

FEATURES

- Reduction in Board Size due to Miniature Package SOT-23-6.
- Ultra-Low Quiescent Current at $3\ \mu\text{A}$ ($V_{CC}=3.9\text{V}$).
- Ultra-Low Power-Down Current at $0.3\ \mu\text{A}$ ($V_{CC}=2.0\text{V}$).
- Precision Overcharge Protection Voltage $4.35\text{V} \pm 50\text{mV}$ for the DW_LP1
- Load Detection Function during Overcharge Mode.
- Two Detection Levels for Overcurrent Protection.

DESCRIPTION

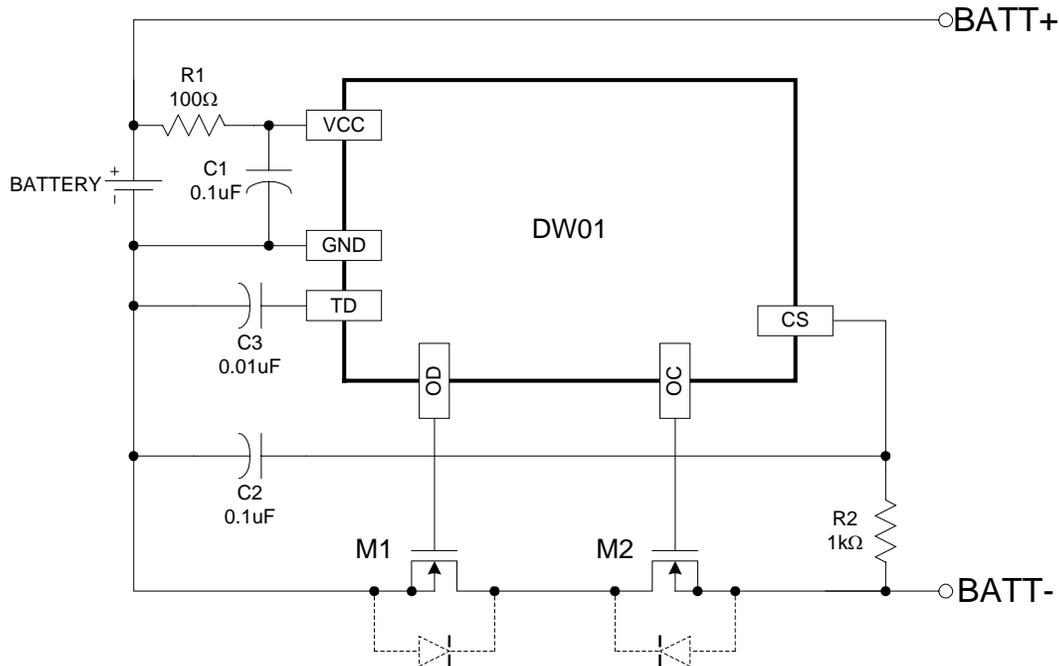
The DW_LP1 battery protection IC is designed to protect lithium-ion battery from damage or degrading the lifetime due to overcharge, overdischarge, and/or overcurrent for one-cell lithium-ion battery powered systems, Such as cellular phones. The ultra-small package and less required external components make it ideal to integrate the DW_LP1 into the limited space of battery pack.

The accurate $\pm 50\text{mV}$ overcharging detection voltage ensures Safe and full utilization charging. The very low standby current drains little current from the cell while in storage.

APPLICATIONS

- Protection IC for One-Cell Lithium-Ion Battery Pack.

TYPICAL APPLICATION CIRCUIT



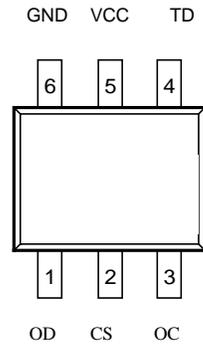
Protection Circuit for One-Cell Lithium-Ion Battery

