High-Accuracy Protector for 2-5 Cells Li-ION/Polymer Battery

1 Descriptions

The SC5550 is a high-accuracy protection IC for 2-5 cells rechargeable battery application. It integrates complete battery protection functions including battery over voltage protection, battery under voltage protection, 3-levels discharge over current protection, charge over current protection, battery over and under temperature protection under both charging and charging condition, chip thermal shutdown protection etc. Besides, the voltage protection delay time is flexible to set by external resistor.

SC5550 provides secondary battery over voltage protection and indication function. This can be cooperated with fuse, to enhance battery safety.

In addition, SC5550 also integrates CTRC/CTRD control pin to support stacked application, up to 6-10 cells application.

The SC5550 consumes low supply current under normal working status and automatically enters sleep mode when battery voltage is lower than under voltage protection threshold, which ensures cells' storing time longer.

SC5550 is available in TSSOP-20 footprint.

2 Features

- Support 2-5 cells Li-ion/LiFePO4 rechargeable battery
- IC working temperature range: -40°C~+85°C
- Support over voltage protection (OVP)
  - 3.0 V to 4.575V, ±35mV accuracy (Ta=+25°C)
- Support under voltage protection (UVP)
  - 1.2V to 3V, ±50mV accuracy (Ta=+25°C)
- Support cell disconnection detection
- Support over voltage secondary protection and indication
- OVP and UVP delay time adjusted by external resistor
- Support 3-levels discharge over current protection:
  - Discharging over current 1 (DOC1): 10mV-85mV
  - Discharging over current 2 (DOC2): 2 x DOC1
  - Short circuit protection (SCP): 4 x DOC1
- Support charge over current protection (COC):
  - Charging over current (COC): 5mV-80mV
- Support battery temperature protection
  - Charging over temperature (COT): +45°C/+50°C
  - Charging under temperature (CUT): -5°C/0°C
  - Discharging over temperature (DOT): +65°C/+70°C
  - Discharging under temperature (DUT): -15°C/-10°C
- Support NTC disconnection detection
- Support 0V battery charging function
- Support separate path for charge and discharge
- Support stacked application
- Support chip thermal shutdown
- Low power consumption:
  - Normal mode (20µA for typically)
  - sleep mode (6µA for typically)

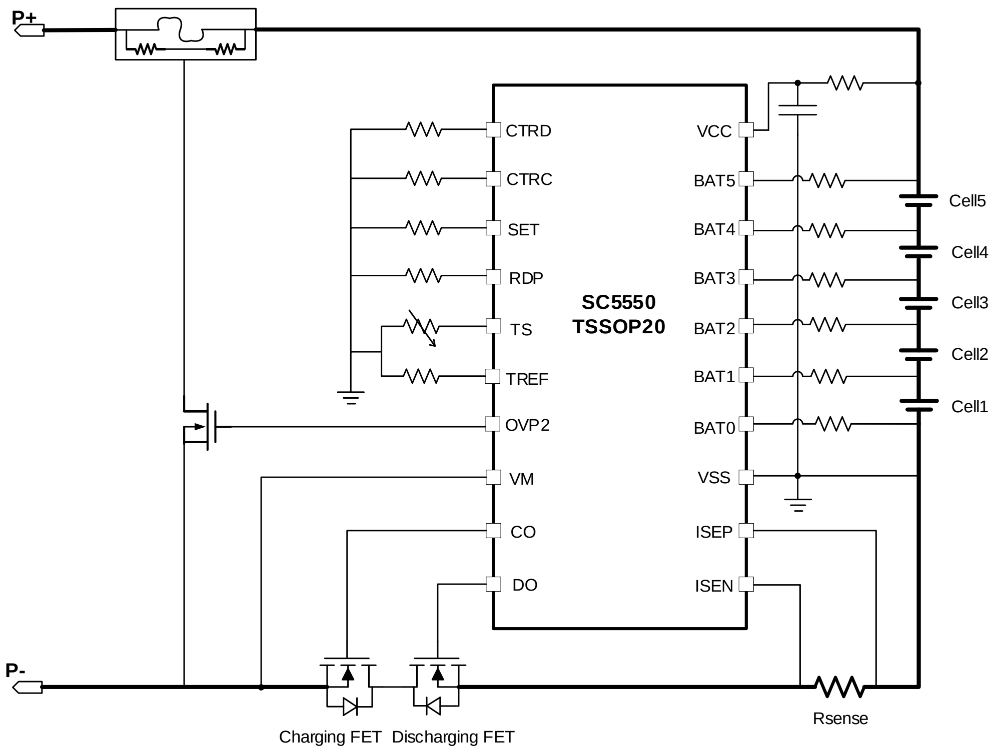
3 Applications

- Power tool
- Electrical bikes
- UPS backup battery

4 Device Information

PART NUMBER	PACKAGE	BODY SIZE
SC5550	20 pin TSSOP	6.5mm x 6.4mm x 1.2mm

5 Typical Application Circuit



Simplified Application Circuit

6 Selection Guide

Table 1 Part Number List

Part Number	V_{OVP}	V_{OVP} Hys.	V_{ODV}	V_{ODV} Hys.	V_{DOC1}	V_{DOC2}	V_{SC}	V_{COC}
SC5550BABA	4.375V	200mV	2.5V	200mV	+45mV	2*V_{DOC1}	4*V_{DOC1}	-15mV
SC5550FAAB	4.25V	200mV	2.8V	200mV	+80mV	2*V_{DOC1}	4*V_{DOC1}	-40mV

Part Number	t_{DOC1}/t_{DOC2}/t_{SC}/t_{COC}	T_{COT}/T_{CUT}/T_{DOT}/T_{DUT}	0V Charging	Cell Balancing
SC5550BABA	24ms/1024µs/512µs/10ms	45°C/0°C/70°C/-15°C	Y	N
SC5550FAAB	24ms/1024µs/512µs/10ms	45°C/0°C/65°C/-10°C	Y	N

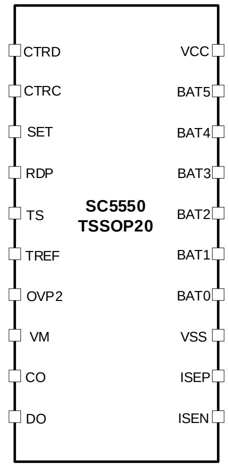
Note: If the requirement product is not on the above table, please consult the sales for more selection option.

