Protection Integrated Circuit for 3S/4S-Cell Li-Ion and Li-Polymer Batteries

1. Description

IP3255 provides multi-protection with high precision for battery, such as overcharge protection (OVP), over-discharge protection (UVP), over current protection (OCC&ODC) and temperature protection.

By switching the SEL pin, IP3255 can provide protection for 3-serial or 4-serial cell pack.

2. Features

- **Detect Voltage with A High Degree of Accuracy**
  - Overcharge Protection (OVP)
    Detection voltage
    3.500V ~ 4.100V, step 50mV
    4.100V ~ 4.575V, step 25mV
    Accuracy ±25mV
  - OVP Release Detection voltage
    3.450V ~ 4.050V, step 100mV
    4.050V ~ 4.400V, step 50mV
    Accuracy ±100mV
  - Over-discharge Protection(UVP)
    Detection voltage
    1.800V ~ 2.000V, step 50mV
    2.000V ~ 2.900V, step 100mV
    Accuracy ±80mV
  - UVP release Detection voltage
    2.000V ~ 3.1000V, step 100mV
    Accuracy ±100mV
- **Detect Current with A High Degree of Accuracy**
  - Discharge Over-Current protection 1
    0.03V ~ 0.34V, step 10mV
    Accuracy ±25mV
  - Charge Over-Current protection
    0.03V ~ 0.34V, step 10mV
    Accuracy ±25m
  - Discharge Over-Current protection 2
    0.35V ~ 0.70V, step 50mV
    Accuracy ±50mV
  - Short-circuit detection voltage：
    VSS+1.20V
    Accuracy ±0.3V
- **Delay times for overcharge detection, over-discharge detection and overcurrent detection 1 can be set by external capacitors (delay times for overcurrent detection 2 and 3 are fixed internally).**
- **Cell Balancing**
  - Support Increasing balancing current by external MOS
  - Cell Balancing Threshold voltage：
    3.4V ~ 3.9V, step 25mV
    3.9V ~ 4.45V, step 50mV
    Accuracy ±30mV
- **IP3254 will shut down MOS when battery line cut off**
- **Low current consumption**
  - During operation： 35μA max
  - During power-down：3.5μA max
- **Package：TSSOP16**

3. Applications

- Li-ion rechargeable battery packs
- Li-polymer rechargeable battery packs

4. Pin Configuration and Functions

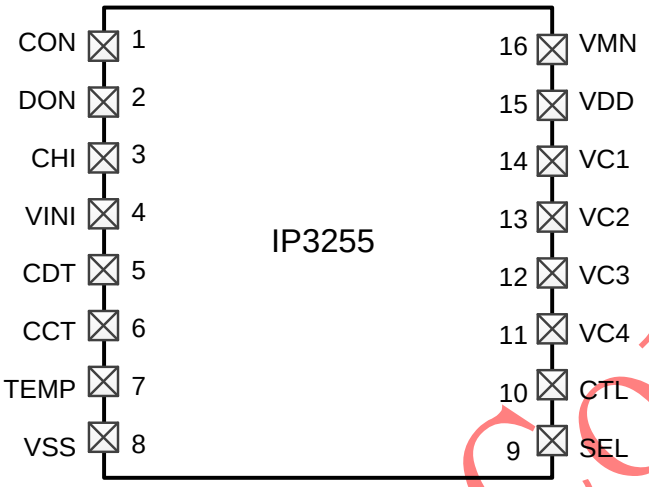


Figure1. PIN Configuration

Table1. 16-Lead Pin Functions

PIN No.	Name	Description
1	CON	FET gate connection pin for charge control (open drain output)
2	DON	FET gate connection pin for discharge control FET (CMOS output)
3	CHI	Pin for charger detection
4	VINI	Pin for voltage detection between VSS and VINI (Pin for overcurrent detection)
5	CDT	Capacitor connection pin for delay for over-discharge detection, delay for overcurrent detection 1
6	CCT	Capacitor connection pin for delay for overcharge current
7	TEMP	Temperature protection detection input (NTC thermistor bias current source)
8	VSS	Input pin for negative power supply, Connection pin for battery 4's negative voltage
9	SEL	Pin for switching 3-series or 4-series cell VSS level: 3-series cell, VDD level : 4-series cell
10	CTL	Control of charge FET and discharge FET
11	VC4	Connection pin for battery 3's negative voltage, Connection pin for battery 4's positive voltage
12	VC3	Connection pin for battery 2's negative voltage, Connection pin for battery 3's positive voltage
13	VC2	Connection pin for battery 1's negative voltage, Connection pin for battery 2's positive voltage
14	VC1	Connection pin for battery 1's positive voltage

15	VDD	Input pin for positive power supply, Connection pin for battery 1's positive voltage
16	VMN	Pin for voltage detection between VSS and VMN (Pin for SC detection)

Table2. Product Name List 1(1/2)

Product	OVP	OVP release	UVP	UVP release	ODC1	ODC2	OCC
IP3255AAA	4.350V	4.150V	2.00V	2.70V	0.30V	0.35V	-
IP3255AAE	4.350V	4.150V	2.00V	2.70V	0.20V	0.35V	-
IP3255AAF	4.350V	4.150V	2.40V	3.00V	0.20V	0.35V	0.20V
IP3255AAG	4.250V	4.100V	2.30V	2.70V	0.13V	0.35V	-
IP3255AAH	4.350V	4.150V	2.40V	2.70V	0.10V	0.35V	-
IP3255AAI	4.350V	4.150V	2.40V	3.00V	0.30V	0.35V	-
IP3255AAK	4.350V	4.150V	2.70V	3.00V	0.20V	0.35V	-
IP3255AAL	4.300V	4.150V	2.40V	3.00V	0.20V	0.35V	0.20V
IP3255AAM	4.200V	4.100V	2.50V	2.70V	0.30V	0.35V	-
IP3255AAN	4.250V	4.150V	2.50V	3.00V	0.10V	0.35V	-
IP3255AAQ	3.900V	3.800V	2.30V	2.70V	0.20V	0.35V	-
IP3255AAV	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255AAZ	3.650V	3.400V	2.50V	2.80V	0.20V	0.35V	0.10V
IP3255ABA	3.900V	3.800V	2.00V	2.50V	0.15V	0.35V	-
IP3255ABC	4.175V	3.975V	2.70V	3.00V	0.10V	0.35V	-
IP3255ABD	4.450V	4.250V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255ABE	4.250V	4.10V	3.00V	3.10V	0.20V	0.35V	-
IP3255ABF	4.400V	4.200V	2.80V	3.00V	0.17V	0.50V	0.10V

