Protection IC for 1-Cell Battery Pack

Features

- High Detection Accuracy
  - Overcharge Detection: ±25mV
  - Overdischarge Detection: ±50mV
  - Discharge Overcurrent Detection: ±15mV
  - Charge Overcurrent Detection: ±30mV
- High Withstand Voltage
  - Absolute maximum ratings: 28V (V- pin and CO pin)
- Ultra Small Package
  - SOT-23-5
  - SOT-23-6
  - DFN-6L

Description

The NT1702 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 NT1702 series with state-of-art design and process.

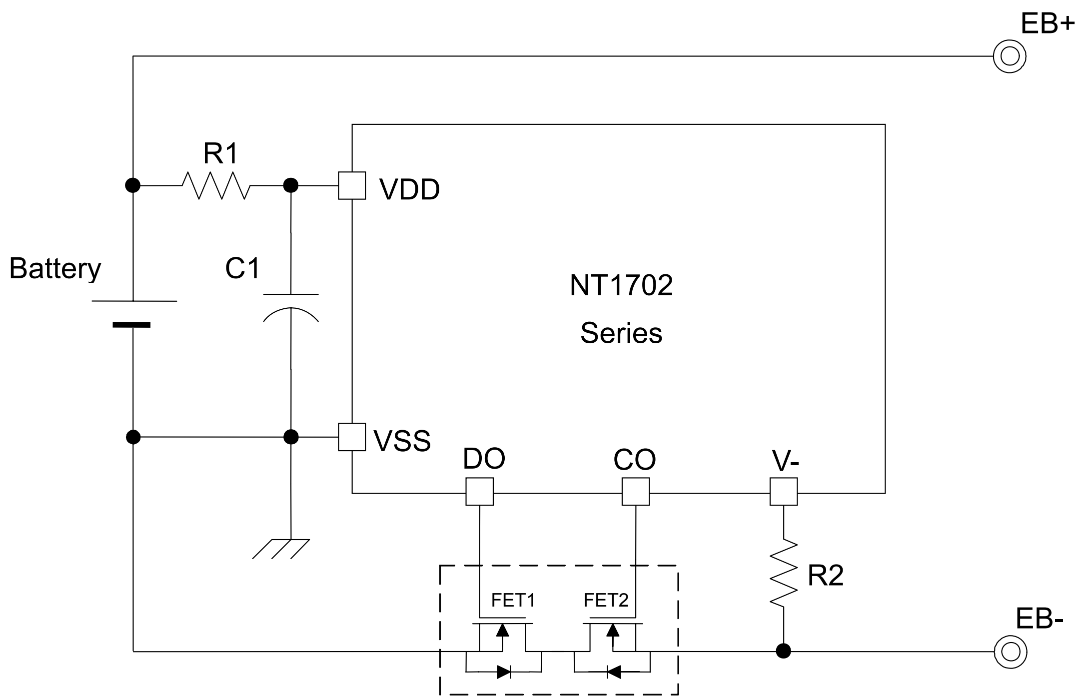
To minimize power consumption, NT1702 series activates power down mode when an overdischarge event is detected (for power-down mode enabled version). Besides, NT1702 series performs protection functions with four external components for miniaturized PCB.

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

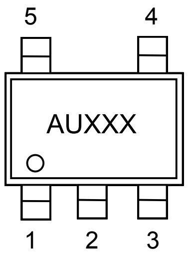
Typical Application Circuit



Package and Pin Description

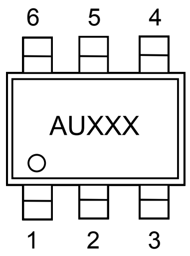
NT1702A description

SOT-23-5



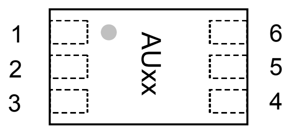
Pin No.	Symbol	NT1702A pin description
1	V-	Voltage detection between V- pin and VSS pin (Overcurrent / charger detection pin)
2	VDD	Connection for positive power supply input
3	VSS	Connection for negative power supply input
4	DO	Connection of discharge control FET gate
5	CO	Connection of charge control FET gate

SOT-23-6



Pin No.	Symbol	NT1702A pin description
1	DO	Connection of discharge control FET gate
2	V-	Voltage detection between V- pin and VSS pin (Overcurrent / charger detection pin)
3	CO	Connection of charge control FET gate
4	NC	No connection
5	VDD	Connection for positive power supply input
6	VSS	Connection for negative power supply input

DFN-6L



Pin No.	Symbol	NT1702A pin description
1	NC	No connection
2	CO	Connection of charge control FET gate
3	DO	Connection of discharge control FET gate
4	VSS	Connection for negative power supply input
5	VDD	Connection for positive power supply input
6	V-	Voltage detection between V- pin and VSS pin (Overcurrent / charger detection pin)

Ordering Information

NT1702A-XXX XX

- XX — Package Type
  - A5: SOT-23-5
  - A6: SOT-23-6
  - B3: DFN-6L
- XXX — Version code
- A — Serial number: A

Product version code:

(1) SOT-23-6

Table1: (For Li-ion or Li-polymer battery cell)

NT1702	Overcharge Detection Voltage V_{DET1} (V)	Over charge Release Function	Overcharge Release Voltage V_{REL1} (V)	Over discharge Detection Voltage V_{DET2} (V)	Over discharge Release Voltage V_{REL2} (V)	Overcurrent Detection Voltage V_{DET3} (V)	0V Battery Charge Function	Power down mode Function	Delay time
HFK	4.280	(b)	4.130	2.800	3.100	0.150	Unavailable	Yes	(1)
HQM	4.280	(b)	4.080	2.300	2.300	0.130	Unavailable	Yes	(1)
HQR	4.280	(b)	4.080	2.300	2.300	0.100	Unavailable	Yes	(1)
HFR	4.280	(b)	4.130	2.800	3.100	0.100	Unavailable	Yes	(1)
FLK	4.325	(a)	4.125	2.500	2.900	0.150	Unavailable	Yes	(1)
GZK	4.300	(b)	4.100	2.500	2.900	0.150	Unavailable	Yes	(1)
JQM	4.275	(a)	4.075	2.300	2.300	0.130	Available	Yes	(2)

(2) SOT-23-5

Table 2: (For Li-ion or Li-polymer battery cell)

NT1702	Overcharge Detection Voltage V_{DET1} (V)	Over charge Release Function	Overcharge Release Voltage V_{REL1} (V)	Over discharge Detection Voltage V_{DET2} (V)	Over discharge Release Voltage V_{REL2} (V)	Overcurrent Detection Voltage V_{DET3} (V)	0V Battery Charge Function	Power down mode Function	Delay time
HFK	4.280	(b)	4.130	2.800	3.100	0.150	Unavailable	Yes	(1)
HQR	4.280	(b)	4.080	2.300	2.300	0.100	Unavailable	Yes	(1)
HFR	4.280	(b)	4.130	2.800	3.100	0.100	Unavailable	Yes	(1)
HXW	4.280	(b)	4.280	2.800	2.800	0.050	Unavailable	Yes	(1)
JQM	4.275	(a)	4.075	2.300	2.300	0.130	Available	Yes	(2)

(3) DFN-6L

Table 3: (For Li-ion or Li-polymer battery cell)

NT1702	Overcharge Detection Voltage V_{DET1} (V)	Over charge Release Function	Overcharge Release Voltage V_{REL1} (V)	Over discharge Detection Voltage V_{DET2} (V)	Over discharge Release Voltage V_{REL2} (V)	Overcurrent Detection Voltage V_{DET3} (V)	0V Battery Charge Function	Power down mode Function	Delay time
HFK	4.280	(b)	4.130	2.800	3.100	0.150	Unavailable	Yes	(1)
HQM	4.280	(b)	4.080	2.300	2.300	0.130	Unavailable	Yes	(1)
HQR	4.280	(b)	4.080	2.300	2.300	0.100	Unavailable	Yes	(1)
HFR	4.280	(b)	4.130	2.800	3.100	0.100	Unavailable	Yes	(1)
FLK	4.325	(a)	4.125	2.500	2.900	0.150	Unavailable	Yes	(1)
HXW	4.280	(b)	4.280	2.800	2.800	0.050	Unavailable	Yes	(1)
JQM	4.275	(a)	4.075	2.300	2.300	0.130	Available	Yes	(2)

Remark

1. Please contact our sales office for the products with detection voltage value other than those specified above.
2. Please reference the session “Overcharge Protection Release” for more detail about overcharge release function (a) and (b)
3. Please reference the characteristics for delay time, (1) and (2)

Table4: (For Detection Delay Time)

Delay time	Overcharge delay time t_{DET1} (S)	Overdischarge delay time t_{DET2} (mS)	Discharge overcurrent delay time t_{DET3} (mS)	Charge overcurrent delay time t_{DET4} (mS)	Load short-circuiting delay time t_{SHORT} (uS)
(1)	1.2	150	9	9	300
(2)	1.2	38	9	9	300

