3Cell Li-Ion/Polymer Battery Pack Protection IC

■ General Description

LN 8953 is a highly integrated, low cost, battery pack protection and monitor IC which features Over Voltage (OV), Under Voltage (UV), Over Current (OC), Short Circuit (SC), Over Temperature (OT) protection functions for managing Li-Ion /Polymer, 3 cell battery packs for power-tools, notebook PC and UPS applications etc.

LN8953's over current protection has high accuracy voltage detection (±10mV). Thus LN8953 can use lower current-sense resistors (such as 2.5mΩ, 5mΩ) to reduce power dissipation and thermal issues while maintaining high accuracy current detection.

LN8953 has three levels over-current protection using three, accurate integrated comparators. These current comparators provide accurate and timely protection, and avoid any unexpected false-trigger situations. LN8953 supports three modes for OC/SC release, i.e. Charger plugging-in Release, Load-open Release and Timer Release (optional). Timer Release delay time set shares with OV delay capacitor set. This optional function will help ensure that the load-always-connected system can be released when there is no charger plugging-in.

LN8953 provides a special EXTC pin to control both charge and discharge MOSFET. When EXTC pin is in floating state, LN8953 will enter sleep mode to save power consumption; When EXTC pin is tied to VCC, OZ8953 will enter normal working mode but turn off charge and discharge MOSFETs; When EXTC pin is tied to VSS, LN8953 will also work in normal working mode, but charge and discharge MOSFETs' status will be decided by protection event.

With integrated MOSFET driver circuit, LN8953 is able to directly drive both the charge PMOS FET at Pack+ side and discharge NMOS FET at Pack- side.

■ Features

- High Accuracy Voltage Detection

  Over voltage threshold range

  - V_{OV}: 3.6~4.35V; ±25 mV
  - Hysteresis Voltage: 0V, 0.1~0.275V

  Under voltage threshold range

  - V_{UV}: 2.0~3.0V; ±80 mV
  - Hysteresis Voltage: 0~1.0V
- Three-level High Accuracy Over-Current Detection

  Over Current 1: V_{DOC1} = 0.025~0.35V; ±10mV

  Over Current 2: V_{DOC2} = 2.0*V_{DOC1}

  Short Circuit: V_{DSC} = 4.5*V_{DOC1}
- Supports three modes for OC/SC release

  Charger-plugging in Release

  Load-open Release

  Timer-Release (optional)
- Support Over/Under-Temperature Protection
- Permanent Failure (PF): Blow fuse or OV indicator
- 0V Battery Charge Support
- Low power consumption:

  Normal Mode: <34uA

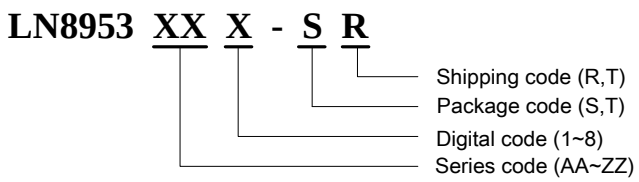
  Shut-Down Mode: <01uA

  Sleep Mode: <3.0uA
- Green Package: SOP14 or TSSOP14
-

■ Applications

- Power Tools
- Notebook PC
- UPS
- Remote Controlled Vehicles

■ Product Name Structure



Shipping code		Package code	
R	Reel	S	SOP14
T	Tape	T	TSSOP14

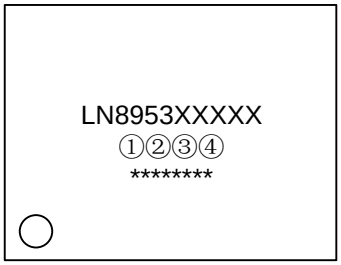
Digital code	OC/SC Timer Release	PF/OVI Function select	TDOC1 time Set		
1	Timer release enable	PF Protection Function	No Set(=0)	TDOC1=TUVP =1.0S	Load-open for UV Release Enable
2	Timer release enable	OVI Function	Set(=1)	TDOC1=2*TUVP =2.0S	Load-open for UV Release Enable
3	Timer release enable	PF Protection Function	No Set(=0)	TDOC1=TUVP =1.0S	Load-open for UV Release Enable
4	Timer release enable	OVI Function	Set(=1)	TDOC1=2*TUVP =2.0S	Load-open for UV Release Enable
5	Timer release disable	PF Protection Function	No Set(=0)	TDOC1=TUVP =1.0S	Load-open for UV Release Disable
6	Timer release disable	OVI Function	Set(=1)	TDOC1=2*TUVP =2.0S	Load-open for UV Release Disable
7	Timer release disable	PF Protection Function	No Set(=0)	TDOC1=TUVP =1.0S	Load-open for UV Release Disable
8	Timer release disable	OVI Function	Set(=1)	TDOC1=2*TUVP =2.0S	Load-open for UV Release Disable

Product Series List	OV Detection Voltage	OV Release Voltage	UV Detection Voltage	UV Release Voltage	OC Detection Voltage	PF/OVI Function	OS/SC Timer Release	TDOC1 TimerSet
LN8953AA7	4.25 ±0.025	4.15 ±0.025	2.7 ±0.08	3.0 ±0.08	0.10 ±0.01	OVI	Disable	Set=0
LN8953AB7	3.75 ±0.025	3.55 ±0.025	2.2 ±0.08	2.7 ±0.08	0.10 ±0.01	OVI	Disable	Set=0
LN8953AC6	4.20 ±0.025	4.20 ±0.025	2.0 ±0.08	2.7 ±0.08	0.35 ±0.01	PF	Disable	Set=1
LN8953AD5	4.20	4.10	2.5	3.0	0.10	PF	Disable	Set=0

