

DATA SHEET

Product	Battery Protect Solution IC
Product code	SP31ABE (001-SP31ABE-00)
Production Form	TEP - 6L,BD5x2
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■ Contents

1. Features	Page 1
2. Outline	Page 2
3. Pin Assignment	Page 3
4. Block Diagram	Page 3
5. Absolute Maximum Rating	Page 4
6. Electrical Characteristics	Page 4
7. Measuring Circuit	Page 9
8. Operation	Page 10
1) Overcharge detector (VD1)	Page 10
2) Overdischarge detector (VD2)	Page 10
3) Discharge overcurrent detector, Short detector (VD3, Short Detector)	Page 11
4) Charger overcurrent detector	Page 11
9. Application Circuit	Page 12
10. Timing Chart	Page 13
11. Package Description	Page 15
12. Marking Contents	Page 16

Battery Protect Solution IC

■ Features

1. The protection IC and The Dual-Nch MOSFET to use common Drain are integrated into One-packaging IC.
2. Reduced Pin-Count by fully connecting internally.
3. Application Part
 - 1) Protection IC
 - ① Uses high withstand voltage CMOS process.
 - The charger section can be connected up to absolute maximum rating 30V.
 - ② Detection voltage precision
 - Overcharge detection voltage
 $\pm 30\text{mV}$ ($T_a=25^\circ\text{C}$), $\pm 41\text{mV}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Overdischarge detection voltage
 $\pm 58\text{mV}$ ($T_a=25^\circ\text{C}$), $2.300[+63, -76]\text{mV}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Discharge overcurrent detection voltage
 $\pm 20\text{mV}$ ($T_a=25^\circ\text{C}$), $\pm 22\text{mV}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Charge overcurrent detection voltage
 $\pm 30\text{mV}$ ($T_a=25^\circ\text{C}$), $\pm 32\text{mV}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - ③ Built-in detection delay times (timer circuit)
 - Overcharge detection delay time
 $1.0\pm 0.3\text{s}$ ($T_a=25^\circ\text{C}$), $1.00[+0.94, -0.42]\text{s}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Overdischarge detection delay time
 $20.0\pm 6\text{ms}$ ($T_a=25^\circ\text{C}$), $20.0[+20.01, -8.58]\text{ms}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Discharge overcurrent detection delay time
 $6.0\pm 2\text{ms}$ ($T_a=25^\circ\text{C}$), $6.0[+10.4, -3.6]\text{ms}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Charging overcurrent detection delay time
 $8.0\pm 3.0\text{ms}$ ($T_a=25^\circ\text{C}$), $8.0[+13.38, -5]\text{ms}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - Short detection delay time
 $300\pm 200\mu\text{s}$ ($T_a=25^\circ\text{C}$), $300[+370, -202]\mu\text{s}$ ($T_a=-30\sim 70^\circ\text{C}$)
 - ④ 0V charge function allowed
4. Common Drain Dual-Nch MOSFET
 - ① Using advanced trench technology to provide excellent $R_{DS(ON)}$, low gate charge and operation with gate voltage as low as 2.5V while retaining a 12V $V_{GS(MAX)}$.
 - ② The protection for ESD
 - ③ Common drain configuration
 - ④ General characteristics
 - V_{DS} (V) = 30V
 - I_D (A) = 8A
 - $R_{SS(ON)} < 46\text{m}\Omega$ ($V_{GS} = 4.5\text{V}$, $I_D = 5\text{A}$)
 - ESD Rating : 2000V HBM

Battery Protect Solution IC**SP31ABE****■ Outline**

This is a battery protect solution IC which is integrated with built-in the protection IC to use a lithium ion/lithium polymer secondary batteries developed for 1-cell series and Dual-Nch MOSFET. It functions to protect the battery by detecting overcharge, overdischarge, discharge overcurrent, charge overcurrent and other abnormalities as turning off internal Nch MOSFET. The protection IC is composed of four voltage detectors, short detection circuit, reference voltage sources, oscillator, counter circuit and logical circuits.

The C_{OUT} pin (charge FET control pin) and D_{OUT} pin (discharge FET control pin) outputs are CMOS output, and can drive the internal Nch MOSFET directly. The C_{OUT} output becomes low level after delay time fixed in the IC if overcharge is detected. The D_{OUT} output becomes low level after delay time fixed in the IC if overdischarge, discharge overcurrent or short is detected.

On overcharge state, if the V_{DD} voltage is less than the overcharge release voltage, the C_{OUT} output becomes high level after delay time fixed in the IC. On overdischarge state, if the voltage of the battery rises more than the overdischarge detection voltage with connecting the charger, the D_{OUT} output becomes high level after delay time fixed in the IC. Charging current can be supplied to the battery discharged up to 0V.

Once discharge overcurrent or short have been detected, if the state of discharge overcurrent or short is released by opening the loads, the D_{OUT} output becomes high level after delay time fixed in the IC. On overdischarge state, the supply current is reduced as less as possible. Once charge overcurrent has been detected, the state of charge overcurrent is released by opening the charger and setting the load.

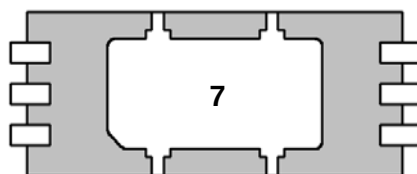
Battery Protect Solution IC

Pin Assignment

[Package: TEP-6L(5.0x2.0)]