IP3255ACA	4.200V	4.100V	2.80V	3.00V	0.20V	0.35V	0.20V
IP3255ACB	4.350V	4.150V	2.00V	2.70V	0.30V	0.35V	0.30V
IP3255ACC	4.15V	3.95V	2.75V	3.05V	0.10V	0.35V	-
IP3255ACD	4.450V	4.250V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255ACE	4.350V	4.150V	2.00V	2.70V	0.20V	0.35V	0.20V
IP3255ACF	4.350V	4.150V	2.40V	3.00V	0.20V	0.35V	0.20V
IP3255ACG	4.275V	4.100V	2.30V	2.70V	0.13V	0.35V	0.13V
IP3255ACH	4.350V	4.150V	2.40V	2.70V	0.10V	0.35V	0.10V
IP3255ACI	4.350V	4.150V	2.40V	3.00V	0.30V	0.35V	0.30V
IP3255ACJ	3.900V	3.800V	2.00V	2.50V	0.15V	0.35V	0.15V
IP3255ACK	4.350V	4.150V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255ACL	4.300V	4.150V	2.40V	3.00V	0.20V	0.35V	0.20V
IP3255ACM	4.200V	4.100V	2.50V	2.70V	0.30V	0.35V	0.30V
IP3255ACN	4.250V	4.150V	2.50V	3.00V	0.10V	0.35V	0.10V
IP3255ACP	3.950V	3.800V	2.90V	3.00V	0.05V	0.35V	0.05V
IP3255ACQ	3.900V	3.800V	2.30V	2.70V	0.30V	0.35V	0.30V
IP3255ACV	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255ACW	4.250V	4.150V	2.80V	3.00V	0.15V	0.35V	0.15V
IP3255ACX	3.650V	3.500V	2.70V	2.90V	0.20V	0.35V	0.30V
IP3255ADA	4.450V	4.250V	2.70V	3.00V	0.10V	0.35V	0.10V
IP3255BAA	4.350V	4.150V	2.00V	2.70V	0.30V	0.35V	-
IP3255BAE	4.350V	4.150V	2.00V	2.70V	0.20V	0.35V	-
IP3255BAF	4.350V	4.150V	2.40V	3.00V	0.20V	0.35V	-
IP3255BAG	4.275V	4.100V	2.30V	2.70V	0.13V	0.35V	-
IP3255BAH	4.350V	4.150V	2.40V	2.70V	0.10V	0.35V	-
IP3255BAI	4.350V	4.150V	2.40V	3.00V	0.30V	0.35V	-

IP3255BAK	4.350V	4.150V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255BAL	4.300V	4.150V	2.40V	3.00V	0.20V	0.35V	-
IP3255BAM	4.200V	4.100V	2.50V	2.70V	0.30V	0.35V	-
IP3255BAN	4.250V	4.150V	2.50V	3.00V	0.10V	0.35V	-
IP3255BAQ	3.900V	3.800V	2.30V	2.70V	0.30V	0.35V	-
IP3255BAR	4.275V	4.100V	2.80V	3.00V	0.12V	0.35V	0.05
IP3255BAV	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	-
IP3255BCD	4.450V	4.250V	2.70V	3.00V	0.20V	0.35V	0.20V
IP3255BCR	4.250V	4.150V	2.50V	3.00V	0.05V	0.35V	0.03V
IP3255BCS	3.750V	3.650V	2.30V	2.70V	0.05V	0.35V	0.03V
IP3255BCV	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	0.2V
IP3255BCX	3.650V	3.500±0.05V	2.70V	2.90V	0.20V	0.35V	0.03V
IP3255BCN	4.250V	4.150V	2.50V	3.00V	0.10V	0.35V	0.10V
IP3255BCK	4.300V	4.150V	2.70V	3.00V	0.05V	0.35V	0.2
IP3255BAW	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	-
IP3255BCW	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	0.2V
IP3255BBF	3.750V	3.600V	2.30V	2.70V	0.10V	0.35V	0.05V
IP3255ACU	4.220V	4.100V	2.70V	3.00V	0.22V	0.45V	0.08V
IP3255BBA	3.900V	3.800V	2.50V	2.70V	0.15V	0.35V	0.15V
IP3255BBL	4.300V	4.150V	2.40V	3.00V	0.20V	0.35V	-
IP3255BCA	4.250V	4.150V	2.50V	3.00V	0.10V	0.35V	0.10V
IP3255BBC	3.750V	3.600V	2.30V	2.70V	0.10V	0.35V	0.05V
IP3255BAC	4.250V	4.150V	2.70V	3.00V	0.20V	0.35V	0.1V
IP3255BBD	3.750V	3.600V	2.30V	2.70V	0.10V	0.35V	0.10V
IP3255BDA	4.450V	4.250V	2.70V	3.00V	0.10V	0.35V	0.10V
IP3255BCM	3.750V	3.650V	2.50V	2.70V	0.10V	0.35V	0.05V

IP3255SAA	4.300V	4.150V	1.80V	2.00V	N	N	-
IP3255SAC	3.850V	3.650V	1.80V	2.00V	N	N	-
IP3255SAD	4.450V	4.250V	2.50V	3.00V	0.20V	0.35V	0.20V

Table3. Product Name List 2(2/2)

Product	Low-temperature protection threshold during charging	High-temperature protection threshold during charging	Low-temperature protection threshold during discharging	High-temperature protection threshold during discharging	Balancing	0V-battery charge
IP3255AAA	-8℃	55℃	-15℃	66℃	N	N
IP3255AAE	-8℃	55℃	-15℃	66℃	N	N
IP3255AAF	-8°C	55°C	-15°C	66°C	N	N
IP3255AAG	-8°C	55°C	-15°C	66°C	N	N
IP3255AAH	-8°C	55°C	-15°C	66°C	N	N
IP3255AAI	-8°C	55°C	-15°C	66°C	N	N
IP3255AAK	-8°C	55°C	-15°C	66°C	N	N
IP3255AAL	-8°C	55°C	-15°C	66°C	N	N
IP3255AAM	-8°C	55°C	-15°C	66°C	N	N
IP3255AAN	-8°C	55°C	-15°C	66°C	N	N
IP3255AAQ	-8°C	55°C	-15°C	66°C	N	N
IP3255AAV	-8°C	55°C	-15°C	66°C	N	N
IP3255AAZ	-8°C	55°C	-15°C	66°C	N	N
IP3255ABA	-8°C	55°C	-15°C	66°C	N	N
IP3255ABC	-8°C	55°C	-15°C	66°C	N	N
IP3255ABD	-8°C	55°C	-15°C	66°C	N	N
IP3255ABE	-8°C	55°C	-15°C	66°C	N	N

