DESCRIPTIONS

The EC9527A is the 1-cell protection IC for lithium-ion/lithium-polymer rechargeable battery pack. This protection IC was developed for use with lithium-ion/lithium polymer 1-cell serial batteries.

It detects over-charge, over-discharge, discharge over-current and other abnormalities, and functions to protect the battery by turning off the external FETs. The IC also has a built-in timer circuit (for detection delay times), so fewer external parts can be used in protection circuit configuration.

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

FEATURE

■ Detection Accuracy
- -Over-charge Detection: ±40mV
- -Over-discharge Detection: ±100mV
- -Discharge Over-current Detection: ±20mV

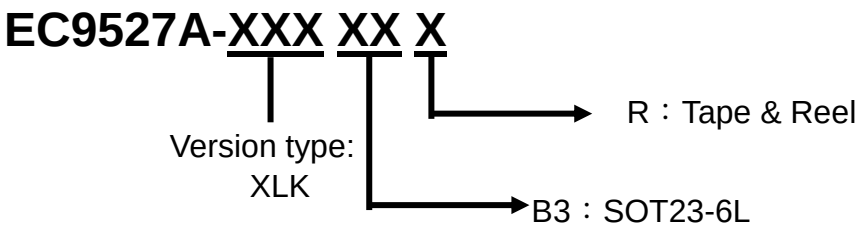
■ High Withstand Voltage
- -Absolute maximum ratings: 24V (V- pin and CO pin)

■ Ultra Small Package：SOT23-6

APPLICATION

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

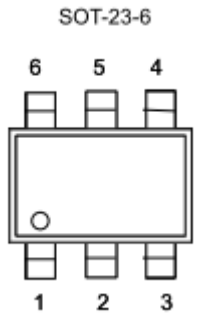
ORDERING INFORMATION



Part Number	Package	Marking	Marking Information
EC9527A-XLKB3R	SOT23-6L	9527A LLLLL	1. LLLLL：Lot No.

Product Name	Version Code	Pack-age Type	Over-charge detection Voltage V_{DET1} (V)	Over-charge release Voltage V_{REL1} (V)	Over-discharge detection voltage V_{DET2} (V)	Discharge over-current detection voltage V_{DET3} (V)	0V Battery Charge Function	Power down mode Function
EC9527A	XLK	B3	4.290	4.090	2.500	0.150	Available	No

