



SANYO Semiconductors

DATA SHEET

CMOS IC LV51141T — 1-Cell Lithium-Ion Battery Protection IC

Overview

The LV51141T is protection IC for rechargeable Li-ion battery by high withstand voltage CMOS process.

The LV51141T 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	V _{CO}		V _M -0.3 to V _{DD} +0.3	V
Output voltage of D _O	V _{DO}		V _{SS} -0.3 to V _{DD} +0.3	V
Power dissipation	P _D		350	mW
Operating temperature	T _{opr}		-40 to +85	°C
Storage temperature	T _{stg}		-55 to +125	°C

■ Any and all SANYO Semiconductor Co.,Ltd. products described or contained herein are, with regard to "standard application", intended for the use as general electronics equipment (home appliances, AV equipment, communication device, office equipment, industrial equipment etc.). The products mentioned herein shall not be intended for use for any "special application" (medical equipment whose purpose is to sustain life, aerospace instrument, nuclear control device, burning appliances, transportation machine, traffic signal system, safety equipment etc.) that shall require extremely high level of reliability and can directly threaten human lives in case of failure or malfunction of the product or may cause harm to human bodies, nor shall they grant any guarantee thereof. If you should intend to use our products for applications outside the standard applications of our customer who is considering such use and/or outside the scope of our intended standard applications, please consult with us prior to the intended use. If there is no consultation or inquiry before the intended use, our customer shall be solely responsible for the use.

■ Specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein stipulate the performance, characteristics, and functions of the described products in the independent state, and are not guarantees of the performance, characteristics, and functions of the described products as mounted in the customer's products or equipment. To verify symptoms and states that cannot be evaluated in an independent device, the customer should always evaluate and test devices mounted in the customer's products or equipment.

SANYO Semiconductor Co., Ltd.

TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

LV51141T

Electrical Characteristics at $T_{opr} = 25^{\circ}\text{C}$, unless otherwise specified

