Lithium-Ion Battery Charge Control
Monolithic IC MM1581

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 and disable charging due to abnormal temperature, etc. It is also equipped with a 2-channel LED driver to allow the charge status to be displayed.

Features

1. Operating supply voltage 4.8~15.0V
2. Operating ambient temperature -20~85°C
3. Current consumption 7.0mA typ.
4. Low voltage detection voltage 1.54V typ. (rank A) 2.60V typ. (rank B)
5. BAT pin output voltage 4.20±0.03V
6. Recharge detection voltage 3.99V typ.
7. Precharge detection voltage 3.07V typ.
8. Fast-charge current setting Rsense=0.256V/Iq_{CHG} Example: For 0.512A, 0.256V/0.512A=0.5Ω (Rsence)
   Precharge current 0.026V/Rsence=0.026/0.5Ω=0.052A
   Full-charge adjustable for rank A
   Full-charge current Example: When ADJ = 0.25V, 5 * 0.Ω *full-charge current=0.25V, full-charge current=0.1A
9. Recharge delay time 0.48s (C1=0.1μF)
10. Full-charge detection delay time 0.52s (C2=0.1μF)
11. Temperature detection delay time 0.049s (C3=0.1μF)
12. LED switching delay time 1.0s (C2=0.1μF)

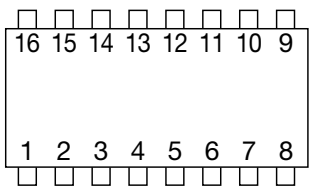
Package

TSOP-16A

Application

For lithium-ion/lithium-polymer battery protection circuits

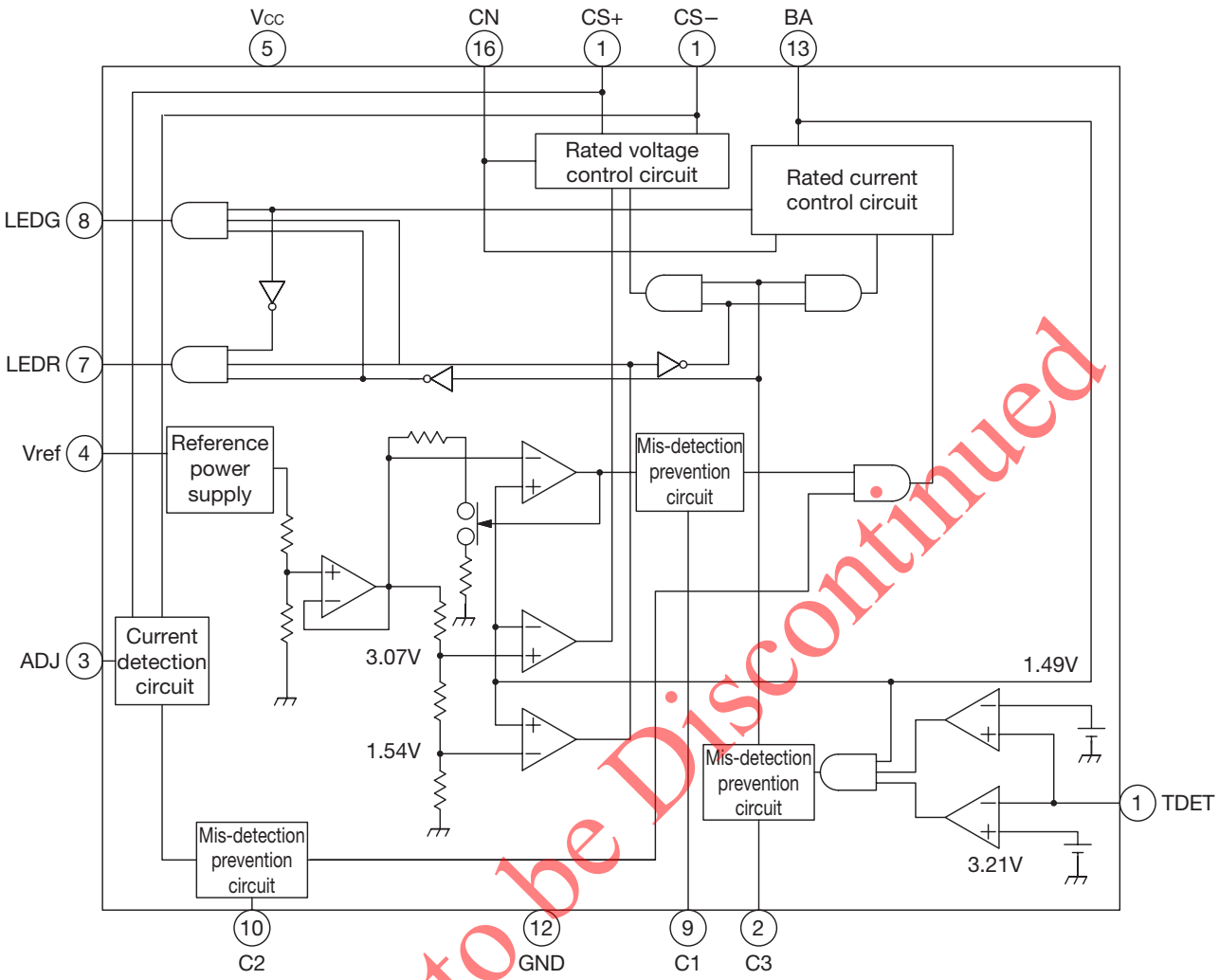
Pin Assignment



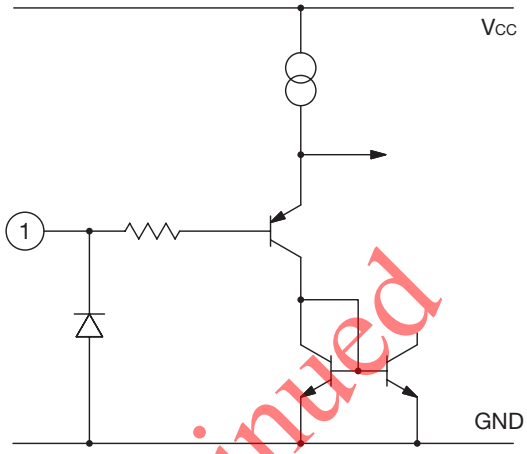
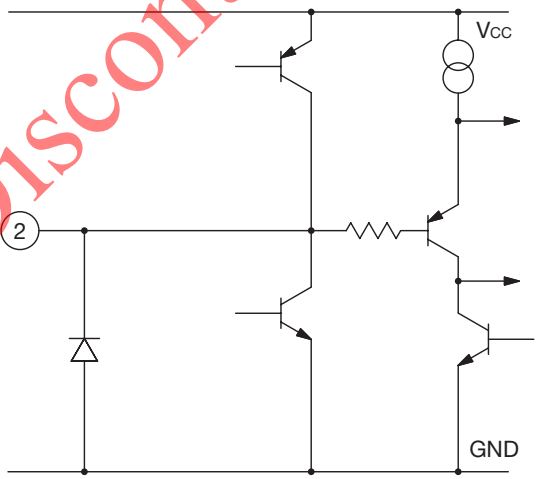
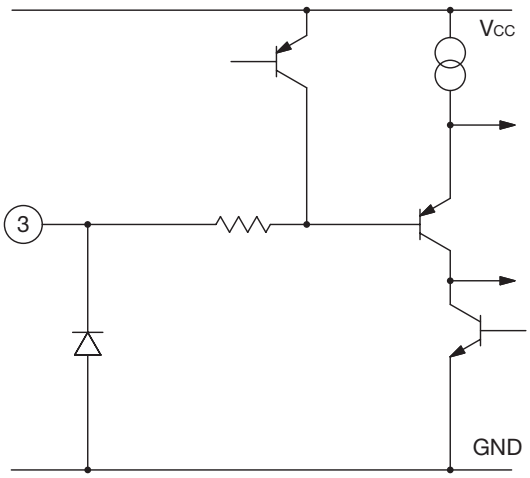
TSOP-16A
(TOP VIEW)

