Lithium-Ion Battery Charge Control (with timers)
Monolithic IC MM1639

Outline

This is a lithium-ion battery charge control IC. It incorporates constant-voltage and constant-current circuits for easy implementation of lithium-ion battery charge. It includes functions to disable charging to overdischarged batteries, disable charging due to abnormal temperature, etc., and timer functions. It is also equipped with a 2-channel LED driver to allow the charge status to be displayed.

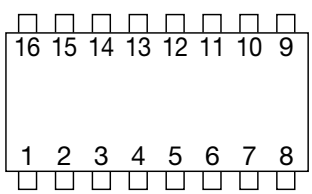
Features

1. Operating supply voltage 2.7~5.9V
2. Operating ambient temperature -20~70°C
3. Current consumption 5.0mA typ.
4. Low voltage detection voltage 2.0V typ.
5. BAT pin output voltage 4.20±0.03V (Ta=0~50°C)
6. Recharge detection voltage 3.90V typ.
7. Precharge detection voltage 2.90V typ.
8. Fast-charge current setting Rsense=0.22V/IqCHG Example: For 0.70A, 0.22V/0.70A=0.31Ω (Rsence)
   Precharge current 0.026V/Rsence=0.026/0.31Ω=0.084A
   Full-charge current Example: 0.018V/0.31Ω=0.058A
   Adjustable full-charge: normally fixed at 0.103V. Full-charge current can be varied by adjusting the ADJ pin voltage.
   Example: For 0.2A, the ADJ2 pin voltage is 0.062 × 4 = 0.248V.
   (Adjustable by placing 50kΩ between ADJ2 and VREF)
9. Total timer (C=0.01uF, for R = 130k T=1.77ms)
   Precharge timer T × 2^{19} Overvoltage detect delay time T × 2^{8}
   Full-charge timer T × 2^{23} Recharge detection delay time T × 2^{5}
   1mA charge timer T × 2^{13} LED R blinking cycle T × 2^{10}
   Full-charge delay time T × 2^{9}
   Overcurrent detection delay time T × 2^{8}
10. During timeout, abnormal charge, 1mA charge MM1639E LED-R=blinking
    MM1639F LED-R=off

Package

VSOP-16A

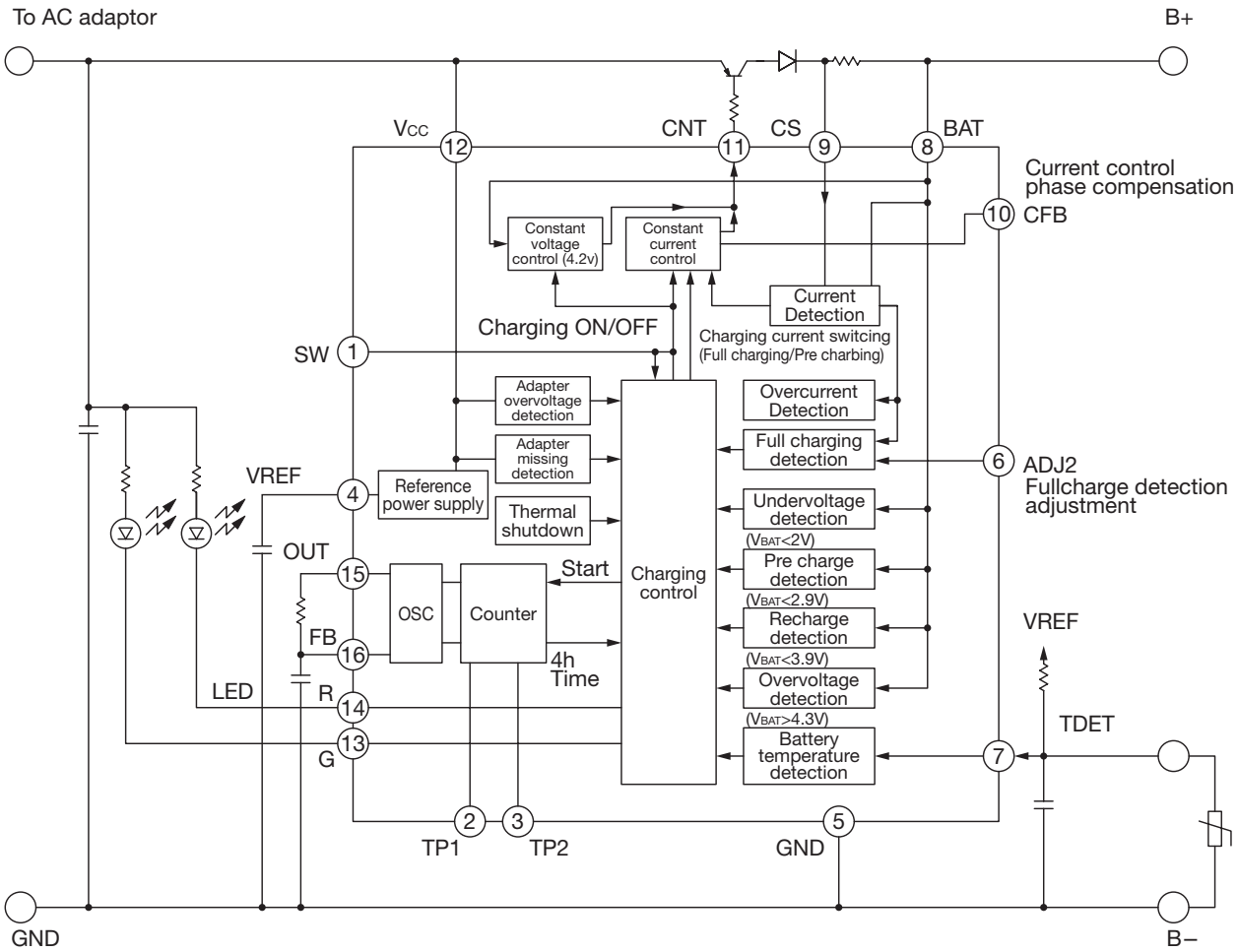
Pin Assignment



VSOP-16A

1	SW	9	CS
2	TP1	10	CFB
3	TP2	11	CNT
4	V_{REF}	12	V_{CC}
5	GND	13	LED G
6	ADJ2	14	LED R
7	T_{DET}	15	OSC OUT
8	BAT	16	OSC FB–

