

# Protection of Lithium Ion Battery (one cell) Monolithic IC MM1491

## Outline

This IC is a smaller, higher precision type of lithium ion battery protection IC as compared to the MM1301 series, and precision of  $\pm 25\text{mV}$  is guaranteed at  $0^\circ\text{C} \sim 50^\circ\text{C}$ .

MM1301 had both  $V_{CC}$  and  $V_{IN}$  pins, but MM1491 has only the  $V_{CC}$  pin.

## 1-Cell Protection ICs

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

Model	Package	Overcharge detection voltage (V)	Overcharge detection voltage temperature conditions	Overcharge detection hysteresis voltage (V)	Overdischarge detection voltage (V)	Overdischarge resumption voltage (V)	Overcurrent detection voltage (mV)
	SOT-26A						
MM1491	AN	4.200 $\pm$ 0.025	C	200 $\pm$ 100	2.3 $\pm$ 0.1	3.00 $\pm$ 0.12	200 $\pm$ 26
	BN	4.350 $\pm$ 0.025	C	200 $\pm$ 100	2.4 $\pm$ 0.1	3.00 $\pm$ 0.12	200 $\pm$ 26
	GN	4.280 $\pm$ 0.025	C	200 $\pm$ 100	2.3 $\pm$ 0.1	2.90 $\pm$ 0.12	120 $\pm$ 16
	HN	4.200 $\pm$ 0.025	C	200 $\pm$ 100	2.3 $\pm$ 0.1	3.90 $\pm$ 0.12	200 $\pm$ 26
	JN	4.250 $\pm$ 0.025	C	200 $\pm$ 100	2.3 $\pm$ 0.1	3.00 $\pm$ 0.12	200 $\pm$ 26
	MN	4.250 $\pm$ 0.025	C	150 $\pm$ 100	2.4 $\pm$ 0.1	3.00 $\pm$ 0.12	150 $\pm$ 20
	SN	4.295 $\pm$ 0.025	C	150 $\pm$ 100	2.4 $\pm$ 0.1	3.00 $\pm$ 0.12	150 $\pm$ 20
	WN	4.325 $\pm$ 0.025	C	200 $\pm$ 100	2.5 $\pm$ 0.1	3.00 $\pm$ 0.12	200 $\pm$ 26
	YN	4.300 $\pm$ 0.025	C	150 $\pm$ 100	2.4 $\pm$ 0.1	3.00 $\pm$ 0.12	150 $\pm$ 20
	ZN	4.325 $\pm$ 0.025	C	200 $\pm$ 100	2.5 $\pm$ 0.1	3.00 $\pm$ 0.12	200 $\pm$ 26

\* The series will continue to be expanded.

\* Overcharge and overdischarge voltages and overcurrent detection voltage can be changed at the customer's request.

## Features

- Overcharge detection voltage  $T_a = 0 \sim +50^\circ\text{C}$   $V_{CEL} \pm 25\text{mV}$
- Overcharge detection dead time  $C_{TD} = 0.01\mu\text{F}$  100 ms
- Consumption current (normal mode  $V_{CEL} = 3.6\text{V}$ )  $10\mu\text{A}$  typ.
- Consumption current (overdischarge mode  $V_{CEL} = 1.9\text{V}$ )  $0.05\mu\text{A}$  typ.
- Overcurrent detection reset conditions Load open: between both ends of battery pack  $50\text{M}\Omega$  typ. load