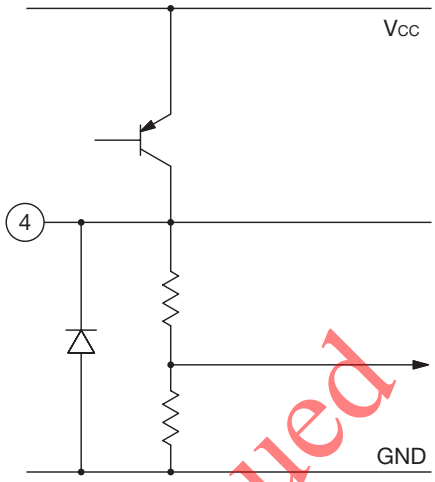
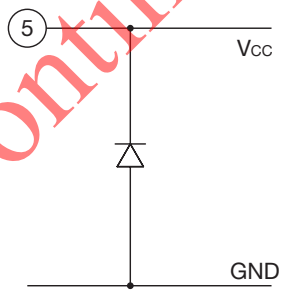
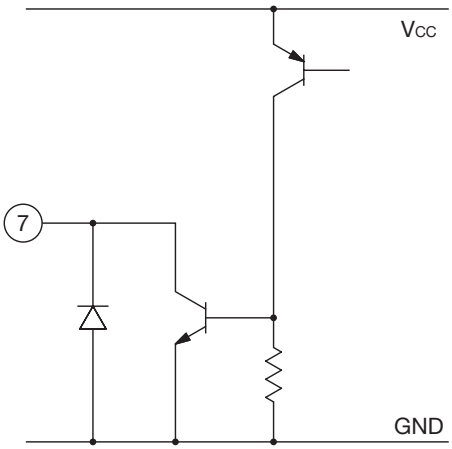
1	TDET	9	C1
2	C3	10	C2
3	ADJ	11	N. C
4	VREF	12	GND
5	Vcc	13	BAT
6	N. C	14	CS–
7	LEDR	15	CS+
8	LEDG	16	CNT

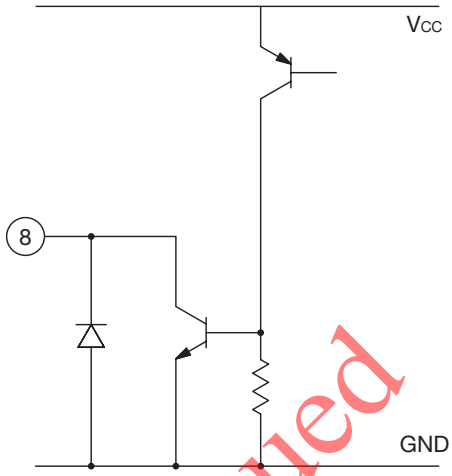
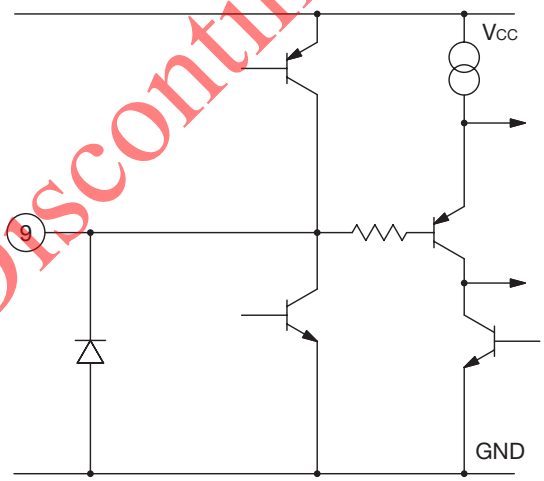
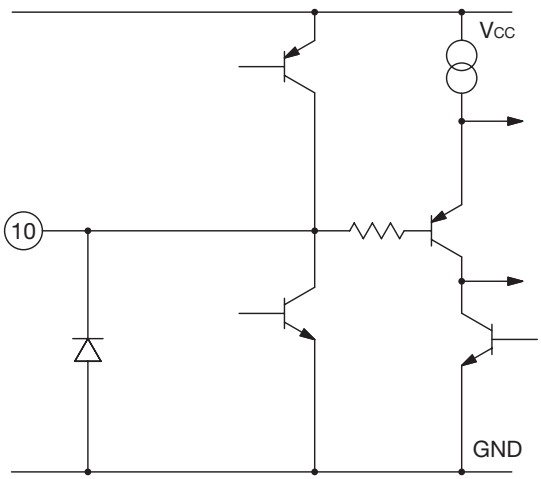
Block Diagram

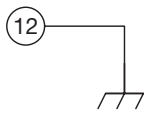
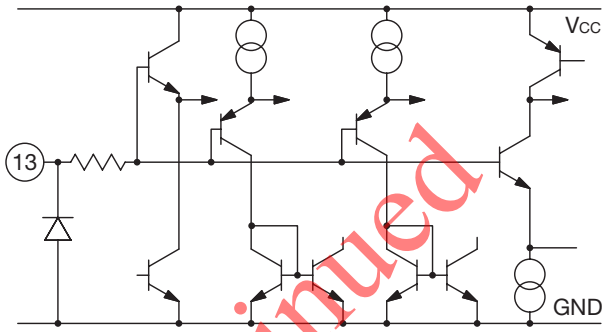
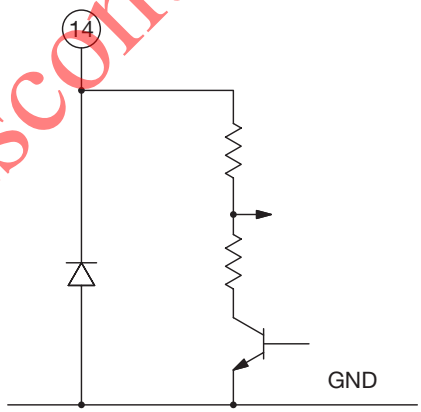
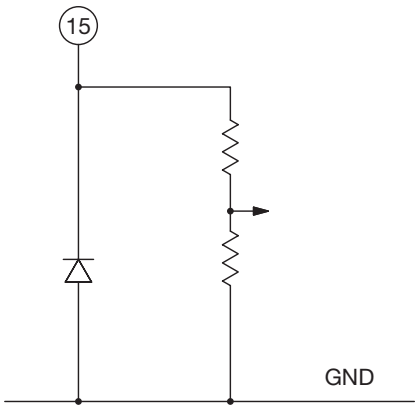


