# Lithium Ion Battery Charging Control
# Monolithic IC MM1532

## Outline

This IC is a lithium ion battery charging controller, with protection circuits such as constant-current, constant-voltage charging and pre-charge, battery temperature detection function and others all on one chip.
The timer function on charging IC MM1475 has been omitted to achieve a smaller package, changed SW function from MM1485.

## Features

1. Output voltage (Ta = 0 ~ +50℃)      4.200±30mV
2. Consumption current 1               1.5mA typ.
   Pre-charge function
   Adaptor (primary side) abnormality detection function
3. Battery temperature detection function
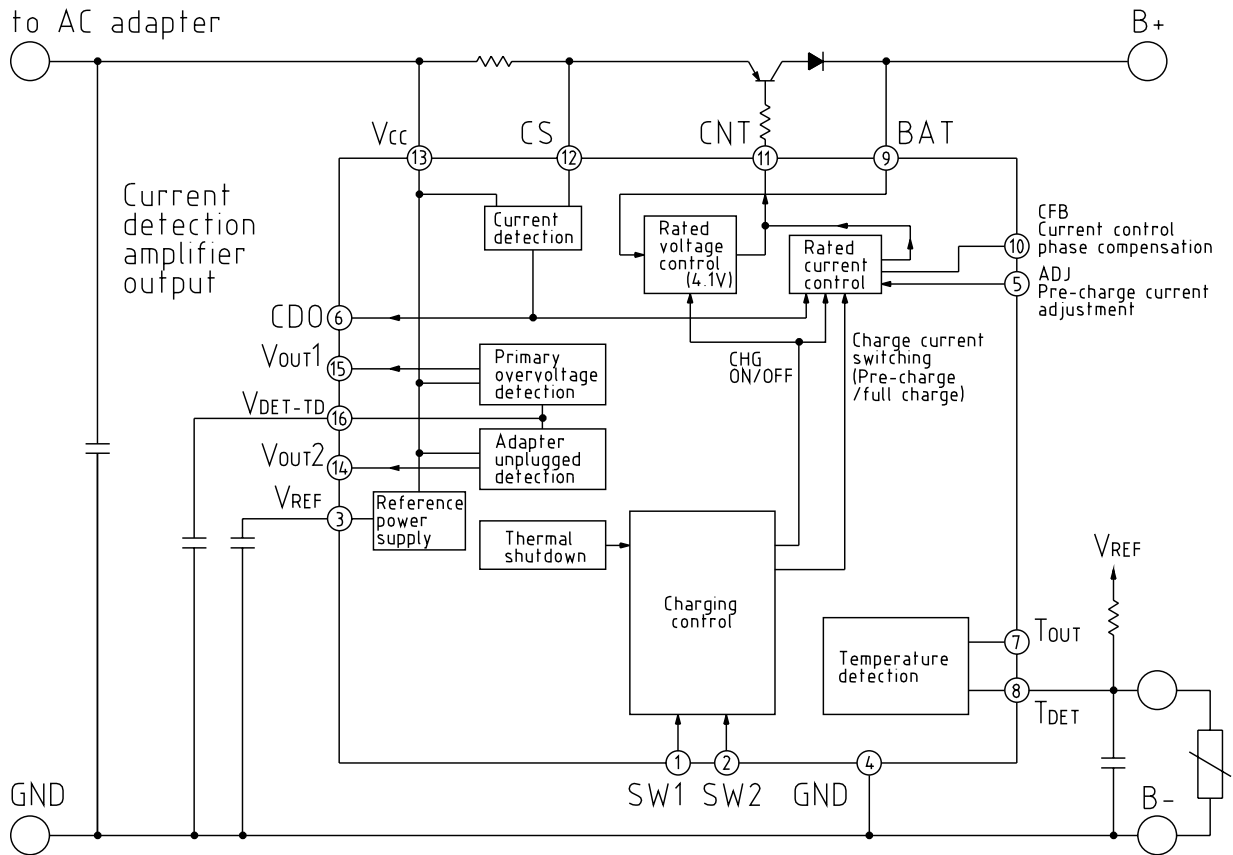
## Package

