Protection IC for 1-Cell Battery Pack

Features

- High Detection Accuracy
  - Over-charge Detection: ±15mV
  - Over-discharge Detection: ±35mV
  - Discharge Over-current Detection: ±10mV/ ±15mV
  - Charge Over-current Detection: ±20mV
- High Withstand Voltage
  - Absolute maximum ratings: 28V (V- pin and CO pin)
- Ultra Small Package
  - SON-1.6X1.6-6L

Description

The NT1713 series are the 1-cell protection IC for lithium-ion/lithium-polymer rechargeable battery pack. The high accuracy voltage detector and delay time circuits are built in NT1713 series with state-of-art design and process.

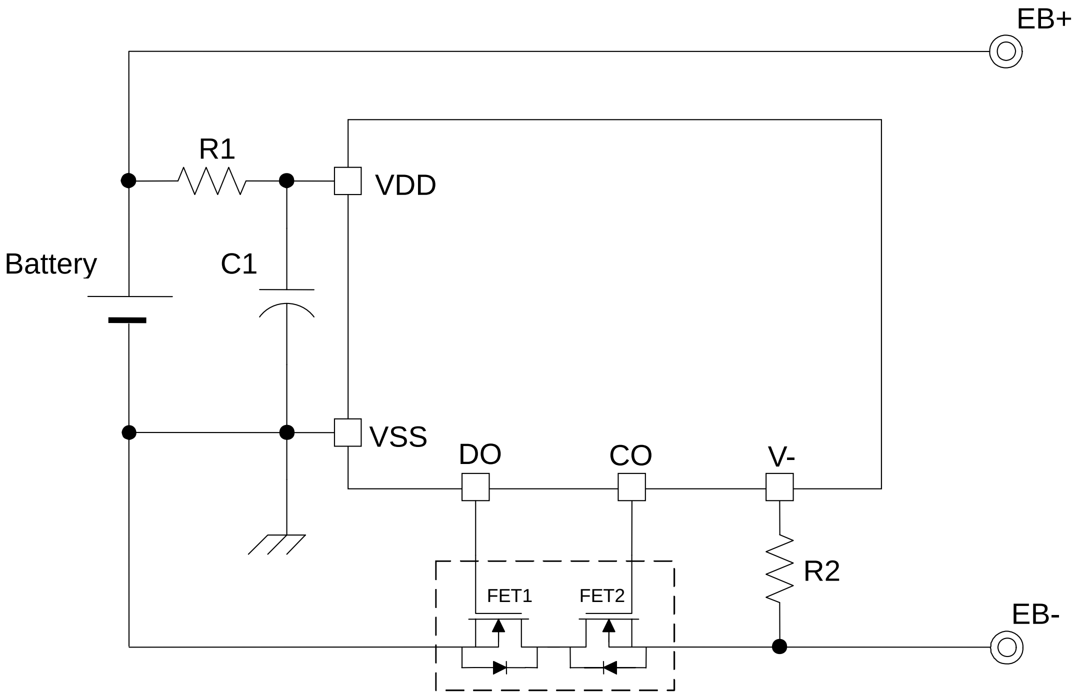
To minimize power consumption, NT1713 series activates power down mode when an over-discharge event is detected (for power-down mode enabled version). Besides, NT1713 series performs protection functions with four external components for miniaturized PCB.

The tiny package is especially suitable for compact portable device, i.e. slim mobile phone and Bluetooth earphone.

Application

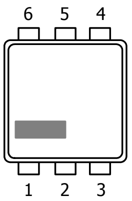
- Mobile phone battery packs
- Digital camera battery packs
- Bluetooth earphone Li-ion battery module

