

## Single Cell Li-Ion & Li-Pol Battery Protection IC

### General Description

The DS6091 series are protection ICs for rechargeable single-cell lithium ion ( Li + ) battery away from overcharge / discharge voltage or excessive load currents. It also includes a short-circuit protector to prevent large external short-circuit currents.

These ICs are composed of two voltage detectors, reference cells, delay circuits, short circuit protectors, logic circuits and MOSFET switches.

When the charging voltage exceeds the detector threshold from a low value to a value higher than VDET1, the MOSFET switch is turned off. After detecting overcharge, when the VBAT voltage drops below the "VREL1" level, or when the charger is disconnected from the charger to VBAT, it can be reset and the MOSFET switch is turned on.

When the discharge voltage is below the detector threshold from a high value to another lower than VDET2, the MOSFET switch is turned off after an internal fixed delay time.

After the DS6091 series detects the over-discharge voltage, connect the charger to the battery pack, and when the battery power supply voltage is higher than the over-discharge detector threshold, the MOSFET switch is turned on.

After the internal fixed delay time accompanied by the built-in over-current detector, the over-load current can be sensed and cut off by the MOSFET switch being turned off.

Once the excess current is detected, it can be released by removing the battery pack from the load system and the MOSFET switch is turned on. In addition, the short-circuit protector will immediately turn off the MOSFET switch under the action of the external short-circuit current.

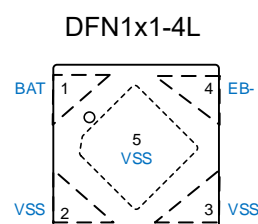
### Features

- Provide complete protection
- Integrate Advanced Power MOSFET with Equivalent of 35mΩ R<sub>SS(ON)</sub>
- Over-temperature Protection
- Over-charge Current Protection
- Over-discharge Current Protection
- Load Short Circuiting Protection
- High-Accuracy Voltage Detection
- Low Current Consumption
  - Operation Mode : 1.0uA
  - Power-down Mode : 0.1μA
- Delay Times are generated inside
- DFN1x1-4L Package Available

### Applications

- Laptop, Palmtops and PDAs
- Smart Phones
- MP3 Players
- Low-Power Handheld Devices
- TWS & E-Cig
- One Cell Lithium-ion Battery Pack

### Pin Configurations



**Ordering Information**

DS6091FVXX

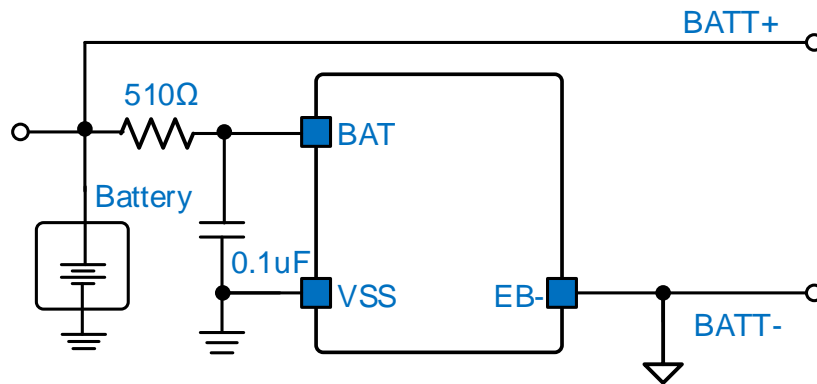
Designator	Description	Symbol	Description	
F	Function Type	A	0V Charging	Sleep mode
		B		Sampling mode
		C	Not 0V Charging	Sleep mode
		D		Sampling mode
V	Voltage Type	A	UV = 2.5V	OV = 4.25V
		B		OV = 4.30V
		C	UV = 2.8V	OV = 4.40V
		D		OV = 4.45V
		E		OV = 4.30V
XX	Package Type	D4	DFN1x1-4L	

