DESCRIPTIONS

The EC9528A 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 EC9528A series with state-of-art design and process.

To minimize power consumption, EC9528A series activates power down mode when an over-discharge event is detected (for power-down mode enabled version). Besides, EC9528A 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.

FEATURE

■High Detection Accuracy
- Over-charge Detection:±15mV
- Over-discharge Detection: ±35mV
- Discharge Over-current Detection: ±10mV
- Charge Over-current Detection:±20mV

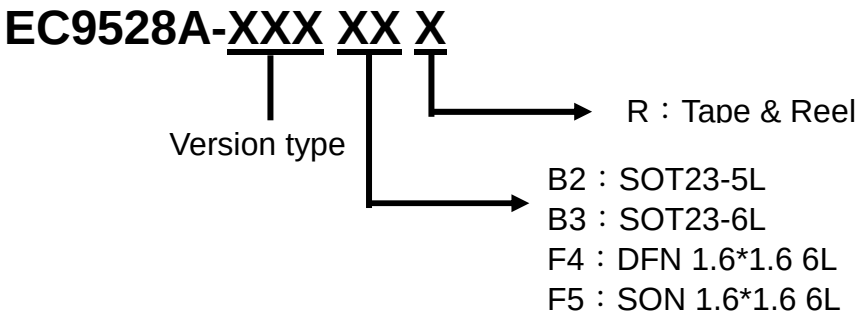
■ High Withstand Voltage
- Absolute maximum ratings: 28V(V- pin and CO pin)

■ Ultra Small Package :
SOT-23-5
SOT-23-6
DFN-1.6X1.6-6L
SON-1.6X1.6-6L

APPLICATION

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

ORDERING INFORMATION



Part Number	Package	Marking	Marking Information
EC9528A-HQAB2R	SOT23-5L	BNXXX LLLL	1. BN：Product code 2. XXX：Version code(see note 1) 3. LLLL：Lot No.
EC9528A-XXXB3R	SOT23-6L	BNXXX LLLL	
EC9528A-XXXF4R	DFN 1.6*1.6 6L	BNXX LLLL	1. BN：Product code 2. XX： Version code(see note 1) 3. LLLL：Lot No.
EC9528A-XXXF5R	SON 1.6*1.6 6L	BNXX LLLL	

Note 1：Version code (For marking)

Version Code	Version Code			
Version Code	Version Code	Version Code	Version Code	Version Code
Version	SOT-23-5	SOT-23-6	DFN-1.6X1.6-6L	SON-1.6X1.6-6L
HFA	-	HFA	10	10
HFB	-	HFB	11	11
HQA	HQA	HQA	-	13
HQB	HQB	HQB	-	14
HQC	-	HQC	12	12
NHA	NHA	NHA	-	15
NHB	NHB	NHB	-	16

Product version code:

Table1: Detection threshold level table

Version Code	Pack-age Type	Over-charge Detection Voltage VDET1 (V)	Over-charge Hysteresis Voltage VHYS1 (V)	Over-discharge detection voltage VDET2 (V)	Over-discharge release voltage VREL2 (V)	Discharge over-current detection voltage VDET3 (V)	Charge over-current detection voltage VDET4 (V)	Load short-circuiting detection voltage VSHORT(V)	0V Battery Charge Function	Delay Time Table 2
HFA	B3/F4/F5	4.280	0.00	2.3	2.3	0.10	-0.1	0.5	Un-available	(1)
HFB	B3/F4/F5	4.280	0.00	2.3	2.3	0.13	-0.1	0.5	Un-available	(1)
HQA	B2/B3/F5	4.280	0.15	2.8	3.1	0.15	-0.1	0.5	Un-available	(2)
HQB	B2/B3/F5	4.280	0.15	2.8	3.1	0.10	-0.1	0.5	Un-available	(2)
HQC	B3/F4/F5	4.280	0.00	2.8	3.1	0.15	-0.1	0.5	Un-available	(1)
NHA	B2/B3/F5	4.425	0.20	2.4	2.4	0.10	-0.1	0.5	Un-available	(1)
NHB	B2/B3/F5	4.425	0.20	2.4	2.4	0.15	-0.1	0.5	Un-available	(1)

Note: *: (Please check detail at below description) For Overcharge release condition:

When the battery voltage is lower than $V_{DET1} - V_{HYS1}$ and the V- pin voltage is between charge overcurrent detection voltage (V_{DET4}) and short detection voltage (V_{SHORT}), the EC9528A series would release this condition.

When the battery voltage is lower than $V_{DET1} - V_{HYS1}$ and charger is removed, the EC9528A series can be released fromthis condition.

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

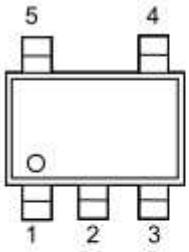
Table2: Delay Time table

Delay time	Over-charge delay time t_{VDET1} (S)	Over-discharge delay time t_{VDET2} (mS)	Discharge over-current delay time t_{VDET3} (mS)	Charge over-current delay time t_{VDET4} (mS)	Load short-circuiting delay time t_{SHORT} (uS)
(1)	1.0 +/- 20%	125 +/- 20%	8.0 +/- 20%	8.0 +/- 20%	400 +/- 20%
(2)	1.2 +/- 20%	150 +/- 20%	9.0 +/- 20%	9.0 +/- 20%	300 +/- 20%

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

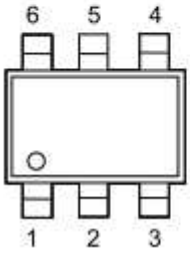
Package and Pin Description

SOT-23-5



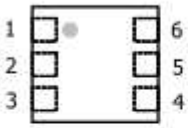
Pin No.	Symbol	Pin description
1	V-	Voltage detection between V- pin and Vss pin (Over-current / charger detection pin)
2	VDD	Connection for positive power supply input
3	Vss	Connection for negative power supply input
4	DO	Connection of discharge control FET gate
5	CO	Connection of charge control FET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

SOT-23-6



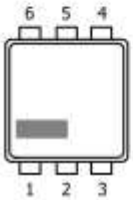
Pin No.	Symbol	Pin description
1	DO	Connection of discharge control FET gate
2	V-	Voltage detection between V- pin and VSS pin (Over-current / charger detection pin)
3	CO	Connection of charge control FET gate
4	NC	No connection
5	VDD	Connection for positive power supply input
6	Vss	Connection for negative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