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	SOT-23-5 & SOT23-6	250	mW
		DFN-6L	250	
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

(Ta = 25°C)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Overcharge detection voltage	--	V_{DET1}-0.025	V_{DET1}	V_{DET1}+0.025	V
V_{REL1}	Overcharge 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 overcurrent detection voltage	V_{DD}=3.5V	V_{DET3}-0.015	V_{DET3}	V_{DET3}+0.015	V
V_{DET4}	Charge overcurrent 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
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	3.0	5.5	μA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=2.0V, V- floating			0.2	μA
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)	0.2	0.3	1.5	V

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
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	-	5	10	MΩ
R_{DOH}	DO pin H resistance	V_{DO}=3.0V, V_{DD}=3.5V, V-=0V	-	5	10	KΩ
RDOL	DO pin L resistance	VDO=0.5V, VDD=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	100	200	400	KΩ

Electrical Characteristics

(Ta = -40°C to +85°C)*

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Overcharge detection voltage	--	V_{DET1}-0.060	V_{DET1}	V_{DET1}+0.040	V
V_{REL1}	Overcharge 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 overcurrent detection voltage	V_{DD}=3.5V	V_{DET3}-0.021	V_{DET3}	V_{DET3}+0.024	V
V_{DET4}	Charge overcurrent 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
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		3.0	7.0	μA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=2.0V, V- floating			0.3	μA
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)	0.1	0.3	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	-	5	15	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	72	200	440	KΩ

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

Detection Delay time (1)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Delay Time (Ta = 25°C)						
t_{VDET1}*	Output delay time of overcharge	-	0.96	1.2	1.4	s
		V_{DD}=4.28V, C_{ISS}=1200pF, V_{TH}=0.6V	0.96	1.22	1.42	s
		V_{DD}=4.28V, C_{ISS}=1200pF, V_{TH}=0.4V	0.95	1.23	1.43	s
t_{VDET2}	Output delay time of overdischarge	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	11	ms
		V_{DET2} ≦2.5V	6	9	12	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	240	300	360	µs
t_{VDET4}*	Output delay time of charge over current	V_{DD}=3.5V	7.2	9	11	ms
		V_{DD}=3.5V, C_{ISS}=1200pF, V_{TH}=0.6V	15.1	19.5	23.8	ms
		V_{DD}=3.5V, C_{ISS}=1200pF, V_{TH}=0.4V	16.8	21.6	26.4	ms
Delay Time (Ta = -40°C to +85°C)						
t_{VDET1}	Output delay time of overcharge	-	0.7	1.2	2.0	s
t_{VDET2}	Output delay time of overdischarge	V_{DET2} ＞2.5V	83	150	255	ms
		V_{DET2} ≦2.5V	64	150	275	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	5	9	15	ms
		V_{DET2} ≦2.5V	3.8	9	16	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	150	300	540	µs
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	5	9	15	ms

*: 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 overcharge (tV_{DET1}) and charge overcurrent (tV_{DET4}) of NT1702 are prolonged approximately "10ms" to turn off the N-channel MOSFETs to cutting off the current flowing path.

Detection Delay time (2)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Delay Time (Ta = 25°C)						
t_{VDET1}*	Output delay time of overcharge	-	0.96	1.2	1.4	s
		V_{DD}=4.28V, C_{ISS}=1200pF, V_{TH}=0.6V	0.96	1.22	1.42	s
		V_{DD}=4.28V, C_{ISS}=1200pF, V_{TH}=0.4V	0.95	1.23	1.43	s
t_{VDET2}	Output delay time of overdischarge	V_{DET2} ＞2.5V	30	38	46	ms
		V_{DET2} ≦2.5V	25	38	51	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	7.2	9	11	ms
		V_{DET2} ≦2.5V	6	9	12	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	240	300	360	μs
t_{VDET4}*	Output delay time of charge over current	V_{DD}=3.5V	7.2	9	11	ms
		V_{DD}=3.5V, C_{ISS}=1200pF, V_{TH}=0.6V	15.1	19.5	23.8	ms
		V_{DD}=3.5V, C_{ISS}=1200pF, V_{TH}=0.4V	16.8	21.6	26.4	ms
Delay Time (Ta = -40°C to +85°C)						
t_{VDET1}	Output delay time of overcharge	-	0.7	1.2	2.0	s
t_{VDET2}	Output delay time of overdischarge	V_{DET2} ＞2.5V	21	38	65	ms
		V_{DET2} ≦2.5V	16	38	70	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	5	9	15	ms
		V_{DET2} ≦2.5V	3.8	9	16	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	150	300	540	μs
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	5	9	15	ms

*: 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 overcharge (tV_{DET1}) and charge overcurrent (tV_{DET4}) of NT1702 are prolonged approximately "10ms" to turn off the N-channel MOSFETs to cutting off the current flowing path.

Test Circuits

- **Overcharge, overdischarge and the release detection voltages** (test circuit 1)
  1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF, then NT1702 series enters operating mode.
  2) Increase V1 voltage (from 3.5V) gradually. The V1 voltage is the overcharge detection voltage (V_{DET1}) when CO pin goes low (from high).
  3) Decrease V1 gradually. The V1 voltage is the overcharge release detection voltage (V_{REL1}) when CO pin goes high again.
  4) Continue decreasing V1. The V1 voltage is the overdischarge detection voltage (V_{DET2}) when DO pin goes low. Then increase V1 gradually. The V1 voltage is the overdischarge release detection voltage (V_{REL2}), when DO pin returns to high.

  Note: The overcharge and overdischarge release voltages are defined in versions.

- **Discharge overcurrent detection voltage** (test circuit 1)
  1) Set V1=3.5 V, V2=0V, S1=ON and S2=OFF and NT1702 series enters operating condition.
  2) Increase V2 (from 0V) gradually. The V2 voltage is the discharge overcurrent detection voltage (V_{DET3}) when DO pin goes low (from high).

- **Charge overcurrent detection voltage** (test circuit 1)
  1) Set V1=3.5V, V3=0V, S1=OFF and S2=ON and NT1702 series enters operating condition.
  2) Increase V3 gradually. The V3 voltage is the charge overcurrent 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 NT1702 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.

- **Overcharge, overdischarge 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 overcharge 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 overdischarge 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 overcurrent 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 overcurrent 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 overcurrent 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 overcurrent 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=2.0V and S1=ON enter overdischarge 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 NT1702 series enters overdischarge 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 NT1702 series enters discharge overcurrent 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 overcharge 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 overdischarge 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).

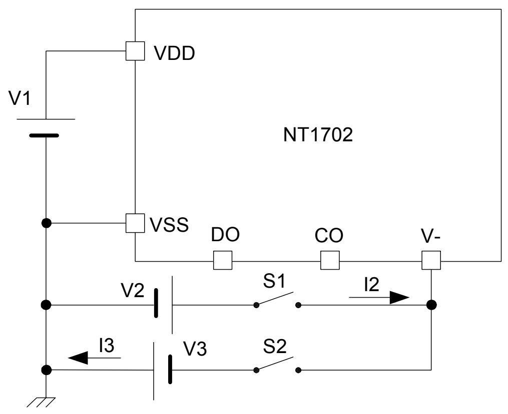
- **0V battery charge inhibition battery voltage (products with 0V battery charging function is "Unavailable")** (test circuit 4)
  1) Set V1=0V, V2=-4V and increase V1 gradually.
  2) The V1 voltage is the 0V charge inhibition voltage (V_{0INH}) when CO pin switches from low to high (V_{V-} + 0.1V or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

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

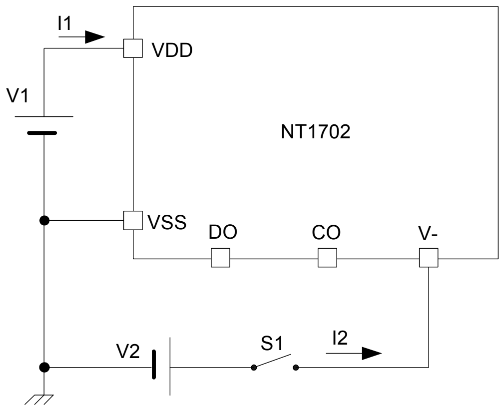
Recommended:

1) '0 V charge available' doesn't means NT1702 can recover the zero-V cell to be full charged if this cell has been already damaged due to too low voltage.
2) In NT1702, the '0 V charge inhibition' voltage is rather lower (0.3V~0.5V). That is, NT1702 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.