TSOP-16A

## Applications

1. Lithium ion battery charging control

## Absolute Maximum Ratings (Ta=25℃)

| Item | Symbol | Ratings | Unit |
|---|---|---|---|
| Storage temperature | $T_{STG}$ | –40~+125 | ℃ |
| Operating temperature | $T_{OPR}$ | –20~+70 | ℃ |
| Power supply voltage | $V_{CCMAX}$ | –0.3~+15 | V |
| Allowable loss | $P_D$ | 250 | mW |
| SW2 Input voltage | $V_{SW2}$ | -0.3~$V_{CC}$+0.3 | V |

# Block Diagram



**SW1 and SW2 Specifications**

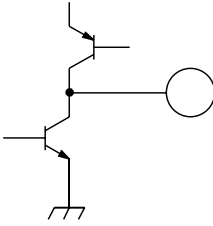| SW1 | SW2 | Charge | Current Limit |
|-----|-----|--------|---------------|
| L | H | ON | Controlled by the adaptor (current limit 1:450mV) |
| H | H | ON | Controlled by the adaptor (current limit 1:450mV) |
| L | L | OFF | |
| H | L | ON | Controlled by the IC (current limit 2:25mV) |

# Pin Assignment



TSOP-16A
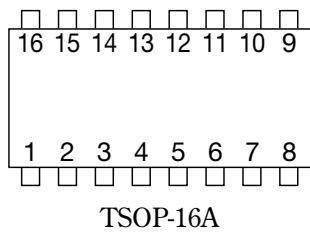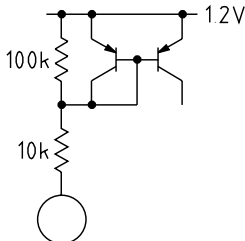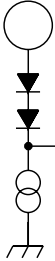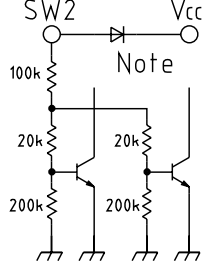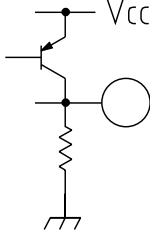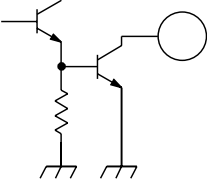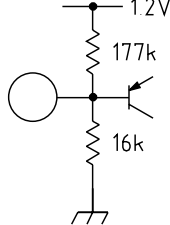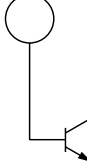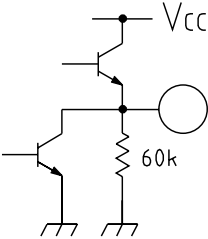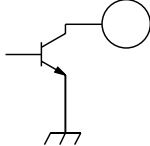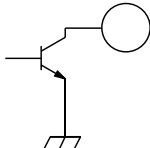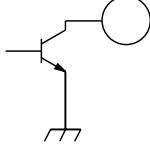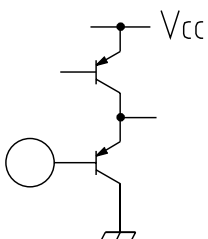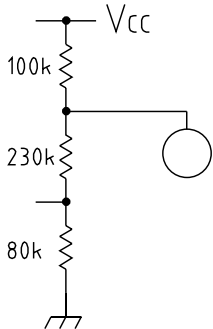
| | | | |
|---|---|---|---|
| 1 | SW1 | 9 | BAT |
| 2 | SW2 | 10 | CFB |
| 3 | $V_{REF}$ | 11 | CNT |
| 4 | GND | 12 | CS |
| 5 | ADJ | 13 | $V_{CC}$ |
| 6 | CDO | 14 | $V_{OUT2}$ |
| 7 | $T_{OUT}$ | 15 | $V_{OUT1}$ |
| 8 | $T_{DET}$ | 16 | $V_{DET-TD}$ |

