Lithium-Ion Battery Charge Control (1 cell)
Monolithic IC MM3204 Series

Applications

This IC is a linear charge control IC for 1-cell lithium-ion/lithium-polymer batteries.
It incorporates a power MOSFET and a reverse-current block circuit for easy implementation of charge control of lithium-ion batteries.
It also incorporates an LED display circuit to allow the charge status to be displayed.

Features

1. Constant-voltage charge control
2. Constant-current control
3. Includes a power MOSFET
4. Includes a charge timer
5. Incorporates a reverse-current block circuit
6. Outputs the charge status display to the LED and microprocessor

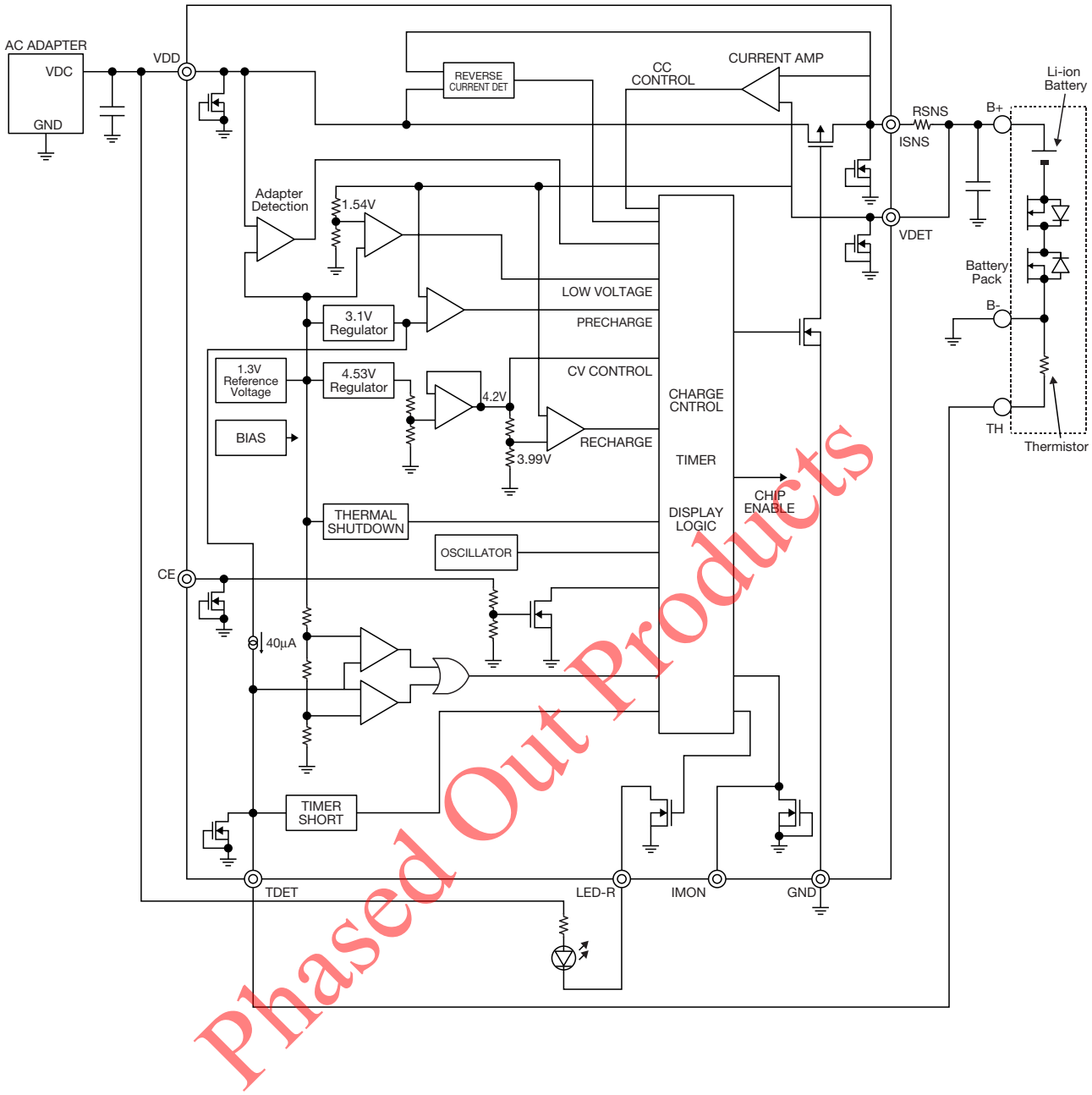
Package

PLP-8B

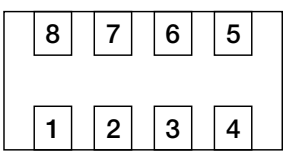
Applications

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

Block Diagram



Pin Assignment



PLP-8B
(TOP-VIEW)

1	V_{DD}
2	IMON
3	LED-R
4	GND
5	CE
6	TDET
7	VDET
8	ISNS

Pin Description

Pin No.	Symbol	Function
1	V_{DD}	Power input pin. Connect to an AC adapter
2	IMON	Charge current monitor pin.
3	LED-R	LED R connect pin. (open drain output) Turn on during charging.
4	GND	GND pin.
5	CE	Chip enable pin. (active high)
6	TDET	Battery temperature detect input pin.
7	VDET	Battery voltage detect pin. Connect to the low potential side of a detect resistor.
8	ISNS	Charge current detect input pin. Connect to the high potential side of a detect resistor.

Absolute Maximum Ratings (*1)

Item	Symbol	Ratings	Units
Storage temperature	T_{STG}	−55~+150	°C
Operating temperature	T_{OPR}	−40~+85	°C
Junction temperature	T_J	−40~+150	°C
V_{DD} pin voltage	$V_{IN}1$	−0.3~+7	V
CE, LED-R, IMON, ISNS, VDET pin voltage	$V_{IN}2$	−0.3~+6	V
TDET pin voltage	$V_{IN}3$	−0.3~+3.5	V
V_{DD}, ISNS pin current	$I_{VDD, ISNS}$	1.2	A
Allowable loss	Pd	2 *2	W

note : *1 Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

note : *2 When mounted on a SR4 (glass epoxy) PC board. (50×50×1.0tmm, Copper foil area 60%)

Recommended Operating Conditions

Item	Symbol	Ratings	Units
Operating temperature	T_{OPR}	−40~+85	°C
V_{DD} operating voltage	V_{OP}	4.6~5.9	V

Electrical Characteristics (Except where noted otherwise Ta=−40~85°C, V_{DD}=5.0V *3)

