英集芯科技 INJOINIC TECHNOLOGY

IP3232

2-Series and 3-Series lithium-ion/polymer Battery Packs Protector

1 Features

- **High accuracy protection voltage per cell:**
  - ✧ Overcharge protection voltage V_{OVN} (N = 1 ~ 3):
    3.55 V ~ 4.60 V (Step: 10 mV, Accuracy : ±25 mV)
  - ✧ Overcharge release voltage V_{OVRN} (N = 1 ~ 3):
    3.30 V ~ 4.60 V (Step: 50 mV, Accuracy: ±25 mV)
  - ✧ Overdischarge protection voltage V_{UVN} (N = 1 ~ 3):
    2.00 V ~ 3.20 V (Step: 10 mV, Accuracy: ±25 mV)
  - ✧ Overdischarge release voltage V_{UVRN} (N = 1 ~ 3):
    2.00 V ~ 3.40 V (Step: 100 mV, Accuracy: ±35 mV)
- **Current protection (VI current-sensing):**
  - ✧ Discharge overcurrent 1 protection voltage V_{DOC1}:
    0.010 V ~ 0.300 V (Step: 5 mV, Accuracy: ±10 mV)
  - ✧ Discharge overcurrent 2 protection voltage V_{DOC2}:
    0.020 V ~ 0.600 V (Step: 10 mV, Accuracy: ±20 mV)
  - ✧ Discharge short-circuit protection voltage V_{SC}:
    0.040 V ~ 1.200 V (Step: 20 mV, Accuracy: ±40 mV)
- **Charge overcurrent protection:**
  - ✧ Charge overcurrent protection voltage V_{COC}:
    -0.01 V ~ -0.30 V (Step: 5 mV, Accuracy: ±10 mV)
- **Internal delay time (overcharge protection, over-discharge protection, overcurrent protection),**
  Set by internal circuit without external capacitor
- **NTC temperature protection**
- **Independent charge (CO) and discharge (DO) FET drivers**
- **Absolute maximum rating is up to 28V**
- **Wide VDD voltage range: 3.3V to 24V**
- **Ultra low quiescent current:**
  6.5μA (Normal mode)
  0.5μA (Power down mode)
- **Open-wire detection (OW)**
- **0V battery charge forbidden**
- **Charge and discharge status detection**
- **Load locking during overdischarge**
- **Power down mode**
- **External control of charge-discharge by CTL*[1]**
- **Operation temperature: −40°C ~ +85°C**
- **Package: MSOP-10/DFN10(0303)**
- **Support partially separating charging and discharging port**

*[1]Note1: The CTL function must use DFN10 (0303).

2 Applications

- **Lithium-ion rechargeable battery packs**
- **Lithium polymer rechargeable battery packs**
- **Power tools, e-robot, e-bike, vacuum cleaner**

3 Description

The IP3232 device is a low-power battery pack protector that provides a primary protection solution for 2-Series and 3-Series lithium-ion/polymer rechargeable battery. The device implements a suite of voltage, current, temperature detection and protections for Li-ion/polymer rechargeable battery packs. Protection thresholds and delay time are factory-programmed and available in a variety of configurations.

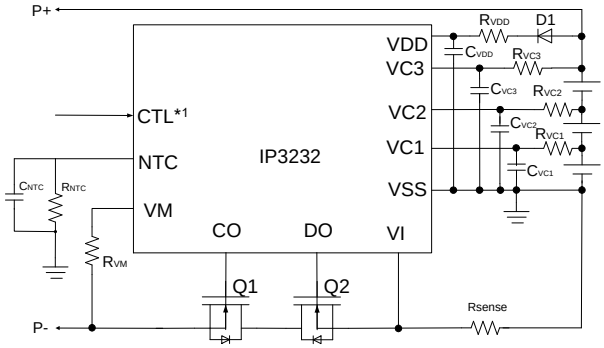


Figure 1: Typical Application for 3-Series Cells

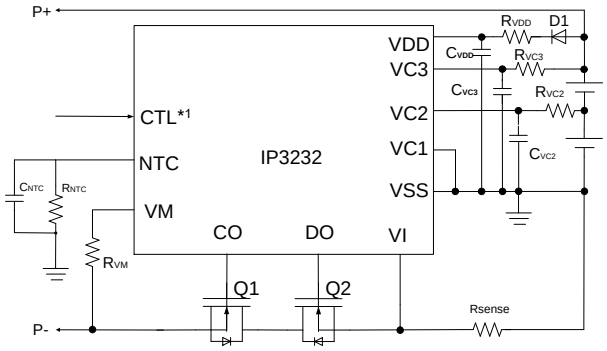


Figure 2: Typical Application for 2-Series Cells

4 Pin Configuration and Function

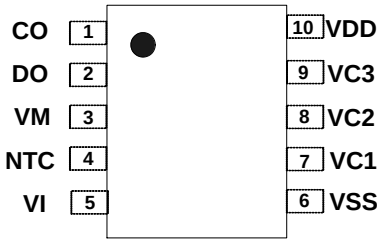


Figure 3: IP3232 MSOP10 Pin Assignments

Pin	Name	Description
1	CO	Charge control FET driver
2	DO	Discharge control FET driver
3	VM	Load and adapter detection pin
4	NTC	Over/under temperature detection thermistor measurement input
5	VI	Current detection Pin
6	VSS	Negative power supply, connect to the negative terminal of cell1
7	VC1	Negative terminal for cell 2, positive terminal for cell 1
8	VC2	Negative terminal for cell 3, positive terminal for cell 2
9	VC3	Positive terminal for cell 3
10	VDD	Positive power supply, connect to positive terminal of cell 3

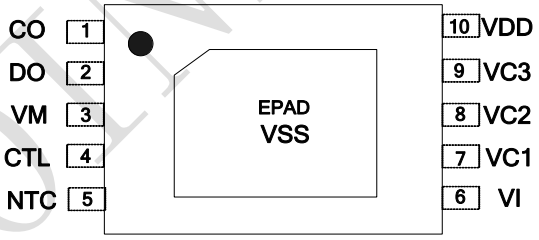


Figure 4: IP3232 DFN10 (0303) Pin Assignments

Pin	Name	Description
1	CO	Charge control FET driver
2	DO	Discharge control FET driver
3	VM	Load and adapter detection pin
4	CTL*[1]	Input pin for charge-discharge control
5	NTC	Over/under temperature detection thermistor measurement input
6	VI	Current detection Pin
7	VC1	Negative terminal for cell 2, positive terminal for cell 1
8	VC2	Negative terminal for cell 3, positive terminal for cell 2
9	VC3	Positive terminal for cell 3
10	VDD	Positive power supply, connect to positive terminal of cell 3
EPAD	VSS	Negative power supply, connect to the negative terminal of cell1

5 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
VDD pin input voltage range	VDD to VSS	-0.3 ~28	V
VC1, VC2, VC3, CTL pin	VC1, VC2, VC3, CTL to VSS	VSS-0.3 ~ VDD+0.3	V
NTC, VI pin	NTC, VI to VSS	VSS-0.3 ~ 6	V
DO to VSS voltage range	DO to VSS	VSS-0.3 ~ VDD+0.3	V
CO, VM to VDD pin	CO, VM to VDD	-28 ~ 0.3	V
Storage Temperature Range	Tstg	-55 ~ 125	°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	120	°C/W
ESD (Human Body Model)	ESD	2	KV

*Stresses beyond these listed parameters may cause permanent damage to the device. Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.

6 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input voltage	VDD	3.3	--	24	V
Battery voltage per cell	VC1, VC2, VC3	0	--	4.6	V
Operating Temperature	T_A	-40	--	85	°C

*Device performance cannot be guaranteed when working beyond these recommended operating conditions.