IP3255ABF	-8℃	55℃	-15℃	66℃	N	N
IP3255ACA	-8℃	55℃	-15℃	66℃	N	N
IP3255ACB	-8℃	55℃	-15℃	66℃	N	N
IP3255ACC	-8℃	55℃	-15℃	66℃	N	N
IP3255ACD	-8℃	55℃	-15℃	66℃	N	N
IP3255ACE	-8℃	55℃	-15℃	66℃	N	N
IP3255ACF	-8℃	55℃	-15℃	66℃	N	N
IP3255ACG	-8℃	55℃	-15℃	66℃	N	N
IP3255ACH	-8℃	55℃	-15℃	66℃	N	N
IP3255ACI	-8℃	55℃	-15℃	66℃	N	N
IP3255ACJ	-8℃	55℃	-15℃	66℃	N	N
IP3255ACK	-8℃	55℃	-15℃	66℃	N	N
IP3255ACL	-8℃	55℃	-15℃	66℃	N	N
IP3255ACM	-8℃	55℃	-15℃	66℃	N	N
IP3255ACN	-8℃	55℃	-15℃	66℃	N	N
IP3255ACP	-8℃	55℃	-15℃	66℃	N	N
IP3255ACQ	-8℃	55℃	-15℃	66℃	N	N
IP3255ACV	-8℃	55℃	-15℃	66℃	N	N
IP3255ACW	-8℃	55℃	-15℃	66℃	N	N
IP3255ACX	-8℃	55℃	-15℃	66℃	N	N
IP3255ADA	-8℃	55℃	-15℃	66℃	N	N
IP3255BAA	-8℃	55℃	-15℃	66℃	Y	N
IP3255BAE	-8℃	55℃	-15℃	66℃	Y	N
IP3255BAF	-8℃	55℃	-15℃	66℃	4.25V	N
IP3255BAG	-8℃	55℃	-15℃	66℃	4.15V	N
IP3255BAH	-8℃	55℃	-15℃	66℃	4.25V	N

IP3255BAI	-8℃	55℃	-15℃	66℃	Y	N
IP3255BAK	-8℃	55℃	-15℃	66℃	4.250V	N
IP3255BAL	-8℃	55℃	-15℃	66℃	4.200V	N
IP3255BAM	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BAN	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BAQ	-8℃	55℃	-15℃	66℃	3.85V	N
IP3255BAR	0℃	50℃	-19℃	59℃	4.15V	N
IP3255BAV	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BCD	-8℃	55℃	-15℃	66℃	4.350V	N
IP3255BCR	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BCS	-8℃	55℃	-15℃	66℃	3.50V	N
IP3255BCV	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BCX	-8℃	55℃	-15℃	66℃	3.55V	N
IP3255BCN	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BCK	-8℃	55℃	-15℃	66℃	4.05V	N
IP3255BAW	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BCW	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BBF	-8℃	55℃	-15℃	66℃	3.650V	N
IP3255ACU	-8℃	55℃	-15℃	66℃	N	N
IP3255BBA	-8℃	55℃	-15℃	66℃	3.800V	N
IP3255BBL	-8℃	55℃	-15℃	66℃	4.200V	N
IP3255BCA	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BBC	-8℃	55℃	-15℃	66℃	3.650V	N
IP3255BAC	-8℃	55℃	-15℃	66℃	4.150V	N
IP3255BBD	-8℃	55℃	-15℃	66℃	3.650V	N
IP3255BDA	-8℃	55℃	-15℃	66℃	4.35V	N

IP3255BCM	-8℃	55℃	-15℃	66℃	3.650V	N
IP3255SAA	N	N	N	N	N	N
IP3255SAC	-	N	N	N	N	N
IP3255SAD	-8℃	55℃	-15℃	66℃	N	N

Note: 1.For products with other parameters, please contact our company's business department

2. The short circuit detection voltage is 1.2V.

5. Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
VDD	V_{DD}	V_{SS} - 0.3 ~ V_{SS} + 26	V
INPUT VOLTAGE	VC1、VC2、VC3、VC4、CTL、SEL、DON、CON、VMN、CHI	V_{SS} - 0.3 ~ V_{DD} + 0.3	V
	VINI、CCT、CDT、TEMP	V_{SS} - 0.3 ~ V_{SS} + 12	V
Max operating temperature	T_{opr}	-40 ~ +80	℃
Storage temperature	T_{stg}	-40 ~ +125	℃
Thermal resistance junction-ambient	θ_{JA}	50	℃/W
Electrostatic Discharge（HBM）	ESD	2	kV

*Stresses beyond those listed under Absolute Maximum Ratings can cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.

6. Electrical Characteristics

Typical Values stated where TA = 25 ℃

parameter	Symbol	Test condition	Min	Typ	Max	Unit
Voltage						
OVP	V_{CU}	-	V_{CU}-0.025	V_{CU}	V_{CU}+0.025	V
OVP Release	V_{CL}	-	V_{CL}-0.05	V_{CL}	V_{CL}+0.05	V
UVP	V_{DL}	-	V_{DL}-0.08	V_{DL}	V_{DL}+0.08	V
UVP Release	V_{DR}	-	V_{DR}-0.1	V_{DR}	V_{DR}+0.1	V
ODC1	V_{IOV1}	-	V_{IOV1}-0.025	V_{IOV1}	V_{IOV1}+0.025	V
ODC2	V_{IOV2}	-	V_{IOV2}-0.05	V_{IOV2}	V_{IOV2}+0.05	V
SC	V_{IOV3}	-	0.9	1.2	1.5	V
OCC	V_{CIOV}	-	V_{CIOV}-0.025	V_{CIOV}	V_{CIOV} +0.025	V
Balancing Threshold	V_{CBON}	-	V_{CBON}-0.025	V_{CBOFF}	V_{CBON}+0.025	V
Delay Time						
Delay for OVP	t_{CU}	CCT 0.1uF	0.5	1.0	1.5	s
Delay for UVP	t_{DL}	CDT 0.1uF	50	100	150	ms
Delay for ODC1	t_{IOV1}	CDT 0.1uF	5	10	15	ms
Delay for ODC2	t_{IOV2}	FET 2.2nF	0.5	1.0	1.5	ms
Delay for SC	t_{IOV3}	FET 2.2nF	100	200	300	μs
Delay for OCC	t_{CIOV}	FET 2.2nF	5	10	15	ms
Power Consumption						
Current Consumption in NORMAL mode	I_{OPE}	V1=V2=V3=V4=3.5	15	20	25	μA
Current Consumption in power down mode	I_{PDN}	V1=V2=V3=V4=1.5	2.5	3.5	5.0	μA
Others						
VMN to VSS Pull-down Resistor	R_{VMS}	-	0.5	1	1.5	MΩ
VMN to VDD Pull-up Resistor	R_{VMD}	-	450	900	1800	kΩ
TEMP Current	I_{TEMP}	-	16.5	18	19.5	uA

