Built-in MOSFET Single Lithium Battery Protection IC

SL19 7-1 is internally installed with a high-accuracy voltage detection circuit and a delay circuit, to realize over-charging, over-discharging and over-current protection to the battery by detecting voltage and current of the battery. It is applicable to protective circuits of single Li-ion/Li-polymer rechargeable batteries.

■ Functional characteristics

1) High-accuracy voltage detection function:
   - Over-charging detection voltage 3.5 V ~ 4.5 V accuracy ±25 mV
   - Over-charging hysteresis voltage 0.2 V accuracy ±50 mV
   - Over-discharging detection voltage 2.0 V ~ 3.2 V accuracy ±80 mV
   - Over-discharging hysteresis voltage 0.6 V accuracy ±100 mV
2) Discharging over-current detection function:
   - Over-current detection voltage 0.05 V ~ 0.10 V accuracy ±10mV
   - Short circuit detection voltage 0.400 V accuracy±100mV
3) Charging over-current detection voltage -0.05 V~-0.10 V accuracy±20mV
4) Load detection function
5) Charger detection function
6) 0V charging function
1) Low current consumption:
   - Working mode 2.2 μA (typical value) (Ta = ±25℃)
   - Over-discharging consumption current (with function of self-recovery in over-discharging) 0.7 μA (typical value) (Ta = ±25℃)
   - Sleep current (with function of sleep) 0.05 μA (typical value) (Ta =±25℃)
2) Free from lead and halogen
3) Built-in low breakover internal resistance N-MOSFET
   - VDS = 16V
   - ESD Rating：2000V HBM

■ Product model

Parameters / Product name	RSS (ON)	Over-charging protection voltage V_{OC}	Over-charging relief voltage V_{OCR}	Over-charging protection voltage V_{OD}	Over-discharging relief voltage V_{ODR}	Discharging overcurrent V_{EC1}	Short circuit V_{SHORT}	Charging over-current V_{CHA}	Over-charging locking	Over-discharging locking
SL19 7 -1	60 mΩ	4 .275 V	4.075 V	2.800 V	3.000 V	0.050 V	1.000 V	-0.050 V	Y	Y

