Protection IC for 1-Cell Battery Pack

Features

- High Detection Accuracy
  - Over-charge Detection: ±25mV
  - Over-discharge Detection: ±50mV
  - Discharge Over-current Detection: ±15mV
  - Charge Over-current Detection: ±30mV
- High Withstand Voltage
  - Absolute maximum ratings: 28V
    (V- pin and CO pin)
- Ultra Small Package
  - DFN-6L

Description

The NT1703 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 NT1703 series with state-of-art design and process.

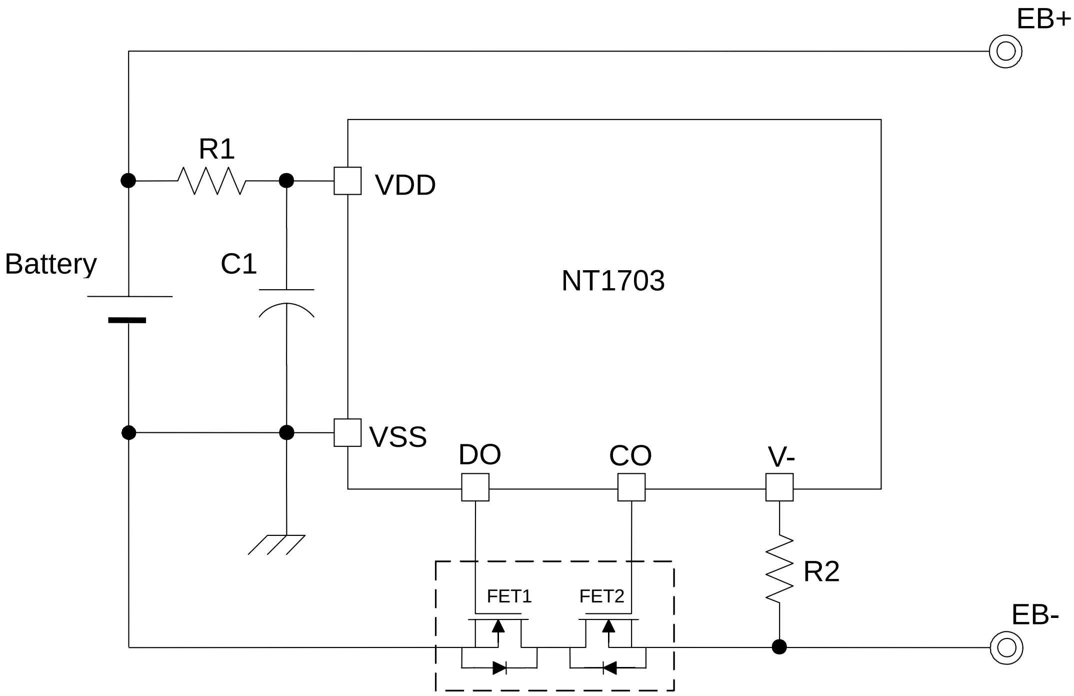
To minimize power consumption, NT1703 series activates power down mode when an over-discharge event is detected (for power-down mode enabled version). Besides, NT1703 series performs protection functions with four external components for miniaturized PCB.

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

Application

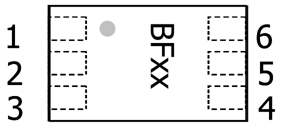
- Mobile phone battery packs
- Digital camera battery packs
- Bluetooth earphone Li-ion battery module

Typical Application Circuit



Package and Pin Description

DFN-6L



Pin No.	Symbol	NT1703 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)

Ordering Information

NT1703-XXX XX

- XX: Package Type — B3: DFN-6L
- XXX: Version code

Product version code:

(1) DFN-6L

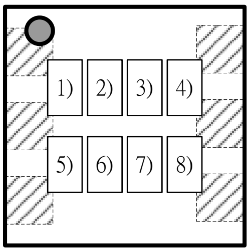
NT1703	Over-charge Detection Voltage V_{DET1} (V)	Over-charge Release Voltage V_{REL1} (V)	Over-discharge Detection Voltage V_{DET2} (V)	Over-discharge Release Voltage V_{REL2} (V)	Discharge Over-current Detection Voltage V_{DET3} (V)	0V Battery Charge Function	Power down mode Function	Delay time
HXW	4.280	4.280	2.800	2.800	0.050	Available	Yes	(1)

Delay time	Over-charge delay time t_{DET1} (S)	Over-discharge delay time t_{DET2} (mS)	Discharge over-current delay time t_{DET3} (mS)	Charge over-current delay time t_{DET4} (mS)	Load short-circuiting delay time t_{SHORT} (uS)
(1)	1.2	150	9	6	300

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

Marking Information

DFN-6L
Top view



1) : Product code (B)

2) : Type code (F)

3) to 4) : Version code

5) to 8) : Lot number

Product name vs. Version code

Product name	Version code
	DFN-6L
	3) 4)
NT1703-HXW	02

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
P_D	Power Dissipation	DFN-6L	250	mW
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}-0.025	V_{DET1}	V_{DET1}+0.025	V
V_{REL1}	Over-charge release voltage	$V_{DET1} \neq V_{REL1}$	V_{REL1}-0.05	V_{REL1}	V_{REL1}+0.05	V
		$V_{DET1} = V_{REL1}$	V_{REL1}-0.025	V_{REL1}	V_{REL1}+0.025	V
V_{DET2}	Over-discharge detection voltage	--	V_{DET2}-0.05	V_{DET2}	V_{DET2}+0.05	V
V_{REL2}	Over-discharge release voltage	$V_{DET2} \neq V_{REL2}$	V_{REL2}-0.10	V_{REL2}	V_{REL2}+0.10	V
		$V_{DET2} = V_{REL2}$	V_{REL2}-0.05	V_{REL2}	V_{REL2}+0.05	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V	V_{DET3}-0.015	V_{DET3}	V_{DET3}+0.015	V
V_{DET4}	Charge over-current detection	V_{DD}=3.5V	-0.13	-0.10	-0.07	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V	0.30	0.50	0.70	V
Detection Delay Time 【Table 5 Delay time (1)】						
t_{VDET1}*	Output delay time of over-charge	-	0.96	1.20	1.40	s
		VDD=4.28V, C_{ISS}=1200pF, V_{TH}=0.6V	0.96	1.22	1.42	s
		VDD=4.28V, C_{ISS}=1200pF, V_{TH}=0.4V	0.95	1.23	1.43	s
t_{VDET2}	Output delay time of over-discharge	V_{DET2} ＞2.5V	120	150	180	ms
		V_{DET2} ≦2.5V	100	150	200	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	7.2	9.0	10.8	ms
		V_{DET2} ≦2.5V	6.0	9.0	12.0	ms
t_{VDET4}*	Output delay time of charge over current	V_{DD}=3.5V	4.8	6.0	7.2	ms
		V_{DD}=3.5V, Vchg=4.3V C_{ISS}=1200pF, V_{TH}=0.6V	16	18	20	ms
		V_{DD}=3.5V, Vchg=4.3V C_{ISS}=1200pF, V_{TH}=0.4V	32	34	36	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	240	300	360	us

(Continued)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Current Consumption (power-down function enabled)						
V_{DD}	Operating input voltage	V_{DD} - V_{SS}	2.2		6.0	V
I_{DD}	Supply current	V_{DD}=3.5V, V-=0V	1.0	3.5	6.5	uA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=2.0V, V- floating			0.2	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	-	5	10	KΩ
R_{COL}	CO pin L resistance	V_{CO}=0.5V, V_{DD}=4.5V, V-=0V	-	2.5	5	MΩ
R_{DOH}	DO pin H resistance	V_{DO}=3.0V, V_{DD}=3.5V, V-=0V	-	5	10	KΩ
R_{DOL}	DO pin L resistance	V_{DO}=0.5V, V_{DD}=1.8V, V-=0V	-	5	10	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

*: Please note that a N-channel MOSFET"turning off delay time"will be affected by 1.Input capacitance (C_{ISS}). 2.Gate threshold voltage (V_{TH}); It causes the delay times of over-charge (tV_{DET1}) and charge over-current (tV_{DET4}) of NT1703 are prolonged approximately "10ms" to turn off the N-channel MOSFETs to cutting off the current flowing path.

