# Linear Single Cell Li-Ion Battery Charger IC

## General Description

The RP1553 is a fully integrated low cost single-cell Li-Ion battery charger IC ideal for portable applications. The RP1553 is capable of being powered up from AC adapter. The RP1553 enters sleep mode when AC adapter is removed.

The RP1553 optimizes the charging task by using a control algorithm including preconditioning mode, fast charge mode and constant voltage mode. The charging task is terminated as the charge current drops below the preset threshold. The AC adapter charge current can be programmed up to 1A with an external resister. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures.

The RP1553 features 18V maximum rating voltages for AC adapter. The other features are under voltage protection, over voltage protection for AC adapter supply and battery temperature monitoring.

## Features

- **18V Maximum Rating for AC Adapter**
- **Internal Integrate P-MOSFETs**
- **AC Adapter Power Good Status Indicator**
- **Charge Status Indicator**
- **Under Voltage Protection**
- **Over Voltage Protection**
- **Automatic Recharge Feature**
- **Battery Temperature Monitoring**
- **Small 10-Lead WDFN Package**
- **Thermal Feedback Optimizing Charge Rate**
- **RoHS Compliant and 100% Lead (Pb)-Free**

## Applications

- Digital Cameras
- Cellular Phones
- Personal Data Assistants (PDAs)
- MP3 Players
- Hand Held PCs

## Ordering Information

RP1553□ □

- □ : Package Type
  QW : WDFN-10L 3x3 (W-Type)
- □ : Operating Temperature Range
  G : Green (Halogen Free with Commercial Standard)

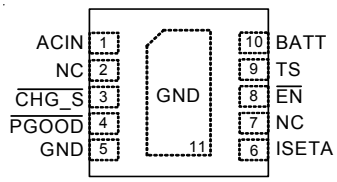
Note :

Richpower Green products are :

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

## Pin Configurations

(TOP VIEW)

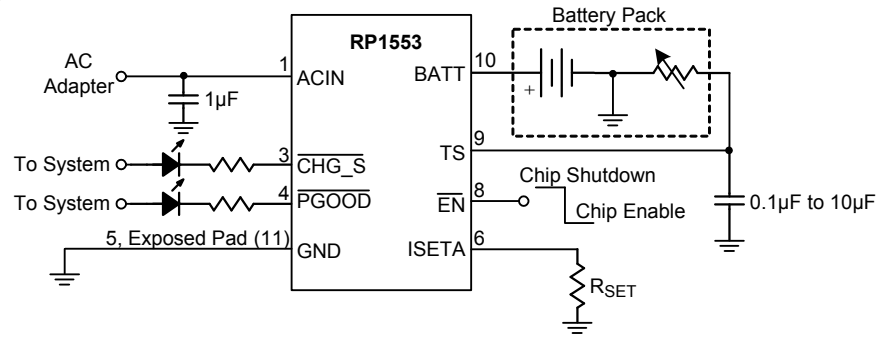


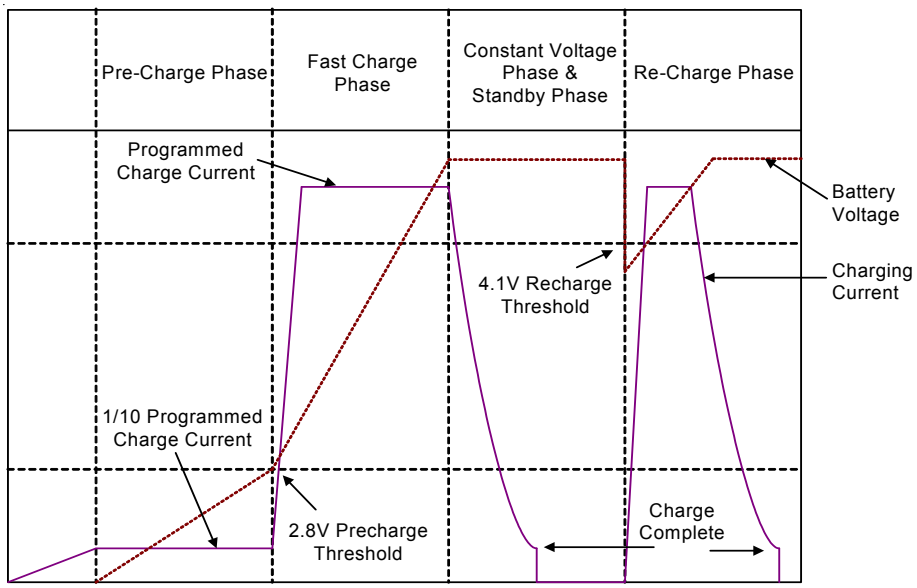

WDFN-10L 3x3

## Marking Information

For marking information, contact our sales representative directly or through a Richpower distributor located in your area, otherwise visit our website for detail.

