TP3201

1cell Li-ion battery Protector IC

DataSheet

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http://www.topro.com.tw

HQ:
5 F, No.10, Prosperity Road 1, Science-Based Industrial Park, Hsinchu 300, Taiwan, R.O.C
300 新竹科學工業園區展業一路 10 號 5 樓
TPE:
5 F, No.27, Min Chuan W. Rd. Taipei 104, Taiwan, R.O.C
104 台北市民權西路 27 號 5 樓
SHENZHEN:
Room 802, Tower A, World Trade Plaza, Fahong Rd., Fatian, Shenzhen, China
深圳市福田區福虹路 9 號世貿廣場 A 座 802 室(郵編：518033)

H.Q.: Tel:886-3-5632515 Fax:886-3-5641728
TPE.: Tel:886-2-25856858 Fax:886-2-25941104
SHENZHEN:TEL:755-3679985 Fax:755-3679518

TOPRO
凌越科技
Topro Technology Inc.

TP3201

1cell Li-ion battery Protector IC

General Specification

The TP3201 series are protection IC for over-charge/discharge of rechargeable one-cell Lithium-ion (Li+) batteries by CMOS process. The TP3201 series can detect over-charge/discharge of Li+ one-cell and excess load current, further include a short circuit protector for preventing large external short circuit current.

Each of these ICs is composed of three voltage detectors, a reference unit, a hysteresis circuit, and a short circuit protector. When charging voltage crosses the detector threshold from a low value to a value higher than V_{DET1}, the output of C_{OUT} pin, the output of over-charge detector/VD1, switches to low level, charger's negative pin level. After detecting overcharge the VD1 can be reset and the output of C_{OUT} pin becomes "H" when the V_{DD} voltage is coming down to a level lower than ' $V_{DET1} - V_{HYS1}$ ", or when a charger is disconnected from the battery pack while the V_{DD} level is in between 'V_{DET1}" and ' $V_{DET1} - V_{HYS1}$ " in the TP3201 version.

The output of D_{OUT} pin, the output of over-discharge detector/VD2, switches to "L" after internally fixed delay time passed, when discharging voltage crosses the detector threshold from a high value to a value lower than V_{DET2}. An excess load current can be sensed and cut off after internally fixed delay time passed through the built in excess current detector, VD3, with D_{OUT} being enabled to low level. Once after detecting excess current, the VD3 is released and D_{OUT} level switches to "H" by detaching a battery pack from a load system.

Further, short circuit protector makes Dout level to "L" immediately with external short circuit current and removing external short circuit leads D_{OUT} level to "H". After detecting over-discharge, supply current will be kept extremely "L" by halting some internal circuits operation. The output delay of over - charge detectors can be set by connecting external capacitors. Output type of C_{OUT} and D_{OUT} are CMOS. SOT26-w is available.

Model	Package	Overcharge detection Voltage(V)	Overcharge detection Hysteresis voltage(mV)	Overdischarge Detection Voltage(V)	Overcurrent Detection Voltage(mV)
	SOT-26-W				
TP3201	101E	4.35±0.05	200±50	2.5	200±30
	101F	4.35±0.05	200±50	2.5	100±30

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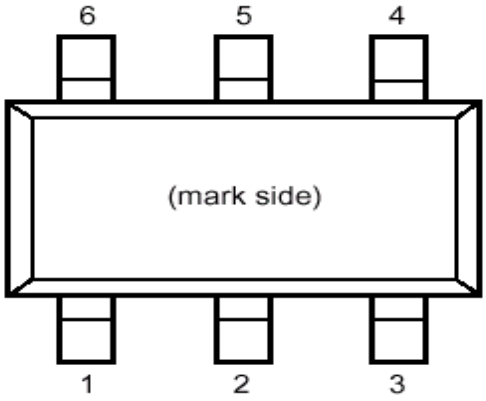
Contents：