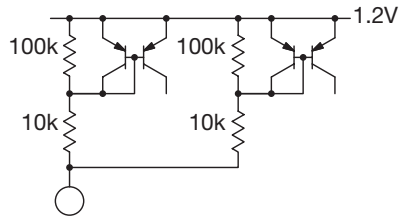
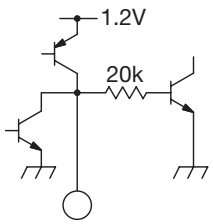
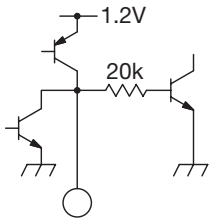
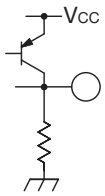
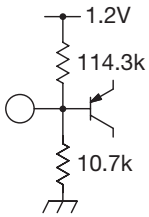
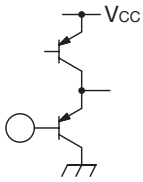
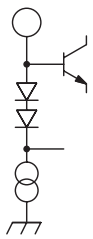
Internal Equivalent Circuit Diagram

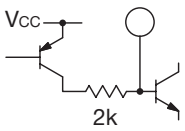
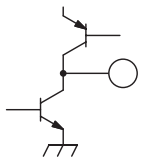
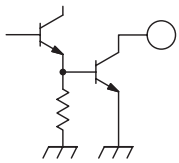
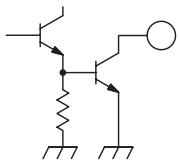
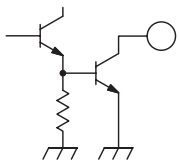
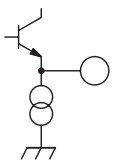
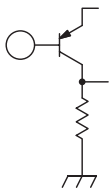


Pin Description

Pin no.	Pin name	I/O	Function
1	SW	INPUT	Forced charging OFF pin. L : Forced charging circuit ON. H : Forced charging circuit OFF. Charging stop is forced.
2	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.)
3	TP2	INPUT/ OUTPUT	Test pin 2. Full charge timer test pin. Sane structure as TP1.
4	V_{REF}	OUTPUT	Reference power supply output pin. Outputs l.2V typ. reference voltage. Used for temperature detection reference power supply and ADJ2 adjustment.
5	GND	INPUT	GND pin.
6	ADJ2	INPUT	Full charge detection adjustment pin. Pin voltage is set at 103mV 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.
7	T_{DET}	INPUT	Temperature detection input pin. Apply potential resistance divided by external resistor and thermistor from reference voltage When using. Reset state will exist if T_{DET} pin does not reach the specified potential.
8	BAT	INPUT	Battery voltage input pins. Detect battery voltage and control charging.
9	CS	INPUT	Current detection pin. Detects current by external resistor (between CS and BAT) Voltage drop and controls charging current.
10	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.
11	CNT	OUTPUT	Charging control output pin. Controls external PNP-Tr base for rated current rated voltage charging.
12	V_{CC}	INPUT	Power supply input pin.
13	LED G	OUTPUT	LED G control output pin. NPN-Tr open collector output. Refer to the flow chart for ON/OFF.
14	LED R	OUTPUT	LED R control output pin. NPN-Tr open collector output. Refer to the flow chart for ON/OFF.
15	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 l30kΩ and capacitor 0.01μF
16	OSC FB–	INPUT	Oscillator inverted input pin.

Pin Description 2 The value of components below is typical one.

Pin no.	Pin name	Internal equivalent circuit diagram
1	SW	
2	TP1	
3	TP2	
4	V_{REF}	
6	ADJ2	
7	T_{DET}	
8	BAT	

Pin no.	Pin name	Internal equivalent circuit diagram
9	CS	
10	CFB	
11	CNT	
13	LED G	
14	LED R	
15	OSC OUT	
16	OSC FB–	

Absolute Maximum Ratings (Ta=25°C)

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

Recommended Operating Conditions (Ta=25°C)

Item	Symbol	Ratings	Units
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, V_{CC}=5V) (Models listed MM1639E)

Item	Symbol	Measurement conditions	Measurement pin	Min.	Typ.	Max.	Units
Current consumption	I_{CC}		12		5.0	7.0	mA
Reference voltage	V_{REF}		4		1.207		V
ADP detection voltage L	V_{ADPL}	V_{CC}: H→L	14	2.35	2.45	2.55	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	14	6.1	6.3	6.5	V
ADP detection voltage H hysteresis voltage width	V_{ADPHW}		14	50	100	150	mV
BAT pin leak current	I_{BAT}		8.9			1	µA
BAT pin output voltage	V_{BAT}	Ta=0~+50°C	8	4.170	4.200	4.230	V
CNT pin output voltage	V_{CNT}	I_{CNT}=20mA	11			0.5	V
SW pin input current	I_{SW}		1	80	120	160	µA
SW pin input voltage H	V_{SWH}	Charging control circuit: OFF	1	0.6		1.20	V
SW pin input voltage L	V_{SWL}	Charging control circuit: ON	1			0.25	V
Current limit 1	V_{L1}	Full charge	8, 9	0.20	0.22	0.24	V
Current limit 2	V_{L2}	Pro-charge	8, 9	21	26	31	mV
Full charge detection	V_F		8, 9	13	18	23	mV
Overcurrent detection			8.9	0.26	0.29	0.31	V
Low voltage detection	V_{LV}	V_{BAT}: L→H	8	1.90	2.00	2.10	V
Low voltage detection hysteresis voltage width	V_{LVW}		8	25	50	100	mV
Pre-charge detection voltage	V_P	V_{BAT}: L→H	8	2.80	2.90	3.00	V
Pro-charge detection hysteresis voltage width	V_{PW}		8	25	50	100	mV
Re-charge detection voltage	V_R	V_{BAT}: H→L	8	3.85	3.90	3.95	V