Typical Application Circuit



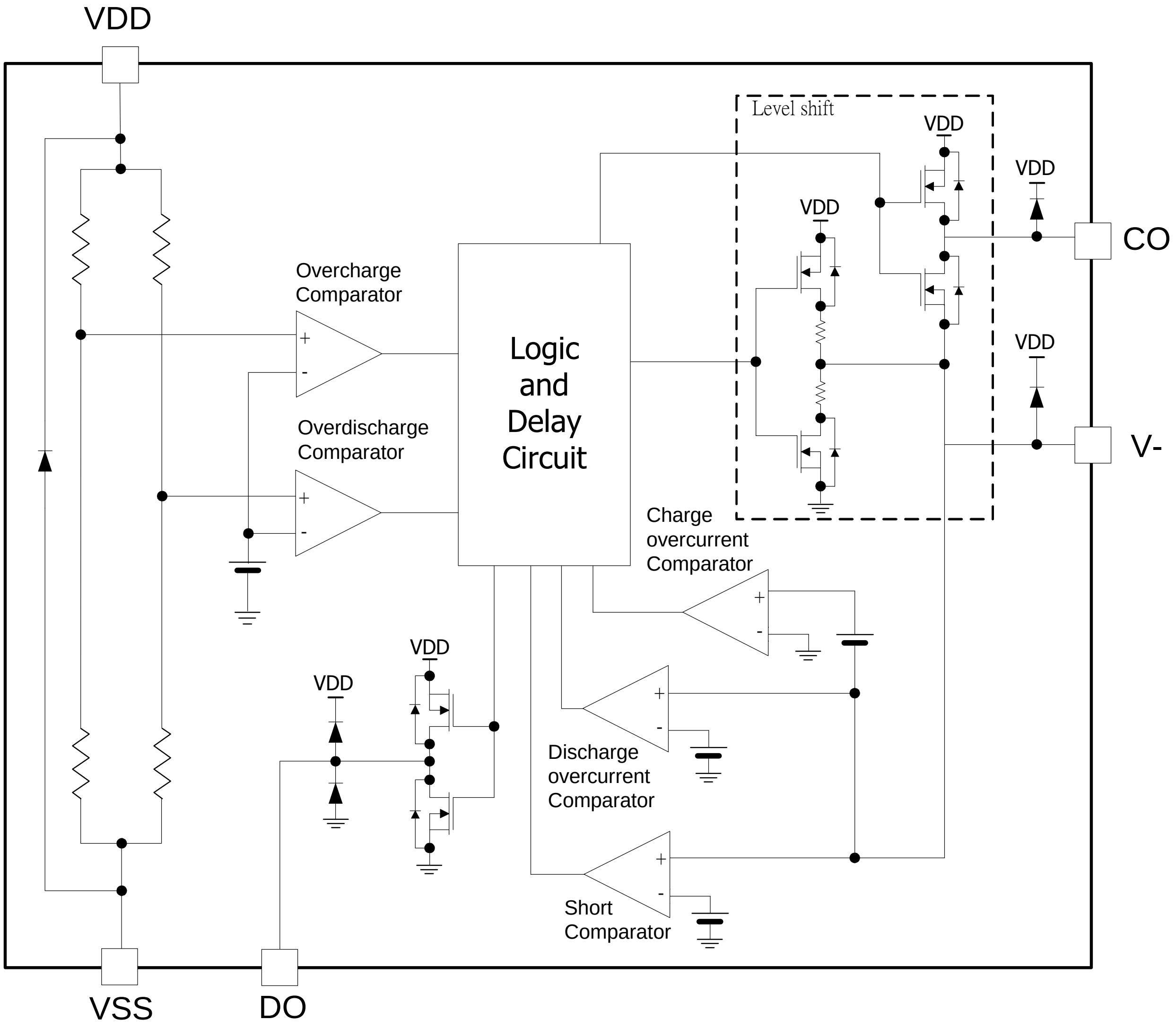
Package and Pin Description

SON-1.6X1.6-6L



Pin No.	Symbol	Pin description
1	NC	No connection
2	CO	Connection of charge control FET gate
3	DO	Connection of discharge control FET gate
4	V_{SS}	Connection for negative power supply input
5	V_{DD}	Connection for positive power supply input
6	V-	Voltage detection between V- pin and VSS pin (Over-current / charger detection pin)

Block Diagram



Ordering Information

NT1713A -XXX XX

- XX: Package Type
  - C1: SON-1.6x1.6-6L
- XXX: Version code

Product version code:

Table1: Detection threshold level table

Product Name	Version Code	Package Type	Over-charge Detection Voltage V_{DET1} (V)	Over-charge Hysteresis Voltage V_{HYS1} (V)	Over-discharge detection voltage V_{DET2} (V)	Over-discharge release voltage V_{REL2} (V)	Discharge over-current detection voltage V_{DET3} (V)	Charge over-current detection voltage V_{DET4} (V)	Load short-circuiting detection voltage V_{SHORT}(V)	0V Battery Charge Function	Delay Time Table 2
NT1713A	NQA	C1	4.425	0.20	2.8	3.0	0.038	-0.05	0.3	Available	(1)

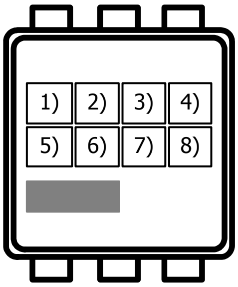
Table2: Delay Time table

Delay time	Over-charge delay time t_{VDET1} (S)	Over-discharge delay time t_{VDET2} (mS)	Discharge over-current delay time t_{VDET3} (mS)	Charge over-current delay time t_{VDET4} (mS)	Load short-circuiting delay time t_{SHORT} (uS)
(1)	1.0 +/- 20%	125 +/- 20%	8.0 +/- 20%	8.0 +/- 20%	400 +/- 20%

Remark Please contact our sales office for the products with detection voltage value other than those specified above.

Marking Information

SON-1.6zx1.6-6L
Top view



1) to 2) : Product code (**BN**)

3) to 4) : Version code

5) to 8) : Lot number

Product name vs. Version code

Product Name	Version Code	Version Code
		(3)(4) Version Code
		SON-1.6X1.6-6L
NT1713A	NQA	19

Absolute Maximum Ratings

Symbol	Descriptions		Rating	Units
V_{DD}	Supply Voltage		-0.3 to 7	V
V-	V- pin		V_{DD} - 28 to V_{DD} + 0.3	V
V_{CO}	Output Voltage	CO pin	V_{DD} -28 to V_{DD} + 0.3	V
V_{DO}		DO pin	Vss - 0.3 to V_{DD} + 0.3	V
T_{OPT}	Operating Temperature Range		-40 to +85	°C
T_{STG}	Storage Temperature Range		-55 to +125	°C

Applying any over "Absolute Maximum Ratings" practice can permanently damage the device. These data are indicated the absolute maximum values only but not implied any operating performance.

Electrical Characteristics (For Li-ion)

(Ta = 25°C)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	V_{DET1}-0.015	V_{DET1}	V_{DET1}+0.015	V
V_{HYS1}	Over-charge hysteresis voltage	--	V_{HYS1}-0.020	V_{HYS1}	V_{HYS1}+0.020	V
V_{DET2}	Over-discharge detection voltage	--	V_{DET2}-0.035	V_{DET2}	V_{DET2}+0.035	V
V_{REL2}	Over-discharge release voltage	$V_{DET2} \neq V_{REL2}$	V_{REL2}-0.050	V_{REL2}	V_{REL2}+0.050	V
		$V_{DET2} = V_{REL2}$	V_{REL2}-0.035	V_{REL2}	V_{REL2}+0.035	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V $V_{DET3}(typ) \leqq 0.150V$	V_{DET3}-0.010	V_{DET3}	V_{DET3}+0.010	V
V_{DET4}	Charge over-current detection	V_{DD}=3.5V	V_{DET4}-0.020	V_{DET4}	V_{DET4}+0.020	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V V_{SHORT}(typ)=0.30V	V_{SHORT}-0.05	V_{SHORT}	V_{SHORT}+0.05	V

(Continued)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Delay Time 【Table 2 Delay time (1)】						
t_{VDET1}	Output delay time of over-charge	-	0.8	1.0	1.2	s
t_{VDET2}	Output delay time of over-discharge	-	100	125	150	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	6.4	8.0	9.6	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	6.4	8.0	9.6	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	320	400	480	us
Current Consumption (power-down function enabled)						
V_{DD}	Operating input voltage	V_{DD} - V_{SS}	2.0		6.0	V
I_{DD}	Supply current	V_{DD}=3.5V, V-=0V	1.0	3.0	5.5	uA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=1.8V, V- floating			0.1	uA
0V Battery Charging Function						
V_{0CHA}	0 V battery charge starting charger voltage	0 V battery charging function "available"	0.5	1.0	1.5	V
V_{0INH}	0V battery charge inhibition battery voltage	0 V battery charging function "unavailable" (Vcharger=4V~14V)	0.5	1.0	1.5	V
Output Resistance						
R_{COH}	CO pin H resistance	V_{CO}=3.0V, V_{DD}=3.5V, V-=0V	1.25	2.50	5.00	KΩ
R_{COL}	CO pin L resistance	V_{CO}=0.5V, V_{DD}=4.5V, V-=0V	0.75	1.50	3.00	KΩ
R_{DOH}	DO pin H resistance	V_{DO}=3.0V, V_{DD}=3.5V, V-=0V	1.25	2.50	5.00	KΩ
R_{DOL}	DO pin L resistance	V_{DO}=0.5V, V_{DD}=1.8V, V-=0V	1.75	3.50	7.00	KΩ
V- Internal Resistance						
R_{VMD}	Internal resistance between V- and V_{DD}	V_{DD}=1.8V, V-=0V	100	300	900	KΩ
R_{VMS}	Internal resistance between V- and V_{SS}	V_{DD}=3.5V, V-=1.0V	50	100	300	KΩ

