TS2208A/B
Li-Ion Battery Protector

SOT-26

Pin assignment
1. D_{OUT}
2. V-
3. C_{OUT}
4. C_{EXT}
5. V_{DD}
6. V_{SS}

Ideal for One-Cell Rechargeable Li-Ion Battery

General Description

The TS2208A/B series are over-charge/discharge protection ICs for rechargeable one-cell Lithium-ion batteries. They bear an over-charge/over-discharge threshold for the battery cell voltage during charging/discharging process, and also provide on-time protection when excess current or short circuit occurs.

The TS2208A/B series are essentially composed of a reference unit and three voltage detectors. During charging process, when the cell voltage/V_{DD} crosses the over-charge threshold voltage V_{C1}, the over charge detector (COM1) will switch the output pin (C_{OUT}) to a low level within a delay time (t_{C1}), and thus turning off the MOSFET connected to the charging path. The C_{OUT} pin may change to high level again when the V_{DD} voltage falls below "$V_{C1}-V_{HYS}$", or when V_{DD} falls below V_{C1} while the charger is disconnected from the battery pack.

During the discharging process, when the V_{DD} voltage crosses the over-discharge threshold voltage (V_{D1}), the over-discharge detector (COM2) will switch D_{OUT} to low level within a delay time (t_{D1}), and thus turning off the MOSFET connecting the discharging path. In the mean time, the TS2208A/B series will enter a low current standby mode. Once into standby mode, it can only be released from standby after the battery pack is connected to a charger.

The conditions of excess current and short circuit protection are both determined according to the voltage at the V- pin. As the voltage of V- pin reaches a greater value than V_{OC}, which means an undesirable large current is flowing through the path, D_{OUT} will be switched to a low level and the path is cutoff after internally pre-set delay time (t_{OC}) elapses. In the case of short circuit, i.e. V- rises above V_{SHORT}, the path will also be cutoff but with almost no delay time. Once the excess current or short circuit fault is removed, the built-in resistor at the V- pin, typically 100kohm, will pull V- down to V_{SS} and bringing the IC back to normal operation.

Together with the application circuit, the TS2208A/B will function as a consummate protector for Li-ion battery packs which leads to safety and long lifetime.

Features

✧ Low current consumption
   Supply current 3uA (typ) and standby current 0.1uA
✧ High withstand voltage up to 22V (VDD ~ V-)
✧ High accuracy voltage detection
✧ Over charge detector
✧ Over discharge detector
✧ Over current and short circuit protection
✧ Small package of SOT-26

Applications

✧ Over-charge and over-discharge protection for Li-ion cell pack
✧ High precision protectors for cell-phones and other gadget using on board Li-ion cell battery

Ordering Information

Part No.	Threshold Voltage	Reel
TS2208ACX6	4.33V ~ 4.37V	Black
TS2208BCX6	4.26V ~ 4.30V	White

Note: Marking B**XX**,
   **XX** is wafer and assembly lot code (A~Z and 1~9)

Pin Description

No.	Symbol	Description
1	D_{OUT}	Output of over discharge detection
2	V-	Pin for charger negative input
3	C_{OUT}	Output of over charge detection
4	C_{EXT}	Pin for external capacitor Setting COM1 delay time
5	V_{DD}	Power supply
6	V_{SS}	Ground

