OZ8953

5 Cell
Li-Ion/Polymer Battery Pack Protection IC

FEATURES

- **High Accuracy Voltage Detection**
  - Over voltage threshold range
    - V_{OVP}: 3.6~4.35V; ±25 mV
    - Hysteresis Voltage: 0V, 0.1~0.275V
  - Under voltage threshold range
    - V_{UVP}: 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: $V_{SC} = 4.5*V_{DOC1}$
- **Comprehensive Built-in Protection Functions**
- **Programmable Delay Timer Setting for OCP**
- **Supports three modes for OC/SC release**
  - Charger-plugging in Release
  - Load-open Release
  - Timer-Release (optional)
- **Support Over-Temperature Protection (COT & DOT)**
- **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: SOP16 or SSOP16**

APPLICATIONS

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

ORDERING INFORMATION

Part Number	Temp Range	Package
OZ8953AA-1	-40°C to 85°C	16-pin SOP/SSOP Lead-Free

(See Options Selection Table on page 27, Table 9 & Table 10)

GENERAL DESCRIPTION

OZ8953 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, 5 cell battery packs for power-tools, notebook PC and UPS applications etc.

OZ8953's over current protection has high accuracy voltage detection (±10mV). Thus OZ8953 can use lower current-sense resistors (such as 2.5mΩ, 5mΩ) to reduce power dissipation and thermal issues while maintaining high accuracy current detection.

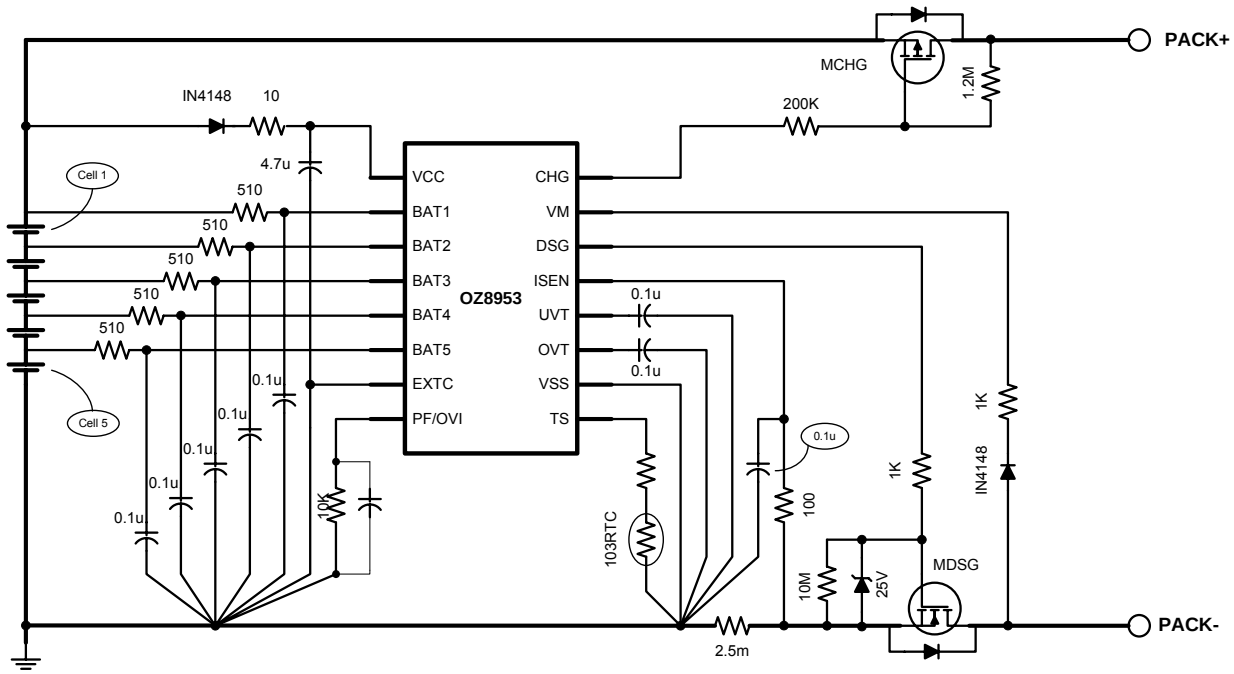
OZ8953 has three levels over-current protection using three, accurate integrated comparators. These current comparators provide accurate and timely protection, and avoid any unexpected false-trigger situations.

OZ8953 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.

OZ8953 provides a special EXTC pin to control both charge and discharge MOSFET. When EXTC pin is in floating state, OZ8953 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, OZ8953 will also work in normal working mode, but charge and discharge MOSFETs' status will be decided by protection event.

With integrated MOSFET driver circuit, OZ8953 is able to directly drive both the charge PMOS FET at Pack+ side and discharge NMOS FET at Pack- side.

TYPICAL APPLICATION DIAGRAM



BLOCK DIAGRAM

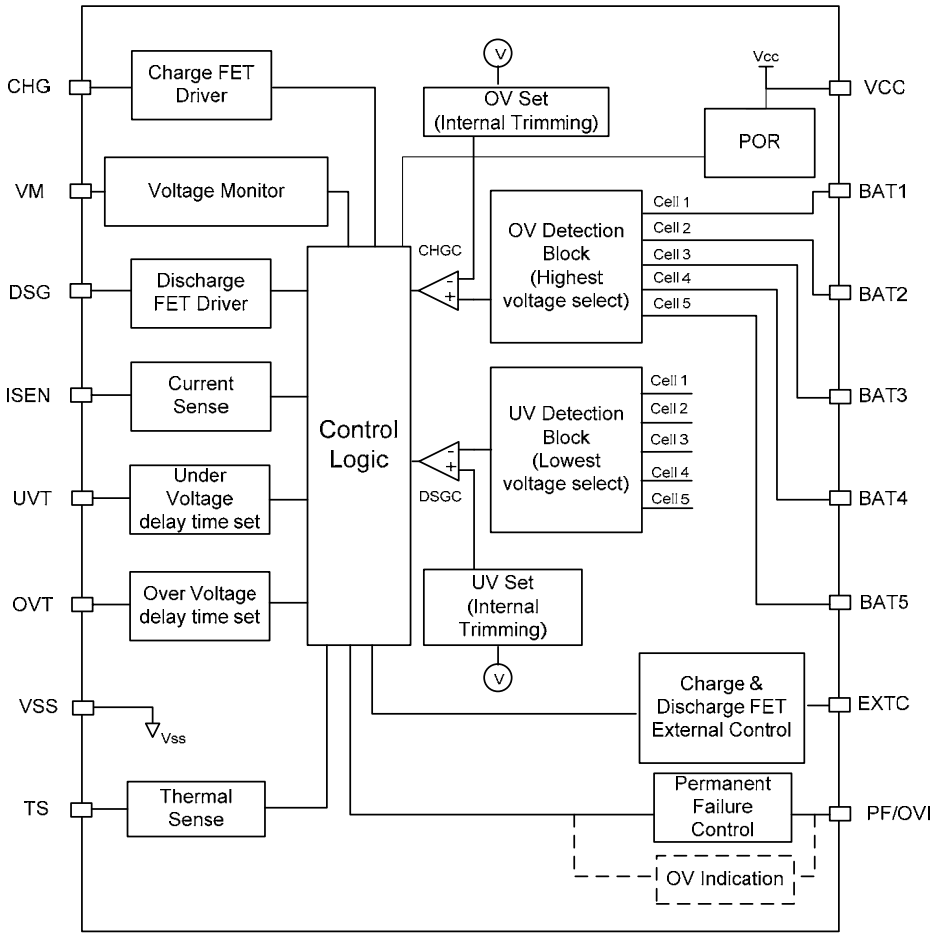


Figure 1 OZ8953 Block Diagram

PIN DIAGRAM

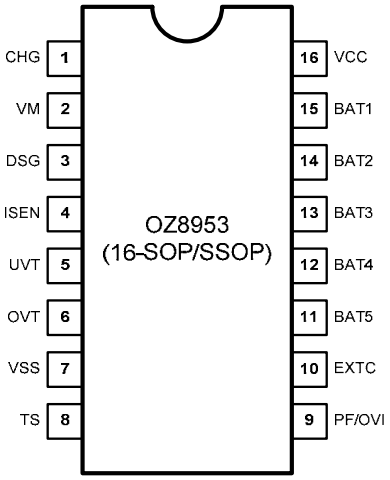


Figure 2 OZ8953 Pin Diagram

PIN DESCRIPTION

Table 1 Pin Description

Pin No.	Pin Name	I/O	Type	Description
1	CHG	I/O	Analog	Charge power MOSFET control and charger-in detection pin.
2	VM	I	Analog	Voltage Monitor input pin. It is for OC/SC release when load opens.
3	DSG	O	Analog	Discharge power MOSFET control pin.
4	ISEN	I	Analog	Current sense input for OC/SC protection.
5	UVT	I/O	Analog	Under Voltage protection delay time set pin.
6	OVT	I/O	Analog	Over Voltage protection delay time set pin.
7	VSS	P	Power	GROUND pin.
8	TS	I/O	Analog	Thermal sense input pin/Test input pin.
9	PF/OVI	O	Analog	Permanent-Failure (PF) Blow Fuse Protection. (Active high) or Over Voltage Indication (Active high), This is an alternative function pin.
10	EXTC	I	Analog	External control pin – Control both charge & discharge Power MOSFET.
11	BAT5	I	Analog	Connect to Cell5 positive terminal and Cell4 negative terminal.
12	BAT4	I	Analog	Connect to Cell4 positive terminal and Cell3 negative terminal.
13	BAT3	I	Analog	Connect to Cell3 positive terminal and Cell2 negative terminal.
14	BAT2	I	Analog	Connect to Cell2 positive terminal and Cell1 negative terminal.
15	BAT1	I	Analog	Connect to Cell1 positive terminal.
16	VCC	P	Power	Power supply pin.