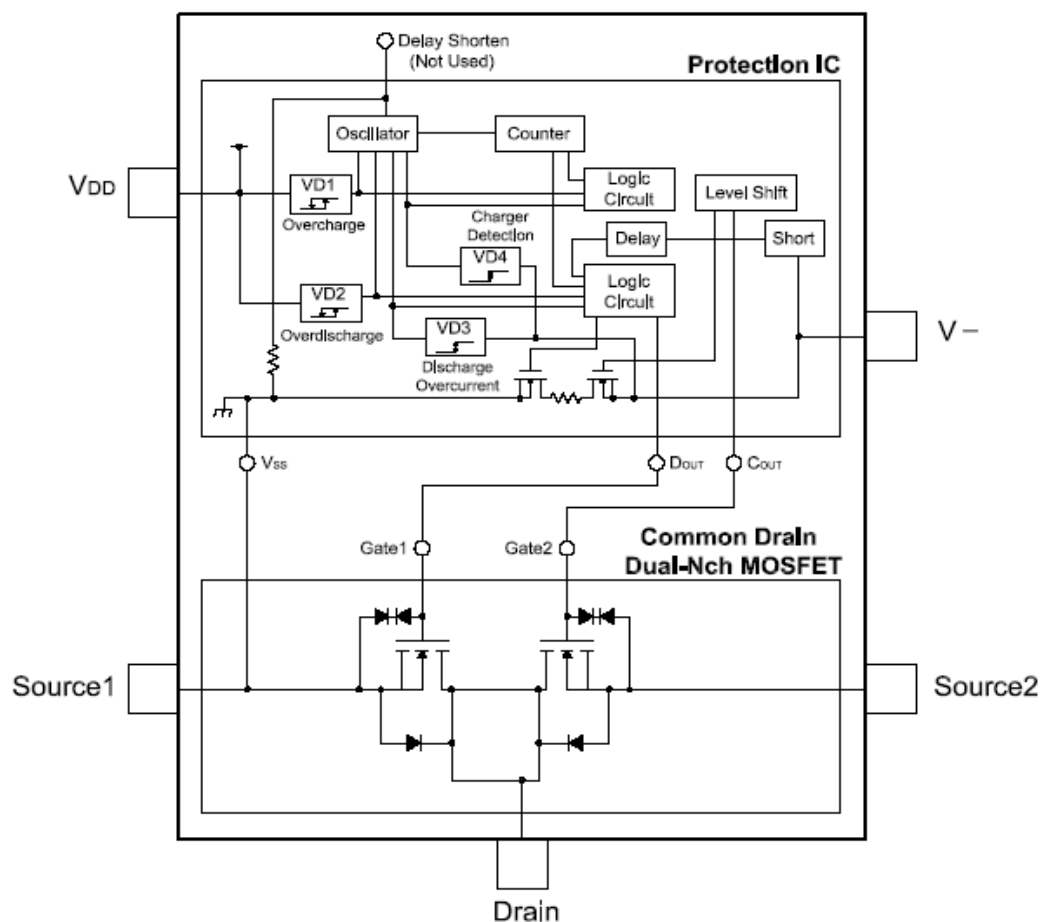
< TOP VIEW >



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1	Source 1 (Same as VSS)
2	Source 1 (Same as VSS)
3	V _{DD}
4	V-(VM)
5	Source 2
6	Source 2
7	Drain

Block Diagram



Battery Protect Solution IC

■ Absolute Maximum Rating

※ $T_{OPR}=25^{\circ}\text{C}$, Source1(V_{SS})=0V

Item	Symbol	Rating	Unit
Supply Voltage	V_{DD}	-0.3 ~ 12	V
V- Terminal Input Voltage	V-	$V_{DD}-30 \sim V_{DD}+0.3$	V
C _{OUT} Terminal Output Voltage	V_{COUT}	$V_{DD}-30 \sim V_{DD}+0.3$	V
D _{OUT} Terminal Output Voltage	V_{DOUT}	$V_{SS}-0.3 \sim V_{DD}+0.3$	V
Operation Temperature	T_{OPR}	-40 ~ +85	°C
Storage Temperature	T_{STG}	-55 ~ +125	°C
Drain-Source Voltage	V_{DS}	30	V
Gate-Source Voltage	V_{GS}	±12	V

■ Electrical Characteristics

※ $T_{OPR}=25^{\circ}\text{C}$

Item	Symbol	Measure Condition	Min.	Typ.	Max.	Unit	*1
Operating Input Voltage	V_{DD1}	$V_{DD} - V_{SS}$	1.5	-	5.0	V	A
Minimum operating voltage for 0V charging	V_{ST}	$V_{DD} - V_{-}$, $V_{DD} - V_{SS}=0\text{V}$	-	-	1.8	V	A
Overcurrent Release Resistance	R_{SHORT}	$V_{DD} = 3.6\text{V}$, $V_{-} = 1\text{V}$	20	45	70	kΩ	F
		$T_{OPR} = -30 \sim 70^{\circ}\text{C}$	18.1	45	79.5		
C _{OUT} Pin Nch ON Voltage	V_{OL1}	$I_{OL}=50\mu\text{A}$, $V_{DD}=4.5\text{V}$	-	0.4	0.5	V	-
C _{OUT} Pin Pch ON Voltage	V_{OH1}	$I_{OH}=-50\mu\text{A}$, $V_{DD}=3.9\text{V}$	3.4	3.7	-	V	-
D _{OUT} Pin Nch ON Voltage	V_{OL2}	$I_{OL}=50\mu\text{A}$, $V_{DD}=2.0\text{V}$	-	0.2	0.5	V	-
D _{OUT} Pin Pch ON Voltage	V_{OH2}	$I_{OL}=-50\mu\text{A}$, $V_{DD}=3.9\text{V}$	3.4	3.7	-	V	-
Current Consumption	I_{DD}	$V_{DD} = 3.9\text{V}$, $V_{-} = 0\text{V}$	-	4.0	6.5	μA	H
		$T_{OPR} = -30 \sim 70^{\circ}\text{C}$	-	4.0	7.13		
Current Consumption at Stand-By	I_S	$V_{DD} = 2.0\text{V}$	-	-	0.1	μA	H
		$T_{OPR} = -30 \sim 70^{\circ}\text{C}$	-	-	0.11		
Overcharge Detection Voltage	V_{DET1}	$R1 = 1\text{k}\Omega$	4.245	4.275	4.305	V	B
		$T_{OPR} = -5 \sim 55^{\circ}\text{C}$	4.245	4.275	4.305		
Overdischarge Detection Voltage	V_{DET2}	Detect falling edge of supply voltage	2.242	2.300	2.358	V	D
Discharging Overcurrent Detection Voltage	V_{DET3}	Detect rising edge of 'V-' pin voltage	0.080	0.100	0.120	V	F
Charging Overcurrent Detection Voltage	V_{DET4}	Detect falling edge of 'V-' pin voltage	-0.130	-0.100	-0.070	V	G
Short Detection Voltage	V_{SHORT}	$V_{DD} = 3\text{V}$	0.55	0.8	1.0	V	F

