ACEDW01

One Cell Lithium-ion/Polymer Battery Protection IC

Description

This protection IC was developed for use with lithium-ion/lithium polymer 1-cell serial batteries.

It detects overcharge, overdischarge, discharge overcurrent and other abnormalities, and functions to protect the battery by turning off the external MOSFET.

The IC also has a built-in timer circuit (for detection delay times), so fewer external parts can be used in protection circuit configuration.

Features

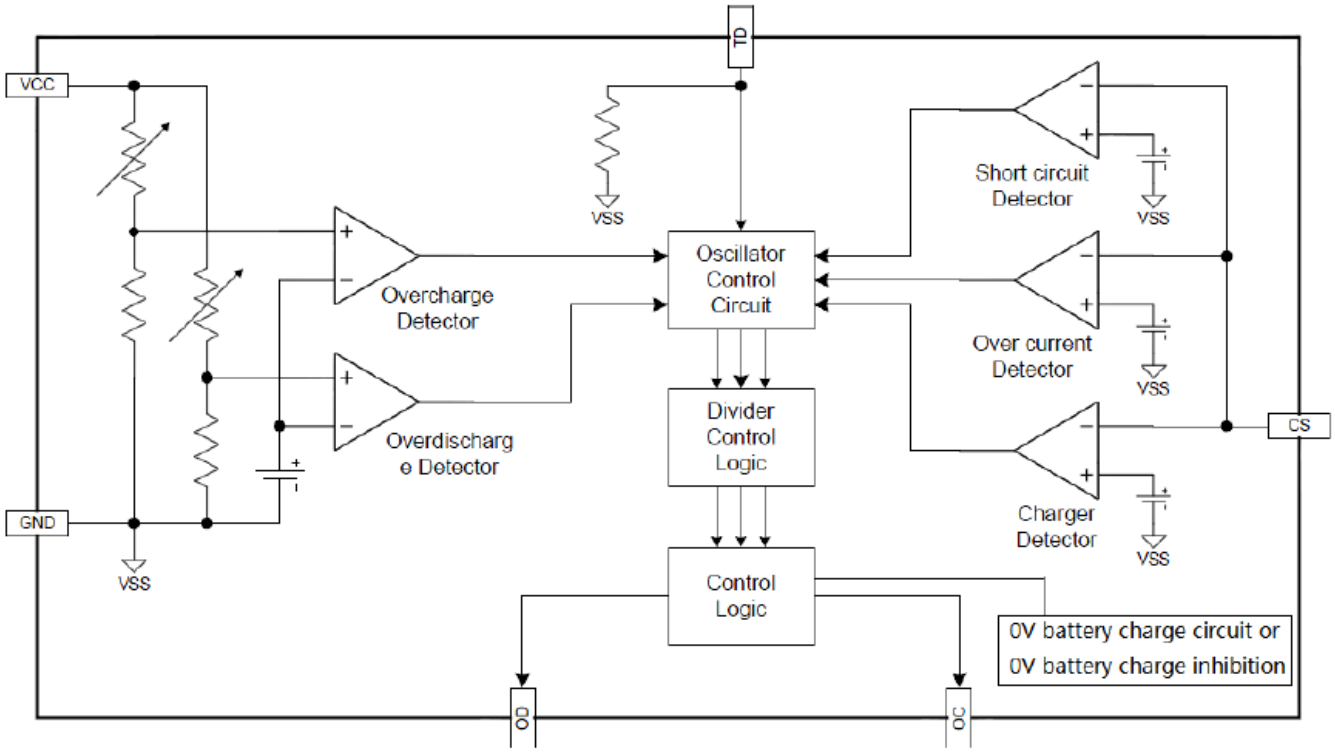
1. High-accuracy voltage detection circuit
- Overcharge detection voltage 4.200 to 4.400V Accuracy: ±50Mv
- Overcharge release voltage 3.900 to 4.400V Accuracy: ±50mV
- Overdischarge detection voltage 2.30 to 3.00V Accuracy: ±100mV
- Overdischarge release voltage 2.30 to 3.40V Accuracy: ±100mV
- Discharge overcurrent detection voltage 150mV Accuracy: ±100mV
- Short-circuiting detection voltage 1.35V Accuracy: ±100mV

2. Delay times are generated by an internal circuit (external capacitors are unnecessary).
- Overcharge delay time 100ms typ.
- Overdischarge delay time 50ms typ.
- Discharge overcurrent delay time 10ms typ.
- Charge overcurrent detection voltage 10ms typ.
- Short circuit delay time 5μs typ.

3. Power-down function “Yes” / No” are selectable (See Model List).
4. Auto overdischarge recovery function “Yes” / “No” are selectable (See Model List).
5. Low current consumption
- Operation mode 3.0μA typ., 6.0μA max. (VCC=3.9V)
- Power-down mode 0.1μA max. (VCC=2.0V)
- Auto overdischarge mode 2.0μA max. (VCC=2.0V)

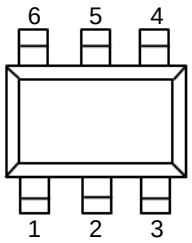
6. 0 V battery charge function “available” / “unavailable” are selectable (See Model List).
7. operation temperature range -40℃~+85℃

Block Diagram



Packaging Type

SOT-23-6



SOT-23-6	Symbol	Direction	Function
1	OD	O	MOSFET gate connection pin for discharge control
2	CS	I	Input pin for current sense, charger detect
3	OC	O	MOSFE gate connection pin for charge control
4	TD	I	Test pin for reduce delay time
5	VCC	-	Power supply, through a resistor (R1)
6	GND	-	Ground pin

Ordering Information

ACEDW01XX + H

- H: Halogen - free
- +: Pb - free
- XX: GM : SOT-23-6

Model list

Over charge detection voltage	Over charge release voltage	Over discharge detection voltage	Over discharge release voltage	OV battery charge function	Other function
VOCP	**VOCR**	**VODP**	**VODR**	**V0V**	**-**
4.30V	4.10V	2.40V	3.00V	Available	Auto overdischarge recovery function

Function

Normal Status

This IC monitors the voltage of the battery connected between the VCC pin and GND pin and the voltage difference between the CS pin and GND pin to control charging and discharging.

When the battery voltage is in the range from overdischarge detection voltage (VODP) to overcharge detection voltage (VOCP), and the CS pin voltage is in the range from the charger detection voltage (VCH) to discharge overcurrent detection voltage (VOI1), the IC turns both the charging and discharging control MOSFET on. This condition is called the normal status.

Under this condition, charging and discharging can both be carried out freely.

Caution: Discharging may not be enacted when the battery is first time connected. To regain normal status, CS and GND pin must be shorted or the charger must be connected.

Overcharge Protection

When the voltage of the battery cell exceeds the overcharge protection voltage (VOCP) beyond the overcharge delay time (TOC) period, charging is inhibited by turning off of the charge control MOSFET. The overcharge condition is released in two cases:

1. The voltage of the battery cell becomes lower than the overcharge release voltage (VOCR) through self-discharge.
2. The voltage of the battery cell falls below the overcharge protection voltage (VOCP) and a load is connected.

When the battery voltage is above VOCP, the overcharge condition will not release even a load is connected to the pack.

Overdischarge Status

1. Products with Power-down Function

When the battery voltage falls below than the overdischarge detection voltage (VODR) during discharging in the normal status and the detection continues longer than the overdischarge detection delay time (TOD), the ACEDW01 series will turn the discharging control MOSFET off(OD pin) so as to stop discharging. This condition is called the overdischarge status.

When the MOSFET is off, CS pin voltage is pulled up by the resistor to VCC in the IC, at this time; the power consumption is reduced to the lowest. This condition is called the "SLEEP MODE".

The overdischarge status will be released by two cases:

A. When CS pin voltage is equal to or lower than the charge overcurrent detection voltage (VCIP) by charging and the VCC pin voltage is higher than the overdischarge detection voltage (VODR).
B. When CS pin voltage is equal to or higher than the charge overcurrent detection voltage (VCIP) by charging and the VCC pin voltage is higher than the overdischarge release voltage (VODR).

2. Products with Auto Overdischarge Recovery Function

When the battery voltage falls below than the overdischarge detection voltage (VODP) during discharging in the normal status and the detection continues longer than the overdischarge detection delay time (TOD), the ACEDW01 series will turn the discharging control MOSFET off(OD pin) so as to stop discharging. This condition is called the overdischarge status.

