# Lithium-ion battery charge control IC
# Monolithic IC MM3458

## Outline

This IC does not require an externally provided sensing resistor or reverse-current protection diode, enabling reductions in the component count and the amount of generated heat.
Battery safety is ensured by limiting the charging current and battery voltage when the battery is at high and low temperatures.
It conforms to the new PSE law.

## Features

1. BAT Regulation Voltage 4.2V±30mV(0.7%)
2. Fast Charge Current 558mA±5%
3. Preliminary current, high-speed charging current, charging completion current can be set using external resistors (maximum charging current is 1.5 A) .
4. A battery temperature detection function is provided via a thermistor, and so the charging voltage and current can be controlled according to the battery temperature.
5. Chip temperature detection enables control of IC temperature rises at high-power charging. The battery can therefore be charged with optimal charging regulation.
6. Built-in charging timer. Charging timer time can be freely set using external resistor.
7. Small package SSON-10A (2.7×2.5×0.6mm)

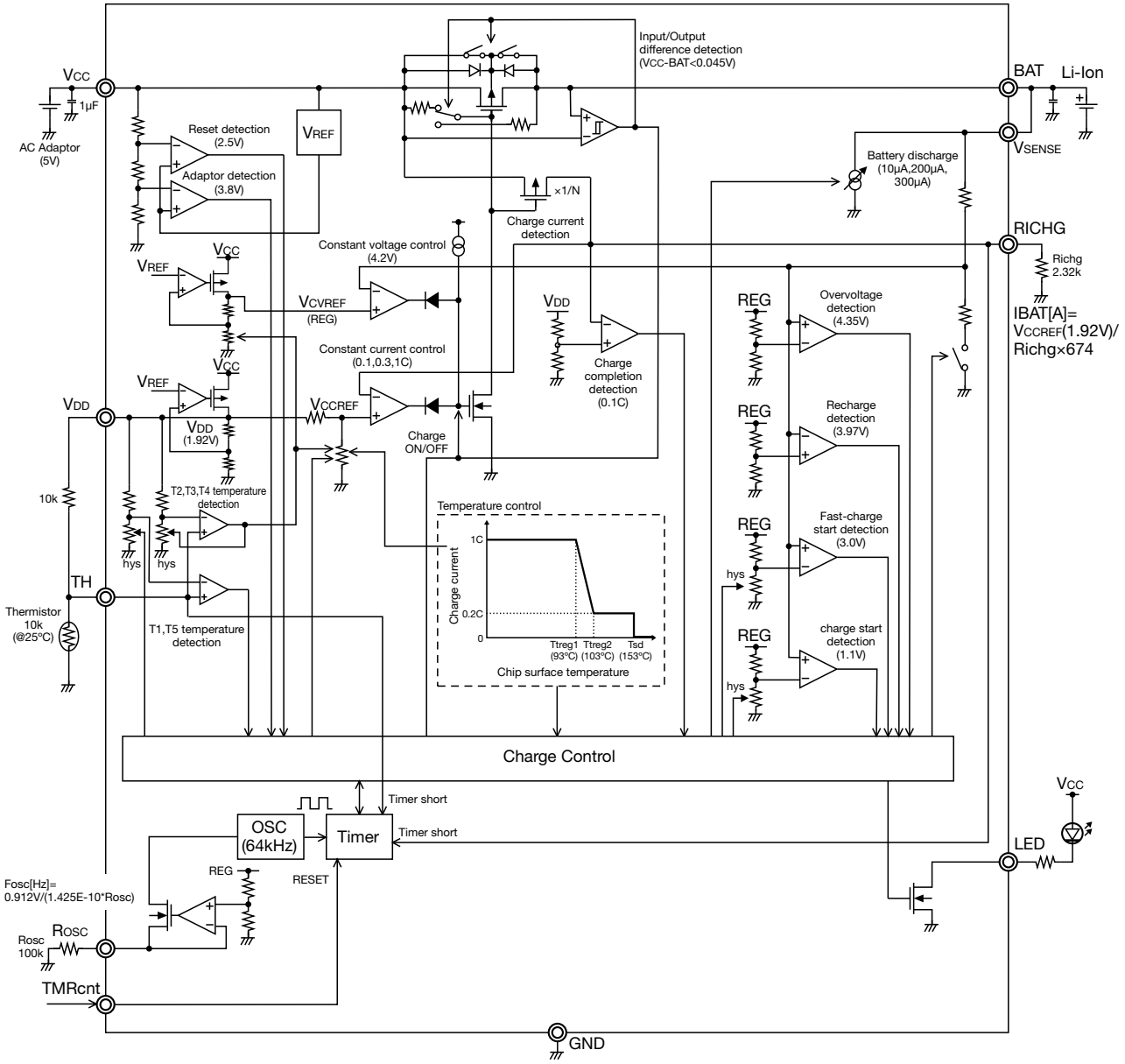
## Package

SSON-10A

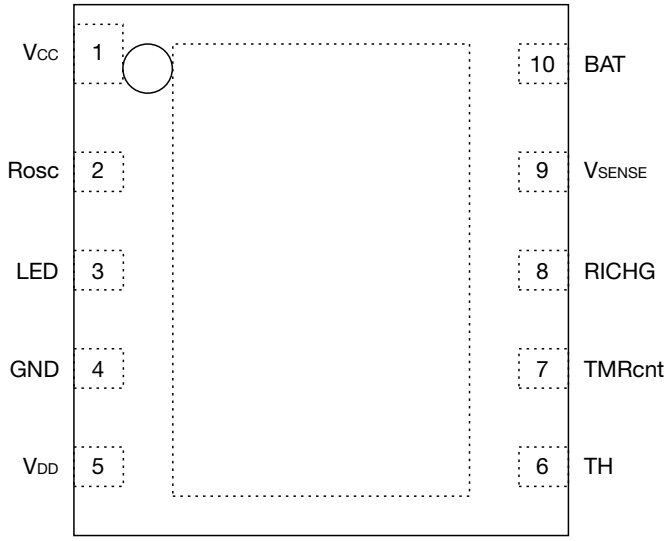
## Applications

1. Cellular phones
2. Portable music players
3. Digital still cameras
4. Portable game devices

# Block Diagram



## Pin Assignment




SSON-10A
(TOP VIEW)

| | | | |
|---|---|---|---|
| 1 | $V_{CC}$ | 6 | TH |
| 2 | Rosc | 7 | TMRcnt |
| 3 | LED | 8 | RICHG |
| 4 | GND | 9 | $V_{SENSE}$ |
| 5 | $V_{DD}$ | 10 | BAT |

## Pin Description

| Pin No. | Symbol | Function |
|---|---|---|
| 1 | $V_{CC}$ | Power supply, charge Tr input pin. Connect to an AC adaptor. |
| 2 | Rosc | Oscillation frequency setting resistance connection pin<br>fosc=0.912V/(1.425E-10×Rosc)<br>* Estimation : The fosc value for each Rosc value is specified on the Characteristics page. |
| 3 | LED | LED connect pin (Nch open drain output) Turn on during charging. |
| 4 | GND | Ground pin |
| 5 | $V_{DD}$ | Battery temperature detecting reference voltage pin<br>* It is not recommended to be used other than as battery temperature detecting reference voltage (resistance connection) since it is also used for internal charge current reference voltage. |
| 6 | TH | Battery temperature detection input pin. Connect to a thermistor.<br>Used for both a timer and a Blinking cycle time reduction pin<br>Enter time reduction mode when TH>($V_{CC}$–approx.1.0V), $V_{CC}$>3.8V, and when maintaining 32ms×2. |
| 7 | TMRcnt | Timer (trickle charge timer, fast charge timer) ON/OFF control pin<br>High: Timer stops, Low/open: Timer is valid. |
| 8 | RICHG | Charge current setting resistance connection pin<br>ICHG=674×1.92V/RICHG<br>* Estimation: The ICHG value for each RICHG value is specified on the Characteristics page.<br>Used for both a timer and a blinking cycle time reduction pin<br>Enter time reduction mode when RICHG>($V_{CC}$–approx. 1.0V), $V_{CC}$>3.8V, and when maintaining 32ms×2. |
| 9 | $V_{SENSE}$ | Battery voltage detection, constant voltage charge control pin<br>Connect to the positive side of a battery pack. |
| 10 | BAT | Charge Tr output pin<br>Connect to the positive side of a battery pack. |

## Absolute Maximum Ratings

| Item | Symbol | Ratings | Units |
|---|---|---|---|
| Storage temperature | $T_{STG}$ | −55~+150 | °C |
| Operating temperature | $T_{OPR}$ | −40~+85 | °C |
| $V_{CC}$, Rosc, $V_{DD}$, TH, TMRcnt, RICHG, $V_{SENSE}$, BAT pin voltage | Vin | −0.3~+6.0 | V |
| BAT pin output current | IBAT | 1.5 | A |
| LED pin sink current | ILED | 20 | mA |
| Power dissipation | Pd | 1.94 (*1) | W |

note : *1 When mounted on a 40 × 40 × 1.6tmm (epoxy glass, double-sided, copper layer 90%) PC board.

## Recommended Operating Conditions

| Item | Symbol | Ratings | Units |
|---|---|---|---|
| Operating temperature | $T_{OPR}$ | 0~+45 | °C |
| $V_{CC}$ Operating voltage | Vop | 4.0~6.0 | V |

## Electrical Characteristics (Except where noted otherwise Ta=0~45°C, $V_{CC}$=5.0V)

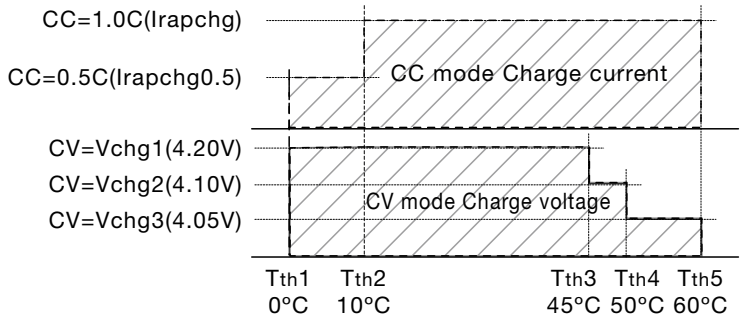
| Item | Symbol | Measurement conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Supply current 1 | $I_{CC}1$ | During fast charge (Irapchg = 500mA setting) | | 3.0 | 4.5 | mA |
| Supply current 2 (*1) | $I_{CC}2$ | During fast charge (Irapchg = 1000mA setting) | | 3.5 | 5.2 | mA |
| Leak current 1 | Ileak | Inflow current of BAT/$V_{SENSE}$ pin under the following conditions :<br>1. BAT (=$V_{SENSE}$)=4.2V AC adaptor is unconnected<br>2. $V_{CC}$=4.8V charging is completed | | 1 | 2 | µA |
| Leak current 1 (*1) | Ileak | Inflow current of BAT/$V_{SENSE}$ pin under the following condition:<br>1. BAT (=$V_{SENSE}$)=1.0~4.2V AC adaptor unconnected | | 1 | 2 | µA |
| Reset detection voltage | Vpor | Reset mode when $V_{CC}$<$V_{POR}$ | 2.3 | 2.5 | 2.7 | V |
| ADP detection voltage | Vadp | Charging stops when $V_{CC}$<Vadp | 3.6 | 3.8 | 4.0 | V |
| $V_{SENSE}$ pin discharge current 1 | Idischg1 | $V_{SENSE}$ (=BAT)=3.2V in charge error mode | | 10 | 20 | µA |
| $V_{SENSE}$ pin discharge current 2 | Idischg2 | $V_{SENSE}$ (=BAT)=3.2V | 100 | 200 | 300 | µA |
| Charge start detection voltage | Vstart | Used for battery connection detection as well<br>Charging stops when $V_{SENSE}$ (=BAT)<Vstart | 1.0 | 1.1 | 1.2 | V |
| Charge start detection voltage hysteresis | Vstarthys | Not applied to battery voltage detection immediately after reset release | 50 | 100 | 150 | mV |
| Fast-charge start detection voltage | Vqchgon | | 2.9 | 3.0 | 3.1 | V |
| Fast-charge start detection voltage hysteresis | Vqchgonhys | Applied to detection voltage from fast charge to trickle charge | 40 | 80 | 120 | mV |
| Recharge detection voltage | Vrechg | Charging restarts when $V_{SENSE}$ (=BAT)<Vrechg | 3.87 | 3.97 | 4.07 | V |
| BAT regulation voltage Vchg1>Vchg2>Vchg3 | Vchg1 | Vth3<VTH≦Vth1 | 4.17 | 4.20 | 4.23 | V |
| | Vchg2 | Vth4<VTH≦Vth3 | 4.05 | 4.10 | 4.15 | |
| | Vchg3 | Vth5<VTH≦Vth4 | 4.00 | 4.05 | 4.10 | |
| Charge stop I/O potential difference 1 | Vdef1 | Charge stops when $V_{CC}$–BAT<Vdef1<br>$V_{CC}$=High→Low | 5 | 30 | 65 | mV |
| Charge stop I/O potential difference 2 | Vdef2 | Charge stops when $V_{CC}$–BAT<Vdef2<br>$V_{CC}$=Low→High | 5 | 45 | 65 | mV |
| Battery overvoltage detection voltage | Vov | $V_{CC}$=>Vov+100mV | 4.27 | 4.35 | 4.43 | V |

note : *1 The parameter is guaranteed by design.