Battery Protect Solution IC

※ $T_{OPR}=25^{\circ}\text{C}$

Item	Symbol	Measure Condition	Min.	Typ.	Max.	Unit	*1
Overcharge Detection Delay Time	$t_{V_{DET1}}$	$V_{DD} = 3.6\text{V} \rightarrow 4.4\text{V}$	0.70	1.00	1.30	s	B
Overcharge Release Delay Time	$t_{V_{REL1}}$	$V_{DD}=4\text{V}, V_{-}=0\text{V} \rightarrow 1\text{V}$	11.0	16.0	21.0	ms	B
Overdischarge Detection Delay Time	$t_{V_{DET2}}$	$V_{DD} = 3.6\text{V} \rightarrow 2.2\text{V}$	14.0	20.0	26.0	ms	D
Overdischarge Release Delay Time	$t_{V_{REL2}}$	$V_{DD}=3\text{V}, V_{-}=3\text{V} \rightarrow 0\text{V}$	0.7	1.2	1.7	ms	E
Discharging Overcurrent Detection Delay Time	$t_{V_{DET3}}$	$V_{DD}=3\text{V}, V_{-}=0\text{V} \rightarrow 1.0\text{V}$	4.0	6.0	8.0	ms	F
Discharging Overcurrent Release Delay Time	$t_{V_{REL3}}$	$V_{DD}=3.0\text{V}, V_{-}=3\text{V} \rightarrow 0\text{V}$	0.7	1.2	1.7	ms	F
Charging overcurrent Detection delay time	$t_{V_{DET4}}$	$V_{DD}=3\text{V}, V_{-}=0\text{V} \rightarrow -1\text{V}$	5.0	8.0	11.0	ms	G
Charging Overcurrent Release Delay Time	$t_{V_{REL4}}$	$V_{DD}=3.0\text{V}, V_{-}=-1\text{V} \rightarrow 0\text{V}$	0.7	1.2	1.7	ms	G
Short Detection Delay Time	t_{SHORT}	$V_{DD}=3\text{V}, V_{-}=0\text{V} \rightarrow 3\text{V}$	100	300	500	μs	F
Drain-Source Breakdown Voltage	BV_{DSS}	$I_D=250\mu\text{A}, V_{GS}=0\text{V}$	30	—	—	V	
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS}=24\text{V}, V_{GS}=0\text{V}$ $T_J=55^{\circ}\text{C}$	—	—	1 5	μA	
Gate-Body Leakage Current	I_{GSS}	$V_{DS}=0\text{V}, V_{GS}=\pm 10\text{V}$	—	—	10	μA	
Gate Threshold Voltage	$V_{GS(th)}$	$V_{DS}=V_{GS}, I_D=250\mu\text{A}$	0.6	1.0	1.5	V	
Static Source-Source ON-Resistance	$R_{SS(ON)}$	$V_{GS}=10\text{V}, I_D=5\text{A}$ $T_J=125^{\circ}\text{C}$	—	34 52	40 62	$\text{m}\Omega$	
		$V_{GS}=4.5\text{V}, I_D=5\text{A}$	—	40	46	$\text{m}\Omega$	
		$V_{GS}=2.5\text{V}, I_D=3\text{A}$	—	52	66	$\text{m}\Omega$	
Diode Forward Voltage	V_{SD}	$I_S=1\text{A}, V_{GS}=0\text{V}$	0.50	0.76	0.90	V	
Maximum Body-Diode Continuous Current	I_S		—	—	4.5	A	

Note : *1 The test circuit symbols.

Battery Protect Solution IC

※ T_{OPR}=-30~70℃ *2

Item	Symbol	Measure Condition	Min.	Typ.	Max.	Unit	*1
Overcharge Detection Voltage	V _{DET1}	R1=1kΩ	4.234	4.275	4.316	V	B
Overdischarge Detection Voltage	V _{DET2}	R1 = 1kΩ	2.224	2.300	2.363	V	D
Discharging Overcurrent Detection Voltage	V _{DET3}	V _{DD} = 3.0V, R2 = 2.2kΩ	0.078	0.100	0.122	V	F
Charging Overcurrent Detection Voltage	V _{DET4}	Detect rising edge of 'V-' pin voltage	-0.132	-0.100	-0.068	V	G
Short Detection Voltage	V _{SHORT}	V _{DD} =3.0V	0.45	0.80	1.10	V	F
Overcharge Detection Delay Time	tV _{DET1}	V _{DD} =3.6V→4.4V	0.58	1.00	1.94	s	B
Overcharge Release Delay Time	tV _{REL1}	V _{DD} =4.5V→3.6V	9.0	16.0	31.38	ms	B
Overdischarge Detection Delay Time	tV _{DET2}	V _{DD} =3.6V→2.2V	11.42	20.0	40.01	ms	D
Overdischarge Release Delay Time	tV _{REL2}	V _{DD} =3V, V-=3V→0V	0.54	1.20	2.41	ms	E
Discharging Overcurrent Detection Delay Time	tV _{DET3}	V _{DD} =3.0V, V-=0V→0.5V	2.4	6.0	16.4	ms	F
Discharging Overcurrent Release Delay Time	tV _{REL3}	V _{DD} =3.0V, V-=3V→0V	0.54	1.20	2.41	ms	F
Charging Overcurrent Detection Delay Time	tV _{DET4}	V _{DD} =3.0V, V-=0V→-1V	3.00	8.00	21.38	ms	G
Charging Overcurrent Release Delay Time	tV _{REL4}	V _{DD} =3.0V, V-= -1V→0V	0.54	1.20	2.41	ms	G
Short Detection Delay Time	t _{SHORT}	V _{DD} =3.0V, V-=0V→3V	98	300	670	μs	F

Note : *1 The test circuit symbols.

*2 The all parameters on this page is guaranteed by design.

