

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

## Features

- |   |                                    |                                       |
|---|------------------------------------|---------------------------------------|
| 1. Consumption current (during overcharge)        | $V_{CELL} = 4.5$ $R_{OC} = 270$ kΩ | 150µA typ.                            |
| 2. Consumption current (normal)                   | $V_{CELL} = 3.5$ V                 | 15µA typ.                             |
| 3. Consumption current (during overdischarge)     | $V_{CELL} = 1.9$ V                 | 0.5µA typ.                            |
| 4. Consumption current (during overdischarge)     | $V_{CELL} = 1.0$ V                 | 0.1µA max.                            |
| 5. Overcharge detection voltage (Ta = 0°C ~ 50°C) |                                    | 435 ± 25mV (detected for each cell)   |
| 6. Hysteresis voltage                             |                                    | 220mV ± 50mV (detected for each cell) |
| 7. Overdischarge detection voltage                |                                    | 2.30 ± 0.1V (detected for each cell)  |
| 8. Overdischarge release voltage                  |                                    | 3.50V ± 0.2V (detected for each cell) |
| 9. Overcurrent detection threshold                |                                    | 150mV ± 15mV                          |
| 10. Reset after overcurrent detection             |                                    | Load open                             |
| 11. Operating limit voltage                       |                                    | 0.9V max.                             |