## Typical Application Circuit

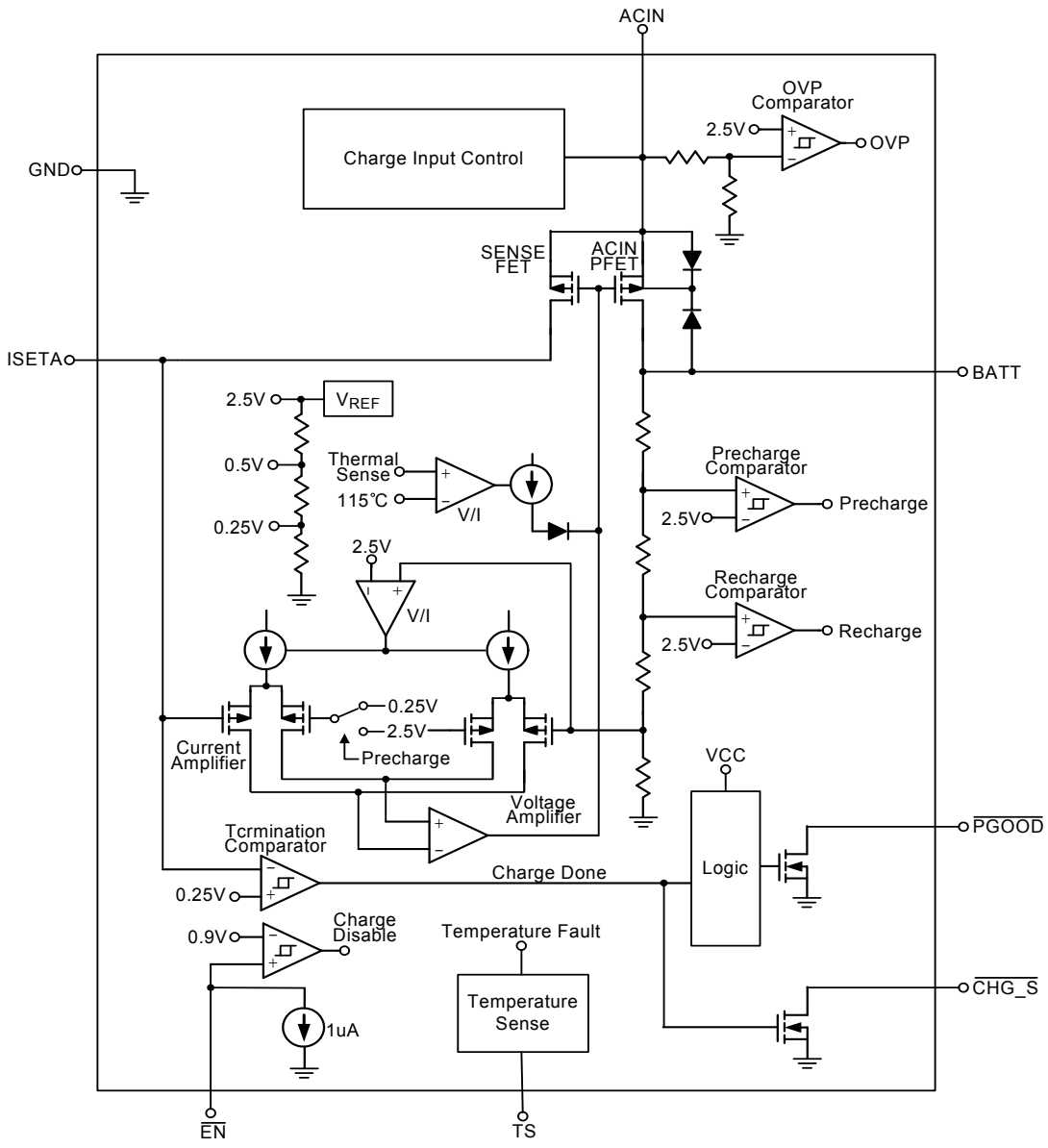


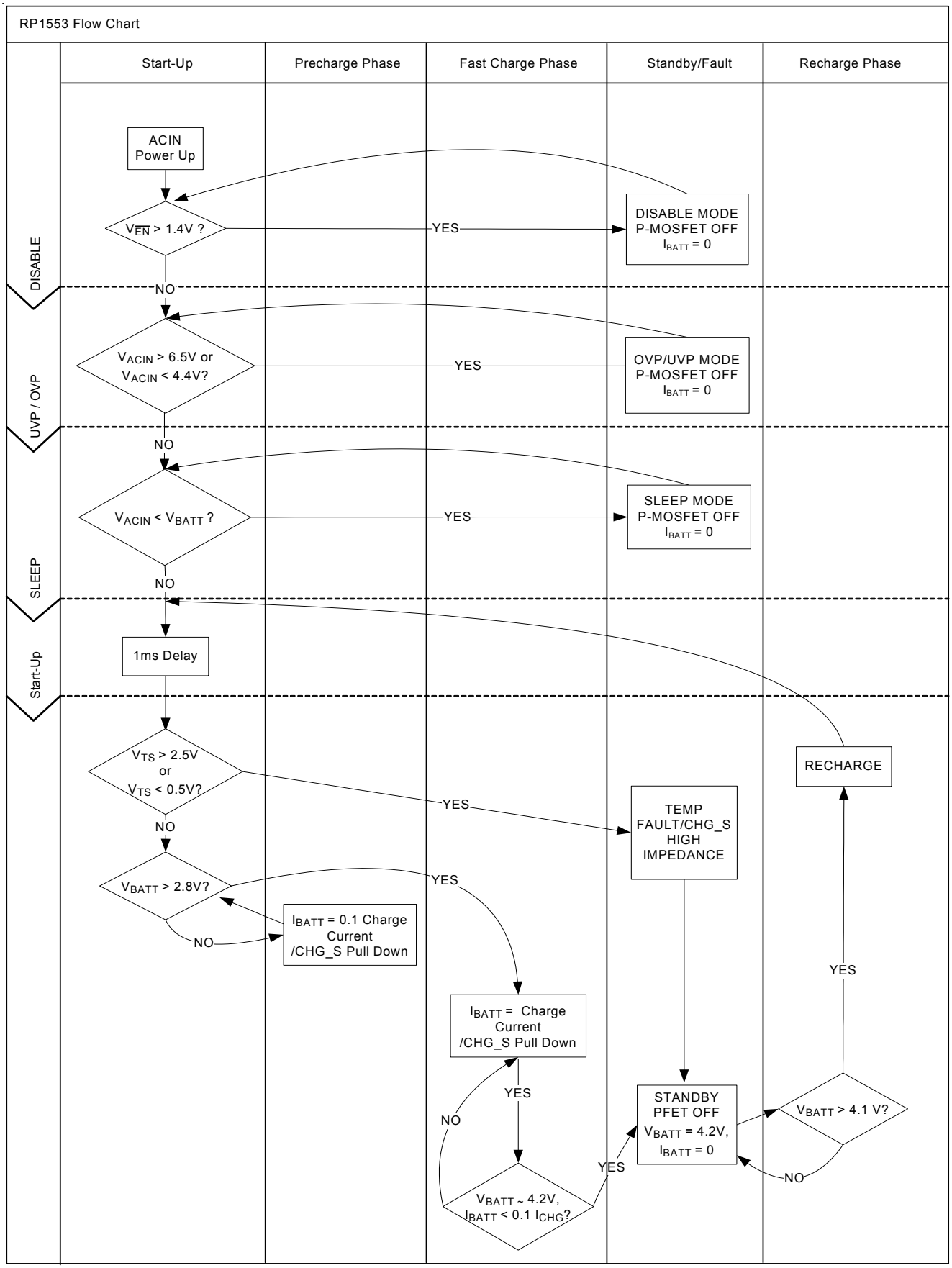

## Functional Pin Description

| Pin No. | Pin Name | Pin Function |
|---|---|---|
| 1 | ACIN | Wall Adaptor Charge Input Supply. |
| 2, 7 | NC | No Internal Connection. |
| 3 | $\overline{\text{CHG\_S}}$ | Charge Status Indicator Output (open drain). |
| 4 | $\overline{\text{PGOOD}}$ | Power Good Indicator Output (open drain). |
| 5 | GND | Ground. |
| 6 | ISETA | Wall Adaptor Supply Charge Current Set Point. |
| 8 | $\overline{\text{EN}}$ | Charge Enable Input (active low). |
| 9 | TS | Temperature Sense Input. |
| 10 | BATT | Battery Charge Current Output. |