ABSOLUTE MAXIMUM RATINGS

Table 2 (T_a=25°C unless otherwise specified)

Item	*Symbol*	*Applied Pin*	*Absolute Maximum Ratings*
Supply voltage range between VCC and VSS pin	V_{CC}	VCC	V_{SS} - 0.3V to V_{SS} + 38V
Input pin voltage 1	V_{IN1}	ISEN, UVT, OVT, TS	V_{SS} - 0.3V to V_{SS} + 5.0V
Input pin voltage 2	V_{IN2}	VM, EXTC	V_{SS} - 0.3V to V_{CC} + 0.3V
Cell voltage input range: BAT(k-1) - BAT(k), k=2~5, & BAT5 - VSS	V_{CELL}	—	- 0.3V to + 5.0V
CHG pin output voltage	V_{CHG}	CHG	- 0.3V to V_{SS} + 38V
DSG pin output voltage	V_{DSG}	DSG	V_{SS} - 0.3V to V_{SS} + 15V
PF/OVI pin output voltage	$V_{PF/OVI}$	PF/OVI	V_{SS} - 0.3V to V_{SS} + 5.0V
Operating free-air temperature range	T_a	—	-40°C to 85°C
Storage temperature range	T_{stg}	—	-40°C to 125°C
Package thermal resistance	θ_{JA}	—	48.7°C/W

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

ELECTRICAL CHARACTERISTICS*(1)

Table 3a (T_a=25°C unless otherwise specified)

Symbol	*Parameter*	*Conditions*	*Min.*	*Typ.*	*Max.*	*Unit*
Over-Voltage (OV) Protection*(2)						
V_{OVP}	Over-Voltage detection threshold	Li-Ion/Polymer Battery: 4.0~4.35V; Phosphate Battery: 3.6~3.95V, adjustable	V_{OVP} – 0.025	V_{OVP}	V_{OVP} + 0.025	V
$V_{OV-STEP}$	Over-Voltage adjustment per step	Li-Ion/Polymer and Phosphate battery		50		mV/step
$V_{OVR-DELTA}$	Over-Voltage Release Hysteresis voltage	Li-Ion/Polymer and Phosphate battery	0V, 0.1~0.275V, adjustable			
$V_{OVR-STEP}$	Over-Voltage Release adjustment per step	Li-Ion/Polymer and Phosphate battery		12.5		mV/step
V_{OVR}	Over-Voltage Release threshold	V_{OVR}=V_{OVP}-$V_{OVR-DELTA}$	V_{OVR} - 0.03	V_{OVR}	V_{OVR} + 0.03	V
Permanent-Failure (PF) Blow Fuse Protection*(2)						
V_{PF}	Permanent Failure (PF) Blow Fuse detection threshold	V_{PF}=V_{OVP}+150mV	V_{PF} – 0.025	V_{PF}	V_{PF} + 0.025	V
V_{PFR}	Permanent Failure (PF) Blow Fuse release threshold	V_{PFR}= V_{OVR}	V_{PFR} – 0.03	V_{PFR}	V_{PFR} + 0.03	V
Under-Voltage (UV) Protection*(2)						
V_{UVP}	Under-Voltage detection threshold	Li-Ion/Polymer and Phosphate Battery, 2.0~3.0V, adjustable	V_{UVP} – 0.07	V_{UVP}	V_{UVP} + 0.07	V
$V_{UV-STEP}$	Under-Voltage threshold adjustment per step	Li-Ion/Polymer and Phosphate battery		100		mV/step

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Under-Voltage (UV) Protection*(2)						
$V_{UVR-DELTA}$	Under-Voltage Release Hysteresis voltage (ΔV)	Li-Ion/Polymer and Phosphate battery	0~1.0V, adjustable			
$V_{UVR-STEP}$	Under-Voltage Release threshold adjustment per step	Li-Ion/Polymer and Phosphate battery		100		mV/step
V_{UVR}	Under-Voltage Release threshold	$V_{UVR}=V_{UVP}+V_{UVR-DELTA}$	V_{UVR} -0.08	V_{UVR}	V_{UVR} + 0.08	V
Discharge Over-Current (DOC) Protection*(2)						
V_{DOC1}	Over-Current (level-1) DOC1 detection threshold	0.025~0.35V, adjustable	V_{DOC1} – 0.01	V_{DOC1}	V_{DOC1} + 0.01	V
$V_{DOC1-STEP}$	Over-Current (level-1) DOC1 threshold adjustment per step			25		mV/step
V_{DOC2}	Over-Current (level-2) DOC2 detection threshold	V_{DOC2} = 2.0*V_{DOC1}	V_{DOC2} – 0.02	V_{DOC2}	V_{DOC2} + 0.02	V
V_{SC}	Short-Circuit (SC) detection threshold	V_{SC} = 4.5*V_{DOC1}	V_{SC} – 0.045	V_{SC}	V_{SC} + 0.045	V
External Over-Temperature (OT) Protection*(3)						
t_{DOTP}	Discharge Over - Temperature detection threshold		t_{DOTP} –5	t_{DOTP}	t_{DOTP} + 5	℃
$t_{DOTR-DELTA}$	Discharge Over - Temperature Release Hysteresis threshold			15		℃
t_{DOTR}	Discharge Over - Temperature Release detection threshold	t_{DOTR}= t_{DOTP} -$t_{DOTR-DELTA}$	t_{DOTR} - 5	t_{DOTR}	t_{DOTR} + 5	℃
t_{COTP}	Charge Over - Temperature detection threshold		t_{COTP} –5	t_{COTP}	t_{COTP} + 5	℃
$t_{COTR-DELTA}$	Charge Over - Temperature Release Hysteresis threshold			3		℃
t_{COTR}	Charge Over - Temperature Release detection threshold	t_{COTR}= t_{COTP} -$t_{COTR-DELTA}$	t_{COTR} - 5	t_{COTR}	t_{COTR} + 5	℃
V_{TH-DSG}	Discharge state detection threshold		1	5	8	mV

*(1) Min and Max values shown in the Electrical Characteristics table are target values based on simulation results. These values are subject to change upon completion of the Design Verification process.
*(2) All the protection threshold and release values are one time programmable only. Customers can request any combination of them in the given setting range through our sales person
*(3) OT threshold in this table is based on 103AT type of external thermistor. Customer can adjust the OT threshold by adding external resistor series/parallel with thermistor.

ELECTRICAL CHARACTERISTICS*(1) (Contd.)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
External Delay/Release Time Set						
T_{OVP}	Over-voltage Protection delay time	Capacitance on OVT pin, C_{OVT}=0.1uF	0.6	0.9	1.2	S
T_{OT-DET}	Over-temperature detection period time	Capacitance on OVT pin, C_{OVT}=0.1uF	0.5	1.0	2.0	S
T_{PF}	Permanent Failure (PF) Blow Fuse Protection delay time	Capacitance on OVT pin, C_{OVT}=0.1uF; T_{PF} = 3.0 * T_{OVP}	1.8	2.7	3.6	S
T_{UVP}	Under-voltage Protection delay time	Capacitance on UVT pin, C_{UVT}=0.1uF	0.7	1.0	1.3	S
$T_{SHUT\ DOWN}$	Shut down delay time	Capacitance on OVT pin, C_{OVT}=0.1uF;	3.5	5.5	7.5	S
T_{DOC1}	Discharge Over-Current Protection delay time (level-1)	Capacitance on UVT pin, C_{UVT}=0.1uF; T_{DOC1} = T_{UVP}	0.5	1.0	1.3	S
		T_{DOC1} =2 * T_{UVP}*(2)	1.0	2.0	2.8	S
T_{DOC2}	Discharge Over-Current Protection delay time (level-2)	Capacitance on UVT pin, C_{UVT}=0.1uF; T_{DOC2} = 10% * T_{DOC1}	50	100	150	mS
		T_{DOC2} =15% * T_{DOC1}*(2)	210	300	390	mS
T_{SC}	Internal fixed Short-Circuit Protection delay time		100	250*(3)	500	µS
T_{OCR}	OC/SC release delay time	Capacitance on OVT pin, C_{OVT}=0.1uF T_{OCR}=T_{OVP}	0.5	0.9	1.3	S
Power Supply						
V_{CC}	The Voltage between VCC pin and VSS pin		4.0*(4)		30	V
$V_{TH-HVNMOS}$*(5)	The Threshold of HV NMOS-FET to determine charger-in headroom			3.1	3.7	V
$V_{HEAD-ROOM}$*(6)	Wake-Up Headroom between charger input and battery pack	CHG pin ramps up, V_{BAT1} >$V_{TH-HVNMOS}$ I_{CHG} >1uA	0.6	0.4		V
		CHG pin ramps up, V_{BAT1} <=$V_{TH-HVNMOS}$ I_{CHG} >1uA		6.0		V
$V_{PWR-ON-RST}$*(7)	Chip Power On reset voltage	VCC ramps up		7.1	9.2	V
I_{NORMAL}	Power consumption under normal mode	I_{VCC} current from VCC pin		17	25*(8)	µA
$I_{SHUT\ DOWN}$	Power consumption under shut down mode	I_{VCC} current from VCC pin		0.4	0.7	µA
I_{SLEEP}	Power consumption under sleep mode	EXTC pin floating		1.6	2.5	µA

* (1) Min and Max values shown in the Electrical Characteristics table are target values based on simulation results. These values are subject to change upon completion of the Design Verification process.
* (2) Configured by O2Micro, based on customer's request, refer to option selection table.
* (3) RC Filter set on ISEN pin will be used to adjust the SC time externally.
* (4) When V_{CC} voltage is lower than the minimal operation voltage 4.0V, the DSG and CHG are both OFF, but the internal state machine of OZ8953 is not guaranteed.
* (5) $V_{TH-HVNMOS}$ is the threshold of internal HV NMOS-FET. When the voltage of BAT1 pin is higher than $V_{TH-HVNMOS}$ and once charger is plugged-in, the CHG pin will be pulled down to V_{SS} and charge MOSFET will be turned on.
* (6) $V_{HEAD-ROOM}$ is the difference voltage between the charger voltage and the battery pack voltage when chip wakes up from shut down mode. In shut down mode, charger input needs to be $V_{HEAD-ROOM}$ higher than battery pack voltage to wake up chip when V_{CC} reaches $V_{TH-HVNMOS}$. The $V_{HEAD-ROOM}$ needs to be at least 6V when V_{CC} is lower than $V_{TH-HVNMOS}$.
* (7) $V_{PWR-ON-RST}$ is the threshold of power-on reset. When the V_{CC} voltage is higher than $V_{PWR-ON-RST}$, OZ8953 will start up.
* (8) When OV protection is triggered, normal mode current consumption will increase. The current will be the normal working current plus self-sink current I_{SINK}. I_{SINK} is defined in Over-Voltage self-sink function section.

ELECTRICAL CHARACTERISTICS*(1) (Contd.)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
Driver voltage or current							
I_{CHG}	The current sink into CHG pin	Charge MOSFET turn on V(CHG,VSS) <30V		3.5	6.0	10.0	μA
		Charge MOSFET turn off V(CHG,VSS) <30V		0	High impedance	0. 12	μA
V_{DSG}	The voltage of DSG pin	Discharge MOSFET turn on	1) $V_{CC}>V_{CCTH}$*(2)	7	10.5	12	V
			2) $V_{CC}<V_{CCTH}$	V_{CC}-1.15	V_{CC}-0.65	V_{CC}-0.15	V
		Discharge MOSFET turn off		0.15	0.33	0.5	V
I_{BAT1}	BAT1 sink current in normal working mode	All V_{CELL}=3.6V			9	12	μA
I_{BATn} (n=2~5)	BATn (n=2~5) sink current in normal working mode	All V_{CELL}=3.6V		-0.20	-	0.30	μA
V_{EXTCH}	EXTC pin input voltage – "H"	$V_{CC}>V_{PWR-ON-RST}$		V_{CC}-1.5			V
V_{EXTCL}	EXTC pin input voltage – "L"	$V_{CC}>V_{PWR-ON-RST}$				1.5	V

***** (1) Min and Max values shown in the Electrical Characteristics table are target values based on simulation results. These values are subject to change upon completion of the Design Verification process
* (2) When V_{CC} is low level, the voltage of DSG will change linearly with V_{CC}. However, when V_{CC} reaches to above the value (V_{CCTH}), the voltage of DSG pin will be fixed and is about 10.5V. V_{CCTH} is around 10.5V±0.65V at typical case.

