

Protective Circuit for Lithium Batteries

I. Description:

DW01 is a protective circuit for subulate lithium batteries, which is designed to prevent loss of service life or damages of batteries due to over-charging, over-discharging and over-current. It is equipped with a high-accuracy voltage detection and time delay circuit. With the function of 0V charging enabling, it can recover functions automatically.

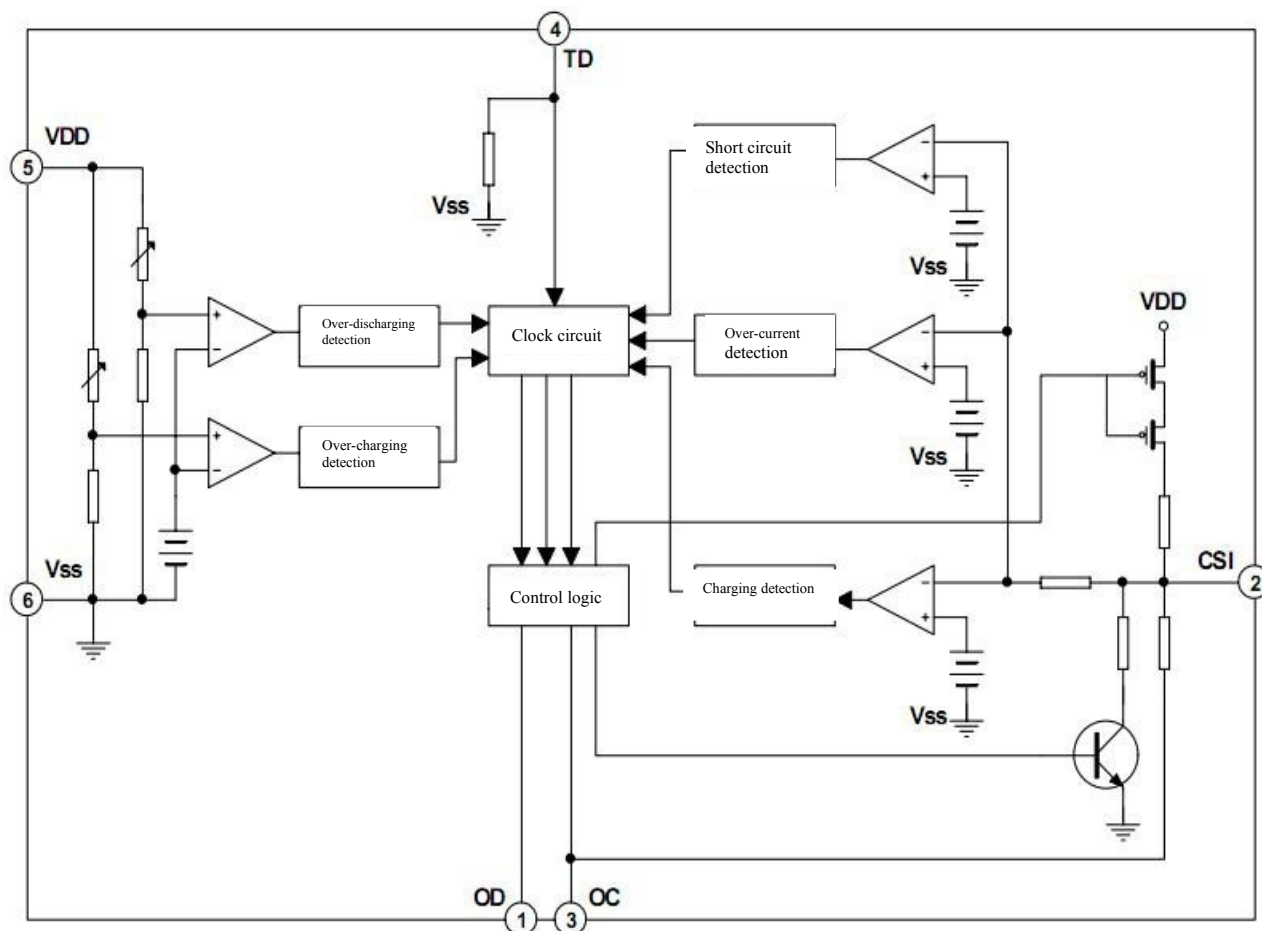
II. Main Features

- Low working current
- Over-charging detection 4.28V, over-charging relief 4.08V
- Over-charging detection 2.4V, over-charging relief 3.0V
- Over-discharging detection 0.15V, over-discharging relief 1.3V
- Charger detection
- Over-current protection reset resistance
- With self-recovery function
- 0V charging enabling
- Wide ranges for working voltage
- Small packaging

III. Application

It is the protective circuit for single subulate batteries.

IV. Internal Block Diagram



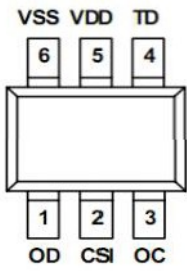
V. Absolute Parameters

Parameters	Symbols	Parameter range value	Unit
Supply voltage	VDD	VSS-0.3~VSS+12	V
OC output pin voltage	VOC	VDD-15~VDD+0.3	V
OD output pin voltage	VOD	VSS-0.3~VDD+0.3	V
CSI input pin voltage	VCSI	VDD+15~VDD+0.3	V
Working temperature	Topr	-40~+85	°C
Storage temperature	Tstg	-40~+125	°C

VI. Electrical Characteristic Parameters(T_a = 25 °C unless otherwise specified)

Parameters	Symbols	Testing conditions	Min value	Typical value	Max value	Unit
Working voltage						
Working voltage	VDD	--	1.5	--	10	V
Current consumption						
Working current	IDD	VDD=3.9V	--	4.0	6.0	uA
Detection voltage						
Over-charging detection voltage	VOCD	--	4.24	4.28	4.33	V