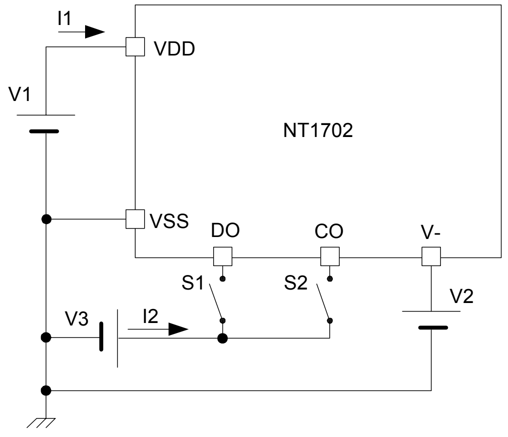
Test Circuit



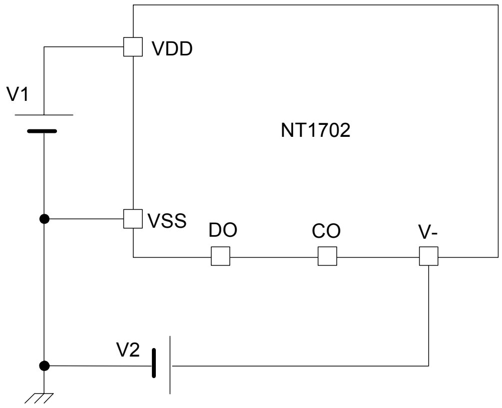
Test circuit 1



Test circuit 2



Test circuit 3



Test circuit 4

Operation

The NT1702 series provides overcharge, overdischarge, discharge overcurrent, charge overcurrent and load short-circuiting protections for the 1-cell battery pack. NT1702 series continuously monitors the voltage of battery between VDD pin and VSS pin to control overcharge and overdischarge 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 NT1702 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 overcurrent and discharge overcurrent current conditions.

(1) Normal Condition (Operation mode)

The NT1702 series turns both the charging and discharging control MOSFETs on when the voltage of battery is in the range from overcharge detection voltage (V_{DET1}) to overdischarge detection voltage (V_{DET2}), and the VM pin voltage is in the range from overcurrent detection voltage (V_{DET4}) to discharge overcurrent detection voltage (V_{DET3}). This is called the normal condition that charging and discharging can be carried out freely.

Caution: The NT1702 series may be needed connecting a charger to return to normal condition, when the battery is connected for the first time.

(2) Overcharge Condition

1) Overcharge Protection:

When the VDD voltage is higher than the overcharge detection voltage (V_{DET1}) and lasts for longer than the overcharge detection delay time (t_{VDET1}), NT1702 series turns off the external charging MOSFET to protect the pack from being overcharged, which CO pin turns to “L” from “H” level.

2) Overcharge Protection Release:

(a) When the battery voltage is lower than V_{REL1} and the V- pin voltage is between charge overcurrent detection voltage (V_{DET4}) and discharge overcurrent detection voltage (V_{DET3}), the NT1702 series would release this condition.

When the battery voltage is lower than V_{DET1} and charger is removed, the NT1702 series can be released from this condition.

(b) When the battery voltage is lower than V_{REL1} and the V- pin voltage is between charge overcurrent detection voltage (V_{DET4}) and short detection voltage (V_{SHORT}), the NT1702 series would release this condition.

When the battery voltage is lower than V_{REL1} and charger is removed, the NT1702 series can be released from this condition.

<u>: About overcharge release condition please reference to NT1702AN02.</u>*

(3) Overdischarge Condition

1) Overdischarge Protection:

When the VDD voltage is lower than the overdischarge detection voltage (V_{DET2}) and lasts longer than overdischarge detection delay time (t_{VDET2}), NT1702 series turns off the external discharge MOSFET to protect the pack from being overdischarged, which DO pin turns to “L” from “H” level. In overdischarge 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) Overdischarge Protection Release:

The overdischarge protection is released when

(a) a charger is connected and V- pin voltage is lower than –0.7V (Typ.) and battery voltage is higher than the overdischarge voltage, or

(b) a charger is connected, and V- pin voltage is higher than –0.7V (Typ.) and battery voltage is higher than the overdischarge release voltage.

(4) Discharge Overcurrent Condition

1) Discharge Overcurrent Protection:

The NT1702 series provides discharge overcurrent protection and load short-circuiting protection:

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

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

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

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

2) Discharge Overcurrent 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 overcurrent status returns to normal mode.

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

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

(5) Charge Overcurrent Condition

The NT1702 series provides charge overcurrent protection to prevent the battery pack from being connected to an unexpected charger.

1) Charge Overcurrent Protection

When the voltage of V- pin is lower than charge overcurrent 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 Overcurrent Release: Charge overcurrent protection can be only released by disconnecting the charger.

(6) Power Down Condition

1) Entering to Power Down Mode:

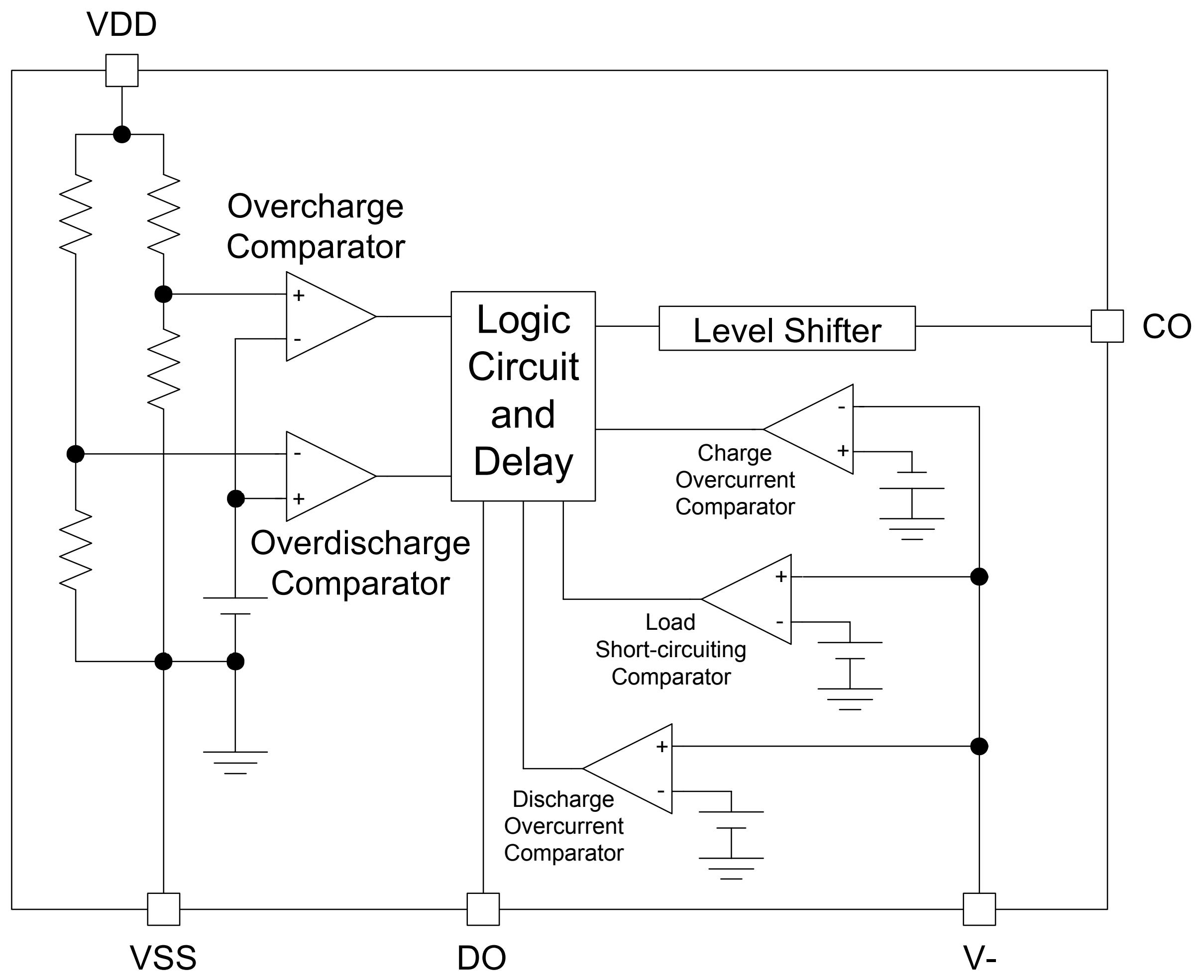
NT1702 series enters the power down mode when overdischarge protection occurs and V- pin voltage is higher than VDD/2 (typical). The V- pin voltage is pulled-up to the VDD through the R_{VMD} resistor. The internal circuits is shut off, therefore, the power-down current ($I_{STANDBY}$) is reduced to be low 0.2uA (Max.).

