英集芯科技 INJOINIC TECHNOLOGY

IP3221

2-Series lithium-ion/polymer Battery Packs Protector

1 Features

- **High accuracy protection voltage per cell:**
  - ✧ Overcharge protection voltage n (n = 1,2): 3.5V ~ 4.6V (step: 10 mV) Accuracy: ±25 mV
  - ✧ Overcharge release voltage n (n = 1,2): 3.3V ~ 4.6V (step: 50 mV) Accuracy: ±50 mV
  - ✧ Overdischarge protection voltage n (n = 1,2): 2.0V ~ 3.2V (step: 10 mV) Accuracy: ±30 mV
  - ✧ Overdischarge release voltage n (n = 1,2): 2.0V ~ 3.4V (step: 100 mV) Accuracy: ±100 mV
- **Discharge overcurrent protection:**
  - ✧ Discharge overcurrent protection voltage: 0.05V ~ 0.30V (step: 10 mV) Accuracy: ±10 mV
- **Discharge short-circuit protection:**
  - ✧ Discharge short-circuit protection voltage: 0.5V / 1V Accuracy: ±200 mV
- **Charge overcurrent protection:**
  - ✧ Charge overcurrent protection voltage: -0.3V ~ -0.12V (step: 20 mV) Accuracy: ±20 mV
- **Internal delay time**
  - ✧ Overcharge protection delay time: 1s
  - ✧ Overdischarge protection delay time / Discharge overcurrent protection delay time: 128ms/8ms or 1s/1s
  - ✧ Charge overcurrent protection delay time: 8ms
  - ✧ Discharge short-circuit protection delay time: 250µs
- **Independent charge (CHG) and discharge (DSG) FET drivers**
- **Absolute maximum rating is up to 26V**
- **Wide VDD voltage range: 3.3V to 12V**
- **Ultra low quiescent current:**
  - **Normal mode: 5µA (Typ.)**
  - **Power-down mode: 0.1µA**
- **Charger and load detection**
- **Charger locking during overcharge**
- **Power-down function**
- **0V battery charge function permission**
- **Operation temperature: −40°C ~ +85°C**
- **Package: SOT-23-6**

2 Applications

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

3 Description

The IP3221 device is a low-power battery pack protector that provides a primary protection solution for 2-Series lithium-ion/polymer rechargeable battery. The device implements a suite of voltage, current protections for Li-ion/polymer rechargeable battery packs. Protection thresholds and delay time are factory-programmed and available in a variety of configurations.

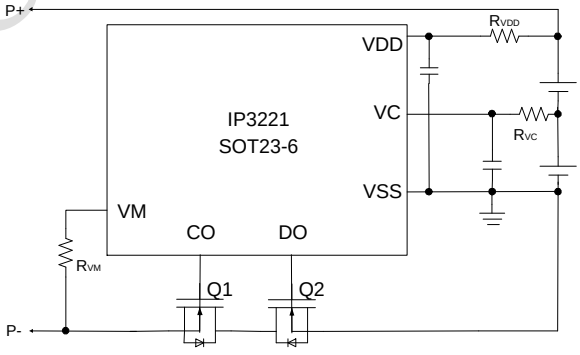


Figure 1: IP3221 Simplified Application Circuit

4 Pin Configuration and Function

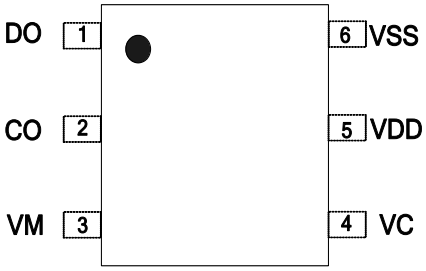


Figure 2: SOT23-6 Pin Assignments

Pin	Name	Description
1	DO	Discharge control FET driver
2	CO	Charge control FET driver
3	VM	Load and adapter detection pin, also the current detection pin
4	VC	Negative terminal for cell 2, positive terminal for cell 1
5	VDD	Positive power supply, connect to positive terminal of cell 2
6	VSS	Negative power supply, connect to negative terminal of cell 1

5 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
VDD pin input voltage	VDD to VSS	-0.3 ~12	V
VC pin input voltage	VC to VSS	VSS-0.3 ~ VDD+0.3	V
DO pin input voltage	DO to VSS	VSS-0.3 ~ VDD+0.3	V
CO pin input voltage	CO to VDD	-26 ~ 0.3	V
VM pin input voltage	VM to VDD	-26 ~ 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	--	12	V
Battery voltage per cell	Vx	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