Package and Pin Description

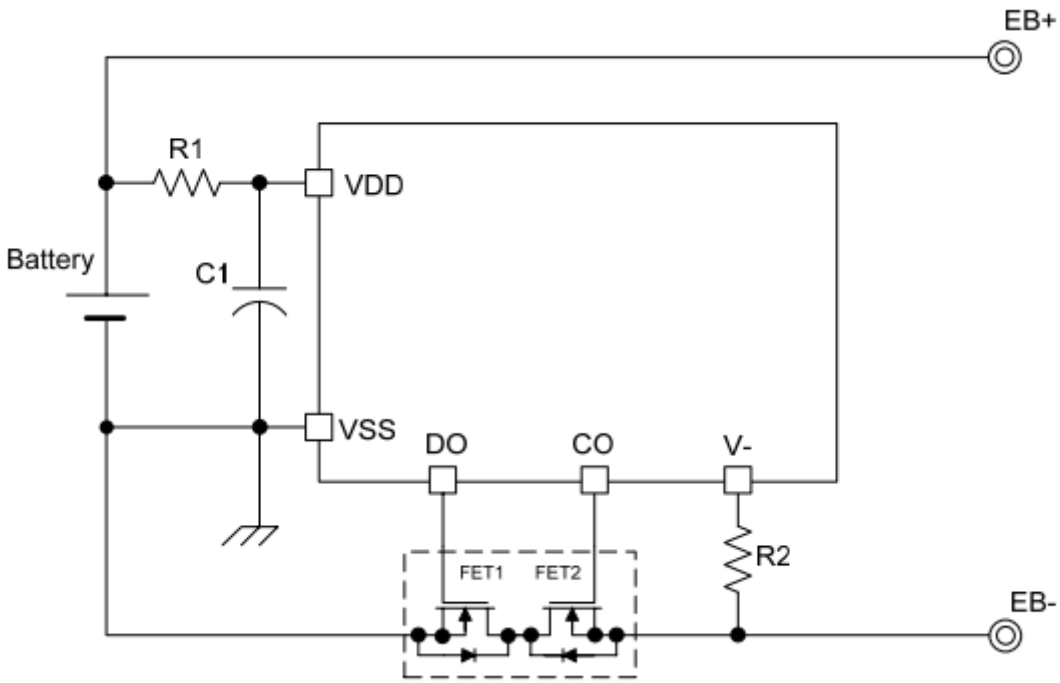


Pin No.	Symbol	Description
1	DO	Connection of discharge control FET gate
2	V-	Voltage detection between V- pin and VSS pin (Over-current / charger detection pin)
3	CO	Connection of charge control FET gate
4	NC	No connection
5	VDD	Connection for positive power supply input
6	VSS	Voltage detection between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

