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APPROVAL SHEET

Product	Battery Protect Solution IC
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■ Contents

■ 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

±35mV (Ta=25℃), [+44, -50]mV (Ta=-30~70℃)

- Overdischarge detection voltage

±58mV (Ta=25℃), [+63, -76]mV (Ta=-30~70℃)

- Discharge overcurrent detection voltage

±20mV (Ta=25℃), [+21, -22]mV (Ta=-30~70℃)

- Charging overcurrent detection voltage

±30mV (Ta=25℃), ±32mV (Ta=-30~70℃)

③ Built-in detection delay times (timer circuit)

- Overcharge detection delay time

5.00±1.50s (Ta=25℃), 5.00[+3.1,－1.85]s (Ta=-30~70℃)

- Overdischarge detection delay time

20.0±6.0ms (Ta=25℃), 20.0[+12.4,－7.2]ms (Ta=-30~70℃)

- Discharge overcurrent detection delay time

12.0±4.0ms (Ta=25℃), 12.0[+7.4,－4.6]ms (Ta=-30~70℃)

- Charging overcurrent detection delay time

16.0±5.0ms (Ta=25℃), 16.0[+10.0,－6.1]ms (Ta=-30~70℃)

- Short detection delay time

300[+200,－70]µs (Ta=25℃), 300[+295,－85]µs (Ta=-30~70℃)

④ 0V charge function allowed

2) FET

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
- $R_{SS(ON)}$ < 46mΩ (V_{GS} = 4.5V, I_D = 5A)
- ESD Rating : 2000V HBM

■ 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.

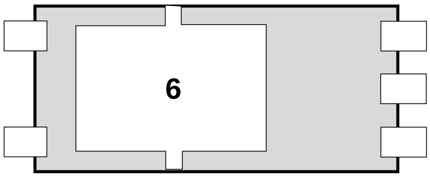
Once discharge overcurrent or short have been detected, if the state of discharge overcurrent or short is released by opening the loads, the D_{OUT} output becomes high level after delay time fixed in the IC. On overdischarge state, the supply current is reduced as less as possible. Once charge overcurrent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

■ Pin Assignment

[Package: TEP-5L]

<TOP VIEW>

<BOTTOM VIEW>

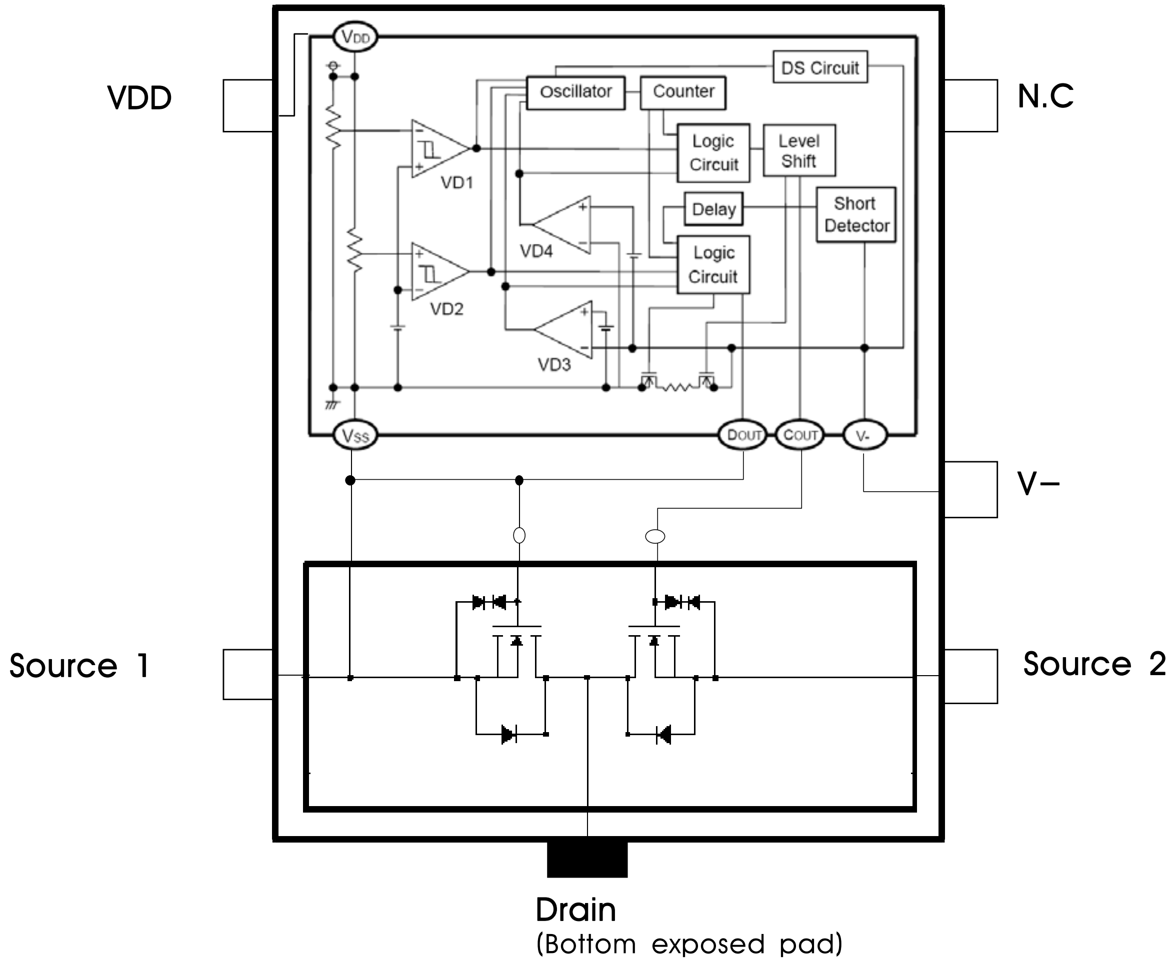


1	**V_{DD}**
2	**Source 1** (same as V_{SS})
3	**Source 2**
4	**N.C** (No connected)
5	**V–**
6	**Drain**

■ Pin Function

Symbol	Pin Function Description
VDD	VDD is a positive power supply, connected to the positive terminal of the cell through 1kΩ resistor.
S1	S1 is a negative power supply, connected to the negative terminal of the cell and discharge FET source for internal.
S2	Negative charge input pin, S2 is connected to charge FET source.
V−	V− is Overcurrent detect and negative power supply of charge FET. When the discharge current increases and the V− input voltage exceeds the overcurrent limit(Vdet3), or the short-circuit current limit (Vshort), the IC will control internal MOSFET to stop charging. If the input voltage drops to Vdet3 or below, it recovers from the overcurrent state.

