Contents

BATTERY PROTECTION IC (FOR A SINGLE-CELL PACK) S-8241 Series

The S-8241 is a series of lithium-ion/lithium polymer rechargeable battery protection ICs incorporating high-accuracy voltage detection circuits and delay circuits.
These ICs are suitable for protection of single-cell lithium ion/lithium polymer battery packs from overcharge, overdischarge and overcurrent.

■ Features

(1) Internal high-accuracy voltage detection circuit

- Overcharge detection voltage 3.9 V to 4.4 V (5 mV-step) Accuracy of ± 25 mV(+25°C) or ± 30 mV(-5°C to +55°C)
- Overcharge release voltage 3.8 V to 4.4 V (*1) Accuracy of ± 50 mV

*1: Overcharge release voltage = Overcharge detection voltage - Overcharge hysteresis

The overcharge hysteresis can be selected in the range 0.0, or 0.1 to 0.4 V in 50mV steps.
(However, selection "Overcharge release voltage<3.8 V" is impossible.)

- Overdischarge detection voltage 2.0 V to 3.0 V (100 mV-step) Accuracy of ± 80 mV
- Overdischarge release voltage 2.0 V to 3.4 V (*2) Accuracy of ± 100 mV

*2: Overdischarge release voltage = Overdischarge detection voltage + Overdischarge hysteresis

The overdischarge hysteresis can be selected in the range 0.0 to 0.7 V in 100mV steps.
(However, selection "Overdischarge release voltage>3.4 V" is impossible.)

- Overcurrent 1 detection voltage 0.05 V to 0.3 V (5 mV-step) Accuracy of ± 20 mV
- Overcurrent 2 detection voltage 0. 5 V (fixed) Accuracy of ± 100 mV

(2) A high voltage withstand device is used for charger connection pins (VM and CO pins: Absolute maximum rating = 26 V)

(3) Delay times (overcharge: tCU; overdischarge: tDL; overcurrent 1: tIOV1; overcurrent 2: tIOV2) are generated by an internal circuit. (External capacitors are unnecessary.) Accuracy of ± 30 %

(4) Internal three-step overcurrent detection circuit (overcurrent 1, overcurrent 2, and load short-circuiting)

(5) Either the 0V battery charging function or 0V battery charge inhibiting function can be selected.

(6) Versions with and without a power-down feature can be selected.

(7) Charger detection function and abnormal charge current detection function

- The overdischarge hysteresis is released by detecting a negative VM pin voltage (typ. -1.3 V). (Charger detection function)
- If the output voltage at DO pin is high and the VM pin voltage becomes equal to or lower than the charger detection voltage (typ. -1.3 V), the output voltage at CO pin goes low. (Abnormal charge current detection function)

(8) Low current consumption

- Operation 3.0 μA typ. 5.0 μA max.
- Power-down mode 0.1 μA max.

(9) Wide operating temperature range: -40 to +85 °C

(10) Small package SOT-23-5 (5-pin), SON-5 (5-pin)

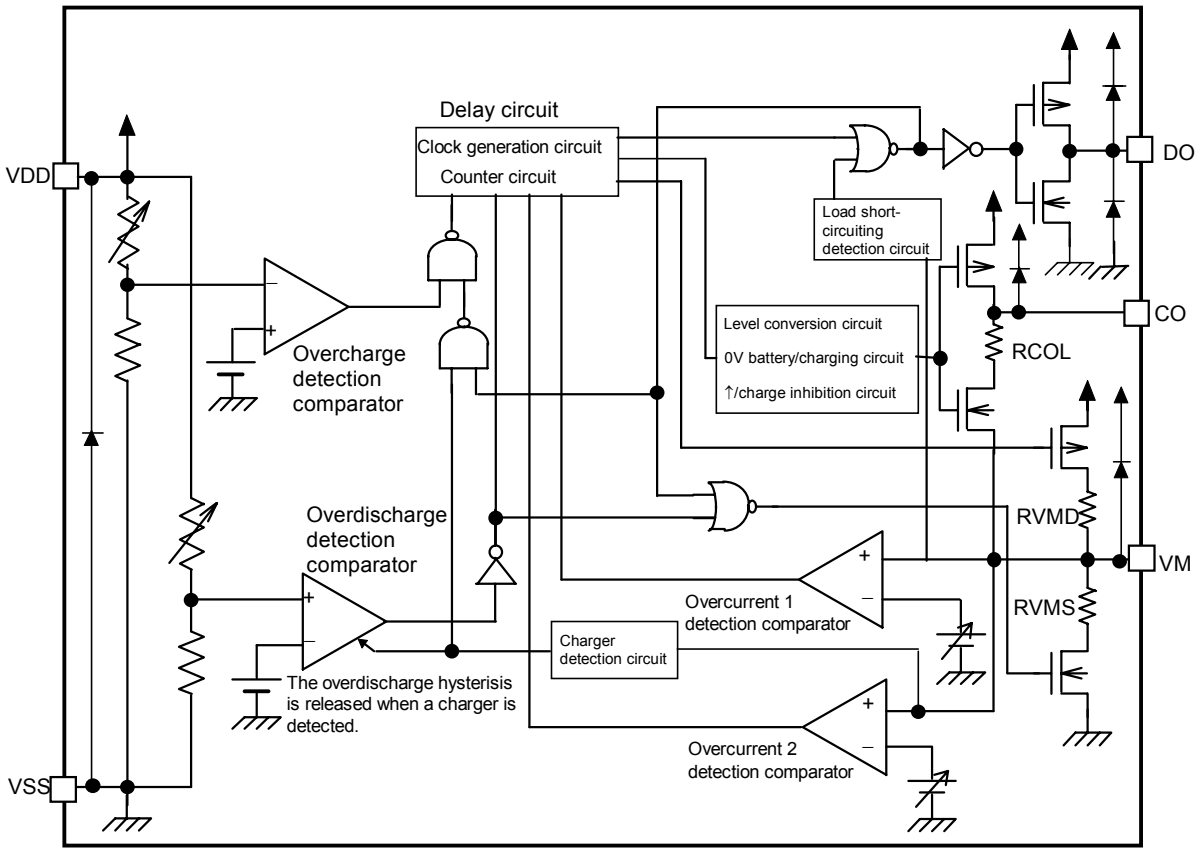
■ Applications

- Lithium-ion rechargeable battery packs
- Lithium- polymer rechargeable battery packs

■ Package Name

- SOT-23-5 (5-pin) (PKG drawing code : MP005-A)
- SON-5 (5-pin) (PKG drawing code : PN005-A)

■ Block Diagram



Note: The diode in the IC is a parasitic diode.

Figure 1 Block Diagram

■ The meaning of product model number

Model number: S-8241AB∆□□-product abbreviation (GB∆)-reel orientation (T2 or TF)

Symbol	Meaning	Description
∆	Serial number	Is set from A to Z in sequence.
□□	Package form	MC:SOT-23-5, PN:SON-5

■ Selection Guide

Model No./Item	Over-charge detection voltage	Over-charge release voltage	Over-discharge detection voltage	Over-discharge release voltage	Over-current 1 detection voltage	0V battery charging function	Delay time combi-nation*	Power down feature
S-8241ABAMC-GBA-T2	4.275 V	4.075 V	2.3 V	2.9 V	0.100 V	unavailable	(1)	Available
S-8241ABCMC-GBC-T2	4.350 V	4.100 V	2.3 V	2.8 V	0.075 V	unavailable	(1)	Available
S-8241ABDMC-GBD-T2	4.275 V	4.175 V	2.3 V	2.4 V	0.100 V	available	(1)	Available
S-8241ABDPN-KBD-TF								
S-8241ABEMC-GBE-T2	4.295 V	4.095 V	2.3 V	3.0 V	0.200 V	unavailable	(1)	Available
S-8241ABFMC-GBF-T2	4.325 V	4.075 V	2.5 V	2.9 V	0.100 V	unavailable	(1)	Available
S-8241ABGMC-GBG-T2	4.200 V	4.100 V	2.3 V	3.0 V	0.100 V	unavailable	(1)	Available
S-8241ABHMC-GBH-T2	4.325 V	4.125 V	2.3 V	2.3 V	0.100 V	available	(1)	Available
S-8241ABIMC-GBI-T2	4.280 V	4.080 V	2.3 V	2.3 V	0.160 V	unavailable	(1)	Available
S-8241ABKMC-GBK-T2	4.325 V	4.075 V	2.5 V	2.9 V	0.150 V	unavailable	(1)	Available
S-8241ABLMC-GBL-T2	4.320 V	4.070 V	2.5 V	2.9 V	0.100 V	unavailable	(1)	Available
S-8241ABNPN-KBN-TF	4.350V	4.050V	2.35V	2.65V	0.150V	available	(1)	Available
S-8241ABOMC-GBO-T2	4.350V	4.15V	2.3V	3.0V	0.150V	available	(2)	Available
S-8241ABPMC-GBP-T2	4.350V	4.15V	2.3V	3.0V	0.200 V	available	(2)	Available

*The delay time combination (1), (2) is as follows.

Delay time combination	Overcharge detection delay time	Overdischarge detection delay time	Overcurrent 1 detection delay time
(1)	1.0 s	125 ms	8 ms
(2)	0.125s	31ms	16ms

It is possible to change the detection voltage for products other than those listed above. Also, delay time can be changed within the following range. For details, please contact our sales office.

Delay time	Symbol	Optional range			Remarks
Overcharge detection delay time	tCU	0.25 s	0.5 s	1.0 s	Choose from the list at left.
Overdischarge detection delay time	tDL	31 ms	62.5 ms	125 ms	Choose from the list at left.
Overcurrent 1 detection delay time	tIOV1	4 ms	8 ms	16 ms	Choose from the list at left.

* Boxes in bold line indicate standard products.

■ Pin Assignment

For details of package, refer to the attached drawing.

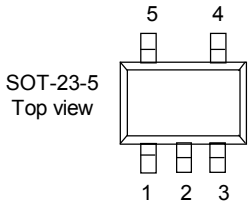


Figure 2

Pin No.	Symbol	Description
1	VM	Voltage detection pin between VM and VSS (Overcurrent detection pin)
2	VDD	Positive power input pin
3	VSS	Negative power input pin
4	DO	FET gate connection pin for discharge control (CMOS output)
5	CO	FET gate connection pin for charge control (CMOS output)

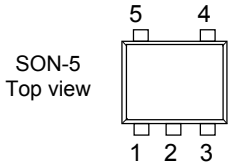


Figure 3

Pin No.	Symbol	Description
1	VM	Voltage detection pin between VM and VSS (Overcurrent detection pin)
2	VDD	Positive power input pin
3	CO	FET gate connection pin for charge control (CMOS output)
4	DO	FET gate connection pin for discharge control (CMOS output)
5	VSS	Negative power input pin

■ Absolute Maximum Ratings

(Ta = 25°C unless otherwise specified)

Item	Symbol	Applicable pin	Rating		Unit
Input voltage between VDD and VSS *	V_{DS}	VDD	V_{SS} -0.3 to V_{SS} +12		V
VM Input pin voltage	V_{VM}	VM	V_{DD} -26 to V_{DD} +0.3		V
CO output pin voltage	V_{CO}	CO	V_M -0.3 to V_{DD} +0.3		V
DO output pin voltage	V_{DO}	DO	V_{SS} -0.3 to V_{DD} +0.3		V
Power dissipation	P_D		SOT-23-5	250	mW
			SON-5	150	
Operating temperature range	Topr		-40 to +85		°C
Storage temperature range	Tstg		-40 to +125		°C

Note: This IC contains a circuit that protects it from static discharge, but take special care that no excessive static electricity or voltage which exceeds the limit of the protection circuit is applied to the IC.