Item	Symbol	Measurement conditions	Measurement pin	Min.	Typ.	Max.	Units
Overvoltage detection voltage	V_{OV}	V_{BAT}: L→H	8	4.30	4.35	4.40	V
Battery temperature detection voltage H	V_{TH}	Low temperature 3°C ± 3°C detection	7	0.835	0.860	0.885	V
Battery temperature detection voltage L1	V_{TL1}	High temperature 43°C ± 3°C detection (Charging start)	7	0.390	0.413	0.435	V
Battery temperature detection voltage L2	V_{TL2}	High temperature 50°C ± 3°C detection (during charging)	7	0.335	0.353	0.370	V
T_{DET} input bias current	I_T		7		30	150	nA
LED R pin output voltage	V_{LEDR}	I_{LEDR}=10mA	14			0.4	V
LED G pin output voltage	V_{LEDG}	I_{LEDG}=10mA	13			0.4	V
Timer error time	⊿T	Not including external deviation	13, 14	−10		10	%

*Current limits 1 and 2 and full charge detection are specified art current detection resistor voltage drop.
*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.
*Temperature detection is the setting value at B constant 3435 (10KC15-1 608 made by Ishizuka Denshi).
*Use a capacitor with good temperature characteristics in the oscillator. Capacitor deviation will contribute to timer error.
*When the battery overdischarge condition. a charge 1 mA for 14 seconds. and then it does not switch to pro-charging during that interval. it means the IC has identified a battery abnormality.

Electrical Characteristics 2 OSC CR Setting Reference Note

OSC CR-Oscillation Cycle Examples

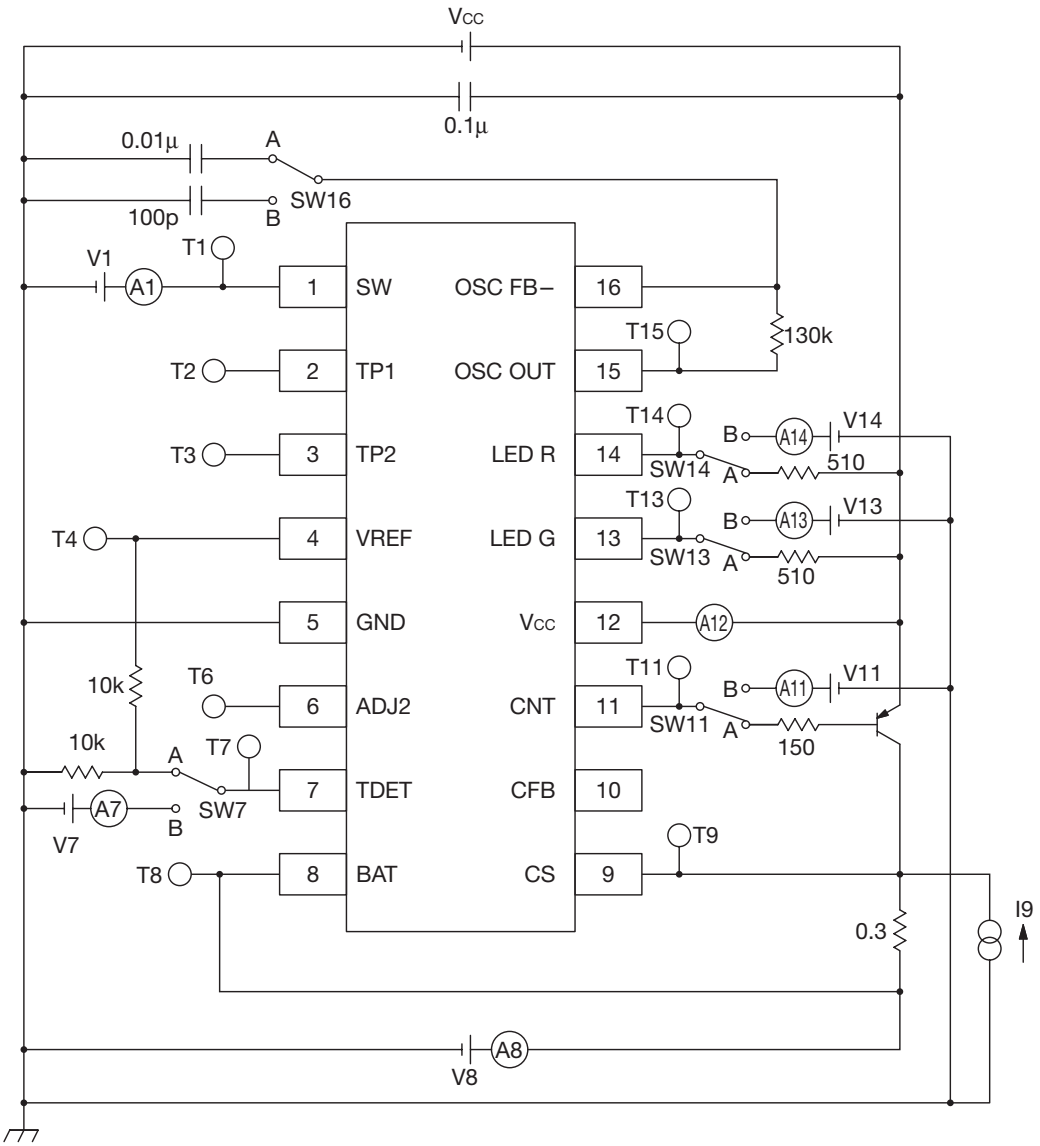
C \ R	75k	100k	120k	130k	150k	200k
0.0047μ	0.47ms	0.63ms	0.75ms	0.82ms	0.94ms	1.26ms
0.0082μ	0.83ms	1.10ms	1.32ms	1.43ms	1.65ms	2.20ms
0.01μ	1.03ms	1.37ms	1.63ms	1.77ms	2.04ms	2.73ms
0.015μ	1.48ms	1.98ms	2.38ms	2.58ms	2.97ms	3.95ms
0.022μ	2.16ms	2.87ms	3.44ms	3.73ms	4.30ms	5.76ms

