Protection of Lithium Ion Batteries (one cell)
Monolithic IC MM1291

Outline

This is a protection IC for one-cell series that protects lithium ion batteries during excess charging, discharging, or overcurrent. If abnormalities occur during charging and excess voltage is applied, it has a function that turns off the external FET switch when voltage is applied to each battery beyond a specified time (overcharging detection). It also has a function that turns off the external FET switch when the voltage for each battery falls below a set voltage, to prevent excess discharge when discharging the battery (discharging detection). At that time, the IC is switched to low current consumption mode. Also, when there is a large current flow due to shorting or other reasons, there is a functions for turning off the external FET switch (overcurrent detection). These function comprise a protection circuit, with few external parts, for lithium ion batteries.

1-Cell Protection ICs

Package		Overcharge detection voltage	Hysteresis	Dead time	Overdischarge detection	Release voltage	Delay	Overcurrent detection		
SOP-8	VSOP-8							Overcurrent	Detec time	shot-mode
MM1291AF	AW	4.35V	200mV	at Ctd= 0.082μF	∗ 2.6V 2.4V	2.9V	min. 5mS	100mV	min. 5mS	No
BF	BW	4.25V	200mV		∗ 2.6V 2.4V	2.9V		100mV		No
CF		4.10V	25mV		∗ 2.6V 2.4V	2.9V		150mV		No
DF		4.35V	25mV	min. 0.5S	∗ 2.6V 2.4V	2.9V		100mV		No
EF		4.35V	27mV		∗ 2.6V 2.4V	2.9V	typ. 10mS	100mV	typ. 10mS	No
GF		4.225V	27mV		∗ 2.6V 2.4V	2.9V		100mV		No
HF	HW	4.35V	200mV	typ. 1S	∗ 2.6V 2.4V	2.9V	max. 15mS	50mV	max. 15mS	0.45V
	JW	4.25V	270mV		2.3V	2.9V		125mV		0.45V
KF		4.25V	200mV	max. 1.5S	2.3V	2.9V		50mV		0.9V
	MW	4.30V	270mV		2.3V	2.9V		125mV		0.45V

Note : Under open-load conditions, returns to normal mode from overcurrent mode.
(For MM1291A to G, J, M, 5MΩ or higher; for MM1291H, K, 50MΩ or higher)

Features

1. Current consumption (during overcharging)	V_{CC}=4.5V	V_{CC} pin 40μA typ.	V_{IN} pin 3μA typ.
2. Current consumption (normal)	V_{CC}=3.5V	V_{CC} pin 7μA typ.	V_{IN} pin 2μA typ.
3. Current consumption (during excess discharge)	V_{CC}=1.9V	0.7μA typ.	
4. Consumption current (during excess discharge)	V_{CC}=1.0V	0.17μA max.	
5. Overcharge detection voltage (Ta=−20°C~+70°C)		A 4.35V±50mV	
		B 4.25V±50mV	
		C 4.10V±50mV	
6. Overcharge detection hysteresis		A 200mV typ.	
		B 200mV typ.	
		C 27mV typ.	
7. Overcharge non-induction time	C_{TD}=0.082μF	1S typ.	
8. Excess discharge voltage 1	V_{CS}=0V	2.6V±0.1V	
9. Excess discharge voltage 2	V_{CS}=0.05V	2.4V±0.1V	
10.Excess discharge reset voltage		2.9V±0.12V	
11.Excess discharge during non-induction		10mS typ.	
12.Overcurrent detection voltage		A 100mV±10mV	
		B 100mV±10mV	
		C 150mV±15mV	
13.Reset after overcurrent detection		load release	
14.Overcurrent detection non-induction time		10mS typ.	

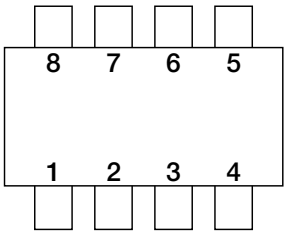
Package

SOP-8C, SOP-8D (MM1291□F)
VSOP-8A (MM1291□W)
*The box represents the rank resulting from the combination of protection functions.