ORDERING INFORMATION

DW_LP1 PACKAGE TYPE
SOT-23-6

TEMPERATURE RANGE
-10°C~+70°C

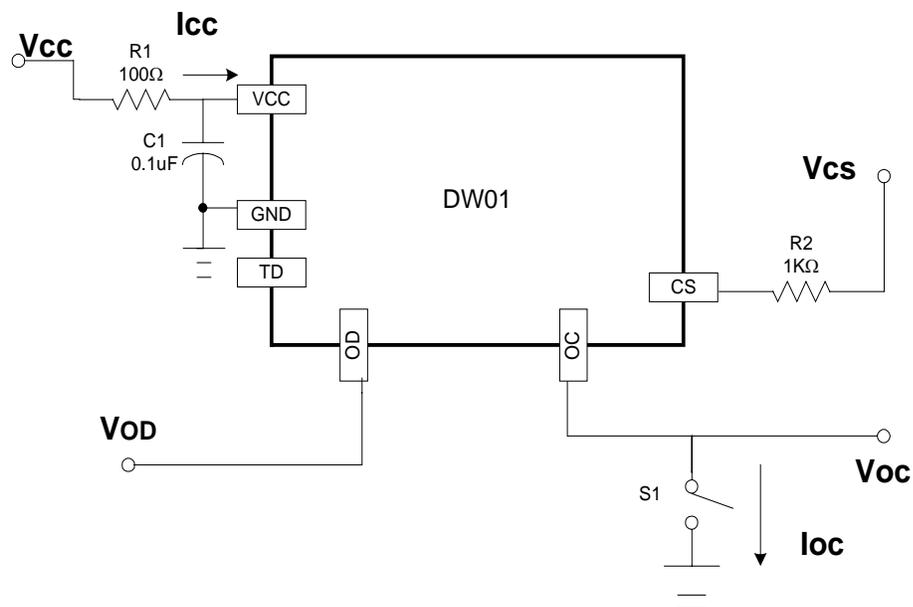
OVERCHARGE PROTECTION
4.35V



ABSOLUTE MAXIMUM RATINGS

Supply Voltage.....	10V
DC Voltage Applied On Other Pins.....	15V
Operating Temperature Range.....	-10 ~+70
Storage Temperature Range.....	-40 ~+120

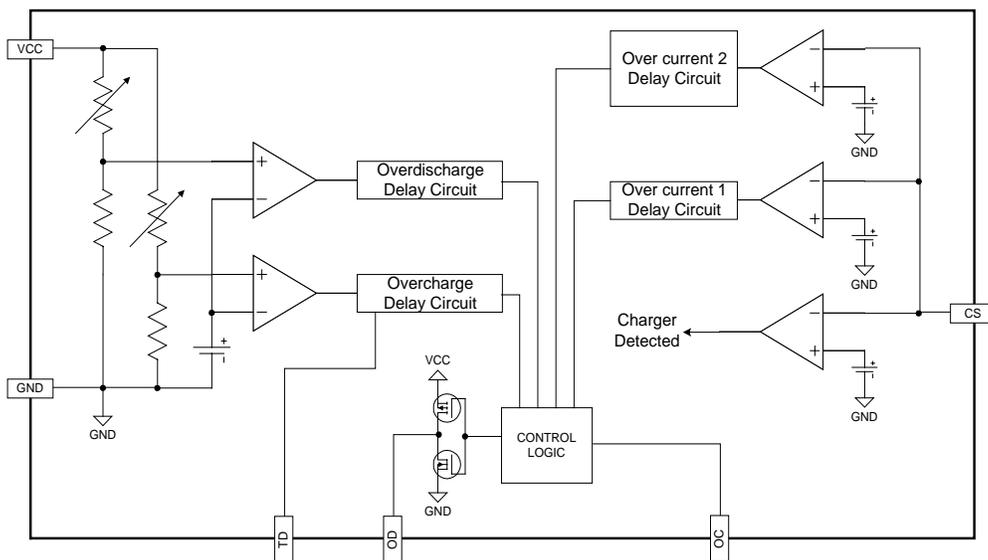
Test Circuit



ELECTRICAL CHARACTERISTICS (Ta=25°C, unless otherwise specified.)
Model Name DW_LP1