DFN-1.6X1.6-6L



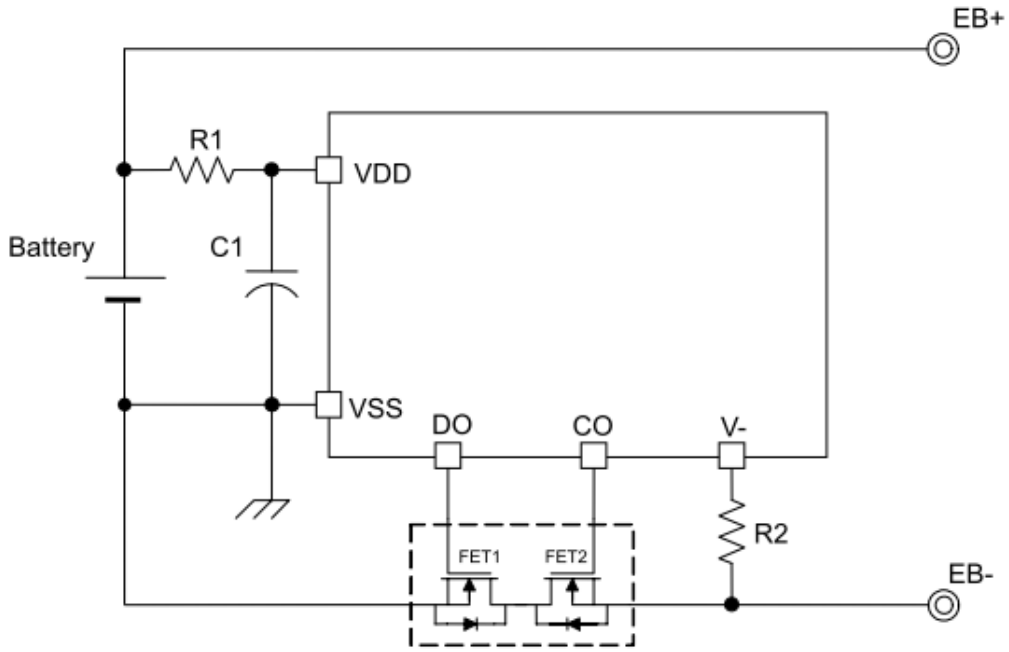
Pin No.	Symbol	Pin description
1	NC	No connection
2	CO	Connection of charge control FET gate
3	DO	Connection of discharge control FET gate
4	Vss	Connection for negative power supply input
5	VDD	Connection for positive power supply input
6	V-	Voltage detection between V- pin and VSS pin (Over-current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

SON-1.6X1.6-6L

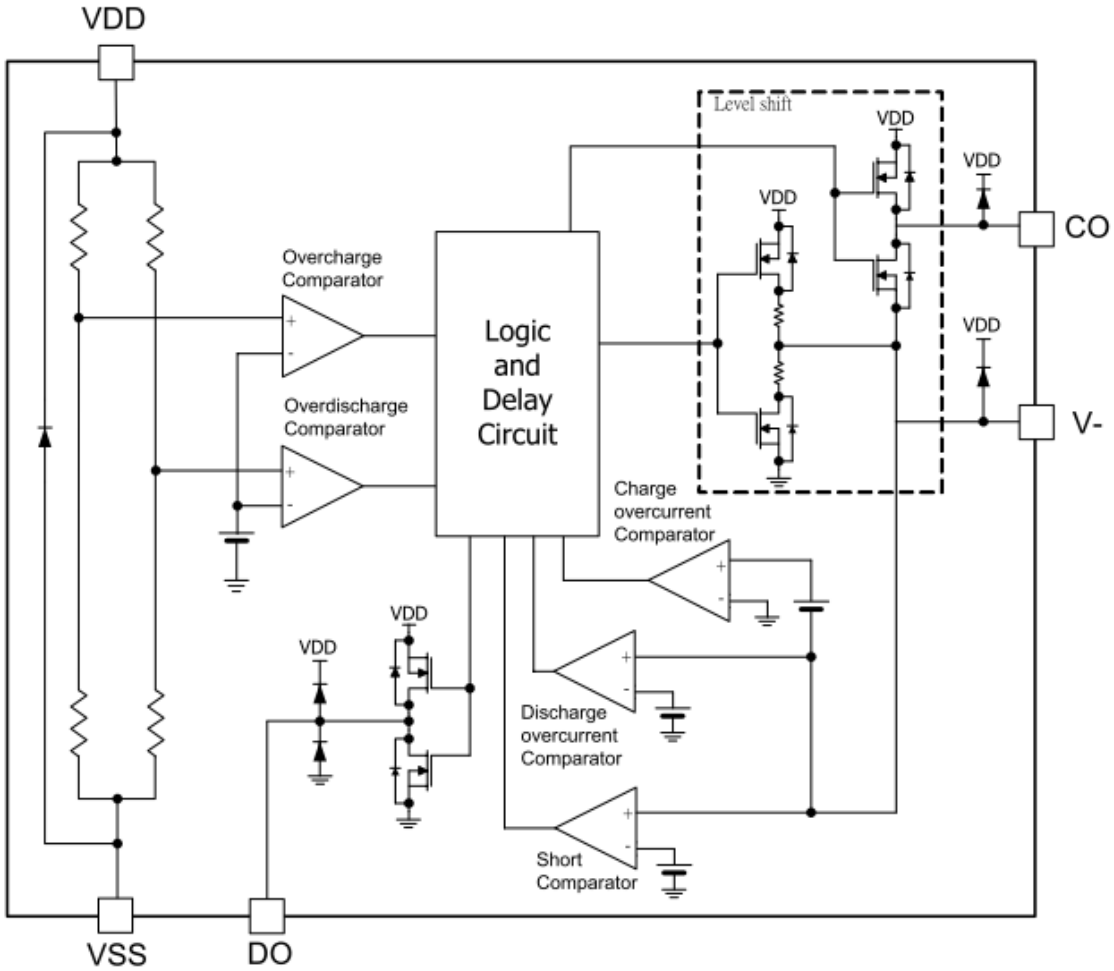


Pin No.	Symbol	Pin description
1	NC	No connection
2	CO	Connection of charge control FET gate
3	DO	Connection of discharge control FET gate
4	Vss	Connection for negative power supply input
5	VDD	Connection for positive power supply input
6	V-	Voltage detection between V- pin and VSS pin (Over-current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