Table 2 Selection Options

Parameter	Description	Range
V_{OVP}	Charge over voltage protection threshold	3V~4.575V, 25mV/step
V_{OCV} hysteresis	Charge Over voltage release hysteresis	0/100mV/200mV/400mV
V_{ODV}	Discharge under voltage protection threshold	1.2V~3V, 100mV/step
V_{ODV} hysteresis	Discharge under voltage release hysteresis	0/100mV/200mV/400mV
V_{DOC1}	Discharge over current threshold 1	10~85mV, 5mV/step
V_{COC}	Charging over current threshold	5~80mV, 5mV/step
T_{COT}	Charging over temperature	+45°C/+50°C
T_{CUT}	Charging under temperature	-5°C/0°C
T_{DOT}	Discharging over temperature	65°C/70°C
T_{DUT}	Discharging under temperature	-15°C/-10°C

7 Terminal Configuration and Functions

TOP VIEW



TERMINAL		I/O	DESCRIPTION
TSSOP20	NAME		
1	CTRD	I	Discharging FET stacked input, connect with VSS if not used.
2	CTRC	I	Charging FET stacked input, connect with VSS if not used.
3	SET	I	Connect a resistor to determine cell numbers setting. 0Ω for 2 cells, 40kΩ for 3 cells, 80kΩ for 4 cells, float for 5 cells.
4	RDP	I	Connect with external resistor to adjust OVP and UVP delay time.
5	TS	I	Battery temperature detection pin. Connected with an NTC resistor to provide temperature protection. Connect a 10-kΩ resistor to VSS pin if the function is not used.
6	TREF	O	Temperature protection reference.
7	OVP2	O	Secondary over voltage indication and output pin.
8	VM	I	Load and charger detection pin.
9	CO	O	Gate control of charging mosfet.
10	DO	O	Gate control of discharging mosfet.
11	ISEN	I	Current sense negative input.
12	ISEP	I	Current sense positive input.
13	VSS	P	Cell ground pin.
14	BAT0	I	Cell 1 negative terminal.
15	BAT1	I	Cell 1 positive terminal and cell 2 negative terminal.
16	BAT2	I	Cell 2 positive terminal and cell 3 negative terminal.
17	BAT3	I	Cell 3 positive terminal and cell 4 negative terminal.
18	BAT4	I	Cell 4 positive terminal.
19	BAT5	I	Cell 5 positive terminal.
20	VCC	P	Internal power supply. Connect a 1uF ceramic capacitor between VCC and GND.

8 Specifications

8.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	Unit
Voltage range at terminals (2)	VCC, BAT5, BAT4, BAT3, BAT2, BAT1, CTRD, CTRC	-0.3	40	V
	BAT5-BAT4, BAT4-BAT3, BAT3- BAT2, BAT2-BAT1, BAT1-BAT0	-0.3	6	V
	VM	-30	40	V
	DO	-0.3	25	V
	CO	-30	25	V
	BAT0, RDP, SET, TREF, TS, ISEN, ISEP, OVP2	-0.3	5.5	V
T_J	Operating junction temperature range	-40	150	°C
T_{stg}	Storage temperature range	-65	150	°C

(1) Stresses beyond those listed under *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 under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to network ground terminal.

8.2 Recommended Operating Conditions

		MIN	TYP	MAX	UNIT
V_{CC}	VCC voltage range	3		25	V
C_{VCC}	VCC RC filter capacitor		1		μF
R_{VCC}	VCC RC filter resistor		1		kΩ
BAT_X-BAT_{X-1}	Battery voltage range			5.5	V
T_A	Operating ambient temperature	-40		85	°C
T_J	Operating junction temperature	-40		125	°C

8.3 Electrical Characteristics

T_J= +25°C and V_{CC} = 20V unless otherwise noted.

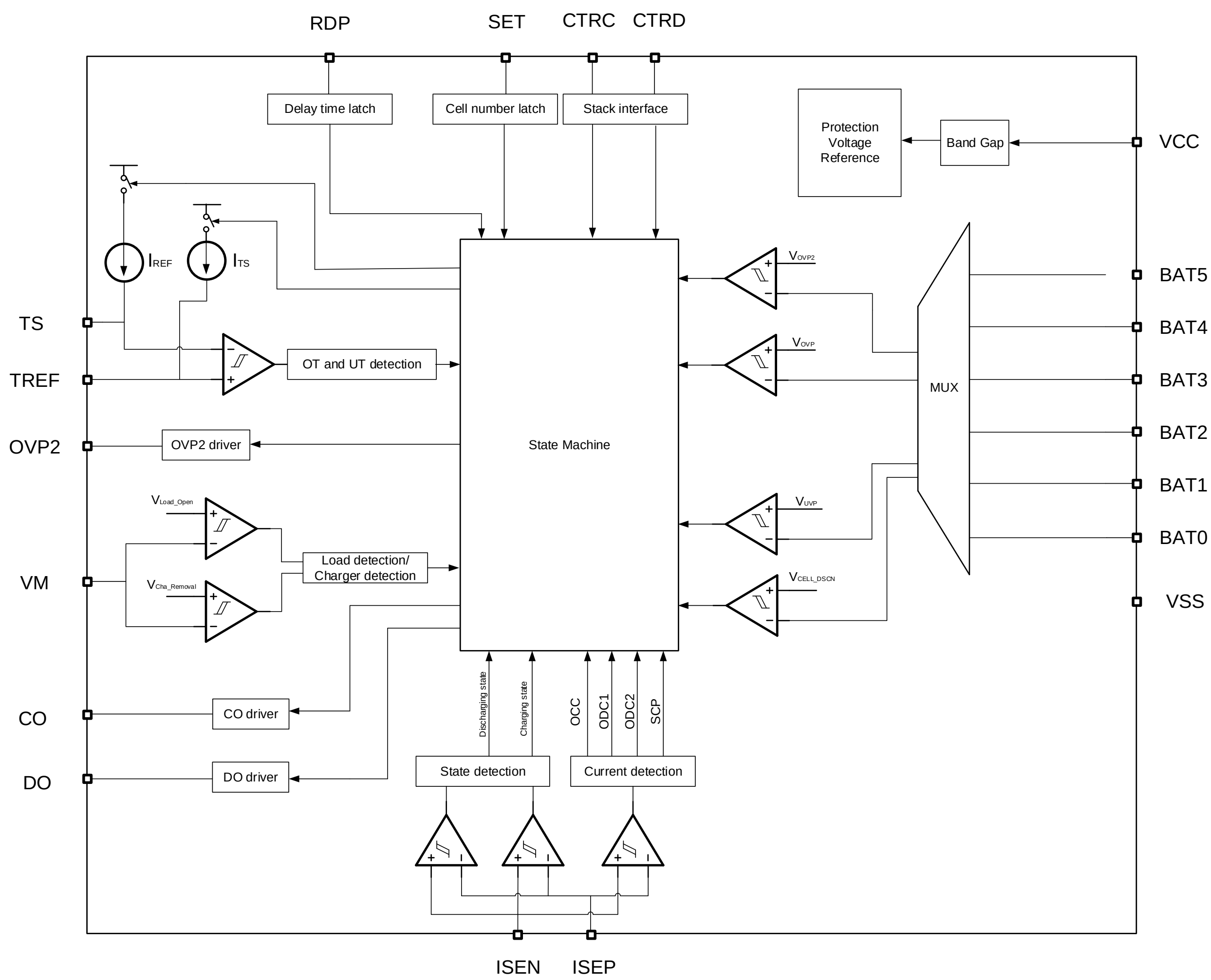
Parameter	Description	Test condition	Min.	Typ.	Max.	Unit
Supply Voltage						
V_{CC}	Operating input voltage		3		25	V
V_{POR}	Power on reset threshold	VCC rising		3		V
V_{SHUT}	Shutdown mode	VCC falling		2.8		V
I_{NORMAL}	Supply current in normal mode	BAT_X=4V, V_{CC}=20V		20		μA
I_{SLEEP}	Supply current in sleep mode	BAT_X< V_{UVP}		6		μA
$I_{SHUTDOWN}$	Supply current in shutdown mode	V_{CC}<V_{SHUT}, no charger plug-in		0.4		μA
Voltage Protection						
V_{OVP}	Charge over voltage protection threshold	Ta=+25°C	V_{OVP} - 0.035	V_{OVP}	V_{OVP} + 0.035	V
		Ta=-40°C~+85°C	V_{OVP} - 0.050	V_{OVP}	V_{OVP} + 0.050	V
	Charge over protection release hysteresis	falling hysteresis=0mV		0	50	mV
		falling hysteresis=100mV	50	100	150	mV
		falling hysteresis=200mV	150	200	250	mV
		falling hysteresis=400mV	350	400	450	mV
t_{OVP}	OVP protection delay time	R_{DP}= 0Ω		512		ms
		R_{DP}= 40kΩ		1024		ms
		R_{DP} = 80kΩ		2048		ms
		R_{DP} = float		4096		ms
V_{OVP2}	Charge Over secondary protection voltage threshold	With respect to V_{OVP}	25	50	75	mV
t_{OVP2}	Over charge secondary protection delay time	R_{DP}= 0Ω		512		ms
V_{UVP}	Discharge under voltage protection threshold	Ta=+25°C	V_{UVP} - 0.050	V_{UVP}	V_{UVP} + 0.050	V
		Ta=-40°C~+85°C	V_{UVP} - 0.080	V_{UVP}	V_{UVP} + 0.080	V
	Discharge under voltage protection release hysteresis	rising hysteresis=0mV		0	50	mV
		rising hysteresis=100mV	50	100	150	mV
		rising hysteresis=200mV	150	200	250	mV