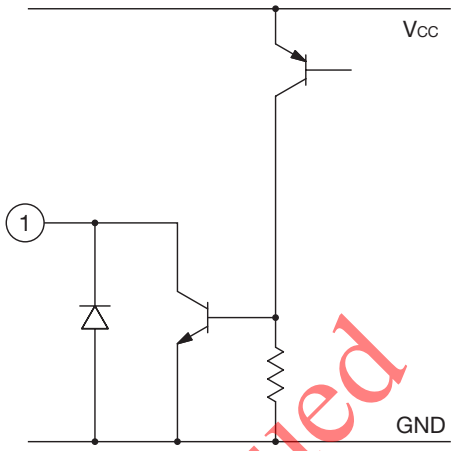
Pin Description

Pin no.	Pin name	I/O	Function	Internal equivalent circuit diagram
1	TDET	Input	Temperature detection and battery connection detection pin (used for both)	
2	C3	Input	Temperature detection delay. Time setting pin (TPd=49ms C3=0.1µF)	
3	ADJ	Input	Charging detection voltage setting pin (typ.=49ms C3=0.1µF)	

Pin no.	Pin name	I/O	Function	Internal equivalent circuit diagram
4	V_{REF}	Output	Reference voltage output in (typ.=4.53V)	
5	Vcc	Input	Power voltage	
6	N. C	N.C		
7	LEDR	Output	LED connection pin Lights up during charging (open collector output)	

Pin no.	Pin name	I/O	Function	Internal equivalent circuit diagram
8	LEDG	Input	LDE connection pin when charging is complete (open collector output)	
9	C1	Input	Current detection delay time setting pin (typ.=0.48s C3=1.0µF)	
10	C2	Input	Current detection delay time setting pin (typ.=0.48s C2=1.0µF)	

Pin no.	Pin name	I/O	Function	Internal equivalent circuit diagram
11	N. C	N. C		
12	GND		GND pin	
13	BAT	Input	Battery voltage detection pin	
14	CS–	Input	Charging current detection pin (connect to low detection resistance side)	
15	CS+	Input	Charging current detection pin (connect to high detection resistance side)	

Pin no.	Pin name	I/O	Function	Internal equivalent circuit diagram
16	CNT	Output	Output pin (open collector output)	

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Ratings	Units
Storage temperature	T_{STG}	−40~+150	°C
Operating temperature	T_{OPR}	−20~+85	°C
Supply voltage	V_{IN}	−0.3~+16	V
CNT pin output current	I_{CNT}	30	mA
TDET pin output voltage	V_{TIN}	−0.3~Vcc	V
Allowable loss	Pd	400 (Not attached)	mW

Recommended Operating Conditions (Ta=25°C)

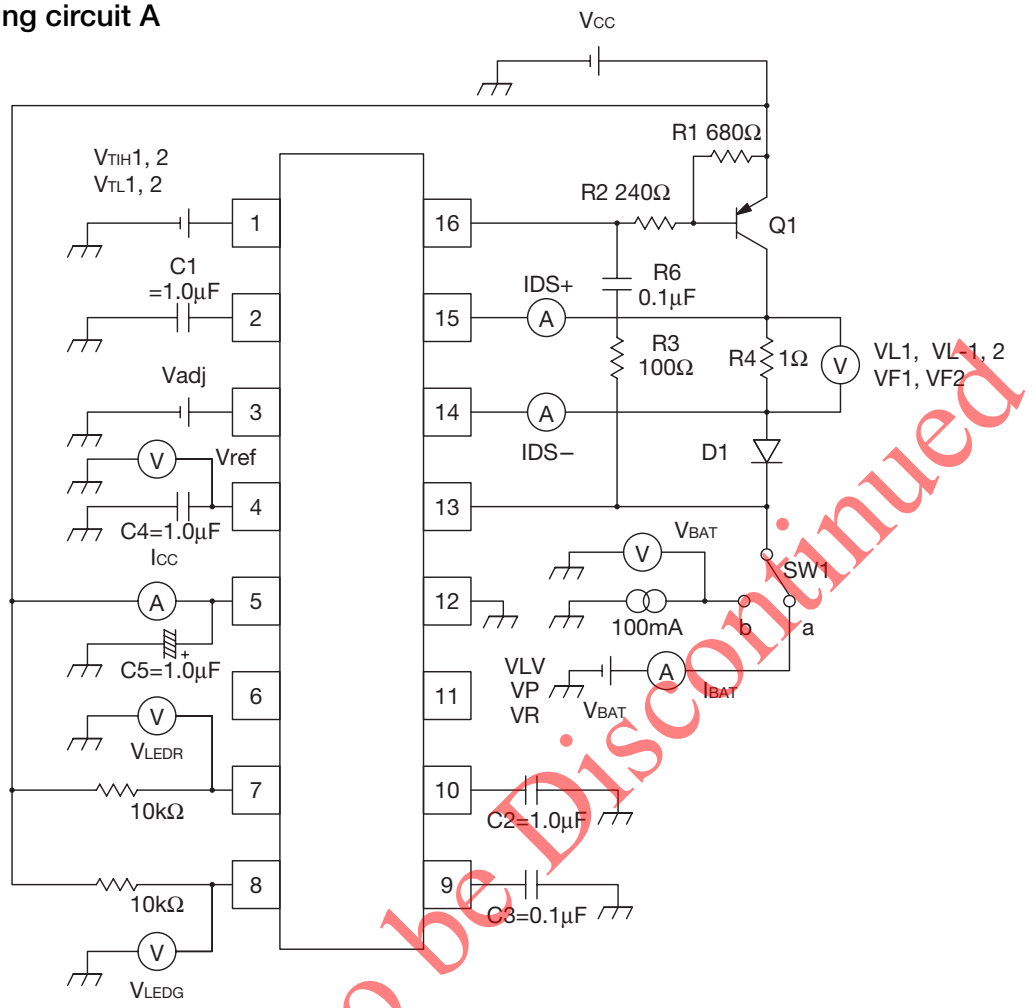
Item	Symbol	Ratings	Units
Operating temperature	T_{OPR}	−20~+85	°C
CNT current	1_{CNT}	0~30	mA
Operating voltage	V_{OP}	4.8~15.0	V

Electrical Characteristics (Except where noted otherwise, Ta=25°C, Vcc=12V, VSENSE=3.6V, C1=1.0µF, C2=1.0µF, C3=0.1µF)