Electrical Characteristics (For Li-ion)

(Ta = 0°C to +70°C)*

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	V_{DET1}-0.060	V_{DET1}	V_{DET1}+0.040	V
V_{REL1}	Over-charge release voltage	$V_{DET1} \neq V_{REL1}$	V_{REL1}-0.08	V_{REL1}	V_{REL1}+0.065	V
		$V_{DET1} = V_{REL1}$	V_{REL1}-0.060	V_{REL1}	V_{REL1}+0.040	V
V_{DET2}	Over-discharge detection voltage	--	V_{DET2}-0.11	V_{DET2}	V_{DET2}+0.13	V
V_{REL2}	Over-discharge release voltage	$V_{DET2} \neq V_{REL2}$	V_{REL2}-0.15	V_{REL2}	V_{REL2}+0.19	V
		$V_{DET2} = V_{REL2}$	V_{REL2}-0.11	V_{REL2}	V_{REL2}+0.13	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V	V_{DET3}-0.021	V_{DET3}	V_{DET3}+0.024	V
V_{DET4}	Charge over-current detection	V_{DD}=3.5V	-0.14	-0.10	-0.06	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V	0.16	0.50	0.84	V
Detection Delay Time 【Table 5 Delay time (1)】						
t_{VDET1}	Output delay time of over-charge	-	0.7	1.2	2.0	s
t_{VDET2}	Output delay time of over-discharge	V_{DET2} ＞2.5V	83	150	255	ms
		V_{DET2} ≦2.5V	83	150	255	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	5	9	15	ms
		V_{DET2} ≦2.5V	5	9	15	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	3.3	6	10	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	150	300	540	us

(Continued)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Current Consumption (power-down function enabled)						
V_{DD}	Operating input voltage	$V_{DD} – V_{SS}$	2.2		6.0	V
I_{DD}	Supply current	V_{DD}=3.5V, V-=0V		3.5	7.5	uA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=2.0V, V- floating			0.3	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	-	5	15	KΩ
R_{COL}	CO pin L resistance	V_{CO}=0.5V, V_{DD}=4.5V, V-=0V	-	2.5	10	MΩ
R_{DOH}	DO pin H resistance	V_{DO}=3.0V, V_{DD}=3.5V, V-=0V	-	5	15	KΩ
R_{DOL}	DO pin L resistance	V_{DO}=0.5V, V_{DD}=1.8V, V-=0V	-	5	15	KΩ
V- internal Resistance						
R_{VMD}	Internal resistance between V- and V_{DD}	V_{DD}=1.8V, V-=0V	78	300	1310	KΩ
R_{VMS}	Internal resistance between V- and V_{SS}	V_{DD}=3.5V, V-=1.0V	36	100	220	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 NT1703 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 low (from high).
  3) Decrease V1 gradually. The V1 voltage is the over-charge release detection voltage (V_{REL1}) when CO pin goes high again.
  4) Continue decreasing V1. The V1 voltage is the over-discharge detection voltage (V_{DET2}) when DO pin goes low. Then increase V1 gradually. The V1 voltage is the over-discharge release detection voltage (V_{REL2}), when DO pin returns to high.

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

- **Discharge over-current detection voltage** (test circuit 1)
  1) Set V1=3.5 V, V2=0V, S1=ON and S2=OFF and NT1703 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 low (from high).

- **Charge over-current detection voltage** (test circuit 1)
  1) Set V1=3.5V, V3=0V, S1=OFF and S2=ON and NT1703 series enters operating condition.
  2) Increase V3 gradually. The V3 voltage is the charge over-current detection voltage (V_{DET4}) when CO pin goes low (from high).

- **Load short-circuiting detection voltage** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF and NT1703 series enters operating condition.
  2) Increase V2 immediately (within 10uS) till DO pin goes "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 switches from high to low.
  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 switches from high to low.

- **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 (t_{VDET3}) is the period from the time V2 gets to 0.25V till DO pin switches from high to low.

- **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 gets 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 switches from high to low.

- **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=1.5V and S1=ON enter over-discharge condition and measure current I1. I1 is the power down current consumption ($I_{STANDBY}$).

- **Resistance between V- and VDD, V- and Vss** (test circuit 2)
  1) Set V1=1.8V, V2=0V and S1=ON and NT1703 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 NT1703 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 charge starting charger voltage (products with 0V battery charging function is "Available")** (test circuit 4)
  1) Set V1=V2=0V, decrease V2 gradually.
  2) The V2 voltage is the 0V charge starting voltage (V_{0CHA}) when CO pin switches from low to high (V_{V-} + 0.1V or higher).

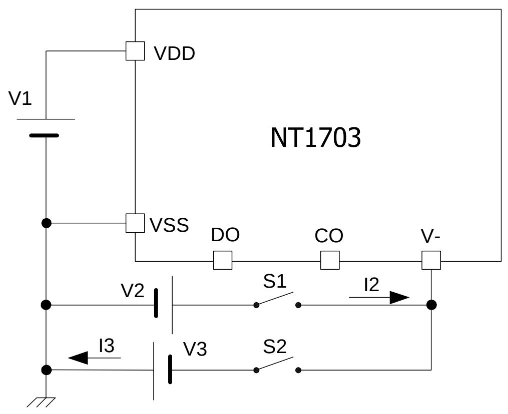
- **0V battery charge inhibition battery voltage (products with 0V battery charging function is "Unavailable")** (test circuit 4)
  1) Set V1=1.6V, V2=4V and decrease V1 with decreasing step of 0.1V.
  2) The V1 voltage is the 0V charge inhibition voltage (V_{0INH}) when CO pin switches from high (V_{V-} + 0.1V or higher) to low.

  Note: The charger voltage should not be higher than 14V of 0V battery charge inhibition battery voltage.

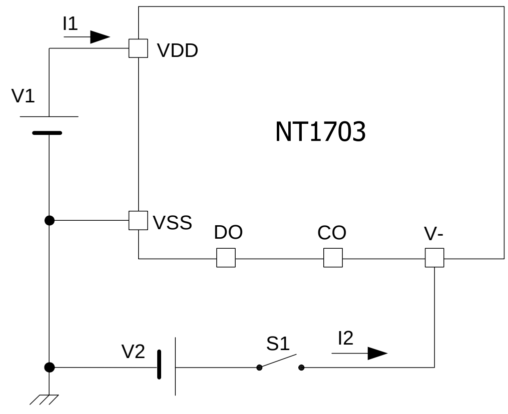
Recommended:

1) '0 V charge available' doesn't means NT1703 can recover the zero-V cell to be full charged if this cell has been already damaged due to too low voltage.
2) In NT1703, the '0 V charge inhibition' voltage is rather lower (0.5V). That is, NT1703 allows charging such low voltage cell and recover it.
3) For safety consideration, we strongly recommended to select '0 V charge inhibition' to prevent from charging a damaged cell.

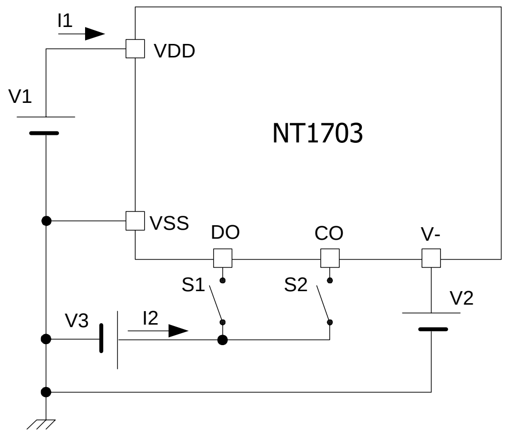
Test Circuit



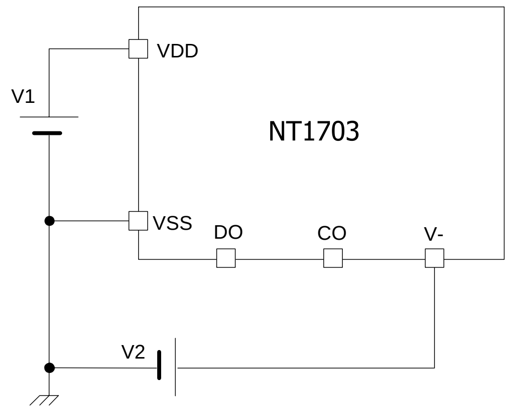
Test circuit 1



Test circuit 2



Test circuit 3



Test circuit 4

Operation

The NT1703 series provides over-charge, over-discharge, discharge over-current, charge over-current and load short-circuiting protections for the 1-cell battery pack. NT1703 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 NT1703 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 NT1703 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 VM 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 NT1703 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}), NT1703 series turns off the external charging MOSFET to protect the pack from being over-charged, which CO pin turns to "L" from "H" level.

