Ordering number : ENA1024

SANYO Semiconductors
DATA SHEET

LV51140T — CMOS IC 1-Cell Lithium-Ion Battery Protection IC

Overview

The LV51140T is protection IC for rechargeable Li-ion battery by high withstand voltage CMOS process.
The LV51140T protect single-cell Li-ion battery from over-charge, over-discharge, charge over-current and discharge over-current.

Features

• High accuracy detection voltage	Over-charge detection	±25mV
	Over-charge hysteresis	±25mV
	Over-discharge detection	±25%
	Charge over-current detection	±0.3V
	Discharge over-current detection	±20mV
• Delay time (internal adjustment)		
• Low current consumption	Operation	Typ. 3.0μA
	Over-discharge condition	Max. 0.1μA
• 0V cell battery charging function		

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_{DD}		V_{SS}-0.3 to V_{SS}+7	V
Input voltage of V_M	V_M		V_{DD}-28 to V_{DD}+0.3	V
Output voltage of C_O	VCO		V_M-0.3 to V_{DD}+0.3	V
Output voltage of D_O	VDO		V_{SS}-0.3 to V_{DD}+0.3	V
Power dissipation	P_D		350	mW
Operating temperature	Topr		-40 to +85	°C
Storage temperature	Tstg		-55 to +125	°C

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Electrical Characteristics at Topr = 25°C, unless otherwise specified

Parameter	Symbol	Conditions	Test circuit	Ratings			Unit
				min	typ	max	
Detection voltage							
Over-charge detection voltage	VC		1	4.225	4.250	4.275	V
Over-charge hysteresis voltage	VHc		1	0.175	0.2	0.225	V
Over-discharge detection voltage	Vdc		1	2.438	2.500	2.563	V
Over-discharge reset voltage	VRdc		1	2.633	2.700	2.768	V
Charge over-current detection voltage	VIc		2	-1.000	-0.700	-0.400	V
Discharge over-current detection voltage	VIdc		2	0.180	0.200	0.220	V
Load short-circuiting detection voltage	Vshort	Based on V_{DD}, V_{DD} = 3.5V	2	-1.7	-1.3	-1.0	V
Input voltage							
Input voltage between V_{DD} and V_{SS}	V_{DD}	Internal circuit operating voltage	-	1.8		7.0	V
0V battery charge starting charger voltage	Vcha	Acceptable	3		0.9	1.4	V
Current consumption							
Current consumption on operation	Iopr	V_{DD} = 3.5V, V_M = 0V	4		3.0	6.0	μA
Current consumption on shutdown	Isdn	V_{DD} = V_M = 1.8V	4			0.1	μA
Output resistance							
C_O : Pch ON resistance	Rcop	C_O = 3.0V, V_{DD} = 3.5V, V_M = 0V	5	1.5	3.0	4.5	kΩ
C_O : Nch ON resistance	Rcon	C_O = 0.5V, V_{DD} = 4.6V, V_M = 0V	5	0.5	1.0	1.5	kΩ
D_O : Pch ON resistance	Rdop	D_O = 3.0V, V_{DD} = 3.5V, V_M = 0V	5	1.7	3.5	5.0	kΩ
D_O : Nch ON resistance	Rdon	D_O = 0.5V, V_{DD} = V_M = 1.8V	5	1.7	3.5	5.0	kΩ
Discharge over-current release resistance	Rdwn	V_{DD} = 3.5V, V_M = 1.0V	5	15.0	30.0	60.0	kΩ
Detection delay time							
Over-charge detection delay time	tc	V_{DD} = VC-0.2V→VC+0.2V, V_M = 0V	6	0.70	1.0	1.30	s
Over-discharge detection delay time	tdc	V_{DD} = Vdc+0.2V→Vdc-0.2V, V_M = 0V	6	21.7	31.0	40.3	ms
Charge over-current detection delay time	tic	V_{DD} = 3.5V, V_M = 0V→-1.0V	6	5.6	8.0	10.4	ms
Discharge over-current detection delay time	tidc	V_{DD} = 3.5V, V_M = 0V→1.0V	6	5.6	8.0	10.4	ms
Load short-circuiting detection delay time	tshort	V_{DD} = 3.5V, V_M = 0V→3.5V	6	190	370	550	μs
Release delay time							
Release delay time 1 Over-discharge release Charge over-current release (*1) Discharge over-current release Load short-circuiting release	trel1		6	1.0	2.0	3.0	ms
Release delay time 2 Over-charge release	trel2	V_{DD} = VC+0.2V→VC-0.2V, V_M = 1.0V	6	8.0	16.0	24.0	ms

Note : *1 Upon connecting to charger upon over-discharge, the delay time after recovery from over-discharge.