**Example:** 0V Charging / Sleep Mode / UV=2.5V / OV=4.25V / DFN1x1-4L. Part no = DS6091AAD4

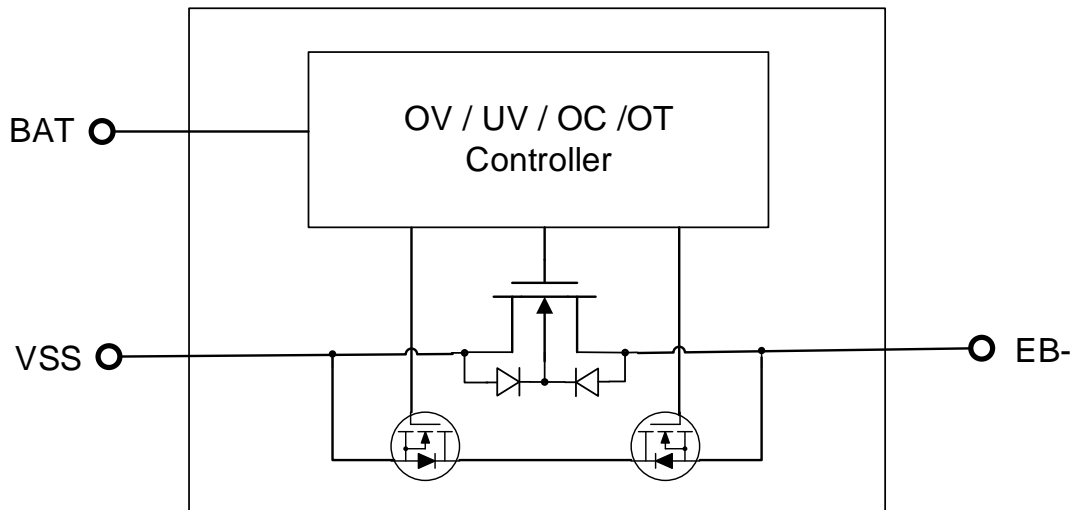
**Description of Functional Pins**

Pin No	Pin Name	Pin Function
DFN1x1-4L		
1	BAT	Input of Supply Voltage .
2 , 3	VSS	Ground, connect the negative terminal of the battery to these pins. Please connect these pins with EPAD by wide metal routings .
4	EB-	The negative terminal of the battery pack. The internal MOSFET switch connects this terminal to VSS . Please connect these pins by wide metal routings.
Exposed Pad ( 5 )	VSS	Substrate of Chip. Leave floating or tie to VSS.

**Typical Application Circuits**



**Function Block Diagram**



**Absolute Maximum Ratings** (Note 1)

BAT to VSS -----	-0.3V to 8V
EB- to VSS -----	-8V to 9V
Package Thermal Resistance (Note 2)	
DFN1x1-4L, $\theta_{JA}$ -----	195 °C /W
Lead Temperature (Soldering, 10 sec.) -----	260 °C
Junction Temperature -----	150 °C
Storage Temperature Range -----	-60 °C to 150 °C
ESD Susceptibility	
HBM -----	2KV
MM -----	200V

**Recommended Operating Conditions**

Input Voltage BAT -----	1.5V to 5.5V
Junction Temperature Range -----	-40 °C to 125 °C
Ambient Temperature Range -----	-40 °C to 85 °C

**Electrical Characteristics**

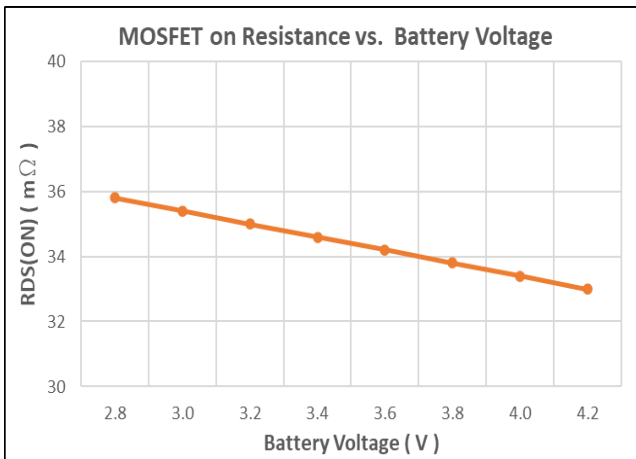
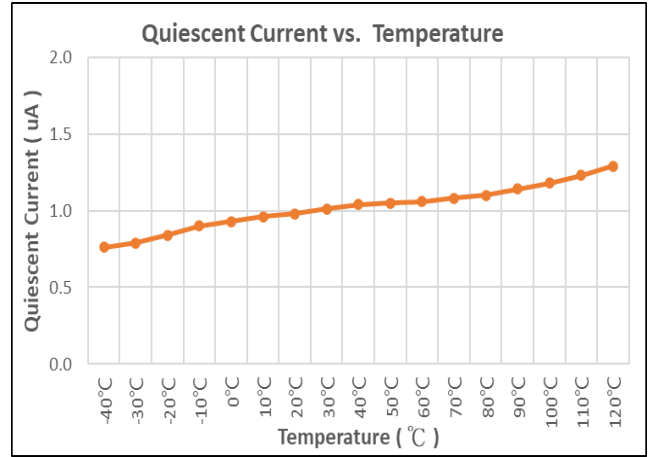
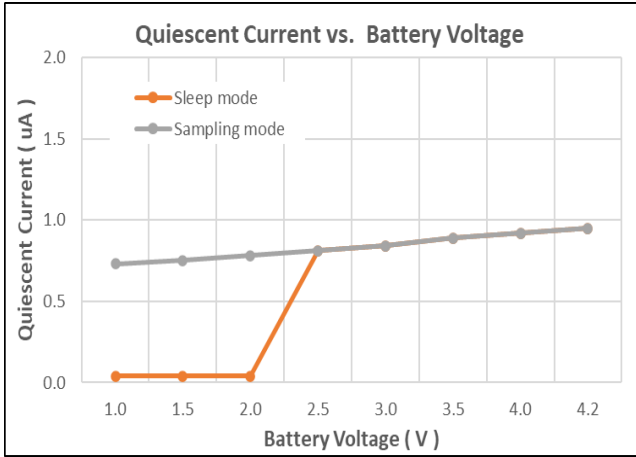
(  $V_{BAT} = 3.6V$ ,  $T_A = 25^\circ C$  unless otherwise specified )