Item	Symbol	Measurement conditions	Measurement Circuit	Min.	Typ.	Max.	Units
Consumption current	Icc	When LED OFF	a	4	7	10	mA
Reference voltage	Vref		a	4.30	4..53	4.76	V
Low voltage detection voltage	VLV	VBAT: L→H	a	1.44	1.54	1.64	V
Pre-charge detection voltage	VP	VBAT: L→H	a	2.97	3.07	3.17	V
BAT pin output voltage	VBAT		a	4.17	4.20	4.23	V
Re-charge detection voltage	VR	VBAT: H→L	a	3.89	3.99	4.09	V
BAT pin input current	IBAT		b	–2		2	µA
Current Limit 1	VIL1	1.54V < Battery voltage <3. 07V Pre-charge	a	15	26	37	mV
Current Limit 2–1	VIL2–1	5.0V ≦ Vcc ≦ 8.0V 3.07V ≦ Battery voltage ≦ 4.2V Quick charge	a	232	256	280	mV
Current Limit 2–2	VIL2–2	8.0V<Vcc ≦ 15.0V 3.07V ≦ Battery voltage ≦ 4.2V Quick charge	a	237	257	275	mV
Full charge detection voltage 1	VFl	Vadj=0.13V	a	15	26	37	mV
Full charge detection voltage 2	VF2	Vadj=0.5V	a	75	100	125	mV
CS+ pin input current	ICS+	VCS+ –3.6V	a		60	85	µA
CS– pin input current	ICS–	VCS–=3.6V	a		60	85	µA
LED R pin output voltage	VLEDR	ILED R=10mA	b			0.4	V
LED G pin output voltage	VLEDG	ILED G=10mA	b			0.4	V
Battery temperature detection voltage H1	VTH1	Vref=4.53V	a	3.11	3.21	3.31	V
Battery temperature detection voltage L1	VTL1		a	1.39	1.49	1.59	V
Battery temperature detection voltage H2	VTH2		a	3.13	3.23	3.33	V
Battery temperature detection voltage L2	VTH2		a	1.49	1.59	1.69	V
TDET pin input bias current	IT		b	–1.0			µA
CNT pin output voltage	VCNT	ICNT=20mA	b		1.0	2.0	V
CNT pin leak current	ICNT	VOUT=15V	b			l.0	µA
Re-charge detection delay time	tdcl	Re-charge time C1=1.0µF	c	0.34	0.48	0.62	s
Connection detection time 1	tdBDET	4.2V constant voltage output time C2=1.0µF	c	0.37	0.52	0.67	s
Fullcharge detection delay time	tdIDET	C2=1.0µF	c	0.37	0.52	0.67	s
LED switching delay time	tdILED	C2=1.0µF	c	0.71	1.00	1.3	s
Discharge time	tdchg	C2=1.0µF (after current detection)	c	13	41		ms
Temperature detection delay time	tdc3	C3=0.1µF	c	34	49	64	ms

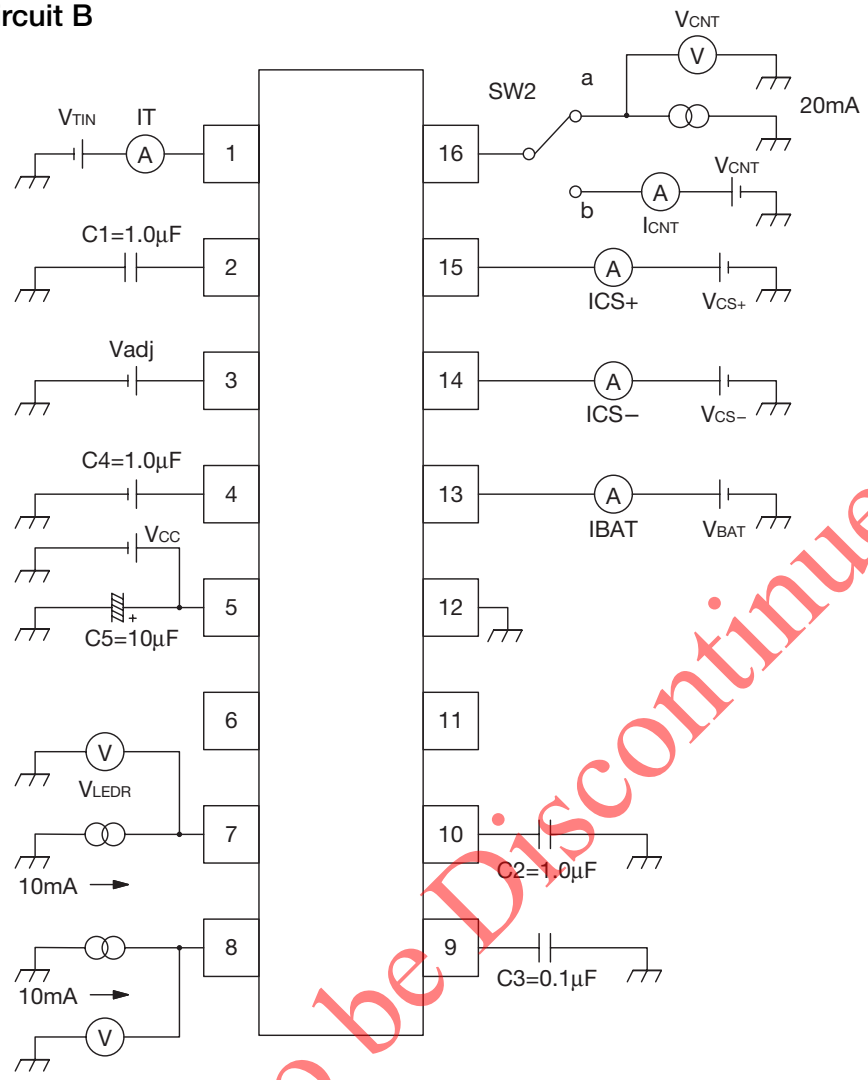
Measuring Circuit

Measuring circuit A



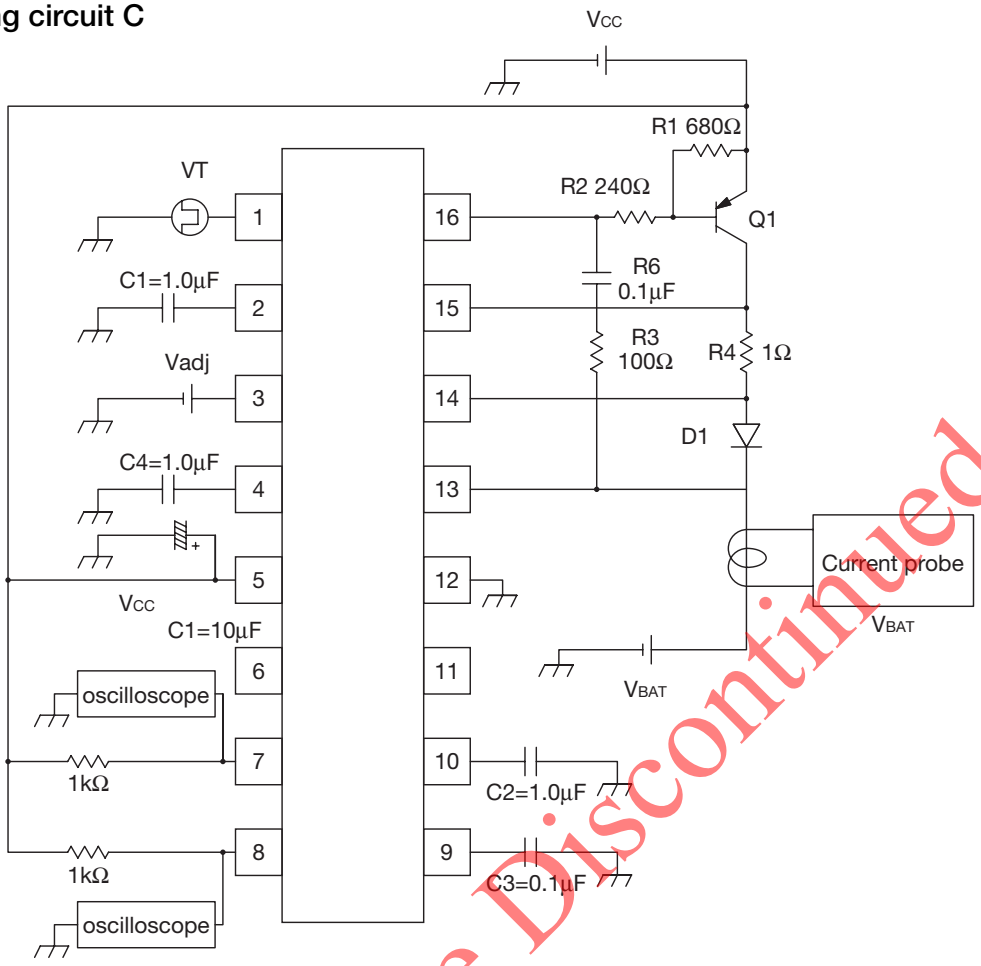
Note SW1 = b only during BAT pin output voltage measurement

