BM309 Series

3/4 cell Li Battery Protectors

General Description

The BM309 Series are highly integrated protection ICs for lithium-ion and lithium polymer rechargeable battery packs in notebook PCs, power tools, electric bicycles and UPS applications.

The BM309s work constantly to monitor each cell's voltage, the charge/discharge current and the environment temperature to provide overcharge, over-discharge, excess current, short circuit, abnormal charge, overheat safety protections, etc. Particularly for excess current and overheat, it provides an easy way to adjust the threshold, internal/external selectably.

It also supports external bleeding for cell-capacity balance function to avoid unbalanced capacity between each cell.Thus, the battery can work for longer.

Extended function module embedded in the BM309s can make themself work for battery packs with multiple BM309s.

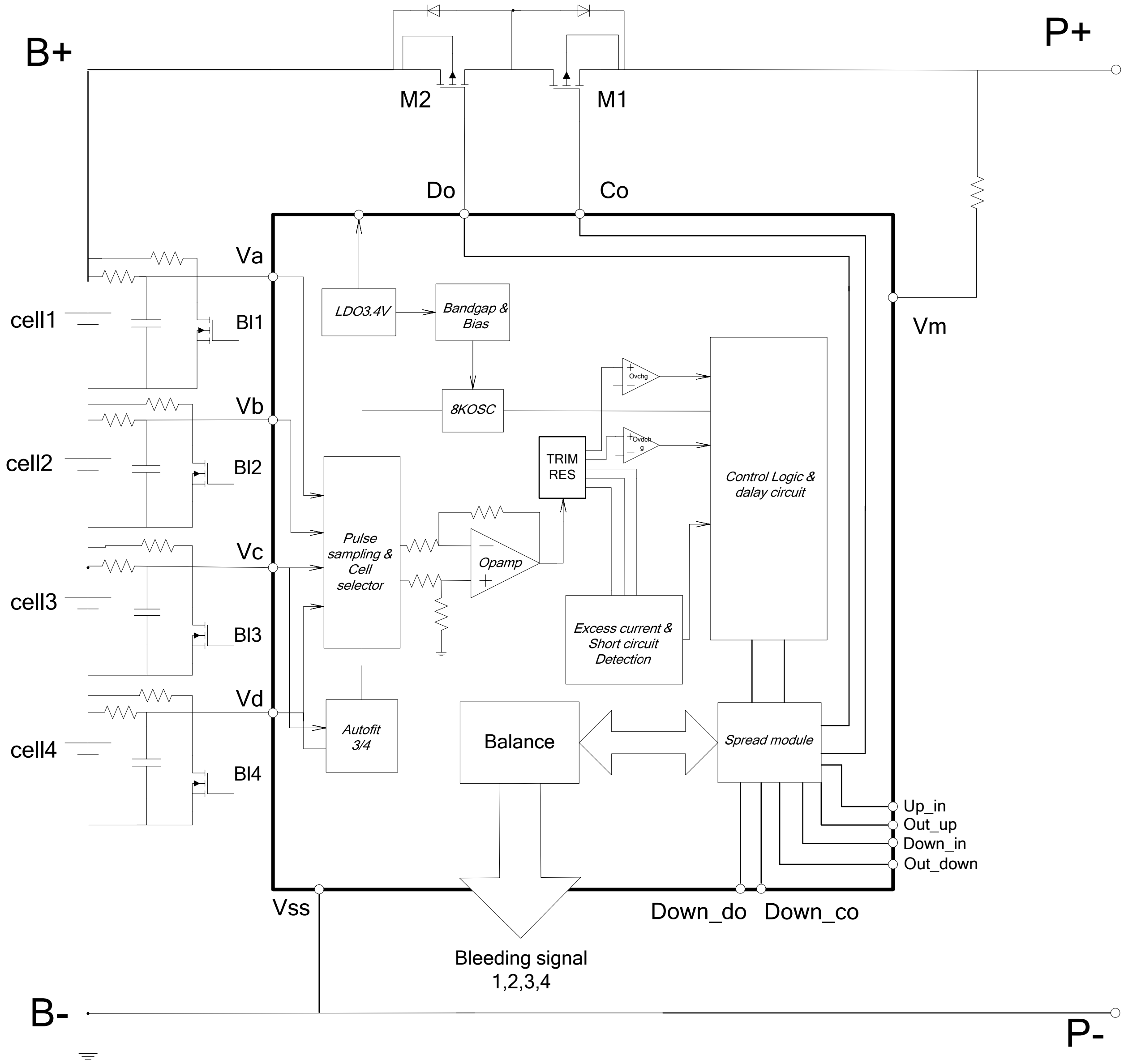
Features

- Supports 3/4 Series Lithium-ion and Lithium polymer rechargeable Battery or 6-20 Series if used in the extended condition