ELECTRICAL CHARACTERISTICS*(1)

Table 3b (T_a= -40°C to 85°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Over-Voltage (OV) Protection*(2)						
V_{OVP}	Over-Voltage detection threshold	Li-Ion/Polymer Battery: 4.0~4.35V; Phosphate Battery: 3.6~3.95V, adjustable	V_{OVP} – 0.045	V_{OVP}	V_{OVP} + 0.045	V
$V_{OV-STEP}$	Over-Voltage adjustment per step	Li-Ion/Polymer and Phosphate battery		50		mV/step
$V_{OVR-DELTA}$	Over-Voltage Release Hysteresis voltage	Li-Ion/Polymer and Phosphate battery	0V, 0.1~0.275V, adjustable			
$V_{OVR-STEP}$	Over-Voltage Release adjustment per step	Li-Ion/Polymer and Phosphate battery		12.5		mV/step
V_{OVR}	Over-Voltage Release threshold	V_{OVR}=V_{OVP}-$V_{OVR-DELTA}$	V_{OVR} - 0.035	V_{OVR}	V_{OVR} + 0.035	V
Permanent-Failure (PF) Blow Fuse Protection*(2)						
V_{PF}	Permanent Failure (PF) Blow Fuse detection threshold	V_{PF}=V_{OVP}+150mV	V_{PF} – 0.035	V_{PF}	V_{PF} + 0.035	V
V_{PFR}	Permanent Failure (PF) Blow Fuse release threshold	V_{PFR}= V_{OVR}	V_{PFR} – 0.035	V_{PFR}	V_{PFR} + 0.035	V
Under-Voltage (UV) Protection*(2)						
V_{UVP}	Under-Voltage detection threshold	Li-Ion/Polymer and Phosphate Battery, 2.0~3.0V, adjustable	V_{UVP} – 0.08	V_{UVP}	V_{UVP} + 0.08	V
$V_{UV-STEP}$	Under-Voltage threshold adjustment per step	Li-Ion/Polymer and Phosphate battery		100		mV/step

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Under-Voltage (UV) Protection*(2)						
$V_{UVR-DELTA}$	Under-Voltage Release Hysteresis voltage (ΔV)	Li-Ion/Polymer and Phosphate battery	0~1.0V, adjustable			
$V_{UVR-STEP}$	Under-Voltage Release threshold adjustment per step	Li-Ion/Polymer and Phosphate battery		100		mV/step
V_{UVR}	Under-Voltage Release threshold	$V_{UVR}=V_{UVP}+V_{UVR-DELTA}$	V_{UVR} -0.08	V_{UVR}	V_{UVR} + 0.08	V
Discharge Over-Current (DOC) Protection*(2)						
V_{DOC1}	Over-Current (level-1) DOC1 detection threshold	0.025~0.35V, adjustable	V_{DOC1} – 0.01	V_{DOC1}	V_{DOC1} + 0.01	V
$V_{DOC1-STEP}$	Over-Current (level-1) DOC1 threshold adjustment per step			25		mV/step
V_{DOC2}	Over-Current (level-2) DOC2 detection threshold	V_{DOC2} = 2.0*V_{DOC1}	V_{DOC2} – 0.02	V_{DOC2}	V_{DOC2} + 0.02	V
V_{SC}	Short-Circuit (SC) detection threshold	V_{SC} = 4.5*V_{DOC1}	V_{SC} – 0.08	V_{SC}	V_{SC} + 0.08	V
External Over-Temperature (OT) Protection*(3)						
t_{DOTP}	Discharge Over - Temperature detection threshold		t_{DOTP} –5	t_{DOTP}	t_{DOTP} + 5	℃
$t_{DOTR-DELTA}$	Discharge Over - Temperature Release Hysteresis threshold			15		℃
t_{DOTR}	Discharge Over - Temperature Release detection threshold	t_{DOTR}= t_{DOTP} -$t_{DOTR-DELTA}$	t_{DOTR} - 5	t_{DOTR}	t_{DOTR} + 5	℃
t_{COTP}	Charge Over - Temperature detection threshold		t_{COTP} –5	t_{COTP}	t_{COTP} + 5	℃
$t_{COTR-DELTA}$	Charge Over - Temperature Release Hysteresis threshold			3		℃
t_{COTR}	Charge Over - Temperature Release detection threshold	t_{COTR}= t_{COTP} -$t_{COTR-DELTA}$	t_{COTR} - 5	t_{COTR}	t_{COTR} + 5	℃
V_{TH-DSG}	Discharge state detection threshold		1	5	10	mV

*(1) Min and Max values shown in the Electrical Characteristics table are target values based on simulation results. These values are subject to change upon completion of the Design Verification process.
*(2) All the protection threshold and release values are one time programmable only. Customers can request any combination of them in the given setting range through our sales person
*(3) OT threshold in this table is based on 103AT type of external thermistor. Customer can adjust the OT threshold by adding external resistor series/parallel with thermistor.

ELECTRICAL CHARACTERISTICS*(1) (Contd.)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
External Delay/Release Time Set						
T_{OVP}	Over-voltage Protection delay time	Capacitance on OVT pin, C_{OVT}=0.1uF	0.6	0.9	1.2	S
T_{OT-DET}	Over-temperature detection period time	Capacitance on OVT pin, C_{OVT}=0.1uF	0.5	1.0	2.0	S
T_{PF}	Permanent Failure (PF) Blow Fuse Protection delay time	Capacitance on OVT pin, C_{OVT}=0.1uF; T_{PF} = 3.0 * T_{OVP}	1.8	2.7	3.6	S
T_{UVP}	Under-voltage Protection delay time	Capacitance on UVT pin, C_{UVT}=0.1uF	0.7	1.0	1.3	S
$T_{SHUT\ DOWN}$	Shut down delay time	Capacitance on OVT pin, C_{OVT}=0.1uF;	3.5	5.5	7.5	S
T_{DOC1}	Discharge Over-Current Protection delay time (level-1)	Capacitance on UVT pin, C_{UVT}=0.1uF; T_{DOC1} = T_{UVP}	0.4	1.0	1.4	S
		T_{DOC1} =2 * T_{UVP}*(2)	0.8	2.0	2.8	S
T_{DOC2}	Discharge Over-Current Protection delay time (level-2)	Capacitance on UVT pin, C_{UVT}=0.1uF; T_{DOC2} = 10% * T_{DOC1}	40	100	180	mS
		T_{DOC2} =15% * T_{DOC1}*(2)	120	300	540	mS
T_{SC}	Internal fixed Short-Circuit Protection delay time		100	250*(3)	500	µS
T_{OCR}	OC/SC release delay time	Capacitance on OVT pin, C_{OVT}=0.1uF T_{OCR}=T_{OVP}	0.4	0.9	1.4	S
Power Supply						
V_{CC}	The Voltage between VCC pin and VSS pin		4.0*(4)		30	V
$V_{TH-HVNMOS}$*(5)	The Threshold of HV NMOS-FET to determine charger-in headroom			3.1	3.96	V
$V_{HEAD-ROOM}$*(6)	Wake-Up Headroom between charger input and battery pack	CHG pin ramps up, V_{BAT1} >$V_{TH-HVNMOS}$ I_{CHG} >1uA	0.6	0.4		V
		CHG pin ramps up, V_{BAT1} <=$V_{TH-HVNMOS}$ I_{CHG} >1uA		6.0		V
$V_{PWR-ON-RST}$*(7)	Chip Power On reset voltage	VCC ramps up		7.1	9.2	V
I_{NORMAL}	Power consumption under normal mode	I_{VCC} current from VCC pin		17	34*(8)	µA
$I_{SHUT\ DOWN}$	Power consumption under shut down mode	I_{VCC} current from VCC pin		0.4	1.0	µA
I_{SLEEP}	Power consumption under sleep mode	EXTC pin floating		1.6	3.0	µA

* (1) Min and Max values shown in the Electrical Characteristics table are target values based on simulation results. These values are subject to change upon completion of the Design Verification process.
* (2) Configured by O2Micro, based on customer's request, refer to option selection table.
* (3) RC Filter set on ISEN pin will be used to adjust the SC time externally.
* (4) When V_{CC} voltage is lower than the minimal operation voltage 4.0V, the DSG and CHG are both OFF, but the internal state machine of OZ8953 is not guaranteed.
* (5) $V_{TH\text{-}HVNMOS}$ is the threshold of internal HV NMOS-FET. When the voltage of BAT1 pin is higher than $V_{TH\text{-}HVNMOS}$ and once charger is plugged-in, the CHG pin will be pulled down to V_{SS} and charge MOSFET will be turned on.
* (6) $V_{HEAD\text{-}ROOM}$ is the difference voltage between the charger voltage and the battery pack voltage when chip wakes up from shut down mode. In shut down mode, charger input needs to be $V_{HEAD\text{-}ROOM}$ higher than battery pack voltage to wake up chip when V_{CC} reaches $V_{TH\text{-}HVNMOS}$. The $V_{HEAD\text{-}ROOM}$ needs to be at least 6V when V_{CC} is lower than $V_{TH\text{-}HVNMOS}$.
* (7) $V_{PWR\text{-}ON\text{-}RST}$ is the threshold of power-on reset. When the V_{CC} voltage is higher than $V_{PWR\text{-}ON\text{-}RST}$, OZ8953 will start up.
* (8) When OV protection is triggered, normal mode current consumption will increase. The current will be the normal working current plus self-sink current I_{SINK}. I_{SINK} is defined in Over-Voltage self-sink function section.

ELECTRICAL CHARACTERISTICS*(1) (Contd.)

