General description /产品概述

The BM301 is a professional protection IC for 3 cells rechargeable battery pack; it is highly integrated, high accuracy and generally used in power tools, electric bicycle and UPS applications. The BM301 works constantly to monitor each cell's voltage, the current of charge or discharge, wire breaking or not and temperature of the environment to provide overcharge, over-discharge, discharge overcurrent, short circuit, charge overcurrent, breaking wire and temperature protections, etc. Besides, it also can change the protection delay time of over-discharge and discharge overcurrent by setting the internal fuse.

BM301 系列 IC 是一款高精度、高集成度的专用 3 节可充电电池保护芯片，适用于电动工具、吸尘器以及小型后备电源等。芯片通过检测各节电池的电压、充放电电流、环境温度以及采样线通断等信息实现电池过充、过放、放电过电流、短路、充电过电流、高温以及断线等保护功能，通过内部修调选择来调节过充、过放、放电过流保护延时。

Features /产品特点

(1) High-accuracy voltage detection for each cell
各节电池的高精度电压检测功能

• Overcharge threshold 过充电检测电压	3.6 V ~ 4.6 V	accuracy: ±25 mV (+25℃) 精度±25 mV（+25℃） accuracy: ±40 mV (-40℃ to +85℃) 精度±40 mV（-40℃至+85℃）
• Overcharge hysteresis 过充电迟滞电压	0.12 / 0.25 V	accuracy: ±50 mV 精度±50 mV
• Over-discharge threshold 过放电检测电压	1.6 V ~ 3.0 V	accuracy: ±80 mV 精度±80 mV
• Over-discharge hysteresis 过放电迟滞电压	0 / 0.2 / 0.4 V	accuracy: ±100 mV 精度±100 mV

(2) Three grades voltage detection of discharge overcurrent
3 段放电过电流检测功能

• Discharge overcurrent 1 过电流检测电压 1	0.030 / 0.050 / 0.100 / 0.150 V	accuracy: ±15 mV 精度±15 mV
• Discharge overcurrent 2 过电流检测电压 2	0.075 / 0.250 / 0.300 / 0.400 V	
• Short circuit 短路检测电压	0.400 / 0.500 / 0.600 / 0.800 V	

(3) Charge overcurrent detection
充电过电流检测功能

• Detection voltage 充电过电流检测电压	-0.030 / -0.050 / -0.1 V

(4) Setting of output delay time
延时内置可选
Over-discharge, discharge overcurrent 1 and discharge overcurrent 2 protection delay time can be setting the inside fuse.

・通过修调选择设置内置过充电、过放电、放电过流 1、放电过流 2 等保护延迟时间

(5) Overcharge temperature protection
充放电高温保护功能

(6) Charger detection, load detection
充电器负载检测功能

(7) Wide operation temperature range:-40℃~85℃
宽工作温度范围：-40℃~85℃

(8) Breaking wire protection
断线保护功能

(9) Low power consumption:
低功耗：

・Operation mode 12 uA （+25℃）
工作时

・Sleeping mode 5 uA （+25℃）
休眠时

Package /封装形式

・MSOP10 /SSOP10

Applications /应用领域

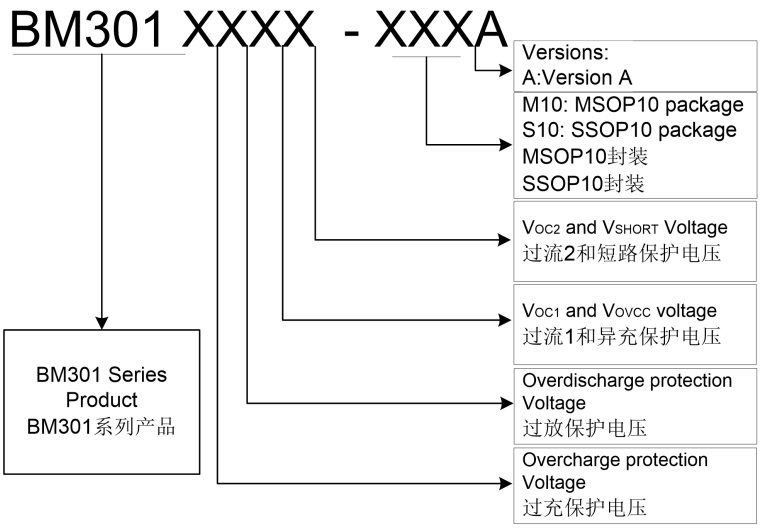
・Power tool /电动工具
・Notebook /笔记本电脑
・UPS backup battery /后备电源

Product catalogue /产品选型

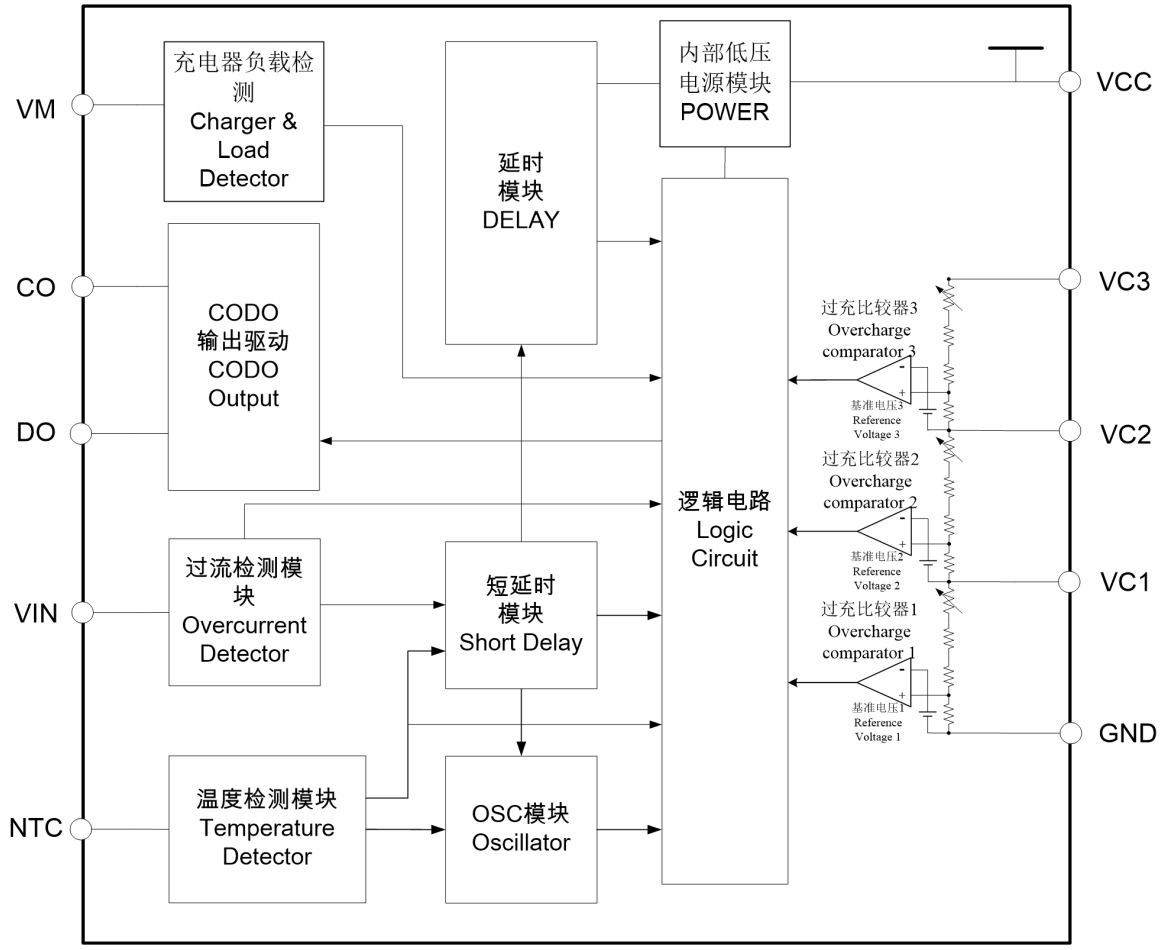
型号/项目	过充电检测电压 V_{DET1}	过充电解除电压 V_{REL1}	过放电检测电压 V_{DET2}	过放电解除电压 V_{REL2}	放电过流 1 检测电压 V_{OC1}	放电过流 2 检测电压 V_{OC2}	短路检测电压 V_{SHORT}	充电过流检测电压 V_{OVCC}	温度保护选择 Temp
BM301TNDB-M10A	4.250V	4.130V	2.800V	3.000V	0.100V	0.250V	0.500V	-0.05V	55℃/75℃
BM301TJDB-M10A	4.250V	4.130V	2.500V	2.700V	0.100V	0.250V	0.500V	-0.05V	55℃/75℃
BM301BFGB-M10A	3.650V	3.450V	2.130V	2.410V	0.100V	0.250V	0.500V	-0.08V	55℃/75℃
BM301RMDB-M10A	4.200V	4.080V	2.750V	3.000V	0.100V	0.250V	0.500V	-0.05V	50℃/70℃
BM301TNDB-S10A	4.250V	4.130V	2.800V	3.000V	0.100V	0.250V	0.500V	-0.05V	55℃/75℃