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>Detection Voltage</b>						
Over-charge Detection Voltage	$V_{DET1}$	OV Type A		4.25		V
		OV Type B & E		4.30		
		OV Type C		4.40		
		OV Type D		4.45		
Over-charge Release Voltage	$V_{REL1}$	OV Type A		4.05		V
		OV Type B & E		4.10		
		OV Type C		4.20		
		OV Type D		4.25		
Over-discharge Detection Voltage	$V_{DET2}$	UV Type A & B		2.5		V
		UV Type C & D & E		2.8		
Over-discharge Release Voltage	$V_{REL2}$	UV Type A & B		2.7		V
		UV Type C & D & E		3.0		
<b>Detection Current</b>						
Over-discharge Current Detection	$I_{ODD}$	$V_{BAT} = 3.6V$		0.4		A
Over-charge Current Detection	$I_{OCD}$	$V_{BAT} = 3.6V$		0.35		A
Load Short-Circuiting Detection Current Consumption	$I_{SHORT}$	$V_{BAT} = 3.6V$		1		A
Current Consumption in Normal Operation	$I_{OP}$	$V_{BAT} = 3.6V$ $V_{EB-} = 0V$		1.0		$\mu A$
Current Consumption in Power Down	$I_{DN}$	$V_{BAT} = 2.0V$ $V_{EB-} = \text{Floating}$		0.1		$\mu A$
<b>MOSFET on Resistance ( VSS to VEB- )</b>						
Equivalent MOSFET on Resistance	$R_{DS(ON)}$	$V_{BAT} = 3.6V$ $I_{EB-} = 0.1A$		35		$m\Omega$
<b>Over Temperature Protection</b>						
Over Temperature Protection	$T_{SD}$			125		$^\circ C$
Over Temperature Recovery Degree	$T_{SDR}$			105		$^\circ C$
<b>Detection Delay Time</b>						
Over-charge Voltage Detection Delay Time	$tV_{DET1}$			180		mS
Over-discharge Voltage Detection Delay Time	$tV_{DET2}$			45		mS
Over-discharge Current Detection Delay Time	$tI_{ODD}$			10		mS
Over-charge Current Detection Delay Time	$tI_{OCD}$			10		mS
Load Short-Circuiting Detection Delay Time	$tI_{SHORT}$			270		$\mu S$

**Note 1.** Stresses beyond those listed “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

**Note 2.**  $\theta_{JA}$  is measured at  $T_A = 25^\circ\text{C}$  on a DSTECH EVB board.

Typical Characteristics



## Application Guideline

### **Over-charge Detector ( VOCD )**

The VOCD monitors VBAT pin voltage. When the VBAT voltage exceeds the threshold of VOCD VDET1 from a low value, VOCD detects and turn off the MOSFET switch.

After detecting over-charge, there are two situations to release VOCD .

The first one is when the VBAT voltage drops to a level lower than "VREL1" during the charger is still connecting. The second case is when the charger is disconnected from the battery pack and a load is connected to VBAT, a discharge current can pass through the internal parasitic diode. When the VBAT level is discharged below "VDET1", VOCD can be reset and turn on the MOSFET switch again.