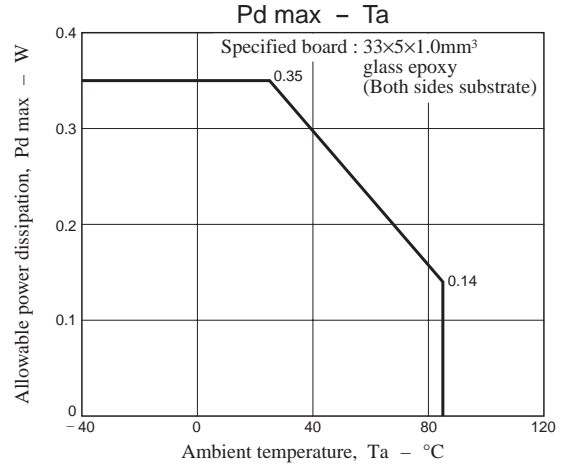
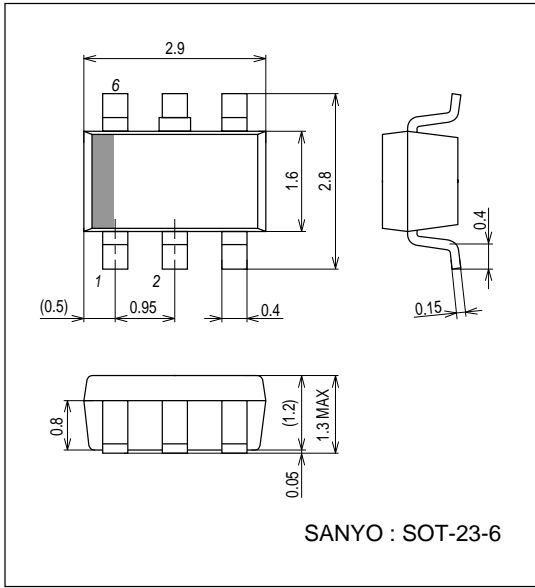
Parameter	Symbol	Conditions	Test circuit	Ratings			Unit
				min	typ	max	
Detection voltage							
Over-charge detection voltage	VC		1	4.225	4.250	4.275	V
Over-charge hysteresis voltage	VHc		1	0.175	0.2	0.225	V
Over-discharge detection voltage	Vdc		1	2.925	3.000	3.075	V
Over-discharge reset voltage	VRdc		1	3.120	3.200	3.280	V
Charge over-current detection voltage	Vlc		2	-1.000	-0.700	-0.400	V
Discharge over-current detection voltage	Vldc		2	0.100	0.120	0.140	V
Load short-circuiting detection voltage	Vshort	Based on V_{DD} , $V_{DD} = 3.5\text{V}$	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	$V_{DD} = 3.5\text{V}$, $V_M = 0\text{V}$	4		3.0	6.0	μA
Current consumption on shutdown	Istdn	$V_{DD} = V_M = 1.8\text{V}$	4			0.1	μA
Output resistance							
C_O : Pch ON resistance	Rcop	$C_O = 3.0\text{V}$, $V_{DD} = 3.5\text{V}$, $V_M = 0\text{V}$	5	1.5	3.0	4.5	$\text{k}\Omega$
C_O : Nch ON resistance	Rcon	$C_O = 0.5\text{V}$, $V_{DD} = 4.6\text{V}$, $V_M = 0\text{V}$	5	0.5	1.0	1.5	$\text{k}\Omega$
D_O : Pch ON resistance	Rdop	$D_O = 3.0\text{V}$, $V_{DD} = 3.5\text{V}$, $V_M = 0\text{V}$	5	1.7	3.5	5.0	$\text{k}\Omega$
D_O : Nch ON resistance	Rdon	$D_O = 0.5\text{V}$, $V_{DD} = V_M = 1.8\text{V}$	5	1.7	3.5	5.0	$\text{k}\Omega$
Discharge over-current release resistance	Rdwn	$V_{DD} = 3.5\text{V}$, $V_M = 1.0\text{V}$	5	15.0	30.0	60.0	$\text{k}\Omega$
Detection delay time							
Over-charge detection delay time	tc	$V_{DD} = VC - 0.2\text{V} \rightarrow VC + 0.2\text{V}$, $V_M = 0\text{V}$	6	0.70	1.0	1.30	s
Over-discharge detection delay time	tdc	$V_{DD} = V_{dc} + 0.2\text{V} \rightarrow V_{dc} - 0.2\text{V}$, $V_M = 0\text{V}$	6	21.7	31.0	40.3	ms
Charge over-current detection delay time	tic	$V_{DD} = 3.5\text{V}$, $V_M = 0\text{V} \rightarrow -1.0\text{V}$	6	5.6	8.0	10.4	ms
Discharge over-current detection delay time	tidc	$V_{DD} = 3.5\text{V}$, $V_M = 0\text{V} \rightarrow 1.0\text{V}$	6	5.6	8.0	10.4	ms
Load short-circuiting detection delay time	tshort	$V_{DD} = 3.5\text{V}$, $V_M = 0\text{V} \rightarrow 3.5\text{V}$	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	$V_{DD} = VC + 0.2\text{V} \rightarrow VC - 0.2\text{V}$, $V_M = 1.0\text{V}$	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.