Typical Application Circuit



Block Diagram



Absolute Maximum Ratings

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

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

Electrical Characteristics (For Li-ion) (Ta = 25℃)

Symbo	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	V_{DET1}-0.015	V_{DET1}	V_{DET1}+0.015	V
V_{HYS1}	Over-charge hysteresis voltage	--	V_{HYS1}-0.020	V_{HYS1}	V_{HYS1}+0.020	V
V_{DET2}	Over-discharge detection voltage	--	V_{DET2}-0.035	V_{DET2}	V_{DET2}+0.035	V
V_{REL2}	Over-discharge release voltage	$V_{DET2} \neq V_{REL2}$	V_{REL2}-0.050	V_{REL2}	V_{REL2}+0.050	V
		$V_{DET2} = V_{REL2}$	V_{REL2}-0.035	V_{REL2}	V_{REL2}+0.035	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V	V_{DET3}-0.010	V_{DET3}	V_{DET3}+0.010	V
V_{DET4}	Charge over-current detection	V_{DD}=3.5V	-0.12	-0.10	-0.08	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V	0.40	0.50	0.60	V
Detection Delay Time【Table 2 Delay time (1)】						
t_{VDET1}	Output delay time of over-charge	-	0.8	1.0	1.2	s
t_{VDET2}	Output delay time of over-discharge	-	100	125	150	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	6.4	8.0	9.6	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	6.4	8.0	9.6	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	320	400	480	us
Detection Delay Time【Table 2 Delay time (2)】						
t_{VDET1}	Output delay time of over-charge	-	0.96	1.2	1.44	s
t_{VDET2}	Output delay time of over-discharge	-	120	150	180	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	7.2	9.0	10.8	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	7.2	9.0	10.8	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}	2.0		6.0	V
I_{DD}	Supply current	V_{DD}=3.5V, V-=0V	1.0	3.0	5.5	uA
$I_{STANDBY}$	Power-down current (power-down function enabled IC only)	V_{DD}=1.8V, V- floating			0.1	uA
0V battery Charging Function						
V_{0CHA}	0 V battery charge starting charger voltage	0 V battery charging function “available”	0.5	1.0	1.5	V
V_{0INH}	0V battery charge inhibition battery voltage	0 V battery charging function “unavailable” (Vcharger=4V~14V)	0.5	1.0	1.5	V
Output Resistance						
R_{COH}	CO pin H resistance	V_{CO}=3.0V, V_{DD}=3.5V, V-=0V	1.25	2.50	5.00	KΩ
R_{COL}	CO pin L resistance	V_{CO}=0.5V, V_{DD}=4.5V, V-=0V	0.75	1.50	3.00	KΩ
R_{DOH}	DO pin H resistance	V_{DO}=3.0V, V_{DD}=3.5V, V-=0V	1.25	2.50	5.00	KΩ
R_{DOL}	DO pin L resistance	V_{DO}=0.5V, V_{DD}=1.8V, V-=0V	1.75	3.50	7.00	KΩ
V- internal Resistance						
R_{VMD}	Internal resistance between V- and V_{DD}	V_{DD}=1.8V, V-=0V	100	300	900	KΩ
R_{VMS}	Internal resistance between V- and V_{SS}	V_{DD}=3.5V, V-=1.0V	50	100	300	KΩ

Electrical Characteristics(For Li-ion) (Ta = -10oC to +60oC)*

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	V_{DET1}-0.025	V_{DET1}	V_{DET1}+0.025	V
V_{HYS1}	Over-charge hysteresis voltage	--	V_{HYS1}-0.030	V_{HYS1}	V_{HYS1}+0.030	V
V_{DET2}	Over-discharge detection voltage	--	V_{DET2}-0.050	V_{DET2}	V_{DET2}+0.050	V
V_{REL2}	Over-discharge release voltage	$V_{DET2} \neq V_{REL2}$	V_{REL2}-0.080	V_{REL2}	V_{REL2}+0.080	V
		$V_{DET2} = V_{REL2}$	V_{REL2}-0.050	V_{REL2}	V_{REL2}+0.050	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V	V_{DET3}-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	0.35	0.50	0.65	V
Detection Delay Time 【Table 2 Delay time (1)】						
t_{VDET1}	Output delay time of over-charge	-	0.7	1.0	1.3	s
t_{VDET2}	Output delay time of over-discharge	-	88	125	163	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	5.0	8.0	11.0	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	5.0	8.0	11.0	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	280	400	520	us
Detection Delay Time 【Table 2 Delay time (2)】						
t_{VDET1}	Output delay time of over-charge	-	0.84	1.2	1.56	s
t_{VDET2}	Output delay time of over-discharge	-	105	150	195	ms
t_{VDET3}	Output delay time of discharge over current	V_{DD}=3.5V	6.0	9.0	12.0	ms
t_{VDET4}	Output delay time of charge over current	V_{DD}=3.5V	6.0	9.0	12.0	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	210	300	390	us

(Continued)

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

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

Test Circuits

Over-charge, over-discharge and the release detection voltages (test circuit 1)

1) Set V1=3.5V, V2=0V, S1=ON and S2=OFF, then EC9528A 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 voltage gap is the over-charge hysteresis detection voltage (V_{HYS1}) 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 V1gradually. 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=3.5V, V2=0V, S1=ON and S2=OFF and EC9528A 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 EC9528A 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 EC9528A 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 VDET1-0.2V to VDET1+0.2V immediately (within 10us). The over-charge detection delay time (tVDET1) 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 (tV_{DET2}) 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 (tV_{DET3}) 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 (tV_{DET4}) 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 (tSHORT) 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=1.8V 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 EC9528A series enters over-discharge condition. V1/I2 is the internal resistance between V- and V_{DD} pin (R_{VMD}).
2) Set V1=3.5V, V2=1.0V and S1=ON and EC9528A series enters discharge over-current condition. V2/I2 is the internal resistance between V- and V_{SS} 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=1.8 V, 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, increase 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 then decrease 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.