7 Product List

IP3232 XX

IC CODE for DFN10(0303)
Range: from EA to ZZ

IP3232 MXX

IC CODE for MSOP-10
Range: from MEA to MZZ

Table 1: Product list

Product list 1 (1/3)

Product name	V_{OV}	V_{OVR}	V_{UV}	V_{UVR}	V_{DOC1}	V_{DOC2}	V_{SC}	V_{COC}
IP3232MEA	4.250V	4.150V	2.700V	3.000V	0.100V	0.200V	0.400V	-0.100V
IP3232MEB	4.250V	4.150V	2.700V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232MEC	4.250V	4.150V	2.500V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232MED	3.750V	3.550V	2.300V	2.600V	0.100V	0.200V	0.400V	-0.050V
IP3232MEE	3.650V	3.550V	2.500V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232MEF	4.250V	4.150V	2.700V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232MEG	4.250V	4.150V	2.500V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232MEH	3.750V	3.550V	2.300V	2.600V	0.100V	0.200V	0.400V	-0.050V
IP3232MEI	3.650V	3.550V	2.500V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232MEJ	4.250V	4.100V	2.800V	3.000V	0.150V	0.180V	0.500V	-0.100V
IP3232MEK	3.750V	3.550V	2.700V	3.000V	0.050V	0.100V	0.200V	-0.025V
IP3232MEL	4.250V	4.050V	2.700V	3.100V	0.080V	0.150V	0.400V	-0.040V
IP3232MEM	4.280V	4.080V	2.500V	3.000V	0.100V	0.200V	0.500V	-0.050V
IP3232EA	4.250V	4.150V	2.500V	3.000V	0.150V	0.250V	0.400V	-0.050V
IP3232EB	3.750V	3.650V	2.300V	2.700V	0.100V	0.350V	1.200V	-0.100V
IP3232EC	4.280V	4.080V	2.700V	3.000V	0.100V	0.200V	0.400V	-0.050V
IP3232ED	3.650V	3.450V	2.500V	2.800V	0.100V	0.150V	0.200V	-0.025V

Product list 2 (2/3)

Product name	t_{OV}	t_{UV}	t_{DOC1}	t_{DOC2}	t_{SC}	t_{COC}	t_{PD}
IP3232MEA	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEB	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEC	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MED	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s

IP3232MEE	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEF	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEG	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEH	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEI	1.0s	1.0s	1.0s	64ms	280μs	64ms	2s
IP3232MEJ	1.0s	256ms	16ms	8ms	280μs	16ms	2s
IP3232MEK	2.0s	2.0s	2.0s	64ms	560μs	64ms	32s
IP3232MEL	1.0s	1.0s	1.0s	64ms	280μs	64ms	-
IP3232MEM	1.0s	1.0s	1.0s	64ms	280μs	64ms	-
IP3232EA	1.0s	1.0s	64ms	16ms	280μs	64ms	-
IP3232EB	1.0s	512ms	32ms	8ms	280μs	8ms	2s
IP3232EC	1.0s	1.0s	1.0s	64ms	280μs	64ms	32s
IP3232ED	1.0s	1.0s	256ms	8ms	280μs	64ms	2s

Product list 3 (3/3)

Product name	Overdischarge load locking function	Power down mode selection	Cell count	CTL function	Temperature detection	T_{UTC}	T_{OTC}	T_{UTD}	T_{OTD}
IP3232MEA	Disable	Enable	3-series	Disable	Enable	0°C	55°C	-20°C	70°C
IP3232MEB	Enable	Enable	3-series	Disable	Enable	0°C	50°C	-20°C	65°C
IP3232MEC	Enable	Enable	3-series	Disable	Enable	0°C	50°C	-20°C	65°C
IP3232MED	Enable	Enable	3-series	Disable	Enable	-5°C	55°C	-20°C	70°C
IP3232MEE	Enable	Enable	3-series	Disable	Enable	-5°C	55°C	-20°C	70°C
IP3232MEF	Enable	Enable	2-series	Disable	Enable	0°C	50°C	-20°C	65°C
IP3232MEG	Enable	Enable	2-series	Disable	Enable	0°C	50°C	-20°C	65°C
IP3232MEH	Enable	Enable	2-series	Disable	Enable	-5°C	55°C	-20°C	70°C
IP3232MEI	Enable	Enable	2-series	Disable	Enable	-5°C	55°C	-20°C	70°C
IP3232MEJ	Enable	Enable	2-series	Disable	Enable	0°C	55°C	-20°C	65°C
IP3232MEK	Disable	Enable	2-series	Disable	Enable	0°C	55°C	-20°C	70°C
IP3232MEL	Disable	Disable	3-series	Disable	Enable	0°C	55°C	-20°C	70°C
IP3232MEM	Disable	Disable	3-series	Disable	Enable	0°C	55°C	-20°C	70°C
IP3232EA	Disable	Disable	2-series	Disable	Enable	0°C	55°C	-20°C	65°C
IP3232EB	Disable	Enable	2-series	Enable	Enable	0°C	50°C	-20°C	65°C
IP3232EC	Enable	Enable	2-series	Enable	Enable	0°C	55°C	-20°C	70°C
IP3232ED	Disable	Enable	3-series	Disable	Enable	0°C	55°C	-20°C	70°C

Table 2：Function options

Temperature detection	Enable	Disable
Overdischarge load locking function	Enable	Disable
Power down mode selection	Enable	Disable
CTL function *[1]	Enable	Disable
Cell count	2-series	3-series

8 Electrical Characteristics

Unless otherwise specified, T_A = -40°C to 85°C, VDD = 10.5V, CTL = 3.5V, typical value @T_A=25°C.

Parameter	Symbol	Test Conditions		Range			Unit
				Min.	Typ.	Max.	
VDD - VSS voltage				3.3	-	28	V
VDD - VM voltage				3.3	-	28	V
Quiescent current	I_Q （input power）	VDD = VC3 = 10.5V, VC2 = 7V, VC1 = 3.5V		-	6.5	9	μA
Shut-down current (Power down)	I_Q （input power）	Shutdown down(VDD=6V)		-	0.5	1	μA
Overcharge protection voltage (N=1, 2, 3)	V_{OVN}	T_A = 25°C		V_{OVN}-0.025	3.55 ~ 4.60 STEP: 10mV	V_{OVN}+0.025	V
		T_A = -20°C ~ +60°C		V_{OVN}-0.030		V_{OVN}+0.030	
		T_A = -40°C ~ +85°C		V_{OVN}-0.040		V_{OVN}+0.040	
Overcharge release voltage (N=1, 2, 3)	V_{OVRN}	$V_{OVN} \neq V_{OVRN}$	T_A = 25°C	V_{OVRN}-0.025	3.30 ~ 4.60	V_{OVRN}+0.025	V
			T_A = -20°C ~ +60°C	V_{OVRN}-0.030		V_{OVRN}+0.030	
			T_A = -40°C ~ +85°C	V_{OVRN}-0.040		V_{OVRN}+0.040	
		$V_{OVN} = V_{OVRN}$	T_A = 25°C	V_{OVRN}-0.015	3.55 ~ 4.60	V_{OVRN}+0.015	
			T_A = -20°C ~ +60°C	V_{OVRN}-0.030		V_{OVRN}+0.030	
			T_A = -40°C ~ +85°C	V_{OVRN}-0.040		V_{OVRN}+0.040	
Overdischarge protection voltage (N=1, 2, 3)	V_{UVN}	T_A = 25°C		V_{UVN}-0.025	2.0 ~ 3.2 STEP: 10mV	V_{UVN}+0.025	V
		T_A = -20°C ~ +60°C		V_{UVN}-0.040		V_{UVN}+0.040	
		T_A = -40°C ~ +85°C		V_{UVN}-0.050		V_{UVN}+0.050	
Overdischarge release voltage (N=1, 2, 3)	V_{UVRN}	$V_{UVN} \neq V_{UVRN}$	T_A = 25°C	V_{UVRN}-0.035	2.0 ~ 3.4	V_{UVRN}+0.035	V
			T_A = -20°C ~ +60°C	V_{UVRN}-0.050		V_{UVRN}+0.050	
			T_A = -40°C ~ +85°C	V_{UVRN}-0.060		V_{UVRN}+0.060	
		$V_{UVN} = V_{UVRN}$	T_A = 25°C	V_{UVRN}-0.025	2.0 ~ 3.2	V_{UVRN}+0.025	
			T_A = -20°C ~ +60°C	V_{UVRN}-0.040		V_{UVRN}+0.040	
			T_A = -40°C ~ +85°C	V_{UVRN}-0.050		V_{UVRN}+0.050	
0V battery charge forbidden voltage	V_{0INH}	0V battery charge forbidden		-	$\frac{2}{3}$×V_{UVN}	-	V
Discharge overcurrent 1 protection voltage	V_{DOC1}	T_A = 25°C		V_{DOC1}-10	10 ~ 300 STEP: 5mV	V_{DOC1}+10	mV
		T_A = -40°C ~ +85°C		V_{DOC1}-15		V_{DOC1}+15	
Discharge overcurrent 2 protection voltage	V_{DOC2}	T_A =25°C		V_{DOC2}-20	20 ~ 600 STEP: 10mV	V_{DOC2}+20	mV
		T_A = -20°C ~ +60°C		V_{DOC2}-25		V_{DOC2}+25	
		T_A = -40°C ~ +85°C		V_{DOC2}-30		V_{DOC2}+30	
Discharge short circuit protection voltage	V_{SC}	T_A =25°C		V_{SC}-40	40 ~ 1200 STEP: 20mV	V_{SC}+40	mV
Discharge overcurrent release voltage	V_{DOCR}	VM threshold		1.1	1.2	1.3	V
Charge overcurrent protection voltage	V_{COC}	T_A = 25°C		V_{COC} -10	-10 ~ -300 STEP: 5mV	V_{COC} +10	mV
		T_A = -40°C ~ +85°C		V_{COC} -15		V_{COC} +15	
Overcharge protection delay time	t_{OV}	-		t_{OV}×0.8	512 / 4000	t_{OV}×1.2	ms
Overdischarge	t_{UV}	-		t_{UV}×0.8	256	t_{UV}×1.2	ms