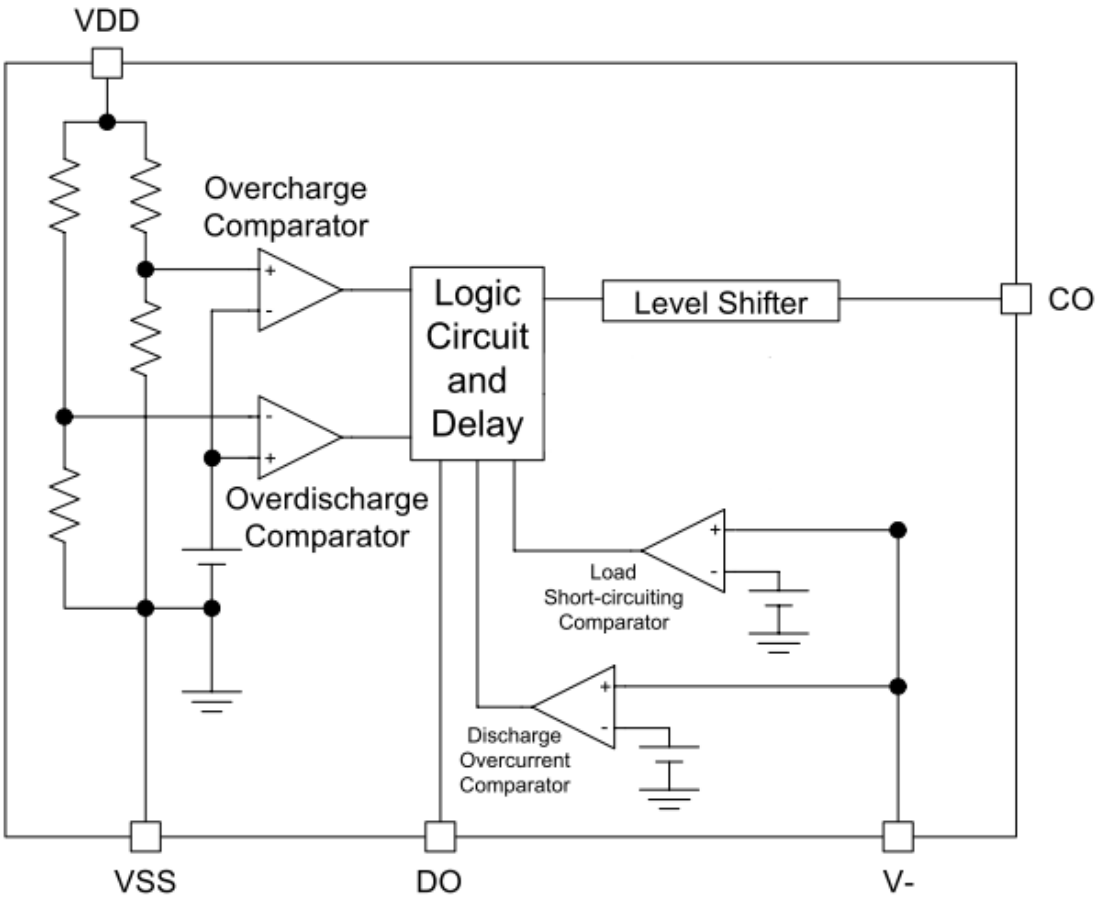
Pin assignment compatible with

RICOH R542X,
SEIKO S-8261,
RICHTEK RT9541CER,
FORTUNE DW-01, DW-02.

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} - 24 to V_{DD} + 0.3	V
V_{CO}	Output Voltage	CO pin	V_{DD} -24 to V_{DD} + 0.3	V
V_{DO}		DO pin	Vss - 0.3 to V_{DD} + 0.3	V
P_D	Power Dissipation		150	mW
T_{OPT}	Operating Temperature Range		-40 to +85	℃
T_{STG}	Storage Temperature Range		-55 to +125	℃

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℃)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	4.250	4.290	4.330	V
V_{REL1}	Over-charge release voltage	--	3.990	4.090	4.190	V
V_{DET2}	Over-discharge detection voltage	--	2.4	2.5	2.6	V
V_{REL2}	Over-discharge release voltage	--	2.6	2.7	2.8	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V	0.13	0.15	0.17	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V	0.30	0.50	0.70	V
Detection Delay Time						
t_{VDET1}	Output delay time of over-charge	-	96	160	224	ms
t_{VDET2}	Output delay time of over-discharge	-	10.8	18.0	25.2	ms
t_{VDET3}	Output delay time of discharge over-current	V_{DD}=3.5V	3.9	6.5	9.1	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	180	300	420	υs
Current Consumption						
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	υA
0V battery Charging Function						
V_{0CHA}	0 V battery charge starting charger voltage	0 V battery charging function “available”	1.0			V

Electrical Characteristics (Ta = -40~85℃)

Symbol	Item	Conditions	MIN	TYP	MAX	Unit
Detection Voltage						
V_{DET1}	Over-charge detection voltage	--	4.250	4.290	4.330	V