IP3221 XX

IC CODE
Range from AA to ZZ

Table 1: Product list

Product name	V_{OV}	V_{OVR}	V_{UV}	V_{UVR}	V_{DIOV}	V_{SHORT}	V_{CIOV}	Charger Locking Function	Power-down Function	Delay Time Combination *1
IP3221AA	4.340V	4.140V	2.300V	3.000V	300mV	1.0V	-200mV	Available	Available	（1）
IP3221AB	4.420V	4.220V	3.000V	3.200V	150mV	0.5V	-140mV	Available	Unavailable	（1）
IP3221AC	4.280V	4.080V	2.900V	3.000V	200mV	1.0V	-200mV	Available	Available	（1）
IP3221AD	4.280V	4.080V	2.250V	2.950V	200mV	1.0V	-200mV	Available	Available	（1）
IP3221AE	4.240V	4.040V	2.800V	3.000V	200mV	1.0V	-200mV	Unavailable	Available	（1）
IP3221AF	4.240V	4.040V	2.800V	3.000V	100mV	1.0V	-120mV	Unavailable	Unavailable	（1）
IP3221AG	4.300V	4.150V	2.300V	3.000V	300mV	0.5V	-220mV	Unavailable	Unavailable	（1）
IP3221AH	4.300V	4.100V	2.700V	3.000V	200mV	1.0V	-200mV	Available	Unavailable	（1）
IP3221AI	4.220V	4.070V	2.400V	2.900V	150mV	0.5V	-160mV	Available	Available	（1）
IP3221AJ	4.480V	4.280V	2.850V	3.050V	150mV	0.5V	-160mV	Available	Unavailable	（1）
IP3221AK	4.280V	4.080V	2.800V	3.000V	200mV	0.5V	-220mV	Unavailable	Unavailable	（1）
IP3221AL	4.250V	4.150V	2.700V	3.000V	200mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AM	4.280V	4.080V	2.400V	3.000V	230mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AN	4.230V	4.130V	2.500V	3.000V	200mV	0.5V	-180mV	Unavailable	Available	（1）
IP3221AO	4.280V	4.080V	2.000V	2.700V	200mV	0.5V	-220mV	Available	Available	（2）
IP3221AP	4.350V	4.150V	2.300V	3.000V	200mV	0.5V	-200mV	Available	Available	（1）
IP3221AQ	4.350V	4.150V	2.300V	2.900V	200mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AR	4.250V	4.050V	2.500V	3.000V	200mV	0.5V	-200mV	Unavailable	Available	（1）
IP3221AS	4.280V	4.080V	2.500V	3.000V	150mV	0.5V	-160mV	Available	Available	（1）
IP3221AT	4.480V	4.280V	2.500V	3.000V	60mV	0.5V	-120mV	Available	Available	（1）
IP3221AU	4.250V	4.050V	2.400V	3.000V	200mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AV	4.250V	4.050V	2.400V	3.000V	220mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AW	4.380V	4.180V	2.700V	2.900V	200mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AX	3.750V	3.600V	2.100V	2.300V	200mV	0.5V	-200mV	Available	Available	（1）
IP3221AY	3.650V	3.450V	2.000V	2.500V	200mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221AZ	4.250V	4.100V	3.200V	3.400V	200mV	0.5V	-200mV	Available	Available	（1）
IP3221BA	4.420V	4.220V	2.700V	3.000V	150mV	0.5V	-140mV	Available	Unavailable	（1）
IP3221BB	3.720V	3.570V	2.300V	2.500V	200mV	0.5V	-200mV	Unavailable	Unavailable	（1）
IP3221BC	4.250V	4.150V	2.800V	3.000V	100mV	0.5V	-120mV	Unavailable	Unavailable	（2）
IP3221BD	4.250V	4.100V	3.000V	3.000V	200mV	0.5V	-200mV	Available	Available	（1）
IP3221BE	4.300V	4.150V	2.800V	3.000V	150mV	0.5V	-160mV	Available	Available	（1）
IP3221BF	4.250V	4.050V	2.200V	2.900V	300mV	0.5V	-200mV	Available	Unavailable	（1）
IP3221BG	4.340V	4.140V	2.300V	3.000V	300mV	0.5V	-200mV	Available	Available	（1）
IP3221BI	4.280V	4.080V	2.900V	3.000V	200mV	0.5V	-200mV	Available	Available	（1）
IP3221BJ	4.280V	4.080V	2.250V	2.950V	200mV	0.5V	-200mV	Available	Available	（1）
IP3221BN	4.300V	4.100V	2.700V	3.000V	200mV	0.5V	-200mV	Available	Unavailable	（1）
IP3221CP	4.280V	4.080V	2.250V	2.950V	200mV	1.0V	-200mV	Available	Unavailable	（1）
IP3221DV	4.280V	4.080V	2.250V	2.950V	200mV	0.5V	-200mV	Available	Unavailable	（1）

*1： Refer to Table 2 for details of the delay time.

Note: If you need a product other than the above specifications, please contact our business department.

Table 2： Delay time list

Delay time combinations	Overcharge protection delay time [t_{OV}]	Overdischarge protection delay time [t_{UV}]	Discharge overcurrent protection delay time [t_{DIOV}]	Discharge short-circuit protection delay time [t_{SHORT}]	Charge overcurrent protection delay time[t_{CIOV}]
（1）	1s	128ms	8ms	250μs	8ms
（2）	1s	1s	1s	250μs	8ms

8 Electrical Characteristics

Unless otherwise specified, T_A = -40°C to 85°C, VDD = 7.6V, typical value @T_A=25°C.

