

Protection of Lithium-Ion Batteries

Monolithic IC MM1412

Outline

This IC is used to protect lithium-ion batteries consisting of two cells. It adopts a compact package and has the functions of previous models, with functions for overcharge detection, overdischarge detection and overcurrent detection. A dead time can be set externally.

Features

1. Overcharge detection voltage accuracy (0°C to 50°C) $\pm 25\text{mV/cell}$
2. Consumption current ($V_{\text{cell}}=4.5\text{V}$) $150\mu\text{A typ.}$
3. Consumption current ($V_{\text{cell}}=3.5\text{V}$) $15.0\mu\text{A typ.}$
4. Consumption current ($V_{\text{cell}}=1.9\text{V}$) $0.5\mu\text{A typ.}$
5. Overcharge sensing dead time can be set externally.

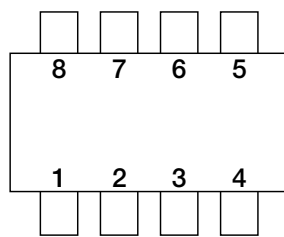
Package

VSOP-8A

Applications

IC for protection of lithium-ion batteries consisting of two cells.

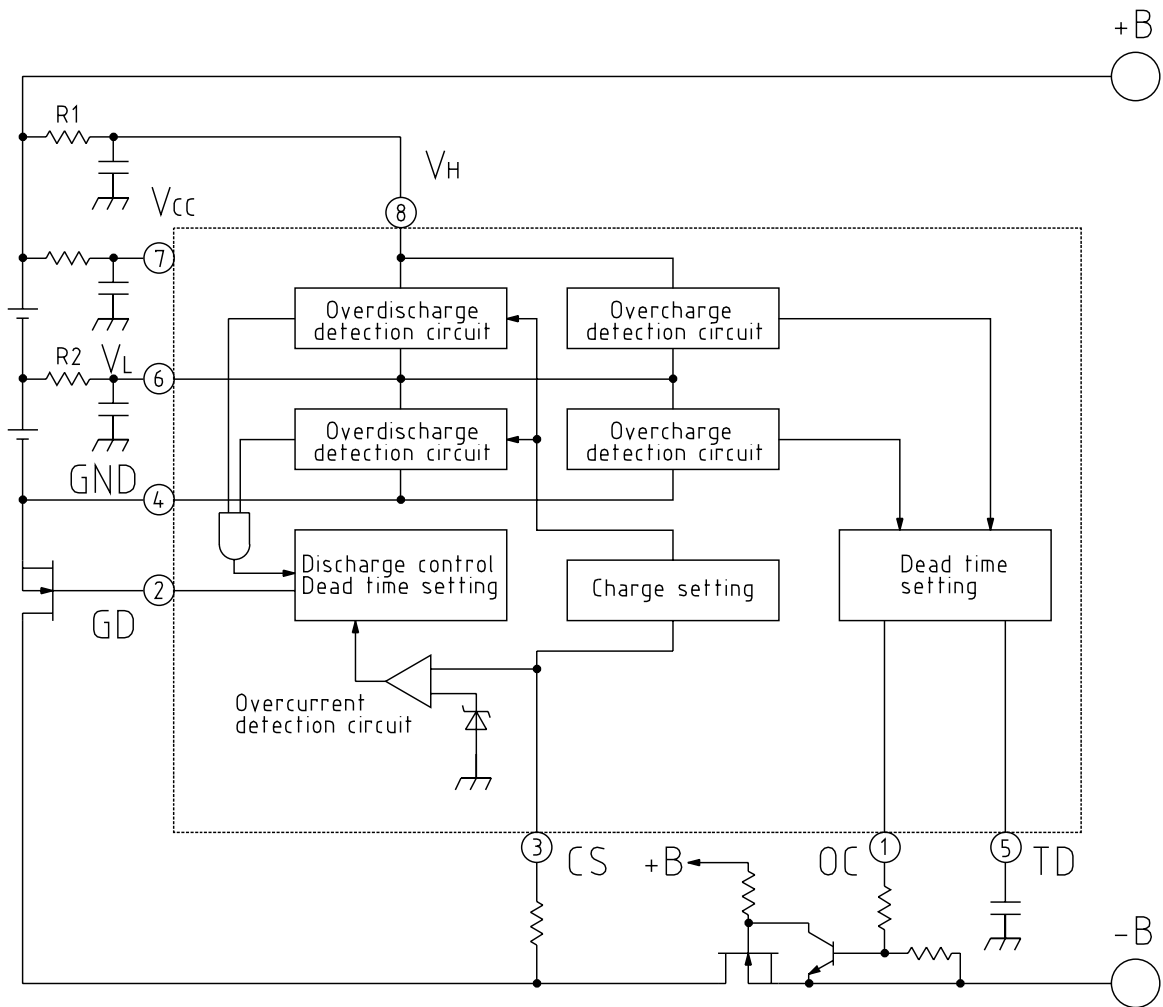
Pin Assignment



VSOP-8A

| | |
|---|-----------------|
| 1 | OC |
| 2 | GD |
| 3 | CS |
| 4 | GND |
| 5 | TD |
| 6 | VL |
| 7 | V _{CC} |
| 8 | VH |

Block Diagram



Pin Description

| Pin No. | Pin name | Functions |
|---------|----------|--|
| 1 | OC | Overcharge detection output pin PNP _{TR} 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 | 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 $-6\text{mV}/^\circ\text{C}$.)

(4) Overcurrent mode

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

Absolute Maximum Ratings (Ta=25°C)

| Item | Symbol | Ratings | Unit |
|--------------------------|----------------------|----------------------|------|
| Storage temperature | T _{STG} | -40~+125 | °C |
| Operating temperature | T _{OPR} | -20~+70 | °C |
| Power supply voltage | V _{CC} max. | -0.3~+18 | V |
| OC pin impressed voltage | V _{OC} max. | -0.6~V _{CC} | V |
| CS pin impressed voltage | V _{CS} max. | -0.6~V _{CC} | V |
| Allowable loss | P _d | 300 | mW |