	±0.025	±0.025	±0.08	±0.08	±0.01			
LN8953AE5	4.25 ±0.025	4.0 ±0.025	2.5 ±0.08	3.0 ±0.08	0.05 ±0.01	PF	Disable	Set=0
LN8953AF5	4.25 ±0.025	4.15 ±0.025	2.5 ±0.08	3.0 ±0.08	0.15 ±0.01	PF	Disable	Set=0
LN8953AG5	4.20 ±0.025	4.10 ±0.025	2.5 ±0.08	3.0 ±0.08	0.075 ±0.01	PF	Disable	Set=0
LN8953AH5	4.20 ±0.025	4.10 ±0.025	2.5 ±0.08	3.0 ±0.08	0.125 ±0.01	PF	Disable	Set=0
LN8953AI6	4.22 ±0.025	4.22 ±0.025	2.3 ±0.08	2.3 ±0.08	0.10 ±0.01	PF	Disable	Set=1
LN8953AJ7	4.20 ±0.025	4.00 ±0.025	2.5 ±0.08	2.5 ±0.08	0.10 ±0.01	PF	Disable	Set=0
LN8953AK5	4.25 ±0.025	4.00 ±0.025	2.8 ±0.08	3.3 ±0.08	0.075 ±0.01	PF	Disable	Set=0