Package Dimensions

unit : mm (typ)

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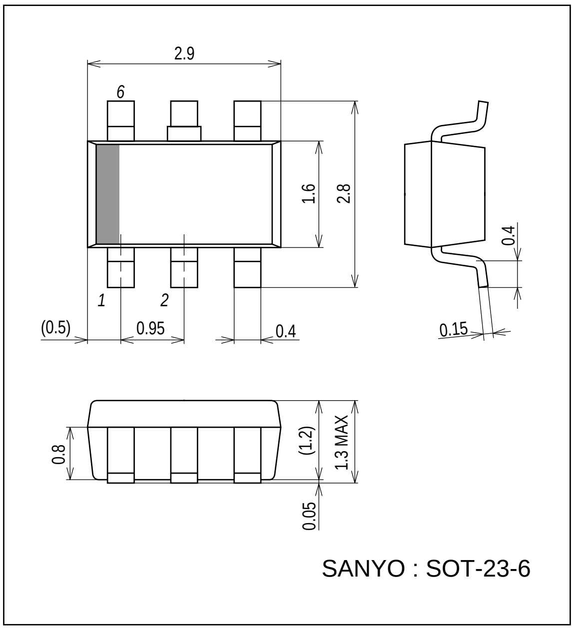
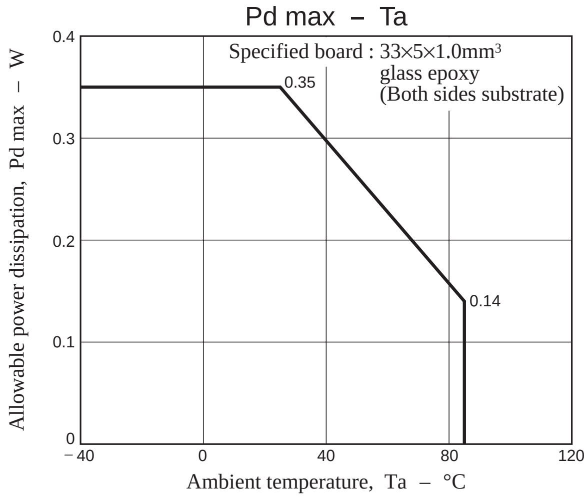
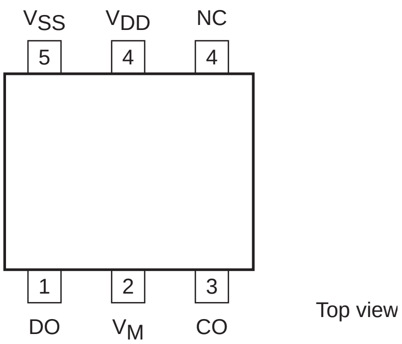




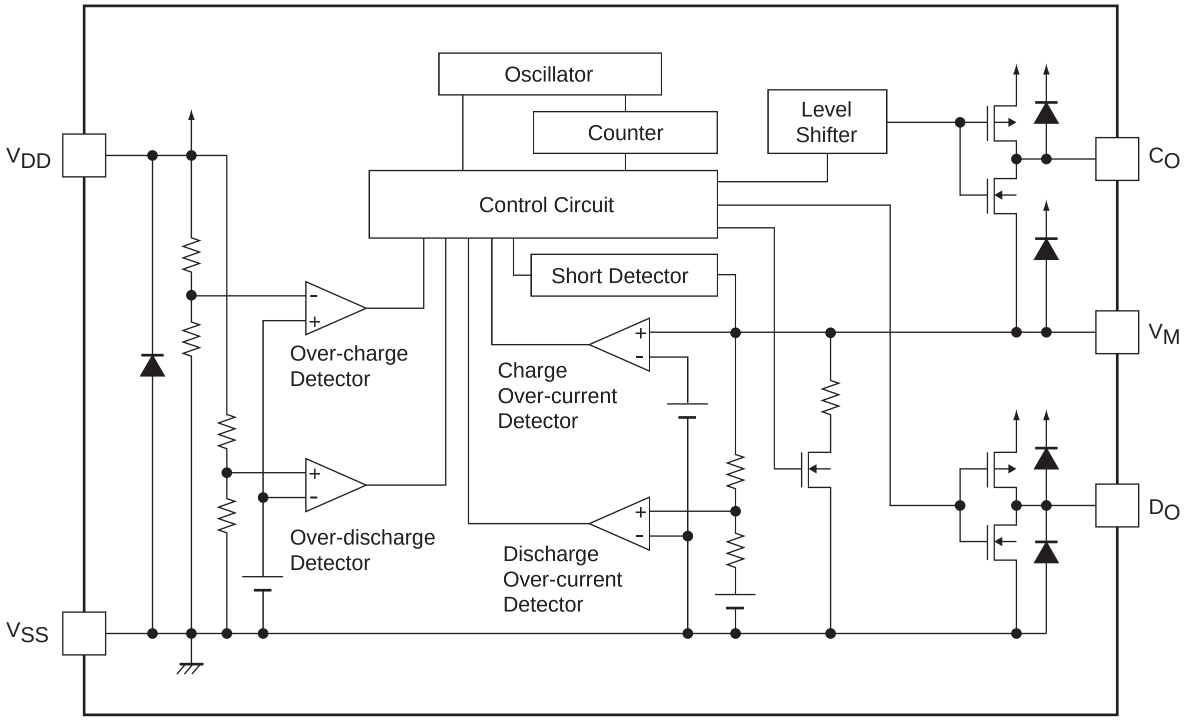
Pin Assignment



Pin Function

Pin No.	Pin Name	Description
1	D_O	FET gate connection for discharge control (CMOS output)
2	V_M	Voltage monitoring for charger negative
3	C_O	FET gate connection for charge control (CMOS output)
4	NC	N/C
5	V_{DD}	Positive power input
6	V_{SS}	Negative power input

Block Diagram



Measurement Conditions

- Over-charge detection voltage, Over-charge hysteresis voltage --- [Circuit 1]
  Set V1 = 3.5V and V2 = 0V. Over-charge detection voltage VC is V1 at which VCO goes "Low" from "High" when V1 is gradually increased from 3.5V. Then IC is released from the over-charge state and VCO goes "High" from "Low" at the voltage "Measured VC-VHc" when V1 is gradually decreased.
  If V2 is set to the greater value than discharge over-current detection voltage VIdc in the over-charge state, VHc is canceled and then IC is released from the over-charge state at VC.