The overdischarge status will be released by three cases:

A. When CS pin voltage is equal to or lower than the charge overcurrent detection voltage (VCIP) by charging and the VCC pin voltage is higher than the overdischarge detection voltage (VODP).
B. When CS pin voltage is equal to or higher than the charge overcurrent detection voltage (VCIP) by charging and the VCC pin voltage is higher than the overdischarge release voltage (VODR).
C. Without connecting a charger, if the VCC pin voltage is higher than overdischarge release voltage (VODR), the overdischarge status will be released, namely Auto Overdischarge Recovery Function.

Overcurrent Protection

In normal mode, the ACEDW01 continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent protection voltage (VOI1) beyond the overcurrent delay time (TOI1) period, the overcurrent protection circuit operates and discharging is inhibited by turning off the discharge control MOSFET. The overcurrent condition returns to the normal mode when the load is released or the impedance between BATT+ and BATT － is larger than 500KΩ. The ACEDW01 provides two overcurrent detection levels (0.15V and 1.35V) with two overcurrent delay time (TOI1 and TOI2) corresponding to each overcurrent diction level.

Charge Detection after Overdischarge

When overdischarge occurs, the discharge control MOSFET turns off and discharging is inhibited. However, charging is still permitted through the parasitic diode of MOSFET. Once the charger is connected to the battery pack, the ACEDW01 immediately turns on all the timing generation and detection circuitry. Charging progress is sensed if the voltage between CS and GND is below charge detection threshold voltage (VCH).

Charge Overcurrent Status

When a battery is in the normal status, the voltage of the CS pin is lower than the charge overcurrent detection voltage (VCIP). When the charge current is higher than the specified value and the status lasts beyond the charge overcurrent detection delay time (TCIP), the charge control MOSFET will be turned off and charging is stopped. This status is called the charge overcurrent status.

This IC will be restored to the normal status from the charge overcurrent status when the voltage at the CS pin returns to charge overcurrent detection voltage (VCIP) or higher by removing the charger.

0V Battery Charging Function "Available"

This function is used to recharge a connected battery which voltage is 0V due to self-discharge. When the 0V battery charge starting charger voltage (V0V) or a higher voltage is applied between the battery+ (BATT+) and battery- (BATT-) pins by connecting a charger, the charging control MOSFET gate is fixed to the VCC pin voltage. When the voltage between the gate and the source of the charging control MOSFET becomes equal to or higher than the turn on voltage due to the charger voltage, the charging control MOSFET is turned on to initiate charging. At this time, the discharging control MOSFET is off and the charging current flows through the internal parasitic diode In the discharging control MOSFET. When the battery voltage becomes equal to or higher than overdischarge detection voltage (VODP), the ACEDW01 series will enter into the normal status.

Caution

A. Some battery providers do not recommend charging for a completely self-discharged battery. Please ask the battery provider to determine whether to enable or prohibit the 0V battery charging function.

B. The 0V battery charge function has higher priority than the charge overcurrent detection function. Consequently, a product in which use of the 0V battery charging function is enabled to forcibly charge a battery and the charge current cannot be detected when the battery voltage is lower than overdischarge detection voltage (VODP).

0V Battery Charging Function "Unavailable"

When a battery that is internally short-circuited (0V battery) is connected, the unavailable 0V charging function will prohibit recharging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V0IN) or lower, the charging control MOSFET gate is fixed to the BATT- pin voltage to prohibit charging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V0IN) or higher, charging can be implemented.

Caution

A. Some battery providers do not recommend charging for a completely self-discharged battery. Please ask the battery provider to determine whether to enable or prohibit the 0V battery charging function.

Selection of External Control MOSFET

Because the overcurrent protection voltage is preset, the threshold current for overcurrent detection is determined by the turn-on resistance of the charge and discharge control MOSFETs. The turn-on resistance of the external control MOSFETs can be determined by the equation: RON=VOI1/(2*IT) (IT is the overcurrent threshold current). For example, if the overcurrent threshold current IT is designed to be 3A, the turn-on resistance of the external control MOSFET must be 25mΩ. Be aware that turn-on resistance of the MOSFET changes with temperature variation due to heal dissipation. It changes with the voltage between gate and source as well. (Turn-on resistance of MOSFET increases as the voltage between gate and source decreases). As the turn-on resistance of the external MOSFET changes, the design of the overcurrent threshold current changes accordingly.

Suppressing the Ripple and Disturbance form Charger

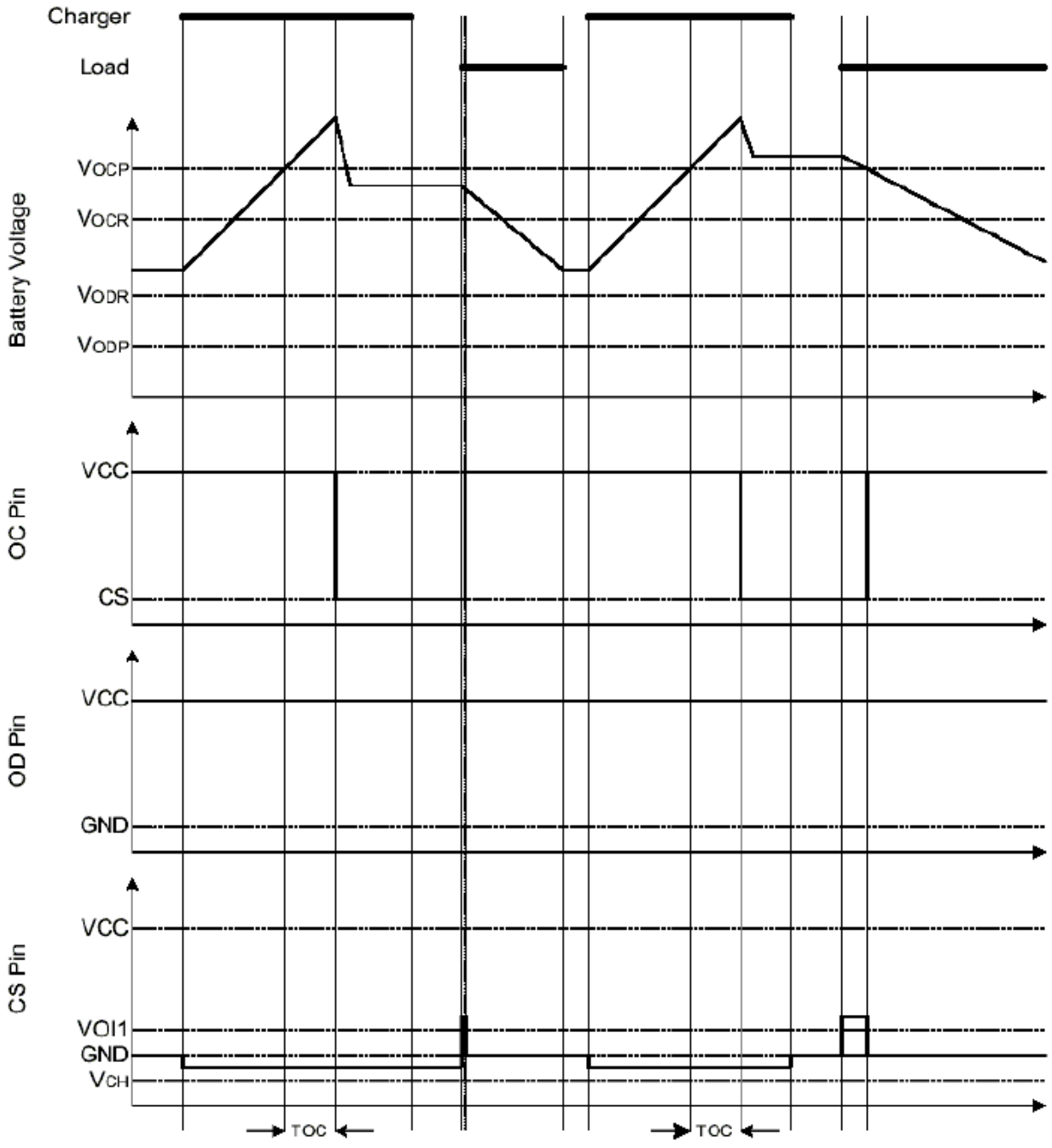
To suppress the ripple and disturbance from charger, connection R1 and C1 to VCC is recommended.