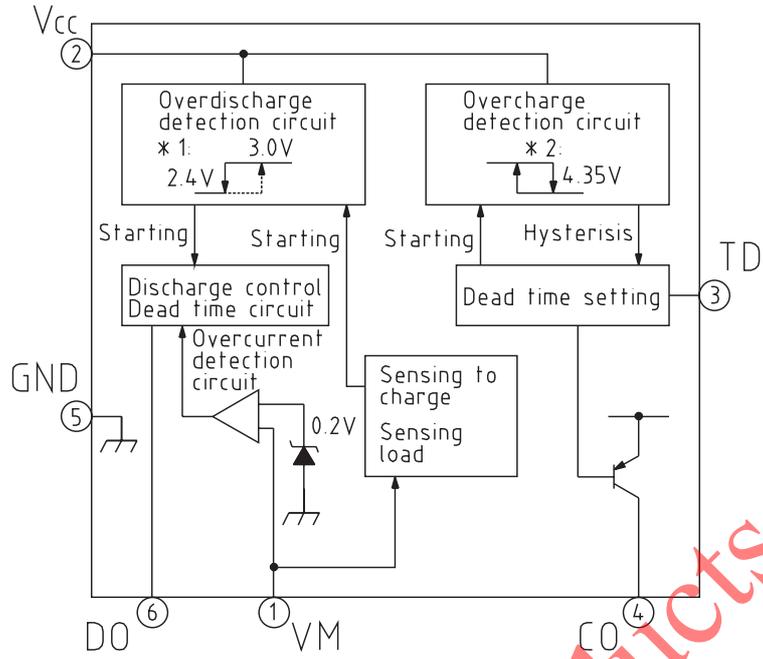
## Package

SOT-26A

## Applications

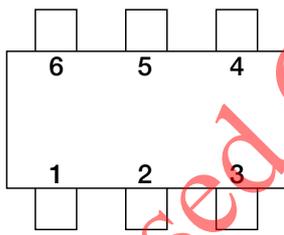
Lithium ion battery packs (for battery protection)

Block Diagram



- \*1: Over-discharge detection voltage
- \*2: Over-charge detection voltage

Pin Assignment



SOT-26A

1	VM
2	Vcc
3	TD
4	CO
5	GND
6	DO

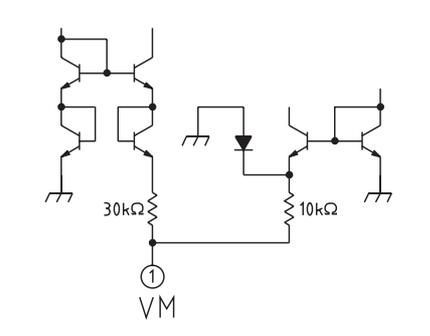
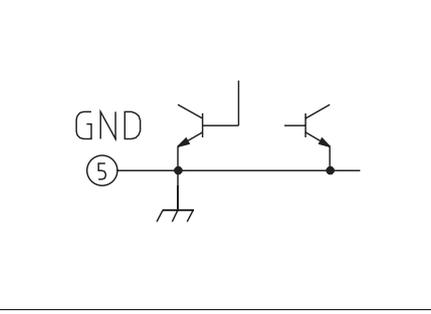
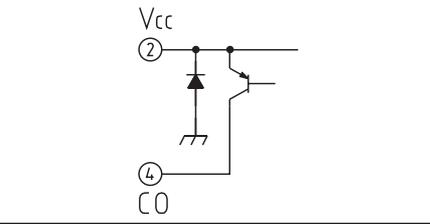
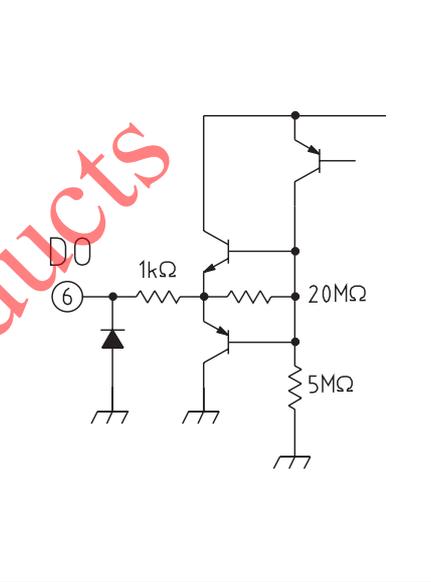
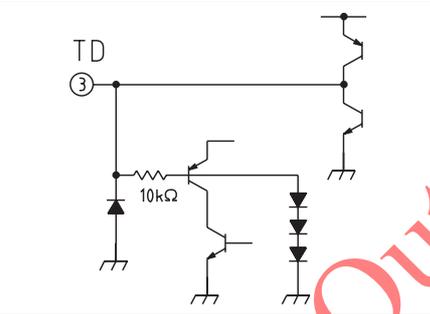
**Pin Description**

PIN No.	PIN Name	TERMINAL EXPLANATIONS
1	VM	Overcurrent detection input pin. Detects discharge current by connection to charging control FET source pin. Discharge current = (voltage between VM and GND) / (FET × 2 ON resistance)
2	VCC	The positive source pin of this IC and connecting the positive terminal of the cell.
3	TD	Setting the dead time of over-charge detection with the outer capacitor.
4	CO	This pin drives the gate of the charge control N-ch FET, needs to connect resistor between source and gate of FET. Over-charge mode (when charging) : FET OFF Over-charge mode (when discharging) : FET ON Over-discharge mode (when discharging) : FET OFF Over-discharge mode (when charging) : FET ON Normal mode : FET ON
5	GND	The ground pin of this IC and connecting the negative terminal of the cell.
6	DO	This pin drives the gate of the discharge control N-ch FET. Over-discharge mode : FET OFF Over-discharge current mode : FET OFF Over-charge mode : FET ON Normal mode : FET ON