Electrical Characteristics (For Li-ion)

(Ta = -10 ~ 60°C)*

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	V_{DET1}-0.025	V_{DET1}	V_{DET1}+0.025	V
V_{HYS1}	Over-charge hysteresis voltage	--	V_{HYS1}-0.030	V_{HYS1}	V_{HYS1}+0.030	V
V_{DET2}	Over-discharge detection voltage	--	V_{DET2}-0.050	V_{DET2}	V_{DET2}+0.050	V
V_{REL2}	Over-discharge release voltage	$V_{DET2} \neq V_{REL2}$	V_{REL2}-0.080	V_{REL2}	V_{REL2}+0.080	V
		$V_{DET2} = V_{REL2}$	V_{REL2}-0.050	V_{REL2}	V_{REL2}+0.050	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V V_{DET3}(typ)≦0.150V	V_{DET3}-0.015	V_{DET3}	V_{DET3}+0.015	V
V_{DET4}	Charge over-current detection	V_{DD}=3.5V	V_{DET4}-0.030	V_{DET4}	V_{DET4}+0.030	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V V_{SHORT}(typ)=0.30V	V_{SHORT}-0.09	V_{SHORT}	V_{SHORT}+0.09	V
Detection Delay Time 【Table 2 Delay time (1)】						
t_{VDET1}	Output delay time of over-charge	-	0.7	1.0	1.3	s
t_{VDET2}	Output delay time of over-discharge	-	88	125	163	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	5.0	8.0	11.0	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	5.0	8.0	11.0	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	280	400	520	us

(Continued)

Current Consumption (power-down function enabled)						
V_{DD}	Operating input voltage	$V_{DD} – V_{SS}$	2.0		6.0	V
I_{DD}	Supply current	V_{DD}=3.5V, V-=0V	1.0	3.0	6.0	uA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=1.8V, V- floating			0.1	uA
0V Battery Charging Function						
V_{0CHA}	0 V battery charge starting charger voltage	0 V battery charging function "available"	0.3	1.0	1.7	V
V_{0INH}	0V battery charge inhibition battery voltage	0 V battery charging function "unavailable" (Vcharger=4V~14V)	0.3	1.0	1.7	V
Output Resistance						
R_{COH}	CO pin H resistance	V_{CO}=3.0V, V_{DD}=3.5V, V-=0V	1.00	2.50	5.00	KΩ
R_{COL}	CO pin L resistance	V_{CO}=0.5V, V_{DD}=4.5V, V-=0V	0.60	1.50	3.00	KΩ
R_{DOH}	DO pin H resistance	V_{DO}=3.0V, V_{DD}=3.5V, V-=0V	1.00	2.50	5.00	KΩ
R_{DOL}	DO pin L resistance	V_{DO}=0.5V, V_{DD}=1.8V, V-=0V	1.40	3.50	7.00	KΩ
V- Internal Resistance						
R_{VMD}	Internal resistance between V- and V_{DD}	V_{DD}=1.8V, V-=0V	78	300	900	KΩ
R_{VMS}	Internal resistance between V- and V_{SS}	V_{DD}=3.5V, V-=1.0V	26	100	300	KΩ

*: The specification for this temperature range is guaranteed by design because products are not screened at high to low temperature.

Test Circuits

- **Over-charge, over-discharge and the release detection voltages** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF, then NT1713 series enters operating mode.
  2) Increase V1 voltage (from 3.5V) gradually. The V1 voltage is the over-charge detection voltage (V_{DET1}) when CO pin goes to low (from high).
  3) Decrease V1 gradually. The voltage gap is the over-charge hysteresis detection voltage (V_{HYS1}) when CO pin goes to high (from low) again.
  4) Continue decreasing V1. The V1 voltage is the over-discharge detection voltage (V_{DET2}) when DO pin goes to low (from high). Then increase V1 gradually. The V1 voltage is the over-discharge release detection voltage (V_{REL2}), when DO pin goes to high (from low).

  Note: The over-charge and over-discharge release voltages are defined in versions.

- **Discharge over-current detection voltage** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF and NT1713 series enters operating condition.
  2) Increase V2 (from 0V) gradually. The V2 voltage is the discharge over-current detection voltage (V_{DET3}) when DO pin goes to low (from high).

- **Charge over-current detection voltage** (test circuit 1)
  1) Set V1=3.5V, V3=0V, S1=OFF and S2=ON and NT1713 series enters operating condition.
  2) Increase V3 gradually. The V3 voltage is the charge over-current detection voltage (V_{DET4}) when CO pin goes to low (from high).

- **Load short-circuiting detection voltage** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF and NT1713 series enters operating condition.
  2) Increase V2 immediately (within 10uS) till DO pin goes to low (from high) with a delay time which is between the minimum and the maximum of Load short-circuiting delay time.

- **Over-charge, over-discharge delay time** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF to enter operating condition.
  2) Increase V1 from V_{DET1}-0.2V to V_{DET1}+0.2V immediately (within 10us). The over-charge detection delay time (t_{VDET1}) is the period from the time V1 gets to V_{DET1}+0.2V till CO pin goes to low (from high).
  3) Set V1=3.5V, V2=0V, S1=ON and S2 = OFF to enter operating condition.
  4) Decrease V1 from V_{DET2}+0.2V to V_{DET2}-0.2V immediately (within 10us). The over-discharge detection delay time (t_{VDET2}) is the period from the time V1 gets to V_{DET2}-0.2V till DO pin goes to low (from high).

- **Discharge over-current delay time** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF to enter operating condition.
  2) Increase V2 from 0V to 0.25V immediately (within 10us). The discharge over-current detection delay time (tVDET3) is the period from the time V2 gets to 0.25V till DO pin goes to low (from high).

- **Charge over-current delay time** (test circuit 1)
  1) Set V1=3.5V, V3=0V, S1=OFF and S2=ON to enter operating condition.
  2) Increase V3 from 0V to 0.3V immediately (within 10us). The charge over-current detection delay time (t_{VDET4}) is the period from the time V3 gets to 0.3V till CO pin goes to low (from high).

- **Load short-circuiting delay time** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF to enter operating condition.
  2) Increase V2 from 0V to 1.0V immediately (within 10us). The Load short-circuiting detection voltage delay time (t_{SHORT}) is the period from the time V2 gets to 1.0V till DO pin goes to low (from high).

- **Operating & power down current consumption** (test circuit 2)
  1) Set V1=3.5V, V2=0V and S1=ON to enter operating condition and measure the current I1. I1 is the operating condition current consumption (I_{DD}).
  2) Set V1=V2=1.8V and S1=ON enter over-discharge condition and measure current I1. I1 is the power down current consumption ($I_{STANDBY}$). (for power-down mode enabled version)

- **Resistance between V- and VDD, V- and Vss** (test circuit 2)
  1) Set V1=1.8V, V2=0V and S1=ON and NT1713 series enters over-discharge condition. V1/I2 is the internal resistance between V- and VDD pin (R_{VMD}).
  2) Set V1=3.5V, V2=1.0V and S1=ON and NT1713 series enters discharge over-current condition. V2/I2 is the internal resistance between V- and VSS pin (R_{VMS}).