Parameter	Symbol	Test Conditions	Min.	Tpy.	Max.	Unit
Quiescent current	I_Q (VDD current)	VDD=7.6V	-	5	8	μA
Shut-down current (Power-down)	I_Q (VDD current)	VDD=4V	-	0.1	0.4	μA
Overcharge protection (n=1,2)	V_{OV}	T_A=25°C	V_{OV}-0.025	3.5~4.6	V_{OV}+0.025	V
Overcharge release voltage (n=1,2)	V_{OVR}	T_A=25°C	V_{OVR}-0.050	3.3~4.6	V_{OVR}+0.050	V
Overdischarge protection voltage(n=1,2)	V_{UV}	T_A=25°C	V_{UV}-0.030	2.0~3.2	V_{UV}+0.030	V
Overdischarge release voltage(n=1,2)	V_{UVR}	T_A=25°C	V_{UVR}-0.1	2.0~3.4	V_{UVR}+0.1	V
0V battery charging starting charger voltage	V_{0CHA}	0V battery charge function permission	1.2	-	-	V
Discharge overcurrent protection voltage	V_{DIOV}	T_A=25°C	V_{DIOV}-10	50~300 STEP:10mV	V_{DIOV}+10	mV
Discharge short-circuit protection voltage	V_{SHORT}	T_A=25°C	V_{SHORT}-200	500 1000	V_{SHORT}+200	mV
Charge overcurrent protection voltage	V_{CIOV}	T_A=25°C	V_{CIOV}-20	-120~-300 STEP:20mV	V_{CIOV}+20	mV
Overcharge protection delay time	t_{OV}	T_A=25°C	t_{OV}×0.8	1000	t_{OV}×1.2	ms
Overdischarge protection delay time	t_{UV}	T_A=25°C	t_{UV}×0.8	128 1000	t_{UV}×1.2	ms
Discharge overcurrent protection delay time	t_{DIOV}	T_A=25°C	t_{DIOV}×0.8	8 1000	t_{DIOV}×1.2	ms
Discharge short-circuit protection delay time	t_{SHORT}	T_A=25°C	t_{SHORT}×0.7	250	t_{SHORT}×1.3	μs
Charge overcurrent protection delay time	t_{CIOV}	T_A=25°C	t_{CIOV}×0.8	8	t_{CIOV}×1.2	ms
VM pull up resistance	R_{VMD}	T_A=25°C	-	1	-	MΩ
VM pull down resistance	R_{VMS}	T_A=25°C	-	20	-	kΩ
DO voltage	V_{DO}	-	V_{VDD}-0.15	-	V_{VDD}	V
CO voltage	V_{CO}	-	V_{VDD}-0.15	-	V_{VDD}	V

9 Functional Description

System Diagram

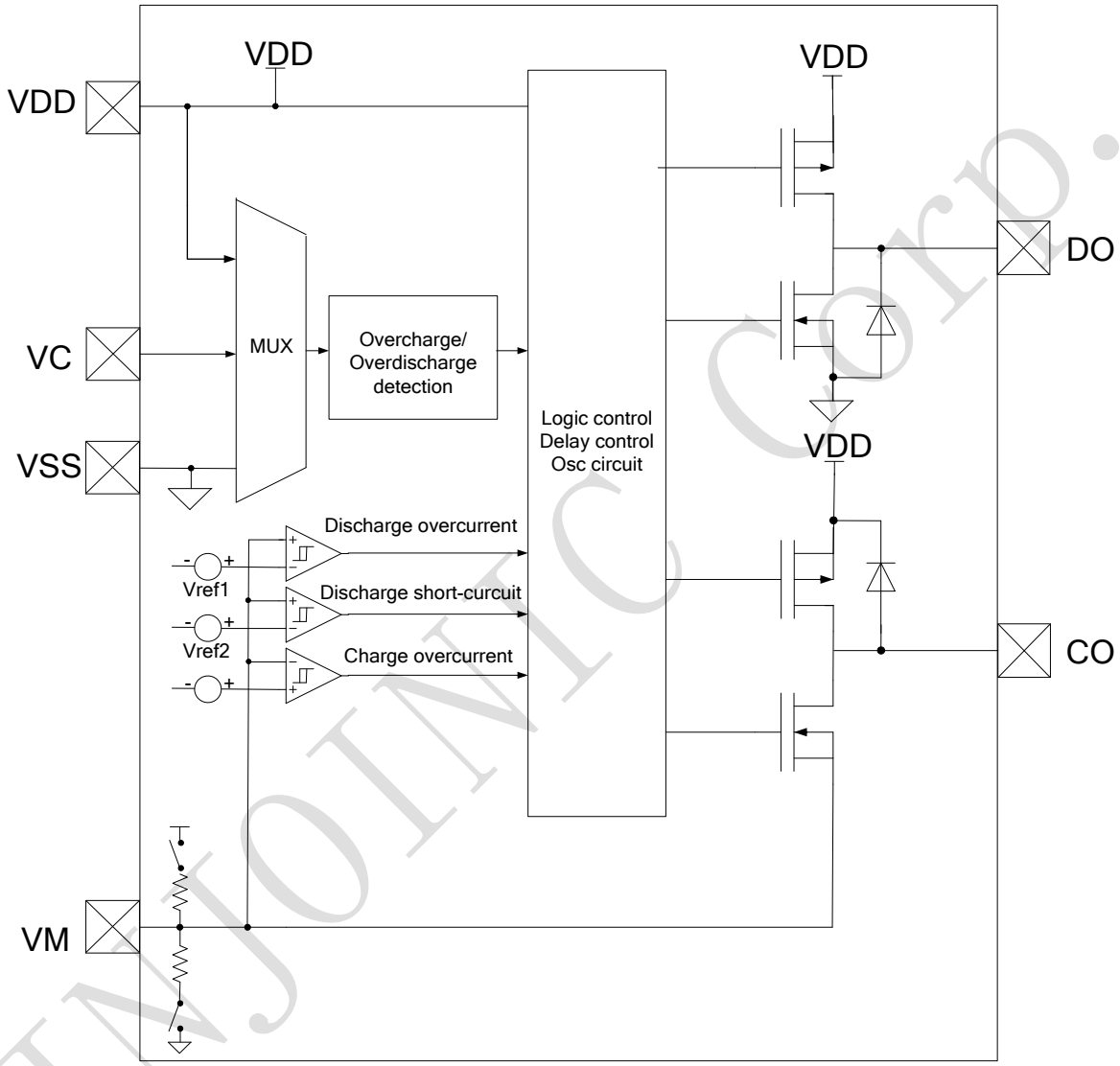


Figure 3: IP3221 Internal System Diagram

Overview

The IP3221 device is a low power dissipation battery pack protector which provides a primary protection solution for 2-Series lithium-ion/polymer rechargeable battery. The device implements a suite of voltage, current 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_{OV} during charging in the normal status and the condition continues for the overcharge protection delay time (t_{OV}) or longer, IP3221 turns the charging control FET (Q1) off to stop charging, the CO pin will be pulled down to the VM pin. This condition is called the overcharge status. The overcharge release delay time is internally fixed at 4ms. The overcharge status is released in the following cases:

With Overcharge Locking Function:

• When the charger is not existed and all the cell battery voltages fall below the overcharge release voltage (V_{OVR}), IP3221 will release the overcharge status.