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Units
Supply current	I_{DD}	$V_{DD}>V_{ADPL}$		0.5	0.9	mA
Supply current (Power off)	$I_{DD\ (OFF)}$	CE<V_{CEOFF}		60	120	µA
Sleep current	Islp	$V_{DD}<V_{ADPL}$ Current into VDET and ISNS pin		6	20	µA
VDET, ISNS current (Charging completion)	I_ISNS	VDET=4.2V, when charging stops Current into VDET and ISNS pin		15	30	µA
ADP detection voltage L1	V_{ADPL1}	V_{DD} rising threshold Under-voltage lockout	4.20	4.35	4.50	V
ADP detection voltage L2	V_{ADPL2}	V_{DD} falling threshold Under-voltage lockout	2.45	2.60	2.75	V
ADP detection voltage H	V_{ADPH}	Ta=25°C, V_{DD} rising threshold	6.20	6.40	6.60	V
ADP detection voltage H hysteresis	$V_{ADPH\ (HYS)}$	Ta=25°C		80		mV
Low voltage detection voltage	V_chgon	VDET pin threshold	1.44	1.54	1.64	V
Precharge detection voltage	V_Qchgon	VDET pin threshold	3.00	3.10	3.20	V
VDET regulation voltage	V_cv	Ta=25°C	4.17	4.20	4.23	V
			4.16	4.20	4.24	
Voltage detection output voltage	V_vdet			1.30		V
Charge current set voltage H	V_IchgH	ISNS-VDET voltage Fast-charge current set voltage	199	210	221	mV
Charge current set voltage L	V_IchgL	ISNS-VDET voltage Precharge current set voltage	12	21	30	mV
Charge completion detection voltage	V_Icmplt	ISNS-VDET voltage	13	18	23	mV
Recharge detection voltage	V_rechg	VDET pin threshold	3.89	3.99	4.09	V
Sleep-mode entry threshold voltage	V_reverse	Sleep mode ON threshold			V_{DD} ≦ ISNS+50	mV
Sleep-mode exit threshold voltage	$V_{\_reverse(exit)}$	Sleep mode OFF threshold	V_{DD} ≧ ISNS+220			mV
Delay time for the initial connection	Tdelay_1st	Ta=25°C, when charging stops		55		ms
Charge time for the initial connection	Tchg_1st	Ta=25°C	260	385	510	ms
Voltage detection delay time	Tdly_Vdet	Ta=25°C	46	55	64	ms
Current detection delay time	Tdly_Idet	Ta=25°C	315	440	565	ms
Recharge detection delay time	Tdly_rechg	Ta=25°C	315	440	565	ms
Temperature detection delay time	Tdly_tdet	Ta=25°C	315	440	565	ms
Temperature sense current source	Its	Ta=25°C	36	40	44	µA
Battery temperature detection voltage H (low temperature detection at 3°C)*1, *2	V_{TH}	TDET rising threshold	0.973	1.002	1.031	V
Battery temperature detection voltage L1 (when charging starts, high temperature detection at 43°C)*1, *2	V_{TL1}	TDET falling threshold	0.196	0.207	0.218	V
Battery temperature detection voltage L2 (during charging, high temperature detection at 50°C)*1, *2	V_{TL2}	TDET falling threshold	0.158	0.164	0.170	V
Precharge timer	Tprechg	Ta=25°C	1,530	1,800	2,070	s
Fast-charge timer	Tfastchg	Ta=25°C	12,240	14,400	16,560	s
LED-R output voltage	V_LED-R	IoL=5mA			0.15	V
Current sense amp gain	Avcs	ISNS-VDET voltage ≧ 50mV	13.3	14.0	14.7	dB
		ISNS-VDET voltage < 50mV	10.0	14.0	18.0	dB

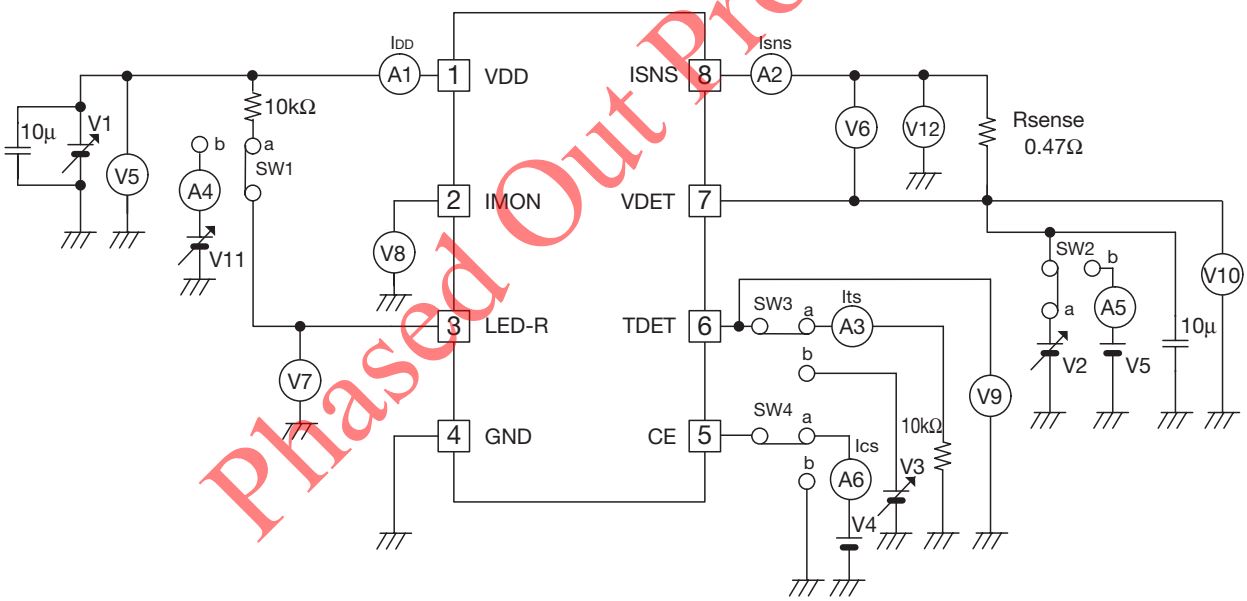
Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Units
IMON output voltage (Charging)	V_{IMON}	Fast-charge: ISNS-VDET voltage = 210mV	973	1050	1140	mV
		Precharge: ISNS-VDET voltage = 21mV	67	105	166	mV
Thermal shutdown	Thermal			155		°C
Thermal shutdown hysteresis	Thermal hys			15		°C
CE Low-level input voltage	V_{CEL}	Charge OFF threshold	0		0.3	V
CE High-level input voltage	V_{CEH}	Charge ON threshold	2		V_{DD}	V
CE input current	I_{CE}			10	20	μA
Power MOSFET ON resistance	R_{ON}	VDET=3.3V, IBAT=440mA, Ta=25°C		0.34	0.51	Ω

note : *1 Temperature detection is set to B constant 3435 (Ishizuka Electronics).

note : *2 When applying 3.2V < TDET < 3.5V to the TDET pin, the device enters time shortening mode that reduces oscillation period of OSC, and precharge/fast-charge timer period.

note : *3 Limits over the operating temperature range of −40°C to 85°C are guaranteed by design, characterization, and correlation with statistical process controls.