Battery Protect Solution IC

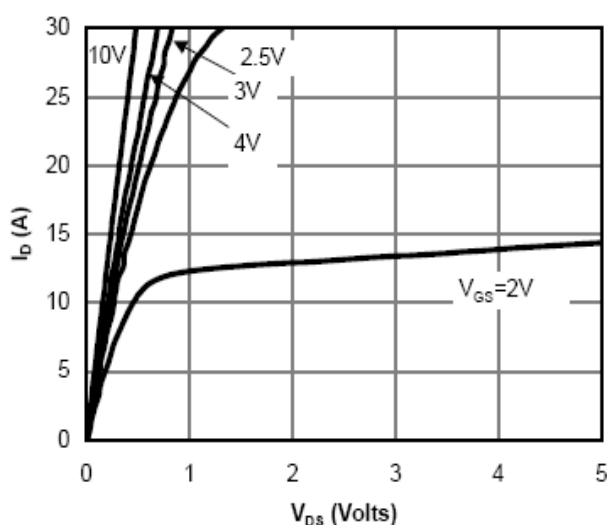


Figure 1 : On-Regin Characteristics

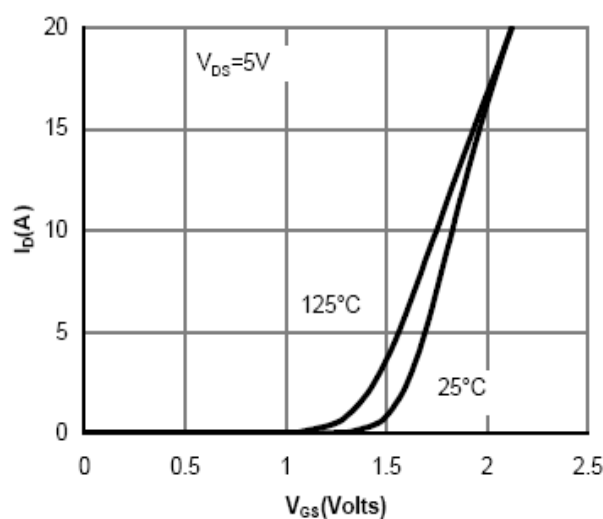


Figure 2: Transfer Characteristics

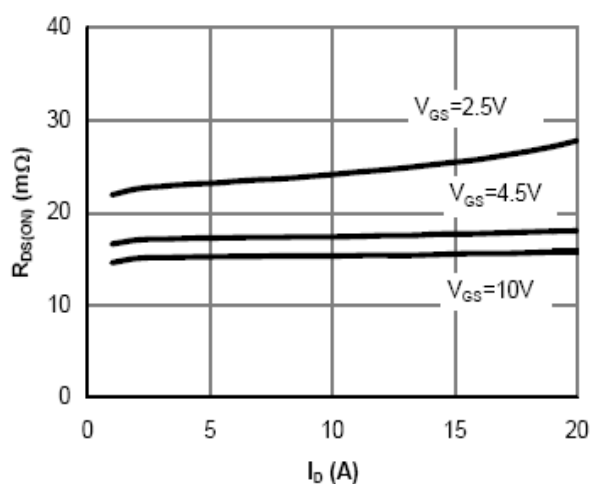


Figure 3: On-Resistance vs. Drain Current and Gate Voltage

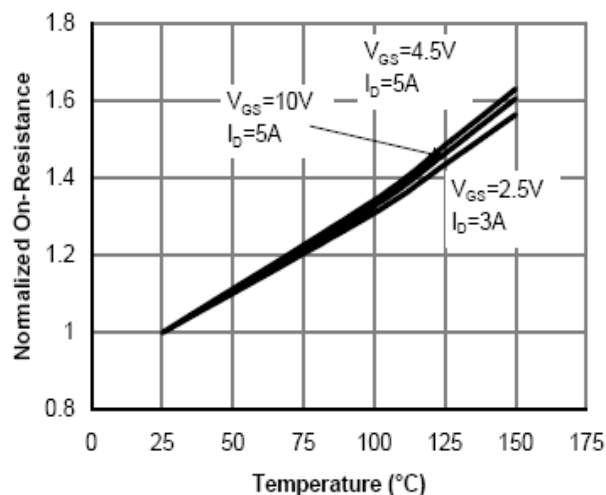


Figure 4: On-Resistance vs. Junction Temperature

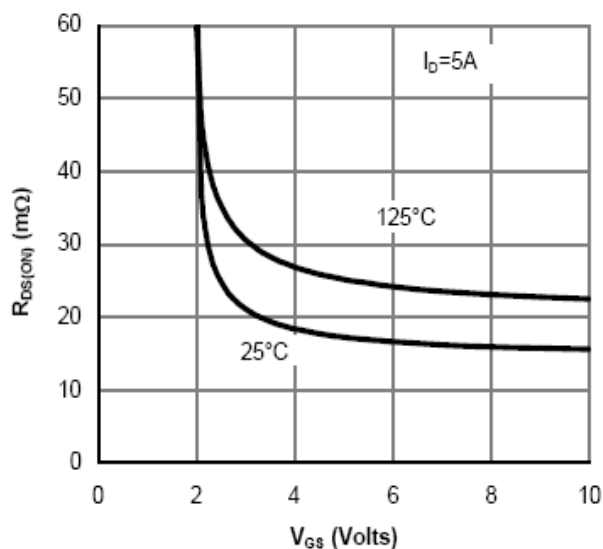


Figure 5: On-Resistance vs. Gate-Source Voltage

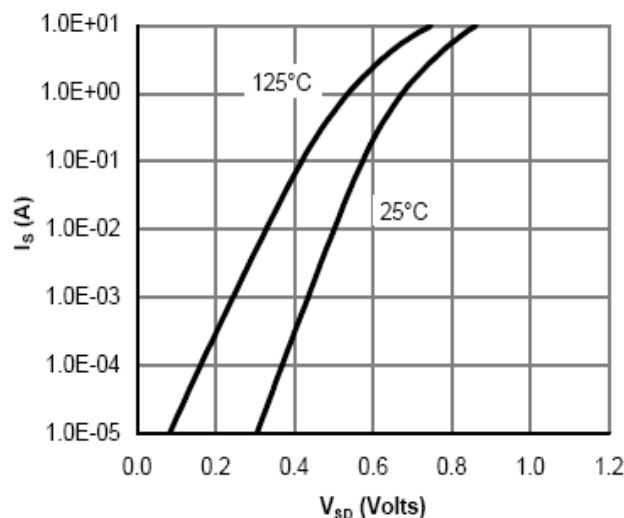
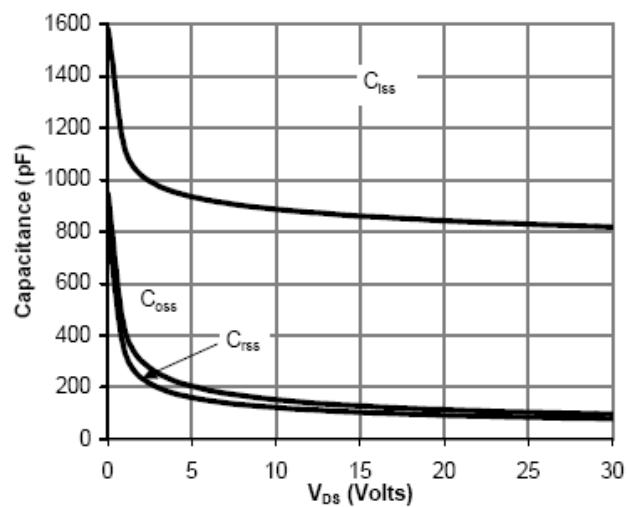
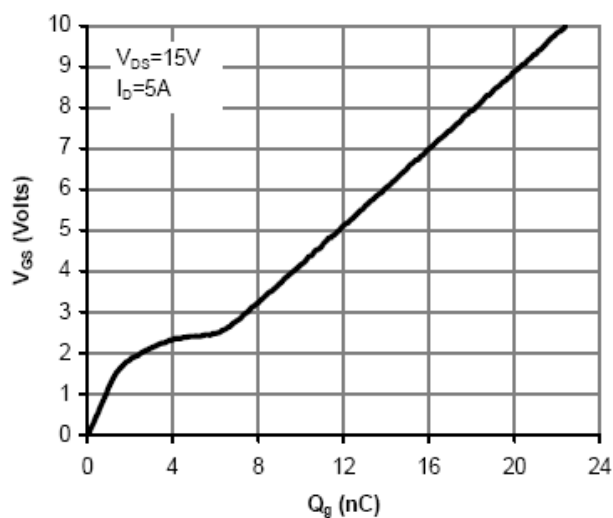


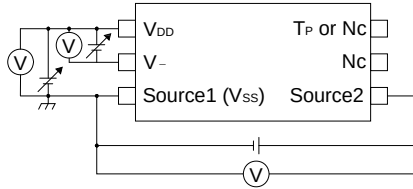
Figure 6: Body-Diode Characteristics

Battery Protect Solution IC


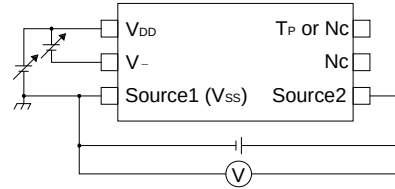
Battery Protect Solution IC

■ Measuring Circuit

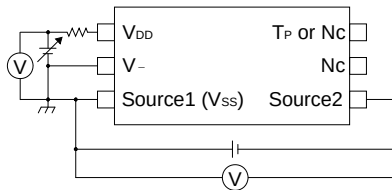
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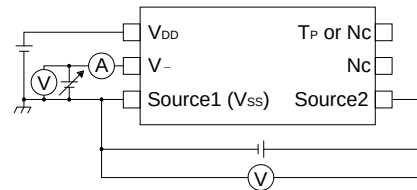
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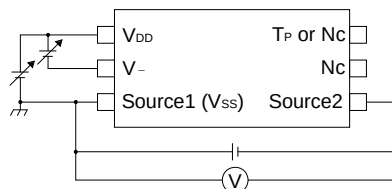
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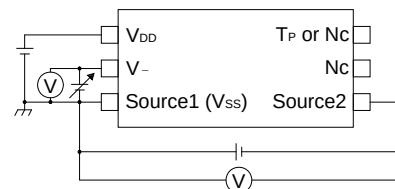
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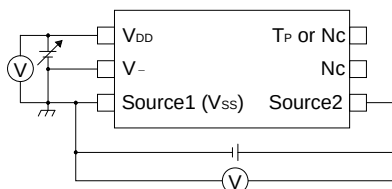
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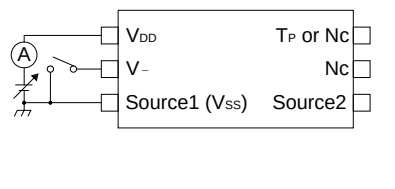
G.



D.



H.



Battery Protect Solution IC**■ Operation****1. Overcharge detector (VD1)**

The VD1 monitors V_{DD} pin voltage during charge. In the state of charging the battery, it will detect the overcharge state of the battery if the V_{DD} terminal voltage becomes higher than the overcharge detection voltage(Typ. 4.275V). And then the C_{OUT} terminal turns to low level, so the internal charging control Nch MOSFET turns OFF and it forbids to charge the battery.

