IC for Control of Lithium-ion Batteries Charging
Monolithic IC MM1433

Outline

This IC is used to control charging of lithium-ion batteries. This one IC incorporates functions for constant-current and constant-voltage charging and for precharging, for an overcharge timer, battery temperature detection, and other protective functions. It was developed by adding to the previous MM1332 and 1333 the above-described functions.

Features

1. Charging voltage accuracy ±30mV/cell.
2. Consumption current 5mA typ.
3. Precharge function.
4. Recharge function.
5. Overcharge timer.
6. Battery temperature detection function.
7. We can supply type for one and two cells.

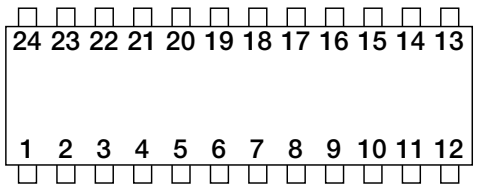
Package

TSOP-24A

Applications

IC for control of lithium-ion batteries charging.

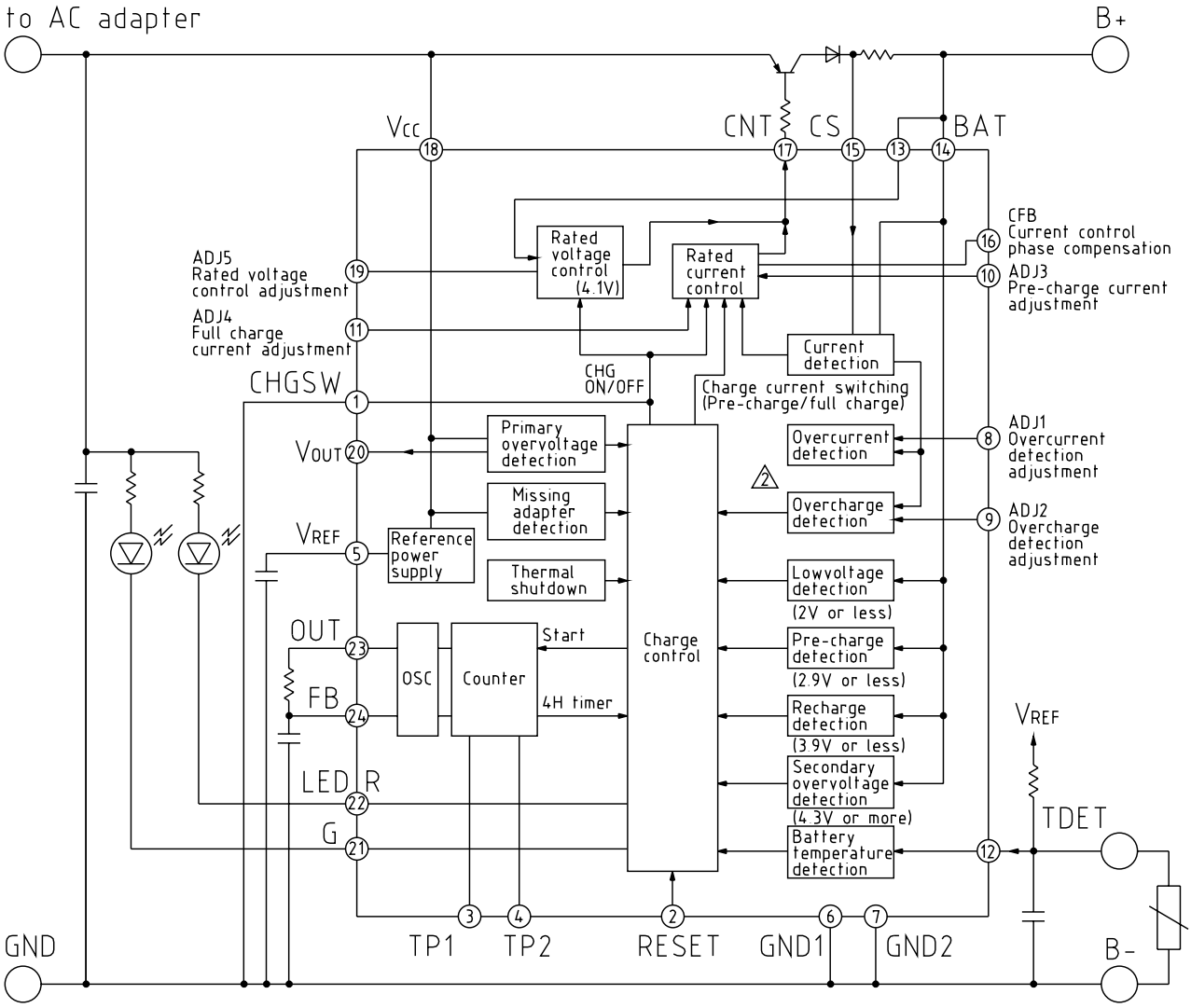
Pin Assignment



TSOP-24A

1	CHGSW	13	BAT1
2	RESET	14	BAT2
3	TP1	15	CS
4	TP2	16	CFB
5	VREF	17	CNT
6	GND1	18	V_{CC}
7	GND2	19	ADJ5
8	ADJ1	20	V_{OUT}
9	ADJ2	21	LED G
10	ADJ3	22	LED R
11	ADJ4	23	OSC OUT
12	TDET	24	OSC FB–