备注：温度保护默认为充电过温 55℃，放电过温 75℃。
另可选择充电过温 50℃，放电过温 70℃。若有此需求，请与我司联系。

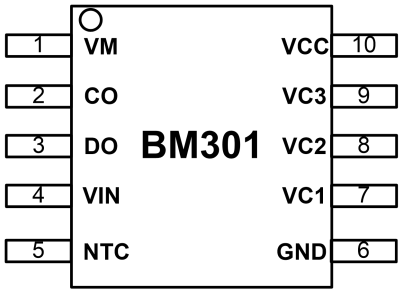
Products name structure /产品命名规则



Block Diagram /功能框图



Pin Configurations /引脚排布



Top View

Pin number 引脚号	name 名称	Description 描述
1	VM	Voltage detection terminal 1 for detecting load or charger 过放和过电流保护锁定、充电器及负载检测端子
2	CO	Charge power MOSFET control terminal, high level and Hi-Z output 充电控制 MOS 栅极连接端子，高电平与高阻态输出
3	DO	Discharge power MOSFET control terminal, CMOS output 放电控制 MOS 栅极连接端子，CMOS 输出
4	VIN	Charge and Discharge overcurrent Voltage detection terminal 2 放电过电流及充电过电流检测端子
5	NTC	Cell temperature detection 接负温度系数热敏电阻，用于温度检测
6	GND	Ground pin of the IC, Cell1 negative input 芯片的地、电池 1 的负电压连接端子
7	VC1	Cell1 positive input, Cell2 negative input 电池 1 的正电压、电池 2 的负电压连接端子
8	VC2	Cell2 positive input, Cell3 negative input 电池 2 的正电压、电池 3 的负电压连接端子
9	VC3	Cell3 positive input 电池 3 的正电压
10	VCC	Power supply,Cell3 positive input 芯片的电源、电池 3 的正电压连接端子

Absolute Maximum Ratings /绝对最大额定值

Item 项目	Symbol 符号	Description 适用端子	Ratings 绝对最大额定值	Unit 单位
Power supply voltage 电源电压	VCC	-	GND-0.3 ~ GND+30	V
Single cell input voltage 各节电池电压	VC_N	VC3、VC2、VC1	GND-0.3 ~ GND+6	V
CO output voltage CO 输出端子电压	V_{CO}	CO	GND-20 ~ VCC+0.3	V
Operating temperature 工作环境温度	T_A	-	-40 ~ +85	℃
Storage temperature 贮存温度	T_{STG}	-	-40 ~ +125	℃
HBM 人体模型静电放电	V_{ESD}	-	2000	V

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded in any conditions.

注意：绝对最大额定值是指无论在任何条件下都不能超过的额定值。一旦超过此额定值，有可能造成产品劣化等物理性损伤。

Electrical Characteristics /电气特性

（TA=25℃ unless otherwise specified）（除特殊说明外：TA=25℃）

Item 项　目		Symbol 符号	Test conditions*1 测试条件*1	Min 最小值	Typ 典型值	Max 最大值	Unit 单位	Test circuit
Power supply voltage 电源电压		VCC	-	5	-	30	V	1
Operating consumption 正常功耗		I_{VCC}	V1=V2=V3=3.5V	-	12	18	μA	
VC3 功耗		I_{VC3}	V1=V2=V3=V4=3.5V	-	2	4	μA	
Sleeping consumption 休眠功耗		I_{STB}	V1=V2=V3=2.0V	-	5	10	μA	
Overcharge 过充电	Protection threshold 保护阈值	V_{DET1}	V1=V2=3.5V V3=3.5→4.4V	V_{DET1} -0.025	V_{DET1}	V_{DET1} +0.025	V	2
	Protection delay time 保护延时	T_{OV}	V1=V2= 3.5V C_{OV}=0.1μF V3=3.5V→4.4V	512	1024	1536	ms	
	Release threshold 解除阈值	V_{REL1}	V1=V2=3.5V V3=4.4V→3.5V	V_{REL1} -0.05	V_{REL1}	V_{REL1} +0.05	V	

	Release delay time 解除延时	T_{REL1}	V1=V2=3.5V V3=4.4V→3.5V	8	16	24	ms	
	Temperature factor(1) 温度系数 1	K_{U1}	Ta= -40℃ to 85℃	-0.6	0	0.6	mV/℃	
Over-discharge 过放电	Protection threshold 保护阈值	V_{DET2}	V1=V2=3.5V V3=3.5V→2.0V	V_{DET2} -0.08	V_{DET2}	V_{DET2} +0.08	V	
	Protection delay time 保护延时	T_{OVD}	V1=V2=3.5V C_{OVD}=0.1μF V3=3.5V→2.0V	512	1024	1536	ms	
	Release threshold 解除阈值	V_{REL2}	V1=V2=3.5V V3=2.0V→3.5V	V_{REL2} -0.10	V_{REL2}	V_{REL2} +0.10	V	
	Release delay time 解除延时	T_{REL2}	V1=V2=3.5V V3=2.0V→3.5V	8	16	24	ms	
Discharge overcurrent 1 放电过流 1	Protection threshold 保护阈值	V_{OC1}	V1=V2=V3=3.5V V4=0V→0.12V	V_{OC1} *85%	V_{OC1}	V_{OC1} *115%	V	3
	Protection delay time 保护延时	T_{OC1}	V1=V2=V3=3.5V C_{OC1}=0.1μF V4=0V→0.12V	512	1024	1536	ms	
	Release delay time 解除延时	T_{ROC1}	V1=V2=V3=3.5V V4=0V→0.12V→0V	25	50	75	ms	
	Resistance between VM and GND 过流下拉电阻	R_{VMS}	V1=V2=V3=3.5V V4=0V→0.12V	50	100	150	kΩ	
	Temperature factor(2) 温度系数 2	K_{U2}	Ta= -40℃ to 85℃	-0.1	0	0.1	mV/℃	
Discharge overcurrent 2 放电过流 2	Protection threshold 保护阈值	V_{OC2}	V1=V2=V3=3.5V V4=0V→0.5V	V_{OC2} *80%	V_{OC2}	V_{OC2} *120%	V	
	Protection delay time 保护延时	T_{OC2}	V1=V2=V3=3.5V C_{OC2}=0.1μF V4=0V→0.5V	48	96	144	ms	
	Release delay time	T_{ROC2}	V1=V2=V3=3.5V V4=0V→0.5V→0V	25	50	75	ms	

