DIO7110
True Monolithic Li-Ion/Polymer Battery Protector in Tiny Thin Package

Features

- Ultra Compact Protection Solution
- 56mΩ Pass Resistance
- 1.3μA Operation Current
- Factory Programmable OVP Threshold Options
  4.2V to 4.55V with 0.05V per Step
- Over-Charge/Discharge Current Protection
  4 Threshold Combination Options
- Battery Under-Voltage Protection
  2.4V/2.5V/2.8V/3.0V Options
- 100nA Deep Discharging Shutdown
- 0V Battery Charge Function
- With High Efficiency Charging Mode
- Input Surge Clamping
- Input Over-Voltage Safe
- Load Short-Circuit Safe
- Reverse Polarity Battery Safe
- Input Reversed-Attaching Safe
- Available in Green DFN1.5*2-6 Package

Applications

- Wireless Chargers
- Portable Equipment
- Communication Systems

Descriptions

The DIO7110 is designed for primary protection of Li-Ion/Polymer rechargeable cells. The product integrates all the protections required for safe operation of polymer rechargeable cells. The device is packaged in a tiny and thin package. Its small solution size leaves more space for fitting the battery cell into a given cavity for small size wearable devices.

The DIO7110 integrates all the protections and the required low on-resistance disconnect switch on one die. The protection features include charging and discharging protection, detection and protection of a cell in over-charging, over-discharging, over-current, and battery under-voltage. The low standby current drains little current from cell while in storage.

The DIO7110 operates in -40°C to 85°C temperature range, and is in a thin and low profile DFN1.5*2-6 package. This package is convenient for small cell packing design.

Typical Applications

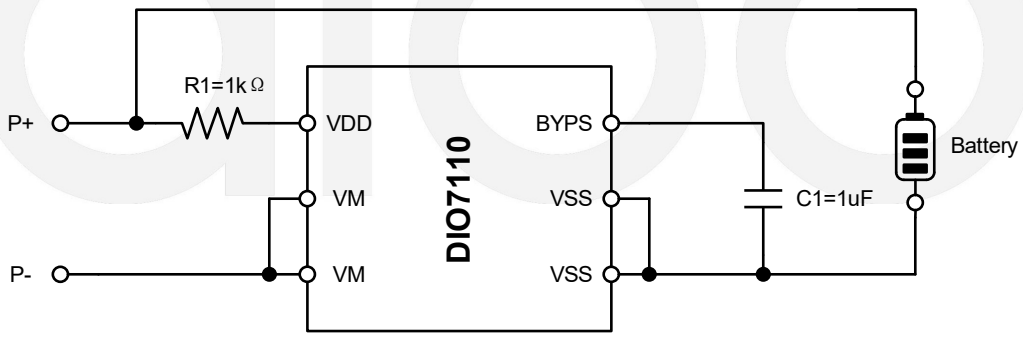


Figure 1. Typical Application Circuit

Ordering Information

Order Part Number	Top Marking		T_A	Package	
DIO7110aaabcLD6	DXbc	Green	-40 to 85°C	DFN1.5*2-6	Tape & Reel, 3000

Order Part Number: DIO7110aaabcLD6								
Over Voltage Threshold Options								
Option Code "**aaa**"	**420**	**425**	**430**	**435**	**440**	**445**	**450**	**455**
Over Voltage Threshold V_{OV} (V)	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55
Under Voltage Threshold Options								
Option Code "**b**"	**A**		**B**		**C**		**D**	
Under Voltage Threshold V_{UV} (V)	2.4		2.5		2.8		3.0	
Current Threshold Combination Options								
Option Code "**c**"	**A**		**B**		**C**		**D**	
Over Charge Current I_{OC} (A)	1.33		0.66		1.33		0.66	
Over Discharge Current I_{OD} (A)	1.33		1.33		0.66		0.66	
Short Circuit Current (A)	2.68		2.68		1.96		1.96	