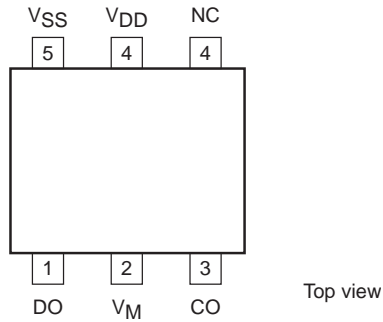
Package Dimensions

unit : mm (typ)

3356



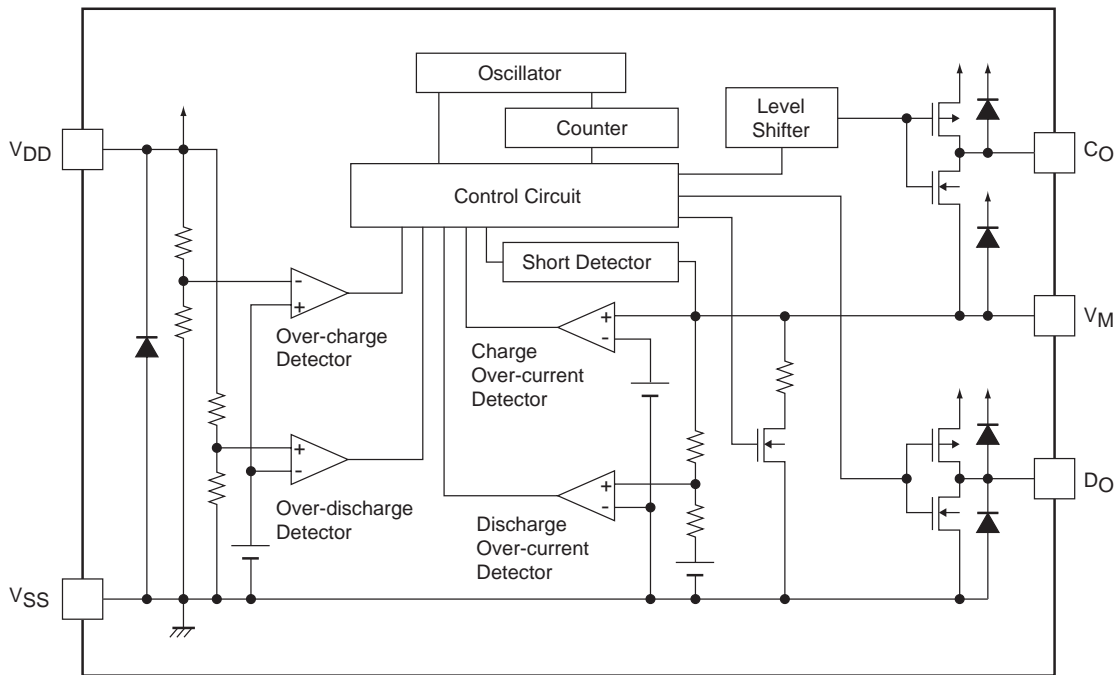
Pin Assignment



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 $V_1 = 3.5V$ and $V_2 = 0V$. Over-charge detection voltage V_C is V_1 at which V_{CO} goes "Low" from "High" when V_1 is gradually increased from $3.5V$. Then IC is released from the over-charge state and V_{CO} goes "High" from "Low" at the voltage "Measured $V_C - V_{Hc}$ " when V_1 is gradually decreased.
 If V_2 is set to the greater value than discharge over-current detection voltage V_{Idc} in the over-charge state, V_{Hc} is canceled and then IC is released from the over-charge state at V_C .
- Over-discharge detection voltage --- [Circuit 1]
 Set $V_1 = 3.5V$ and $V_2 = 0V$. Over-discharge detection voltage V_{dc} is V_1 at which V_{DO} goes "Low" from "High" when V_1 is gradually decreased from $3.5V$. Next, set V_2 under to charge over-current detection voltage V_{Ic} . Then IC is released from the over-discharge state at V_{dc} and V_{DO} goes "High" from "Low".
- Charge over-current detection voltage --- [Circuit 2]
 Set $V_1 = 3.5V$ and $V_2 = 0V$. Charge over-current detection voltage V_{Ic} is V_2 at which V_{CO} goes "Low" from "High" when V_2 is gradually decreased from $0V$.
- Discharge over-current detection voltage --- [Circuit 2]
 Set $V_1 = 3.5V$ and $V_2 = 0V$. Discharge over-current detection voltage V_{Idc} is V_2 at which V_{DO} goes "Low" from "High" when V_2 is gradually increased from $0V$.
- Load short-circuiting detection voltage --- [Circuit 2]
 Set $V_1 = 3.5V$ and $V_2 = 0V$. Load short-circuiting detection voltage V_{short} is V_2 at which V_{DO} goes "Low" from "High" within a time between the minimum and the maximum value of load short-circuiting detection delay time t_{short} , when V_2 is increased rapidly within $10\mu s$.
- 0V battery charge starting charger voltage --- [Circuit 3]
 Set $V_1 = V_2 = 0V$ and decrease V_2 gradually. 0V battery charge starting charger voltage V_{cha} is V_2 when V_{CO} goes "High" ($V_1 - 0.1V$ or higher).

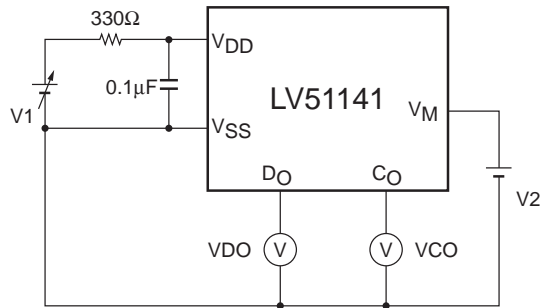
Continued on next page.

Continued from preceding page.