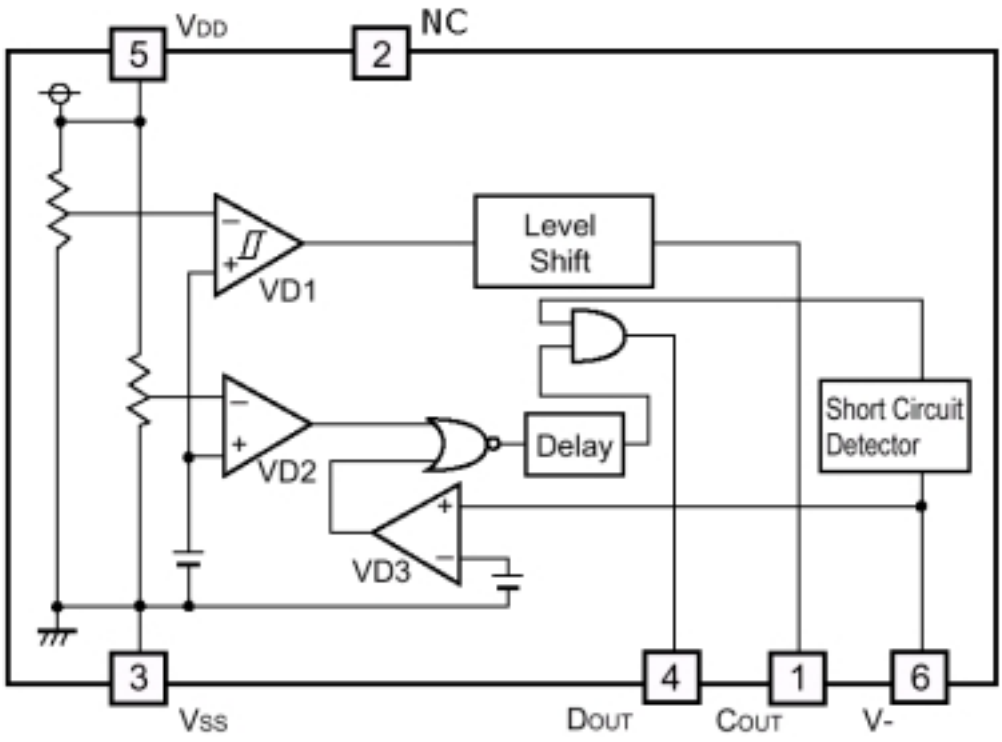
Pin Configurations and Package Type



3.PIN Descriptions :

Pin No	Symbol	Pin description
1	COUT	Output of over-charge detection, CMOS output
2	NC	
3	VSS	Ground
4	DOUT	Output of over-discharge detection, CMOS output
5	VDD	Power supply
6	V-	Pin for charger negative input

4.Function Block Diagram :



5.Function Descriptions :

● VD1/Over-Charge Detector

- The VD1 monitors V_{DD} pin voltage. When the V_{DD} voltage crosses over-charge detector threshold V_{DET1} from a low value to a value higher than the V_{DET1} the VD1 can sense over-charging and an external charge control Nch-MOS-FET turns to "OFF' with C_{OUT} pin being at "L".

- A level shifter incorporated in a buffer driver for the C_{OUT} pin makes the "L" of C_{OUT} pin to the V- pin voltage and the "H" of C_{OUT} pin is set to V_{DD} voltage with CMOS buffer.

Reset conditions from overcharging of TP3201

- There can be two cases to reset the VD1 making the C_{OUT} pin level to "H" again after detecting overcharge. Resetting the VD1 makes the charging system ready for resumption of charging process.

  The first case is in such condition that a time when the V_{DD} voltage is coming down to a level lower than "V_{DET1}- V_{HYS1}".

  While in the second case, disconnecting a charger from the battery pack can make the VD1 resetting when the V_{DD} level is within hysteresis width ($V_{DET1} – V_{HYS1}<V_{DD}<v_{DET1}$)

- After detecting overcharge with the V_{DD} voltage of higher than V_{DET1}, connecting system load to the battery pack makes load current allowable through parasitic diode of external charge control Nch-MOS-FET. The C_{OUT} level would be "H" when the V_{DD} level is coming down to a level below the V_{DET1} by continuous drawing of load current.

● VD2/Over-Discharge Detector

- The VD2 monitors a V_{DD} pin voltage. When the V_{DD} voltage crosses the over-discharge detector threshold V_{DET2} from a high value to a value lower than the V_{DET2}, the VD2 can sense an over-discharging and the external discharge control Nch-MOS-FET turns to "OFF" with the D_{OUT} pin being at "L".

- Resetting the VD2 with the D_{OUT} pin level being "H" again after detecting over-discharge is only possible by connecting a charger to the battery pack. When the V_{DD} voltage stays under over-discharge detector threshold V_{DET2} charge current can flow through parasitic diode of external discharge control Nch-MOS-FET, then after the V_{DD} voltage comes up to a value larger than V_{DET2} discharging process would be advanced through "ON" state discharge control Nch-MOS-FET. Connecting a charger to the battery pack makes the D_{OUT} level being "H" instantaneously when the V_{DD} voltage is higher than V_{DET2}.

