Battery Protection IC for 2-Cell

Features

- High Detection Accuracy
  - -Overcharge Detection: ±25 mV
  - -Overdischarge Detection: ±80 mV
  - -Discharge Overcurrent Detection: ±20 mV
- Programmable Delay Time, or Optional Internal Delay Time
- High Input-Voltage Device
  - -Absolute Maximum Rating: 20V
  - -Operating Voltage range: 2V to 18V
- Low Power Consumption
  - -Operation Mode: 4uA Typ.
  - -Power-Down Mode: 0.1uA Max.
- Optional 0 V Battery Charging Function
- Package: 8-Pin TSSOP

Descriptions

The NT1721 protects lithium-ion/lithium-polymer rechargeable battery in the event of overcharge, overdischarge and discharge overcurrent for a 2-serial-cell lithium-ion/lithium- polymer battery pack.

The NT1721 contains high-accuracy voltage detection circuits and delay circuits.

If any of the above abnormal conditions occur. NT1721 will turn off its external MOSFETs to protect the battery pack.

NT1721 will enter into power down mode when overdischarge protection occurs to minimize the current consumption.

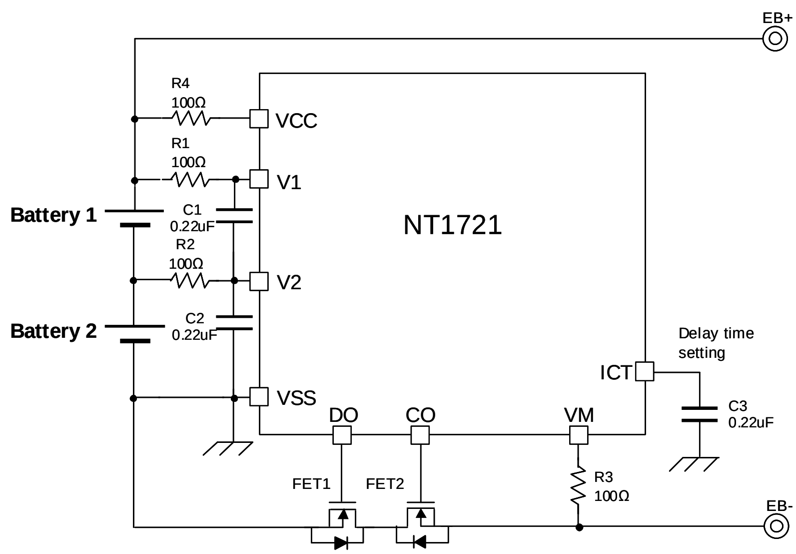
NT1721 will charge the external capacitor for delay time control. NT1721 provides optionally a internal delay time control by connecting ICT pin to GND.

The 0 V battery charging function is available for NT1721 by customer's request.

Applications

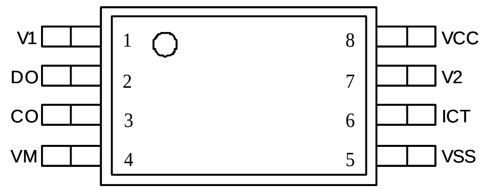
- Portable Instrumentation
- Portable DVD
- DSC

Typical Application Circuit



Pin Configurations

NT1721



TSSOP-8

Ordering Information

NT1721-XX XX

- Package Type
  Q0: TSSOP8
- Version Type

Marking Information

1721-XX

- Version Type

Part Number	Overcharge Detection Voltage 1,2 ($V_{CU1,2}$)	Overcharge Release Voltage 1,2 ($V_{CD1,2}$)	Overdischarge Detection Voltage1,2 ($V_{DD1,2}$)	Overdischarge Release Voltage 1,2 ($V_{DU1,2}$)	Discharge Overcurrent Detection Voltage 1 (V_{DOU1})	0 V Battery Charging Function
NT1721-ABQ0	4.35V ± 25mV	4.15V ± 50mV	2.30V ± 80mV	3.0V ± 100mV	0.3V ± 20mV	Available

For any changes to the detection voltage or other parameters, please contact Neotec.

Pin Descriptions

NO.	Name	Descriptions
1	V1	Detects pin for VCC voltage (Connects battery 1 positive voltage).
2	DO	Connects FET gate for discharge control (CMOS output).
3	CO	Connects FET gate for charge control (CMOS output).
4	VM	Detects pin for VM voltage (Overcurrent detection pin).
5	VSS	Negative power input pin (connect battery 2 negative voltage).
6	ICT	Connects capacitor for delay circuit.
7	V2	The middle pin between two batteries (Connects battery 1 negative voltage and battery 2 positive voltage).
8	VCC	Positive power input pin (Connects battery 1 positive voltage).