protection delay time				2000		
Discharge overcurrent 1 protection delay time	t_{DOC1}	-	t_{DOC1}×0.8	8 4000	t_{DOC1}×1.2	ms
Discharge overcurrent 2 protection delay time	t_{DOC2}	-	t_{DOC2}×0.8	8 64	t_{DOC2}×1.2	ms
Discharge short circuit protection delay time	t_{SC}	-	t_{SC}×0.7	280 560	t_{SC}×1.3	μs
Charge overcurrent protection delay time	t_{COC}	-	t_{COC}×0.8	8 64	t_{COC}×1.2	ms
CTL control charge-discharge inhibition delay time	t_{CTL}	-	t_{CTL}×0.8	4	t_{CTL}×1.2	ms
CTL pin voltage "H"	V_{CTLH}	-	3.2	3.5	3.8	V
CTL pin voltage "L"	V_{CTLL}	-	1.2	1.5	1.8	V
CTL pull-down current	I_{CTL}	-		0.2	0.3	μA
VM to VDD resistance	R_{VMD}	T_A = 25°C	0.6	1.2	1.8	MΩ
VM to VSS resistance	R_{VMS}	T_A = 25°C	0.25	0.5	0.75	MΩ
CO to VDD resistance	R_{COD}	T_A = 25°C		10		KΩ
CO to VM resistance	R_{COM}	T_A = 25°C		10		KΩ
DO to VDD resistance	R_{DOD}	T_A = 25°C		10		KΩ
DO to VSS resistance	R_{DOS}	T_A = 25°C		0.4		KΩ
Discharge-status detection voltage threshold	Vdis_status_th	VI	-	2	-	mV
Discharge-status detection voltage hysteresis	Vdis_status_hys	VI	-	1.5	-	mV
Charge-status detection voltage threshold	Vchg_status_th	VI	-	-2	-	mV
Charge-status detection voltage hysteresis	Vchg_status_hys	VI	-	-1.5	-	mV
NTC charge-status over temperature protection	T_{OTC}	NTC temperature rising NTC:103AT	T_{OTC} -2	T_{OTC}	T_{OTC} +2	°C
	T_{OTCR}	NTC temperature falling NTC:103AT	T_{OTCR} -2	T_{OTCR}	T_{OTCR} +2	°C
NTC discharge-status over temperature protection	T_{OTD}	NTC temperature rising NTC:103AT	T_{OTD} -2	T_{OTD}	T_{OTD} +2	°C
	T_{OTDR}	NTC temperature falling NTC:103AT	T_{OTDR} -2	T_{OTDR}	T_{OTDR} +2	°C
NTC charge-status under temperature protection	T_{UTC}	NTC temperature falling NTC:103AT	T_{UTC} -2	T_{UTC}	T_{UTC} +2	°C
	T_{UTCR}	NTC temperature rising NTC:103AT	T_{UTCR} -2	T_{UTCR}	T_{UTCR} +2	°C
NTC discharge-status under temperature protection	T_{UTD}	NTC temperature falling NTC:103AT	-22	-20	-18	°C
	T_{UTDR}	NTC temperature rising NTC:103AT	-12	-10	-8	°C
OTD, OTC, UTD, UTC delay time	t_{NTC_FAULT}	-	1.5	3	5	s

Open-wire detection delay time	t_{OW_DELAYN}	-	3	4	5	s
Power down mode delay time	t_{PD}	Options	-	0 / 2 / 32	-	s

Note: Please choose the MOSFETs based on the terminal resistance of CO and DO.

9 Functional Description

System Diagram

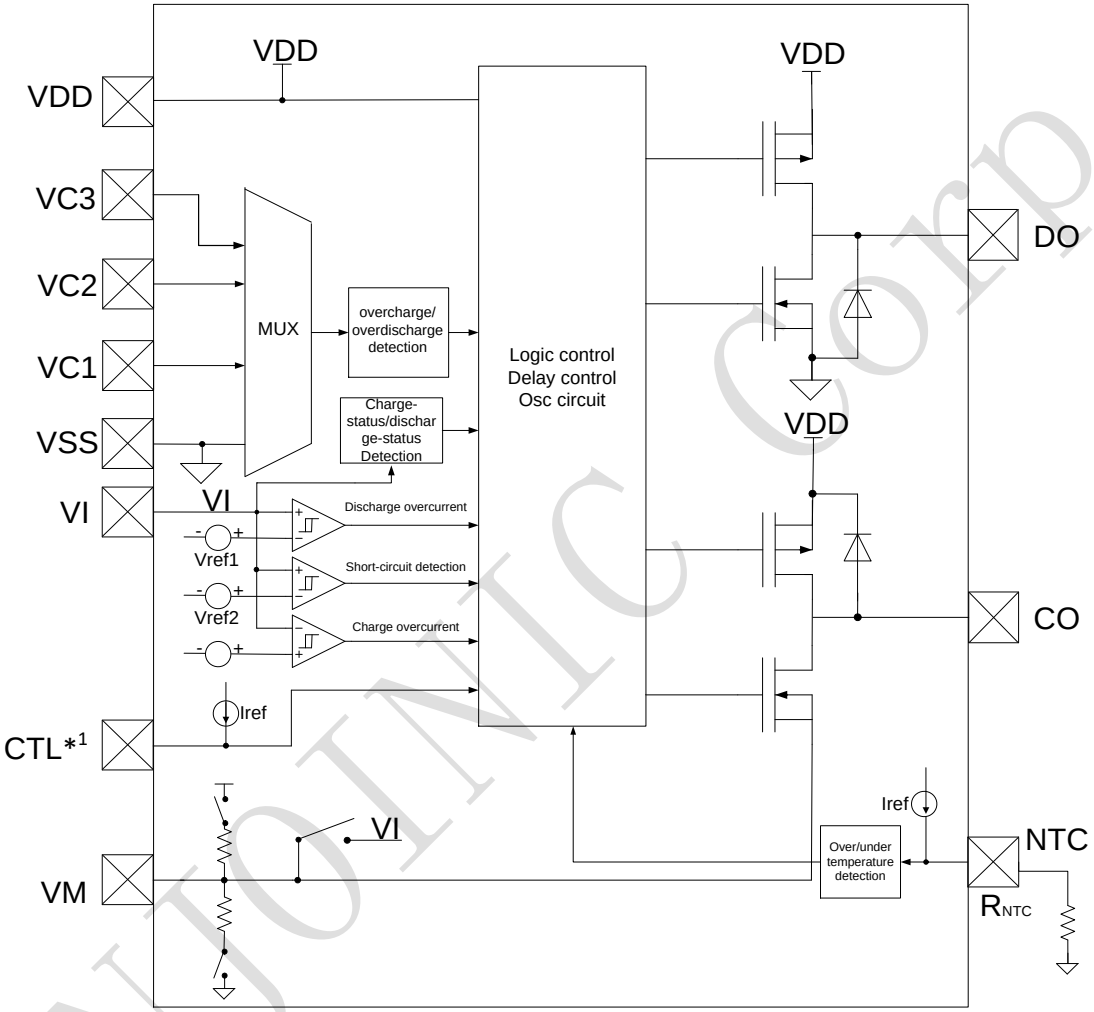


Figure 5: IP3232 Internal System Diagram

Overview

The IP3232 device is a low power dissipation battery pack protector that provides a primary protection solution for 2-Series and 3-Series lithium-ion/polymer rechargeable battery. The device implements a suite of voltage, current, and temperature detection and protections for Li-ion/polymer rechargeable battery packs. Protection thresholds and delays are factory-programmed and available in a variety of configurations.

Overcharge status

When any cell battery voltage becomes higher than V_{OVN} during charging in the normal status and the condition continues for the overcharge protection delay time (t_{OV}) or longer, IP3232 turns the charge control FET off to stop charging. This status is called the overcharge status. The overcharge status is released in the following three cases:

(1) In the case that the VM voltage is lower than 0.35V (Typ.), IP3232 releases the overcharge status when all the cell battery voltages fall below overcharge release voltage (V_{OVRN}).