Block Diagram

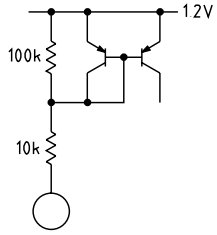
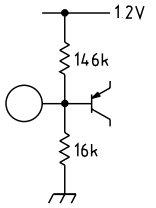
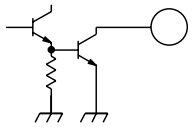
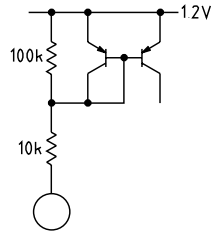
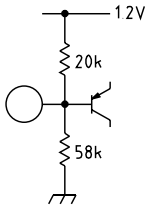
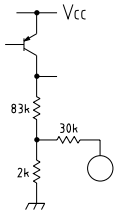
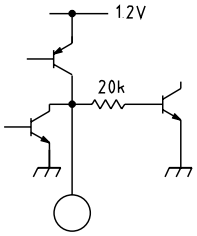
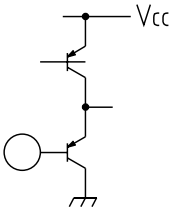
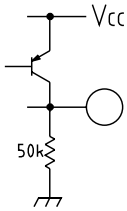
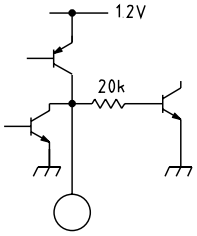
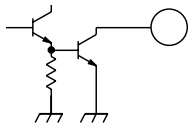
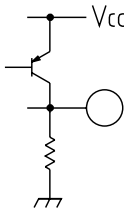
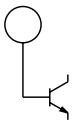
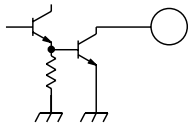
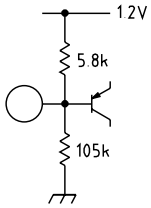
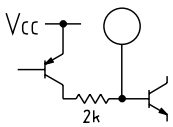
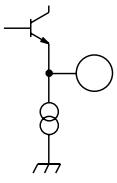
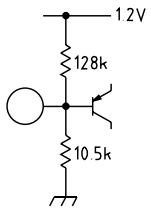
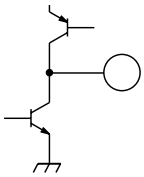
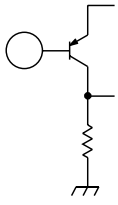


Pin Description

Pin No.	Pin name	I/O	Functions
1	CHGSW	Input	Forced charging OFF pin L: Forced charging circuit ON (OFF for reset) H: Charging stop is forced
2	RESET	Input	Logic reset pin L: Forced charging circuit ON (start) H: Forced charging circuit OFF
3	TP1	Input/ Output	Test pin 1 Pre-charge timer test pin Inverts while counting (the middle stage of the several FF stages) and output to TP1, to permit monitoring. Also, TP1 output signal is inverted again inside the IC and inputs to the next stage FF. (Timer setting is done by binary counter.)
4	TP2	Input/ Output	Test pin 2 Full charge timer test pin Same structure as TP1
5	VREF	Output	Reference power supply output pin Outputs 1.2V typ. reference voltage. Used for temperature detection reference power supply and ADJ1 - ADJ4 adjustment.
6	GND1	Input	Ground pin.
7	GND2	Input	Ground pin.
8	ADJ1	Input	Overcurrent detection adjustment pin Set so that overcurrent detection does not function. Pin voltage is 1.16V typ.
9	ADJ2	Input	Full charge detection adjustment pin Pin voltage is set at 93mV typ. Full charge detection value can be changed by adjusting pin voltage with an external resistor, etc. Full charge detection is done by comparing ADJ2 pin voltage and 12dB voltage drop value between CS and BAT.
10	ADJ3	Input	Pre-charge current adjustment pin Pin voltage is set at 120mV typ. Pre-charge current can be changed by adjusting pin voltage with an external resistor, etc. Pre-charge current control is done by comparing ADJ3 pin voltage and 12dB voltage drop value between CS and BAT.
11	ADJ4	Input	Full charge current adjustment pin Pin voltage is set at 0.89mV typ. Full charge current can be changed by adjusting pin voltage with an external resistor, etc. Full charge current control is done by comparing ADJ4 pin voltage and 12dB voltage drop value between CS and BAT. When full charge current is controlled to rated current by an adapter, short ADJ4 pin and VREF pin so that rated current control does not function in the IC.

Pin No.	Pin name	I/O	Functions
12	TDET	Input	Temperature detection input pin Apply potential resistance divided by external resistor and thermistor from reference voltage when using. Reset state will exist if TDET pin does not reach the specified potential.
13	BAT1	Input	Battery voltage input pins Detect battery voltage and control charging.
14	BAT2	Input	
15	CS	Input	Current detection pin Detects current by external resistor (between CS and BAT) voltage drop and controls charging current.
16	CFB	Input	Rated current control phase compensation pin Oscillation is improved by connecting an external capacitor (around 100pf) between CFB and CNT for phase compensation.
17	CNT	Output	Charging control output pin Controls external PNP-Tr base for rated current rated voltage charging.
18	Vcc	Input	Power supply input pin
19	ADJ5	Input	Rated voltage control adjustment pin Allows fine adjustment of rated voltage value. For example, rated voltage value rises by around 15mV (at 4.1V typ.) when ADJ5-GND is shorted.
20	VOUT	Output	Overvoltage detection output pin For Vcc overvoltage input: L For Vcc recommended operating voltage: H
21	LED G	Output	LED C control output pin NPN-Tr open collector output. Refer to the flow chart for ON/OFF.
22	LED R	Output	LED R control output pin NPN-Tr open collector output. Refer to the flow chart for ON/OFF.
23	OSC OUT	Output	Oscillator output pin Timer setting time changes according to oscillation frequency. Oscillation frequency is determined by an external resistor (connected between OSC OUT and OSC FB) and capacitor (connected between OSC FB and GND). For example, the full charge timer setting is 4H for external resistor of 130kΩ and capacitor of 0.01μF.
24	OSC FB–	Input	Oscillator inverted input pin

Pin Description (The values below are average values)

Pin No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram
1	CHGSW		10	ADJ3		17	CNT	
2	RESET		11	ADJ4		19	ADJ5	
3	TP1		12	TDET		20	VOUT	
4	TP2		13	BAT1		21	LED G	
5	VREF		14	BAT2		22	LED R	
8	ADJ1		15	CS		23	OSC OUT	
9	ADJ2		16	CFB		24	OSC FB–	

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Ratings	Unit
Storage temperature	T_{STG}	–40~+125	°C
Operating temperature	T_{OPR}	–20~+70	°C
Power supply voltage	V_{CC} max.	–0.3~+15	V
Allowable loss	Pd	250	mW