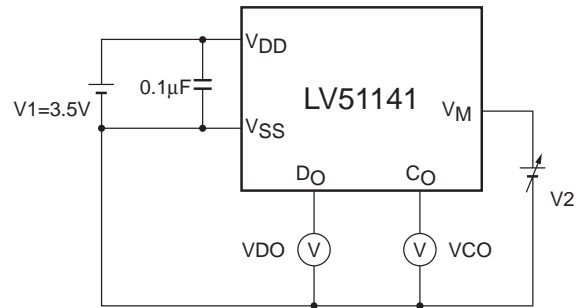
- Current consumption on operation and shutdown --- [Circuit 4]
Set $V_1 = 3.5V$ and $V_2 = 0V$ on normal condition. I_{DD} shows current consumption on operation I_{opr} .
Set $V_1 = V_2 = 1.8V$ on over-discharge condition. I_{DD} shows current consumption on shutdown I_{sdn} .
- C_o : Pch ON resistance, C_o : Nch ON resistance --- [Circuit 5]
Set $V_1 = 3.5V$, $V_2 = 0V$ and $V_3 = 3.0V$. $(V_1 - V_3)/|I_{Co}|$ is Pch ON resistance R_{cop} .
Set $V_1 = 4.6V$, $V_2 = 0V$ and $V_3 = 0.5V$. $V_3/|I_{Co}|$ is Nch ON resistance R_{con} .
- D_o : Pch ON resistance, D_o : Nch ON resistance --- [Circuit 5]
Set $V_1 = 3.5V$, $V_2 = 0V$ and $V_4 = 3.0V$. $(V_1 - V_4)/|I_{Do}|$ is Pch ON resistance R_{dop} .
Set $V_1 = V_2 = 1.8V$ and $V_4 = 0.5V$. $V_4/|I_{Do}|$ is Nch ON resistance R_{don} .
- Discharge over-current release resistance --- [Circuit 5]
Set $V_1 = 3.5V$, $V_2 = 0V$ at first. And then, set $V_2 = 1.0V$. $V_2/|I_{VM}|$ is discharge over-current release resistance R_{dwn} .
- Over-charge detection delay time, Release delay time 2 --- [Circuit 6]
Set $V_2 = 0V$. Increase V_1 from the voltage $V_C - 0.2V$ to $V_C + 0.2V$ rapidly within $10\mu s$. Over-charge detection delay time t_c is the time needed for VCO to go "Low" just after the change of V_1 .
Next, set $V_2 = 1V$ and decrease V_1 from $V_C + 0.2V$ to $V_C - 0.2V$ rapidly within $10\mu s$. Over-charge release delay time t_{rel2} is the time needed for VCO to go "High" just after the change of V_1 .
- Over-discharge detection delay time, Release delay time 1 --- [Circuit 6]
Set $V_2 = 0V$. Decrease V_1 from the voltage $V_{dc} + 0.2V$ to $V_{dc} - 0.2V$ rapidly within $10\mu s$. Over-discharge detection delay time t_{dc} is the time needed for VDO to go "Low" just after the change of V_1 .
Next, set $V_2 = -1V$ and increase V_1 from $V_{dc} - 0.2V$ to $V_{dc} + 0.2V$ rapidly within $10\mu s$. Release delay time 1 t_{rel1} in case of over-discharge is the time needed for VDO to go "High" just after the change of V_1 .
- Charge over-current detection delay time, Release delay time 1 --- [Circuit 6]
Set $V_1 = 3.5V$ and $V_2 = 0V$. Decrease V_2 from $0V$ to $-1V$ rapidly within $10\mu s$. Charge over-current delay time t_{ic} is the time needed for VCO to go "Low" just after the change of V_2 .
Next, increase V_2 from $-1V$ to $0V$ rapidly within $10\mu s$. Release delay time 1 t_{rel1} in case of charge over-current is the time needed for VCO to go "High" just after the change of V_2 .
- Discharge over-current detection delay time, Release delay time 1 --- [Circuit 6]
Set $V_1 = 3.5V$ and $V_2 = 0V$. Increase V_2 from $0V$ to $1V$ rapidly within $10\mu s$. Discharge over-current delay time t_{idc} is the time needed for VDO to go "Low" just after the change of V_2 .
Next, decrease V_2 from $1V$ to $0V$ rapidly within $10\mu s$. Release delay time 1 t_{rel1} in case of discharge over-current is the time needed for VDO to go "High" just after the change of V_2 .
- Load short-circuiting detection delay time, Release delay time 1 --- [Circuit 6]
Set $V_1 = 3.5V$ and $V_2 = 0V$. Increase V_2 from $0V$ to $3.5V$ rapidly within $10\mu s$. Load short-circuiting detection delay time t_{short} is the time needed for VDO to go "Low" just after the change of V_2 .
Next, decrease V_2 from $3.5V$ to $0V$ rapidly within $10\mu s$. Release delay time 1 t_{rel1} in case of load short-circuiting is the time needed for VDO to go "High" just after the change of V_2 .