- \* •Overcharge mode: Battery voltage > overcharge detection voltage
- Normal mode: Overdischarge detection voltage < battery voltage < overcharge detection voltage  
Discharge current < overcurrent detection level
- Overdischarge mode: Overdischarge detection voltage > battery voltage
- Overcurrent mode: Discharge current > overcurrent detection level, voltage between VM and GND = discharge current × FET ON resistance  
(discharge/charge control FET)

Phased Out Products

**Pin Description**

Pin No.	Pin name	Equivalent circuit diagram	Pin No.	Pin name	Equivalent circuit diagram
1	V <sub>M</sub>		5	GND	
2	V <sub>CC</sub>		6	DO	
4	C <sub>O</sub>				
3	T <sub>D</sub>				

**Absolute Maximum Ratings (T<sub>a</sub>=25°C)**

Item	Symbol	Ratings	Unit
Storage temperature	T <sub>STG</sub>	-40~+125	°C
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Supply voltage	V <sub>CC</sub> max.	-0.3~+18	V
Pin voltage	V <sub>CO</sub> max. V <sub>VM</sub> max.	V <sub>CC</sub> -28~V <sub>CC</sub>	V
Allowable loss	P <sub>D</sub>	200	mV

**Recommended Operating Conditions**

Item	Symbol	Ratings	Unit
Operating temperature	T <sub>OPR</sub>	-20~+70	°C
Supply voltage	V <sub>OP</sub>	+1.8~+10	V

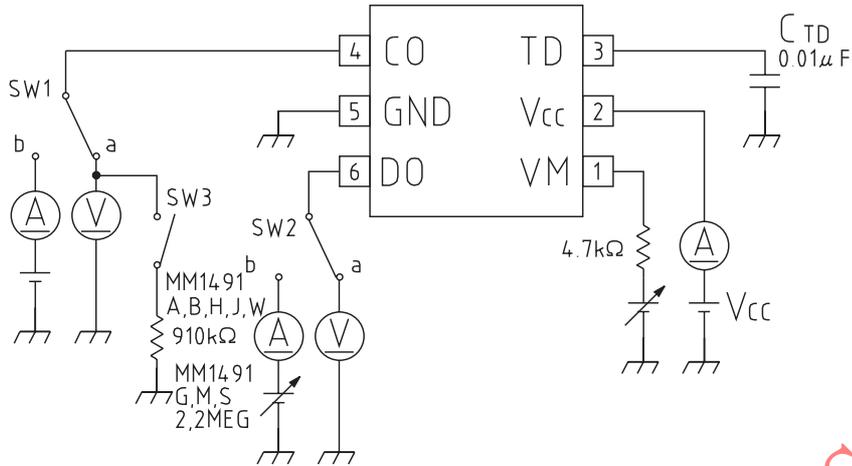
**Electrical Characteristics** (Unless otherwise specified Ta=25°C, Vcc=3.6V, model name MM1491B)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit
Current consumption 1 (Condition : SET)	I <sub>CC1</sub>	V <sub>CC</sub> =3.6V : Set between CO-GND : 910kΩ connected		10.0	14.0	μA
Current consumption 2 (Condition : IC only)	I <sub>CC2</sub>	V <sub>CC</sub> =3.6V : IC only between CO-GND : 910kΩ connected		6.0	10.0	μA
Current consumption 3 (FET : OFF on SET)	I <sub>CC3</sub>	V <sub>CC</sub> =3.6V : Discharge FET OFF between CO-GND : 910kΩ no connected				μA
Current consumption 4 (FET : OFF on SET)	I <sub>CC4</sub>	V <sub>CC</sub> =1.9V : Discharge FET OFF between CO-GND : 910kΩ no connected		0.05	0.3	μA
Current consumption 5 (Condition : SET)	I <sub>CC5</sub>	V <sub>CC</sub> =4.5V between CO-BG : 910kΩ connected		35	60	μA
Over-charge voltage	V <sub>ALM1</sub>	Ta=0°C ~ 50°C V <sub>CC</sub> : L → H	4.325	4.350	4.375	V
Over-charge hysteresis	V <sub>ALM1</sub>	V <sub>CC</sub> : H → L	100	200	300	mV
Over-discharge voltage	V <sub>ALM2</sub>	V <sub>CC</sub> : H → L	2.30	2.40	2.50	V
Release over-discharge mode			2.88	3.00	3.12	V
Over-current detect level	V <sub>VMD</sub>	V <sub>VM</sub> : L → H	174	200	226	mV
Release over-current level	V <sub>VMDf</sub>	V <sub>VM</sub> : H → L		130		mV
Condition of release over-current mode		Load condition		50		MΩ
Short detect level	V <sub>VMSHT</sub>			1.3		V
Over-discharge dead time	t <sub>ALM2</sub>		7.0	10.0	15.0	ms
Over-current dead time	t <sub>VMD</sub>	V <sub>M</sub> : 0V → 0.5V	7.0	10.0	15.0	ms
Short detect delay time	t <sub>VMSHT</sub>	V <sub>M</sub> : 0V → 2V		0.02	0.20	ms
Over-charge dead time	t <sub>ALM1</sub>	C <sub>TD</sub> =0.01μF	50	100	150	ms
DO pin low level	V <sub>GDH</sub>	V <sub>CC</sub> =3.6V	V <sub>CC</sub> -0.3	V <sub>CC</sub> -0.1	V <sub>CC</sub>	V
DO pin source current 1	I <sub>DOH1</sub>	V <sub>DO</sub> =V <sub>CC</sub> -1.0V		-100	-30	μA
DO pin source current 2	I <sub>DOH2</sub>	V <sub>DO</sub> =V <sub>CC</sub> -0.3V		-0.40	-0.07	μA
DO pin sink current 1	I <sub>DOL1</sub>	V <sub>VM</sub> >1.0V V <sub>DO</sub> =1.0V	50	300		μA
DO pin sink current 2	I <sub>DOL2</sub>	V <sub>VM</sub> >1.0V V <sub>DO</sub> =0.3V	30	100		μA
CO pin source current 1	I <sub>CO1</sub>	V <sub>CO</sub> =V <sub>CC</sub> -1.0V		-20	-10	μA
CO pin source current 2	I <sub>CO2</sub>	V <sub>CO</sub> =V <sub>CC</sub> -0.3V		-15	-5	μA
Start trigger voltage	V <sub>ST</sub>	V <sub>VM</sub> : 0V → -0.5V	-0.2	-0.1	0	V
Over-voltage charger protection	V <sub>PRO</sub>	V <sub>CC</sub> =3.6V, between GND-VM voltage	-1.5	-2.5	-3.0	V
OV charge minimum voltage	V <sub>OV</sub>	V <sub>CC</sub> =0V, Charger voltage		2.0	3.0	V