Block Diagram
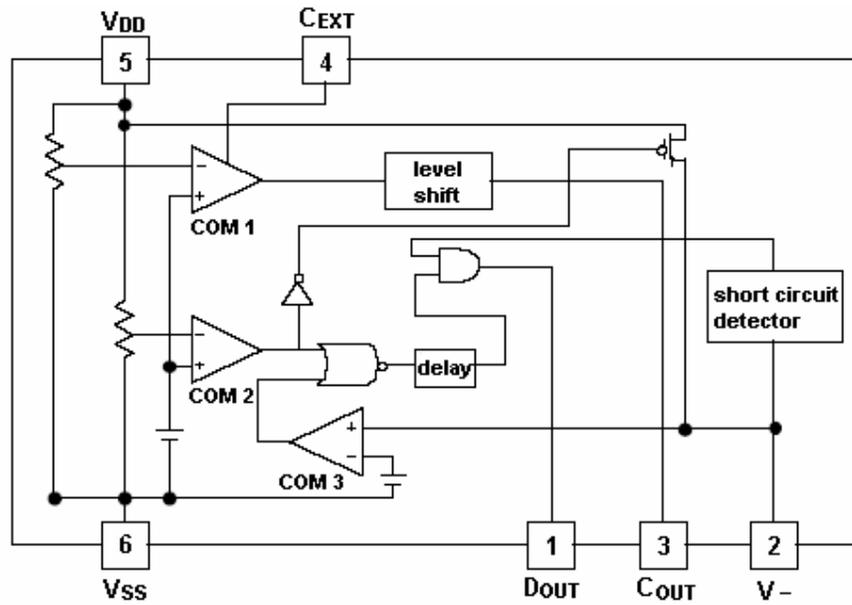
Typical Application
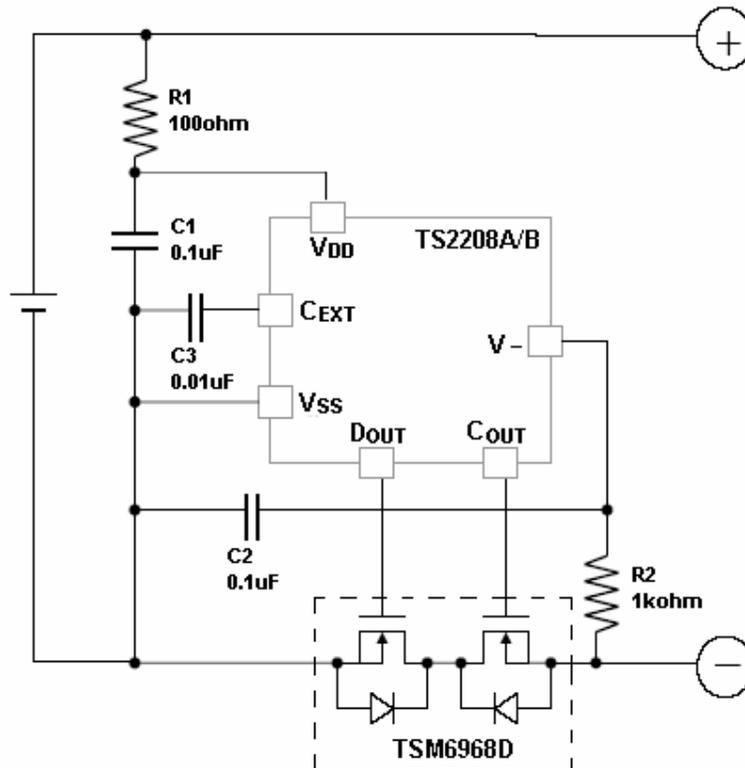
Absolute Maximum Rating

Supply Voltage		V_{DD}	-0.3 to 12	V
Input Voltage	V- pin	V-	V_{DD}-22 to V_{DD} +0.3	V
	V_{CT} pin	VCext	V_{DD}-0.3 to V_{DD} +0.3	V
Output Voltage	C_{OUT} pin	VC_{OUT}	V_{DD}-22 to V_{DD} +0.3	V
	D_{OUT} pin	VD_{OUT}	V_{DD}-0.3 to V_{DD} +0.3	V
Power Dissipation		P_D	150	mW
Operating Temperature Range		T_{OPT}	-40 to +85	^{o}C
Storage Temperature Range		T_{STG}	-50 to +120	^{o}C

Note:
Absolute Maximum ratings are threshold limit values that must not be exceeded even for an instant under any conditions. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily functional operation below these limits.

Electrical Characteristics (Ta = 25 ^{o}C, unless otherwise specified.)