Marking Definition: DXbc								
Product code								
Option Code "**D**"	Product code							
Over Voltage Threshold Options								
Option Code "**X**"	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Over Voltage Threshold V_{OV} (V)	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55
Under Voltage Threshold Options								
Option Code "**b**"	**A**		**B**		**C**		**D**	
Under Voltage Threshold V_{UV} (V)	2.4		2.5		2.8		3.0	

Current Threshold Combination Options				
Option Code "**c**"	**A**	**B**	**C**	**D**
Over Charge Current I_{OC} (A)	1.33	0.66	1.33	0.66
Over Discharge Current I_{OD} (A)	1.33	1.33	0.66	0.66
Short Circuit Current (A)	2.68	2.68	1.96	1.96

Pin Assignment

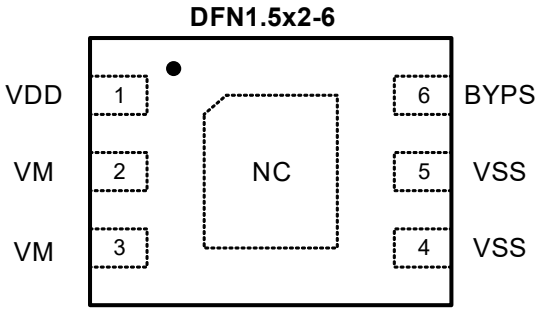


Figure 2. Pin Assignment(Top View)

Pin Descriptions

Pin	Name	Type	Description
1	VDD	P	Power input and output, the battery pack positive connection. The default sate after battery attached is Closed or locked-off, dependent on the external circuitry.
2.3	VM	P	Power input and output, the battery pack cathode. Short this pin to the VSS pin to release off the lock-open state, and make the output path closed.
4,5	VSS	G	Ground of internal circuit. Connect to battery cathode end.
6	BYPS	I/O	Bypass pin and disconnection locked-off triggering input. Place a 1uF capacitor between this and VSS pin. Shorting this pin to VM pin momentarily places the circuit into locked-open state.
Thermal Pad	NC	NC	Not connected internally. Can be connected to VSS.

Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Symbol	Rating	Unit
Supply Voltage	V_{DD}	-0.3 to 8	V
V_M Pin Input Voltage	V_M	V_{DD}−10 to V_{DD}+0.3	V
Supply Voltage to VM Pin Voltage	V_{DD}-V_M	-0.3 to 10	V
Power Consumption at T_A=25℃	P_d	400	mW
Operating Temperature Range	T_A	-40 to 85	°C
Storage Temperature Range	T_{STG}	-55 to 125	°C
Maximum Junction Temperature	T_J	125	°C
Lead temperature（Soldering, 10 sec）	T_L	260	°C
Package thermal resistance（junction to ambient）	Θ_{JA}	240	°C/W
ESD Susceptibility	HBM	6000	V

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Parameter	Symbol	Rating	Unit
Battery Voltage Range	V_{DD}-V_{SS}	0 to 5.5	V
VM Voltage Range	V_{DD}-V_M	V_{DD}-5 to V_{DD}+0.3	V
Operating Temperature Range	T_A	-40 to 85	°C

Electrical Characteristics

T_A = 25°C, V_{BAT} = 3.6V, unless otherwise noted. Specifications subject to change without notice.