2) Power Down Mode Release:

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

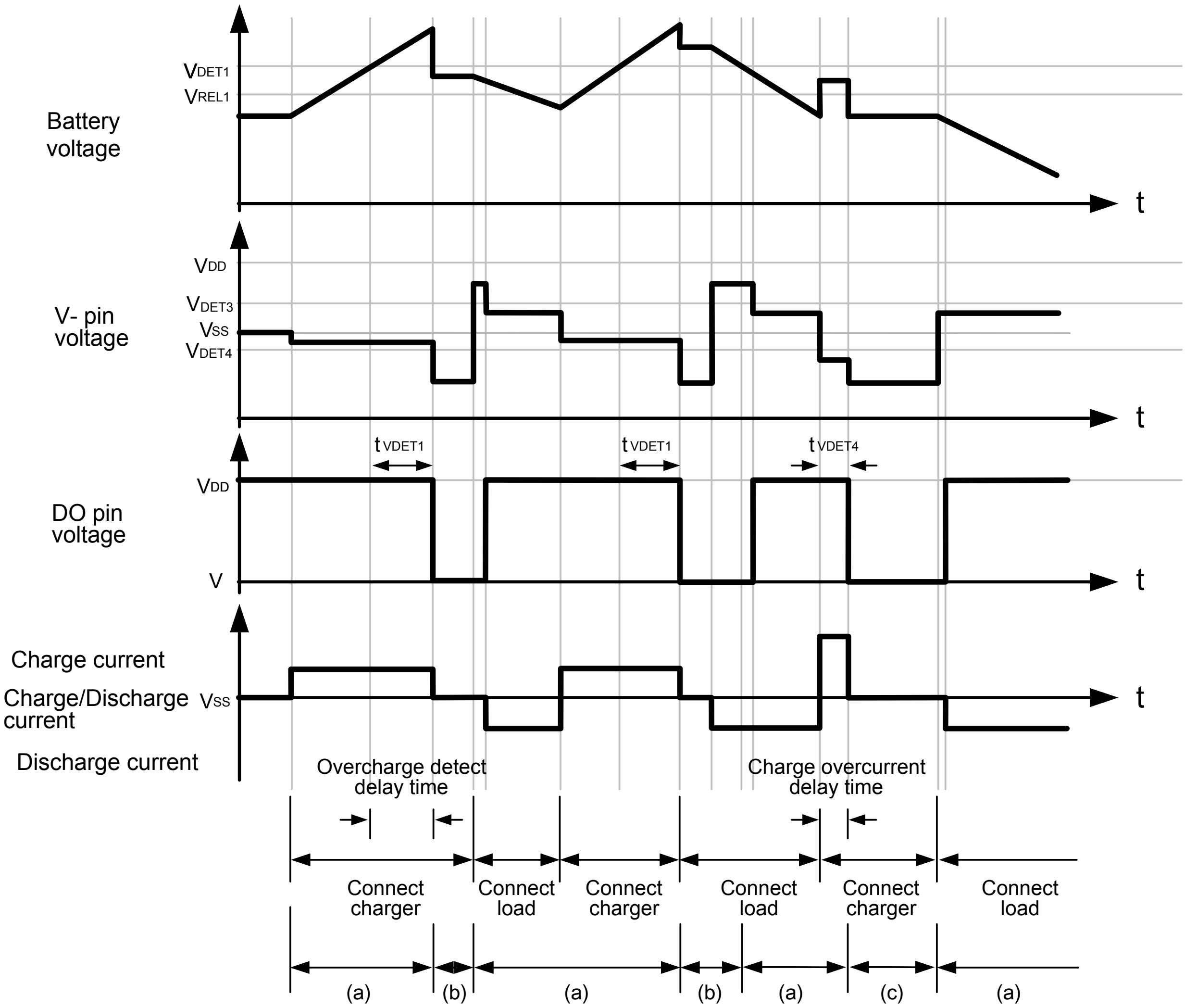
Note: Power down condition is for power down mode enabled version only.