* Pulse (μsec) noise exceeding the above input voltage (V_{SS} + 12 V) may cause damage to the IC.

■ Electrical Characteristics (1) Other than detection delay time (25°C)

(Ta = 25°C unless otherwise specified)

Item	Symbol	Measure-ment conditions	Remarks	Min.	Typ.	Max.	Unit	Measure-ment circuit
DETECTION VOLTAGE								
Overcharge detection voltage VCU=3.9 to 4.4 V 5mV Step	VCU	1	–	VCU -0.025	VCU	VCU +0.025	V	1
			Ta= -5°C to 55°C(*1)	VCU -0.030	VCU	VCU +0.030		
Overcharge release voltage VCU–VCL=0 to 0.4 V 50mV Step	VCL	1	When VCL ≠ VCU	VCL -0.050	VCL	VCL +0.050	V	1
			When VCL = VCU	VCL -0.025	VCL	VCL +0.025		
Overdischarge detection voltage VDL=2.0 to 3.0 V 100mV Step	VDL	1	–	VDL -0.080	VDL	VDL +0.080	V	1
Overdischarge release voltage VDU–VDL=0 to 0.7 V 100mV Step	VDU	1	When VDU ≠ VDL	VDU -0.100	VDU	VDU +0.100	V	1
			When VDU = VDL	VDU -0.080	VDU	VDU +0.080		
Overcurrent 1 detection voltage VIOV1=0.05 to 0.3V 5mV Step	VIOV1	2	–	VIOV1 -0.020	VIOV1	VIOV1 +0.020	V	1
Overcurrent 2 detection voltage	VIOV2	2	–	0.4	0.5	0.6	V	1
Load short-circuiting detection voltage	VSHORT	2	VM voltage based on VDD	-1.7	-1.3	-0.9	V	1
Charger detection voltage	VCHA	3	–	-2.0	-1.3	-0.6	V	1
Overcharge detection voltage temperature factor(*1)	TCOE1	–	Ta= -5°C to 55°C	-0.5	0	0.5	mV/°C	–
Overcurrent 1 detection voltage temperature factor(*1)	TCOE2	–	Ta= -5°C to 55°C	-0.1	0	0.1	mV/°C	–
INPUT VOLTAGE, OPERATING VOLTAGE								
Input voltage between VDD and VSS	VDS1	–	absolute maximum rating	-0.3	–	12	V	–
Input voltage between VDD and VM	VDS2	–	absolute maximum rating	-0.3	–	26	V	–
Operating voltage between VDD and VSS	VDSOP1	–	Internal circuit operating voltage	1.5	–	8	V	–
Operating voltage between VDD and VM	VDSOP2	–	Internal circuit operating voltage	1.5	–	24	V	–
CURRENT CONSUMPTION Power-down feature available								
Current consumption during normal operation	I OPE	4	VDD=3.5V, VM=0V	1.0	3.0	5.0	μA	1
Current consumption at power down	I PDN	4	VDD=VM =1.5V	–	–	0.1	μA	1
CURRENT CONSUMPTION Power-down feature unavailable								
Current consumption during normal operation	I OPE	4	VDD=3.5V, VM=0V	1.0	3.0	5.0	μA	1
Overdischarge current consumption	I OPED	4	VDD=VM =1.5V	1.0	2.0	3.5	μA	1
OUTPUT RESISTANCE								
CO pin H resistance	RCOH	6	CO=3.0V,VDD=3.5V,VM=0V	0.1	2	10	kΩ	1
CO pin L resistance	RCOL	6	CO=0.5V,VDD=4.5V,VM=0V	150	600	2400	kΩ	1
DO pin H resistance	RDOH	7	DO=3.0V,VDD=3.5V,VM=0V	0.1	1.3	6.0	kΩ	1
DO pin L resistance	RDOL	7	DO=0.5V,VDD=VM=1.8V	0.1	0.5	2.0	kΩ	1
VM INTERNAL RESISTANCE								
Internal resistance between VM and VDD	RVMD	5	VDD=1.8V, VM =0V	100	300	900	kΩ	1
Internal resistance between VM and VSS	RVMS	5	VDD=VM =3.5V	50	100	150	kΩ	1
0V BATTERY CHARGING FUNCTION The 0 V battery function is either "0 V battery charging function" or "0 V battery charge inhibiting function" depending upon the product type.								
0V battery charge starting charger voltage	V0CHA	10	0V batt. cha. Available	0.0	0.8	1.5	V	1
0V battery charge inhibiting battery voltage	V0INH	11	0V batt. cha. Unavailable	0.6	0.9	1.2	V	1

(*1) : Since products are not screened by high and low temperatures, the specification for this temperature range is guaranteed by design, not production tested.

■ Electrical Characteristics (2) Other than detection delay time (-40 to 85°C*1)

(Ta = (-40 to 85°C*1)unless otherwise specified)

Item	Symbol	Measure-ment conditions	Remarks	Min.	Typ.	Max.	Unit	Measure-ment circuit
DETECTION VOLTAGE								
Overcharge detection voltage VCU=3.9 to 4.4 V 5mV Step	VCU	1	–	VCU -0.055	VCU	VCU +0.040	V	1
Overcharge release voltage VCU–VCL=0 to 0.4 V 50mV Step	VCL	1	When VCL ≠ VCU	VCL -0.095	VCL	VCL +0.060	V	1
			When VCL = VCU	VCL -0.055	VCL	VCL +0.040		
Overdischarge detection voltage VDL=2.0 to 3.0 V 100mV Step	VDL	1	–	VDL -0.120	VDL	VDL +0.120	V	1
Overdischarge release voltage VDU–VDL=0 to 0.7 V 100mV Step	VDU	1	When VDU ≠ VDL	VDU -0.140	VDU	VDU +0.140	V	1
			When VDU = VDL	VDU -0.120	VDU	VDU +0.120		
Overcurrent 1 detection voltage VIOV1=0.05 to 0.3V 5mV Step	VIOV1	2	–	VIOV1 -0.026	VIOV1	VIOV1 +0.026	V	1
Overcurrent 2 detection voltage	VIOV2	2	–	0.37	0.5	0.63	V	1
Load short-circuiting detection voltage	VSHORT	2	VM voltage based on VDD	-1.9	-1.3	-0.7	V	1
Charger detection voltage	VCHA	3	–	-2.2	-1.3	-0.4	V	1
Overcharge detection voltage temperature factor(*1)	TCOE1	–	Ta= -40°C to 85°C	-0.7	0	0.7	mV/°C	–
Overcurrent 1 detection voltage temperature factor(*1)	TCOE2	–	Ta= -40°C to 85°C	-0.2	0	0.2	mV/°C	–
INPUT VOLTAGE, OPERATING VOLTAGE								
Input voltage between VDD and VSS	VDS1	–	absolute maximum rating	-0.3	–	12	V	–
Input voltage between VDD and VM	VDS2	–	absolute maximum rating	-0.3	–	26	V	–
Operating voltage between VDD and VSS	VDSOP1	–	Internal circuit operating voltage	1.5	–	8	V	–
Operating voltage between VDD and VM	VDSOP2	–	Internal circuit operating voltage	1.5	–	24	V	–
CURRENT CONSUMPTION Power-down feature available								
Current consumption during normal operation	I OPE	4	VDD=3.5V, VM=0V	0.7	3.0	6.0	μA	1
Current consumption at power down	I PDN	4	VDD=VM =1.5V	–	–	0.1	μA	1
CURRENT CONSUMPTION Power-down feature unavailable								
Current consumption during normal operation	I OPE	4	VDD=3.5V, VM=0V	0.7	3.0	6.0	μA	1
Overdischarge current consumption	I OPED	4	VDD=VM =1.5V	0.6	2.0	4.5	μA	1
OUTPUT RESISTANCE								
CO pin H resistance	RCOH	6	CO=3.0V,VDD=3.5V,VM=0V	0.07	2	13	kΩ	1
CO pin L resistance	RCOL	6	CO=0.5V,VDD=4.5V,VM=0V	100	600	3500	kΩ	1
DO pin H resistance	RDOH	7	DO=3.0V,VDD=3.5V,VM=0V	0.07	1.3	7.3	kΩ	1
DO pin L resistance	RDOL	7	DO=0.5V,VDD=VM=1.8V	0.07	0.5	2.5	kΩ	1
VM INTERNAL RESISTANCE								
Internal resistance between VM and VDD	RVMD	5	VDD=1.8V, VM =0V	78	300	1310	kΩ	1
Internal resistance between VM and VSS	RVMS	5	VDD=VM =3.5V	39	100	220	kΩ	1
0V BATTERY CHARGING FUNCTION The 0 V battery function is either "0 V battery charging function" or "0 V battery charge inhibiting function" depending upon the product type.								
0V battery charge starting charger voltage	V0CHA	10	0V batt. cha. Available	0.0	0.8	1.7	V	1
0V battery charge inhibiting battery voltage	V0INH	11	0V batt. cha. Unavailable	0.4	0.9	1.4	V	1

(*1) : Since products are not screened by high and low temperatures, the specification for this temperature range is guaranteed by design, not production tested.

■ Electrical Characteristics (3) Detection delay time (25°C)

(Ta = 25°C unless otherwise specified)

Item	Symbol	Measure-ment conditions	Remarks	Min.	Typ.	Max.	Unit	Measure-ment circuit
DELAY TIME								
Overcharge detection delay time	tCU	8	–	0.7	1.0	1.3	s	1
Overdischarge detection delay time	tDL	8	–	87.5	125	162.5	ms	1
Overcurrent 1 detection delay time	tIOV1	9	–	5.6	8	10.4	ms	1
Overcurrent 2 detection delay time	tIOV2	9	–	1.4	2	2.6	ms	1
Load short-circuiting detection delay time	tSHORT	9	–	–	10	50	μs	1

■ Electrical Characteristics (4) Detection delay time (-40 to 85°C*1)

(Ta = -40 to 85°C *1 unless otherwise specified)

Item	Symbol	Measure-ment conditions	Remarks	Min.	Typ.	Max.	Unit	Measure-ment circuit
DELAY TIME								
Overcharge detection delay time	tCU	8	–	0.55	1.0	1.7	s	1
Overdischarge detection delay time	tDL	8	–	69	125	212	ms	1
Overcurrent 1 detection delay time	tIOV1	9	–	4.4	8	14	ms	1
Overcurrent 2 detection delay time	tIOV2	9	–	1.1	2	3.4	ms	1
Load short-circuiting detection delay time	tSHORT	9	–	–	10	73	μs	1

(*1) : Since products are not screened by high and low temperatures, the specification for this temperature range is guaranteed by design, not production tested.

■ Measurement Circuits

Unless otherwise specified, the output voltage levels "H" and "L" at CO and DO pins are judged by the threshold voltage (1.0 V) of a Nch FET. Judge the CO pin level with respect to VM and the DO pin level with respect to VSS.

(1) Measurement Condition 1, Measurement Circuit 1

〈〈 Overcharge detection voltage, Overcharge release voltage, Overdischarge detection voltage, Overdischarge release voltage〉〉

Set V1=3.5V and V2=0V under normal condition. Increase V1 from 3.5 V gradually. The voltage between VDD and VSS when CO='L' is the overcharge detection voltage (VCU).
Decrease V1 gradually. The voltage between VDD and VSS when CO='H' is the overcharge release voltage (VCL). Further decrease V1 gradually. The voltage between VDD and VSS when DO='L' is the overdischarge detection voltage (VDL). Increase V1 gradually. The voltage between VDD and VSS when DO='H' is the overdischarge release voltage (VDU).

