Protection of Lithium-Ion Batteries (one cell)
Monolithic IC MM1421

Outline

This is a smaller, high-precision version of the conventional MM1301 series of lithium ion battery protection ICs. Precision of ±25mV at 0 ~ 50°C is guaranteed. Also, MM1421 charging reset is overdischarge reset pin 2 voltage, and MM1491 overdischarge reset pin 2 voltage is set at 3.0 ~ 3.9V.

1-Cell Protection ICs

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 (mV)	Overdischarge detection voltage (V)	Overdischarge reset voltage (V)	Overcurrent detection voltage (mV)
	SOT-26A						
MM1421	AN	4.200±0.025	C	200±100	2.3±0.1	charging reset	200±26
	JN	4.250±0.025	C	200±100	2.3±0.1	charging reset	200±26
	LN	4.350±0.025	C	200±100	2.4±0.1	charging reset	200±26
	NN	4.275±0.025	C	200±100	2.3±0.1	charging reset	120±26

* We are continuing to develop the series for the future.
* Overcharge, overdischarge voltages and overcurrent detection voltage can be changed to customize the ICs.

Features

1. Overcharge detection voltage accuracy (0°C to 50°C) V_{CEL} ± 25mV
2. Overcharge detection dead time C_{TD}=0.01μF 100ms
3. Consumption current (V_{CEL}=0.01V) 10.0μA typ.
4. Consumption current (V_{CEL}=3.6V) 0.1μA typ.
5. Overdischarge reset Load open: 50MΩ typ. load between both ends of battery pack

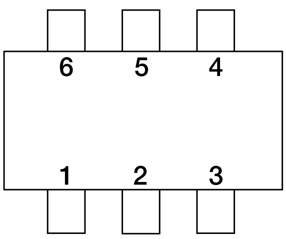
Package

SOT-26A

Applications

IC for protection of single-cell lithium-ion batteries.

