

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		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)

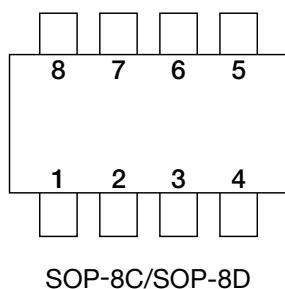
VSOP-8A (MM1291□W)

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

Applications

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

Pin Assignment



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.

The diagram illustrates the internal architecture of the TP1 battery protection IC. Key components and their connections are as follows:

- Power and Control Pins:**
 - Pin 8:** VIN, connected to the positive battery terminal (+B) through resistor R1 and capacitor C1.
 - Pin 7:** Vcc, connected to the positive battery terminal (+B) through resistor R2 and capacitor C2.
 - Pin 1:** GND, connected to the negative battery terminal (-B).
 - Pin 2:** GD, connected to the negative battery terminal (-B) through transistor Q1.
- Internal Functional Blocks:**
 - Excess discharge detection circuit:** Monitors the battery voltage. It includes a shaded region representing a voltage range from 2.4V to 2.6V and a 2.9V threshold. It is connected to pins 8 and 7.
 - Overcharge detection circuit:** Monitors for overcharge conditions. It has two outputs, *1 and *2, connected to pins 8 and 7 respectively.
 - Discharge control non-induction circuit:** Controls the discharge process. It has inputs for 'Normal' and 'Starting' and is connected to pins 8 and 7.
 - Charge SW control:** Controls the charging switch. It has inputs for 'During shorting' and 'Starting' and is connected to pins 8 and 7.
 - Charge detection:** Detects charging status. It is connected to pins 8 and 7.
 - Excess discharge detection hysteresis:** Provides hysteresis for the excess discharge detection. It is connected to pins 8 and 7.
 - Overcharge non-induction circuit:** Controls the overcharge non-induction process. It has inputs for 'Starting' and 'Vcc' and is connected to pins 8 and 7.
- Output and Protection Components:**
 - CS (Pin 3):** Connected to the positive battery terminal (+B) through resistor R3 (4.7kΩ).
 - TD (Pin 6):** Connected to the positive battery terminal (+B) through resistor R4.
 - OC (Pin 4):** Connected to the positive battery terminal (+B) through resistor R5.
 - Q2:** A PNP transistor used for discharge control, connected to the positive battery terminal (+B) and the negative battery terminal (-B).
 - TP1:** The main protection IC, connected to the positive battery terminal (+B) and the negative battery terminal (-B).
 - C4:** A capacitor connected to the negative battery terminal (-B).
 - C6:** A capacitor connected to the positive battery terminal (+B).

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

The timing diagram illustrates the behavior of the ADXL345 under various conditions. The signals shown are:

- V_{IN} (V_{CC})**: Power supply voltage. It shows transitions between 'Excess discharge', 'Normal', 'Charge', and 'Overcurrent protection' states. Labels include VALM, VALML, VDF, VS1, and OV.
- CS**: Chip select. It shows a sequence of operations, including 'Load release' and 'unsettled' states. The signal is labeled with *1, 1.0V, VCS, and VST.
- GD**: General data output. It shows the output data, with labels for TOO, TOC1, TOD, TOC2, and TALM.
- TD**: Data output. It shows the output data, with labels for TOO, TOC1, TOD, TOC2, and TALM.
- OC**: Output compare. It shows the output compare signal, with labels for TOO, TOC1, TOD, TOC2, and TALM.

The diagram also includes labels for 'Charge', 'Overcurrent protection', 'Excess discharge', and 'Normal' states, indicating the device's response to different power and load conditions.

***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	mW

* 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 _{GD1} > 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 _{GD1}	V _{CC} =V _{IN} =3.5V, V _{CS} =0.5V		0.1	0.3	V
GD pin output voltage L2	V _{GD2}	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	μA

*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	mW

*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	μA

*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	mW

* 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.