Time of Each Times

Item	Calculation formula	Examples of calculation (for C=0.01μF,R=l 30kΩ)
Pre-charge timer	$T \times 2^{19}$	15min. 28s
Full charge timer	$T \times 2^{23}$	4h 7min.
1mA charge time	$T \times 2^{13}$	14.5s
Full charge detection delay time	$T \times 2^{9}$	0.90s
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

T : OSC oscillation cycle

Measuring Circuit



Measuring Procedures

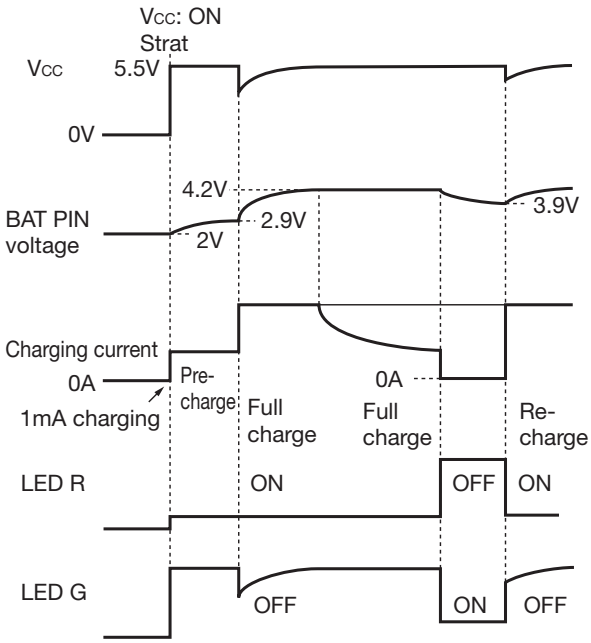
(Except where noted otherwise, Ta=25°C, V_{CC}=5V, V1=0V, V8=4.27V, SW7 ,11, 13, 14, 16: A, I9=0mA)

Item	Measuring procedures
Current consumption	V1=1.2V. Measure A12 current value I_{CC}.
Reference voltage	Measure T4 potential V_{REF}.
ADP detection voltage L	Gradually lower V_{CC} from 5V; V_{CC}-potential is V_{ADPL} when T14 potential goes over V_{CC}–0.5V.
ADP detection voltage L hysteresis voltage width	Gradually lower V_{CC}-from 2V. V_{CC}-potential is $V_{ADPL}2$ when T14 potential drops below 0.5V. $V_{ADPLW}=V_{ADPL}2-V_{ADPL}$
ADP detection voltage H	Gradually increase V_{CC} from 5V. V_{CC} potential is V_{ADPH} when T14 potential goes over V_{CC}–0.5V
ADP detection voltage H hysteresis voltage width	Gradually lower V_{CC} from 7V V_{CC}-potential is $V_{ADPH}2$ when T14 potential drops below 0.5V. $V_{ADPHW}=V_{ADPH}-V_{ADPH}2$
BAT pin leak current	V_{CC}=0V. SW11: B, V11=0V, Measure A8 current value I_{BAT}.
BAT pin output voltage	Gradually lower V8 from 3.5V. T8 potential is V_{BAT} when T9-T8 potential difference falls to less than 20mV.
CNT pin output voltage	V8=3.5V. SW1 1: B. Gradually raise V11 from 0V. T11 potential is V_{CNT} When A11 current value 20mA.
SW pin input current	Measure Al current value T_{SW}.
SW pin input current voltage H	V8=3.5V. Raise V1 from 0V to 12V. SW: ON when A8 is bigger than 500mA. SW; OFF when A8 is smaller than 1 mA. Measure V_{SW}-
CHGSW pin input current voltage L	
Current limit 1	V8=3.5V. T9–T8 potential difference is V_L1.
Current limit 2	V8=2.5V. T9–T8 potential difference is V_L2.
Full charge detection	SW1 6: B. I9=100mA. Gradually reduce I9 current value after reset. T9-T8 potential difference is V_F when T13 potential goes under 0.5V.
Overcurrent detection	I9=500mA. Gradually increase I9 current value after reset. T9-T8 potential difference is V_{OC} when T14 potent;al starts to repeat HI/LOW.
Low voltage detection voltage	Gradually raise V8 from 0V. T8 potential is V_{LV} when A8 current value goes over 50mA.
Low voltage detection Hysteresis voltage Width	radially lower V8 from 2.5V. T8 potential is $V_{LV}2$ when A8 current goes over 10mA. $V_{LVW}=V_{LV}-V_{LV}2$
Pre-charge detection voltage	Gradually raise V8 from 2.5V. T8 potential is V_P when A8 current value goes over 500mA.
Pre-charge detection Hysteresis voltage width	Gradually Bower V8 from 3.5V. T8 potential is V_P2 when A8 current value goes under 150mA. $V_{PW}=V_P-V_P2$
Re-charge detection voltage	Wait about 1 see at V8=4. 27V; in full charge detection state, gradually lower V8 potential to lower T13 potential to under 0.5V. T8 potential is V_R When T13 potential is more than V_{CC}-0.5V.