| 11 (Exposed Pad) | GND | Exposed pad should be soldered to PCB board and connected to GND. |

## Function Block Diagram



**Table**


RP1553 Flow Chart
Start-Up
Precharge Phase
Fast Charge Phase
Standby/Fault
Recharge Phase
DISABLE
UVP / OVP
SLEEP
Start-Up
ACIN Power Up
VEN > 1.4V ?
YES
NO
DISABLE MODE P-MOSFET OFF IBATT = 0
VACIN > 6.5V or VACIN < 4.4V?
YES
NO
OVP/UVP MODE P-MOSFET OFF IBATT = 0
VACIN < VBATT ?
YES
NO
SLEEP MODE P-MOSFET OFF IBATT = 0
1ms Delay
VTS > 2.5V or VTS < 0.5V?
YES
NO
TEMP FAULT/CHG_S HIGH IMPEDANCE
VBATT > 2.8V?
YES
NO
IBATT = 0.1 Charge Current /CHG_S Pull Down
IBATT = Charge Current /CHG_S Pull Down
YES
NO
VBATT ~ 4.2V, IBATT < 0.1 ICHG?
YES
NO
STANDBY PFET OFF VBATT = 4.2V, IBATT = 0
VBATT > 4.1 V?
YES
NO
RECHARGE