Ordering Information

- **SOP-14/ TSSOP14**

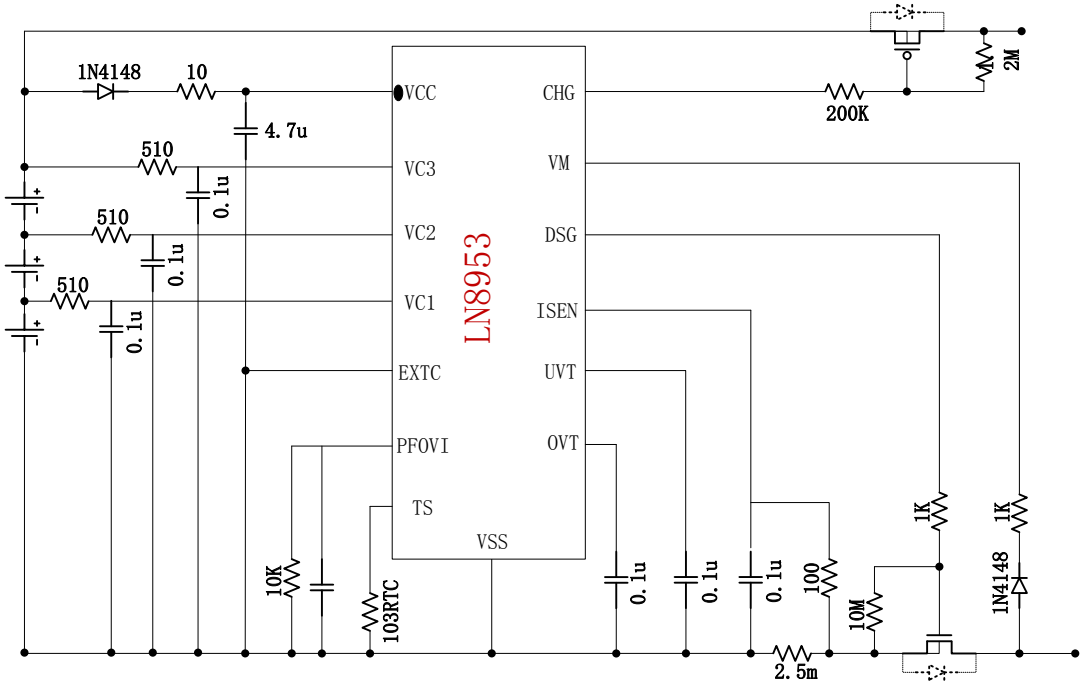


LN8953XXXXX **Represents the Product model**

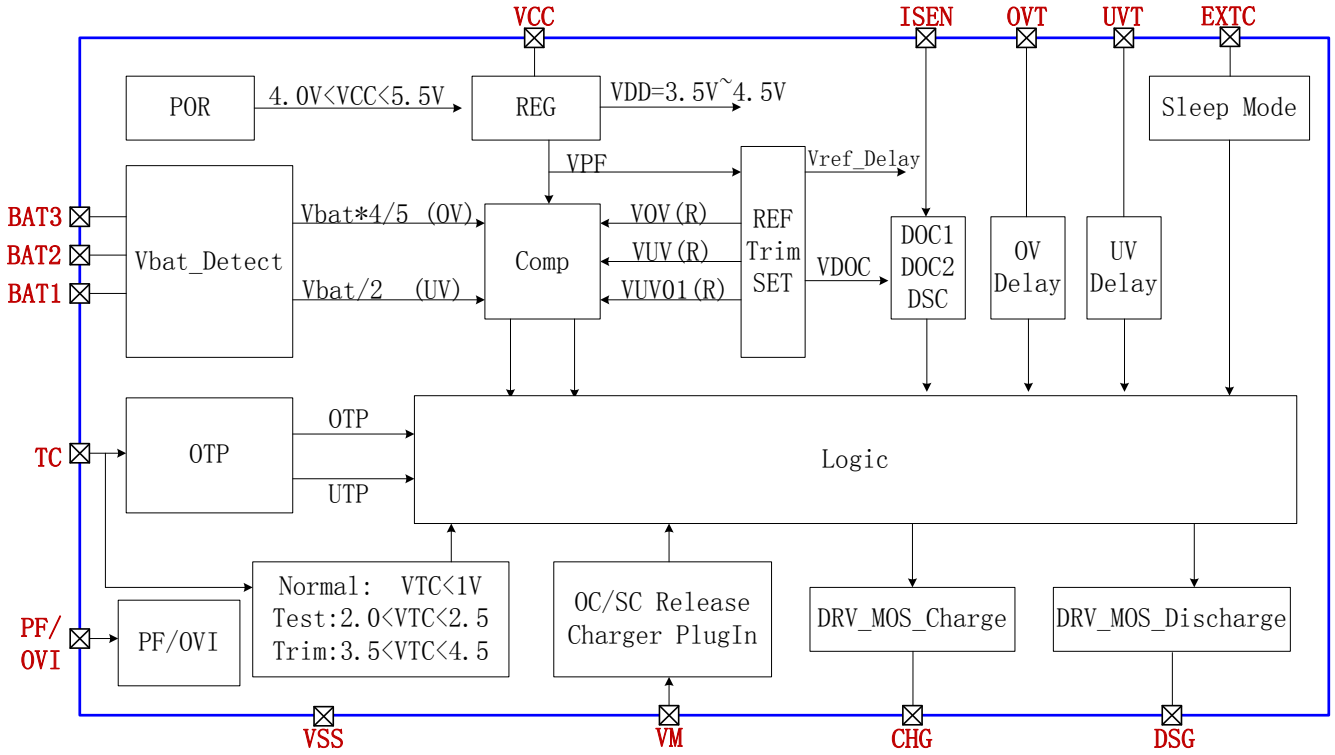
①②③④ **Represents the version number**

********:Number of several, represents the quality tracking information!**

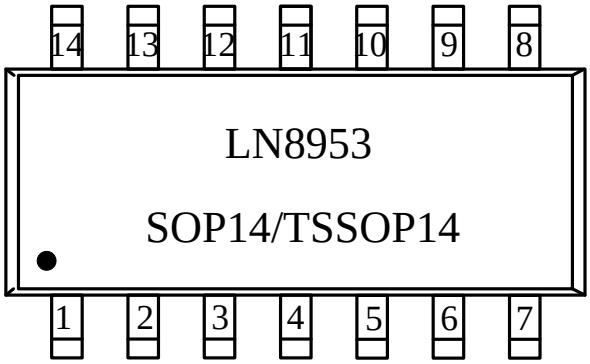
Typical Application Diagram



■ Block Diagram



■ Pin Diagram



Top View

■ Pin Description

Pin No.	Pin Name	Description
1	CHG	Charge power MOSFET control and charger-in detection pin
2	VM	Voltage monitor input pin. It is for OC/SC release when load open.
3	DSG	Discharge power MOSFET control pin.
4	ISEN	Current sense input for OC/SC protection.
5	UVT	Under voltage protection delay time set pin.
6	OVT	Over voltage protection delay time set pin.
7	VSS	Ground pin.
8	TS	Thermal sense input pin/Test input pin.
9	PFOVI	Permanent-Failure(PF)Blow Fuse protection.
10	EXTC	External control pin.
11	VC1	Connect to Cell1 positive terminal and Cell2 negative terminal.
12	VC2	Connect to Cell2 positive terminal and Cell3 negative terminal.
13	VC3	Connect to Cell3 positive terminal.
14	VCC	Power supply pin.

■ ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Applied Pin	Absolute Maximum Ratings
Supply voltage range between VCC and VSS pin	VCC	VCC	VSS-0.3V to VSS+24V
Input pin voltage 1	Vin1	ISEN, UVT, OVT, TS	VSS-0.3V to VSS+5V
Input pin voltage 2	Vin2	VM, EXTC	VSS-0.3V to VCC+0.3V
Cell voltage input range	Vcell		-0.3V to +5.0V
CHG pin output voltage	Vchg	CHG	VSS-0.3V to VSS+24V
DSG pin output voltage	Vdsg	DSG	VSS-0.3V to VSS+15V
PFOVI pin output voltage	Vpfovi	PFOVI	VSS-0.3V to +5.0V
Operating free-air temperature range	Ta		-40℃ to 85℃
Storage temperature range	Tstg		-40℃ to 125℃
Package thermal resisitance			48.7℃/W

Caution: the absolute maximum ratings are rated values. The phusical damage could be suffered beyond these values. The performance can not be gurarnteed at maximum rating.