- **Output resistance** (test circuit 3)
  1) Set V1=3.5V, V2=0V, V3=3.0V, S1=OFF and S2=ON to enter operating condition. (V3-V1)/I2 is the internal resistance (R_{COH}).
  2) Set V1=4.5V, V2=0V, V3 =0.5V, S1=OFF and S2=ON to enter over-charge condition. V3/I2 is the internal resistance (R_{COL}).
  3) Set V1=3.5V, V2=0V, V3=3.0V, S1=ON and S2=OFF to enter operating condition. (V3-V1)/I2 is the internal resistance (R_{DOH}).
  4) Set V1=1.8V, V2=0V, V3 =0.5V, S1=ON and S2=OFF to enter over-discharge condition. V3/I2 is the internal resistance (R_{DOL}).

- **0V battery charging function** (test circuit 4)

  0V battery charge starting charger voltage (0V battery charging function is "Available")
  1) Set V1=V2=0V, decrease V2 gradually.
  2) The V2 voltage is the 0V charge starting voltage (V_{0CHA}) when CO pin voltage goes to (V2+0.1) from V2.

  0V battery charge inhibition battery voltage (0V battery charging function is "Unavailable")
  1) Set V1=1.6V, V2=-4V then decrease V1 gradually.
  2) The V1 voltage is the 0V charge inhibition voltage (V_{0INH}) when CO pin voltage goes to V2 from V1

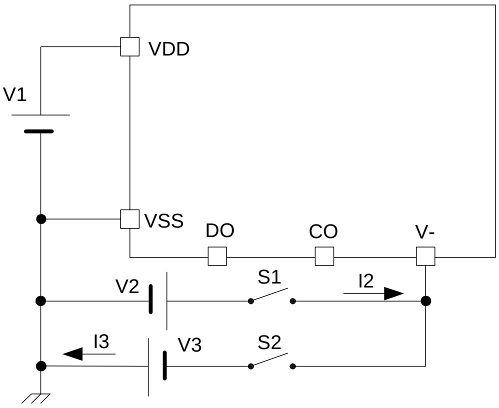
  Note: 1. Charger voltage should not be higher than 14V.
  2. To reduce the effects of measurement loading errors, a multi-meter with extra high input impedance (e.g. 10G ohm, a general multi-meter is 10M ohm) is suggested for CO pin voltage test.

- **Shorten mode for overcharge and over-discharge functions by force voltage to DO pin** (test circuit 5)
  1) Set V1=3.5V then NT1713 series enters operating mode.
  2) Set V2= 0.5V, increase V1 voltage (from 3.5V) gradually. The V1 voltage is the over-charge detection voltage (V_{DET1}) when CO pin goes to low (from high).
  3) Decrease V1 gradually. The voltage gap is the over-charge hysteresis detection voltage (V_{HYS1}) when CO pin goes to high (from low).
  4) Continue decreasing V1. The V1 voltage is the over-discharge detection voltage (V_{DET2}) when the voltage drop (V_{R1K}*I1) on DO pin by shorten mode circuit. Then increase V1 gradually. The V1 voltage is the over-discharge release detection voltage (V_{REL2}), when DO pin goes to high (from low).

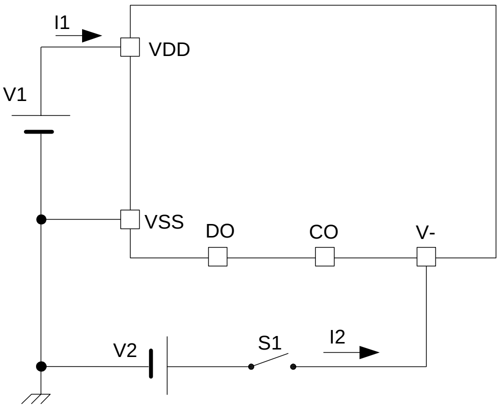
Recommended:

1) "0 V charge available" doesn't means NT1713 series can recover the zero-V cell to be full charged if this cell has been already damaged due to too low voltage.
2) For safety consideration, we strongly recommended to select "0 V charge inhibition" version to prevent from charging a damaged cell.

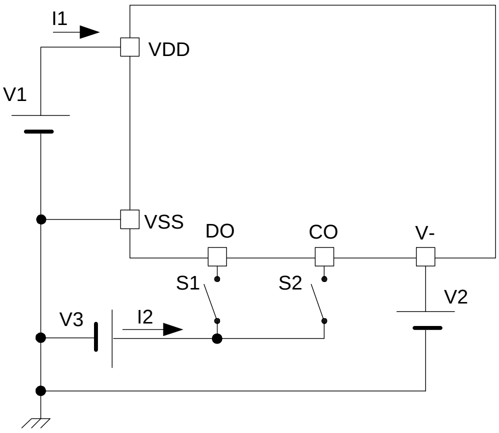
Test Circuit



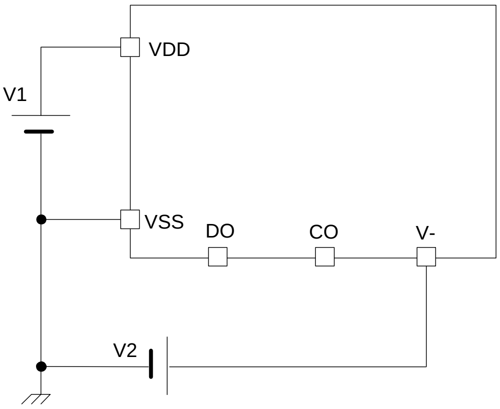
Test circuit 1



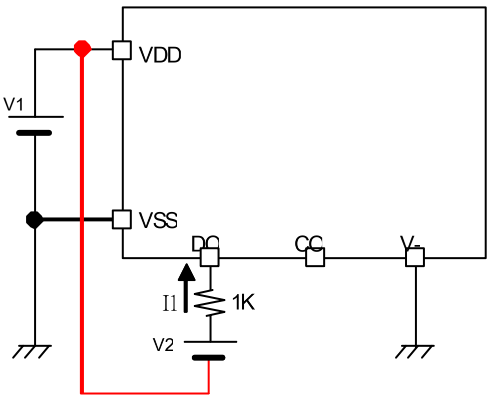
Test circuit 2



Test circuit 3



Test circuit 4



Test circuit 5

Operation

The NT1713 series provides over-charge, over-discharge, discharge over-current, charge over-current and load short-circuiting protections for the 1-cell battery pack. NT1713 series continuously monitors the voltage of battery between VDD pin and VSS pin to control over-charge and over-discharge protections. When the battery pack is in charging stage, the current flows from the charger to the battery through EB+ and EB-; the voltage between V- pin and VSS pin is negative. On the other hand, when the battery pack is in discharging stage, the current flows from battery to the load through EB+ and EB-; the voltage between V- pin and VSS pin is positive. The NT1713 series also monitors the voltage which is determined by the current of charge and discharge and the series Rds(on) of MOSFETs between V- pin and VSS pin to detect charge over-current and discharge over-current current conditions.