## Package

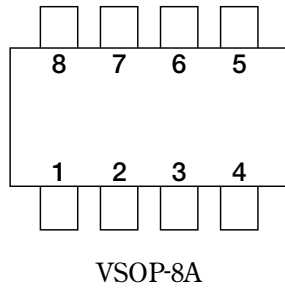
VSOP-8A  
SOP-8C  
SOP-8E



### Applications

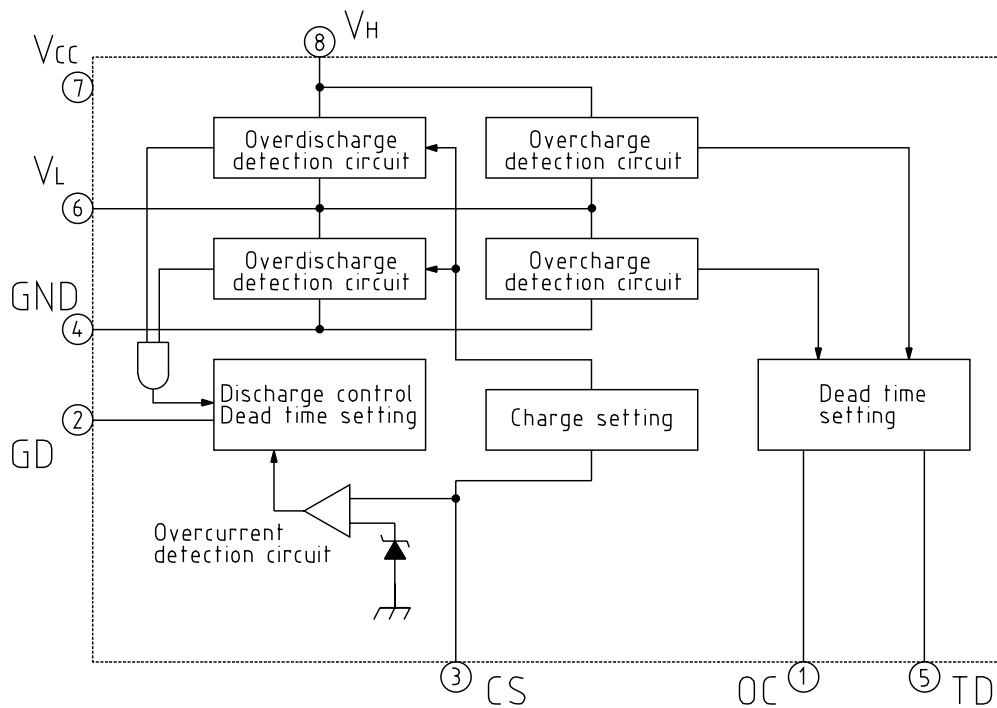
1. Cell phone
2. Movie

### Pin Assignment



1	OC
2	GD
3	CS
4	GND
5	TD
6	VL
7	V <sub>CC</sub>
8	V <sub>H</sub>

### Block Diagram



**Pin Description**

Pin No.	Pin name	Functions
1	OC	Overcharge detection output pin PNP <sub>TR</sub> open collector output Overcharge mode: ON Normal mode, overdischarge mode, overcurrent mode: OFF
2	GD	Discharge control FET (N-ch) control output pin Normal mod, overcharge mode: H Overdischarge mode, overcurrent mode: L
3	CS	Overcurrent detection input pin Monitors discharge current equivalently by the voltage drop between discharge control FET source 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 Dead time can be set by adding a capacitor between TD and GND pins.
6	VL	Battery intermediate potential input pin Connection pin for lower cell positive electrode side and upper cell negative electrode side.
7	V <sub>CC</sub>	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  $-6\text{mV}/^\circ\text{C}$ .)

(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		5	TD	
2	GD		6	VL	
3	CS		8	VH	

## Absolute Maximum Ratings

Item	Symbol	Ratings	Unit
Storage temperature	T <sub>STG</sub>	-40~+125	°C
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Power supply voltage	V <sub>CC</sub> max.	-0.3~+18	V
OC pin impressed voltage	V <sub>OC</sub> max.	-0.6~V <sub>CC</sub>	V
CS pin impressed voltage	V <sub>CS</sub> max.	-0.6~V <sub>CC</sub>	V
Allowable loss	P <sub>d</sub>	300	mW

## Recommended Operating Conditions

Item	Symbol	Ratings	Unit
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Operating power supply voltage	V <sub>OP</sub>	+0.9~+18	V

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

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Unit
Overcharge detection voltage	V <sub>OC</sub>	Ta=0°C~50°C	4.325	4.350	4.375	V
Overcharge detection hysteresis voltage	ΔV <sub>OC</sub>		170	220	270	mV
Overdischarge detection voltage	V <sub>OD</sub>		2.20	2.30	2.40	V
Consumption current 1	I <sub>VH1</sub>	V <sub>H</sub> =V <sub>L</sub> =1.0V V <sub>CS</sub> =1.4V			0.1	μA
Consumption current 2	I <sub>VH2</sub>	V <sub>H</sub> =V <sub>L</sub> =1.9V V <sub>CS</sub> =3.2V		0.5	0.8	μA
Consumption current 3	I <sub>VH3</sub>	V <sub>H</sub> =V <sub>L</sub> =3.5V		15.0	20.0	μA
Consumption current 4	I <sub>VH4</sub>	V <sub>H</sub> =V <sub>L</sub> =4.5V, R <sub>OC</sub> =270kΩ		150		μA
VL pin input current	I <sub>VL</sub>	V <sub>H</sub> =V <sub>L</sub> =3.5V	-0.3	0	0.3	μA
Overdischarge release voltage	V <sub>DF</sub>	Discharge resume by voltage rise	3.30	3.50	3.70	V
GD pin H output voltage	V <sub>GDH</sub>	V <sub>H</sub> =V <sub>L</sub> =3.5V, I <sub>L</sub> =-10μA	V <sub>H</sub> -0.3	V <sub>H</sub> -0.2		V
GD pin L output voltage	V <sub>GDL</sub>	V <sub>H</sub> =V <sub>L</sub> =3.5V, I <sub>L</sub> =10μA		0.2	0.3	V
OC pin output current	I <sub>OCH</sub>	V <sub>H</sub> =V <sub>L</sub> =4.5V	30	150		μA
Overcurrent detection threshold value	V <sub>CS1</sub>		135	150	165	mV
Overcurrent short threshold value	V <sub>CS2</sub>	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	t <sub>OC1</sub>		7	12	18	ms
Overcurrent detection delay time 2	t <sub>OC2</sub>	*1		30	100	μs
Overdischarge detection delay time	t <sub>OD</sub>		8	13	20	ms
Overcharge detection dead time	t <sub>OCH</sub>	C <sub>TC</sub> =0.18μF	0.5	1.0	1.5	s
Start-up voltage	V <sub>ST</sub>	V <sub>H</sub> =V <sub>L</sub> =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:

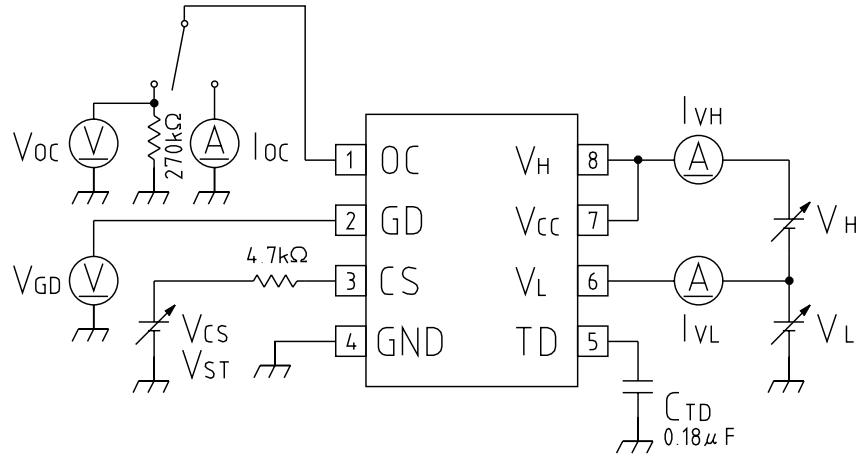
Overcharge detection dead time:  $t_{ALM} = 5.55 \times C_{TD}[s]$

[C<sub>TD</sub>: external capacitor, Unit:μF]

## Measuring Circuit

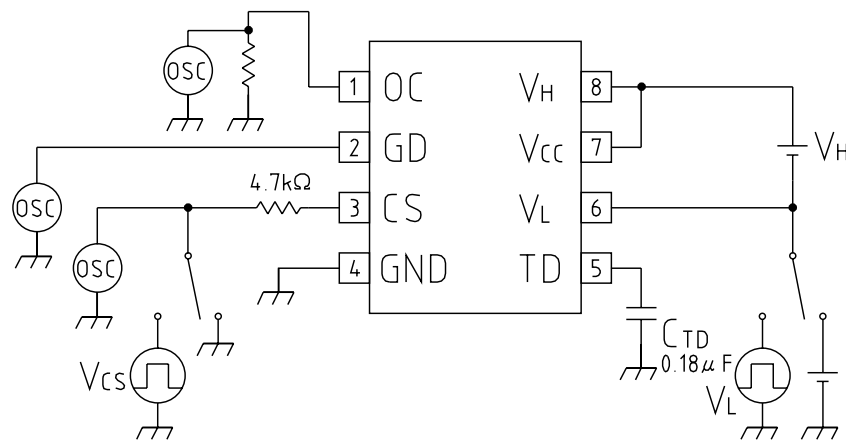
### Measuring Circuit 1

( $V_{OC}$ ,  $\Delta V_{OC}$ ,  $V_{OD}$ ,  $V_{DF}$ ,  $V_{ST}$ ,  $V_{CS}$ ,  $I_{DCH}$ ,  $V_{GDH}$ ,  $V_{GDL}$ )

