Eternal Semiconductor Inc.

DW01A

1. General Description

The DW01A IC is best created for single-cell lithium-ion/lithium polymer rechargeable battery protection and it also comprises high-accuracy voltage detectors and delay circuits. This IC is suitable for protecting single-cell rechargeable lithium-ion/lithium polymer battery packs against the problems of overcharge, overdischarge and overcurrent.

2. Features

The features that DW01A comprised is as follows:

- Overcharge detection voltage   4.300V   Accuracy: ±50mV

- Overcharge release voltage   4.100V   Accuracy: ±50mV

- Overdischarge detection voltage   2.50V   Accuracy: ±75mV

- Overdischarge release voltage   2.90V   Accuracy: ±75mV

- Discharge overcurrent detection voltage   150mV   Accuracy: ±30mV

- Short-circuiting detection voltage   1.36V   Accuracy: ±350Mv

- Charger detection voltage   -1.2V

- Delay times are generated by an internal circuit (external capacitors are unnecessary).

- Low Quiescent current consumption @ 6.0 uA for DW01A (Typ, VDD=3.9V)

- Low over discharge current @ 2.5uA for DW01A (Max, VDD=2.0V)

- Low power down standby current consumption @ 1.0uA for DW01A (Max, VDD=2.0V)

- 0V battery charging function available

- High voltage device is used for charger connection in OC and CS

- Wide operating temperature range   −40°C to +85 °C

- Small package   SOT-23-6L

3. Applications

- lithium-ion rechargeable battery packs

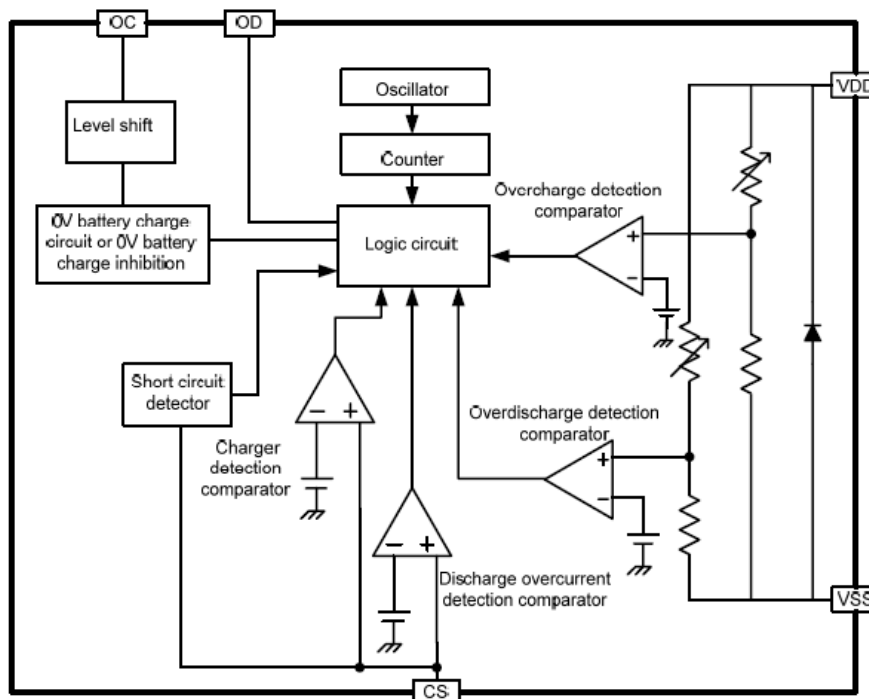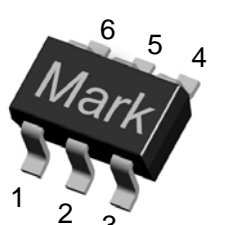- lithium polymer rechargeable battery packs

4. Product Ordering Information

Model	Over-charge Detection Voltage V	Over-charge Release Voltage V	Over-discharge Voltage V	Over-discharge Release Voltage V	Discharge Over-current Voltage V	0V Charge function	Auto Recovery
DW01A	4.30±0.05 V	4.10±0.05V	2.50±0.075 V	2.90V±0.075 V	0.15±0.03V	YES	YES

5. Block Diagram

6. Pin Configuration and Package Information

Pin	Symbol	Description	Package
1	OD	MOSFET gate control pin for discharge	
2	CS	Input pin for current sense Charger control	
3	OC	MOSFET gate control pin for charge	
4	TP	Test pin for reduce delay time	SOT-23-6L
5	VDD	Positive power input pin	
6	VSS	Negative power input pin	

7. Absolute Maximum Ratings

(VSS=0V, Ta=25°C unless otherwise specified)