# Pin Description

| Pin No. | Pin Name | I/O | Function |
|---|---|---|---|
| 1 | SW1 | Input | Charging control switching pin. |
| 2 | SW2 | Input | Switches charging ON/OFF and charging current by combinations of SW1 and SW2 L and H. |
| 3 | $V_{REF}$ | Output | Reference power supply output pin.<br>Outputs 1.2V typ.  reference voltage. |
| 4 | GND | Input | GROUND pin. |
| 5 | ADJ | Input | Pre-charge current adjustment pin.<br>Pin voltage is set at 100mV typ.  Pre-charge current can be adjusted by adjusting the pin voltage with an external resistor, etc.<br>Pre-charge current is controlled by comparing the ADJ pin voltage and voltage drop value of 12dB between $V_{CC}$-CS. |
| 6 | $C_{DO}$ | Output | Current detection output pin.<br>Outputs current difference value of 18dB between $V_{CC}$-CS. |
| 7 | $T_{OUT}$ | Output | Temperature detection output pin.<br>Normal temperature:  Output Tr OFF<br>High temperature detection:  Output Tr ON |
| 8 | $T_{DET}$ | Input | Temperature detection input pin.<br>Use external resistor and thermistor to apply resistance-divided potential from reference voltage. |
| 9 | BAT | Input | Battery voltage input pin.<br>Detects battery voltage and controls charging. |
| 10 | CFB | Input | Constant-current control phase compensation pin.<br>Connect an external capacitor (around 100pF) between CFB and CNT to perform phase compensation for improved oscillation. |
| 11 | CNT | Output | Charging control output pin.<br>Controls external PNP-Tr base and performs constant-current, constant-voltage charging. |
| 12 | CS | Input | Current detection pin.<br>Current is detected by voltage drop at external resistor between $V_{CC}$-CS  and charging current is controlled. |
| 13 | $V_{CC}$ | Input | Power supply input pin. |
| 14 | $V_{OUT2}$ | Output | Adaptor unplugged detection output pin.<br>$V_{CC}$ low voltage input:  Output Tr OFF<br>$V_{CC}$ recommended operating voltage:  Output Tr ON |
| 15 | $V_{OUT1}$ | Output | Overvoltage detection output pin.<br>$V_{CC}$ overvoltage input:  Output Tr OFF<br>$V_{CC}$ recommended operating voltage:  Output Tr ON |
| 16 | $V_{DET}$-TD | Input | Overvoltage detection delay time setting pin.<br>Delay time can be set by connecting an external capacitor. |

## Pin Description The following valaeis typical

| Pin No. | Pin name | Internal equivalent circuit diagram | Pin No. | Pin name | Internal equivalent circuit diagram |
|---------|----------|--------------------------------------|---------|----------|--------------------------------------|
| 1 | SW1 |  | 9 | BAT |  |
| 2 | SW2 |  | 10 | CFB |  |
| 3 | VREF |  | 11 | CNT |  |
| 5 | ADJ |  | 12 | CS |  |
| 6 | CDO |  | 14 | VOUT2 |  |
| 7 | TOUT |  | 15 | VOUT1 |  |
| 8 | TDET |  | 16 | VDET-TD |  |