After detecting overcharge, it will release the overcharge state if the V_{DD} terminal voltage becomes lower than the overcharge release voltage. And then the C_{OUT} terminal turns to high level, so the internal charging control Nch MOSFET turns ON, and it accepts to charge the battery.

When the V_{DD} terminal voltage is higher than the overcharge detection voltage, to disconnect the charger and connect the load, leave the C_{OUT} terminal low level, but it accepts to conduct load current via the paracritical body diode of the internal Nch MOSFET. And then if the V_{DD} terminal voltage becomes lower than the overcharge detection voltage, the C_{OUT} terminal turns to high level, so the internal Nch MOSFET turn ON, and it accepts to charge the battery.

The overcharge detection and release have delay time decided internally. When the V_{DD} terminal voltage becomes higher than the overcharge detection voltage, if the V_{DD} terminal voltage becomes lower than the overcharge detection voltage again within the overcharge detection delay time(Typ. 1.00s), it will not detect overcharge. And in the state of overcharge, when the V_{DD} terminal voltage becomes lower than the overcharge release voltage, if the V_{DD} terminal voltage backs higher than the overcharge release voltage again within the overcharge release delay time(Typ. 16ms), it will not release overcharge.

The output driver stage of the C_{OUT} terminal includes a level shifter, so it will output the V_- terminal voltage as low level. The output type of the C_{OUT} terminal is CMOS output between V_{DD} and V_- terminal voltage.

2. Overdischarge detector (VD2)

The VD2 monitors V_{DD} pin voltage during discharge. In the state of discharging the battery, it will detect the overdischarge state of the battery if the V_{DD} terminal becomes lower than the overdischarge detection voltage (Typ. 2.300V). And then the D_{OUT} terminal turns to low level, so the internal discharging control Nch MOSFET turn OFF and it forbids to discharge the battery.