Shorten mode for overcharge and overdischarge functions by force voltage to Dout pin
(test circuit 5)

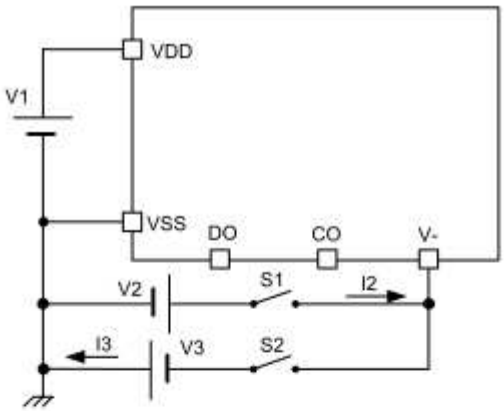
1) Set V1=3.5V then NT1713 series enters operating mode.
2) Set V2= 0.5V, increase V1 voltage (from 3.5V) gradually. The V1 voltage is the over-charge detection voltage (V_{DET1}) when CO pin goes low (from high).
3) Decrease V1 gradually. The voltage gap is the over-charge hysteresis detection voltage (V_{HYS1}) when CO pin goes high again.
4) Continue decreasing V1. The V1 voltage is the over-discharge detection voltage (V_{DET2}) when the voltage

drop(VR1K*I1) on DO pin by shorten mode circuit. Then increase V1 gradually. The V1 voltage is the over-discharge release detection voltage (V_{REL2}), when DO pin returns to high.

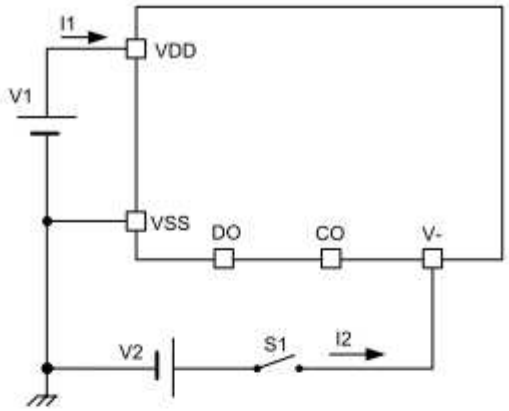
Recommended:

1) '0 V charge available' doesn't means EC9528A series can recover the zero-V cell to be full charged if this cell has been already damaged due to too low voltage.
2) In EC9528A series, the '0 V charge inhibition' voltage is rather lower (0.5V). That is, EC9528A series allow 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.

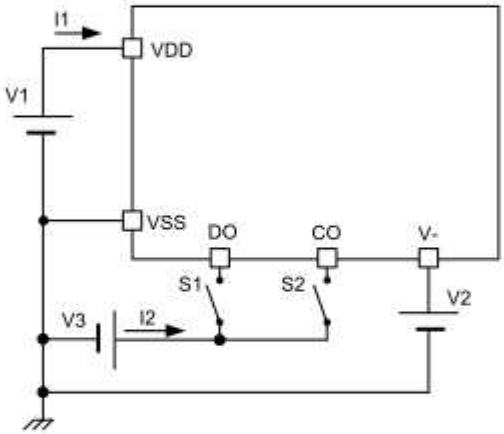
Test Circuit



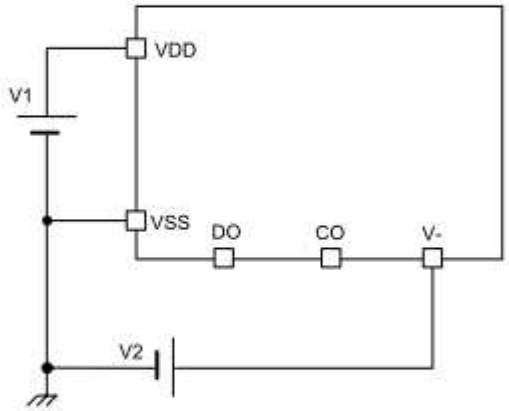
Test circuit 1



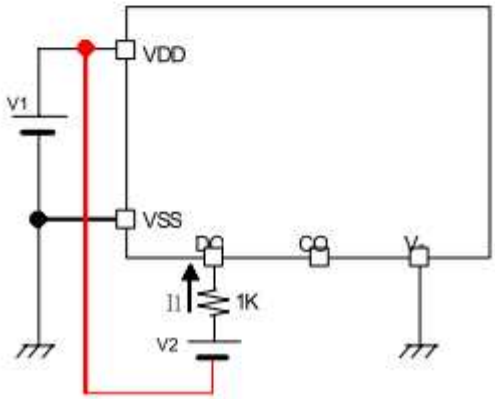
Test circuit 2



Test circuit 3



Test circuit 4



Test circuit 5

Operation

The EC9528A series provides over-charge, over-discharge, discharge over-current, charge over-current and load short-circuiting protections for the 1-cell battery pack. EC9528A series continuously monitors the voltage of battery between V_{DD} pin and V_{SS} 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 V_{SS} 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 V_{SS} pin is positive. The EC9528A 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 V_{SS} pin to detect charge over-current and discharge over-current current conditions.

(1) Normal Condition (Operation mode)

The EC9528A 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 EC9528A **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 V_{DD} voltage is higher than the over-charge detection voltage (V_{DET1}) and lasts for longer than the over-charge detection delay time (tV_{DET1}), EC9528A 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 V_{DET1} - V_{HYS1} and the V- pin voltage is between charge over-current detection voltage (V_{DET4}) and discharge over-current detection voltage (V_{DET3}), the EC9528A series would be automatically released from this condition.
When the battery voltage is lower than V_{DET1} and charger is removed, the EC9528A series can be automatically released from this condition.

(3) Over-discharge Condition

1) Over-discharge Protection:
When the V_{DD} voltage is lower than the over-discharge detection voltage (V_{DET2}) and lasts longer than over-discharge detection delay time (tV_{DET2}), EC9528A 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 V_{DD} by a resistor (RVMD) between the V- pin and V_{DD} pin. After that, when V- pin voltage is higher than $V_{DD}/2$(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 EC9528A 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 (tV_{DET3}).