■ Block Diagram



■ Absolute Maximum Rating

※ T_{OPR}=25℃, Source1(V_{SS})=0V

Item	Symbol	Rating	Unit
Supply Voltage	V_{DD}	−0.3 ~ 12.0	V
V− Terminal Input Voltage	V−	V_{DD}−30 ~ V_{DD}+0.3	V
DS Terminal Input Voltage	VDS	V_{SS}−0.3 ~ V_{DD}+0.3	V
C_{OUT} Terminal Output Voltage	V_{COUT}	V_{DD}−30 ~ V_{DD}+0.3	V
D_{OUT} Terminal Output Voltage	V_{DOUT}	V_{SS}−0.3 ~ V_{DD}+0.3	V
Operation Temperature	T_{OPR}	−40 ~ 85	℃
Storage Temperature	T_{STG}	−55 ~ 125	℃
Drain−Source Voltage	V_{DS}	30	V
Gate−Source Voltage	V_{GS}	±12	V

■ Electrical Characteristics

※ T_{OPR}=25℃

Item	Symbol	Measure Condition	Min.	Typ.	Max.	Unit	*1
Operating Input Voltage	$V_{DD}1$	V_{DD} − V_{SS}	1.5	−	5.0	V	A
Minimum Operating Voltage for 0V Charging	V_{ST}	VDD−V−, VDD−Vss=0V	−	−	1.8	V	A
		T_{OPR}= −30~70℃			1.95		
Overcurrent Release Resistance	R_{SHORT}	V_{DD}=3.6V, V−=1.0V	20	45	70	kΩ	F
		T_{OPR}= −30~70℃	18.1	45	79.5		
C_{OUT} Pin Nch ON Voltage	$V_{OL}1$	I_{OL}=50㎂, V_{DD}=4.5V	−	0.4	0.5	V	−
C_{OUT} Pin Pch ON Voltage	$V_{OH}1$	I_{OH}=−50㎂, V_{DD}=3.9V	3.4	3.7	−	V	−
D_{OUT} Pin Nch ON Voltage	$V_{OL}2$	I_{OL}=50㎂, V_{DD}=2.0V	−	0.2	0.5	V	−
D_{OUT} Pin Pch ON Voltage	$V_{OH}2$	I_{OL}=−50㎂, V_{DD}=3.9V	3.4	3.7	−	V	−
Current Consumption	I_{DD}	V_{DD}=3.9V, V−=0V	−	4.0	6.5	㎂	L
		T_{OPR}= −30~70℃		4.0	7.13		
Current Consumption at Stand−By	I_S	V_{DD}=2.0V	−	−	0.1	㎂	L
		T_{OPR}= −30~70℃	−	−	0.11		
Overcharge Detection Voltage	$V_{DET}1$	R1=1㏀	4.265	4.300	4.335	V	B
Overcharge Release Voltage	$V_{REL}1$	R1=1㏀	4.050	4.100	4.150	V	B
Overdischarge Detection Voltage	$V_{DET}2$	Detect falling edge of supply voltage	2.242	2.300	2.358	V	D
Overdischarge Release Voltage	$V_{REL}2'$	Vchg=4.2V , R1=1㏀	2.240	2.300	2.360	V	E
Discharging Overcurrent Detection Voltage	$V_{DET}3$	Detect rising edge of 'V−' pin voltage	0.110	0.130	0.150	V	F
Charging Overcurrent Detection Voltage	$V_{DET}4$	Detect rising edge of 'V−' pin voltage	−0.130	−0.100	−0.070	V	G
Short Detection Voltage	V_{SHORT}	V_{DD}=3.0V	0.55	0.80	1.00	V	F

Note : *1 The test circuit symbols.

※ T_{OPR}=25℃

Item	Symbol	Measure Condition	Min.	Typ.	Max.	Unit	*1
Overcharge Detection Delay Time	$tV_{DET}1$	V_{DD}=3.6V→4.4V	3.50	5.00	6.50	s	B
Overcharge Release Delay Time	$tV_{REL}1$	V_{DD}=4.5V→3.6V	11.0	16.0	21.0	ms	B
Overcharge Detection Delay Timer Reset Time	$tV_{RST}1$	V_{DD}=3.6V→4.4V→3.6V→4.4V Timer reset time *2	8.0	16.0	24.0	ms	B
Overdischarge Detection Delay Time	$tV_{DET}2$	V_{DD}=3.6V→2.2V	14.0	20.0	26.0	ms	D
Overdischarge Release Delay Time	$tV_{REL}2$	V_{DD}=2.0V→3.0V	0.7	1.2	1.7	ms	E
Discharging Overcurrent Detection Delay Time	$tV_{DET}3$	V_{DD}=3.0V, V-=0V→0.5V	8.0	12.0	16.0	ms	F
Discharging Overcurrent Release Delay Time	$tV_{REL}3$	V_{DD}=3.0V, V-=3V→0V	0.7	1.2	1.7	ms	F
Charging Overcurrent Detection Delay Time	$tV_{DET}4$	V_{DD}=3.0V, V-=0V→-1V	11.0	16.0	21.0	ms	G
Charging Overcurrent Release Delay Time	$tV_{REL}4$	V_{DD}=3.0V, V-=-1V→0V	0.7	1.2	1.7	ms	G
Short Detection Delay Time	t_{SHORT}	V_{DD}=3.0V, V-=0V→3V	230	300	500	µs	F
Drain-Source Breakdown Voltage	BV_{DSS}	I_D=250µA, V_{GS}=0V	30	-	-	V	
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS}=24V, V_{GS}=0V T_J=55℃	-	-	1 5	µA	
Gate-Body Leakage Current	I_{GSS}	V_{DS}=0V, V_{GS}=±10V	-	-	10	µA	
Gate-Source Breakdown Voltage	BV_{GSO}	V_{DS}=0V, I_G=±250µA	±12	-	-	V	
Gate Threshold Voltage	$V_{GS(th)}$	V_{DS}=V_{GS}, I_D=250µA	0.6	1.0	1.5	V	
Static Source-Source ON-Resistance	$R_{SS(ON)}$	V_{GS}=10V, I_D=5A	29	34	40	mΩ	
		T_J=125℃	47	52	62	mΩ	
		V_{GS}=4.5V, I_D=5A	35	40	46	mΩ	
		V_{GS}=3.9V, I_D=5A	36	41	48	mΩ	
		V_{GS}=2.5V, I_D=3A	47	52	66	mΩ	
Diode Forward Voltage	V_{SD}	I_S=1A, V_{GS}=0V	0.50	0.76	0.90	V	
Maximum Body-Diode Continuous Current	I_S				4.5	A	

Note : *1 The test circuit symbols.
*2 The parameter is guaranteed by design.