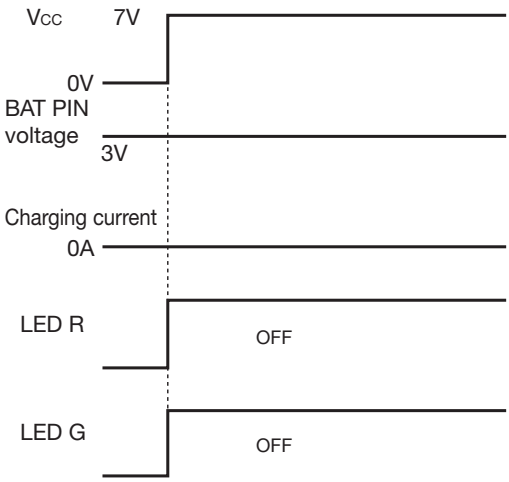
Item	Measuring procedures
Overvoltage detection voltage	Gradually raise V8 from 4V. T8 potential is V_{OV} when T14 potential starts to repeat HL/LOW.
Battery temperature detection voltage H	V8=3.5V, SW7: B, Gradually raise V7 from 0.6V. T7 potential is V_{TH} when A8 current value goes under 1mA.
Battery temperature detection voltage L1	V8=3.5V, SW7: B, Gradually raise V7 from 0V. T7 potential is $V_{TL}1$ when A8 current value goes over 500mA.
Battery temperature detection voltage L2	V8=3.5V, SW7: B, Gradually lower V7 from 0.6V. T7 potential is $V_{TL}2$ when A8 current value goes over 1mA.
T_{DET} input bias current	SW7: B, V7=0V. Measure A7 current value IT.
LED R pin output voltage	V8=3.5V, SW14: B, Gradually raise V14 from 0V. T14 potential is V_{LEDR} when A14 current value is 10mA.
LED G pin output voltage	Wait about 1s at V8=4.27V: in full charge detection state, make T13 potential 0.5V or less. Next at SW13: B, gradually raise V13 from 0V. T13 potential is V_{LEDG} when A13 current value is 10mA.

Timing Chart (Models listed MM1639E)

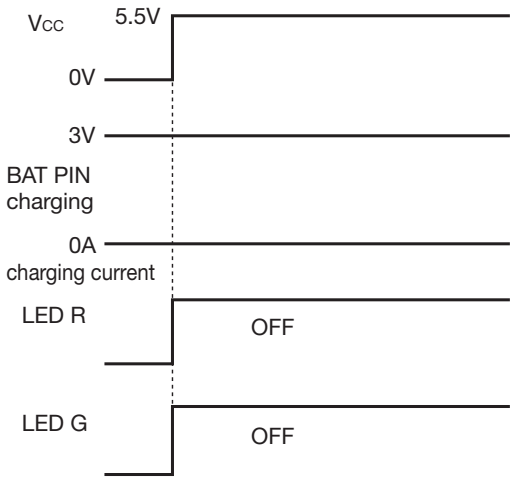
When charging normally



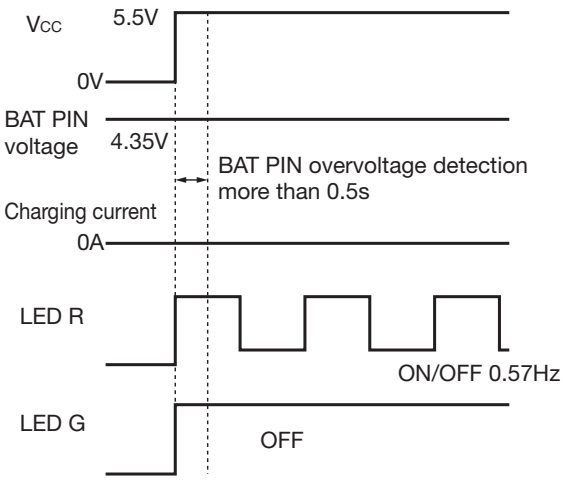
When connecting abnormal adapter



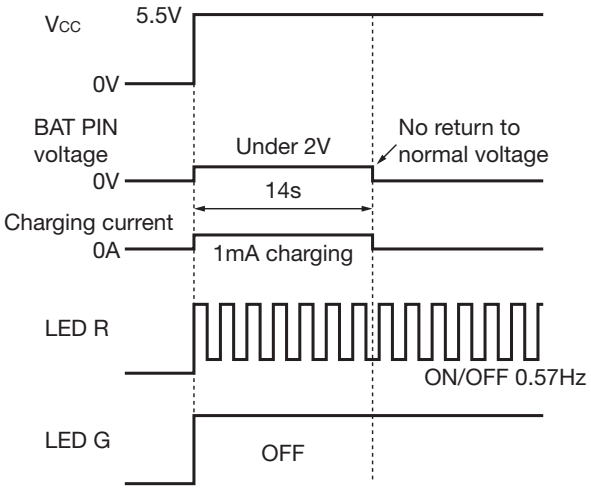
When battery setting error (temperature detection pin open)