Block Diagram



Timing Chart

(1) Overcharge, Charge Overcurrent Operation



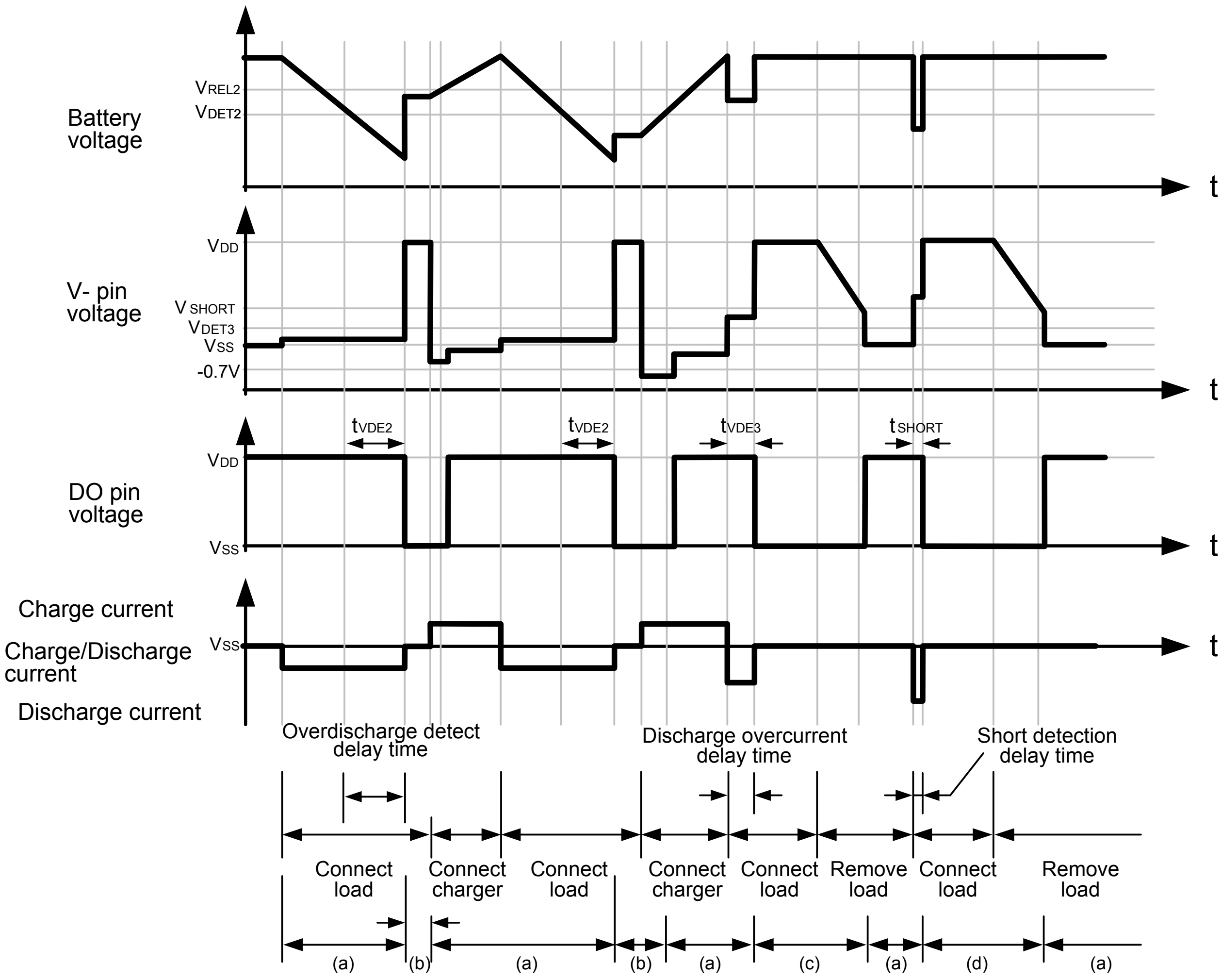
(a) Normal condition

(b) Overcharge condition

(c) Charge overcurrent condition

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

(2) Overdischarge, Discharge Overcurrent, Load Short-Circuiting Operation



(a) Normal condition

(b) Overdischarge condition

(c) Discharge overcurrent condition

(d) Load short-circuit condition

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

Recommended Application Circuit

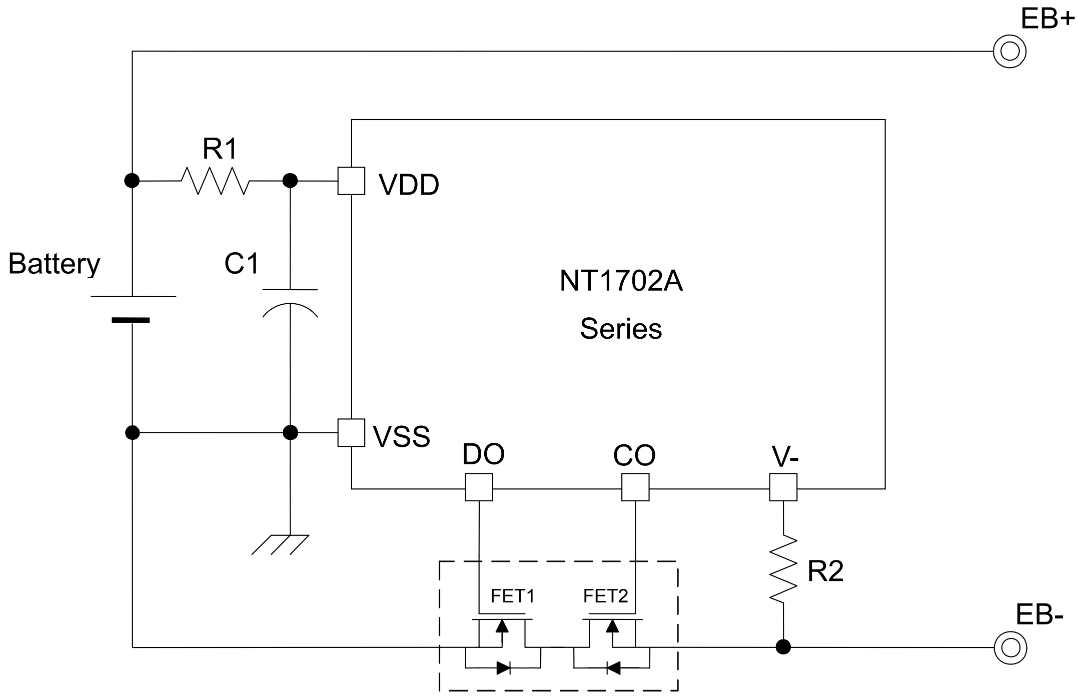


Table1 Constant for external components

Symbol	Parts	Purpose	Recommended	Min.	Max.	Remarks
FET1	N channel MOSFET	Discharge control	----	----	----	*1) 0.4 V ≤ Threshold voltage ≤ Overdischarge detection voltage. Gate to source withstand voltage ≥ Charger voltage.
FET2	N channel MOSFET	Charge control	----	----	----	*1) 0.4 V ≤ Threshold voltage ≤ Overcharge detection voltage. Gate to source withstand voltage ≥ Charger voltage.
R1	Resistor	ESD protection for power fluctuation	470Ω	240Ω	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.

*1) If the threshold voltage of an FET is lower than 0.4V, the FET may failed to stop the charging current.
If an FET has a threshold voltage equal to or higher than the overdischarge detection voltage, discharging may be stopped before overdischarge 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 overcharge detection voltage and release voltage higher than the defined voltage (listed in page 4)
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) 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.

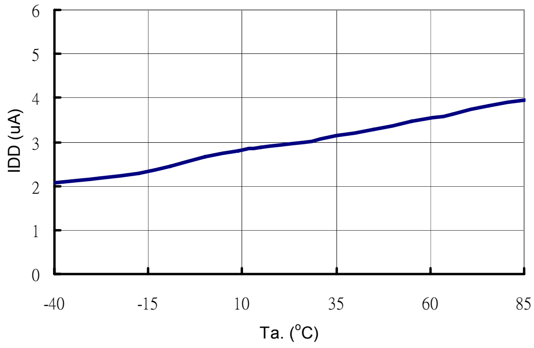
Caution: 1) The above constants may be changed without notice.
2) The application circuit above is for reference only. To determine the correct constants, evaluation of actual application is required.

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.

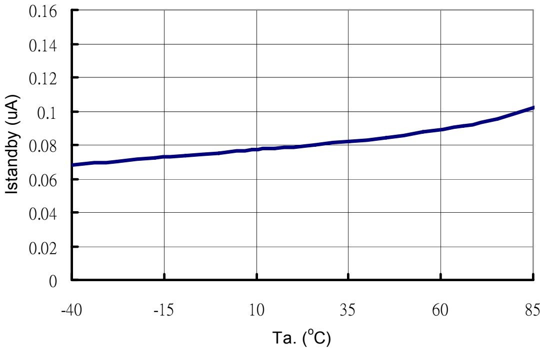
Characteristics (Typical Data)

a) Current consumption

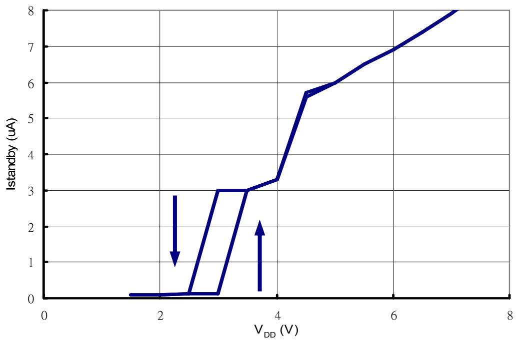
1) IDD vs. Ta.



2) Istandby vs. Ta.

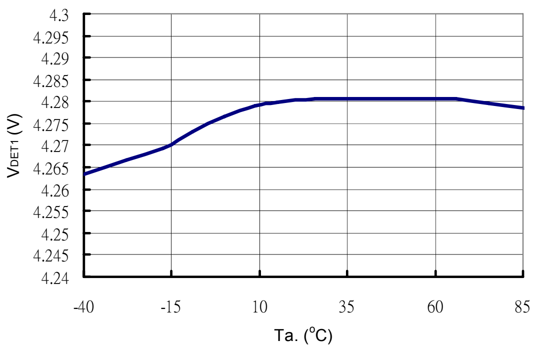


3) Istandby vs. V_{DD}

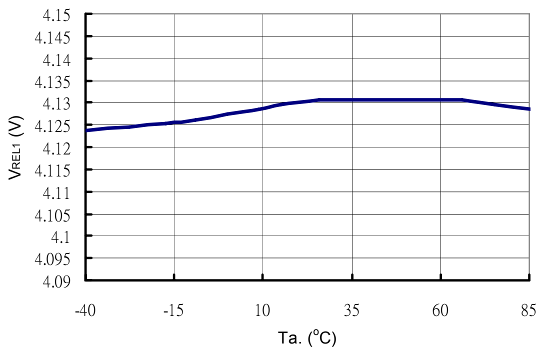


b) Overcharge detection voltage / overdischarge detection voltage / overcurrent detection voltage, and delay time.

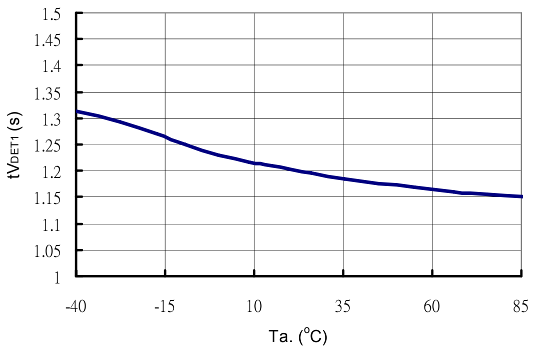
1) V_{DET1} vs. Ta.



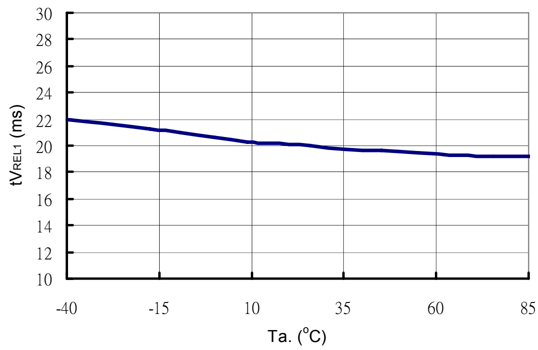
2) V_{REL1} vs. Ta.



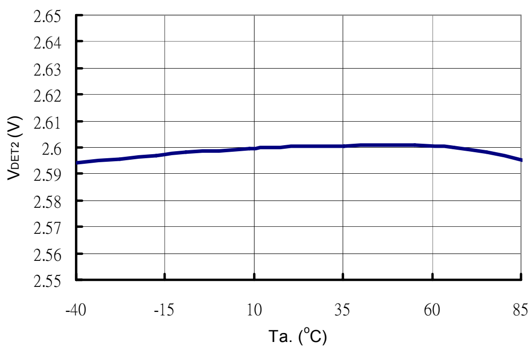
2) tV_{DET1} vs. Ta.



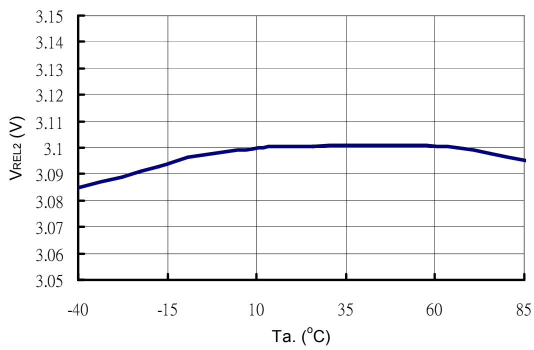
3) tV_{REL1} vs. Ta.



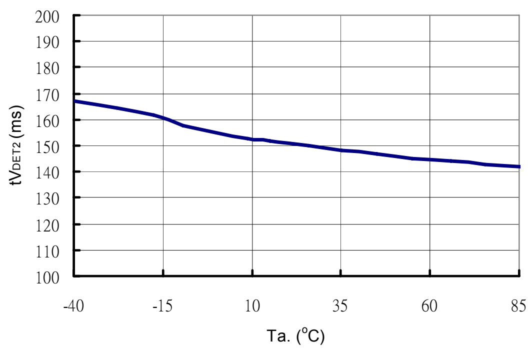
4) V_{DET2} vs. Ta.