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply Current	VCC=3.9V	ICC		3.0	6.0	uA
Power-Down Current	VCC=2.0V	IPD		0.3	0.6	uA
Overcharge Protection Voltage	DW_LP1	VOCP	4.3	4.35	4.4	V
Overcharge Hysteresis Voltage		VHYS	150	200	250	mV
Overdischarge Protection Voltage		VODP	2.30	2.40	2.50	V
Overdischarge Release Voltage		VODR	2.90	3.00	3.10	V
Overcurrent Protection Voltage		VOIP(VOI1)	120	150	180	mV
Short Current Protection Voltage	VCC=3.6V	VSIP(VOI2)	1.25	1.35	1.45	V
Overcharge Delay Time	C _{TD} =0.01uF	TOC		200	400	ms
Overdischarge Delay Time	VCC=3.6V to 2.0V	TOD		10	20	ms
Overcurrent Delay Time (1)	VCC=3.6V	TOI1		10	20	ms
Overcurrent Delay Time (2)	VCC=3.6V	TOI2		5	50	us
Load Detection Threshold Voltage		VLD	0.12	0.15	0.18	V
Charger Detection Threshold Voltage		VCH	-0.8	-0.6	-0.4	V
OD Pin Output "H" Voltage		VDH	VCC-0.1	VCC-0.02		V
OD Pin Output "L" Voltage		VDL		0.01	0.1	V
OC Pin Output "H" Voltage		VCH	VCC-0.1	VCC-0.02		V
OC Pin Output "L" Voltage		VCL		0.01	0.1	V

BLOCK DIAGRAM



PIN DESCRIPTIONS

PIN 1:OD - MOSFET gate connection pin for discharge control.

PIN 2:CS - Input pin for current sense, charger detect.

PIN 3:OC - MOSFET gate connection pin for charge control.

PIN 4:TD - Pin for external capacitor setting output delay of Overcharge Protection Voltage.

PIN 5:VCC - Power supply, through a resistor. (R1)

PIN 6:GND - Ground pin.

APPLICATION INFORMATIONS

THE OPERATION

Overcharge Protection

When the voltage of the battery cell exceeds the overcharge protection voltage (VOCP) beyond the overcharge delay time (TOC) period, charging is inhibited by the turning-off of the charge control MOSFET. The overcharge condition is released in two cases:

1. The voltage of the battery cell becomes lower than the overcharge release voltage (VOCR or VOCP- VHYS) through self-discharge.
2. The voltage of the battery cell falls below the overcharge protection voltage (VOCP) and a load is connected.

When the battery voltage is above VOCP, the overcharge condition is never released even a load is connected to the pack.

Overdischarge Protection

When the voltage of the battery cell goes below the overdischarge protection voltage (VODP) beyond the overdischarge delay time (TOD) period, discharging is inhibited by the turning-off of the discharge control MOSFET. The overdischarge delay time defaults to 10ms.

Inhibition of discharging is immediately released when the voltage of the battery cell becomes higher than overdischarge release voltage (VODR) through charging.

Overcurrent Protection

In normal mode, the DW_LP1 continuously monitors the discharge current by sensing the voltage of CS pin. If the voltage of CS pin exceeds the overcurrent protection voltage (VOIP) beyond the overcurrent delay time (TOI) period, the overcurrent protection circuit operates and discharging is inhibited by the turning-off of the discharge control MOSFET. The overcurrent condition returns to the normal mode when the load is released and the impedance between the BATT+ and BATT.

The DW_LP1 is provided with the two overcurrent detection levels (0.15V and 1.35V) and the two overcurrent delay time (TOI1 and TOI2) corresponding to each overcurrent detection level.

Load Detection after Overcharge

The load detection function after overcharge is implemented by detecting the CS pin voltage. Once a load is connected to the battery pack after overcharge, discharge current flows through the parasitic diode of MOSFET and there is a diode voltage drop between CS and GND. Load is determined to be connected to the pack if the CS pin voltage is above load detection threshold voltage (VLD).