## Absolute Maximum Ratings (Note 1)

- ACIN Input Voltage ---------- –0.3V to 18V
- $\overline{EN}$ Input Voltage ---------- –0.3V to 6V
- Output Current ---------- 1.2A
- Power Dissipation, $P_D$ @ $T_A$ = 25°C
  WDFN-10L 3x3 ---------- 0.926W
- Package Thermal Resistance (Note 4)
  WDFN-10L 3x3, $\theta_{JA}$ ---------- 108°C/W
  WDFN-10L 3x3, $\theta_{JC}$ ---------- 8.2°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 2)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

## Recommended Operating Conditions (Note 3)

- ACIN Input Voltage Range ---------- 4.5V to 6V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

## Electrical Characteristics

(ACIN = 5V, $T_A$ = 27°C, Unless Otherwise specification)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **Supply Input** | | | | | | |
| ACIN UVP Rising Threshold Voltage | $V_{UV\_HIGH}$ | | -- | 4.4 | 4.5 | V |
| ACIN UVP Hysteresis | $V_{UV\_LOW}$ | | 50 | 80 | 120 | mV |
| ACIN Standby Current | $I_{STBY}$ | $V_{BATT}$ = 4.5V | -- | 300 | 500 | μA |
| ACIN Shutdown Current | $I_{SHDN}$ | $V_{\overline{EN}}$ = HIGH | -- | 50 | 100 | μA |
| ACIN UVP Current | $I_{UVP}$ | $V_{ACIN}$ = 4V, $V_{USB}$ = 4V, $V_{BATT}$ = 3V | -- | 150 | 250 | μA |
| BATT Sleep Leakage Current | $I_{SLEEP}$ | $V_{ACIN}$ = 4V, $V_{USB}$ = 4V, $V_{BATT}$ = 4.5V | -- | 2 | 5 | μA |
| **Voltage Regulation** | | | | | | |
| BATT Regulation Voltage | $V_{REG}$ | $I_{BATT}$ = 60mA | 4.158 | 4.2 | 4.242 | V |
| Regulation Voltage Accuracy | | | –1 | – | +1 | % |
| ACIN MOSFET | $R_{DS(ON)\_ACIN}$ | $I_{BATT}$ = 500mA | -- | 600 | -- | mΩ |
| **Current Regulation** | | | | | | |
| ISETA Set Voltage (Fast Charge Phase) | $V_{ISETA}$ | $V_{BATT}$ = 3.5V | 2.45 | 2.5 | 2.55 | V |
| Full Charge Setting Range | $I_{CHG\_AC}$ | | 100 | – | 1200 | mA |
| ACIN Charge Current accuracy | $I_{CHG\_AC}$ | $V_{BATT}$ = 3.8V, $R_{ISET}$ = 1.5kΩ | -- | 500 | -- | mA |

*To be continued*

| Parameter | | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **Precharge** | | | | | | | |
| BATT Pre-Charge Rising Threshold | | $V_{PRECH}$ | | 2.6 | 2.8 | 3 | V |
| BATT Pre-Charge Threshold Hysteresis | | $\Delta V_{PRECH}$ | | 50 | 100 | 200 | mV |
| Pre-Charge Current | | $I_{PCHG}$ | $V_{BATT}$ = 2V | 8 | 10 | 12 | % |
| **Recharge Threshold** | | | | | | | |
| BATT Re-Charge Falling Threshold Hysteresis | | $\Delta V_{RECH\_L}$ | $V_{REG} - V_{BATT}$ | 60 | 100 | 150 | mV |
| **Charge Termination Detection** | | | | | | | |
| ISETA Charge Termination Set Voltage | | $V_{TERM}$ | $V_{BATT}$ = 4.2V | 225 | 250 | 275 | mV |
| Termination Current Ratio (default) | | $I_{TERM}$ | $V_{BATT}$ = 4.2V | -- | 10 | -- | % |
| **Logic Input/Output** | | | | | | | |
| $\overline{CHG\_S}$ Pull Down Voltage | | $V_{\overline{CHG\_S}}$ | TBD, $I_{\overline{CHG\_S}}$ = 5mA | -- | 65 | -- | mV |
| $\overline{PGOOD}$ Pull Down Voltage | | $V_{\overline{PGOOD}}$ | TBD, $I_{\overline{PGOOD}}$ = 5mA | -- | 220 | -- | mV |
| $\overline{EN}$ Threshold | Logic-High Voltage | $V_{IH}$ | | 1.5 | -- | -- | V |
| | Logic-Low Voltage | $V_{IL}$ | | -- | -- | 0.4 | V |
| $\overline{EN}$ Pin Input Current | | $I_{\overline{EN}}$ | $V_{\overline{EN}}$ = 2V | -- | -- | 2 | µA |
| **Battery Temperature Sense** | | | | | | | |
| TS Pin Source Current | | $I_{TS}$ | $V_{TS}$ = 1.5V | 96 | 102 | 108 | µA |
| TS Pin Threshold | Low Voltage | $V_{TS\_LOW}$ | Falling | 0.485 | 0.5 | 0.515 | V |
| | High Voltage | $V_{TS\_HIGH}$ | Rising | 2.45 | 2.5 | 2.55 | V |
| **Protection** | | | | | | | |
| Thermal Regulation | | | | -- | 125 | -- | °C |
| OVP SET | | | Internal Default | -- | 6.5 | -- | V |