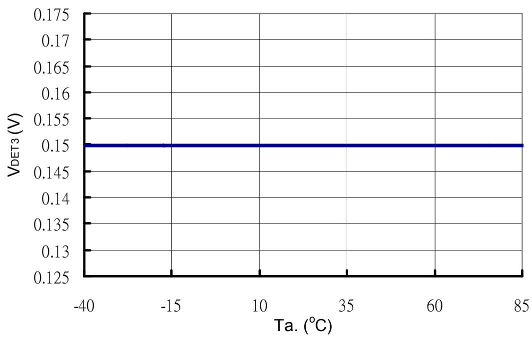
5) V_{REL2} vs. Ta.



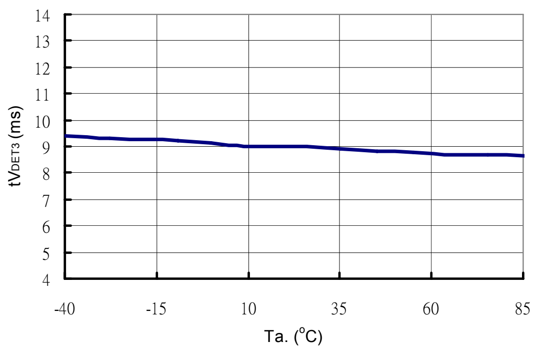
6) tV_{DET2} vs. Ta.



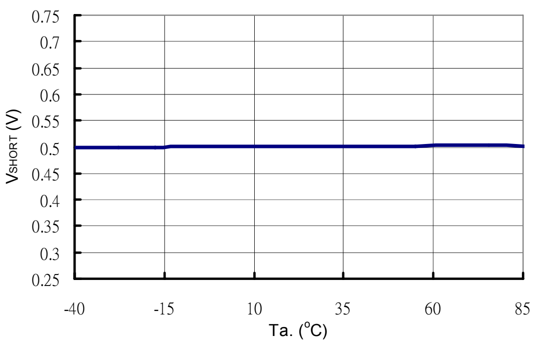
7) V_{DET3} vs. Ta.



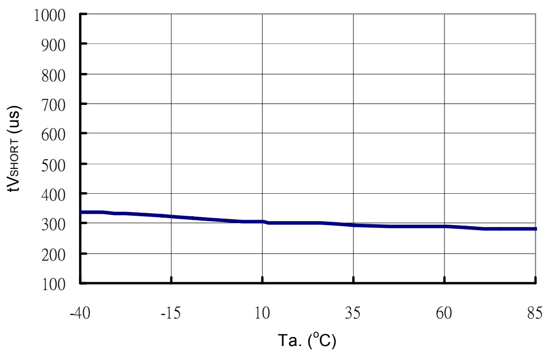
8) tV_{DET3} vs. Ta.



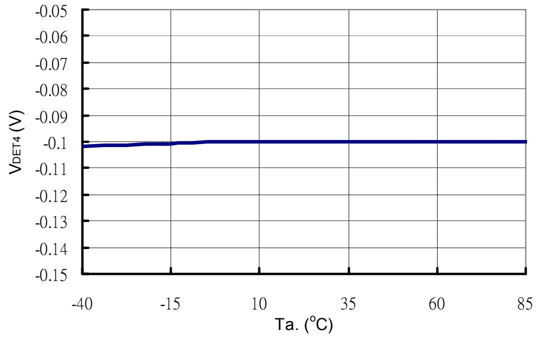
9) V_{SHORT} vs. Ta.



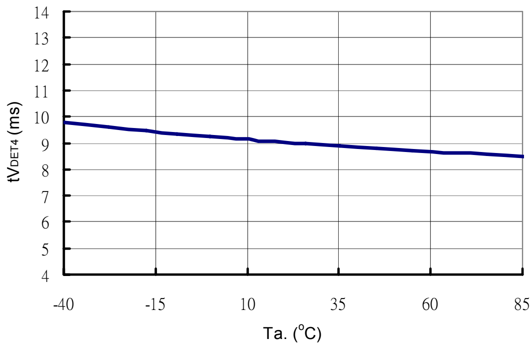
10) tV_{SHORT} vs. Ta.



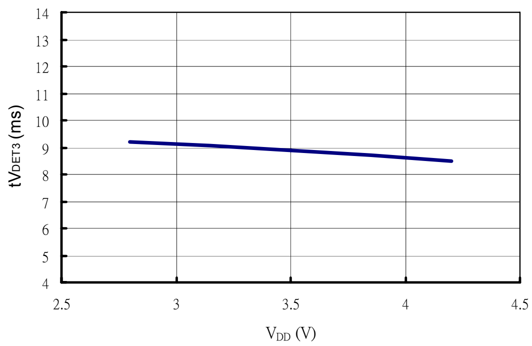
11) V_{DET4} vs. Ta.



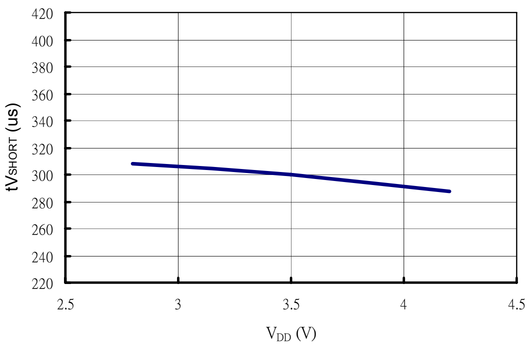
12) tV_{DET4} vs. Ta.