Over-charging relief voltage	VOCR	--	4.03	4.08	4.13	V
Over-discharging detection voltage	VODL	--	2.30	2.40	2.50	V
Over-discharging relief voltage	VODR	--	2.90	3.00	3.10	V
Over-current 1 detection voltage	VOI1	--	0.12	0.15	0.18	V
Over-current 2 (short circuit current) detection voltage	VOI2	VDD=3.6V	0.80	1.30	1.75	V
Over-current reset resistance	Rshort	VDD=3.6V	50	100	150	KΩ
Over-appliance detection voltage	VCH	--	-0.8	-0.5	-0.2	V
Delay time						
Over-charging detection delay time	TOC	VDD= 3.6V~4.4V	--	120	200	ms
Over-discharging detection delay time	TOD	VDD= 3.6V~2.0V	--	40	120	ms
Over-current 1 detection delay time	TOI1	VDD=3.6V	--	10	20	ms
Over-current 2 (short circuit current) detection delay time	TOI2	VDD=3.6V	-	400	600	us
Others						
OC pin output high level voltage	Voh1	--	VDD-0.1	VDD-0.02	--	V
OC pin output low level voltage	Vol1	--	--	0.01	0.1	V
OD pin output high level voltage	Voh2	--	VDD-0.1	VDD-0.02	--	V
OD pin output low level voltage	Vol2	--	-	0.01	0.1	

VII. Pin Configuration Diagram

	Lead foot No.	Pin name	I/O	Functional description
	1	OD	O	The connecting pin for discharging control FET threshold
	2	CSI	I/O	The current induction input pin, for charger detection
	3	OC	O	The connecting pin for charging control FET threshold
	4	TD	I	The pin for delay time testing
	5	VDD	I	The pin for positive supply input
	6	VSS	I	The pin for negative supply input

VIII. Functional Description

- Normal conditions

If $VODL > VDD > VOCU$, and $VCH < VCSI < VOI1$, both M1 and M2 are opened (refer to typical application circuit diagram). At this time, both charging and discharging can be conducted normally.