Protection the CS pin

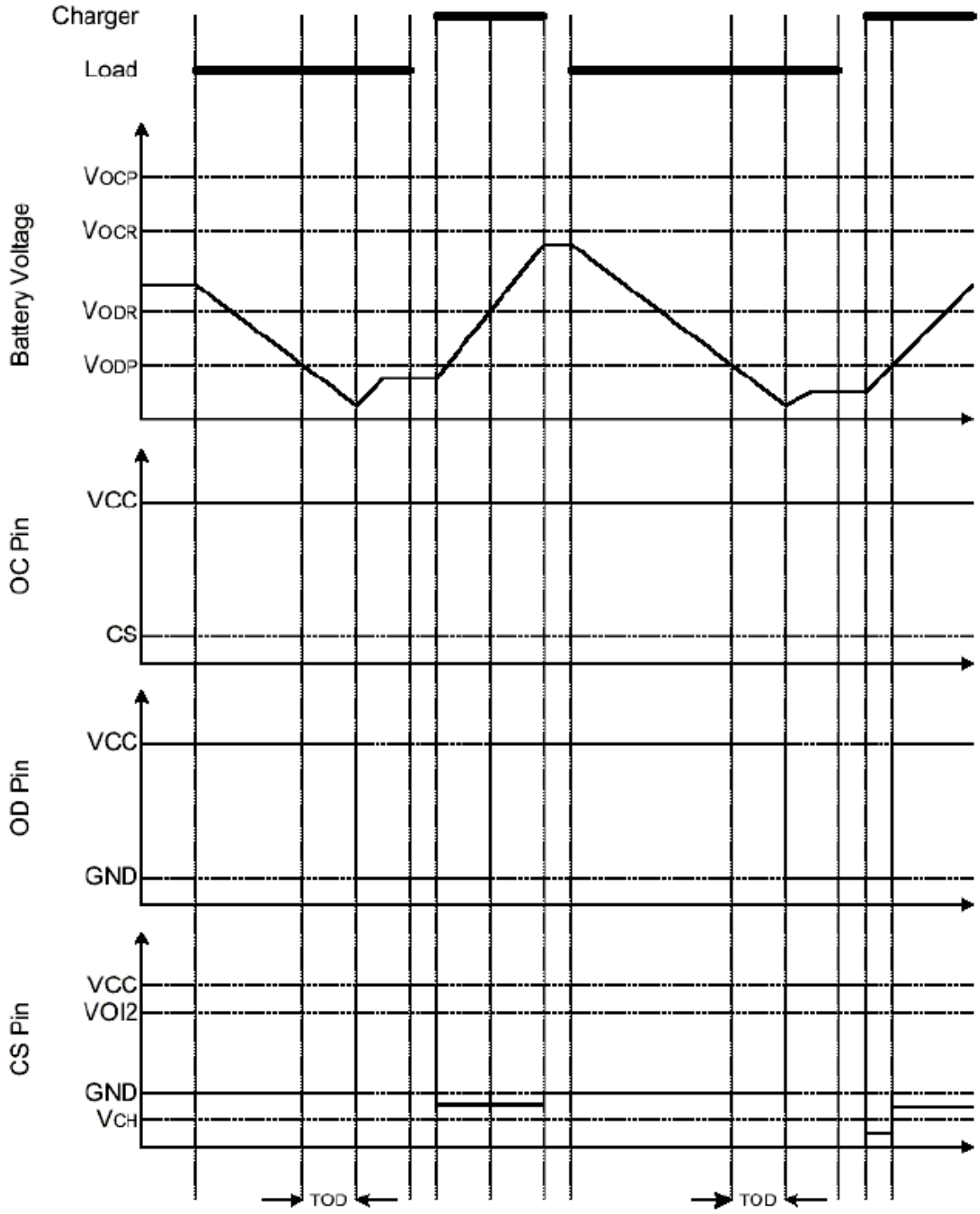
R2 is used for latch-up protection when charger is connected under overdischarge condition and overstress protection at reverse connection of a charger.

Timing Diagram

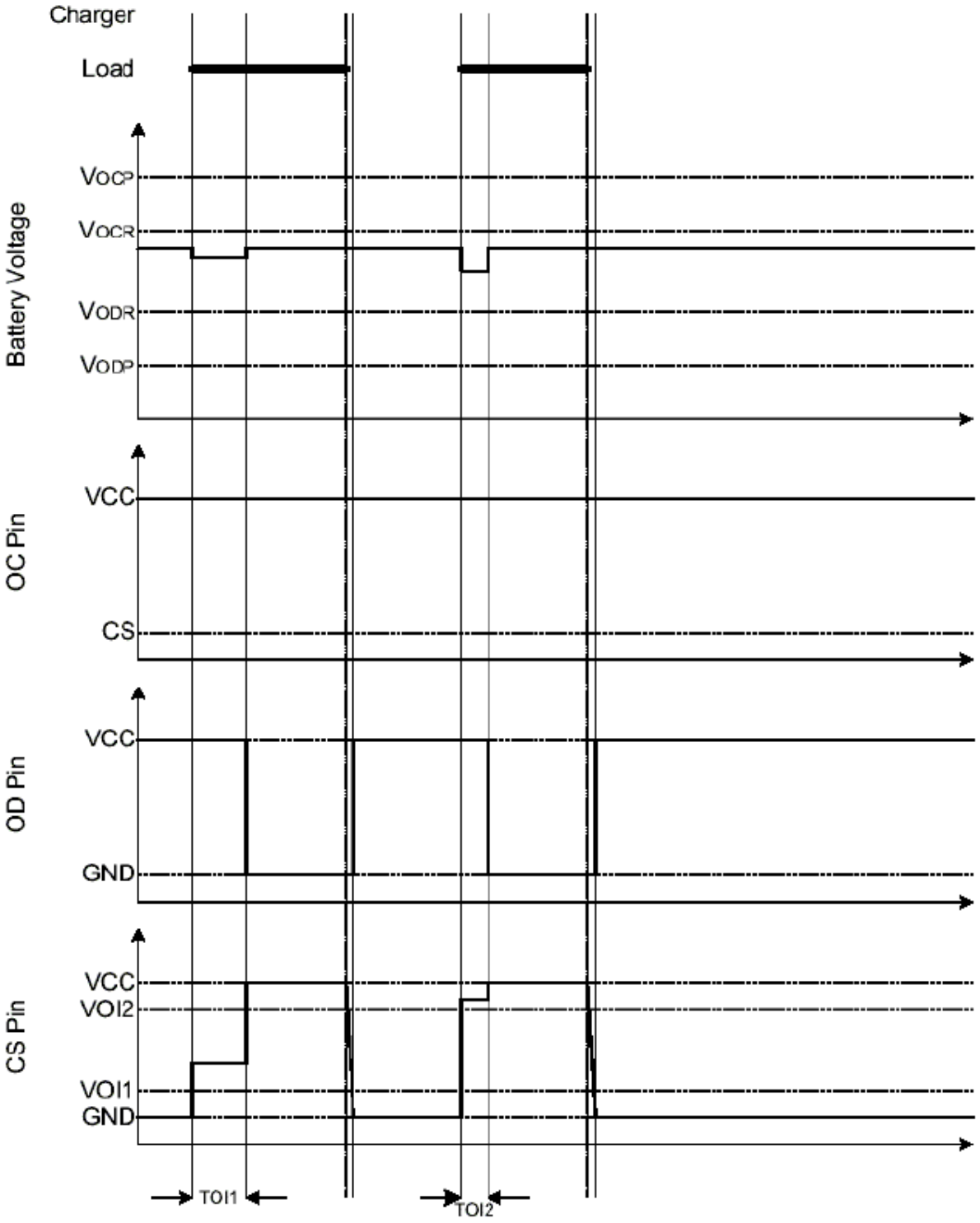
Overcharge Condition → Load Discharging → Normal Condition



Overdischarge Condition → Charging by a Charger → Normal Condition



Over Current Condition → Normal Condition



Absolute Maximum Ratings

(GND=0V, Temperature=25℃ unless otherwise specified)