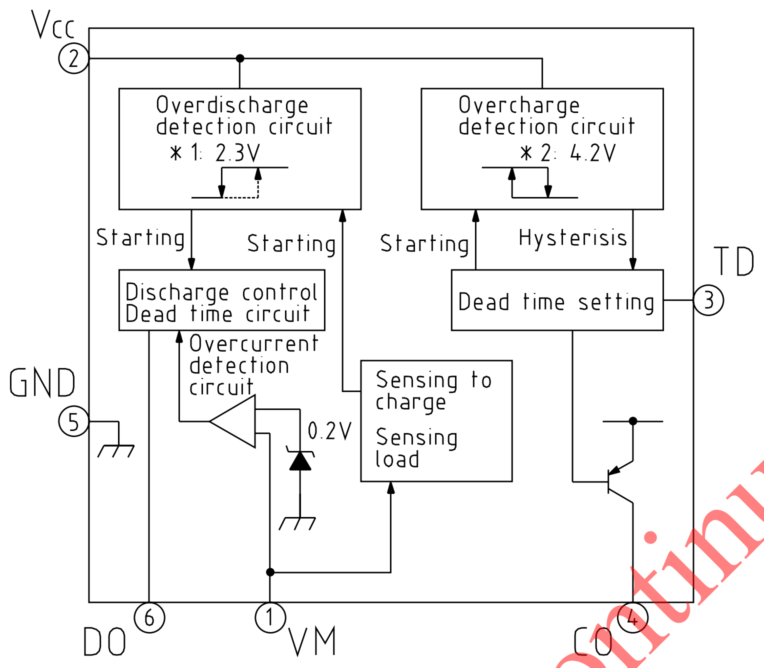
Pin Assignment



SOT-26A

1	VM
2	V_{CC}
3	TD
4	CO
5	GND
6	DO

Block Diagram



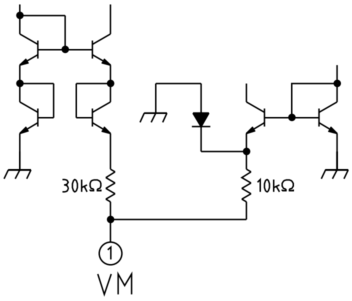
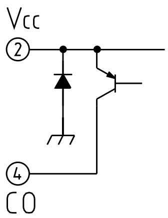
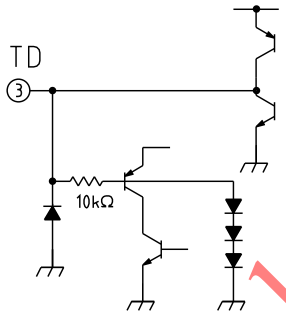
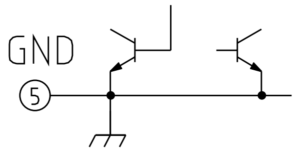
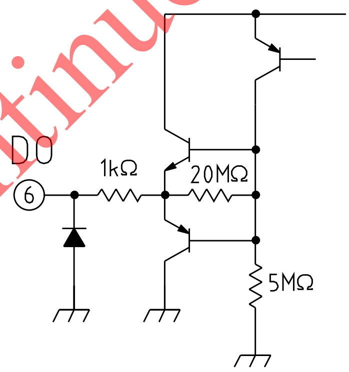
Note 1 : Overdischarge voltage
Note 2 : Overcharge voltage

Pin Description

Pin No.	Pin Name	Function
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	Positive power supply pin.
3	TD	Overcharge detection dead time setting pin.
4	CO	Charging control FET (N-ch) gate connection pin. An external resistor is required between gate and source. Turns off charging control FET (N-ch) for overcharge mode (during charging) and overdischarge mode. Also, overcharge mode (during discharge) turns charging control FET (N-ch) ON, and suppresses FET power consumption.
5	GND	Negative power supply pin. Also, negative input pin for battery connected between Vcc and GND.
6	DO	Discharge control FET (N-ch) gate connection pin. Turns gate OFF for overdischarge mode and overcurrent mode. Turns gate ON for overcharge mode and normal mode.

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

Pin Assignment

Pin No.	Pin name	Equivalent circuit diagram
1	V_M	
2 4	V_{CC} CO	
3	TD	
5	GND	
6	DO	

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Ratings	Unit
Storage temparature	T_{STG}	–40~+125	°C
Operating temparature	T_{OPR}	–20~+70	°C
Supply voltage	V_{CC} max.	–0.3~+18	V
CO pin voltage	V_{CO} max.	V_{CC}–28~V_{CC}	V
V_M pin voltage	V_{VM} max.		
Allowable loss	Pd	200	mW

Recommended Operating Conditions

Item	Symbol	Ratings	Unit
Operating temparature	T_{OPR}	–20~+70	°C
Power supply voltage	V_{OP}	+1.8~+10	V

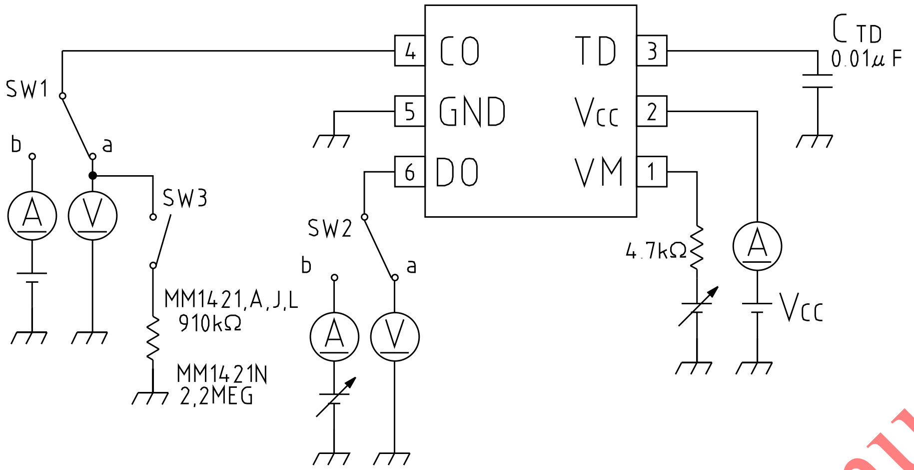
Electrical Characteristics (Except where noted otherwise, Ta=25°C, V_{CC}=3.6V)