DON	V_{DON2}	-	10	11.5	13	V
Drain-Source On-state Resistance of Balancing MOS	R_{ON}	-	5	10	15	mΩ

7. Functional Block Diagram

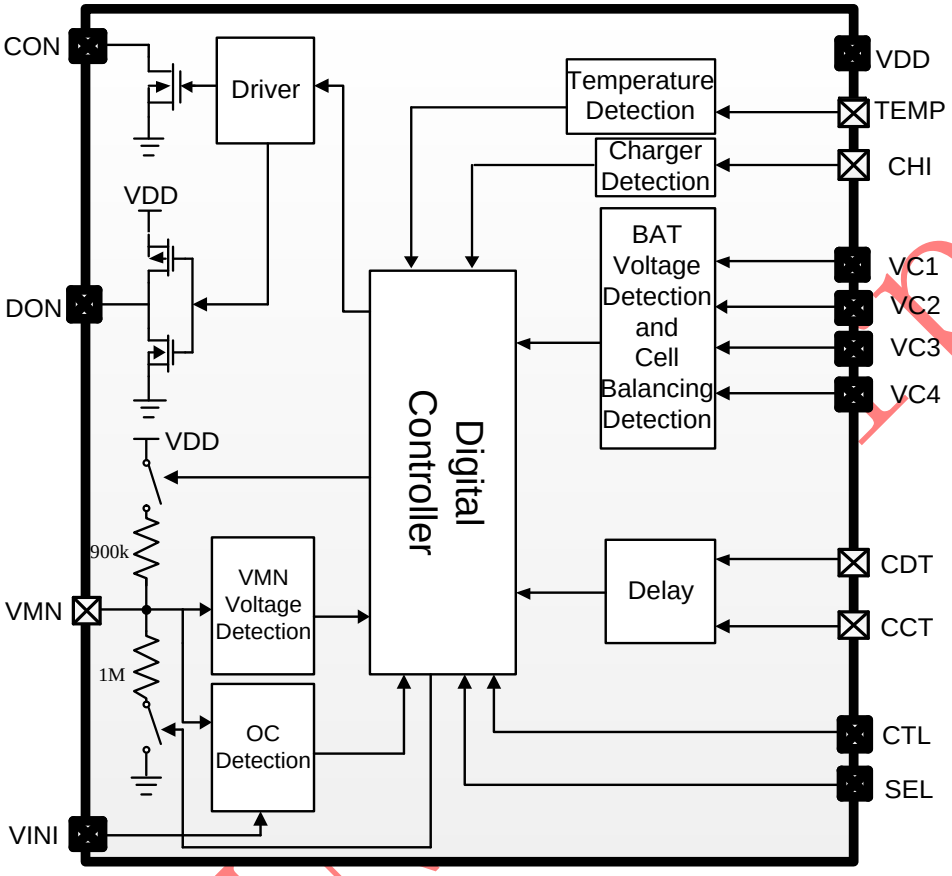


Figure2. IP3255 Functional Block Diagram

8. Function Description

8.1. OVP

Once VBATn > V_{CU} and t> t_{CU} , the overcharge protection is triggered. The logic circuit in IP3255 will shut down the charge FET to prevent charging.

OVP will release when

(1) All VBATn < V_{CL}

(2) All VBATn < V_{CU} ， and VMN >1/40×VDD

8.2. Over-discharge Protection

Once VBATn < V_{DL} and t < t_{DL}, the over-discharge protection is triggered. The logic circuit in IP3255 will shut down the discharge FET to prevent discharging.

UVP will release when

(1) All VBATn > V_{DR} , and 0V < VMN <1.5V

(2) All VBATn > V_{DL} ， and VMN<0V

8.3. Discharge Over-Current protection

When a battery is in normal operation, once the current going through the FETs is greater than I_{IOV} and t> t_{IOV}, the logic circuit in IP3255 will shut down the discharge FET. And then IP3255 goes into ODC status. In this status, the VMN is connected to VSS with a internal resistor R_{VMS}.

If the load is disconnected or the adapter is connected, the VMN < $V_{IOV3}$and IP3255 goes to normal operation.

8.4. Charge Over-Current protection

When a battery is in normal operation, once the current going through the FETs is greater than I_{CIOV} and t> t_{CIOV}, the logic circuit in IP3255 will shut down the charge FET. And then IP3255 goes into OCC status.

IP3255 returns to normal operation only when charger is disconnected.

8.5. Temperature protection

The NTC thermistor is connected to the TEMP PIN, the TEMP voltage is changing as the temperature is changing. Battery discharging or charging is allowed when the TEMP voltage is between the high-temperature protection threshold voltage and the low-temperature protection threshold voltage. The logic circuit in IP3255 will shut down the discharge FET or charge FET to prevent discharging or charging if the TEMP voltage is

outside of the range.

The detection voltage, temperature protection threshold and NTC thermistor's value is as shown in Table3. Temperature protection range can be changed when NTC thermistor is connected with series resistance or parallel resistance.

Table4. Detection voltage, temperature protection threshold and NTC thermistor's value

	detection voltage	130AT(B=3435)NTC temperature(℃)	130AT(B=3435)NTC thermistor' value(kΩ)
high-temperature protection threshold during charging	65mV	55	3.61
low-temperature protection threshold during charging	0.71V	-8	39.5
high-temperature protection threshold during discharging	45mV	66	2.5
low-temperature protection threshold during discharging	0.99V	-15	55

When the IP3255 is in temperature protection status, battery discharging or charging is allowed again if the TEMP voltage exceeds the temperature protection release voltage.

The temperature protection release voltage:

High-temperature state: high-temperature protection threshold voltage+9 mV

Low-temperature state: low-temperature protection threshold voltage-110 mV

Note: When the TEMP PIN is floating, temperature protection will not occur.