Measuring Circuit



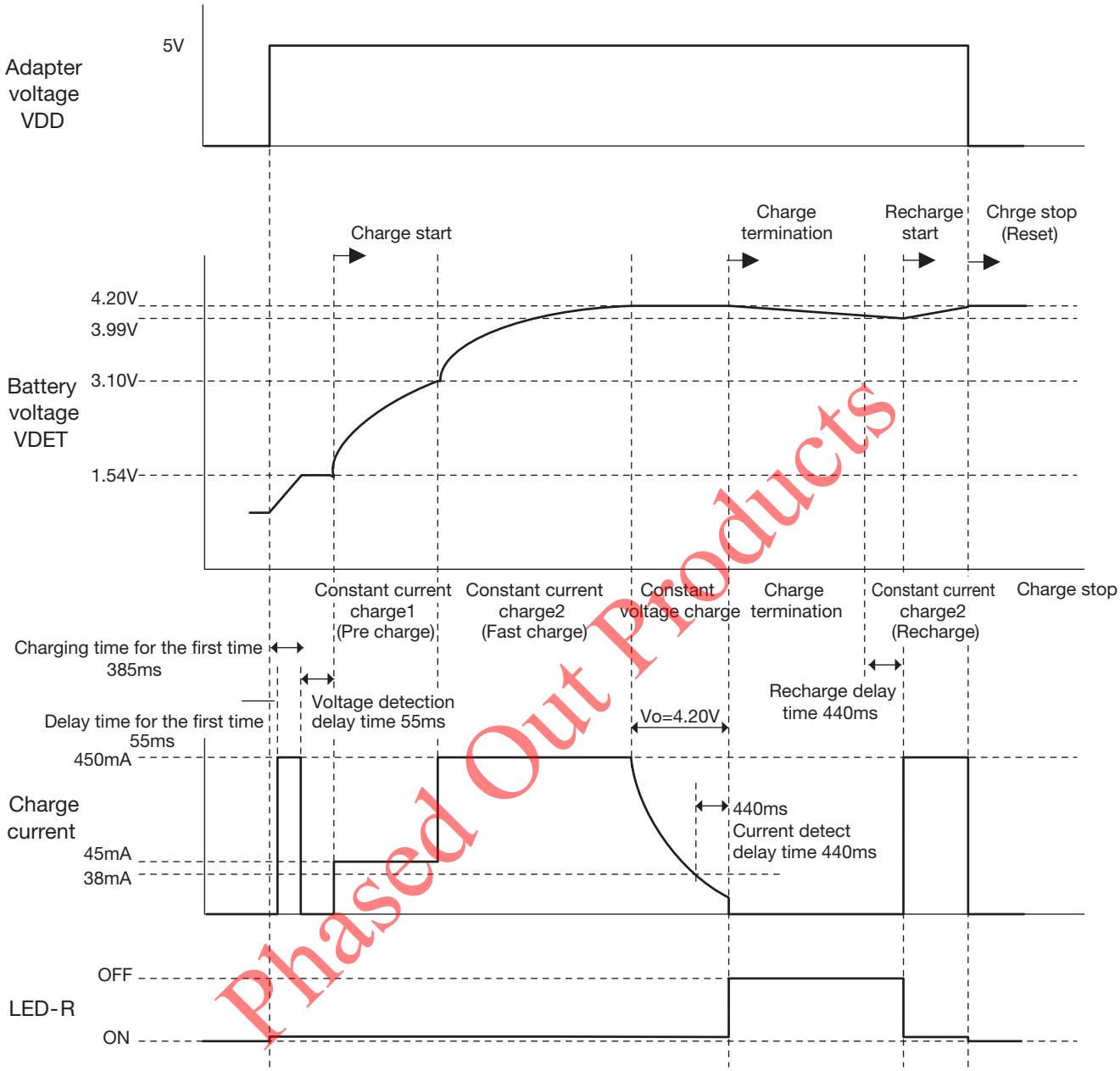
Measurement Procedures

Item	Measurement Procedures
Supply current	Measure the current of A1 when SW1 : open, SW2 : open, SW3 : open, SW4 : a, V1=5V, V4=5V.
Supply current (Power off)	Measure the current of A1 when SW1 : open, SW2 : open, SW3 : open, SW4 : b, V1=5V.
Sleep current	Measure the current of A5 that flows from V5 when decreasing the voltage of V1 below V_{ADPL2} from 5V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=4.1V.
ADP detection voltage L1	V_{ADPL1} is the voltage of V5 when the current of A2 reaches over 450mA while gradually increasing the voltage of V1 from 2V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=3.5V.
ADP detection voltage L2	V_{ADPL2} is the voltage of V5 when the current of A2 falls below 1mA while gradually decreasing the voltage of V1 from 5V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=2.0V.
ADP detection voltage H	V_{ADPH} is the voltage of V5 when the current of A2 falls below 1mA while gradually increasing the voltage of V1 from 5V to 7V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=3.5V.
ADP detection voltage H hysteresis	VADPH2 is the voltage of V5 when the current of A2 reaches over 450mA while gradually decreasing the voltage of V1 from 7V to 5V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=3.5V. $V_{ADPH(HYS)}=V_{ADH1}-V_{ADH2}$
Low voltage detection voltage	Measure the voltage of V10 when the current of A2 reaches over 45mA while gradually decreasing the voltage of V2 from 2V when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V2=2V, V4=5V.
Precharge detection voltage	Measure the voltage of V10 when the current of A2 reaches over 450mA while gradually increasing the voltage of V2 from 2.5V when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V2=2.5V, V4=5V.
VDET regulation voltage	Measure the voltage of V10 when the current of A2 starts decreasing while gradually increasing the voltage of V2 from 3.5V when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V2=3.5V, V4=5V.
Voltage detection output voltage	Measure the voltage of V10 during voltage detection delay time when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V5=0.5V, V4=5V.
Charge current set voltage H	Measure the potential difference of V6 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V5=3.5V, V4=5V.
Charge current set voltage L	Measure the potential difference of V6 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V5=2.5V, V4=5V.
Charge completion detection voltage	Measure the potential difference of V6 when the potential of V7 goes H from L while gradually increasing the voltage of V2 from 3.5V when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V4=5V.
Recharge detection voltage	Measure the voltage of V10 when the potential of V7 goes L from H while gradually decreasing from V2=4.2V (after full-charge detection) when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V4=5V.
Sleep-mode entry threshold voltage	Measure the potential difference between V5 and V6 when the current of A2 falls below 1mA while gradually increasing the voltage of V1 from 5V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V5=2.8V, V4=5V.
Sleep-mode exit threshold voltage	Measure the potential difference between V5 and V6 when the current of A2 reaches over 45mA while gradually increasing the voltage of V1 after sleep mode when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V5=2.8V, V4=5V.

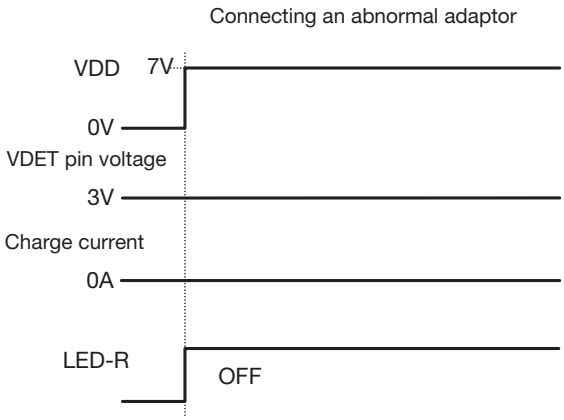
Item	Measurement Procedures
Voltage detection delay time	Measure the time until the current of more than 450mA (fast-charge current) flows to A2 from when the charge time for the initial connection terminates after applying V1=5V when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V5=3.5V (fast-charge state), V4=5V, V1=5V.
Current detection delay time	Measure the time when the potential of V7 goes H from L when varying the voltage of V5 from 4V to 4.25V when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V5=4V, V4=5V.
Recharge detection delay time	Measure the time when the potential of V7 goes L from H while gradually decreasing the voltage of V2 when SW1 : a, SW2 : a, SW3 : a, SW4 : a, V2=4.2V (after full-charge detection), V4=5V.
Temperature detection delay time	Measure the time when the potential of V7 goes H from L when varying the voltage of V3 from 0.5V to 1.2V when SW1 : a, SW2 : b, SW3 : b, SW4 : a, V3=0.5V, V4=5V, V5=3.5V.
Temperature sense current source	Measure the current of A3 when SW1 : open, SW2 : open, SW3 : a, SW4 : a, V4=5V.
Battery temperature detection voltage H (low temperature detection at 3°C)	Measure the voltage of V9 when the current of A2 falls below 1mA while gradually increasing the voltage of V3 from 0.5V when SW1 : a, SW2 : b, SW3 : b, SW4 : a, V3=0.5V, V4=5V, V5=3.5V.
Battery temperature detection voltage L1 (when charging starts, high temperature detection at 43°C)	Measure the voltage of V9 when the current of A2 reaches over 450mA while gradually increasing the voltage of V3 when SW1 : a, SW2 : b, SW3 : b, SW4 : a, V3=0.1V, V4=5V, V5=3.5V (fast-charge).
Battery temperature detection voltage L2 (during charging, high temperature detection at 50°C)	Measure the voltage of V9 when the current of A2 falls below 1mA while gradually decreasing the voltage of V3 when SW1 : a, SW2 : b, SW3 : b, SW4 : a, V3=0.5V, V4=5V, V5=3.5V (fast-charge).
Precharge timer	Measure the time when the current of A2 falls below 1mA after voltage detection delay time when SW1 : a, SW2 : b, SW3 : b, SW4 : a, V3=3.5V (time shortening mode), V4=5V, V5=2.5V (precharge).
Fast-charge timer	Measure the time when the current of A2 falls below 1mA after voltage detection delay time when SW1 : a, SW2 : b, SW3 : b, SW4 : a, V3=3.5V (time shortening mode), V4=5V, V5=3.5V (fast-charge).
LED-R output voltage	Measure the voltage of V7 when the current of A4 reaches 5mA while gradually increasing the voltage of V11 when SW1 : b, SW2 : b, SW3 : a, SW4 : a, V4=5V, V11=0V, V5=3.5V (fast-charge).
Current sense amp gain	Measure the ratio of the potential of V6 to V8 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=2.5V or 3.5V.
IMON output voltage (charging)	Measure the voltage of V8 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=2.5V or 3.5V.
CE Low-level input voltage	Measure the voltage of V4 when the current of A2 falls below 1mA while gradually decreasing the voltage of V4 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=3.5V.
CE High-level input voltage	Measure the voltage of V4 when the current of A2 reaches over 450mA while gradually increasing the voltage of V4 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=0V, V5=3.5V.
CE input current	Measure the current of A6 when SW1 : a, SW2 : b, SW3 : a, SW4 : a, V4=5V, V5=3.5V.