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Unit
Consumption current 1 (condition: SET)	I_{CC1}	V_{CC} = 3.6V: Set state between CO-GND: 910kΩ connected		10.0	14.0	μA
Consumption current 2 (condition: IC only)	I_{CC2}	V_{CC} = 3.6V: IC alone between CO-GND: 910kΩ not connected		6.0	10.0	μA
Consumption current 3 (FET: OFF on SET)	I_{CC3}	V_{CC}=3.6V: Discharge FET OFF state between CO-BG: 910kΩ not connected		0.4	1.2	μA
Consumption current 4 (FET: OFF on SET)	I_{CC4}	V_{CC}=1.9V: Discharge FET OFF state between CO-GND: 910kΩ not connected		0.1	1.0	μA
Consumption current 5 (condition: SET)	I_{CC5}	V_{CC}=4.5V between CO-BG: 910kΩ connected		35	60	μA
Overcharge detection voltage	V_{ALM}	Ta=0~50°C V_{CC}: L→H	4.175	4.200	4.225	V
Overcharge hysterisis voltage	⊿V_{ALM}	V_{CC}: H→L	100	200	300	mV
Overdischarge detection voltage	V_{OD}	V_{CC}: H→L	2.20	2.30	2.40	V
Release overdischarge voltage	V_{ODF}	Charging reset				
Overcurrent detection level	V_{VMD}	V_{VM}: L→H	174	200	226	mV
Release overcurrent level	V_{VMDF}	V_{VM}: H→L		130		mV
Release overcurrent level	I_{CSL}	Load condition		50		MΩ
Short detection voltage	V_{VMSHT}			1.3		V
Overdischarge detection dead time	t_{OD}		7.0	10.0	15.0	ms
Overcurrent detection dead time	t_{CS}	V_M: 0V→0.5V	7.0	10.0	15.0	ms
Short detection delay time	t_{VMSHT}	V_M: 0V→2V		0.02	0.20	ms
Overcharge detection dead time	t_{ALM}	C_{TD}=0.01μF	50	100	150	ms
DO pin output voltage	V_{GDH}		V_{CC}–0.3	V_{CC}–0.1	V_{CC}	V
DO pin source current 1	I_{DOH1}	V_{DO}=V_{CC}–1.0V		–100	–30	μA
DO pin source current 2	I_{DOH2}	V_{DO}=V_{CC}–0.3V		–0.40	0.07	μA
DO pin sink current 1	I_{DOL1}	V_{VM}>1.0V, V_{DO}=1.0V	50	300		μA
DO pin sink current 2	I_{DOL2}	V_{VM}>1.0V, V_{DO}=0.3V	30	100		μA
DO pin sink current 3	I_{DOL3}	V_{CC}=3.6V, V_{DO}=1V (Stand-by mode)	1	5		μA
CO pin source current 1	I_{CO1}	V_{CO}=V_{CC}–1.0V		–20	–10	μA
CO pin source current 2	I_{CO2}	V_{CO}=V_{CC}–0.3V		–15	–5	μA
CO pin source current 3	I_{CO3}	V_{CO}=V_{CC}–0.3V (Stand-by mode)		–1	–0.2	μA
Starting trigger voltage	V_{ST}	V_{VM}: 0V→–0.5V	–0.2	–0.1	0	V
Over-voltage charger protection	V_{PRO}	V_{CC}=3.6V, GND-VM: voltage	–1.5	–2.5	-3.0	V
0V charge minimum voltage	V_{0V}	V_{CC}=0V, Charger voltage		2.0	3.0	V