2) Over-charge Protection Release:

   When the battery voltage is lower than VREL1 and the V- pin voltage is between charge over-current detection voltage (VDET4) and discharge over-current detection voltage (VDET3), the NT1703 series would be automatically released from this condition.

   When the battery voltage is lower than VDET1 and charger is removed, the NT1703 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}), NT1703 series turns off the external discharge MOSFET to protect the pack from being over-discharged, which DO pin turns 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, 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.

(4) Discharge Over-current Condition

1) Discharge Over-current Protection:

The NT1703 series provides discharge over-current protection and load short-circuiting 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 "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).

Note:

If the voltage of V- pin is larger than threshold voltage 1.8V ±500mV, NT1703 will get into "***Heavy Load Protection***" then will speed up protection delay time to prevent discharging MOSFET from damage.

And the "***Heavy Load Protection***" delay time is 240us~20us.

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:

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

(5) Charge Over-current Condition

The NT1703 series provides charge over-current protection to prevent the battery pack from being connected to an unexpected charger.

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 "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:

NT1703 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 0.2uA (Max.).

2) Power Down Mode Release:

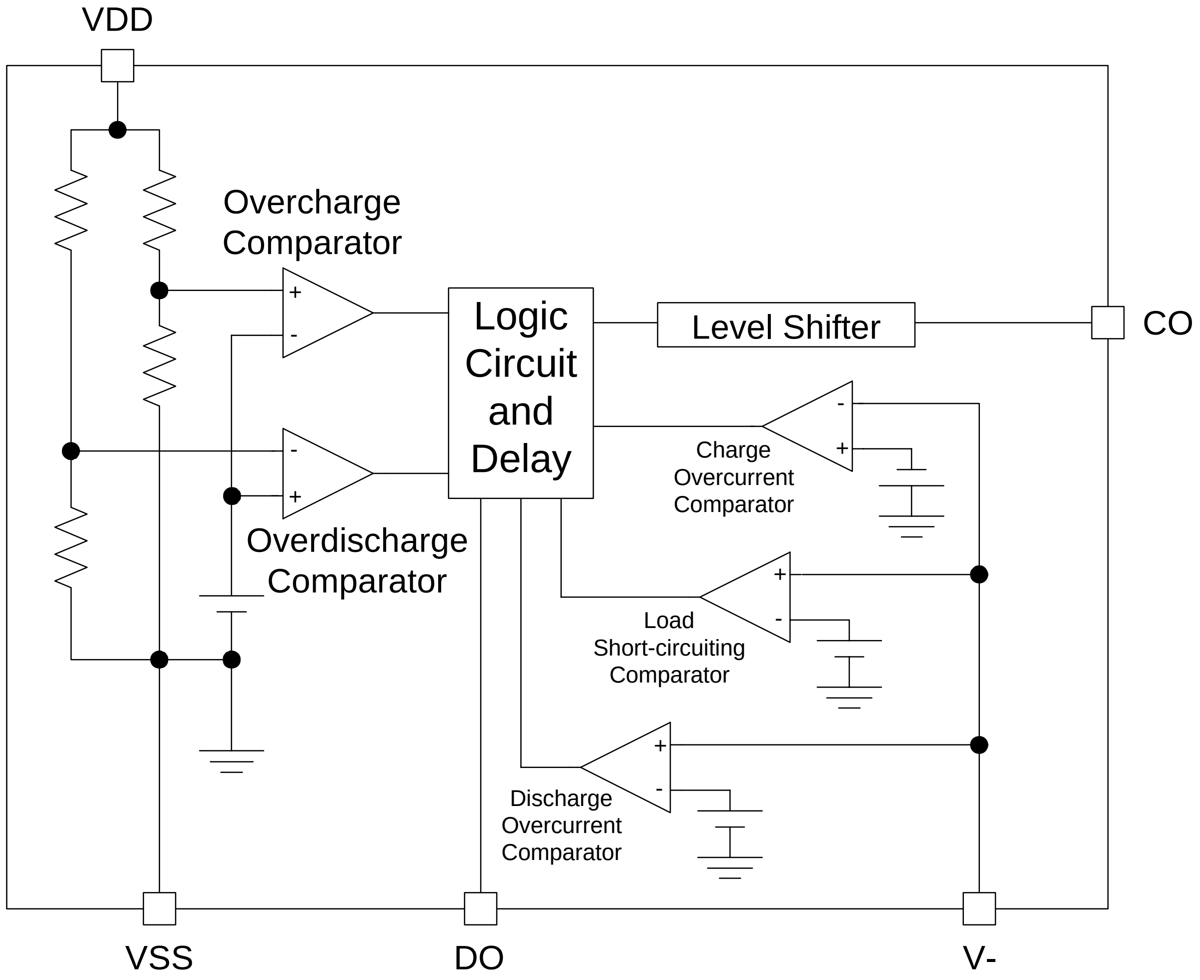
The power down mode is automatically released when a charger is connected and V- pin voltage is lower than VDD/2 (typical).

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

Remark:

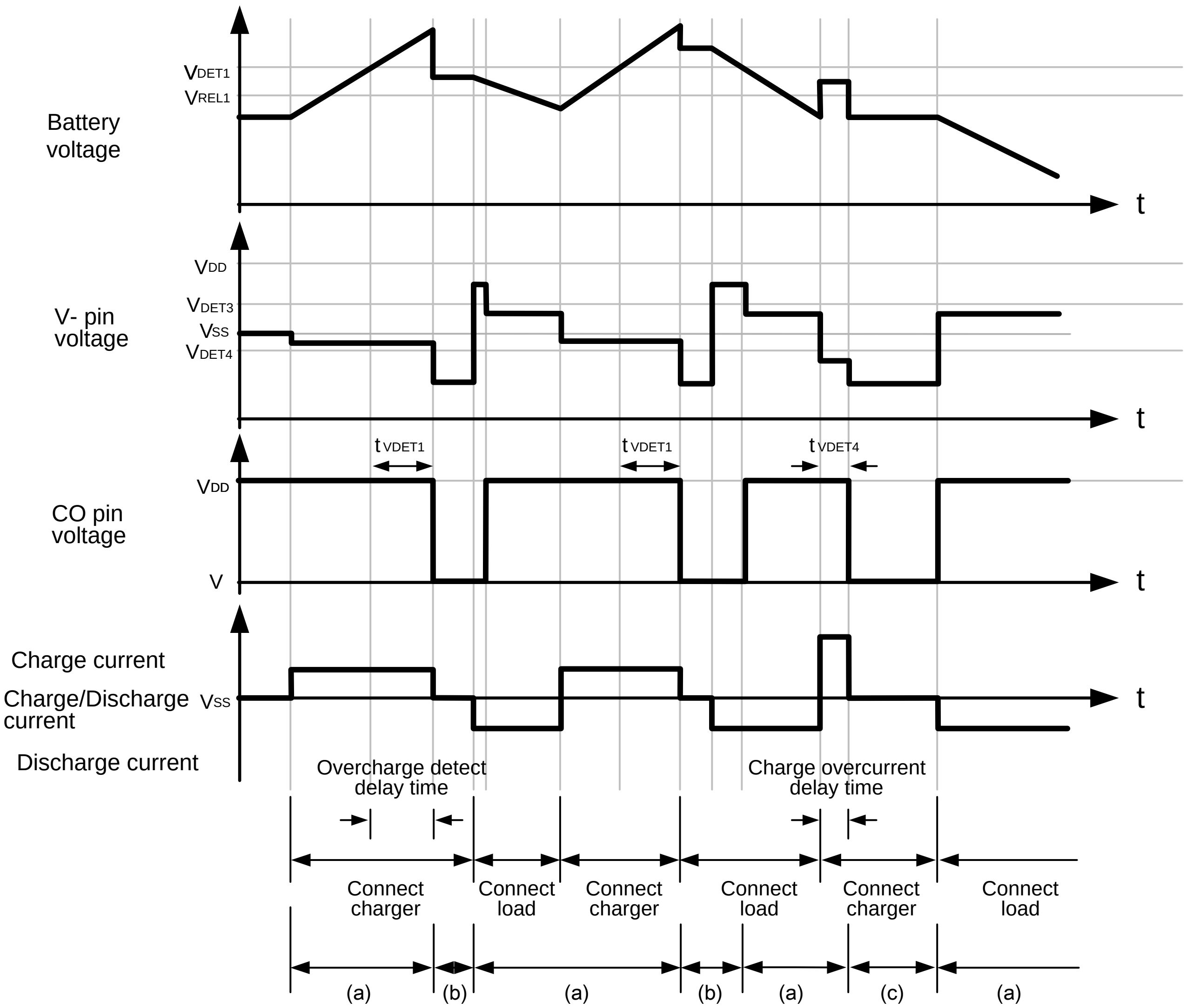
Neotec provides the test mode on the DO pin by Vdd+0.5V, to reduce over-charge and over-discharge delay time.