(2) In the case that the VM voltage is equal to or higher than 0.35V (Typ.), IP3232 releases the overcharge status when all the cell battery voltages fall below V_{OVN}.

(3) In the case that the VI voltage is equal to or higher than Vdis_status_th(discharge current detected), IP3232 pull CO up to VDD, and turn on the charge control FET(Q1), even though all battery voltages are higher than V_{OVN}.

The overcharge release delay is internally fixed at 4ms.

Overdischarge status

When any cell battery voltage falls below V_{UVN} during discharging in the normal status and the condition continues for the overdischarge protection delay time (t_{UV}) or longer, IP3232 turns the discharge control FET(Q2) off to stop discharging. This status is called the overdischarge status.

The overdischarge status is released in the following cases:

With power-down function：

Under the overdischarge status, when the VM voltage is higher than 3.5V and this condition continues for the power down mode delay time t_{PD} or longer, the power-down function works and the current consumption is reduced to 500nA. By connecting a battery charger, the power-down function is released.

• If charger is not connected, IP3232 maintains the overdischarge status even when the battery voltage reaches V_{UVRN} or higher.

• If charger is connected, the battery voltage reaches V_{UVN} or higher and IP3232 releases the overdischarge status.

• In the case that the VI voltage is equal to or higher than Vchg_status_th(charge current detected), IP3232 pull DO up to VDD, and turn on the discharge control FET(Q2), even though all battery voltages are lower than V_{UVN}.

Without power-down function：

Under the overdischarge status, the power-down function does not work even when the VM voltage is higher than 3.5V.

• If charger is not connected, the battery voltage reaches V_{UVRN} or higher and IP3232 releases the overdischarge status.

•If charger is connected, the battery voltage reaches V_{UVN} or higher and IP3232 releases the overdischarge status.

• In the case that the VI voltage is equal to or higher than Vchg_status_th(charge current detected), IP3232 pull DO up to VDD, and turn on the discharge control FET(Q2), even though all battery voltages are lower than V_{UVN}.

The overdischarge release delay is internally fixed at 4ms.

Discharge overcurrent status

Under the discharge status, the VI pin voltage will increase with the increase of discharge current.

When the VI pin voltage is equal to or higher than V_{DOC1}, this condition continues for the discharge overcurrent 1 protection delay time (t_{DOC1}) or longer, IP3232 will be in the discharge overcurrent 1 status. When the VI pin voltage is equal to or higher than V_{DOC2}, this condition continues for the discharge overcurrent 2 protection delay time (t_{DOC2}) or longer, IP3232 will be in the discharge overcurrent 2 status. When the VI pin voltage is equal to or higher than V_{SC}, this condition continues for the discharge short circuit protection delay time (t_{SC}) or longer, IP3232 will be in the discharge short circuit status. After any of the three states mentioned above appears, the discharge control FET(Q2) will be turned off.

Under the discharge overcurrent status, VM pin and VSS pin are connected by resistor in IP3232. However, the VM pin voltage is the VDD pin voltage due to the load as long as the load is connected. When the load is disconnected, VM pin returns to the VSS pin voltage. When the VM pin voltage returns to V_{DOCR} or lower, IP3232 releases the discharge overcurrent status.

Charge overcurrent status

When the charge current is equal to or higher than the specified value, the VI pin voltage is equal to or lower than V_{COC}, this condition continues for the charge overcurrent protection delay time (t_{COC}) or longer, the charge control FET(Q1) is turned off and charging is stopped. This status is called the charge overcurrent status. IP3232 releases the charge overcurrent status when the VM pin voltage is 0.35V (Typ.) or higher by removing the charger or connecting load. The charge overcurrent protection isn't functional in the overdischarge status.

CTL control logic*[1]

When the CTL pin voltage is equal to or lower than CTL pin voltage "L" (V_{CTLL}) and the status continues for the charge-discharge inhibition delay time (t_{CTL}) or longer, the charge control FET(Q1) and the discharge control FET(Q2) are turned off, and charging and discharging is stopped. This status is called the charge-discharge inhibition status. IP3232 releases charge-discharge inhibition status when the CTL pin voltage is equal to or higher than CTL pin voltage "H" (V_{CTLH}). When the CTL pin is floating, the internal pull-down resistance pulls CTL to voltage "L".

0V battery charge forbidden

If the voltage of any battery is lower than the 0V battery charging prohibition voltage threshold, it is prohibited to charge the battery.

Open-wire detection (OW)

An OW fault is detected when at least one of the cell is open wire, and the status continues for the delay time (t_{OW_DELAYN}) or longer, the charge control FET(Q1) and discharge control FET(Q2) are turned off. The OW fault recovers when the cell voltage in fault turn normal, the recovery conditions of charge control FET(Q1) and discharge control FET(Q2) is depended on the OV, UV, OC faults' recovery conditions.

t_{OW_DELAYN} start counting when the OW is detected, not the OW occurs.

Charge-status and discharge-status detection

IP3232 integrates a charge and discharge status comparator. The charge-status is detected when the VI voltage is lower than -2mV, the hysteresis is -0.5mV. The discharge-status is detected when the VI voltage is higher than 2mV, the hysteresis is 0.5mV. charge-status detection during discharge protection status, discharge-status detection during charge protection status, when the charge or discharge status changed, it will turn on the FET quickly to protect the MOSFETs' body diode.

When the device is during overcharge, charge over temperature, charge under temperature event, the CO FET is off and the DO FET is on. If a discharge occurs(VI > Vdis_status_th) and the temperature meet the discharge requirements, the device would turn on the CO FET to protect the MOSFET body diode after 1ms delay time.

When the device is during overdischarge event, the DO FET is off and the CO FET is on. If a charge occurs (VI< Vchg_status_th) , the device would turn on the DO FET to protect the MOSFET body diode after 1ms delay time.

Overdischarge load locking

When IP3232 is under the overdischarge status, and VM will be pulled up by external load. If the overdischarge load locking function is enabled and the load exists, the DO terminal will remain low, even if the battery voltage increases above V_{UVRN}. When the load is removed, and the VM voltage drops below the 1.2V (Typ.) and this condition continues for delay time 64ms (Typ.) or longer, the load locking status will be removed and IP3232 will be under the overdischarge status again. At this time, IP3232 releases the DO terminal according to the normal overdischarge release conditions.

If both the overdischarge load locking function and the power-down function are enabled, when IP3232 is under the overdischarge status and the load has existed for the power down mode delay time (t_{PD}) or longer, the IP3232 will be in power down mode and the DO terminal will remain low even if the battery voltage has increased above V_{UVRN}.

NTC Status

In the process of charge and discharge, too high or too low temperature will damage the cell. Therefore, the thermistor R_{NTC} needs to be used to sense the temperature change. When the temperature reaches the set protection value and remains for a period of time, temperature protection will occur. IP3232 will turn off the charging or discharging MOS tube to protect the high and low temperature of cell charging and discharging.

Unless otherwise specified, T_{OTCR} is 10°C lower than T_{OTC}. T_{OTDR} is 10°C lower than T_{OTD}. T_{UTCR} is 10°C higher than T_{UTC}. T_{UTDR} is 10°C higher than T_{UTD}.

Charge over temperature

When IP3232 detects that the temperature is higher than T_{OTC} during charging and the condition continues for the delay time (t_{NTC_FAULT}) or longer, IP3232 turns the charge control FET (Q1) off to stop charging.

The charge over temperature is released in the following two cases:

1.If IP3232 detects that the temperature is lower than T_{OTCR} and this condition continues for 3s(Typ.) or longer, IP3232 will release the charge over temperature and turn on the charge control FET(Q1).

2.If a discharge occurs(VI > Vdis_status_th) in the charge over temperature status, IP3232 will turn on the charge control FET(Q1) to protect MOSFET body diode after 1ms delay time.

Charge under temperature

When IP3232 detects that the temperature is lower than T_{UTC} during charging and the condition

continues for the delay time (t_{NTC_FAULT}) or longer, IP3232 turns the charge control FET (Q1) off to stop charging.

The charge under temperature is released in the following two cases:

1.If IP3232 detects that the temperature is higher than T_{UTCR} and this condition continues for 3s(Typ.) or longer, IP3232 will release the charge over temperature and turn on the charge control FET(Q1).

2.If a discharge occurs(VI > Vdis_status_th) in the charge under temperature status, IP3232 will turn on the charge control FET(Q1) to protect MOSFET body diode after 1ms delay time.

Discharge over temperature

When IP3232 detects that the temperature is higher than T_{OTD} during discharging and the condition continues for the delay time (t_{NTC_FAULT}) or longer, IP3232 turns the discharge charge control FET (Q2) off to stop discharging.