Item	Symbol	Rating	Unit
Input voltage between VDD and VSS pin	V_{DD}	1.5 to 10	V
OC output pin voltage	V_{OC}	VDD -0.5 to VDD +0.4	V
OD output pin voltage	V_{OD}	VSS-0.5 to VDD +0.4	V
CS input pin voltage	V_{CS}	VDD -25 to VDD +0.3	V
Operating Temperature Range	T_{OP}	-40 to + 85	°C
Storage Temperature Range	T_{ST}	-55 to +125	°C
Power dissipation	PD	150	mW

8. Electrical Characteristics

(VSS=0V, Ta=25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating input voltage	V_{DD}	-	1.5	-	8	V
Operating voltage between OC & CS	-	-	1.5	-	25	V
Minimum operating voltage for 0V Charging	Vst	V_{DD}=V_{CS} V_{DD}-V_{SS}=0V	-	-	1.2	V
Discharging overcurrent release resistance	R_{short}	V_{DD} =3.6,CS=1.0V	15	30	45	KΩ
Current consumption	I_{DD}	V_{DD} =3.5V,CS=0V	-	3.0	6.0	µA
Overcharge detection voltage	V_{CU}	R1=100Ω	4.25	4.30	4.35	V
Overcharge Release Voltage	V_{CR}	R1=100Ω	4.05	4.10	4.15	V
Over-discharge Detection Voltage	V_{DL}	R1=100Ω	2.425	2.50	2.575	V
Over-discharge Release Voltage **(Unless ECDW01)**	V_{DR}	R1=100Ω	2.825	2.90	2.975	V
Discharge Overcurrent Detection Voltage	V_{DIP}	V_{DD} =3.6V R1=1.0KΩ	120	150	180	mV
Short Circuit Detection Voltage	V_{SIP}	V_{DD} =3.0V	0.82	1.36	1.75	V
Charger Detection Voltage	V_{CHA}	V_{DD} =3.6V, R2=1.0k	0.3	0.7	1.1	V
Overcharge Delay Time	T_{OC}	V_{DD} =3.9V to 4.5V	75	110	150	ms
Overdischarge Delay Time	T_{OD}	V_{DD} =3.6V to 2.0V	40	55	70	ms
Discharge Overcurrent Delay Time	T_{DIP}	V_{DD} =3.6V	5	7	10	ms
Short Circuit Delay Time	T_{SIP}	V_{DD} =3.0V	-	400	600	µs
OD Pin Output "H" Voltage	V_{DH}	V_{DD} =3.6V,CS=0V, I_{OCH}=-10uA	VDD-0.4	VDD-0.2		V
D Pin Output "L" Voltage	V_{DL}	V_{DD} =2.0V, CS=0V, I_{ODL}=10uA	-	0.2	0.4	V
OC Pin Output "H" Voltage	V_{CH}	V_{DD} =3.6V, CS=0V, I_{OCH}=-10uA	VDD-0.4	VDD-0.2		V
OC Pin Output "L" Voltage	V_{CL}	V_{DD}=4.5V,CS=0V, I_{OCL}=10uA	-	0.2	0.4	V