Timing Chart

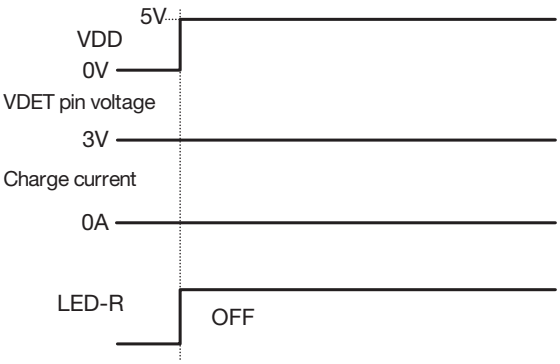
Normal charge



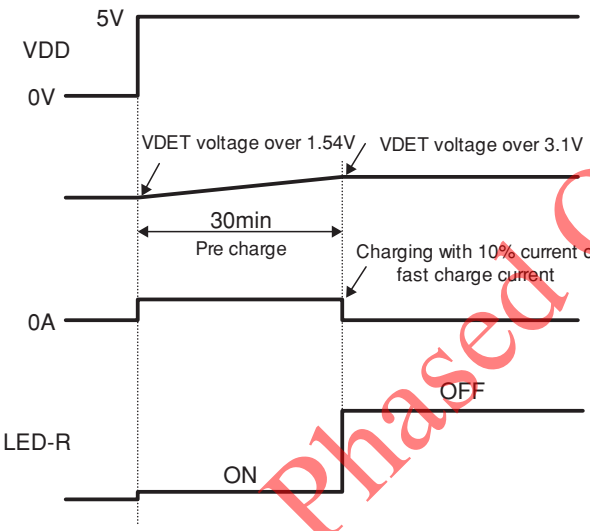
Connecting an abnormal adaptor



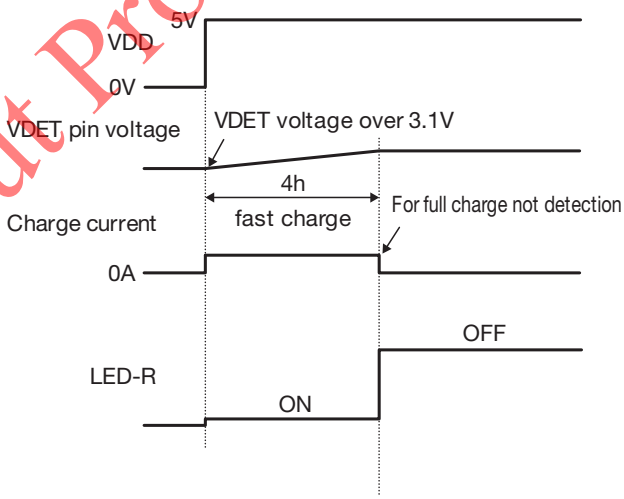
Setting a battery improperly (Temperature detection pin ; open)