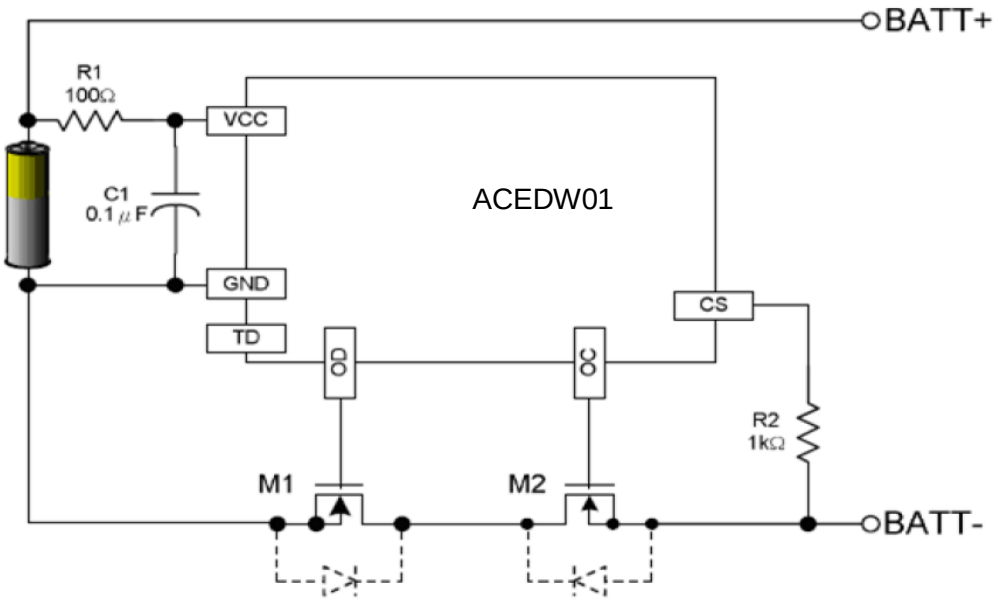
Item	Symbol	Rating	Unit
Input voltage between VCC and GND	VCC	GND-0.3 to GND+10	V
OC output pin voltage	VOC	VCC-14 to VCC+0.3	V
OD output pin voltage	VOD	GND-0.3 to VCC+0.3	V
CS input pin voltage	VCS	VCC-14 to VCC+0.3	V
Operating temperature range	TOP	-40 to +85	℃
Storage temperature range	TST	-40 to +125	℃

Electrical Characteristics

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Supply Current	VCC=3.9V	ICC		3	6.0	uA
Power-Down Current	VCC=2.0V	IPD		0.1	0.6	uA
Auto Overdischarge Recovery Current	VCC=2.0V	IOD		2.0	3.0	uA
Overcharge Protection Voltage	4.2~4.4V Adjustable	VOCP	VOCP-0.05	VOCP	VOCP+0.05	V
Overcharge Hysteresis Voltage	3.9~4.4V Adjustable	VOCR	VOCR-0.05	VOCR	VOCR+0.05	V
Overdischarge Protection Voltage	2.3~3.0V Adjustable	VODP	VODP-0.1	VODP	VODP+0.1	V
Overdischarge Release Voltage	2.3~3.4V Adjustable	VODR	VODR-0.1	VODR	VODR+0.1	V
Overcurrent Protection Voltage		VOI1	120	150	180	mV
Short Current Protection Voltage	VCC=3.6V	VOI2	1.05	1.35	1.65	V
Overcharge Delay Time		TOC		100	200	ms
Overdischarge Delay Time	VCC=3.6V to 2.0V	TOD		50	100	ms
Overcurrent Delay Time(1)	VCC=3.6V	TOI1		10	20	ms
Overcurrent Delay Time(2)	VCC=3.6V	TOI2		5	50	us

Charge Overcurrent Delay Time	VCC=3.6V, CS=-1.2V	TCIP		10	20	ms
Load Detection Threshold Voltage		VLD		0.15	0.18	V
Charger Detection Threshold Voltage		VCH	-1.2	-0.7	-0.2	V
Charge overcurrent detection voltage		VCIP	-1.2	-0.7	-0.2	V
OD Pin Output “ H ” Voltage		VODH	VCC-0.1	VCC-0.02		V
OD Pin Output “ L ” Voltage		VODL		0.1	0.5	V
OC Pin Output “ H ” Voltage		VOCH	VCC-0.1	VCC-0.02		V
OC Pin Output “ L ” Voltage		VOCL		0.1	0.5	V
0V battery charge Starting charger voltage	0V battery charging Function “available”	VOV	1.2			V
0V battery charge Inhibition charger voltage	0V battery charging Function “unavailable”	V0IN			0.5	V

Typical Application Circuit

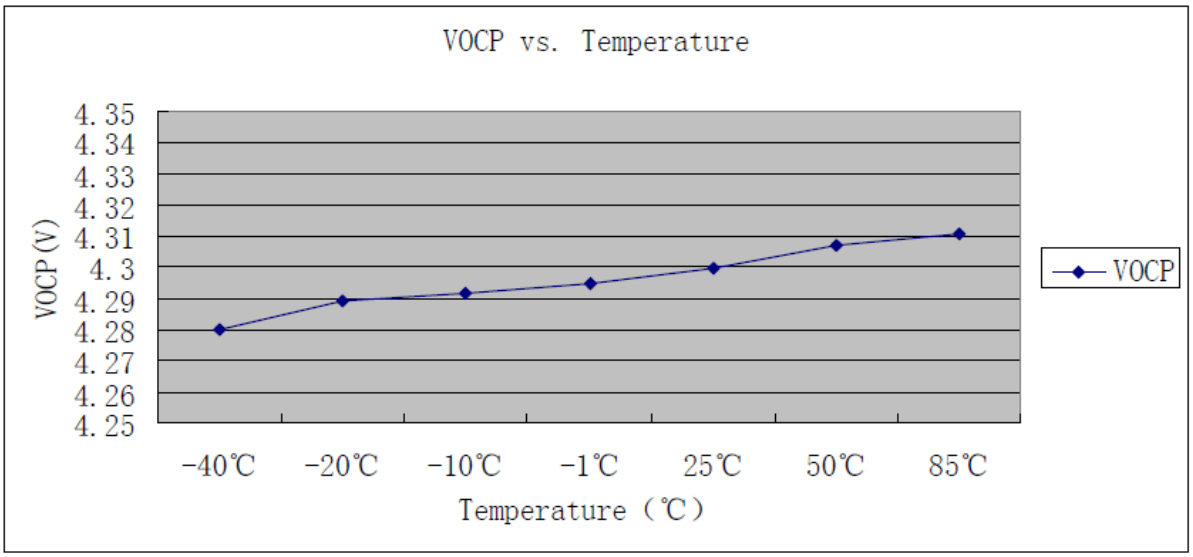


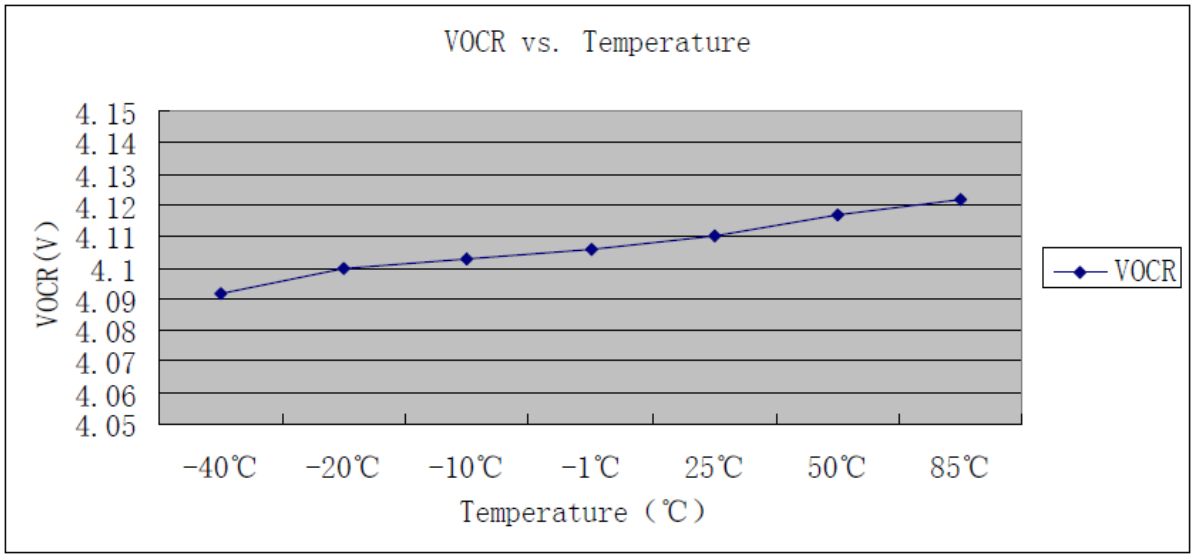
Symbol	Device Name	Purpose	Min	Typ	Max	Remark
R1	Resistor	Limit current, stabilize VCC and Strengthen ESD protection	100Ω	100Ω	100Ω	(1)
R2	Resistor	Limit current	1KΩ	1KΩ	1KΩ	(2)
C1	Capacitor	Stabilize VCC	0.01uF	0.01uF	0.01uF	(3)
M1	N-MOSFET	Discharge control				(4)
M2	N-MOSFET	Charge control				(5)