Absolute Maximum Ratings

Symbol	Descriptions	Rating	Units
V_{DS}	Input voltage between VCC and VSS	V_{SS}–0.3 to V_{SS}+20	V
V_{V1}	V1 Input terminal voltage	V_{SS}–0.3 to V_{CC}+0.3	V
V_{V2}	V2 Input terminal voltage	V_{SS}–0.3 to V_{CC}+0.3	V
V_{ICT}	ICT Input terminal voltage	V_{SS}–0.3 to V_{CC}+0.3	V
V_{VM}	VM Input terminal voltage	V_{CC}–20 to V_{CC}+0.3	V
V_{DO}	DO output terminal voltage	V_{SS}–0.3 to V_{CC}+0.3	V
V_{CO}	CO output terminal voltage	V_{VM}–0.3 to V_{CC}+0.3	V
P_D	Power dissipation	300	mW
T_{opr}	Operating temperature range	–40 to +85	°C
T_{stg}	Storage temperature range	–40 to +125	°C

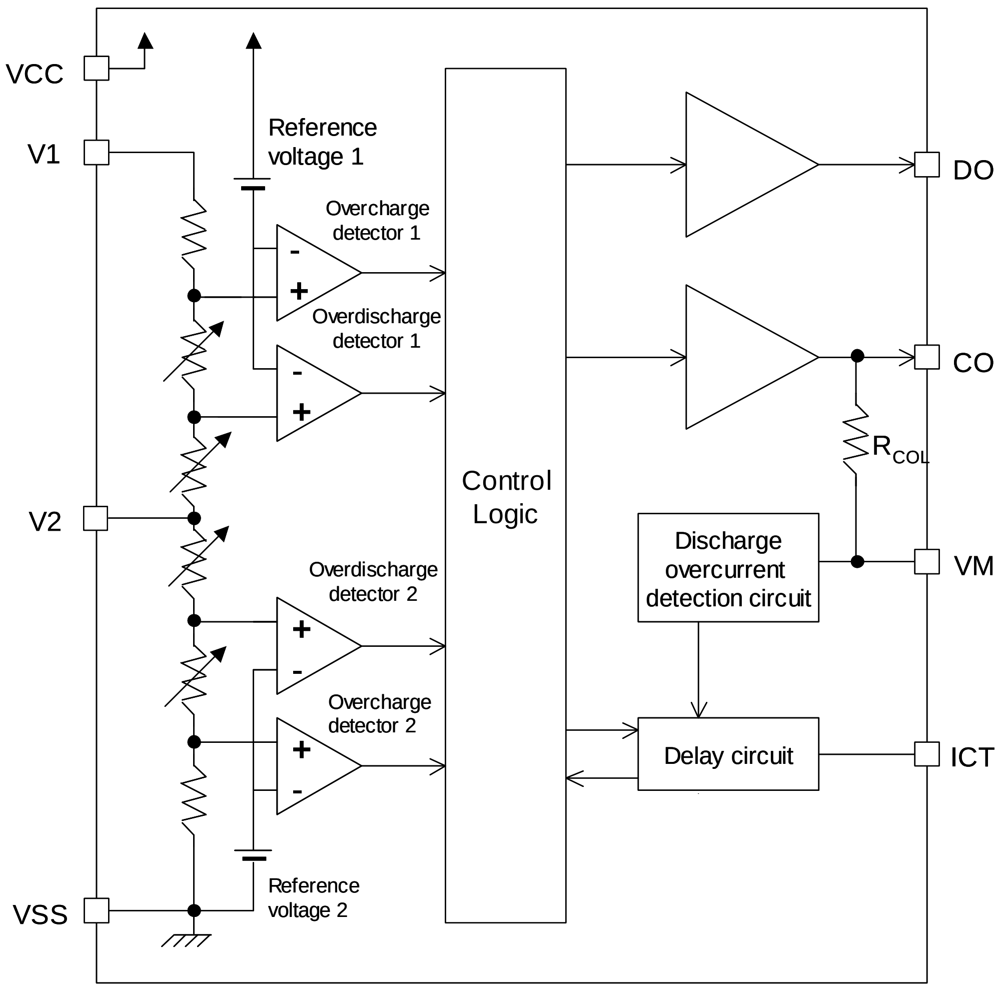
Caution: The absolute maximum ratings are rated values. The product could suffer from physical damage when the voltage and/or temperature exceed its maximum ratings. These values must, therefore, not be exceeded under any conditions.