Measuring circuit B

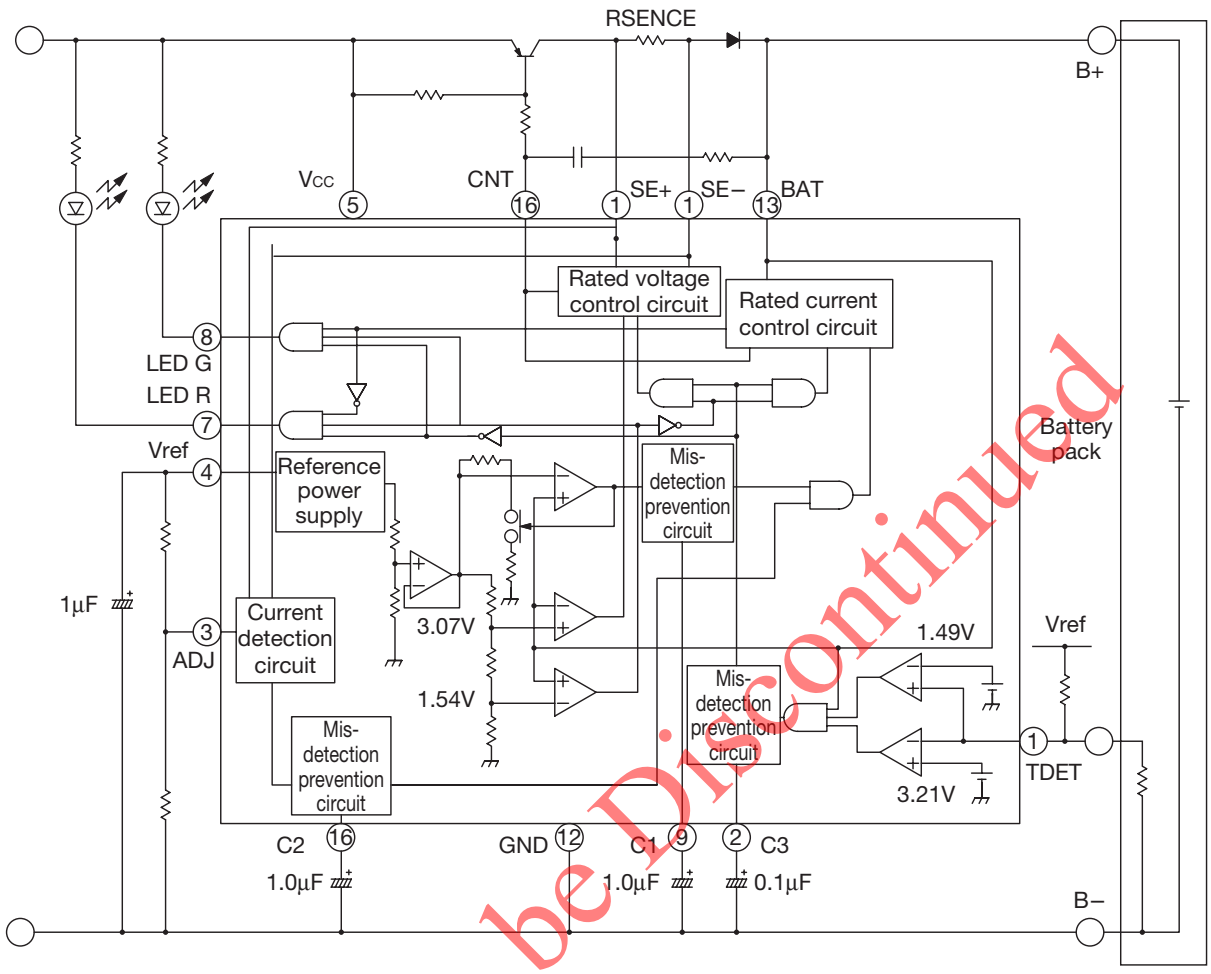


Note SW2 = b only during CNT pin gain leak current measurement

Measuring circuit C



Application Circuit



Operation

12-1 Charging operation

Charging is prohibited in the following cases.

1. AC adaptor or battery is not connected properly.
2. TDET pin voltage is outside the range from battery temperature detection voltage L1 to battery temperature detection voltage H1.

If neither of the above problems exists, charging starts.

12-2 Battery voltage check operation

·When potential within the range from battery temperature detection voltage L1 to battery temperature detection voltage H1 is impressed on the TDET pin, then after temperature detection delay time, V_{BAT} output voltage is 4.2V. Then, after 1.15 seconds (when C2 = 2.2μF) output voltage is switched to 1.46V, battery voltage is detected and charging starts.

(Voltage detection is not performed during this time.)

Also, during 4.2V constant voltage output, current detection resistance voltage drop is limited to 256mV.

12-3 Abnormal battery detection

·Charging is stopped if, after battery voltage check, the battery is deemed abnormal because battery voltage goes below low voltage detection voltage.

12-4 Pre-charge operation

·Charging is done by pre-charge current when, after battery voltage check, battery voltage is below low voltage detection voltage (V_{LV}).

12-5 Full charge operation

·When battery voltage rises and BAT pin voltage reaches pre-charge detection voltage (VP), the battery is charged by full charging current. The standard value for full charging current is determined by the value obtained by dividing current limit 1 (VL1) by the external resistance between CS+ and CS-.

·When battery voltage rises, the operation switches from constant current charging to constant voltage charging when BAT pin voltage approaches BAT pin output voltage (V_{BAT}).

·After switching to constant voltage charging, charging current gradually diminishes. When charging current goes below the value obtained by dividing full charge detection voltage (V_F) by the external resistance between CS + -CS, charging is completed after full charge detection delay time and the LED G pin open collector NPNP transistor goes on.

(LED G stays lit except when (1) AD adaptor is removed, or (2) when outside battery temperature detection voltage range (including removal of battery).)