8.6. Delay time setting

$$t_{CU}(s) = 10 \times C_{CCT}(\mu F)$$
$$t_{DL}(s) = 1 \times C_{CDT}(\mu F)$$
$$t_{IOV1}(s) = 0.1 \times C_{CDT}(\mu F)$$

8.7. CTL & SEL

CTL is the control pin of DON&CON.

SEL is used for select number of battery.

Table5. CTL setting

CTL	CON	DON
High	High-Z	GND
Open	High-Z	GND
Low	Normal	Normal

Table6. SEL setting

SEL	number of battery.
High	4
Open	NA
Low	3

8.8. Cell Balancing

Cell balancing is performed by comparing the cell voltages with respect to cell balancing threshold voltages, evaluating the results of the comparison and controlling the cell balancing FET, which over a period of time will allow for closer cell voltages, thereby extending battery pack life.

V_{CBON} is the balancing threshold. The balancing FET will be turned on if any cell voltage exceeds $V_{CBON.}$ Cell balancing of all the odd numbered cells can happen at the same time, and balancing of all the even numbered cells can also happen at the same time, but odd and even cells are not balanced at the same time.

When using the integrated MOSFETs for cell balancing, the cell monitor filter resistance R_{VCn} controls the amount of cell balancing current the device can supply to the cells. The cell balancing currents of Internal cell balancing is: $I_{CBn} = 0.417 * V_{BATn} / (R_{VCn} + R_{VCn+1})$.

External MOSFETs have to be used if higher cell balancing currents are required. In the case of external balancing, the balancing current is controlled by the resistor R_{CBn} in series with the external MOSFET. The cell balancing currents of external cell balancing is: $I_{CBn} = 0.417 * V_{BATn} / R_{CBn}$.

the cell balancing will be turned off when:

(1) All the cell voltage are higher or lower than the balancing threshold voltages(V_{CBON}).

(2) Any abnormal situation occurs, such as open circuit, UVP, OC, OT and so on.

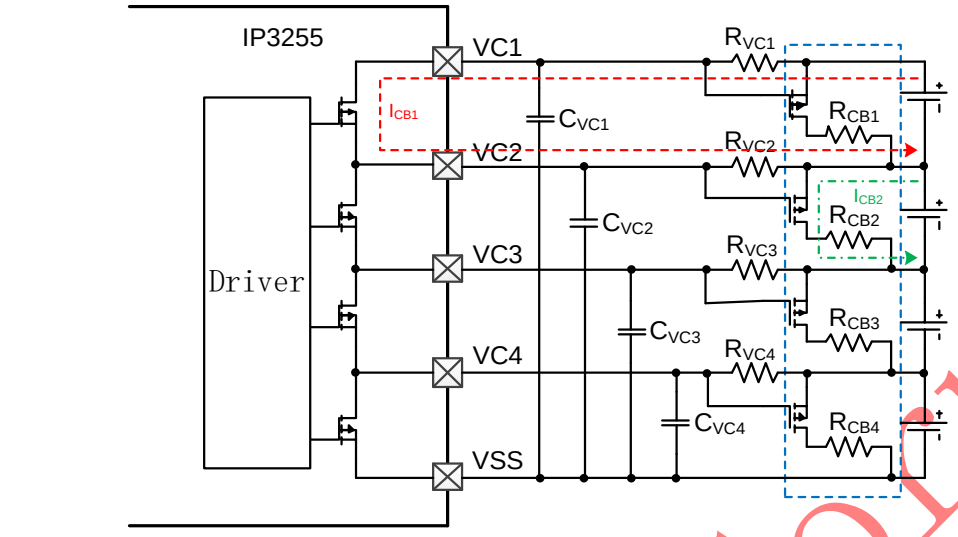


Figure3. Cell Balancing

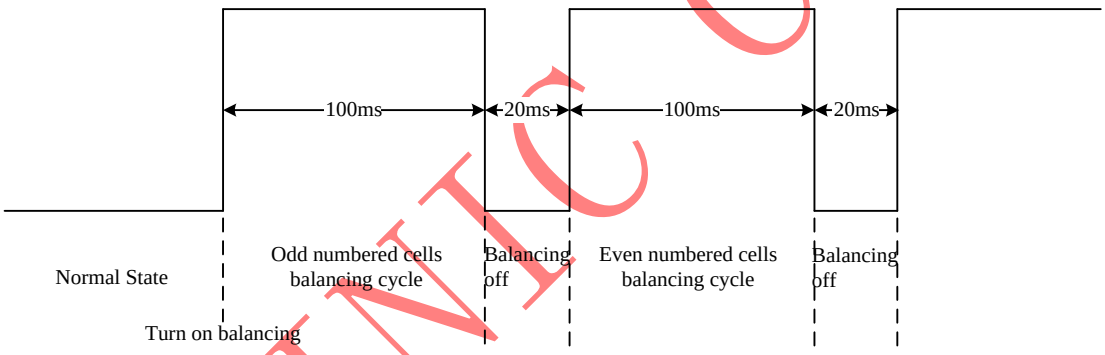
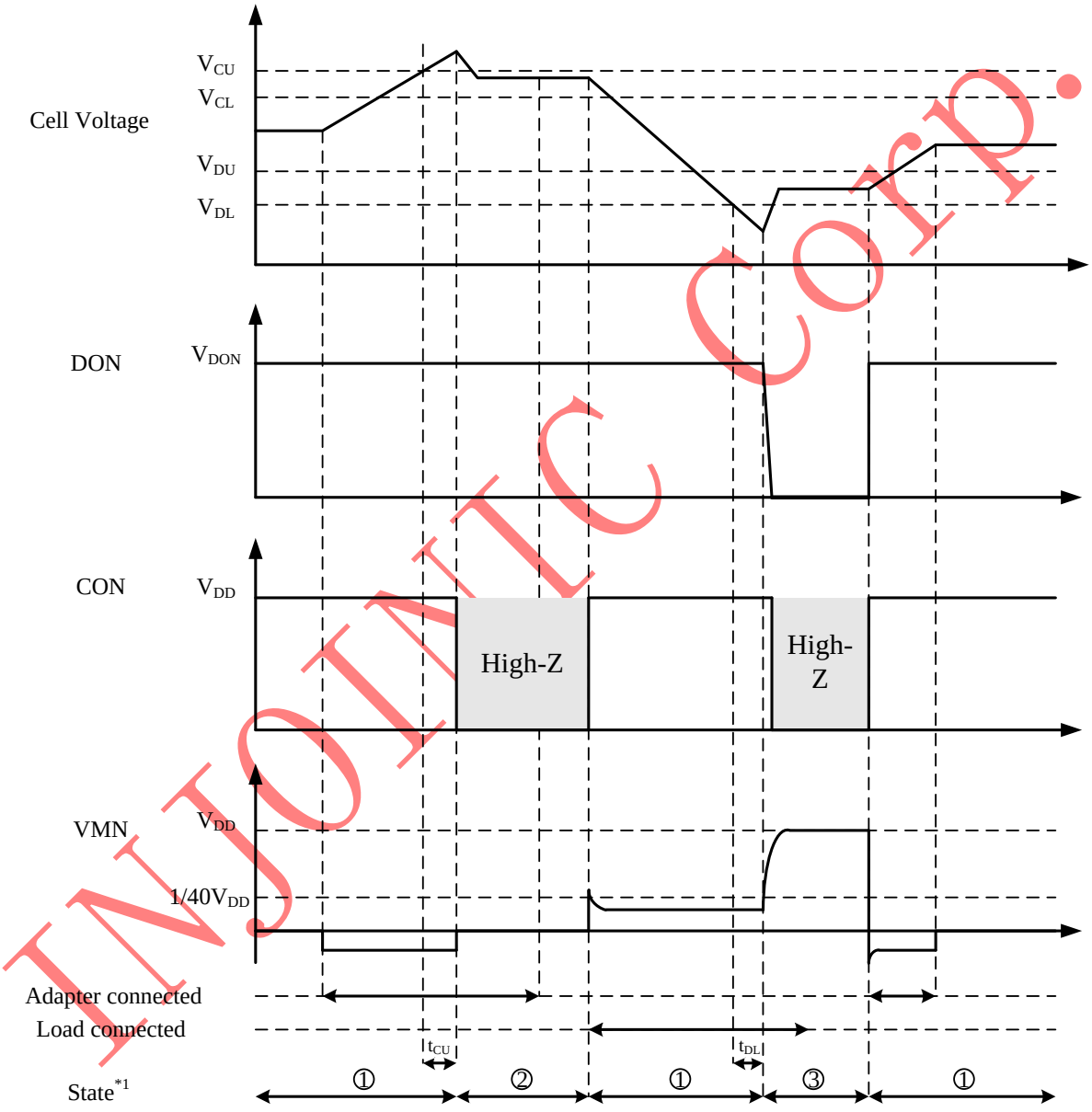