- Over-charging state

When entering into the charging state from the normal state, VDD can be used to detect the voltage of the battery.

When the voltage of the battery is in the charging state, the voltage of the VDD is larger than VOCU, and the delay time is more than TOC, M2 is closed.

- Relief of the over-charging state

In the over-charging state, in order to relieve this state and enter into the normal state, there are two methods.

- 1) If the battery discharges by itself and $VDD < VOICR$, M2 is opened, and it returns to the normal state.
- 2) After removing the charger and connect with the load, if $VOICR < VDD < VOCU$ and $VCSI > VOI1$, M2 is opened, and it returns to the normal state.

- Over-discharging detection

When it enters into the discharging state from the normal state, the voltage of the battery can be detected through VDD. When the voltage of the battery enters into the over-discharging state, if the voltage of VDD is lower than that of VODL and the delay time is longer than TOD, M1 is closed.

- Relief of the power-off mode

When the battery is in the power-off mode, if it is connected with a charger and $VCH < VCSI < VOI2$, $VDD < VODR$, M1 is still closed at this time. But the power-off mode is relieved. If $VDD > VODR$, M1 is opened, and it returns to the normal mode. Or when the load is suspended and the voltage of VDD recovers to $VDD > VODR$, M1 is opened, and it returns to the normal mode (self-recovery function).

- Charging detection

If a charger is connected with the battery in the power-off mode, the voltage is changed into $VCSI < VCH$ and $VDD > VODL$. M1 is opened and it returns to the normal mode.

- Over-current/short circuit current detection

In the normal mode, in condition of excessive discharging current, it is detected that the voltage is higher than VOIX (VIO1 or VIO2) based on the CSI pin and the delay is larger than TOIX (TIO1 or TIO2), it indicates the over-current (short circuit) state.

M1 is closed, and CSI is pulled to VSS through the internal resistance RCSIS.

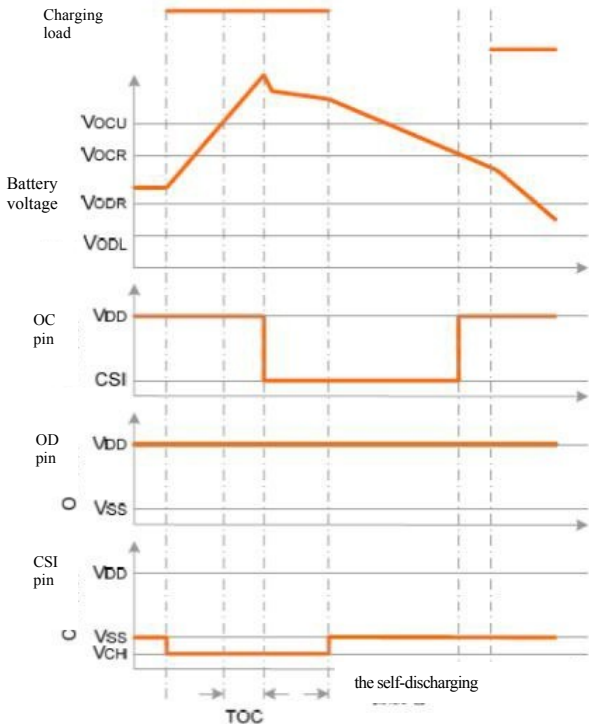
- Relief of the over-current/short circuit current state

When the protective circuit is kept in the over-current/short circuit current state, remove the load, or the resistance between VBAT+ and VBAT- is larger than 500KΩ, and $VCSI < VOI1$, then M1 is opened and it returns to the normal conditions.