## Electrical Characteristics (Except where otherwise indicated Ta=25°C, Vcc=5V)

| Item | Symbol | Conditions | Measurement pin | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Consumption current 1 | $I_{CC1}$ | $V_{SW1}$=1.2, $V_{SW2}$=0V | 13 | | 1.5 | 2.3 | mA |
| Consumption current 2 | $I_{CC2}$ | $V_{SW1}$=0, $V_{SW2}$=5V | 13 | | 3.5 | 5.3 | mA |
| Reference voltage | $V_{REF}$ | | 3 | | 1.207 | | V |
| ADP detection voltage L | $V_{ADPL}$ | $V_{CC}$ : H→L | 14 | 2.70 | 2.80 | 2.90 | V |
| ADP detection voltage L hysteresis voltage width | $V_{ADPLW}$ | | 14 | 50 | 100 | 150 | mV |
| ADP detection voltage H | $V_{ADPH}$ | $V_{CC}$ : L→H | 15 | 5.8 | 6.0 | 6.2 | V |
| ADP detection voltage H hysteresis voltage width | $V_{ADPHW}$ | | 15 | 50 | 100 | 150 | mV |
| BAT pin leak current | $I_{BAT}$ | | 9 | | | 1 | μA |
| BAT pin output voltage | $V_{BAT}$ | Ta=0~+50°C | 9 | 4.170 | 4.200 | 4.230 | V |
| CNT pin output voltage | $V_{CNT}$ | $I_{CNT}$=20mA | 11 | | | 0.5 | V |
| SW1 pin input current | $I_{SW1}$ | | 1 | 40 | 60 | 80 | μA |
| SW1 pin input voltage H | $V_{SW1H}$ | | 1 | 0.6 | | 1.20 | V |
| SW1 pin input voltage L | $V_{SW1L}$ | | 1 | | | 0.25 | V |
| SW2 pin input current | $I_{SW2}$ | | 2 | 6 | 12 | 18 | μA |
| SW2 pin input voltage H | $V_{SW2H}$ | | 2 | 2 | | $V_{CC}$ | V |
| SW2 pin input voltage L | $V_{SW2L}$ | | 2 | | | 0.25 | V |
| Current limit 1 | $V_{L1}$ | Quick charge | 12,13 | 0.35 | 0.45 | 0.55 | V |
| Current limit 2 | $V_{L2}$ | Pre-charge | 12,13 | 20 | 25 | 30 | mV |
| Current detection amp gain | $G_I$ | | 6 | 17.5 | 18.0 | 18.5 | dB |
| Current detection amp output offset voltage | $V_{OFF}$ | | 6 | –4.5 | 0 | 4.5 | mV |
| Current detection amp output current outflow | $I_{CDO}$ | | 6 | 0.5 | 1.0 | | mA |
| $V_{OUT1}$ pin output voltage | $V_{OUT1}$ | $I_{OUT1}$=0.12mA | 15 | | 0.2 | 0.4 | V |
| $V_{OUT2}$ pin output voltage | $V_{OUT2}$ | $I_{OUT2}$=0.12mA | 14 | | 0.2 | 0.4 | V |
| Battery temperature detection voltage | $V_{TDET}$ | $V_{TDET}$ : H→L | 8 | 0.390 | 0.413 | 0.435 | V |
| Battery temperature detection voltage hysteresis voltage width | $V_{TDETW}$ | | 8 | 30 | 60 | 90 | mV |
| $T_{OUT}$ pin output voltage | $V_{TOUT}$ | $I_{TOUT}$=0.12mA | 7 | | 0.2 | 0.4 | V |
| $T_{DET}$ input bias current | $I_T$ | | 8 | | 30 | 150 | nA |

＊ Current limits 1 and 2 are prescribed by the amount of current detection resistor voltage drop.