Applications

1. Cellular phones
2. PHS
3. MD
4. others

Pin Assignment



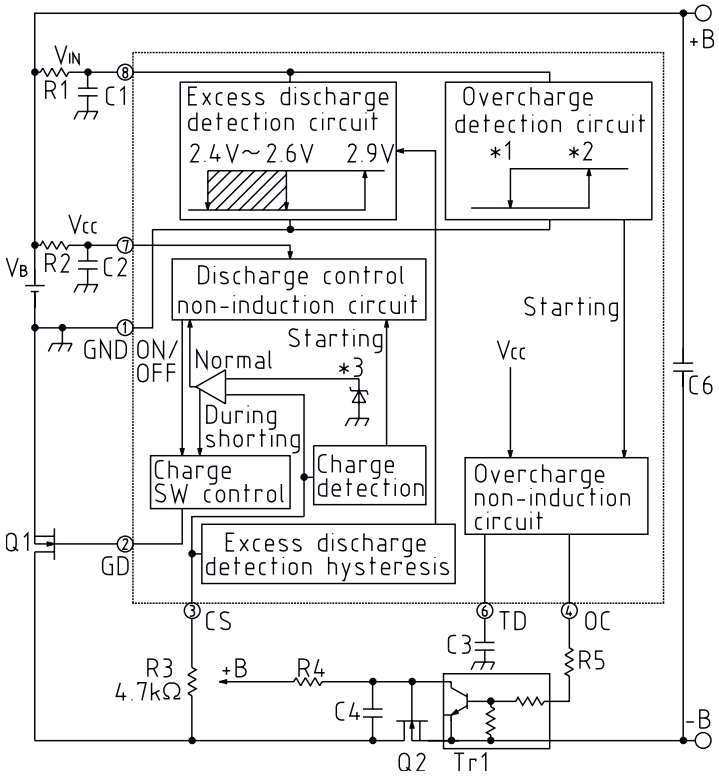
SOP-8C/SOP-8D

1	GND
2	GD
3	CS
4	OC
5	CE
6	TD
7	VCC
8	VIN

Pin Description

Pin No.	NAME	I/O	Description
1	GND	Input	Negative power supply for this IC. Also acts as detection pin for the battery connected between VIN-GND.
2	GD	Output	Nch-FET gate connection pin for discharge control. Switches gate OFF when excess discharge is detected, and for current protection. Switches gate ON when excess discharge is detected in normal state.
3	CS	Input	Detection pin for voltage between CS-GND. Detects excess discharge using Nch-FET (discharge control) ON resistor and discharge current.
4	OC	Output	Control pin for Nch-FET for charge control. Switches FET off by activating an external transistor when excess charging is detected.
5	N.C		
6	TD	Input	This pin sets non-induction time for overcharge detection. It charges the capacitor connected between TD-GND with a fixed current during overcharging.
7	VCC	Input	Positive power supply pin for the IC.
8	VIN	Input	Detection pin for the battery connected between VIN-GND.

Block Diagram

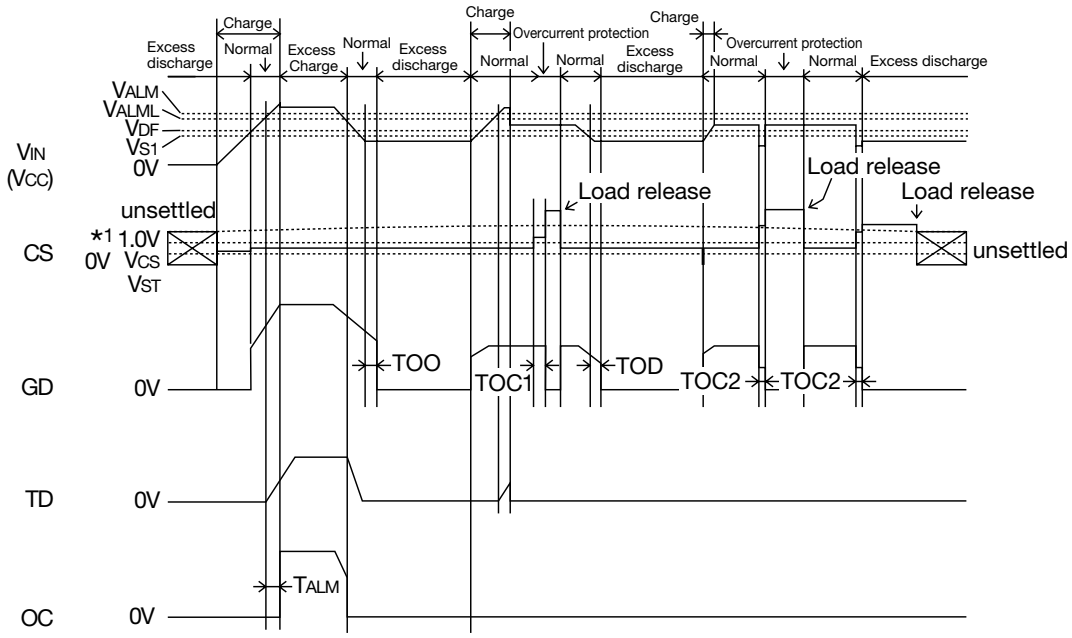


VS indicates average values.