Measurement Circuits

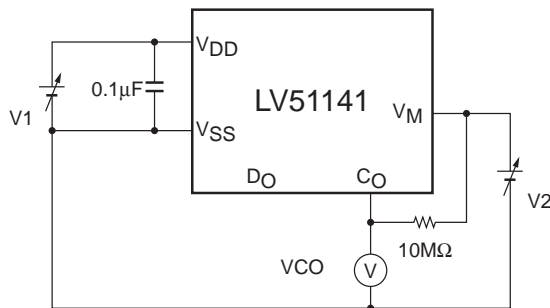
• Circuit 1



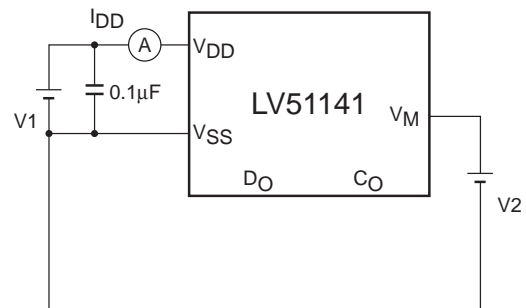
• Circuit 2



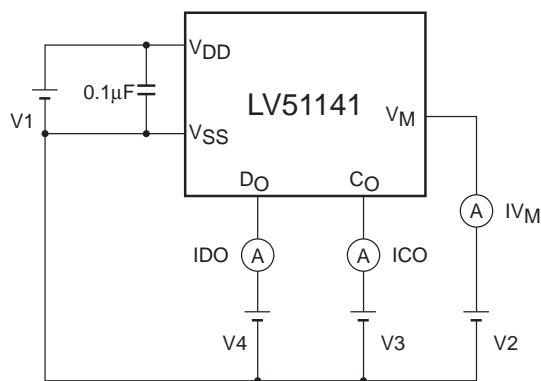
• Circuit 3



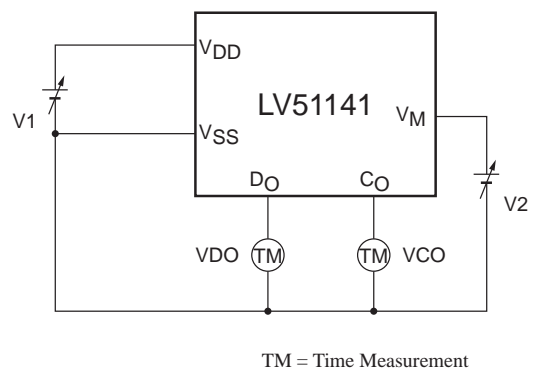
• Circuit 4



• Circuit 5

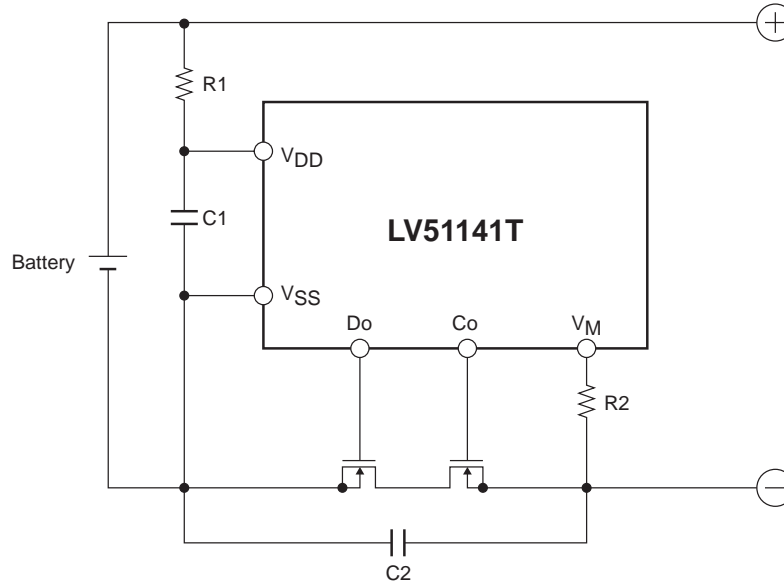


• Circuit 6



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 (V_{dc}) to the over-charge detection voltage (V_C) and the V_M terminal voltage is in the range from the charge over-current detection voltage (V_{Ic}) to the discharge over-current detection voltage (V_{Idc}), 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 (V_{Idc}) to the short-circuiting detection voltage (V_{short}) and that state is maintained during more than the discharge over-current detection delay time (t_{idc}), 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 V_{short} and that state is maintained during more than the load short-circuiting detection delay time (t_{short}), 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 (R_{dwn}) 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 V_{Idc} , and if that state is maintained during more than the release delay time 1 (t_{rel1}), 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 V_{Idc} . The standard is expressed with the following equation.

$$\text{Resistance value for automatic return} = R_{dwn} \times (V_{DD} / V_{Idc} - 1)$$

- 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 (V_{Ic}) and that state is maintained during more than the charge over-current detection delay time (t_{ic}), 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 equal to or higher than V_{Ic} and that state is maintained during more than the release delay time 1 (t_{rel1}) 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 (t_{ic}) 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 (V_C) and that state is maintained during more than the over-charge detection delay time (t_c), 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 V_C-V_{Hc} without load and that state is maintained during more than the delay time 2 (t_{rel2}), this IC turns on the charge control FET and returns to the normal condition.

* V_{Hc} : 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 V_f 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 (V_{Idc}) and V_{DD} is equal to or less than V_C , this IC returns to the normal condition when this state continues more than the delay time 2 (t_{rel2}).

(3) In case (2), if the V_M terminal voltage is higher than the discharge over-current detection voltage (V_{Idc}) and V_{DD} is equal to or higher than V_C , battery is discharged until V_{DD} becomes less than V_C , and then this IC returns to the normal condition when this state continues more than the delay time 2 (t_{rel2}).

- Over-discharge detection

When the battery voltage (V_{DD}) under the normal condition becomes equal to or less than the over-discharge detection voltage (V_{dc}) and that state continues for more than the over-discharge detection time (t_{dc}), 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 (V_{Ic}), the IC returns to the normal condition when V_{DD} becomes equal to or higher than V_{Rdc} and this state continues more than the delay time1 (t_{rel1}).