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Over-Charge Voltage Threshold	V_{OV}	DIO7110-420_ _	T_A=25°C	4.165	4.200	4.235	V
			T_A=-20°C to 55°C	4.152		4.248	
			T_A=-40°C to 85°C	4.100		4.300	
		DIO7110-425_ _	T_A=25°C	4.215	4.250	4.285	
			T_A=-20°C to 55°C	4.202		4.298	
			T_A=-40°C to 85°C	4.150		4.350	
		DIO7110-430_ _	T_A=25°C	4.265	4.300	4.335	
			T_A=-20°C to 55°C	4.252		4.348	
			T_A=-40°C to 85°C	4.200		4.400	
		DIO7110-435_ _	T_A=25°C	4.315	4.350	4.385	
			T_A=-20°C to 55°C	4.302		4.398	
			T_A=-40°C to 85°C	4.250		4.450	
		DIO7110-440_ _	T_A=25°C	4.365	4.400	4.435	
			T_A=-20°C to 55°C	4.352		4.448	
			T_A=-40°C to 85°C	4.300		4.500	
		DIO7110-445_ _	T_A=25°C	4.415	4.450	4.485	
			T_A=-20°C to 55°C	4.402		4.498	
			T_A=-40°C to 85°C	4.350		4.550	
		DIO7110-450_ _	T_A=25°C	4.465	4.500	4.535	
			T_A=-20°C to 55°C	5.452		4.548	
			T_A=-40°C to 85°C	4.400		4.600	
		DIO7110-455_ _	T_A=25°C	4.515	4.550	4.585	
			T_A=-20°C to 55°C	4.502		4.598	
			T_A=-40°C to 85°C	4.450		4.650	
OV Release Hysteresis	V_{OVHYS}	Voltage lower than the battery voltage			200		mV
Battery Under Voltage Threshold	V_{UV}	DIO7110-_ _ _A_	T_A=25°C	2.362	2.400	2.438	V
			T_A=-20°C to 55°C	2.350		2.450	
			T_A=-40°C to 85°C	2.290		2.510	
		DIO7110-_ _ _B_	T_A=25°C	2.462	2.500	2.538	
			T_A=-20°C to 55°C	2.450		2.550	
			T_A=-40°C to 85°C	2.390		2.610	
		DIO7110-_ _ _C_	T_A=25°C	2.762	2.800	2.838	
			T_A=-20°C to 55°C	2.750		2.850	
			T_A=-40°C to 85°C	2.690		2.910	
		DIO7110-_ _ _D_	T_A=25°C	2.962	3.000	3.038	
			T_A=-20°C to 55°C	2.950		3.050	
			T_A=-40°C to 85°C	2.890		3.110	
UV Release Hysteresis	V_{UVHYS}				100		mV

Over-Discharge Current	I_{OD}	DIO7110-_ _ _ _ C	T_A=25°C	0.50	0.66	0.82	A
		-_ _ _ _ D	T_A=-20°C to 55°C	0.43		0.94	
		DIO7110-_ _ _ _ A	T_A=25°C	1.00	1.33	1.66	
		-_ _ _ _ B	T_A=-20°C to 55°C	0.85		1.91	
Over-Charge Current	I_{OC}	DIO7110-_ _ _ _ B	T_A=25°C	0.35	0.66	1.00	A
		-_ _ _ _ D	T_A=-20°C to 55°C	0.26		1.25	
		DIO7110-_ _ _ _ A	T_A=25°C	0.75	1.33	2.00	
		-_ _ _ _ C	T_A=-20°C to 55°C	0.56		2.50	
Pass Resistance	R_P	T_A=25°C			56	64	mΩ
		T_A=-20°C to 55°C				78	
Operating Current	I_{OP}	T_A=25°C			1.3	1.8	uA
		T_A=-20°C to 55°C				2.8	
Shutdown Current	I_{SHDN}					0.1	uA
Over-Voltage Detection Delay	t_{OVPD}				160		ms
Under-Voltage Detection Delay	t_{UVPD}				40		ms
Over-Discharge Current Detection Delay	t_{ODD}				10		ms
Over-Charge Current Detection Delay	t_{OCD}				10		ms
Discharge Short-Circuit Detection Delay	t_{OCSD}				0.2		ms
Discharge Short-Circuit Current	I_{SC}	DIO7110-_ _ _ _ A			2x I_{OD}		A
		-_ _ _ _ B					
		DIO7110-_ _ _ _ C			3x I_{OD}		
		-_ _ _ _ D					
Over Temperature Pretection	T_{OTP}				150		°C
Over Temperature Pretection Hysteresis	T_{OTPHYS}				20		°C

Application Information

The DIO7110 monitors voltage and current applied on battery cell connected between VDD and VSS, and opens the connection between battery and pack terminal with its internal switches when a fault condition is detected.

Normal Condition

Battery voltage is between the over discharge voltage threshold and over charge voltage threshold, and no overcharge current and over discharge current is detected, charging and discharging can be carried out freely, this condition is called the normal operating condition.