9. Example of Battery Protection IC Connection
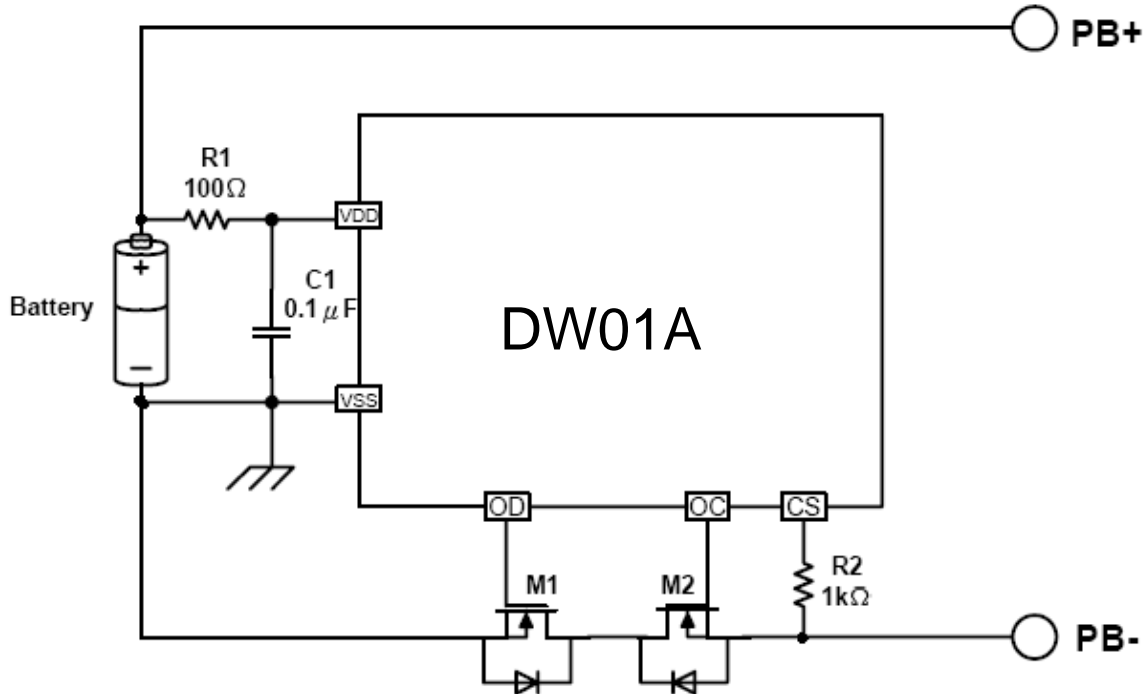
Symbol	Device Name	Purpose	Min.	Typ.	Max.	Remark
R1	Resistor	limit current, stabilize VDD and strengthen ESD protection	100Ω	100Ω	470Ω	*1
R2	Resistor	limit current	1.0 KΩ		2.0kΩ	*2
C1	Capacitor	stabilize VDD	0.01 μF	0.1μF	1.0μF	*3
M1	N-MOSFET	Discharge control	-	-	-	*5
M2	N-MOSFET	Charge control	-	-	-	*6

*1. R1 should be as small as possible to avoid lowering the overcharge detection accuracy due to current consumption. When a charger is connected in reversed, the current flows from the charger to the IC. At this time, if R1 is connected to high resistance, the voltage between VDD pin and VSS pin may exceed the absolute maximum rating.

*2. If R2 has a resistance higher than 2kΩ, the charging current may not be cut-off when abnormal over-current appeared during charging. Please select as large a resistance as possible to prevent current when a charger is connected in reversed.

*3. C1 will stabilize the supply voltage of VDD，the value of C1 should be equal to or more than 0.01μF.

*4. If a MOSFET with a threshold voltage equal to or higher than the overdischarge detection voltage is applied, discharging may be stopped before overdischarge is detected.

*5. If the withstanding voltage between the gate and source is lower than the charger voltage, the MOSFET may be destroyed.

10. Description of Operation

10.1. Normal Status

This IC monitors the voltage of the battery connected between the VDD pin and VSS pin and the voltage difference between the CS pin and VSS pin to control charging and discharging.

When the battery voltage is in the range from overdischarge detection voltage (V_{DL}) to overcharge detection voltage (V_{CU}), and the CS pin voltage is in the range from the charger detection voltage (V_{CHA}) to discharge overcurrent detection voltage (V_{DIP}), the IC turns both the charging and discharging control MOSFET on. This condition is called the normal status. Under this condition, charging and discharging can both be carried out freely.

10.2. Over-charge Status

Under the normal status, as soon as the battery voltage becomes higher than the overcharge detection voltage (V_{CU}) during charging and the detection continues longer than the overcharge detection delay time (T_{OC}), the DW01A will turn the charging control MOSFET off (OC pin) to stop charging .This condition is called the overcharge status.

The overcharge status can be released by the following two cases:

(1)The voltage of the battery cell is equal to or lowers than the overcharge release voltage (V_{CR}) due to self-discharge.

(2)When load is connected and the battery voltage falls below the overcharge protection voltage (V_{CU}).

10.3. Over-discharge Status

When the battery voltage falls below than the overdischarge detection voltage (V_{DL}) during discharging in the normal status and the detection continues longer than the overdischarge detection delay time (T_{OD}), the DW01A will turn the discharging control MOSFET off(OD pin) so as to stop discharging. This condition is called the overdischarge status.

When the MOSFET is off, CS pin voltage is pulled up by the resistor to VDD in the IC, at this time, the power consumption is reduced to the lowest. This condition is called the "SLEEP MODE".

The overdischarge status will be released by two cases:

(1) When CS pin voltage is equal to or lower than the charger detection voltage (V_{CHA}) by charging and the VDD pin voltage is higher than overdischarge detection voltage(V_{DL}).

(2) When CS pin voltage is equal to or higher than the charger detection voltage (V_{CHA}) by charging and the VDD pin voltage is higher than overdischarge release voltage (V_{DR}).