·If battery voltage is already at BAT pin voltage when charging starts, charging is completed after full charge detection delay time, and the LED G pin open collector NPN transistor goes on.

12-6 Re-charge operation

·After full charge detection, battery voltage drops from charging completed state, and re-charge starts when it goes below re-charge detection voltage.

12-7 Temperature monitoring function

·The potential divided from V_{REF} by the external resistor and thermistor is monitored by the TDET pin.

·When a thermistor is not used, a resistor can be connected to enable charging, but temperature protection will no longer operate. Battery open detection assumes a removable thermistor in the battery pack. A battery open detection circuit would be required if a thermistor is not used.

12-8 Charging state verification

·The open collector NPN transistor inside LEDR normally goes on during pre-charging and full charging operations. When a PULL UP connection is made to LEDR via the red LED and a resistor, pre-charging and full charging can be verified by the red LED lighting up and staying lit.

12-9 Charging complete verification

·When full charge is detected, the open collector NPN transistor inside the LEDR pin goes off after full charge delay time elapses, and the open collector NPNP transistor inside the LEDG pin goes on. Full charge can be verified by making pull-up connections between the LEDR pin and red LED and LEDG pin and green LED via resistors and checking that the red LED is off and the green LED is flashing,

12-10 Check charging prohibited state

·For the following charging prohibited states, the LED G pin and LED R pin open collector NPN transistors remain off. The LEDs do not light up.

1. Battery is not connected properly.
2. AC adapter is not connected properly.
3. Battery temperature is outside charging start temperature range.

12-11 Recovery after charging prohibited state

·The conditions are as follows for recovery after charging prohibited state:

1. Cut connection to charger and re-connect.
2. Cut battery connection and re-connect.

12-12 Quick charge and charging complete settings

1. Setting current value (Iqchg) for quick charge

Quick charge current value Icqchg depends on sensing resistor resistance value Rsense. Insert the desired quick charge value Iqchg into the following formula and set the sensing resistor value.

$$\text{Rsense } (\Omega) = \frac{\text{Charging current setting voltage 2}}{\text{Iqchg (mA)}} = \frac{256\text{mV}}{\text{Iqchg (mA)}}$$

Pre-charge current at this time becomes the following value.

$$\text{Pre-charge current (A)} = \frac{\text{charging current setting voltage 1}}{\text{Rsense } (\Omega)} = \frac{26\text{mV}}{\text{Rsense } (\Omega)}$$

2. Setting charging complete detection current value (Icomp)

Charging complete detection current value Icomp depends on sensing resistor resistance value Rsense and ADJ pin voltage Vadj. Insert the desired charging complete detection current value and the sensing resistor value set in 1. into the following formula to set ADJ pin voltage.

Vadj (V) =5 × Rsense (Ω) × Icomp (A) (Note) is IC internal fixed value

Note

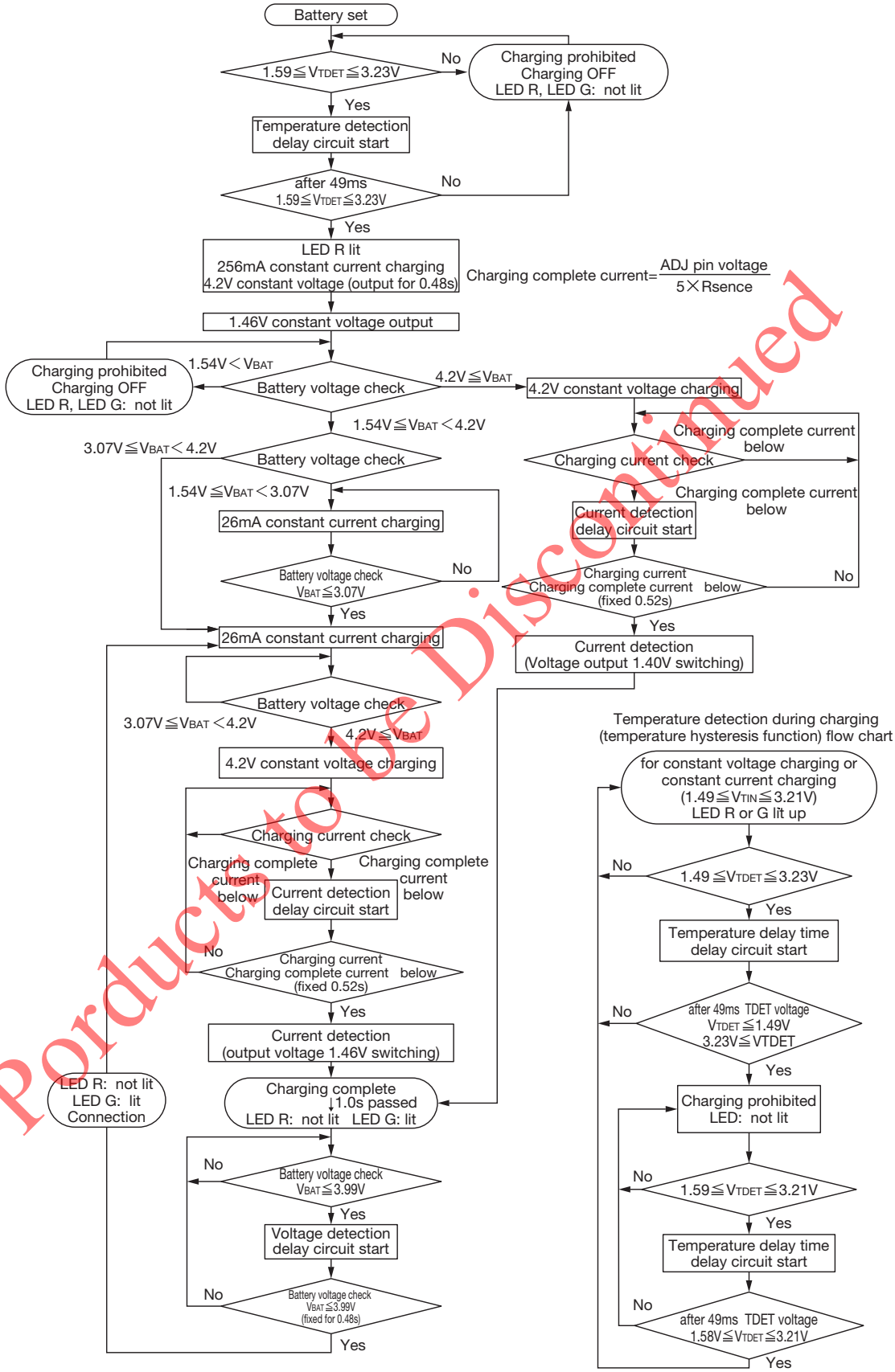
The graph below shows examples of ADJ pin voltage setting and the relationship between charging complete detection current (Icomp) and ADJ pin voltage (Vadj). Please use as reference for sensing resistor and ADJ pin voltage settings.