- When a cell voltage equals to zero, connecting charger to the battery pack makes the system allowable for charge with higher charge voltage than Vst, 1.2V Max.

- An output delay time for the over-discharge detection is fixed internally. Though the V_{DD} voltage would be going down to a lower level than V_{DET2} if it is within a time period of the output delay time, VD2 would not output a signal for turning “OFF” of discharge control Nch-MOS-FET.

- After detection of an over-discharge by VD2, supply current would be reduced to 0.3 μATYP. at V_{DD}=2.0V and into standby, only the charger detector is operating.

- The output type of D_{OUT} pin is CMOS having “H” level of V_{DD} and “L” level of Vss.

● VD3/Excess Current Detector, Short Circuit Protector

- Both of the excess current detector and short circuit protector can work when both control Nch-MOS-FETs are in “ON” state.
  When the V- pin voltage is going up to a value between the short protection voltage Vshort and excess current threshold V_{DET3}, the excess current detector operates and further soaring of V- pin voltage higher than Vshort makes the short circuit protector enabled. As a result the external discharge control Nch-MOS-FET turns to “OFF” with the D_{OUT} pin being at “L”.

- An output delay time for the excess current detector is internally fixed, 8ms TYP. at Vote=3.0V. A quick recovery of V- pin level from a value between Vshort and V_{DET3} within the delay time keeps the discharge control FET staying “ON” state.
  When the short circuit protector is enabled, the D_{OUT} would be "L" and its delay time would be 5μs TYP.

- The V- pin has a built-in pull down resistor, TYP.100 kΩ, connected to the Vss pin.
  After an excess current or short circuit protection is detected, removing a cause of excess current or external short circuit makes an external discharge control Nch-MOS-FET to an "ON" state automatically with the V- pin level being down to the Vss level through the built-in pull down resistor.

- When V_{DD} voltage is higher than V_{DET2} at a time when the excess current is detected the TP3201 does not enter a standby mode, while V_{DD} voltage is lower than V_{DET2} the TP3201 enters a standby mode.
  After detecting short circuit the TP3201 will not enter a standby mode.

6.Absolute Maximum Rating :

Vss=0V

Symbol	Item		Rating	Unit
V_{DD}	Supply Voltage		-0.3 to 18V	V
V-	Input Voltage	V- pin	V_{DD}-20 to V_{DD}+0.3 V	V
V_{COUT}	Output Voltage	C_{OUT} pin	V_{DD}-20 to V_{DD}+0.3	V
V_{DOUT}		D_{OUT} pin	V_{DD}-0.3 to V_{DD}+0.3	V
P_D	Power Dissipation		150	mW
T_{OPT}	Operating Temperature Range		-10 to 85	℃
Tstg	Storage Temperature Range		-55 to 125	℃

ABSOLUTE MAXIMUM RATINGS
Absolute Maximum ratings are threshold limit values that must not be exceeded even for an instant under any conditions. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

7.DC Electrical Characteristic :

◆ TP3201

Topt=25℃

Symbol	Item	Conditions		MIN	TYP	MAX	Unit
V_{DD}	Operating input voltage	Voltage defined as V_{DD}-Vss		1.5		18	V
Vst	Minimum operating voltage for 0V charging	Voltage defined as V_{DD}-V-, V_{DD}-Vss=0V				1.2	V
V_{DET1}	Over-charge threshold voltage	Detect rising edge of supply voltage		4.30	4.35	4.40	V
V_{HYS1}	Over-charge threshold hysteresis range			0.15	0.2	0.25	V
t_{VDET1}	Output delay time of over-charge	V_{DD}=3.6V→ 4.3V		50	75	100	ms
V_{DET2}	Over-discharge threshold voltage	Detect falling edge of supply voltage		2.437	2.50	2.563	V
t_{VDET2}	Output delay time of over-discharge	V_{DD}=3.6V→2.4V		7	10	13	ms
V_{DET3}	Excess current threshold voltage	Detect rising edge of "V-" pin voltage	101E	0.17	0.20	0.23	V
			101F	0.7	0.10	0.13	
t_{VDET3}	Output delay time of excess current	V_{DD}=3.0V		9	13	17	ms