＊ Safety can not be guaranteed if this IC is damaged and control no longer is possible.  Please protect with something other than this IC.
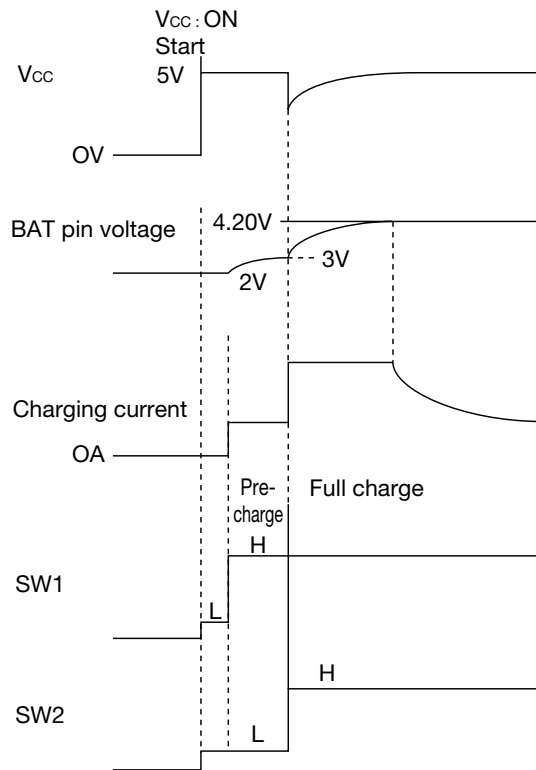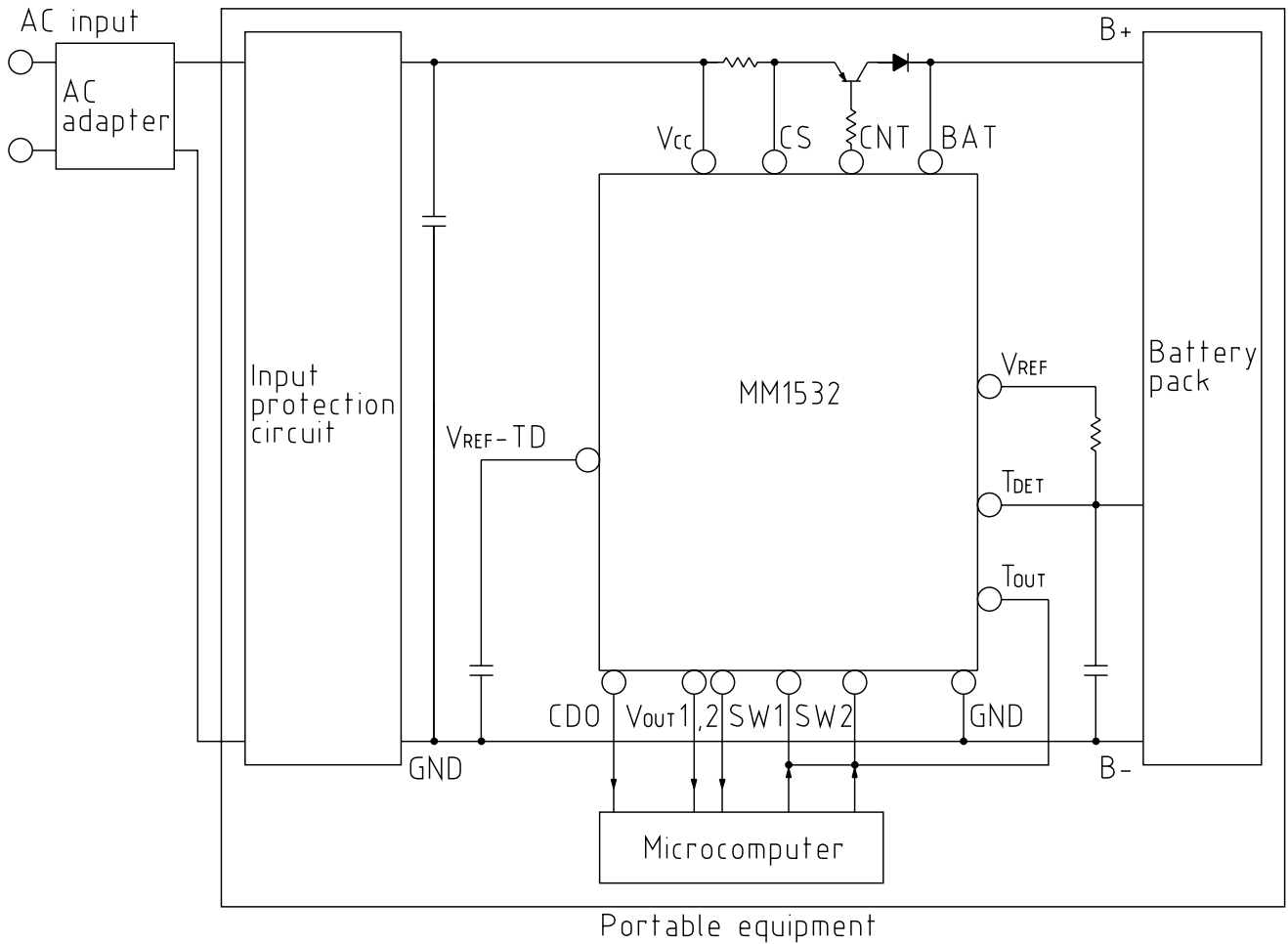
## Measuring Circuit
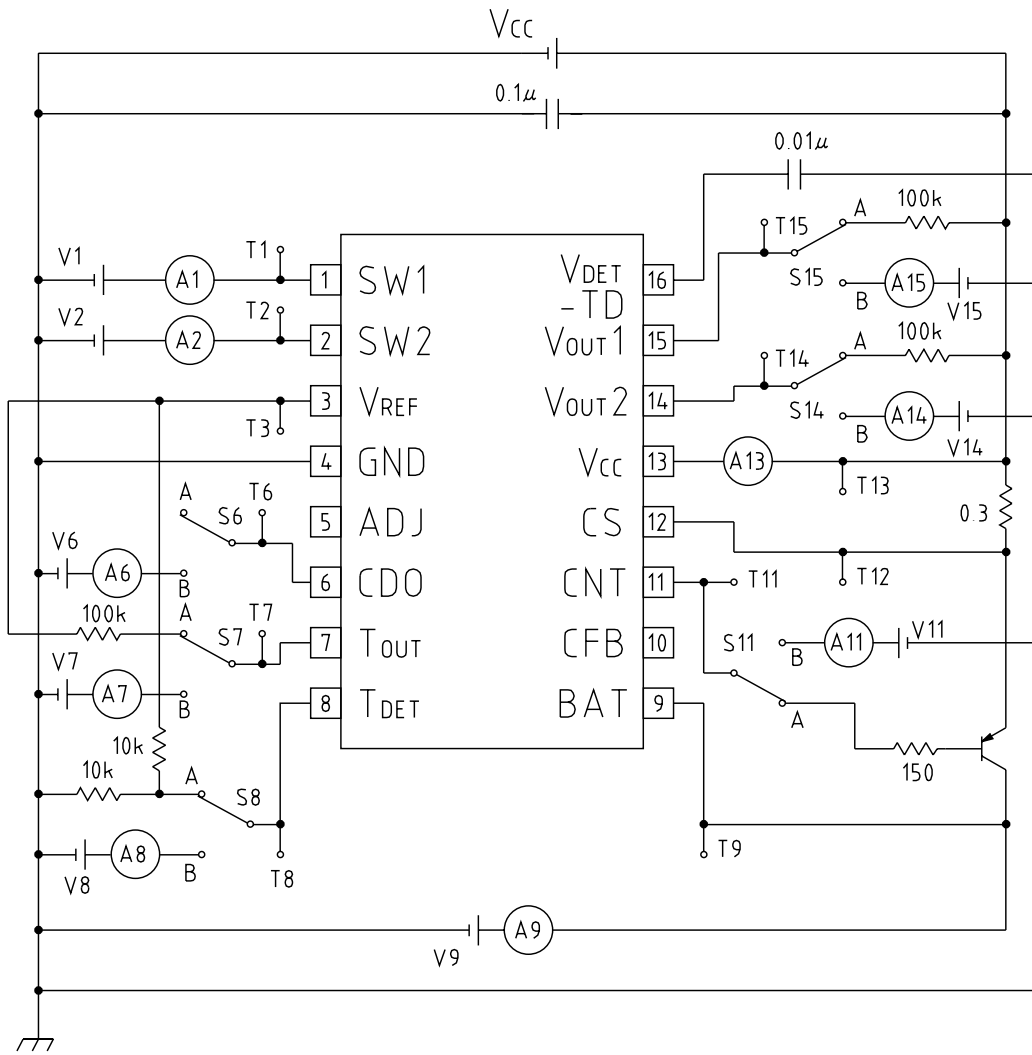
## Measurement Procedures