ADJ pin voltage setting examples

Quick charge	256mA	450mA		512mA		700mA	
Sensing resistor Rsense	1Ω	0.56Ω		0.50Ω		0.36Ω	
Charging complete current Icomo	26mA	100mA	130mA	100mA	130mA	100mA	130mA
ADJ pin voltage Vadj=5×Rs×Icomo	125mV	280mV	364mV	250mV	325mV	180mV	234mV

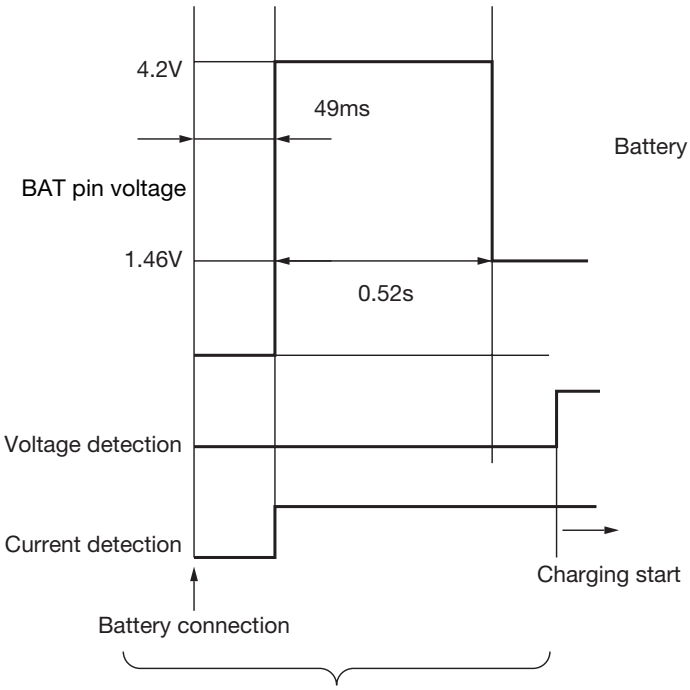
Use several 10kΩ for ADJ resistor (R, R2) total resistance value.

Flow Chart

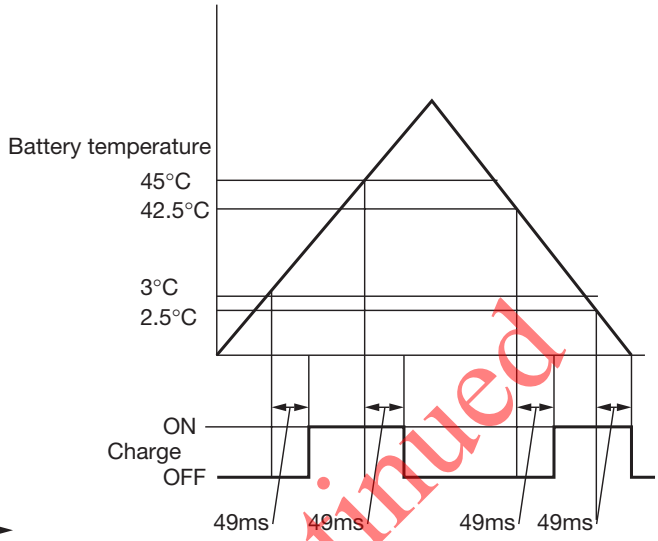


Timing Chart

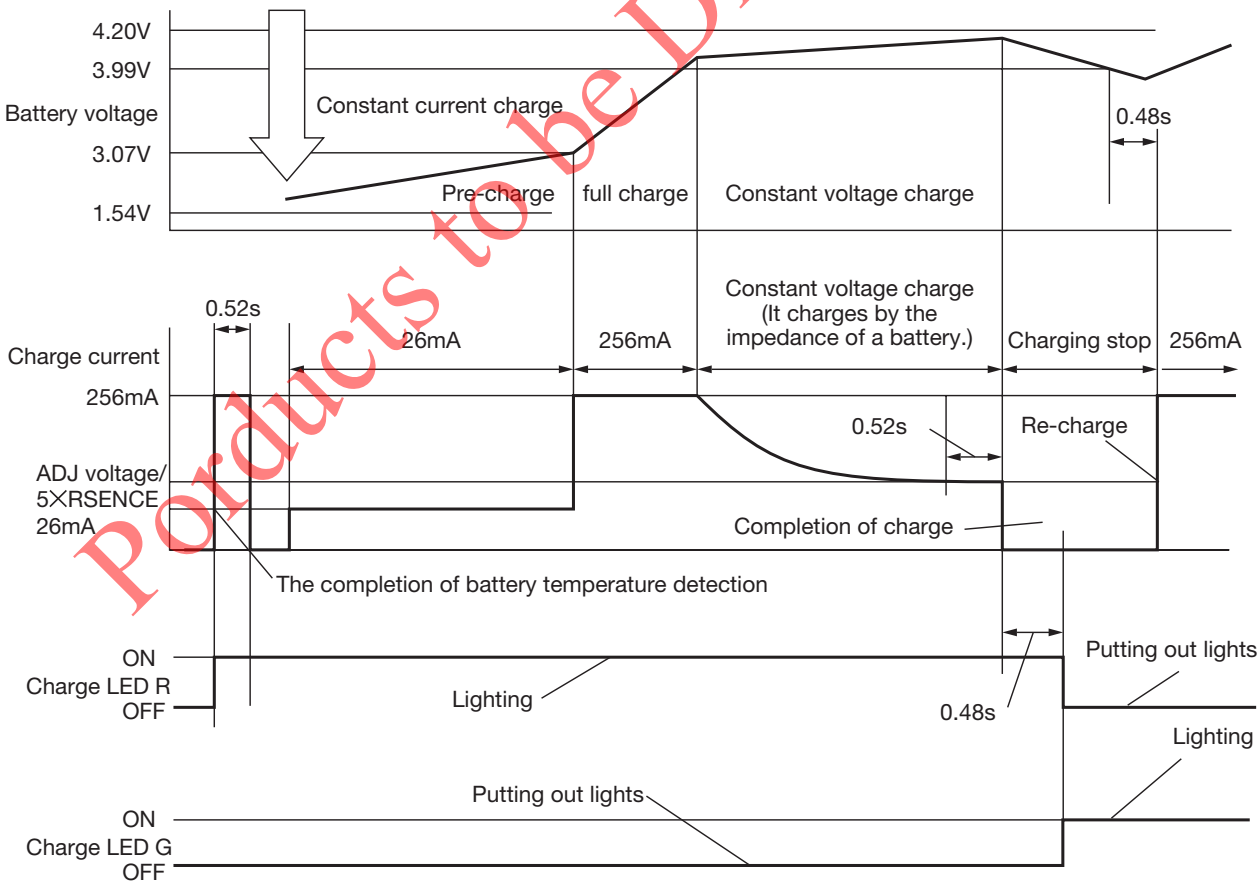
Timing at the time of battery connection