Parameter	Conditions		Symbol	Min	Typ	Max	Unit
Operating input voltage	Voltage defined as V_{DD}-V_{SS}		V_{DD1}	1.5	--	10	V
Over-charge threshold voltage	Detect rising edge of supply voltage	TS2208A	V_{C1}	4.33	4.35	4.37	V
		TS2208B		4.26	4.28	4.30	
Over-charge threshold hysteresis range			V_{HYS}	0.15	0.20	0.25	V
Over-charge delay time	C_3= 0.01µF, V_{DD} = 3.6V to 4.4V		t_{C1}	60	75	90	ms
Over-discharge threshold voltage	Detect falling edge of supply voltage		V_{D1}	2.437	2.500	2.563	V
Over-discharge delay time	V_{DD}= 3.6V to 2.4V		t_{D1}	7	10	13	ms
Over current detection voltage	Detect rising edge of "V-" pin voltage		V_{OC}	0.17	0.20	0.23	V
Over current detection delay time	V_{DD}= 3.0V		t_{OC}	9	14	17	ms
Short circuit detection voltage	V_{DD}= 3.0V		Vshort	V_{DD}-1.2	V_{DD}-0.9	V_{DD}-0.6	V
Short circuit detection delay time	V_{DD}= 3.0V		tshort	--	5	50	µS
Reset resistance for excess current protection	V_{DD}= 3.6V,V-=1.0V		Rshort	50	100	150	KΩ
Nch ON voltage of C_{OUT}	I_{OL} = 50µA, V_{DD}= 4.4V		V_{OL1}	--	0.3	0.5	V
Pch ON voltage of C_{OUT}	I_{OH} = -50µA, V_{DD}= 3.9V		V_{OH1}	3.4	3.8	--	V
Nch ON voltage of C_{OUT}	I_{OH} = 50µA, V_{DD}= 2.4V		V_{OL2}	--	0.2	0.5	V
Pch ON voltage of C_{OUT}	I_{OH}= -50µA, V_{DD}= 3.9V		V_{OH2}	3.4	3.7	--	V
Supply current	V_{DD}= 3.9V,V-= 0V		I_{DD}	--	3	5	µA
Standby current	V_{DD}= 2.0V		$I_{standby}$	--	--	0.1	µA

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Operation Description

COM1 (Over-Charge Detector)

COM1 is the monitor of the voltage at the V_{DD} pin. COM1 senses an over charging condition and if this condition continues longer than the delay time (t_{C1}), When the voltage at V_{DD} exceeds the over charge detector threshold V_{C1}. the C_{OUT} pin goes to a "L" level thus turns off the external charge control N-ch MOSFET. An internal level shifter is incorporated in the buffer driver at the C_{OUT} pin to drive the "L" level of C_{OUT} equal to the V- pin voltage. By the way, the "H" level of C_{OUT} is set equal to V_{DD}.

The delay time (t_{C1}) of over-charging is decided by the external capacitor C_3 connected between the Vss and Cext pin, it can be estimated as $\mathbf{t_{C1} = [C_3 \times (V_{DD}\text{-}0.7)] / (0.48 \times 10^{-6})}$. However, if the over-charge condition doesn't last long enough to cover the time delay window, C_{OUT} will not go "L" and the charging process continues.

Required Conditions to Reset COM1 from Over Charging

After the MOSFET, the charge control is turns off, COM1 can be reset under two conditions. As resetting COM1 means C_{OUT} returns to "H" again and the charging path is reconnected to restart of charging process. One of the condition to reset COM1 is when V_{DD} falls to lower than "V_{C1} - V_{HYS}" as a result of battery cell internal discharge. Disconnecting the battery pack from the charger can also reset COM1 even when V_{DD} is still within the hysteresis window (V_{C1} - $V_{HYS} \leq V_{DD} < V_{C1}$).