- Over-discharge detection voltage --- [Circuit 1]
  Set V1 = 3.5V and V2 = 0V. Over-discharge detection voltage Vdc is V1 at which VDO goes "Low" from "High" when V1 is gradually decreased from 3.5V. Next, set V2 under to charge over-current detection voltage VIc. Then IC is released from the over-discharge state at Vdc and VDO goes "High" from "Low".

- Charge over-current detection voltage --- [Circuit 2]
  Set V1 = 3.5V and V2 = 0V. Charge over-current detection voltage VIc is V2 at which VCO goes "Low" from "High" when V2 is gradually decreased from 0V.

- Discharge over-current detection voltage --- [Circuit 2]
  Set V1 = 3.5V and V2 = 0V. Discharge over-current detection voltage VIdc is V2 at which VDO goes "Low" from "High" when V2 is gradually increased from 0V.

- Load short-circuiting detection voltage --- [Circuit 2]
  Set V1 = 3.5V and V2 = 0V. Load short-circuiting detection voltage Vshort is V2 at which VDO goes "Low" from "High" within a time between the minimum and the maximum value of load short-circuiting detection delay time tshort, when V2 is increased rapidly within 10μs.

- 0V battery charge starting charger voltage --- [Circuit 3]
  Set V1 = V2 = 0V and decrease V2 gradually. 0V battery charge starting charger voltage Vcha is V2 when VCO goes "High" (V1-0.1V or higher).

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- Current consumption on operation and shutdown --- [Circuit 4]
  Set V1 = 3.5V and V2 = 0V on normal condition. I_{DD} shows current consumption on operation Iopr.
  Set V1 = V2 = 1.8V on over-discharge condition. I_{DD} shows current consumption on shutdown Isdn.

- Co : Pch ON resistance, Co : Nch ON resistance --- [Circuit 5]
  Set V1 = 3.5V, V2 = 0V and V3 = 3.0V. (V1-V3)/|ICo| is Pch ON resistance Rcop.
  Set V1 = 4.6V, V2 = 0V and V3 = 0.5V. V3/|ICo| is Nch ON resistance Rcon.

- Do : Pch ON resistance, Do : Nch ON resistance --- [Circuit 5]
  Set V1 = 3.5V, V2 = 0V and V4 = 3.0V. (V1-V4)/|IDo| is Pch ON resistance Rdop.
  Set V1 = V2 = 1.8V and V4 = 0.5V. V4/|IDo| is Nch ON resistance Rdon.

- Discharge over-current release resistance --- [Circuit 5]
  Set V1 = 3.5V, V2 = 0V at first. And then, set V2 = 1.0V. V2/|IV_M| is discharge over-current release resistance Rdwn.

- Over-charge detection delay time, Release delay time 2 --- [Circuit 6]
  Set V2 = 0V. Increase V1 from the voltage VC-0.2V to VC+0.2V rapidly within 10μs. Over-charge detection delay time tc is the time needed for VCO to go "Low" just after the change of V1.
  Next, set V2 = 1V and decrease V1 from VC+0.2V to VC-0.2V rapidly within 10μs. Over-charge release delay time trel 2 is the time needed for VCO to go "High" just after the change of V1.

- Over-discharge detection delay time, Release delay time 1 --- [Circuit 6]
  Set V2 = 0V. Decrease V1 from the voltage Vdc+0.2V to Vdc-0.2V rapidly within 10μs. Over-discharge detection delay time tdc is the time needed for VDO to go "Low" just after the change of V1.
  Next, set V2 = -1V and increase V1 from Vdc-0.2V to Vdc+0.2V rapidly within 10μs. Release delay time 1 trel1 in case of over-discharge is the time needed for VDO to go "High" just after the change of V1.

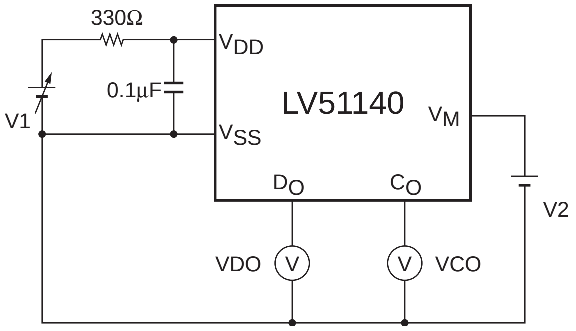
- Charge over-current detection delay time, Release delay time 1 --- [Circuit 6]
  Set V1 = 3.5V and V2 = 0V. Decrease V2 from 0V to -1V rapidly within 10μs. Charge over-current delay time tic is the time needed for VCO to go "Low" just after the change of V2.
  Next, increase V2 from -1V to 0V rapidly within 10μs. Release delay time 1 trel1 in case of charge over-current is the time needed for VCO to go "High" just after the change of V2.