Block Diagram



Timing Chart

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



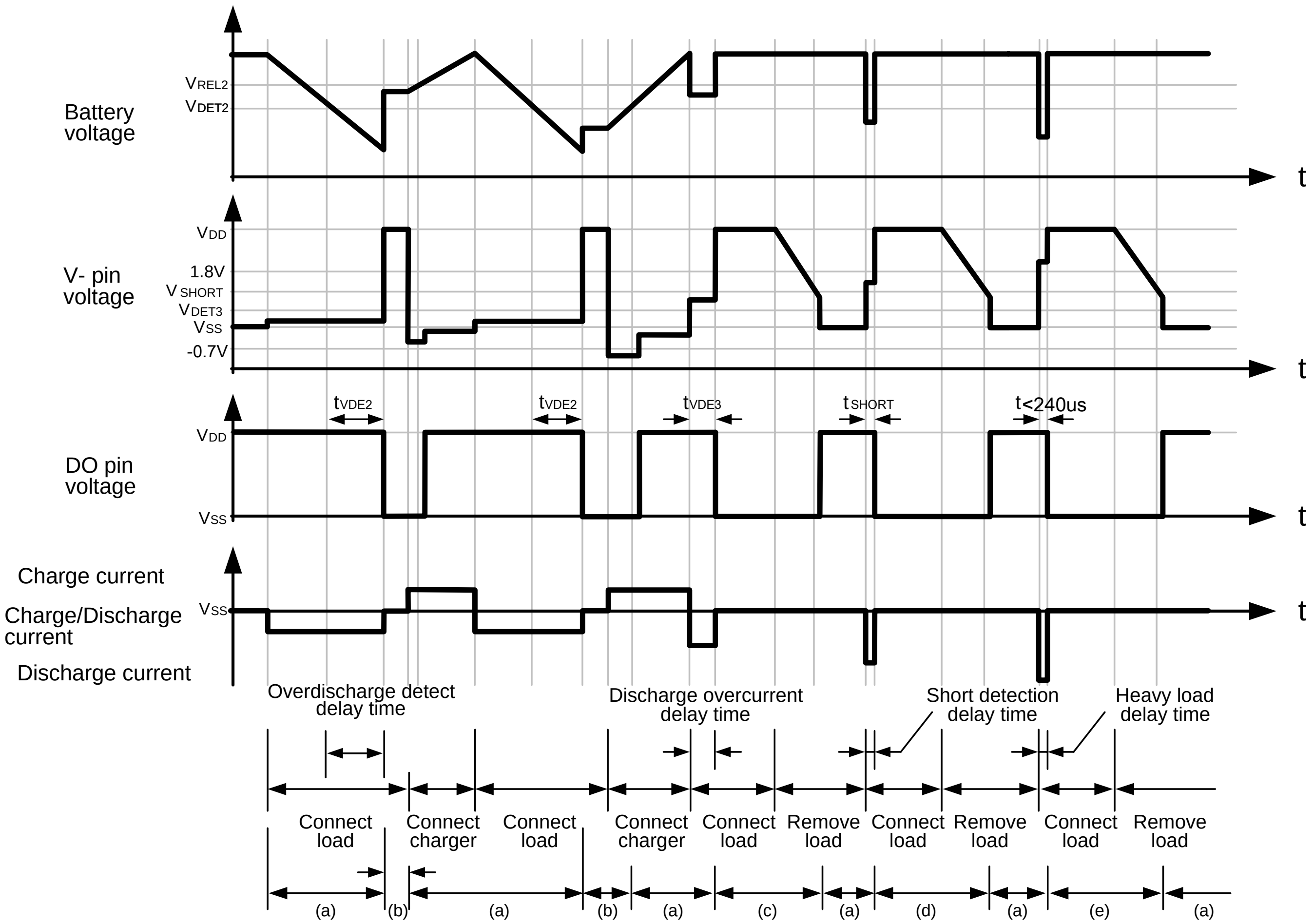
(a) Normal condition

(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

(e) Heavy load protection

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

Recommended Application Circuit

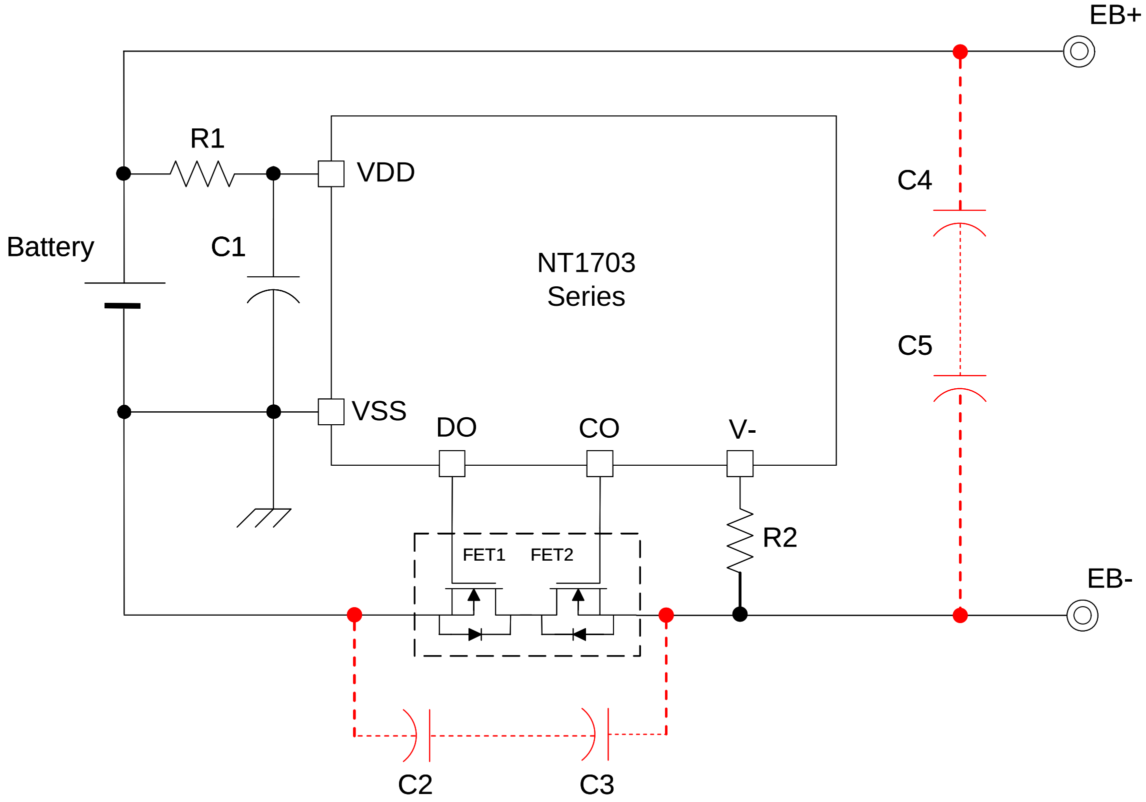


Table1 Constant for external components

Symbol	Parts	Purpose	Recommended	Min.	Max.	Remarks
FET1	N channel MOSFET	Discharge control	-	-	-	*1) 0.4 V ≤ Threshold voltage ≤ Over-discharge detection voltage. Gate to source withstand voltage ≥ Charger voltage.
FET2	N channel MOSFET	Charge control	-	-	-	*1) 0.4 V ≤ Threshold voltage ≤ Over-discharge detection voltage. Gate to source withstand voltage ≥ Charger voltage.
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	2KΩ	*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.