(Except where otherwise indicated Ta = 25°C, Vcc = 5V, Vcc: current limit 0.5A, V1 = 0V, V2 = Vcc, V9 = 4.27V, S6, 7, 8, 11, 14, 15: A)

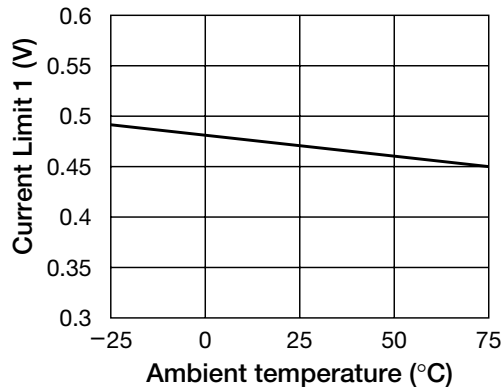| Item | Measurement Procedure |
|---|---|
| Consumption current 1 | Measure A13 current value $I_{CC1}$ at V1 =1.2V,  V2 = 0V. |
| Consumption current 2 | Measure A13 current value $I_{CC2}$. |
| Reference voltage | Measure T3 potential $V_{REF}$. |
| ADP detection voltage L | Gradually lower Vcc from 5V.  Vcc potential is $V_{ADPL}$ when T14 potential goes above Vcc – 0.5V. |
| ADP detection voltage L hysteresis voltage width | Gradually raise Vcc from 2V.  Vcc potential is $V_{ADPL2}$ when T14 potential goes under 0.5V.   $V_{ADPLW} = V_{ADPL2} – V_{ADPL}$ |
| ADP detection voltage H | Gradually raise Vcc from 5V.  Vcc potential is $V_{ADPH}$ when T15 potential goes above Vcc – 0.5V. |
| ADP detection voltage H hysteresis voltage width | Gradually lower Vcc from 7V.  Vcc potential is $V_{ADPH2}$ when T15 potential goes under 0.5V.  $V_{ADPHW} = V_{ADPH} – V_{ADPH2}$. |
| BAT pin leak current | Vcc = 0V, V2=0V, S11: B, V11 = 0V.  Measure A9 current value $I_{BAT}$. |
| BAT pin output voltage | Gradually raise V9 from 3.5V.  T9 potential is $V_{BAT}$ when the potential difference between T13–T12 is 20mV or less. |
| CNT pin output voltage | V9 = 3.5V, S11: B.  Gradually raise V11 from 0V.  T11 potential is $V_{CNT}$ when A11 current value is 20mA. |
| SW1 pin input current | Measure A1 current value $I_{SW1}$. |
| SW1 pin input voltage H | V9 = 3.5V, V2 = 0V.  Raise V1 from 0V to 1.2V.  Identify $V_{SW1}$ H or L; when A9 is 50mA or higher, charging ON at current limit 2, and when A9 is 1mA or lower, |
| SW1 pin input voltage L | charging is OFF. |
| SW2 pin input current | V1=0V, V2=2V.  Measure A2 current value $I_{SW2}$. |
| SW2 pin input voltage H | V9 = 3.5V, V1=0V.  Raise V2 from 0V to Vcc.  Identify $V_{SW2}$ H or L; when A9 is 450mA or higher, charging ON at current limit 1, and when A9 is 1mA or lower, |
| SW2 pin input voltage L | charging is OFF. |
| Current limit 1 | V1 = 0V, V2=Vcc, V9=3.5V.  Gradually raise Vcc current limit value and measure the potential difference between T13–T12, $V_{L1}$. |
| Current limit 2 | V1 = 1.2V, V2=0V, V9=2.5V.  Potential difference between T13–T12 is $V_{L2}$. |
| Current detection amp gain | V9 = 3.5V.  The potential difference fluctuation between T13–T12 when Vcc current limit value is changed from 100mA to 200mA is $\triangle$Va and the T6 potential fluctuation is $\triangle$Vb. $G_1 = 20\log |\triangle Vb/ \triangle Va|$ |
| Current detection amp output offset voltage | V9 = 4.0V.  T6 potential is Vb2 when Vcc current limit is 100mA. $V_{OFF} = Vb2/8 – 30mV$ |
| Current detection amp output current outflow | V9 = 3.5V, Vcc current limit value is 300mA, S6: B, V6 = 0V.  Measure A6 current value. |
| $V_{OUT1}$  pin output voltage | S15: B.  Gradually raise V15 from 0V.  T15 potential is $V_{OUT1}$ when A15 current value is 0.12mA. |
| $V_{OUT2}$ pin output voltage | S14: B.  Gradually raise V14 from 0V. T14 potential is $V_{OUT2}$ when A14 current value is 0.12mA. |
| Battery temperature detection voltage hysteresis voltage width | S8: B.  Gradually lower V8 from 0.6V.  T8 potential is $V_{TDET}$ when T7 potential is 0.3V or under. |
| Battery temperature detection voltage hysteresis voltage width | S8: B.  Gradually raise V8 from 0V.  T8 potential is $V_{TDET2}$ when T7 potential is 0.8V or higher.  $V_{TDETW} = V_{TDET2} – V_{TDET}$. |
| $T_{OUT}$ pin output voltage | S8: B, V8 = 0V, S7: B.  Gradually raise V7 from 0V.  T7 potential is $V_{TOUT}$ when A7 current value is 0.12mA. |
| $T_{DET}$ input bias current | S8: B, V8 = 0V.  Measure A8 potential value $I_T$. |