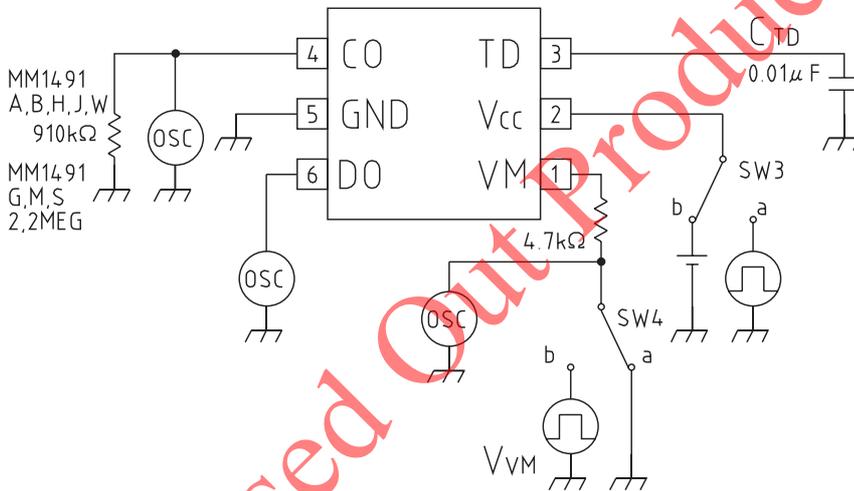
\*The overcurrent detection current value is V<sub>vm</sub>/ (FET's on resistance × 2).