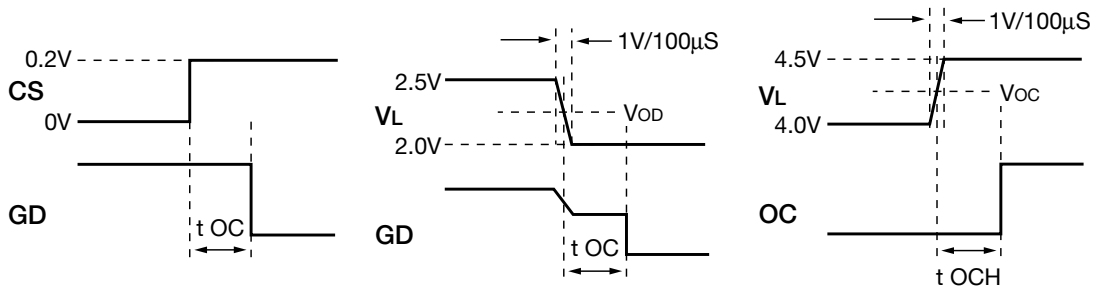


### Measuring Circuit 2

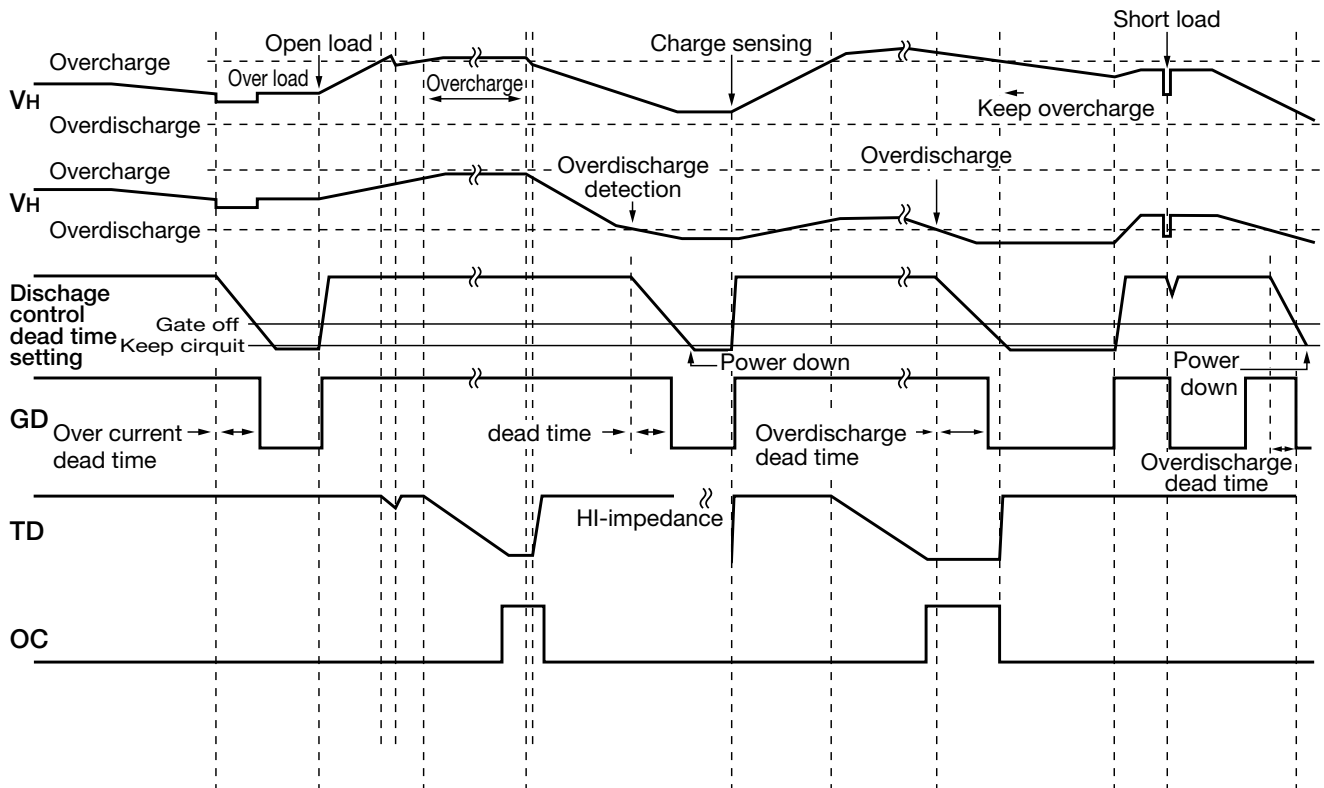
( $t_{OC}$ ,  $t_{OD}$ ,  $t_{OCH}$ )