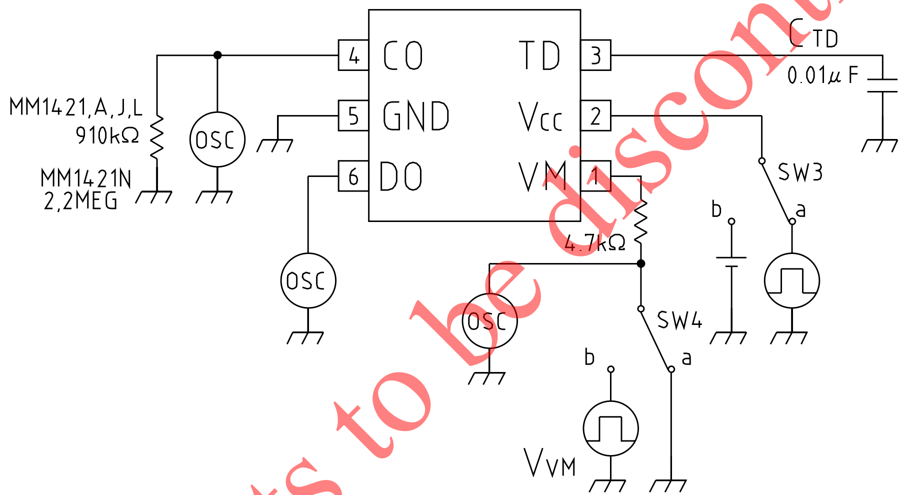
Note: Overcurrent detection current value is V_{VM}/(FET ON resistance×2).