(2) Measurement Condition 2, Measurement Circuit 1

〈〈 Overcurrent 1 detection voltage, Overcurrent 1 release voltage, Overcurrent 2 detection voltage, Load short-circuiting detection voltage 〉〉

Set V1=3.5V and V2=0V under normal condition. Increase V2 from 0 V gradually. The voltage between VM and VSS when DO='L' is the overcurrent 1 detection voltage (VIOV1).
Set V1=3.5V and V2=0V under normal condition. Increase V2 from 0 V at a rate of 1 ms to 4 ms. The voltage between VM and VSS when DO='L' is the overcurrent 2 detection voltage (VIOV2).
Set V1=3.5V and V2=0V under normal condition. Increase V2 from 0 V at a rate of 1 μs to 50 μs. The voltage between VM and VDD when DO='L' is the load short-circuiting detection voltage (VSHORT).

(3) Measurement Condition 3, Measurement Circuit 1

〈〈 Charger detection voltage, (=abnormal charge current detection voltage) 〉〉

- For products with overdischarge hysteresis only

Set V1=1.8V and V2=0V under overdischarge condition. Increase V1 gradually, set V1=(VDU+VDL)/2 (within overdischarge hysteresis, overdischarge condition), then decrease V2 from 0 V gradually. The voltage between VM and VSS when DO='H' is the charger detection voltage (VCHA).

Set V1=3.5V and V2=0V under normal condition. Decrease V2 from 0 V gradually. The voltage between VM and VSS when CO='L' is the abnormal charge current detection voltage.
The abnormal charge current detection voltage has the same value as the charger detection voltage (VCHA) .

(4) Measurement Condition 4, Measurement Circuit 1

〈〈 Normal operation current consumption, Power-down current consumption, Overdischarge current consumption 〉〉

Set V1=3.5V and V2=0V under normal condition. The current IDD flowing through VDD pin is the normal operation consumption current (IOPE).
For products with power-down feature
Set V1=V2=1.5V under overdischarge condition. The current IDD flowing through VDD pin is the power-down current consumption (IPDN).
For products without power-down feature
Set V1=V2=1.5V under overdischarge condition. The current IDD flowing through VDD pin is the overdischarge current consumption (IOPED).

(5) Measurement Condition 5, Measurement Circuit 1

〈〈 Internal resistance between VM and VDD, Internal resistance between VM and VSS 〉〉

Set V1=1.8V and V2=0V under overdischarge condition. Measure current IVM flowing through VM pin. 1.8V/|IVM| is the internal resistance (RVMD) between VM and VDD.
Set V1=V2=3.5V under overcurrent condition. Measure current IVM flowing through VM pin. 3.5V/|IVM| is the internal resistance (RVMS) between VM and VSS.

(6) Measurement Condition 6, Measurement Circuit 1

〈〈 CO pin H resistance, CO pin L resistance 〉〉

Set V1=3.5V, V2=0V and V3=3.0V under normal condition. Measure current ICO flowing through CO pin. 0.5V/|ICO| is the CO pin H resistance (RCOH).
Set V1=4.5V, V2=0V and V3=0.5V under overcharge condition. Measure current ICO flowing through CO pin. 0.5V/|ICO| is the CO pin L resistance (RCOL).

(7) Measurement Condition 7, Measurement Circuit 1

〈〈 DO pin H resistance, DO pin L resistance 〉〉

Set V1=3.5V, V2=0V and V4=3.0V under normal condition. Measure current IDO flowing through DO pin. 0.5V/|IDO| is the DO pin H resistance (RDOH).
Set V1=1.8V, V2=0V and V4=0.5V under overdischarge condition. Measure current IDO flowing through DO pin. 0.5V/|IDO| is the DO pin L resistance (RDOL).

(8) Measurement Condition 8, Measurement Circuit 1

〈〈 Overcharge detection delay time, Overdischarge detection delay time 〉〉

Set V1=3.5V and V2=0V under normal condition. Increase V1 gradually to overcharge detection voltage (VCU) - 0.2 V and increase V1 to the overcharge detection voltage (VCU) + 0.2 V momentarily (within 10 μs). The time after V1 becomes the overcharge detection voltage until CO goes "L" is the overcharge detection delay time (tCU).
Set V1=3.5V and V2=0V under normal condition. Decrease V1 gradually to overdischarge detection voltage (VDL) + 0.2 V and decrease V1 to the overdischarge detection voltage (VDL) - 0.2 V momentarily (within 10 μs). The time after V1 becomes the overdischarge detection voltage (VDL) until DO goes "L" is the overdischarge detection delay time (tDL).

(9) Measurement Condition 9, Measurement Circuit 1

〈〈 Overcurrent 1 detection delay time, Overcurrent 2 detection delay time, Load short-circuiting detection delay time, Abnormal charge current detection delay time 〉〉

Set V1=3.5V and V2=0V under normal condition. Increase V2 from 0 V to 0.35 V momentarily (within 10 μs). The time after V2 becomes overcurrent 1 detection voltage (VIOV1) until DO goes "L" is overcurrent 1 detection delay time (tIOV1).
Set V1=3.5V and V2=0V under normal condition. Increase V2 from 0 V to 0.7 V momentarily (within 1 μs). The time after V2 becomes overcurrent 1 detection voltage (VIOV1) until DO goes "L" is overcurrent 2 detection delay time (tIOV2).

Note! 〉 Overcurrent 2 detection delay time begins when overcurrent 1 is detected. (Because the delay circuit is shared.)

Set V1=3.5V and V2=0V under normal condition. Increase V2 from 0 V to 3.0 V momentarily (within 1 μs). The time after V2 becomes the load short-circuiting detection voltage (VSHORT) until DO goes "L" is the load short-circuiting detection delay time (tSHORT).
Set V1=3.5V and V2=0V under normal condition. Decrease V2 from 0 V to -2.5 V momentarily (within

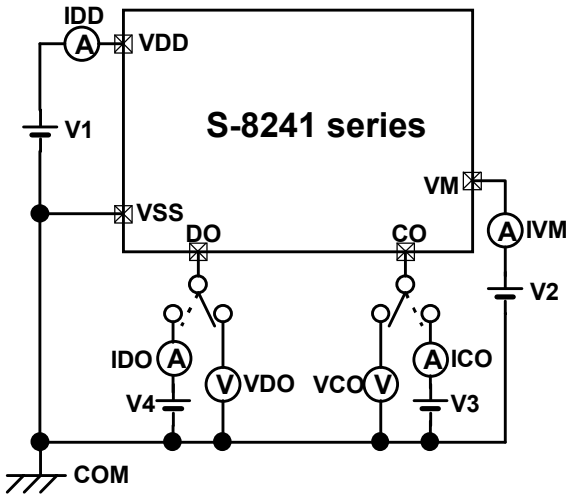
10 μs). The time after V2 becomes the charger detection voltage (VCHA) until CO goes "L" is the abnormal charge current detection delay time.
The abnormal charge current detection delay time has the same value as the overcharge detection delay time.

(10) Measurement Condition 10, Measurement Circuit 1 (Product with 0V battery charging function)
〈〈 0V battery charge start charger voltage 〉〉

Set V1=V2=0V and decrease V2 gradually. The voltage between VDD and VM when CO='H' (VM + 0.1 V or higher) is the 0V battery charge start charger voltage (V0CHA).

(11) Measurement Condition 11, Measurement Circuit 1 (Product with 0V battery charge inhibiting function)
〈〈 0V battery charge inhibiting battery voltage 〉〉

Set V1=0V and V2=-4V. Increase V1 gradually. The voltage between VDD and VSS when CO='H' (VM + 0.1 V or higher) is the 0V battery charge inhibiting battery voltage (V0INH).



Measurement circuit 1

Figure 4

■ Description of Operation

Normal condition

This IC monitors the voltage of the battery connected to VDD and VSS pins and the differences in voltages between VM and VSS pins to control charging and discharging. If the battery voltage is in the range from the overdischarge detection voltage (VDL) to the overcharge detection voltage (VCU), and the VM pin voltage is in the range from the charger detection voltage (VCHA) to the overcurrent 1 detection voltage (VIOV1) (the current flowing through the battery is equal to or lower than a specified value), both the charging and discharging control FETs turn on. In this condition, charging and discharging can be carried out freely. This condition is called the normal condition.

Overcurrent condition

If the discharging current becomes equal to or higher than a specified value (the VM pin voltage is equal to or higher than the overcurrent detection voltage) during discharging under normal condition and it continues for the overcurrent detection delay time or longer, the discharging control FET turns off to stop discharging. This condition is called an overcurrent condition. (The overcurrent means overcurrent 1, overcurrent 2, or load short-circuiting.)

The VM and VSS pins are shorted by the RVMS resistor in the IC under the overcurrent condition. When a load is connected, the VM pin voltage equals the VDD potential due to the load.
The overcurrent condition returns to the normal condition when the load is released and the impedance between the EB+ and EB- pins (see Figure 9 for a connection example) is the automatic recoverable load resistance (see the equation [1] below) or higher. When the load is removed, the VM pin, which and the VSS pin are shorted with the RVMS resistor, goes back to the VSS potential. The IC detects that the VM pin potential returns to overcurrent 1 detection voltage (VIOV1) or lower and returns to the normal condition.

Automatic recoverable load resistance = {Battery voltage / (Minimum value of overcurrent 1 detection voltage) - 1} x (RVMS maximum value) --- [1]
Example: Battery voltage = 3.5 V and overcurrent 1 detection voltage (VIOV1) = 0.1 V
Automatic recoverable load resistance = (3.5 V / 0.07 V -1) x 200kΩ = 9.8MΩ

*Note: The automatic recoverable load resistance is different with the battery voltage and overcurrent 1 detection voltage settings.
To enable automatic recovery from over current, check the overcurrent 1 detection voltage setting for the IC to be used, and determine the minimum value of the open load using the above equation [1].

Overcharge condition

If the battery voltage becomes higher than the overcharge detection voltage (VCU) during charging under normal condition and it continues for the overcharge detection delay time (tCU) or longer, the charging control FET turns off to stop charging. This condition is called an overcharge condition.
The overcharge condition is released in two cases (① and ②) for each of the products with and without overcharge hysteresis:

♦ Products with overcharge hysteresis (overcharge detection voltage (VCU) > overcharge release voltage (VCL))

① If the battery voltage falls below the overcharge release voltage (VCL), the charging control FET turns on and the normal condition returns.

② If a load is installed and discharging starts, the charging control FET turns on and the normal condition returns. The release mechanism is as follows: the discharge current flows through an internal parasitic diode of the charging FET immediately after a load is installed and discharging starts, and the VM pin voltage increases by about 0.7 V (Vf voltage of the diode) from the VSS pin voltage momentarily. The IC detects this voltage (overcurrent 1 detection voltage or higher) and releases the overcharge condition. Consequently, if the battery voltage is equal to or lower than the overcharge detection voltage (VCU), the normal condition returns immediately. If the battery voltage is higher than the overcharge detection voltage (VCU), the normal condition does not return until the battery voltage falls below the overcharge detection voltage (VCU) even if a load is installed. If the VM pin voltage is equal to or lower than the overcurrent 1 detection voltage when a load is installed and discharging starts, the normal condition does not return.

!Note:

If the battery is charged to a voltage higher than the overcharge detection voltage (VCU) and the battery voltage does not fall below the overcharge detection voltage (VCU) even when a heavy load (which causes an overcurrent) is installed, detection/delay of overcurrent 1 and overcurrent 2 do not work until the battery voltage falls below the overcharge detection voltage (VCU). However, an actual battery has an internal impedance of several dozens of mΩ, and the battery voltage drops immediately after a heavy load which causes an overcurrent is installed, and therefore, detection/delay of overcurrent 1 and overcurrent 2 work. Detection/delay of load short-circuiting work regardless of the battery voltage.

♦ Products without overcharge hysteresis (Overcharge detection voltage (VCU) = Overcharge release voltage (VCL))

① If the battery voltage falls below the overcharge release voltage (VCL), the charging control FET turns on and the normal condition returns.