※ T_{OPR}=-30~70℃ *2

Item	Symbol	Measure Condition	Min.	Typ.	Max.	Unit	*1
Overcharge Detection Voltage	$V_{DET}1$	R1=1kΩ	4.250	4.300	4.344	V	B
Overcharge Release Voltage	$V_{REL}1$	R1=1kΩ	4.028	4.100	4.164	V	B
Overdischarge Detection Voltage	$V_{DET}2$	Detect falling edge of supply voltage	2.224	2.300	2.363	V	D
Overdischarge Release Voltage	$V_{REL}2'$	Vchg=4.2V , R1=1kΩ	2.230	2.300	2.370	V	E
Discharging Overcurrent Detection Voltage	$V_{DET}3$	Detect rising edge of 'V-' pin voltage	0.108	0.130	0.151	V	F
Charging Overcurrent Detection Voltage	$V_{DET}4$	Detect rising edge of 'V-' pin voltage	-0.132	-0.100	-0.068	V	G
Short Detection Voltage	V_{SHORT}	V_{DD}=3.0V	0.50	0.80	1.07	V	F
Overcharge Detection Delay Time	$tV_{DET}1$	V_{DD}=3.6V→4.4V	3.15	5.00	8.10	s	B
Overcharge Release Delay Time	$tV_{REL}1$	V_{DD}=4.5V→3.6V	9.8	16.0	25.9	ms	B
Overcharge Detection Delay Timer Reset Time	$tV_{RST}1$	V_{DD}=3.6V→4.4V→3.6V→4.4V Timer reset time *2	5.0	16.0	50.0	ms	B
Overdischarge Detection Delay Time	$tV_{DET}2$	V_{DD}=3.6V→2.2V	12.8	20.0	32.4	ms	D
Overdischarge Release Delay Time	$tV_{REL}2$	V_{DD}=3V, V-=3V→0V	0.62	1.2	2.02	ms	E
Discharging Overcurrent Detection Delay Time	$tV_{DET}3$	V_{DD}=3.0V, V-=0V→0.5V	7.4	12.0	19.4	ms	F
Discharging Overcurrent Release Delay Time	$tV_{REL}3$	V_{DD}=3.0V, V-=3V→0V	0.62	1.2	2.03	ms	F
Charging Overcurrent Detection Delay Time	$tV_{DET}4$	V_{DD}=3.0V, V-=0V→-1V	9.9	16.0	26.0	ms	G
Charging Overcurrent Release Delay Time	$tV_{REL}4$	V_{DD}=3.0V, V-=-1V→0V	0.62	1.2	2.03	ms	G
Short Detection Delay Time	t_{SHORT}	V_{DD}=3.0V, V-=0V→3V	215	300	595	µs	F

Note : *1 The test circuit symbols.