Measuring Circuit

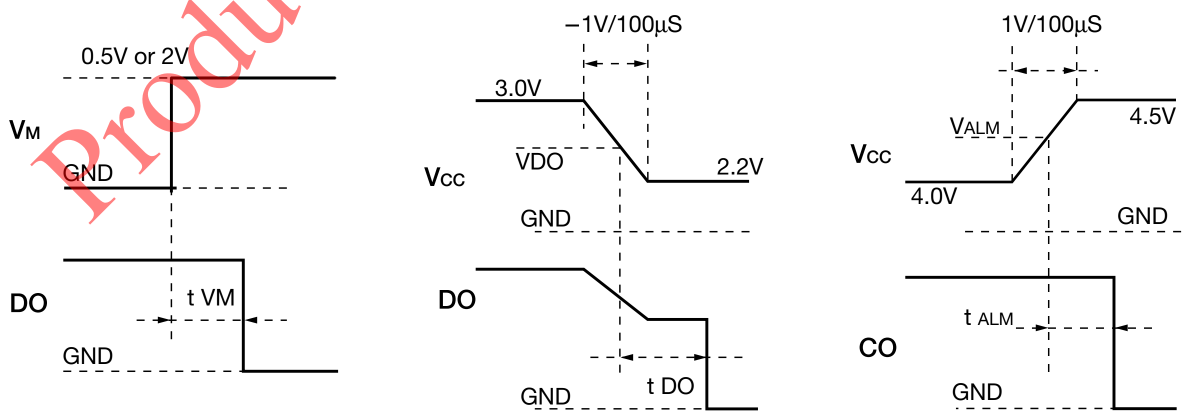
Measuring circuit 1



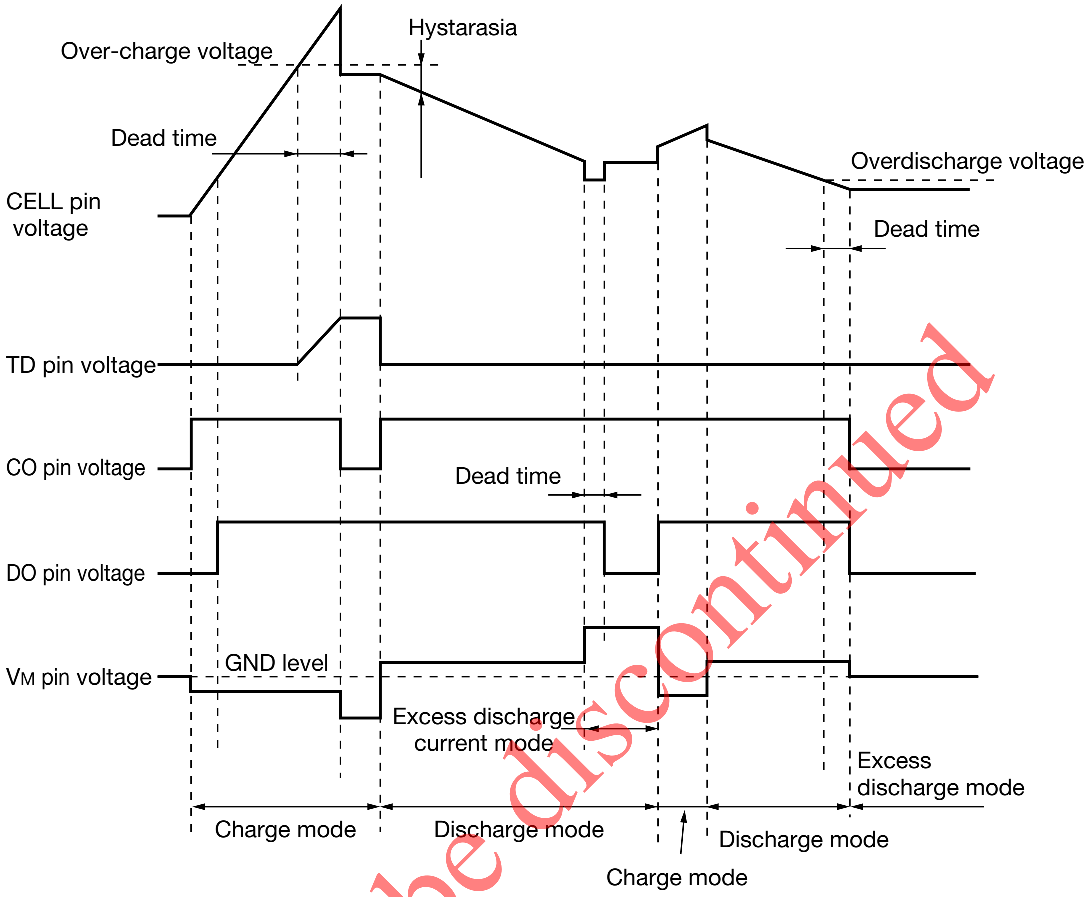
Measuring circuit 2



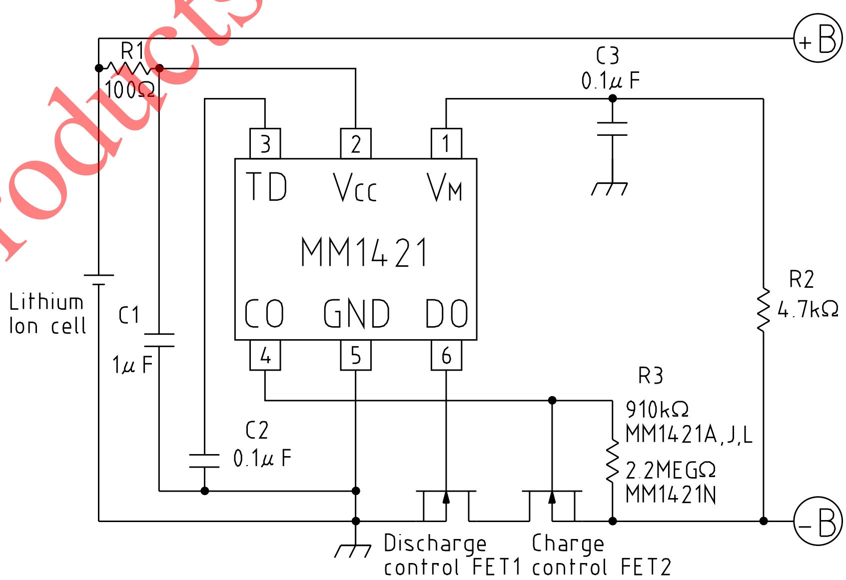
Note :



