Protection of Lithium-Ion Batteries

Monolithic IC MM1412

Outline

This IC protects lithium ion batteries in the event of overcharge, overdischarge and overcurrent. It has the following two functions: an overcurrent detection function that turns the external FET-SW off when a problem occurs during charging, etc. and excess voltage is impressed on each battery for longer than a certain time, and an overdischarge detection function that turns the external FET-SW off when battery voltage drops below a certain voltage during discharge, in order to prevent battery overdischarge. When these functions operate, the IC is put into low consumption current mode. It also has an overcurrent detection function that turns the FET-SW off when excess current flows due to a short or the like.

Series Table

Temperature conditions A: Ta= $-25 \sim 75^{\circ}$ C, B: Ta= $-20 \sim 70^{\circ}$ C, C: Ta= $0 \sim 50^{\circ}$ C, D: Ta= $0 \sim 40^{\circ}$ C, E: Ta= $-20 \sim 25^{\circ}$ C

Model	Package		Overcharge detection	Overcharge detection voltage	Overcharge detection	Overdischarge detection	Overdischarge reset	Overcurrent detection	
	SOP-8C, E	VSOP-8A		temperature conditions	hysteresis voltage (V)	voltage (V)	voltage (V)	voltage (mV)	
		AW	4.350 ± 0.025	C	220 ± 50	2.3±0.1	3.5±0.2	150±15	
		CW	4.295±0.025	С		2.3±0.1	3.5±0.2	150±15	
	EF	EW	4.250±0.025	С	300±50	2.3±0.1	3.5±0.2	150±15	
		FW	4.250±0.025	С	220±50	2.0±0.1	3.1±0.2	150±15	
		GW	4.300±0.025	С	220±50	2.0±0.1	3.1±0.2	140±15	
MM1412		HW	4.225±0.025	С		2.3±0.1	3.5±0.2	150±15	
WWW1412		JW	4.250±0.025	С	150±50	4.5±0.2		150±15	
		KW	4.350±0.025	С	220±50	2.3±0.1	3.5±0.2	100±15	
		LW	4.125±0.025	С		2.3±0.1	3.5±0.2	150±15	
		MW	4.125±0.025	С		2.0±0.1	3.1±0.2	100±15	
		NW	4.190±0.025	С		2.0±0.1	3.1±0.2	100±15	
		PW	4.300±0.025	С	220±50	2.0±0.1	3.1±0.2	75±15	

Features

1. Consumption current (during overcharge) VCELL = $4.5 \, \text{Roc} = 270 \, \text{k}\Omega$ 150µA typ.

2. Consumption current (normal) $V_{CELL} = 3.5V$ 15 μ A typ. 3. Consumption current (during overdischarge) $V_{CELL} = 1.9V$ 0.5 μ A typ.

4. Consumption current (during overdischarge) VCELL = 1.0V 0.1μA max.

5. Overcharge detection voltage ($Ta = 0^{\circ}C \sim 50^{\circ}C$) 435 ± 25mV (detected for each cell)

of evoluting detection voltage (14 = 0 0 0)

6. Hysteresis voltage 220mV \pm 50mV (detected for each cell) 7. Overdischarge detection voltage 2.30 \pm 0.1V (detected for each cell)

8. Overdischarge release voltage $3.50V \pm 0.2V$ (detected for each cell)

0.9V max.

9. Overcurrent detection threshold $150 \text{mV} \pm 15 \text{mV}$ 10. Reset after overcurrent detection Load open

11. Operating limit voltage

Package

VSOP-8A

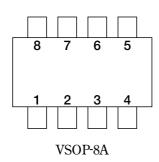
SOP-8C

SOP-8E

Applications

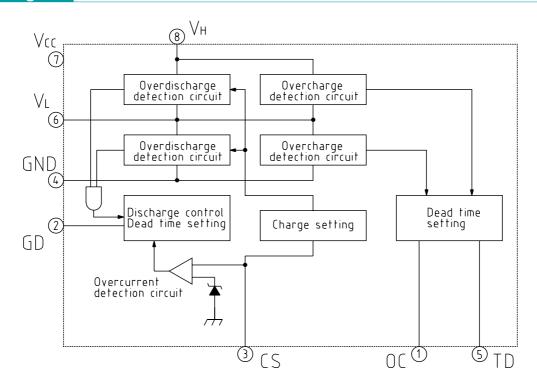
- 1. Cell phone
- 2. Movie

Pin Assignment



OC		
GD		
CS		
GND		
TD		
VL		
Vcc		
VH		

Block Diagram



Pin Description

Pin No.	Pin name	Functions
		Overcharge detection output pin
1	oc	PNPTR open collector output
•		Overcharge mode: ON
		Normal mode, overdischarge mode, overcurrent mode: OFF
		Discharge control FET (N-ch) control output pin
2	GD	Normal mod, overcharge mode: H
		Overdischarge mode, overcurrent mode: L
	CS	Overcurrent detection input pin
3		Monitors discharge current equivalently by the voltage drop between discharge control FET source
3		and drain. Stops discharge when voltage between CS pin and GND pin goes above overcurrent
		detection threshold value, and holds until load is released.
4	GND	Ground pin, or lower cell load negative pole input pin.
5	TD	Overcharge detection dead time setting pin
3	וש	Dead time can be set by adding a capacitor between TD and GND pins.
6	VL	Battery intermediate potential input pin
U		Connection pin for lower cell positive electrode side and upper cell negative electrode side.
7	Vcc	Power supply input pin
8	VH	Upper cell positive electrode input pin

Note: Mode Descriptions

(1) Overcharge mode

Either H cell or L cell battery voltage exceeds overcharge detection voltage. Overcharge detection operation delay can be set by the dead time setting pin.