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

Fig1. I_D - V_{DS}

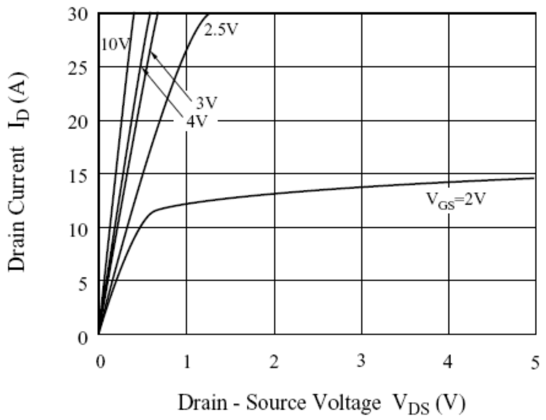


Fig2. $R_{DS(ON)}$ - I_D

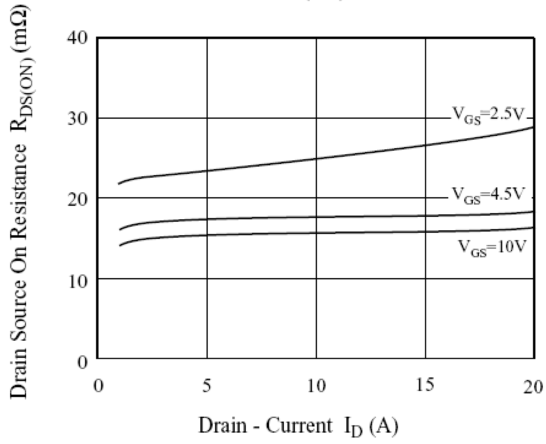


Fig3. I_D - V_{GS}

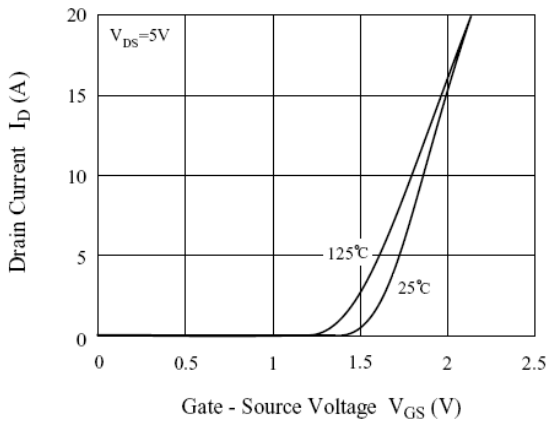


Fig4. $R_{DS(ON)}$ - T_j

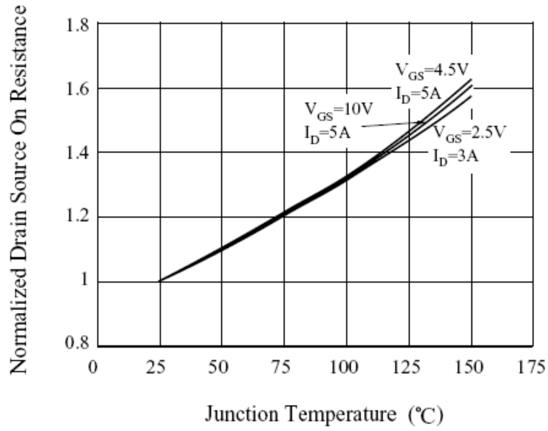


Fig5. $R_{DS(ON)}$ - V_{GS}

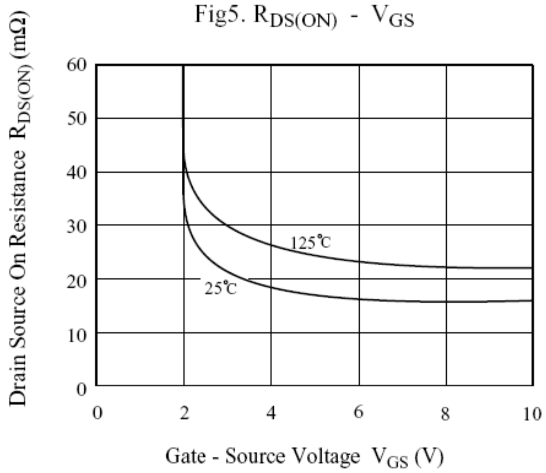


Fig6. I_{DR} - V_{SDF}

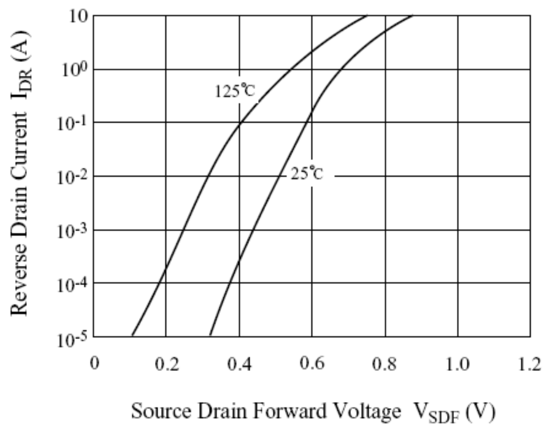


Fig7. V_{GS} - Q_g

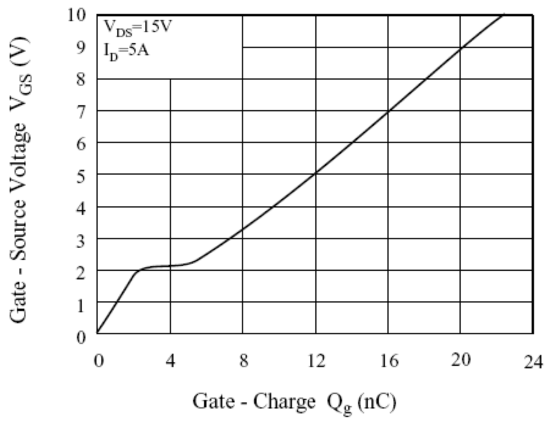
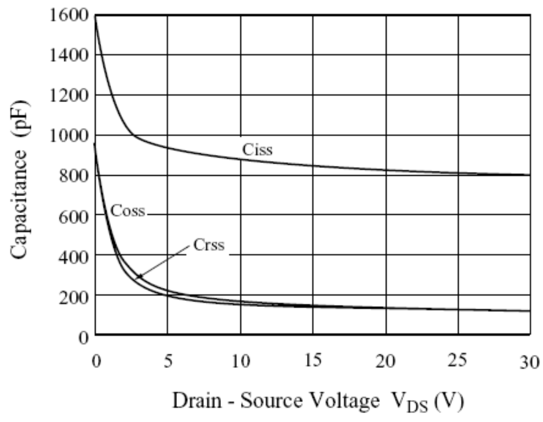
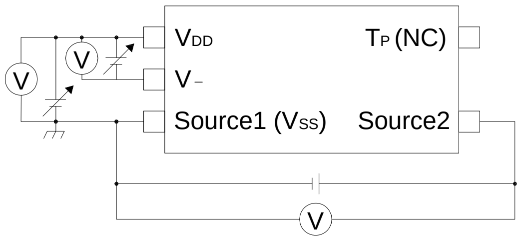


Fig8. C - V_{DS}



■ Measuring Circuit

A.



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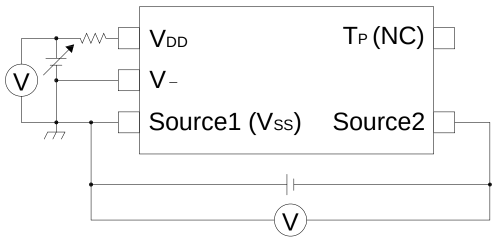

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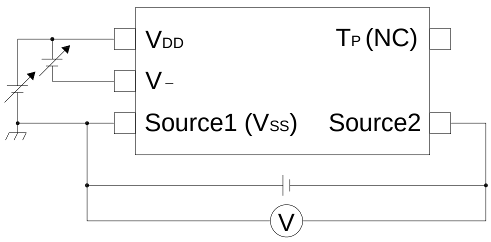

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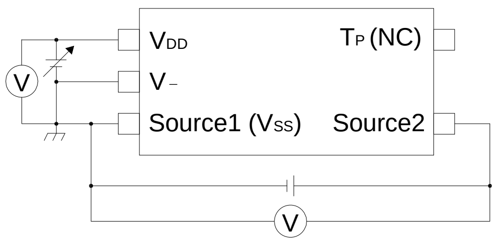

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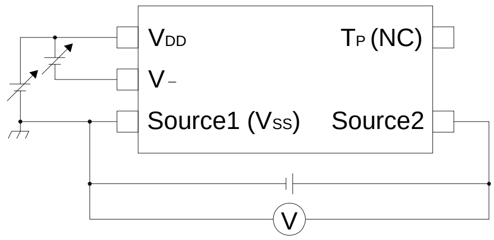

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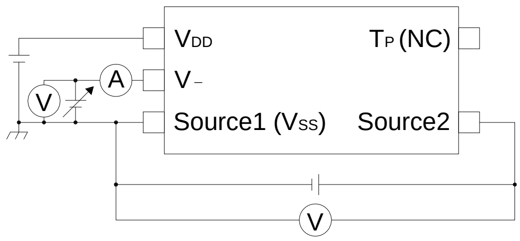
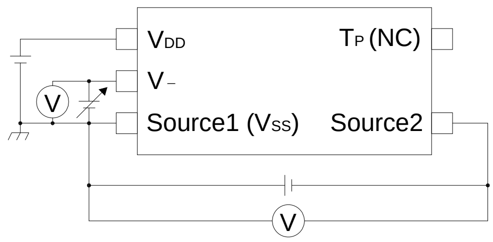
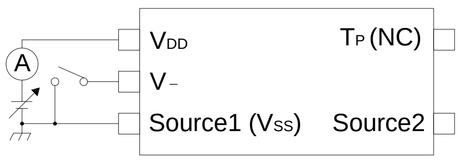


G.



H.