**Note 1.** Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 for extended periods may remain possibility to affect device reliability.

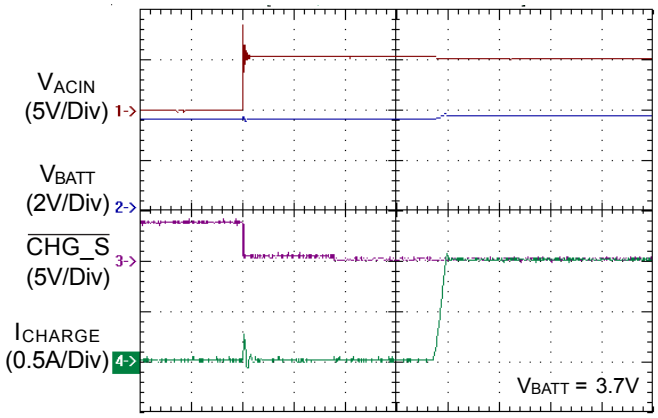
**Note 2.** Devices are ESD sensitive. Handling precaution is recommended.

**Note 3.** The device is not guaranteed to function outside its operating conditions.

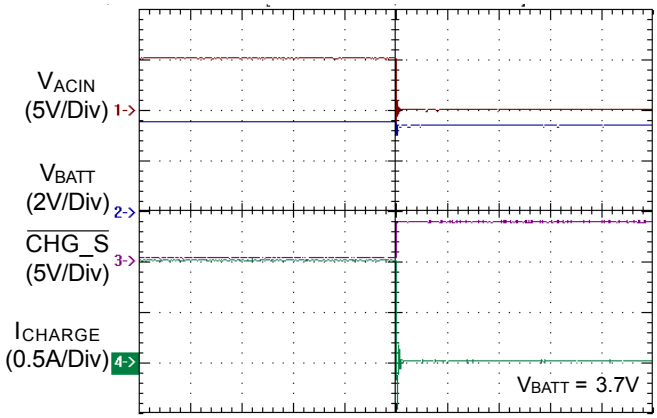
**Note 4.** $\theta_{JA}$ is measured in the natural convection at $T_A$ = 25°C on a high effective thermal conductivity test board (4 layers, 1S) of JEDEC 51-7 thermal measurement standard. The case point of $\theta_{JC}$ is on the expose pad for the WDFN package.