The release from the overdischarge state is done by connecting the charger. If the charger is connected and the V_{DD} terminal voltage is lower than the overdischarge detection voltage, it accepts to conduct charge current via the paracritical body diode of the internal Nch MOSFET. And then if the V_{DD} terminal voltage becomes higher than the overdischarge detection voltage, the D_{OUT} terminal turns to high level, so the internal Nch MOSFET turns ON, and it accepts to discharge the battery. If the charger is connected and the V_{DD} terminal voltage is higher than the overdischarge detection voltage, the D_{OUT} terminal will turn to high level with the delay time.

Battery Protect Solution IC

When the battery voltage is about 0V, if the charger voltage is higher than the minimum operating voltage for 0V charging (Max. 1.8V), the C_{OUT} terminal outputs high level and it accepts to conduct charging current.

The overdischarge detection have delay time decided internally. When the V_{DD} terminal voltage becomes lower than the overdischarge detection voltage, if the V_{DD} terminal voltage becomes higher than the overdischarge detection voltage again within the overdischarge detection delay time (Typ. 20ms), it will not detect overdischarge. Moreover, the overdischarge release delay time (Typ. 1.2ms) exists, too.

All the circuits are stopped, and after the overdischarge is detected, it is assumed the state of the standby, and decreases the current (standby current) which IC consumes as much as possible. (When V_{DD}=2V, Max. 0.1uA).

The output type of the D_{OUT} terminal is CMOS output between V_{DD} and V_{SS} terminal voltage.

3. Discharge overcurrent detector, Short detector (VD3, Short Detector)

In the state of chargeable and dischargeable, VD3 monitors the voltage level of V₋ pin. If the V₋ terminal voltage becomes higher than the discharging overcurrent detection voltage (Typ. 0.100V) by short of loads, etc., it will detect discharging overcurrent state. If the V₋ terminal voltage becomes higher than short detection voltage (Typ. 0.8V), it will detect discharging overcurrent state, too. And then the D_{OUT} terminal outputs low level, so the internal discharging control Nch MOSFET turns OFF, and it protects from large current discharging.

The discharging overcurrent detection has delay time decided internally. When the V₋ terminal voltage becomes higher than the discharging overcurrent detection voltage, if the V₋ terminal voltage becomes lower than the discharging overcurrent detection voltage within the discharging overcurrent detection delay time (Typ. 6ms), it will not detect discharging overcurrent. Moreover, the discharging overcurrent release delay time (Typ. 1.2ms) exists, too.

The short detection delay time (Typ. 300us) decided internally exists, too.

The discharging overcurrent release resistance (Typ. 45kohm) is built into between V₋ terminal and V_{SS} terminal. In the state of discharging overcurrent or short, if the load is opened, V₋ terminal is pulled down to the V_{SS} via the discharging overcurrent release resistance. And when the V₋ terminal voltage becomes lower than the discharging overcurrent detection voltage, it will automatically release discharging overcurrent or short state. If discharging overcurrent or short is detected, the discharging overcurrent release resistance turns ON. On the normal state (chargeable and dischargeable state), the discharging overcurrent release resistance is OFF.

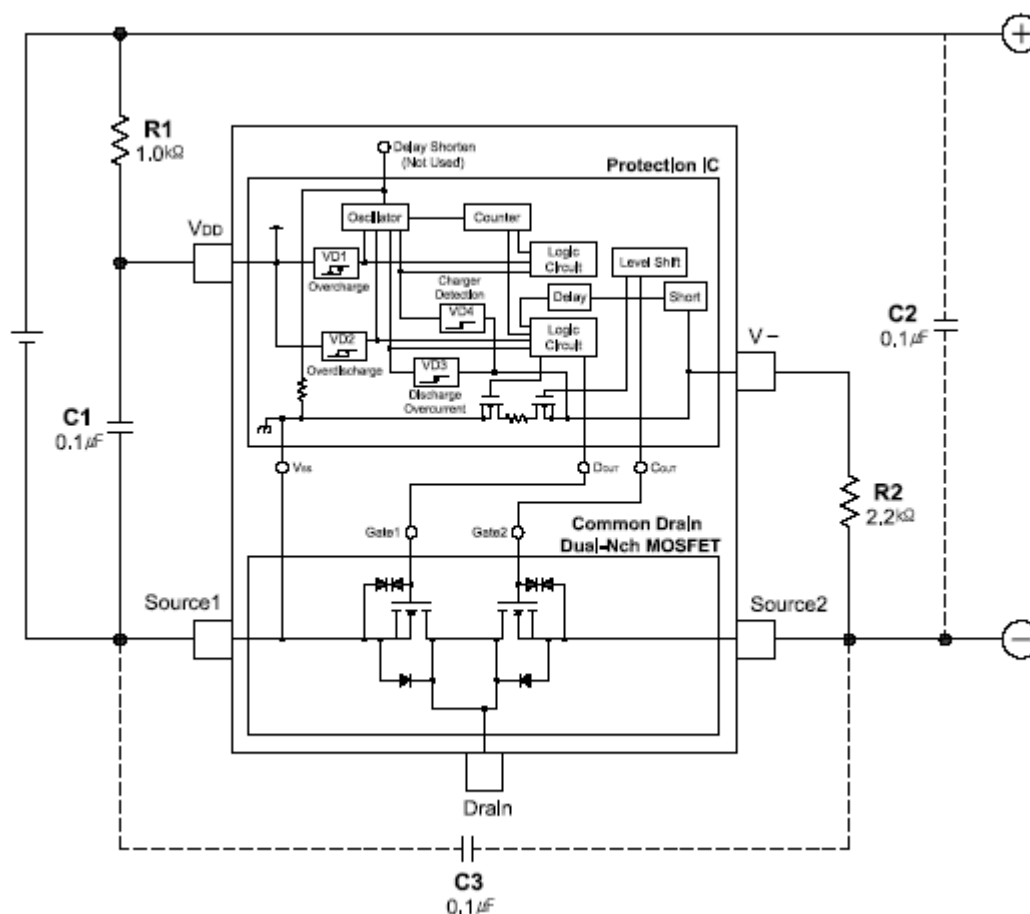
4. Charge overcurrent detector (VD4)

In the state of chargeable and dischargeable, VD4 monitors the voltage level of V₋ pin. If the V₋ terminal voltage becomes lower than charging overcurrent detection voltage (Typ. -0.100V) by abnormal voltage or current charger, etc., it will detect charging overcurrent state. And then the C_{OUT} terminal outputs low level, so the internal charging control Nch MOSFET turn OFF, and it protects from large current charging.