■ 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. 4.300V). 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(Typ.4.100V). 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 paracitical 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. 5.00s), 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 overdiscahrge 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 paracitical 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 overdiscahrge detection voltage, the D_{OUT} terminal will turn to high level with the delay time.

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 chargable and dischargabe, VD3 monitors the voltage level of V_- pin. If the V_- terminal voltage becomes higher than the discharging overcurrent detection voltage (Typ. 0.130V) by short of loads, etc., it will detect discharging overcurrent state. If the V_- terminal voltage becomes higher then 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. 12ms), it will not detect discharging overcurrent. Morever, 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. 50kohm) 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 discahrging overcurrent or short state. if discharging overcurrent or short is detected, the discharging overcurrent release resistance turns ON. On the normal state (chargable and dischargable state), the discharging overcurrent release resistance is OFF.

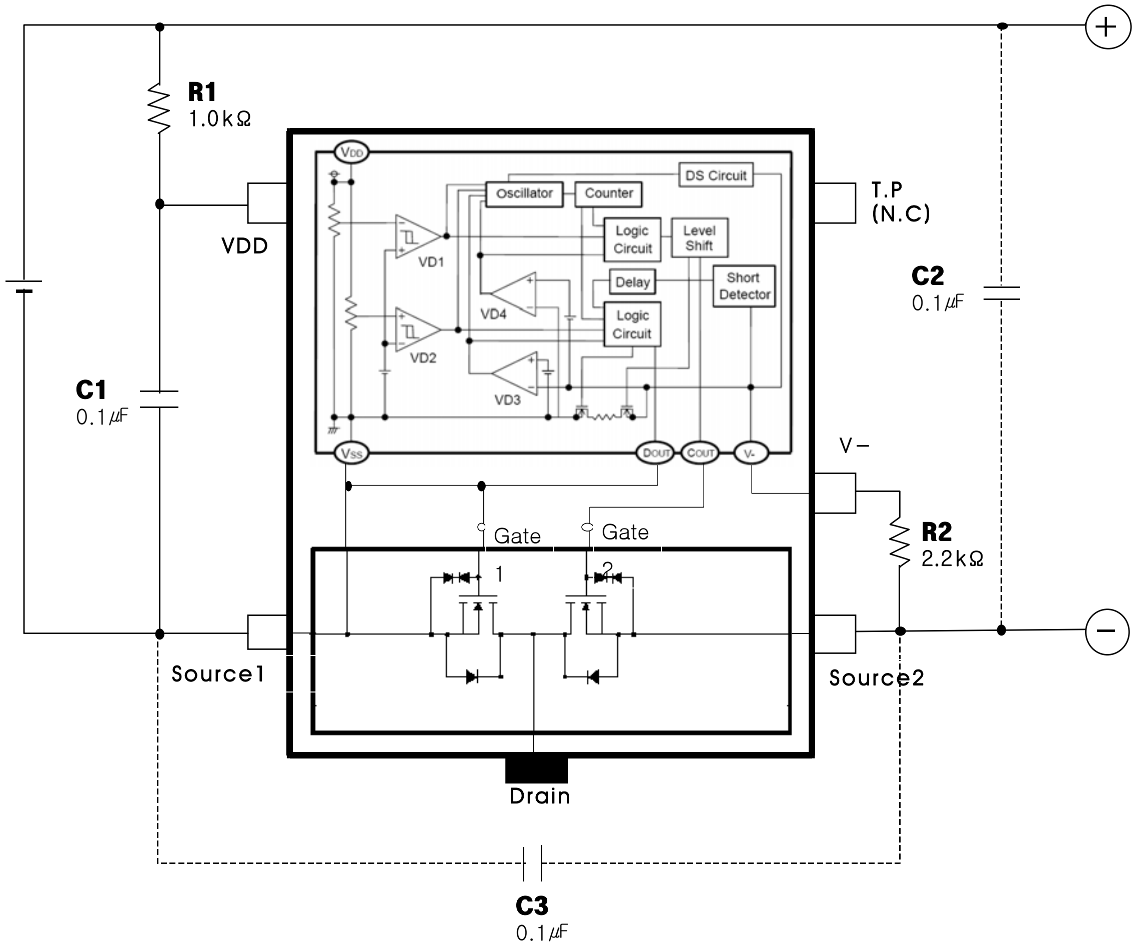
4. Charge overcurrent detector (VD4)

In the state of chargable and dischargable, 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.

The charging overcurrent detection has delay time decided internally. When the V_- terminal voltage becomes lower than the charging overcurrent detection voltage, if the V_- terminal voltage becomes higher than the charging overcurrent detection voltage within the charging overcurrent detection delay time (Typ. 16ms), it will not detect charging overcurrent. Morever, the charging overcurrent release delay time (Typ. 1.2ms) exists, too.

■ Application Circuit (Example)