		rising hysteresis=400mV	350	400	450	mV
t_{UVP}	UVP protection delay time	R_{DP}= 0Ω		1024		ms
		R_{DP}= 40kΩ		2048		ms
		R_{DP}= 80kΩ		4096		ms
		R_{DP}= float		8192		ms
Current Protection						
V_{DOC1}	Discharge over current 1 detection accuracy, 10~85mV	V_{DOC1}<=20mV	-30%		30%	
		V_{DOC1}=40mV	-20%		20%	
		V_{DOC1}=60mV	-15%		15%	
		V_{DOC1}=80mV	-15%		15%	
t_{DOC1}	DOC1 protection delay time			24		ms
V_{DOC2}	Discharge over current 2 detection accuracy	2*V_{DOC1}	-20%	2*V_{DOC1}	20%	
t_{DOC2}	DOC2 protection delay time			1024		μs
V_{SDC}	Short circuit discharge current protection threshold	4*V_{DOC1}	-20%	4*V_{DOC1}	20%	
t_{SDC}	Short circuit discharge current protection delay time			512		μs
V_{COC}	Charge over current detection	V_{COC}<= 20mV	-30%		30%	
		V_{DOC}> 20mV	-20%		20%	
		V_{COC}=60mV	-25%		25%	
		V_{COC}=80mV	-25%		25%	
t_{COC}	COC protection delay time			10		ms
Cell Disconnection Protection						
t_{CELL_DSCN}	Cell disconnection detection cycle			32		s
V_{CELL_DSCN}	Cell disconnection threshold for each cell	BAT_X - BAT_{X-1} voltage falling edge		0.4		V
$V_{CELL\_DSCN\_HYS}$	Cell disconnection protection release hysteresis voltage	Rising hysteresis		100		mV
State Comparator						

V_{STATE_C}	Charging state detection voltage threshold	ISEP-ISEN		2.5		mV
	Exit charging state detection voltage hysteresis	ISEP-ISEN		1.25		mV
V_{STATE_D}	Discharging state detection voltage threshold	ISEP-ISEN		-2.5		mV
	Exit discharging state detection voltage hysteresis	ISEP-ISEN		-1.25		mV
NTC protection						
V_{TS_DSCN}	TS disconnection detection voltage threshold	Rising edge		1.38		V
t_{TS_DSCN}	TS disconnection protection cycle			4		s
t_{TS_DET}	Temperature protection detection cycle			1		s
R_{DOT}	Resistor value of TS pin to trigger DOT	T_{REF}=10kΩ, DOT threshold= +70°C	2.07	2.26	2.45	kΩ
	Resistor value of TS pin to release from DOT	hysteresis= 10°C		2.99		kΩ
R_{DUT}	Resistor value of TS pin to trigger DUT	T_{REF}=10kΩ, DUT threshold= -15°C	50	50.8	51.6	kΩ
	Resistor value of TS pin to release from DUT	hysteresis= 10°C		33.9		kΩ
R_{COT}	Resistor value of TS pin to trigger COT	T_{REF}=10kΩ, COT threshold= 45°C	4.9	5.1	5.3	kΩ
	Resistor value of TS pin to release from COT	hysteresis= 10°C		6.94		kΩ
R_{CUT}	Resistor value of TS pin to trigger CUT	T_{REF}=10kΩ, CUT threshold= 0°C	26.4	27.4	28.4	kΩ
	Resistor value of TS pin to release from CUT	hysteresis= 10°C		18.5		kΩ
Charge and Discharging FET drivers						
V_{FETON}	CO/DO output high voltage	VDD=18V, CL = 10nF		12		V
		VDD=5V, CL = 10nF		4.5		V
t_{CO_ON}	CO on rise time	CL = 10nF, 10% to 90%		40		us
t_{DO_ON}	DO on rise time	CL = 10nF, 10% to 90%		110		us
t_{DO_OFF}	DO off fall time	CL = 10nF, 90% to 10%		2		us
Load Detection and Charger Removal Detection						
V_{Load_Open}	VM voltage to detect load open in discharge over current state	VM falling edge, in DOC state		2.1		V
$V_{Cha\_Removal}$	VM voltage to detect charger removal in charge over current state	VM rising edge, in COC state		-0.15		V
Stack Application						
V_{CTR1}	CTRC and CTRD voltage threshold to drive FET on	Rising edge, with respect to VSS	22.3			V

V_{CTR2}	CTRC and CTRD voltage to disable stack application	Falling edge, with respect to VSS			0.5	V
$t_{CTR\_deg\_on}$	deglitch time of CTRC or CTRD pin drive FET on			7		ms
$t_{CTR\_deg\_on}$	deglitch time of CTRC or CTRD pin drive FET off			7		ms
0V charger function						
V_{0CHA}	0V battery enable charger voltage			3		V
Thermal protection						
T_{SHUT}	Thermal shutdown temperature	Rising edge		150		°C
		Falling hysteresis		20		°C

9 Functional Block Diagram



10 Feature Description

10.1 Overview

SC5550 works in three modes according to the detection condition: Normal mode, Sleep mode and Shutdown mode. SC5550 initialed voltage, current and temperature detection according to different mode.