Table 1

■ Application fields

- Intelligent wearable devices
- Bluetooth headsets

■ Package

- DFN 2*2-6L

■System functional block diagram

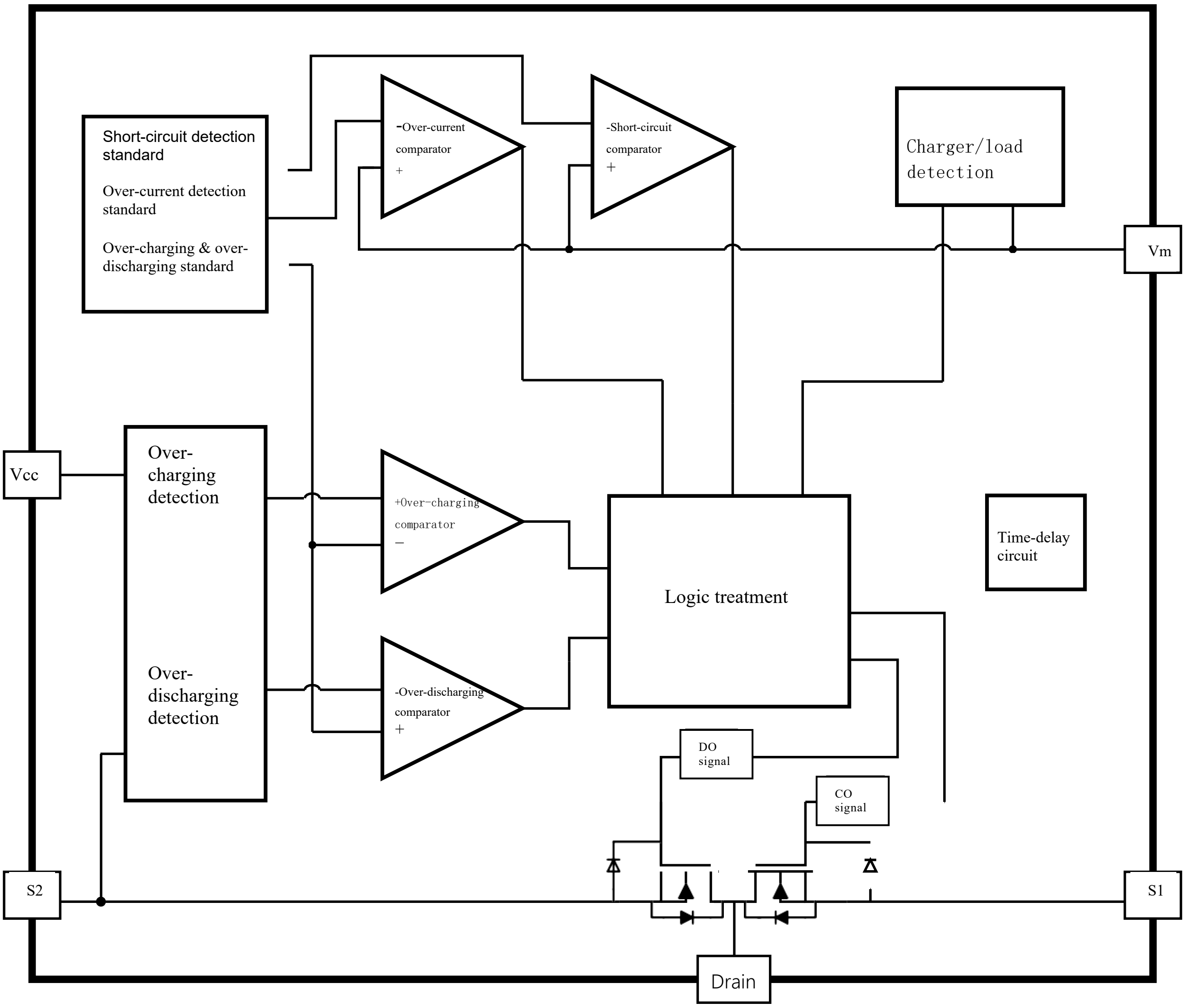
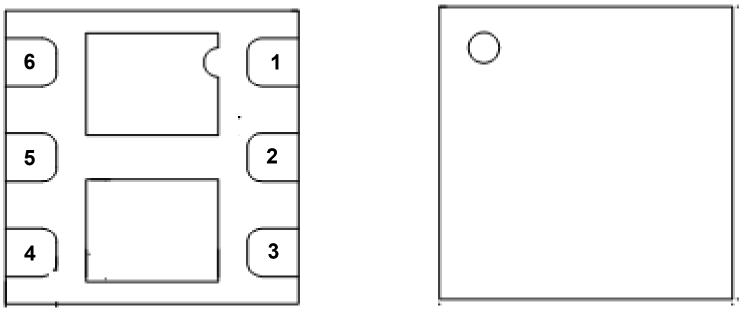


Figure 1

■Pin Arrangement

Diagram



Bottom view **Top view**

Figure 2 DFN2*2-6L package

No. of pin	Symbol	Description
1	VM	The charging and discharging current detection end, connected with the charger or the negative pole of the load
2	S1	The charging MOSFET source end, connected with the charger or the negative pole of the load
3	S1	The charging MOSFET source end, connected with the charger or the negative pole of the load
4	S2	The power ground end, connected with the negative pole of the power supply (battery)
5	S2	The power ground end, connected with the negative pole of the power supply (battery)
6	VCC	The power input end, connected with the positive pole of the power supply (battery)
7	-	The chip underlayer connection, required to be suspended in midair
8	-	Common-drain connecting end of the charging and discharging MOSFET

Table 2

■Absolute Max rated value

(Ta = 25°C ,unless otherwise noted)

Item	Symbol	Applicable terminal	Absolute Max. rated value	Unit
Supply voltage	VCC	VCC	-0.3 ~ 7	V
Vm end input voltage	Vm	Vm	VCC-15 to VCC+0.3	V
Gate-Source withstand voltage	V_{GS}	GS	±12	V
Drain-Source withstand voltage	V_{DS}	DS	16	V
Drain Current	ID		5	A
Operating ambient temperature	T_{OPR}		40 ~ 85	°C
Storge temperature	T_{STG}		40 ~ 125	°C

Table 3

Notes: It may lead to unrecoverable damages to the chip if the applied voltage exceeds the absolute max. rated value.