Electrical Characteristics (Part No. NT1721-ABQ0)

Ta = 25°C

Item	Symbol	Methods	Circuit	Notice	Min.	Typ.	Max.	Unit
Detection voltage								
Overcharge detection voltage 1,2	$V_{CU1,2}$	1,2	1	3.90 ~ 4.6	$V_{CU1.2}$ –0.025	$V_{CU1.2}$	$V_{CU1.2}$ +0.025	V
Overcharge release voltage 1,2	$V_{CD1,2}$	1,2	1	3.90 ~ 4.6	$V_{CD1.2}$ –0.05	$V_{CD1.2}$	$V_{CD1.2}$ +0.05	V
Overdischarge detection voltage 1,2	$V_{DD1,2}$	1,2	1	1.70 ~ 2.6	$V_{DD1.2}$ –0.08	$V_{DD1.2}$	$V_{DD1.2}$ +0.08	V
Overdischarge release voltage 1,2	$V_{DU1,2}$	1,2	1	1.70 ~ 3.8	$V_{DU1.2}$ –0.1	$V_{DU1.2}$	$V_{DU1.2}$ +0.1	V
Discharge overcurrent detection voltage 1	V_{DOV1}	3	1	0.07 ~ 0.30	V_{DOV1} -0.020	V_{DOV1}	V_{DOV1} +0.020	V
Discharge overcurrent detection voltage 2	V_{DOV2}	3	1	VCC Referance	–2.3	–1.9	–1.5	V
Temperature coefficient 1 for detection voltage	T_{COE1}	–	–	Ta=–40 to 85℃	–0.6	0	0.6	mV/℃
Temperature coefficient 2 for detection voltage	T_{COE2}	–	–	Ta=–40 to 85℃	–0.24	–0.05	0	mV/℃
Delay time when ICT connect C3=0.22uF								
Overcharge detection delay time 1,2	$t_{CU1,2}$	8,9	5	1.0 s	0.65	1	1.35	s
Overdischarge detection delay time 1,2	$t_{DD1,2}$	8,9	5	0.1 s	65	100	135	ms
Discharge overcurrent detection delay time 1	t_{DOV1}	10	5	0.01 s	6.5	10	13.5	ms
Input voltage								
Input voltage between VCC and VSS	V_{DS}	–	–	Absolute maximum rating	–0.3	–	20	V
Operating voltage								
Operating voltage between VCC and VSS	V_{DSOP}	–	–	–	2	–	18	V
Current consumption								
Current consumption during normal operation	I_{OPE}	4	2	V1=V2=3.6V	2	4	8	uA
Current consumption at power down	I_{PDN}	4	2	V1=V2=1.5V	–	–	0.1	uA
Output voltage								
DO “H” voltage	$V_{DO(H)}$	6	3	Iout=10 uA	V_{CC}–0.05	V_{CC}–0.01	V_{CC}	V
DO “L” voltage	$V_{DO(L)}$	6	3	Iout=10 uA	V_{SS}	V_{SS} +0.003	V_{SS} +0.05	V
CO “H” voltage	$V_{CO(H)}$	7	4	Iout=10 uA	V_{CC}–0.15	V_{CC}–0.05	V_{CC}	V
CO pin internal resistance								
Resistance between VSS and CO	R_{COL}	7	4	V_{CO}-VSS=9.4V	–	7.2	–	MΩ
Internal resistance								
Resistance between VCC and VM	R_{VCM}	5	2	V_{CC}-V_{VM}=0.5V	–	200	–	KΩ
Resistance between VSS and VM	R_{VSM}	5	2	V_{VM}-V_{SS}=1.1V	–	200	–	KΩ
0 V battery charging function								
0 V charge starting voltage	V_{0CHA}	11	6	0 V battery charging Available	1.3	1.7	2.1	V
0 V charge inhibiting voltage 1,2	$V_{0INH1,2}$	12,13	6	0 V battery charging Unavailable	0.75	0.8	0.85	V

Block Diagram



Measurement Methods

(1) Measurement 1 (Measurement circuit 1)

1) Set V1=V2=3.6V, V3=0V, S1=OFF to enter normal condition.
2) Increase V1 voltage from 3.6V gradually. The V1 voltage is overcharge detection voltage 1 (V_{CU1}) when CO pin switches from high to low.
3) Decrease V1 gradually. The V1 voltage is overcharge release voltage 1 (V_{CD1}) when CO pin switches from low to high.
4) Further decrease V1. The V1 voltage is overdischarge detection voltage 1 (V_{DD1}) when DO pin switches from high to low. Increase V1 gradually. The V1 voltage is overdischarge release voltage 1 (V_{DU1}) when DO pin switches from low to high.

(2) Measurement 2 (Measurement circuit 1)

1) Set V1=V2=3.6V, V3=0V, S1=OFF to enter normal condition.
2) Increase V2 voltage from 3.6V gradually. The V2 voltage is overcharge detection voltage 2 (V_{CU2}) when CO pin switches from high to low.
3) Decrease V2 gradually. The V2 voltage is overcharge release voltage 2(V_{CD2}) when CO pin switches from low to high.
4) Further decrease V2. The V2 voltage is overdischarge detection voltage 2 (V_{DD2}) when DO pin switches from high to low. Increase V2 gradually. The V2 voltage is overdischarge release voltage 2 (V_{DU2}) when DO pin switches from low to high.