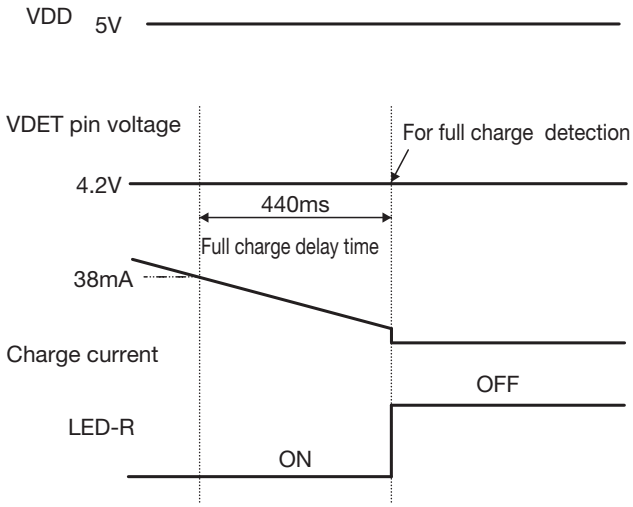
Precharge timeup



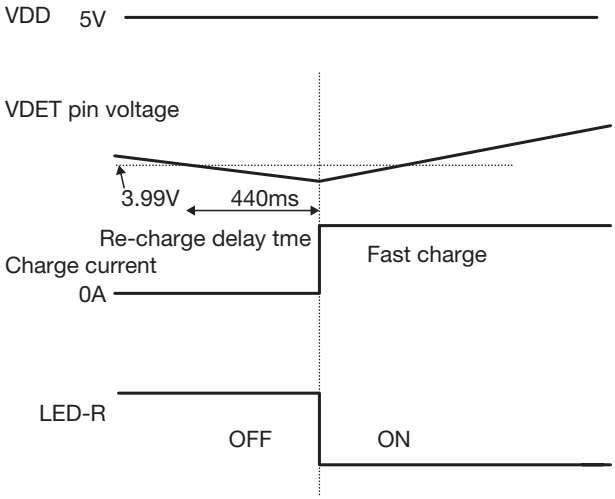
Fast-charge timeup



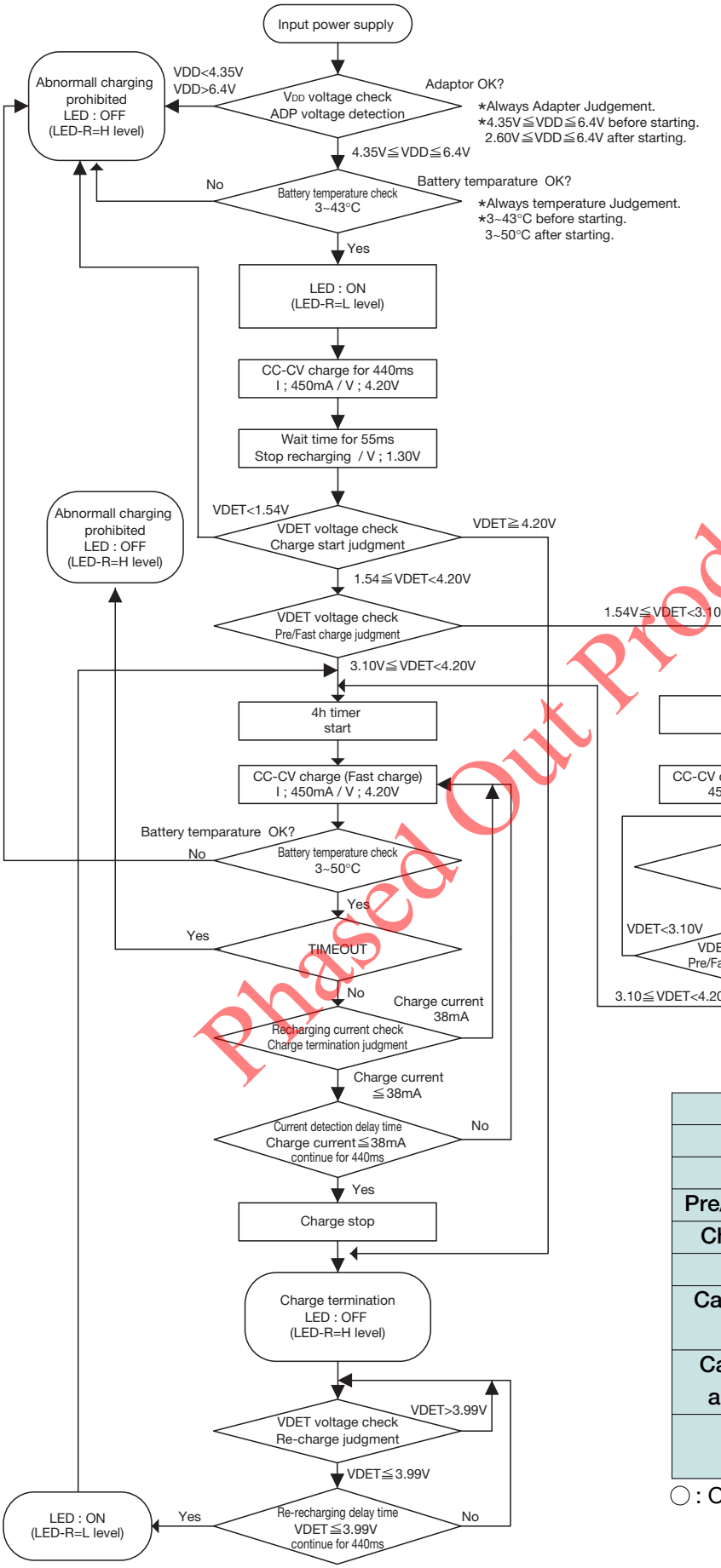
Full-charge detection



Recharge detection



Flow Chart



*1 All typ numeric value

*2 Charge current value and charge termination current value for Rsense=0.4Ω

LED Display	
	LED-R
Charging	○
Pre/Fast timer time up	×
Charge termination	○→×
Recharging	×→○
Case of temperature abnomaly	×
Case of connecting abnormal adapter	×
Case of setting battery error	×

○ : ON ×: OFF

Operation Description

(1) Battery Voltage Detection

Output voltage is set to 4.2V after power-on. Then, 0.44 sec later, it is switched to 1.3V to detect the battery voltage. (Voltage is not detected during this time)
Voltage drop of the current sense resistor is limited to 210mV at 4.2V constant voltage output.
Then, constant current charging starts on the following condition: 1.54V < battery voltage < 4.2V

(2) Constant Current Control and Current Detection

Charge current is detected by ISNS pin and VDET pin to perform constant current control.
Voltage drop of the current sense resistor is set to 21mV on the following condition:
1.54V < battery voltage < 3.1V
If the battery voltage is 3.1V or more voltage drop is set to 210mV.
It is judged as charge completion (chattering prevention function) when charge current during constant voltage charging is detected, battery voltage is 4.2V or more, and voltage drop of the current sense resistor keeps a voltage which is below 18mV for 0.44 sec . Then, LED-R turns off, and it is switched to 1.3V constant voltage output.

(3) Constant Voltage Control

Battery voltage and output voltage are detected by VDET pin.
It is switched to 4.2V constant voltage control when the battery voltage is 4.2V or more by constant current charge.
It is judged as charge completion (chattering prevention function) when voltage drop of the current sense resistor keeps a voltage which is below 18mV during constant voltage charging for 0.44 sec. Then, LED-R turns off, and charging stops.

(4) Voltage Detection

Battery voltage is detected by VDET pin and it is judged as overdischarge battery or short circuit battery when the battery voltage is 1.54V or less to prohibit charging.
When the battery voltage is 1.54V or more, charge current is set in two ways depending on the battery voltage. If it is 1.54V or more but less than 3.1V, voltage drop of the current sense resistor is set to 21mV, and if it is 3.1V or more, voltage drop is set to 210mV.
It is switched to constant voltage charge when the battery voltage becomes 4.2V during constant current charging.
It starts recharging when the battery voltage keeps 3.99V or less for 0.44 sec. (chattering prevention function)

(5) LED-R

Output type is open drain of the NMOS transistor.
The charge condition is indicated using an LED.
LED-R turns ON during charging (light-on) and turns OFF when charging is complete (light-off).
During recharging, LED-R turns ON in the charging state (light-on) and turns OFF when charging is complete (light-off).

(6) Charge Current Setting

The current value "IchgH"during fast-charging depends on the resistance value "Rsense" of the sense resistor.

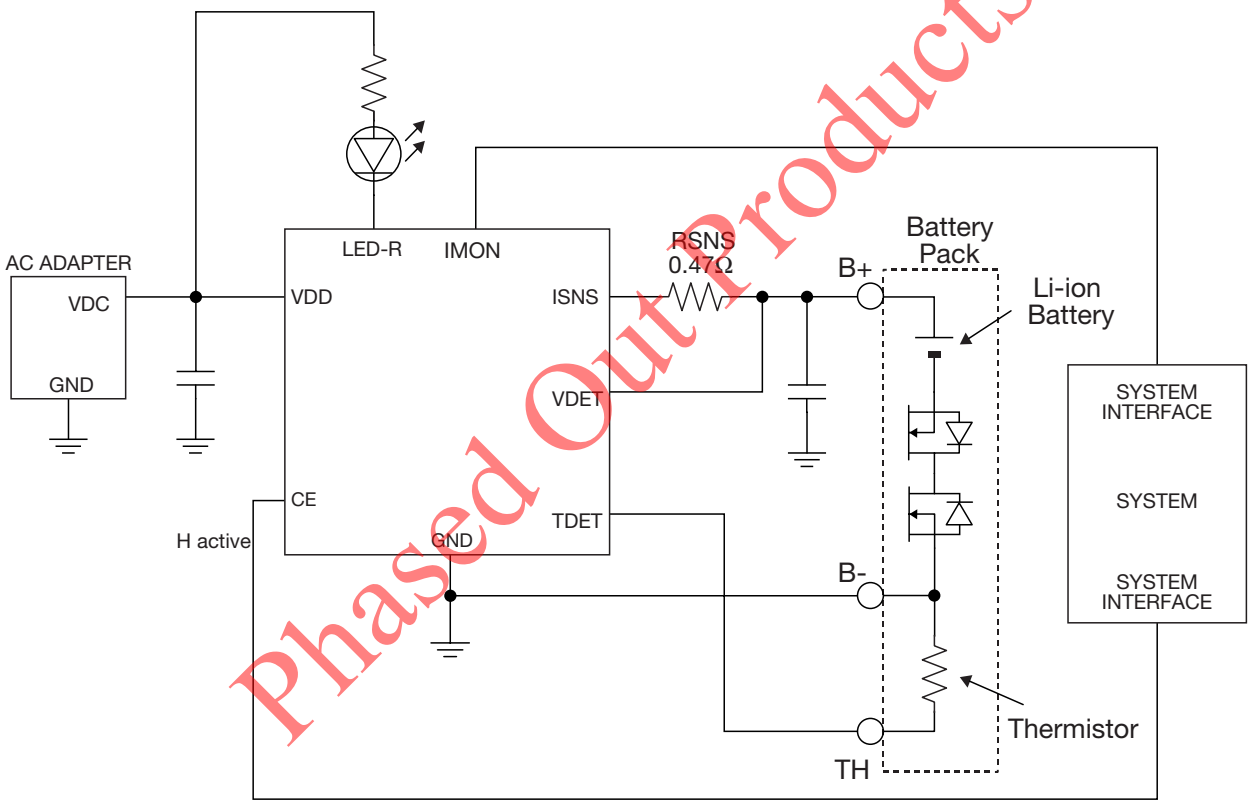
Apply a desired fast-charge current value "IchgH" to the equation below to set the sense resistor value.