It release charging overcurrent state if the abnormal charger is disconnected and the load is connected.

Battery Protect Solution IC

■ Application Circuit (Example)



✳ Application Hint

R1 and C1 stabilize a supply voltage ripple. However, the detection voltage rises by the current of penetration in IC of the voltage detection when R1 is enlarged, so the value of R1 is adjusted to 1kohm or less. Moreover, adjust the value of C1 to 0.1uF or more to do the stability operation, please.

R1 and R2 resistors are current limit resistance if a charger is connected reversibly or a highvoltage charger that exceeds the absolute maximum rating is connected. R1 and R2 may cause a power consumption will be over rating of power dissipation, therefore the 'R1+R2' should be more than 1kohm. Moreover, if R2 is too enlarged, the charger connection release cannot be occasionally done after the overdischarge is detected, so adjust the value of R2 to 10kohm or less, please.

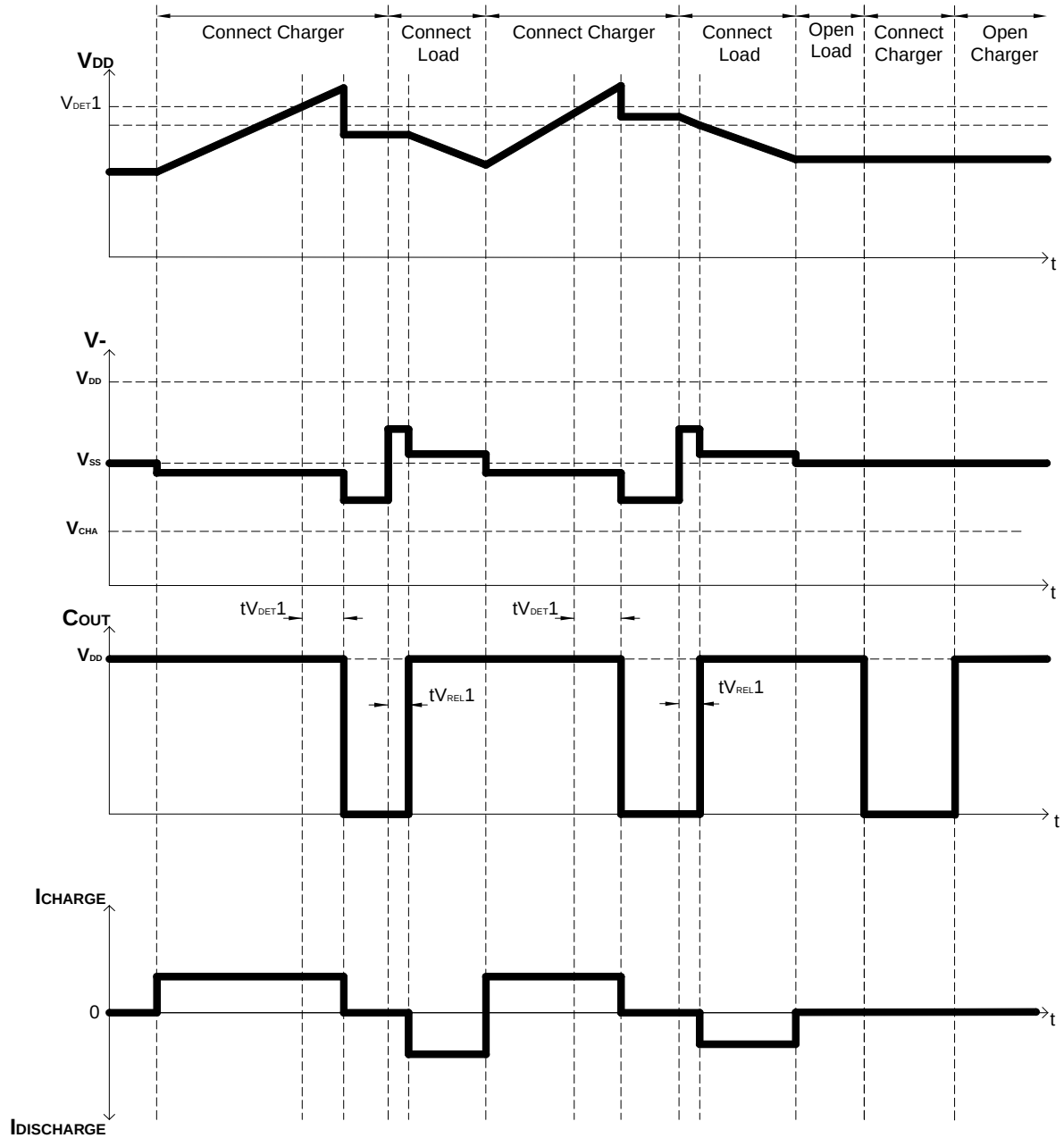
C2 and C3 capacitors have effect that the system stability about voltage ripple or imported noise. After check characteristics, decide that these capacitors should be inserted or not, where should be inserted, and capacitance value, please.