If the V_M terminal voltage is lower than the charge over-current detection voltage (V_{Ic}), same as the above-mentioned case, the IC returns to the normal condition when V_{DD} becomes equal to or higher than V_{dc} and this state continues more than the delay time1 (t_{rel1}).

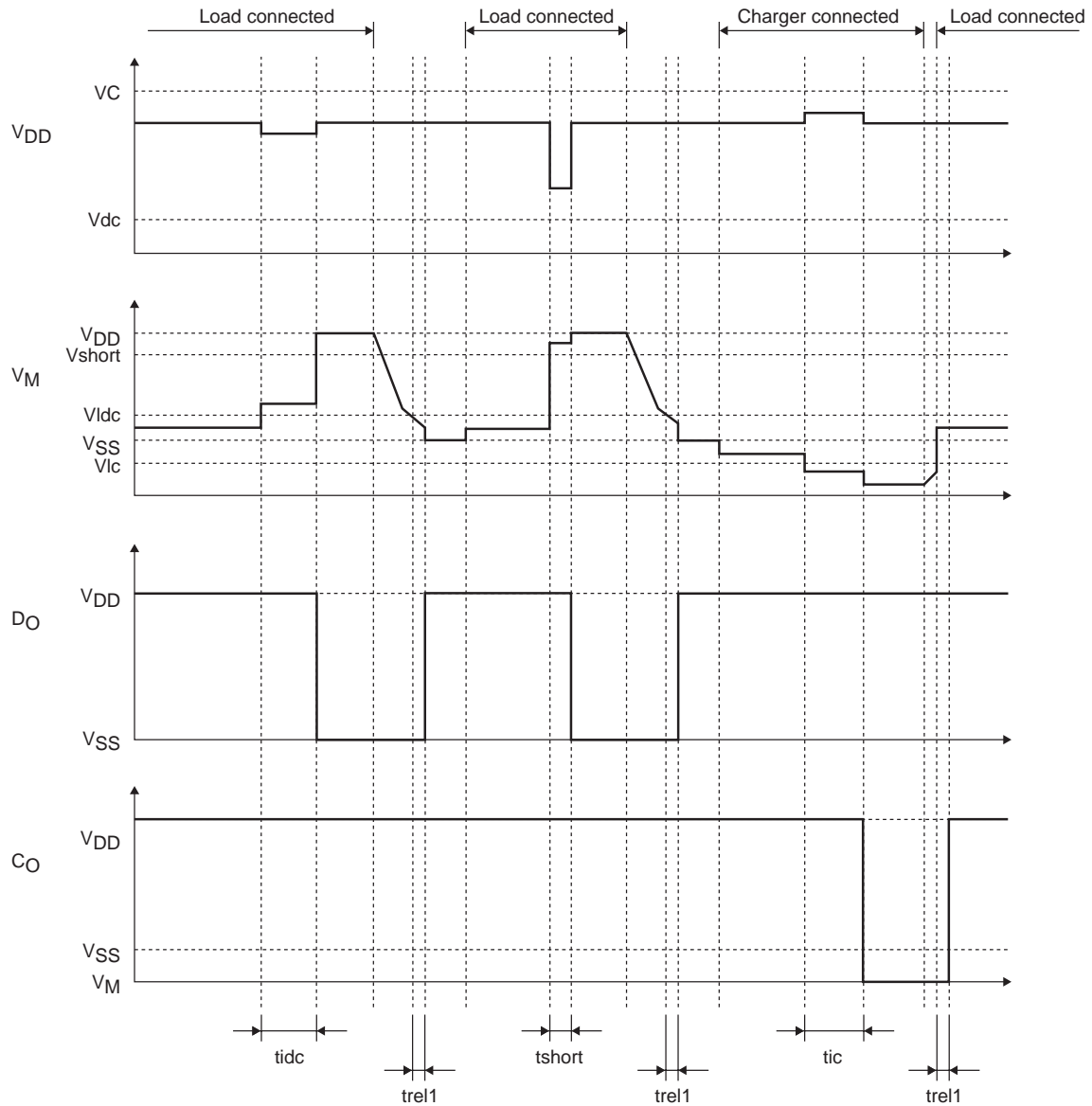
This IC stops all internal circuits (Shutdown condition) after detecting the over-discharge and reduces current consumption. (Max 0.1 μ A, at $V_{DD} = 1.8V$)

- 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 (V_{cha}), 0V battery charge becomes possible when CO terminal outputs V_{DD} terminal potential and turns on the charge control FET.