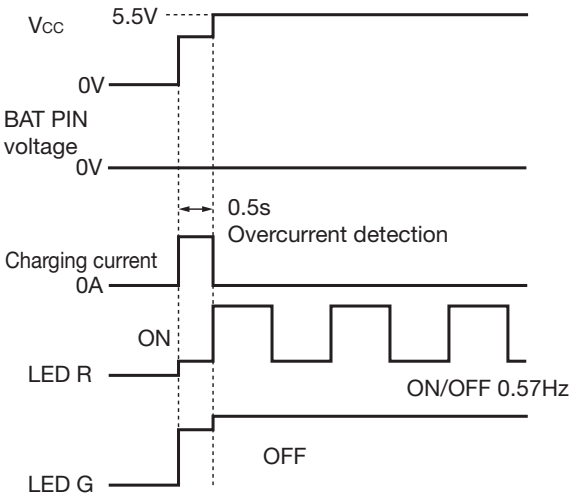
When overcharged battery setting



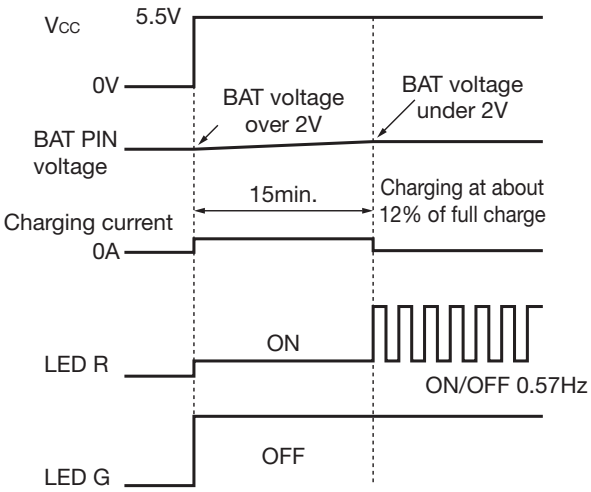
When setting overdischarged battery



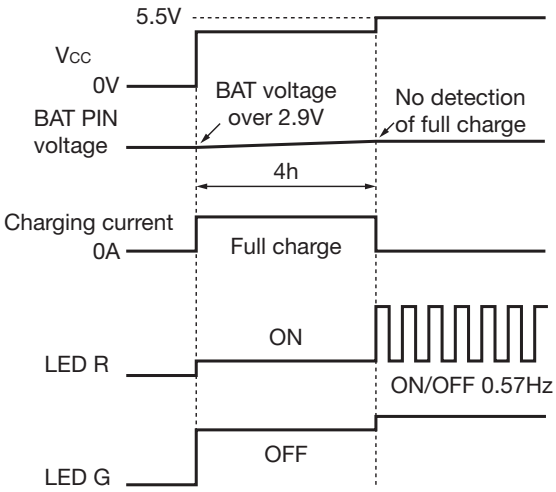
When overcurrent detection



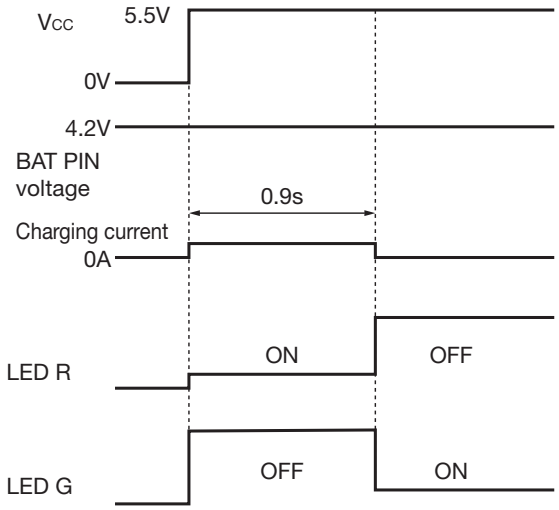
When times up for pre-charge



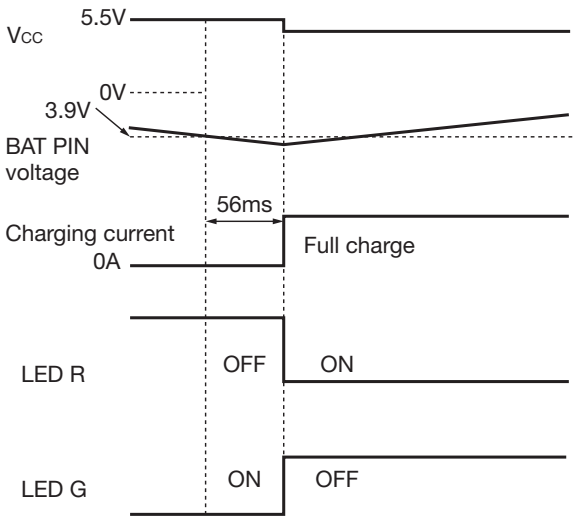
When times up for full-charge



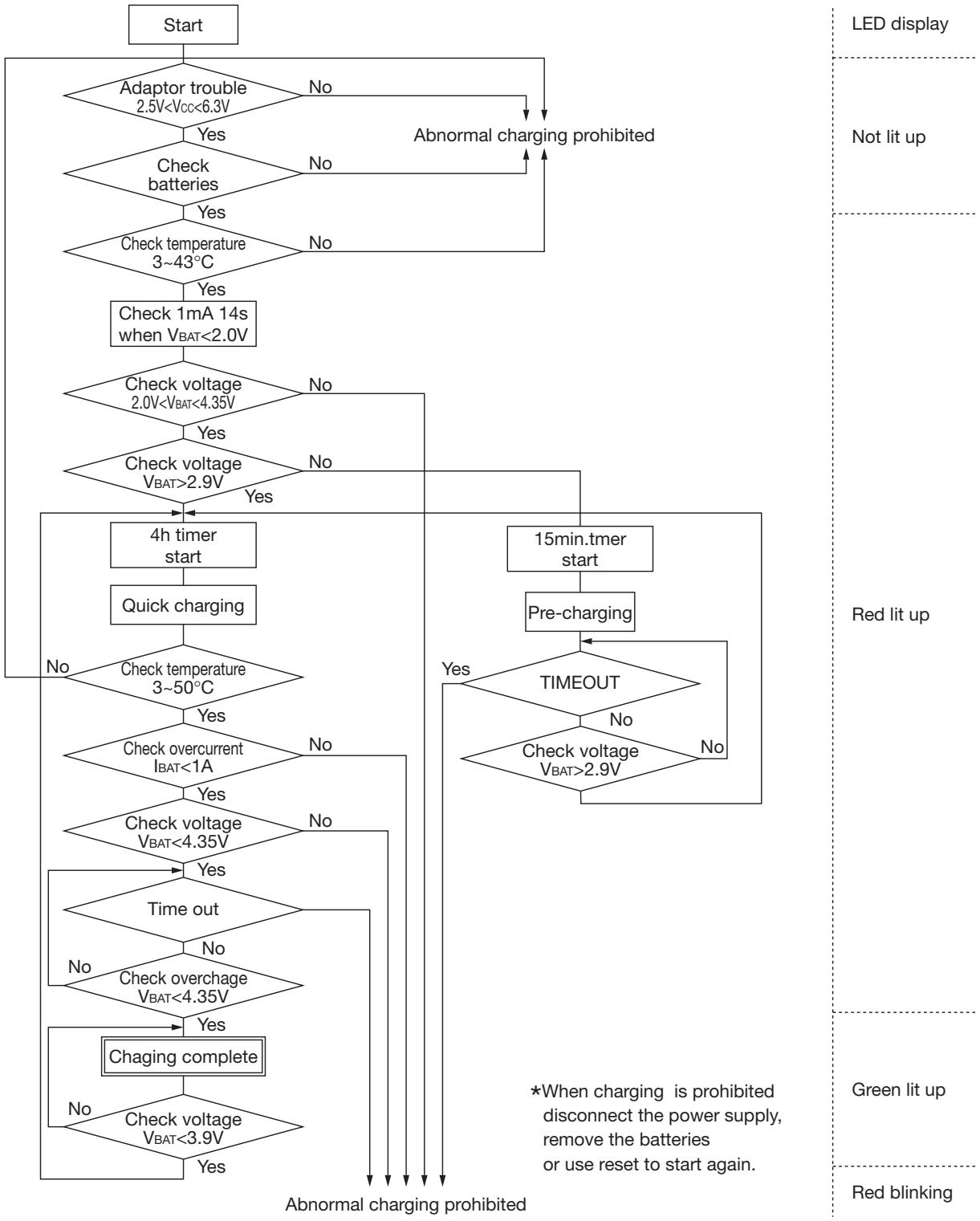
When setting full charge battery



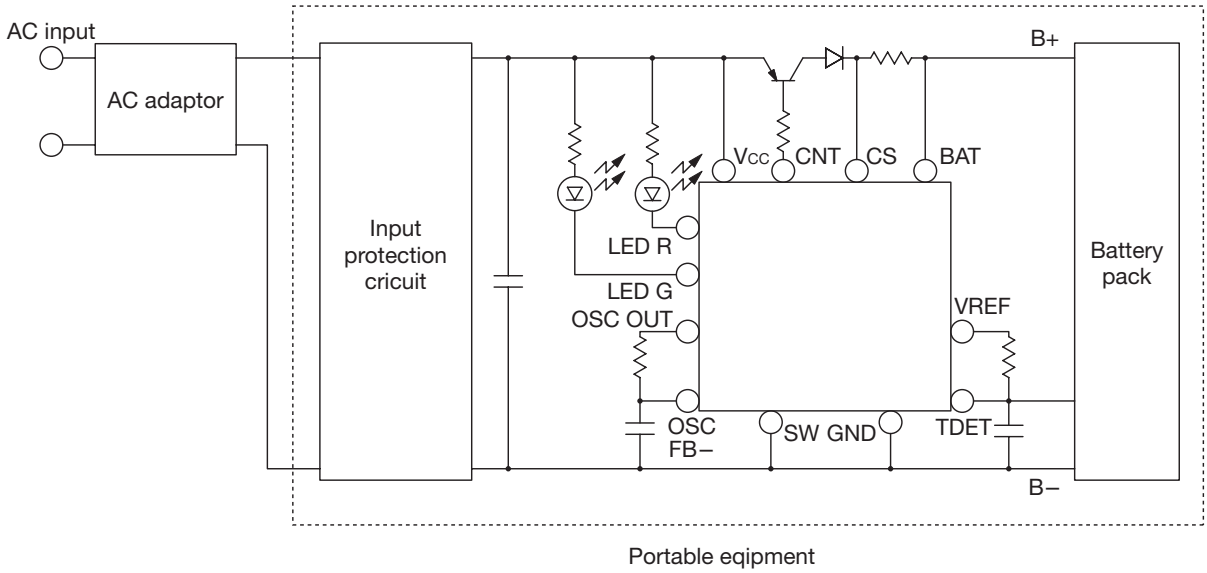
When recharge detecting