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
Driver voltage or current							
I_{CHG}	The current sink into CHG pin	Charge MOSFET turn on V(CHG,VSS) <30V		3.5	6.0	10.0	μA
		Charge MOSFET turn off V(CHG,VSS) <30V		0	High impedance	0.17	μA
V_{DSG}	The voltage of DSG pin	Discharge MOSFET turn on	1) $V_{CC}>V_{CCTH}$*(2)	6.5	10.5	12	V
			2) $V_{CC}<V_{CCTH}$	V_{CC}-1.15	V_{CC}-0.65	V_{CC}-0.15	V
		Discharge MOSFET turn off		0.15	0.3	0.7	V
I_{BAT1}	BAT1 sink current in normal working mode	All V_{CELL}=3.6V			9	15	μA
I_{BATn} (n=2~5)	BATn (n=2~5) sink current in normal working mode	All V_{CELL}=3.6V		-0.25	-	0.40	μA
V_{EXTCH}	EXTC pin input voltage – "H"	$V_{CC}>V_{PWR\text{-}ON\text{-}RST}$		V_{CC}-1.5			V
V_{EXTCL}	EXTC pin input voltage – "L"	$V_{CC}>V_{PWR\text{-}ON\text{-}RST}$				1.5	V

***** (1) Min and Max values shown in the Electrical Characteristics table are target values based on simulation results. These values are subject to change upon completion of the Design Verification process
* (2) When V_{CC} is low level, the voltage of DSG will change linearly with V_{CC}. However, when V_{CC} reaches to above the value (V_{CCTH}), the voltage of DSG pin will be fixed and is about 10.5V. V_{CCTH} is around 10.5V±0.65V at typical case.

POWER MODE

In OZ8953, 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, OZ8953 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, OZ8953 will work in normal working state.
- 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. → 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.

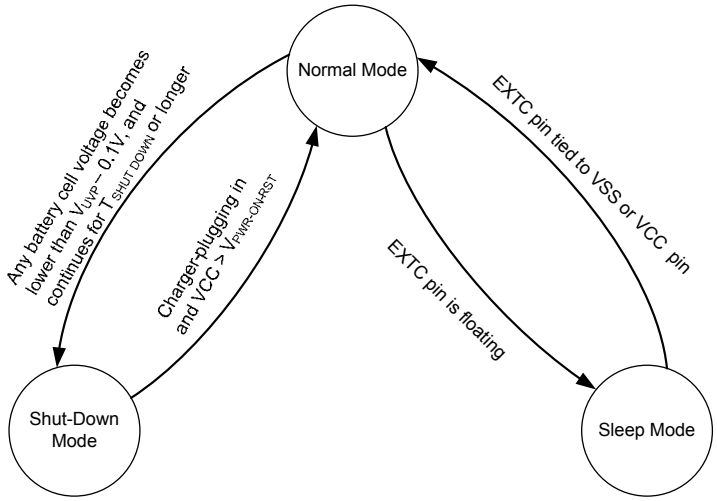


Figure 4 OZ8953 power mode transition diagram

Table 5 OZ8953 power mode transition description

Initial Mode	***Condition***	***Final Mode***
Normal Mode	Any battery cell voltage becomes lower than V_{UVP} – 0.1V, and continues for $T_{SHUT\ DOWN}$ or longer	Shut-Down Mode
Normal Mode	EXTC pin is floating	Sleep Mode
Shut-Down Mode	Charger-plugging in and VCC>$V_{PWR-ON-RST}$	Normal Mode
Sleep Mode	EXTC pin tied to VSS or VCC pin	Normal Mode

FUNCTIONAL DESCRIPTION

OZ8953 is a very flexible and accurate battery protection IC for 5 series cell applications. With a large selection of models, OZ8953 can implement flexible protection architecture for a wide-range of applications.

1. Normal Working state

When all the following conditions have been satisfied:

- All cell voltages are between V_{OVP} and V_{UVP}
- 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_{COTP}
- Discharge temperature is less than t_{DOTP}
- EXTC pin is tied to VSS or VCC pin

OZ8953 will work in normal working state under normal mode.

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 T_{OVP} or longer

Over Voltage (OV) 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 V_{GS} voltage of the charge MOSFET will drop to 0V, turning off the charge MOSFET.

The release condition of Over-Voltage protection is as follows:

(1) All battery cell voltages drop to V_{OVR} or lower.

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

$$T_{OVP} = 0.9s * \frac{C_{OVT}}{0.1uF} \quad \text{..... (1)}$$

3. Under-Voltage Protection state

Under Voltage (UV) protection is also referred as over discharge protection.

UV conditions are satisfied when:

- Any battery cell voltage becomes lower than V_{UVP}

AND

- Continues for T_{UVP} or longer

When Under-Voltage protection has been activated, as above, the DSG pin output level will be at V_{SS}. 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 V_{UVR} or higher.

AND

(2) The load is open or charger plugging-in is detected. (Optional function, which is configured by O2Micro. Please review model options on page 28.)

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.

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

$$T_{UVP} = 1.0s * \frac{C_{UVT}}{0.1uF} \quad \text{..... (2)}$$

4. Over-Current Protection state

OZ8953 has three levels Over-Current (OC) protection (V_{DOC1}, V_{DOC2} and V_{SC}).

- V_{DOC1} is level-1 voltage set for R_{SENSE} voltage
- V_{DOC2} is 2.0 times as high as V_{DOC1}
- V_{SC} is 4.5 times as high as V_{DOC1}

There are three synchronous comparators integrated in OZ8953, which are used to detect the OC level and immediately assert protection control signals.

V_{DOC1}: When the discharge current is higher than the specified OC level-1 value (the voltage between ISEN Pin and VSS pin is higher than V_{DOC1}) and continues for T_{DOC1} or longer, DSG

pin will output V_{SS} level and turn off the discharge MOSFET.

V_{DOC2}: If the discharge current is higher than specified OC level-2 value (the voltage between ISEN Pin and VSS pin is higher than V_{DOC2}) and continues for T_{DOC2} or longer, DSG pin will output V_{SS} level and turn off the discharge MOSFET.

V_{SC}: V_{SC} is level-3 voltage set for discharge current protection, it is also considered as short-circuit (SC) protection, if SC occurs (the voltage between ISEN Pin and VSS pin is higher than V_{SC}) and continues for T_{SC} or longer, DSG pin will output V_{SS} level and turn off the discharge MOSFET.

As these three protections are synchronous, when any one of the aforementioned Over-Current conditions occurs, OZ8953 enters over-current protection state.

Both T_{DOC1} and T_{DOC2} are related to external capacitor C_{UVT} connected to the UVT pin. There is one model selectable value to get double delay time for T_{DOC1} and triple delay time for T_{DOC2}. (Note: the model selectable value is configured by O2Micro. Please review model options on page 28.)

$$T_{DOC1} = 1.0s * \frac{C_{UVT}}{0.1uF} \quad \text{..... (3)}$$

$$T_{DOC2} = 0.1s * \frac{C_{UVT}}{0.1uF} \quad \text{..... (4)}$$

OR

$$T_{DOC1} = 2.0s * \frac{C_{UVT}}{0.1uF} \quad \text{..... (5)}$$

$$T_{DOC2} = 0.3s * \frac{C_{UVT}}{0.1uF} \quad \text{..... (6)}$$

There is a fixed internal time delay for SC, which is around 250uS. Please refer to figure 5 Over-Current Protection input circuit. Besides the internal fixed SC time delay, the total SC protection delay time $T_{SC-TOTAL}$ will also rely on the following factors

1) RC filter time constant. The larger the RC time constant, the longer the delay time will be.
2) The current amplitude of SC. If the amplitude is slightly higher than the SC threshold, the delay time will be a little longer.
3) If the current amplitude is much higher, the delay time will be shorter.
4) Discharge MOSFET gate-capacitance and gate series resistance. The larger the time constant formed by gate-capacitance and series resistance, the longer the delay time will be.

$$T_{SC-TOTAL} = T_{SC} + k * (R * C) \quad \text{..... (7)}$$

Here, K = 1~3, it depends on current amplitude.

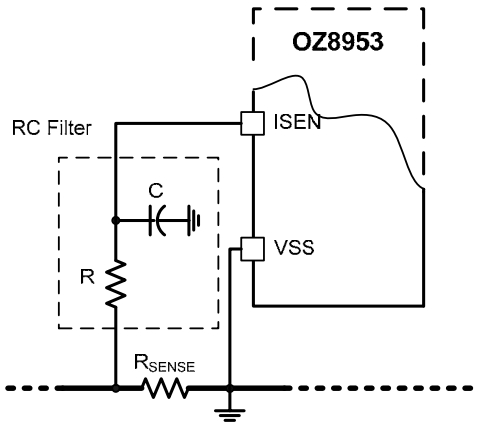


Figure 5 Over-Current (OC) Protection Input

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 V_{CC} level by the load. There are three release conditions for OC/SC protection state:

(1) When load is open, VM pin will drop to V_{SS} 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 V_{SS} 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 T_{OCR}, 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.

The Over-Current protection flowchart is shown in figure 6 below:

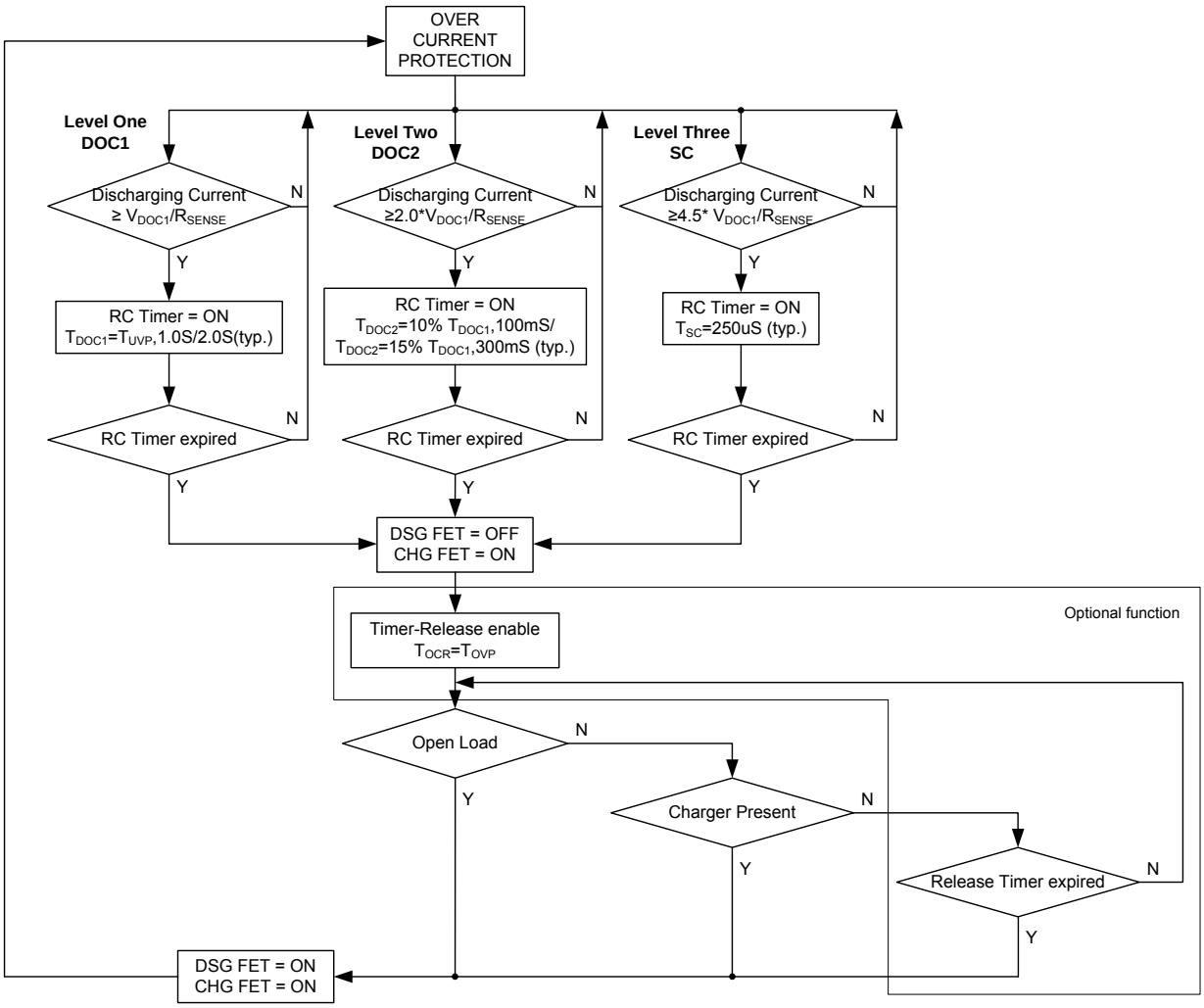


Figure 6 Over-Current Protection Flow

5. Over-Temperature Protection state

TS pin is used for battery temperature protection during charge and discharge state. OZ8953 identifies the charge state and discharge state by detecting the voltage at the ISEN Pin, if it is higher than V_{TH-DSG} (4mV typical), OZ8953 regards it as discharge state. Otherwise, OZ8953 will regard it as charge state.

During discharge state, if battery cell temperature is higher than t_{DOTP}, OZ8953 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_{COTP}, 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_{COTP}, OZ8953 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 set could be adjusted flexibly by adjusting external additional resistor R_{SER} and R_{PAR} in series or parallel shown in figure 7 below.

Following is the calculation steps to get the value of R_{SER} and R_{PAR} to set the expected OT protection thresholds correctly.

1) Set the expected COT temperature. And look up table to get the resistance of R_T at the corresponding temperature, i.e. $R_{T(COT)}$.
2) If expected COT temperature is bigger than 50°C, R_{PAR} can be removed, calculating R_{SER} using equation (8):

$$R_{SER} = R_{REFL} - R_{T(COT)} \quad \text{..... (8)}$$

Here, R_{REFL}=0.4R_{REF}. R_{REF} is 10KΩ (default, 1% accuracy). → R_{REFL}=4KΩ.

3) After get R_{SER}, we can get the resistance of R_T at DOT temperature, i.e. $R_{T(DOT)}$ using equation (9):

$$R_{T(DOT)} = R_{REFH} - R_{SER} \quad \text{..... (9)}$$

Here, R_{REFH}=0.235R_{REF}. → R_{REFH}=2.35 KΩ.

4) Look up table to get the DOT temperature.

OR

5) If expected COT temperature is less than 50°C, R_{SER} should be shorted. calculating R_{PAR} using equation (10):

$$R_{PAR} = \frac{R_{REFL} \times R_{T(COT)}}{R_{REFL} - R_{T(COT)}} \quad \text{..... (10)}$$

6) After get R_{PAR}, we can get the resistance of R_T at DOT temperature, i.e. $R_{T(DOT)}$ using equation (11):

$$R_{T(DOT)} = \frac{R_{PAR} \times R_{REFH}}{R_{PAR} - R_{REFH}} \quad \text{..... (11)}$$

7) Look up table to get the DOT temperature.

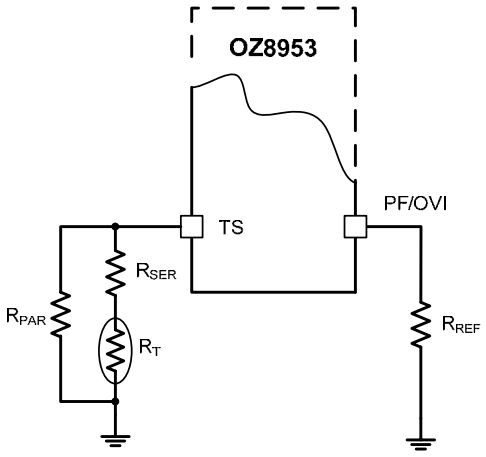


Figure 7 Over-Temperature Protection External Circuit

Typical COT and DOT set are shown in table 6 that follows:

Table 6 typical COT and DOT set

Item	COT Protection Threshold	DOT Protection Threshold	R_{SER}	R_{PAR}
1	40°C	62°C	0Ω	13KΩ
2	45°C	64°C	0Ω	20KΩ
3	50°C	68°C	0Ω	100KΩ
4	50°C	70°C	0Ω	-
4	55°C	75°C	0.47KΩ	-
5	60°C	87°C	1.0KΩ	-
6	65°C	>100°C	1.5KΩ	-

When OZ8953 is under Shut-Down mode or Sleep mode, it will not do COT/DOT detection. OZ8953 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, OZ8953 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, OZ8953 will regard it as charge state, thus DOT event will never occur, while COT detection will work normally. Please refer to figure 8 for COT/DOT detection timing.

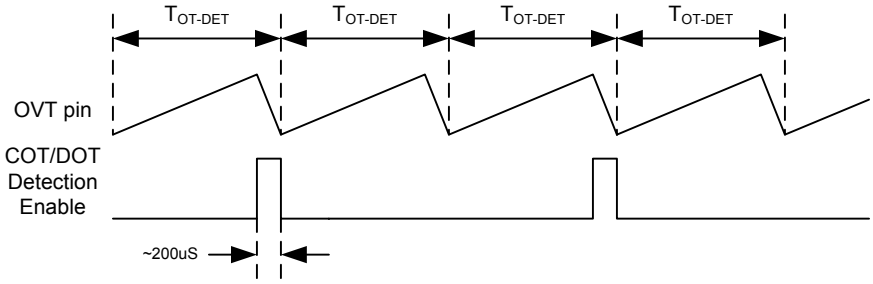


Figure 8 COT/DOT detection timing

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 by O2Micro before product shipment.OZ8953 XX-1,-2 & -5,-6 support Permanent Failure (PF) Blow Fuse protection function, when any battery cell voltage becomes higher than V_{PF} and continues for T_{PF} or longer, OZ8953 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. Refer to Figure 17 for an example. The output voltage level is:

$$V_{PF/OVI} \cong V_{PF} \times 0.8 + 0.75V \pm 0.2V \quad \ldots\ldots \quad (12)$$

When all the cell voltage drops below V_{PFR}, the PF state will be released.

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 by O2Micro before product shipment. OZ8953 XX-3,-4 & -7,-8 support OV indication function, when any battery cell voltage becomes higher than V_{OVP} and continues for T_{OVP} or longer, the PF/OVI pin will output high level, which can be used to drive one buffer and turn on LED indication. Refer to Figure 18 for an

example. The output voltage level is the same as the PF drive output shown in equation (12).

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, OZ8953 will enter sleep mode (lower power consumption). When EXTC pin is Low level (V_{EXTC}<V_{EXTCL}), OZ8953 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.

Table 7 EXTC function

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

9. 0V Battery Charge Function

OZ8953 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 V_{UVP} – 0.1V.
In shut-down mode, if OZ8953 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 OZ8953 power-on reset voltage $V_{PWR-ON-RST}$ plus one diode forward voltage (refer to D4 device in Figure 17), OZ8953 will enter normal working mode.

10. Over-Voltage Self-Sink Function

This function is used to protect over-voltage battery pack. OZ8953 provides I_{SINK} discharge current internally when OVI or PF occurs. Please refer to figure 9.
When OZ8953 is set as OVI output function, once OV protection occurs, OZ8953 will not stop I_{SINK} discharging shown in equation (12) till all cell voltages drop to V_{OVR} or lower.
When OZ8953 is set as Permanent-Failure (PF) Blow Fuse protection function, once PF protection occurs, OZ8953 will also not stop I_{SINK} discharging, till all cell voltages drop to V_{PFR} or lower. The discharging current I_{SINK} is given as:

$$I_{SINK} \approx \frac{V_{PF} \times 0.8 + 0.75V \pm 0.2V}{R_{REF}} \quad \text{..... (13)}$$

For example, when V_{OVP} is 4.25V and R_{REF} is 10KΩ, I_{SINK} will be around 400uA.

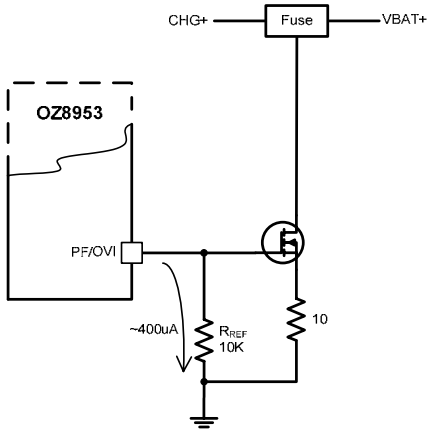


Figure 9 Over-Voltage Self-Sink

Note: R_{REF} is a fixed 10KΩ resistor. When R_{REF} is changed to other values, it will affect COT/DOT setting

11. Protection Delay Time Set

OZ8953 provides two pins (OVT & UVT) for flexible delay time. Over Voltage protection delay time (T_{OVP}) 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.

Min. Typ. Max.

T_{OVP} (S) = [6.0, 9.0, 12.0] x C_{OVT}/1.0uF

T_{PF} (S) = 3.0 x T_{OVP}

T_{UVP} (S) = [7.0, 10.0, 13.0] x C_{UVT}/1.0uF

T_{DOC1} (S) = 1.0 x T_{UVP} or 2.0 x T_{UVP}

T_{DOC2} (S) = 0.1 x T_{UVP} or 0.3 x T_{UVP}

T_{SC} (μS) = [100, 250, 500]

12. `Shut-down Mode

When any cell's voltage is lower than V_{UVP} and continues for T_{UVP}, OZ8953 enters UV protection state and turns off discharge MOSFET; when any cell's voltage continues dropping to V_{UVP} – 0.1V or lower and continues for $T_{SHUT\ DOWN}$ or longer, OZ8953 will enter Shut-Down mode. For example, V_{UVP} is set to 2.5V, when any cell's voltage is lower than 2.5V and continues for T_{UVP} or longer, OZ8953 will turn off discharge MOSFET, when any cell voltage drops to 2.4V and continues for T_{SHUT_DOWN} or longer, OZ8953 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}=V_{SS}

13. Test Mode

Test mode is used by O2Micro only for product test and internal evaluation. To enter test mode, one voltage V_{TS} (range: 1.5V to 2.5V) is needed to be added on TS pin before OZ8953 power-up, otherwise OZ8953 will not enter test mode. Please refer to table 8 for operation mode selection.