② If a load is installed and discharging starts, the charging control FET turns on and the normal condition returns. The release mechanism is as follows: the discharge current flows through an internal parasitic diode of the charging FET immediately after a load is installed and discharging starts, and the VM pin voltage increases by about 0.7 V (Vf voltage of the diode) from the VSS pin voltage momentarily. The IC detects this voltage (overcurrent 1 detection voltage or higher), increases the overcharge detection voltage by about 50 mV, and releases the overcharge condition. Consequently, if the battery voltage is equal to or lower than the overcharge detection voltage (VCU) + 50 mV, the normal condition returns immediately. If the battery voltage is higher than the overcharge detection voltage (VCU) + 50 mV, the normal condition does not return until the battery voltage falls below the overcharge detection voltage (VCU) + 50 mV even if a load is installed. If the VM pin voltage is equal to or lower than the overcurrent 1 detection voltage when a load is installed and discharging starts, the normal condition does not return.

!Note:

If the battery is charged to a voltage higher than the overcharge detection voltage (VCU) and the battery voltage does not fall below the overcharge detection voltage (VCU) + 50 mV even when a heavy load (which causes an overcurrent) is installed, detection/delay of overcurrent 1 and overcurrent 2 do not work until the battery voltage falls below the overcharge detection voltage (VCU) + 50 mV. However, an actual battery has an internal impedance of several dozens of mΩ, and the battery voltage drops immediately after a heavy load which causes an overcurrent is installed, and therefore, detection/delay of overcurrent 1 and overcurrent 2 work. Detection/delay of load short-circuiting work regardless of the battery voltage.

Overdischarge condition (for products with power-down feature)

If the battery voltage falls below the overdischarge detection voltage (VDL) during discharging under normal condition and it continues for the overdischarge detection delay time (tDL) or longer, the discharging control FET turns off and discharging stops. This condition is called the overdischarge condition. When the discharging control FET turns off, the VM pin is pulled up by the RVMD resistor between VM and VDD in the IC. If the potential difference between VM and VDD falls below 1.3 V (typ.) (load short-circuiting detection voltage), the IC's current consumption is reduced to the power-down current consumption (IPDN). This condition is called the power-down condition. The VM and VDD pins are shorted by the RVMD resistor in the IC under the overdischarge and power-down conditions. The power-down condition is released when the charger is connected and the potential difference between VM and VDD becomes 1.3 V (typ.) or higher (load short-circuiting detection voltage). At this time, the FET is still off. When the battery voltage becomes the overdischarge detection voltage (VDL) or higher (see note), FET turns on and the overdischarge condition changes to the normal condition.

Note: If the VM pin voltage has not reached the charger detection voltage (VCHA), when an overdischarged battery is connected to the charger, the overdischarge condition is released (discharge control FET turns on) as designed, when the battery voltage reaches the overdischarge release voltage (VDU) or higher.

Overdischarge condition (for products without power-down feature)

If the battery voltage falls below the overdischarge detection voltage (VDL) during discharging under normal conditions and this condition continues for the overdischarge detection delay time (tDL) or longer, the discharging control FET turns off and discharging stops. When the discharging control FET turns off, the VM pin is pulled up by the RVMD resistor between VM and VDD in the IC. If the potential difference between VM and VDD falls below 1.3 V (typ.) (load short-circuiting detection voltage), the IC's current consumption is reduced to the overdischarge current consumption (IOPED). This condition is called the overdischarge condition. The VM and VDD pins are shorted by the RVMD resistor in the IC under the overdischarge condition.

If the charger is connected, the overdischarge condition is released in the same way as explained

above in respect to products having the power-down feature. For products without the power-down feature, however, since the VM pin is pulled down by the RVMS resistor between VM and VSS in the IC when the battery voltage reaches the overdischarge release voltage (VDU) or higher even if the charger is not connected, the discharge control FET turns on when the potential difference between VM and VSS falls below the overcurrent 1 detection voltage (VIOV1) if the load is cut off, and the overdischarge condition changes to the normal condition.

Charger detection

If the VM pin voltage is lower than the charger detection voltage (VCHA) when an over-discharged battery is connected with a charger, overdischarge hysteresis is released, and when the battery voltage becomes equal to or higher than the overdischarge detection voltage (VDL), the overdischarge condition is released (the discharging control FET turns on). This action is called charger detection. (The charge time can be reduced via the internal parasitic diode in the discharging control FET by using this charger detection.)

If the VM pin voltage has not reached the charger detection voltage (VCHA), when an overdischarged battery is connected to the charger, the overdischarge condition is released (discharge control FET turns on) as designed, when the battery voltage reaches the overdischarge release voltage (VDU) or higher.

Abnormal charge current detection

If the VM pin voltage falls below the charger detection voltage (VCHA) during charging under normal condition and it continues for the overcharge detection delay time (tCU) or longer, the charging control FET turns off and charging stops. This action is called abnormal charge current detection.

Abnormal charge current detection works if the discharging control FET turns on (DO pin voltage is “H”) and the VM pin voltage falls below the charger detection voltage (VCHA). Consequently, if an abnormal charge current flows to an over-discharged battery, the charging control FET turns off and charging stops after the battery voltage becomes the overdischarge detection voltage or higher (DO pin voltage becomes “H”) and the overcharge detection delay time (tCU) elapses.

Abnormal charge current detection is released when the voltage difference between VM pin and VSS pin becomes less than charger detection voltage (VCHA) by separating the charger.

Since the 0V battery charging function has higher priority than the abnormal charge current detection function, abnormal charge current may not be detected while the battery voltage is low for product with the 0V battery charging function.

Delay circuits

The following detection delay times are generated by dividing the about 2 kHz clock with a counter.

[Ex.]

Overcharge detection delay time (= abnormal charge current detection delay time): 1.0s
Overdischarge detection delay time: 125 ms
Overcurrent 1 detection delay time: 8 ms
Overcurrent 2 detection delay time: 2 ms

Note!

- Overcurrent 2 detection delay time starts when overcurrent 1 is detected. Consequently, if overcurrent 2 is detected after overcurrent 2 detection delay time passes after overcurrent 1 detection, the discharging control FET turns off. At this time, overcurrent 2 detection delay time may seem to be increased (or overcurrent 1 detection delay time may seem to be decreased.).

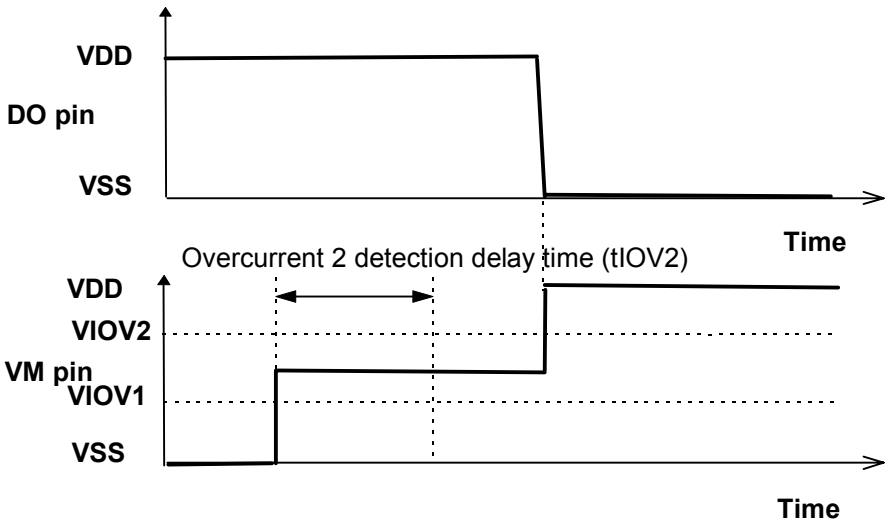


Figure 5

- If an overcurrent condition (overcurrent 1, overcurrent 2 and load short-circuiting) is detected and it continues for the overdischarge detection delay time or longer without releasing a load, the condition changes to the power-down condition when the battery voltage falls below the overdischarge detection voltage. If the battery voltage falls below the overdischarge detection voltage due to an overcurrent, the discharging control FET turns off when the overcurrent is detected. If the battery voltage restores late and the battery voltage after the overdischarge detection delay time is equal to or lower than the overdischarge detection voltage, the condition changes to the power-down condition.

0V battery charging function (*1) (*2)

This function is used to recharge the connected battery after it self-discharges to 0 V. When the 0V battery charging start charger voltage (V0CHA) or higher is applied to between EB+ and EB- pins by connecting the charger, the charging control FET gate is fixed to VDD potential. When the voltage between the gate and source of the charging control FET becomes equal to or higher than the turn-on voltage by the charger voltage, the charging control FET turns on to start charging. At this time, the discharging control FET turns off and the charging current flows through the internal parasitic diode in the discharging control FET. If the battery voltage becomes equal to or higher than the overdischarge release voltage (VDU), the normal condition returns.

0V battery charge inhibiting function (*1)

This function is used to inhibit recharge the connected battery if it is short-circuited (0 V) internally. If the battery voltage becomes 0.9 V (typ.) or lower, the charging control FET gate is fixed to EB- potential to inhibit charging. If the battery voltage is the 0V battery charge inhibiting battery voltage (V0INH) or higher, charging can be performed.

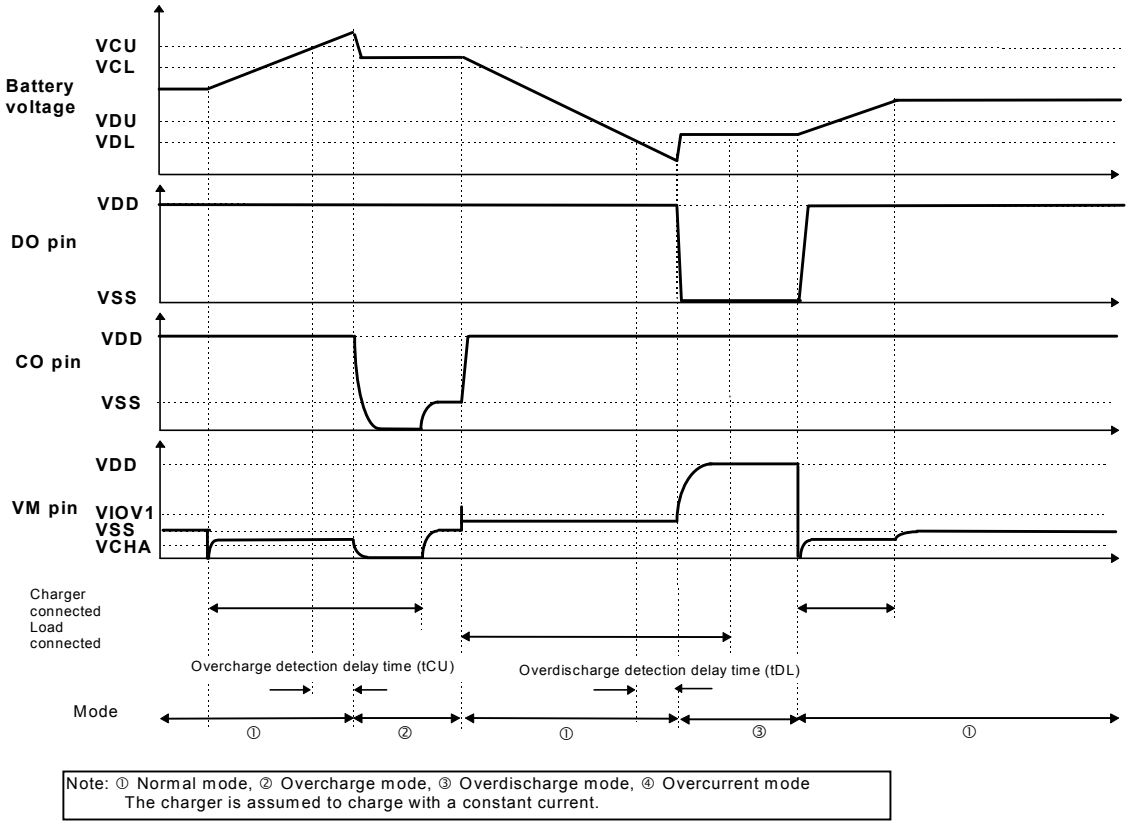
(*1) Some battery providers do not recommend charge for 0V batteries(complete self-discharged). Please refer to battery providers.