After the battery pack is disconnected from the charger, connecting a system load to the battery pack allows current to flow through the parasitic diode of external charge control MOSFET. This discharging current will bring V_{DD} down a little over some time and once V_{DD} drops below V_{C1}, C_{OUT} will become "H".

COM2 (Over-Discharge Detector)

COM2 monitors the cell voltage at the V_{DD} pin. When V_{DD} drops below the over-discharge threshold V_{D2} during the discharging process, COM1 senses an over-charging condition and after delay time (t_{D1}), the D_{OUT} pin goes to a "L" level and thus turning off the external discharge control N-ch MOSFET. As soon as this happens, the V- pin will be pulled "H" by an internal PMOS and TS2208A/B series will be enter a standby mode.

Connecting the battery pack to a charger is a necessary condition for TS2208A/B series to recover from standby mode. With the charger connected, the charge current can flow through the parasitic diode of the external discharge control N-ch MOSFET while V_{DD} is still lower than the over-discharge threshold. Once V_{DD} is charged up to a value higher than V_{D1}, the D_{OUT} pin goes "H". This leads to the "ON" state of both the charge and discharge control MOSFETs, and the charge process proceeds on as long as the charger is connected. Connecting a charger to the battery pack when V_{DD} voltage is already higher then V_{D1} will make D_{OUT} instantaneously "H".

COM3 (Over Current Detector, Short Circuit Protector)

The over current detector and short circuit protector can work when both the charge and discharge control N-ch MOSFETs are "ON".

Under normal operation, the V- pin voltage will be either slightly higher or lower than Vss (dependent on the impedance of the two MOSFETs). However, when the V- pin voltage rises to a value between the short protection voltage Vshort and over current threshold V_{OC}, the TS2208A/B series detect an excess current condition. As a result, the external discharge control N-ch MOSFET goes "OFF" with the D_{OUT} pin being at "L". An output delay time for the over current detection is internally fixed. A quick recovery of V- from a value between Vshort and V_{OC} to the normal value within the delay time keeps the discharge control FET staying at the "ON" state.

Short circuit may as well be explained as a "serious" over current condition. When the V- pin voltage rises to a value not only higher than V_{OC} but also higher than Vshort, the short circuit protector will shut the discharge MOSFET down immediately to protect battery pack from being damaged or exploding.

The V- pin has a built-in pull down resistor. Thus once the cause of over current or short circuit is removed, the V- pin will be pulled down to the ground level through the internal resistor. Therefore, with V- lower than the over current and short circuit protection threshold, D_{OUT} will be turned back on and the TS2208A/B series can continue normal charge or discharge operation.

Notice that when over current or short circuit occurs, the TS2208A/B series will not enter a standby mode.