■ Electrical Charactesistics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Over-Voltage (OV) Protection						
V_{OV}	Over-voltage detection threshold	3.6~4.35 adjustable	V_{OV}-0.025	V_{OV}	V_{OV}+0.025	V
$V_{OV-step}$	Over-voltage adjustment per step			50		mV/step
$V_{OVR-delta}$	Over-voltage Release Hysteresis voltage		0V,0.1~0.275V, adjustable			
$V_{OVR-step}$	Over-voltage Release adjustment per step			12.5		mV/step
V_{OVR}	Over-voltage Release threshold	V_{OVR} =V_{OV}-$V_{OV-delata}$	V_{OVR}-0.03	V_{OVR}	V_{OVR}+0.03	V
Permanent-Failure (PF) Blow Fuse Protection						
V_{PF}	Detection threshold	V_{PF} =V_{OV}+150mV	V_{PF}-0.025	V_{PF}	V_{PF}+0.025	V
V_{PFR}	Release threshold	V_{PFR}=V_{OVR}	V_{PFR}-0.03	V_{PFR}	V_{PFR}+0.03	V
Under-Voltage (UV) Protection						
V_{UV}	Under-voltage detection threshold	2.0~3.0V Adjustable	V_{UV}-0.07	V_{UV}	V_{UV}+0.07	V
$V_{UV-step}$	Under-voltage threshold adjustment per step			100		mV
$V_{UVR-delta}$	Under-voltage Release Hysteresis voltage		0~1.0V, adjustable			
$V_{UVR-step}$	Under-voltage Release			100		mV/Step

	adjustment per step					
V_{UVR}	Under-voltage Release threshold	V_{UVR} =V_{UV}+$V_{UV-delta}$	V_{UVR}-0.08	V_{UVR}	V_{UVR}+0.08	V
Discharge Over-Current (DOC) Protection						
V_{DOC1}	DOC1 detection threshold	0.025~0.35V, Adjustable	V_{DOC1}-0.01	V_{DOC1}	V_{DOC1}+0.01	V
$V_{DOC1-step}$	DOC1 threshold adjustment per step			25		mV
V_{DOC2}	DOC1 detection threshold	0.025~0.35V, Adjustable	V_{DOC1}-0.02	V_{DOC1}	V_{DOC1}+0.02	V
V_{DSC}	Short-Circuit detection threshold	V_{DSC}=4.5*V_{DOC1}	V_{DSC}-0.045	V_{DSC}	V_{DSC}+0.045	V
External Over-Temperature (OT) Protection						
t_{DOT}	Discharge Over-Temperature detection threshold		t_{DOT}-5	t_{DOT}	t_{DOT}+5	℃
$t_{DOTR-delta}$	Discharge Over-Temperature Release Hysteresis			15		℃
t_{DOTR}	Discharge Over-Temperature Release detection	t_{DOTR} =t_{DOT}-$t_{DOT-delta}$	t_{DOTR}-5	t_{DOTR}	t_{DOTR}+5	℃
t_{COT}	Charge Over-Temperature detection threshold		t_{COT}-5	t_{COT}	t_{COT}+5	℃
$t_{COTR-delta}$	Charge Over-Temperature Release Hysteresis			3		℃
t_{COTR}	Charge Over-Temperature Release detection	t_{COTR} =t_{COT}-$t_{COT-delta}$	t_{COTR}-5	t_{COTR}	t_{COTR}+5	℃
V_{TH-DSG}	Discharge state detection threshold		1	5	8	mV
Internal Under-Temperature (UT) Protection						
t_{UT}	Under-Temperature detection threshold			-10		℃
$t_{UT-delta}$	Under-Temperature Release detection			-2.5		℃
External Delay/Release Time Set						
T_{OV}	Over-voltage Protection delay time	C_{OV}=0.1uF		0.9		S
T_{OT-DET}	Over-temperature detection period time	C_{OV}=0.1uF		1.0		S

T_{PF}	Permanent Failure Blow Fuse Protection delay time	T_{PF}=3.0*T_{OV}		2.7		S
T_{UV}	Under-voltage protection delay time			1.0		S
T_{SD}	Shut Down delay time			5.5		S
T_{DOC1}	Discharge Over-current Protection delay time1			1.0		S
T_{DOC2}	Discharge Over-current Protection delay time2			100		mS
T_{DSC}	Internal fixed Short-Circuit Protection delay time			250		uS
T_{OCR}	OC/SC release delay time	T_{OCR}=T_{OV}		0.9		S
Power Supply						
VCC	The Voltage between VCC pin and VSS pin		4		20	V
$V_{TH-HVNMOS}$				3.0	4.0	V
$V_{HEAD-ROOM}$	Wake-up between charger and battery	V_{BAT3}> $V_{TH-HVNMOS}$		0.4		V
		V_{BAT3}< $V_{TH-HVNMOS}$		6.0		V
V_{POR}	Power on reset voltage				4.5	V
I_{NORMAL}	Normal Mode Current from VCC pin			17		uA
I_{SD}	Shutdown Mode Current from VCC pin			0.5		uA
I_{SLEEP}	Sleep Mode Current from VCC pin			1.5		uA

■ Power Mode

In LN8953, there are 3 different power modes: normal mode, shut-down mode and sleep mode. The typical features of those power modes are listed below.

In normal mode:

Continuously check OV, UV, OC and SC events, if any safety events occur, LN8953 will work in related protection state, such as OV protection state, UV protection state, OC protection state and OT protection state. If no safety events occur, LN8953 will work in normal working state.