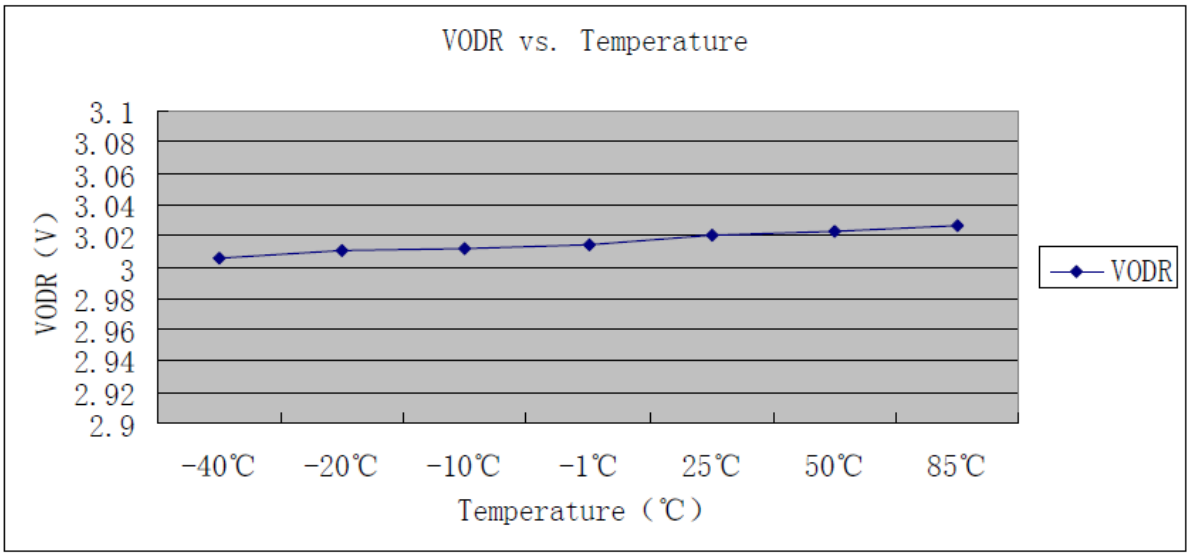
Note:

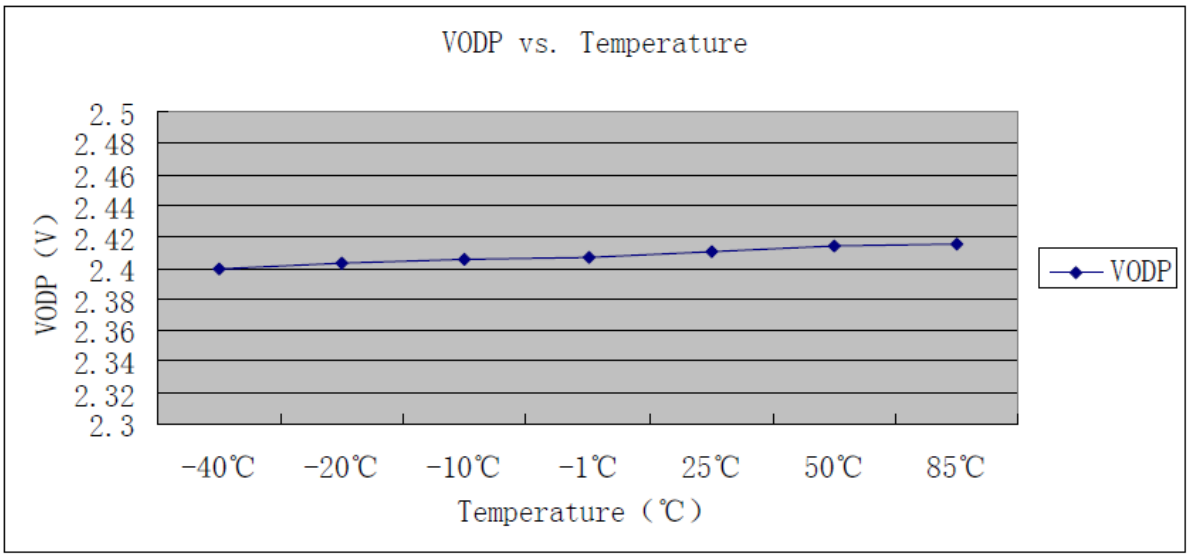
1. R1 should be as small as possible to avoid lowering the overcharge detection accuracy due to current consumption. When a charger is connected in reversed, the current flows from the charger to the IC. At this time, if R1 is connected to high resistance, the voltage between VCC pin and VSS pin may exceed the absolute maximum rating.
2. If R2 has a resistance higher than 2kΩ, the charging current may not be cut when a high-voltage charger is connected. Please select as large a resistance as possible to prevent current when a charger is connected in reversed.
3. C1 will stabilize the supply voltage of VCC，the value of C1 should be equal to or more than 0.01μF.
4. If a NMOSFET with a threshold voltage equal to or higher than the overdischarge detection voltage is applied, discharging may be stopped before overdischarge is detected.
5. If the withstanding voltage between the gate and source is lower than the charger voltage, the FET may be destroyed.