$$Rsense\ [\Omega] = \frac{\text{Charge Current Set Voltage H}}{IchgH\ [mA]} = \frac{210mV}{IchgH\ [mA]}$$

Then, the precharge current "IchgL" is expressed as below.

$$IchgL\ [\Omega] = \frac{\text{Charge Current Set Voltage L}}{Rsense\ [\Omega]} = \frac{21mV}{Rsense\ [\Omega]}$$

Application Circuit

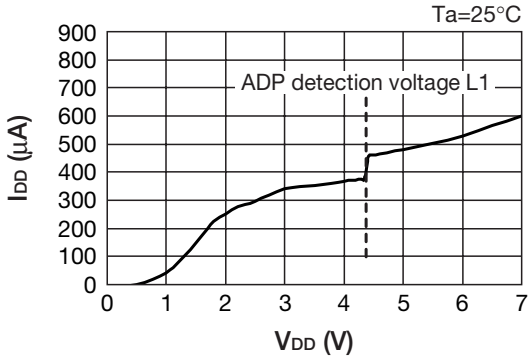


We shall not be liable for any trouble or damage caused by using this circuit.
In the event a problem which may affect industrial property or any other rights of us or a third party is encountered during the use of information described in these circuit, Mitsumi Electric Co., Ltd. shall not be liable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

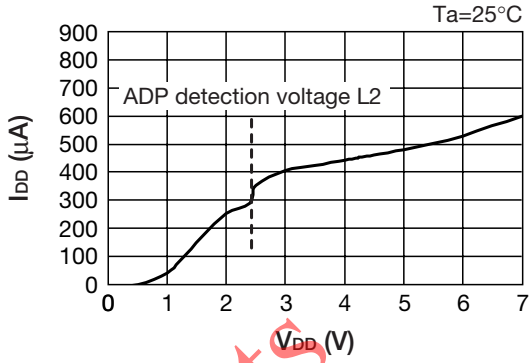
Characteristics

Power supply dependency

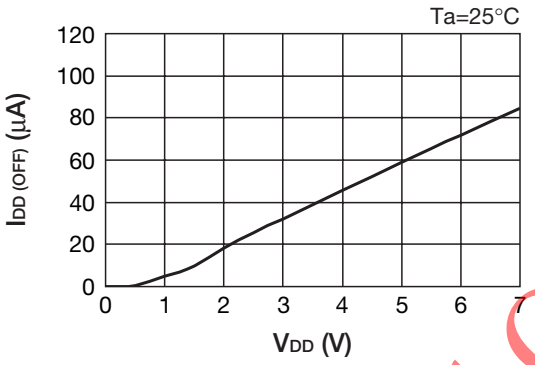
Supply current - Supply voltage VDD rising



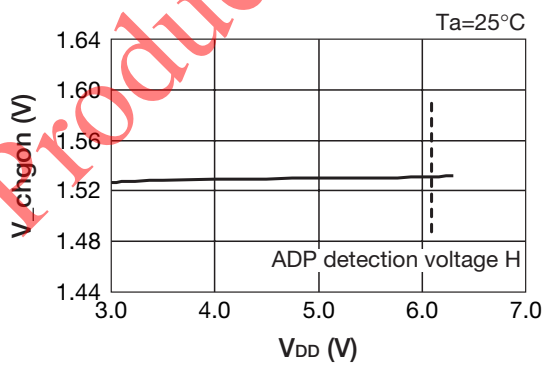
Supply current - Supply voltage VDD falling



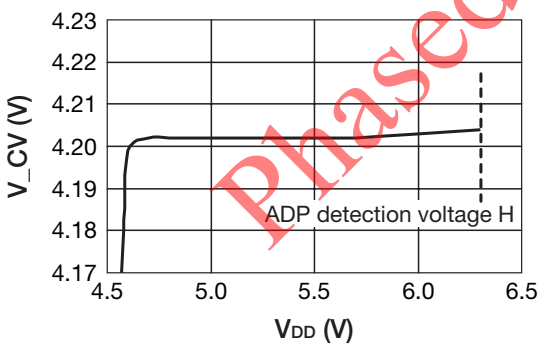
Supply current (OFF) - Supply voltage



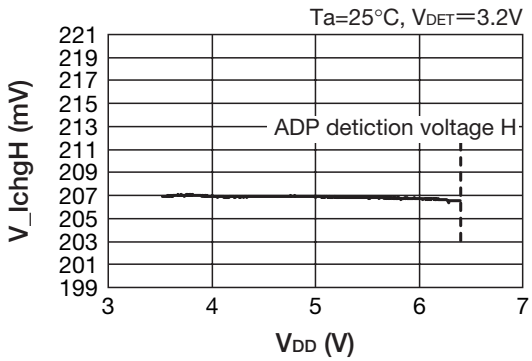
Low voltage detection voltage - Supply voltage



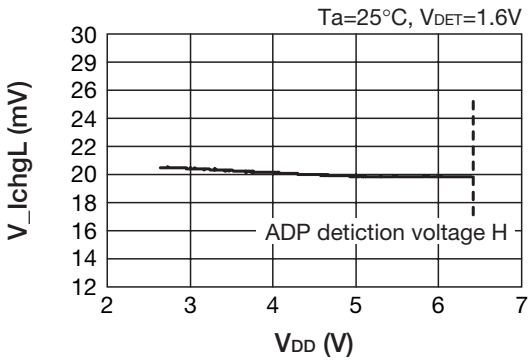
Regulated VDET voltage - Supply voltage



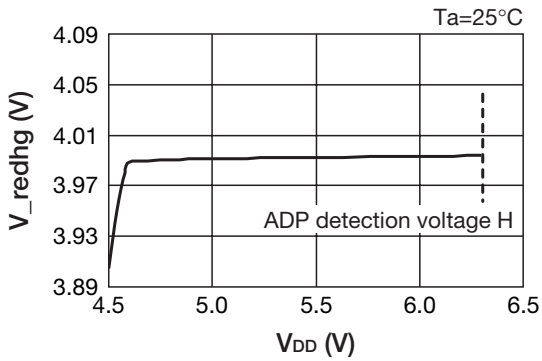
Charge current setting voltage H - Supply voltage



Charge current setting voltage L - Supply voltage

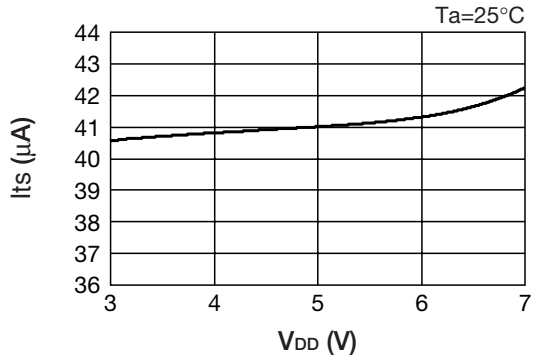


Re-charge detection voltage - Supply voltage

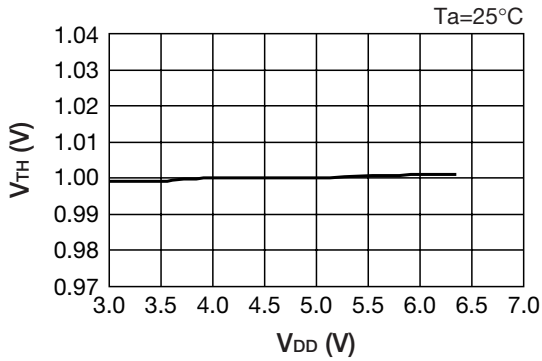


Note: These are typical characteristics.