Over Charge Condition

When battery voltage reaches over-voltage threshold (V_{OV}) and keeps for over-charge detection delay time (T_{OVPD}), the charging path is open circuited. The path closes again in the following two cases:

(1) If VM pin's voltage is less than 0.35V (typical), when battery voltage falls back about V_{OVHYS} below the battery voltage, then over charge condition is released.

(2) If VM pin's voltage is above 0.35V (typical), when battery voltage falls back about V_{OV}, then over charge condition is released.

Over Discharge Condition

In order to protect the battery from over discharging when battery voltage falls below V_{UV}, the discharge path is open circuited and the DIO7110 enters into shutdown sleeping mode in order to further reduce the current consumption, which helps to keep the battery from harmful exhausted conditions as long as possible. The path closes again when a charging supply is applied or the battery voltage rises to about 100mV above the V_{UV} threshold.

In the over discharge condition, the battery charges through the internal power MOSFET body diode. All internal circuitry is OFF. Discharge is not allowed. When battery voltage rises above under-voltage threshold, the chip enters normal operation and charge and discharge modes are allowed.

Over-discharge Current Condition

When over-discharging current condition occurs and keeps for over-discharge current detection delay (T_{OD}), the discharging path opens, and the VM pin is shorted to VSS through internal resistance. The path closes again by load removed or connecting a charger.

Over-charge Current Condition

During a charging condition, if charging current is above 400mA and keeps for 10ms (typical) delay, DIO7110 enters into High Efficiency Charging Mode, and when the charging current increase further, an over-charging current is identified, the DIO7110 enters into the locked-off state. This state can be reset by charger removal (pack removal).

Short-circuit protection

When discharge current exceeds 3 times (DIO7110_ _ _ _ C/D) or 2 times (DIO7110_ _ _ _A/B) of the over-current threshold, discharging path disconnects instantly in t_{OCSD} , in order to protect the battery from potential over

current stress. After this disconnection, the DIO7110 stays in the locked-off non-conducting state until being reactivated.

0V Battery Charge Function

This function is used to recharge the connected battery whose voltage is 0V due to the self-discharge. When the 0V battery charge starting charger voltage or higher is applied between VDD and VM Pins by connecting a charger, In this state the battery charges through the internal power MOSFET body diode. When the battery voltage rises to about 100mV above the Over-discharge Detection Voltage (V_{UV}), the IC enters the normal condition.

Battery delivery state

It is recommended to deliver a battery pack in lock-off non-conducting state to avoid unintentional shorting in production handling or transportation. Places the DIO7110 into a lock-off state after battery attachment by momentarily shorting BYPS and VM.

Pack activation

In order to release the pack from lock-off state and to place it into a conducting state, apply a charging input or connect VM to VSS momentarily.