Recommended Operating Conditions

| Item | Symbol | Ratings | Unit |
|--------------------------------|------------------|----------|------|
| Operating temperature | T _{OPR} | -20~+70 | °C |
| Operating power supply voltage | V _{OP} | +0.9~+18 | V |

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

| Item | Symbol | Measurement conditions | Min. | Typ. | Max. | Unit |
|---|------------------|--|---------------------|---------------------|-------|------|
| Overcharge detection voltage | V _{OC} | Ta=0°C~50°C | 4.325 | 4.350 | 4.375 | V |
| Overcharge detection hysteresis voltage | ΔV _{OC} | | 170 | 220 | 270 | mV |
| Overdischarge detection voltage | V _{OD} | | 2.20 | 2.30 | 2.40 | V |
| Consumption current 1 | I _{VH1} | V _H =V _L =1.0V V _{CS} =1.4V | | | 0.1 | μA |
| Consumption current 2 | I _{VH2} | V _H =V _L =1.9V V _{CS} =3.2V | | 0.5 | 0.8 | μA |
| Consumption current 3 | I _{VH3} | V _H =V _L =3.5V | | 15.0 | 20.0 | μA |
| Consumption current 4 | I _{VH4} | V _H =V _L =4.5V, R _{OC} =270kΩ | | 150 | | μA |
| VL pin input current | I _{VL} | 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, I _L =-10μA | V _H -0.3 | V _H -0.2 | | V |
| GD pin L output voltage | V _{GDL} | V _H =V _L =3.5V, I _L =10μA | | 0.2 | 0.3 | V |
| OC pin output current | I _{OCH} | V _H =V _L =4.5V | 30 | 150 | | μA |
| Overcurrent detection threshold value | V _{CS1} | | 135 | 150 | 165 | mV |
| Overcurrent short threshold value | V _{CS2} | 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 _{OC1} | | 7 | 12 | 18 | mS |
| Overcurrent detection delay time 2 | t _{OC2} | *1 | | 30 | 100 | μS |
| Overdischarge detection delay time | t _{OD} | | 8 | 13 | 20 | mS |
| Overcharge detection dead time | t _{OCH} | C _{TC} =0.18μF | 0.5 | 1.0 | 1.5 | S |
| Start-up voltage | V _{ST} | 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:

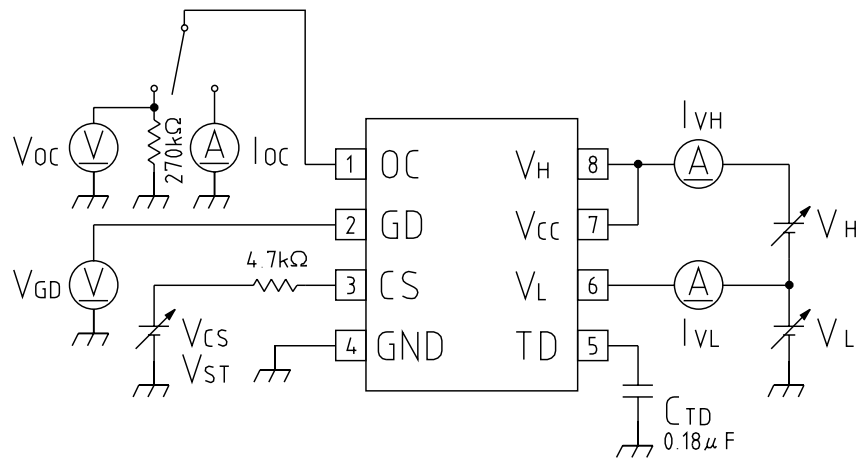
Overcharge detection dead time: $t_{ALM} = 5.55 \times C_{TD}[S]$

[C_{TD}: external capacitor, Unit:μF]

Measuring Circuit

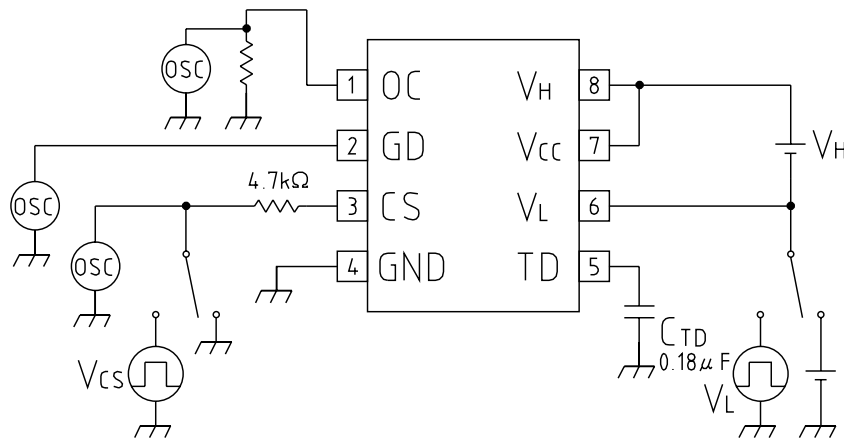
Measuring Circuit 1

(V_{oc} , ΔV_{oc} , V_{OD} , V_{DF} , V_{ST} , V_{CS} , I_{DCH} , V_{GDH} , V_{GDL})