Temperature detection timing

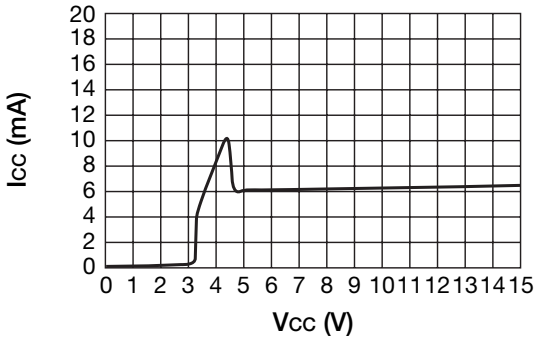


Timing at the time of charge

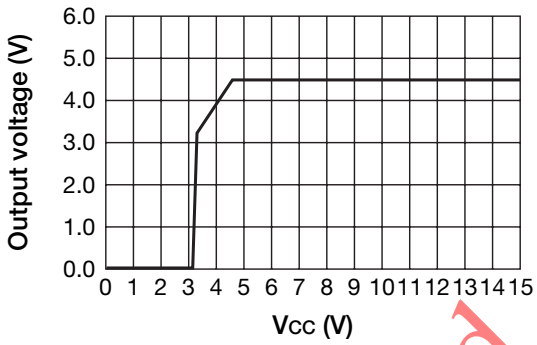


Characteristics (Except where noted otherwise, Ta=25°C, Vcc=12V, VSENSE=3.6V, C1=1.0µF, C2=1.0µF, C3=0.1µF)

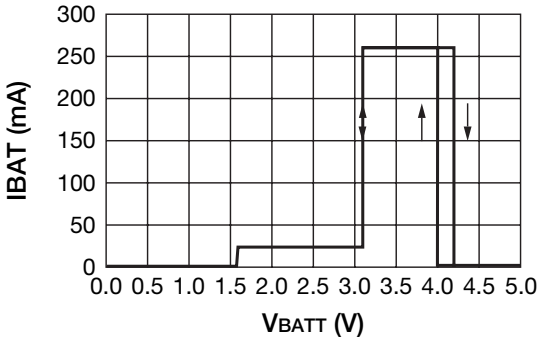
Consumption current characteristic



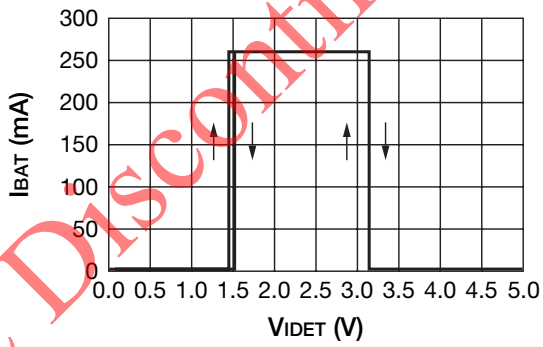
Standard voltage characteristic



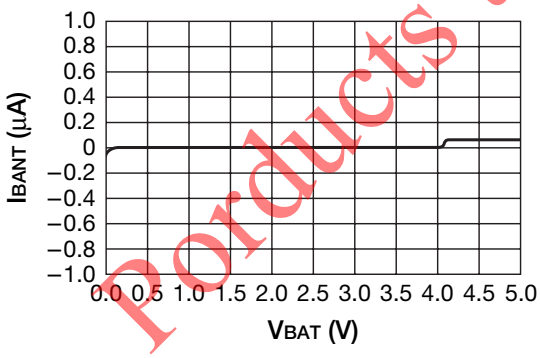
Charge current characteristic



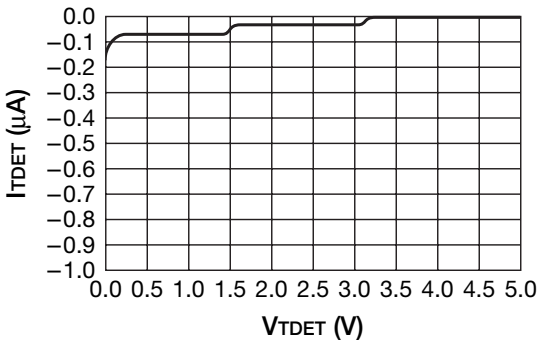
TDEF characteristic



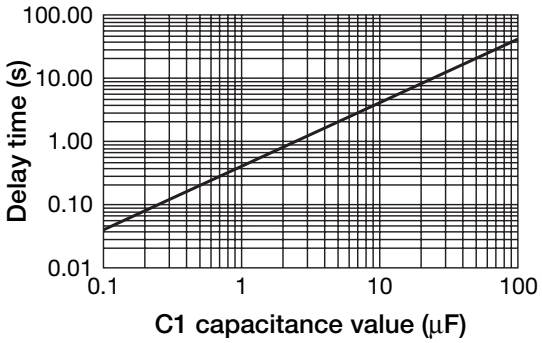
VBAT pin characteristic



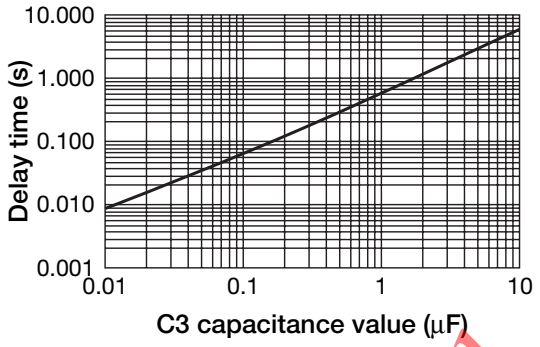
TDET pin current characteristic



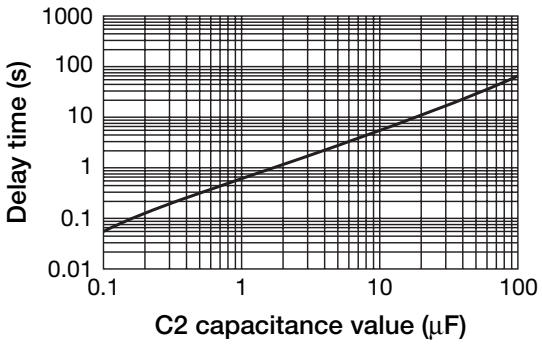
Re-charge delay time vs capacitance value



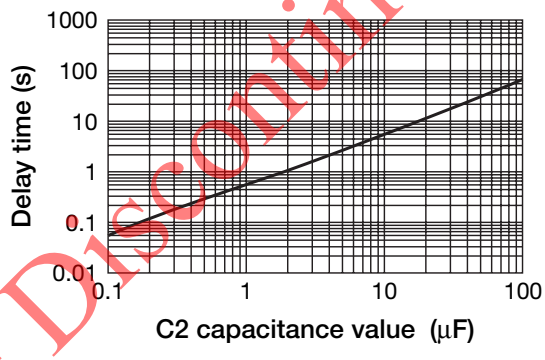
Temperature detection delay time vs capacitance value



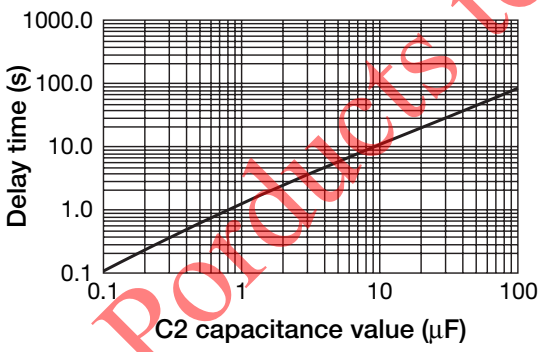
Connection detection delay time vs capacitance value



Full charge detection delay time vs capacitance value



LED switch delay time vs capacitance value



Discharge time vs capacitance value