| Item | Symbol | Measurement conditions | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| Forced charge current | Istart | RICHG=2.32kΩ 0.3C (1.0C=Irapchg) | | 116 | 167 | 219 | mA |
| Trickle-charge current | Iprechg | RICHG=2.32kΩ 0.1C (1.0C=Irapchg) BAT=2.6V | | 40 | 56 | 72 | mA |
| Trickle-charge current (*1) | Iprechg(*) | RICHG=2.32kΩ 0.1C (1.0C=Irapchg) BAT=Vstart~Vqchgon | | 40 | 56 | 72 | mA |
| Fast-charge current | Irapchg | RICHG=2.32kΩ 1.0C BAT=3.6V | Vth5<VTH≦Vth2(1.0C) | 530 | 558 | 586 | mA |
| | Irapchg05 | | Vth2<VTH≦Vth1(0.5C) | 251 | 279 | 307 | |
| Fast-charge current (*1) | Irapchg(*) | RICHG=2.32kΩ 1.0C BAT=Vqchgon~Vchg | Vth5<VTH≦Vth2(1.0C) | 530 | 558 | 586 | mA |
| | Irapchg05(*) | | Vth2<VTH≦Vth1(0.5C) | 251 | 279 | 307 | |
| Fast-charge current2 | Irapchg2 | RICHG=1.30kΩ 1.0C BAT=3.6V | Vth5<VTH≦Vth2(1.0C) | | 1000 | | mA |
| | Irapchg05-2 | | Vth2<VTH≦Vth1(0.5C) | | 500 | | |
| Charge completion current | Ifc | RICHG=2.32kΩ BAT=Vqchgon | | 40 | 56 | 72 | mA |
| Charge completion current (*1) | Ifc(*) | RICHG=2.32kΩ BAT>Vqchgon | | 40 | 56 | 72 | mA |
| Chip temperature detection1(*1) | Ttreg1 | Applied to Tj (chip temperature) | | 83 | 93 | 103 | °C |
| Chip temperature detection2(*1) | Ttreg2 | Applied to Tj (chip temperature) | | | 103 | | °C |
| Chip temperature detection difference (*1) | Tdtreg | Applied to Tj (chip temperature) Ttreg2-Ttreg1 | | 5 | 10 | 15 | °C |
| Thermal shutdown temperature (*1) | Tsd | Applied to Tj (chip temperature) | | 143 | 153 | 163 | °C |
| Temperature detecting reference voltage | $V_{DD}$ | $V_{DD}$ pin Output Voltage | | | 1.92 | | V |
| Temperature detecting reference terminal current (*1) | $I_{DD}$ | $V_{DD}$ pin Output Current | | | 3 | | mA |

note : *1 The parameter is guaranteed by design.

| Item | Symbol | Measurement conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Charge Stop Battery Temperature Detection Voltage T1 | Vth1 | Charge stop threshold when TH pin rises(0°C) | $V_{DD}$× 0.7142 | $V_{DD}$× 0.7313 | $V_{DD}$× 0.7480 | V |
| Charge Recovery Battery Temperature Detection Voltage T1R | Vth1R | Charge recovery threshold when TH pin falls (3°C) | | $V_{DD}$× 0.7055 | | V |
| Charge Battery Temperature Detection Voltage T2 | Vth2 | Charge CC=0.5C threshold when TH pin rises (10°C) | $V_{DD}$× 0.6231 | $V_{DD}$× 0.6419 | $V_{DD}$× 0.6604 | V |
| Charge Battery Temperature Detection Voltage T2R | Vth2R | Charge CC=1C threshold when TH pin falls (13°C) | | $V_{DD}$× 0.6137 | | V |
| Charge Battery Temperature Detection Voltage T3 | Vth3 | Charge CV=4.1V threshold when TH pin falls (45°C) | $V_{DD}$× 0.3149 | $V_{DD}$× 0.3296 | $V_{DD}$× 0.3448 | V |
| Charge Battery Temperature Detection Voltage T3R | Vth3R | Charge CV=4.2V threshold when TH pin rises (41°C) | | $V_{DD}$× 0.3604 | | V |
| Charge Battery Temperature Detection Voltage T4 | Vth4 | Charge CV=4.05V threshold when TH pin falls (50°C) | $V_{DD}$× 0.2804 | $V_{DD}$× 0.2938 | $V_{DD}$× 0.3078 | V |
| Charge Battery Temperature Detection Voltage T4R | Vth4R | Charge CV=4.1V threshold when TH pin rises (45°C) | | $V_{DD}$× 0.3296 | | V |
| Charge Stop Battery Temperature Detection Voltage T5 | Vth5 | Charge stop threshold when TH pin falls (60°C) | $V_{DD}$× 0.2208 | $V_{DD}$× 0.2316 | $V_{DD}$× 0.2431 | V |
| Charge Recovery Battery Temperature Detection Voltage T5R | Vth5R | Charge recovery threshold when TH pin rises (55°C) | | $V_{DD}$× 0.2612 | | V |




* Battery temperature detection (Constant Current Mode/Constant Voltage Mode)

| Item | Symbol | Measurement conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| TMRcnt pin Low-level input voltage | Vtmrl | | | | 0.5 | V |
| TMRcnt pin High-level input voltage | Vtmrh | | 2 | | | V |
| TMRcnt pin Low-level input current | Itmrl | TMRcnt=0V | | | 1 | µA |
| TMRcnt pin High-level input current | Itmrh | TMRcnt=5.0V | | | 10 | µA |
| LED Output pin Low-level voltage | Vledl | Iled=10mA | | | 0.4 | V |
| LED Output pin leak current | Iledleak | LED=5V | –1 | | 1 | µA |
| Series Pass Tr On Resistance | Ron | Io=200mA | | 0.38 | 0.6 | Ω |
| Oscillator frequency (*1) | Foc | Rosc=100kΩ | 57.6 | 64 | 70.4 | kHz |
| LED Blinking Cycle (*1) | Fled | Applied to a LED pin when Rosc=100k and in charge error mode | 0.922 | 1.024 | 1.126 | s |
| LED Blinking Duty (*1) | Dled | Applied to a LED pin when Rosc=100k | 30 | 50 | 70 | % |
| $V_{SENSE}$ pin discharge time (*1) | Tdischg | Foc=64kHz | 58 | 64 | 70 | ms |
| AC Adaptor connection detection time (*1, 2) | Tadp | Foc=64kHz Vpor<Vcc<Vadp<br>Applied when Vcc=>Vadp detection | 24 | | 32 | ms |
| | Tadp2 | Applied when Vcc=<Vpor detection | 32 | 64 | 96 | µs |
| Forced charge time (*1) | Tistart | Foc=64kHz | 480 | 512 | 544 | ms |
| Forced charge OFF time (*1) | Toff | Foc=64kHz | 115 | 128 | 141 | ms |
| Battery voltage detection time (*1, 3) | Tcon | Foc=64kHz | 96 | | 128 | ms |
| Fast charge start voltage detection time (*1, 3) | Tqstart | Foc=64kHz | 96 | | 128 | ms |
| Charge completion current detection time (*1, 4) | Tifc | Foc=64kHz | 192 | | 256 | ms |
| Recharge start voltage detection time (*1, 4) | Trechg | Foc=64kHz | 192 | | 256 | ms |
| Trickle-charge timer (*1) | Tdchg | Valid when Foc=64kHz TMRcnt=Low or Open | 54 | 60 | 66 | min |
| Fast-charge timer (*1) | Tchg | Valid when Foc=64kHz TMRcnt=Low or Open | 270 | 300 | 330 | min |
| Battery overvoltage detection time (*1,3) | Tov | Foc=64kHz | 96 | | 128 | ms |
| Charge stop battery temperature detection time (*1,3) | Tpro | Foc=64kHz<br>Vth1, VTH=L→H or Vth5, VTH=H→L | 96 | | 128 | ms |
| Charge recovery battery temperature detection time (*1,3) | TproR | Foc=64kHz<br>Vth1R, VTH=H→L or Vth5R, VTH=L→H | | | | |

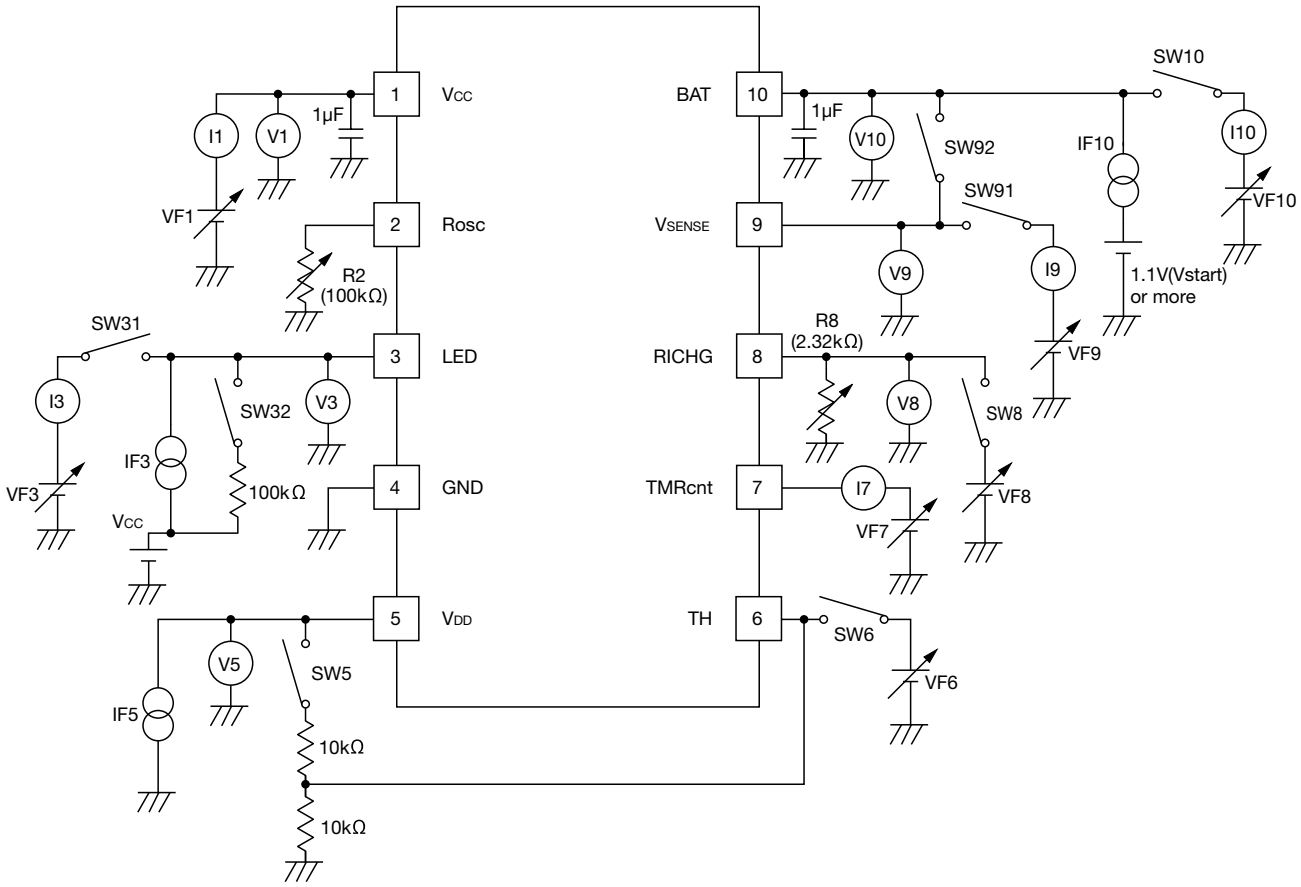
note : *1 The parameter is guaranteed by design.

note : *2 The detection time varies depending on the timing of detection for approximately one clock due to the mode transition system operated when matched 4 times in 8ms.

note : *3 The detection time varies depending on the timing of detection for approximately one clock due to the mode transition system operated when matched 4 times in 32ms.

note : *4 The detection time varies depending on the timing of detection for approximately one clock due to the mode transition system operated when matched 4 times in 64ms.

## Measuring Circuit




• SW setting condition

| Measuring Circuit | SW31 | SW32 | SW5 | SW6 | SW8 | SW91 | SW92 | SW10 |
|---|---|---|---|---|---|---|---|---|
| A | × | × | ○ | × | × | × | ○ | ○ |
| B | × | × | ○ | × | × | ○ | × | ○ |
| C | × | ○ | ○ | × | × | × | ○ | ○ |
| D | × | ○ | × | ○ | × | × | ○ | ○ |
| E | ○ | × | ○ | × | × | × | ○ | ○ |
| F | × | ○ | ○ | × | × | × | ○ | × |
| G | × | × | × | ○ | × | × | ○ | × |