• When the charger is not existed and the load is connected, all the cell battery voltages fall below V_{OV}, IP3221 releases the overcharge status.

Note: When the charger is detected, that is the voltage of the negative terminal (VM) is lower than the charge overcurrent protection voltage threshold (V_{CIOV}), even if the voltage of each battery falls below the overcharge release voltage (V_{OVR}), the overcharge state will not be released.

Without Overcharge Locking Function:

•When all the cell battery voltages fall below overcharge release voltage (V_{OVR}), IP3221 releases the overcharge status.

• When the charger is not existed and the load is connected, all the cell battery voltages fall below V_{OV}, IP3221 releases the overcharge status.

Overdischarge Status

When any cell battery voltage falls below V_{UV} during discharging in the normal status and the condition continues for the overdischarge protection delay time (t_{UV}) or longer, IP3221 turns the discharging control FET (Q2) off to stop discharging. This condition is called the overdischarge status.

Under the overdischarge status, the VM pin and VDD pin are shorted by R_{VMD}. The VM pin is pulled up by R_{VMD}.

The overdischarge status is released in the following cases:

With Power-down Function:

Under the overdischarge status, when the VM voltage is pulled up, the power-down function works and the current consumption is lower than 100nA.

• When the charger is connected, the voltage of the VM terminal is lower than the charge overcurrent protection voltage threshold (V_{CIOV}), and the voltage of each cell reaches V_{UV} or higher, the overdischarge state is released.

• When the charger is connected, the voltage of the VM terminal is higher than the charge overcurrent protection voltage threshold (V_{CIOV}), and the voltage of each cell reaches V_{UVR} or higher, the overdischarge state is released.

Note: When the charger is not connected, even if the voltage of each battery is higher than the overdischarge release voltage (V_{UVR}), the overdischarge state will not be released.

Without Power-down Function:

• When the charger is connected, the voltage of the VM terminal is lower than the charge overcurrent protection voltage threshold (V_{CIOV}), and the voltage of each cell reaches V_{UV} or higher, the overdischarge state is released.

• When the charger is connected, the voltage of the VM terminal is higher than the charge overcurrent protection voltage threshold (V_{CIOV}), and the voltage of each cell reaches V_{UVR} or higher, the overdischarge state is released.

• When the charger is not connected, IP3221 releases the overdischarge status when the each battery voltage reaches V_{UVR} or higher.

Discharge Overcurrent Status

When a battery in the normal status is in the status where the voltage of the VM pin is equal to or higher than V_{DIOV} because the discharge current is equal to or higher than the specified value and the status lasts for the discharge overcurrent protection delay time (t_{DIOV}) or longer, the discharging control FET (Q2) will be turned off and discharging is stopped. This status is called the discharge overcurrent status.

In the discharge overcurrent status, the VM pin and VSS pin are shorted by the R_{VMS}. The voltage of the VM pin is at the VDD potential due to the load as long as the load is connected. When the load is disconnected, the VM pin returns to the VSS potential. If the voltage of the VM pin is lower than V_{DIOV}, IP3221 releases the discharge overcurrent status.

Discharge Short-circuit Status

When a battery in the normal status is in the status where the voltage of the VM pin is equal to or higher than V_{SHORT} because the discharge current is equal to or higher than the specified value and the status lasts for the discharge short-circuit protection delay time (t_{SHORT}) or longer, the discharging control FET (Q2) will be turned off and discharging is stopped. This status is called the discharge short circuit status.

The method of releasing the short-circuit discharge overcurrent state is the same as that of the discharge overcurrent status.

Charge Overcurrent Status

When a battery in the normal status is in the status where the voltage of the VM pin is equal to or lower than V_{CIOV} because the charge current is equal to or higher than the specified value and the status lasts for the charge overcurrent protection delay time (t_{CIOV}) or longer, the charging control FET (Q1) is turned off and charging is stopped. This status is called the charge overcurrent status.

IP3221 releases the charge overcurrent status when the VM pin voltage is higher than the charge overcurrent protection voltage by removing the charger or connecting load.

The charge overcurrent protection function doesn't work is in the overdischarge status.

0V Battery Charge Function Permission

This function is used to recharge a connected battery whose voltage is 0V due to self-discharge. When the 0V battery charge starting charge voltage (V_{0CHA}) or a higher voltage is applied between the P+ and P- pins by connecting a charger, the charging control FET (Q1) is fixed to the VDD potential. When the voltage between the gate and source of the charging control FET (Q1) becomes equal to or higher than the threshold voltage due to the charger voltage, the charging control FET (Q1) is turned on to start charging. At this time, the discharge control FET (Q2) is turned off and the charge current flows through the internal parasitic diode in the discharge control FET (Q2). IP3221 will returns to normal status when the battery voltage becomes equal to or higher than V_{UV}.