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

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:

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

(5) Charge Over-current Condition

The EC9528A 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 (tDET4) 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:

EC9528A series enters the power down mode when over-discharge protection occurs and V- pin voltage is higher than $V_{DD}/2$ (typical). The V- pin voltage is pulled-up to the V_{DD} through the RVMD resistor. The internal circuits is shut off, therefore, the power-down current ($I_{STANDBY}$) is reduced to be low 0.1uA (Max.).

2) Power Down Mode Release:

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

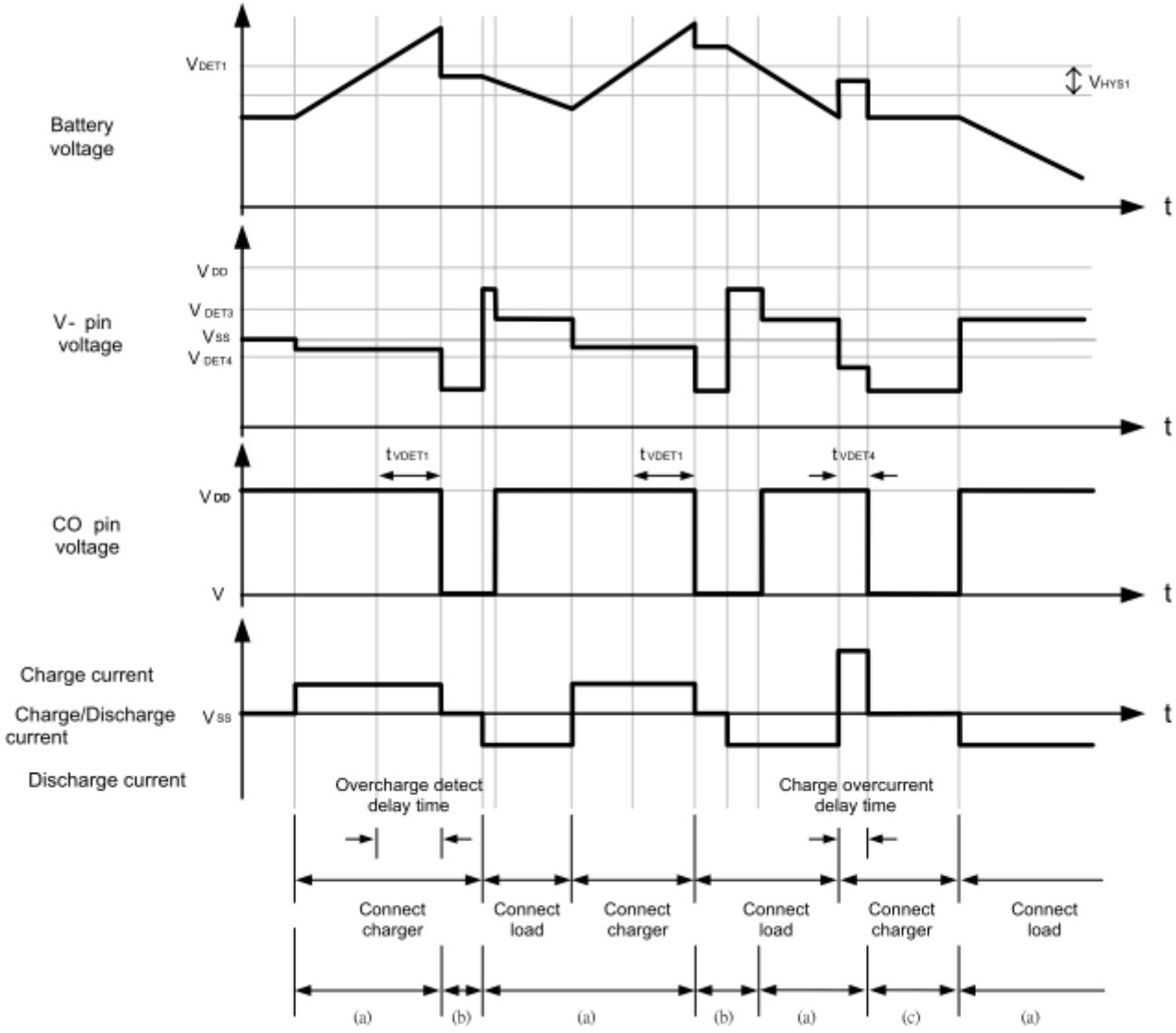
Note: Power down condition is for power down mode enabled version only.

Remark:

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

Timing Chart

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

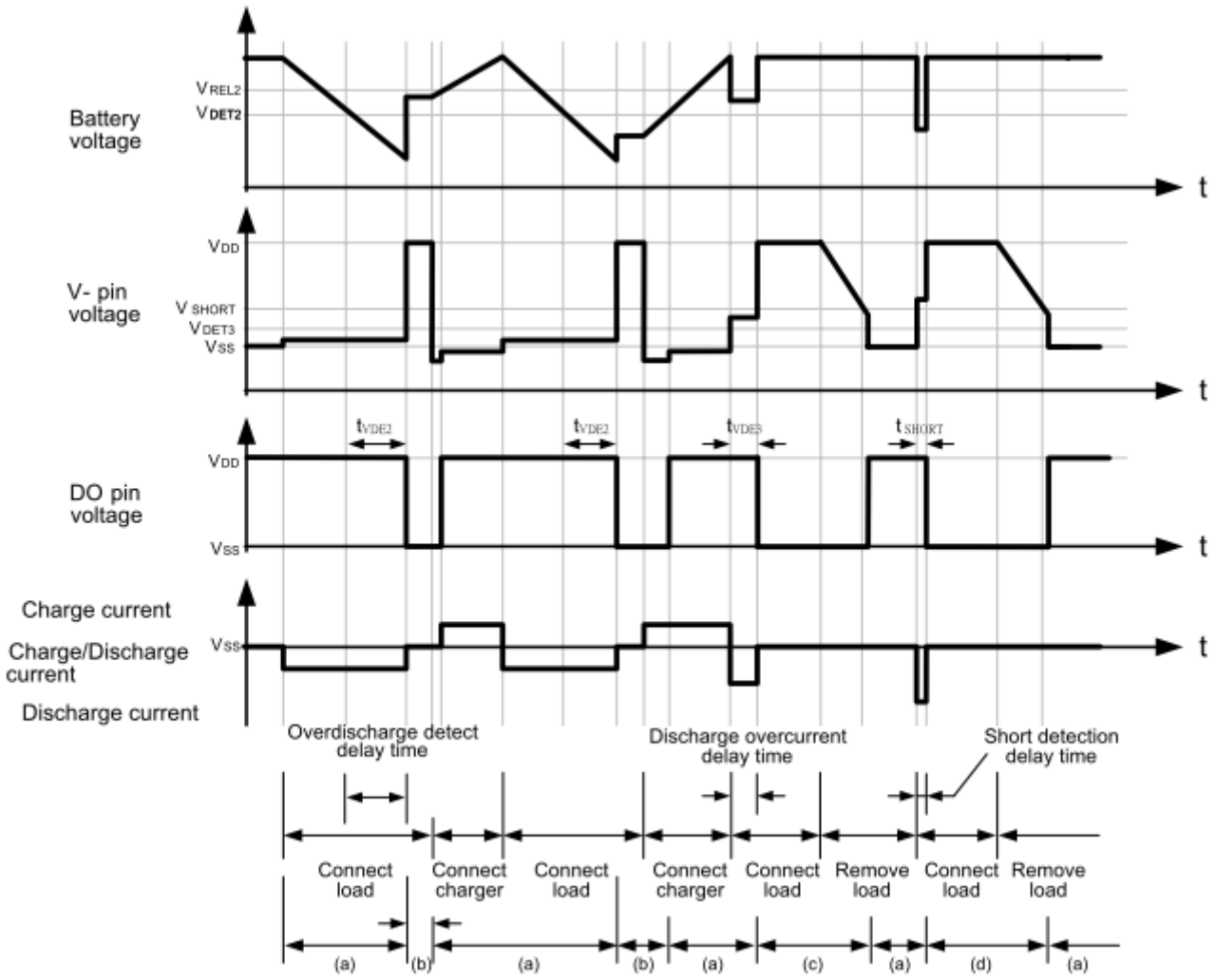


(a) Normal condition

(b) Over-charge condition

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

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



(a) Normal condition

(b) Over-discharge condition

(c) Discharge over-current condition

(d) Load short-circuit condition

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

Recommended Application Circuit

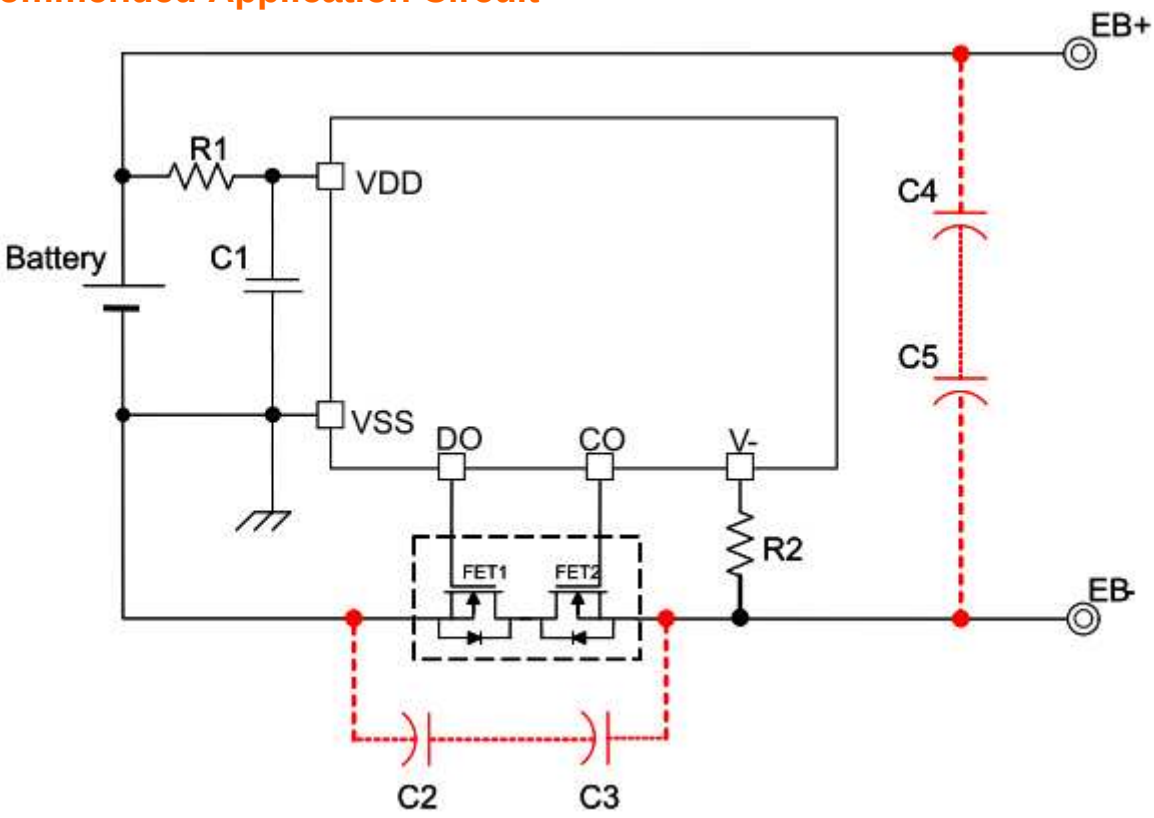


Table1 Constant for external components

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	10KΩ	*4) The resistor is preventing big current when a charger is connected in reverse.
C2	Capacitor	For ESD protection	0.1uF	-	-	*5) Protected MOSFET after system ESD
C3	Capacitor	For ESD protection	0.1uF	-	-	
C4	Capacitor	For ESD protection	0.1uF	-	-	*5) Reduce noise of load and improve system ESD performance.
C5	Capacitor	For ESD protection	0.1uF	-	-	

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

*2) Employing an over-specification (listed in above table) R1 may result in over-charge detection voltage and release voltage higher than the defined voltage If R1 has a higher resistance, the IC may be damaged caused by over absolute maximum rating of V_{DD} 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 V_{CC} 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 V_{CC}(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.