(2) Normal mode

Both H and L cell battery voltages exceed overdischarge detection voltage and are less than overcharge detection voltage.

(3) Overdischarge mode

Either H or L cell battery voltage is less than overdischarge detection voltage.

Overdischarge detection dead time is set internally. Overdischarge mode is released when charging causes voltage to rise above overdischarge detection voltage. Also, when battery voltage goes above overdischarge release voltage, it resets without charging, but the value is set high. (This function is included in case charging can not be detected. Also, this release voltage has a temperature coefficient of $-6mV/^{\circ}C$.)

(4) Overcurrent mode

Voltage between CS and GND exceeds overcurrent detection voltage during discharge.

Pin Description

Pin No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram
1	OC	Overcharge no-response OC	5	TD	Overcharge defection S Overcharge defection
2	GD	Overdischarge Overcurrent delay time set up	6	VL	Overdischarge comparator Overdischarge no-response
3	CS	8 VH 300k 2k 50k Load release	8	VH	Overdischarge comparator Overdischarge no-response

Absolute Maximum Ratings

Item	Symbol	Ratings	Unit	
Storage temperature	Tstg	-40~+125	°C	
Operating temperature	Topr	-20~+70	°C	
Power supply voltage	Vcc max.	-0.3~+18	V	
OC pin impressed voltage	Voc max.	-0.6~Vcc	V	
CS pin impressed voltage	Vcs max.	-0.6~Vcc	V	
Allowable loss	Pd	300	mW	

Recommended Operating Conditions

Item	Symbol	Ratings	Unit	
Operating temperature	Topr	-20~+70	°C	
Operating power supply voltage	Vop	+0.9~+18	V	

Electrical Characteristics (Except where noted otherwise, Ta=25°C) Models listed MM1412A

Item	Symbol	Measurement conditions	Min.	Тур.	Max.	Unit
Overcharge detection voltage	Voc	Ta=0°C~50°C	4.325	4.350	4.375	V
Overcharge detection hysteresis voltage	∠Voc		170	220	270	mV
Overdischarge detection voltage	Vod		2.20	2.30	2.40	V
Consumption current 1	Ivh1	V _H =V _L =1.0V V _C S=1.4V			0.1	μA
Consumption current 2	Ivh2	V _H =V _L =1.9V V _C S=3.2V		0.5	0.8	μA
Consumption current 3	Ivнз	V _H =V _L =3.5V		15.0	20.0	μA
Consumption current 4	Ivh4	$V_H=V_L=4.5V$, Roc=270 $k\Omega$		150		μA
VL pin input current	Ivl	V _H =V _L =3.5V	-0.3	0	0.3	μA
Overdischarge release voltage	V_{DF}	Discharge resume by voltage rise	3.30	3.50	3.70	V
GD pin H output voltage	V_{GDH}	V _H =V _L =3.5V, IL=-10μA	V _H -0.3	VH-0.2		V
GD pin L output voltage	V_{GDL}	V _H =V _L =3.5V, IL=10μA		0.2	0.3	V
OC pin output current	Іосн	V _H =V _L =4.5V	30	150		μA
Overcurrent detection threshold value	Vcs1		135	150	165	mV
Overcurrent short threshold value	Vcs2	When both battery pack pins are shorted	0.35	0.45	0.55	V
Overcurrent release		Load release: Load of 5MEGΩ or more between both battery pack pins				
Overcurrent detection delay time 1	toc1		7	12	18	ms
Overcurrent detection delay time 2	toc2	*1		30	100	μs
Overdischarge detection delay time	tod		8	13	20	ms
Overcharge detection dead time	tосн	Cτc=0.18μF	0.5	1.0	1.5	s
Start-up voltage	Vst	V _H =V _L =2.5V	-0.24	-0.12	-0.04	V

Note 1: Overcurrent short mode delay time (overcurrent delay time 2) is IC response speed.

In actual use, the time for discharging the discharge control FET gate capacity is added.

Also, when voltage change is large due to excess current, the IC internal bias current may turn off temporarily, causing response time to lengthen. Select the time constant for the capacitor connected to the power supply pin so that power supply fluctuation is more than 100µs/1V.