Cycle by cycle to check OT every T_{OT-DET} except in OV state.

Charge and discharge MOSFET status are decided by the safety events and EXTC pin. For example, when OV occurs, charge MOSFET will be OFF, while discharge MOSFET will keep ON.

The typical current consumption is less than 20uA if no safety events occur. If any safety events occurs, the typical current consumption will increase and no more than 30uA.

In shut-down mode:

Do not check all the safety events.

CHG pin is high-impedance, DSG pin is low level. Both charge MOSFET & discharge MOSFET will be OFF.

The typical current consumption is less than 0.8uA.

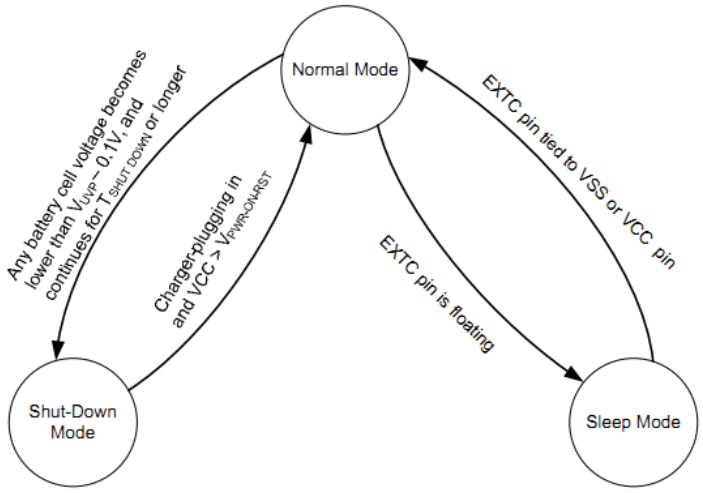
In sleep mode:

Do not check all the safety events.

CHG pin is high-impedance, DSG pin is low level. Æ Both charge MOSFET & discharge MOSFET will be OFF..

The typical current consumption is less than 3.2uA.

The detailed description for power mode transition is shown in figure 4 and also listed in table 5.



Initial Mode	Condition	Final Mode
Normal Mode	Any battery cell voltage becomes lower than VUV-0.1V, and continues for TSHUTDOWN or longer	Shut-Down Mode
Normal Mode	EXTC pin is floating	Sleep Mode
Shut-Down Mode	Charger-plugging in and VCC>VPWR-ON-RST	Normal Mode
Sleep Mode	EXTC pin tied to VSS or VCC pin	Normal Mode

■ Functional Description

LN8953 is a very flexible and accurate battery protection IC for 3 series cell applications. With a large selection of models, LN8953 can implement flexible protection architecture for a wide-range of applications.

1. Normal Working state

LN8953 will work in normal working state under normal mode when all the following conditions have been satisfied:

All cell voltages are between V_{OV} and V_{UV}

Discharge current is less than OC limitation (the voltage between ISEN pin and VSS pin is less than V_{DOC1})

Charge temperature is less than t_{COT}

Discharge temperature is less than t_{DOT}

Temperature is more than t_{UT}.

EXTC pin is tied to VSS or VCC pin .

2. Over-Voltage Protection state

Li-Ion cell chemistries require over voltage protection to prevent damaging the cell, or worse, thermal runaway; potentially generating “rapid cell disassembly”.

Over-Voltage protection is activated when: Any battery cell voltage is higher than V_{OVP} AND Continues for TOVP or longer. Over-Voltage protection will occur with the CHG pin becoming high impendence. CHG pin will be pulled up to PACK+ by external resistor between PACK+ and CHG pin, thus the VGS voltage of the charge MOSFET will drop to 0V, turning off the charge MOSFET.

The release condition of Over-Voltage protection is as follows all battery cell voltages drop to VOVR or lower.

OVP delay time TOVP is set by external capacitor: $T_{OV} = 0.9S * \frac{C_{OV}}{0.1uF}$

3. Under-Voltage Protection state

Under-Voltage protection conditions are satisfied when:

(1) Any battery cell voltage becomes lower than V_{UV}. **And**

(2) Continues for T_{UV} or longer.

When Under-Voltage protection has been activated, the DSG pin output level will be at VSS. This will turn off the discharge MOSFET immediately.

The release conditions of Under-Voltage protection are listed as follows:

(1) All battery cell voltages rise to VUVR or higher. **And**

(2) The load is open or charger plugging-in is detected.

If load-open condition is selected, only when both conditions (1) and (2) are satisfied, Under-Voltage protection can be released. If load-open condition is not selected, once condition (1) is satisfied, Under-Voltage protection can be released.

UV delay time T_{UV} is set by external capacitor C_{UV} tied to the UVT pin,

$$T_{UV} = 1.0S * \frac{C_{UV}}{0.1uF}$$

4. Over-Current Protection state

LN8953 has three levels Over-Current (OC) protection (VDOC1, VDOC2 and VSC):

$$V_{DSC} = 2.25 * V_{DOC2} = 4.5 * V_{DOC1}$$

There are three synchronous comparators integrated in LN8953, which are used to detect the OC level and immediately assert protection control signals. Both T_{DOC1} and T_{DOC2} are related to external capacitor CUV connected to the UVT pin.

$$T_{DOC1} = 1.0S * \frac{C_{UV}}{0.1uF} \quad T_{DOC2} = 0.1S * \frac{C_{UV}}{0.1uF}$$

If OC/SC Timer release enable:

$$T_{DOC1} = 2.0S * \frac{C_{UV}}{0.1uF} \quad T_{DOC2} = 0.3S * \frac{C_{UV}}{0.1uF}$$

There is a fixed internal time delay for DSC, which is around 250uS.