Charge Detection after Overdischarge

When overdischarge occurs, the discharge control MOSFET turns off and discharging is inhibited. However, charging is still permitted through the parasitic diode of MOSFET. Once the charger is connected to the battery pack, the DW_LP1 immediately turns on all the timing generation and detection circuitry. Charging is determined to be in progress if the voltage between CS and GND is below charge detection threshold voltage (VCH).

Power-Down after Overdischarge

When overdischarge occurs, the DW_LP1 will go into power-down mode, turning off all the timing generation and detection circuitry to reduce the quiescent current to 0.3uA (VCC=2.0V). At the same time, the CS pin is pull-high to VCC through a high resistance resistor.

DESIGN GUIDE

Selection of External Control MOSFETS

Because the overcurrent protection voltage is preset, the threshold current for overcurrent detection is determined by the turn-on resistance of the discharge control MOSFET. The turn-on resistance of the external control MOSFETS can be determined by the equation: $R_{ON} = VOIP / (2 \times I_T)$ (IT is the overcurrent threshold current). For example, if the overcurrent threshold current IT is designed to be 3A, the turn-on resistance of the external control MOSFETS must be 25mΩ. Users should be aware that turn-on resistance of the MOSFET changes with temperature variation due to heat dissipation. It changes with the voltage between gate and source as well. (Turn-on resistance of MOSFET increases as the voltage between gate and source decreases). Once the turn-on resistance of the external MOSFET changes, the overcurrent threshold current will change accordingly.

Suppressing the Ripple and Disturbance from Charger

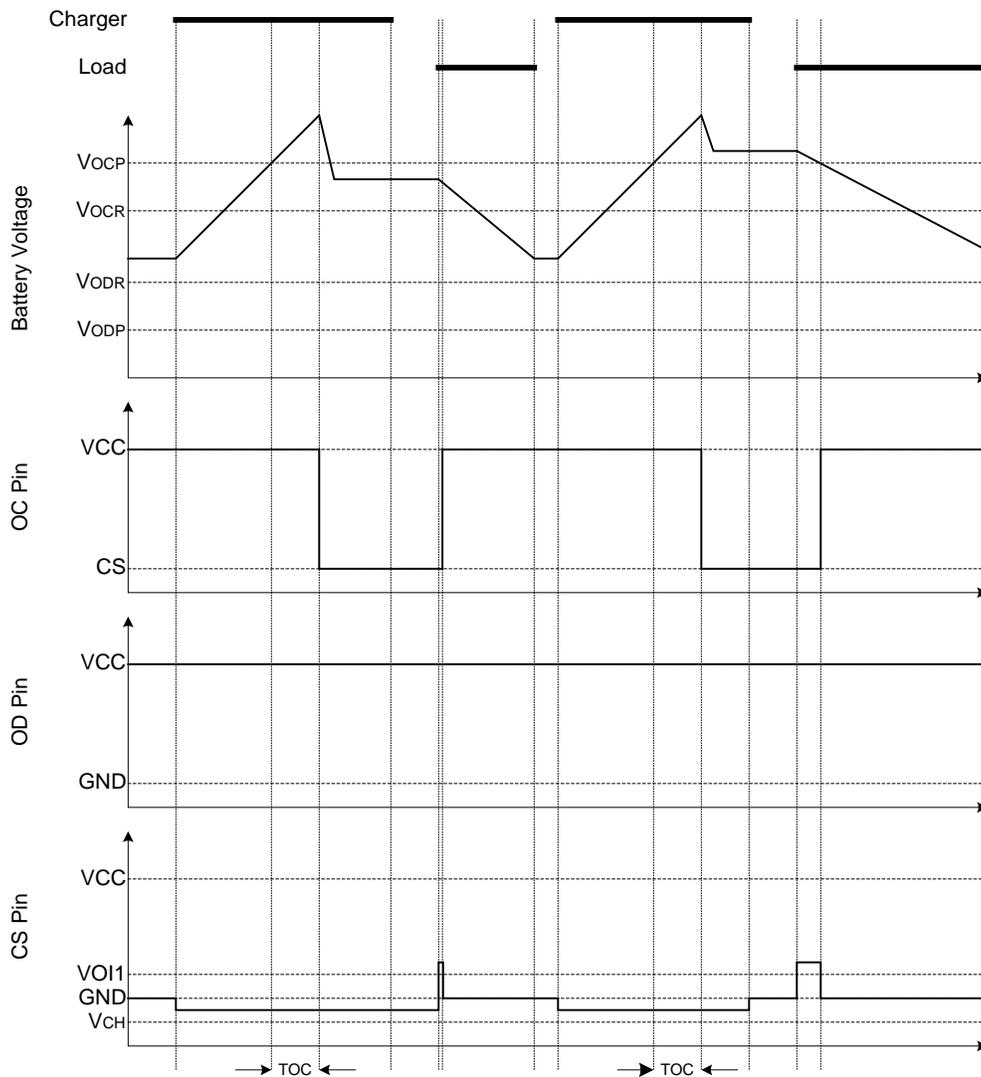
To suppress the ripple and disturbance from charger, connecting RI,C1 to VCC pin is recommended.