VALML is low due to the effect of R1 linked to the VIN pin.

*1	A : 4.150V	*2	A : 4.350V	*3	A : 0.10V
	B : 4.050V		B : 4.250V		B : 0.10V
	C : 4.073V		C : 4.100V		C : 0.15V

Timing Chart



*1 C only

MM1291AFBE

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Rating	Units
Storage temperature	T_{STG}	–40~+125	°C
Operating temperature	T_{OPR}	–20~+70	°C
Power supply voltage	V_{CC}	–0.3~+18	V
Vcc-OC pin voltage	V_{OC}	–18~0	V
CS pin voltage	V_{CS}	–0.6~V_{CC}	V
Allowable loss	P_D	300	mV

* The CS pin will not cause abnormal operation when connected to protection resistor R_{CS} (=4.7kΩ)

Electrical Characteristics (Unless otherwise specified Ta=25°C, V_{CC}=V_{IN}=3.5V, V_{CS}=0V, Measurement circuit 1, SW1 : a)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Units
1 (Normal mode) (I_{S1}=I_{CC}+I_{IN})	I_{CC1}	V_{CC}=V_{IN}=3.5V		8.0	11.0	µA
Consumption current 2 (Overdischarge mode)	I_{OP2}	V_{CC}=V_{IN}=1.9V		0.7	1.0	µA
Overcharge detection voltage	V_{ALM}	Ta=–20°C~70°C V_{CC}=V_{IN}=4.0V→4.5V V_{OC} : L→H	4.300	4.350	4.400	V
Overcharge reset voltage	V_{ALML}	V_{CC}=V_{IN}=4.5V 4.0V V_{OC} : H→L	4.050	4.150	4.240	V
Overcharge hysteresis voltage	⊿V_{ALM}	V_{OC}–V_{OCR}	150	200	250	mV
Excess discharge detection voltage 1	V_{S1}	V_{CC}=V_{IN}=3.1V→2.0V V_{GD} : H→L, V_{CS}=0V	2.50	2.60	2.70	V
Excess discharge detection voltage 2	V_{S2}	V_{CC}=V_{IN}=3.1V→2.0V V_{CS}=0.05V, V_{GD} : H→L	2.30	2.40	2.50	V
Excess discharge reset voltage	V_{ODR}	V_{CC}=V_{IN}=2.0V→3.1V V_{GD} : L→H	2.78	2.90	3.02	V
Starting voltage	V_{ST}	V_{CC}=V_{IN}=2.75V V_{CS}=0V→–0.5V, V_{GD} : L→H	–0.3	–0.1		V
Overcurrent detection voltage	V_{CS}	V_{CS}=0V→0.12V V_{GD} : H→L	90	100	110	mV
Overcurrent protection release			load release (more than 5 MEG)			
Excess discharge detection non-induction time	t_{OD}	V_{CC}=V_{IN}=3.0V→2.4V, *1 measurement circuit 2, SW1 : b, SW2 : a	5.0	10.0	15.0	mS
Excessive current detection during non-induction time	t_{OC1}	V_{CS}=0V→V_{CS}, *1 measurement circuit 2, SW1 : a, SW2 : b	5.0	10.0	15.0	mS
Overcurrent non-induction time	t_{ALM}	V_{CC}=V_{IN}=4.0V→4.5V, *1 measurement circuit 2, SW1 : b, SW2 : a C_{TD}=0.082µF	0.5	1.0	1.5	S
Operating limit voltage *2	V_{OP}	V_{CC} When V_{GDL2} > 0.4V			1.2	V
GD pin output voltage H	V_{GDH}	V_{CC}=V_{IN}=3.5V	V_{CC} –0.3	V_{CC} –0.1		V
GD pin output voltage L1	V_{GDL1}	V_{CC}=V_{IN}=3.5V, V_{CS}=0.5V		0.1	0.3	V
GD pin output voltage L2	V_{GDL2}	V_{CC}=V_{IN}=1.5V		0.2	0.4	V
OC pin output current	I_{OC}	V_{CC}=V_{IN}=4.5V, SW1 : b			–30	uA

*1 Refer to input waveforms.