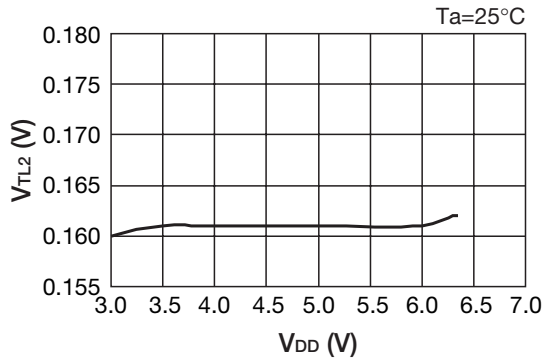
Temperature sense current source - Supply voltage



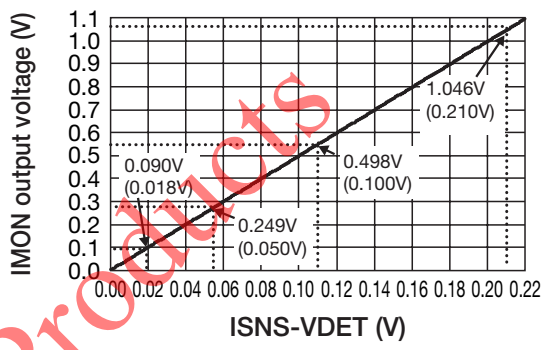
Battery temperature detection voltage H - Supply voltage



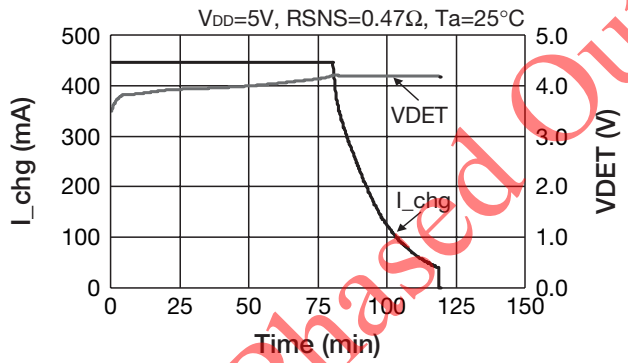
Battery temperature detection voltage L2 - Supply voltage



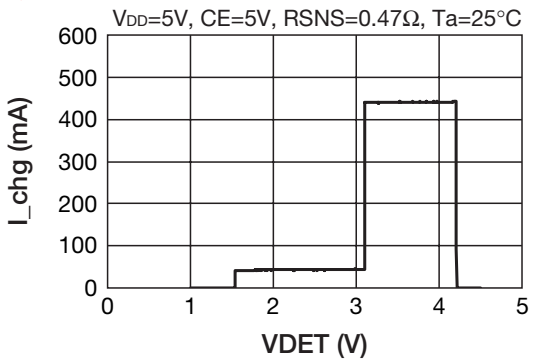
IMON output voltage - ISNS-VDET



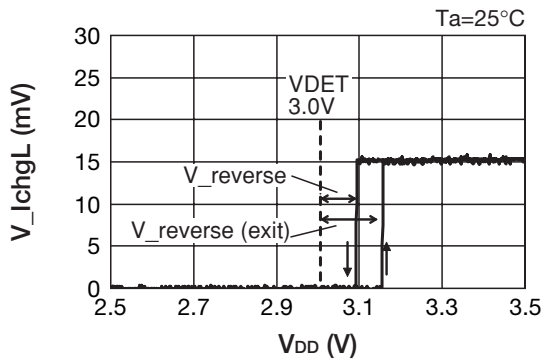
Battery current and voltage - Time



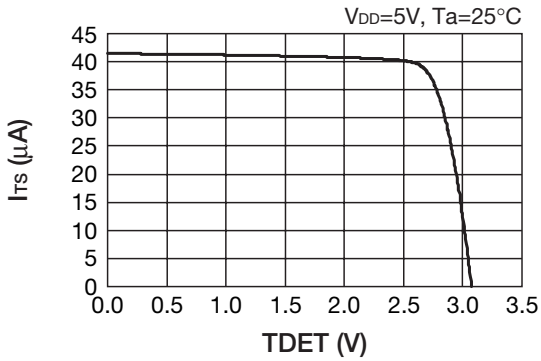
Battery current - Battery voltage



Sleep-mode entry/exit threshold voltage

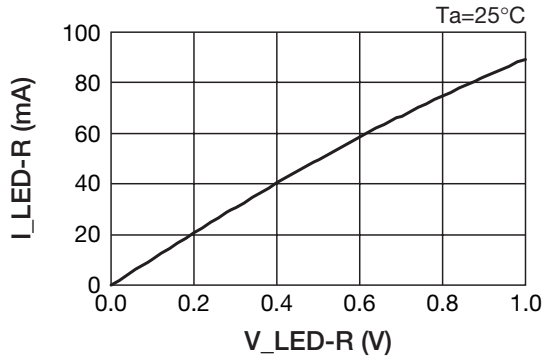


Temperature sense current source - VDET

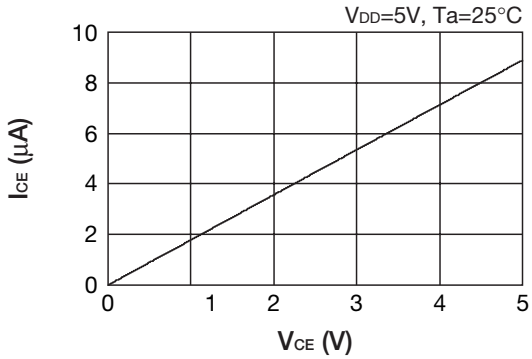


Note: These are typical characteristics.

LED-R output current - LED-R voltage



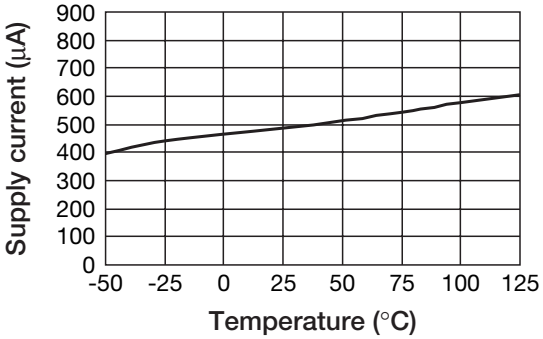
CE input current - CE input voltage



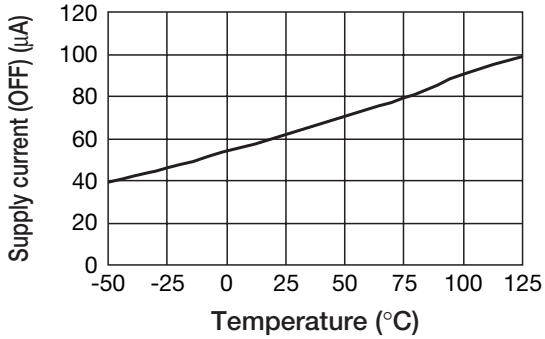
Note: These are typical characteristics.