Figure4. Cell Balancing Algorithm

NOTE: The overcharge detection delay time will increase 120ms at most, once there has cell in cell balancing.

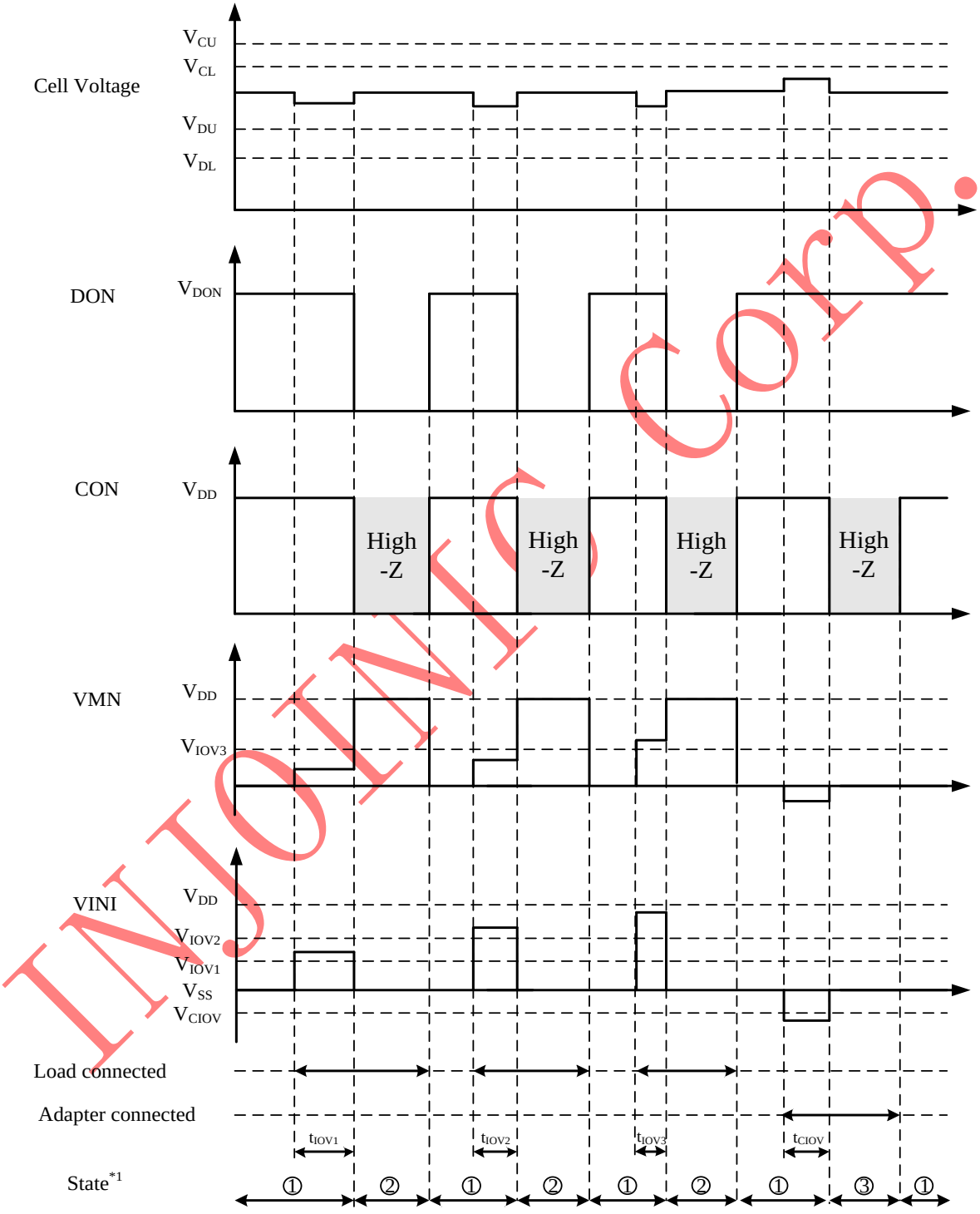
9. Timing Charts

9.1. OVP & UVP detection and release



*1 ①: Normal
②: OVP
③: UVP

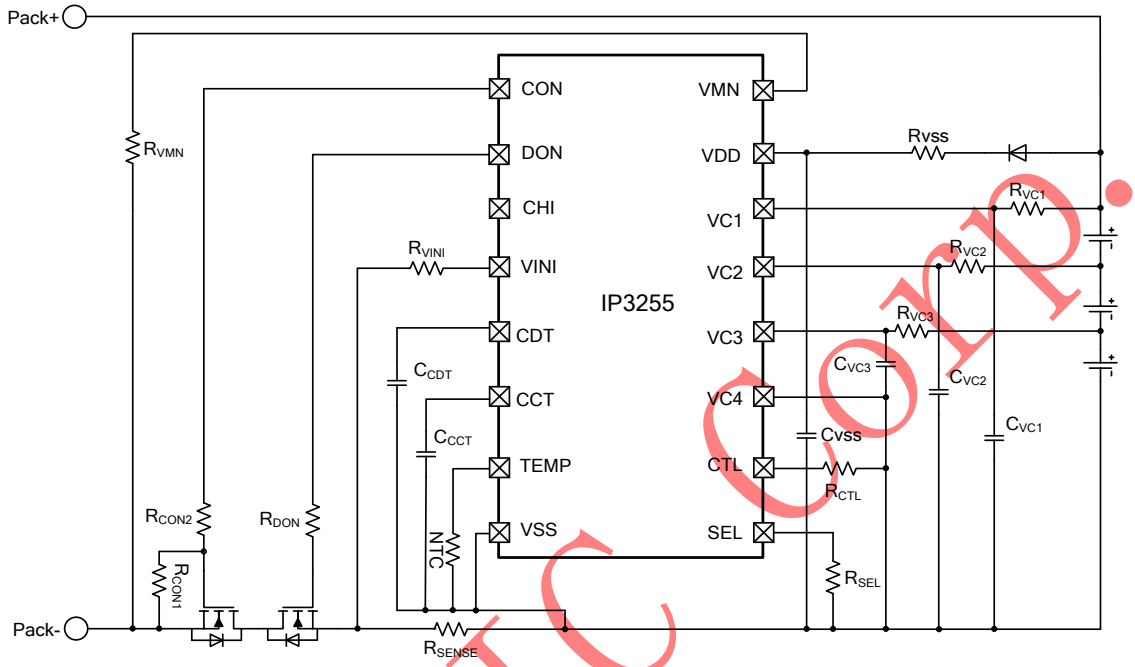
9.2. OC and Short Circuit Detection



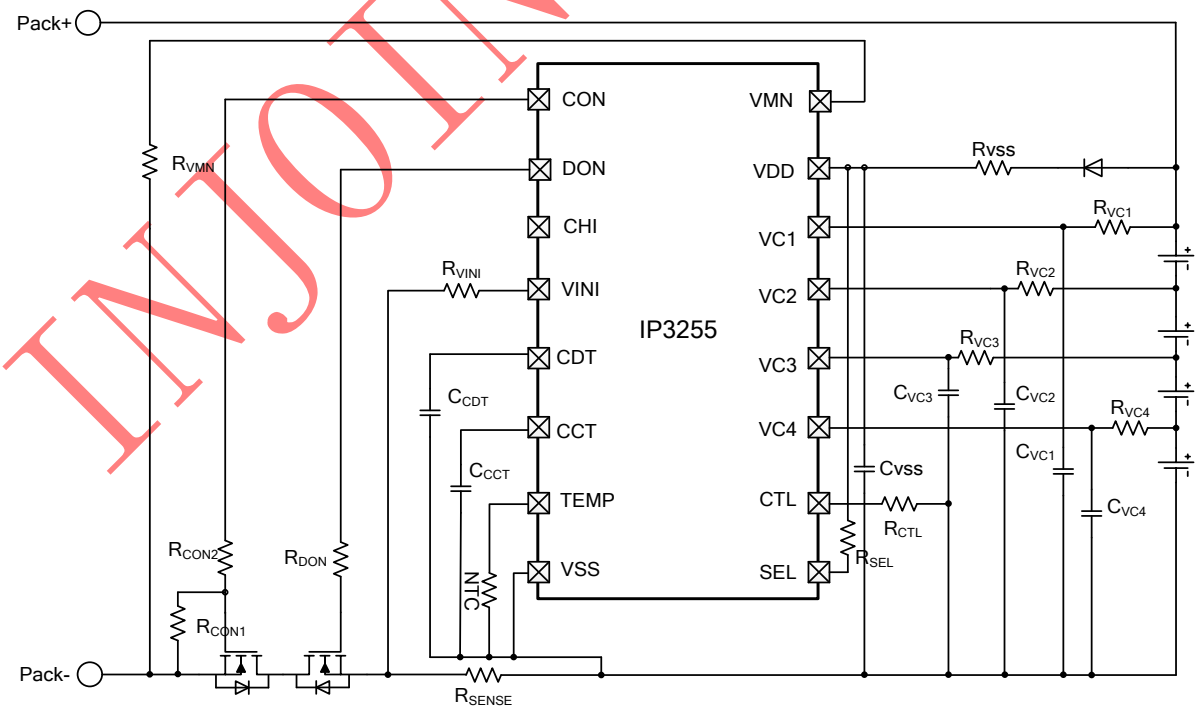
*1 ①: Normal
②: ODC
③: OCC

10. Typical Application

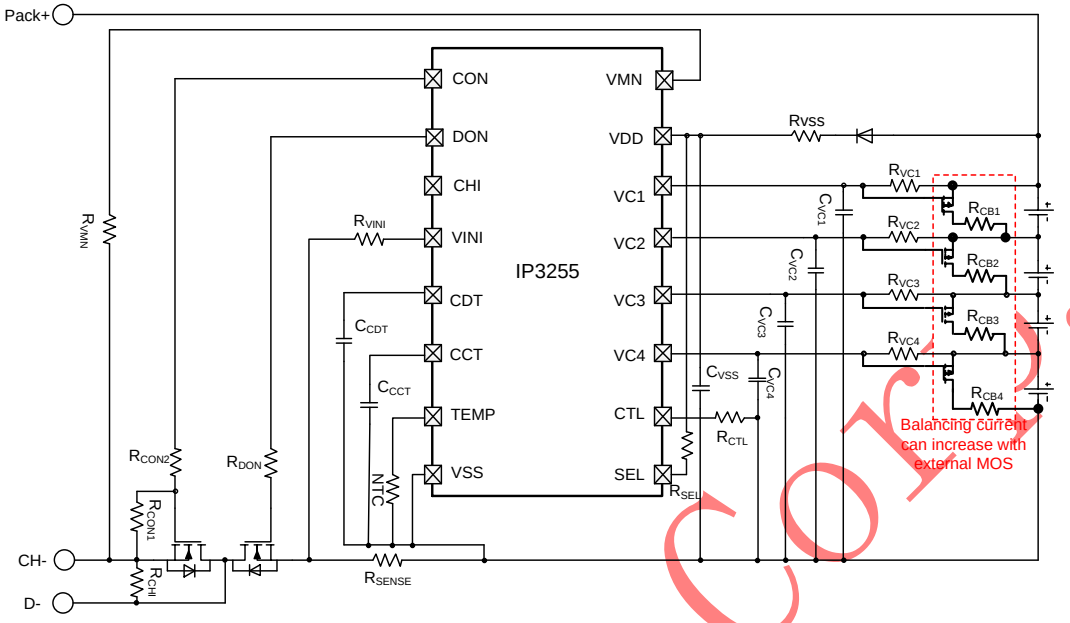
1. 3-serial cell.



2. 4-serial cell.



3. 4-serial cell with separating charging and discharging port.