V_{REL1}	Over-charge release voltage	--	3.990	4.090	4.190	V
V_{DET2}	Over-discharge detection voltage	--	2.4	2.5	2.6	V
V_{REL2}	Over-discharge release voltage	--	2.6	2.7	2.8	V
V_{DET3}	Discharge over-current detection voltage	V_{DD}=3.5V	0.12	0.15	0.18	V
V_{SHORT}	Load short-circuiting detection voltage	V_{DD}=3.5V	0.16	0.50	0.84	V
Detection Delay Time						
t_{VDET1}	Output delay time of over-charge	-	64	160	256	ms
t_{VDET2}	Output delay time of over-discharge	-	7.2	18.0	28.8	ms
t_{VDET3}	Output delay time of discharge over-current	V_{DD}=3.5V	2.6	6.5	10.4	ms
t_{SHORT}	Output delay time of Load short-circuiting detection	V_{DD}=3.5V	120	300	480	us
Current Consumption						
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	7.0	uA
0V battery Charging Function						
V_{0CHA}	0 V battery charge starting charger voltage	0 V battery charging function “available”	1.0			V

Test Circuits

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

1) Set V1=3.5V, V2=0V, S1=ON, then EC9527A enter operating mode.
2) Increase V1 voltage (from 3.5V) gradually. The V1 voltage is the over-charge detection voltage (V_{DET1}) when CO pin goes low (from high).
3) Decrease V1 gradually. The V1 voltage is the over-charge release detection voltage (V_{REL1}) when CO pin goes high again.
4) Continue decreasing V1. The V1 voltage is the over-discharge detection voltage (V_{DET2}) when DO pin goes low. Then increase V1 gradually. The V1 voltage is the over-discharge release detection voltage (V_{REL2}), when DO pin returns to high.
   Note: The over-charge and over-discharge release voltages are defined in versions.