14. Trim Mode

Trim mode is used by O2Micro only to configure internal threshold parameter set before product shipment. To enter trim mode, one voltage V_{TS} (range: 3.5V to 4.5V) needs to be added on TS pin before OZ8953 power-up, otherwise OZ8953 will not enter trim mode.

Table 8 How to enter test mode and trim mode (T_a = 25°C)

Item	Operation Mode	Note
V_{TS} < 1.0V	Normal mode	This mode is for actual application
2.0V < V_{TS} < 2.5V Before OZ8953 powers up	Test mode	Monitor the internal reference voltage
3.5V < V_{TS} < 4.5V Before OZ8953 powers up	Trimming mode	Internal threshold parameter set

TIMING CHART

1 Over Voltage Detection

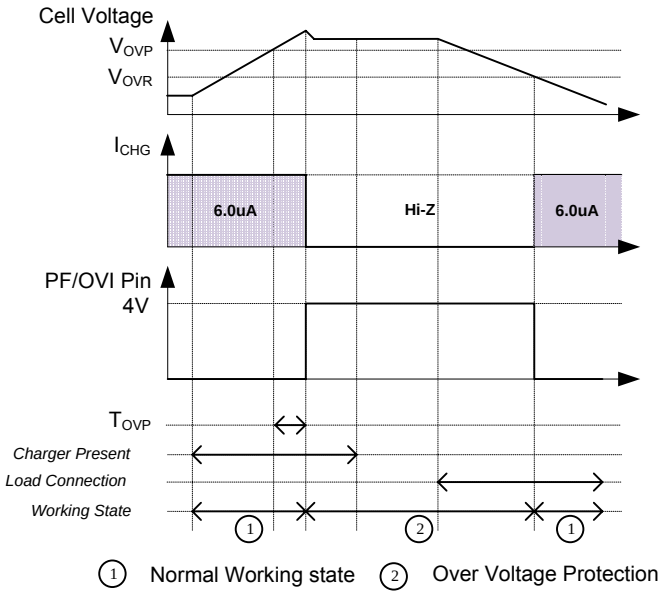


Figure 10 OV Protection Timing

2 Permanent Fail (PF) Blow Fuse Function

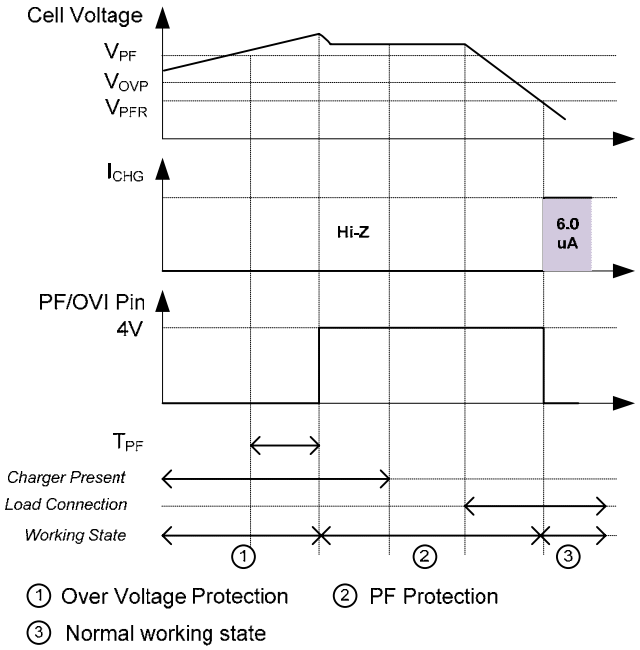


Figure 11 PF Protection Timing

3 Under-Voltage Detection and Shut-Down Mode

3.1 Battery pack Voltage Stays Between $V_{PWR-ON\ RST}$ and $V_{TH-HVNMOS}$

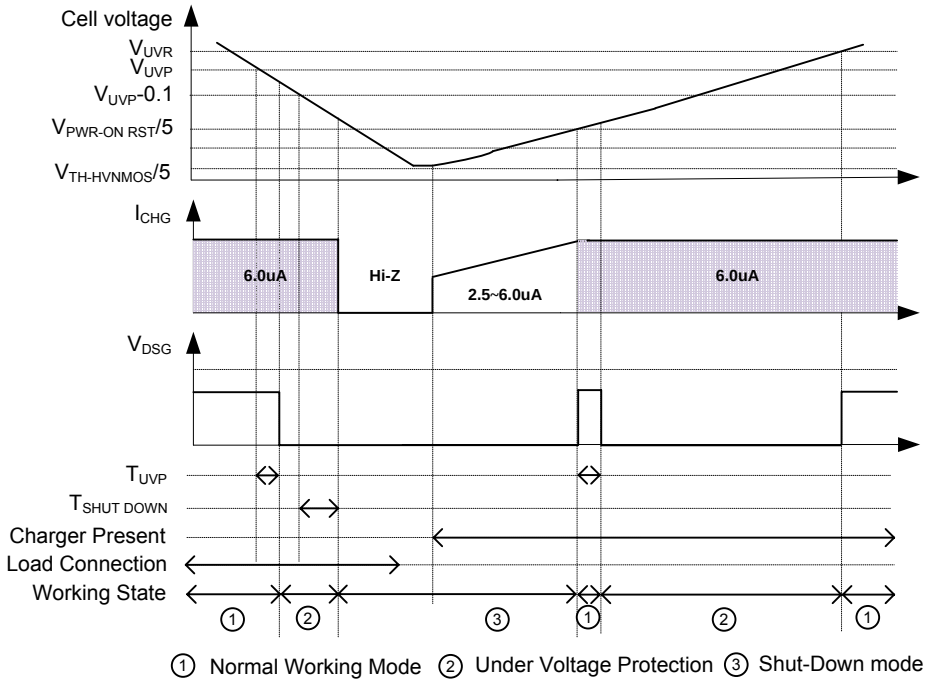


Figure 12 UV Protection and Shut-Down Timing

3.2 Battery pack Voltage Under $V_{TH-HVNMOS}$