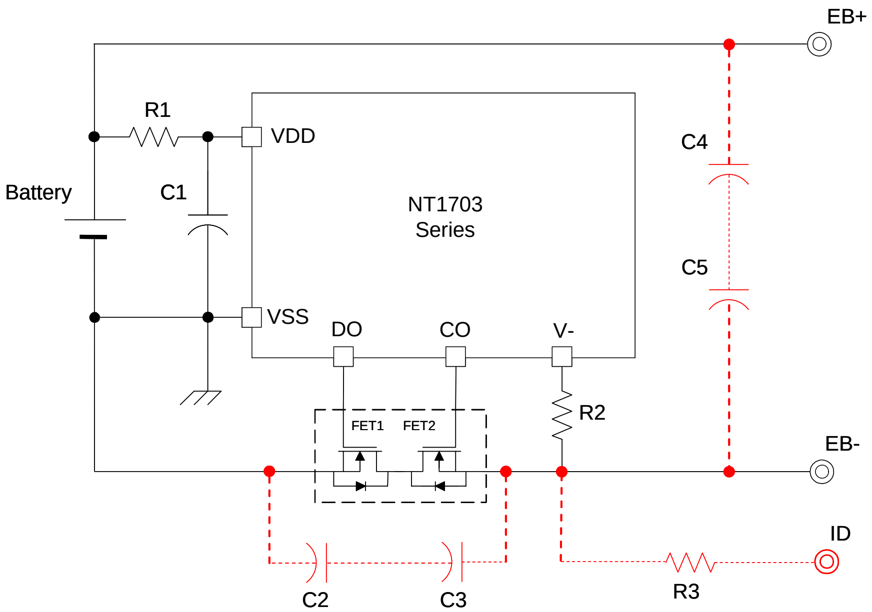
*4) R1 and R2 resistors are current limit resistance for a charger connected reversibly or a large voltage charger that exceeds the absolute rating for VCC is connected, when we connect reverse charger the current flows from charger to R2, internal ESD diode and R1. This current will increase R1 voltage 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.

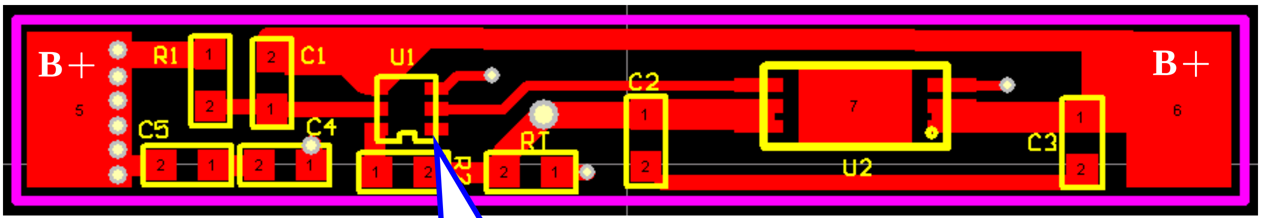
Precautions: 1) The application condition for the input voltage, output voltage, and load current should not exceed the package power dissipation.
2) Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.

PCB Schematic

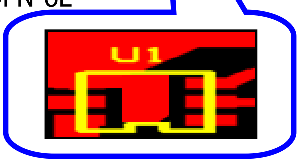


Layout Reference

TOP Layer: Package SOT-23-6

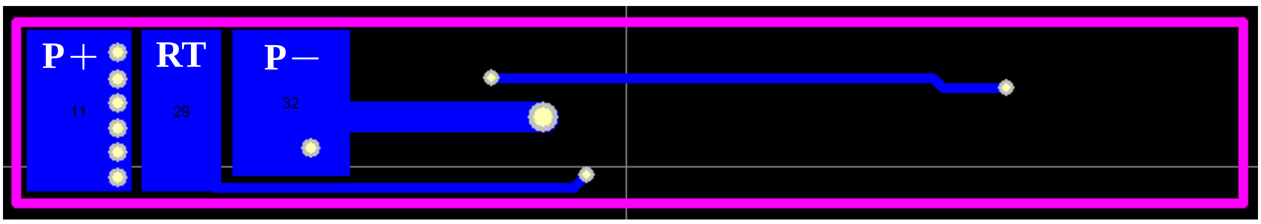


Package DFN-6L



Remark:
Neotec recommends that the thermal pad can be soldered to PCB metal and connected to Vss or floating at DFN-6L package type, which can help to increase the physical stress sustaining ability of package.

Bottom Layer:



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
		RT	ID resistor of load

BOM list:

Standard application circuit:

Symbol	Parts	Value	Symbol	Parts	Value
U1	NT1703	--	R1	Resistor	100Ω
U2	N-MOSFET	AON 5802	R2	Resistor	1KΩ
			C1	Capacitor	0.1uF

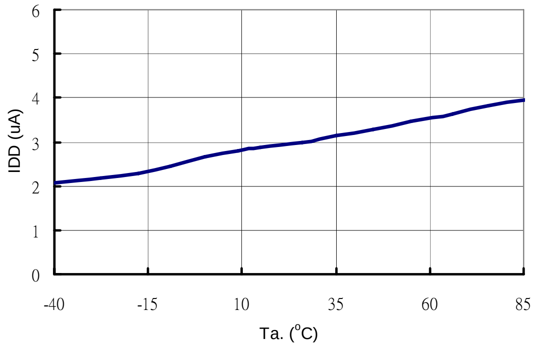
Special application circuit: (Reserve component)

Symbol	Parts	Value	Remarks
RT	Resistor	1KΩ	ID resistor by customer
C2	Capacitor	0.1uF	ESD Protection of MOSFET
C3	Capacitor	0.1uF	ESD Protection of MOSFET
C4	Capacitor	0.1uF	ESD Protection of connected external load
C5	Capacitor	0.1uF	ESD Protection of connected external load

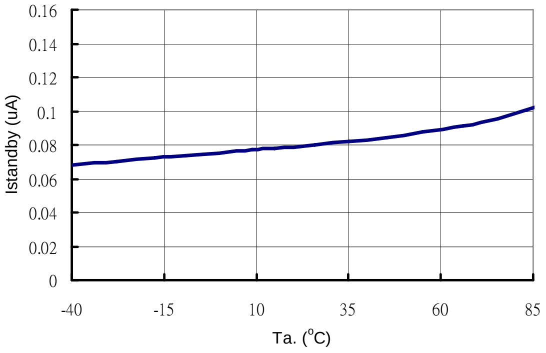
Characteristics (Typical Data)

a) Current consumption

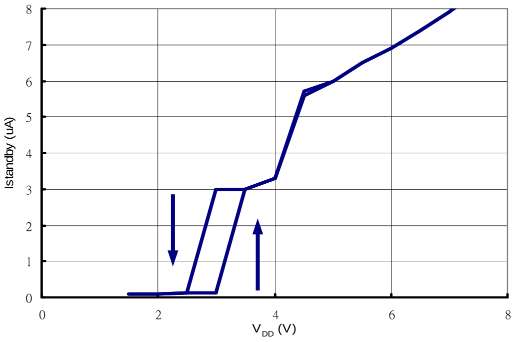
1) IDD vs. Ta.



2) Istandby vs. Ta.