	解除延时							
Short circuit 短路	Protection threshold 保护阈值	V_{SHORT}	V1=V2=V3=3.5V V4=0V→1.2V	V_{SHORT} *80%	V_{SHORT}	V_{SHORT} *120%	V	
	Protection delay time 保护延时	T_{SHORT}	V1=V2=V3=3.5V V4=0V→1.2V→0V	100	300	500	μs	
Charge overcurrent 充电过流	Protection threshold 保护阈值	V_{OVCC}	V1=V2=V3=3.5V V5=0V→-0.2V	V_{OVCC} -0.020	V_{OVCC}	V_{OVCC} +0.020	V	4
	Protection delay time 保护延时	T_{OVCC}	V1=V2=V3=3.5V V5=0V→-0.2V	8	16	24	ms	
Charge over-temperature 充电过温	Protection threshold 保护温度	TCT	V1=V2=V3=3.5V	50	55	60	℃	/
Discharge over-temperature 放电过温	Protection threshold 保护温度	TDT	V1=V2=V3=3.5V	70	75	80	℃	/
Output resistances 输出电阻	CO	R_{CO}	Normal state, Co “H” (12V)正常态，Co 为 “H” (12V)	3	5	8	kΩ	5
	DO	R_{DO}	Normal state, Do “H”(12V)正常态，Do 为“H” (12V)	3	5	8	kΩ	6
			Protecting state, Do “L” 保护态，Do 为“L”	0.40	0.70	1.00		

*1： All the test condition parameters above are designed based on Li+ parameters, other grade parameters can adjust by their own actual voltages.
以上测试条件均以锂电参数参考设计，其他档位参数根据实际电压调整。

*2：The test circuit symbols.
测试电路图的记号。

Function Description /工作说明

1. Overcharge /过充电

During charging, VIN >V_{OVCC} when IC doesn't work in the state of charge overcurrent, If any of V1, V2 or V3 is higher than V_{DET1} and lasts longer than T_{OV}, BM301 chip considers that the batteries work in the state of overcharge, the output voltage of CO will become high resistance from high level, and then it will be pulled down to low level by external resistor. The charge MOSFET will be turned off and stop charging.

电池充电且 VIN >V_{OVCC} 即未发生充电过流时，只要 V1、V2 或 V3 中任意一节电池电压高过 V_{DET1} 并持续时间达到或超过 T_{OV}，芯片即认为电池包中出现了过充电状态，CO 由高电平变为高阻态，被外接电阻下拉至低电平，将充电控制 MOS 管关断，停止充电。

The overcharge protection state will be released if any of the next conditions occurs:

⑴All cells' voltage is less than the overcharge release threshold V_{REL1} and stays a period of time T_{REL1};

⑵VM> 200mV (connecting to the load), battery voltage is lower than V_{DET1} and stays a period of time T_{REL1}.

满足下面两个条件之一即可解除过充电状态：

所有电芯的电压都低于 V_{REL1} 并持续 T_{REL1}；

VM> 200mV（接入负载），电池电压低于 V_{DET1} 并持续 T_{REL1}。

2. Over-discharge /过放电

During discharging, VIN< V_{OC1} when IC doesn't work in the state of discharge overcurrent. If any of V1, V2 or V3 is less than V_{DET2} and lasts longer than T_{OVD}. BM301 chip considers that the batteries work in the state of over-discharge and the output voltage of DO will turn to GND. The discharge MOSFET will be turned off and stop discharging, then the chip will enter sleeping mode.

电池放电且 VIN< V_{OC1} 即未发生放电过流时，只要 V1、V2 或 V3 中任意一节电池电压低于 V_{DET2} 并持续时间达到或超过 T_{OVD}，芯片即认为电池包中出现了过放电状态，DO 由高电平变为低电平，将放电控制 MOS 管关断，停止放电，同时芯片进入休眠模式。

The over-discharge protection state will be released if any of the next conditions occurs:

⑴VM =0mV, all cells' voltage is higher than V_{REL2} and stays a period of time T_{REL2}.

⑵VM <-200mV (connecting to the charger), all cells' voltage is higher than V_{DET2} and stays a period of time T_{REL2}

满足下面两个条件之一即可解除过放电状态（休眠状态）：

VM =0mV 且所有电芯的电压都高于 V_{REL2} 并持续 T_{REL2}；

VM <-200mV（接入充电器），电池电压高于 V_{DET2} 并持续 T_{REL2}。

3. Discharge overcurrent /放电过电流

During discharging, the current varies with the load. The voltage of VIN becomes higher with the current increasing. When the voltage of VIN is higher than V_{OC1} and stays longer than T_{OC1}, we think the IC works in the state of discharge overcurrent 1; When the voltage of VIN is higher than V_{OC2} and stays longer than T_{OC2}, we consider the IC works in the state of discharge overcurrent 2; When the voltage of VIN is higher than V_{SHORT} and stays longer than T_{SHORT}, we think the IC works in the state of short circuit. When any of the three states occurs, the output voltage of DO changes to low level to turn off the discharge MOSFET and stop discharging. At the same time, R_{VMS} which is the inner pulling down resistance of VM is connected, and we know that VM is pad which we can lock the output voltage of DO

by when chip works in the state of discharge overcurrent. Usually V_{OC1} < V_{OC2} < V_{SHORT}, T_{OC1} > T_{OC2} > T_{SHORT}.

在放电时，放电电流随着负载而变化，VIN 电压随着放电电流的增大而增大。当 VIN 电压高于 V_{OC1} 并持续一段时间 T_{OC1}，即认为出现了过电流 1；当 VIN 电压高于 V_{OC2} 并持续 T_{OC2}，即认为出现了过电流 2；当 VIN 电压高于 V_{SHORT} 并持续 T_{SHORT}，即认为出现了短路。三种中任意一种状态出现后，DO 由高电平变为低电平，关断放电 MOS 管停止放电，同时，过流锁定端子 VM 端内部下拉电阻 R_{VMS} 接入。通常 V_{OC1} < V_{OC2} < V_{SHORT}，T_{OC1} > T_{OC2} > T_{SHORT}。

When IC works in discharge overcurrent, the output voltage of DO is locked in low level, it will be released when the following conditions occurs in the same time.

⑴disconnect the load;

⑵VM<3V and stays a period of time T_{ROC1}.

过电流保护时 DO 被锁定为低电平，同时满足以下条件才可解除锁定：

断开负载；且 VM<3V 并持续 T_{ROC1}。

4. Charge overcurrent /充电过电流

During charging, if the current is biggish with VIN<V_{OVCC} and stays longer than T_{OVCC}, the BM301 chip considers that the batteries work in the state of charge overcurrent, the output voltage of CO will be pulled down to low level and the charge MOSFET will be turned off and stop charging. Charge overcurrent protection will be released when we disconnect the charger.