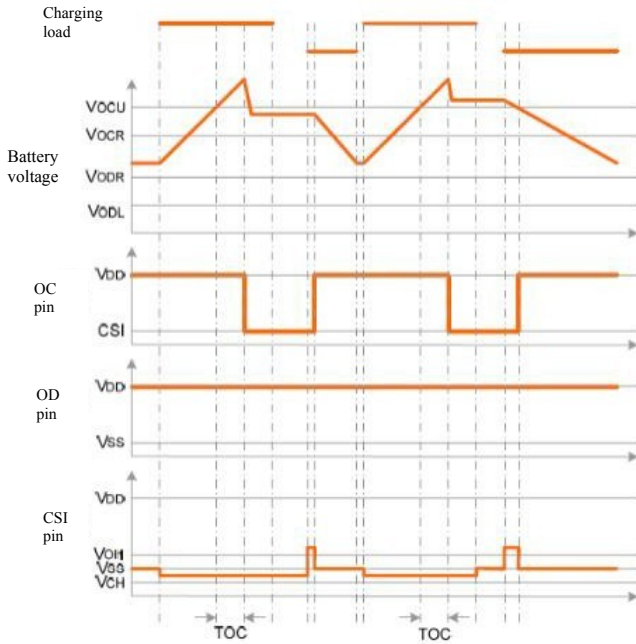
Notes: When the battery is connected to the protective circuit for the first time, the circuit may not enter into the normal mode, and it cannot discharge at this time. In this condition, make the voltage of the pin of CSI equivalent to that of VSS (make a short circuit between CSI and VSS or connect to a charger), to enter into the normal mode.

IX. Sequence Chart

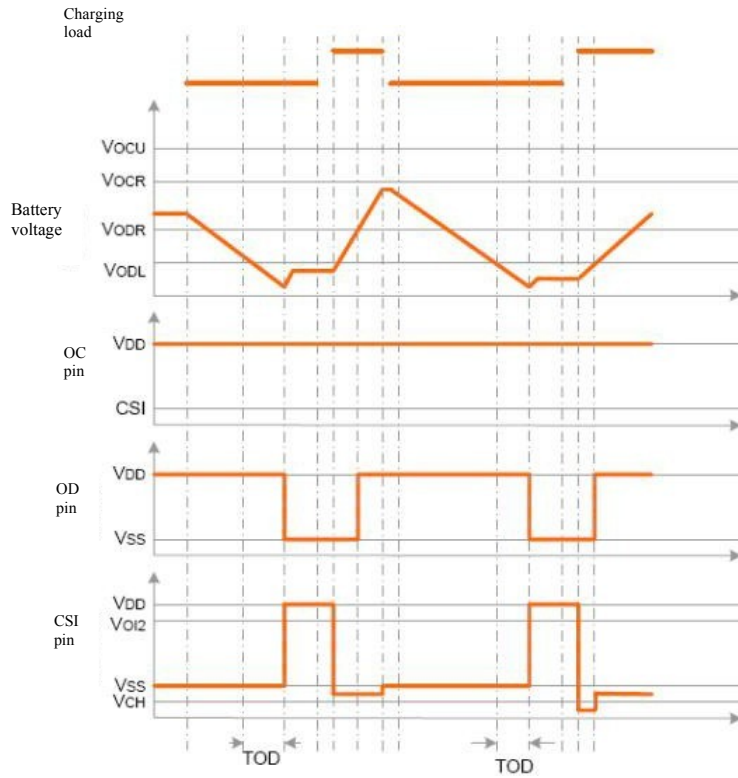
- The over-charging state – the self-discharging state – the normal state