Discharge over-current detection voltage (test circuit 1)

1) Set V1=3.5 V, V2=0V, S1=ON and EC9527A enter 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).

Load short-circuiting detection voltage (test circuit 1)

1) Set V1=3.5V, V2=0V, S1=ON and EC9527A enter 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 to enter operating condition.
2) Increase V1 from V_{DET1}-0.2V to V_{DET1}+0.2V immediately (within 10us). The over-charge detection delay time (t_{VDET1}) is the period from the time V1 gets to V_{DET1}+0.2V till CO pin switches from high to low.
3) Set V1=3.5V, V2=0V, S1=ON and S2 = OFF to enter operating condition.
4) Decrease V1 from V_{DET2}+0.2V to V_{DET2}-0.2V immediately (within 10us). The over-discharge detection delay time (t_{VDET2}) is the period from the time V1 gets to V_{DET2}-0.2V till DO pin switches from high to low.

Discharge over-current delay time (test circuit 1)

1) Set V1=3.5V, V2=0V, S1=ON to enter operating condition.
2) Increase V2 from 0V to 0.25V immediately (within 10us). The discharge over-current detection delay time (t_{VDET3}) is the period from the time V2 gets to 0.25V till DO pin switches from high to low.

Load short-circuiting delay time (test circuit 1)

1) Set V1=3.5V, V2=0V, S1=ON to enter operating condition.
2) Increase V2 from 0V to 1.6V immediately (within 10us). The Load short-circuiting detection voltage delay time (t_{SHORT}) is the period from the time V2 gets to 1.6V till DO pin switches from high to low.

Operating 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}).

0V battery charge starting charger voltage (test circuit 3)

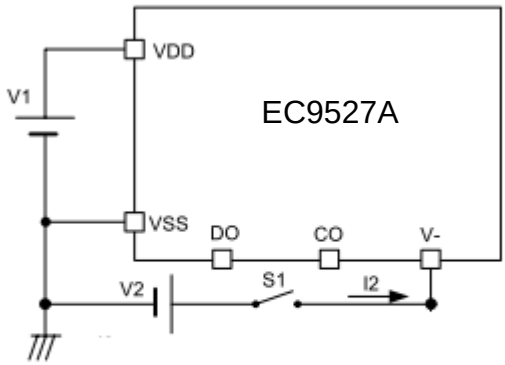
1) Set V1=V2=0V, increase V2 gradually.

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).

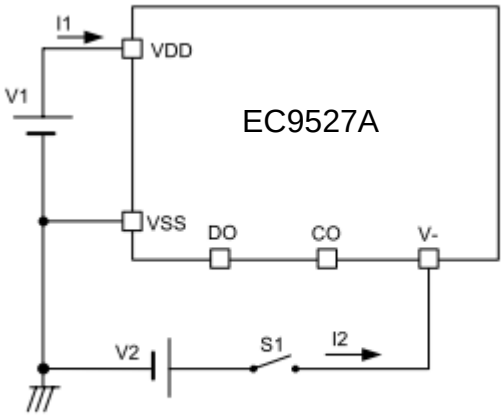
Recommended:

1) '0 V charge available' doesn't means EC9527A can recover the zero-V cell to be full charged if this cell has been already damaged due to too low voltage.
2) For safety consideration, we strongly recommended to select '0 V charge inhibition' to prevent from charging a damaged cell.