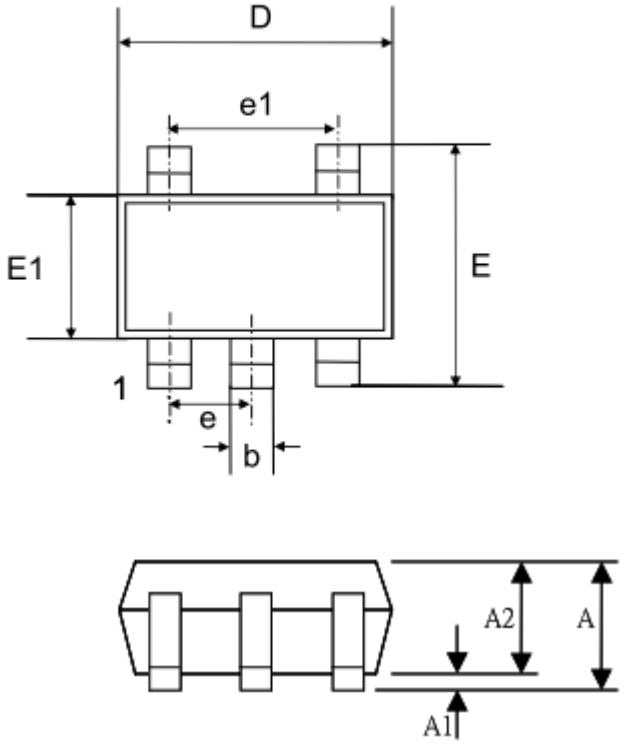
Precautions:

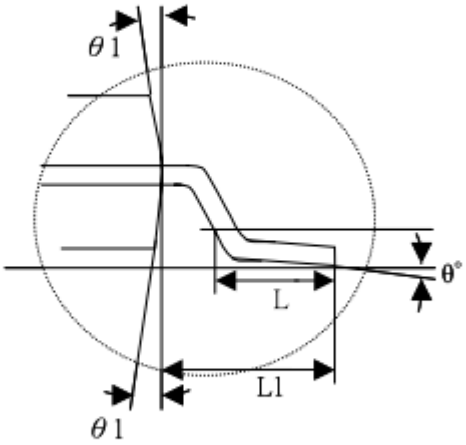
1) The application condition for the input voltage, output voltage, and load current should not exceed the package power dissipation.

2) Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.

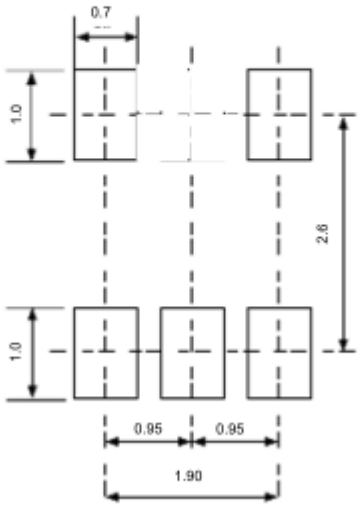
Package Information

SOT-23-5 Dimensions





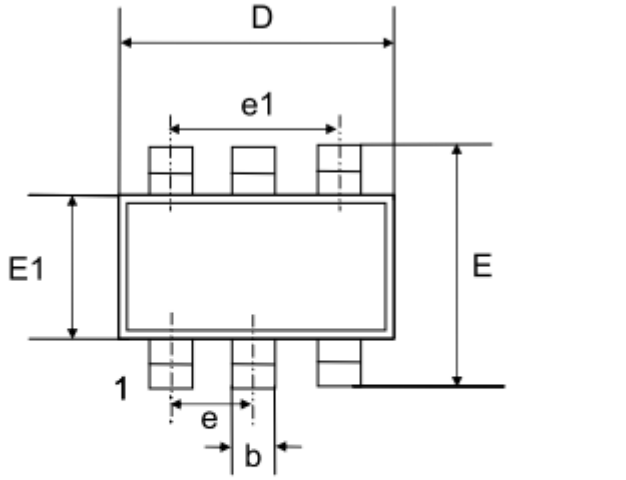
PCB Land Pattern

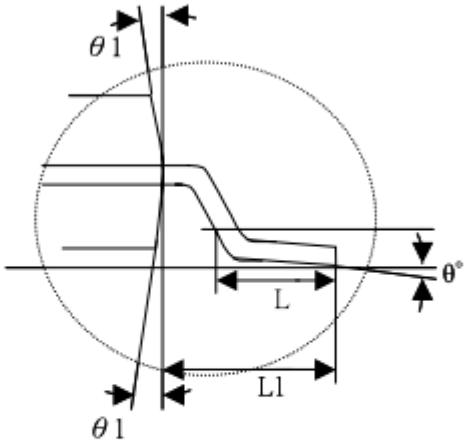


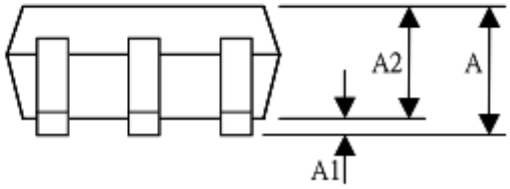
SYMBOL	MIN	NOM	MAX
A	—	—	1.45
A1	0.00	—	0.15
A2	0.90	1.15	1.30
b	0.30	0.4	0.50
c	0.08	—	0.22
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	—	0.95 BSC	—
e1	—	1.90 BSC	—
L	0.30	0.45	0.60
L1	—	0.6 REF	—
L2	—	0.25 BSC	—
θ	0°	4°	8°
θ1	5°	10°	15°