Recommended Operating Conditions

Item	Symbol	Ratings	Unit
Operating temperature	T_{OPR}	–20~+70	°C
Charging control operating voltage	V_{OPR}	2.7~5.9	V

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

Item	Symbol	Conditions	Measurement circuit	Min.	Typ.	Max.	Unit
Consumption current	I_{CC}		18		5.0	7.0	mA
Reference voltage	V_{REF}		5		1.207		V
ADP detection voltage L	V_{ADPL}	V_{CC} : H→L	20	2.35	2.45	2.55	V
ADP detection voltage L Hysteresis voltage width	V_{ADPLW}		20	50	100	150	mV
ADP detection voltage H	V_{ADPH}	V_{CC} : L→H	20	6.1	6.3	6.5	V
ADP detection voltage H Hysteresis voltage width	V_{ADPHW}		20	50	100	150	mV
Impedance for ADP detection output L	Z_{ADPL}		20		30		kΩ
BAT pin leak current	I_{BAT}		13, 14, 15			1	µA
BAT pin output voltage	V_{BAT}	Ta=0~+50°C	13	4.070	4.100	4.130	V
CNT pin output voltage	V_{CNT}	I_{CNT}=20mA	17			0.5	V
CHGSW pin input current	I_{SW}		1	40	60	80	µA
CHGSW pin input voltage H	V_{SWH}	CHGSW : OFF	1	0.6		1.20	V
CHGSW pin input voltage L	V_{SWL}	CHGSW : ON	1			0.25	V
RESET pin input current	I_{RE}		2	40	60	80	µA
RESET pin input voltage H	V_{REH}	Charging control circuit: OFF	2	0.6		1.20	V
RESET pin input voltage L	V_{REL}	Charging control circuit: ON	2			0.25	V
Current limit 1	V_{L1}	Quick charge	14, 15	0.20	0.22	0.24	V
Current limit 2	V_{L2}	Pre-charge	14, 15	21	26	31	mV
Full charge detection	V_F		14, 15	13	18	23	mV
Low voltage detection voltage	V_{LV}	V_{BAT} : L→H	13	1.90	2.00	2.10	V

Item	Symbol	Conditions	Measurement circuit	Min.	Typ.	Max.	Unit
Low voltage detection voltage Hysteresis voltage width	V_{LVW}		13	25	50	100	mV
Pre-charge detection voltage	V_P	V_{BAT} : L→H	13	2.80	2.90	3.00	V
Pre-charge detection voltage Hysteresis voltage width	V_{PW}		13	25	50	100	mV
Re-charge detection voltage	V_R	V_{BAT} : H→L	13	3.85	3.90	3.95	V
Overvoltage detection voltage	V_{OV}	V_{BAT} : L→H	13	4.30	4.35	4.40	V
Battery temperature detection voltage H	V_{TH}	Low temperature 3°C ± 3°C detection	12	0.835	0.860	0.885	V
Battery temperature detection voltage L1	V_{TL1}	High temperature 43°C ± 3°C detection (charging start)	12	0.390	0.413	0.435	V
Battery temperature detection voltage L2	V_{TL2}	High temperature 50°C ± 3°C detection (during charging)	12	0.335	0.353	0.370	V
TDET input bias current	I_T		12		30	150	nA
LED R pin output voltage	V_{LEDR}	I_{LEDR}=10mA	22			0.4	V
LED G pin output voltage	V_{LEDG}	I_{LEDG}=10mA	21			0.4	V
Timer error time	⊿T	Not including external deviation	21, 22	−10		10	%

Note 1: Current limits 1 and 2 and full charge detection are specified at current detection resistor voltage drop.

Note 2: If the IC is damaged and control is no longer possible, its safety can not be guaranteed. Please protect with something other than this IC.

Note 3: Temperature detection is the setting value at B constant 3435 (10KC15-1608 made by Ishizuka Denshi).

Note 4: Use a capacitor with good temperature characteristics in the oscillator. Capacitor deviation will contribute to timer error.

Note 5: If the battery overdischarges, charge 1mA for 14 seconds, and if it does not switch to pre-charging during that interval, it means the IC has identified a battery abnormality.