## Typical Operating Characteristics

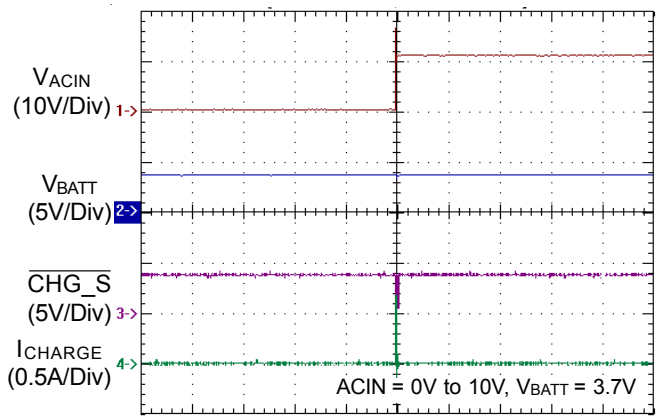
### ACIN Power On



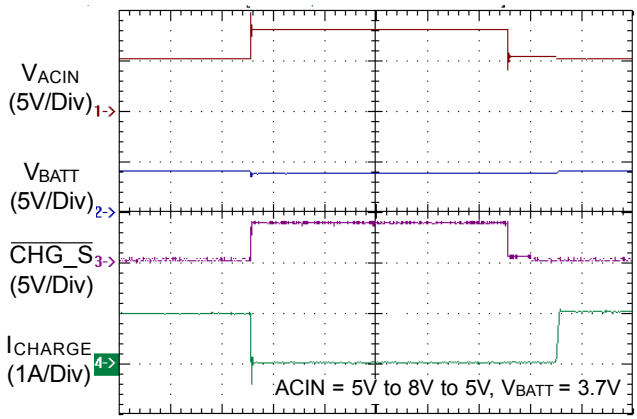

### ACIN Power Off



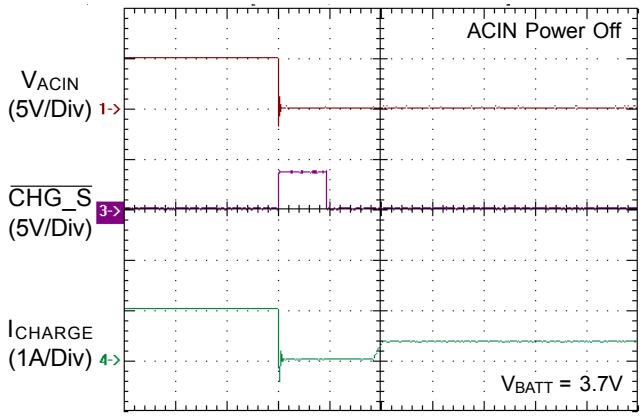

### ACIN OVP



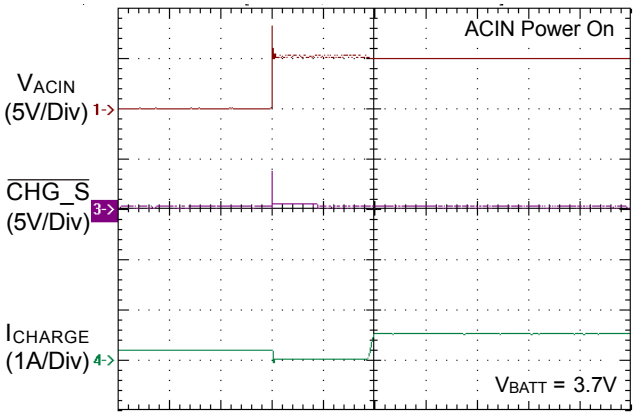

### ACIN OVP




### Input Voltage Transition




### Input Voltage Transition



## Application Information

### Automatically Power Source Selection

The RP1553 is a battery charger IC which is designed for Li-ion Battery with 4.2V rated voltage.

ACIN Mode : When the ACIN input voltage is higher than the UVP voltage level (4.4V), the RP1553 will turn on ACIN P-MOSFET.

Sleep Mode : The RP1553 will enter Sleep Mode when ACIN input voltage are removed. This feature provides low leakage current from the battery during the absence of input supply.

### ACIN Over Voltage Protection

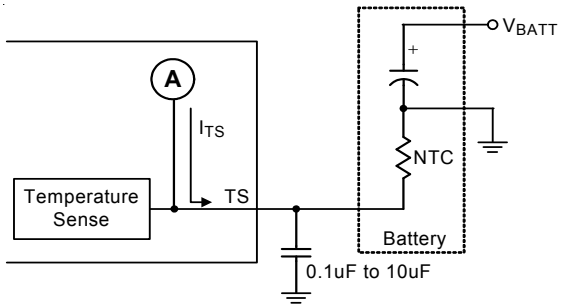
The ACIN input voltage is monitored by an internal OVP comparator. The comparator has an accurate reference of 2.5V from the band-gap reference. The OVP threshold is set by the internal resistive. The protection threshold is set to 6.5V. When the input voltage exceeds the threshold, the comparator outputs a logic signal to turn off the power P-MOSFET to prevent the high input voltage from damaging the electronics in the handheld system. When the input over oltage condition is removed (ACIN < 6V), the comparator re-enables the output by running through the soft-start.

### Battery Temperature Monitoring

The RP1553 continuously monitors battery temperature by measuring the voltage between the TS and GND pins. The RP1553 has an internal current source to provide the bias for the most common 10kΩ negative-temperature coefficient thermal resistor (NTC) (see Figure 1). The RP1553 compares the voltage on the TS pin against the internal VTS_HIGH and VTS_LOW thresholds to determine if charging is allowed.

When the temperature outside the VTS_HIGH and VTS_LOW thresholds is detected, the device will immediately stop the charge. The RP1553 stops charge and keep monitoring the battery temperature when the temperature sense input voltage is back to the threshold between VTS_HIGH and VTS_LOW, the charger will be resumed. Charge is resumed when the temperature returns to the normal range. However the user may modify thresholds by the negative-temperature coefficient thermal resistor or adding two external resistors. (see Figure 2.)

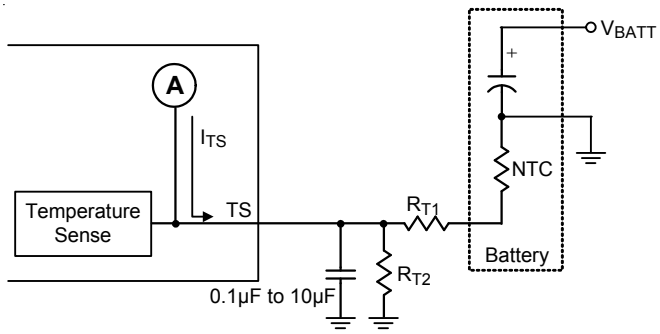
The capacitor should be placed close to TS(Pin 9) and connected to the ground plane. The capacitance value (0.1μF to 10μF) should be selected according to the quality of PCB layout. It is recommended to use 10μF if the layout is poor if prevent noise.