10.1.1 Normal Mode

If no fault occurs, the SC5550 enters into normal mode. In the normal mode, all the detection function is activated. SC5550 will check voltage, current and battery temperature periodically. The SC5550 consumes 20μA current for typically.

10.1.2 Sleep Mode

After any battery voltage is below under voltage threshold and UV protection state is triggered, SC5550 turns off discharging FET and enters sleep mode.

In sleep mode, detection period is prolonged from 500ms to 1s. Besides, detection function related with charging protection is still valid, such as related with discharging protection such as over discharging current (DOC1/DOC2/SDC) is disabled. the supply current is effectively reduced to 6μA typically, which ensures longer storing time when under voltage battery is applied.

10.1.3 Shutdown Mode

If the VCC pin voltage is down below power on reset threshold, SC5550 enters into shutdown mode and consumes extra low current (0.15μA typically). In the shutdown mode, Charging FET control pin (CO) will be Hi-Z and discharging FET control pin (DO) remains low.

10.2 State Comparator

SC5550 distinguishes charging state and discharging state through comparing the differential voltage on sensing resistor with reference voltage of internal state comparator. The comparator is designed with bi-direction high-accuracy ±2.5mV(typ) threshold.

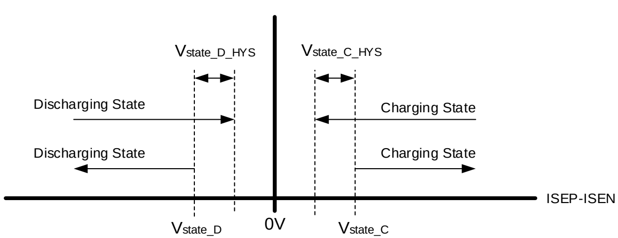


Figure 1. State comparator threshold

10.3 Load Detection and Charger Removal

SC5550 returns to Normal mode by load detection and load removal through VM pin when fault occurs. A high impedance pull-down path to GND is enabled on the VM pin when fault events happens.

VM pin is used for DOC and SCP release detection. When discharge over current protection occurs, the discharging FET is turned off, the VM pin is pulled up to V_{CC} by the load and the internal current sink I_{VM} begin sinking current from the load to the VM pin. If load still exists, VM pin is pulled up to VDD voltage, VM pin is internally clamped. If load is removed, VM pin will be pulled down by internal sinking current. When VM is below $V_{Load\_Reomval}$, which means load removal is detected.

WM pin is also used to detect charger removal. If charger is still connected after charge over voltage or over current fault occurs, VM pin voltage is the charger voltage minus battery voltage which is below V_{Cha_Reomva}. If charger is removed, the VM pin rises until the detection comparator V_{Cha_Reomva} toggles, which means charger removal is detected.

10.4 Charge Over Voltage Protection

Once **any** battery voltage is higher than V_{OVP} for T_{OVP} or longer, the over voltage protection state is activated, the CO pin's output becomes high impedance so that the gate voltage of charging FET can be drawn to PACK- terminal because of pull-low resistor in board. Thus, charging FET is turned off, but discharging FET is kept on.

when **all** OVP battery cells' voltage decreases and is lower than V_{OVPR} for t_{OCVR} or longer. SC5550 releases from OVP state to normal mode.

In OVP state, if load is connected between battery packs, the discharging current flows through the charging FET body diode while the charging FET is OFF. The charging FET might be over-heated, because of high discharge current. To avoid thermal stress failure, the charging FET is turned on when SC5550 detects a voltage drop larger than the discharge state detection threshold across the external current-sense resistor. After load is disconnected but battery voltage is still in OVP state, the charging FET is turned off again.

10.5 Charge Over Voltage Secondary Protection

SC5550 integrates over voltage secondary protection function, in case of that charging FET is damaged in which charging path is always on, battery voltage still rises over OVP threshold.

When **any** battery voltage rises above 50mV above V_{OVP} for t_{OVP2} or longer, over voltage secondary protection is activated. In OVP2 state, OVP2 pin outputs high drives an external N-FET, so that the power path is totally cut off by blowing the fuse.

When **all** the battery voltage falls down and is below V_{OVPR} for t_{OVPR} or longer. SC5550 releases from OVP2 state to normal mode.

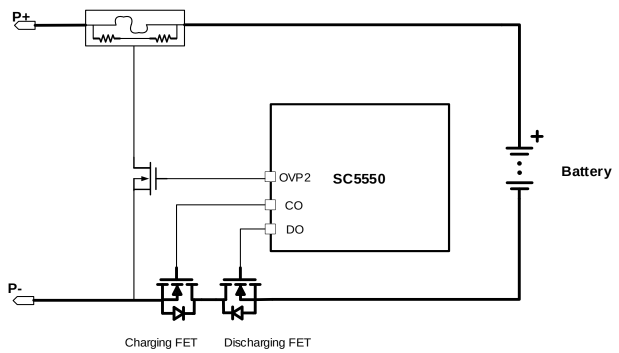


Figure 2. overvoltage secondary protection circuit

10.6 Discharge Under Voltage Protection

Once **any** battery cell voltage is lower than V_{UVP} and lasting for t_{UVP} or longer. the over voltage protection state is activated, the DO pin outputs low. This immediately turns off the discharging FET.

When **all** battery cells' voltage rises and is above V_{UVPR} for T_{UVPR} or longer. SC5550 releases from UVP state to normal mode.

in UVP states, if charger is connected between battery packs, the charging current flows through the discharging FET body diode while the discharging FET is turned off. Similar like OVP state, to avoid discharging FET get over-heated because of large charge current, the discharging FET is turned on when charge state is detected. After charger is disconnected but battery voltage is still in UVP state, the discharging FET is turned off again.

10.7 Charge Over Current Protection

When charge current flows across current-sense resistor, the voltage drop is monitored through sense resistor. Once I_{SEP}-I_{SEN} voltage drop is lower than V_{COC} for t_{COC} or longer, charge over current (COC) protection state is activated. The CO pin's output becomes high impedance, so charging FET is turned off, but discharging FET is kept on.