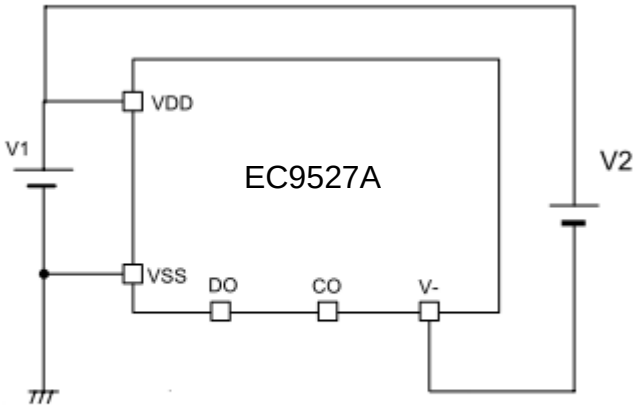
Test Circuit



Test circuit 1



Test circuit 2



Test circuit 3

Operation

The EC9527A provides over-charge, over-discharge, discharge over-current and load short-circuiting protections for the 1-cell battery pack. EC9527A 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 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 EC9527A also monitors the voltage which is determined by the current of discharge and the series Rds(on) of MOSFETs between V- pin and V_{SS} pin to detect discharge over-current current conditions.

(1) Normal Condition (Operation mode)

The EC9527A 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 discharge over-current detection voltage (V_{DET3}). This is called the normal condition that charging and discharging can be carried out freely.

Caution: The EC9527A **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 (t_{VDET1}), EC9527A 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_{REL1} and charger is connected, EC9527A can be released from this condition.
When the battery voltage is lower than V_{DET1} and charger is removed, EC9527A can be 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 (t_{VDET2}), EC9527A turns off the external discharge MOSFET to protect the pack from being over discharged, which DO pin turns to “L” from “H” level.

2) Over-discharge Protection Release:

The over-discharge protection is released when the battery voltage is higher than the over-discharge release voltage (V_{REL2}).

(4) Discharge Over-current Condition

1) Discharge Over-current Protection:

The EC9527A provides discharge over-current protection and load short-circuiting protection:

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

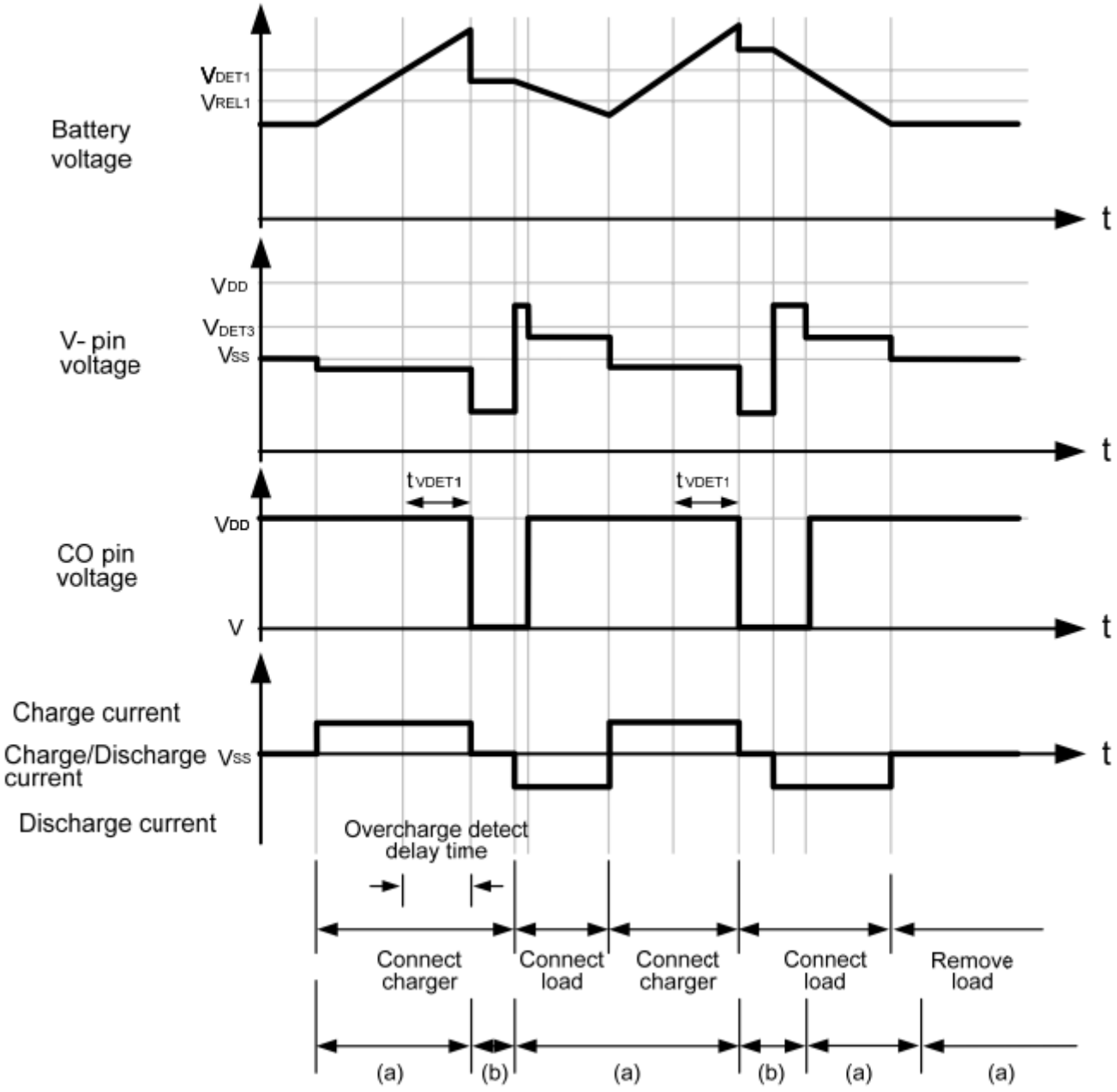
(b) Load short-circuiting protection occurs when V- pin voltage is higher than V_{SHORT} and lasts for a certain delay time (t_{SHORT}) or longer. When above conditions happen, the DO pin goes “L” from ”H” to turn off the discharging MOSFET.