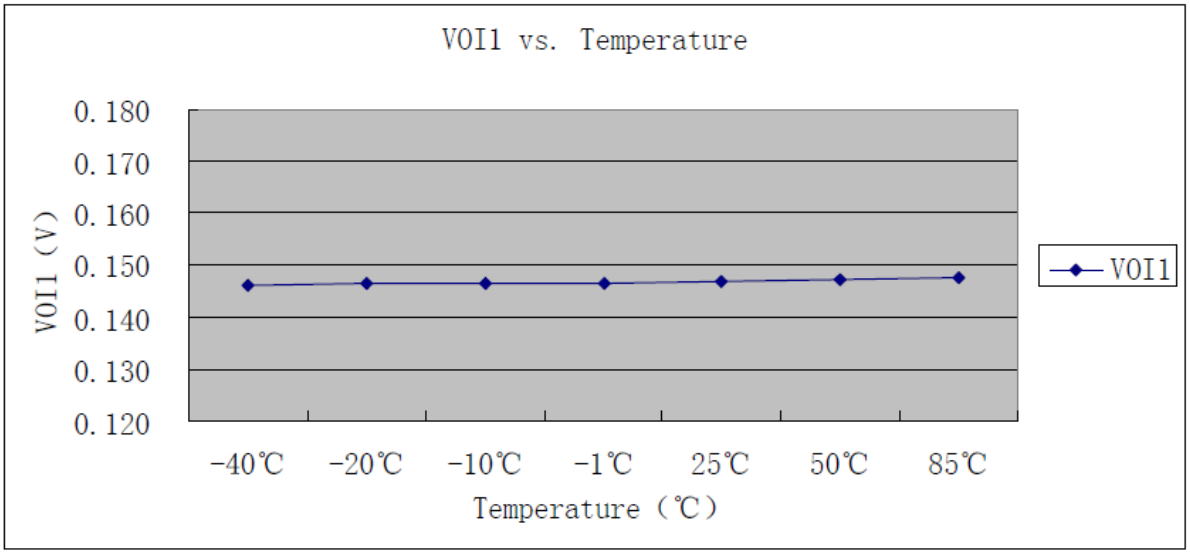
Characteristics

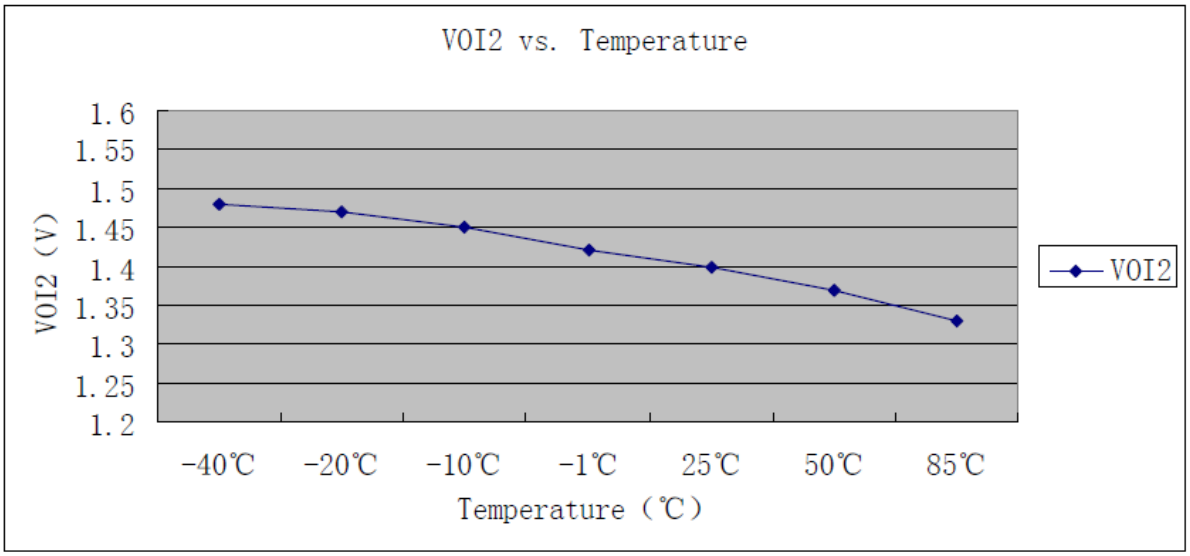


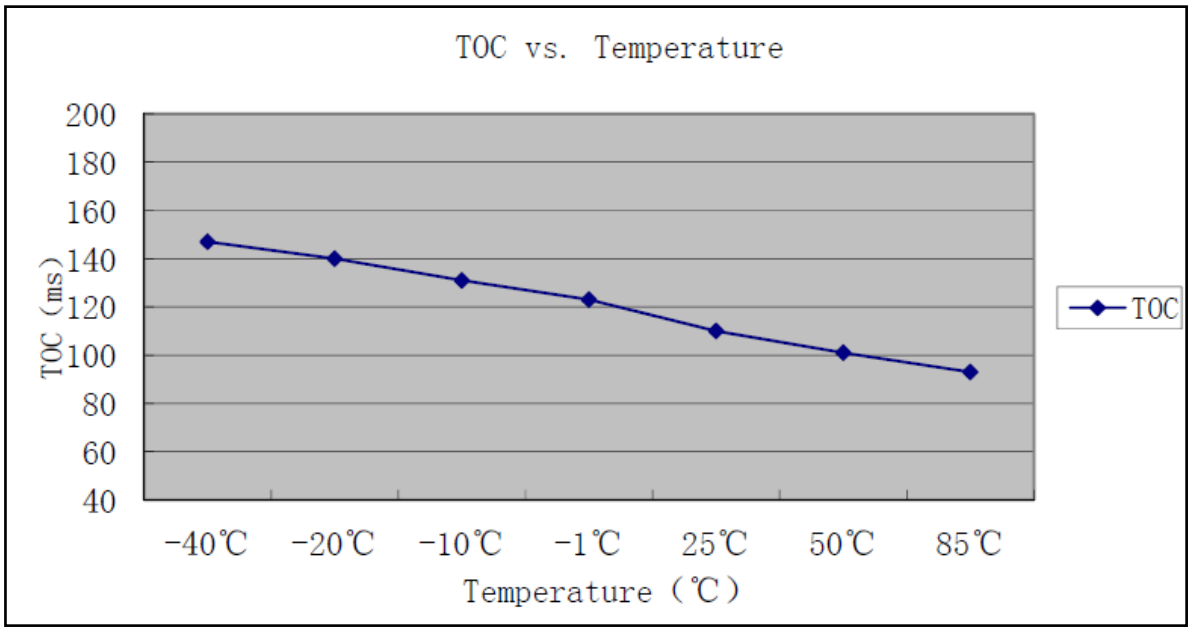


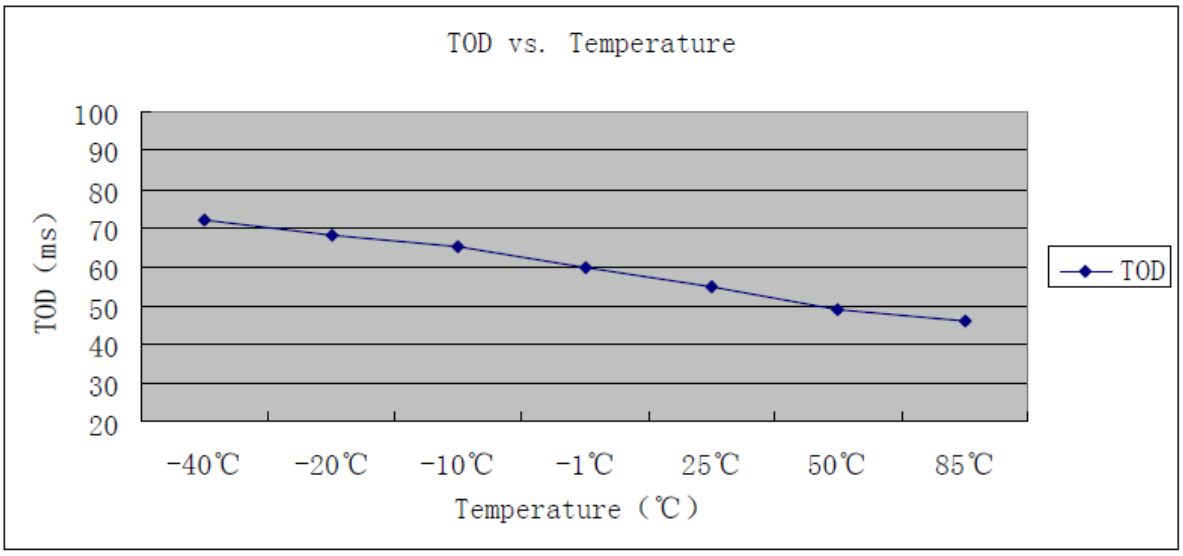


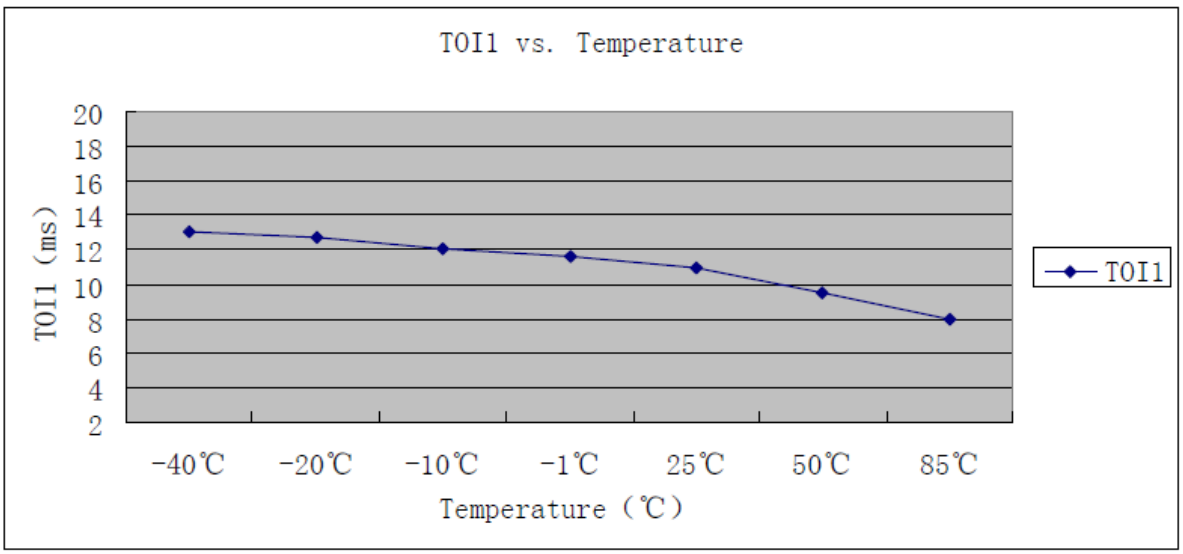

VODP vs. Temperature
VODP (V)
2.5
2.48
2.46
2.44
2.42
2.4
2.38
2.36
2.34
2.32
2.3
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
VODP