(3) Measurement 3 (Measurement circuit 1)

1) Set V1=V2=3.6V, V3=0V, S1=OFF to enter normal condition.
2) Increase V3 from 0V gradually. The V3 voltage is discharge overcurrent detection voltage 1 (V_{DOV1}) when DO pin switches from high to low.
3) Set V1=V2=3.6V, V3=0V, S1=ON to enter normal condition.
4) Increase V3 from 0V gradually. (The voltage change rate < 1.0V/ms) (V1+V2−V3) voltage is discharge overcurrent detection voltage 2 (V_{DOV2}) when DO pin switches from high to low.

(4) Measurement 4 (Measurement circuit 2)

1) Set V1=V2=3.6 V, V3=0 V and S1=ON to enter normal condition and measure the current I1. I1 is the normal condition current consumption (I_{OPE}).
2) Set V1=V2=1.5V and S1=OFF enter overdischarge condition and measure current I1. I1 is the power-down current consumption (I_{PDN}).

(5) Measurement 5 (Measurement circuit 2)

1) Set V1=V2=1.5V, V3=2.5V and S1=ON enter overdischarge condition. (V1+V2−V3)/I2 is the internal resistance between VCC and VM (R_{VCM}).
2) Set V1=V2=3.5V, V3=1.1V and S1=ON, under overcurrent condition. V3/I2 is the internal resistance between VSS and VM (R_{VSM}).

(6) Measurement 6 (Measurement circuit 3)

1) Set V1=V2=3.6V, V3=0V, S1=ON and S2=OFF enter normal condition.
2) Increase V4 from 0V gradually. The V4 voltage is DO ‘H’ voltage ($V_{D0(H)}$) when I1=10uA.
3) Set V1=V2=3.6V,V3=0.5V, S1=OFF and S2=ON enter overcurrent condition. Increase V5 from 0V gradually. The V5 voltage is the DO 'L' voltage ($V_{DO(L)}$) when I2=10uA.

(7) Measurement 7 (Measurement circuit 4)

1) Set V1=V2=3.6V, V3=0V, S1=ON and S2=OFF enter normal condition.
2) Increase V4 from 0V gradually. The V4 voltage is the CO 'H' voltage ($V_{C0(H)}$) when I1=10uA.
3) Set V1=V2=4.7V, V3=0V, V5=9.4V, S1=OFF and S2=ON enter over voltage condition. (V5)/I2 is the CO pin internal resistance ($R_{CO(L)}$).

(8) Measurement 8 (Measurement circuit 5)

1) Set V1=V2=3.6V and V3=0V enter normal condition.
2) Increase V1 from (V_{CU1}-0.2V) to (V_{CU1}+0.2V) immediately (within 10us). The overcharge detection delay time 1(t_{CU1}) is the duration from the time V1 gets to (V_{CU1}+0.2V) until CO pin from high to low.
3) Set V1=V2=3.5V, and V3=0V enter normal condition.
4) Decrease V1 from (V_{DD1}+0.2V) to (V_{DD1}-0.2V) immediately (within 10us). The overdischarge detection delay time 1(t_{DD1}) is the duration from the time V1 gets to (V_{DD1}-0.2V) until DO pin switches from high to low.

(9) Measurement 9 (Measurement circuit 5)

5) Set V1=V2=3.6V and V3=0V enter normal condition.
6) Increase V2 from (V_{CU2}-0.2V) to (V_{CU2}+0.2V) immediately (within 10us). The overcharge detection delay time 2(t_{CU2}) is the duration from the time V2 gets to (V_{CU2}+0.2V) until CO pin from high to low.
7) Set V1=V2=3.5V, and V3=0V enter normal condition.
1) Decrease V2 from (V_{DD2}+0.2V) to (V_{DD2}-0.2V) immediately (within 10us). The overdischarge detection delay time 2(t_{DD2}) is the duration from the time V2 gets to (V_{DD2}-0.2V) until DO pin switches from high to low.

(10) Measurement 10 (Measurement circuit 5)

1) Set V1=V2=3.6V, and V3=0V enter normal condition.
2) Increase V3 from 0 V to 0.5V immediately (within 10us). The discharge overcurrent detection delay time 1 (t_{DOV1}) is the duration from the time V3 gets to 0.5V until DO pin switches from high to low.

(11) Measurement 11 (Measurement circuit 6)

1) Set V1=V2=0V, and V3=2V, and decrease V3 gradually.
2) The V3 voltage is the 0V charge starting voltage (V_{0CHA}) when CO pin switches from high to low (VCC−0.3V or lower).

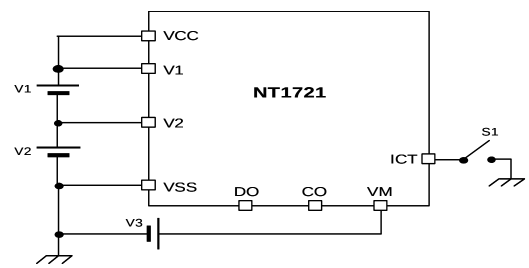
(12) Measurement 12 (Measurement circuit 6)

1) Set V1=0V, V2=3.6V, V3=12V.
2) Increase V1 gradually. The V1 voltage is the 0 V charge inhibiting voltage 1 (V_{0INH1}) when CO pin switches from low to high (V_{VM}+0.3V or higher).