Timing Chart



Application Circuit



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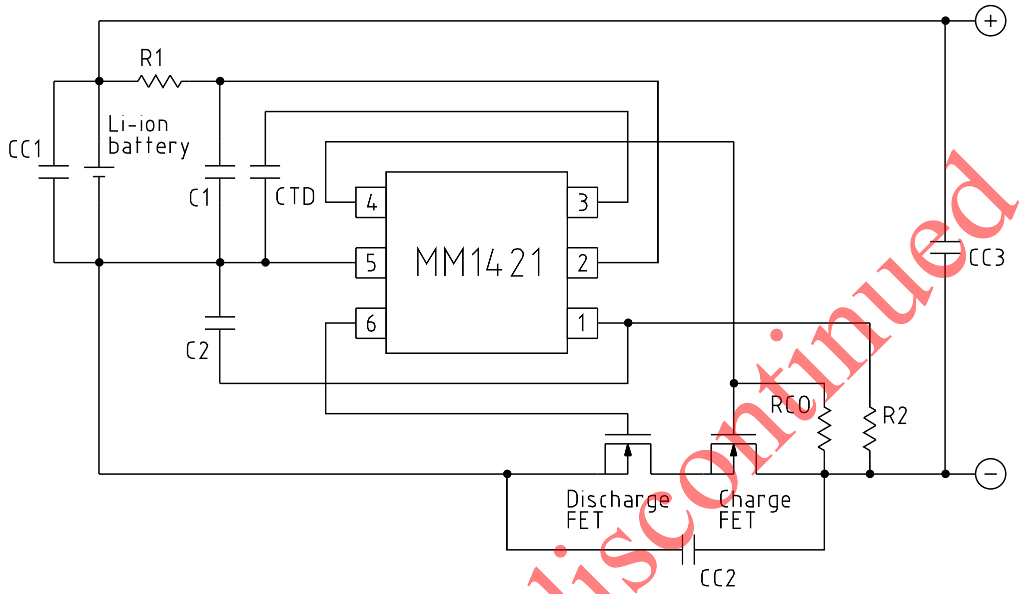
Application Description

Outline

The MM1421 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
- C1 : 1μF
- R2 : 4.7kΩ
- C2 : 0.047μF
- RCO : 2.2MΩ
- 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_{CC} pin voltage. When the V_{CC} voltage crosses overcharge detector threshold VALMI (4.2V typ.) from a low value higher than the VALMI, the overcharge detector can sense a overcharging and an external charge control Nch-MOS-FET tums to "OFF" with the resister (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 resister 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 Vcc (2 pin) is observed when the battery is discharged, and Vcc 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.

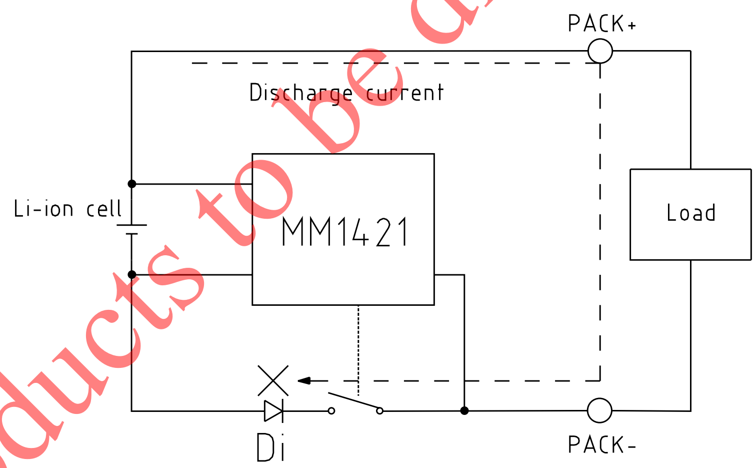
· About the release from the mode of overdischarge
Battery below the overdischarge detecting voltage through the parasitic diode of discharge FET.
The case that Vcc becomes more than the release overdischarge detect voltage by charging, from the mode of overdischarge, is turned on the discharge FET.