Protection at CS pin

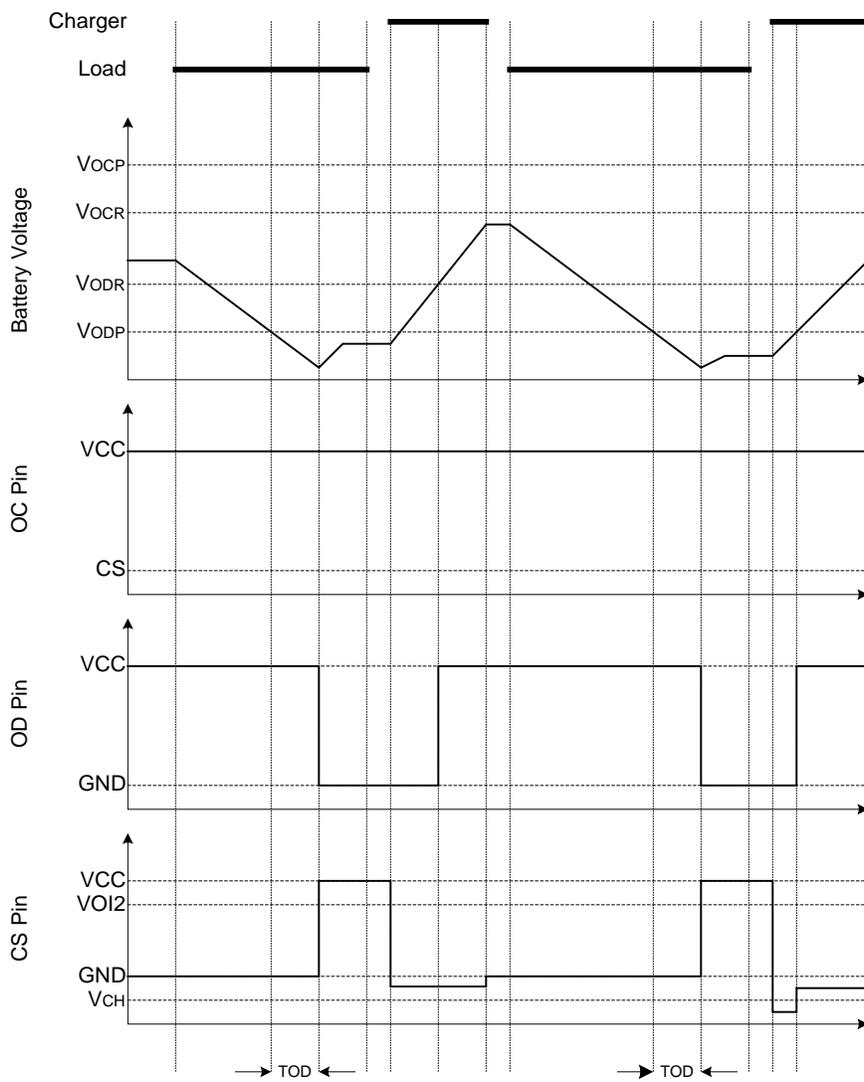
R2 is used for latch-up protection when charger is connected under overdischarge condition and overstress protection at reverse connecting of a charger.