### **Over-discharge Detector ( VODD )**

The VODD is monitoring VBAT pin voltage. When the VBAT voltage is below the over-discharge detector threshold VDET2 , VODD can detect over-discharge, and the internal MOSFET switch will be turned off.

During over-discharge protection, to release VODD, the charger must be connected to the battery pack. When the VBAT voltage remains below the over-discharge detector threshold VDET2, the charging current can flow through the parasitic diode of the internal discharge control MOSFET, which makes the VBAT voltage rises to a value greater than VREL2, the MOSFET is turned on again.

The output delay time of the over-discharge detection is  $t_{VDET2} = 45\text{ms}$  (typical value). The VBAT voltage must keep under VDET2 continuously longer than  $t_{VDET2}$  to make the VOCD send a signal to turn off the discharge control MOSFET .

After detecting over-discharge through VOCD, the

power supply current will drop to  $0.1\mu\text{A}$  and enter the standby state that the charger detector is working only.

### **Excess Current Detector, Short Circuit Protector ( VEOC )**

When the internal MOSFET switch is on , both the over-current detector and the short-circuit protector can work. When the conducting current rises to the overcurrent protection current level, the overcurrent detector will work and the internal MOSFET switch will be turned off.

The output delay time of the internal overcurrent detector is internally fixed, with a typical value of 10ms.

After the short-circuit protector is triggered , the internal MOSFET switch will be turned off after a shorter delay time which is  $270\mu\text{s}$  typically.

The overcurrent detector has a built-in pull-down resistor with a typical value of  $67\text{K}\Omega$  between EB- and VSS pin.

After detecting overcurrent or short circuit protection, eliminating the cause of overcurrent or external short circuit will make the internal MOSFET switch turning on automatically.

### **Abnormal Charge Current Detection**

If the charging current keeps greater than the threshold of Over-charge Current Detection more than the overcharge detection delay time, the DS6091 turns the control MOSFET off and stops charging. This action is called abnormal charge current detection. Remove the charger to turn on the control MOSFET again after abnormal charge current detection.



***Thermal Application***

For continuous operation, do not exceed the absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated as below :

$T_A=25^{\circ}\text{C}$ , DSTECH PCB,

The max PD (Max) = (  $125^{\circ}\text{C} - 25^{\circ}\text{C}$  ) / (  $195^{\circ}\text{C/W}$  ) = 0.51W for DFN1x1-4L packages.

Power dissipation ( PD ) is equal to the product of the output current and the voltage drop across the output pass element, as shown in the equation below:

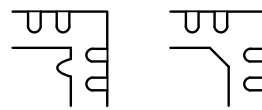
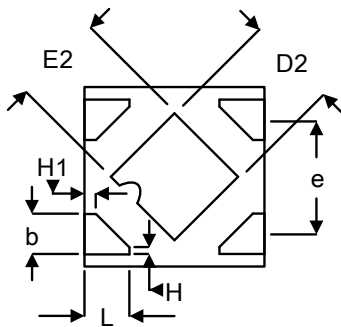
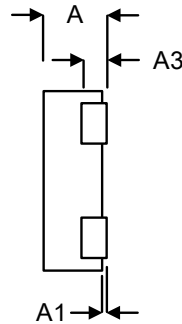
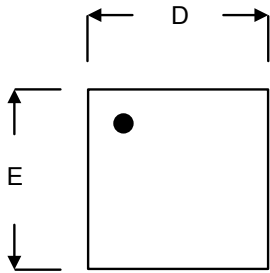
$$\text{PD} = I_{\text{OUT}}^2 \times \text{RDS}_{(\text{ON})}$$

**Layout Consideration**

By placing input and output capacitors on the same side of the PCB as the Charger, and placing them as close as is practical to the package can achieve the best performance. The ground connections for input and output capacitors must be back to the DS6091 ground pin using as wide and as short of a copper trace as is practical.

Connections using long trace lengths, narrow trace widths, and/or connections through via must be avoided. These add parasitic inductances and resistance that results in worse performance especially during transient conditions.

**Package Information:**



**DETAILA**

PIN #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.300	0.400	0.012	0.016
A1	0.000	0.050	0.000	0.002
A3	0.117	0.162	0.005	0.006
b	0.175	0.280	0.007	0.011
D	0.900	1.100	0.035	0.043
D2	0.430	0.550	0.017	0.022
E	0.900	1.100	0.035	0.043
E2	0.430	0.550	0.017	0.022
e	0.650		0.026	
L	0.200	0.300	0.008	0.012
H	0.039		0.002	
H1	0.064		0.003	

**DFN1x1-4L**