## Measurement Conditions (Except where noted otherwise Ta=0~45°C, $V_{CC}$=5.0V)

| Item | Symbol | Measurement circuit | Measuring conditions |
|---|---|---|---|
| Supply current 1 | Icc1 | A | Measure the current of I1-I10 when R8=(Irapchg=500mA setting) and IF10=500mA. |
| Supply current 2 (*1) | Icc2 | A | Measure the current of I1-I10 when R8=(Irapchg=1000mA setting) and IF10=1000mA. |
| Leak current 1 | Ileak | A | 1. Measure the current of I10 when VF1=0V and VF10=4.2V.<br>2. Measure the current of I10 when VF1=4.8V and VF10=4.25V (charge completion mode). |
| Leak current 1 (*1) | Ileak | A | 1. Measure the current of I10 when VF1=0V and VF10=1.0V~4.2V. |
| Reset detection voltage | Vpor | B | When gradually increasing VF1 from 2.3V to 2.7V under the condition of VF9=3.2V and VF10=3.2V, the VF1 when I9 exceeds 100μA should be Vpor. |
| Adaptor detection voltage | Vadp | C | When gradually increasing VF1 from 2.3V to 4.0V under the condition of VF10=3.2V, the VF1 when V3 changes from High to Low should be Vadp. |
| $V_{SENSE}$ pin discharge current 1 | Idischg1 | B | Measure the current of I9 when VF 9=4.5V to 3.2V after being kept under the condition of VF10=3.2V and VF9=4.5V and entering into error mode. |
| $V_{SENSE}$ pin discharge current 2 | Idischg2 | B | Measure the current of I9 immediate after increasing VF1 from 2.3V to 5.0V when VF9=3.2V and VF10=3.2V. |
| Charge start detection voltage | Vstart | C | When gradually increasing VF10 from 1.0V to 1.2V under the condition of VF10=0.5V, the VF10 when the charging starts (\|I10\|>1mA) and V3=High to Low should be Vstart. |
| Charge start detection voltage hysteresis | Vstarthys | C | When gradually decreasing VF10 from 1.2V to 0.8V under the condition of VF10=1.5V, the VF10 when the charging stops (\|I10\|<1mA) and V3=Low to High should be Vstart2. Vstarthys=Vstart–Vstart2 |
| Fast-charge start detection voltage | Vqchgon | A | When gradually increasing VF10 from 2.9V to 3.1V under the condition of VF10=2.5V, the VF10 when \|I10\| exceeds 530mA should be Vqchgon. |
| Fast-charge start detection voltage hysteresis | Vqchgonhys | A | When gradually decreasing VF10 from 3.1V to 2.7V under the condition of VF10=3.5V, the VF10 when \|I10\| falls below 530mA should be Vqchgon2. Vqchgonhys=Vqchgon–Vqchgon2 |
| Recharge detection voltage | Vrechg | C | When gradually decreasing VF10 from 4.07V to 3.87V after being kept in the condition of VF10=4.25V and entering into charge completion mode, the VF10 when the charging restarts (\|I10\|>1mA) and V3=High to Low should be Vrechg. |
| BAT regulation voltage | Vchg | A | Measure the voltage of V9 in fast charge mode and when IF10=–72mA (\|IF10\|>Ifc). |
| Charge stop I/O potential difference 1 | Vdef1 | A | When gradually decreasing VF1 from 4.1V to 4.0V under the condition of fast charge mode, VF1=4.1V, and VF10=4.0V, the V1–V10 when the charging stops (\|I10\|<1mA) should be Vdef1. |
| Charge stop I/O potential difference 2 | Vdef2 | A | When gradually increasing VF1 from 4.0V to 4.1V under the condition of fast charge mode, VF1=4.0V, and VF10=4.0V, the V1–V10 when the charging restarts (\|I10\|>1mA) should be Vdef2. |
| Battery overvoltage detection voltage | Vov | C | When gradually increasing VF10 from 4.27V to 4.43V under the condition of VF10=4.25V, the VF10 when V3 becomes blinking (repeating High⇔Low, charge error mode) should be Vov. |

note : *1 The parameter is guaranteed by design.

| Item | Symbol | Measurement circuit | Measuring circuit |
|---|---|---|---|
| Forced charge current | Istart | A | Measure the current of I10 immediately after increasing VF1 from 2.3V to 5.0V when VF10=3.6V and R8=2.32kΩ. |
| Trickle-charge current | Iprechg | A | Measure the current of I10 when VF10=2.6V and R8=2.32kΩ. |
| Trickle-charge current (*1) | Iprechg(*) | A | Measure the current of I10 when VF10=Vstart~Vqchgon and R8 = 2.32kΩ. |
| Fast-charge current | Irapchg | A | Measure the current of I10 when VF10=3.6V and R8=2.32kΩ. |
| Fast-charge current (*1) | Irapchg(*) | A | Measure the current of I10 when VF10=Vqchgon~Vchg, R8=2.32kΩ. |
| Fast-charge current2 | Irapchg2 | A | Measure the current of I10 when VF10=3.6V and R8=1.30kΩ. |
| Charge completion current | Ifc | B | When gradually increasing VF9 from 4.1V to 4.2V under the condition of VF9=3.6V and VF10=Vqchgon, the \|I10\| immediately before V3=Low to High and the charging stops (\|I10\|>1mA) should be Ifc. |
| Charge completion current (*1) | Ifc(*) | B | When gradually increasing VF9 from 4.1V to 4.2V under the condition of VF9=3.6V and VF10>Vqchgon, the \|I10\| immediately before V3=Low to High and the charging stops (\|I10\|<1mA) should be Ifc. |
| Chip temperature detection 1 (*1) | Ttreg1 | A | When gradually increasing chip temperature from 83°C to 103°C under the condition of fast charge mode, VF1=5V, and VF10=4V, the chip temperature when I10 drops to the value that is 1C (I10 when chip temperature is 25°C)× 95% should be Ttreg1. |
| Chip temperature detection 2 (*1) | Ttreg2 | A | When gradually increasing chip temperature from 85°C to 120°C under the condition of fast charge mode, VF1=5V, and VF10=4V, the chip temperature when I10 drops to the value that is 0.2C(I10 when chip temperature is 125°C)×105% should be Ttreg2. |
| Chip temperature detection difference (*1) | Tdtreg | A | Tdtreg=Ttreg2 -Ttreg1 |
| Thermal shutdown temperature (*1) | Tsd | C | When gradually increasing chip temperature from 143°C to 163°C under the condition of fast charge mode, VF1=5V, and VF10=4V, the chip temperature when V3 becomes blinking (repeating High⇔Low, charge error mode) and the charging stops (\|I10\| < 1mA) should be Tsd. |
| Temperature detecting reference voltage | $V_{DD}$ | D | Measure the voltage of V5 when VF6=1.0V and VF10=3.6V. |
| Temperature detecting reference terminal current (*1) | $I_{DD}$ | D | When gradually decreasing IF5 under the condition of VF6=1.0V and VF10=3.6V, the \|IF5\| when V5=$V_{DD}$×90% should be $I_{DD}$. |
| Charge stop battery temperature detection voltage T1 | Vth1 | D | When gradually decreasing VF6 from 1.0V to 2.0V under the condition of fast charge mode, VF6=1.0V, and VF10=3.6V, the VF6 when V3=Low to High and the charging stops (\|I10\|<1mA) should be Vth1. |
| Charge recovery battery temperature detection voltage T1R | Vth1R | D | When gradually decreasing VF6 from 2.0V to 1.0V under the condition of charge stop temperature detection mode, VF6=2.0V, and VF10=3.6V, the VF6 when V3=High to Low and the charging restarts (\|I10\|>1mA) should be Vth1R. |

note : *1 The parameter is guaranteed by design.

| Item | Symbol | Measurement circuit | Measuring circuit |
|---|---|---|---|
| Charge battery temperature detection voltage T2 | Vth2 | D | When gradually increasing VF6 from 1.0V to 2.0V under the condition of fast charge mode, VF6=1.0V, and VF10=3.6V, the VF6 when charge current 1.0 to 0.5C (\|I10\|<320mA) should be Vth2. |
| Charge battery temperature detection voltage T2R | Vth2R | D | When gradually decreasing VF6 after detected Vth2 under the condition of fast charge mode, VF6=1.0V, and VF10=3.6V, the VF6 when charge current 0.5 to 1.0C (\|I10\|>320mA) should be Vth2R. |
| Charge battery temperature detection voltage T3 | Vth3 | G | When gradually decreasing VF6 from 1.0V to 0V under the condition of fast charge mode, IF10=−72mA (\|IF10\|>Ifc), the VF6 when V9=4.20V(Vchg1) to 4.10V (V9<4.10V, Vchg2) should be Vth3. |
| Charge battery temperature detection voltage T3R | Vth3R | G | When gradually increasing VF6 after detected Vth3 under the condition of fast charge mode, IF10=−72mA (\|IF10\|>Ifc), the VF6 when V9=4.10V(Vchg2) to 4.20V (V9>4.15V, Vchg1) should be Vth3R. |
| Charge battery temperature detection voltage T4 | Vth4 | G | When gradually decreasing VF6 from 1.0V to 0V under the condition of fast charge mode, IF10=−72mA (\|IF10\|>Ifc), the VF6 when V9=4.10V(Vchg2) to 4.05V (V9<4.075V, Vchg3) should be Vth4. |
| Charge battery temperature detection voltage T4R | Vth4R | G | When gradually increasing VF6 after detected Vth4 under the condition of fast charge mode, IF10=−72mA (\|IF10\|>Ifc), the VF6 when V9=4.05V(Vchg3) to 4.10V (V9>4.075V, Vchg2) should be Vth4R. |
| Charge stop battery temperature detection voltage T5 | Vth5 | D | When gradually decreasing VF6 from 1.0V to 0V under the condition of fast charge mode, VF6=1.0V, and VF10=3.6V, the VF6 when V3=Low to High and the charging stops(\|I10\|<1mA) should be Vth5. |
| Charge recovery battery temperature detection voltage T5R | Vth5R | D | When gradually increasing VF6 from 0V to 1.0V under the condition of charge stop temperature detection mode, VF6=0V, and VF10=3.6V, the VF6 when V3=High to Low and the charging restarts(\|I10\|>1mA) should be Vth5R. |
| TMRcnt pin Low-level input voltage | Vtmrl | C | When gradually decreasing from 5.0V to 0V under the condition of fast charge mode, time reduction mode(See Pin description), VF7=5.0V, and VF10=3.6V, the voltage below VF7 should be Vtmrl and the voltage exceeding VF7 should be VtmrH when V3 becomes blinking(repeating High⇔Low, charge error mode) and the charging stops (\|I10\|<1mA). |
| TMRcnt pin High-level input voltage | Vtmrh | | |
| TMRcnt pin Low-level input current | Itmrl | A | Measure the current of I7 under the condition of fast charge mode, VF7=0V, and VF10=3.6V. |
| TMRcnt pin High-level input current | Itmrh | A | Measure the current of I7 under the condition of fast charge mode, VF7=5V, and VF10=3.6V. |
| LED output pin Low-level voltage | Vledl | A | Measure the voltage of V3 under the condition of fast charge mode, IF3=10mA, and VF10=3.6V. |
| LED output pin leak current | Iledleak | E | Measure the current of I3 when VF3=5V and VF10=4.25V (charge completion mode). |
| Series pass Tr On resistance | Ron | A | Measure the voltage of V1–V10 under the condition of fast charge mode, VF1=4.0V, and IF10= –200mA.<br>Ron=(V1–V10)/200mA |
| LED Blinking Cycle (*1) | Fled | C | Measure the blinking cycle(repeating High⇔Low) of V3 after being kept under the condition of VF10=4.5V and entering charge error mode. |
| LED Blinking Duty (*1) | Dled | C | Measure the duty ratio of blinking cycle(repeating High⇔Low) Fled of V3 after being kept in the condition of VF10=4.5V and entering charge error mode. |

note : *1 The parameter is guaranteed by design.

| Item | Symbol | Measurement circuit | Measuring circuit |
|---|---|---|---|
| $V_{SENSE}$ pin discharge time (*1) | Tdischg | B | When increasing VF1 from 2.3V to 5.0V under the condition of VF9=3.6V and VF10=3.6V, measure the time from when VF1>2.5V(Vpor) to when the current of I9 drops below 100µA. |
| AC Adaptor connection detection time (*1) | Tadp | C | 1. After being kept for 128ms and more(more than Tpro) under the condition of VF10=3.6V and VF1=2.3V to 3.6V, measure the time from when VF1>3.8V(Vadp) to when V3=High to Low when increasing VF1 from 3.6V to 5.0V.<br>2. When decreasing VF10 from 5.0V to 3.6V under the condition of fast charge mode and VF10=3.2V, measure the time from when VF1<3.8V(Vadp) to when the fast charge stops(\|I10\|<1mA). |
| | Tadp2 | C | When decreasing VF1 from 5.0V to 2.0V in fast charge mode and when VF10=3.6V, measure the time from when VF1<2.5V(Vpor) to when V3=Low to High. |
| Forced charge time (*1) | Tistart | C | When increasing VF1 from 2.3V to 5.0V under the condition of VF10=3.6V, measure the time from forced charge start(\|I10\|>1mA) to forced charge stop(\|I10\|<1mA). |
| Forced charge OFF time (*1) | Toff | C | After increasing VF1 from 2.3V to 5.0V under the condition of VF10=3.6V, the half time from forced charge stop(\|I10\|<1mA) to fast charge start(\|I10\|>1mA) should be Toff. |
| Battery voltage detection time (*1) | Tcon | C | When decreasing VF10 from 4.25V to 3.8V after charge complete mode under the condition of VF10=4.25V, the half time from when the current of I9 exceeds 100µA to when V3=Low to High and the charging restarts(\|I10\|>1mA) should be Tcon. |
| Fast charge start voltage detection time (*1) | Tqstart | C | When increasing VF10 from 2.6V to 3.6V under the condition of trickle charge mode, VF10=2.6V, and R8=2.32kΩ, measure the time from when VF10>3.0V(Vqchgon) to when fast charge starts(\|I10\|>530mA). |
| Charge completion current detection time (*1) | Tifc | F | When decreasing IF10 from−80mA to −30mA under the condition of fast charge mode and R8=2.32kΩ, measure the time from when IF10>−56mA(Ifc) to when the charging stops (I10>−1mA). |
| Recharge start voltage detection time (*1) | Trechg | C | When decreasing VF10 from 4.25V to 3.8V after charge completion mode under the condition of VF10=4.25V, measure the time from when VF10<3.97V(Vrechg) to when the current of I9 exceeds 100µA. |