■Application circuit

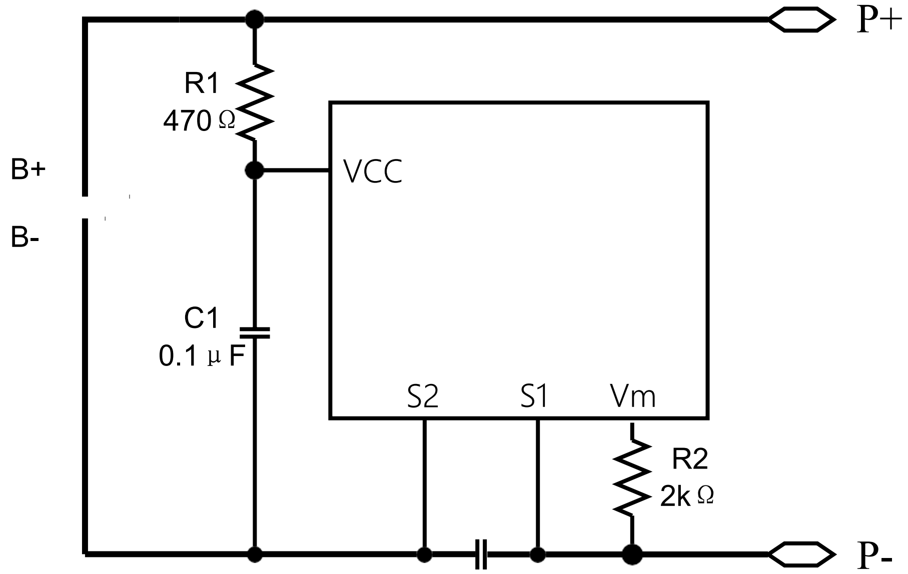


Figure 3

Device identification	Typical value	Device identification	Unit
R1	470	470 ~ 1000	Ω
R2	2	1 ~ 3	kΩ
C1	0.1	≥ 0.1	μF

Notes: R1 and R2 cannot be omitted, and R1 shall be no smaller than 470Ω

■Electrical specifications

(Ta = 25°C, unless otherwise noted)

Item		Symbol	Testing conditions Table 4	Min value	Typical value	Max value	Unit
Chip supply voltage		VCC	-	1.0	-	6.0	V
Normal working current		I_{VCC}	VCC=3.5V	-	2.2	5.0	μA
Sleep consumption current		I_{STB}	VCC =1.5V	-	0.05	0.5	μA
Sleep current		I_{STB}	VCC =2.0V	-	0.7	1.5	μA
Over-charging	Protection voltage	V_{OC}	VCC =3.5→4.5V	V_{OC} -0.025	V_{OC}	V_{OC} +0.025	V
	Relief voltage	V_{OCR}	VCC =4.5→3.5V	V_{OCR} -0.050	V_{OCR}	V_{OCR} +0.050	V
	Protection delay	T_{OC}	VCC =3.5→4.5V	40	80	160	ms
Over-discharging	Protection voltage	V_{OD}	VCC=3.5→2.0V	V_{OD} -0.080	V_{OD}	V_{OD} +0.080	V
	Relief voltage	V_{ODR}	VCC =2.0→3.5V	V_{ODR} -0.100	V_{ODR}	V_{ODR} +0.100	V
	Protection delay	T_{OD}	VCC =3.5→2.0V	20	40	80	ms
Discharging over-current	Protection voltage	V_{EC}	VM-VSS=0→0.20V	V_{EC} -0.010	V_{EC}	V_{EC} +0.010	V
	Protection delay	T_{EC}	VM-VSS=0→0.20V	5	10	20	ms
	Relief delay	T_{ECR}	VM-VSS=0.20→0V	1.0	2.0	4.0	ms
Charging over-current	Protection voltage	V_{CHA}	VSS-VM=0→0.30V	V_{CHA} -0.020	V_{CHA}	V_{CHA} +0.020	V
	Protection delay	T_{CHA}	VSS-VM=0→0.30V	5	10	20	ms
	Relief delay	T_{CHAR}	VSS-VM=0.30V→0	1.0	2.0	4.0	ms
Short circuit	Protection voltage	V_{SHORT}	VM - VSS=0→1.5V	0.3	0.4	0.5	V
	Protection delay	T_{SHORT}	VM - VSS=0→1.5V	150	300	600	μs
	Relief delay	T_{SHORTR}	VM - VSS=1.5V→0V	1.0	2.0	4.0	ms
Source-source Breakover interlay resistance		$R_{SS(on)}$	VCC=3.7V, I_D=1.0A	-	60	80	mΩ
0V charging, charger start-up voltage		V_{OVCH}	The function of permission of charging to 0V batteries	1.2	-	-	V