The discharge over temperature is released in the following cases:

If IP3232 detects that the temperature is lower than T_{OTDR} and this condition continues for 3s(Typ.) or longer, IP3232 will release the discharge over temperature and turn on the discharge control FET(Q2).

Discharge under temperature

When IP3232 detects that the temperature is lower than T_{UTD} during discharging and the condition continues for the delay time (t_{NTC_FAULT}) or longer, IP3232 turns the discharge charge control FET (Q2) off to stop discharging.

The discharge under temperature is released in the following cases:

If IP3232 detects that the temperature is higher than T_{UTDR} and this condition continues for 3s(Typ.) or longer, IP3232 will release the discharge under temperature and turn on the discharge control FET(Q2).

Application

1. The recommended NTC resistance type: 103AT, B=3435
2. The final protection temperature can be changed by series or parallel resistance. At the same time, the protection threshold is also changed.
3. There are 12 options of protection thresholds available for selection:

Table 3: NTC Protection threshold options

Options:	1	2	3	4	5	6	7	8	9	10	11	12
Charging under temperature	0°C	0°C	0°C	0°C	0°C	0°C	-5°C	-5°C	-5°C	-5°C	-5°C	-5°C
Charging over temperature	45°C	45°C	55°C	55°C	50°C *[2]	50°C *[2]	45°C	45°C	55°C	55°C	50°C *[2]	50°C *[2]
Discharging under temperature	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C
Discharging over temperature	65°C	70°C	65°C	70°C	65°C	70°C	65°C	70°C	65°C	70°C	65°C	70°C

*[2]Note2: When Charging over temperature T_{OTC} is 50°C, T_{OTCR} is 45°C.