※ Application Hint

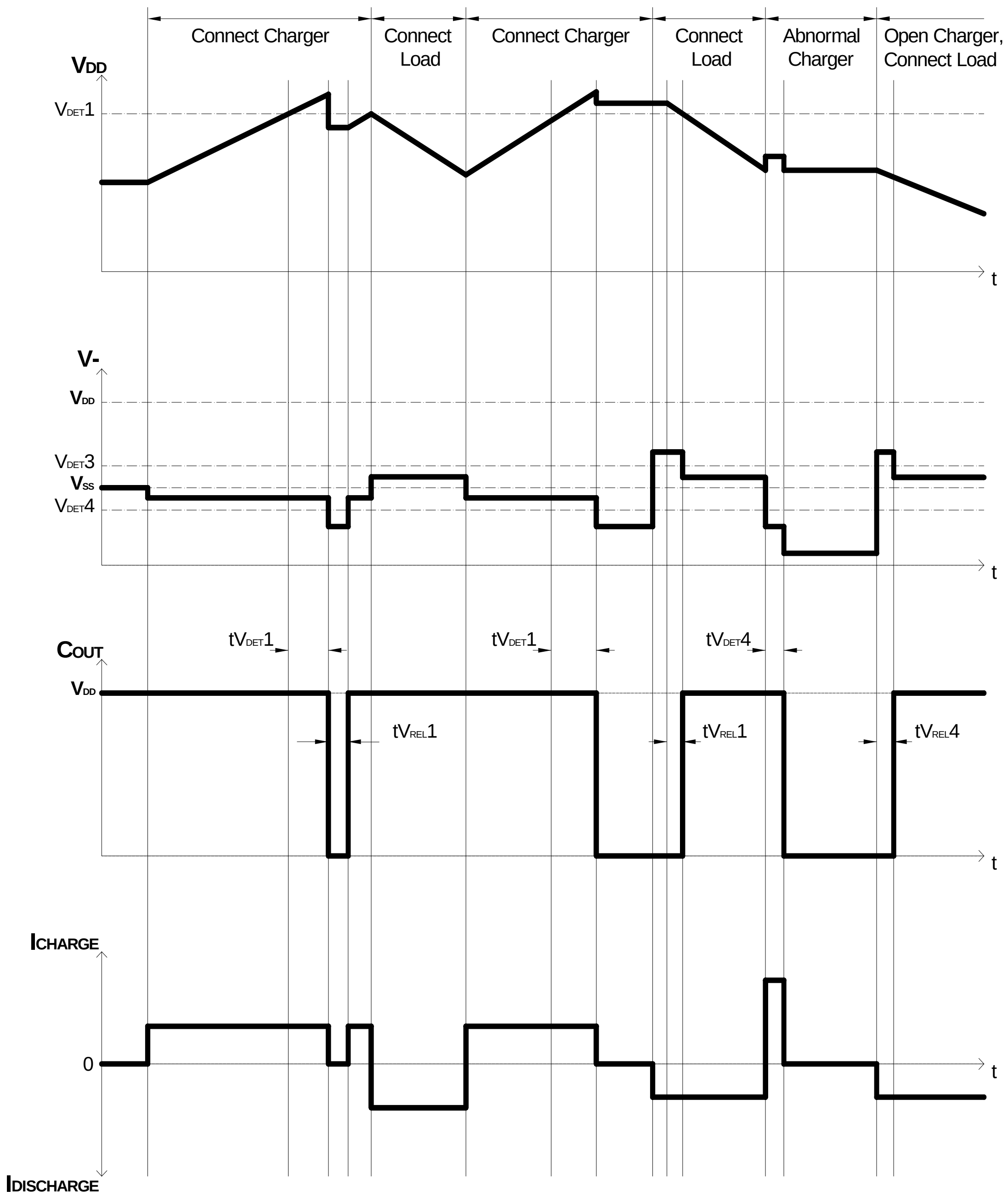
R1 and C1 stabilize a supply voltage ripple. However, the detection voltage rises by the current of penetration in IC of the voltage detection when R1 is enlarged, so the value of R1 is adjusted to 1kohm or less. Moreover, adjust the value of C1 to 0.1uF or more to do the stability operation, please.

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.

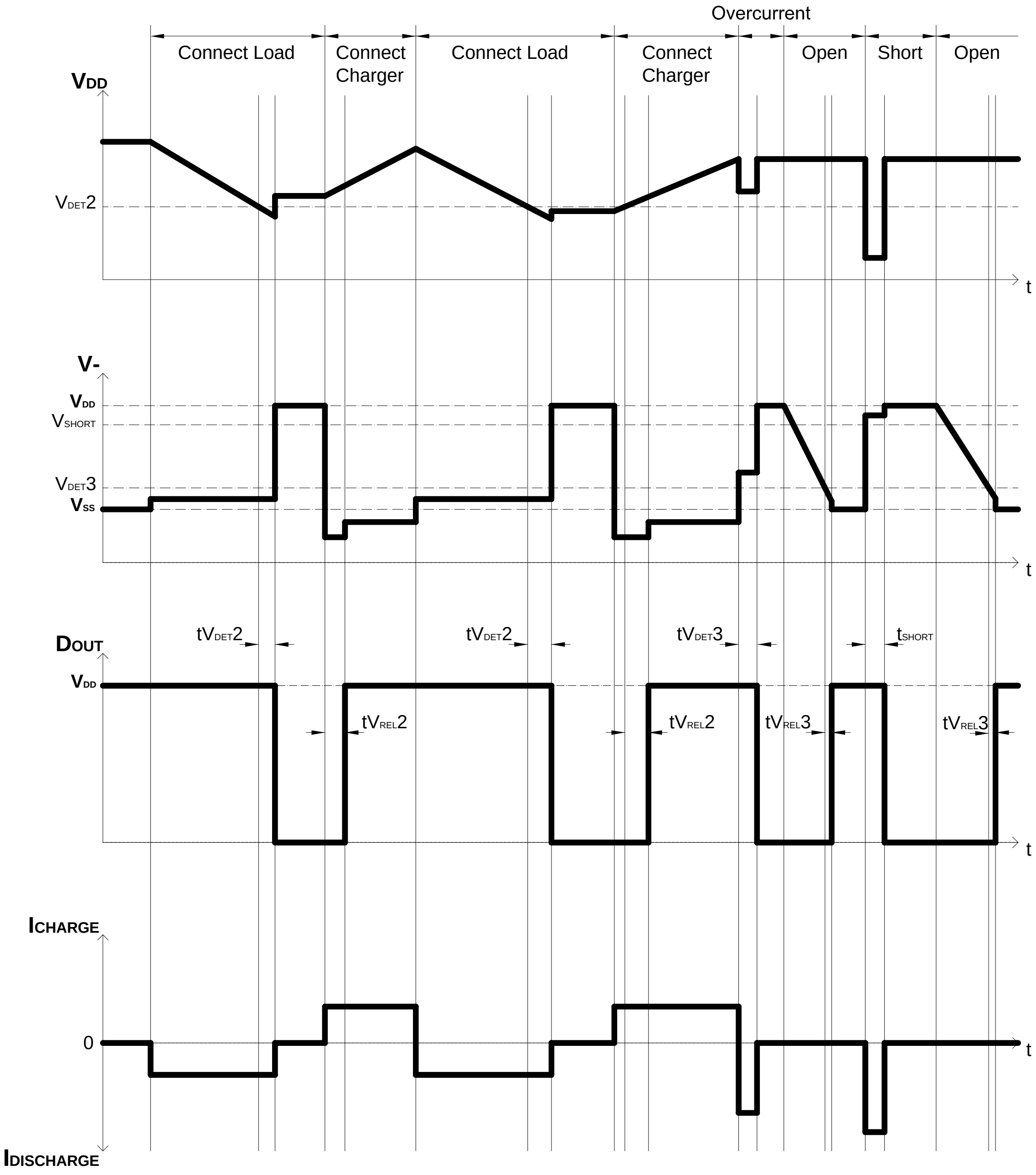
C2 and C3 capacitors have effect that the system stability about voltage ripple or imported noise. After check characteristics, decide that these capacitors should be inserted or not, where should be inserted, and capacitance value, please.