在充电时，如果充电电流过大且 VIN < V_{OVCC} 并持续了一段时间 T_{OVCC}，芯片认为发生了充电过电流状态，CO 被外接电阻下拉至低电平，充电控制 MOS 管关断。若充电器一直存在，充电过流状态被锁定，只有将充电器移除才能解除。

5. Temperature protection /温度保护

Usually, batteries should be prevented charging and discharging from over temperature. The BM301 chip has this over-temperature protection. The thermal resistor connecting to NTC pad is used to detect the battery pack's temperature. Choose the resistance of NTC that the value of B is 3950, NTC resistance is 100KΩ in normal temperature (25℃). The default temperature of charge over-temperature is 55 ℃ , the hysteresis is 5 ℃ . The default temperature of discharge over-temperature is 75℃, the hysteresis is 10℃.

通常，为了防止充放电过程中电芯温度过高给电芯带来的损坏，需要对电芯进行高温保护。BM301 芯片具有温度保护功能，通过 NTC 端子连接热敏电阻用于感应温度变化，NTC 选择 B 值为 3950 的 100K 电阻。温度保护默认为充电高温为 55℃，迟滞 5℃。放电高温为 75℃，迟滞为 10℃。若不需要温度保护功能，NTC 请选择固定阻值为 100K 的电阻即可。

6. Breaking wire protection /断线保护

When one or several wires of VC1, VC2 and VC3 are detected cut from the batteries by the BM301 chip, the IC will consider it enters a state of breaking wire, then CO will be in high resistance and DO will turn to GND level the IC enters low consumption state.

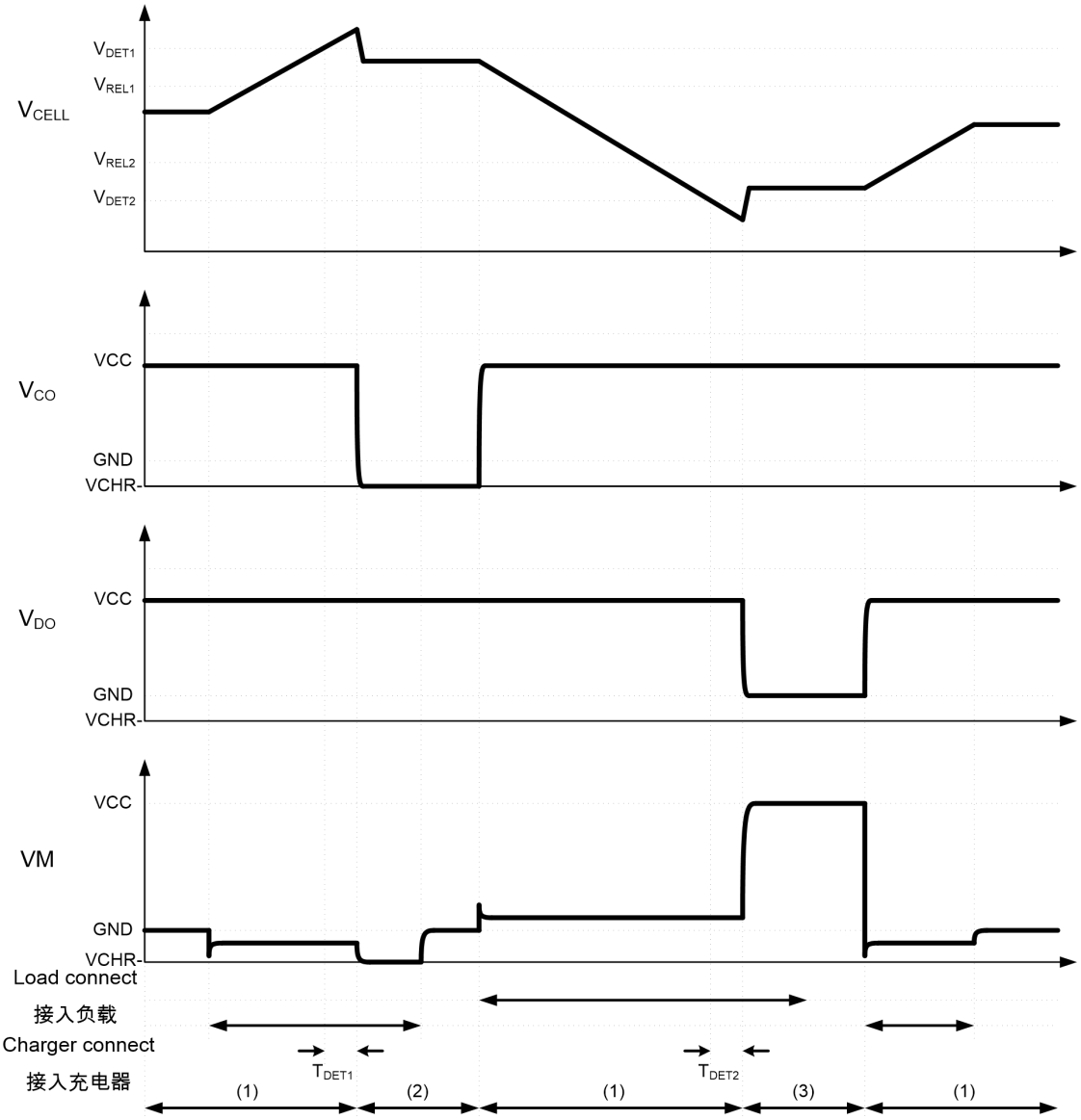
The IC enters low consumption state and when the breaking wires are connected correctly again, the IC will exit breaking wire protection.

当芯片检测到管脚 VC1、VC2 或 VC3 中任意一根或多根与电芯的连线断开，芯片判断为发生了断线，即将 CO 输出高阻态，DO 输出低电平，此保护状态称为断线保护状态。