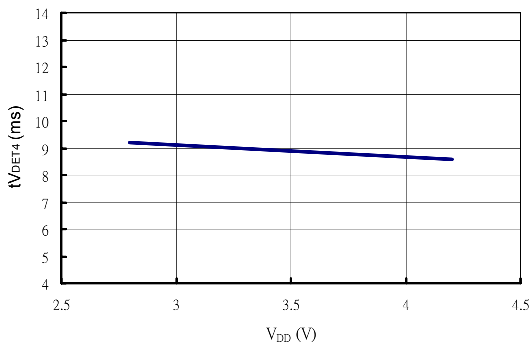
13) tV_{DET3} vs. V_{DD}



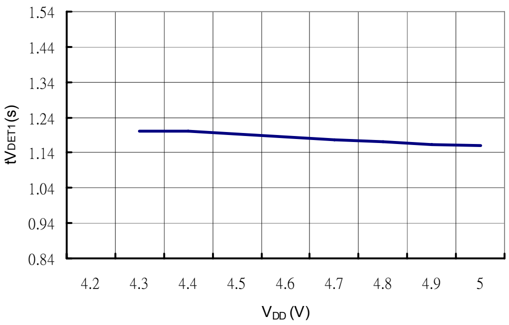
14) tV_{SHORT} vs. V_{DD}



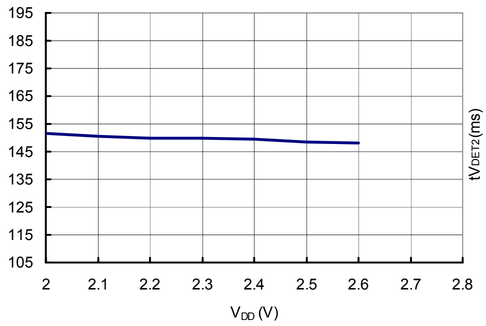
15) tV_{DET4} vs. V_{DD}



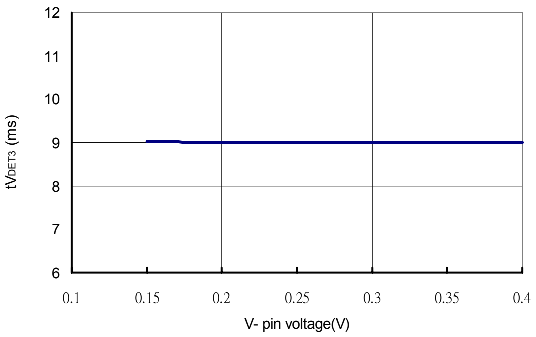
16) tV_{DET1} vs. V_{DD}



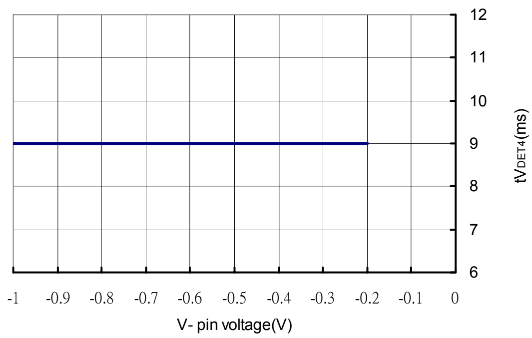
17) tV_{DET2} vs. V_{DD}



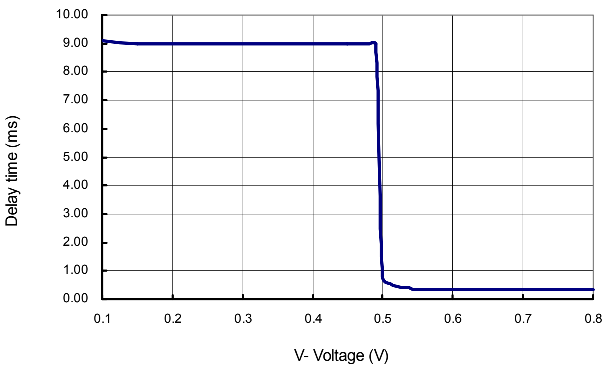
18) tV_{DET3} vs. V- pin voltage



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

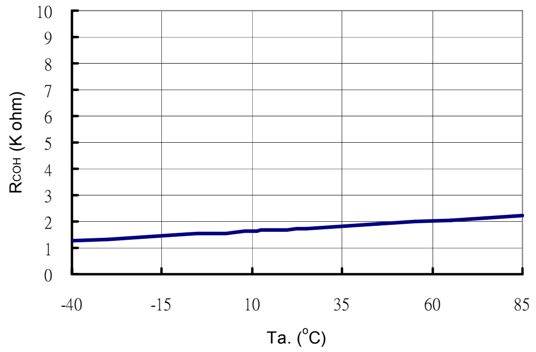


20) tV_{DET3} and tV_{SHORT} vs. V- pin voltage

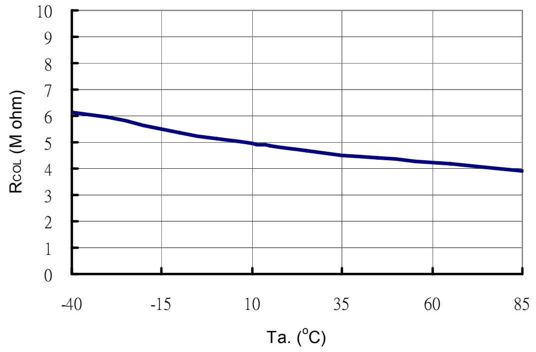


c) Output resistor

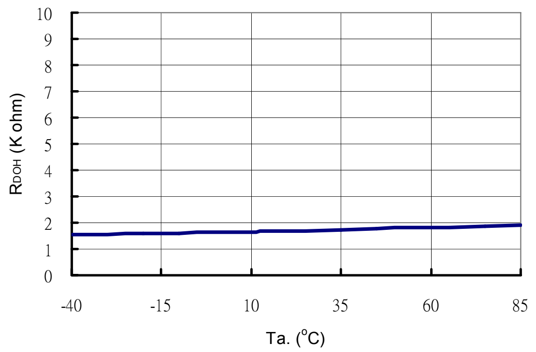
1) R_{COH} vs. Ta.



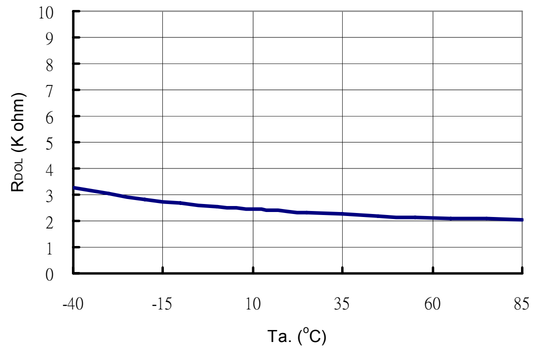
2) R_{COL} vs. Ta.



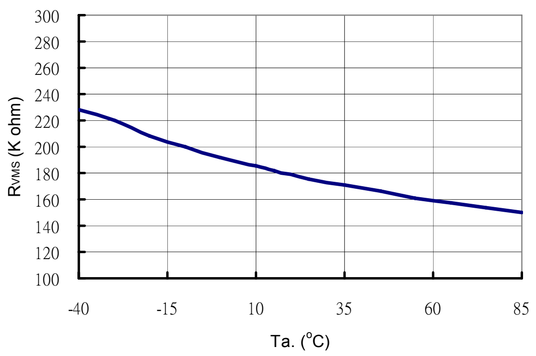
3) R_{DOH} vs. Ta.



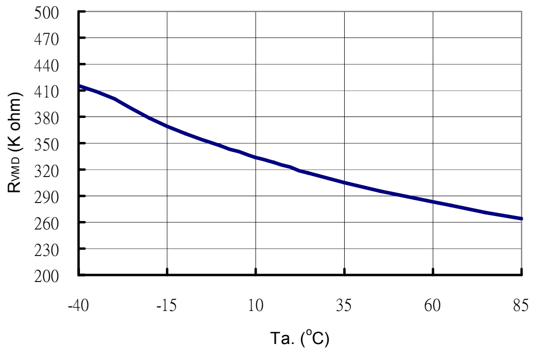
4) R_{DOL} vs. Ta.



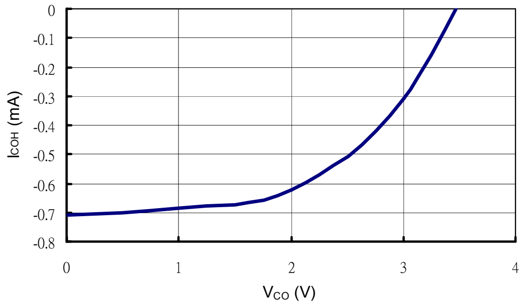
5) R_{VMS} vs. Ta.



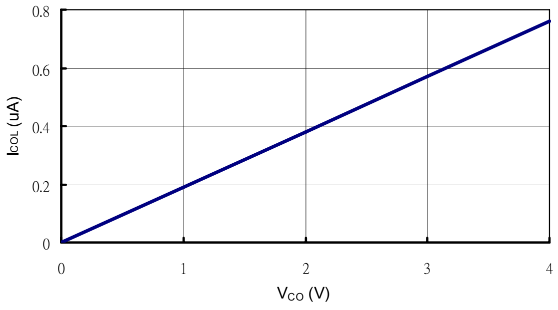
6) R_{VMD} vs. Ta.



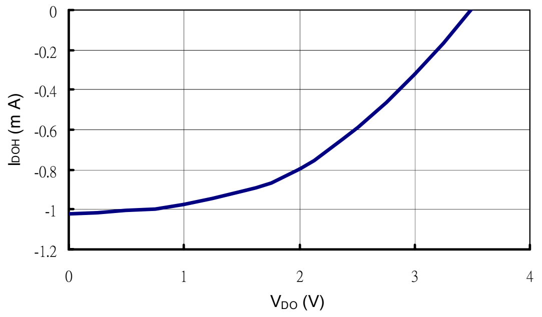
7) I_{COH} vs. V_{CO}



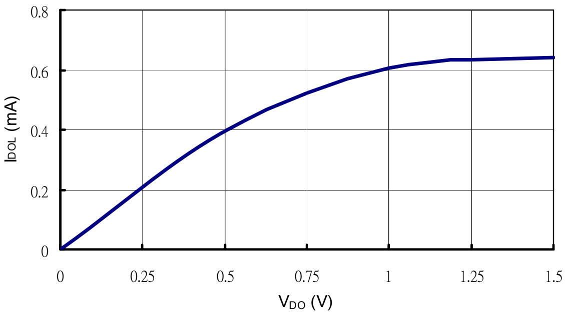
8) I_{COL} vs. V_{CO}



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

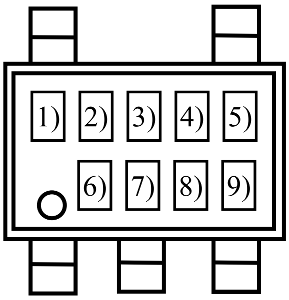


10) I_{DOL} vs. V_{DO}



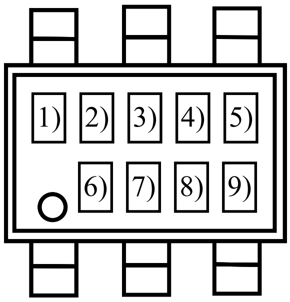
Marking Information

SOT-23-5
Top view



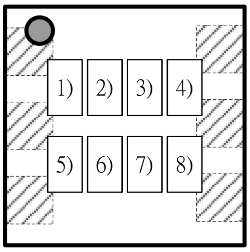
1) : Product code (A)
2) : Type code (U)
3) to 5) : Version code
6) to 9) : Lot number

SOT-23-6
Top view



1) : Product code (A)
2) : Type code (U)
3) to 5) : Version code
6) to 9) : Lot number

DFN-6L
Top view



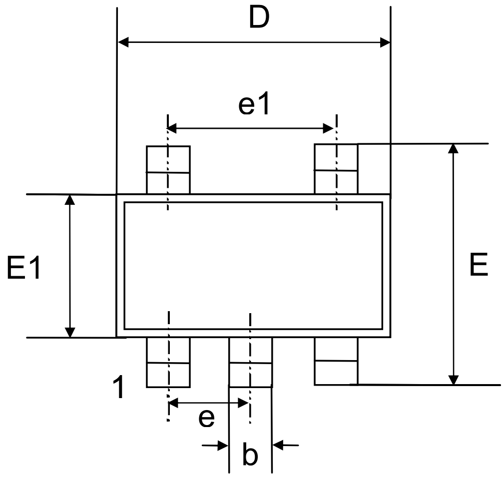
1) : Product code (A)
2) : Type code (U)
3) to 4) : Version code
5) to 8) : Lot numbe