Measuring Circuit

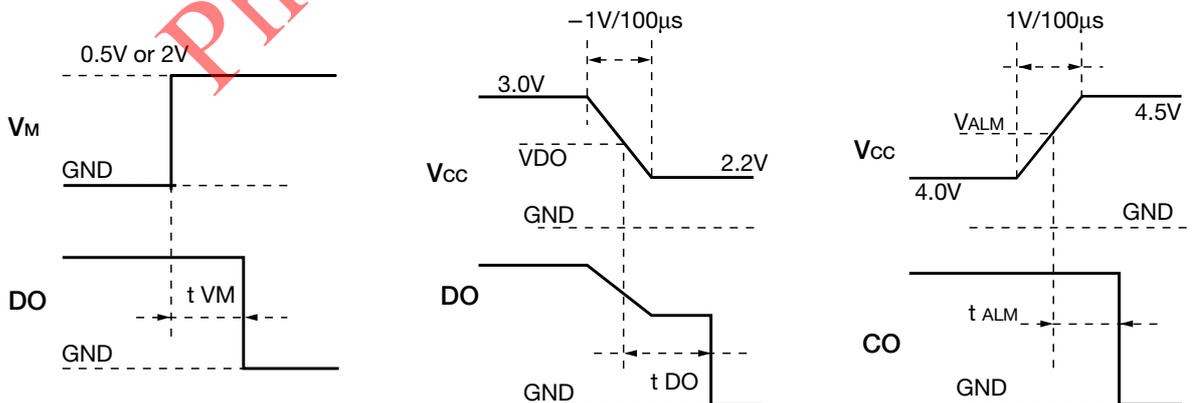
Measuring Circuit 1



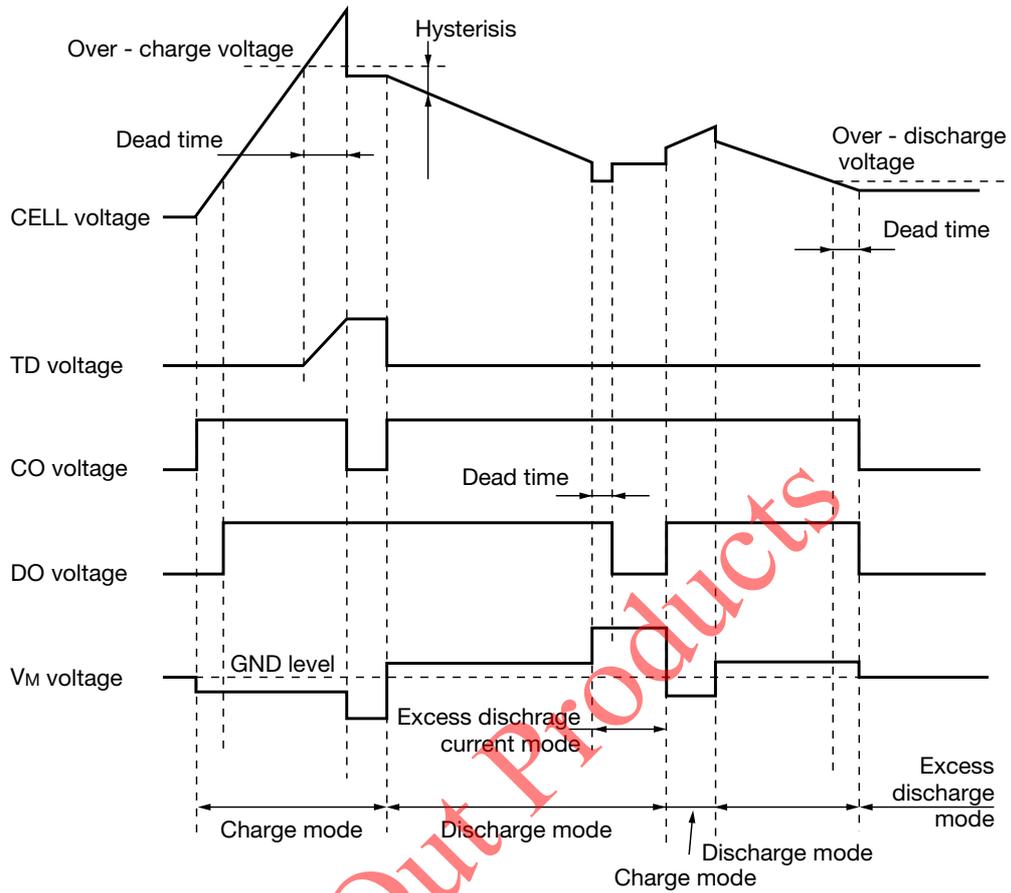
Measuring Circuit 2



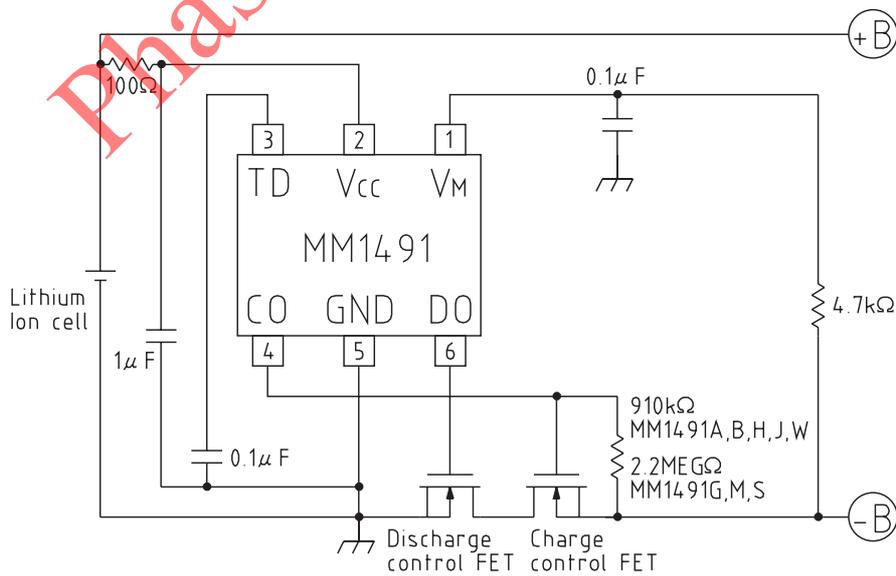
Note :