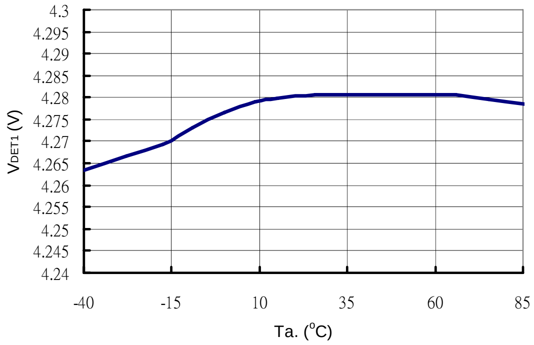


3) Istandby vs. V_{DD}

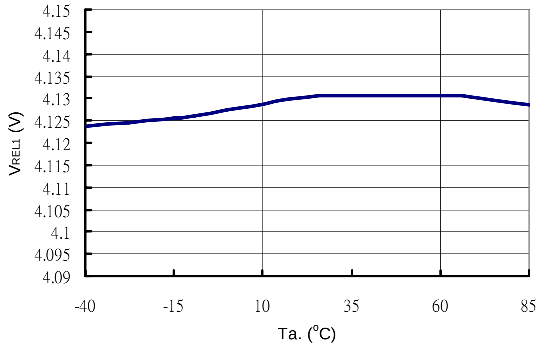


b) Over-charge detection voltage / over-discharge detection voltage / over-current detection voltage, and delay time.

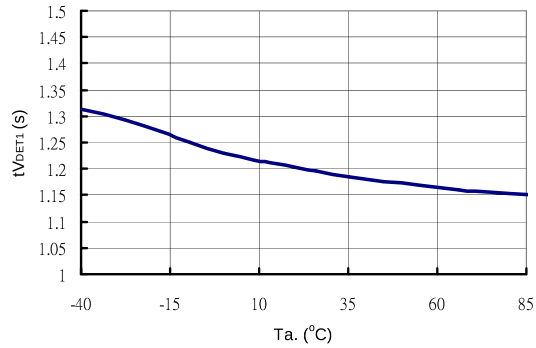
1) V_{DET1} vs. Ta.



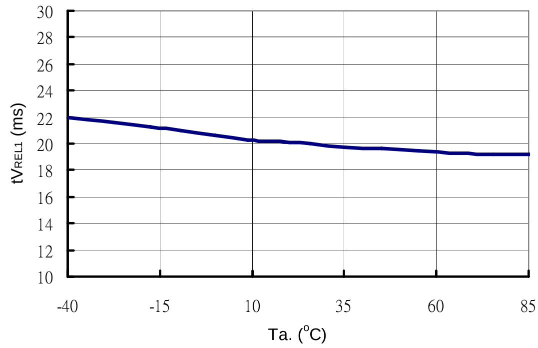
2) V_{REL1} vs. Ta.



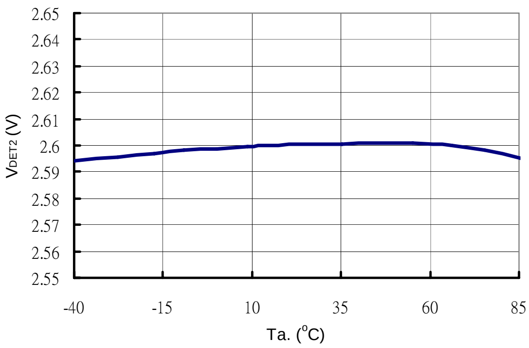
2) tV_{DET1} vs. Ta.



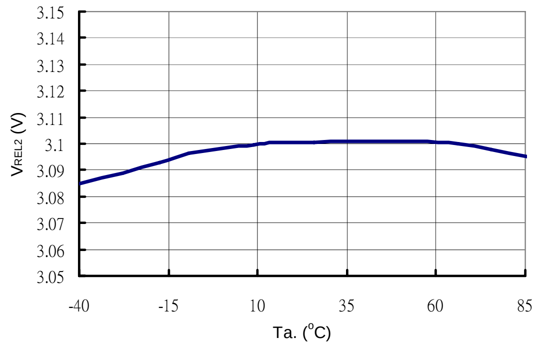
3) tV_{REL1} vs. Ta.



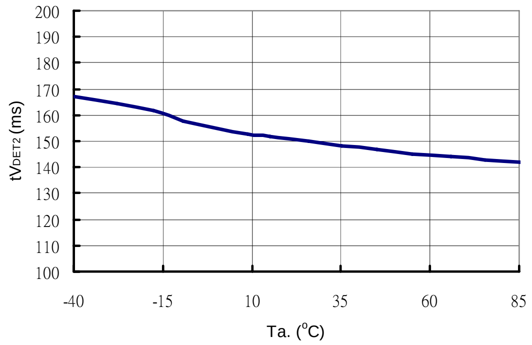
4) V_{DET2} vs. Ta.



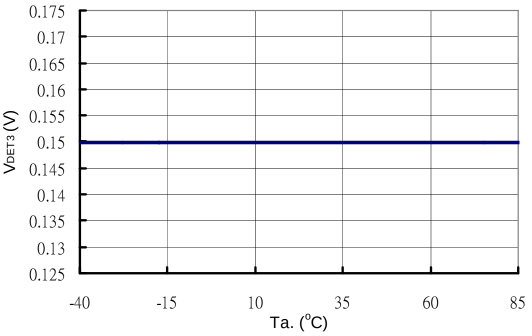
5) V_{REL2} vs. Ta.



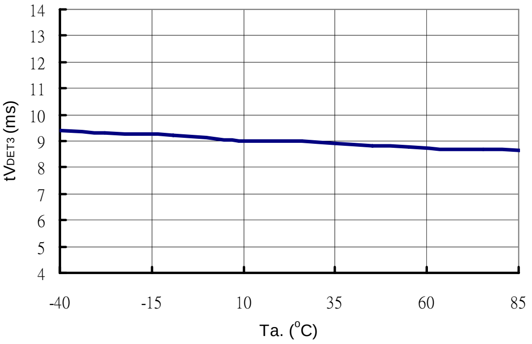
6) tV_{DET2} vs. Ta.



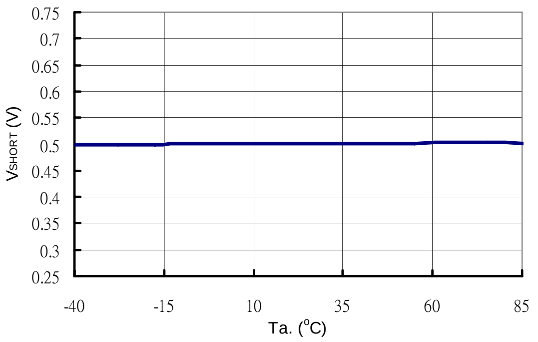
7) V_{DET3} vs. Ta.



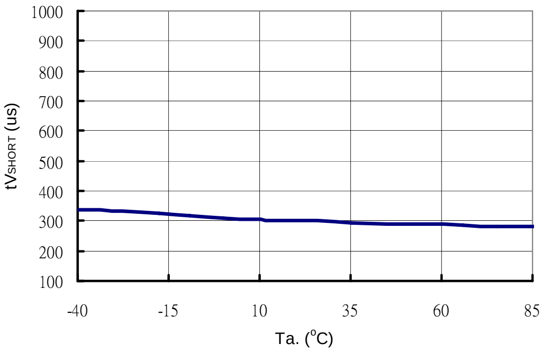
8) tV_{DET3} vs. Ta.



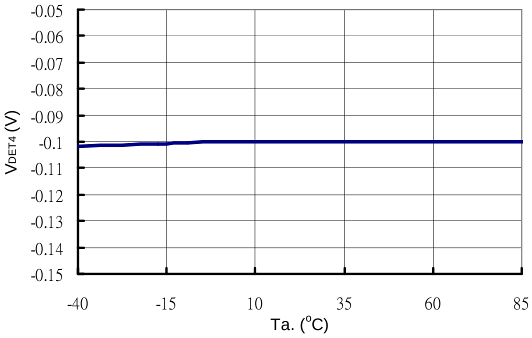
9) V_{SHORT} vs. Ta.