Flow Chart

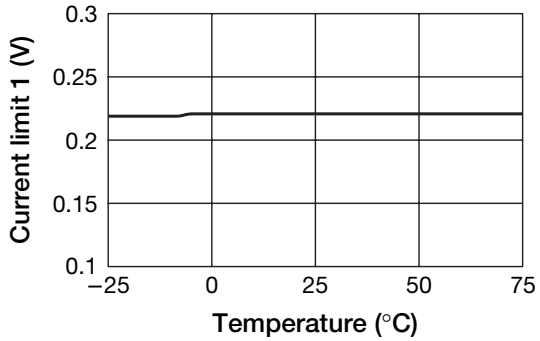

Start
Adaptor trouble
2.5V<Vcc<6.3V
No
Yes
Abnormal charging prohibited
Check batteries
No
Yes
Check temperature
3~43°C
No
Yes
Check 1mA 14s
when VBAT<2.0V
Check voltage
2.0V<VBAT<4.35V
No
Yes
Check voltage
VBAT>2.9V
No
Yes
4h timer start
Quick charging
15min.tmer start
Pre-charging
No
Check temperature
3~50°C
Yes
Yes
TIMEOUT
No
Check voltage
VBAT>2.9V
No
Check overcurrent
IBAT<1A
No
Yes
Check voltage
VBAT<4.35V
No
Yes
Time out
No
No
Check overchage
VBAT<4.35V
Yes