Timing Diagram
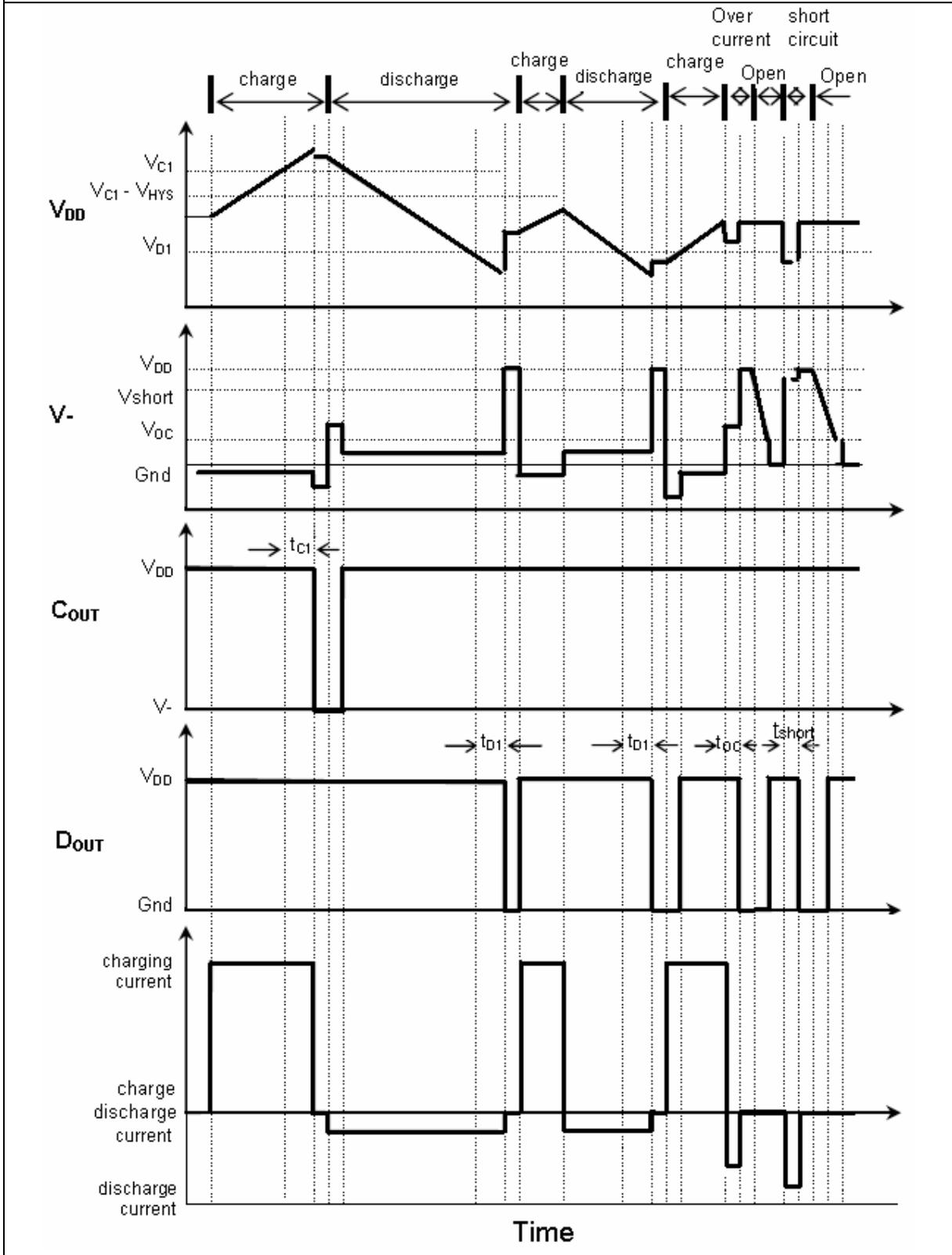
SOT-26 Mechanical Drawing
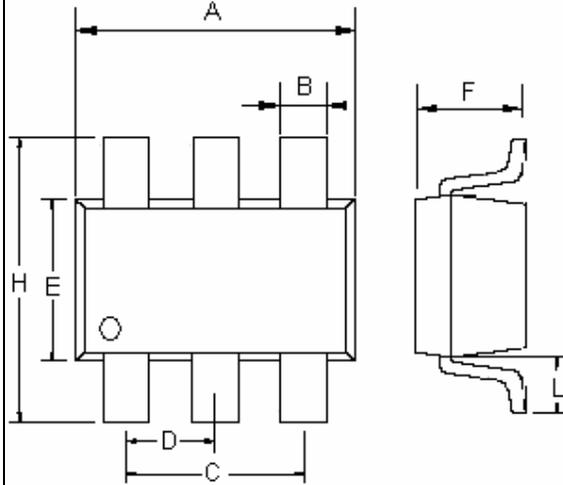
DIM	SOT-26 DIMENSION			
	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.70	3.00	0.106	0.118
B	0.25	0.50	0.010	0.020
C	1.90(typ)		0.075(typ)	
D	0.95(typ)		0.037(typ)	
E	1.50	1.70	0.059	0.067
F	1.05	1.35	0.041	0.053
H	2.60	3.00	0.102	0.118
L	0.60(typ)		0.024(typ)	