Note :



Timing Chart



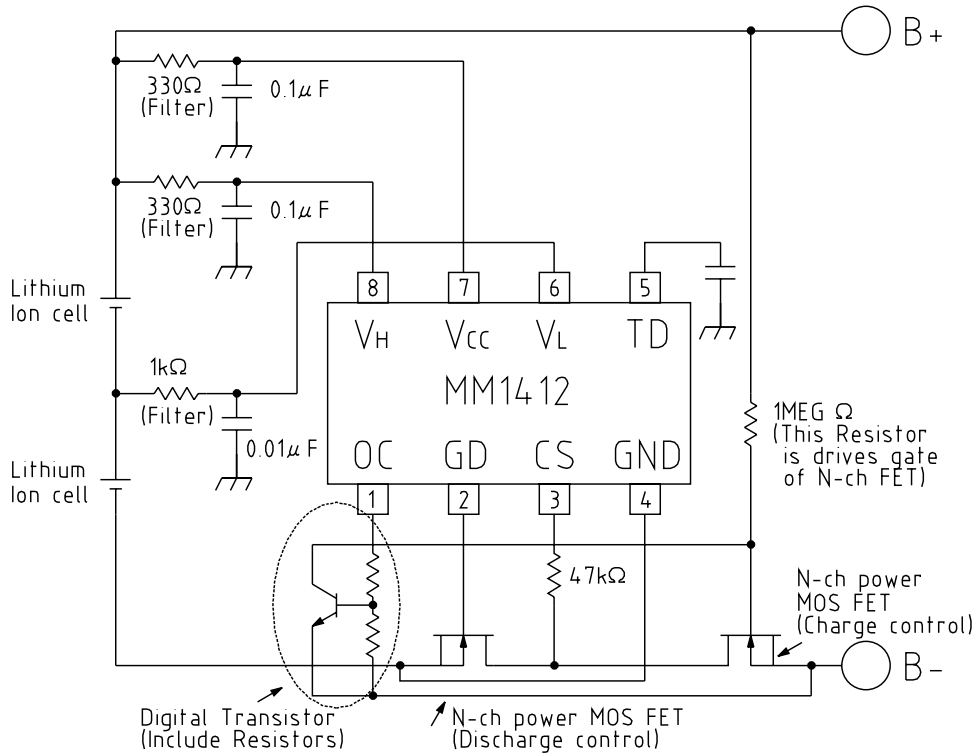
Description

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  $-6\text{mV}/^\circ\text{C}$ .)
- 4) Overcurrent mode  
 The voltage between CS-GND goes above overcurrent detection voltage during discharge.

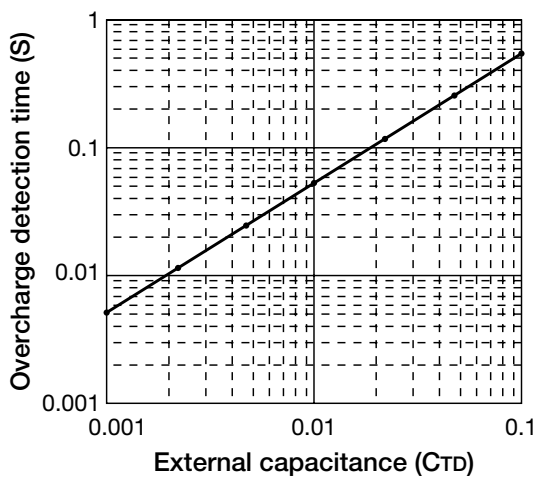
Application Circuit



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:

$$t_{OC} = 5.55 \times C_{TD} \text{ [S]}$$

$t_{OC}$  = Overcharge Detection Time

$C_{TD}$  = External Capacitor...Unit :  $\mu\text{F}$

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