VM pin is used for OC/SC release detection. When OC/SC protection occurs, discharge MOSFET is turned off and VM pin will be pulled up to VCC level by the load. There are three release conditions for OC/SC protection state:

(1) When load is open, VM pin will drop to VSS level by internal pull-down resistor, and OC/SC protection will be released automatically. It is called Load-Open Release.

(2) When charger is plugged in, VM pin will also drop to VSS level, and OC/SC protection will be released automatically. It is called Charger-plugging In Release.

(3) If Timer Release function is disabled, discharge MOSFET will keep OFF till load is opened or charger is plugged in. But if Timer Release function is enabled, after TOCR, discharge MOSFET will be turned on even if load is not open and charger is not plugged in. This optional function will help ensure that the load-always-connected system can be released when there is no charger input.

5. Over-Temperature Protection state

TS pin is used for battery temperature protection during charge and discharge state. LN8953 identifies the charge state and discharge state by detecting the voltage at the ISEN Pin, if it is higher than VTH-DSG (4mV typical), LN8953 regards it as discharge state. Otherwise, LN8953 will regard it as charge state.

During discharge state, if battery cell temperature is higher than t_{DOT}, LN8953 will work in Discharge Over-Temperature (DOT) state and turns off both discharge MOSFET and charge MOSFET. Discharge MOSFET will keep OFF till battery cell temperature is lower than t_{DOTR}. Furthermore, usually t_{DOTR} is higher than t_{COT}, thus charge MOSFET will keep OFF till battery

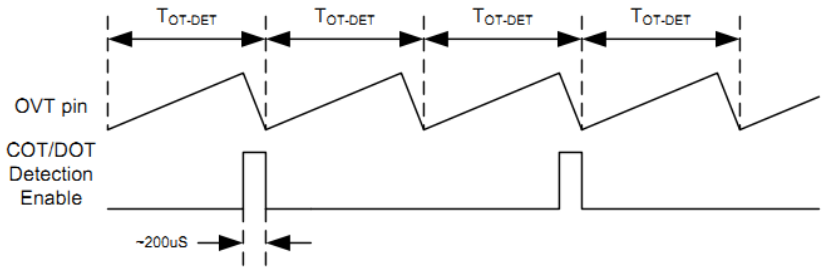
cell temperature is lower than t_{COTR}.

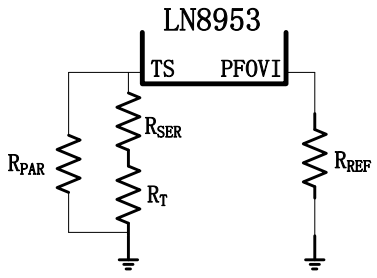
During charge state, if battery cell temperature is higher than t_{COT}, LN8953 will work in Charge OT (COT) state and turns off charge MOSFET. Charge MOSFET will keep OFF till battery cell temperature is lower than t_{COTR}.

The default protection threshold set is 50° C for charging OT and 70° C for discharging OT with a stand-alone 103RTC (10KΩ, thermal sensor resistor) and 10 KΩ reference resistor tied to the PF/OVI pin. This default protection temperature

Item	COT	DOT	R_{SER}	R_{PAR}
1	40℃	62℃	0Ω	13KΩ
2	45℃	64℃	0Ω	20KΩ
3	50℃	68℃	0Ω	100KΩ
4	50℃	70℃	0Ω	-
5	55℃	75℃	0.47kΩ	-
6	60℃	87℃	0.47kΩ	-
7	65℃	>100℃	0.47kΩ	-

When LN8953 is under Shut-Down mode or Sleep mode, it will not do COT/DOT detection. LN8953 will do the COT/DOT detection every T_{OT-DET} time under normal mode when no OV event occur and no OC/SC event occur (Timer-Release function is enabled, but if Timer-Release function is disabled, when OC/SC event occur, LN8953 still do the COT/DOT detection circularly.) BTW, if COT/DOT protection is not needed, a 10KΩ resistor in replace of the thermistor can make COT/DOT event never occur. When OC/SC/UV event occur, discharge MOSFET will be OFF, LN8953 will regard it as charge state, thus DOT event will never occur, while COT detection will work normally.





6. Permanent-Failure (PF) Blow Fuse Protection

Permanent-Failure Blow Fuse protection shares Pin9 with Over-Voltage indication function. It is an alternative function and configured before product shipment. When any battery cell voltage becomes higher than VPF and continues for TPF or longer, LN8953 will work in PF state, PF/OVI pin will output high level, which can be used to drive one buffer to blow the external fuse.

7. Over-Voltage Indication (OVI)

Over-Voltage indication function shares Pin 9 with Permanent-Failure (PF) Blow Fuse protection function, it is an alternative function and configured before product shipment. When any battery cell voltage becomes higher than VOVP and continues for TOVP or longer, the PF/OVI pin will output high level, which can be used to drive one buffer and turn on LED indication.