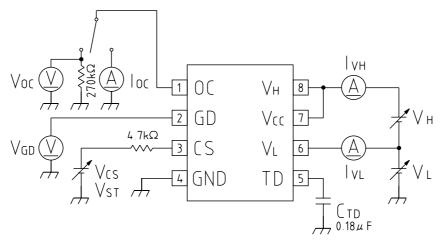
Note 2: Calculate overcharge dead time according to the following formula:

Overcharge detection dead time: talm - 5.55 × CTD[s]

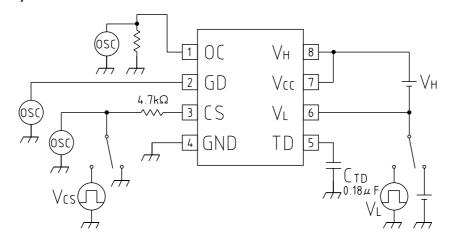
[CTD: external capacitor, Unit:µF]

Measuring Circuit

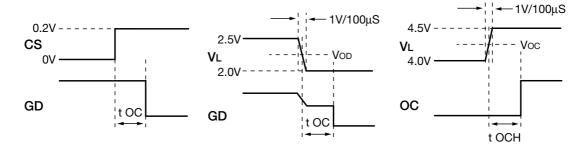
Measuring Circuit 1 (Voc, ∠Voc, Vob, Vbf, Vst, Vcs, Ibch, Vgbh, Vgbl)



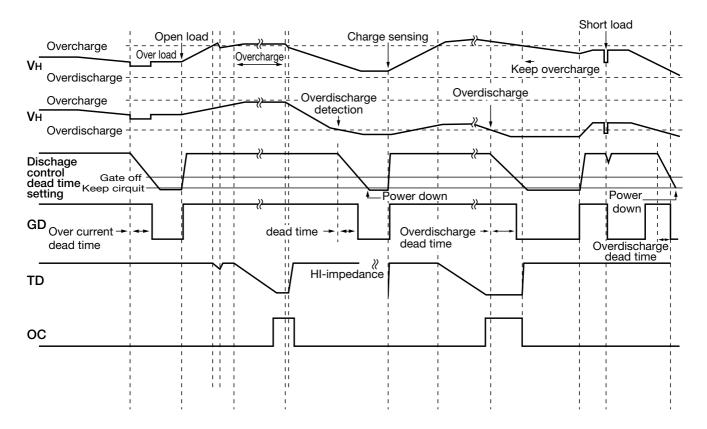
■ Measuring Circuit 2 (toc, tob, toch)



Note:



Timing Chart



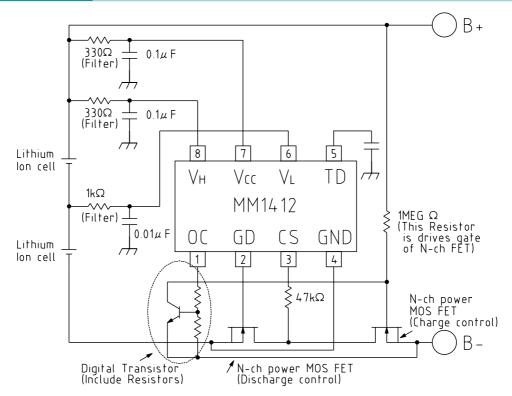
Description

This IC is a lithium ion battery (2-cell in-series type) protection IC. It has built-in overcharge detection, overdischarge detection and overcurrent detection circuits, and controls the FET (external N-MOS FET) that controls charge and discharge.

The operation modes can be divided broadly into four, as follows.

- 1) Overcharge mode
 - The battery voltage of either the H or L cell goes above overcharge detection voltage. Detection operation delay for overcharge detection can be set with the dead time setting pin.
- 2) Normal mode
 - The battery voltage of both H and L cells is above overdischarge detection voltage and below overcharge detection voltage.
- 3) Overdischarge mode
 - The battery voltage of either the H or L cell drops below overdischarge detection voltage. Dead time for overdischarge detection is set internally. Overdischarge mode is released when charging takes place and the voltage goes above overdischarge detection voltage. Also, reset will occur even without charging if battery voltage goes above overdischarge release voltage, but the set value is high. (This function is provided as a measure for cases when charging can not be detected. Further, this release voltage has a temperature coefficient of -6mV/°C.)
- 4) Overcurrent mode
 - The voltage between CS-GND goes above overcurrent detection voltage during discharge.

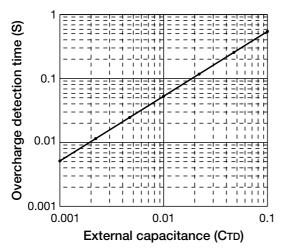
Application Circuit



Note: Applicable circuits shown are typical examples provided for reference purposes. Mitsumi cannot assume responsibility for any problems arising out of the use of these circuits or for any infringement of third party patent and other right due to same.

Characteristics

Overcharge Detection Time (Dead Time)



Note: Dead time can be calculated according to the following formula:

 $toc=5.55\times C_{TD}$ [S]

toc=Overcharge Detection Time CTD=External Capacitor···Unit: µF

The above specifications are representative, and are not guaranteed values.