If charger is still connected with pack+/pack- terminal, the VM voltage is charger voltage minus total battery voltage which equals V_{CHA}-V_{CC}. The VM pin is applied to detect charger removal. When charger is disconnected in COC state, the VM voltage rises above $V_{Cha\_Removal}$, charger removal is detected, SC5550 releases from COC protection to normal mode automatically.

When load is connected in COC state, discharging current flows through diode of discharge diode and the VM voltage rises above $V_{Cha\_Removal}$, which means load connection is detected. Then SC5550 releases from COC protection state to normal mode automatically.

If charge current triggers COC condition in UVP states, COC protection is ignored. But the UVP battery voltage rises quickly with large COC charge current. Once battery voltage resumes to normal, COC protection will be activated.

10.8 Discharge Over Current Protection

SC5550 provides 3-level of over discharging current (DOC) protection: DOC1/DOC2/SCP.

3 simultaneous comparators are integrated which are used to detect DOC1, DOC2 and SCP. Once the comparator toggle, protection control signals are immediately asserted.

The 3-level protection threshold is proportional. V_{DOC1} is the voltage across sense resistor corresponding to level-1 discharge over current. V_{DOC2} is 2 times of V_{DOC1}. V_{SCP} is 4 times of V_{DOC1}.

The 3-level trigger condition is as flow:

- DOC1 state: Discharge current is higher than V_{DOC1} for t_{DOC1} or longer
- DOC2 state: Discharge current is higher than V_{DOC2} for t_{DOC2} or longer
- SCP state: Discharge current is higher than V_{SCP} for t_{SCP} or longer

When any of these above events occur, SC5550 enters the discharge over current (DOC) protection state. the DO pin outputs low and the discharging FET is turned off, so the discharge path is cut off.

Besides the internal fixed time delay, the total protection delay time is dependent upon the following factors: RC filter of sense resistor, gate-capacitance and gate series resistance of discharging FET.

If the load is still connected to battery pack side, the VM is pulled up to VCC with the discharge FET is turned off. When the load is removed in DOC state, the internal pull-down sinking current causes the voltage on the VM pin decreases until the $V_{VM} < V_{Load\_Open}$ (2.1V typically), which means load is removal. Then SC5550 releases from DOC protection to Normal mode.

When charger plugs in DOC state, charge current flows through diode of charging FET and VM pin voltage drops below V_{SS}, which means $V_{VM}<V_{Load\_Open}$ is detected. SC5550 also releases from DOC protection to Normal mode automatically.

10.9 Battery Temperature Protection

SC5550 integrates charging and discharging temperature protection includes charge under temperature protection (CUT), over temperature protection (COT), discharge under temperature protection (DUT) and discharge over temperature protection (DOT).

SC5550 periodically turns on internal current source respectively from TS and TREF pin. The TREF pin is the temperature protection reference pin and it is suggested to be connected with high accuracy 10kΩ resistor (±0.1% is recommended). The TS pin is the thermistor pin and it is suggested to be connected with 103AT type thermistor. The OT and UT threshold can be adjusted by changing Rser and Rpar value.

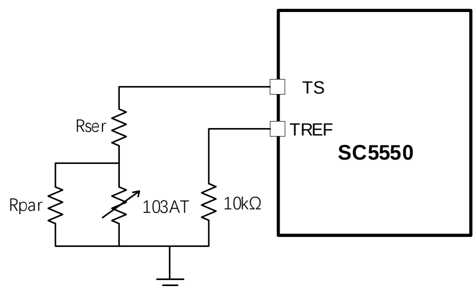


Figure 3. Temperature protection circuit

SC5550 compares the voltage V_{TS} and V_{TREF} according to the charging and discharging state. then decided temperature protection whether is triggered.

When SC5550 is in discharge state:

(1) DOT triggering condition: if battery temperature rises above T_{DOTP} for two consecutive detection, SC5550 will transit to discharge over temperature (DOT) protection state and turn off both the discharging FET and charging FET until the battery cell temperature decreases below t_{DOTR}. t_{DOTR} is usually higher than t_{COTP}, the charging FET will turn off again after next COT detection cycle if the charger is plugged-in until battery cell temperature is below t_{COTR}.

(2) DUT triggering condition: if battery temperature falls down t_{DUTP} for two consecutive detection, SC5550 will transit to discharge under temperature (DUT) protection state and turn off both the discharging FET and charging FET until the battery cell temperature rises above t_{DOTR}. T_{DUTR} is usually higher than t_{CUTP}, the charging FET will turn off again after next CUT detection cycle if the load is still removed until battery cell temperature is above t_{COTR}.

When SC5550 is in charge state:

(1) COT triggering condition: if the battery temperature rises above V_{COT} for two consecutive detection, SC5550 will transit to charge over temperature (COT) protection state and turns off the charging FET. The charging FET will remain off until the battery temperature is below t_{COTR}.

(2) CUT triggering condition: if the battery temperature decreases to less than t_{CUTP} for two consecutive detection, SC5550 will transition to charge under temperature (CUT) protection state and turn off the charging FET. The charging FET will remain off until the battery cell temperature is above t_{CUTR}.

If any fault such as DOC1, DOC2, SCP, or UVP, SC5550 occurs, SC5550 will turn off discharge FET and no longer check for DOT and DUT while continuing to check for CUT and COT.

Similarly, if OCC or OVP occurs, SC5550 will turn off charge FET and no longer check for COT and CUT while continuing to check for DUT and DOT.

10.10 TS Disconnection Detection

SC5550 provides temperature sensor disconnection detection function, checks TS pin state. When temperature sensor resistor is open, TS pin is pulled-up by internal current source. When TS pin voltage is rising above $V_{TS\text{-}DSCN}$ for $t_{TS\text{-}DSCN}$ or longer, temperature sensor disconnection protection state is activated.

At TS disconnection protection state, SC5550 turns off both charge and discharging FET and only executes temperature sensor disconnection check for release periodically.

When TS resistor is reinstalled back and the battery temperature is under normal range, SC5550 releases to normal mode and power path is turned on.

10.11 Cell Disconnection Detection

SC5550 integrates cell disconnection detection function and checks for cell disconnection periodically, in case that the wire connected with BATx is breaking. SC5550 detects cell wire breaking by turn on internal MOSFET to short the cells one by one and then check the BATx voltage.

If the cell disconnection happens, the BATx-BATx-1 is pull down because of internal mosfet turning on. If BATx-BAT(x-1) is below V_{CELL_DSCN}, the cell disconnection protection is triggered. SC5550 will turn off both charging and discharging FET, then only check cell disconnection release detection periodically.

The cell disconnection protection state is released when all cell voltage is above $V_{CELL\_DSCN\_R}$, SC5550 will turn on discharge FET and charge FET.

To distinguish UVP and cell disconnection fault, SC5550 starts a cell disconnection detection before entering sleep mode once UVP protection state is triggered. When SC5550 enters sleep mode, the cell disconnection detection is stopped.