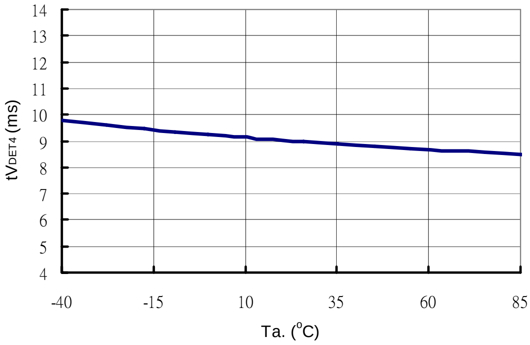
10) tV_{SHORT} vs. Ta.



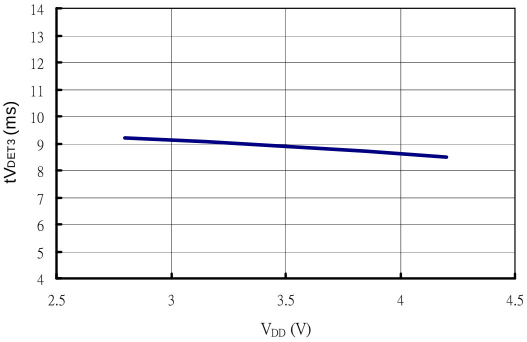
11) V_{DET4} vs. Ta.



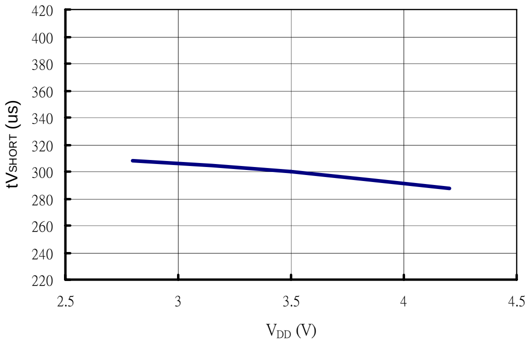
12) tV_{DET4} vs. Ta.



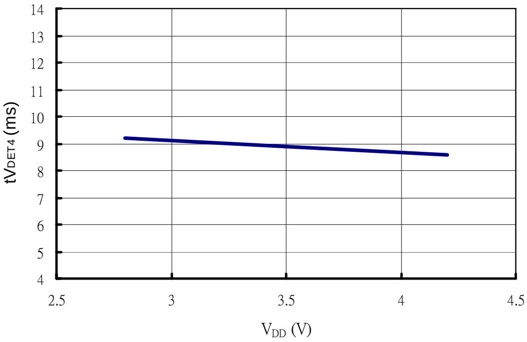
13) tV_{DET3} vs. V_{DD}



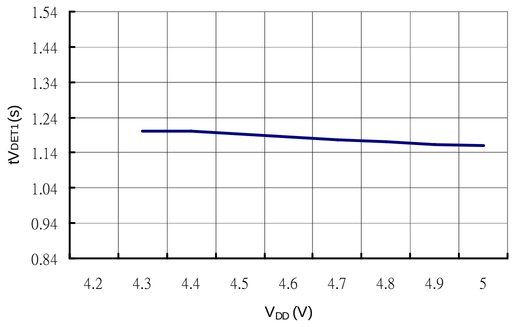
14) tV_{SHORT} vs. V_{DD}



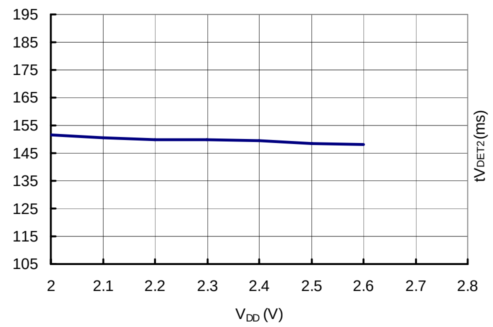
15) tV_{DET4} vs. V_{DD}



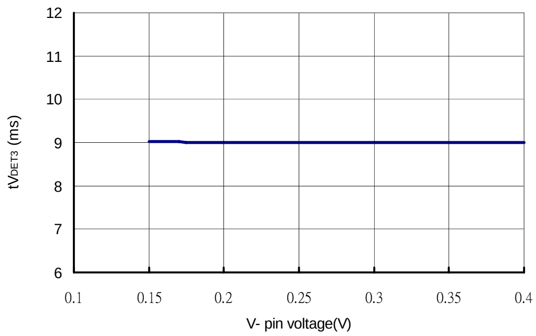
16) tV_{DET1} vs. V_{DD}



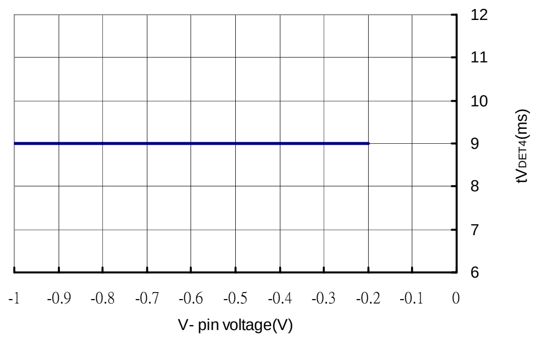
17) tV_{DET2} vs. V_{DD}



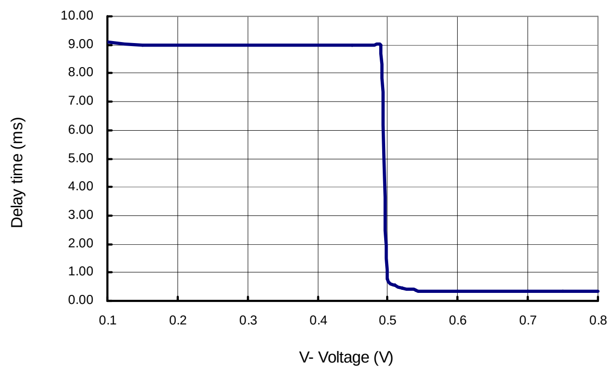
18) tV_{DET3} vs. V- pin voltage



19) tV_{DET4} vs. V- pin voltage

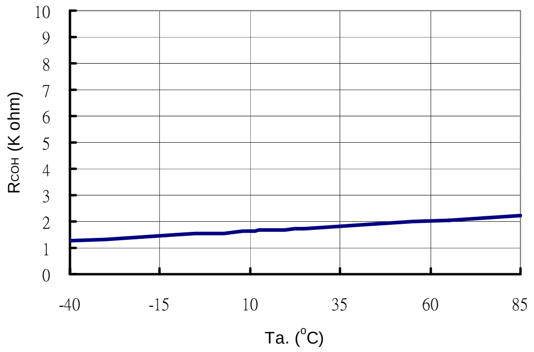


20) tV_{DET3} and tV_{SHORT} vs. V- pin voltage

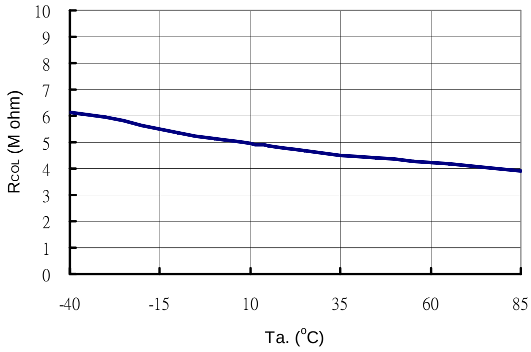


c) Output resistor

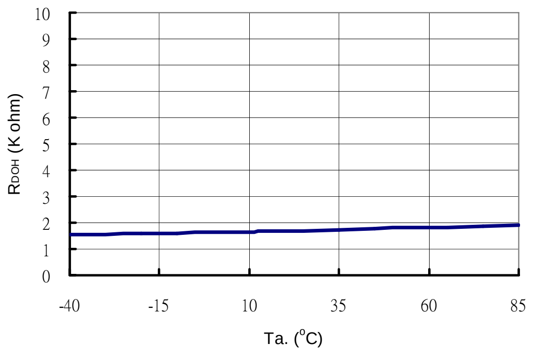
1) R_{COH} vs. Ta.