- Built-in auto-fit between 3/4 cells (without any peripheral circuit added)
- Built-in protections included:
  - Overcharge
  - Over-discharge
  - Excess current
  - Short circuit
  - Abnormal charge
  - Over temperature
- Supports external bleeding for balance
- Supports different charge and discharge loops
- Supports external excess current
- Lower power consumption
- Package: TSSOP24

Applications

- Notebook PC
- Power Tool
- UPS backup battery
- Electric bicycle

Block Diagram



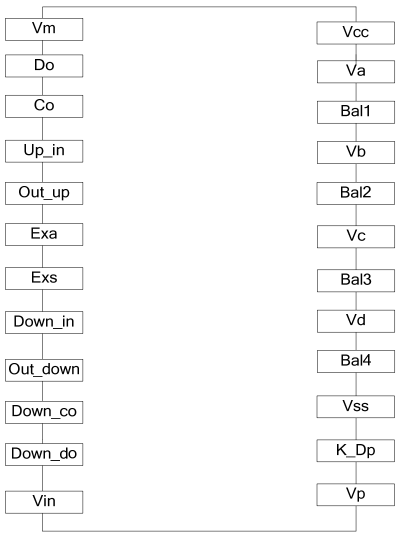
Selection Guide

- Type Number
  BM309XXXX

- Type Number Option
  The first X stands for Overcharge detection threshold voltage (Vdet1)
  The second X stands for Over-discharge detection threshold voltage (Vdet2)
  The third X stands for Excess current 1 detection threshold voltage (Vdet3)
  The fourth X stands for other parameters or versions

Type Number	Vdet1	Vdet2	Vdet3	Vbal1	Vbal2	Package
BM309MHFA	4.300±0.050V	2.500±0.100V	(Vcc-0.20)±0.030V	3.980±0.100V	2.750±0.100V	TSSOP24
BM309LHFA	4.275±0.050V	2.500±0.100V	(Vcc-0.20)±0.030V	3.970±0.100V	2.730±0.100V	TSSOP24