- Discharge over-current detection delay time, Release delay time 1 --- [Circuit 6]
  Set V1 = 3.5V and V2 = 0V. Increase V2 from 0V to 1V rapidly within 10μs. Discharge over-current delay time tidc is the time needed for VDO to go "Low" just after the change of V2.
  Next, decrease V2 from 1V to 0V rapidly within 10μs. Release delay time 1 trel1 in case of discharge over-current is the time needed for VDO to go "High" just after the change of V2.

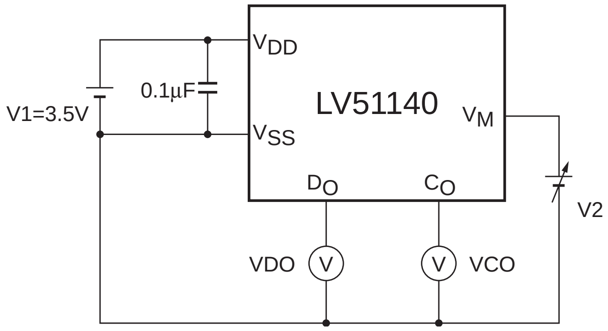
- Load short-circuiting detection delay time, Release delay time 1 --- [Circuit 6]
  Set V1 = 3.5V and V2 = 0V. Increase V2 from 0V to 3.5V rapidly within 10μs. Load short-circuiting detection delay time tshort is the time needed for VDO to go "Low" just after the change of V2.
  Next, decrease V2 from 3.5V to 0V rapidly within 10μs. Release delay time 1 trel1 in case of load short-circuiting is the time needed for VDO to go "High" just after the change of V2.