Vshort	Short detection voltage	V_{DD}=3.0V	V_{DD}-1.1	V_{DD}-0.8	V_{DD}-0.5	V
tshort	Output delay time of short detection	V_{DD}=3.0V		5	50	μs
Rshort	Reset resistance for excess current protection	V_{DD}=3.6V, V-=1.0V	50	100	150	kΩ
V_{OL1}	Nch ON voltage of C_{OUT}	I_{OL}= 50uA, V_{DD}=4.4V		0.2	0.5	V
V_{OH1}	Pch ON voltage of C_{OUT}	I_{OH}= -50uA, V_{DD}=3.9V	3.4	3.8		V
V_{OL2}	Nch ON voltage of D_{OUT}	I_{OL}= 50uA, V_{DD}=2.4V		0.2	0.5	V
V_{OH2}	Pch ON voltage of D_{OUT}	I_{OH}= -50uA, V_{DD}=3.9V	3.4	3.7		V
I_{DD}	Supply current	V_{DD}=3.9V, V- =0V		3.0	6.0	μA
Istandby	Standby current	V_{DD}=2.0V		0.2	0.4	μA

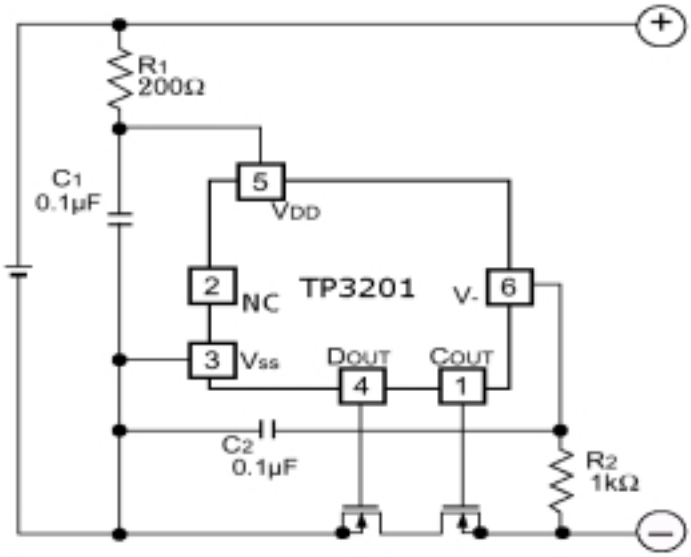
★ Please refer to Test Circuit unless otherwise specified.

8. AC Electrical Characteristic :

FEATURES

◆Low supply current……..	Supply current	TYP. 3.0uA
	Standby current (after detecting over-discharge)	TYP. 0.2uA
◆High withstand voltage……	Absolute maximum ratings 18V (V_{DD} -- V-)	
◆High accuracy detector threshold….	Over-charge detector	±50mV
	Over-discharge detector	±2.5%
◆Variety of detector threshold……	Over-charge detector threshold	4.0V to 4.4V/step of 0.01V
	Over-discharge detector threshold	2.0V to 3.0V/step of 0.05V
◆Built-in protection circuit……..	Excess current trip/Short circuit protector	
◆Output delay of over-charge…….	Time delay at V_{DD}=4.3V	75mS for TP3201
◆Ultra small package……..	SOT-26-w	

9.Application Diagram :



NOTE ON EXTERNAL COMPONENTS
• R_1 and C_1 will stabilize a supply voltage to the TP3201. A recommended R_1 value is less than 1kΩ. A larger value of R_1 leads higher detection voltage, makes some errors, because of shoot through current flowed in the TP3201. • R_2 and C_2 will stabilize a V- pin voltage. The resetting from over-discharge with connecting charger possibly be disabled by larger value of R_2. Recommended value is less than 1kΩ. After an over-charge detection, a system may not draw load current when a battery pack is connected to it in the C version with R_2 and C_2 time constants at relatively larger settings. Recommended C_2 value is less than 1μF. • R_1 and R_2 can operate as a current limiter against setting cell reverse direction or for applying excess charging voltage to the TP3201. While smaller R_1 and C_2 may cause an over power dissipation rating of the TP3201 and a total of "R_1+R_2" should be more than 1kΩ. R_1 should be more than 200Ω. • The time constants $R_1 \times C_1$ or $R2 \times C_2$ must have a relations as below: $R_1 \times C_1 \leqq R_2 \times C_2$ Because in case that $R_1 \times C_1$, time constant for V_{DD} pin, would be larger than $R_2 \times C_2$, time constant for V- pin, then the TP3201 might be into a standby mode after detecting excess current or short circuit current.

10. APPLICATIONS Notes:

◆Over-charge/overdischarge protection for Li+ one-cell pack

◆High precision protectors for cell-phones and any other gadgets using on board Li+ onecell battery