Select Protection Parameters

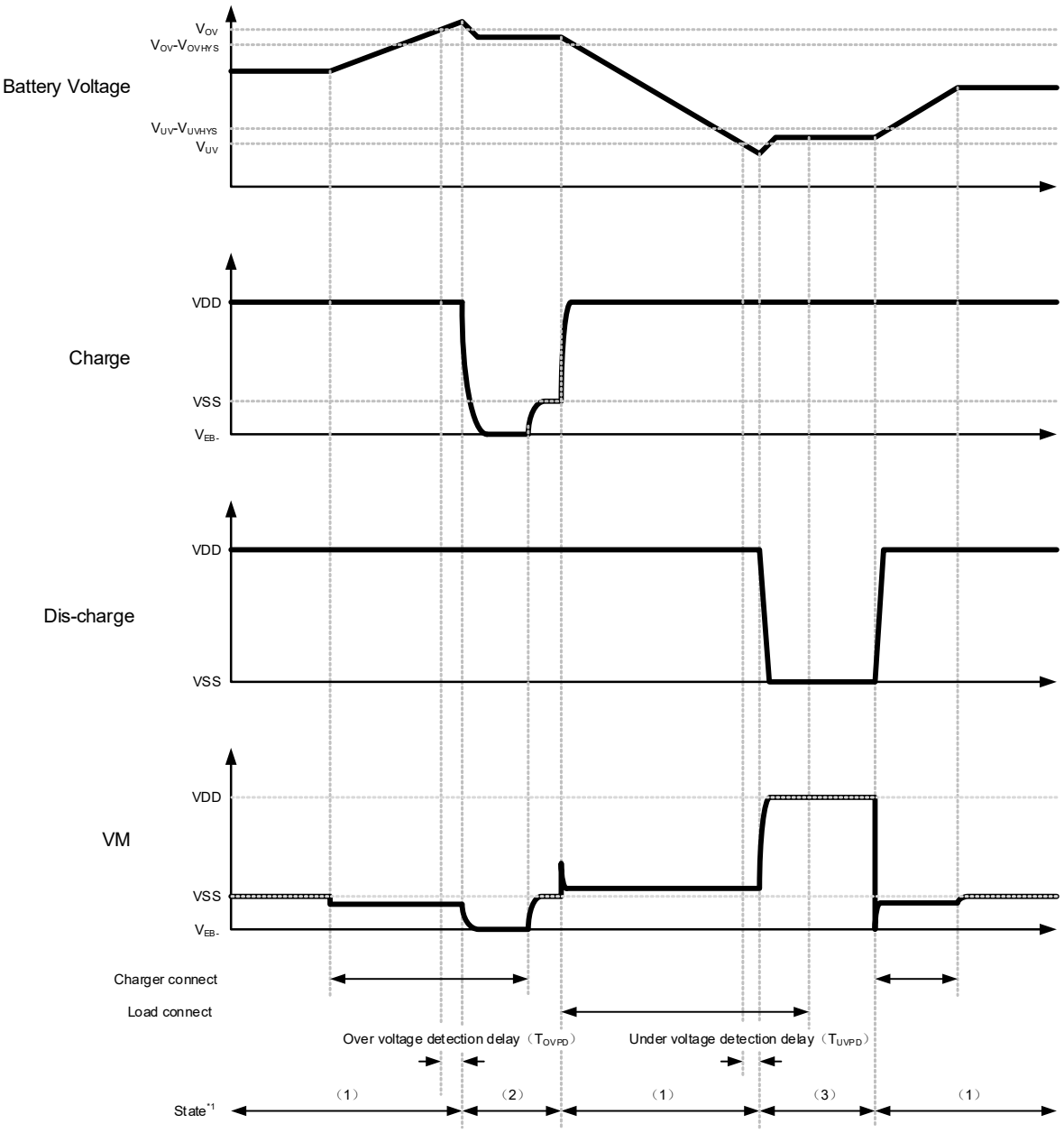
Battery models from different vendors may be customized for different applications. Consult the battery vendor for protection limits for specific battery model. Parameters for the protection circuit and of the charger circuit affecting same variables should be set for proper charge or discharge protection sequence. For example, the over-voltage threshold of the battery should be 50mV~100mV higher than constant voltage threshold of the charger.

Cautions on parameter misalignment

If the V_{OV} is lower than the battery charger's full of charge voltage, the protection circuit cuts off the battery charge path before the battery is fully charged, and turns into the non-conductive lock-off state; if the I_{OC} is lower than the charger's charge current, the protection circuit also turns itself into the lock-off state. In either V_{OV} or I_{OC}, the charger input should be removed and then re-applied for activating the protection circuit from the lock-off state to the conducting state. If the charger is not removed after a V_{OV} or I_{OV} event, the battery will not be charged even if the battery voltage depletes.