断线保护后，芯片进入低功耗。当断开的连线重新正确连接后，芯片退出断线保护状态。

Operation Timing Charts /工作时序图

1. Overcharge/Over-discharge Protection
过充电、过放电保护



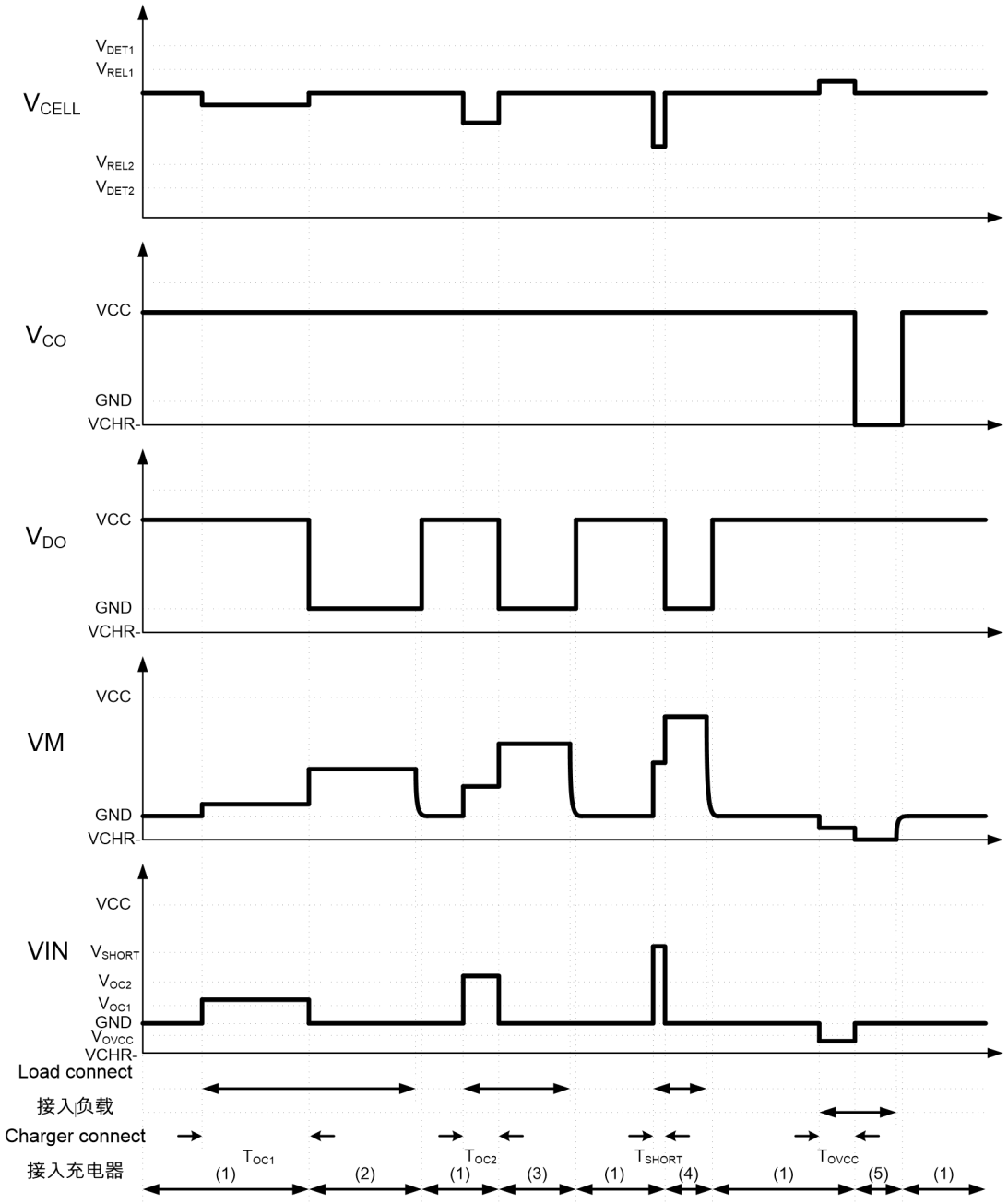
Assuming the charging current is constant, VCHR- is the voltage of the charger's negative terminal:
假定为恒流充电，VCHR-为充电器空载时负端电压：

（1）Normal condition /通常状态；

（2）Overcharge protection state /过充电保护状态；

（3）Over-discharge protection state /过放电保护状态。

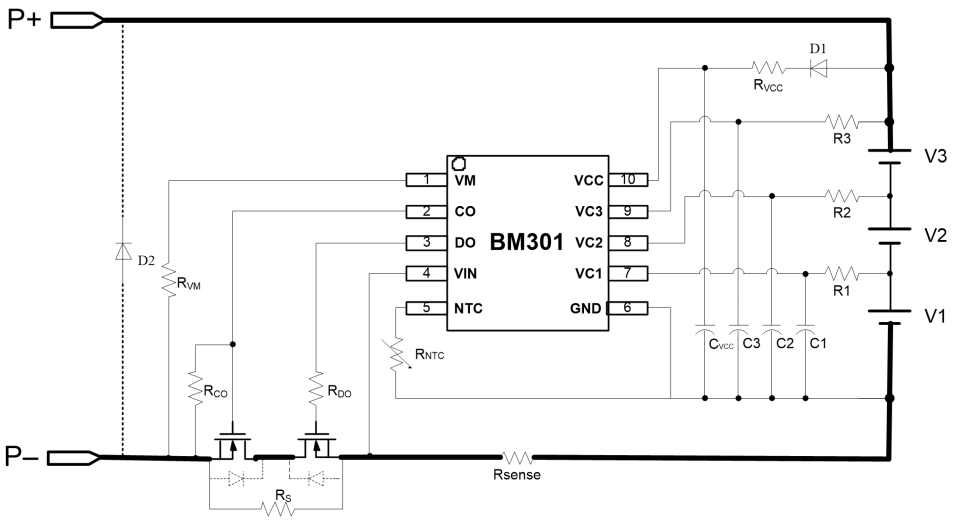
2. Discharge Overcurrent / Short Circuit / Charge Overcurrent Protection
放电过电流、短路、充电过电流保护



Assuming the charging current is constant, VCHR- is the voltage of the charger's negative terminal:
假定为恒流充电，VCHR-为充电器空载时负端电压：

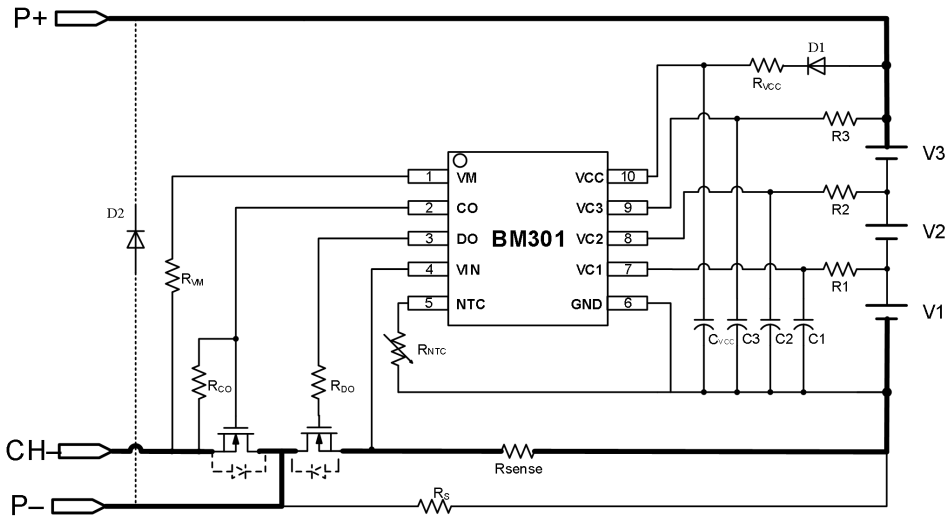
（1） Normal condition /通常状态；
（2） Discharge overcurrent 1 protection state /放电过电流 1 保护状态；
（3） Discharge overcurrent 2 protection state /放电过电流 2 保护状态；
（4） Short circuit protection state /短路保护状态；
（5） Charge overcurrent protection state /充电过电流保护状态。

Application Circuits /应用电路



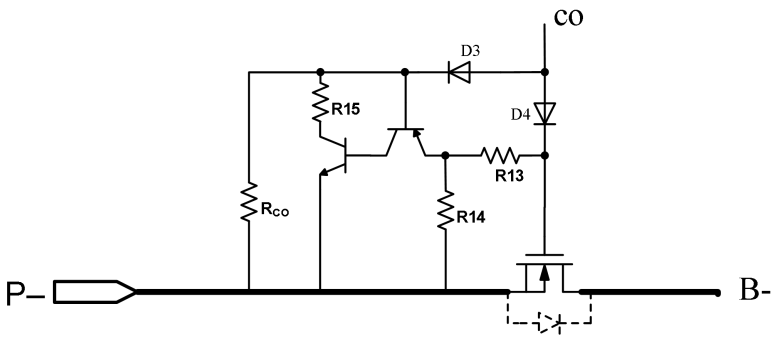
charge and discharge port together

同口应用



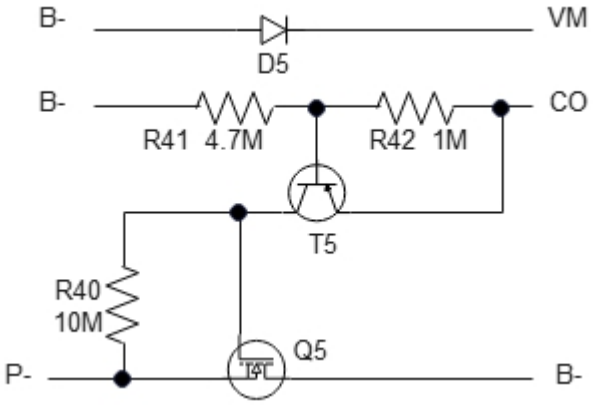
charge and discharge port separated

分口应用



To speed up the response of charge MOSFET，we recommend to add a fast pull-down circuit to CO pin.