OSC CR Setting Reference Materials

(1) OSCR CR-Oscillation Cycle T Examples

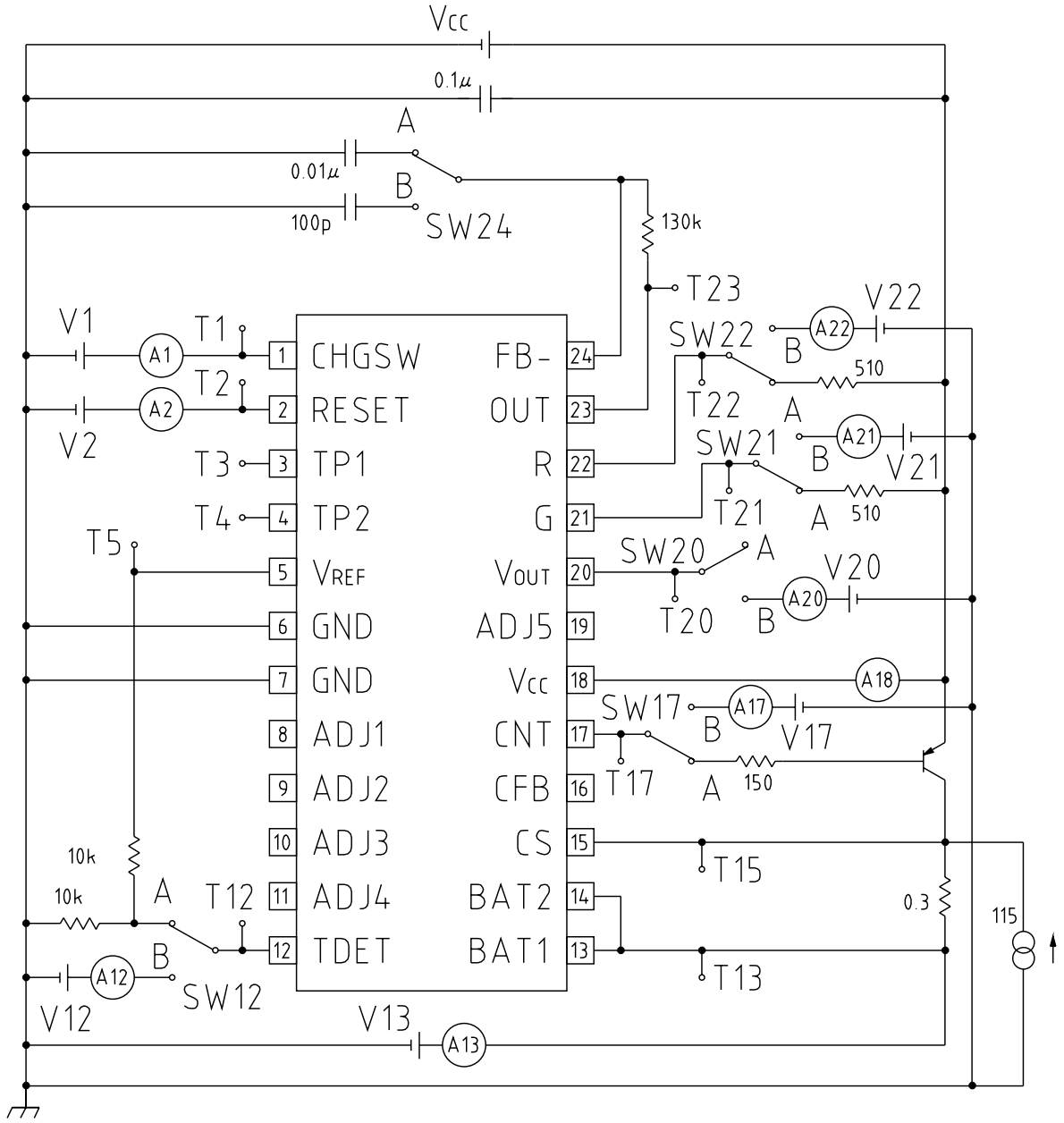
R / C	75k	100k	120k	130k	150k	200k
0.0047μ	0.47mS	0.63mS	0.75mS	0.82mS	0.94mS	1.26mS
0.0082μ	0.83mS	1.10mS	1.32mS	1.43mS	1.65mS	2.20mS
0.01μ	1.03mS	1.37mS	1.63mS	1.77mS	2.04mS	2.73mS
0.015μ	1.48mS	1.98mS	2.38mS	2.58mS	2.97mS	3.95mS
0.022μ	2.16mS	2.87mS	3.44mS	3.73mS	4.30mS	5.76mS

(2) Timer Times

Item	Calculation formula	Examples of calculation (for C = 0.01μ, R = 230k)
Pre-charge timer	$T \times 2^{19}$	15min. 28S
Full charge timer	$T \times 2^{23}$	4h7min.
1mA charge time	$T \times 2^{13}$	14.5S
Full charge detection delay time	$T \times 2^{6}$	0.11S
Overcurrent detection delay time	$T \times 2^{8}$	0.45S
Overvoltage detection delay time	$T \times 2^{8}$	0.45S
Re-charge detection delay time	$T \times 2^{5}$	56.6mS
LED R blinking cycle	$T \times 2^{10}$	1.8S

Note: T: OSC oscillation cycle

Measuring Circuit



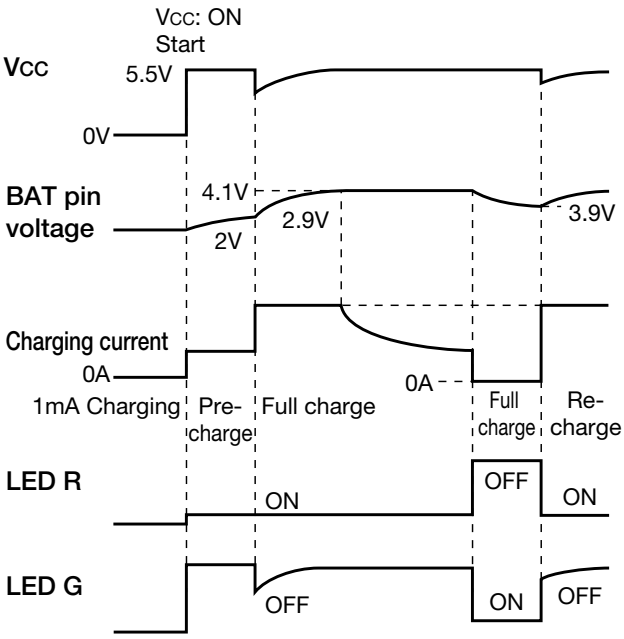
Measurement Procedures

(Except where noted otherwise, Ta = 25°C, V_{CC}=5V, V1=V2=0V, V13=4.2V, SW12, 17, 20, 22, 24:A, I15=0mA Timers are not in time up state.)