10.12 Cell Number Setting

SC5550 supports 2-5 cells protection configuration. The application cell number is configured by **SET** pin resistor, and cell configuration result is latched once the VCC is above V_{POR}.

RSET	Cells configuration
GND	2 cells
40K	3 cells
80K	4 cells
Float	5 cells

10.13 Delay Time Setting

The OVP and UVP delay time can be set by **RDP** pin. The OVP and UVP protection delay time chosen at the same time and delay time setting result is latched once the VCC is above V_{POR}.

RDP	OVP and UVP Delay time
GND	1x
40K	2x
80K	4x
Float	8x

10.14 0V Battery Charging Function

SC5550 supports 0V battery charger function. When external charger voltage is higher than V_{0CHA} (3V typically), the charging FET gate CO is connected to VCC internally. Thus, charging MOSFET is turned on, charging current flows through the diode of discharging FET and battery voltage is charged up. When the battery voltage V_{CC} is above V_{POR}, the discharging MOSFET is turned on and IC enters Normal mode.

10.15 Charging and Discharging Separate Path

SC5550 supports charging and discharging separate path application. Charging and discharging path share the common pack+ terminal. the discharging path only pass through discharge FET only, which reduces discharging path resistance and save cost of discharge FET. The application circuit is shown as below.

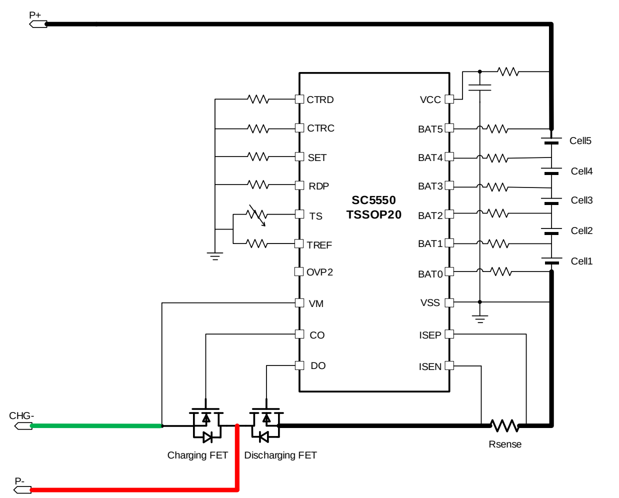


Figure 4. Separate charging and discharging path application

10.16 Stacked Application

SC5550 provides CTRC and CTRD function for stacked application, which can support 6-10 cells batteries application. The 10 cells application circuit is as follow.

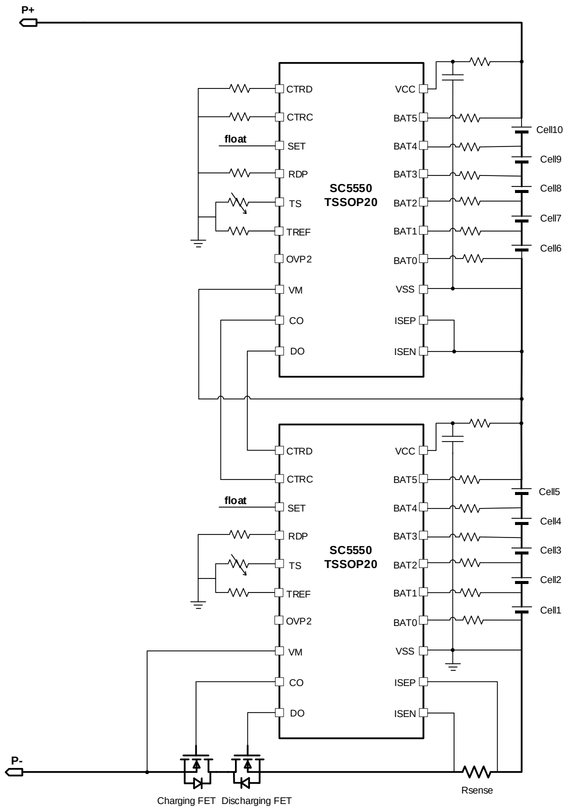


Figure 5. 10 cells stacked application

10.17 Thermal Shutdown

Once the IC detects the junction temperature rises above 150°C, it shuts down the whole IC. When the temperature falls below 130°C, the chip is enabled again.