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■ Timing Chart

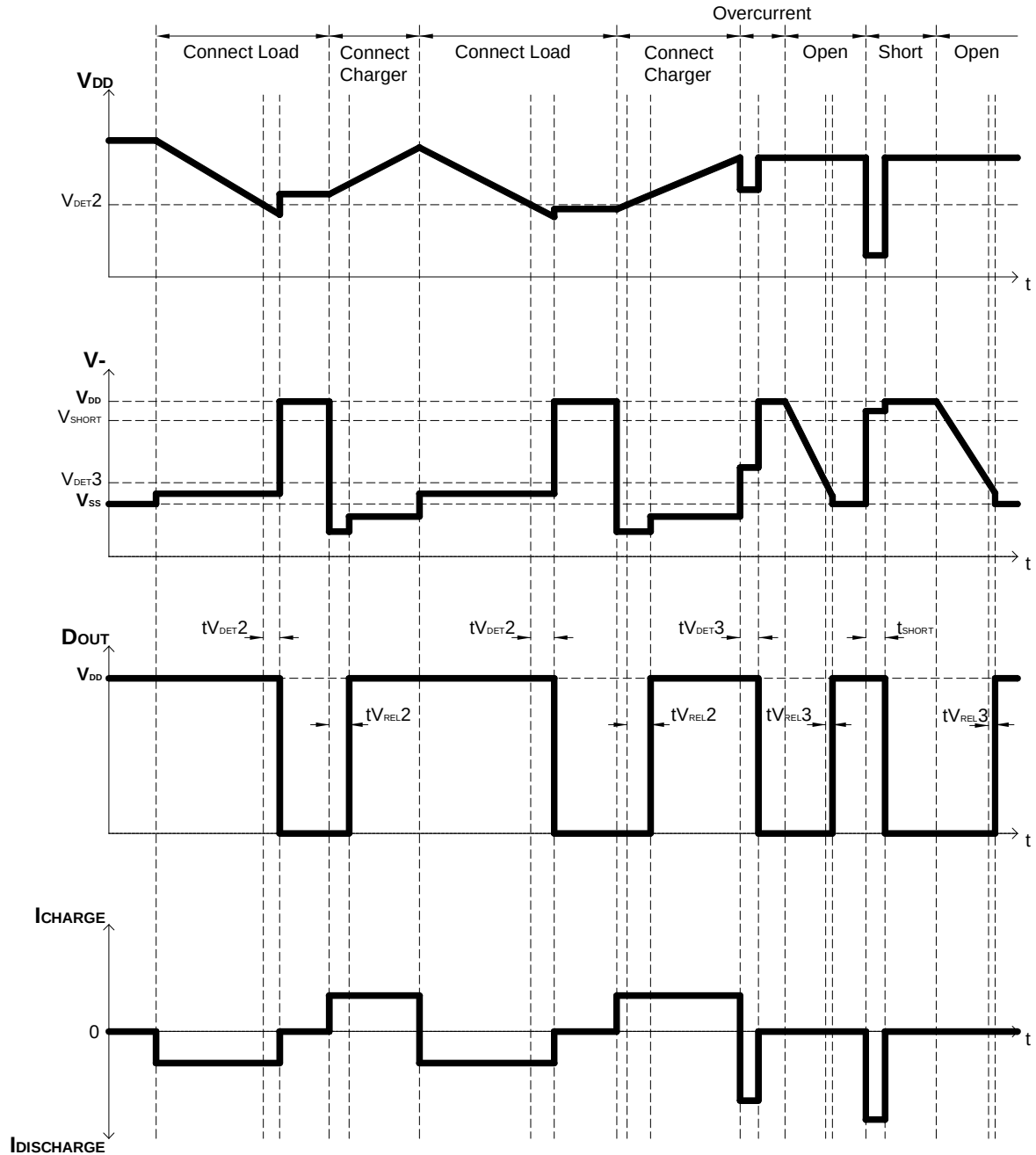
1. Overcharge, Abnormal Charger operations



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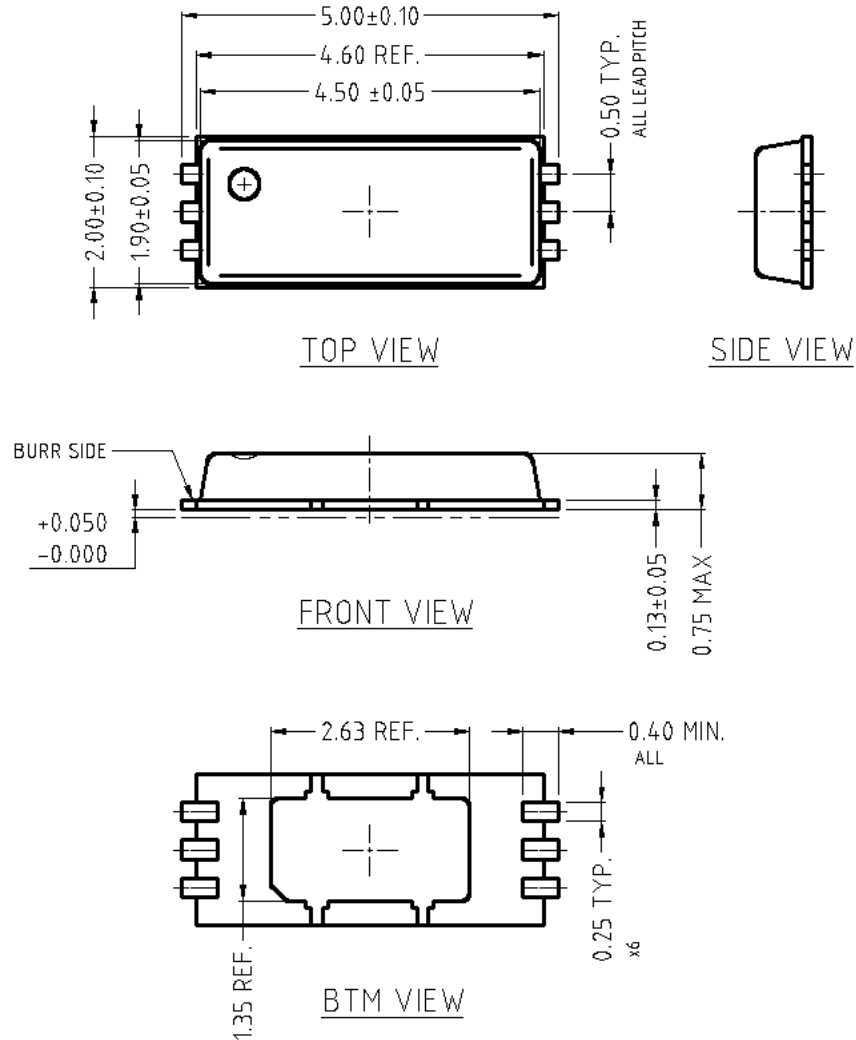
2. Overdischarge, Discharging Overcurrent and Short operations



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■ Package Description



NOTE

1. LEAD BURR : VERTICAL MAX 0.025mm
HORIZONTAL MAX 0.025mm
BURR SIDE : ALL TOP SIDE
2. MOLD BURR & FLASH : PACKAGE OUT LINE BURR MAX 0.100mm
EXPOSED PAD FLASH MAX 0.200mm
3. PACKAGE WARPAGE MAX 0.025mm
4. LEAD AND EXPOSED PAD PLATING : PURE TIN
THICKNESS> 7.62~25.4um

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■ Marking Contents