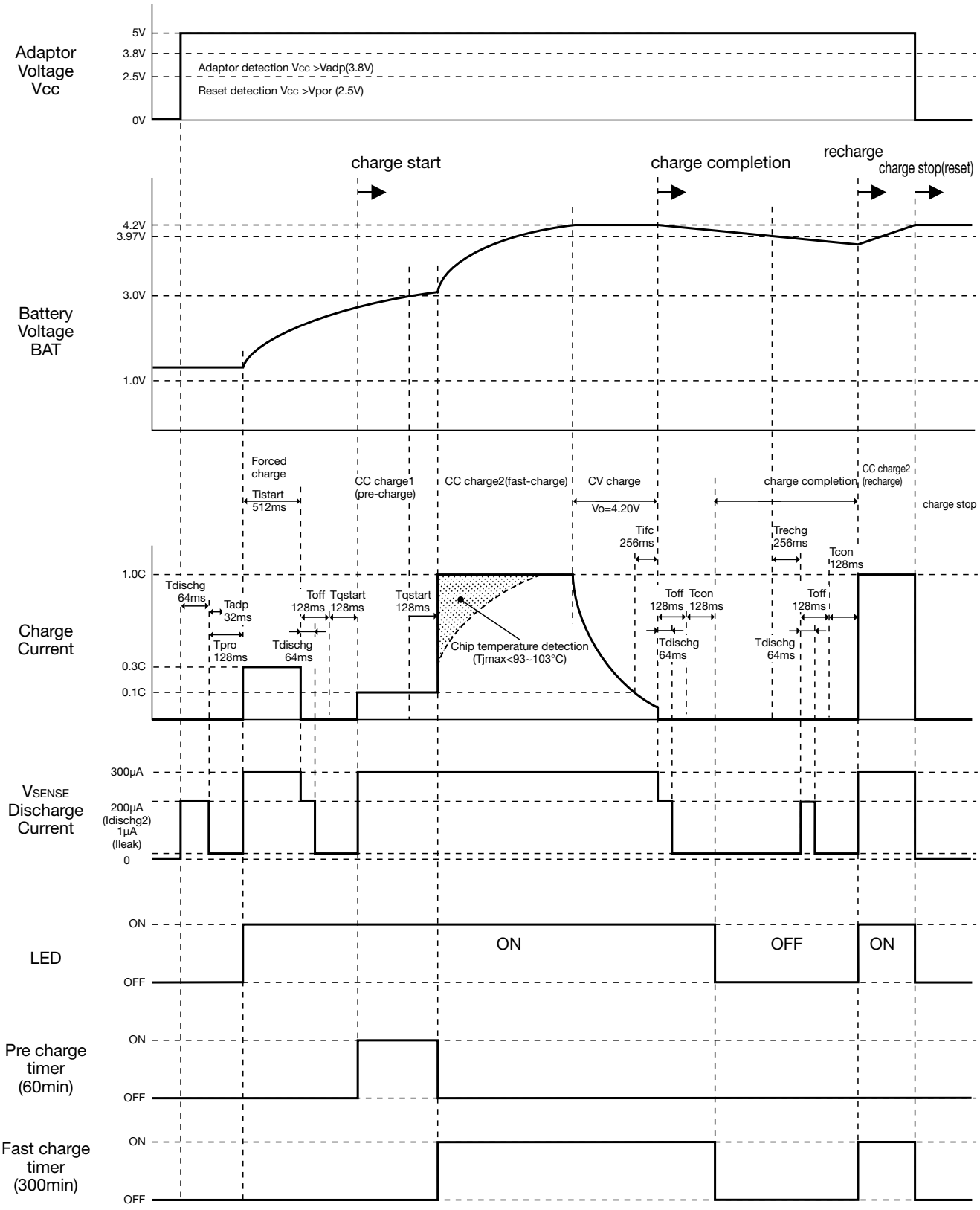
note : *1 The parameter is guaranteed by design.

| Item | Symbol | Measurement circuit | Measuring circuit |
|---|---|---|---|
| Trickle-charge timer (*1) | Tdchg | C | When decreasing VF7 from 5.0V to 0V under the condition of trickle charge mode, VF7=5.0V, VF10=2.6V, and time reduction mode(See Pin description), measure the time from when VF10<0.5V (Vtmr) to when V3 starts blinking(V3=High to Low, charge error mode) and the charging stops(\|I10\|<1mA). Tdchg=Tdchg2×2.304E + 08/109 in time reduction mode due to a TH pin. |
| Fast-charge timer (*1) | Tchg | C | When decreasing VF7 from 5.0V to 0V under the condition of fast charge mode, VF7=5.0V, VF10=3.6V, and time reduction mode(See Pin description), measure Tchg2 that is the time from when VF10<0.5V(Vtmr) to when V3 starts blinking(V3=High to Low, charge error mode) and the charging stops (\|I10\|<1mA). Tchg=Tchg2×1.152E + 09/137 in time reduction mode due to a TH pin. |
| Battery overvoltage detection time (*1) | Tov | C | When increasing VF10 from 3.6V to 4.5V under the condition of fast charge mode and VF10=3.6V, measure the time from when VF10>4.35V(Vov) to when V3 starts blinking (V3=High to Low, charge error mode). |
| Charge stop battery temperature detection time (*1) | Tpro | C | When increasing(decreasing) VF6 from 1.0V to 2.0V(0V) under the condition of fast charge mode, VF6=1.0V, and VF10=3.6V, measure the time from when VF6>Vth1(VF6<Vth5) to when V3=Low to High and the charging stops(\|I10\|<1mA). |
| Charge recovery battery temperature detection time (*1) | Tpro | C | When decreasing (increasing) VF6 from 2.0V(0V) to 1.0V under the condition of charge stop detection mode, VF6=2.0V(0V), and VF10=3.6V, measure the time from when VF6<Vth1R(VF6>Vth5R) to when V3=High to Low and the charging restarts (\|I10\|>1mA). |

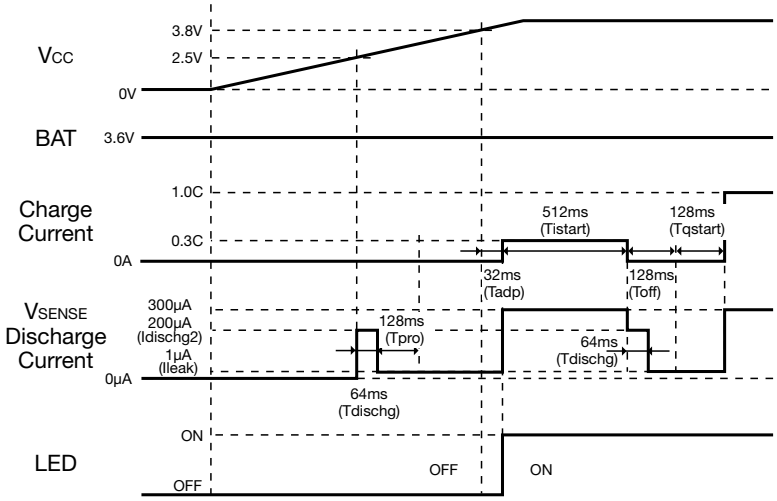
note : *1 The parameter is guaranteed by design.

# Timing Chart (*All typ. numeric value)

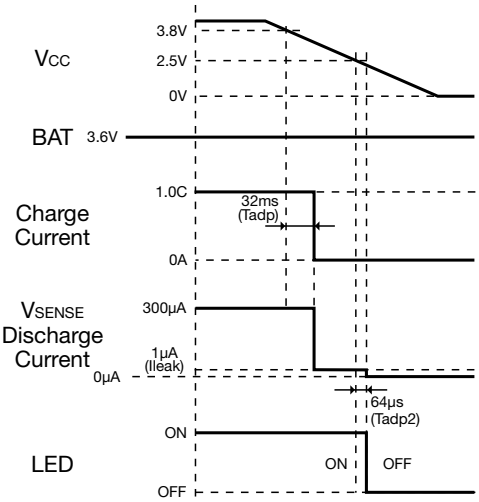
## Normal charge



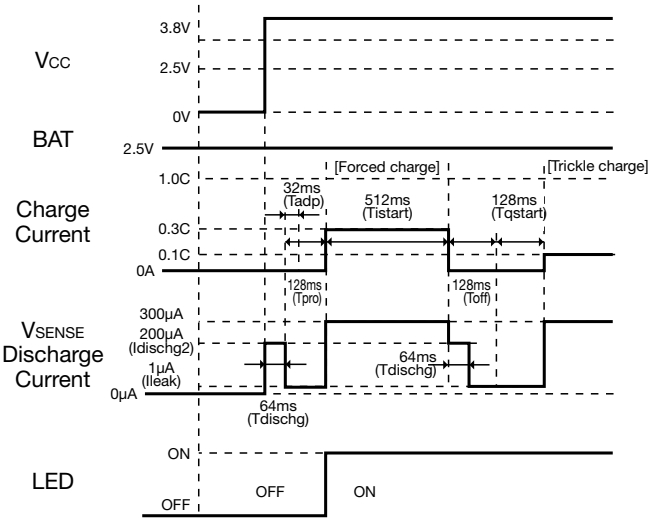
## Input Adaptor



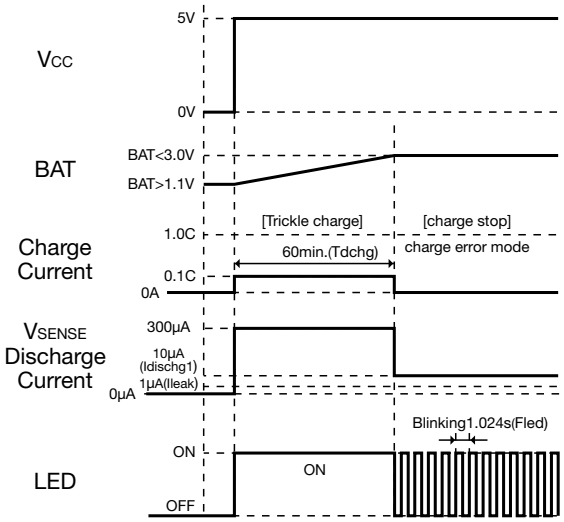

## Release Adaptor



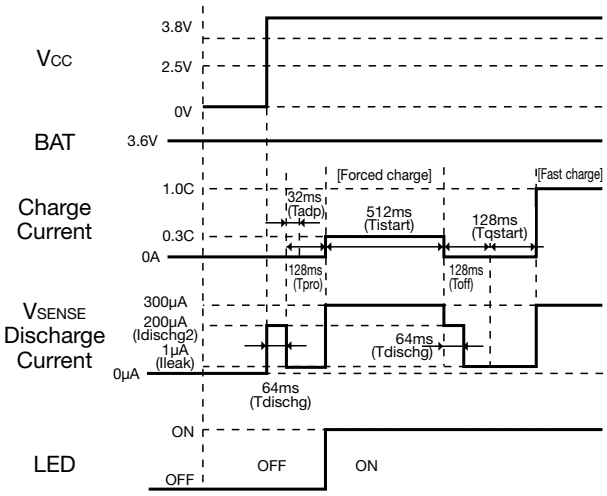

## 1.1V<BAT<3.0V, Charge start (trickle charge)



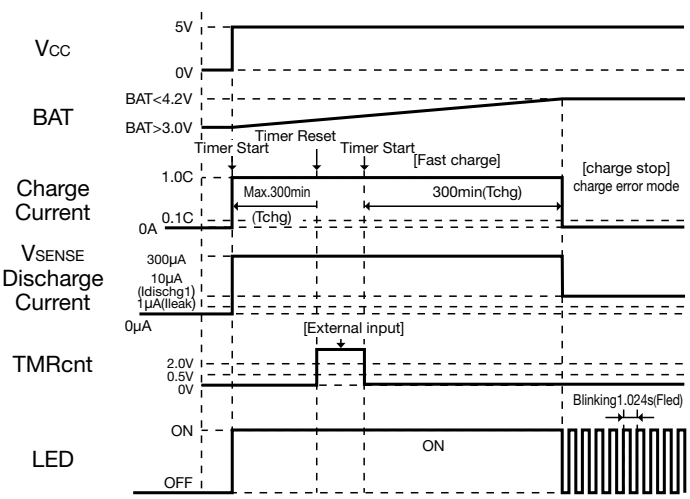

## Trickle charge timeup



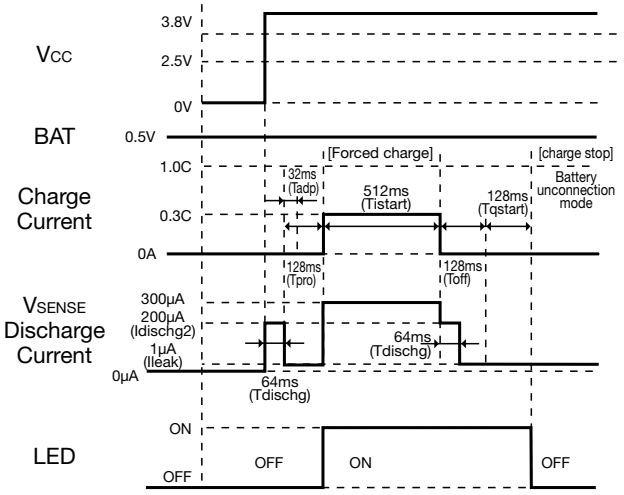

## 3.0V<BAT<4.2V, Charge start (fast charge)



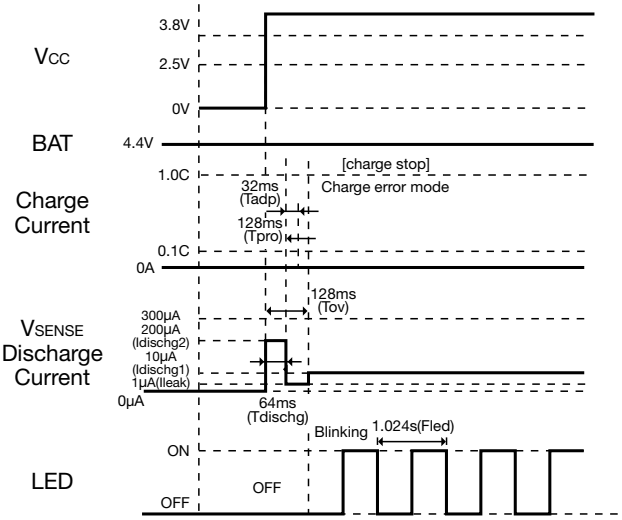

## Fast charge timeup



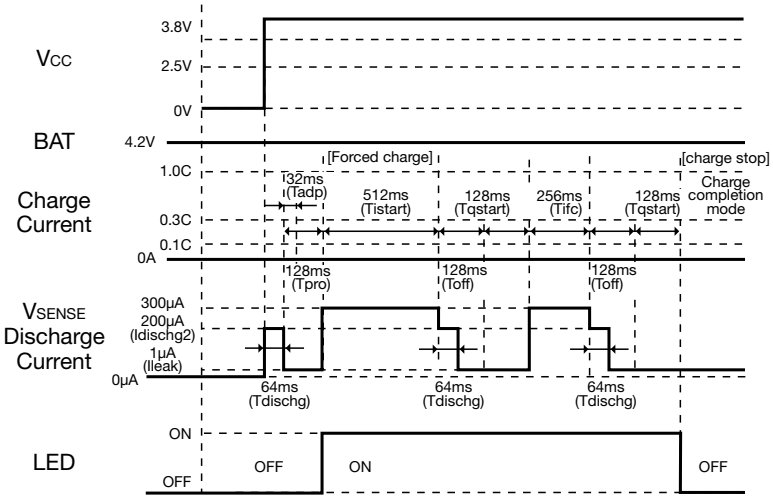
## BAT<1.1V, Charge start (Battery unconnection)