为加快 CO 端 MOS 管的响应速率，推荐添加 CO 端快速下拉电路



It is recommended when the charge voltage is 20V higher than the total battery voltage.
当充电器电压比电池总电压高 20V 时推荐使用

Constants for External Components:
电阻、电容推荐值如下：

Component Symbol 器件标号	Typ. 典型值	Range 范围	Unit 单位
R1、R2、R3、R_{VCC}	1	0.33~2.0	KΩ
R_{DO}	2.0	-	KΩ
R_{CO}	10	3.3~15	MΩ
Rs	1	1.0~10	MΩ
R_{VM}	200	47~330	KΩ
R_{NTC}	100	-	KΩ
Rsense	5	0.1~100	mΩ
C1、C2、C3	0.1	0.047~1	uF
C_{VCC}	2.2	2.2~4.7	uF

备注：R_S =1 MΩ时，过放保护后断负载 DO 可自恢复；R_S =10 MΩ时，过放保护后断负载需接充电器激活。

Test circuit /测试电路

1. Normal and Sleeping Current Consumption /正常功耗及休眠功耗

Test circuit 1 /测试电路 1

(1) Set V1 = V2 = V3 = 3.5V, the current flowing from GND is the normal operating current consumption.
设定 V1 = V2 = V3 = 3.5V，观察电流表的读数，流出 GND 的电流即正常功耗。

(2) On the condition of (1), then set V1 = V2 = V3 = 2.0V, the current flowing from GND is the sleeping current consumption.
在(1)的基础上，设定 V1 = V2 = V3 = 2.0V，观察电流表的读数，流出 GND 的电流即休眠功耗。

2. Overcharge Protection Test /过充电测试

Test circuit 2 /测试电路 2

2.1 Overcharge threshold (V_{DET1}) and Overcharge release threshold (V_{REL1})
过充电保护及保护解除阈值

Set V1 = V2 = V3 = 3.5V, make sure the output voltages of DO and CO pins are “H” level. Increase V3 gradually, monitor CO voltage and keep the condition not shorter than T_{DET1}, the value of V3 when CO turns from “H” to “L” is the overcharge threshold voltage. Decrease V3 and keep the condition not shorter than T_{REL1}, the V3 when CO returns to “H” level again is the overcharge release threshold.

设定 V1 = V2 = V3 = 3.5V，确保 DO、CO 都为“H”。逐渐增大 V3，维持时间不小于过充电保护延时，当 CO 由“H”变“L”时的 V3 电压即为过充电保护阈值电压（V_{DET1}）；逐渐减小 V3，维持时间不小于过充电保护解除延时，当 CO 重新变为“H”时，V3 电压即为过充电保护解除阈值电压（V_{REL1}）。

2.2 Overcharge protection delay time and Overcharge release delay time
过充电保护及过充电回复延时

(1) Set V1 = V2 = V3 = 3.5V, make sure the output voltages of DO and CO pins are “H” level. Increase V3 to 4.4V from 3.5V instantaneously, monitor CO voltage and keep a period of time. The time interval when CO turns from “H” to “L” is the overcharge protection delay time.
设定 V1 = V2 = V3 = 3.5V，确保 DO、CO 都为“H”。将 V3 骤升至 4.4V，监控 CO 电压并维持一段时间，CO 由“H”变“L”的时间间隔即为过充电延时。

(2) Set V1 = V2 = 3.5V, V3 = 4.4V, make sure the output voltage of DO is “H” level, CO is “L” level. Decrease V3 to 3.5V from 4.4V instantaneously, monitor CO voltage and keep a period of time. The time interval when the output voltage of CO turns from “L” to “H” is the overcharge release delay time.
设定 V1 = V2 = 3.5V，V3 = 4.4V，确保 DO 为“H”，CO 为“L”。将 V3 骤降至 3.5V，监控 CO 电压并维持一段时间，CO 由“L”变“H”的时间间隔即为过充电回复延时。

3. Over-discharge Protection Test /过放电测试

Test circuit 2 /测试电路 2

3.1 Over-discharge threshold (V_{DET2}) and Over-discharge release threshold (V_{REL2})
过放电保护及过放电保护解除阈值

Set V1 = V2 = V3 = 3.5V, make sure the output voltages of DO and CO pins are “H” level. Decrease V3 gradually, monitor DO voltage and keep the condition not shorter than T_{DET2}, the value of V3 when the output voltage of DO turns from “H” to “L” is the over-discharge threshold voltage. Increase V3 and keep the condition not shorter than T_{REL2}, the value of V3 when DO returns to “H” level again is the over-discharge release threshold

设定 V1 = V2 = V3 = 3.5V，确保 DO、CO 都为“H”。逐渐减小 V3，维持时间不小于过放电保护延时，当 DO 由“H”变为“L”时的 V3 电压即为过放电保护阈值电压（V_{DET2}）；逐渐增大 V3，维持时间不小于过放电保护解除延时，当 DO 重新变为“H”时，V3 电压即为过放电保护解除电压（V_{REL2}）。

3.2 Over-discharge protection delay time and Over-discharge release delay time
过放及过放回复延时

(1) Set V1 = V2 = V3 = 3.5V, make sure the output voltages of DO and CO pins are “H” level. Decrease V3 to 2.0V instantaneously, monitor DO voltage and keep a period of time. The time interval when DO turns from “H” to “L” is the over-discharge protection delay time.
设定 V1 = V2 = V3 = 3.5V，确保 DO、CO 都为“H”。将 V3 骤降至 2.0V，监控 DO 电压并维持一段时间，DO 由“H”变为“L”的时间间隔即为过放电延时。

(2) Set V1 = V2 = 3.50V, V3 = 2.0V, make sure CO is “H” level, DO is “L” level. Increase V3 to 3.5V instantaneously, monitor DO voltage and keep a period of time. The time interval when the output voltage of DO turns from “L” to “H” is the overcharge release delay time.

设定 V1 = V2 = 3.5V，V3 = 2.0V，确保 DO 为“L”，CO 为“H”。将 V3 骤升至 3.5V，监控 DO 电压并维持一段时间，DO 由“L”变为“H”的时间间隔即为过放电回复延时。

4. Discharge overcurrent and short circuit protection test /放电过电流及短路测试

Test circuit 3 /测试电路 3

4.1 Discharge overcurrent1 and 2 threshold (V_{DET3}, V_{DET4}) and short circuit threshold (V_{SHORT}) 过电流及短路保护阈值

Set V1 = V2 = V3 = 3.5V, V4 = 0V, make sure the output voltages of DO and CO pins are “H” level. Increase V4 gradually, monitor DO voltage and keep the condition for a period of time, the value of V4 when the output voltage of DO turns from “H” to “L”, is the discharge overcurrent 1 threshold (V_{DET3}). Decrease V4, the discharge overcurrent 1 protection will be released. V_{DET4} and V_{SHORT} can also be tested by their protection time differences, but V4 has a larger change.