10 Sequence Charts

Overcharge Protection and Overdischarge Protection

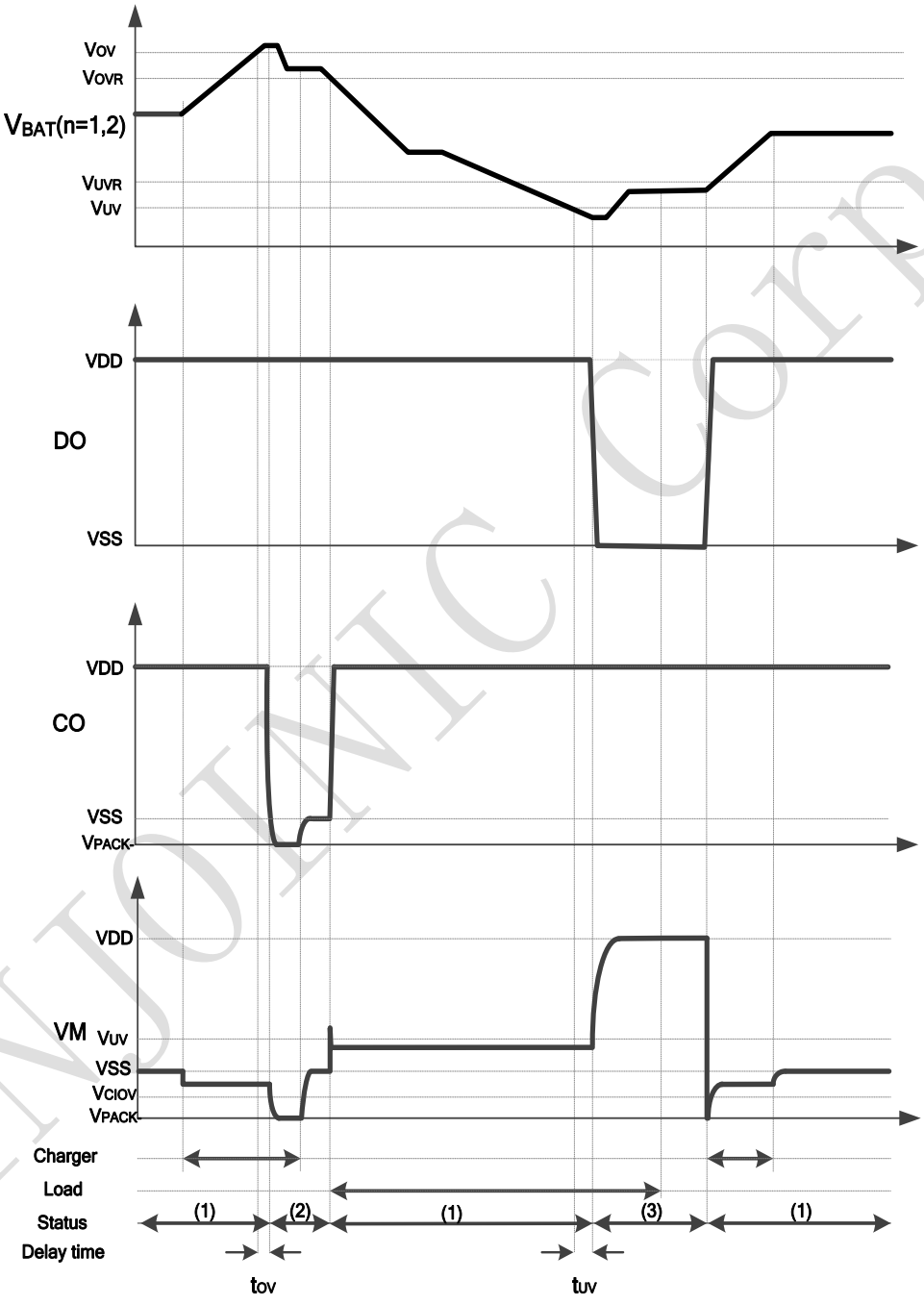


Figure 4: Overcharge protection and overdischarge protection timing chart

Note: (1) Normal status
(2) Overcharge status
(3) Overdischarge status

Discharge Overcurrent Protection

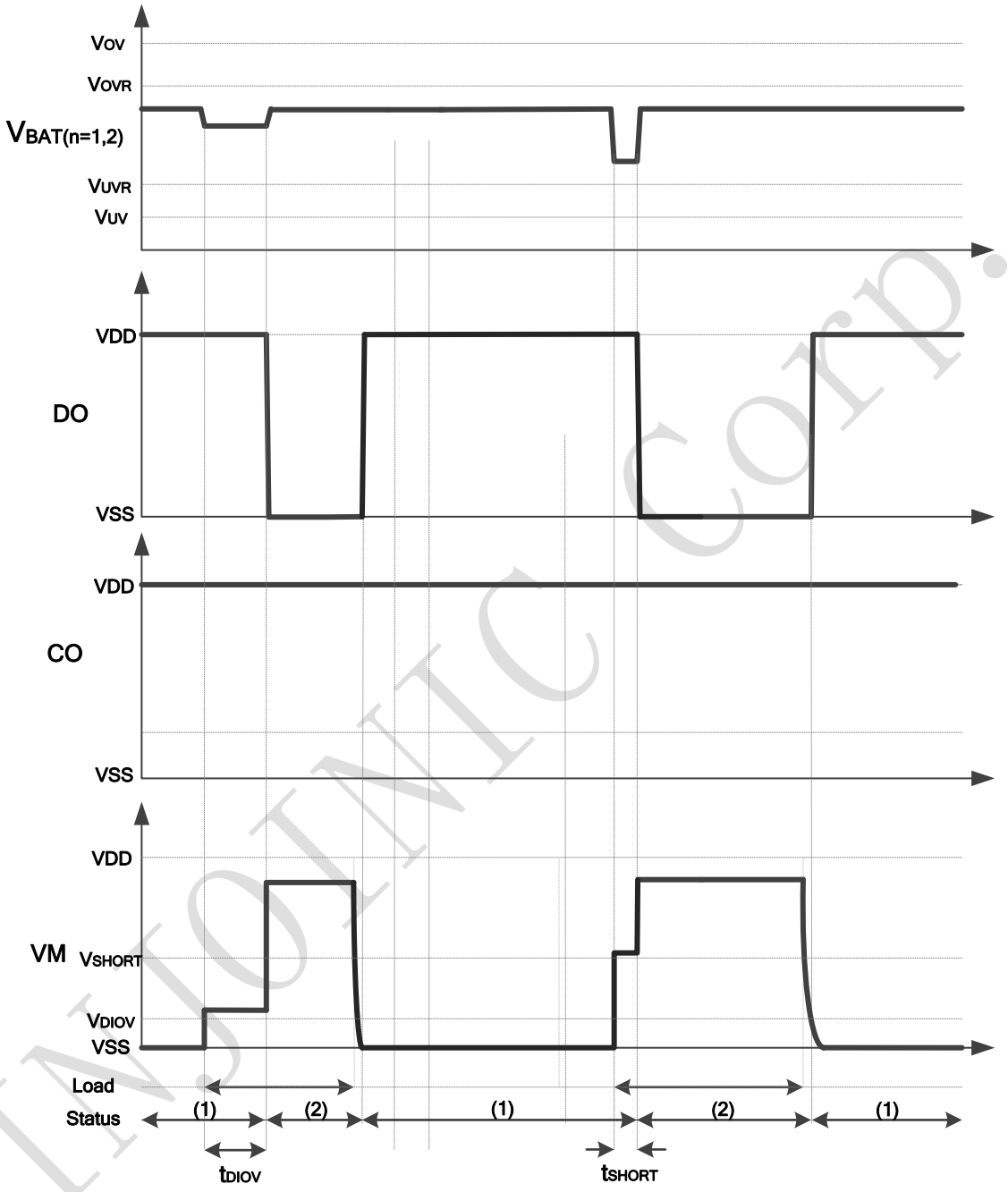


Figure 5: Discharge overcurrent protection timing chart

Note: (1) Normal status

(2) Discharge overcurrent status

Discharge Overcurrent Release