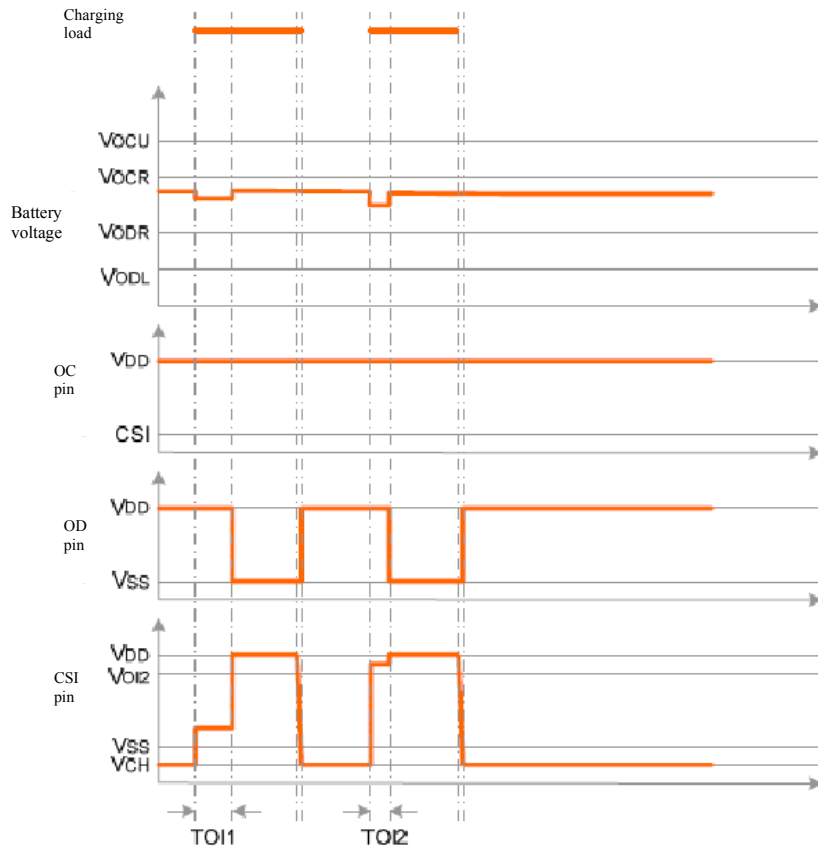
- The over-charging state – load discharging – the normal state