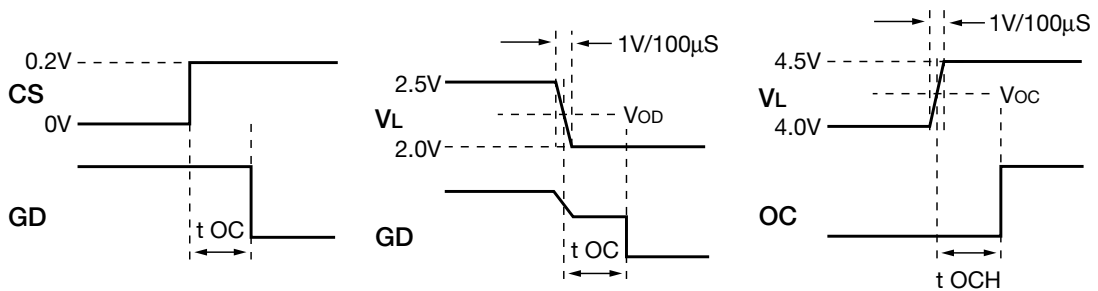


Measuring Circuit 2

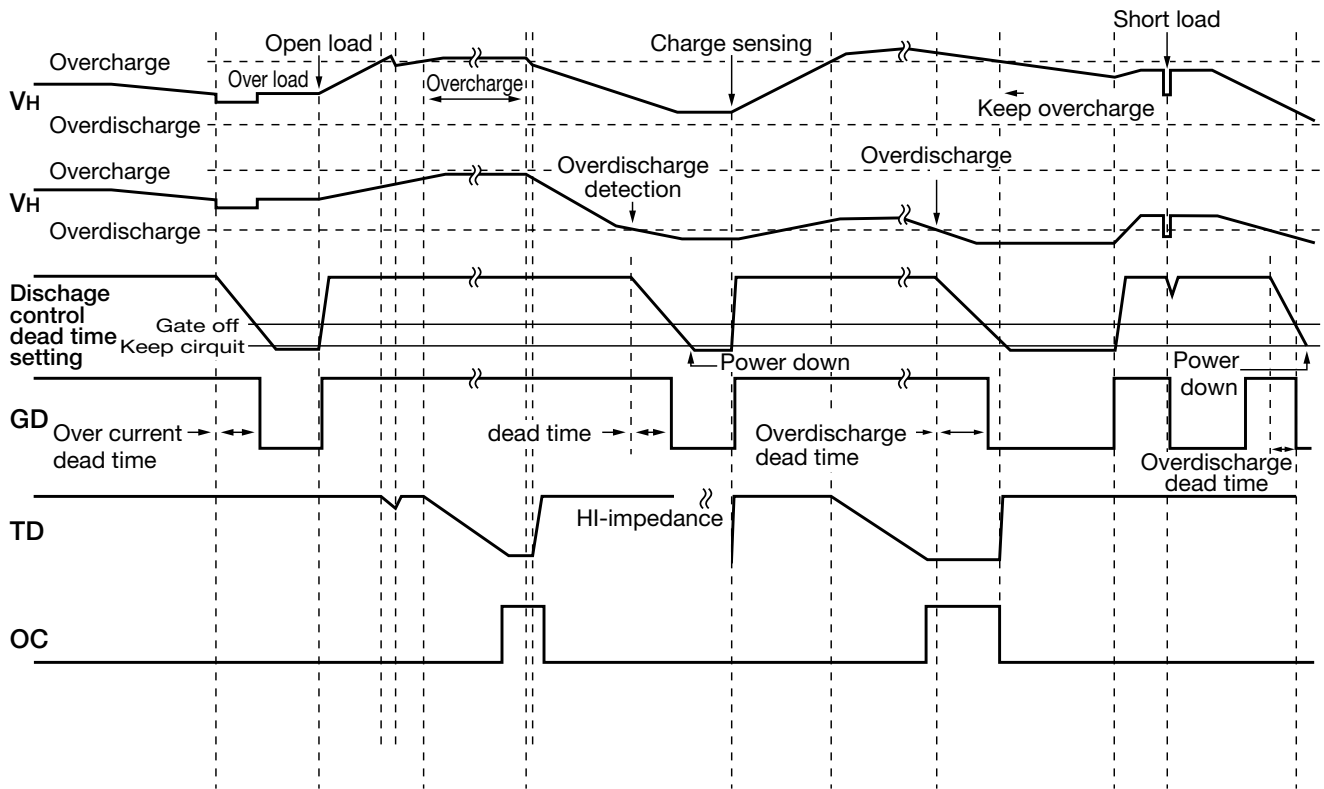
(t_{oc} , t_{od} , t_{och})