(1) Normal Condition (Operation mode)

The NT1713 series turns both the charging and discharging control MOSFETs on when the voltage of battery is in the range from over-charge detection voltage (V_{DET1}) to over-discharge detection voltage (V_{DET2}), and the V- pin voltage is in the range from over-current detection voltage (V_{DET4}) to discharge over-current detection voltage (V_{DET3}). This is called the normal condition that charging and discharging can be carried out freely.

Caution: The NT1713 series may be needed connecting a charger to return to normal condition, when the battery is connected for the first time.

(2) Over-charge Condition

1) Over-charge Protection:

   When the VDD voltage is higher than the over-charge detection voltage (V_{DET1}) and lasts for longer than the over-charge detection delay time (t_{VDET1}), NT1713 series turns off the external charging MOSFET to protect the pack from being over-charged, which CO pin goes to "L" from "H" level.

2) Over-charge Protection Release:

   When the battery voltage is lower than V_{DET1} - V_{HYS1} and the V- pin voltage is between charge over-current detection voltage (V_{DET4}) and discharge over-current detection voltage (V_{DET3}), the NT1713 series would be automatically released from this condition.

   When the battery voltage is lower than V_{DET1} and charger is removed, the NT1713 series can be automatically released from this condition.

(3) Over-discharge Condition

1) Over-discharge Protection:

   When the VDD voltage is lower than the over-discharge detection voltage (V_{DET2}) and lasts longer than over-discharge detection delay time (t_{VDET2}), NT1713 series turns off the external discharge MOSFET to protect the pack from being over-discharged, which DO pin goes to "L" from "H" level. In over-discharge condition V- pin is pulled-up to VDD by a resistor (RVMD) between the V- pin and VDD pin. After that, when V- pin voltage is higher than VDD/2(Typ), the IC gets to power down mode.

2) Over-discharge Protection Release:

   The over-discharge protection is automatically released when

   (a) a charger is connected and V- pin voltage is lower than –0.7V (Typ.) and battery voltage is higher than the over-discharge voltage(V_{DET2}), or

   (b) a charger is connected, and V- pin voltage is higher than –0.7V (Typ.) and battery voltage is higher than the over-discharge release voltage(V_{REL2}).

(4) Discharge Over-current Condition

1) Discharge Over-current Protection:

(a) Discharge over-current protection occurs when V- pin voltage is between V_{DET3} and V_{SHORT} and lasts for a certain delay time (t_{VDET3}).

(b) Load short-circuiting protection occurs when V- pin voltage is higher than V_{SHORT} and lasts for a certain delay time (t_{SHORT}).

When above conditions happen, the DO pin goes to "L" from "H" to turn off the discharging MOSFET.

In discharge over-current and load short-circuiting conditions, V- pin is pulled-down to VSS pin by the internal resistor (RVMS).

2) Discharge Over-current and Load Short-Circuiting Protection Release:

The IC detects the status by monitoring V- pin voltage that is inversely proportional to the impedance (Rload) between two terminals (EB+ and EB-). The Rload increases while the V- pin voltage decreases. When the V- pin voltage equals to V_{SHORT} or lower, discharge over-current status returns to normal mode and the circuit will be automatic recovery.

The relation between V- and Rload is shown as follows:

$$V- = \frac{RVMS}{RVMS + Rload} \times VDD\ ; \quad \text{when } V- \leqq Vshort$$

(5) Charge Over-current Condition

1) Charge Over-current Protection:

When the voltage of V- pin is lower than charge over-current detection voltage (V_{DET4}) and lasts for a certain delay time (t_{DET4}) or longer, the CO pin goes to "L" from "H" to turn off the charging MOSFET.

2) Charge Over-current Release:

Charge over-current protection can be automatically released by disconnecting the charger.

(6) Power Down Condition

1) Entering to Power Down Mode:

NT1713 series enters the power down mode when over-discharge protection occurs and V- pin voltage is higher than VDD/2 (typical). The V- pin voltage is pulled-up to the VDD through the R_{VMD} resistor. The internal circuits is shut off, therefore, the power-down current ($I_{STANDBY}$) is reduced to be low 0.1uA (Max.).

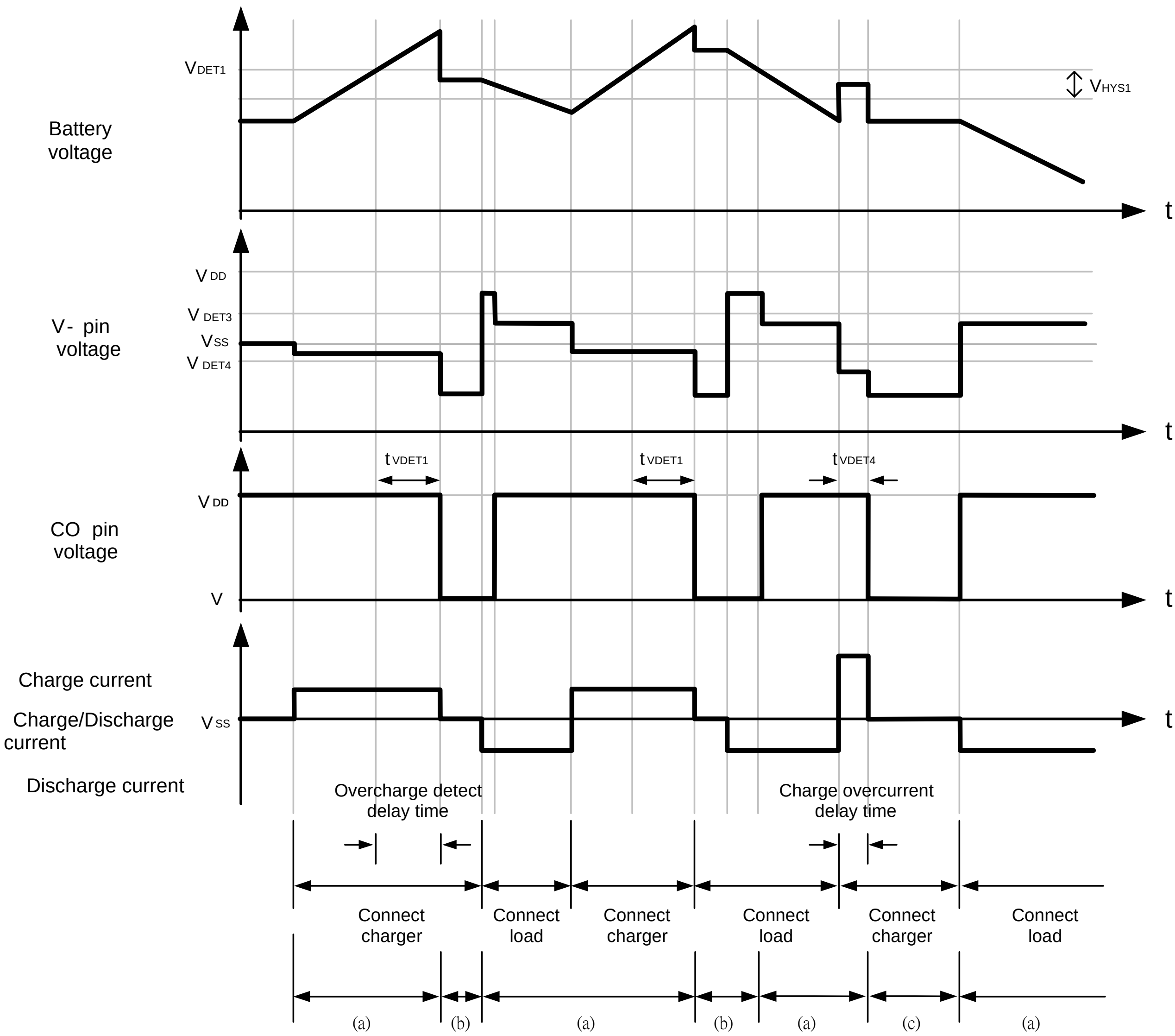
2) Power Down Mode Release:

The power down mode is automatically released when a charger is connected and V- pin voltage is lower than VDD/2 (typical).

Note: Power down condition is for power down mode enabled version only.

Timing Chart

(1) Over-charge, Charge Over-current Operation



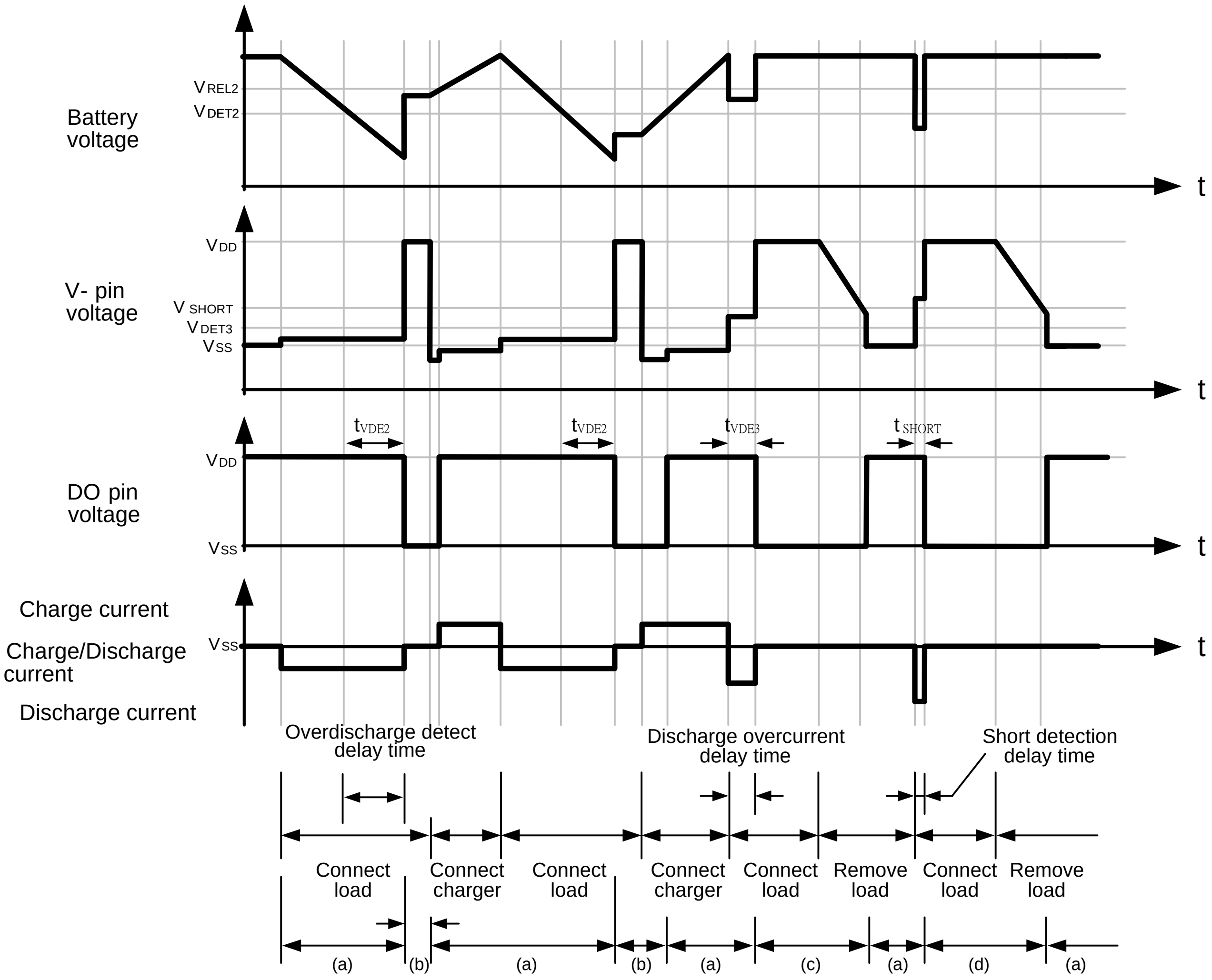
(a) Normal condition

(b) Overcharge condition

(c) Charge over-current condition

: The charger is assumed to charge with a constant current.