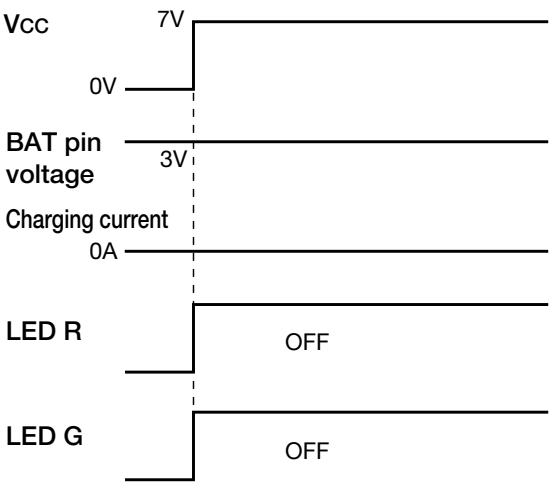
Item	Measurement Procedures
Consumption current	V1 = 1.2V. Measure A18 current value I_{CC}.
Reference voltage	Measure T5 potential V_{REF}.
ADP detection voltage L	Gradually lower Vcc from 5V; V_{CC} – potential is V_{ADPL} when T20 potential drops below 0.5V.
ADP detection voltage L Hysteresis voltage width	Gradually lower V_{CC} – from 2V. V_{CC} – potential is V_{ADPL2} when T20 potential goes over V_{CC} – 0.5V. $V_{ADPLW} = V_{ADLP2} – V_{ADPL}$
ADP detection voltage H	Gradually increase Vcc from 5V. Vcc potential is VADPH when T20 potential drops below 0.5V.
ADP detection voltage H Hysteresis voltage width	Gradually lower V_{CC} from 7V. V_{CC} potential is V_{ADPH2} when T20 potential goes over V_{CC} – 0.5V. $V_{ADPHW} = V_{ADPH} – V_{ADPH2}$
Impedance for ADP Ldetection output	V_{CC} = 7V, SW20: B, V20 – 0.5V, impedance between T20-GND is Z_{ADPL}.
BAT pin leak current	V_{CC} = 0V, SW17: B, V17 = 0V. Measure A13 current value I_{BAT}.
BAT pin output voltage	Gradually lower V13 from 3.5V. T13 potential is V_{BAT} when T15 – T13 potential difference falls to less than 20mV.
CNT pin output voltage	V13 = 3.5V, SW17: B. Gradually raise V17 from 0V. T17 potential is V_{CNT} when A17 current value 20mA.
CHGSW pin input current	Measure A1 current value I_{SW}.
CHGSW pin input voltage H CHGSW pin input voltage L	V13 = 3.5V. Raise V1 from 0V to 1.2V. CHGSW: ON when A13 is more than 500mA. CHGSW: OFF when A13 is less than 1mA. Measure V_{SW}.
RESET pin input current	Measure A2 current value I_{RE}.
RESET pin input voltage H RESET pin input voltage L	V13 = 3.5V. Raise V2 from 0V to 1.2V. Charging control circuit: ON when A13 is more than 500mA. Charging control circuit: OFF when A13 is less than 1mA. Measure V_{RE}.
Current limit 1	V13 = 3.5V. T15-T13 potential difference is V_{L1}.
Current limit 2	V13 = 3.5V. T15-T13 potential difference is V_{L2}.
Full charge detection	SW24: B, I15 = 100mA. Gradually reduce I15 current value after reset. T15 – T13 potential difference is V_F when T21 potential goes under 0.5V.
Low voltage detection voltage	Gradually raise V13 from 0V. T13 potential is V_{LV} when A13 current value goes over 50mA.
Low voltage detection voltage Hysteresis voltage width	Gradually lower V13 from 2.5V. T13 potential is V_{LV2} when A13 current value goes over 10mA. $V_{LVW} = V_{LV} – V_{LV2}$
Pre-charge detection voltage	Gradually raise V13 from 2.5V. T13 potential is V_P when A13 current value goes over 500mA.
Pre-charge detection voltage Hysteresis voltage width	Gradually lower V13 from 3.5V. T13 potential is V_{P2} when A13 current value goes under 150mA. $V_{PW} = V_P = V_{P2}$
Re-charge detection voltage	Wait about 1S at V13 = 4.2V; in full charge detection state, gradually lower V13 potential to lower T21 potential to under 0.5V. T13 potential is V_R when T21 potential is more than V_{CC} – 0.5V.
Overvoltage detection voltage	Gradually raise V13 from 4V. T13 potential is V_{OV} when T22 potential starts to repeat HI/LOW.
Battery temperature detection voltage H	V13 = 3.5V, SW12: B. Gradually raise V12 from 0.6V. T12 potential is V_{TH} when A13 current value goes under 1mA.
Battery temperature detection voltage L1	V13 = 3.5V, SW12: B. Gradually raise V12 from 0V. T12 potential is V_{TL1} when A13 current value goes over 500mA.
Battery temperature detection voltage L2	V13 = 3.5V, SW12: B. Gradually raise V12 from 0.6V. T12 potential is V_{TL2} when A13 current value goes over 1mA.
TDET input bias current	SW12: B, V12 = 0V. Measure A12 current value IT.
LED R pin output voltage	V13 = 3.5V, SW22: B. Gradually raise V22 from 0V. T22 potential is V_{LEDR} when A22 current value is 10mA.
LED G pin output voltage	Wait about 1S at V13 = 4.2V; in full charge detection state, make T21 potential 0.5V or less. Next at SW21: B, gradually raise V21 from 0V. T21 potential is V_{LEDG} when A21 current value is 10mA.