Measurement Circuits

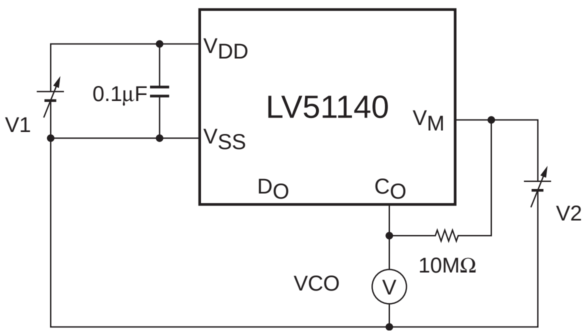
• Circuit 1



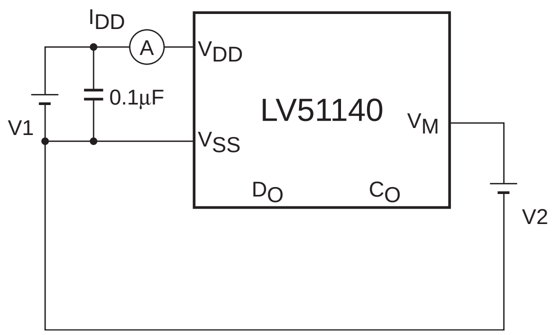
• Circuit 2



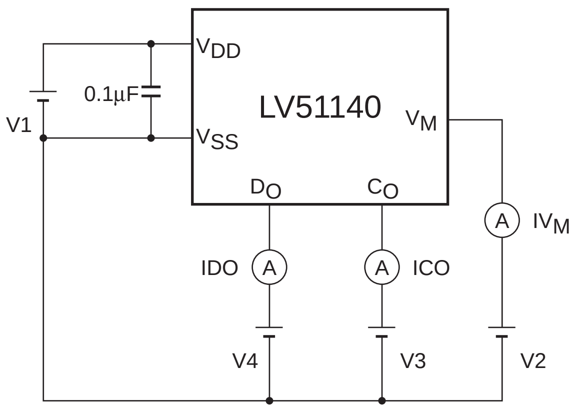
• Circuit 3



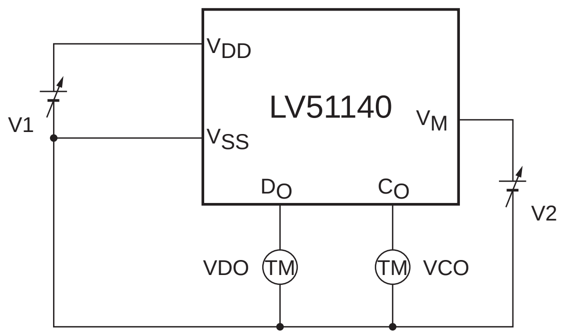
• Circuit 4



• Circuit 5

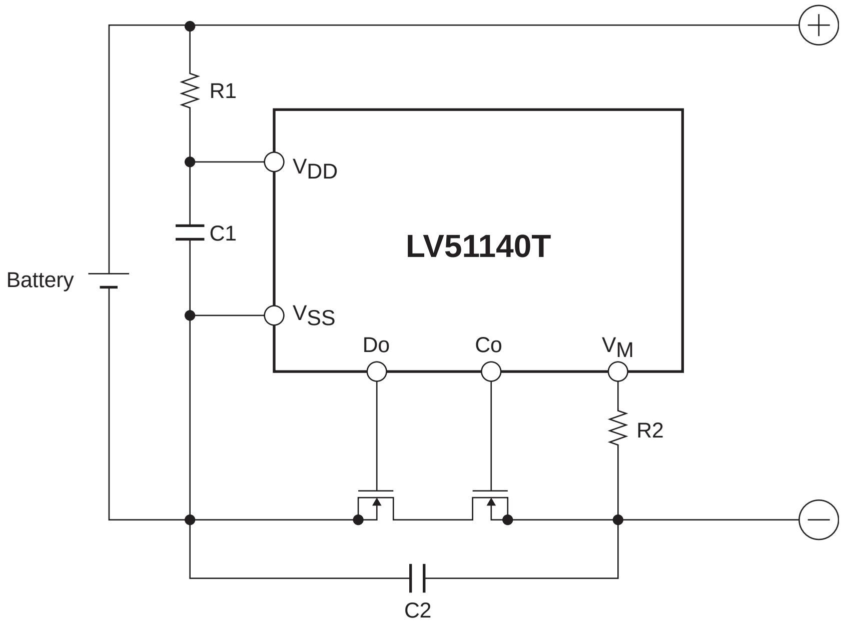


• Circuit 6



TM = Time Measurement

Application Circuit Example



External Components

Items	Symbol	Recommended value
Resistor 1	R1	330Ω
Capacitor 1	C1, 2	0.1μF
Resistor 2	R2	3.9kΩ

- The supply voltage (V_{DD}) to this IC is stabilized by R1 and C1. Moreover, R1 and R2 act as the current restriction resistances at the time of reverse-connecting a charger, or at the time of connecting a charger which outputs the voltage exceeding the absolute maximum rating of this IC. Be sure to connect these components.

- If the value of R1 is too large, the over-charge detection voltage will become high due to the current consumption of this IC. 330Ω is recommended.

- If the value of C1 is too small, this IC may be in a shutdown state at the time of the discharge over-current or the load short-circuiting. 0.1μF is recommended.

- Use the value within the limits shown in the table about the value of R2. In order to reduce the current at the time of reverse-connecting a charger, we recommend to choose R1 and R2 so that the sum total of resistance values is more than 4kΩ. The recommended value of R2 is 3.9kΩ.

Note 1 : The connection diagram and each value of external components shown above are just recommendation. Including a battery and FETs, determine the circuit after sufficient evaluation about your actual application.

Note 2 : The IC is susceptible to static electricity and some pins are easily damaged by it. Handle the IC carefully.

Description of Operation

• Normal condition

This IC monitors the battery voltage (V_{DD}) and the voltage of V_M terminal, and controls charge and discharge.
If the battery voltage (V_{DD}) is in the range from the over-discharge detection voltage (Vdc) to the over-charge detection voltage (VC) and the V_M terminal voltage is in the range from the charge over-current detection voltage (VIc) to the discharge over-current detection voltage (VIdc), this IC turns on both the charge and discharge control FETs. This state is called the normal condition, and charge and discharge are possible together.

• Discharge over-current detection, Load short-circuiting detection

When the discharge current becomes equal to or higher than the specified value under the normal condition, and if the V_M terminal voltage is in the range from the discharge over current detection voltage (VIdc) to the short-circuiting detection voltage (Vshort) and that state is maintained during more than the discharge over-current detection delay time (tidc), this IC turns off the discharge control FET to stop discharge. This state is called the discharge over-current condition.
At that time, if the V_M terminal voltage is equal to or higher than Vshort and that state is maintained during more than the load short-circuiting detection delay time (tshort), this IC turns off the discharge control FET to stop discharge. This state is called the load short-circuiting detection condition.
While load is connected, in both conditions, the V_M terminal voltage equals to V_{DD} potential due to the load, but it falls by the discharge over-current release resistance (Rdwn) when the load is removed and the resistance between (+) and (-) terminals of battery pack (refer to "Application Circuit Example") becomes larger than the value which enables the automatic return.
Then the V_M terminal voltage becomes less than VIdc, and if that state is maintained during more than the release delay time 1 (trel1), this IC returns to normal condition.

Note : The resistance value between (+) and (-) terminals of battery pack for automatic return changes with battery voltage (V_{DD}) or VIdc. The standard is expressed with the following equation.

Resistance value for automatic return = Rdwn × (V_{DD} / VIdc - 1)

• Charge over-current detection

When the charge current becomes equal to or higher than the specified value under the normal condition, if the V_M terminal voltage becomes less than the charge over-current detection voltage (VIc) and that state is maintained during more than the charge over-current detection delay time (tic), this IC turns off the charge control FET to stop charge. This state is called the charge over-current detection condition.
Then the V_M terminal voltage becomes equals to or higher than VIc and that state is maintained during more than the release delay time 1 (trel1) when the charger is removed and the load is connected, this IC returns to the normal condition.

Note : If the V_M terminal voltage becomes equal to or less than V_{SS}-7V (typical), the charge over-current detection delay time (tic) changes as below.