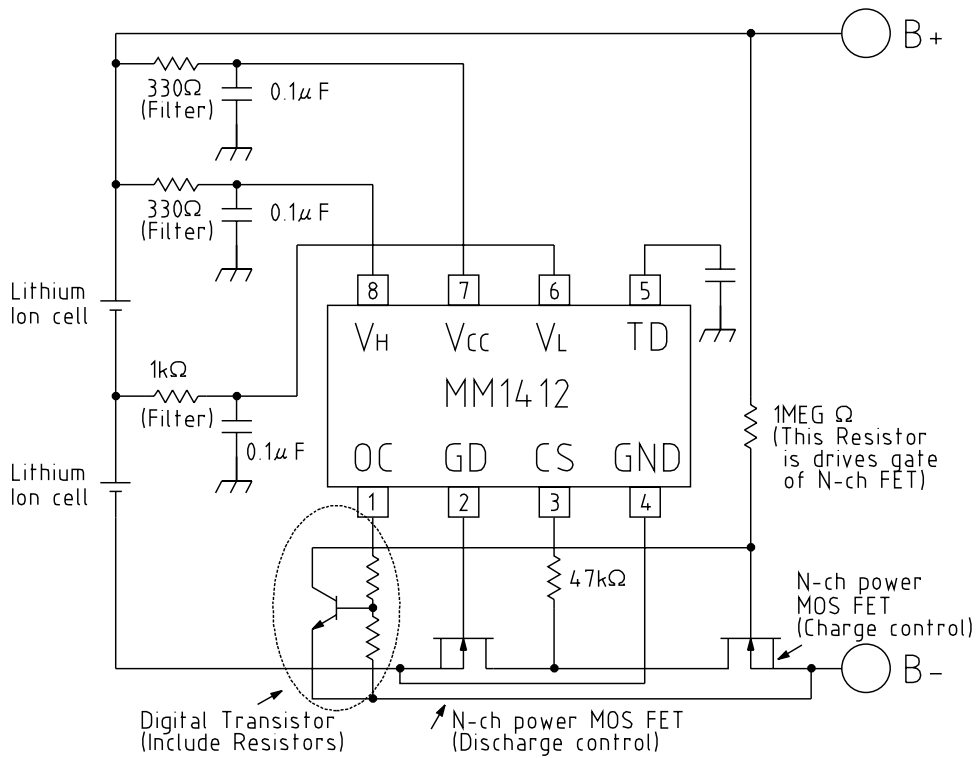
Note :



Timing Chart

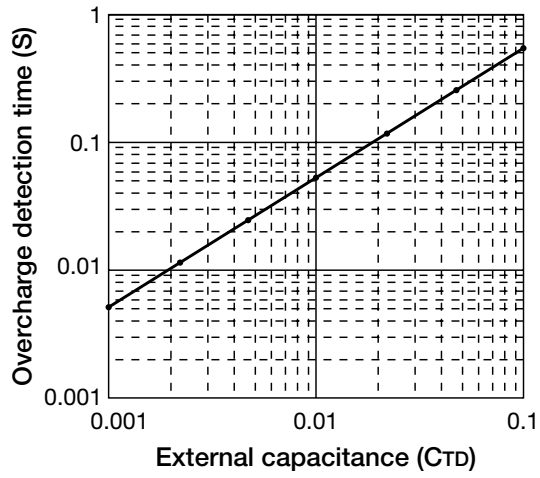


Application Circuit



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 : μF