Chaging 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

Application Circuit

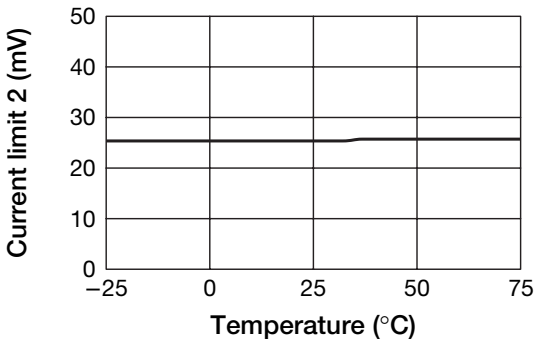


Characteristics

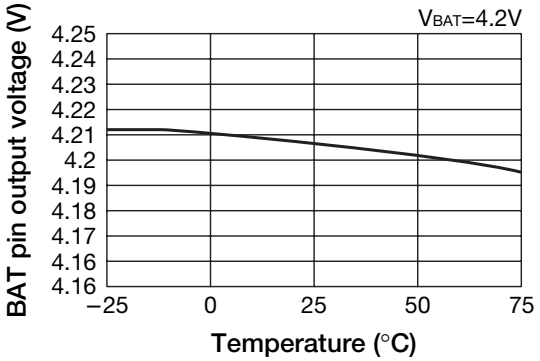
Current limit 1



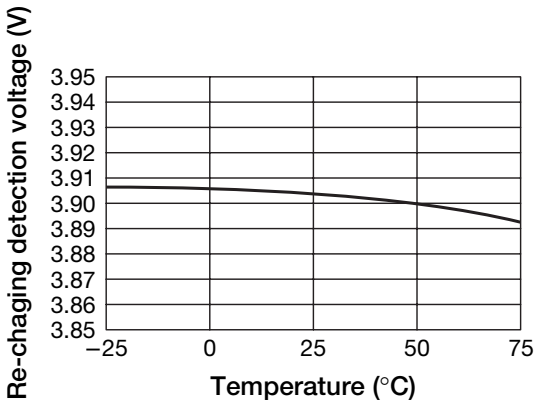
Current limit 2



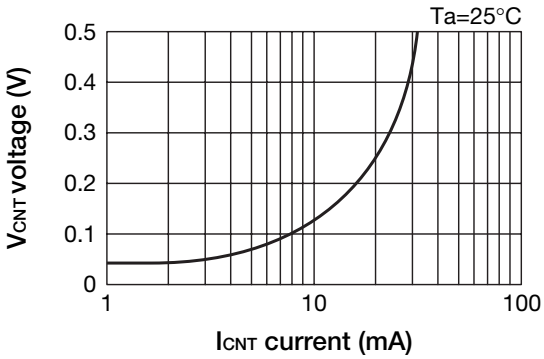
BAT pin output voltage



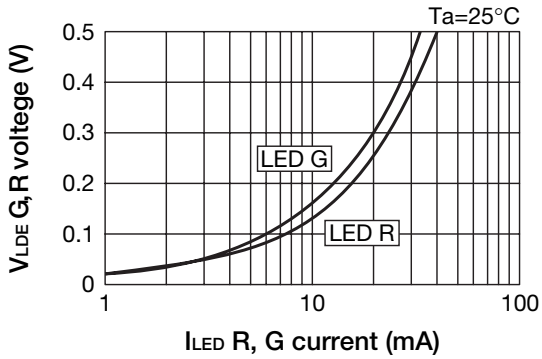
Re-charge detection voltage



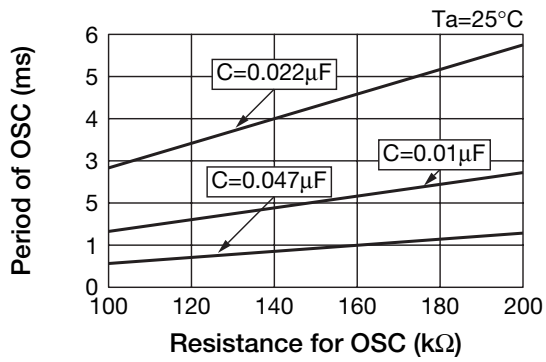
VCNT vs ICNT



LED G, R voltage vs current



Period of OSC



BAT pin leak current