*2 Operation is unstable below the operating limit voltage.

MM1291BFBE

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Rating	Units
Storage temperature	T_{STG}	−40~+125	°C
Operating temperature	T_{OPR}	−20~+70	°C
Power supply voltage	V_{CC}	−0.3~+18	V
V_{CC}-OC pin voltage	V_{OC}	−18~0	V
CS pin voltage	V_{CS}	−0.6~V_{CC}	V
Allowable loss	P_D	300	mV

*The CS pin will not cause abnormal operation when connected to protection resistor R_{CS} (=4.7kΩ)

Electrical Characteristics (Unless otherwise specified Ta=25°C, V_{CC}=V_{IN}=3.5V, V_{CS}=0V, Measurement circuit 1, SW1 : a)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Units
1 (Normal mode) (I_{S1}=I_{CC}+I_{IN})	$I_{CC}1$	V_{CC}=V_{IN}=3.5V		10.0	14.0	µA
Consumption current 2 (Overdischarge mode)	$I_{OP}2$	V_{CC}=V_{IN}=1.9V		0.7	1.0	µA
Overcharge detection voltage	V_{ALM}	Ta=−20°C~70°C V_{CC}=V_{IN}=3.9V→4.4V V_{OC} : L→H	4.200	4.250	4.300	V
Overcharge reset voltage	V_{ALML}	V_{CC}=V_{IN}=4.4V→3.9V V_{OC} : H→L	3.950	4.050	4.150	V
Overcharge hysteresis voltage	V_{OCH}	V_{OC}−V_{OCR}	150	200	250	mV
Excess discharge detection voltage 1	V_{S1}	V_{CC}=V_{IN}=3.1V→2.0V V_{GD} : H→L V_{CS}=0V	2.50	2.60	2.70	V
Excess discharge detection voltage 2	V_{S2}	V_{CC}=V_{IN}=3.1V→2.0V V_{CS}=0.05V, V_{GD} : H→L	2.30	2.40	2.50	V
Excess discharge reset voltage	V_{DF}	V_{CC}=V_{IN}=2.0V→3.1V V_{GD} : L→H	2.78	2.90	3.02	V
Starting voltage	V_{ST}	V_{CC}=V_{IN}=2.75V V_{CS} : 0V→−0.5V, V_{GD} : L→H	−0.3	−0.1		V
Overcurrent detection voltage	V_{CS}	V_{CS}=0V→0.12V V_{GD} : H→L	90	100	110	mV
Overcurrent protection release			load release (more than 5 MEG)			
Excess discharge detection non-induction time	t_{OD}	V_{CC}=V_{IN}=3.0V→2.4V, *1 measurement circuit 2, SW1 : b, SW2 : a	5.0	10.0	15.0	mS
Excessive current detection during non-induction time	$t_{OC}1$	V_{CS}=0V→V_{CS}, *1 measurement circuit 2, SW1 : a, SW2 : b	5.0	10.0	15.0	mS
Overcurrent non-induction time	t_{ALM}	V_{CC}=V_{IN}=4.0V→4.5V, *1 measurement circuit 2, SW1 : b, SW2 : a C_{TD}=0.082µF	0.5	1.0	1.5	S
Operating limit voltage *2	V_{OP}	V_{CC} When $V_{GDL}2$ > 0.4V			1.2	V
GD pin output voltage H	V_{GDH}	V_{CC}=V_{IN}=3.5V	V_{CC} −0.3	V_{CC} −0.1		V
GD pin output voltage L1	$V_{GDL}1$	V_{CS} > 1.0V		0.1	0.3	V
GD pin output voltage L2	$V_{GDL}2$	V_{CC}=V_{IN}=3.5V, V_{CS}=0.5V		0.2	0.4	V
OC pin output current	I_{OC}	V_{CC}=V_{IN}=4.5V, SW1 : b			−30	uA

*1 Refer to input waveforms.

*2 Operation is unstable below the operating limit voltage.