10 Sequence Charts

Overcharge protection and overdischarge protection

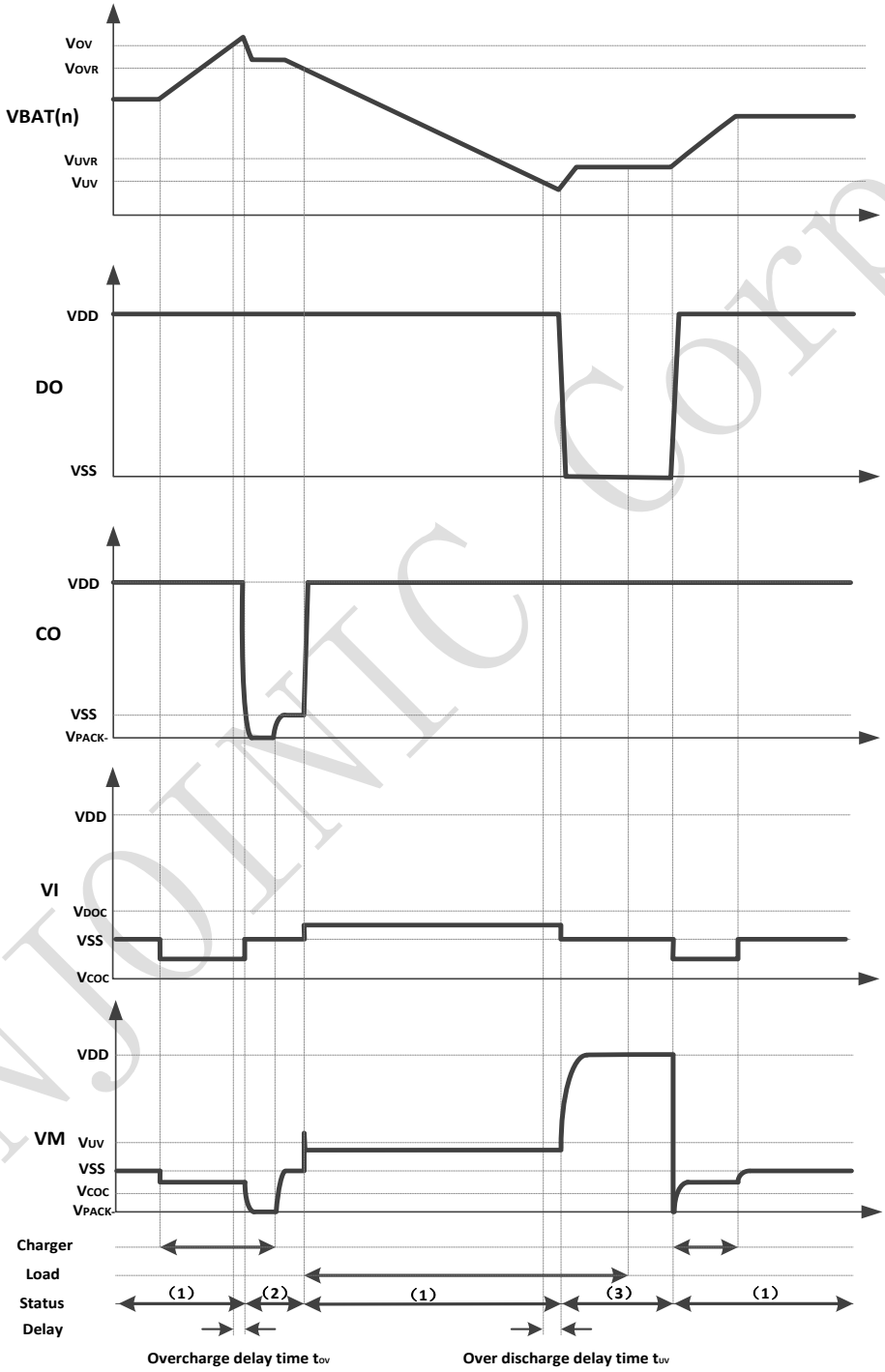


Figure 6: Overcharge protection and overdischarge protection timing chart

Note： (1) Normal status

(2) Overcharge status

(3) Overdischarge status

Charge overcurrent protection

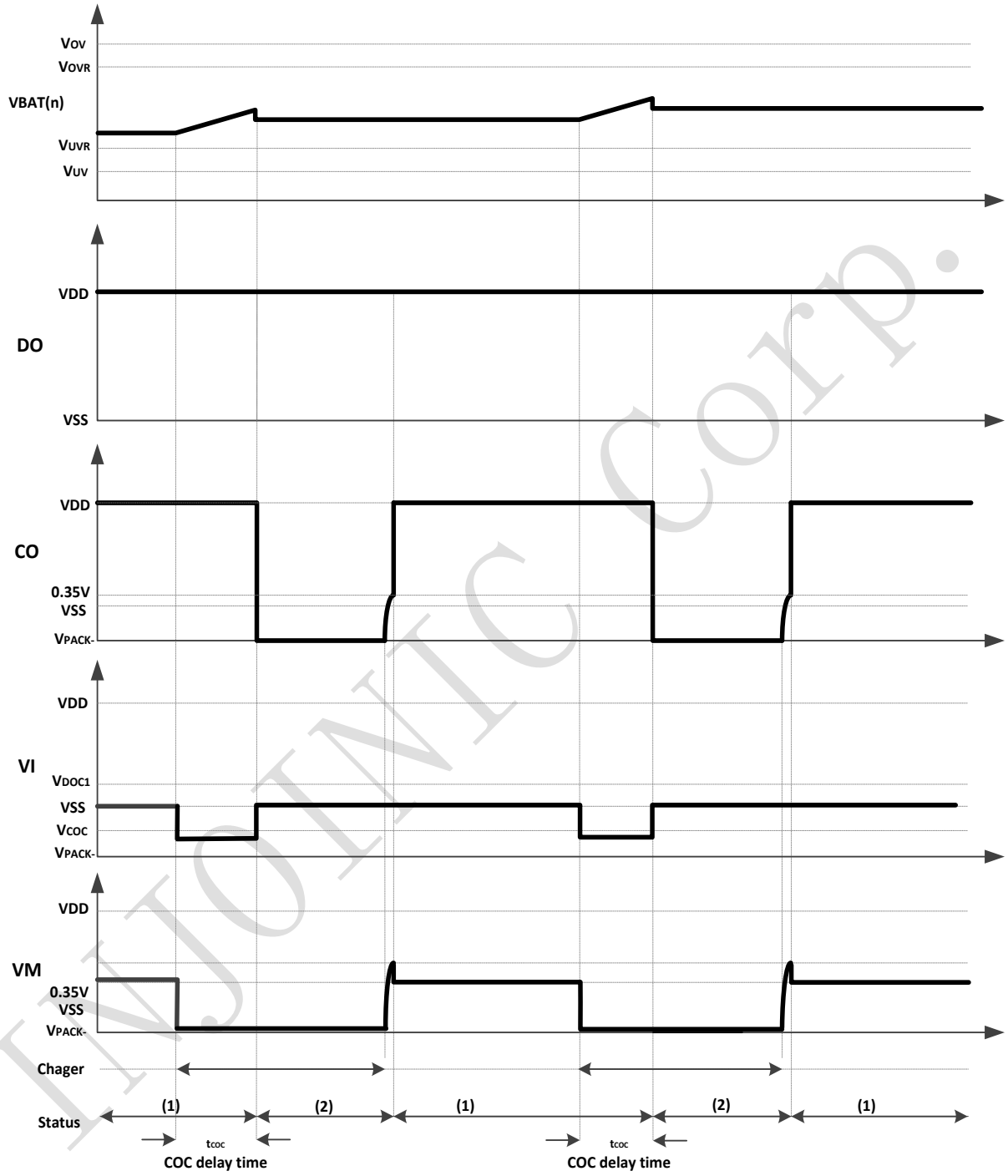


Figure 7: Charge overcurrent protection timing chart

Note： (1) Normal status

(2) Charge overcurrent status

Discharge overcurrent protection

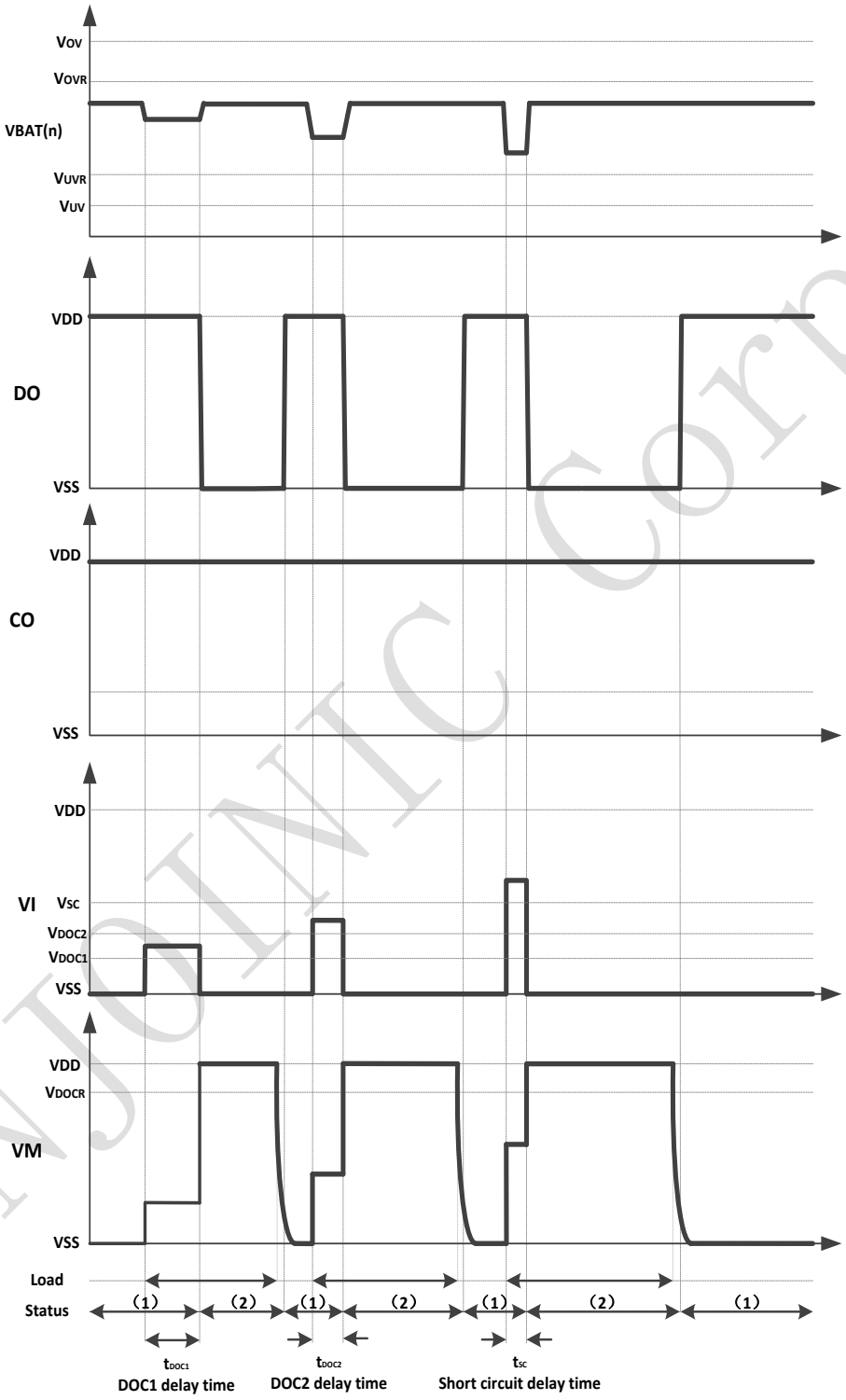


Figure 8: Discharge overcurrent protection timing chart

Note： (1) Normal status

(2) Discharge overcurrent status

Discharge overcurrent release

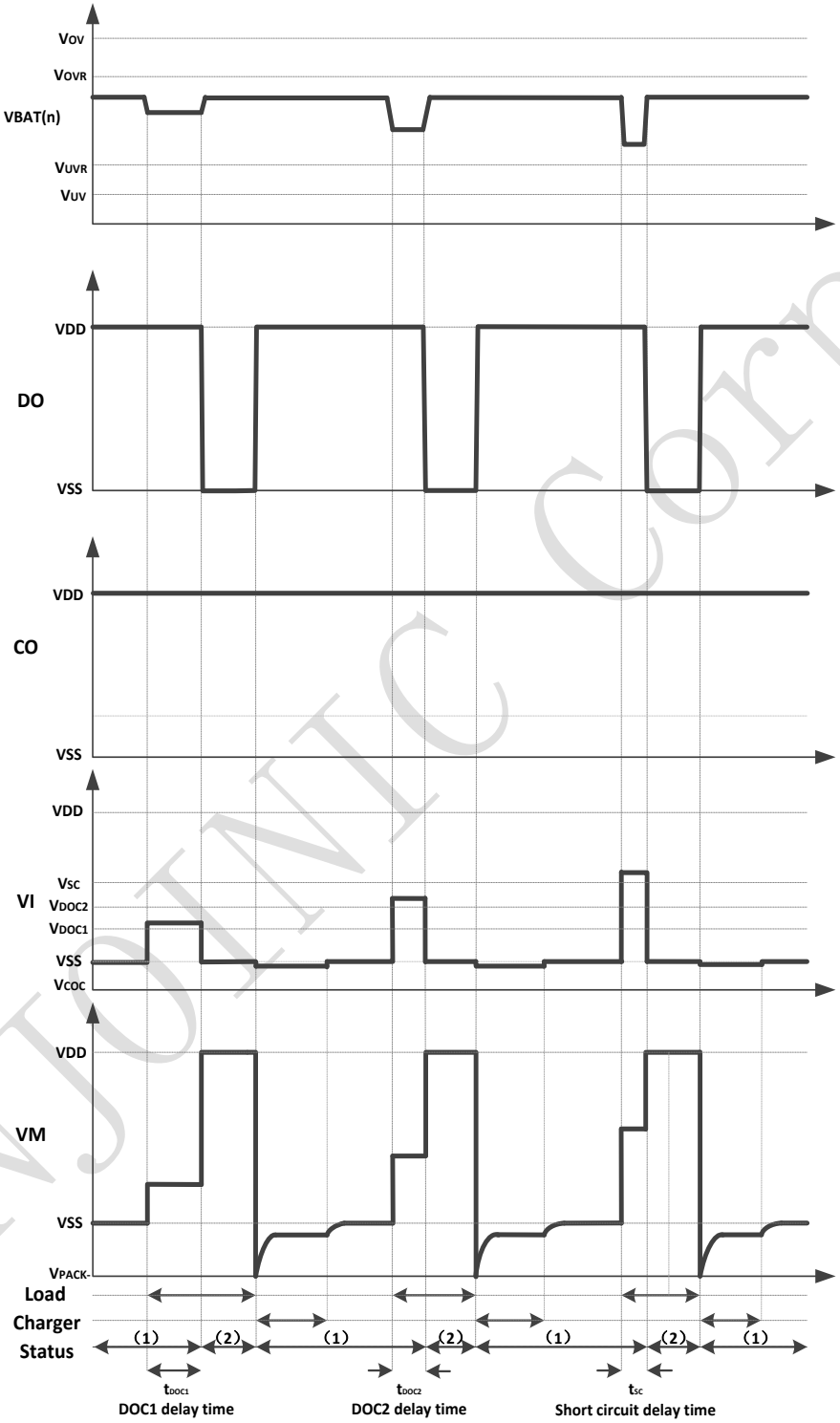