· 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 voltagein delay time even if Vcc 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 Vcc=1.9V : 0.05μA 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.

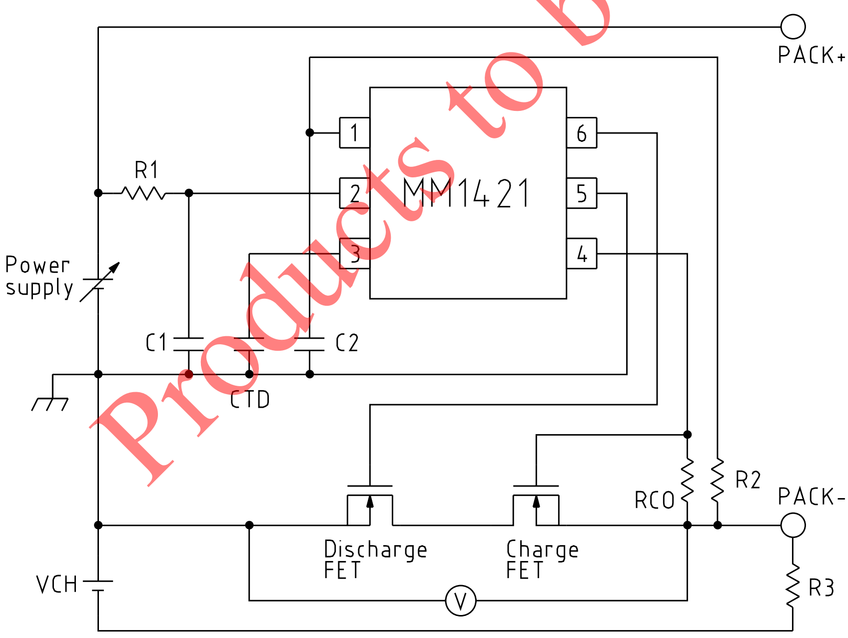
· The voltage change of (−) terminal is suppressed by R2 and C2.
Because the case with which the capacity load is connected includes the case that short detection works, the time constant is given to the terminal V_M for preventing. Use R2 4.7kΩ fixed, and change C2 and adjust the time constant. R1 and R2 can operate also as a part of current limit circuit against for applying excess charging voltage or for setting cell reverce.

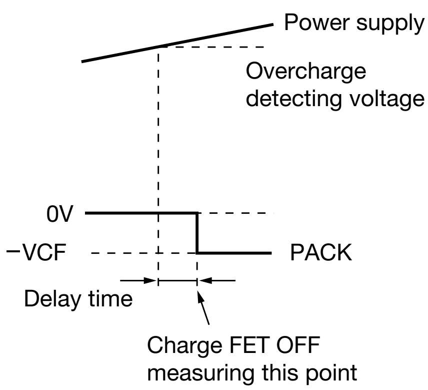
· Please note that the case whose time constant of the terminal V_M is larger than the time constant of the terminal V_{CC} includes the case which becomes a stand-by state when detecting short according to the impedance of the connected battery. Please set in (R1 * C1) ≧ (R2 * C2) as a standard.

· 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 patternning.

· When measuring over-charge voltage in module, evaluate with the measurement figure.
(When the battry has no loads, pack-ocillates if it enters the mode of overcharge detection. Because of the function of load detection.)