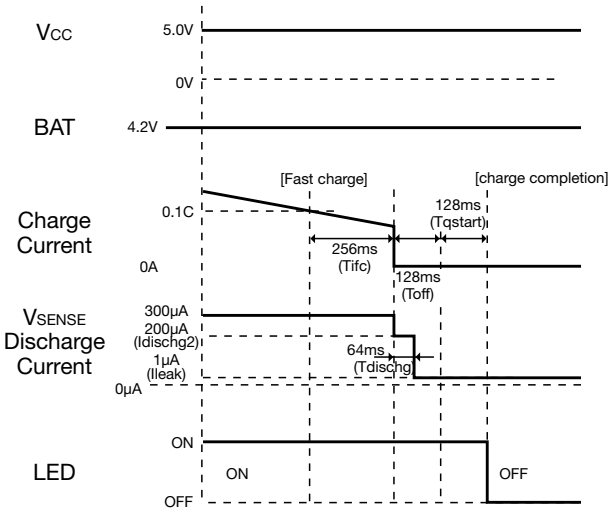

## BAT>4.35V, Charge start (battery overvoltage)



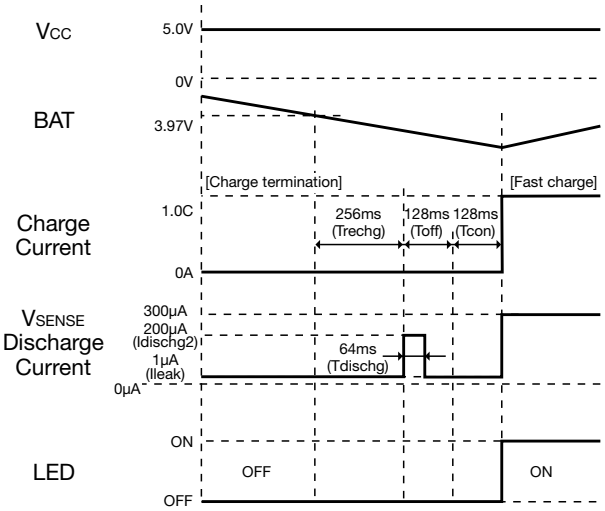

## BAT=4.2V, Charge start (charge completion)



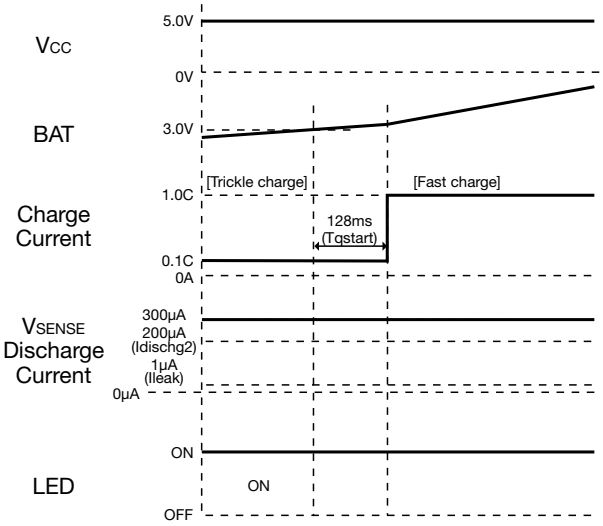

## Full charge detection



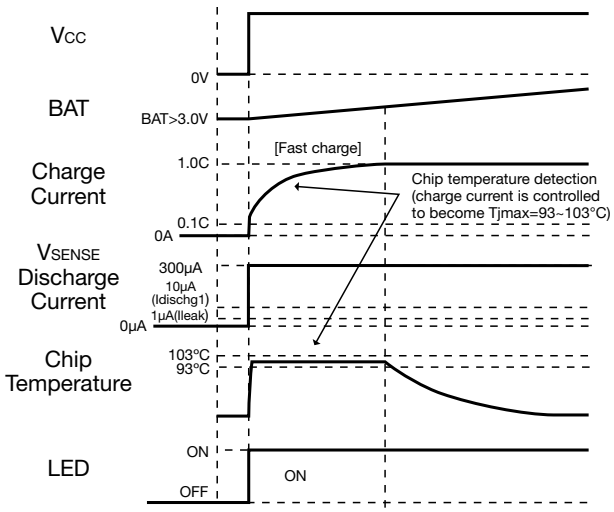

## Recharge detection



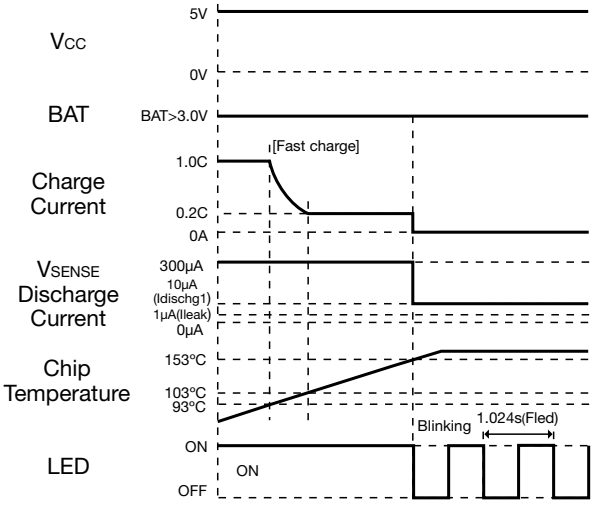
## Fast-charge start voltage detection



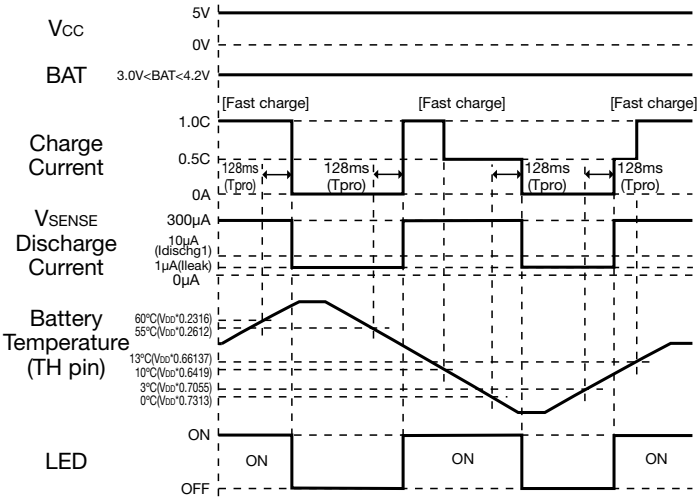

## Chip temperature detection



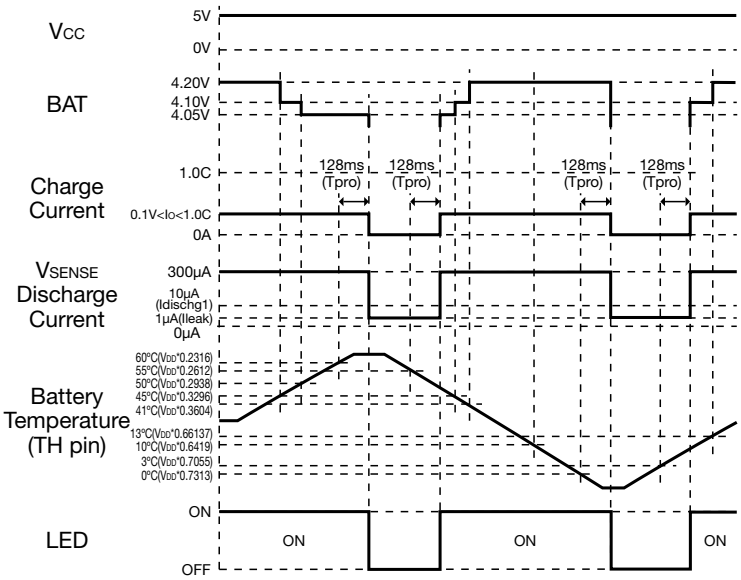

## Thermal shutdown



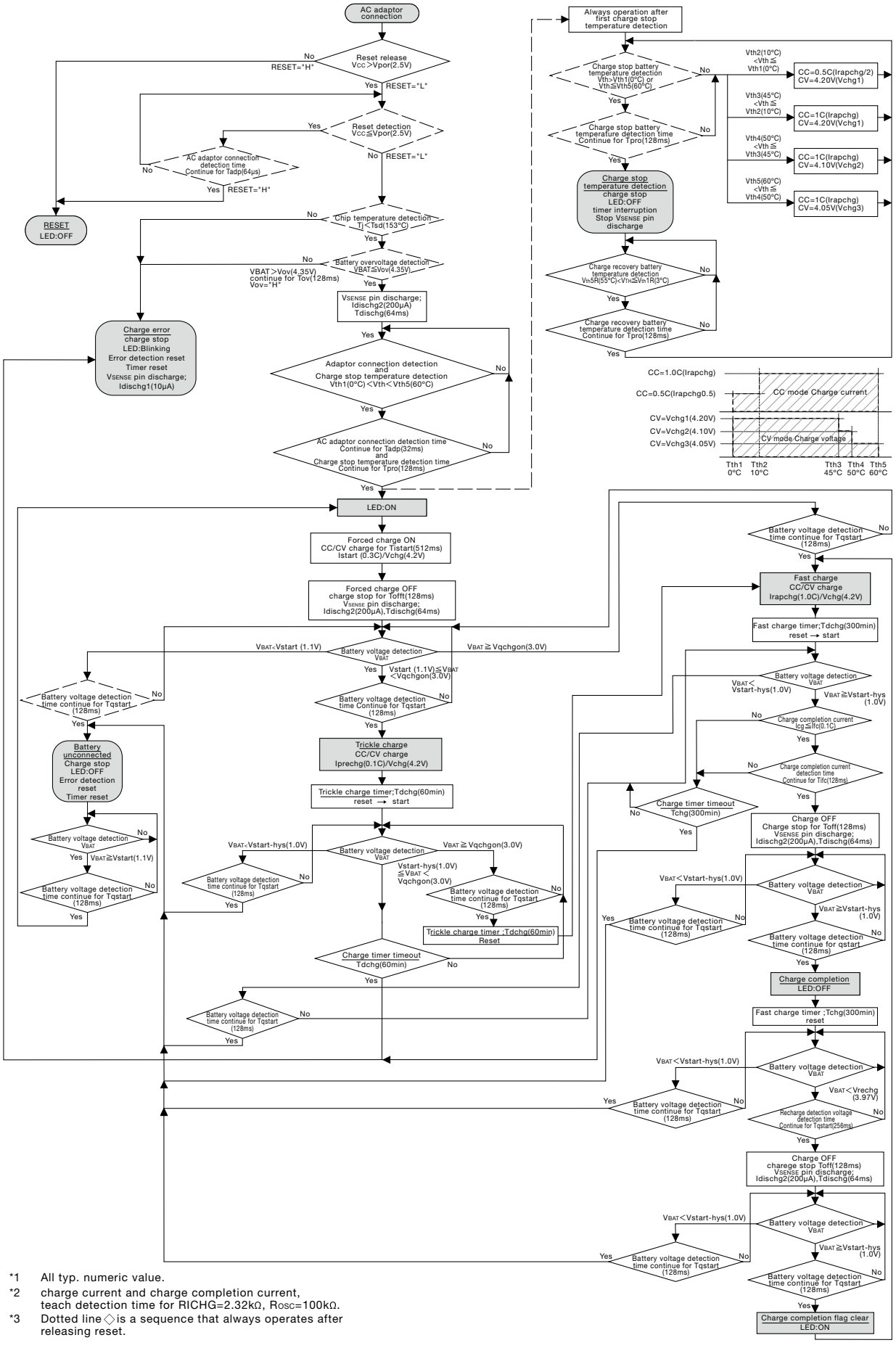

## Battery temperature detection (Constant Current mode)




## Battery temperature detection (Constant Voltage mode)



# Flow Chart



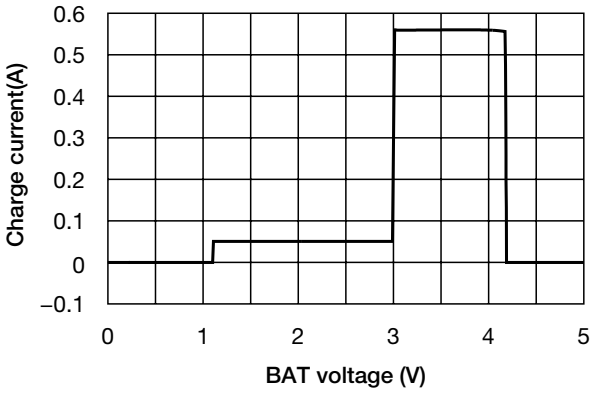

*1 All typ. numeric value.

*2 charge current and charge completion current, teach detection time for RICHG=2.32kΩ, ROSC=100kΩ.

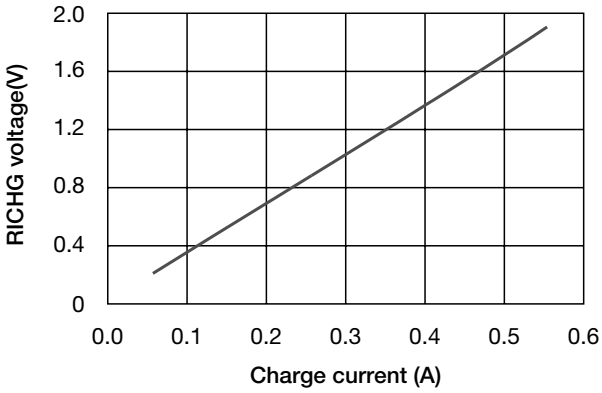
*3 Dotted line ◇ is a sequence that always operates after releasing reset.