Timing Chart

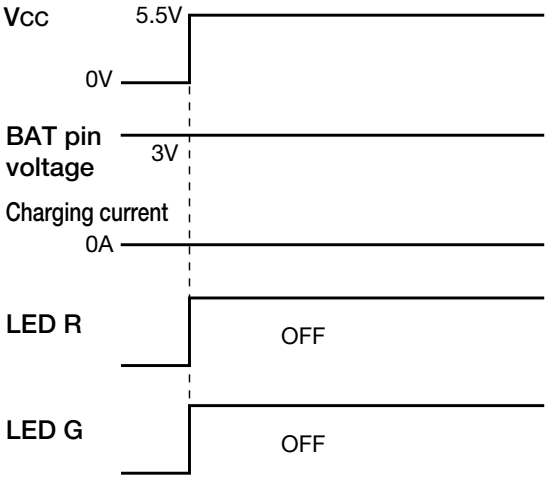
Charging performed normally



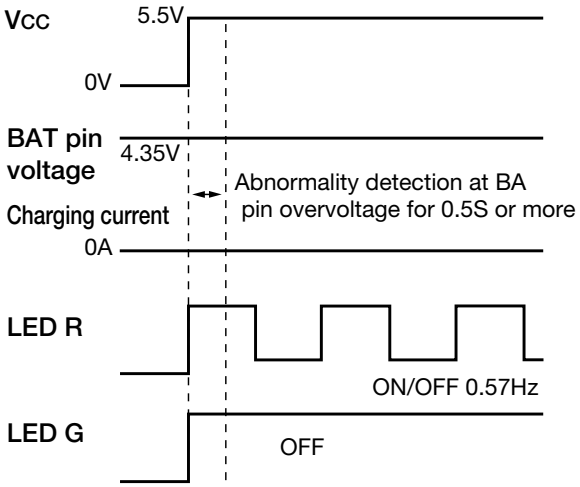
Adapter abnormality



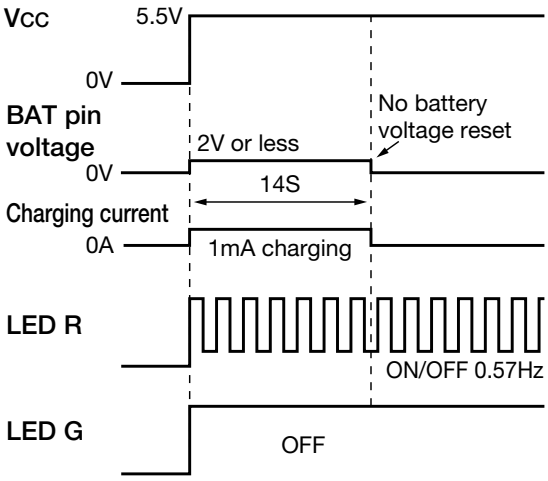
Power supply setting error (temperature detection pin open)