8ms model	→	8ms (not changed)
125ms model	→	7ms (typical)
1.0s model	→	56ms (typical)

• Over-charge detection

When the battery voltage (V_{DD}) under the normal condition becomes equal to or higher than the over-charge detection voltage (VC) and that state is maintained during more than the over-charge detection delay time (tc), this IC turns off the charge control FET and stops charge. This state is called the over-charge detection condition. Release from the over-charge detection condition includes following three cases.

(1) When V_{DD} falls to Vc-VHc without load and that state is maintained during more than the delay time 2 (trel2), this IC turns on the charge control FET and returns to the normal condition.
* VHc : Over-charge hysteresis voltage

(2) When the load is installed and discharge starts, the discharge current flows through the internal parasitic diode of the charge control FET. Then the V_M terminal voltage rises to only the Vf voltage of the internal parasitic diode from V_{SS} potential. At this time, if the V_M terminal voltage is higher than the discharge over-current detection voltage (VIdc) and V_{DD} is equal to or less than VC, this IC returns to the normal condition when this state continues more than the delay time 2 (trel2).

(3) In case (2), if the V_M terminal voltage is higher than the discharge over-current detection voltage (VIdc) and V_{DD} is equal to or higher than VC, battery is discharged until V_{DD} becomes less than VC, and then this IC returns to the normal condition when this state continues more than the delay time 2 (trel2).

- Over-discharge detection

  When the battery voltage (V_{DD}) under the normal condition becomes equal to or less than the over-discharge detection voltage (Vdc) and that state continues for more than the over-discharge detection time (tdc), this IC turns off the discharge control FET and stops discharging. This state is called the over-discharge detection condition. Recovery from the over-discharge detection condition is achieved only by connecting the charger.

- Return from over-discharge

  When the charger is connected and charging starts, the charge current flows through the internal parasitic diode of the discharge control FET. If the V_M terminal voltage is higher than the charge over-current detection voltage (VIc), the IC returns to the normal condition when V_{DD} becomes equal to or higher than VRdc and this state continues more than the delay time1 (trel1).

  If the V_M terminal voltage is lower than the charge over-current detection voltage (VIc), same as the above-mentioned case, the IC returns to the normal condition when V_{DD} becomes equal to or higher than Vdc and this state continues more than the delay time1 (trel1).

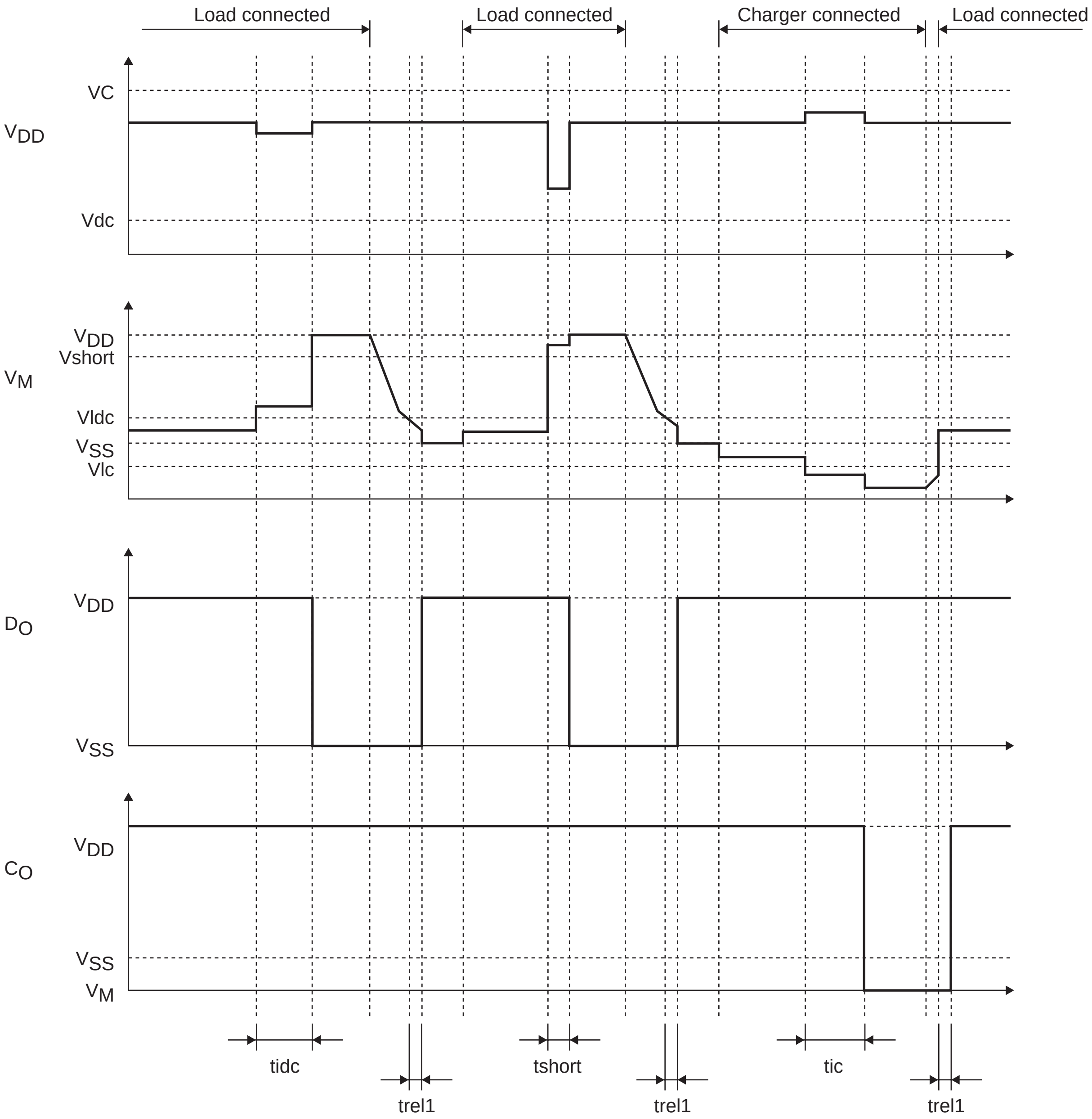
  This IC stops all internal circuits (Shutdown condition) after detecting the over-discharge and reduces current consumption. (Max 0.1μA, at V_{DD} = 1.8V)