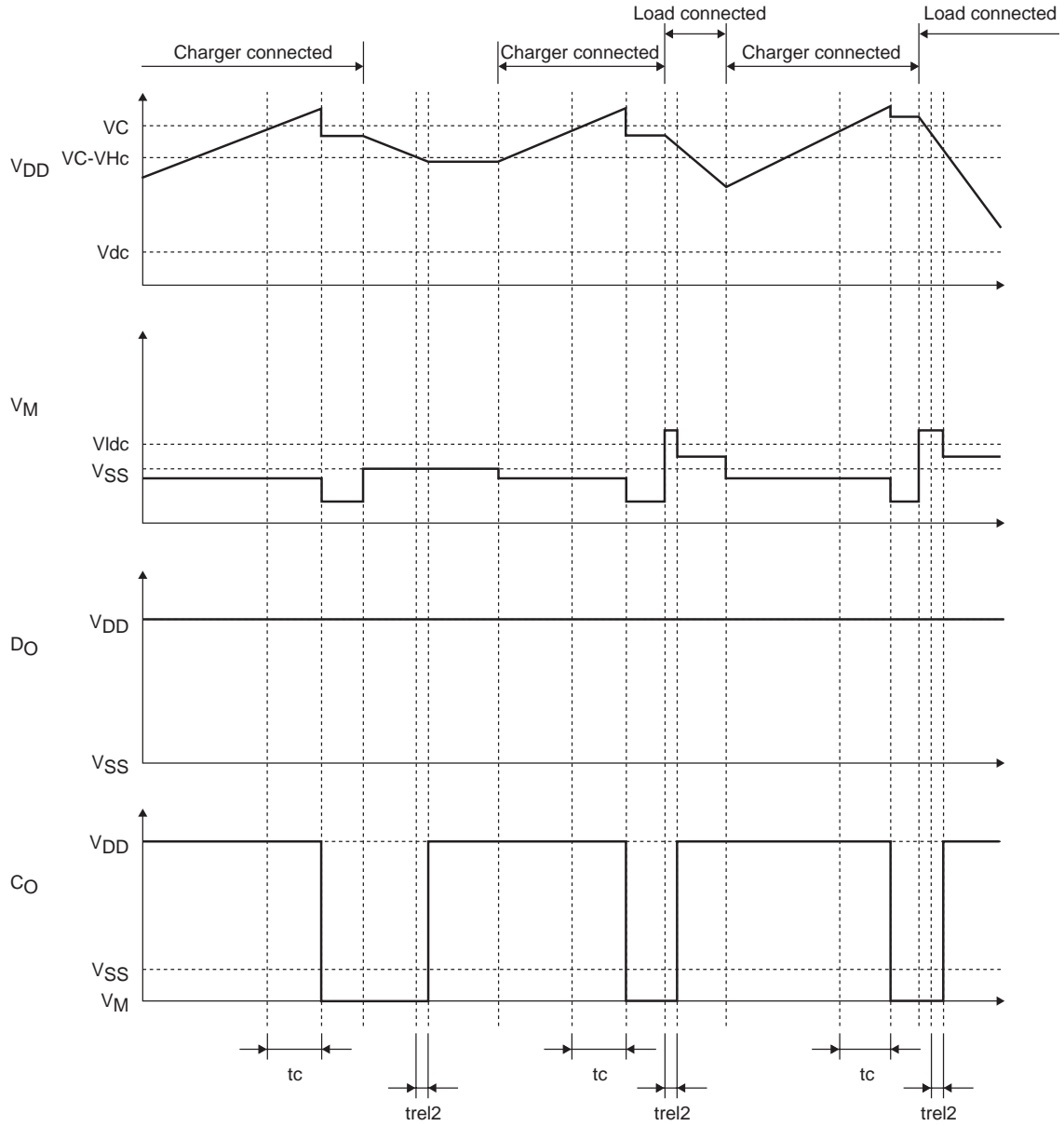
Timing Chart

- 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	tfdc : 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