## Characteristics (Except where noted otherwise $V_{CC}$=5.0V, RICHG=2.32kΩ, $R_{OSC}$=100kΩ, Ta=25°C)

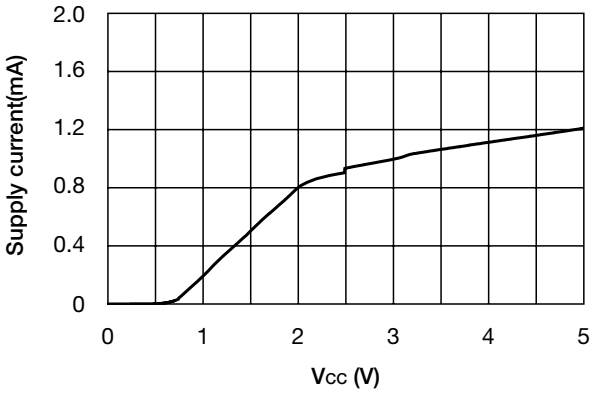
### Charge current - BAT voltage



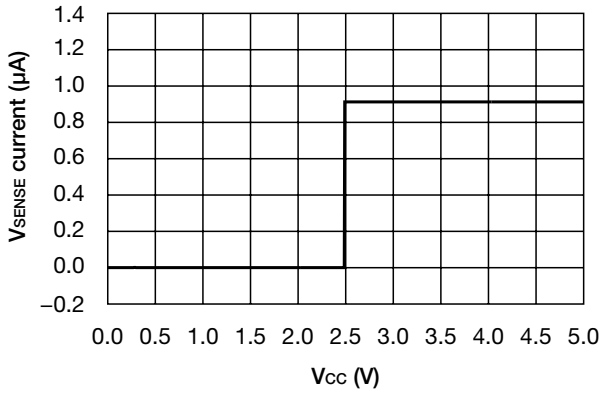

### RICHG voltage - Charge current



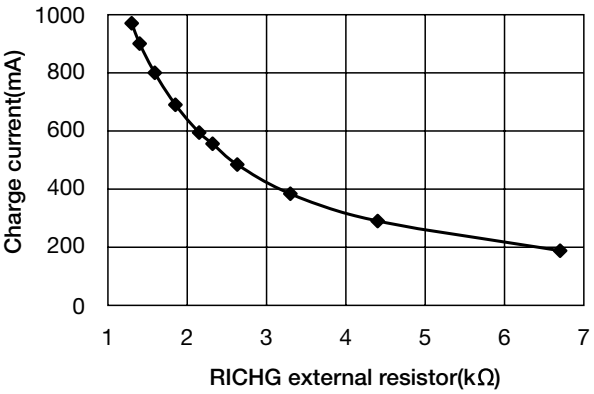

### Supply current - $V_{CC}$ (BAT=4.0V, Charge OFF)



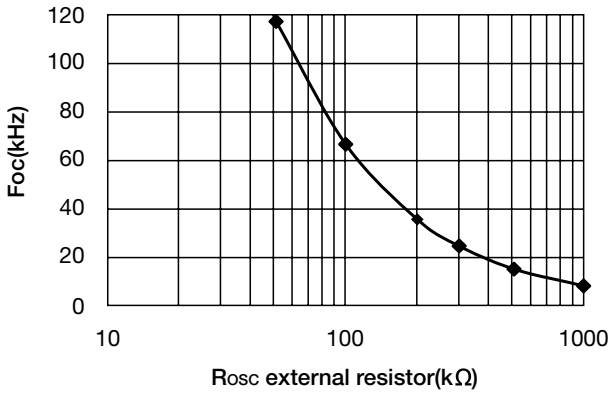

### $V_{SENSE}$ current - $V_{CC}$ (BAT=4.0V, Charge OFF)




### Charge current - RICHG external resistor

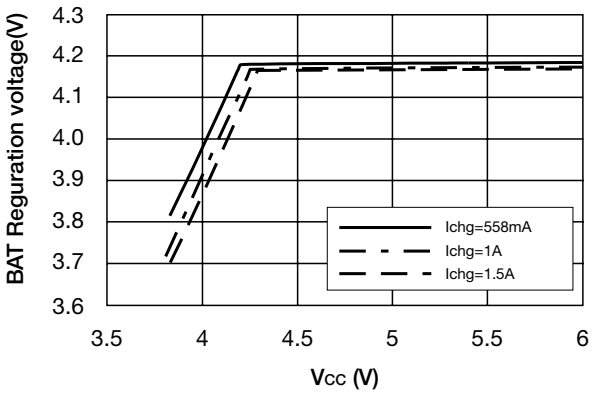



### Foc - $R_{OSC}$ external resistor

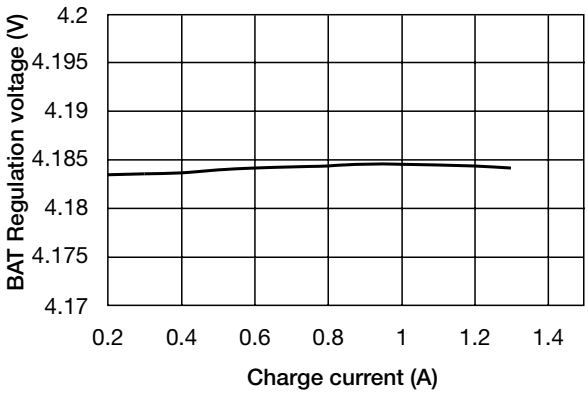



Note : * These are typical characteristics.

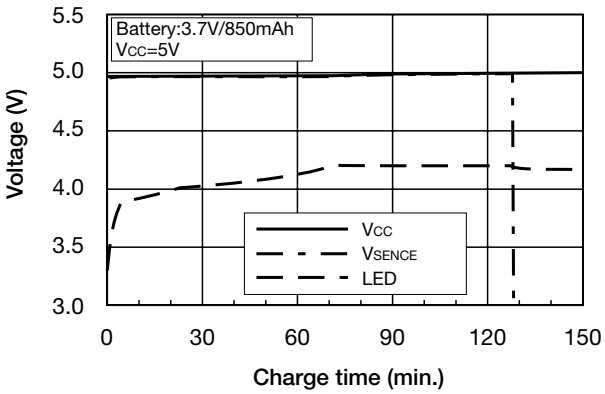
## Line Regulation



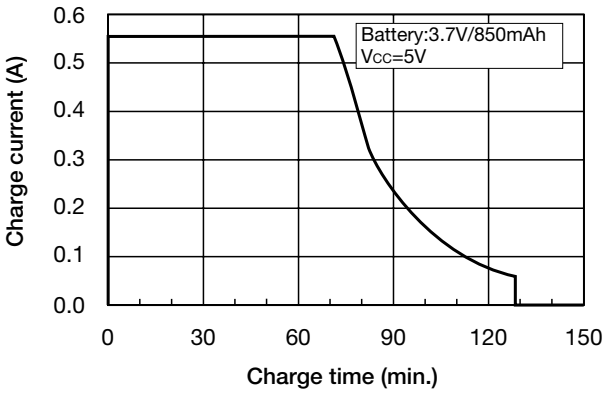

## Load Regulation



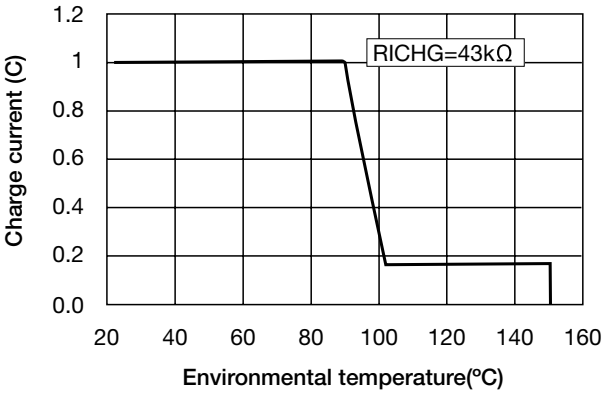

## Battery Charge characteristics



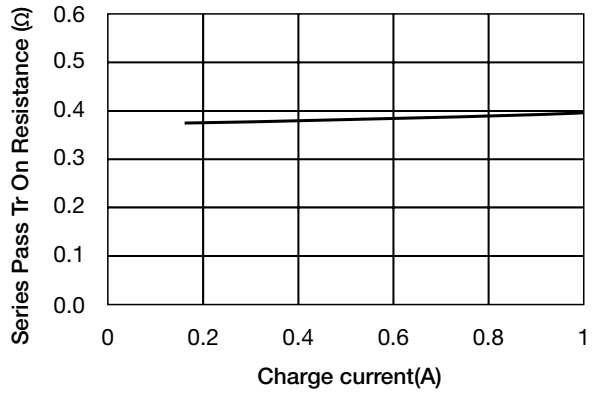

## Battery Charge characteristics




## Chip Temperature Control · Thermal Shutdown



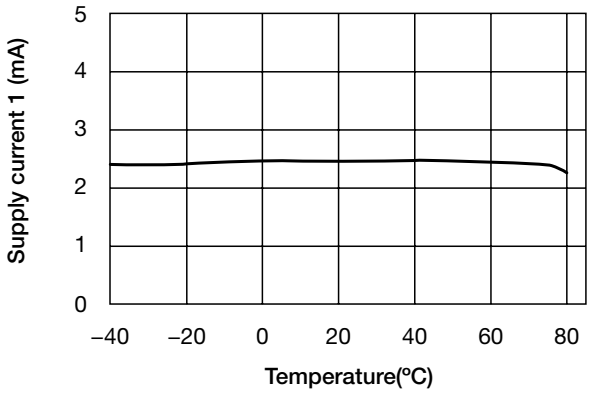

## Series Pass Tr On Resistance - Charge current



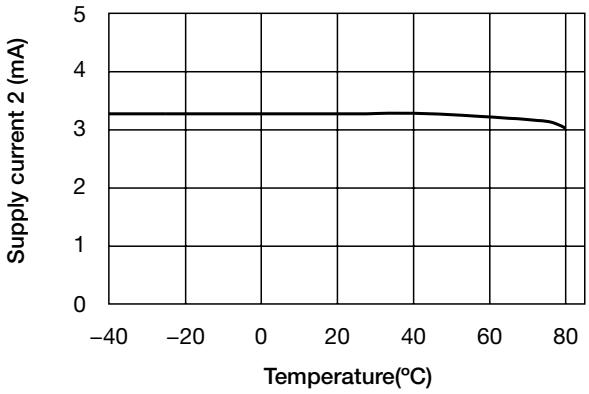

note : * These are typical characteristics.

# Temperature Dependency

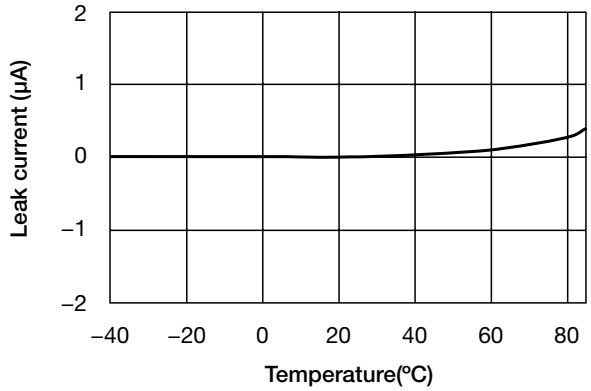
## Supply current 1



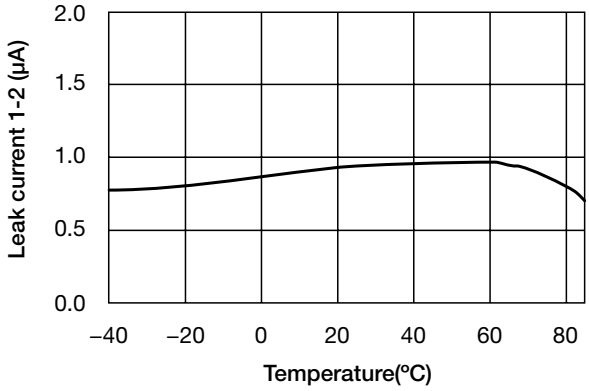

## Supply current 2



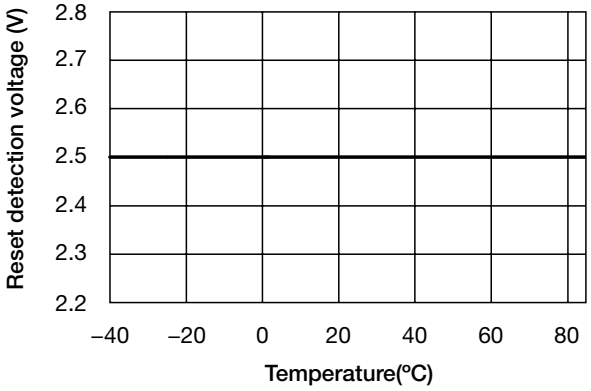

## Leak current 1-1



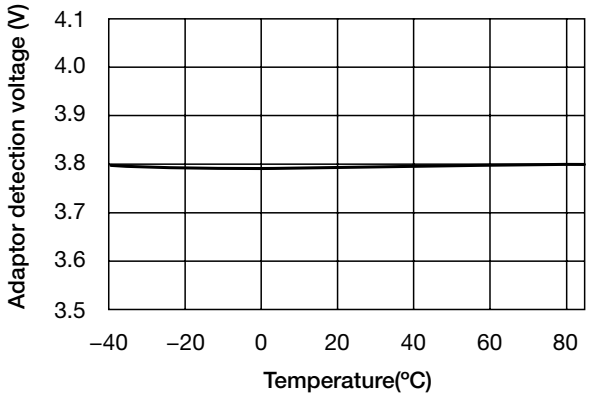

## Leak current 1-2




## Reset detection voltage

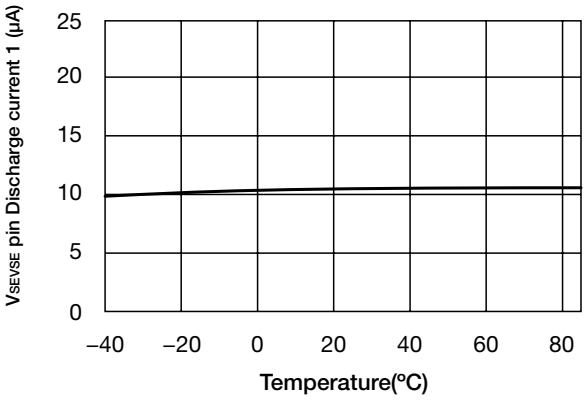



## Adaptor detection voltage

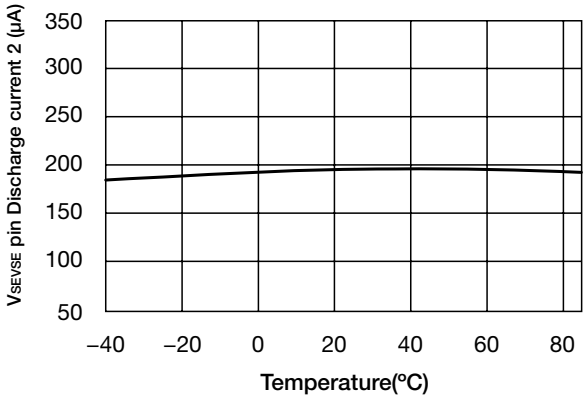



Note : * These are typical characteristics.