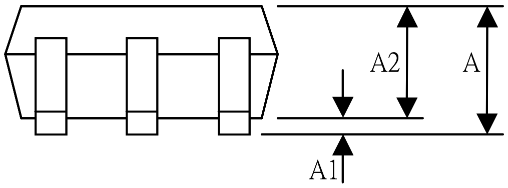
Product name vs. Version code

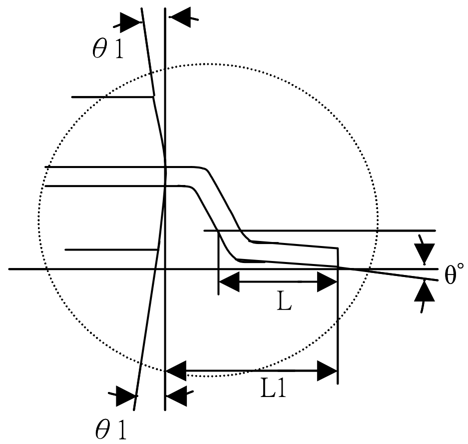
Product name	Version code		
	SOT-23-5	SOT-23-6	DFN-6L
	3) 4) 5)	3) 4) 5)	3) 4)
NT1702-HFK	HFK	HFK	02
NT1702-HQM	-	HQM	03
NT1702-HQR	HQR	HQR	04
NT1702-HFR	HFR	-	05
NT1702-FLK	-	FLK	06
NT1702-HXW	HXW	-	07
NT1702-GZK	-	GZK	-
NT1702-JQM	JQM	-	0C

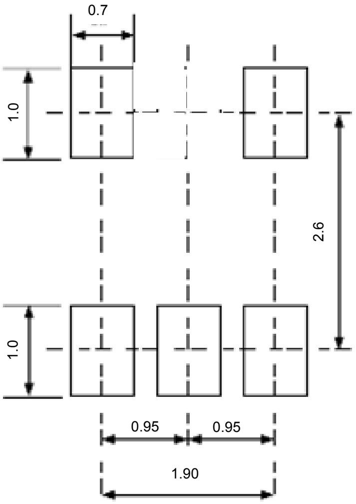
Package Information

SOT-23-5 Dimensions





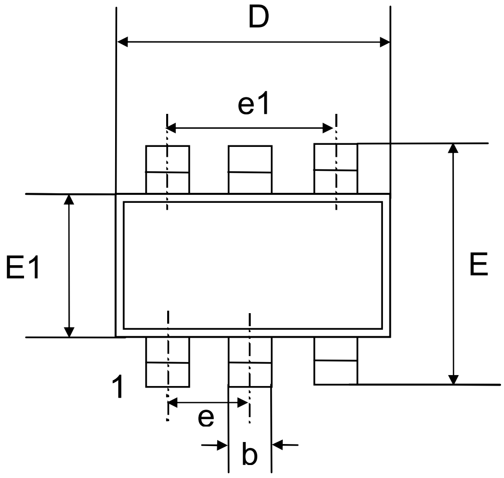


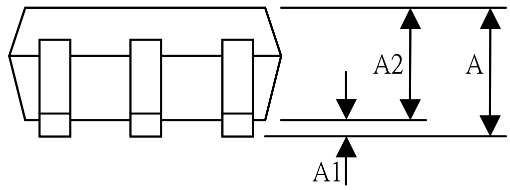


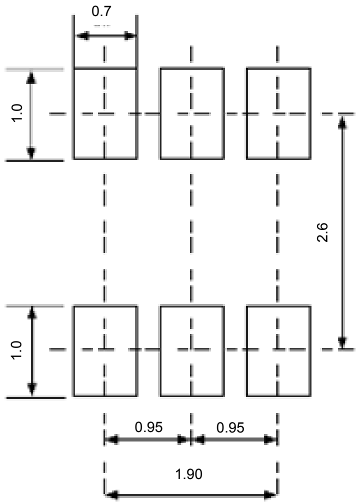
SYMBOL	MIN	NOM	MAX
A	—	—	1.45
A1	0.00	—	0.15
A2	0.90	1.15	1.30
b	0.30	0.4	0.50
c	0.08	—	0.22
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	—	0.95 BSC	—
e1	—	1.90 BSC	—
L	0.30	0.45	0.60
L1	—	0.6 REF	—
L2	—	0.25 BSC	—
θ	0°	4°	8°
θ1	5°	10°	15°

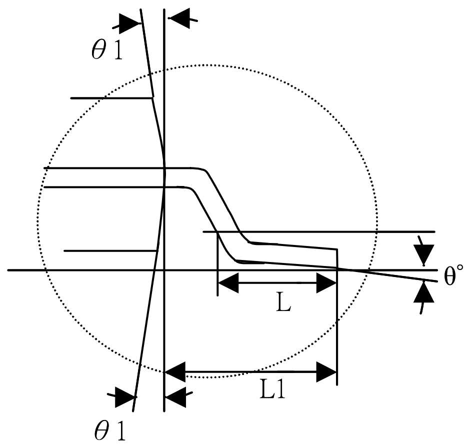
NOTES: 1. All dimensions show in mm
2. Reference: JEDECMO-178AA
3. SOT23-5 / SOT23-6

SOT-23-6 Dimensions





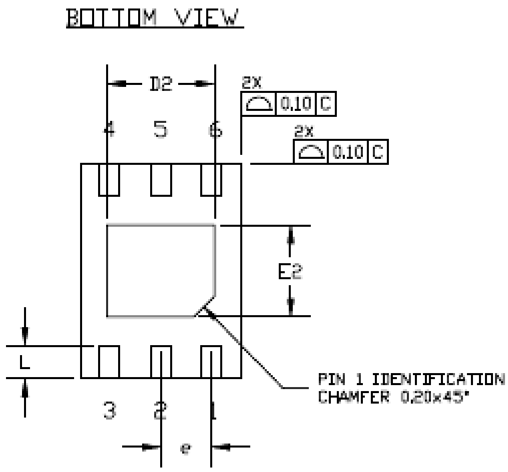


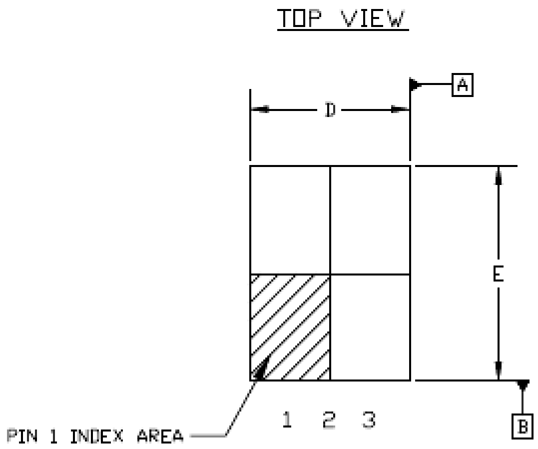


SYMBOL	MIN	NOM	MAX
A	—	—	1.45
A1	0.00	—	0.15
A2	0.90	1.15	1.30
b	0.30	0.4	0.50
c	0.08	—	0.22
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	—	0.95 BSC	—
e1	—	1.90 BSC	—
L	0.30	0.45	0.60
L1	—	0.6 REF	—
L2	—	0.25 BSC	—
θ	0°	4°	8°
θ **1**	5°	10°	15°

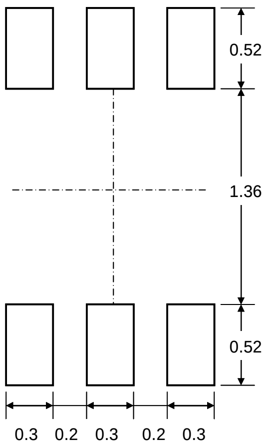
NOTES: 1. All dimensions show in mm
2. Reference: JEDECMO-178AA
3. SOT23-5 / SOT23-6

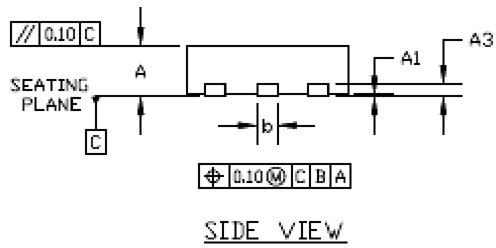
DFN-6L Dimension





PCB Land Pattern

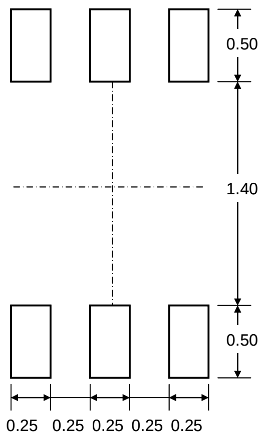




NOTES :

1. DIMENSION AND TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. CONTROLLING DIMENSIONS : MILLIMETER. CONVERTED INCH DIMENSION ARE NOT NECESSARILY EXACT.

Stencil



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