(*2) The 0V battery charging function has higher priority than the abnormal charge current detection function. Consequently, a product with the 0V battery charging function can be charged and abnormal charge current cannot be detected when the battery voltage is low (maximum 1.8 V or lower).

(*3) When a battery is connected to an IC for the first time, the IC may not enter the normal condition (not dischargeable condition). If this occurs, set the VM pin voltage equal to the VSS voltage (short the VM and VSS pins or connect a charger) to enter the normal condition.

■ Operation Timing Chart

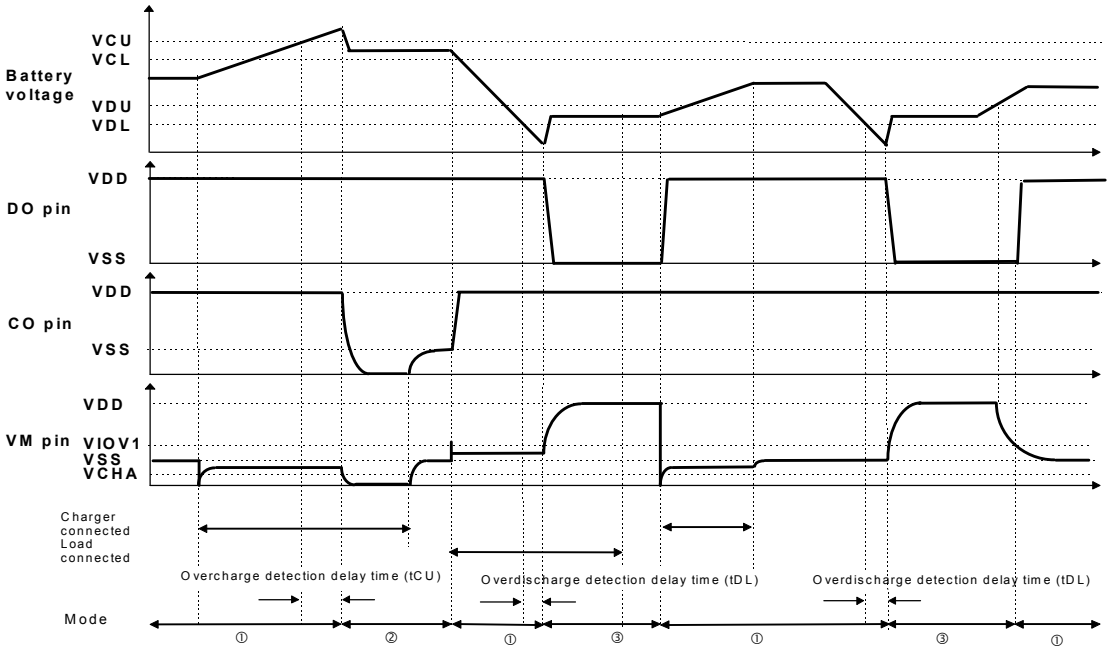
1-1. Overcharge and overdischarge detection (for products with power-down feature)



Note: ① Normal mode, ② Overcharge mode, ③ Overdischarge mode, ④ Overcurrent mode
The charger is assumed to charge with a constant current.

Figure 6-1

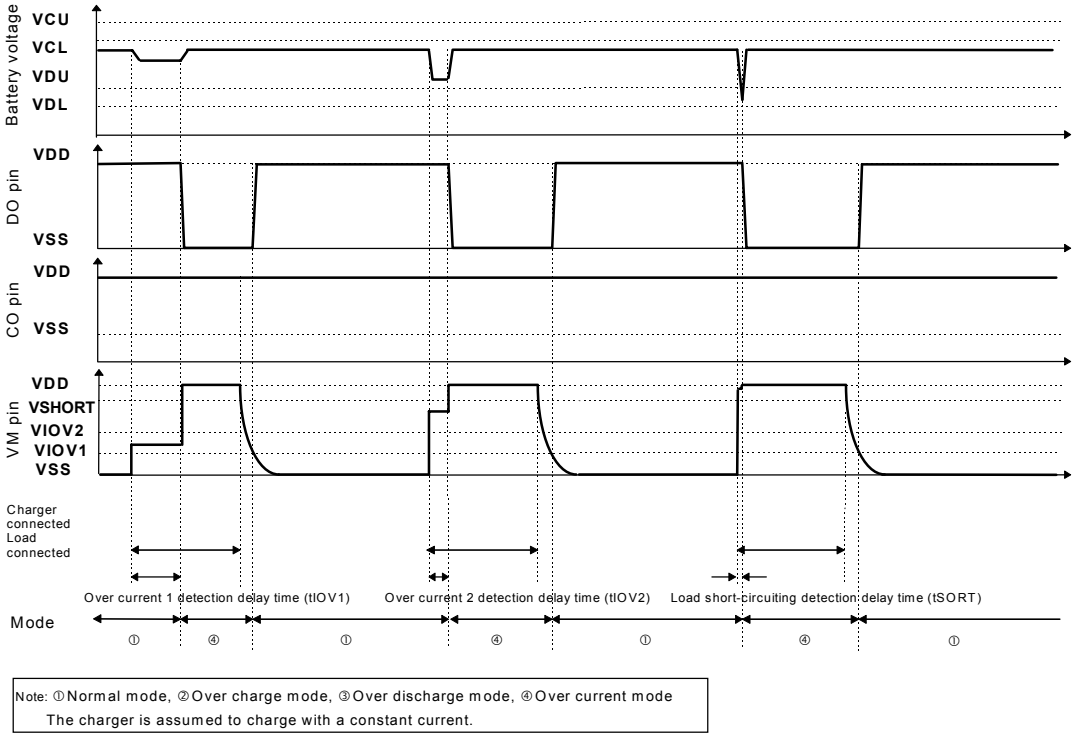
1-2. Overcharge and overdischarge detection (for products without power-down feature)



Note: ① Normal mode, ② Overcharge mode, ③ Overdischarge mode, ④ Overcurrent mode
The charger is assumed to charge with a constant current.

Figure 6-2

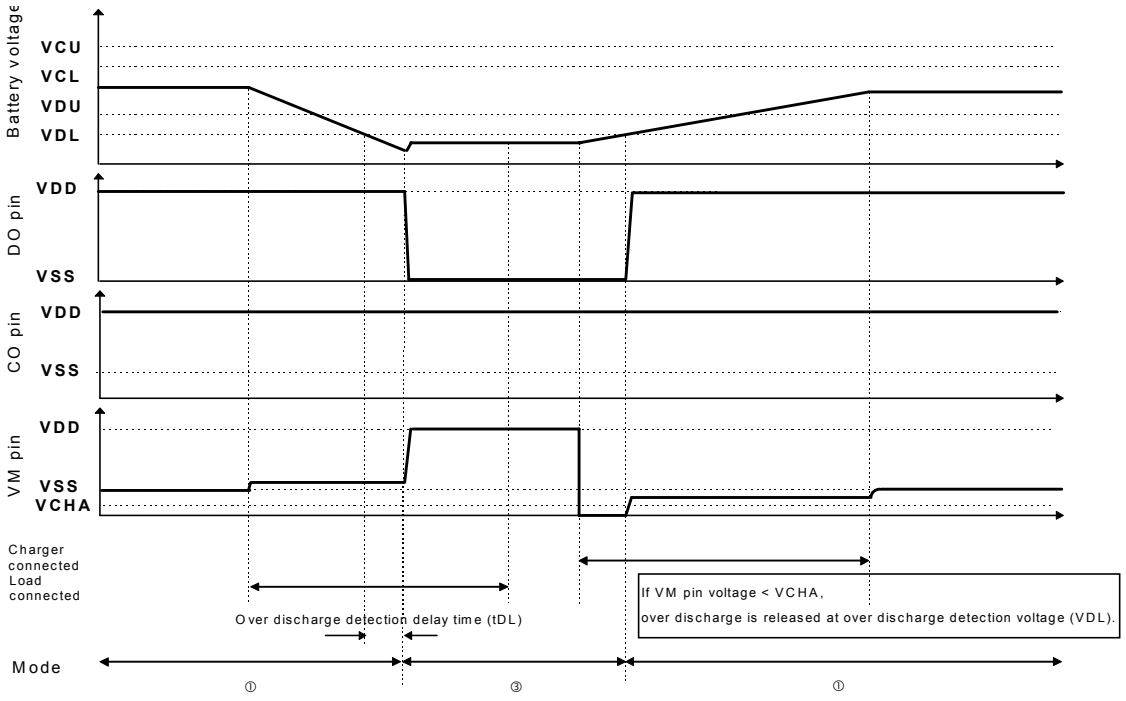
2. overcurrent detection



Note: ①Normal mode, ②Over charge mode, ③Over discharge mode, ④Over current mode
The charger is assumed to charge with a constant current.

Figure 7

3. Charger detection



Note: ①Normal mode, ②Over charge mode, ③Over discharge mode, ④Over current mode
The charger is assumed to charge with a constant current.