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

When the V- pin voltage equals to V_{SHORT} or lower, discharge over-current status returns to normal mode by remove external load.

Timing Chart

(1) Over-charge Operation

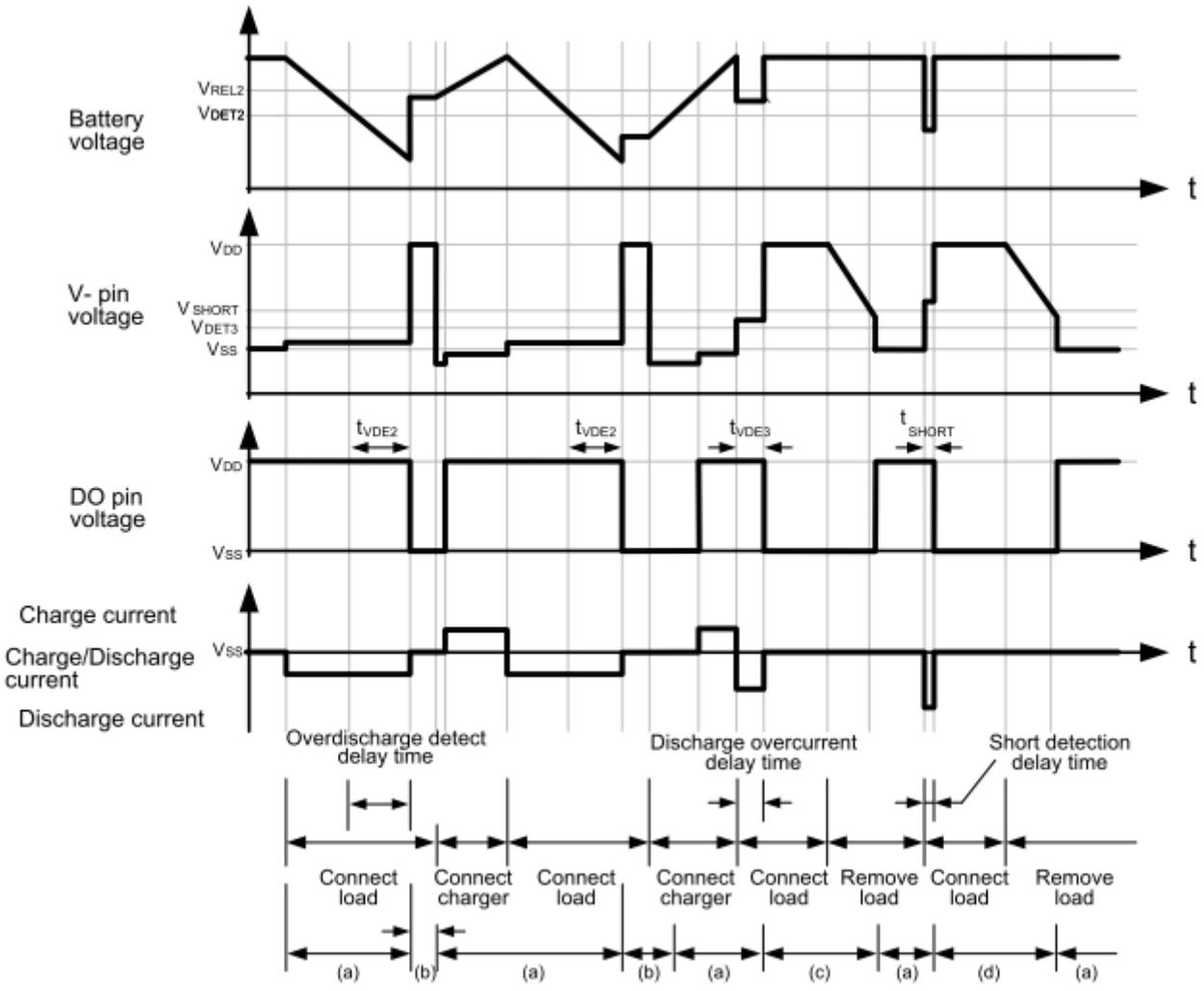


(a) Normal condition

(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

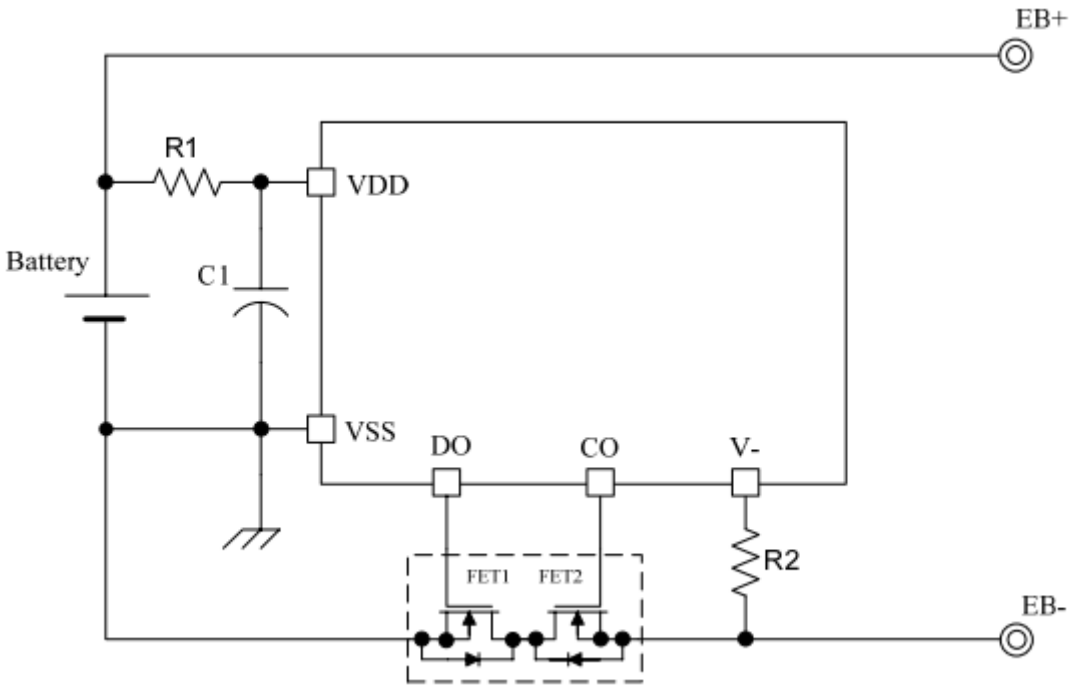


Table1 Constant for external components

Symbol	Parts	Purpose	Recommende	Min.	Max.	Remarks
FET1	N channel MOSFET	Discharge control	-	-	-	*1) 0.4 V ≤ Threshold voltage ≤ Over-discharge detection voltage. Gate to source withstand voltage ≥ Charger voltage.
FET2	N channel MOSFET	Charge control	-	-	-	*1) 0.4 V ≤ Threshold voltage ≤ Over-discharge detection voltage. Gate to source withstand voltage ≥ Charger voltage.
R1	Resistor	ESD protection, for power fluctuation	470Ω	100Ω	1KΩ	*2) Set Resistance to the value 2R1<R2.
C1	Capacitor	For power fluctuation	0.1uF	0.022uF	1.0uF	*3) Install a 0.022uF capacitor or higher.
R2	Resistor	Protection for reverse connection of a charger	1KΩ	300Ω	2KΩ	*4) The resistor is preventing big current when a charger is connected in reverse.