Figure 9: Discharge overcurrent release timing chart

Note： (1) Normal status

(2) Discharge overcurrent status

NTC detection

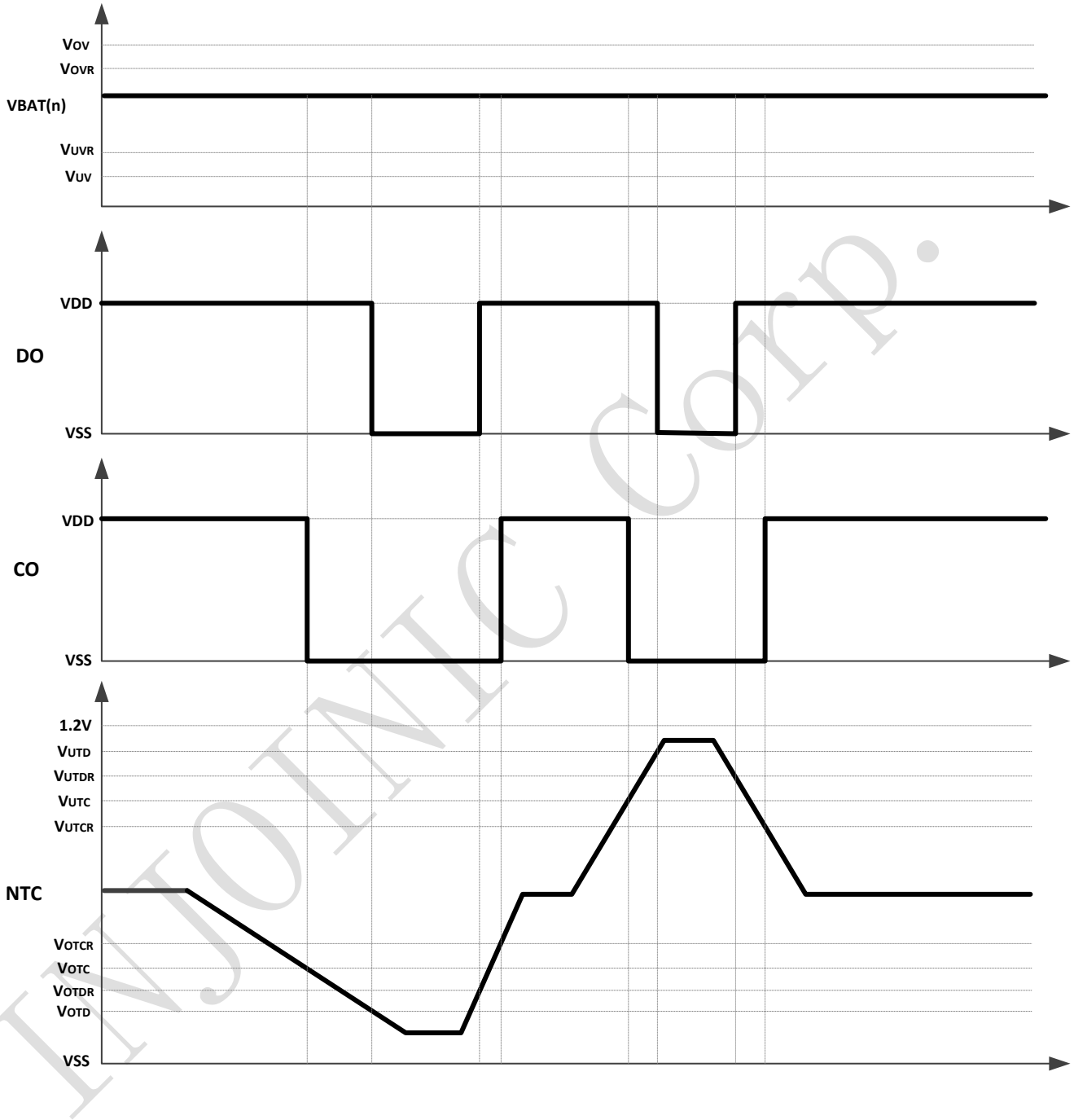


Figure 10: NTC detection timing chart

11 Application Schematic

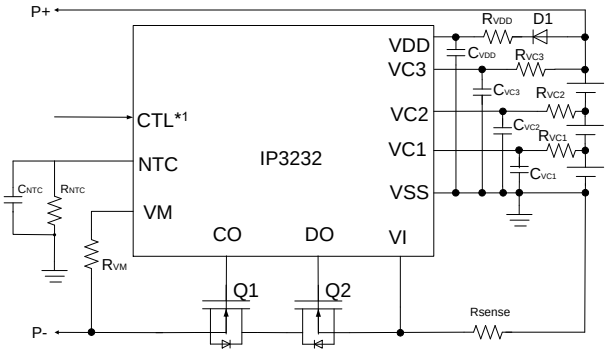


Figure 11: Typical Application for 3-Series Cells

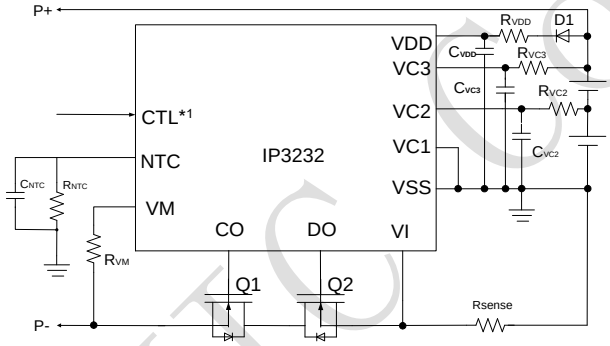


Figure 12: Typical Application for 2-Series Cells

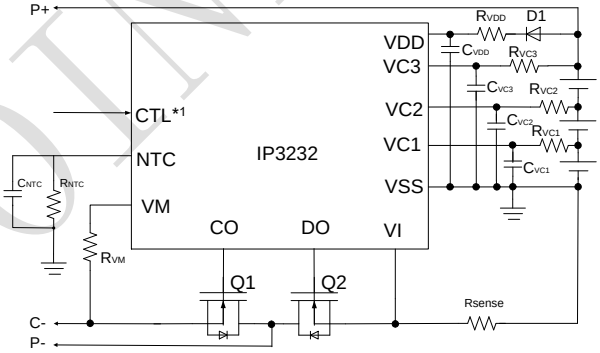


Figure 13: Typical Application for 3-Series Cells with partially separating charging and discharging port

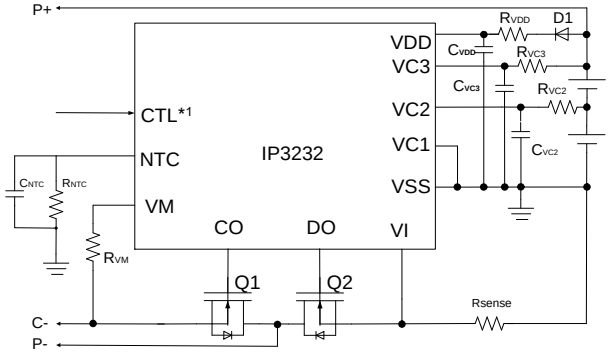


Figure 14: Typical Application for 2-Series Cells with partially separating charging and discharging port