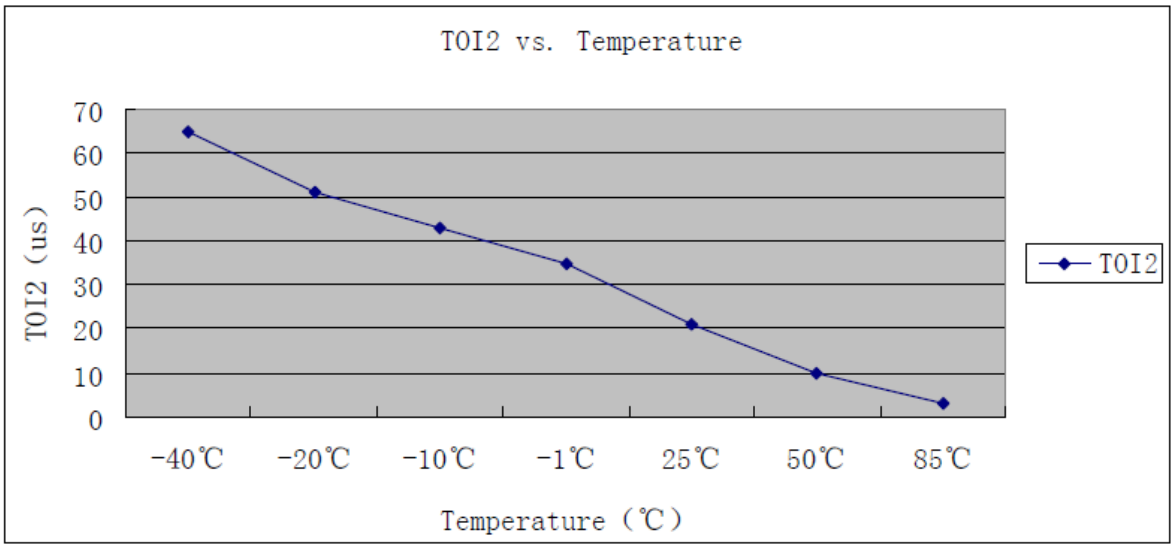

VOI1 vs. Temperature
VOI1 (V)
0.180
0.170
0.160
0.150
0.140
0.130
0.120
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
VOI1

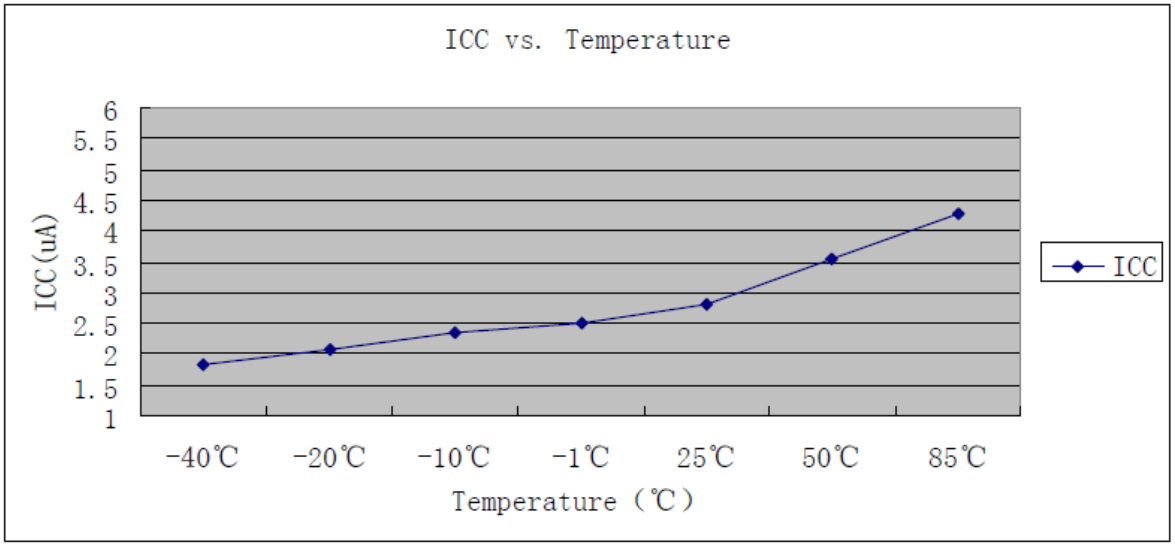

VOI2 vs. Temperature
VOI2 (V)
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
VOI2

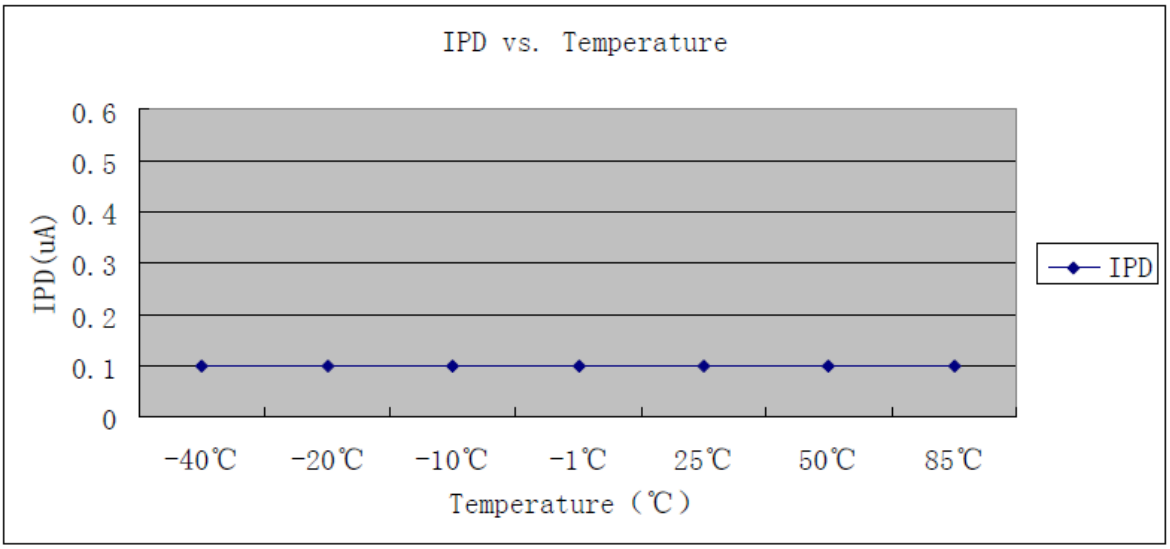

TOC vs. Temperature
200
180
160
140
120
100
80
60
40
TOC (ms)
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
TOC

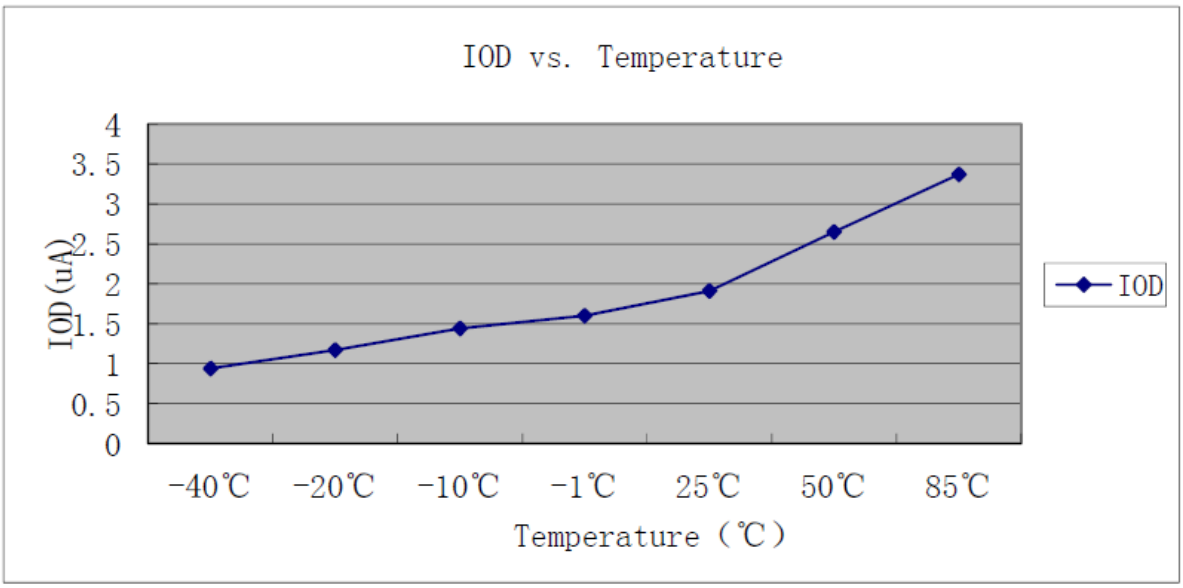

TOD vs. Temperature
100
90
80
70
60
50
40
30
20
TOD (ms)
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
TOD

