |                                     |  |  |                         |   |
| CH6 LDO   | Max. output current (current limit) | P-MOSFET current > 0.45A (PVD6 = 1.5V, VO6 = 1.3V)                     | P-MOSFET off.  | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
| CH7<br>WLED   | Current limit (Step-Up mode)        | N-MOSFET current > 0.8A  | N-MOSFET off, P-MOSFET off. Automatic reset at next clock cycle. | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
|   | PVDD7 OVP                           | PVDD7 > 16V (A0.OVP7 = 0)  | N-MOSFET off, P-MOSFET off. Shutdown CH7 by self                 | No-delay                | VDDI power reset and A2.EN7_DIM7 [4:0] reset or EN1234 pin set to low |
| PVDD7 > 25V (A0.OVP7 = 1)   |                                     |  |  |                         |   |
| CH8 LDO   | Max. output current (current limit) | P-MOSFET current > 0.45A (PVD6 = 3V, VO6 = 2.5V)                       | P-MOSFET off.  | 100ms                   | VDDI power reset or EN1234 pin set to low                             |
| Thermal   | Thermal shutdown                    | Temperature > 155°C  | All channels stop switching                                      | No-delay                | Temperature < (155 – 20)°C  |
| VIN   | VIN UVLO                            | VIN < 3.3V   | No-charge  | No-delay                | No latch  |
|   | VIN OVP                             | VIN > 6.5V   | No-charge  | No-delay                | No latch  |

**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      | 4.950                     | 5.050 | 0.195                | 0.199 |
| D2     | 3.250                     | 3.500 | 0.128                | 0.138 |
| E      | 4.950                     | 5.050 | 0.195                | 0.199 |
| E2     | 3.250                     | 3.500 | 0.128                | 0.138 |
| e      | 0.400                     |       | 0.016                |       |
| L      | 0.350                     | 0.450 | 0.014                | 0.018 |

**W-Type 40L QFN 5x5 Package**

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