NOTE:

1.1.1. The external MOSFETs' V_{GSth} <1.6V.

*1.1.2. When device is in normal operating status, Vg=VDD*Rcon1/(Rcon1+Rcon2)(Vg is the gate voltage of charge MOS). I=VDD/(Rcon1+Rcon2)(I is the current in the path).*

1.1.3. IC can't go into the ODC status if device separates charging and discharging port.

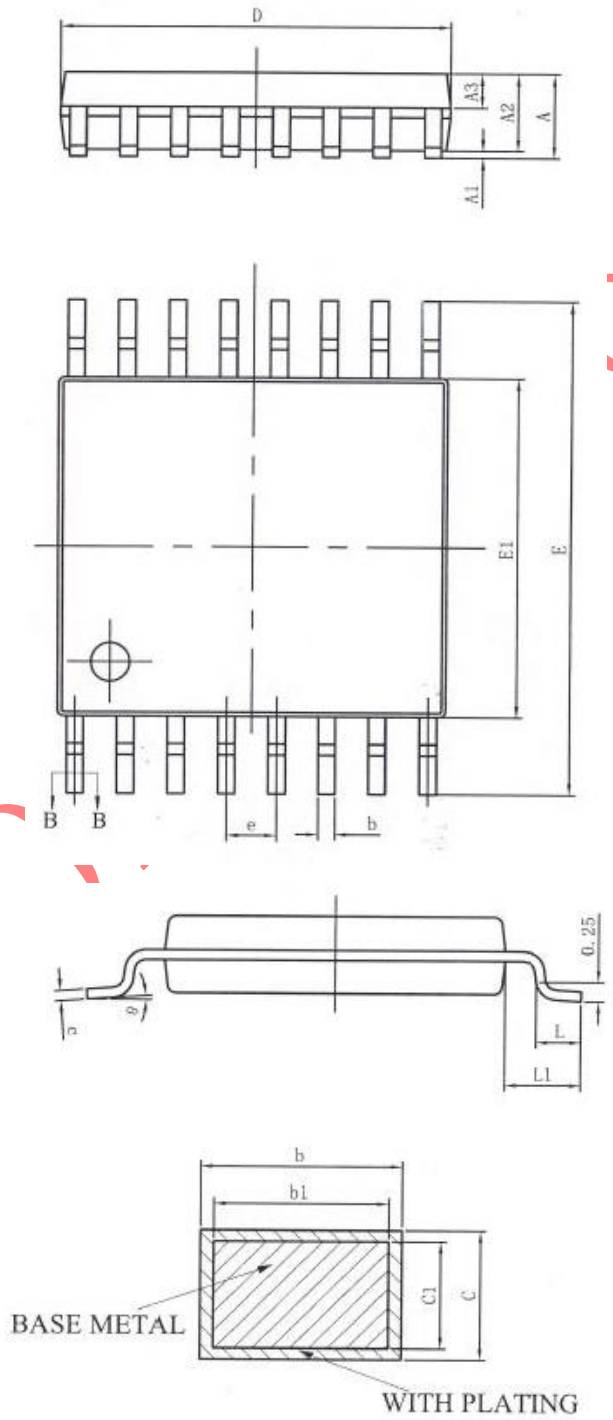
Table7. BOM

Position	Min	Typ	Max	Unit
R_{VC1}、R_{VC2}、R_{VC3}、R_{VC4}	0	1/ 0.1(10mA balancing current)	1	kΩ
R_{DON}	1	5.1	100	kΩ
R_{CON1}	0.1	2	3	MΩ
R_{CON2}	0.1	1	1	MΩ
R_{CHI}	1	1	3	MΩ
R_{VMN}	1	5.1	10	kΩ
R_{CTL}	1	1	100	kΩ