Temperature dependency

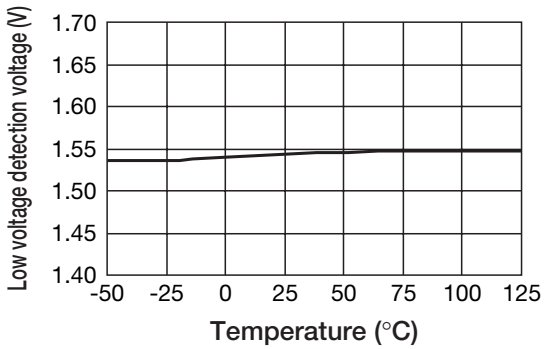
Supply current - Temperature



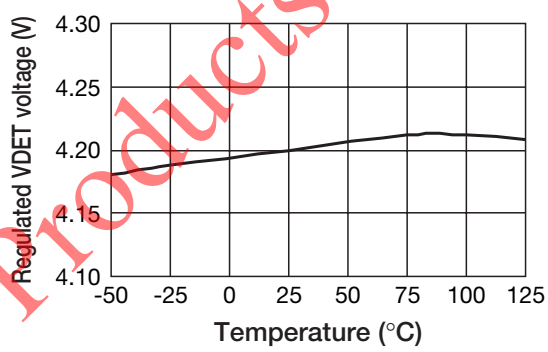
Supply current (OFF) vs temperature



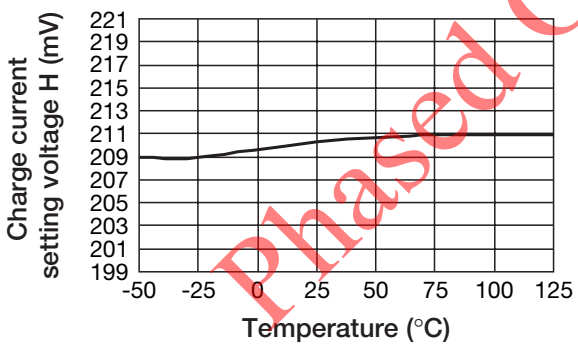
Low voltage detection voltage - Temperature



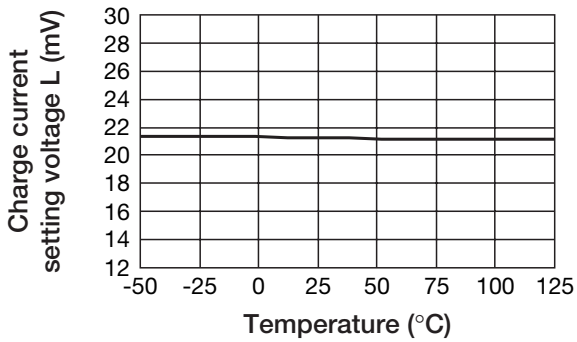
Regulated VDET voltage - Temperature



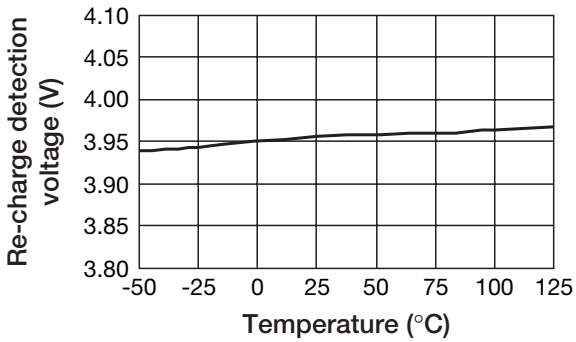
Charge current Setting voltage H - Temperature



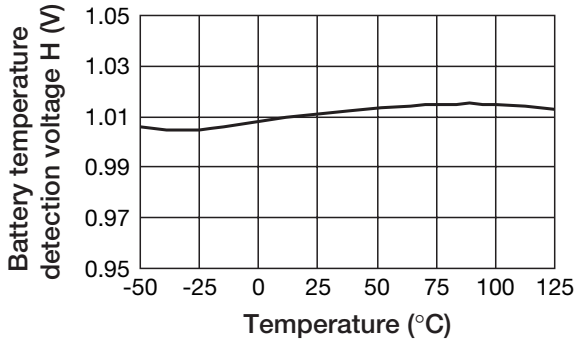
Charge current Setting voltage L - Temperature



Re-Charge detection voltage - Temperature

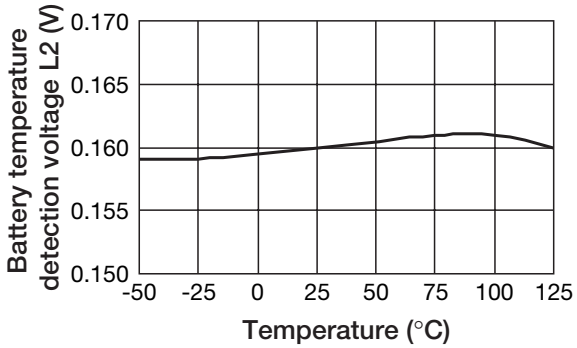


Battery temperature detection voltage H - Temperature

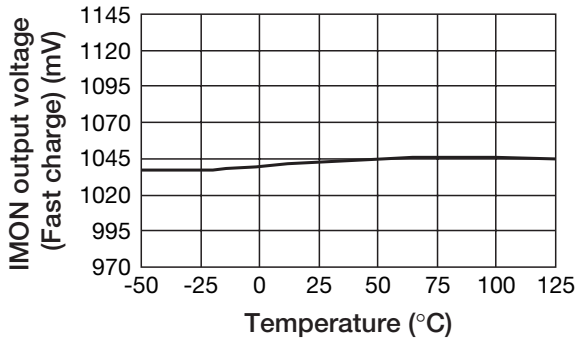


Note: These are typical characteristics.

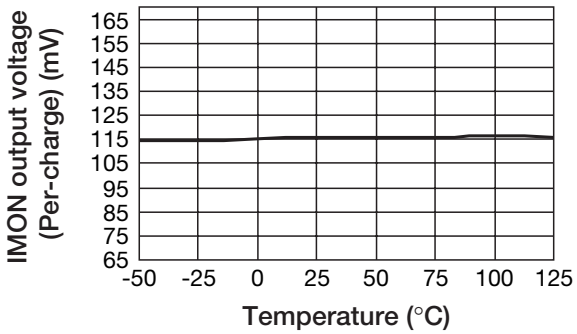
Battery temperature detection voltage L2 - Temperature



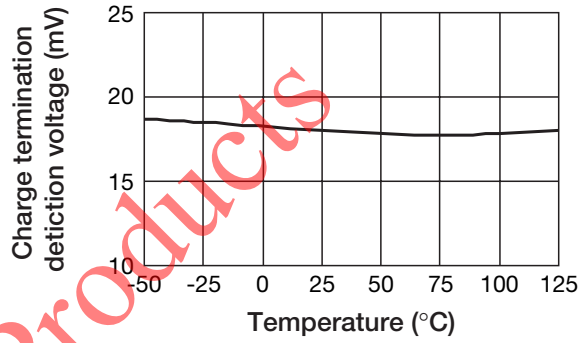
IMON output voltage - temperature (Fast Charge)



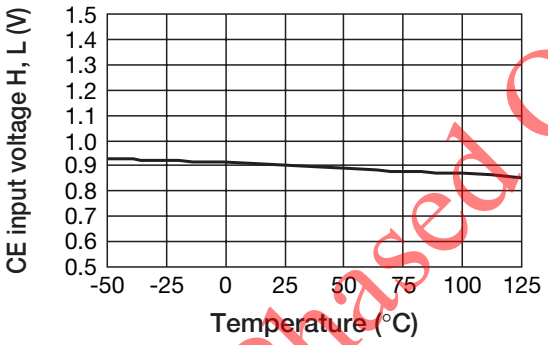
IMON output voltage - temperature (Pre-Charge)



Charge Termination detiction voltage - Temperature



CE Input voltage H, L - Temperature



Note: These are typical characteristics.