8. External Control Function

EXTC has higher priority than the internal protection circuit. When EXTC pin is High level ($V_{EXTC}>V_{EXTCH}$), Charge FET and Discharge FET will be both turned off. When EXTC pin is floating, Both Charge FET and Discharge FET will be also turned off, and meanwhile, LN8953 will enter sleep mode (lower power consumption). When EXTC pin is Low level ($V_{EXTC}<V_{EXTCL}$), LN8953 will turn to normal working mode, and turn on Charge FET and Discharge FET at same time if no protection event (OV/UV/OC/SC/OT) occurs. This feature provides the possibility for the battery pack to enter Sleep-mode even if battery cell is at full capacity (long storage time is allowable). In sleep mode, all the protections are not available.

Item	EXTC Pin	CHG Pin Output	DSG Pin Output	Operation State
$V_{EXTC}>V_{EXTCH}$	High	Hi-Z	Low	Normal Mode
$3V<V_{EXTC}<VCC-3V$	Open	Hi-Z	Low	Sleep Mode
($V_{EXTC}<V_{EXTCL}$	Low	Hi-Z or Sink current Depends on any protection occurs (OV/UV/OC/SC/OT)	Low or High Depends on any protection occurs (OV/UV/OC/SC/OT)	Normal Mode

9. 0V Battery Charge Function

LN8953 provides 0V battery charge function; the charger should provide the pre-charge function to limit the charging current when any battery cell voltage is lower than VUVP – 0.1V.

In shut-down mode, if LN8953 CHG pin is directly used to control charge FET to charge the battery pack, it needs to meet the following conditions:

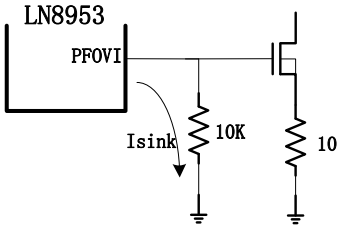
(1) When battery pack voltage is less than $V_{TH-HVNMOS}$, the charger output voltage needs to be around 6V higher than battery pack voltage to turn on charge MOSFET incompletely.

(2) When battery pack voltage is bigger than $V_{TH-HVNMOS}$, the charger output voltage only needs to be around 0.4V (refer to $V_{HEAD-ROOM}$) higher than battery pack voltage to turn on charge MOSFET completely.

When battery pack voltage reaches LN8953 power-on reset voltage VPWR-ON-RST plus one diode forward voltage, LN8953 will enter normal working mode.

10. Over-Voltage Self-Sink Function

This function is used to protect over-voltage battery pack. LN8953 provides I_{SINK} discharge current internally when OVI or PF occurs.



11. Protection Delay Time Set

LN8953 provides two pins (OVT & UVT) for flexible delay time. Over Voltage protection delay time (T_{OV}) and Permanent Failure (PF) Blow Fuse protection delay time (T_{PF}) are determined by the external capacitor connected to the OVT pin. Under Voltage protection delay time (T_{UVP}), and Over Current protection delay time (T_{DOC1} & T_{DOC2}) are determined by the external capacitor connected to the UVT pin. Short Circuit protection internal delay time is fixed internally and final delay time will also rely on external circuitry.

12. Shut-down Mode

When any cell's voltage is lower than V_{UV} and continues for T_{UV}, LN8953 enters UV protection state and turns off discharge MOSFET; when any cell's voltage continues dropping to V_{UV}-0.1V or lower and continues for $T_{SHUT\ DOWN}$ or longer, LN8953 will enter Shut-Down mode. For example, V_{UV} is set to 2.5V, when any cell's voltage is lower than 2.5V and continues for T_{UV} or longer, LN8953 will turn off discharge MOSFET, when any cell voltage drops to 2.4V and continues for T_{SHUT_DOWN} or longer, LN8953 will enter Shut-Down mode.