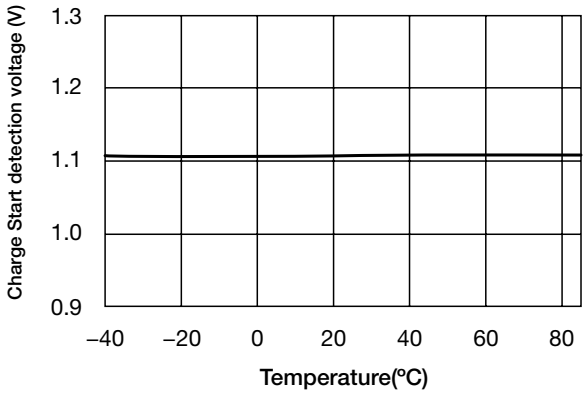
## $V_{SENSE}$ pin Discharge current 1



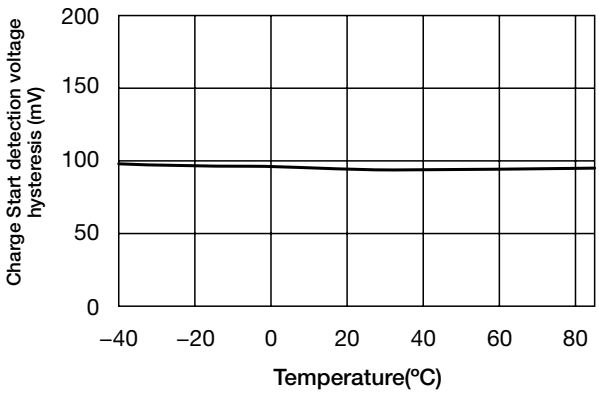

## $V_{SENSE}$ pin Discharge current 2



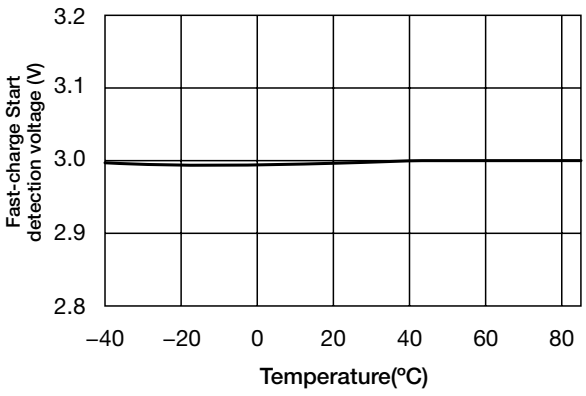

## Charge Start detection voltage



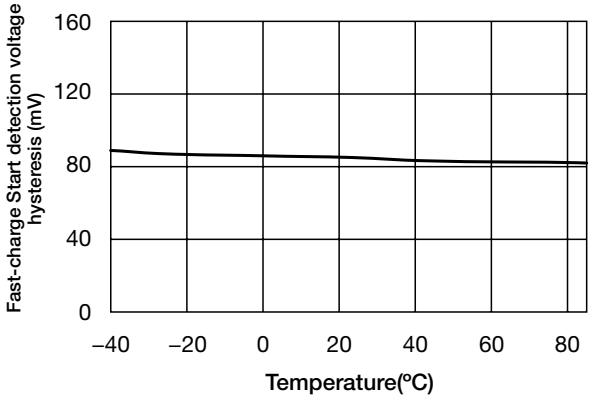

## Charge Start detection voltage hysteresis




## Fast-charge Start detection voltage

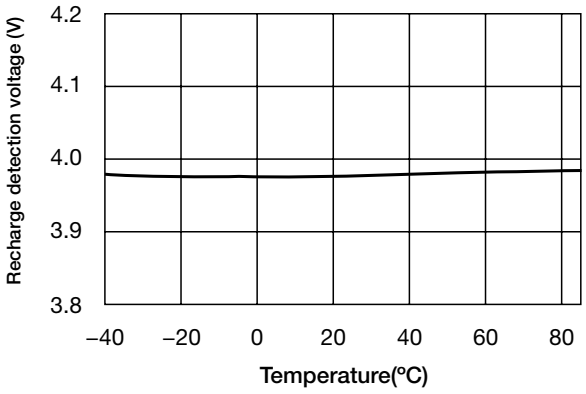



## Fast-charge Start detection voltage hysteresis

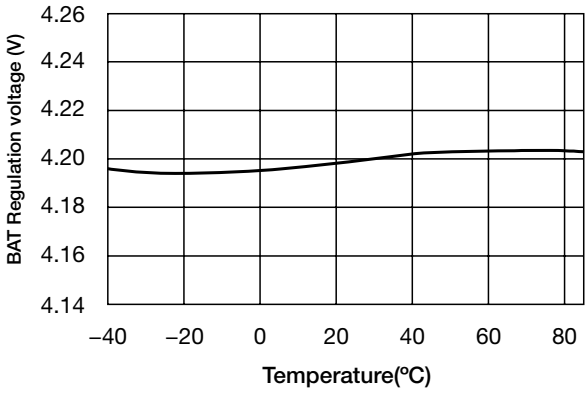



Note : * These are typical characteristics.

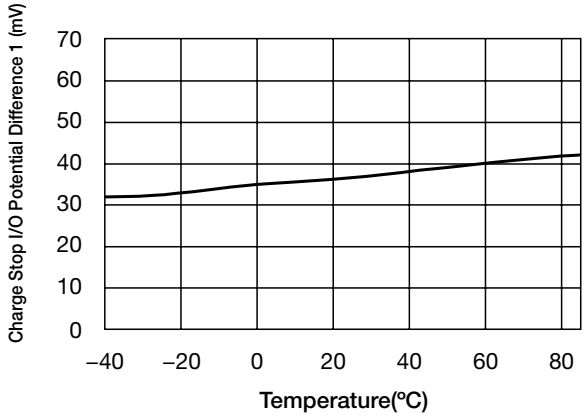
## Recharge detection voltage



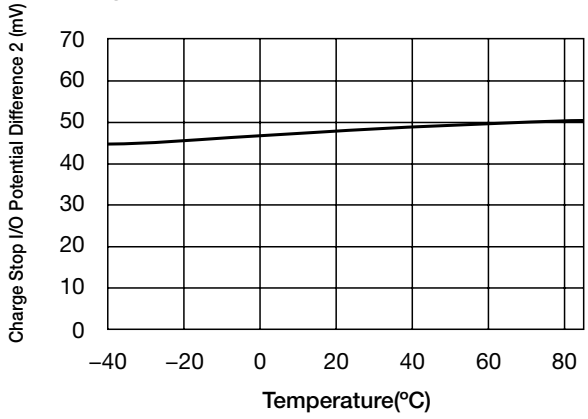

## BAT Regulation voltage



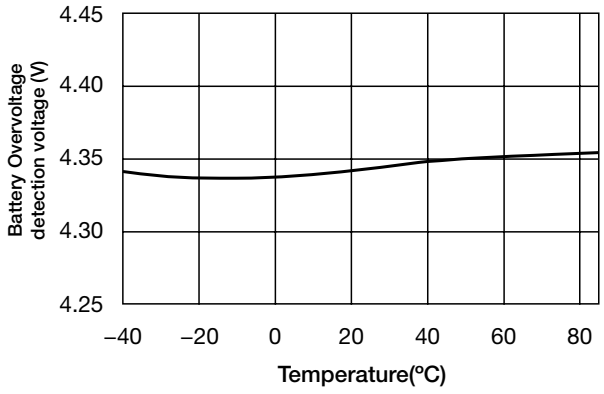

## Charge Stop I/O Potential Difference 1



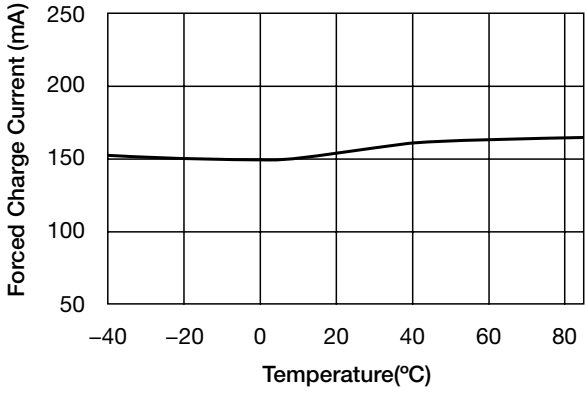

## Charge Stop I/O Potential Difference 2




## Battery Overvoltage detection voltage

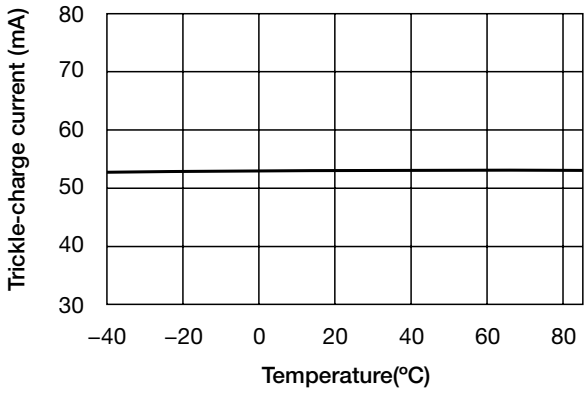



## Forced Charge Current

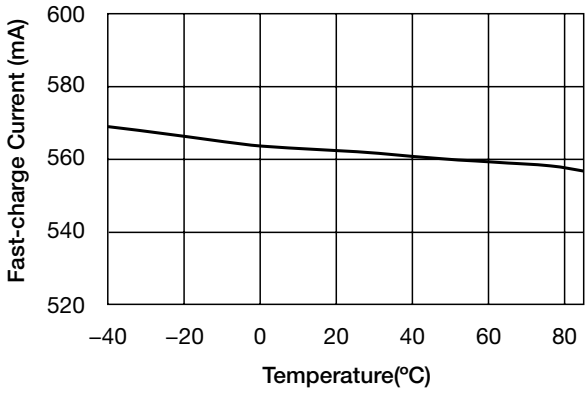



Note : ∗ These are typical characteristics.