- 0V battery charge function

  If the voltage of charger (the voltage between V_{DD} and V_M) is larger than the 0V battery charge starting charger voltage (Vcha), 0V battery charge becomes possible when CO terminal outputs V_{DD} terminal potential and turns on the charge control FET.

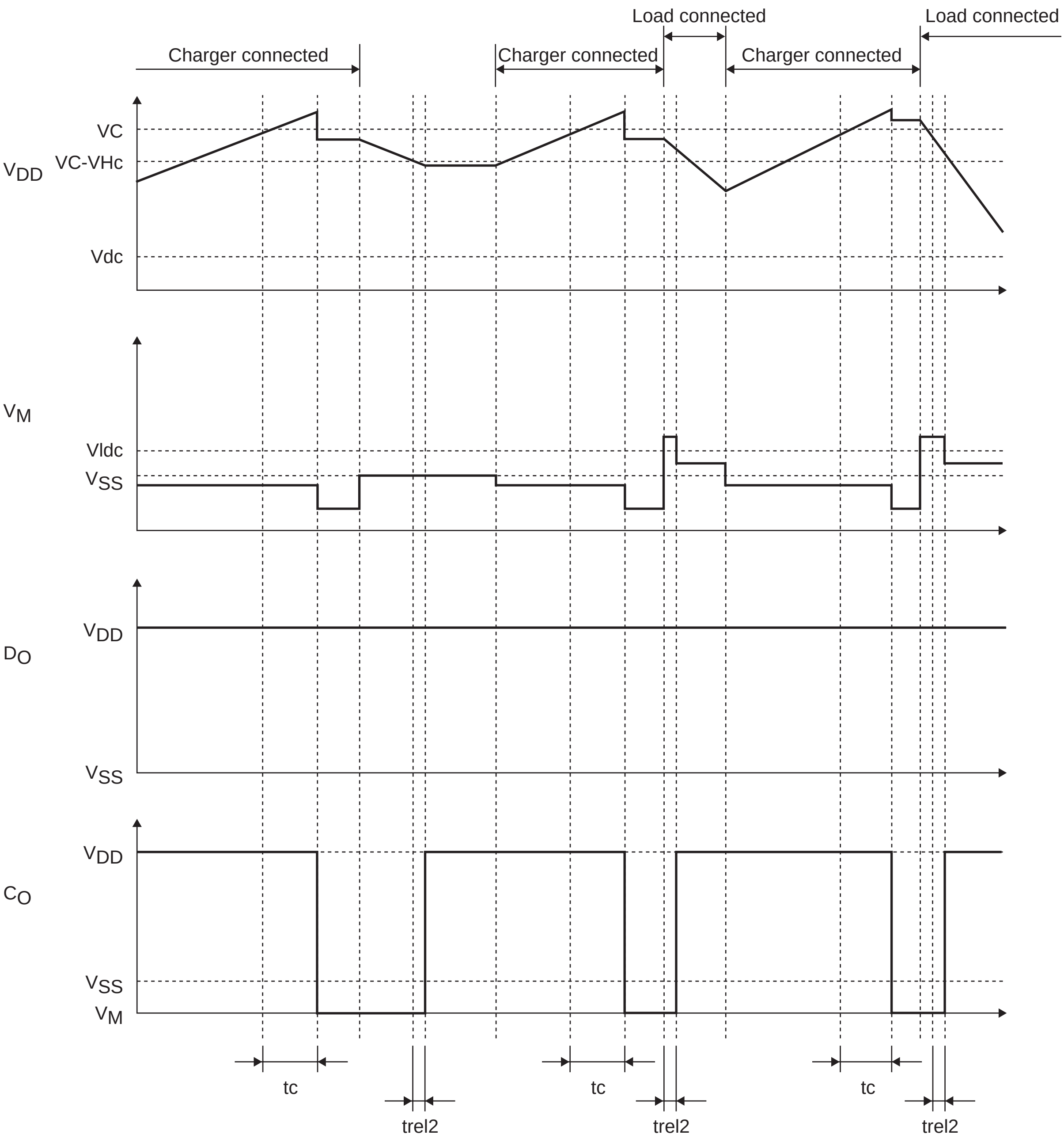
Timing Chart

• Discharge over-current detection, Load short-circuiting detection, Charge over-current detection