$V_{TS} = I_{TS} \times R_{NTC}$

Turn off when $V_{TS} \geq 2.5V$ or $V_{TS} \leq 0.5V$

Figure 1. Temperature Sensing Configuration




$$V_{TS} = I_{TS} \frac{R_{T2} \times (R_{T1} + R_{NTC})}{R_{T1} + R_{T2} + R_{NTC}}$$

Turn off when $V_{TS} \geq 2.5V$ or $V_{TS} \leq 0.5V$

Figure 2. Temperature Sensing Circuit

### Fast-Charge Current Setting

The RP1553 offers ISETA pin to determine the ACIN charge rate from 100mA to 1.2A. The charge current can be calculated as following equation.

$$I_{charge\_ac} = K_{SET} \frac{V_{SET}}{R_{SETA}}$$

The parameter $K_{SET}$ = 300 ; $V_{SET}$ = 2.5V. $R_{SETA}$ is the resistor connected between the ISETA and GND.

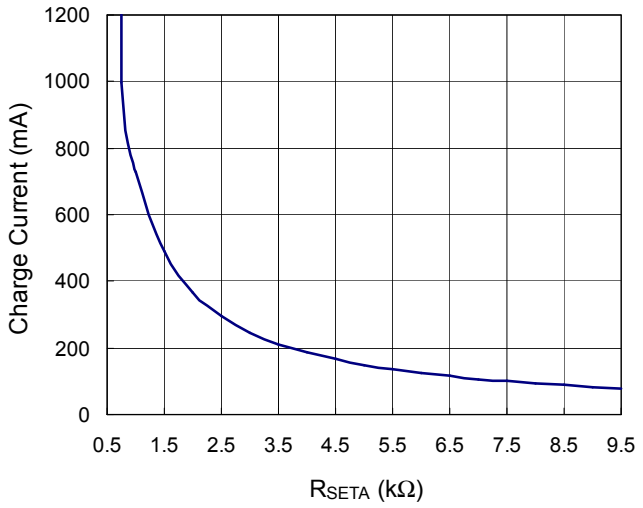



Figure 3. ACIN Mode Charge Current Setting

### Pre- Charge Current Setting

During a charge cycle if the battery voltage is below the VPRECH threshold, the RP1553 applies a pre-charge mode to the battery. This feature revives deeply discharged cells and protects battery life. The RP1553 internal determines the pre-charge rate as 10% of the fast-charge current.

### Battery Voltage Regulation

The RP1553 monitors the battery voltage through the BATT pin. Once the battery voltage level closes to the VREG threshold, the RP1553 voltage enters constant phase and the charging current begins to taper down. When battery voltage is over the VREG threshold, the RP1553 will stop charge and keep to monitor the battery voltage. However, when the battery voltage decreases 100mV below the $V_{REG}$, it will be recharged to keep the battery voltage.

### Charge Status Outputs

The open-drain $\overline{\text{CHG\_S}}$ and $\overline{\text{PGOOD}}$ outputs indicate various charger operations as shown in the following table.

These status pins can be used to drive LEDs or communicate to the host processor. Note that ON indicates the open-drain transistor is turned on and LED is bright.

| Charge State | | $\overline{\text{CHG\_S}}$ | $\overline{\text{PGOOD}}$ |
|---|---|---|---|
| ACIN | Charge | ON | ON |
| | Charge done | OFF | ON |

### Temperature Regulation and Thermal Protection

In order to maximize the charge rate, the RP1553 features a junction temperature regulation loop. If the power dissipation of the IC results in a junction temperature greater than the thermal regulation threshold (125°C), the RP1553 throttles back on the charge current in order to maintain a junction temperature around the thermal regulation threshold (125°C). The RP1553 monitors the junction temperature, $T_J$, of the die and disconnects the battery from the input if $T_J$ exceeds 125°C. This operation continues until junction temperature falls below thermal regulation threshold (125°C) by the hysteresis level. This feature prevents the chip from damage.

### Selecting the Input and Output Capacitors

In most applications, the most important is the high-frequency decoupling capacitor on the input of the RP1553. A 1μF ceramic capacitor, placed in close proximity to input pin and GND pin is recommended. In some applications depending on the power supply characteristics and cable length, it may be necessary to add an additional 10μF ceramic capacitor to the input. The RP1553 requires a small output capacitor for loop stability. A 1μF ceramic capacitor placed between the BATT pin and GND is typically sufficient.