Battery overcharge



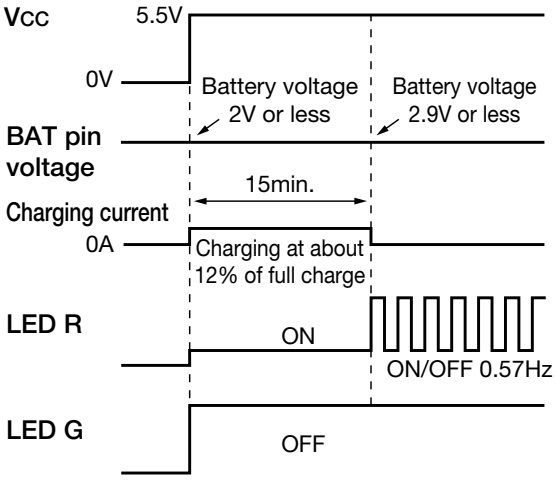
Battery overdischarge



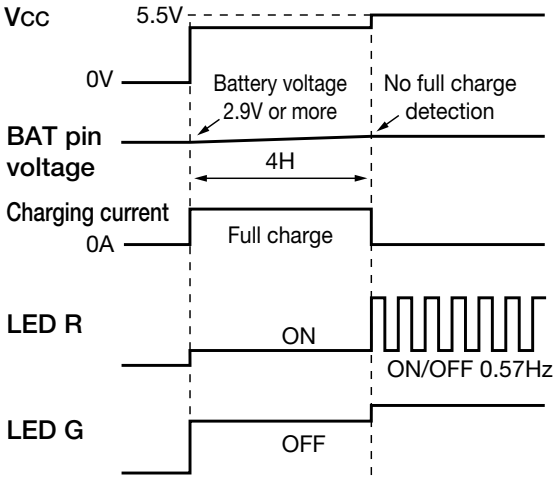
Overcurrent detection

Overcurrent detection does not function

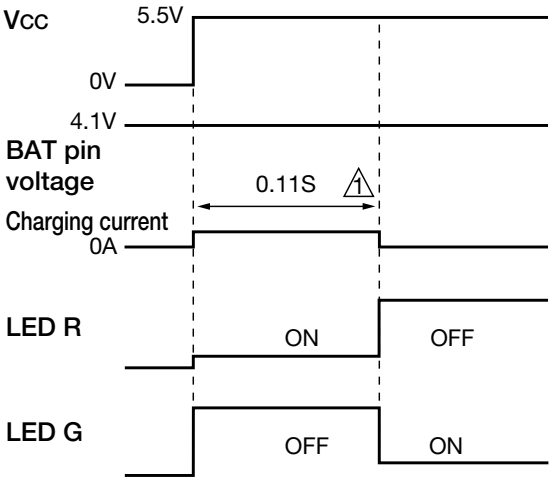
Pre-charge time up



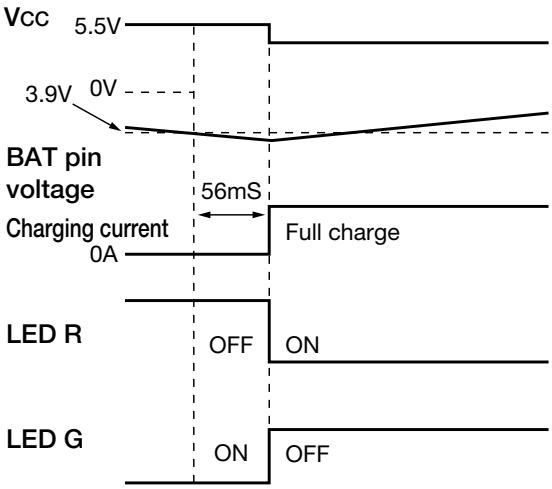
Full charge time up



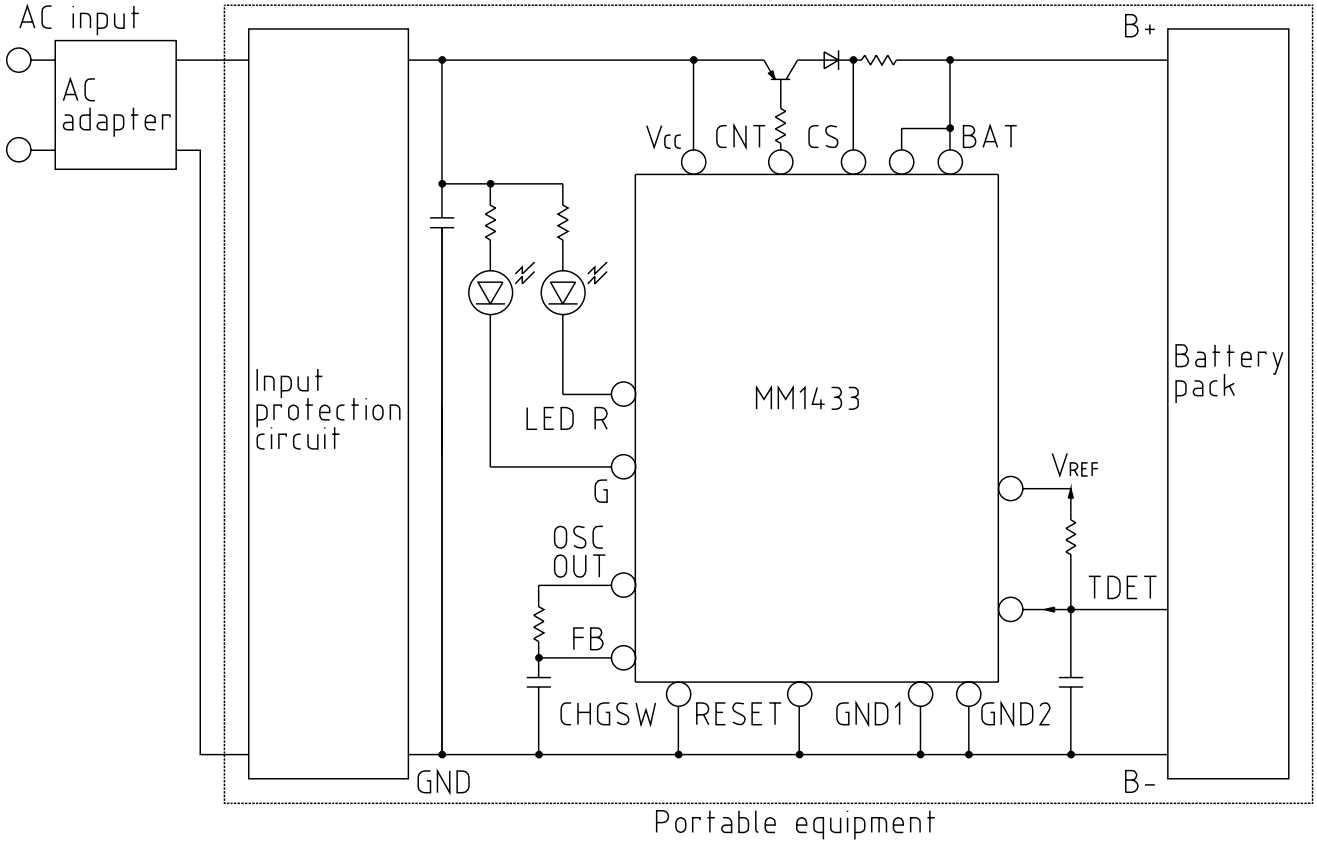
Battery full charge



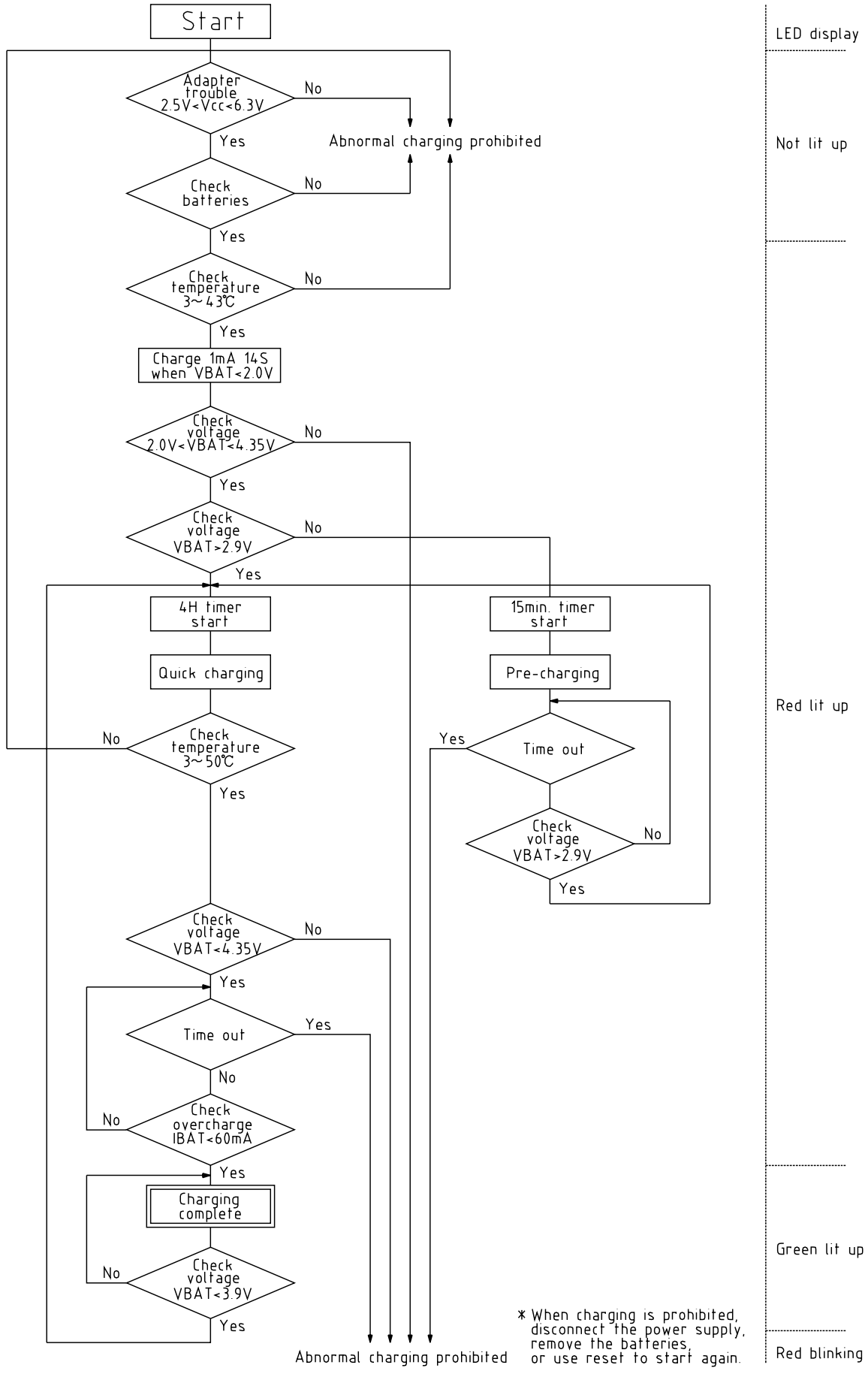
Re-charge detection



Application Circuit

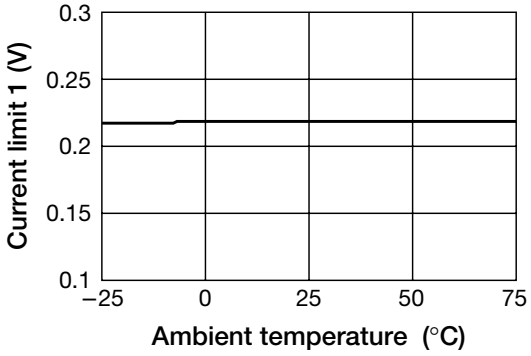


Flow Chart

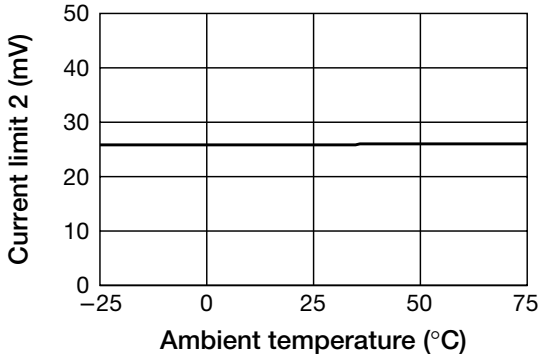

Start
Adapter trouble 2.5V<Vcc<6.3V
No
Yes
Abnormal charging prohibited
Check batteries
No
Yes
Check temperature 3~43℃
No
Yes
Charge 1mA 14S when VBAT<2.0V
Check voltage 2.0V<VBAT<4.35V
No
Yes
Check voltage VBAT>2.9V
No
Yes
4H timer start
Quick charging
No
Check temperature 3~50℃
Yes
15min. timer start
Pre-charging
Yes