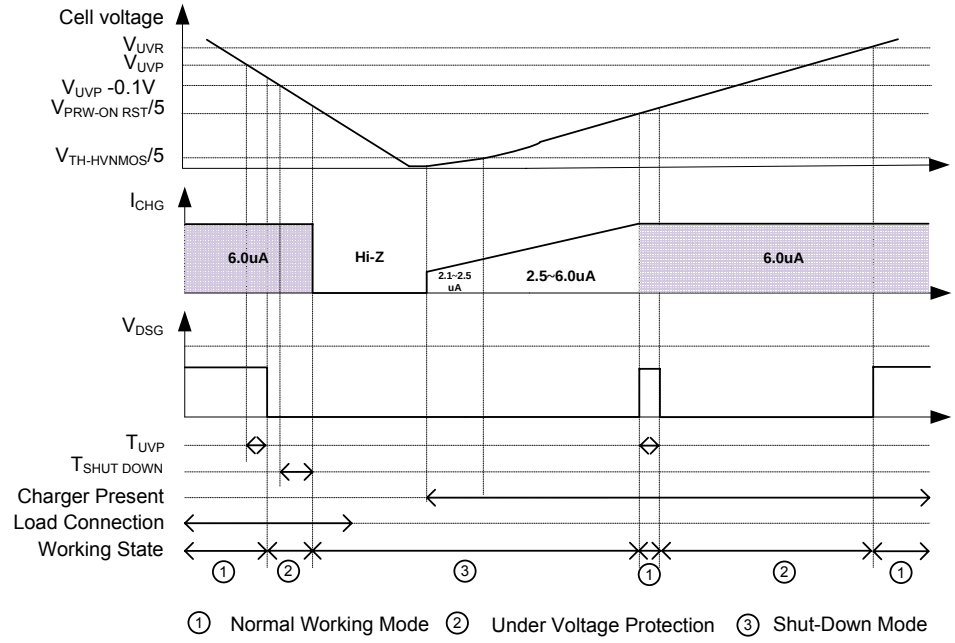


Figure 13 UV Protection and Shut-Down Timing

4 DOC1 Detection with Charger Plugging-in Release

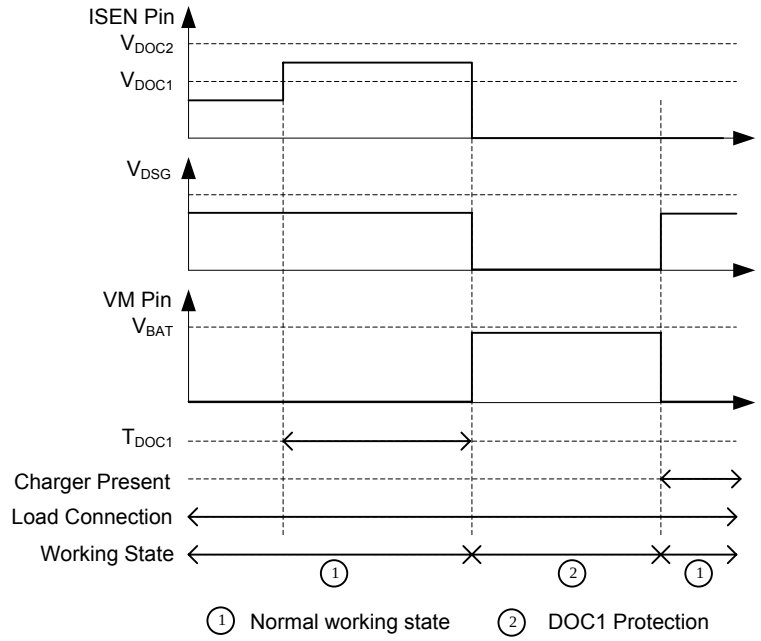


Figure 14 DOC1 Protection with charger plugging-in release timing

5 DOC2 Detection with Charger Plugging-in Release

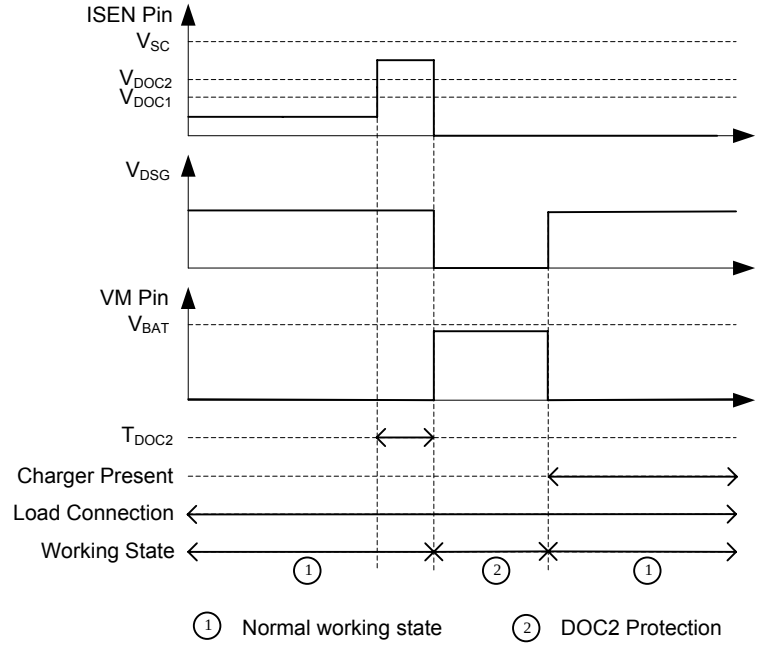


Figure 15 DOC2 Protection with charger plugging-in release timing

6 SC Detection with Load-Open Release

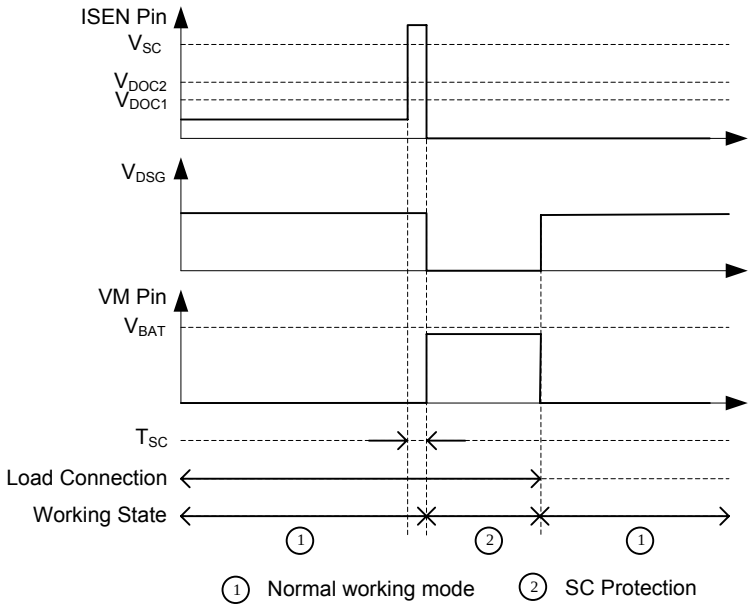


Figure 16 SC Protection with load-open release timing

OZ8953 BATTERY PROTECTION REFERENCE CIRCUIT

1. Three (3) Terminal Battery Pack – Application Circuit: Permanent-Failure Blow Fuse protection

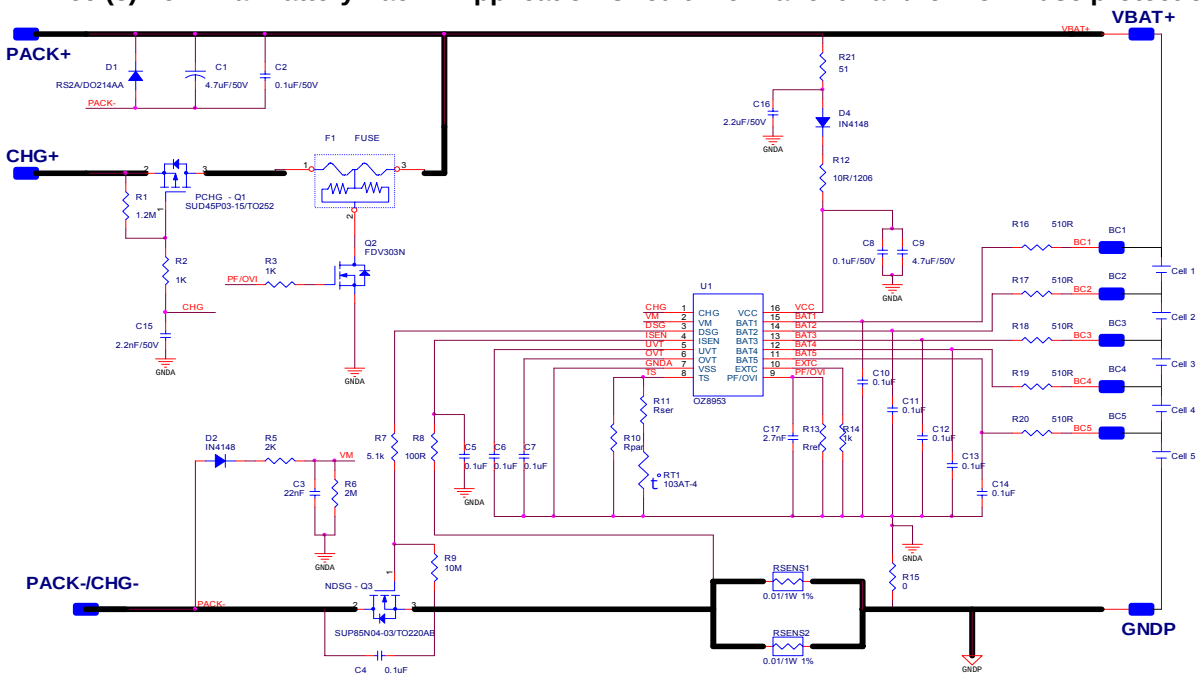


Figure 17 OZ8953 reference circuit (1)

2. Three (3) Terminal Battery Pack – Application Circuit: Over Voltage LED Indicator

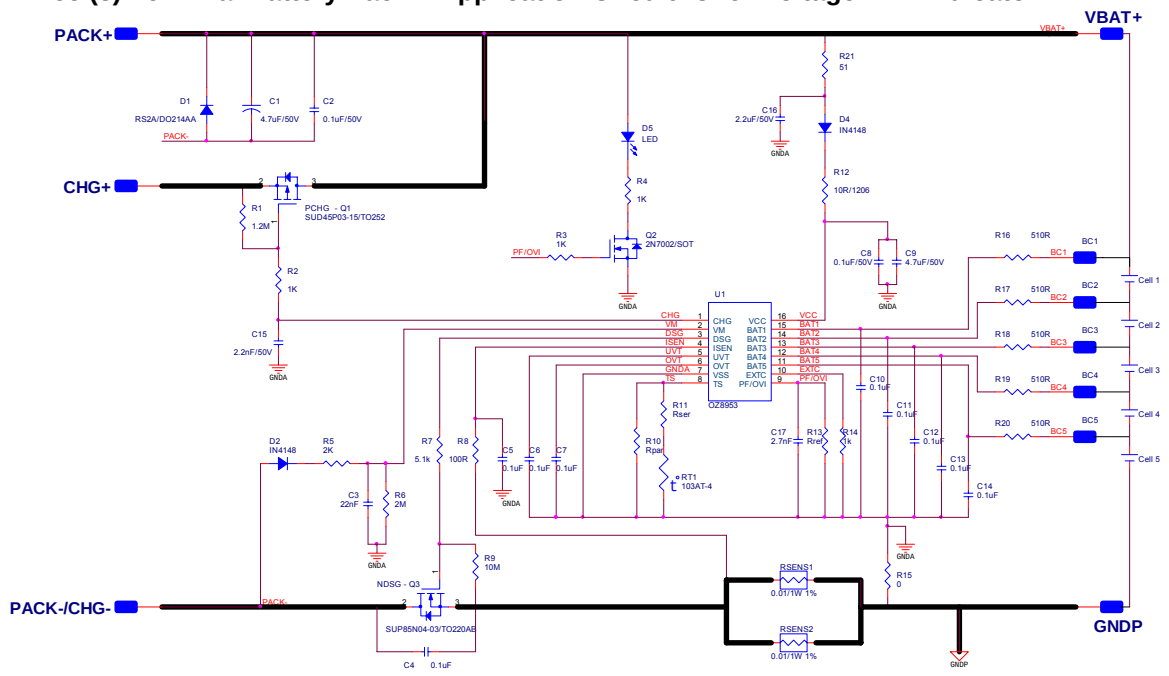


Figure 18 OZ8953 reference circuit (2)

3. Two (2) Terminal Battery Pack – Application Circuit: Over Voltage LED Indicator

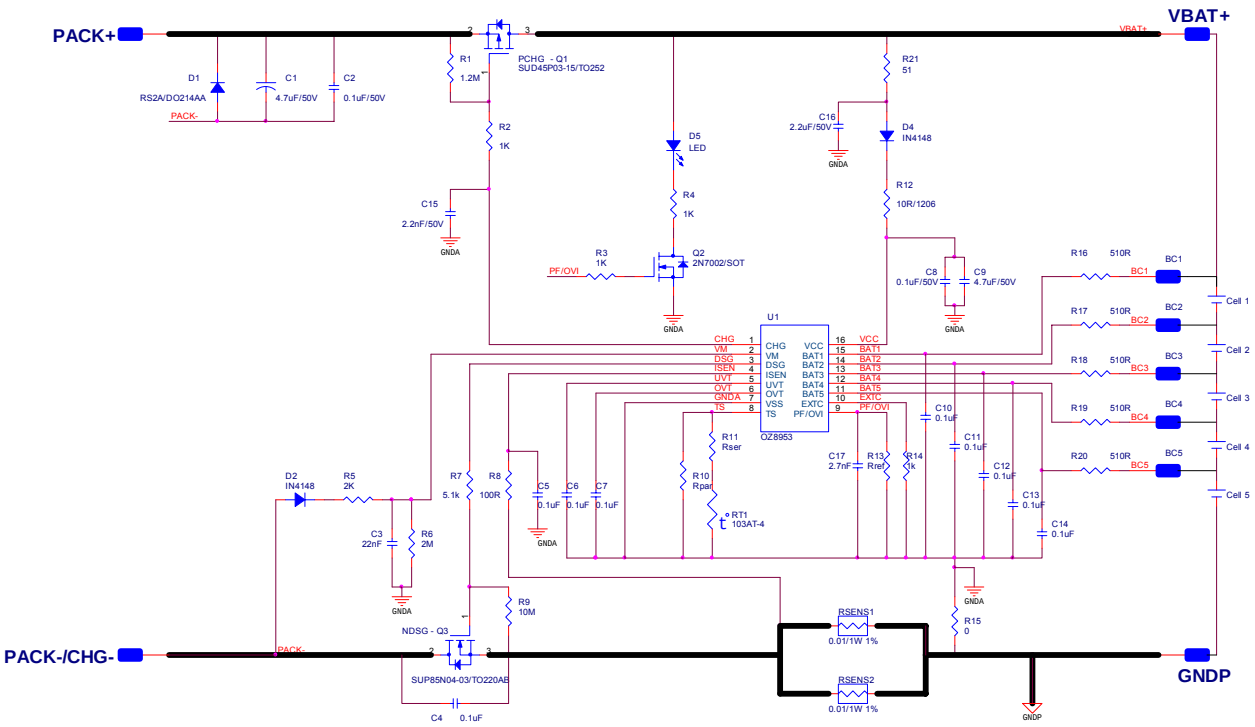


Figure 19 OZ8953 reference circuit (3)