(2) Over-discharge, Discharge Over-current, Load Short-Circuiting Operation



(a) Normal condition

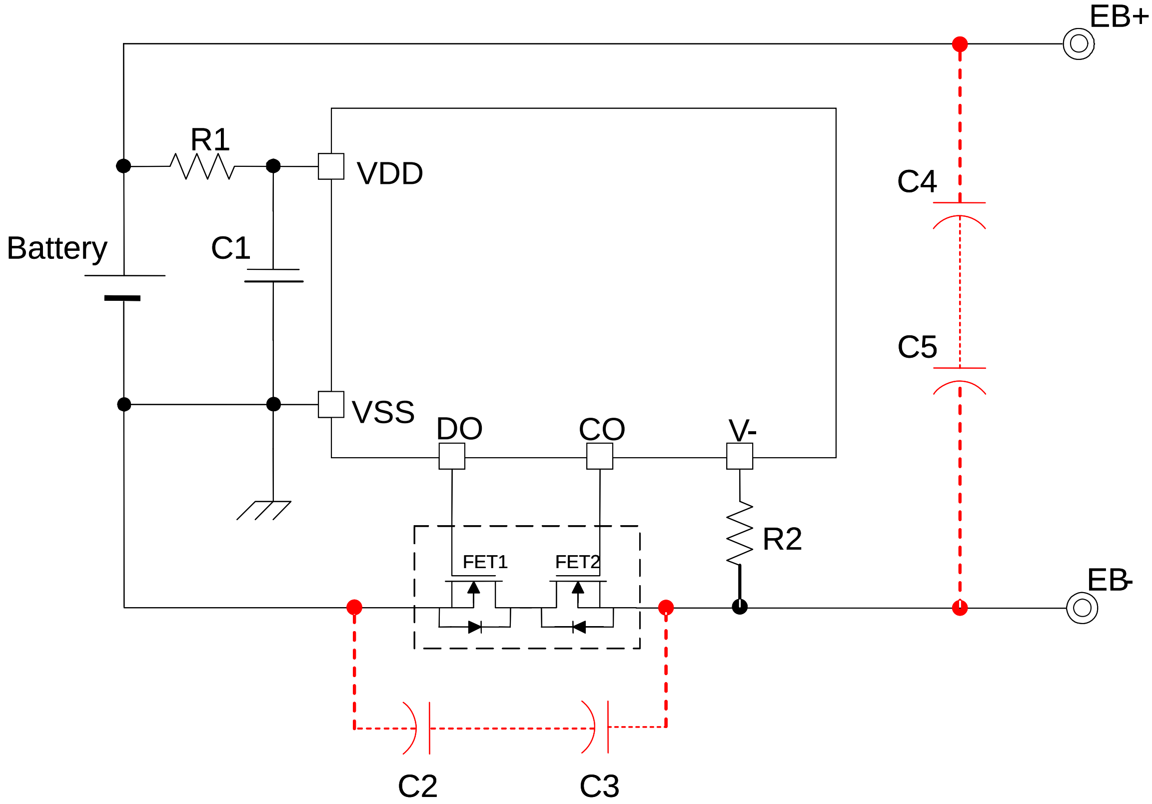
(b) Over-discharge condition

(c) Discharge over-current condition

(d) Load short-circuit condition

: The charger is assumed to charge with a constant current.

Recommended Application Circuit



Constant for external components

Symbol	Parts	Purpose	Recommended	Min.	Max.	Remarks
FET1	N channel MOSFET	Discharge control	-	-	-	*1) Gate to source withstand voltage ≥ Charger voltage.
FET2	N channel MOSFET	Charge control	-	-	-	
R1	Resistor	ESD protection, for power fluctuation	470Ω	100Ω	1KΩ	*2) Set Resistance to the value 2R1≤ R2.
C1	Capacitor	For power fluctuation	0.1uF	0.022uF	1.0uF	*3) Install a 0.022uF capacitor or higher.
R2	Resistor	Protection for reverse connection of a charger	1KΩ	300Ω	10KΩ	*4) The resistor is preventing big current when a charger is connected in reverse.
C2	Capacitor	For ESD protection	0.1uF	-	-	*5) Protected MOSFET after system ESD
C3	Capacitor	For ESD protection	0.1uF	-	-	
C4	Capacitor	For ESD protection	0.1uF	-	-	*5) Reduce noise of load and improve system ESD performance.
C5	Capacitor	For ESD protection	0.1uF	-	-	

*1) If the threshold voltage of FET is lower than 0.4V, the FET may failed to stop the charging current.
If the FET has a threshold voltage equal to or higher than the over-discharge detection voltage, discharging may be stopped before over-discharge is detected.
If the charger voltage is higher than the withstanding voltage between the gate and source, the FET may be damaged.

*2) Employing an over-specification (listed in above table) R1 may result in over-charge detection voltage and release voltage higher than the defined voltage
If R1 has a higher resistance, the IC may be damaged caused by over absolute maximum rating of VDD voltage when a charger is connected reversely.

*3) Applying a smaller capacitance C1 to system, DO may failed to function when load short-circuiting is detected.

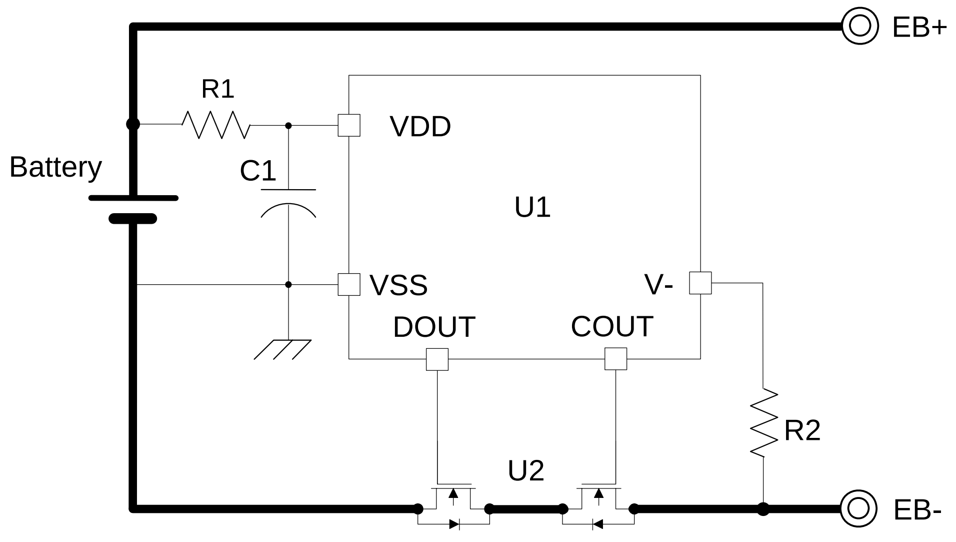
*4) R1 and R2 resistors are current limit resistance for a charger connected reversibly or a large voltage charger that exceeds the absolute rating for VCC is connected, when we connect reverse charger the current flows from charger to R2, internal ESD diode and R1. This current will increase R1 voltage drop. Which can exceed VCC(max). In this case better to use smaller value for R1 and bigger value for R2. But small value of R1 will reduce R-C filter performance and system ESD reliability. Too big value of R2 can cause over-current automatic release problem.
If R2 resistance is higher than 2kΩ, the charging current may not be cut when a high-voltage charger is connected.

*5) As followed this recommended table, the system ESD level could be reached at least ±12KV. We can improve system ESD by connect C2 ~ C5 capacitor of 0.1uF. Both C2 and C3 are protected MOSFET from being assaulted by system ESD. C4 and C5 are improved system ESD and reduce imported noise by load.