设定 V1 = V2 = V3 = 3.5V，V4 = 0V，确保 DO、CO 都为“H”。逐渐增大 V4，维持时间不小于过电流 1 保护延时，当 DO 由“H”变为“L”时的 V4 电压即为过电流 1 保护阈值（V_{DET3}）。过电流 2 阈值（V_{DET4}）及短路阈值（V_{SHORT}）的测试需同时根据设定的保护延时长短去判断。

4.2 Discharge overcurrent protection delay time and release delay time 过电流及过电流回复延时

(1) Set V1 = V2 = V3 = 3.5V, V4 = 0V, make sure the output voltages of DO and CO pins are “H”. Increase V4 to 0.2V instantaneously, monitor DO voltage and keep a period of time. The time interval when the output voltage of DO turns from “H” to “L” is the discharge overcurrent 1 protection delay time.

设定 V1 = V2 = V3 = 3.5V，V4 = 0V，确保 DO、CO 都为“H”。将 V4 骤然增大至 0.2V，监控 DO 电压并维持一段时间，DO 由“H”变为“L”的时间间隔即为过电流 1 延时。

(2) Set V1 = V2 = V3 = 3.5V, V4 = 0V, make sure the output voltages of DO and CO pins are “H”. Increase V4 instantaneously with its value be larger, monitor DO voltage and keep a period of time. The time interval when the output voltage of DO turns from “H” to “L” is the discharge overcurrent 2 protection delay time, make sure its value is less than the discharge overcurrent 1 protection delay time, then the value of V4 at this time is the discharge overcurrent 2 threshold.

设定 V1 = V2 = V3 = 3.5V，V4 = 0，确保 DO、CO 都为“H”。逐步将 V4 骤然增大，即每次增大至的 V4 电压值比前一次大，同时监测 DO 由“H”变为“L”的延时，监测到的第一个比过电流 1 短的延时对应的 V4 的电压即为过电流 2 阈值，这个延时即为过电流 2 延时。

(3) Set V1 = V2 = V3 = 3.5V, V4 = 0V, make sure the voltages of DO and CO pins are “H”. Increase V4 instantaneously with its value larger and larger, monitor DO voltage and keep a period of time. The time interval when DO turns from “H” to “L” is the short circuit protection delay time, make sure its value is less than the discharge overcurrent 2 protection delay time, and the value of V4 at this time is the short circuit threshold.

设定 V1 = V2 = V3 = 3.5V，V4 = 0V，确保 DO、CO 都为“L”。逐步将 V4 骤然增大，即每次增大至的 V4 电压值比前一次大，同时监测 DO 由“H”变为“L”的延时，监测到的第一个比过电流 2 短的延时对应的 V4 的电压即为短路阈值，这个延时即为短路延时。

(4) Set V1 = V2 = V3 = 3.5V, V4 = 0.2V, make sure the output voltage of DO pin and CO pin is “L” and “H”. Decrease V4 to 0V instantaneously, monitor DO voltage and last a period of time. The time interval when DO turns from “L” to “H” is the discharge overcurrent 1 release delay time, we can test the release delay time of discharge overcurrent 2 and short circuit by using the same method.

设定 V1 = V2 = V3 = 3.5V、V4 = 0.2V，确保 DO 为“L”，CO 为“H”。将 V4 骤然降至 0V，监控 DO

电压并维持一段时间，DO 由“L”变为“H”的时间间隔即为过电流 1 回复延时。同样的测试方法可以测出过电流 2 回复延时及短路回复延时。

5. Charge overcurrent protection test /充电过电流测试

Test circuit 4 /测试电路 4

5.1 Charge overcurrent protection threshold /充电过电流保护阈值

Set V1 = V2 = V3 = 3.5V, V5 = 0V, make sure the output voltages of DO and CO pins are “H”. Increase V5 gradually, monitor CO voltage and keep a period of time. The value of V5 when the output voltage of CO turns from “H” to “L” is the charge overcurrent threshold.

设定 V1 = V2 = V3 = 3.5V，V5 = 0V，确保 DO、CO 都为“H”。 逐渐增大 V5，维持时间不小于充电过电流保护延时，Co 由“H”变为“L”时 V5 即为充电过电流保护阈值。

5.2 Charge overcurrent protection delay time /充电过电流保护延时

Set V1 = V2 = V3 = 3.5V, V5 = 0V, make sure the output voltages of DO and CO pins are “H”. Increase V5 to 0.3V instantaneously, monitor the CO voltage and keep a period of time. The time interval when the output voltage of CO pin turns from “H” to “L” is the charge overcurrent protection delay time.

设定 V1 = V2 = V3 = 3.5V，V5 = 0V，确保 DO、CO 都为“H”。将 V5 骤然增大至 0.3V，监控 CO 电压并维持一段时间，CO 由“H”变为“L”的时间间隔即为充电过电流保护延时。

6. Output/Input Resistance Test /输入/输出电阻测试

（1）The output resistances of CO and DO

CO、DO 为高电平时的输出电阻

Test circuit 5 /测试电路 5

Set V1 = V2 = V3 = 3.5V, V6 = 12.0V, turn off the switch K and make sure the output voltage of CO pin is “H”. Measure the voltage V_A of CO pin; turn on the switch K, decrease the voltage V6 gradually from 12V, monitor the value of I_A, and note down the output voltage V_B of CO pin when the value of I_A is 50uA, then the output resistance of CO is calculated as follows: $R_{COH} = (V_A - V_B)/50$ (MΩ).

We can also test the output resistance R_{DOH} of DO pin with using the same method.

设定 V1 = V2 = V3 = 3.5V，V6 = 12.0V，开关 K 断开，确保此时 CO 输出为“H”，测量 CO 端的电压 V_A；闭合开关 K，V6 从 12V 开始降低，监测电流表的读数为 I_A，当 I_A = 50uA 时测得 CO 端的电压 V_B，则 CO 输出电阻 $R_{COH} = (V_A - V_B)/50$ (MΩ)。

同样的测试方法可用于测试 DO 输出电阻 R_{DOH}，只需将测试端子改为 DO 即可。

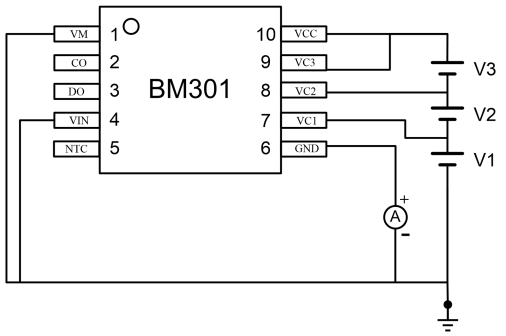
（2）The output resistance when the output voltage of DO pin is “L”

