

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	Hysteresis	Dead time	Overdischarge detection	Release voltage	Delay	Overcurrent detection		
SOP-8	VSOP-8	voltage						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		★ 2.6V 2.4V	2.9V		100mV		No
EF		4.35V	27mV	min. 0.5S	★ 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 40 μA typ.	V_{IN} pin 3 μA typ.
2. Current consumption (normal)	$V_{CC}=3.5V$	V_{CC} pin 7 μA typ.	V_{IN} pin 2 μA typ.
3. Current consumption (during excess discharge)	$V_{CC}=1.9V$	0.7 μA typ.	
4. Consumption current (during excess discharge)	$V_{CC}=1.0V$	0.17 μA max.	
5. Overcharge detection voltage ($T_a=-20^{\circ}C\sim+70^{\circ}C$)		A 4.35V $\pm$ 50mV B 4.25V $\pm$ 50mV C 4.10V $\pm$ 50mV	
6. Overcharge detection hysteresis		A 200mV typ. B 200mV typ. C 27mV typ.	
7. Overcharge non-induction time	$C_{TD}=0.082\mu F$	1S typ.	
8. Excess discharge voltage 1	$V_{CS}=0V$	2.6V $\pm$ 0.1V	
9. Excess discharge voltage 2	$V_{CS}=0.05V$	2.4V $\pm$ 0.1V	
10.Excess discharge reset voltage		2.9V $\pm$ 0.12V	
11.Excess discharge during non-induction		10mS typ.	
12.Overcurrent detection voltage		A 100mV $\pm$ 10mV B 100mV $\pm$ 10mV C 150mV $\pm$ 15mV	
13.Reset after overcurrent detection		load release	
14.Overcurrent detection non-induction time		10mS typ.	

Package

SOP-8C, SOP-8D (MM1291□F)

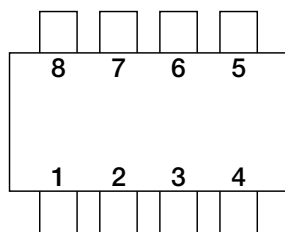
VSOP-8A (MM1291□W)

*The box represents the rank resulting from the combination of protection functions.

Applications

- Cellular phones
- PHS
- MD
- others

Pin Assignment



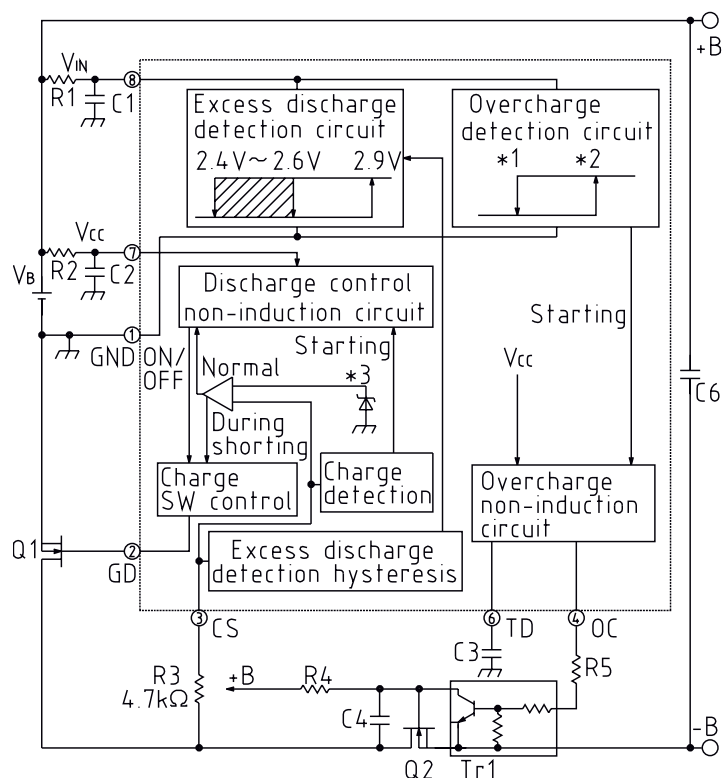
SOP-8C/SOP-8D

1	GND
2	GD
3	CS
4	OC
5	CE
6	TD
7	V _{CC}
8	V _{IN}

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 V _{IN} -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	V _{CC}	Input	Positive power supply pin for the IC.
8	V _{IN}	Input	Detection pin for the battery connected between V _{IN} -GND.

Block Diagram

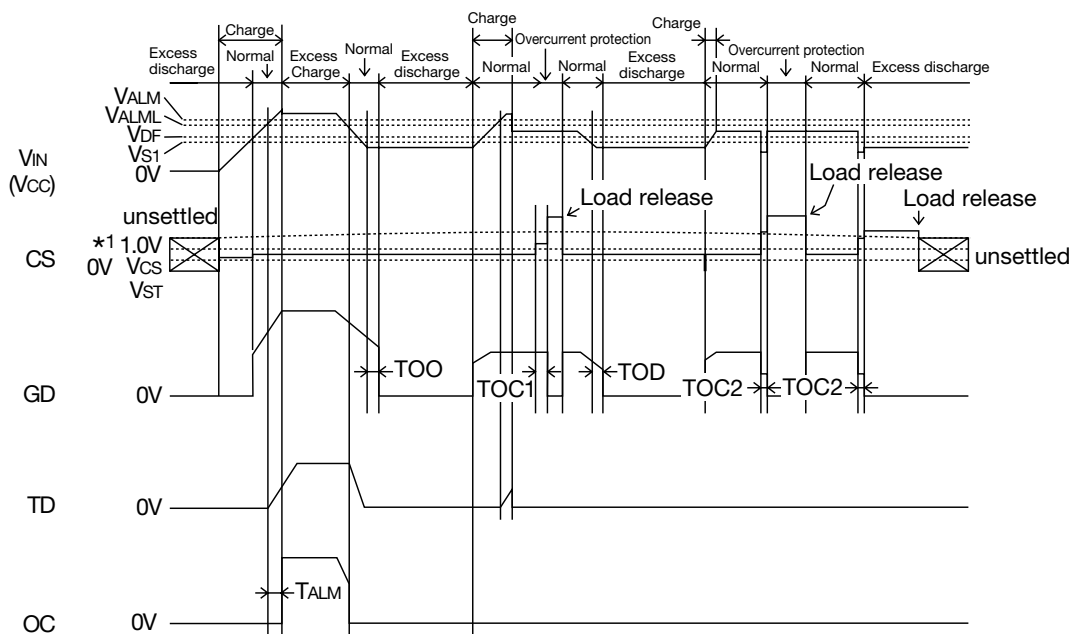


V_s indicates average values.

V_{ALML} is low due to the effect of $R1$ linked to the V_{IN} 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
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 _{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	ΔV _{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 _{GDLH}	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 _{CC1}	V _{CC} =V _{IN} =3.5V		10.0	14.0	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} =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 _{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 _{GDLH}	V _{CC} =V _{IN} =3.5V	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} =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
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} (=4.7k 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	ΔV _{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 _{GD} L2 > 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 _{GD} L1	V _{CS} > 1.0V		0.1	0.3	V
GD pin output voltage L2	V _{GD} L2	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.