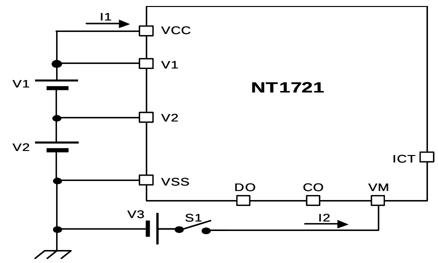
(13) Measurement 13 (Measurement circuit 6)

6) Set V1=3.6V, V2=0V, and V3=12V.
6) Increase V2 gradually. The V2 voltage is the 0 V charge inhibiting voltage 2 (V_{0INH2}) when CO pin switches from low to high (V_{VM}+0.3 V or higher).

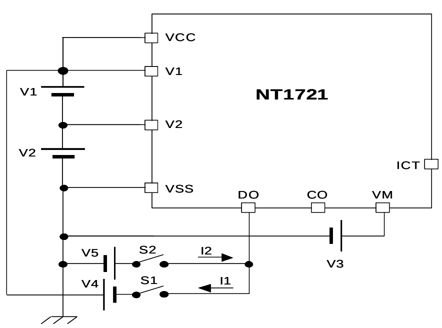
Measurement Circuit



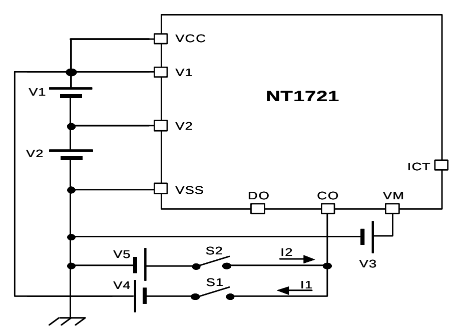
Measurement Circuit 1



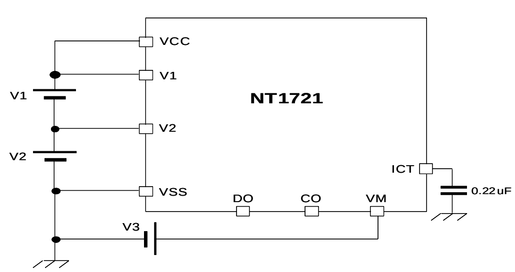
Measurement Circuit 2



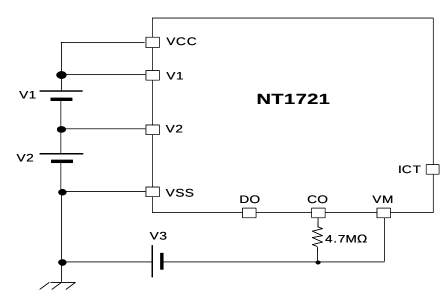
Measurement Circuit 3



Measurement Circuit 4



Measurement Circuit 5



Measurement Circuit 6

Operations

(1) Overcharge Condition

1) Overcharge Protection

If any one of the battery voltages becomes higher than the overcharge detection voltage and it continues for the overcharge detection delay time or longer, the charging FET turns off to stop charging.

2) Overcharge Protection Release

The overcharge protection can be released by either of the following conditions:

a)The battery voltage falls below the overcharge release voltage.

b)Remove charger when the battery voltage is lower than the overcharge detection voltage and higher than the overcharge release voltage.

(2) Overdischarge Condition

1) Overdischarge Protection

If any one of the battery voltages becomes lower than the overdischarge detection voltage and it continues for the overdischarge detection delay time or longer, the discharging FET turns off and discharging stops.

2) Power-down Protection Release

The power-down mode is released when the charger is connected and the voltage between VM and VCC is discharge overcurrent detection voltage 2 or higher.

3) Overdischarge Protection Release

When all the battery voltages become equal to or higher than the overdischarge release voltage and charger is connected to the pack, the overdischarge condition turns back to normal.

(3) Discharge Overcurrent Condition

1) Discharge Overcurrent Protection

When the VM terminal voltage is equal to or higher than the discharge overcurrent detection voltage and continues for the discharge overcurrent detection delay time or longer, the discharging FET turns off to stop discharging.

2) Discharge Overcurrent Protection Release

When removing the load or setting up impedance between the EB- and EB+ terminals, that is equal to or higher than 14M Ohms, the discharge overcurrent protection is released.