Operation Timing Chart

1. Over-charge and over-discharge detection:

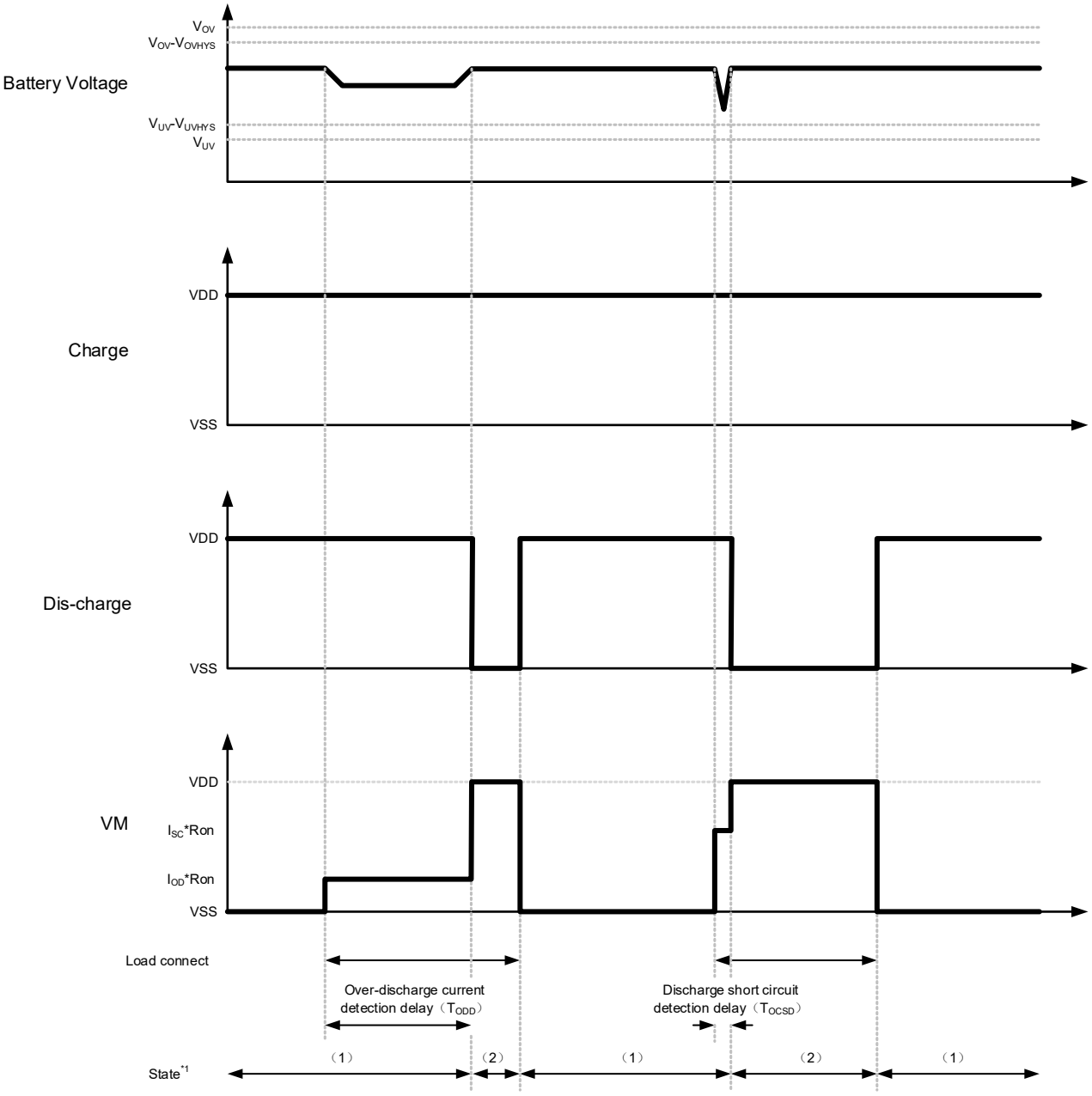


*1. （1）normal condition
（2）over voltage condition
（3）under voltage condition

Note：assume charging with constant current

Figure 3

2. Over-discharge current detection:

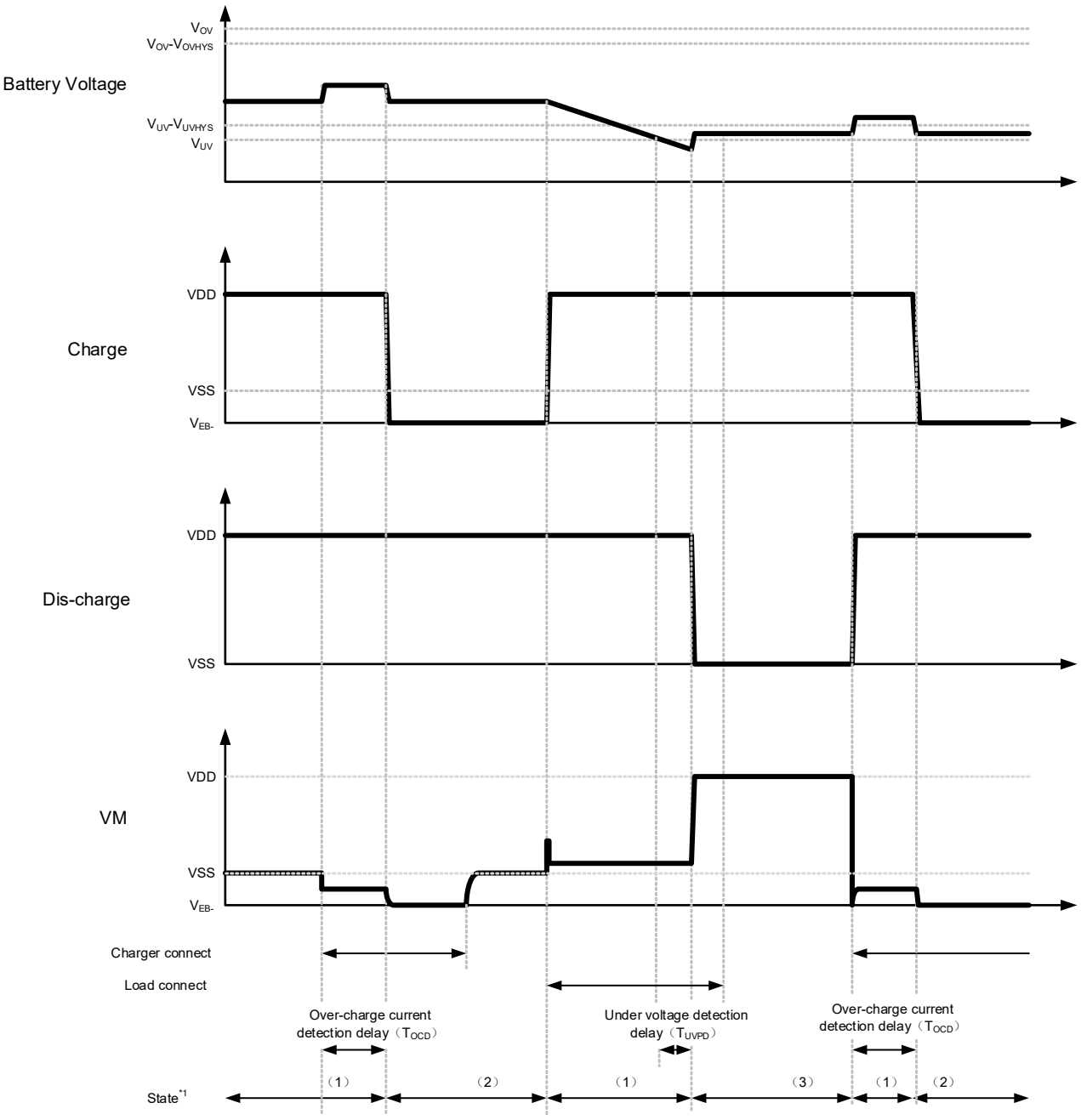


*1.（1）normal condition
（2）over-discharge current condition

Note：assume charging with constant current

Figure 4

3. Over-charge current detection:



*1. (1) normal condition
(2) over-charge current condition
(3) under voltage condition

Note: assume charging with constant current

Figure 5

CONTACT US

Dioo is a professional design and sales corporation for high-quality and performance analog semiconductors. The company focuses on industry markets, such as, cell phone, handheld products, laptop, and medical equipment and so on. Dioo's product families include analog signal processing and amplifying, LED drivers and charger IC. Go to http://www.dioo.com for a complete list of Dioo product families.

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