Figure 8

4. Abnormal charge current detection

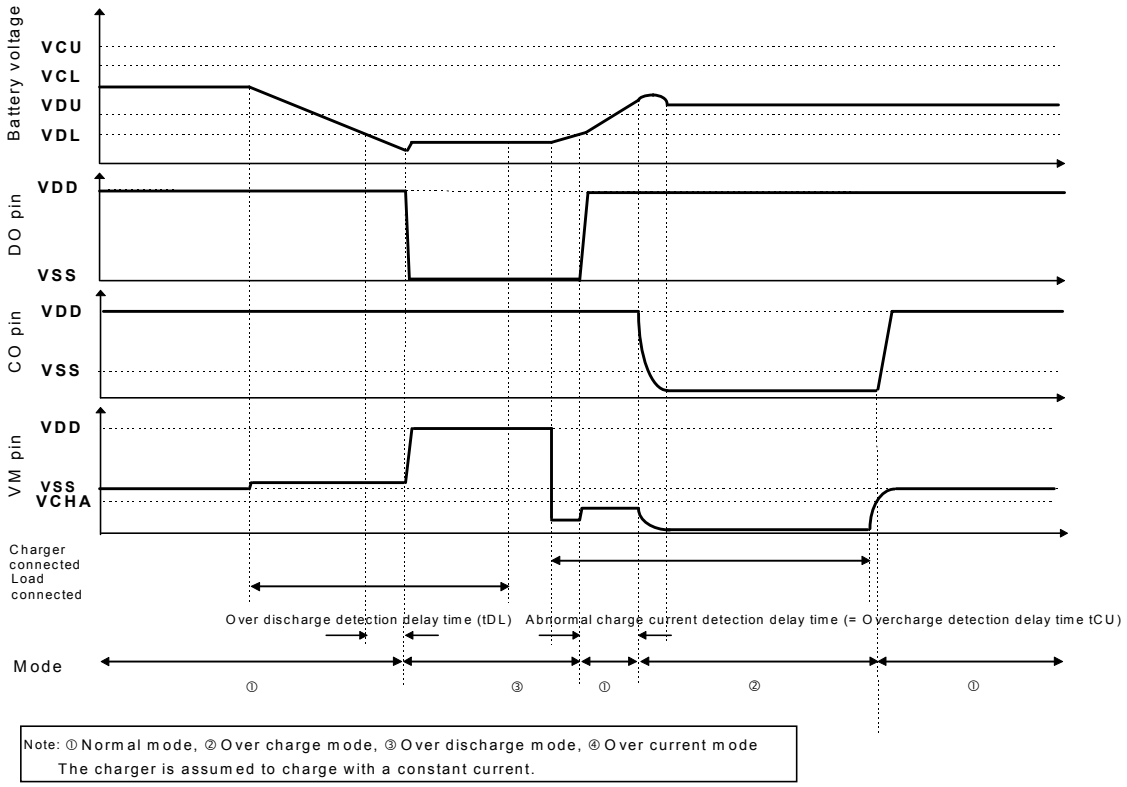


Figure 9

■ Battery Protection IC Connection Example

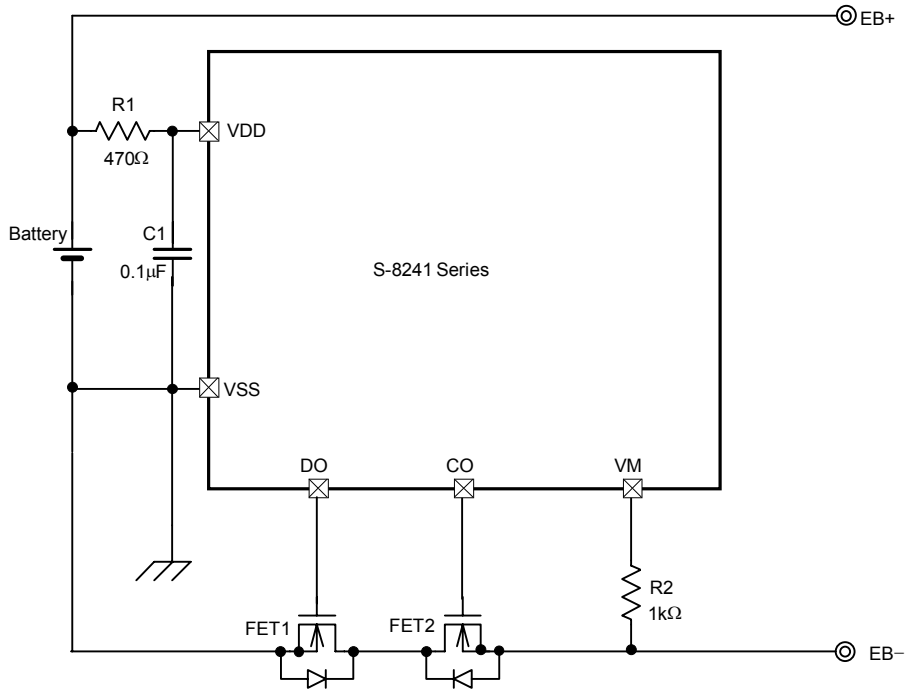


Figure 10

Table 1 Constant

Symbol	Parts	Purpose	Recommend	min.	max.	Remarks
FET1	Nch MOS_FET	Charge control	-----	-----	-----	*1) 0.4 V ≤ Threshold voltage ≤ overdischarge detection voltage Withstand voltage between gate and source ≥ Charger voltage
FET2	Nch MOS_FET	Discharge control	-----	-----	-----	*1) 0.4 V ≤ Threshold voltage ≤ overdischarge detection voltage Withstand voltage between gate and source ≥ Charger voltage
R1	Resistor	For ESD For power fluctuation	470Ω	300Ω	The same value as the R2	*2) Set resistance so that R1 ≤ R2.
C1	Capacitor	For power fluctuation	0.1μF	0.01μF	1.0 μF	*3) Install a capacitor of 0.01 μF or higher between VDD and VSS.
R2	Resistor	Protection at reverse connecting a charger	1KΩ	300Ω	1.3KΩ	*4) To prevent a current from occurring in the event of reverse connection of the charger, set the resistance within the range from 300 Ω to 1.3kΩ.

*1) If an FET with a threshold voltage of 0.4 V or lower is used, the charging current may not be able to be cut.
If an FET with a threshold voltage equal to or higher than the overdischarge detection voltage is used, discharging may stop before overdischarge is detected.
If the withstand voltage between the gate and source is lower than the charger voltage, the FET may be destroyed.

*2) If R1 has a higher resistance than R2 and the charger is connected reversely, current flows from the charger to the IC, and the voltage between VDD and VSS may exceed the absolute maximum rating.
Install a resistor of 300Ω or higher as R1 for ESD protection.
If R1 has a high resistance, the overcharge detection voltage increases by IC current consumption.

*3) If a capacitor of less than 0.01 μF is installed as C1, DO may oscillate when load short-circuiting is detected, a charger is connected reversely, or overcurrent 1 or 2 is detected.
Be sure to install a capacitor of 0.01 μF or higher as C1. With some types of batteries, DO oscillation may not stop unless the C1 capacity is increased. Set the C1 capacity by evaluating actual applications.

*4) If R2 is set to less than 300 Ω, a current which is higher than the permissible loss (power dissipation) flows through the IC and it may be damaged when the charger is connected reversely. If a resistor of higher than 1.3kΩ is installed as R2, the charging current may not be cut when a high-voltage charger is connected.

Note!: The above connection diagram and constants do not guarantee proper operations. Evaluate your actual application and set constants properly.

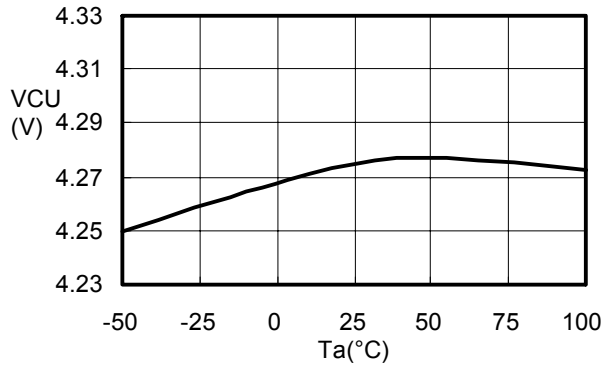
■ Precautions

- Pay attention to the operating conditions for input/output voltage and load current so that the loss of the IC does not exceed the permissible loss (power dissipation) of the package.
- Seiko Instruments Inc. shall not be responsible for any patent infringement by products including the S-8241 Series in connection with the method of using the S-8241 Series in such products, the product specifications or the country of destination thereof.

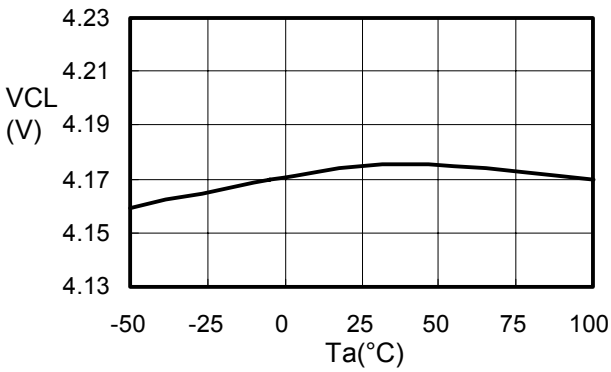
■ Characteristic (typical characteristic)

1. Detection/release voltage temperature characteristics

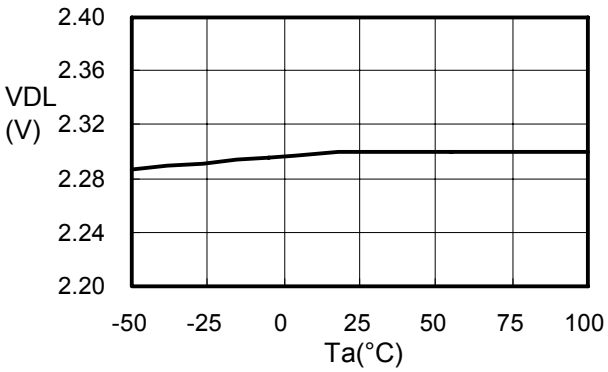
Overcharge detection voltage vs. temperature



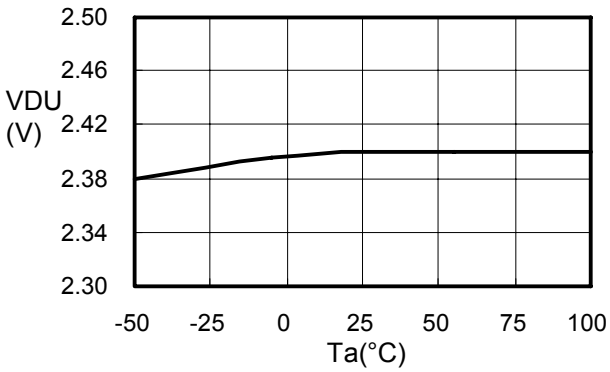
Overcharge release voltage vs. temperature



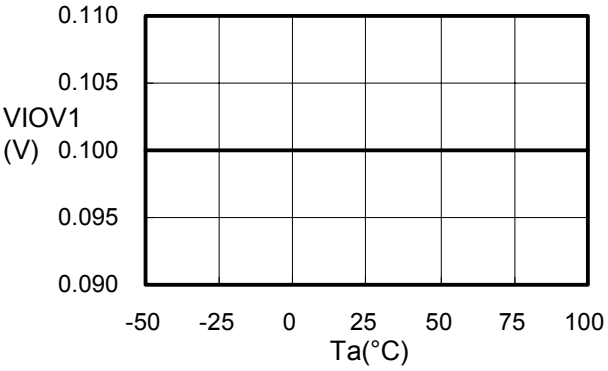
Overdischarge detection voltage vs. temperature



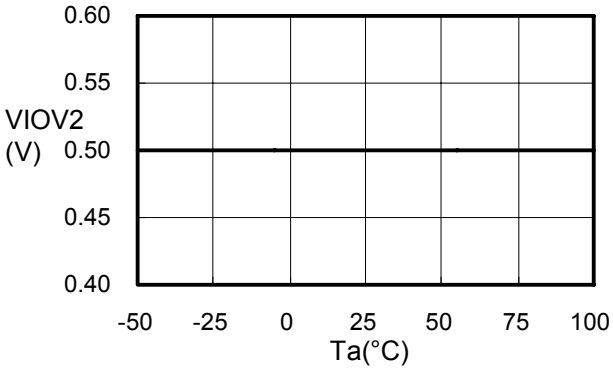
Overdischarge release voltage vs. temperature