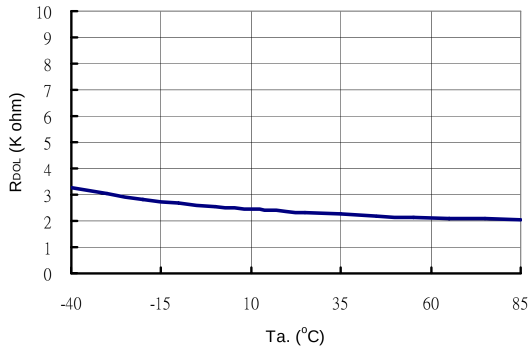
2) R_{COL} vs. Ta.



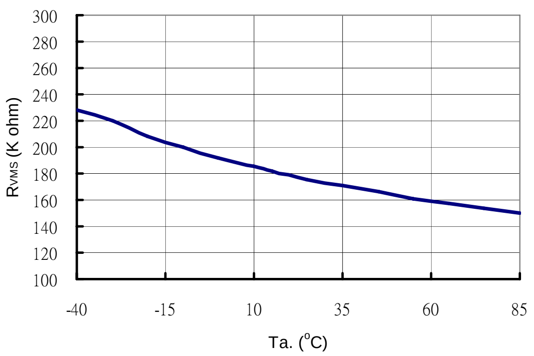
3) R_{DOH} vs. Ta.



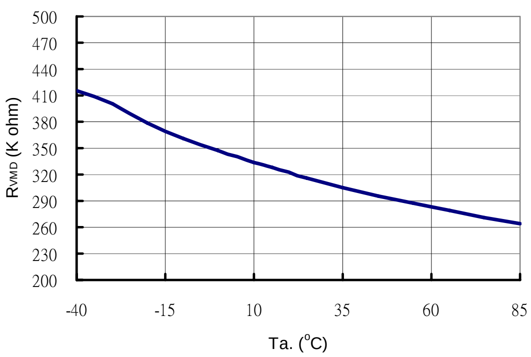
4) R_{DOL} vs. Ta.



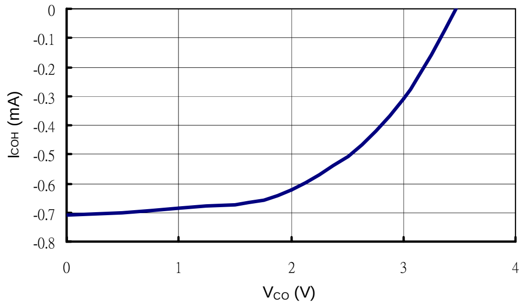
5) R_{VMS} vs. Ta.



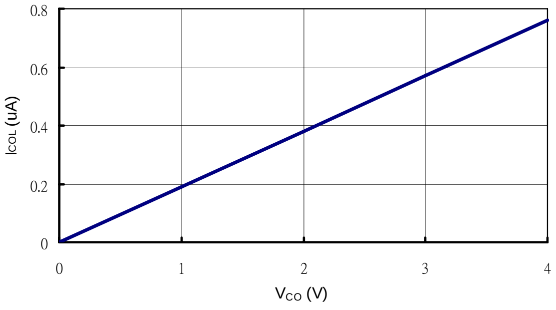
6) R_{VMD} vs. Ta.



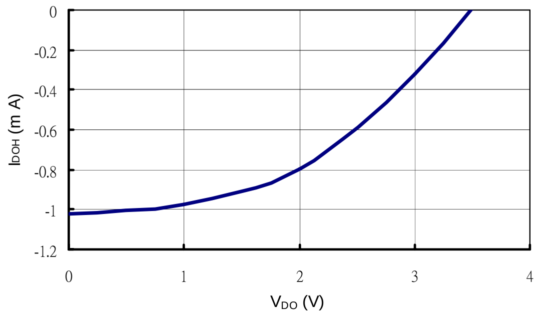
7) I_{COH} vs. V_{CO}



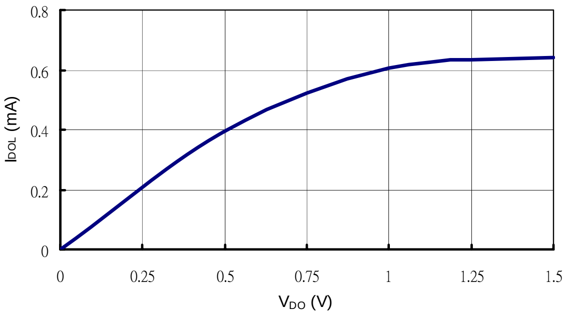
8) I_{COL} vs. V_{CO}



9) I_{DOH} vs. V_{DO}

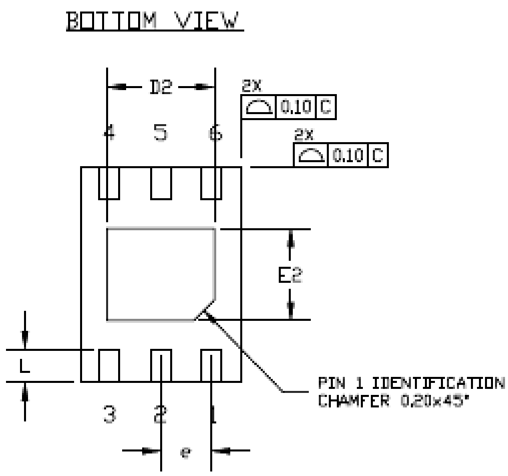


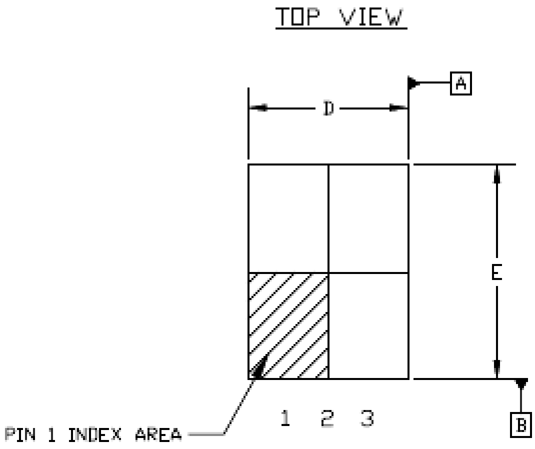
10) I_{DOL} vs. V_{DO}



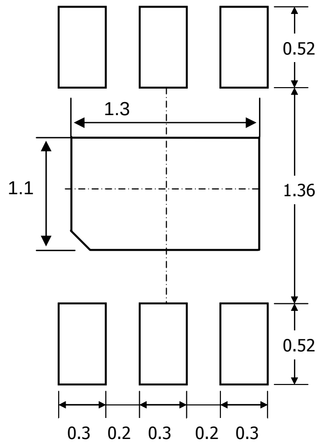
Package Information

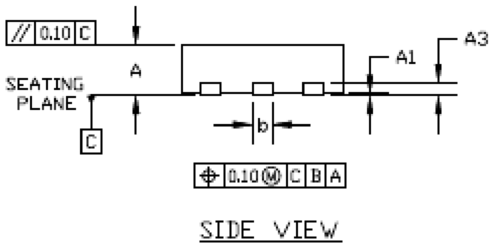
DFN-6L Dimension



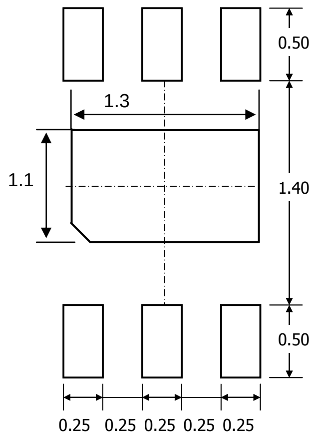


PCB Land Pattern





Steel Plate



Symbol	Dimensions In Millimeters	
	Min.	Max.
A	0.350	0.550
A1	0.000	0.050
A3	0.127REF	
D	1.424	1.620
E	1.924	2.150
D2	1.000	1.200
E2	0.800	1.000
b	0.150	0.300
e	0.500 BSC	
L	0.174	0.370

NOTES: 1. Dimension and tolerance conform to ASME Y14.5M-1994.
2. Controlling dimension millimeter is not necessarily exact.