■Function description

1.Over-charging state

When the voltage of the battery rises to VOC or above and continues for some time T_{OC}, the output of the CO terminal will be reversed, which turns off the charging control MOS pipe and suspends charging; it is known as the over-charging state. When the voltage of the battery declines to under the over-charging relief voltage V_{OCR} and continues for some time T_{OCR}, the over-charging state is relieved, and it recovers to the normal state.

When entering into the over-charging state, in order to relieve this state, there are two conditions as follows:

a. The over-charging locking function

1) Disconnect the charger and connect it with no load, and $V_{CHA}<V_{VM}<V_{EC}$, when the voltage of the battery declines to under the over-charging relief voltage V_{OCR}, the over-charging state will be relieved.

2)Disconnect the charger and connect it with a load; if $V_{VM}>V_{EC}$, it is only needed to achieve VCC<VOC, the over-charging state will be relieved; this function is known as the load detection function. Notes: if the charger is kept connected after detection of over-charging, the over-charging state cannot be relieved even though the chip voltage declines to under V_{OCR}. The over-charging discharging state can be relieved only when the charger is not connected, and VM> VCHA.

b. Over-charging no locking function

1) No matter if the charger is connected, when the voltage of the battery declines to under the over-charging relief voltage V_{OCR}, the over-charging state will be relieved.

2) Disconnect the charger and connect it with a load; if $V_{VM}>V_{EC}$, it is only needed to achieve VCC<V_{OC}, the over-charging state will be relieved; this function is known as the load detection function.

2.Over-discharging state

When the voltage of the battery declines to under V_{OD} and continues for some time T_{OD}, the output of the DO terminal will be reversed, which turns off the discharging control MOS pipe and suspends discharging; it is known as the over-discharging state. When the voltage of the battery rises to above the over-discharging relief voltage VODR and continues for some time T_{ODR}, the over-discharging state is relieved, and it recovers to the normal state.

When entering into the over-discharging state, in order to relieve this state and recover to the normal state, there are some conditions as follows:

3) Connect the charger; if the voltage of the VM terminal is lower than the charging over-current detection voltage (V_{CHA}), when the voltage of the battery is higher than the over-discharging detection voltage (V_{OD}), the over-discharging state is relieved, and it recovers to the normal working state. This function is known as the charger detection function.

4) Connect the charger; if the voltage of the VM terminal is higher than the charging over-current detection voltage (V_{CHA}), when the voltage of the battery is higher than the over-discharging relief voltage (V_{ODR}), the over-discharging state is relieved, and it recovers to the normal working state.