Timing Chart



Application Circuits

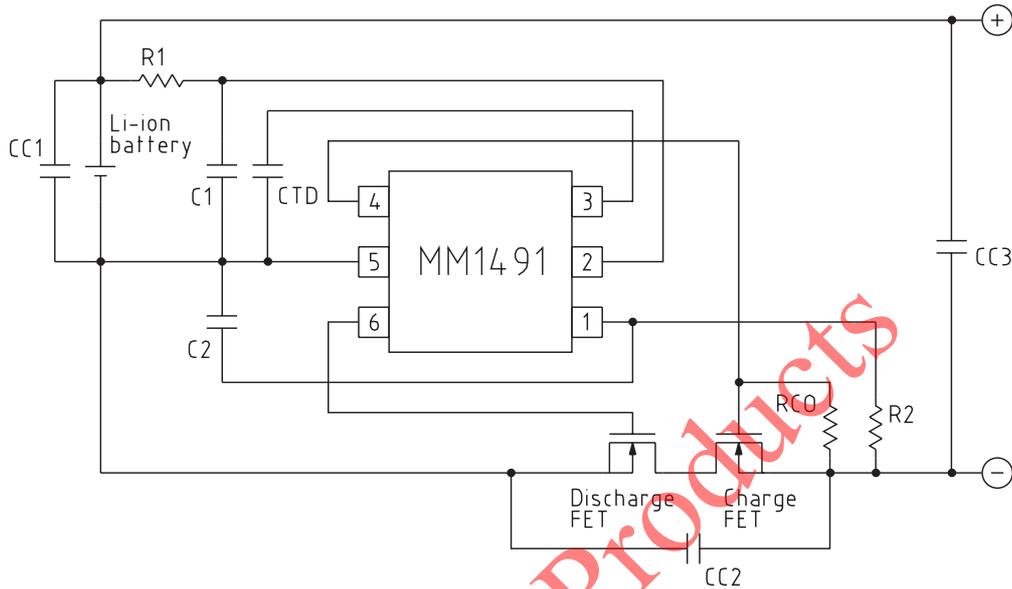


Note: Applicable circuits shown are typical examples provided for reference purposes. Mitsumi cannot assume responsibility for any problems arising out of the use of these circuits or for any infringement of third party patent and other right due to same.

Application Description

Outline

The MM1491 Series are protection IC for over-charge, over-discharge and over-current of rechargeable one-cell Lithium-ion, further include a short circuit protector for preventing large external short circuit current.



Parts List

- R1 : 100Ω
- R2 : 4.7kΩ
- RCO : 2.2MΩ
- C1 : 1μF
- C2 : 0.047μF
- CTD : 0.1μF/Temp. chr. code B
- CC1 : 0.1μF/25V
- CC2 : 0.1μF/25V
- CC3 : 0.1μF/25V