(4) Delay Time

All the delay time can be set by external capacitor.
The ratio of overcharge, overdischarge and discharge overcurrent are 100 :10 :1

	Min.	Typ.	Max.	Ta = 25°C
Overcharge detection delay time				
t_{CU}[s] = Delay factor	(2.955,	4.545,	6.136	) x C3 [uF]
Overdischarge detection delay time				
t_{DD}[s] = Delay factor	(0.2955,	0.4545,	0.6136	) x C3 [uF]
Discharge overcurrent detection delay time				
t_{DOV1}[s] = Delay factor	(0.02955,	0.04545,	0.06136	) x C3 [uF]

(5) 0 V Battery Charging Function

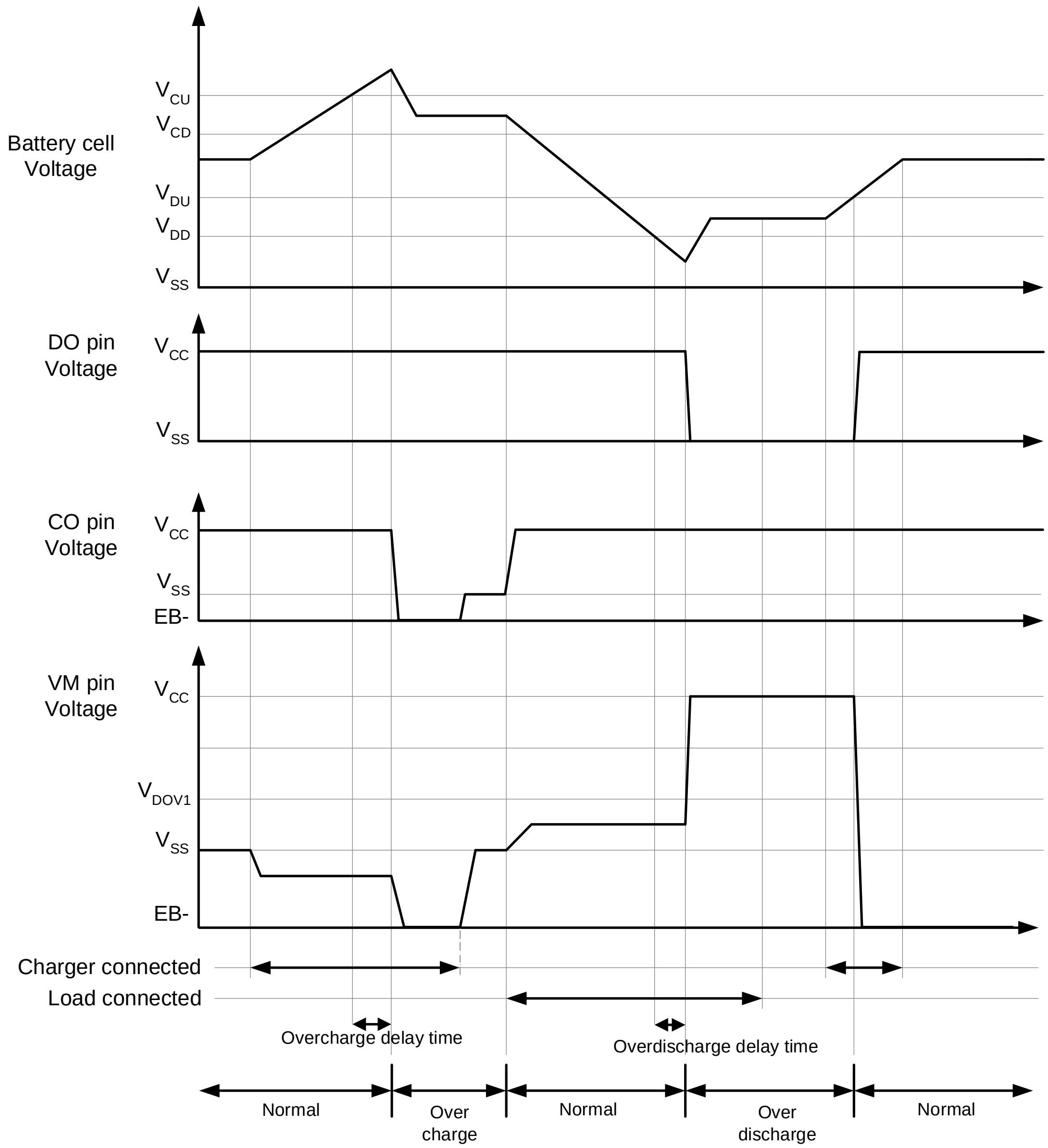
This function is used to recharge both of two serial-connected batteries after they self-discharge to 0 V.