TIMING DIAGRAM

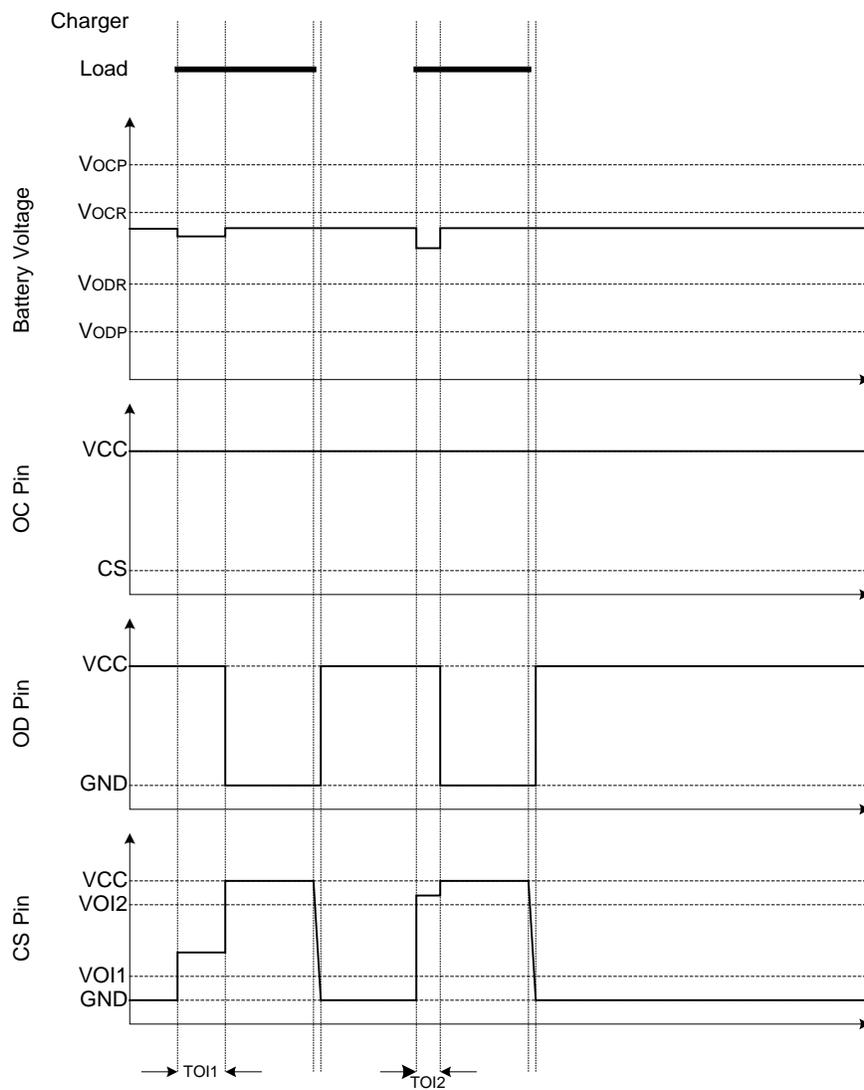
Overcharge Condition → Load Discharging → Normal Condition



Overdischarge Condition → Charging by a Charger → Normal Condition

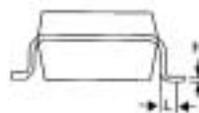
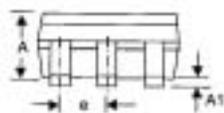
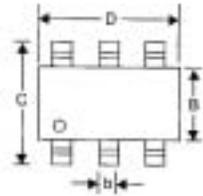


Over Current Condition → Normal Condition



PHYSICAL DIMENSIONS

TOP VIEW
FRONT VIEW
SIDE VIEW
REAR VIEW
BOTTOM VIEW



SYMBOL	MIN (mm)	MAX (mm)
A	0.95	1.30
A1	-	0.13
B	1.40	1.80
b	0.36	0.56
C	2.60	3.00
D	2.70	3.10
e	0.84	1.04
H	0.10	0.25
L	0.36	0.6