*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.

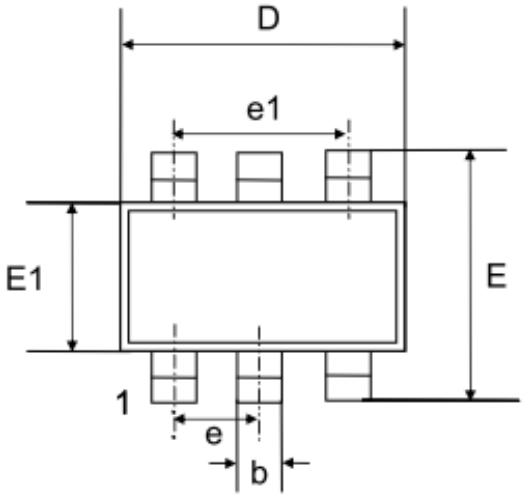
*2) Employing an over-specification (listed in above table) R1 may result in over-charge detection voltage and release voltage higher than the defined voltage. If R1 has a higher resistance, the IC may be damaged caused by over absolute maximum rating of V_{DD} voltage when a charger is connected reversely.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

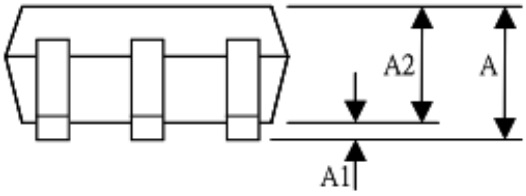
exceeds the absolute rating for V_{CC} is connected, when we connect reverse charger the current flows from charger to R2, internal ESD diode and R1. This current will increase R1 voltage drop. Which can exceed V_{CC}(max). In this case better to use smaller value for R1 and bigger value for R2. But 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.

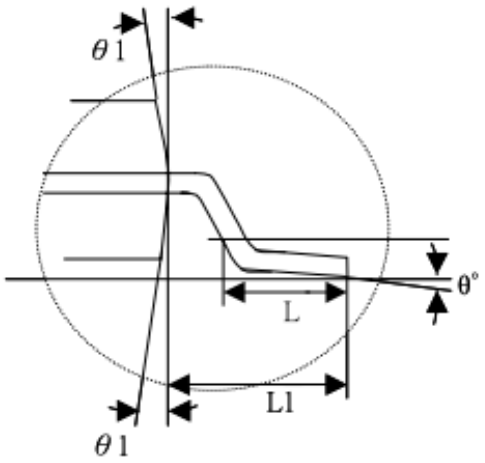
Caution: 1) The above constants may be changed without notice.
2) The application circuit above is for reference only. To determine the correct constants, evaluation of actual application is required.

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







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