### Layout Consideration

The RP1553 is a fully integrated low cost single-cell Li-Ion battery charger ideal for portable applications. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. A short connection is highly recommended. The following guidelines should be strictly followed when designing a PCB layout for the RP1553.

- Input capacitor should be placed close to IC and connected to ground plane. The trace of input in the PCB should be placed far away the sensitive devices or shielded by the ground.

- The GND should be connected to a strong ground plane for heat sinking and noise protection.
- The connection of $R_{SETA}$ should be isolated from other noisy traces. The short wire is recommended to prevent EMI and noise coupling.
- Output capacitor should be placed close to IC and connected to ground plane to reduce noise coupling.
- The TS's capacitor should be placed close to TS (Pin 9) and connected to ground plane. The capacitance (0.1μF to 10μF) base on PCB layout. When PCB has poor layout, the 10μF is recommended to prevent noise.

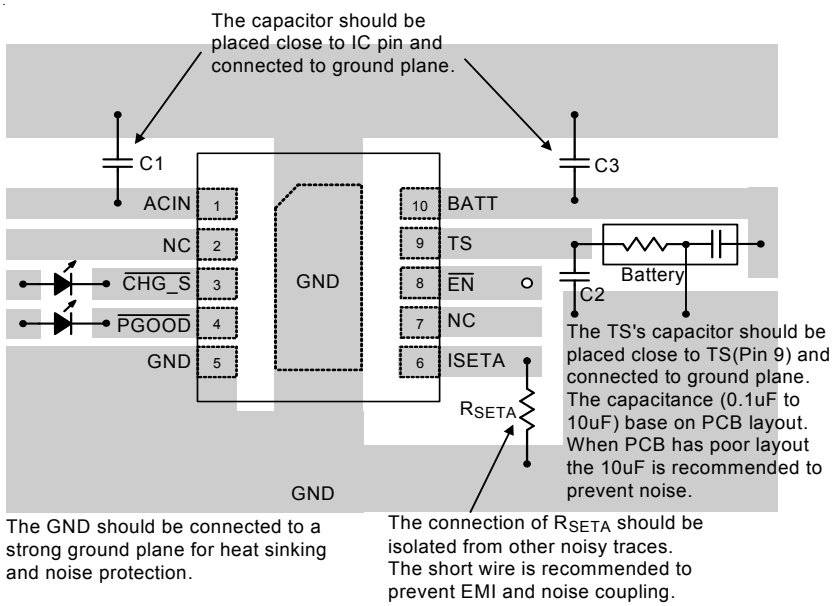
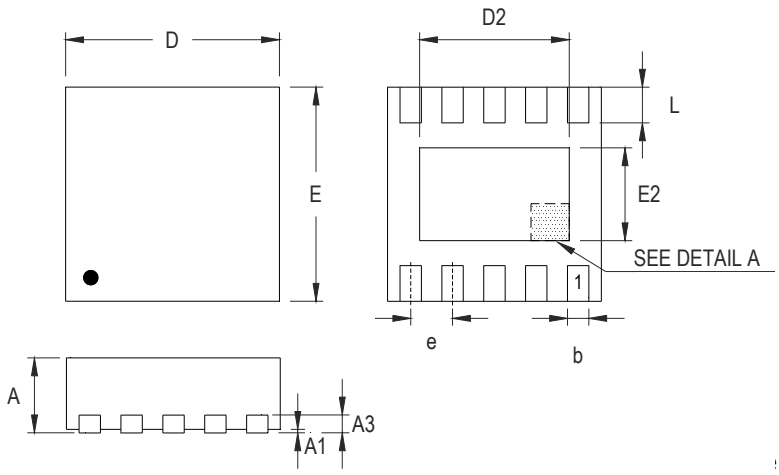
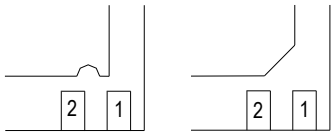



Figure 4

## Outline Dimension




**DETAIL A**

Pin #1 ID and Tie Bar Mark Options

: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.700 | 0.800 | 0.028 | 0.031 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A3 | 0.175 | 0.250 | 0.007 | 0.010 |
| b | 0.180 | 0.300 | 0.007 | 0.012 |
| D | 2.950 | 3.050 | 0.116 | 0.120 |
| D2 | 2.300 | 2.650 | 0.091 | 0.104 |
| E | 2.950 | 3.050 | 0.116 | 0.120 |
| E2 | 1.500 | 1.750 | 0.059 | 0.069 |
| e | 0.500 | | 0.020 | |
| L | 0.350 | 0.450 | 0.014 | 0.018 |

**W-Type 10L DFN 3x3 Package**

**RICHPOWER MICROELECTRONICS CORP.**

Headquarter

Room 2102, 1077 ZuChongZhi Road, Zhang Jiang Hi-TechPark, Pudong New Area, Shanghai, China

Tel: (8621)50277077 Fax: (8621)50276966