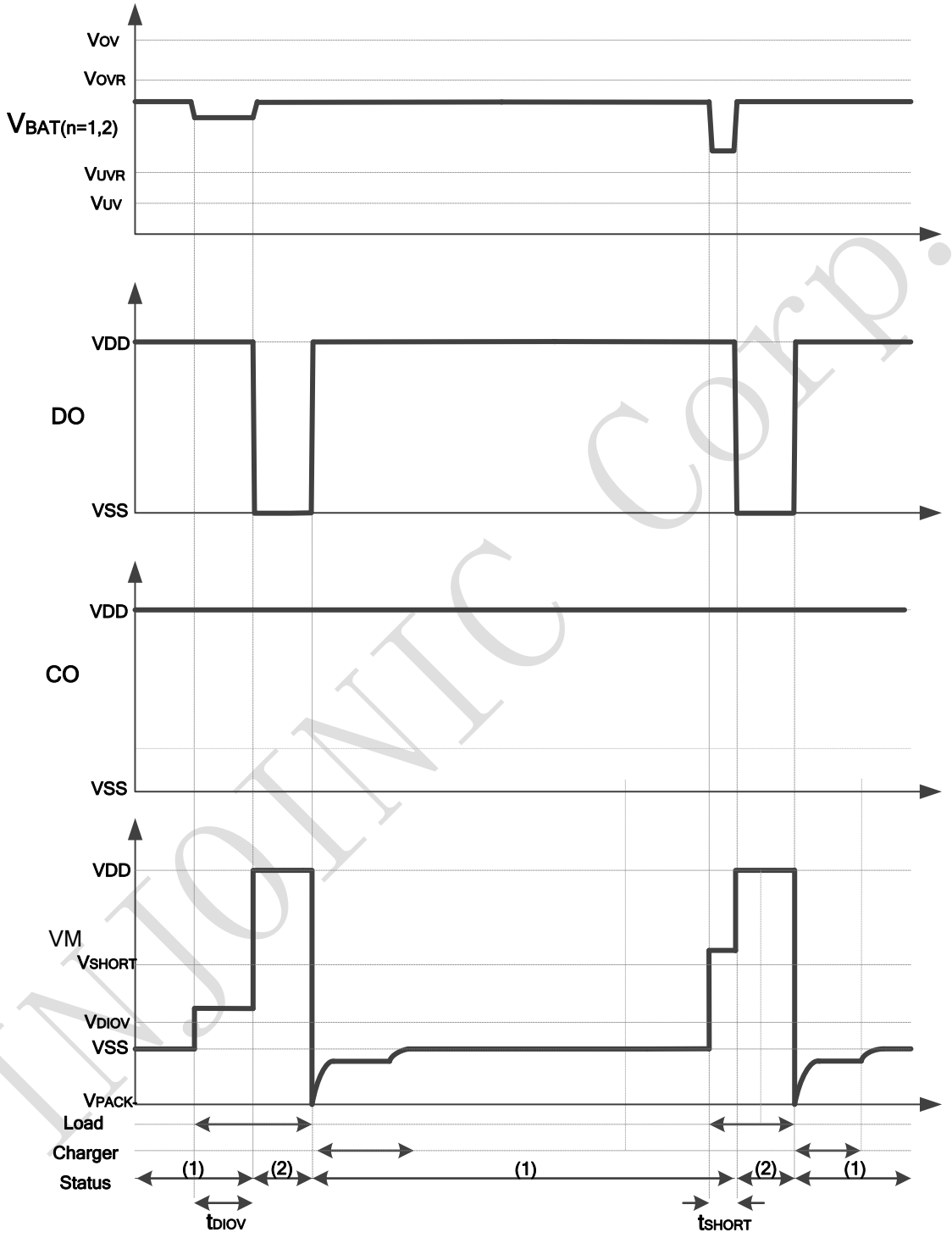


Figure 6: Discharge overcurrent release timing chart

Note： (1) Normal status

(2) Discharge overcurrent status

Charge Overcurrent Protection

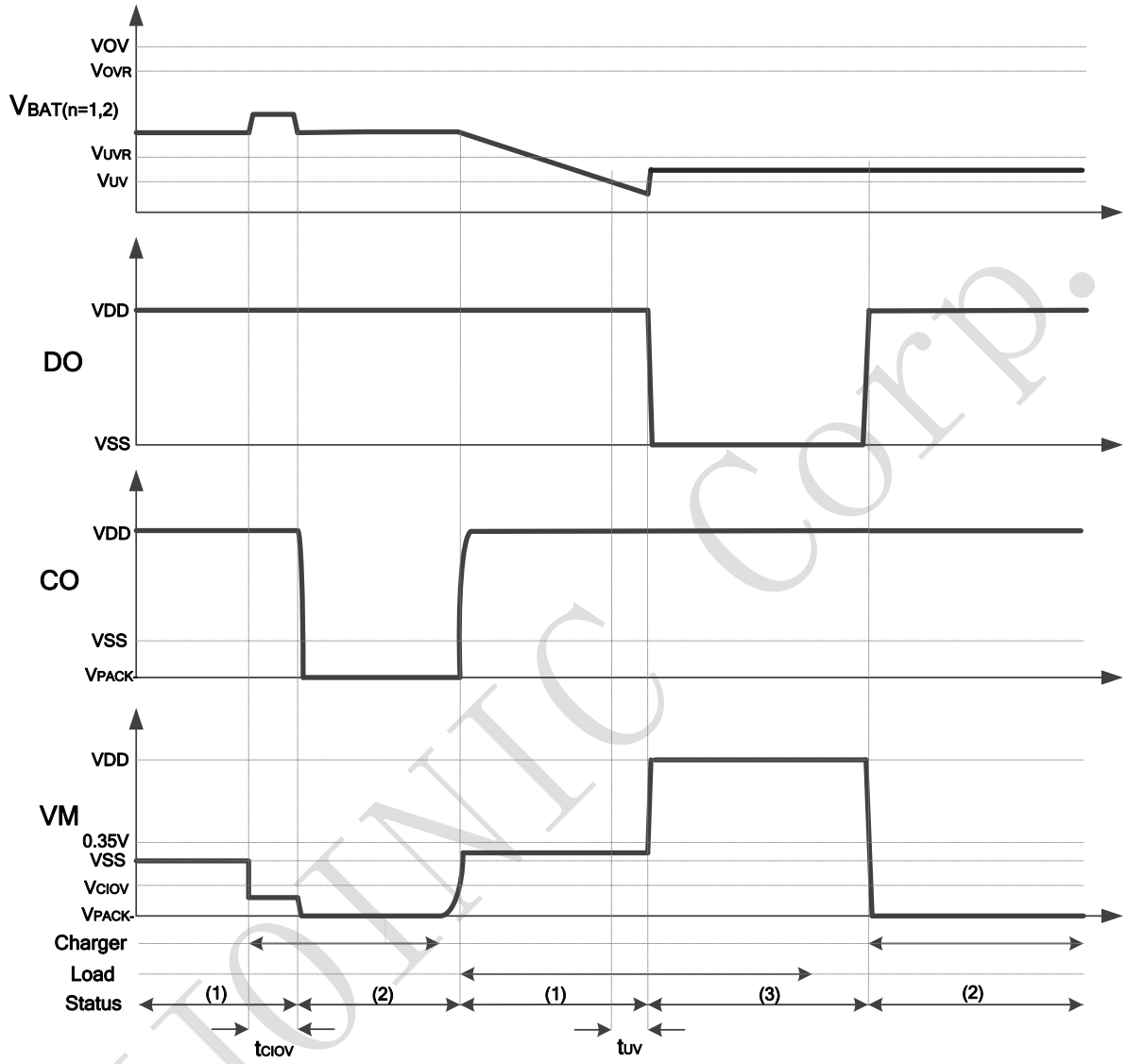


Figure 7: Charge overcurrent timing chart

Note： (1) Normal status

(2) Charge overcurrent status

(3) Overdischarge status

11 Application Schematic

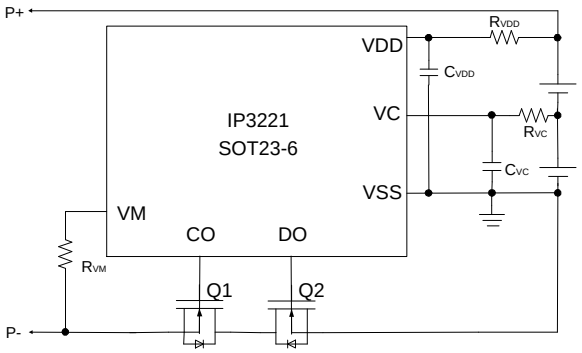


Figure 8: IP3221 typical Application

Table 3: BOM list

Symbol	Device	Function	Typ.	Description
R_{VDD}	Resistor	Power RC filter and current-limiting	4.7kΩ	*1
C_{VDD}	Capacitor	Power RC filter	0.1μF	*2
R_{VC}	Resistor	Power RC filter and current-limiting	4.7kΩ	*1
C_{VC}	Capacitor	Power RC filter	0.1μF	*2
R_{VM}	Resistor	ESD protection and reverse connection of a charger protection	2kΩ	*3
Q1	N MOSFET	Charge control		*4
Q2	N MOSFET	Discharge control		*5

*1. The resistance values of R_{VDD} and R_{VC} are determined by verification, please do not change them arbitrarily.