10.4. Charger detection Status

When the charger is connected to the overdischarge battery, if the voltage of CS pin is lower than charger detection voltage(V_{CHA}), based on the charger detection function, as long as the battery voltage is higher than overdischarge voltage(V_{DL}), the discharge status will be released and discharging control MOSFET (OD pin) will be turned on. This process is called the "charger detection status".
Conversely, if CS pin's voltage is not lower than charger detection voltage (V_{CHA}), the battery voltage has

to reach the overdischarge release voltage (V_{DR}) to relieve the overdischarge status as usual.

10.5. Discharge Overcurrent Status (Discharge Overcurrent & Short Circuit)

Under normal condition, the DW01A continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent detection voltage (V_{DIP}) and the condition lasts beyond the overcurrent delay time (T_{DIP}), discharging will be suspended by turning off the discharge control MOSFET (OD pin). This condition is called the discharge overcurrent status.

If the voltage of CS pin exceeds the short circuit detection voltage (V_{SIP}) and the condition lasts beyond the short circuit delay time (T_{SIP}), discharging will be suspended by turning off the discharge control MOSFET (OD pin). This condition is called the short circuit status.

When the impedance between PB+ and PB-is higher than 1.4MΩ (typ.), the discharge overcurrent condition will be released.

10.6. Abnormal Charge Current detection

Batteries under normal condition during the charging process, if the voltage of CS pin is lower than charger detection voltage (V_{CHA}), and this condition lasts for more than 12ms(typ.), the charging control MOSFET will be switched off (OC pin) to stop charging. This status is called "abnormal charge current detection".

After entering the status of abnormal charge current detection, one way to revert it to normal is to have the CS pin voltage higher than charger detection voltage (V_{CHA}). Abnormal charge current detection voltage (V_{CHA}) for **formularize:**

{I_{CHA}=|V_{CHA}|/R_{ON}}. R_{ON} is turn on resistance of MOSFET

## 10.7. 0V Battery Charging Function "Unavailable"

When a battery which is internally short-circuited (0V battery) is connected, the unavailable 0V charging function will prohibit recharging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V_{0IN}) or lower, the charging control MOSFET gate is fixed to the PB- pin voltage to prohibit charging. When the battery voltage equals to the 0V battery charge inhibition battery voltage (V_{0IN}) or higher, charging can be implemented.

10.8. Recommendations of PCB Layout

10.8.1. The consideration in the design of the PCB Layout for Li-ion battery circuit is to minimize the load resistance. Therefore, the position from MOSFET and B- and P- should be as close as possible. And, the distance of two parallel PCB wires should be larger than 0.25mm. The width of Power and Ground are as wider as possible to low down the grounding resistance.

11. Package information

NOTE: All dimensions are in millimeters.
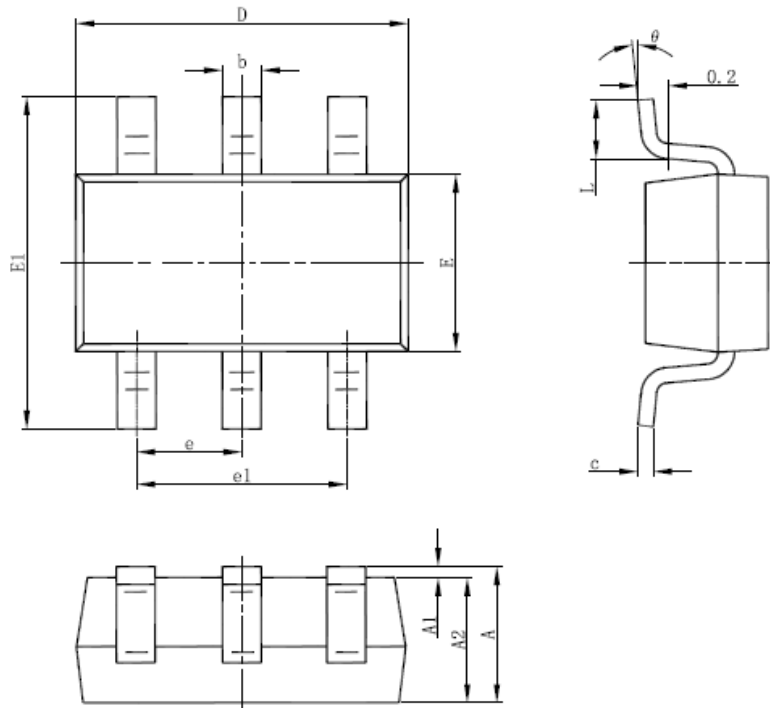
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.040	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.95（BSC)		0.037（BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°