11 Application Information

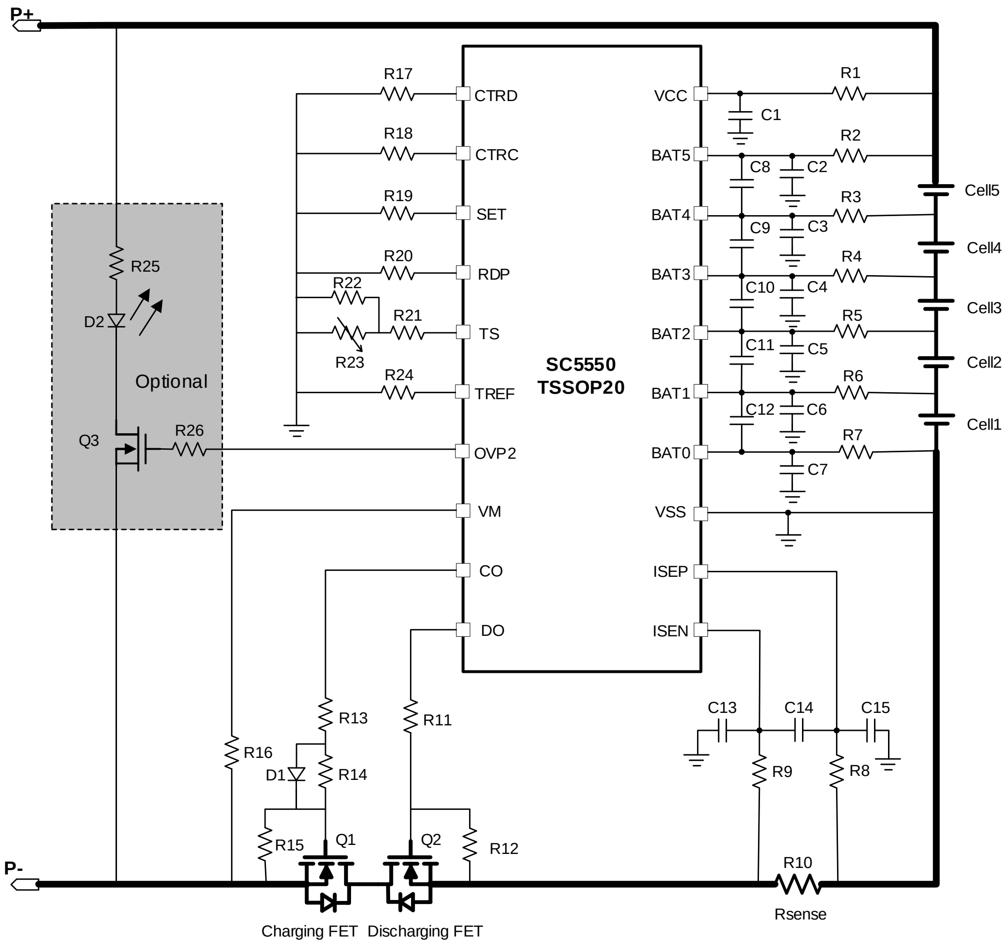


Figure 6. 5 cells application circuit

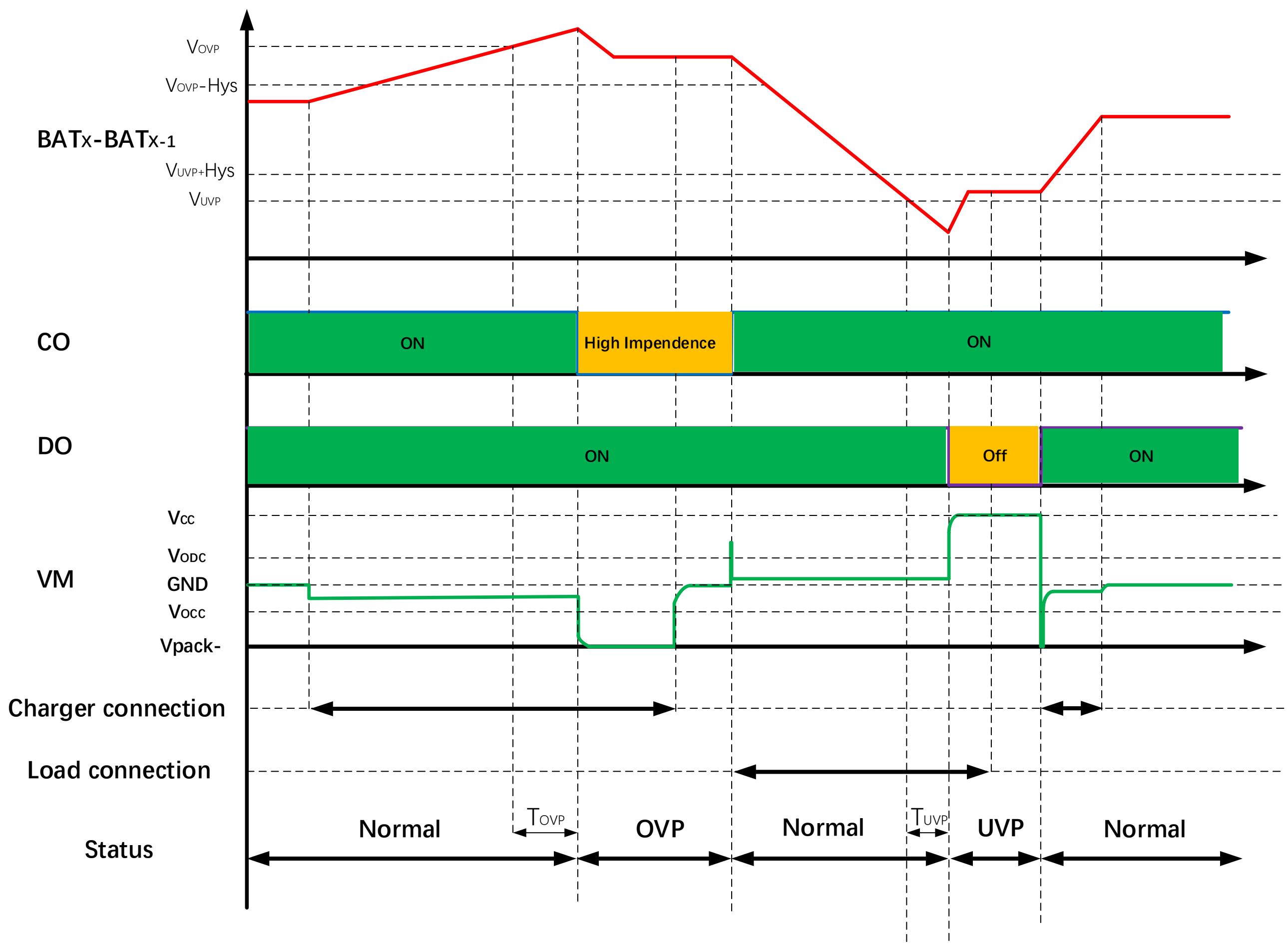
Symbol	Component	Function	Min	Typ	Max	Note
R1	resistor	RC filter for IC supply voltage	100Ω	1kΩ		To ensure the battery voltage
C1	capacitor	RC filter for IC supply voltage	0.1uF	1uF	10uF	the rating must be >25V
R2,R3,R4,R5, R6,R7	resistor	RC filter for battery voltage fluctuation	15Ω	43Ω		
C2,C3,C4,C5, C6,C7	capacitor	RC filter for battery voltage fluctuation		0.1uF	1uF	the rating must be >25V
C8,C9,C10,C11,C12	capacitor	battery voltage ripple suppression during large current discharge		100nF		
C13,C14,C15	capacitor	charging and discharging current sense RC filter for high frequency noise		100nF		
R8, R9	capacitor	charging and discharging current sense RC filter for high frequency noise		100Ω		

R10	capacitor	current sense resistor		5mΩ	10mΩ	The sense resistor must be capable of power dissipation due to large discharge current.
Q1, Q2	MOSFET	charging FET and discharging FET				
R11	resistor	discharging FET driver gate resistor, control the turn-on and turn-off speed.	40kΩ	51kΩ		
R12	resistor	discharging FET driver gate-source resistor		10MΩ		
R13	resistor	charging FET driver gate resistor, control the turn-on speed.		5.1kΩ		
R14	resistor	charging FET driver gate resistor, , control the turn-off speed.		2MΩ		
R15	resistor	charging FET driver gate-source resistor	/	3MΩ	/	
D1	Schottky Didoe	provide fast turn-on path for charging FET				
R16	resistor	current limit	/	100kΩ	/	
R17	resistor	Short to GND, if stack application is not used	/	0Ω	/	
R18	resistor	Short to GND, if stack application is not used	/	0Ω	/	
R19	resistor	Cell setting resistor, float for 5cell application	/	NC	/	
R20	resistor	Delay time setting resistor	/		/	
R21	resistor	temperature sense series resistor, adjust protection threshold		0		
R22	resistor	temperature sense parallel resistor, adjust protection threshold		NC		
R23	resistor	thermal resistor, connected with 103AT-type		10kΩ		
R24	resistor	Reference resistor to provide temperature protection reference	/	10kΩ	/	
R25	resistor	current limit resistor,				**Optional**
R26	resistor	OVP2 fault driver gate resistor				**Optional**
D2	LED	indicating OVP2 occurs				**Optional**
Q3	N-MOSFET	Cooperate with OVP2 driver to indicate fault				**Optional**