*2. The capacitor C_{VDD} and C_{VC} can stabilize the voltage, so do not use the capacitor whose value is below 0.1μF.

*3. Select as large a resistance as possible to prevent large current when a charger is connected in reverse. However, if the resistance value of R_{VM} is too high, the charge current may not be cut.

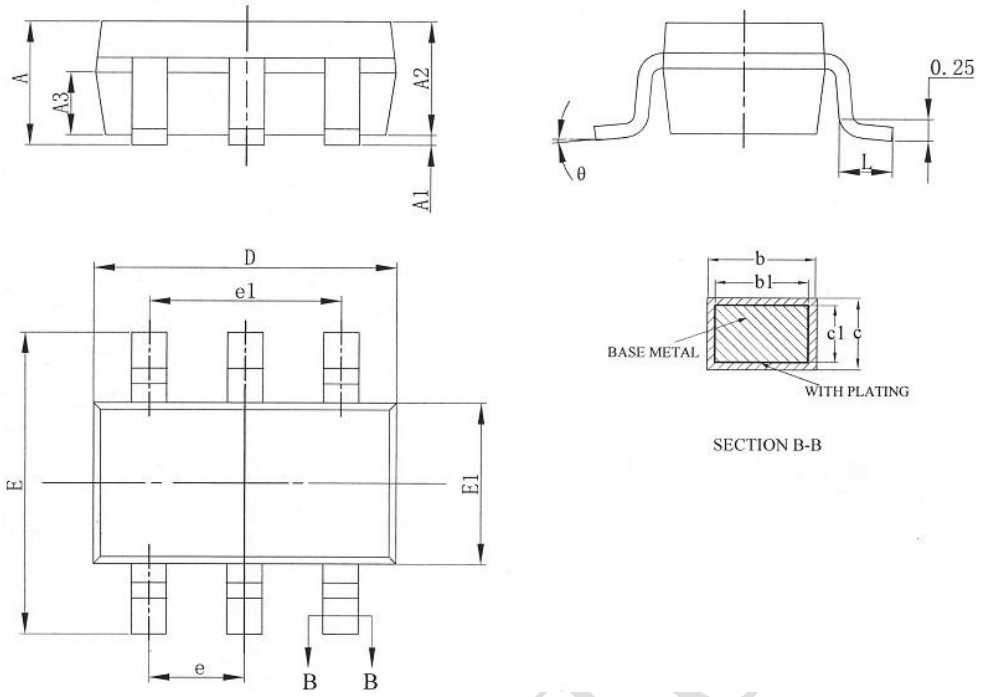
*4. The N-MOSFET may be damaged if the absolute maximum rating of V_{GS} is lower than the charger voltage.

*5. The discharge may be cut before the overdischarge protection if using a N-MOSFET whose $V_{GS(th)}$ is lower than the overdischarge detection voltage.

Caution:

1. The above constants may be changed without notice, please contact us to get the latest datasheet in time.
2. If the external components need to be adjusted, please perform thorough evaluation using the actual application to set the constant.
3. For other applications, please consult our FAE.

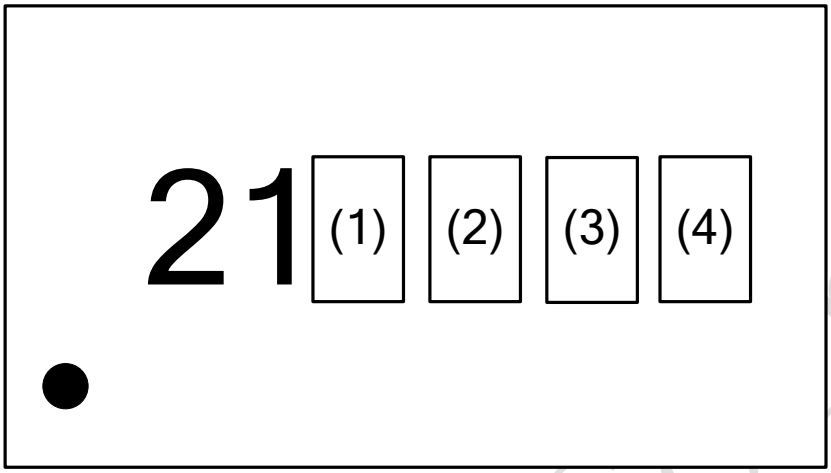
12 Part Dimension Specification



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.25
A1	0.04	—	0.10
A2	1.00	1.10	1.20
A3	0.55	0.65	0.75
b	0.38	—	0.48
b1	0.37	0.40	0.43
c	0.11	—	0.21
c1	0.10	0.13	0.16
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95BSC		
e1	1.90BSC		
L	0.30	—	0.60
θ	0	—	8°

Figure 9: IP3221 SOT23-6

13 Mark Description



1.21 ---Refer to IP3221
2.(1) (2) ---Product Code(AA~ZZ)
3.(3) (4) ---Lot number
4.● ---Pin1 Location

Figure 10: IP3221 SOT23-6 mark

Note: Please confirm with the marketing staff for the final mark.

14 Important Notice

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