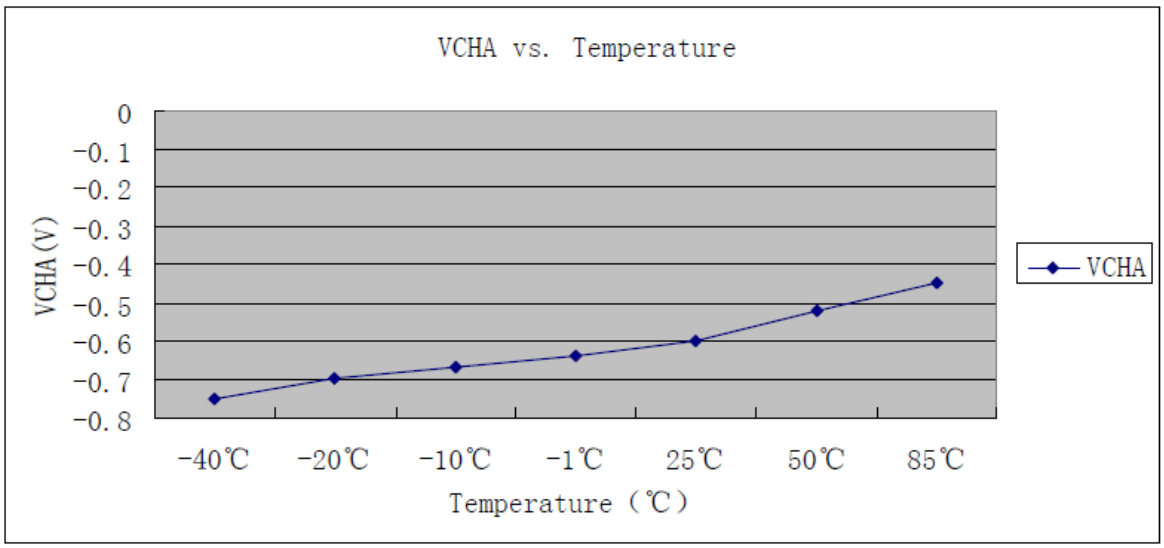

TOI1 vs. Temperature
20
18
16
14
12
10
8
6
4
2
TOI1 (ms)
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
TOI1


TOI2 vs. Temperature
TOI2 (us)
70
60
50
40
30
20
10
0
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
TOI2


ICC vs. Temperature
ICC(uA)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
ICC

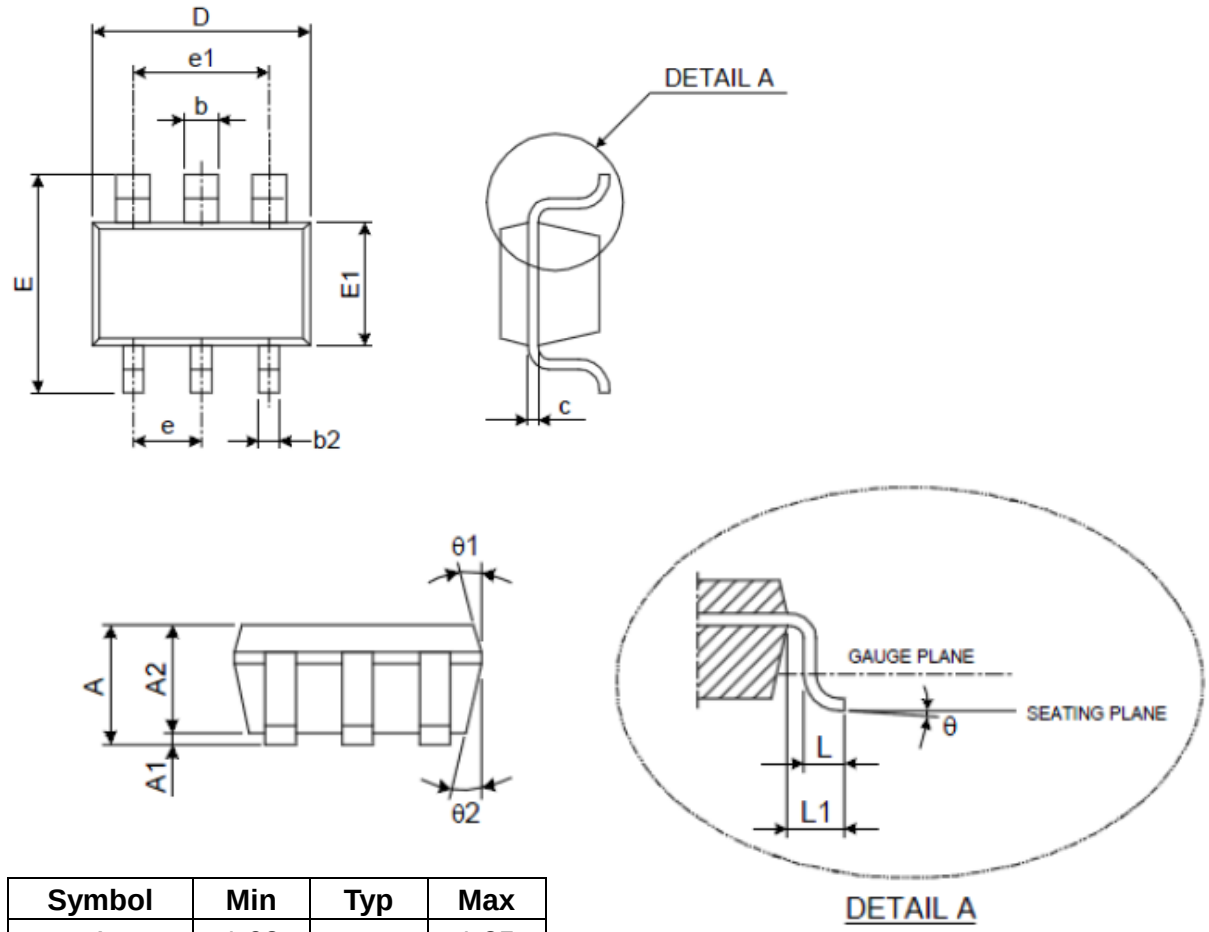

IPD vs. Temperature
IPD(uA)
0.6
0.5
0.4
0.3
0.2
0.1
0
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
IPD


IOD vs. Temperature
IOD(uA)
4
3.5
3
2.5
2
1.5
1
0.5
0
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
IOD


VCHA vs. Temperature
VCHA(V)
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-40℃
-20℃
-10℃
-1℃
25℃
50℃
85℃
Temperature (℃)
VCHA

Packing Information

SOT-23-6



Symbol	Min	Typ	Max
A	1.02	-	1.35
A1	0.05	-	0.15
A2	1.00	1.10	1.20
b	0.40	-	0.55
b2	0.25	-	0.40
c	0.08	-	0.20
D	2.70	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
L	0.35	0.45	0.55
L1	0.60 REF		
e	0.95 BSC		
e1	1.90 BSC		
θ	0°	5°	10°
θ1	3°	5°	7°
θ2	6°	8°	10°

Notes

ACE does not assume any responsibility for use as critical components in life support devices or systems without the express written approval of the president and general counsel of ACE Electronics Co., LTD. As sued herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and shoes failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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