R_{SEL}	1	1	100	kΩ
R_{VINI}	1	1	100	kΩ
R_{SENSE}	0	—	—	mΩ
R_{VSS}	10	51	100	Ω
C_{VC1}、C_{VC2}、C_{VC3}、C_{VC4}	0	0.1/ 1(10mA balancing current)	2.2	μF
C_{CCT}	0.01	0.1	—	μF
C_{CDT}	0.07	0.1	—	μF
C_{VSS}	1	2.2	10	μF

11. PACKAGE

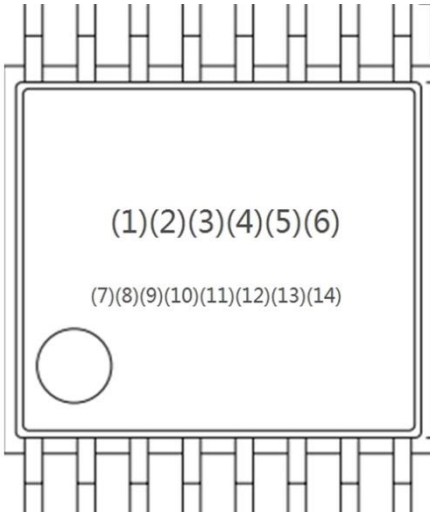
TSSOP-16 as follows:

unit：mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	—	0.29
b1	0.19	0.22	0.25
c	0.13	—	0.18
c1	0.12	0.13	0.14
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
θ	0	—	8°

12. Silk Information



(1)~(6) IC series Name

(7)~(14) Lot Number

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