■ Timing Chart

1. Overcharge, Charging overcurrent operations

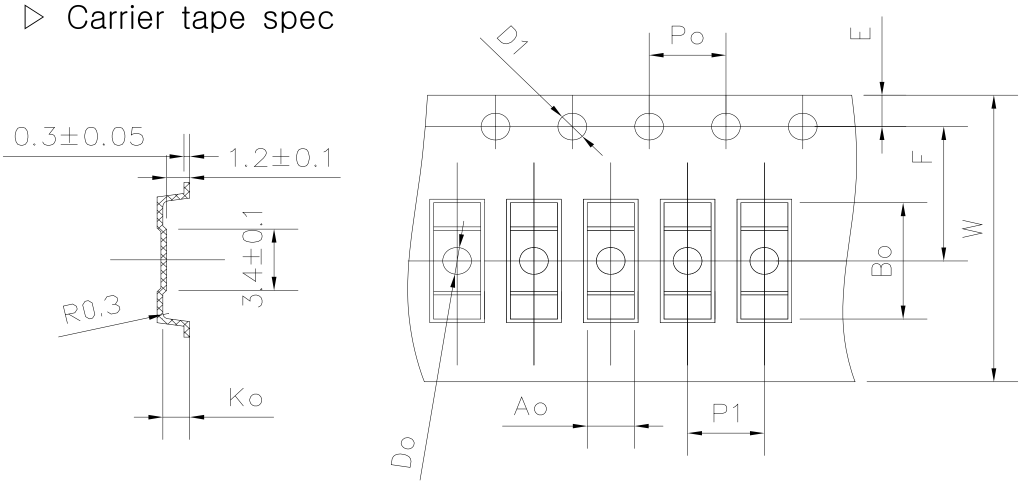


2. Overdischarge, Discharging Overcurrent and Short operations



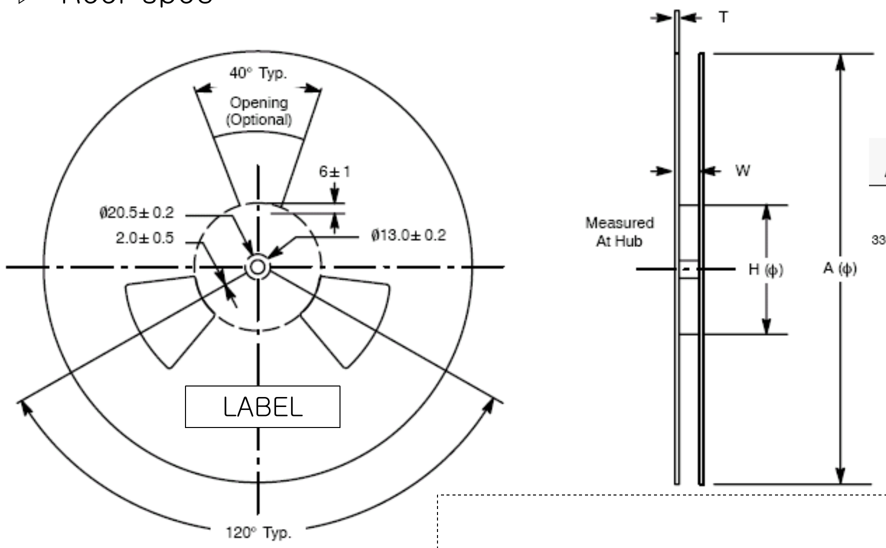
■ Packing spec

▷ Carrier tape spec

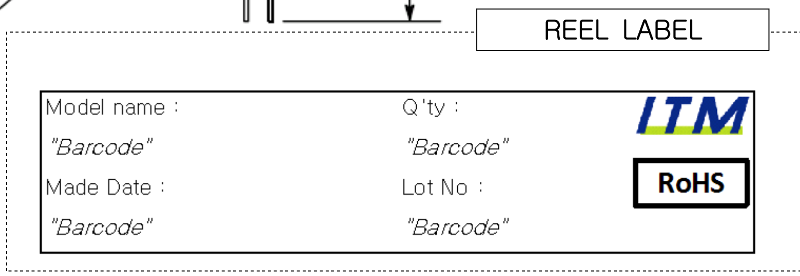


Ao=2.45±0.1
Bo=6.5±0.1
p1=4±0.1
E=1.75±0.1
F=7.5±0.1
W=16±0.3
Po=4±0.1
Do=Ø1.5 +0.1/−0
Ko=1.4±0.1

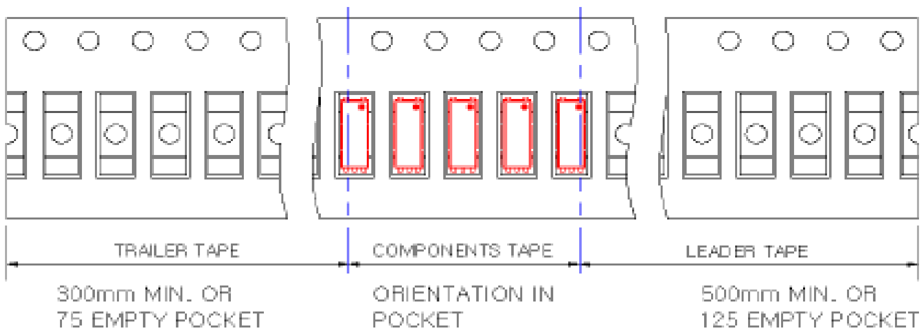
▷ Reel spec



A	W		TAPE WIDTH	H	T
330±2	16.4	+2.0 / −0	16	100±1	2.5±0.5



▷ Taping spec



▷ OUTER BOX PACKING SPECIFICATION

OUT BOX LABEL

ITM ITM Semiconductor Co., LTD

Model No : 'Barcode'