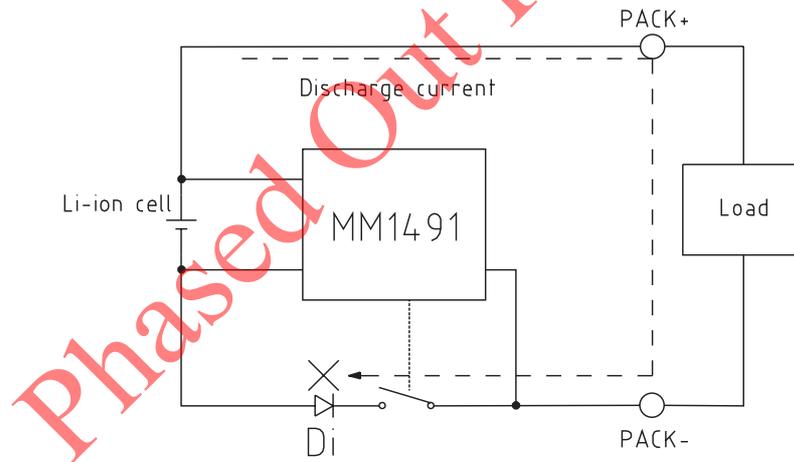
1. Overcharge detection

· The overcharge detector monitors V<sub>CC</sub> pin voltage. When the V<sub>CC</sub> voltage crosses overcharge detector threshold VALMI (4.2V typ.) from a low value higher than the VALMI, the overcharge detector can sense an overcharging and an external charge control Nch-MOS-FET turns to "OFF" with the resistor (910kΩ typ.) between the gate (CO pin) and source of FET, then CO pin "OFF".  
 (This resistor makes the CO pin "L". Current flows the resistor on normal condition, therefore it makes the resistance value larger because to reduce the consumption current. However it makes resistance value smaller than 2.2MΩ because of relation between leak current of FET and cut-off time of FET by gate-source capacitance. : It changes the resistance value from 910KΩ to 2.2MΩ, the consumption current can be reduced about 2μA.)

2. Overdischarge detector

- The voltage of  $V_{CC}$  (2 pin) is observed when the battery is discharged, and  $V_{CC}$  enters the mode of the overdischarge detector under overdischarge detect voltage (2.3V typ.). The electrical discharge is stopped by DO pin (6 pin) outputting "L", and turning off FET for the discharge.
- About the release from the mode of overdischarge  
 Battery below the overdischarge detecting voltage through the parasitic diode of discharge FET.  
 The case that  $V_{CC}$  becomes more than the release overdischarge detect voltage by charging, from the mode of overdischarge, is turned on the discharge FET.
- It is assumed that CO can be assumed to be "H" and charge if the voltage of the charger which connects the charger is over 0V charging minimum operating voltage (2V typ.) at 0V in the voltage of the battery.
- The delay time when overdischarge is detected is set internally (10ms typ.).  
 It does not enter the mode of the overdischarge detection when rising more than the overdischarge detecting voltage in delay time even if  $V_{CC}$  becomes below the overdischarge detecting voltage.
- After overdischarge is detected, all circuit are stopped, and the current which IC consumes is decreased as much as possible. (at  $V_{CC}=1.9V : 0.05\mu A$  typ.)