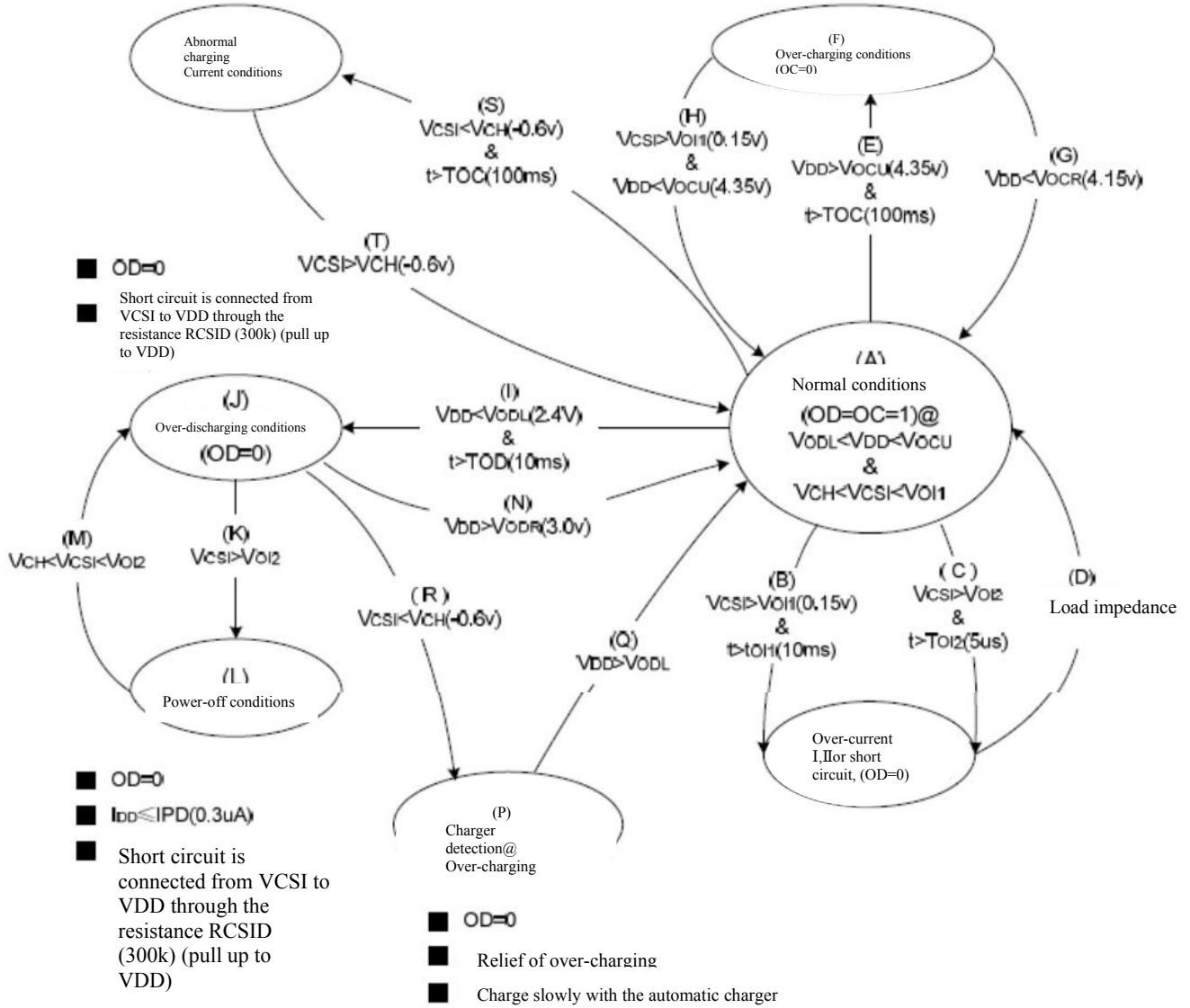
- The over-charging state – charging of the charger – the normal state



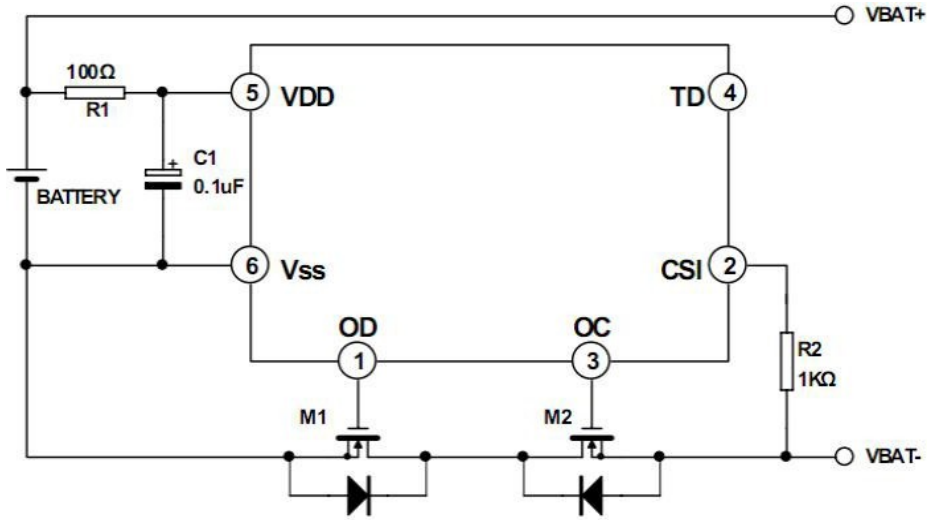
- The over-charging state – the normal state



X. Operation Status Diagram



XI. Typical Application



Notes: The above circuit and references are for reference only, and please set parameters for practical application circuits based on sufficient actual measurement.

XII. Packaging Size and Profile Drawing (unit: mm)

SOT-23-6