(6) Initial Condition

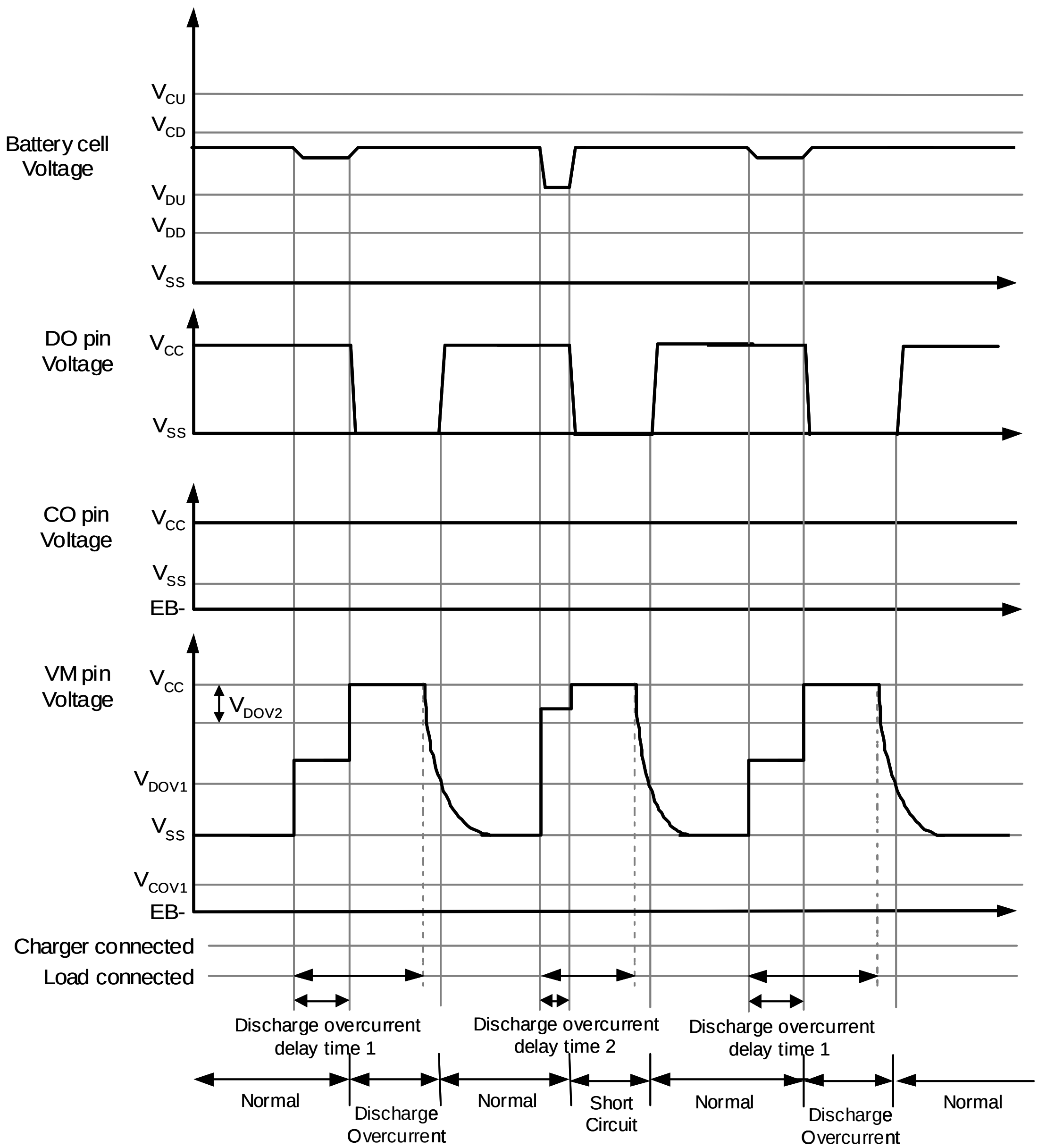
When initially connecting batteries, the IC will enter the power down condition.

Operation Timing Charts

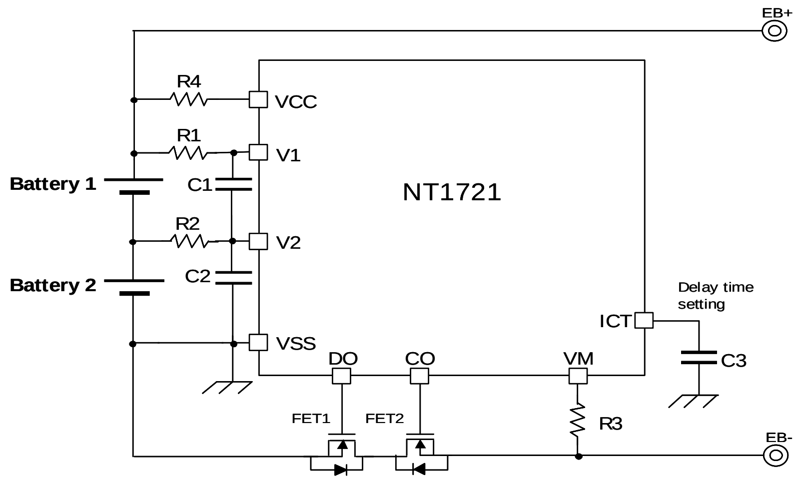
(1) Overcharge Detection, Overdischarge Detection