Overcurrent 1 detection voltage vs. temperature

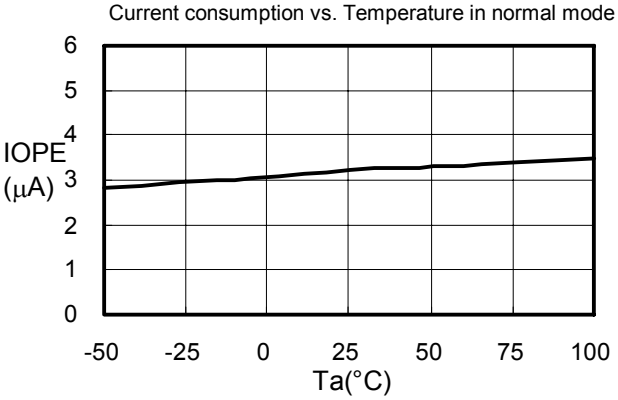


Overcurrent 2 detection voltage vs. temperature

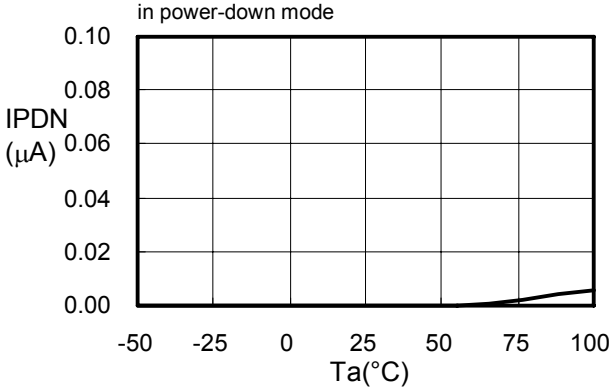


2. Current consumption temperature characteristics

Current consumption vs. Temperature in normal mode

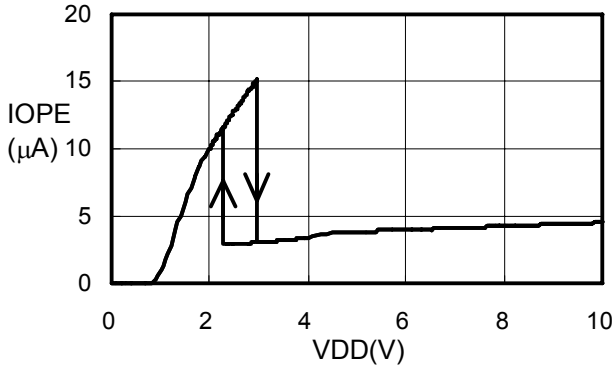


Current consumption vs. Temperature in power-down mode



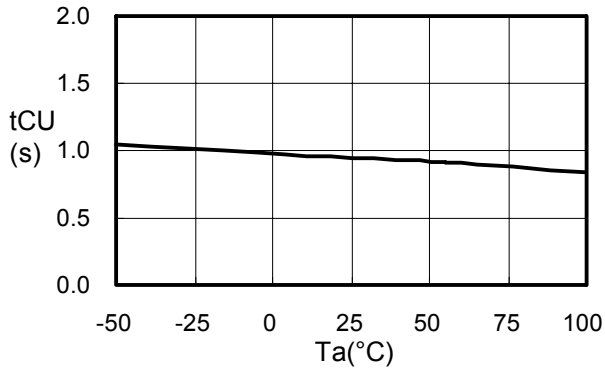
3. Current comsumption Power voltage characteristics (Ta=25°C)

Current consumption - -
power supply volatge dependency VM=VSS

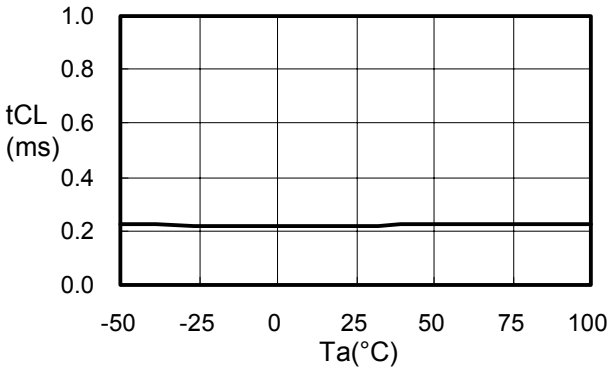


4. Detection/release delay time temperature characteristics

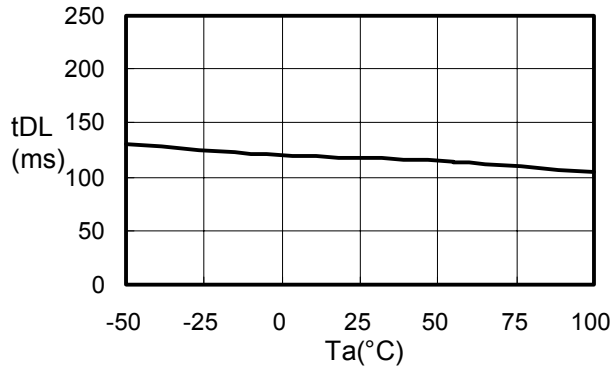
Overcharge detection delay time vs. temperature



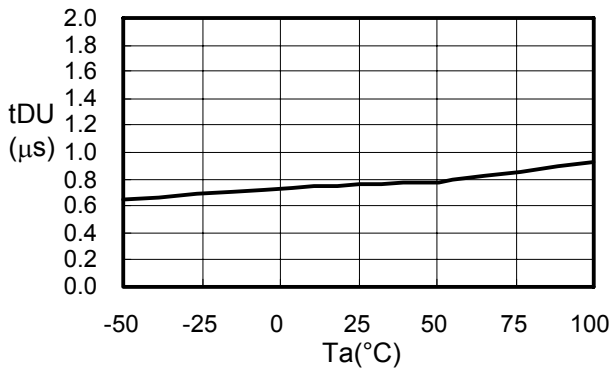
Overcharge release delay time vs. temperature



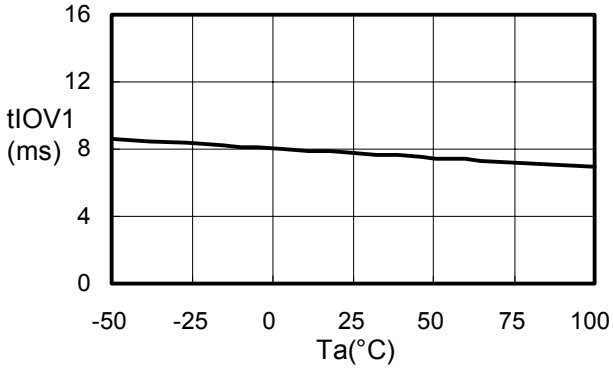
Overdischarge detection delay time vs. temperature



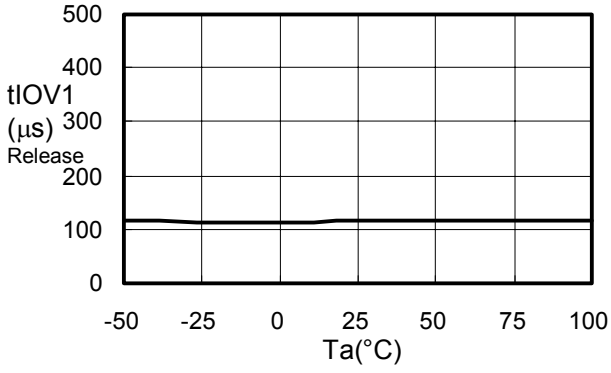
Overdischarge release delay time vs. temperature



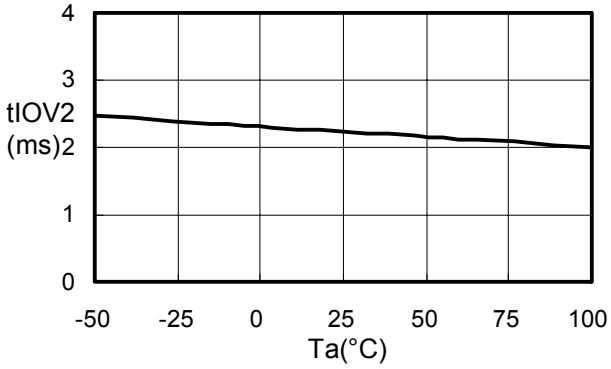
Overcurrent 1 detection delay time vs. temperature



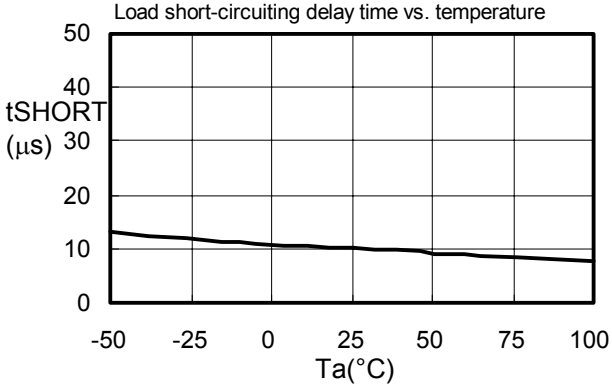
Overcurrent 1 release delay time vs. temperature