Options Selection Table

Item	Parameter	Units	Choices															
1	V_{OVP} (Over Voltage)	V	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	4.20	4.25	4.30	4.35
	Selection filled with **X**																	
	Note: V_{OVP} Threshold requested except listed above need to be specified for range of V_{OVP}: 3.60V to 4.35V with resolution of 50mV → Specified V_{OVP}: _____																	
2	$V_{OVR-DELTA}$ Release Hysteresis	mV	0	100	112.5	125	137.5	150	163	175	188	200	212.5	225	237.5	250	262.5	275
	Selection filled with **X**																	

3	V_{UVP} (Under Voltage)	V	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
	Selection filled with **X**												

4	$V_{UVR-DELTA}$ Release Hysteresis	mV	0	100	200	300	400	500	600	700	800	900	1000
	Selection filled with **X**												

5	Over Current Detection Voltage 1 (V_{DOC1})	mV	25	50	75	100	125	150	175	200	225	250	275	300	325	350
	Selection filled with **X**															

6	OC/SC Timer Release		Enable	Disable
	Only select one; Selection filled with **X**			

7	PF/OV Function Select		PF	OV
	Only select one; Selection filled with **X**			

8	OC Protection Delay time (T_{DOC1}) & UVP Release Method		$1 * T_{UVP}$	$2 * T_{UVP}$
			Depends on UVR & Load-open	Depends on UVR
	Only select one; Selection filled with **X**			

Note: T_{UVP} will be 1second when C_{UVT}=0.1uF

Note: Specific OZ8953 part number will be assigned based on entries in the Options Selection Table shown above

Product Name Structure

1. Product Name

OZ8953 XX - X

- XX: Series code *2 — Sequentially set from AA to ZZ
- X: Digital code *1 — Sequentially set from 1 to 8

***1.** This relates to PF/OVI function. Please refer to table 9 shown below for detailed information:

Table 9

Digital code	OC/SC Timer Release	PF/OVI function select	T_{DOC1} time Set		
1	Timer release enable	Permanent-Failure (PF) Blow Fuse Protection Function	Not set(=0)	T_{DOC1} = T_{UVP}, 1.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Enable
2	Timer release enable	Permanent-Failure (PF) Blow Fuse Protection Function	Set(=1)	T_{DOC1} = 2* T_{UVP}, 2.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Disable
3	Timer release enable	Over Voltage Indication (OVI) Function	Not set(=0)	T_{DOC1} = T_{UVP}, 1.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Enable
4	Timer release enable	Over Voltage Indication (OVI) Function	Set(=1)	T_{DOC1} = 2* T_{UVP}, 2.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Disable
5	Timer release disable	Permanent-Failure (PF) Blow Fuse Protection Function	Not set(=0)	T_{DOC1} = T_{UVP}, 1.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Enable
6	Timer release disable	Permanent-Failure (PF) Blow Fuse Protection Function	Set(=1)	T_{DOC1} = 2* T_{UVP}, 2.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Disable
7	Timer release disable	Over Voltage Indication (OVI) Function	Not set(=0)	T_{DOC1} = T_{UVP}, 1.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Enable
8	Timer release disable	Over Voltage Indication (OVI) Function	Set(=1)	T_{DOC1} = 2* T_{UVP}, 2.0S (default with C_{UVT}=0.1uF)	Load-open for UV Release Disable

***2.** Refer to **"2. Product Series List"**

2. Product Series List

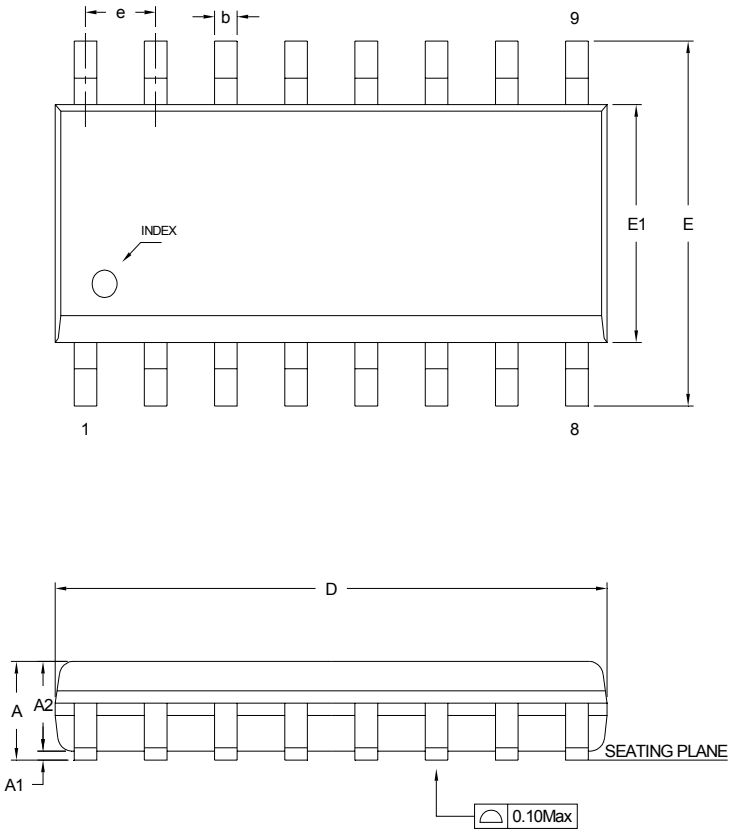
Table 10

Product Series List	OV Detection Voltage	OV Release Voltage	UV Detection Voltage	UV Release Voltage	OC Detection Voltage	PF/OVI Function	OC/SC Timer Release	T_{DOC1} Time Set *(1)
OZ8953AA-7	4.25± 0.025V	4.15± 0.025V	2.7± 0.08V	3.0± 0.08V	0.10± 0.01V	OVI function	Disable	Set=0
OZ8953AB-7	3.75± 0.025V	3.55± 0.025V	2.2± 0.08V	2.7± 0.08V	0.10± 0.01V	OVI function	Disable	Set=0
OZ8953AC-6	4.2± 0.025V	4.2± 0.025V	2.0± 0.08V	2.7± 0.08V	0.35± 0.01V	PF function	Disable	Set=1
OZ8953AD-5	4.20± 0.025V	4.10± 0.025V	2.5± 0.08V	3.0 ± 0.08V	0.10 ± 0.01V	PF function	Disable	Set=0
OZ8953AE-5	4.25± 0.025V	4.0± 0.025V	2.5± 0.08V	3.0± 0.08V	0.05± 0.01V	PF function	Disable	Set=0
OZ8953AF-5	4.25± 0.025V	4.15± 0.025V	2.5± 0.08V	3.0± 0.08V	0.15± 0.01V	PF function	Disable	Set=0
OZ8953AG-5	4.20± 0.025V	4.10± 0.025V	2.5±0.08V	3.0± 0.08V	0.075± 0.01V	PF function	Disable	Set=0
OZ8953AH-5	4.20± 0.025V	4.10± 0.025V	2.5±0.08V	3.0± 0.08V	0.125± 0.01V	PF function	Disable	Set=0
OZ8953AI-6	4.22± 0.025V	4.22± 0.025V	2.3±0.08V	2.3± 0.08V	0.1± 0.01V	PF function	Disable	Set=1
OZ8953AJ-7	4.20± 0.025V	4.0± 0.025V	2.5±0.08V	2.5± 0.08V	0.1± 0.01V	OVI function	Disable	Set=0
OZ8953AK-5	4.25± 0.025V	4.0± 0.025V	2.8± 0.08V	3.3± 0.08V	0.075± 0.01V	PF function	Disable	Set=0

**(1) T_{DOC1} Time set =0: TDOC1 =TUVP & UV load open release Enable;*
*T_{DOC1} Time set =1: TDOC1 =2*TUVP & UV load open release Disable*

PACKAGE INFORMATION

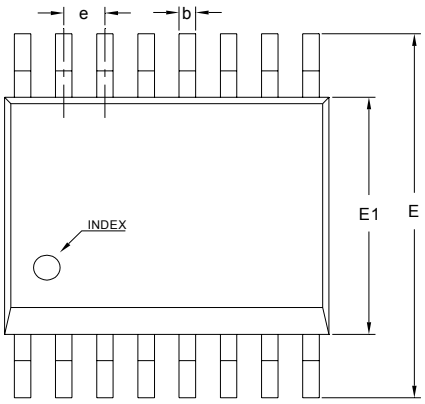
16L SOP 150mil Package Outline Drawing

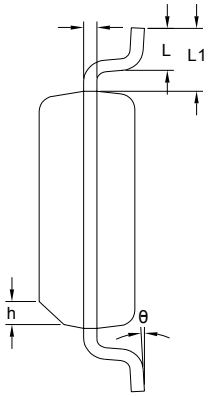


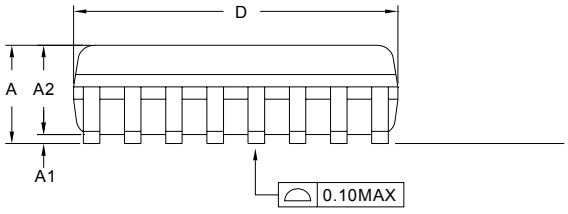
COMMON DIMENSIONS (MM)			
SYMBOL	MIN	NOM	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	-	-
b	0.33	-	0.51
c	0.17	-	0.25
D	9.80	9.90	10.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.40	-	1.27
L1	1.04 REF		
h	0.25	-	0.50
θ	0°	-	8°

NOTE:
1. REFER TO JEDEC STD MS-012 AC
2. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER END. DIMENSION "E1" DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 mm PER SIDE

16L SSOP 150mil Package Outline Drawing







NOTE:
1. REFER TO JEDEC STD MO-137 AB
2. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER END. DIMENSION "E1" DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15 mm PER SIDE

SYMBOL	DIMENSION (MM)		
	MIN	NOR	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	-	-
b	0.20	-	0.30
c	0.17	-	0.25
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	0.635 BSC		
L	0.40	-	1.27
L1	1.04 REF		
h	0.25	-	0.50
θ	0°	-	8°

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