DO 为低电平时的输出电阻

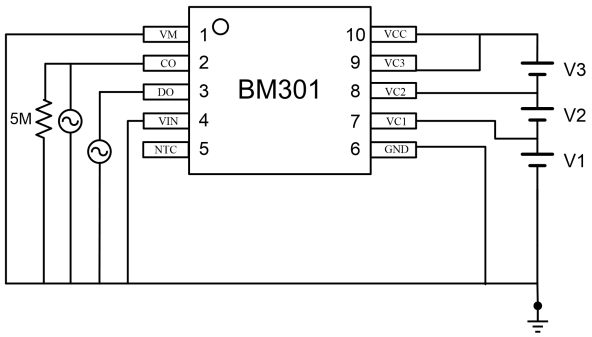
Test circuit6 /测试电路 6

Set V1 = V2 = V3 = 2.00V, V7 = 0.00V, turn off the switch K and make sure the output voltage of DO pin is “L”. Turn on the switch K, increase the voltage V7 gradually from 0V, monitor the value of I_A, note down the output voltage V_{DO} of DO pin when the value of I_A is 50uA, then the output resistance of DO is calculated as follows: $R_{DOL} = V_{DO}/50$ (MΩ)

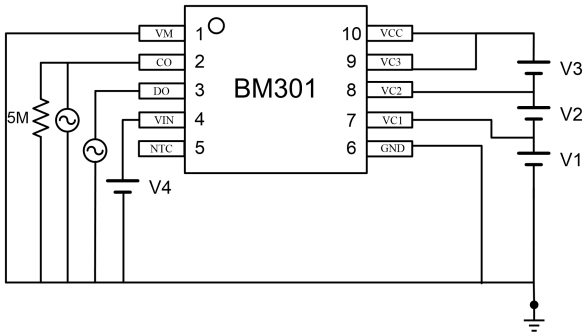
设定 V1 = V2 = V3 = 2.00V、V7 = 0.00V，开关 K 断开，用电压表测试 DO 端电压，确保此时 DO 输出为 0V。将开关 K 闭合，调节 V7 从 0V 开始上升，同时监测电流表的读数为 I_A，当 I_A = -50uA 时测得 DO 电位为 V_{DO}，则 DO 输出电阻 $R_{DOL} = V_{DO}/50$ (MΩ)。



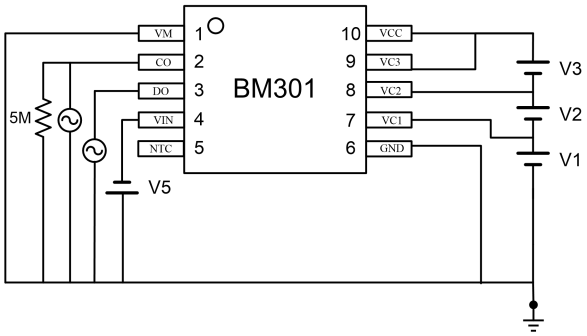
Test circuit 1
测试电路 1



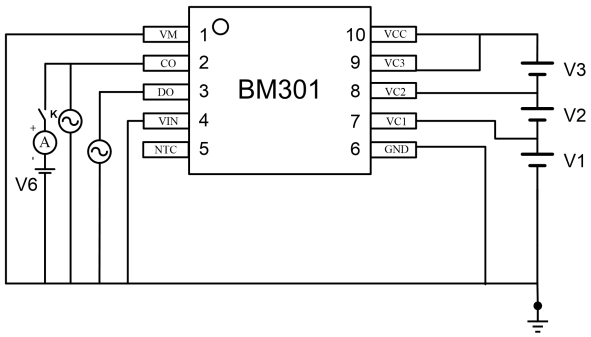
Test circuit 2
测试电路 2



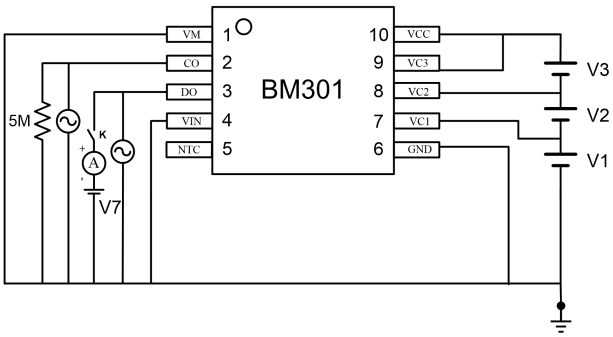
Test circuit 3
测试电路 3



Test circuit 4
测试电路 4



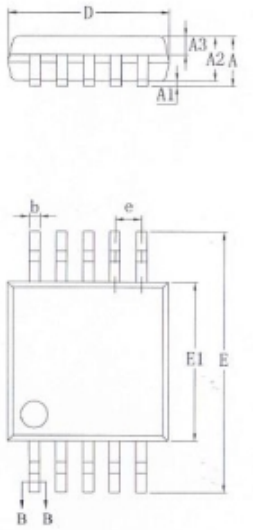
Test circuit 5
测试电路 5

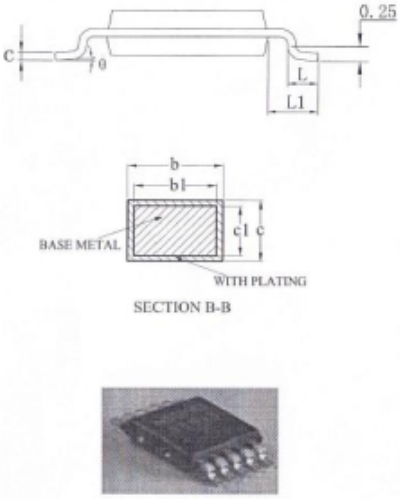


Test circuit 6
测试电路 6

Package Information /封装示意图及参数

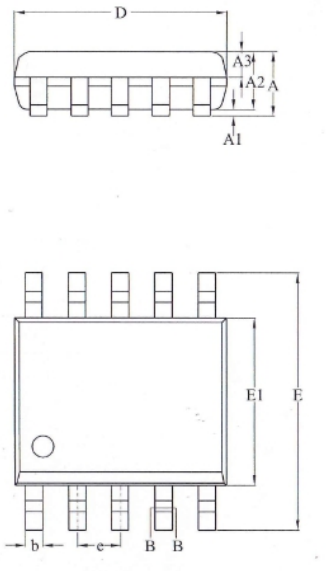
MSOP10

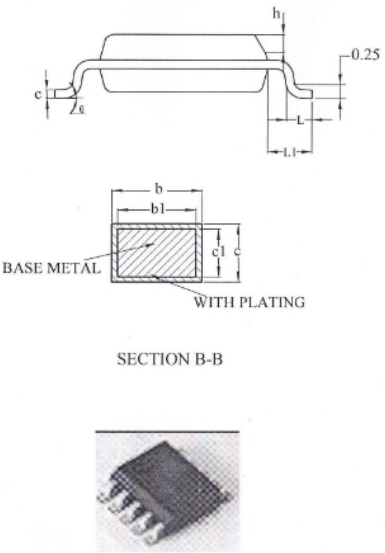




SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.10
A1	0.05	—	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.18	—	0.26
b1	0.17	0.20	0.23
c	0.15	—	0.19
c1	0.14	0.15	0.16
D	2.90	3.00	3.10
E	4.70	4.90	5.10
E1	2.90	3.00	3.10
e	0.50BSC		
L	0.40	—	0.70
L1	0.95REF		
θ	0	—	8°

SSOP10





SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.10	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.47
b1	0.38	0.41	0.44
c	0.20	—	0.24
c1	0.19	0.20	0.21
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.00BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05REF		
θ	0	—	8°

Packing /包装：

MSOP10：MBB packing.13”reel，4000pcs per reel.
MSOP10 封装形式：13 寸的 MBB 静电袋，每盘装 4000 颗。

SSOP10：MBB packing.13”reel，4000pcs per reel.
SSOP10 封装形式：13 寸的 MBB 静电袋，每盘装 4000 颗。

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