Overcurrent 2 detection delay time vs. temperature

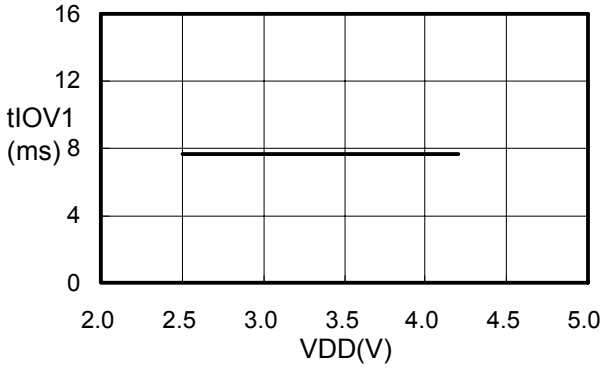


Load short-circuiting delay time vs. temperature

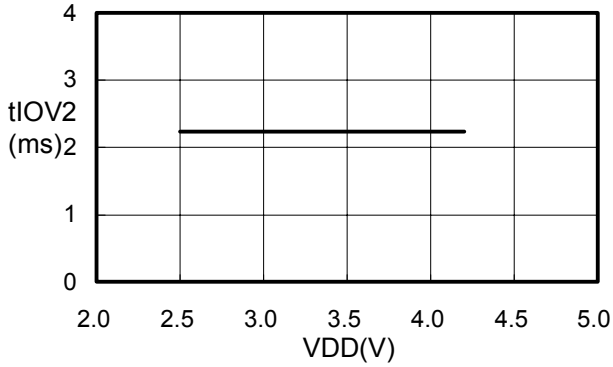


5. Delay time power-voltage characteristics(Ta=25°C)

Overcurrent 1 detection delay time vs. power supply voltage dependency

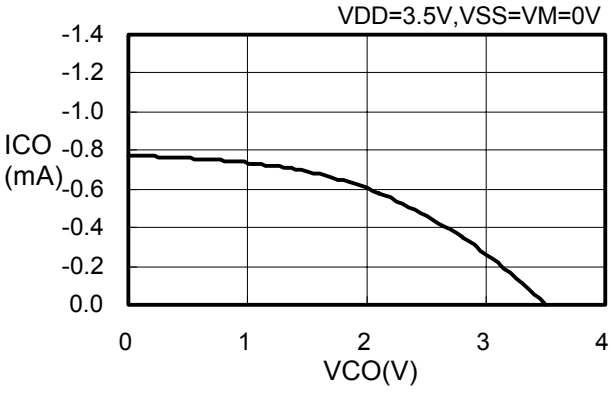


Overcurrent 2 detection delay time vs. power supply voltage dependency

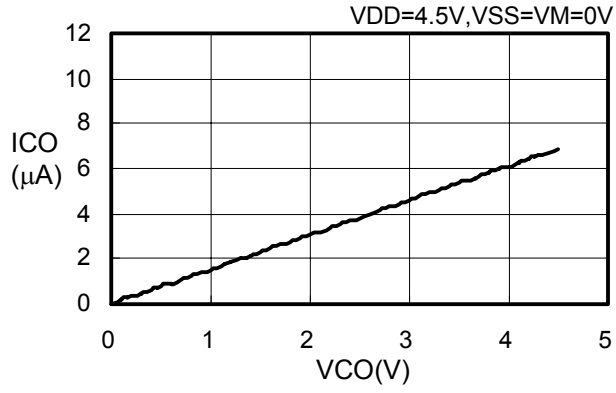


6. CO pin/DO pin output current characteristics(Ta=25°C)

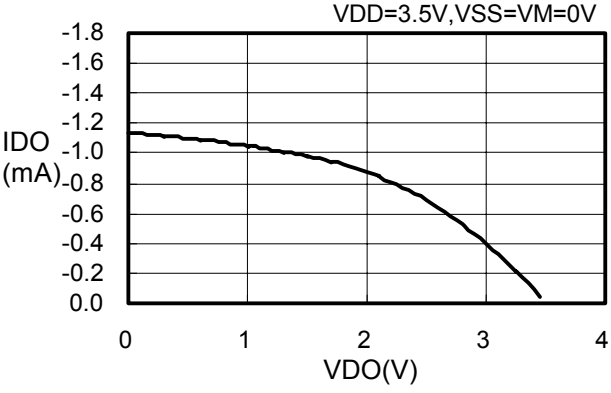
CO pin source current characteristics



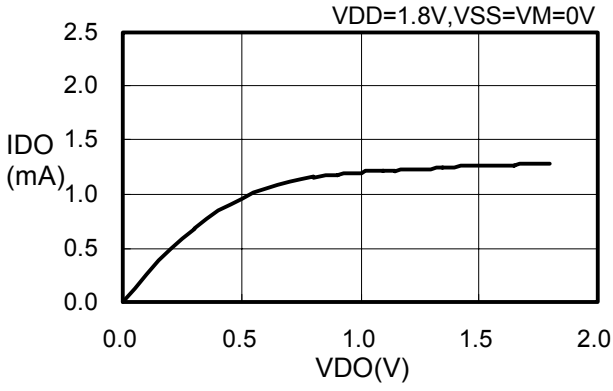
CO pin sink current characteristics



DO pin source current characteristics



DO pin sink current characteristics

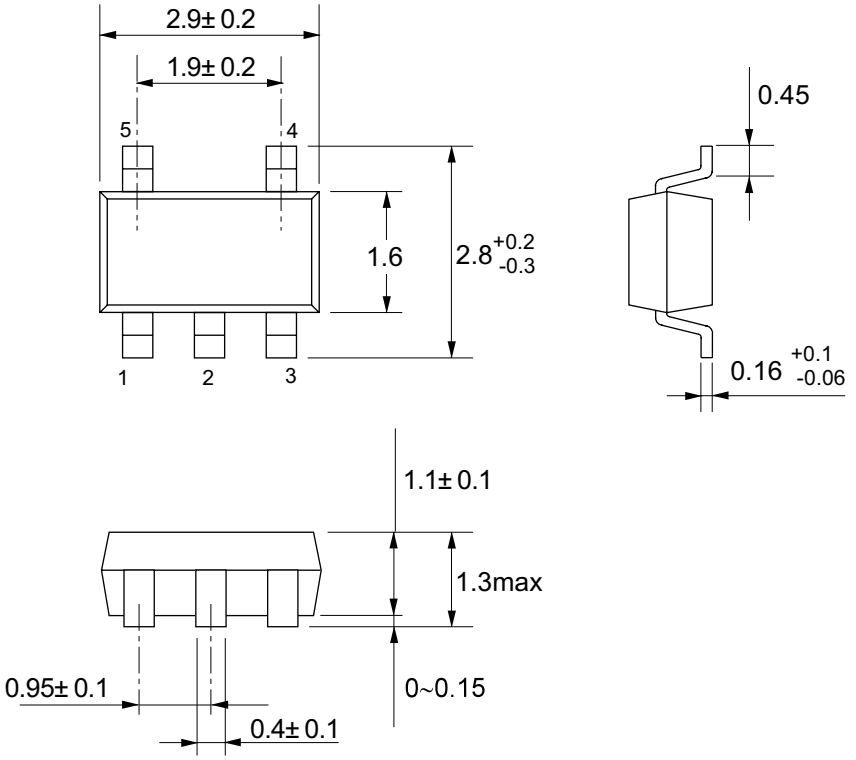


■ SOT-23-5

MP005-A 991105

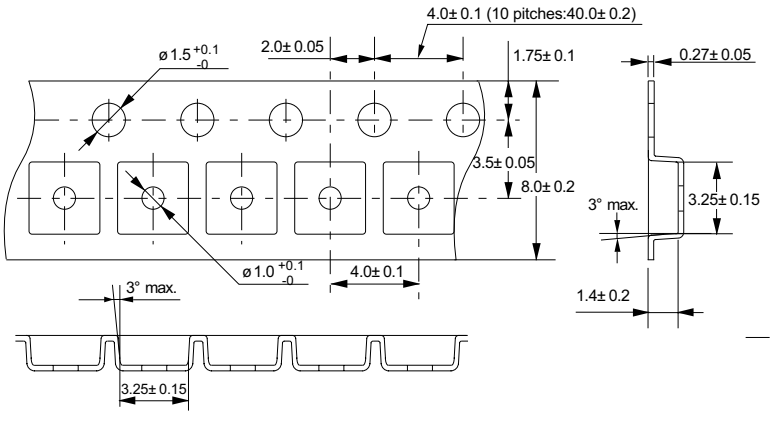
Unit: mm

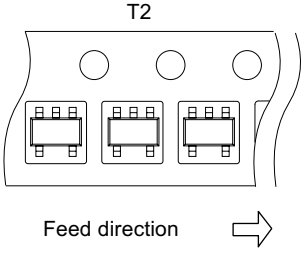
●Dimensions



No.:MP005-A-P-SD-1.0

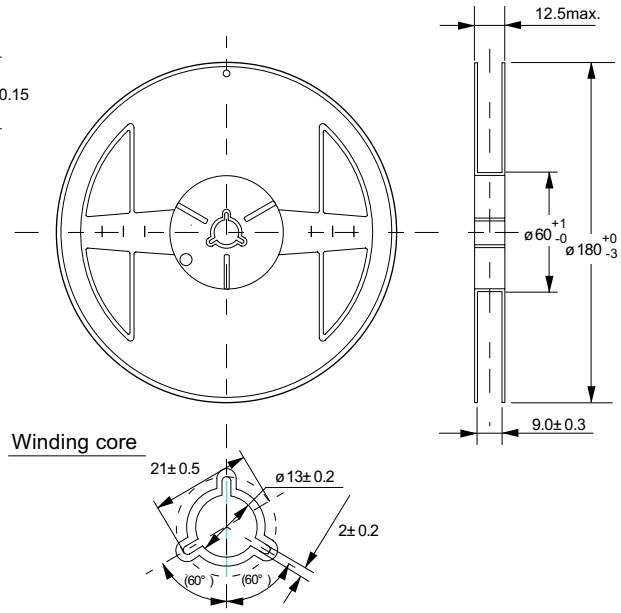
●Taping Specifications





●Reel Specifications

3000 pcs./reel



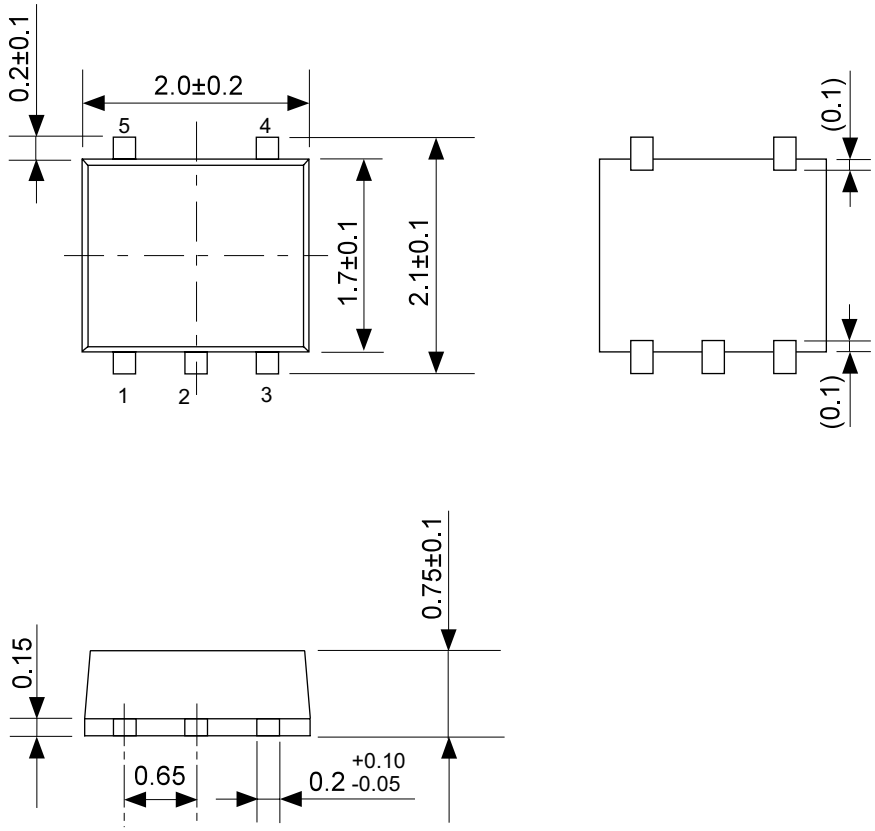
No.:MP005-A-R-SD-1.0

No.:MP005-A-C-SD-1.0

■ SON5 (2017)

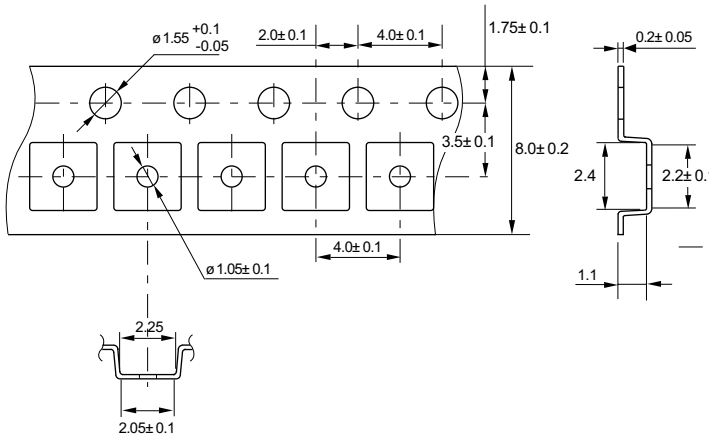
Unit:mm

●Dimensions



No. PN005-A-P-SD-1.0

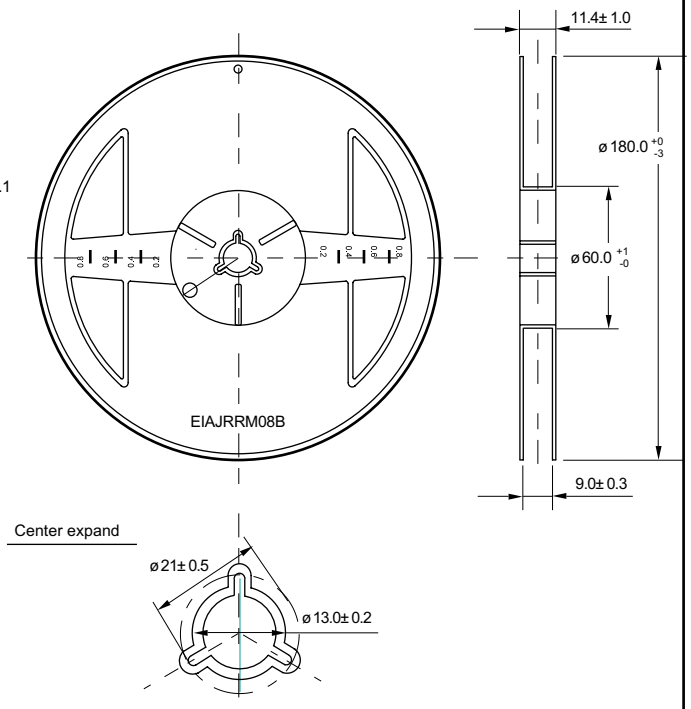
●Taping Specifications



No. PN005-A-C-SD-1.0

●Reel Specifications

1 reel holds 3000 ICs.



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