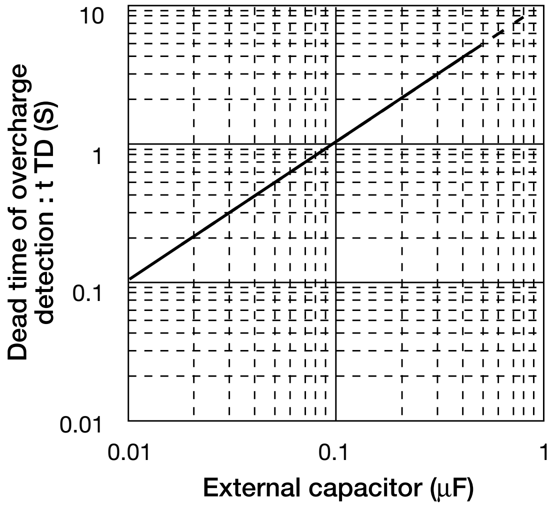
Test circuit to measure over-charge detect voltage



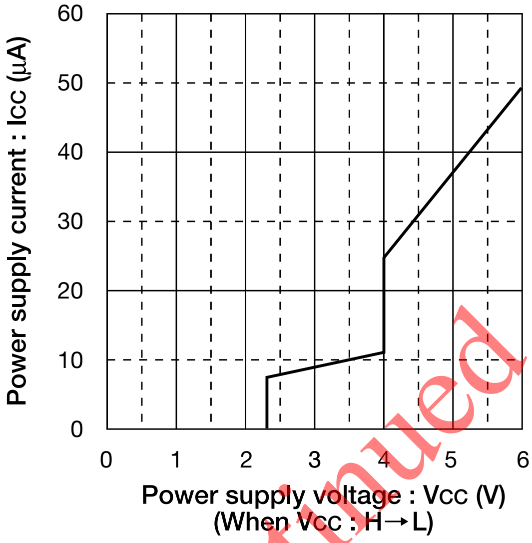


Characteristics

Overcharge detection time

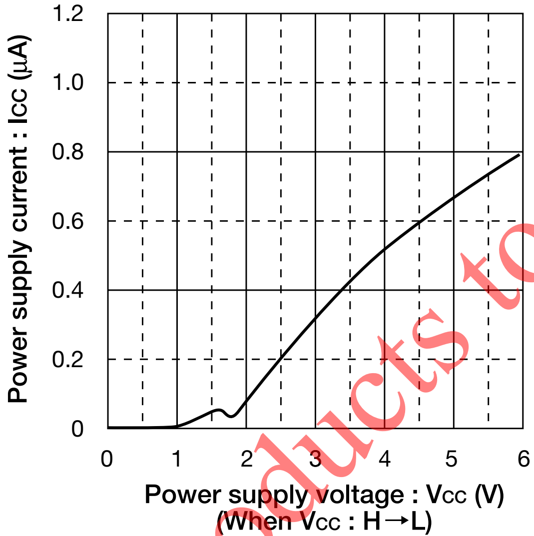


Power supply current vs power supply voltage



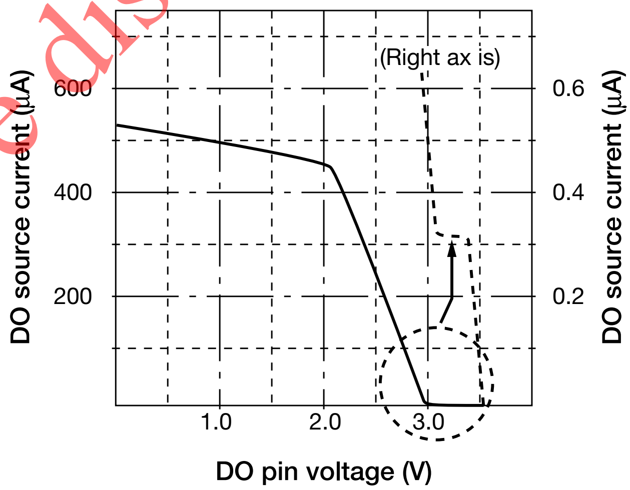
When stand-by mode

Power supply current vs power supply voltage



DO source current vs DO pin voltage

Vcc=3.6V



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