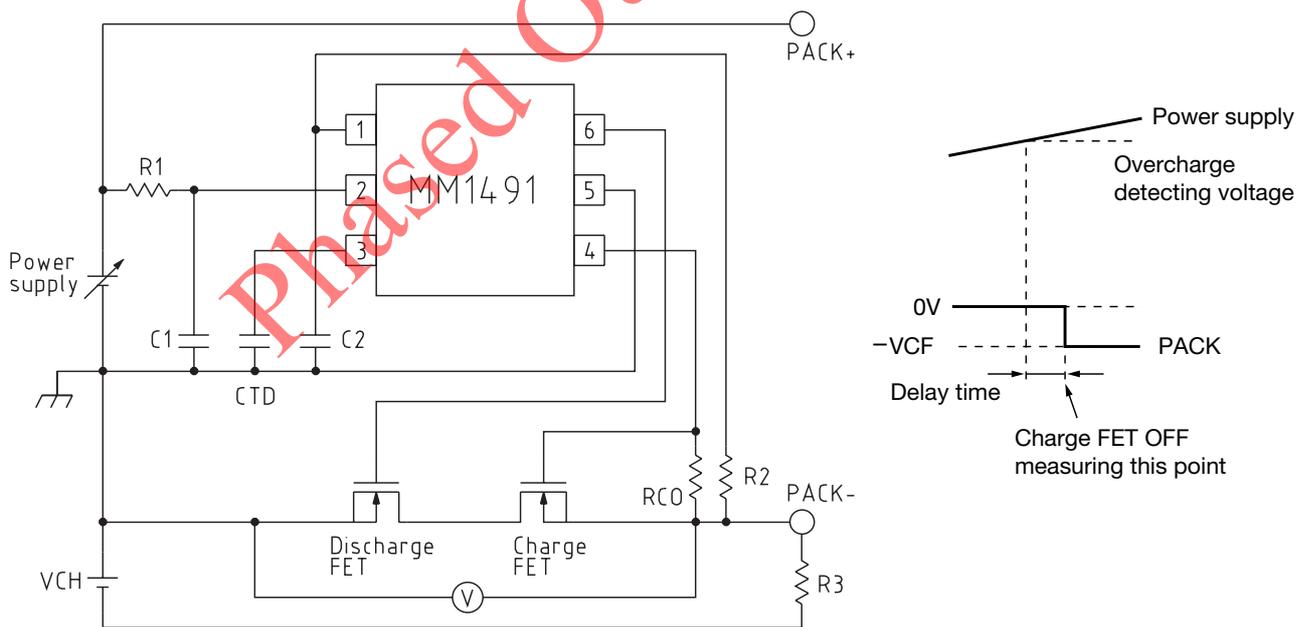
Image figure when over-discharge mode



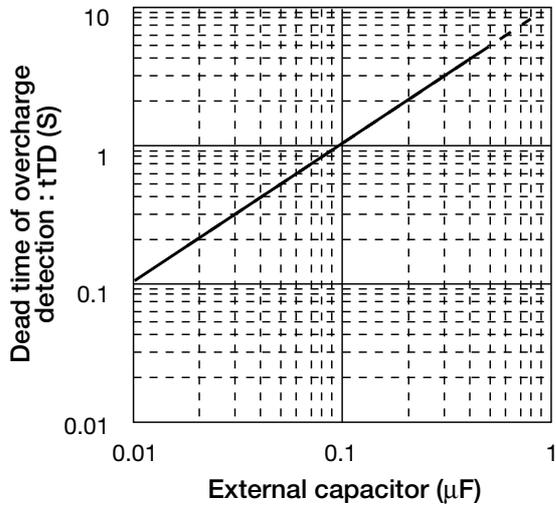
Note on use

- The power supply change is suppressed by R1 and C1. However, the detecting voltage rises about (current consumptions \* resistance) when R1 is enlarged. Uses R1 below 330Ω.
- The voltage change of ( - ) terminal is suppressed by R2 and C2.  
Because the case with which the capacity load is connected includes the case that short detection works, the time constant is given to the terminal V<sub>M</sub> for preventing. Use R2 4.7kΩ fixed, and change C2 and adjust the time constant. R1 and R2 can operate also as a part of current limit circuit against for applying excess charging voltage or for setting cell reverse.
- Please note that the case whose time constant of the terminal V<sub>M</sub> is larger than the time constant of the terminal V<sub>CC</sub> includes the case which becomes a stand-by state when detecting short according to the impedance of the connected battery. Please set in (R1 \* C1) ≥ (R2 \* C2) as a standard.
- Please examine the necessity of CC1, CC2, and CC3 respectively to prevent the malfunction and destruction by ESD or the radio wave when you design the module. Please note that MM1421 of the charge release type has the case which enters the stand-by state by the ESD and radio wave etc. because of module patterning.
- When measuring over-charge voltage in module, evaluate with the measurement figure.  
(When the battery has no loads, pack-ocillates if it enters the mode of overcharge detection. Because of the function of load detection.)

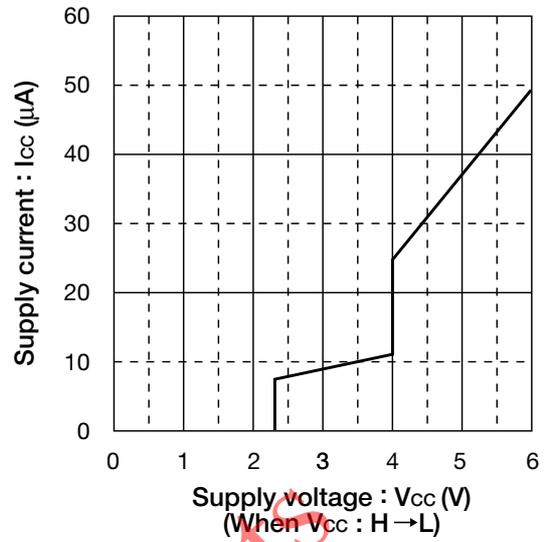
Test circuit to measure over-charge detect voltage



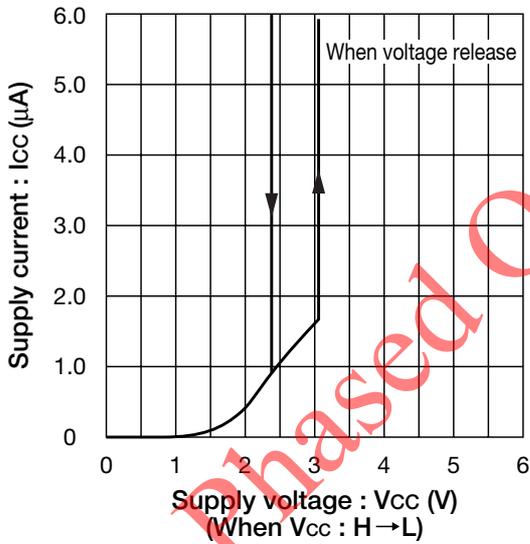
■ Dead time vs external capacitor  
(When overcharge detection)



■ Supply current vs supply voltage



■ When increasing cell voltage  
supply current vs supply voltage



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