Protection for Lithium-Ion Batteries (2-serial cells) Monolithic IC MM1412 October 22, 1998

Outline

Series Table

This IC protects lithium-ion batteries in the event of overcharge, overdischarge and overcurrent. It has the following two functions: an overcharge 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 enters low current consumption 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. Since the functions above are provided, the protection circuitry for lithium-ion batteries can be comprised with fever external components.

Temperature conditions A: Ta=-25 ~ 75°C, B: Ta=-20 ~ 70°C, C: Ta=0 ~ 50°C,

D: Ta=0 ~ 40°C, E: Ta=-20 ~ 25°C

Model	Package		Overcharge	Overcharge detection voltage	Overcharge detection	Overdischarge	Overdischarge	Overcurrent
	SOP-8C, E	VSOP-8A	voltage (V)	temperature conditions	hysteresis voltage (V)	voltage (V)	voltage (V)	voltage (mV)
		AW	4.350 ± 0.025	С	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
NAN41410		HW	4.225±0.025	С		2.3±0.1	3.5±0.2	150±15
111111412		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

 $V_{CELL} = 3.5V$

Features

- 1. Consumption current (during overcharge)
- 2. Consumption current (normal)
- 3. Consumption current (during overdischarge) $V_{CELL} = 1.9V$
- 4. Consumption current (during overdischarge) $V_{CELL} = 1.0V$
- 5. Overcharge detection voltage (Ta = $0^{\circ}C \sim 50^{\circ}C$)
- 6. Hysteresis voltage
- 7. Overdischarge detection voltage
- 8. Overdischarge release voltage
- 9. Overcurrent detection threshold
- 10. Reset after overcurrent detection
- 11. Operating limit voltage

Package

VSOP-8A

 $V_{CELL} = 4.5 \text{ Roc} = 270 \text{ k}\Omega$ 150µA typ. 15µA typ. 0.5µA typ. 0.1µA max. $4.35 \pm 0.025V$ (detected for each cell) 220mV ± 50mV (detected for each cell) $2.30 \pm 0.1V$ (detected for each cell) 3.50V ± 0.2V (detected for each cell) 150mV ± 15mV Load open (5MEG Ω or higher) 0.9V max.

Applications

- 1. Cell phone
- 2. Movie

Pin Assignment



2 GD 3 CS 4 GND 5 TD 6 VL 7 Vcc 8 VH	1	OC
3 CS 4 GND 5 TD 6 VL 7 Vcc 8 VH	2	GD
4 GND 5 TD 6 VL 7 Vcc 8 VH	3	CS
5 TD 6 VL 7 Vcc 8 VH	4	GND
6 VL 7 Vcc 8 VH	5	TD
7 Vcc	6	VL
8 VH	7	Vcc
0 11	8	VH

Block Diagram



Pin Description

Pin No.	Pin name	Functions
		Overcharge detection output pin
1	00	PNPT _R 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
2		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
5		Dead time can be set by adding a capacitor between TD and GND pins.
6	VL	Battery intermediate potential input pin
0		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 upper cell or lower cell battery voltage exceeds overcharge detection voltage. Overcharge detection operation delay can be set by the dead time setting pin.

(2) Normal mode

Both upper cell and lower cell battery voltages exceed overdischarge detection voltage and are less than overcharge detection voltage.

(3) Overdischarge mode

Either upper cell or lower 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 No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram
1	OC	Vcc T Overcharge no-response OC	5	TD	Vcc TD TD TD TD TD TD TD TD TD TD
2	GD	Overdischarge Overdischarge Overcurrent delay time set up GND	6	VL	Overdischarge comparator Overdischarge no-response 4 GND
3	CS	®VH 300k 2k 2k 50k CS	8	VH	Overdischarge comparator Overdischarge no-response 6

Pin Description

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 _{CS} =1.4V			0.1	μA
Consumption current 2	Ivh2	VH=VL=1.9V VCS=3.2V		0.5	0.8	μA
Consumption current 3	Ivh3	$V_{H}=V_{L}=3.5V$		15.0	20.0	μA
Consumption current 4	Ivh4	$V_{H}=V_{L}=4.5V$, $Roc=270k\Omega$		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	Vgdh	$V_{H}=V_{L}=3.5V, IL=-10\mu A$	VH-0.3	VH-0.2		V
GD pin L output voltage	Vgdl	Vh=Vl=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 $5MEG\Omega$ 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	toch	$C_{TD}=0.18\mu F$	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: $t_{ALM} - 5.55 \times C_{TD}[s]$ [CTD: external capacitor, Unit:µF]

Measuring Circuit

Measuring Circuit 1

(VOC, *A*VOC, VOD, VDF, VST, VCS, IDCH, VGDH, VGDL)



Measuring Circuit 2

(toc, tod, 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 upper cell or lower 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 upper cells and lower cells is above overdischarge detection voltage and below overcharge detection voltage.

3) Overdischarge mode

The battery voltage of either the upper cell or lower 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



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

toc=5.55×Стр [s]

toc=Overcharge sensing dead time

CTD=External Capacitor…Unit : µF

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