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

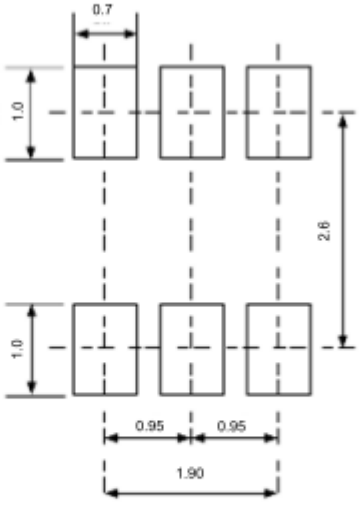
SOT-23-6 Dimensions







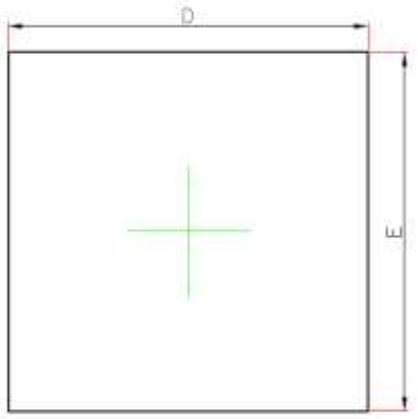
PCB Land Pattern



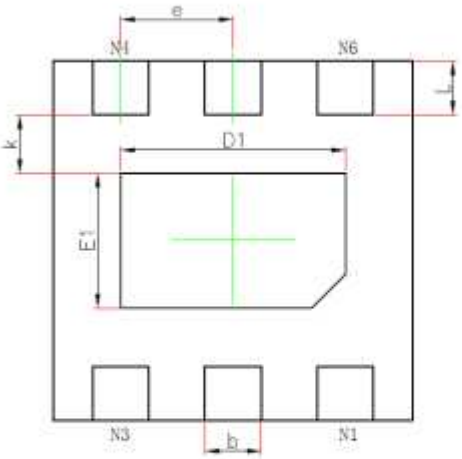
SYMBOL	MIN	NOM	MAX
A	—	—	1.45
A1	0.00	—	0.15
A2	0.90	1.15	1.30
b	0.30	0.4	0.50
c	0.08	—	0.22
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	—	0.95 BSC	—
e1	—	1.90 BSC	—
L	0.30	0.45	0.60
L1	—	0.6 REF	—
L2	—	0.25 BSC	—
θ	0°	4°	8°
θ1	5°	10°	15°

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

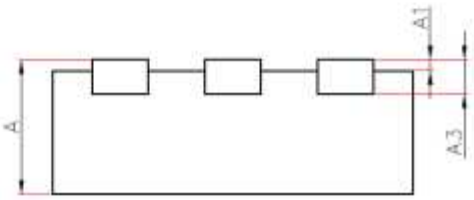
DFN-1.6X1.6-6L Dimension



TOP VIEW

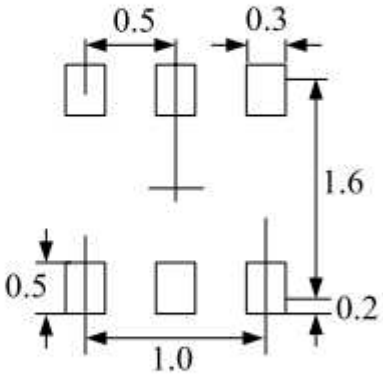


BOTTOM VIEW



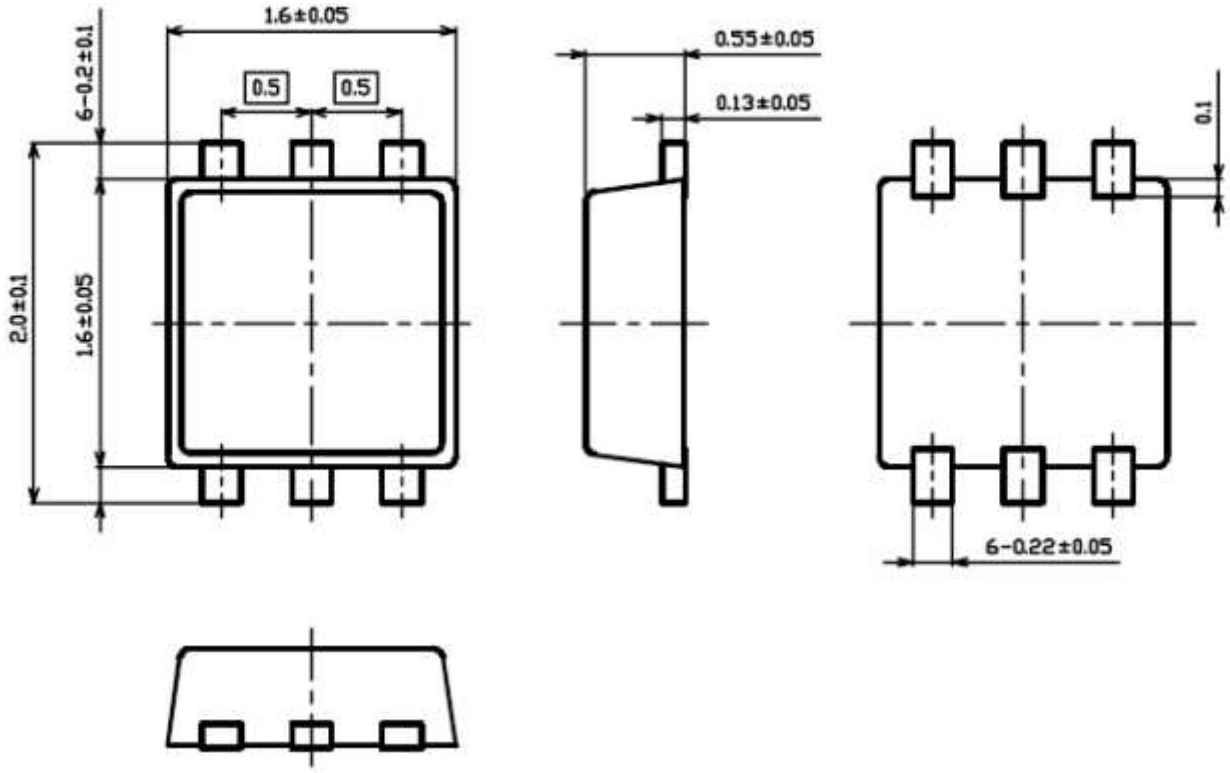
SIDE VIEW

PCB Land Pattern



Symbol	Dimensions in Millimeters	
	Min.	Max.
A	0.500	0.800
A1	0.000	0.050
A3	0.152REF.	
D	1.550	1.650
E	1.550	1.650
E1	0.500	0.700
D1	0.900	1.100
k	0.200MIN.	
b	0.180	0.300
e	0.500BSC.	
L	0.164	0.316

SON-1.6X1.6-6L Dimension



PCB Land Pattern