## Timing Chart

Vcc

Vcc : ON
Start
5V

0V

BAT pin voltage

4.20V

3V

2V

Charging current

0A

Pre-charge

Full charge

SW1

H

L

SW2

H

L

## Application Circuits

AC input

AC adapter

B+

Input protection circuit

Vcc

CS

CNT

BAT

MM1532

VREF

TDET

TOUT

Battery pack

VREF-TD

CDO

VOUT1,2

SW1

SW2

GND

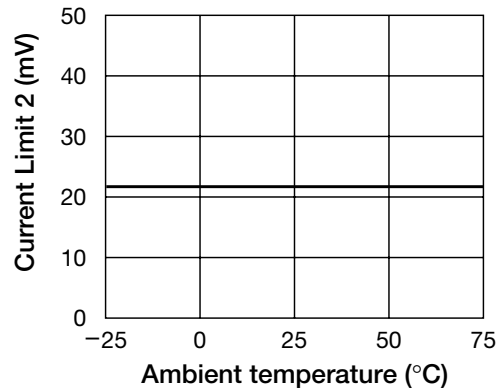GND

B-

Microcomputer

Portable equipment

# Characteristics

## ◼ Current Limit 1 vs Ambient temperature

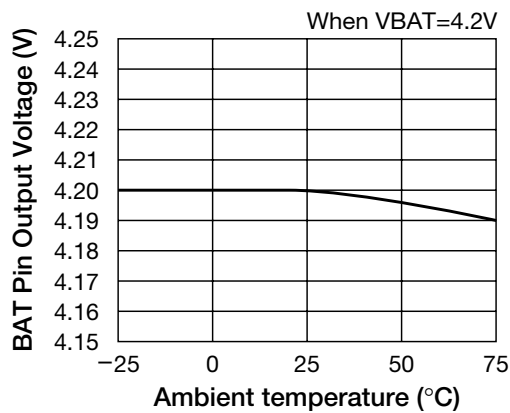Current Limit 1 (V) vs Ambient temperature (°C)

## ◼ Current Limit 2 vs Ambient temperature

Current Limit 2 (mV) vs Ambient temperature (°C)
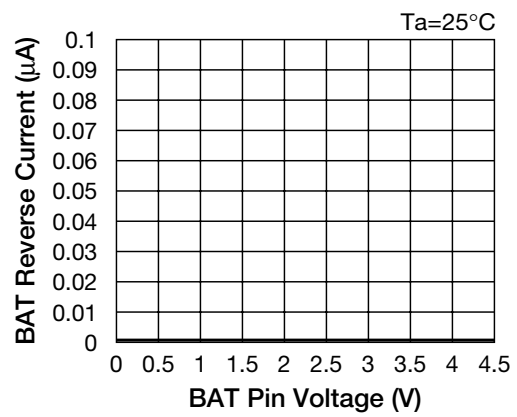
## ◼ BAT Pin Output Voltage vs Ambient temperature

When VBAT=4.2V

BAT Pin Output Voltage (V) vs Ambient temperature (°C)

## ◼ Current Detection Input/Output

Ta=25°C

CDO Output Voltage (V) vs Potential Difference between (CS+) and (CS−) (mV)
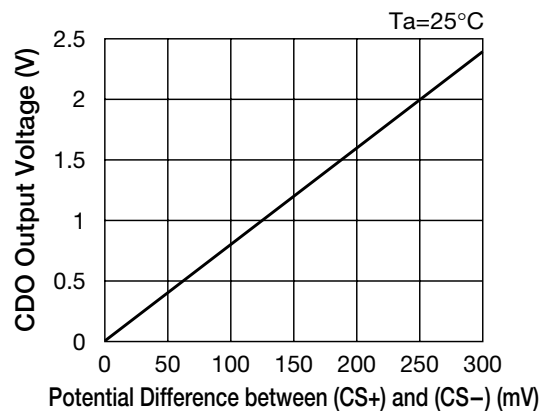
## ◼ VCNT Voltage vs ICNT Current

Ta=25°C

VCNT Voltage (V) vs ICNT Current (mA)
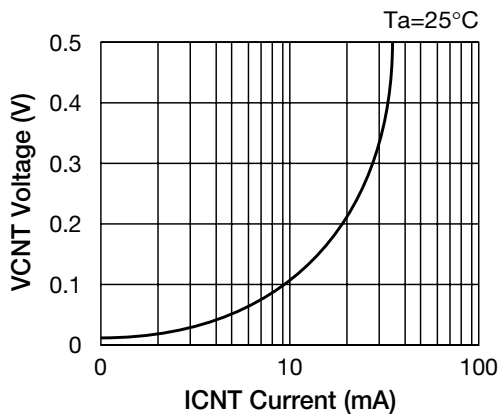
## ◼ BAT Pin Reverse Current vs BAT Pin Voltage

Ta=25°C

BAT Reverse Current (μA) vs BAT Pin Voltage (V)

## ◼ ADP Detection H Delay Time

Ta = 25°C, Vcc = 0→6.5V

ADP Detection H Delay Time (ms) vs Capacitance between (VDET−TD) and GND (μF)