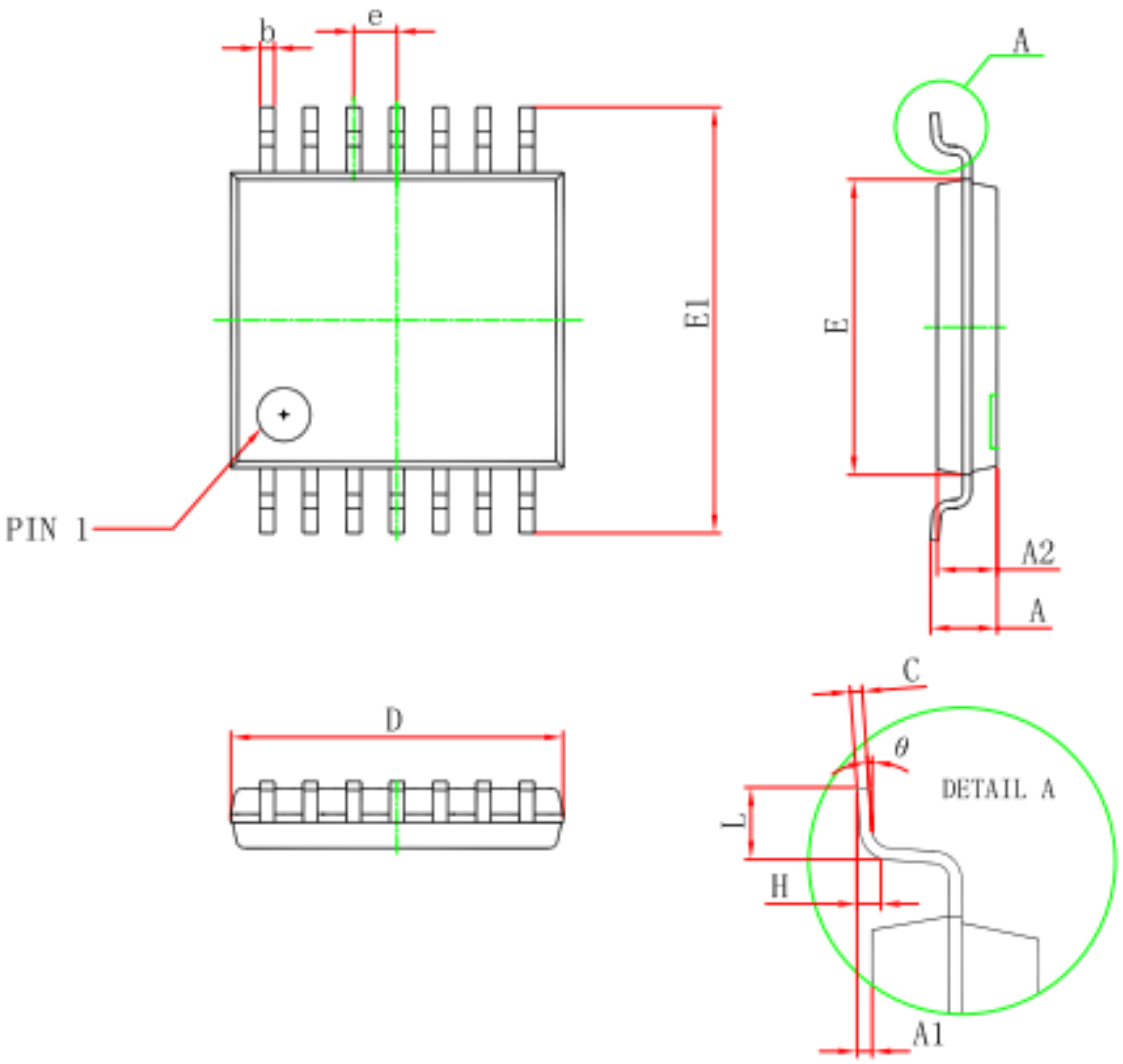
Under Shut-Down mode, typical current consumption is less than 0.8μA, and output pins' state is listed as follows.

(1) CHG pin: High-impedance

(2) DSG pin: V_{DSG}=VSS

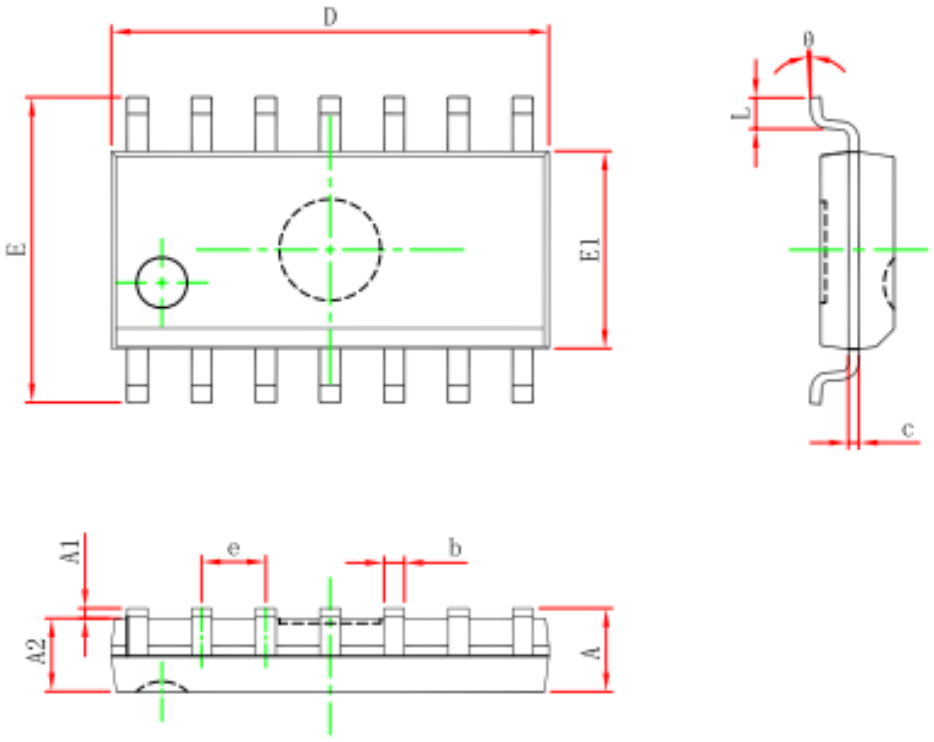
■ Package information

- **SOP14**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

- **TSSOP14**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	——	1.750	——	0.069
A1	0.100	0.250	0.004	0.010
A2	1.250	——	0.049	——
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°