(2) Overcurrent Detection



Application Circuit



Symbol	Parts	Purpose	Recommended	Min.	Max.	Remarks
FET1	Nch MOSFET	Discharge control	-----	-----	-----	1) 0.4 V ≤ Threshold voltage ≤ Overdischarge detection voltage. Gate source withstanding voltage ≥ Charger voltage.
FET2	Nch MOSFET	Charge control	-----	-----	-----	2) 0.4 V ≤ Threshold voltage ≤ Overdischarge detection voltage Gate source withstanding voltage ≥ Charger voltage.
R1	Resistor	ESD protection	100Ω 5%	47Ω	1kΩ	3)
C1	Capacitor	Filter	0.22uF K-type	0uF	1uF	6)
R2	Resistor	ESD protection	100Ω 5%	47Ω	1kΩ	
C2	Capacitor	Filter	0.22uF K-type	0uF	1uF	6)
R4	Resistor	ESD protection	100Ω 5%	=R1 Min.	=R1 Max.	
C3	Capacitor	Delay time setting	0.22uF K-type	0uF	1uF	4) 6)
R3	Resistor	Protection for charger reverse connection	100Ω 5%	47Ω	1kΩ	5)

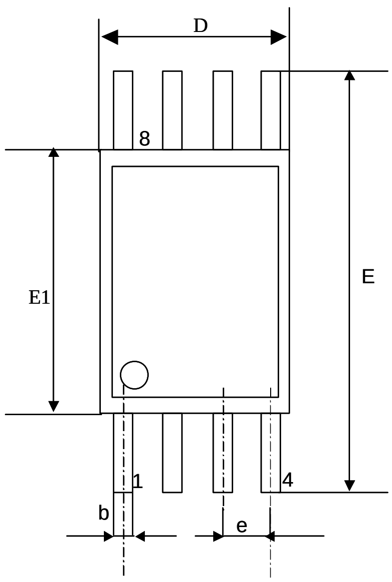
1) If the threshold voltage of an FET is lower than 0.4V, the FET may not stop the charging current. If an FET has a threshold voltage equal to or higher than the overdischarge detection voltage, discharging may stop before overdischarge is detected.
2) If the charger voltage is higher than the withstanding voltage between the gate and source, the FET may be damaged.
3) Using an overspec R1 may result in overcharge detection voltage 1(V_{CU1}) and the release voltage 1(V_{CD1}) higher than the expectation. For instance, 10kΩ(R1) increases overcharge detection voltage by 10mV.
4) The change of the overcharge detection delay time (t_{CU}), the overdischarge detection delay time (t_{DD}), and the discharge overcurrent detection delay time (t_{DOV}) goes along with the external capacitor C3.
5) Using an overspec R3 may result in discharge overcurrent detection voltage 1(V_{DOV1}) higher than specifications. V_{DOV1} changes to $V_{DOV1} = (R3+R_{vsm})/ R_{vsm} \times V_{DOV1}$.
   For example, 100KΩ resistor (R3) causes discharge overcurrent detection voltage 1 (V_{DOV1}) from 0.300V to 0.350 V.

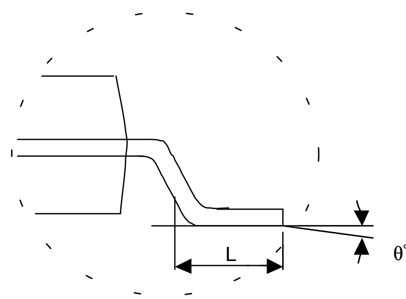
6) High quality capacitors with accurate capacitances such as 0603 K-type or any K-type of *multilayer ceramic chip* MLCC capacitors are recommended to applying in this application. Moreover, applying any of low quality capacitors, which has leakage, inaccurate capacitance values or high capacitance change with DC bias may cause this device goes to power down mode when short happens, or may cause incorrect delay times.

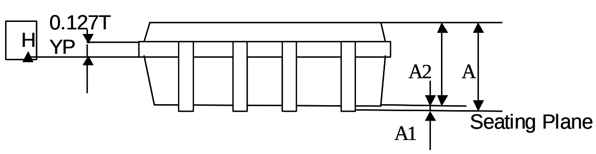
Caution: The application circuit above is for reference only. To determine the correct constants, evaluation of actual application is required.

Package Information

8-Pin TSSOP







SYMBOL	MIN.	NOM.	MAX.
A	—	—	1.20
A1	0.05	—	0.15
A2	0.80	1.00	1.05
b	0.19	0.22	0.30
c	0.09	—	0.20
D	2.90	3.00	3.10
E	6.30	6.40	6.50
E1	4.30	4.40	4.50
e	—	0.65 BSC	—
L	0.45	0.60	0.75
L1	—	1.00	—
θ	0°	—	8°
θ 1	—	12 REF	—

NOTES: All dimensions show in mm