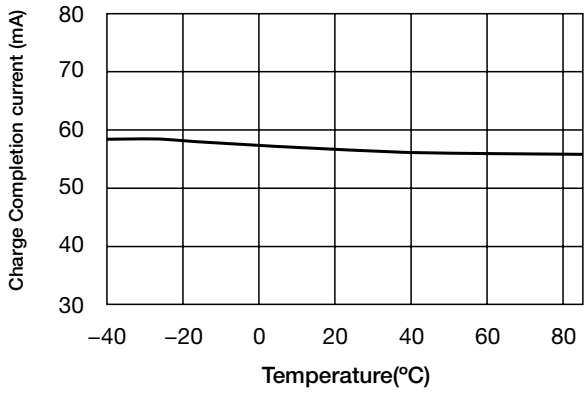
## Trickle-charge current



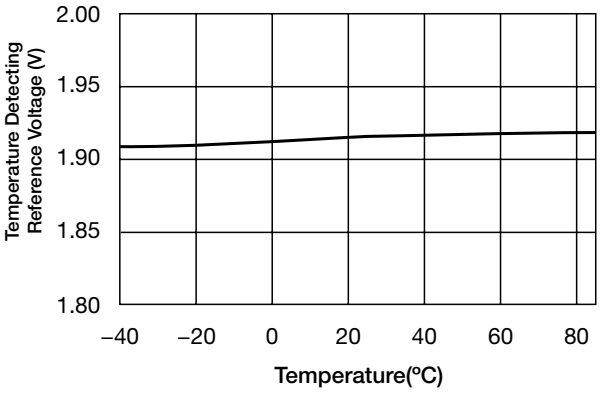

## Fast-charge current



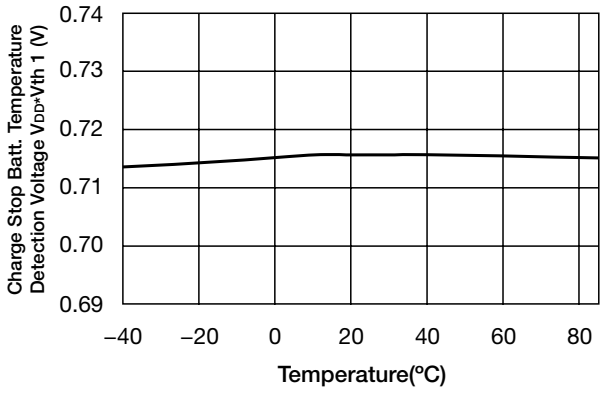

## Charge Completion current



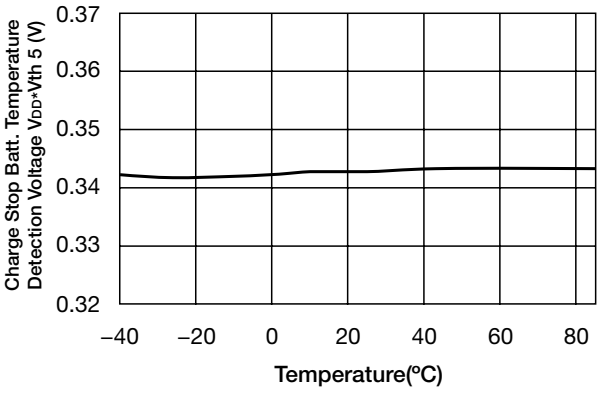

## Temperature Detecting Reference Voltage




## Charge Stop Batt. Temperature Detection Voltage

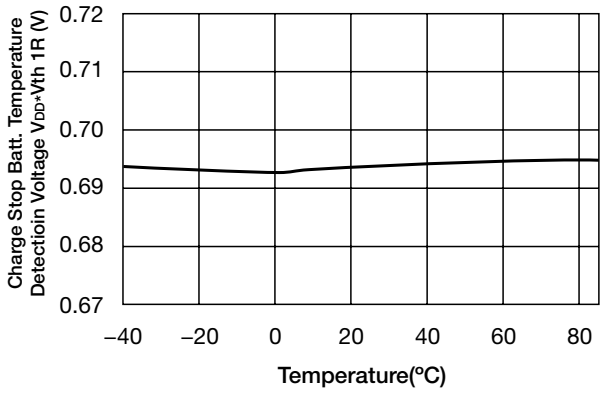



## Charge Stop Batt. Temperature Detection Voltage

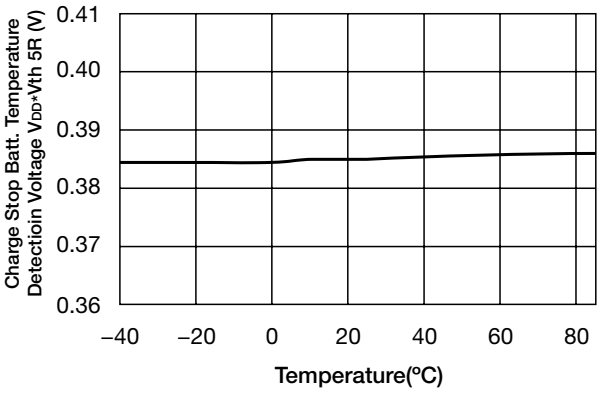



Note : * These are typical characteristics.

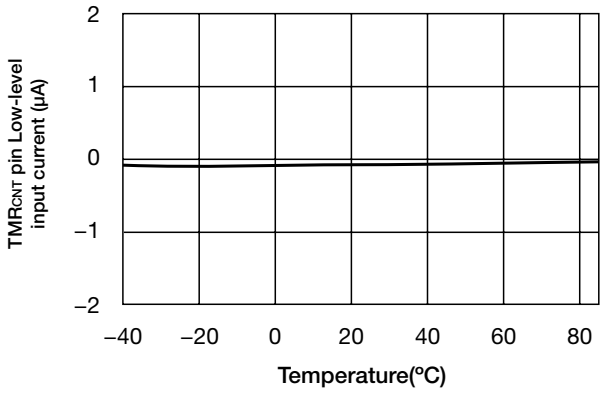
## Charge Recovery Batt. Temperature Detection Voltage



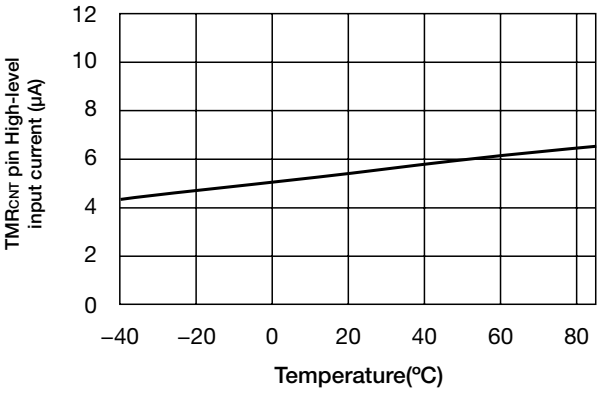

## Charge Recovery Batt. Temperature Detection Voltage



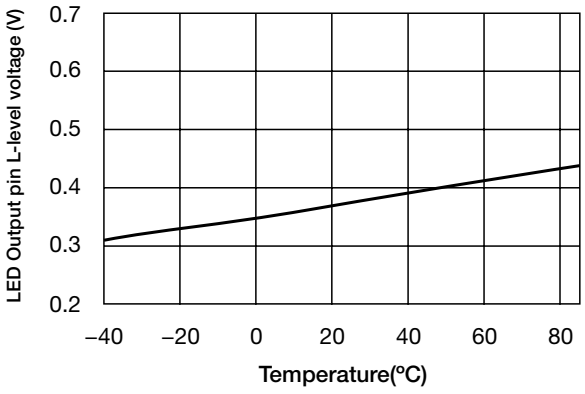

## TMRcnt pin Low-level input current



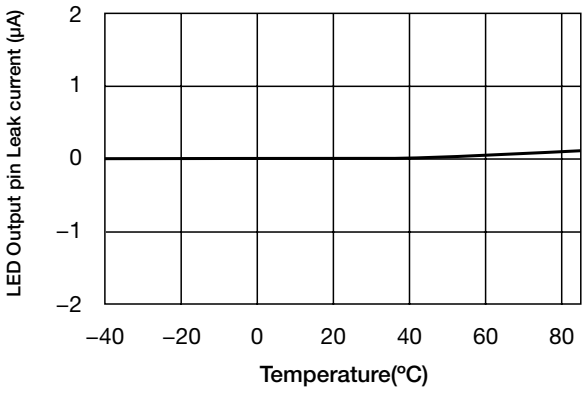

## TMRcnt pin High-level input current




## LED Output pin Low-level voltage

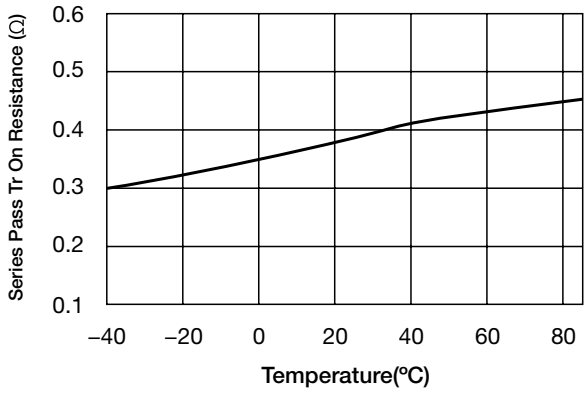



## LED Output pin Leak current

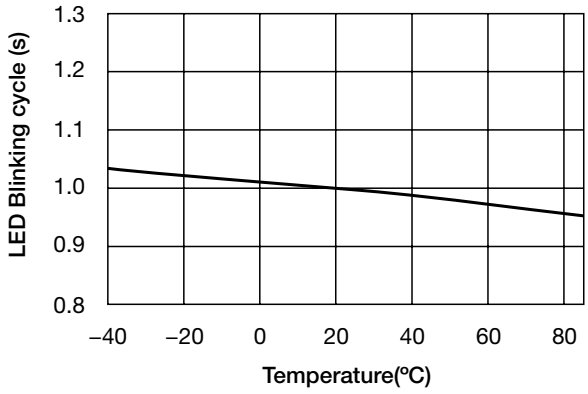



Note : * These are typical characteristics.

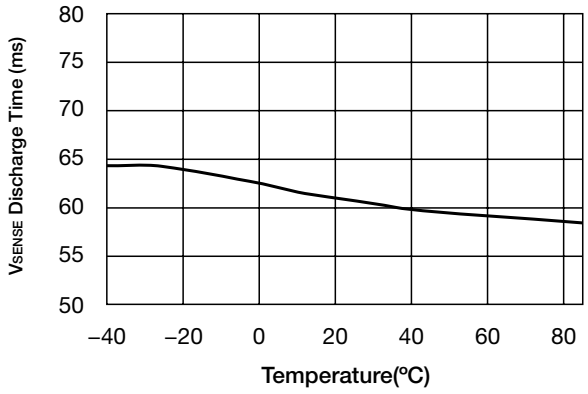
## Series Pass Tr On Resistance



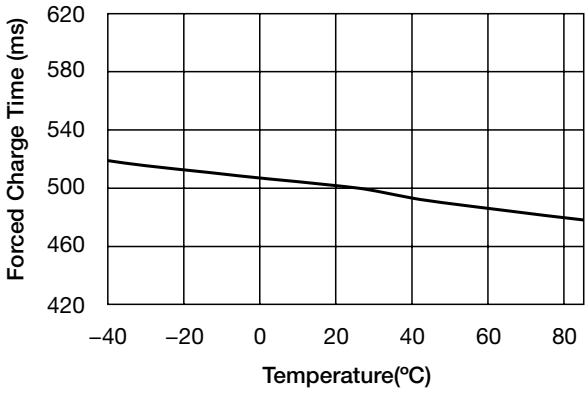

## LED Blinking cycle



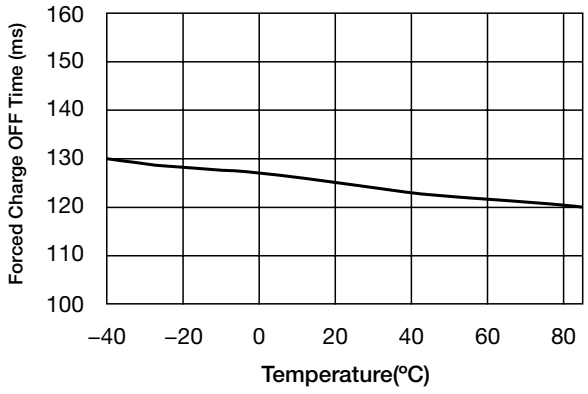

## $V_{SENSE}$ Pin Discharge Time



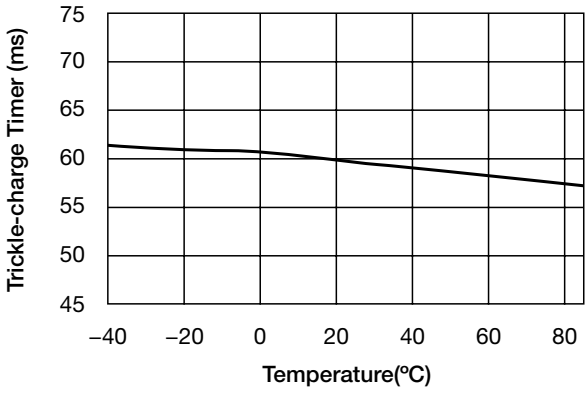

## Forced Charge Time




## Forced Charge OFF Time

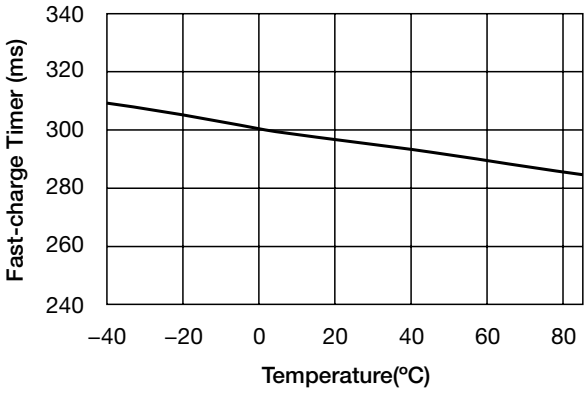



## Trickle-charge Timer



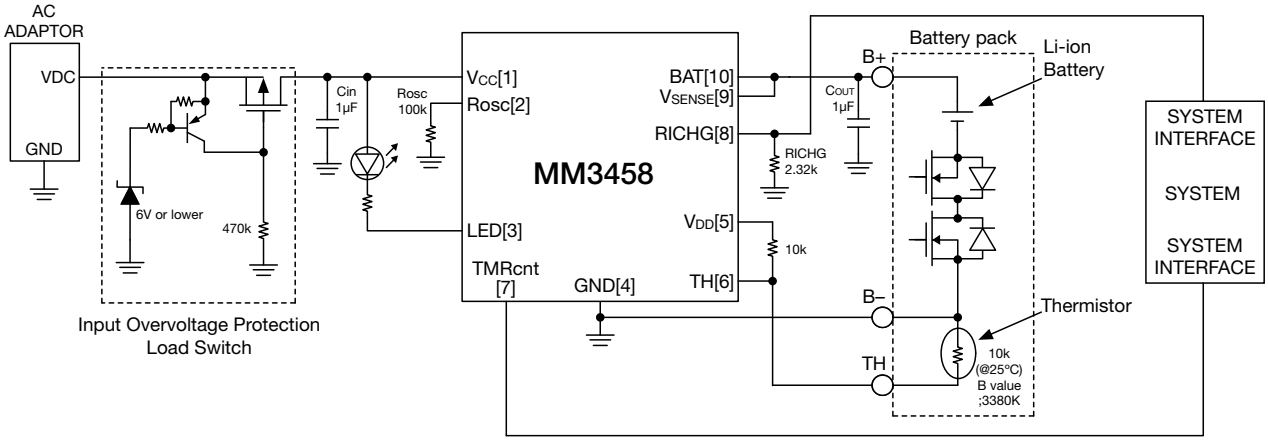

Note : ⋆ These are typical characteristics.

## Fast-charge Timer




Note : * These are typical characteristics.

## Application Circuit




· We shall not be liable for any trouble or damage caused by using this circuit.

· In the event a problem which may affect industrial property or any other rights of us or a third party is encountered during the use of information described in these circuit, Mitsumi Electric Co., Ltd. shall not be liable for any such problem, nor grant.