5) For products with over-discharging no locking function (sleep self-recovery), if the charger is not connected, when the voltage of the battery recovers to above the over-discharging relief voltage (V_{ODR}) automatically, the over-discharging state is relieved, and it recovers to the normal working state;

6) For products with over-discharging locking function (sleep locking), it is required to achieve VM≤0V by connecting the charger, and then meet the condition of 1 or 2 mentioned above, to relieve the over-discharging state, to recover to the normal working state

3.Discharging over-current state

When the battery is in the discharging state, the voltage of the VM end will increase with the growth of the discharging current. When the voltage of the VM end is higher than V_{EC} and continues for some time T_{EC}, the chip judges that there is discharging over-current. When the voltage of the VM end is higher than V_{SHORT} and continues for some time T_{SHORT}, the chip judges that there is short circuit. In any of the 2 states mentioned above, the output of the DO terminal will be reversed, to turn off the discharging control MOS pipe and suspend discharging.

As long as the equivalent resistance value of the load increases or the load is broken off, making VM<VDD-1.0V, the discharging over-current state can be relieved, to recover to the normal state.

4.Charging over-current detection

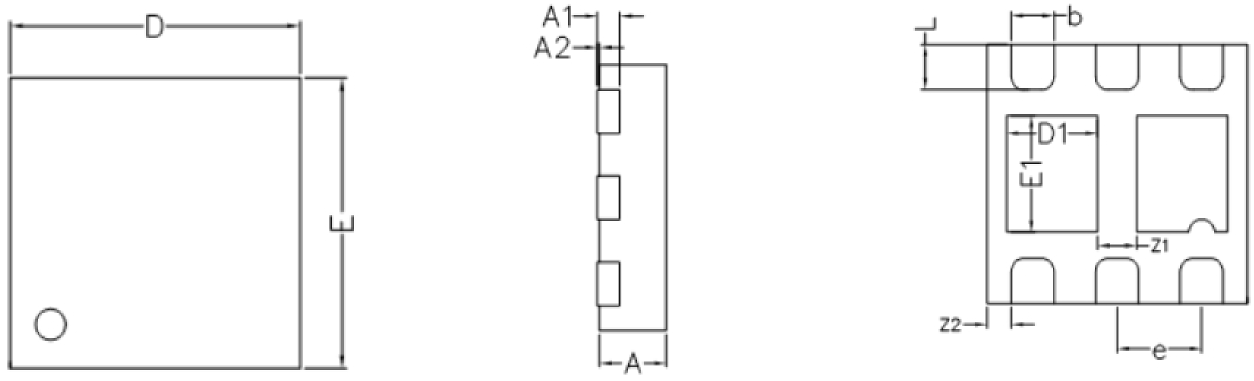
For the battery in normal working state, during the charging process, if the voltage of the VM terminal is lower than the charging over-current detection voltage (V_{CHA}), and the state continues for more than the charging over-current detection delay time (T_{CHA}), the MOSFET used for charging control is turned off, and charging is suspended; this state is known as the charging over-current state. After entering into the charging over-current detection state, if the charger is disconnected, making the voltage of the VM terminal higher than the charging over-current detection voltage (V_{CHA}), the charging over-current state is relieved, and it recovers to the normal working state.

5.0V charging function

The function is used for recharging for the battery of 0V after self-discharging. When the voltage of the charger between the positive pole (P+) and the negative pole (P-) of the battery is higher than the starting voltage (V_{0VCH}) of the charger charging for the 0V battery, the gate pole of the MOSFET used for charging control is fixed as the electric potential of the VDD terminal. The voltage difference between the gate pole of MOSFET and the source pole because of the voltage of the charter is higher than the break-over voltage, the MOSFET used for charging control is broken over (CO terminal opened), and it starts charging. At this time, the MOSFET for discharging control is still disconnected, and the charging current flows through the internal parasitic diode. When the voltage of the battery is higher than the over-discharging detection voltage (V_{OD}), IC enters into the normal working state.

■**Package information**

DFN2X2-6L(T0.55mm P0.65mm) package outline dimension



TOP VIEW **BOTTOW VIEW**

	MIN	NOM	MAX
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D1	0.65	0.70	0.75
E1	0.85	0.90	0.95
L	0.30	0.35	0.40
b	0.28	0.33	0.38
e	0.65BSC		
A	0.50	0.55	0.60
A1	0.15REF		
A2	0.00	--	0.05
Z1	0.25	0.30	0.35
Z2	0.135	0.185	0.235