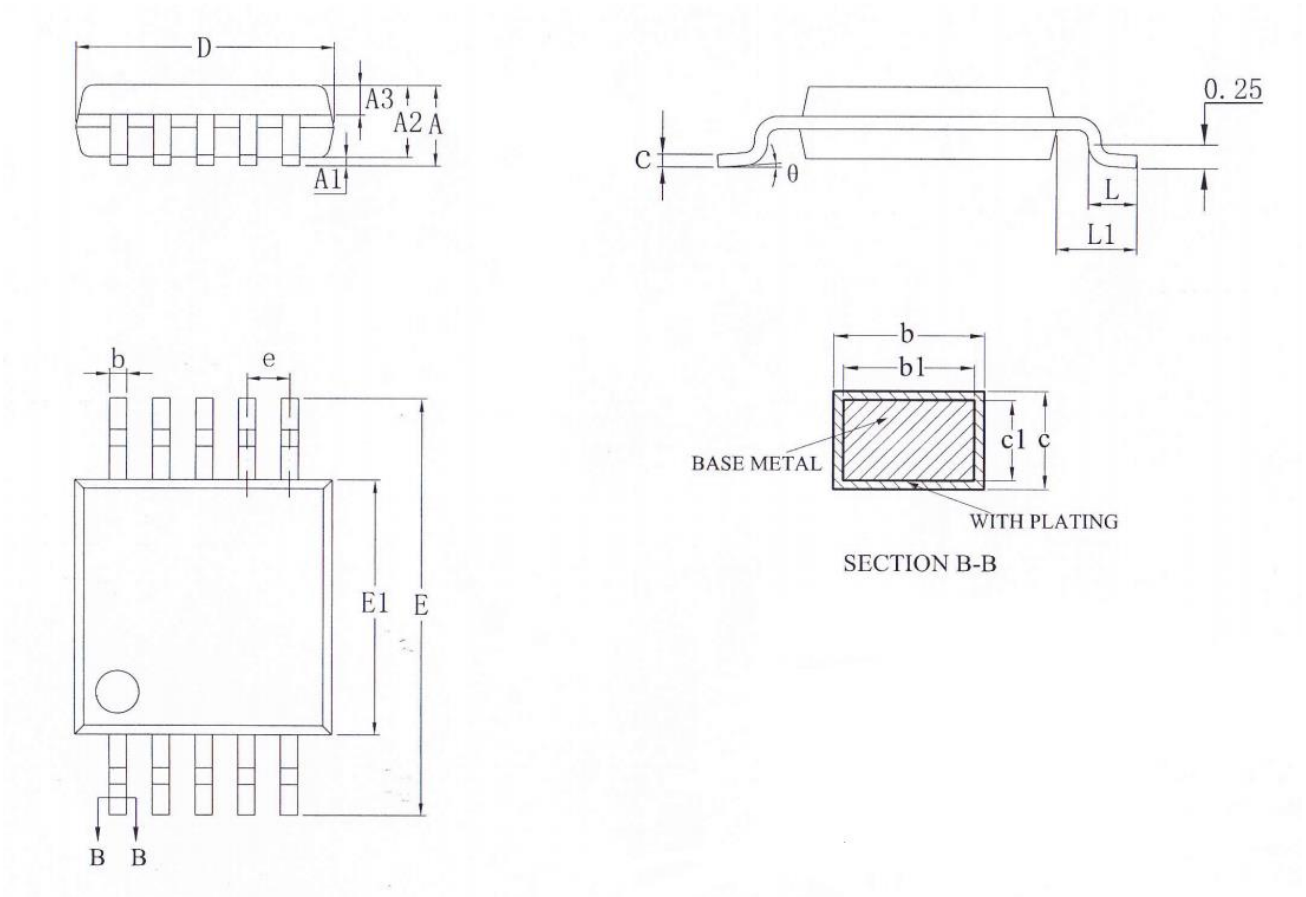
Note：

Symbol	Device	Function	Typ.
R_{VDD}	Resistor	Power RC filter and current-limiting	330Ω
R_{VC3}	Resistor	Power RC filter and current-limiting	330Ω
R_{VC2}	Resistor	Power RC filter and current-limiting	330Ω
R_{VC1}	Resistor	Power RC filter and current-limiting	330Ω
Q1	N MOSFET	Charge protection	
Q2	N MOSFET	Discharge protection	
R_{NTC}	Thermistor	Temperature detection	10k(103AT)
C_{VDD}*[3]	Capacitor	Power RC filter	1μF
C_{VC3}	Capacitor	Power RC filter	1μF
C_{VC2}	Capacitor	Power RC filter	1μF
C_{VC1}	Capacitor	Power RC filter	1μF
C_{NTC}	Capacitor	Power RC filter	10nF
R_{VM}	Resistor	Current-limiting	1kΩ
Rsense	Current sensing resistor	High accuracy current sensing	2mΩ
D1*[4]	BAV21W	VDD protection	

*[3]Note3: In the application of electric tools, the recommended C_{VDD} value is 4.7 μF to 10 μF. Please choose the C_{VDD} value based on the actual current.

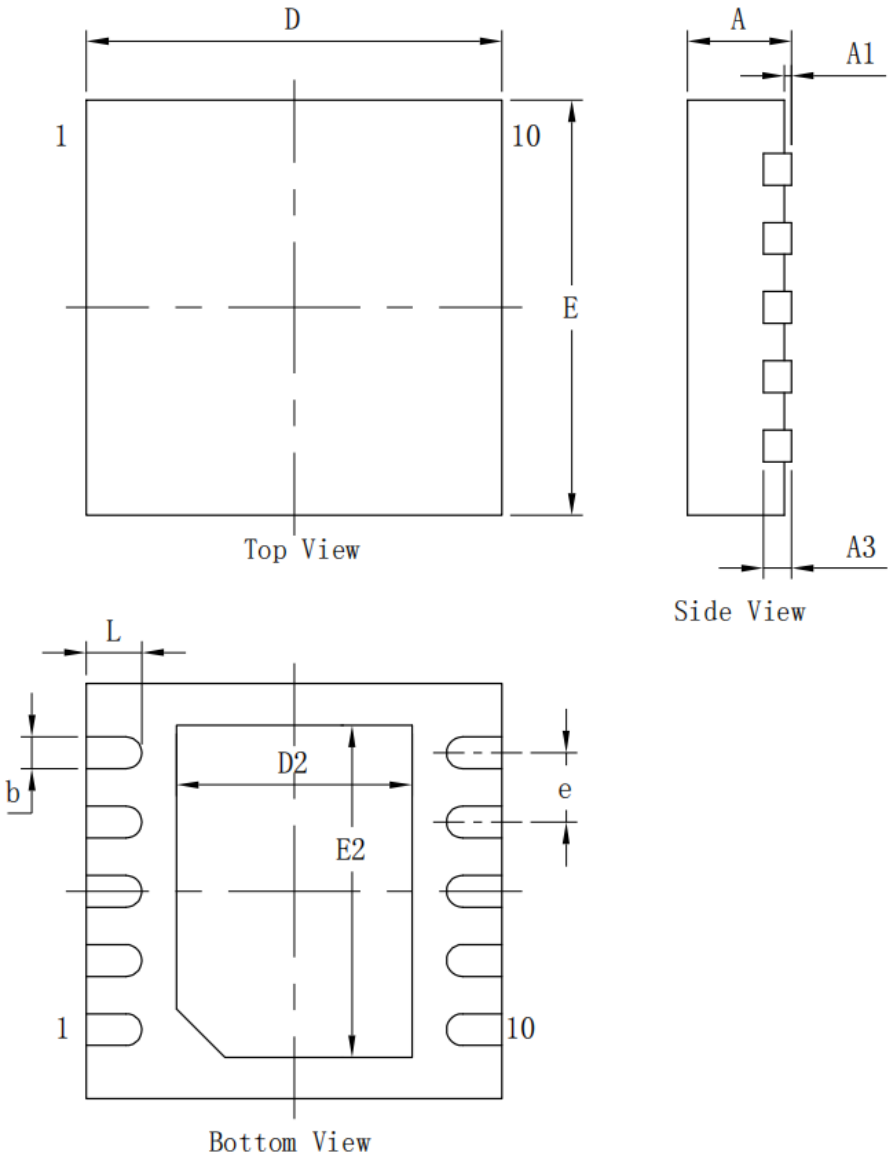
*[4]Note4: In applications such as power battery, if there is an instantaneous surge of load current during startup, please be sure to use the D1 at the VDD pin in the typical application schematic to enhance protection.

12 Part Dimension Specification



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.10
A1	0.05	—	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.18	—	0.26
b1	0.17	0.20	0.23
c	0.15	—	0.19
c1	0.14	0.15	0.16
D	2.90	3.00	3.10
E	4.70	4.90	5.10
E1	2.90	3.00	3.10
e	0.50BSC		
L	0.40	—	0.70
L1	0.95REF		
θ	0	—	8°

Figure 15: IP3232 MSOP10



Symble	DIMENSION IN MM			Symble	DIMENSION IN MM		
	MIN.	NOM.	MAX.		MIN.	NOM.	MAX.
A	0.70	0.75	0.80	E	2.90	3.00	3.10
A1	-	-	0.05	D2	1.60	1.70	1.80
A3	0.203 REF			E2	2.30	2.40	2.50
b	0.18	0.23	0.28	e	0.50 TYP		
D	2.90	3.00	3.10	L	0.35	0.40	0.45

Figure 16: IP3232 DFN10(0303)

13 Mark Description

Note:
1、 --Injoinic logo
2、IP3232YY --Product code
3、XXXXXXXX --Lot number
4、 --PIN1 location

Figure 17: IP3232 DFN10 mark

Note:
1、 --Injoinic logo
2、IP3232MXX --Product code
3、LLLLLL --Lot number
4、● --PIN1 location

Figure 18: IP3232 MSOP10 mark

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