Time out
Check voltage VBAT>2.9V
No
Yes
Check voltage VBAT<4.35V
No
Yes
Time out
Yes
No
No
Check overcharge IBAT<60mA
Yes
Charging complete
No
Check voltage VBAT<3.9V
Yes
Abnormal charging prohibited
* When charging is prohibited, disconnect the power supply, remove the batteries, or use reset to start again.
LED display
Not lit up
Red lit up
Green lit up
Red blinking

Characteristics

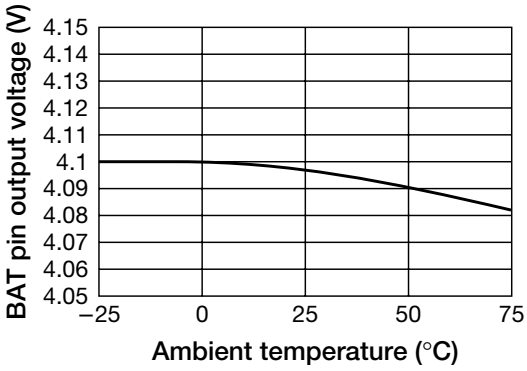
Current limit 1 – Temperature



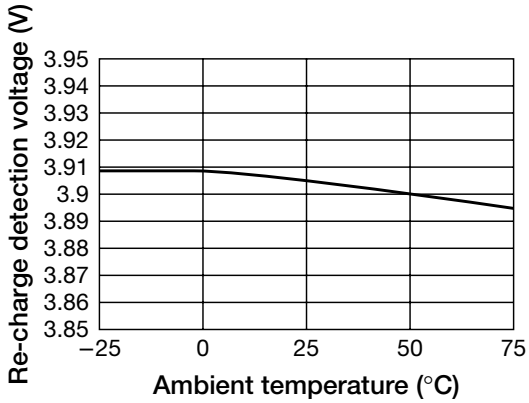
Current limit 2 – Temperature



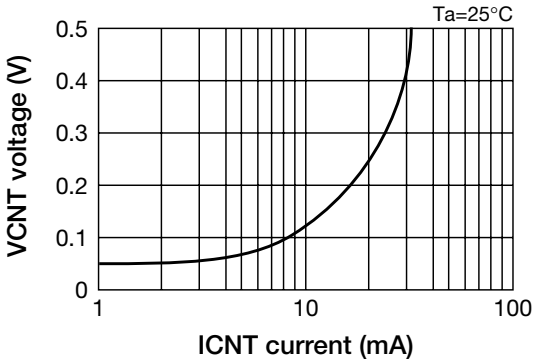
BAT pin output voltage – Temperature



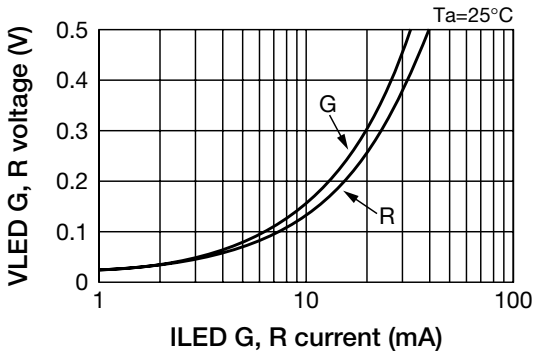
Re-charge detection voltage – Temperature



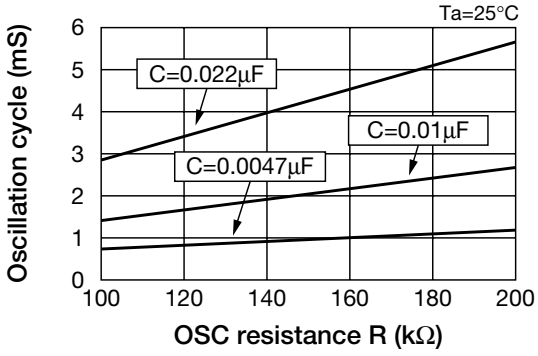
VCNT voltage – ICNT current



VLED G, R voltage - ILED G, R current



OSC oscillation cycle – CR



BAT pin reverse current – BAT pin voltage