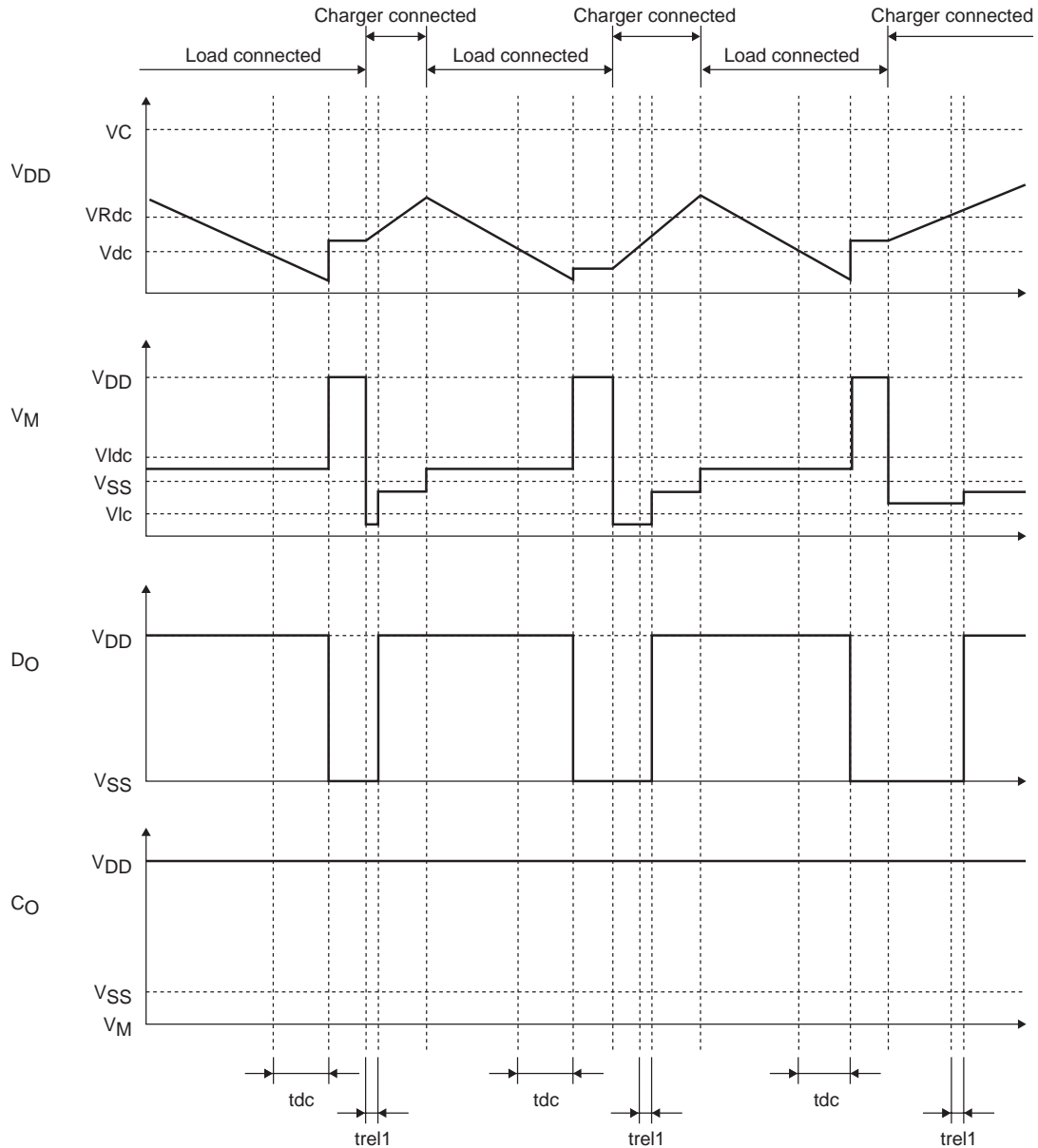


V_C : Over-charge detection voltage
 V_{dc} : Over-discharge detection voltage
 V_{Hc} : Over-charge hysteresis voltage
 V_{dc} : Discharge over-current detection voltage

t_c : Over-charge detection delay time
 t_{rel2} : Release delay time 2

LV51141T

• Over-discharge detection



V_c : Over-charge detection voltage
 V_{dc} : Over-discharge detection voltage
 V_{Rdc} : Return from over-discharge voltage
 V_{ic} : Charge over-current detection voltage
 V_{idc} : Discharge over-current detection voltage

t_{dc} : Over-discharge detection delay time
 t_{rel1} : Release delay time 1

- SANYO Semiconductor Co.,Ltd. assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein.
- SANYO Semiconductor Co.,Ltd. strives to supply high-quality high-reliability products, however, any and all semiconductor products fail or malfunction with some probability. It is possible that these probabilistic failures or malfunction could give rise to accidents or events that could endanger human lives, trouble that could give rise to smoke or fire, or accidents that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.
- In the event that any or all SANYO Semiconductor Co.,Ltd. products described or contained herein are controlled under any of applicable local export control laws and regulations, such products may require the export license from the authorities concerned in accordance with the above law.
- No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or any information storage or retrieval system, or otherwise, without the prior written consent of SANYO Semiconductor Co.,Ltd.
- Any and all information described or contained herein are subject to change without notice due to product/technology improvement, etc. When designing equipment, refer to the "Delivery Specification" for the SANYO Semiconductor Co.,Ltd. product that you intend to use.
- Information (including circuit diagrams and circuit parameters) herein is for example only; it is not guaranteed for volume production.
- Upon using the technical information or products described herein, neither warranty nor license shall be granted with regard to intellectual property rights or any other rights of SANYO Semiconductor Co.,Ltd. or any third party. SANYO Semiconductor Co.,Ltd. shall not be liable for any claim or suits with regard to a third party's intellectual property rights which has resulted from the use of the technical information and products mentioned above.

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