MM1291CFBE

Absolute Maximum Ratings (Ta=25°C)

Item	Symbol	Rating	Units
Storage temperature	T_{STG}	−40~+125	°C
Operating temperature	T_{OPR}	−20~+70	°C
Power supply voltage	V_{CC}	−0.3~+18	V
Vcc-OC pin voltage	V_{OC}	−18~0	V
CS pin voltage	V_{CS}	−0.6~V_{CC}	V
Allowable loss	P_D	300	mV

* The CS pin will not cause abnormal operation when connected to protection resistor R_{CS} (=4.7k Ω)

Electrical Characteristics (Unless otherwise specified Ta=25 °C, V_{CC}=V_{IN}=3.5V, V_{CS}=0V, Measurement circuit 1, SW1 : a)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Units
Current consumption 1 (V_{CC} pin)	I_{CC1}	V_{CC}=4.5V		40	60	µA
Current consumption 2 (V_{CC} pin)	I_{CC2}	V_{CC}=3.5V		8.0	11.0	µA
Current consumption 1 (V_{IN} pin)	I_{IN1}	V_{IN}=4.5V		3.0	5.0	µA
Current consumption 2 (V_{IN} pin)	I_{IN2}	V_{IN}=3.5V		2.0	3.0	µA
Current consumption 3 (V_{CC}, V_{IN} pins)	I_{OP3}	V_{CC}=V_{IN}=1.9V		0.7	1.0	µA
Current consumption 4 (V_{CC}, V_{IN} pins)	I_{OP4}	V_{CC}=V_{IN}=1.0V			0.17	µA
Overcharge detection voltage	V_{ALM}	Ta=−20°C~70°C V_{CC}=V_{IN}=4.0V→4.2V V_{CC} : L→H	4.050	4.100	4.150	V
Overcharge reset voltage	V_{ALML}	V_{CC}=V_{IN}=4.2V→4.0V V_{OC} : H→L	4.018	4.075	4.128	V
Overcharge hysteresis voltage	⊿V_{ALM}	V_{ALM}−V_{ALML}	18	25	32	mV
Excess discharge detection voltage 1	V_{S1}	V_{CC}=V_{IN}=3.1V→2.0V V_{GD} : H→L	2.50	2.60	2.70	V
Excess discharge detection voltage 2	V_{S2}	V_{CC}=V_{IN}=3.1V→2.0V V_{CS}=0.05V, V_{GD} : H→L	2.30	2.40	2.50	V
Excess discharge reset voltage	V_{DF}	V_{CC}=V_{IN}=2.0V→3.1V V_{GD} : L→H	2.78	2.90	3.02	V
Starting voltage	V_{ST}	V_{CC}=V_{IN}=2.75V V_{CS}=0V→−0.5V, V_{GD} : L→H	−0.3	−0.1		V
Overcurrent detection voltage	V_{CS}	V_{CS}=0V→0.17V V_{GD} : H→L	135	150	165	mV
Overcurrent protection release			load release (more than 5 MEG)			
Excess discharge detection non-induction time	t_{OD}	V_{CC}=V_{IN}=3.0V→2.4V, *1 measurement circuit 2, SW1 : b, SW2 : a	5.0	10.0	15.0	mS
Excessive current detection during non-induction time	t_{OC1}	V_{CS}=0V→V_{CS}, *1 measurement circuit 2, SW1 : a, SW2 : b	5.0	10.0	15.0	mS
Overcurrent detection delay	t_{OC2}	V_{CS}=0V→1.0V, *1 measurement circuit 2, SW1 : b, SW2 : a			100	µS
Overcurrent non-induction time	t_{ALM}	V_{CC}=V_{IN}=4.0V→4.5V, *1 measurement circuit 2, SW1 : b, SW2 : a C_{TD}=0.082µF	0.5	1.0	1.5	S
Operating limit voltage *2	V_{OP}	V_{CC} When V_{GDL2} > 0.4V			1.2	V
GD pin output voltage H	V_{GDH}		V_{CC} −0.3	V_{CC} −0.1		V
GD pin output voltage L1	V_{GDL1}	V_{CS} > 1.0V		0.1	0.3	V
GD pin output voltage L2	V_{GDL2}	V_{CC}=V_{IN}=1.5V		0.2	0.4	V
OC pin output current	I_{OC}	V_{CC}=V_{IN}=4.5V, SW1 : b			−30	uA

*1 Refer to input waveforms.

*2 Operation is unstable below the operating limit voltage.