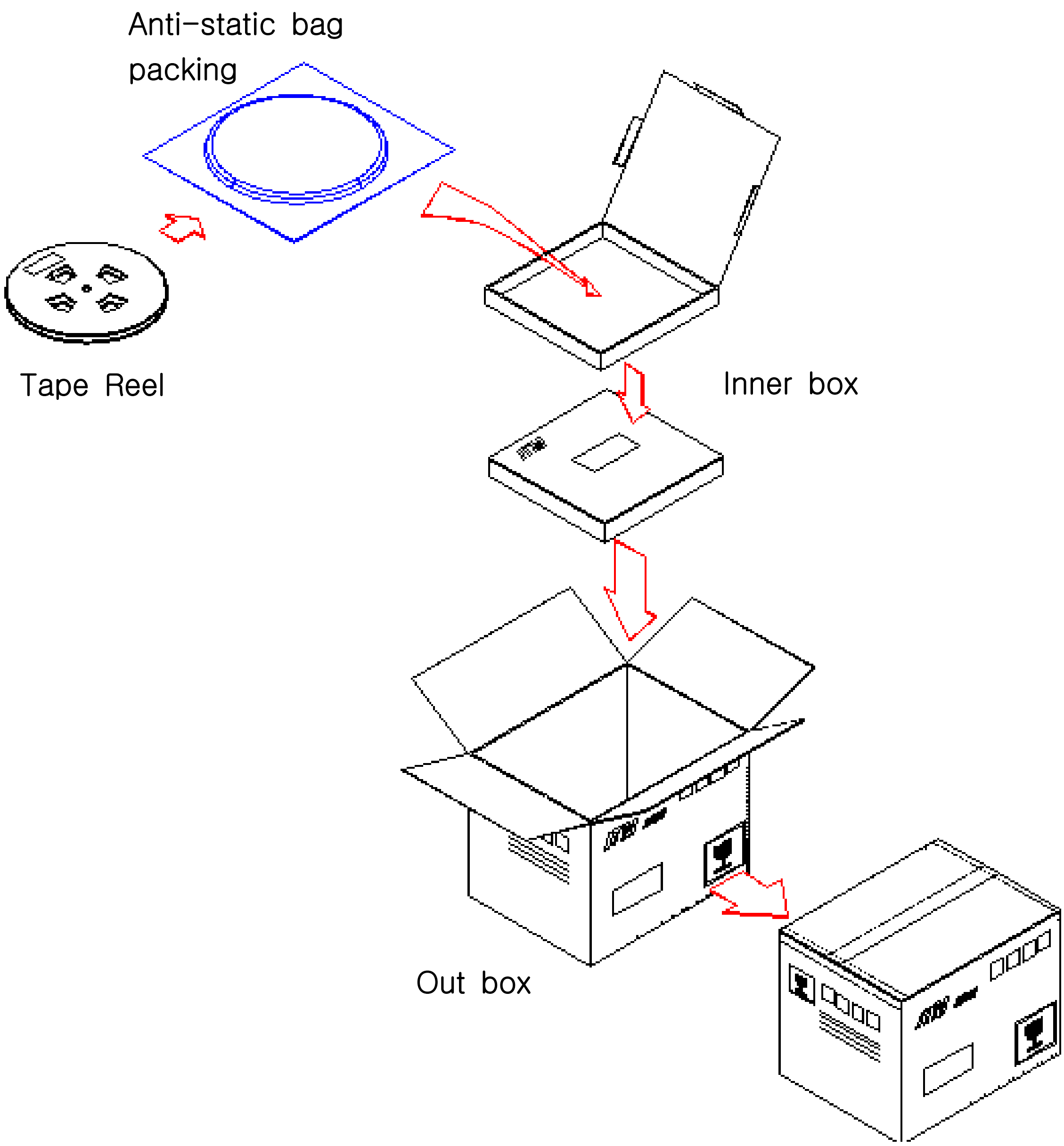
Q'ty : 'Barcode'

Ship Date : 'Barcode'

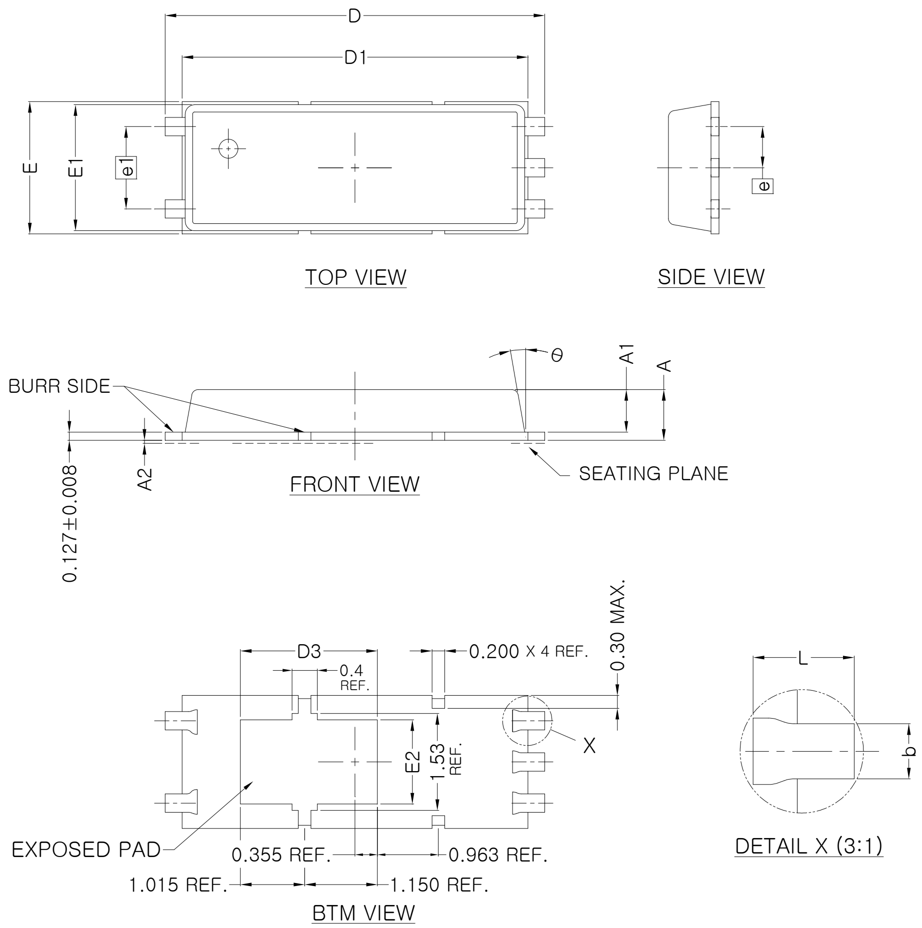
Halogen free

Lot No : 'Barcode'

RoHS



■ Package Description



SYMBOL	DIMENSIONS			NOTE
	MIN.	NOM.	MAX.	
A	0.750	0.800	0.850	
A1	0.623	0.673	0.723	
A2	–	–	0.050	
D	5.900	6.000	6.100	
D1	5.320	5.370	5.420	
D3	2.220 REF.			
E	2.000	2.100	2.200	
E1	1.950	2.000	2.050	
E2	1.330 REF.			
Θ	–	–	10 °	
e	0.650 BSC			
e1	1.300 BSC			
L	0.350	–	–	
b	0.255	0.300	0.390	

NOTE

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

■ Marking Contents