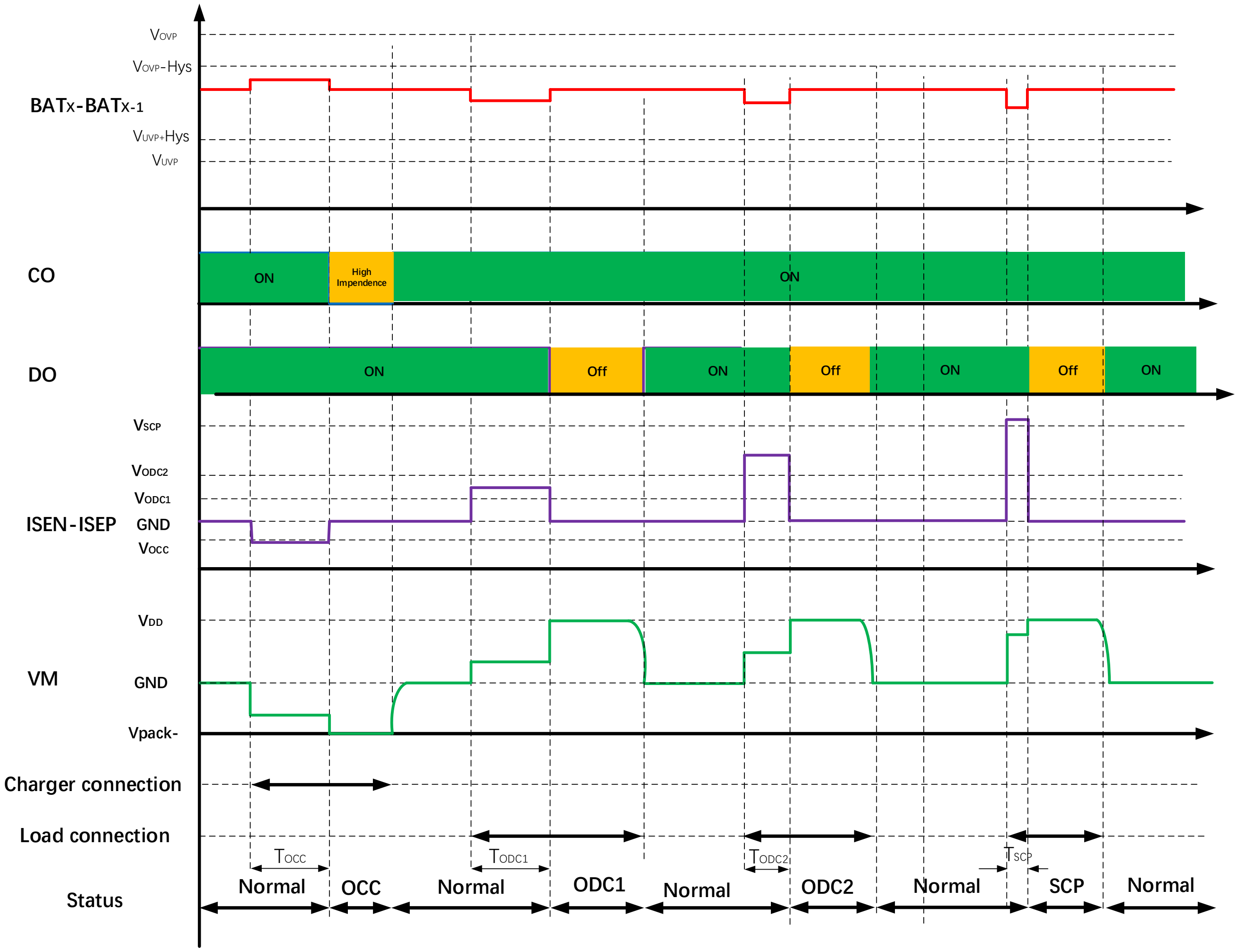
Note: The above recommended value in the chart should be tested under specific application circuit.

12 Working Timing Chart

12.1 Charge over voltage(OVP) and discharge under voltage(UVP) protection

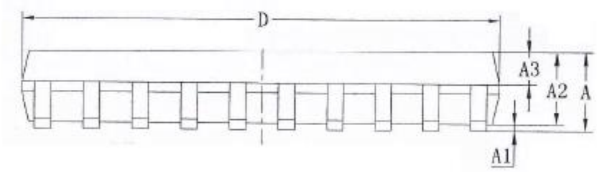


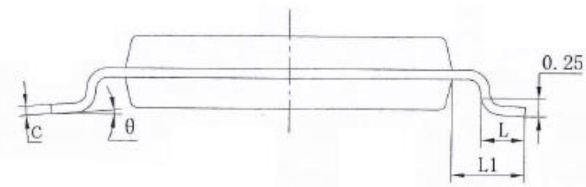
12.2 Charge over current(OCC) and discharge over current(DOC1/DOC2/SCP) protection

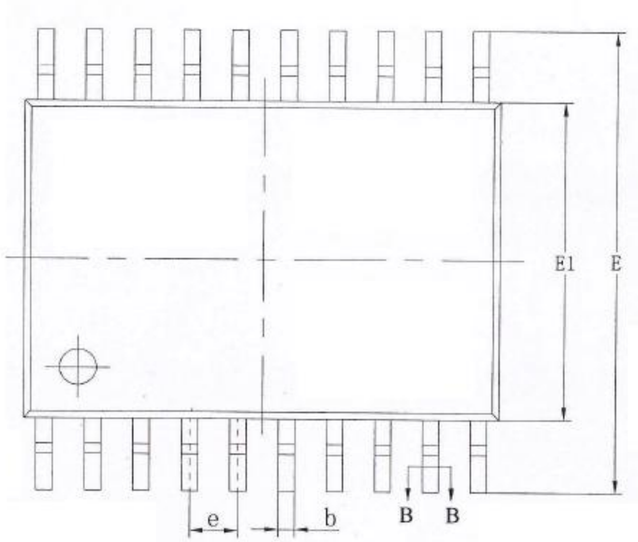


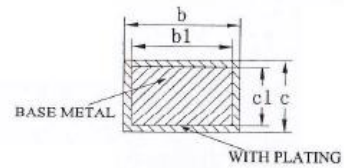
MECHANICAL DATA

TSSOP-20L









SECTION B-B

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.80	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	—	0.28
b1	0.19	0.22	0.25
c	0.13	—	0.17
c1	0.12	0.13	0.14
D	6.40	6.50	6.60
E1	4.30	4.40	4.50
E	6.20	6.40	6.60
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00REF		
θ	0	—	8°

RECOMMENDED FOOTPRINT

Unit (Millimeter)