VC	: Over-charge detection voltage	tic	: Charge over-current detection delay time
Vdc	: Over-discharge detection voltage	tidc	: Discharge over-current detection delay time
VIc	: Charge over-current detection voltage	tshort	: Load short-circuiting detection delay time
VIdc	: Discharge over-current detection voltage	trel1	: Release delay time 1
Vshort	: Load short-circuiting detection voltage		

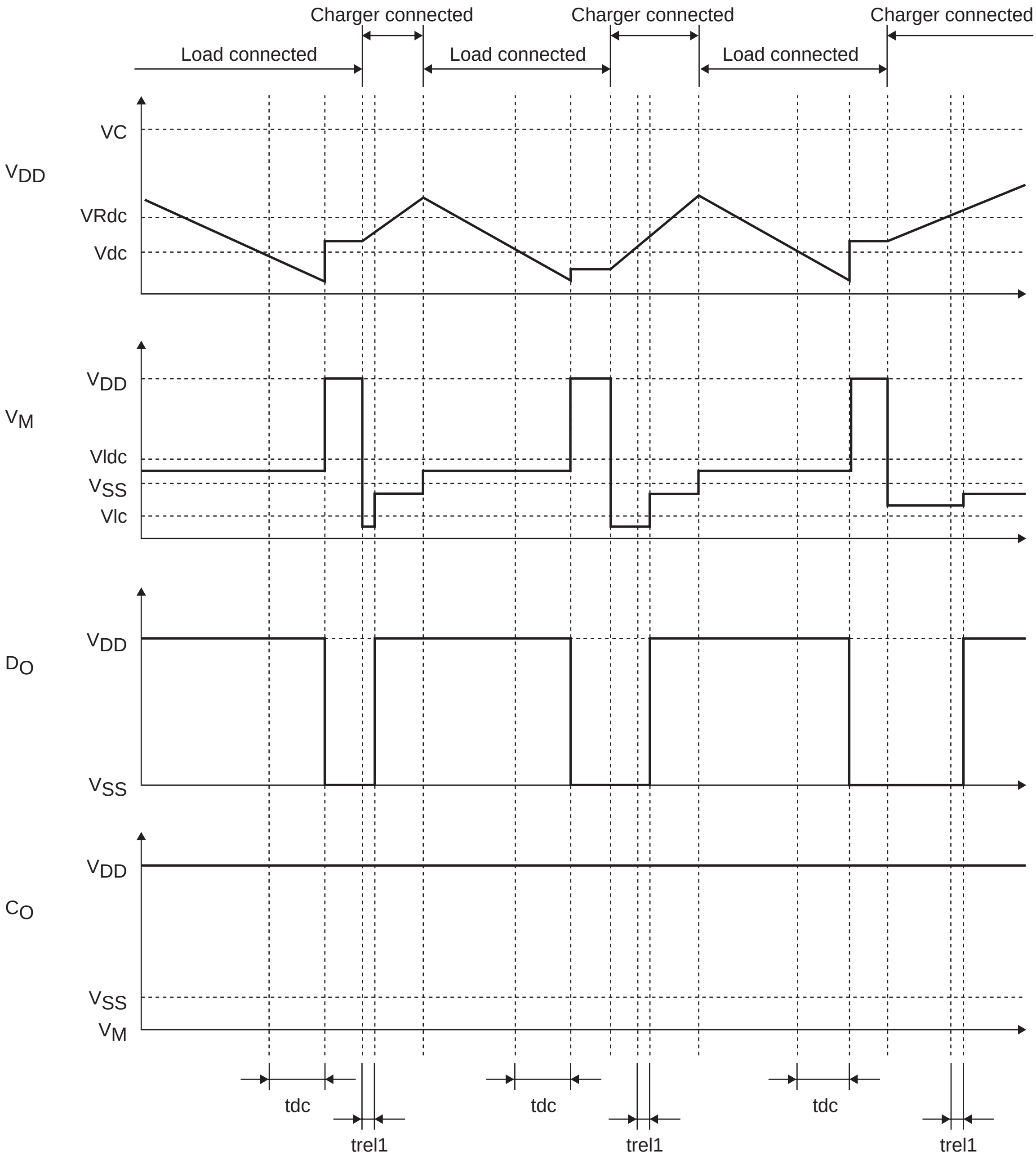
• Over-charge detection



VC : Over-charge detection voltage
Vdc : Over-discharge detection voltage
VHc : Over-charge hysteresis voltage
Vidc : Discharge over-current detection voltage

tc : Over-charge detection delay time
trel2 : Release delay time 2

• Over-discharge detection



VC : Over-charge detection voltage
Vdc : Over-discharge detection voltage
VRdc : Return from over-discharge voltage
Vic : Charge over-current detection voltage
Vidc : Discharge over-current detection voltage

tdc : Over-discharge detection delay time
trel1 : Release delay time 1

This catalog provides information as of May, 2008. Specifications and information herein are subject to change without notice.