Caution: 1) The above constants may be changed without notice.
2) The application circuit above is for reference only. To determine the correct constants, evaluation of actual application is required.

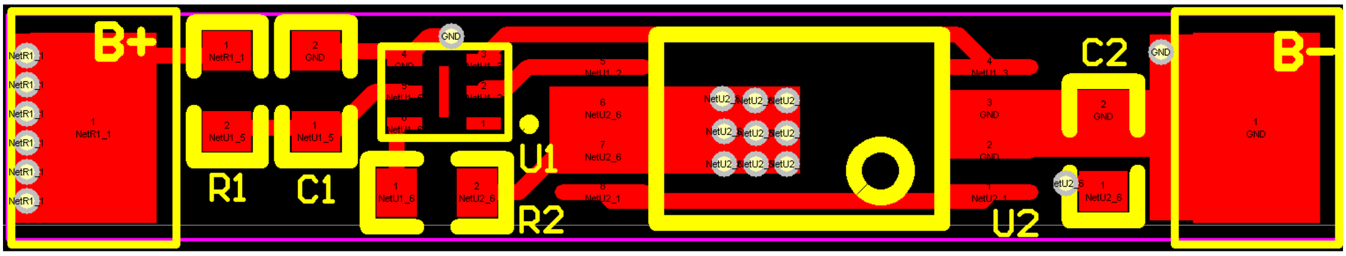
Precautions: 1) The application condition for the input voltage, output voltage, and load current should not exceed the package power dissipation.
2) Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.

PCB Schematic

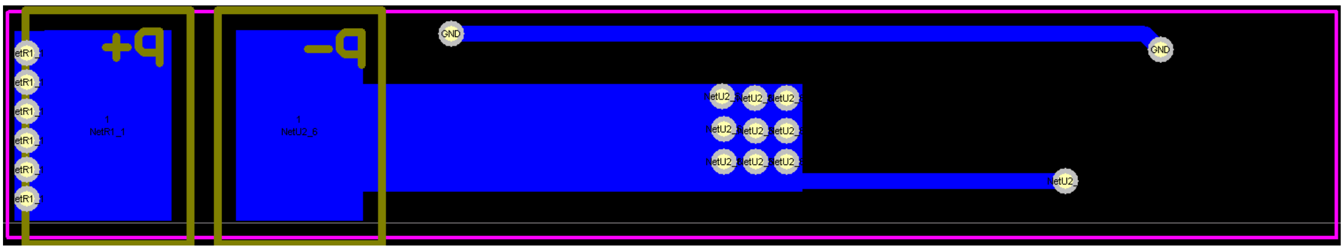


Layout Reference *(takes DFN-1.6x1.6-6L for example)*

Top layer



Bottom layer



Note: *To leave thermal pad floating is suggested (shown above). It can connect to VSS/VDD level as well.*

PCB symbol list:

Symbol	Parts	Symbol	Parts
B+	Positive terminal of Battery	P+	Positive terminal of charger or load
B-	negative terminal of Battery	P-	negative terminal of charger or load

BOM list:

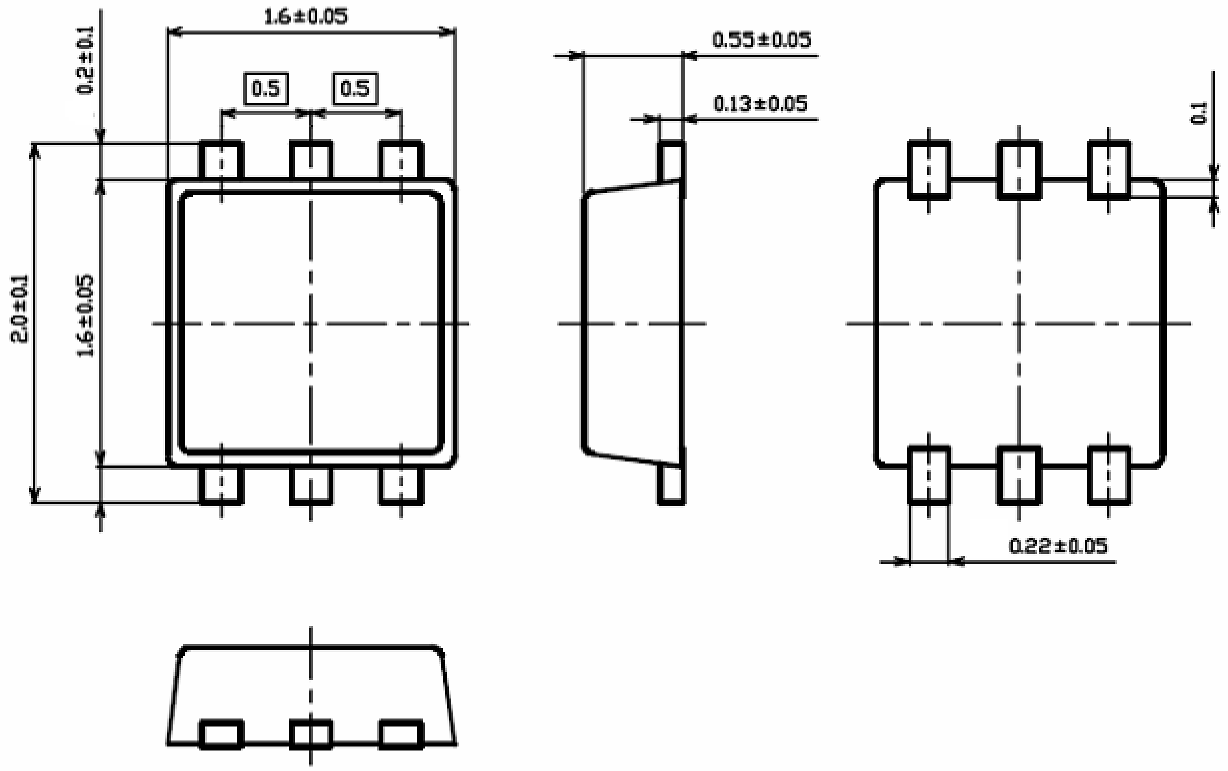
Standard application circuit:

Symbol	Parts	Footprint	Value	Remarks
U1	NT1713 Series	DFN-1.6x1.6-6L	-	-
U2	N-MOSFET	TSSOP8	AO8810	Cut off charge or discharge current
R1	Resistor	0402 @ 1/16W	470Ω	Low pass filter with C1 and ESD protection
R2	Resistor	0402 @ 1/16W	1KΩ	ESD protection
C1	Capacitor	0402 @ 1/16W	0.1uF	Low pass filter with R1 and ESD protection

Package Information

SON-1.6x1.6-6L Dimension

Note: *All dimensions show in mm*



PCB Land Pattern