Pin Configuration

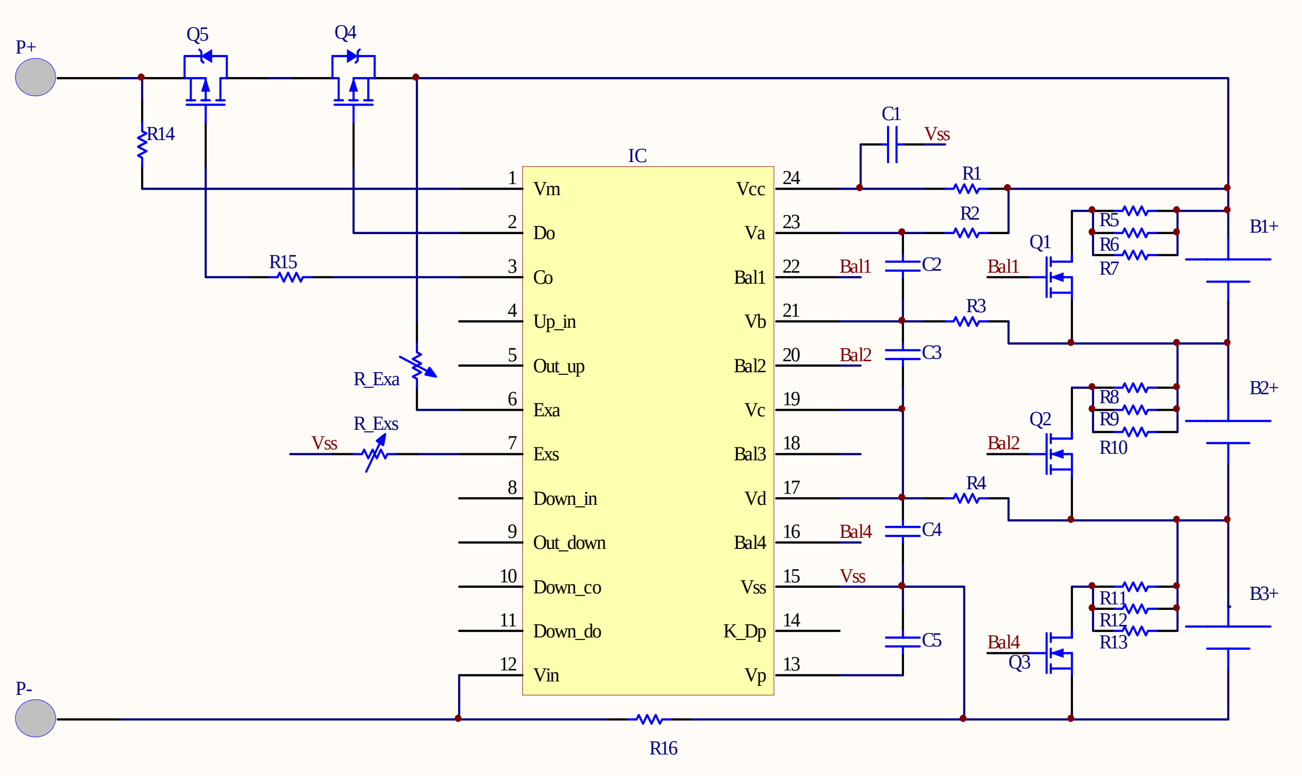


Pin Description :

Name	Pin NO.	I/O	Description
Vm	1	I	Voltage detection
Do	2	O	Discharge power Mosfet control
Co	3	O	Charge power Mosfet control
UP_in	4	I	Cell balance 1 among chips
Out_up	5	O	Cell balance 3 among chips
Exa	6	I	Excess current adjustment connected to Vcc
Exs	7	I	Excess current adjustment connected to Vss
Down_in	8	I	Cell balance 2 among chips
Out_down	9	O	Cell balance 4 among chips
Down_co	10	I	CO from under chip
Down_do	11	I	DO from under chip
Vin	12	I	Discharge current detection
Vp	13	Power	LDO output
K_Dp	14	I	Spread & TRIM control
Vss	15	Ground	Chip ground
Bal4	16	O	Cell4 external bleeding control
Vd	17	I	Cell4 positive input
Bal3	18	O	Cell3 external bleeding control
Vc	19	I	Cell3 positive input
Bal2	20	O	Cell2 external bleeding control
Vb	21	I	Cell2 positive input
Bal1	22	O	Cell1 external bleeding control
Va	23	I	Cell1 positive input
Vcc	24	Power	Power supply

Typical Application Circuits

Used as a single chip



Application in 3-cell battery pack

Recommended value of the resistors and capacitors is as followed:

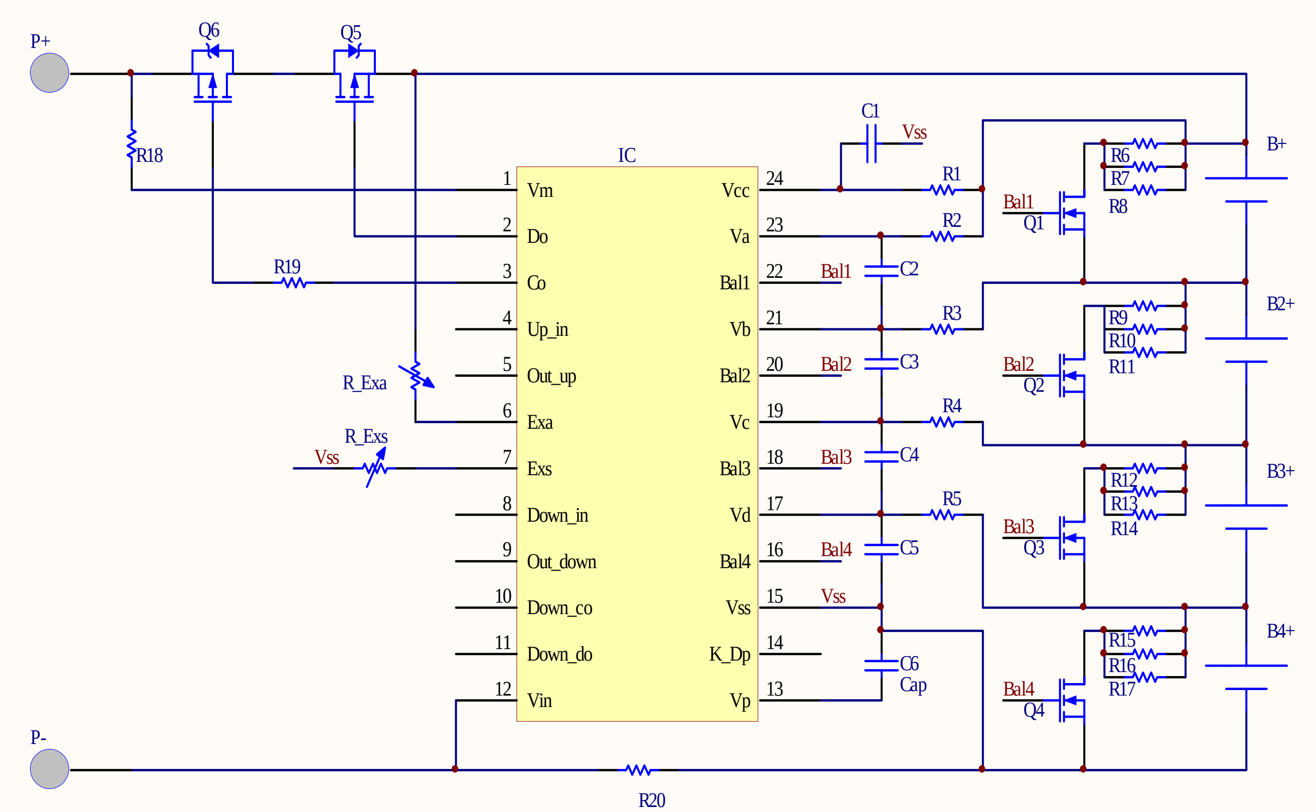
symbol	TYP	Range	Unit
R1	100	100~1000	Ω
R2、R3、R4	200	100~1000	Ω
R5、R6、R7	100	10~	Ω
R8、R9、R10	100	10~	Ω
R11、R12、R13	100	10~	Ω
R14	2	1~10	KΩ
R15	200	10~1000	KΩ
R_Exa	60	10~100	KΩ
R_Exs	80	70~85	KΩ
R16	—	0~100	mΩ
C1、C2、C3、C4、C5	0.1	0.01~2.2	uF

NOTE:

(1) Pin Down_co, Down_do can be used to control Co and Do, the priority is higher than protection circuits.

(2) Pin Vin and Vm have the same priority in the state as Excess current 1, so either can be selected to realize the Excess current 1 protect .

(3) The serial number of resistors and capacitors in the table is only applicable to 3-cell application circuit .



Application in 4-cell battery pack

Recommended value of the resistors and capacitors is as followed:

symbol	TYP	Range	Unit
R1	100	100~1000	Ω
R2、R3、R4、R5	200	100~1000	Ω
R6、R7、R8	100	10~	Ω
R9、R10、R11	100	10~	Ω
R12、R13、R14	100	10~	Ω
R15、R16、R17	100	10~	Ω
R18	2	1~10	KΩ
R19	200	10~10001	KΩ
R_Exa	60	10~100	KΩ
R_Exs	80	70~85	KΩ
R20	—	0~100	mΩ
C1、C2、C3、C4、C5、C6	0.1	0.01~2.2	uF

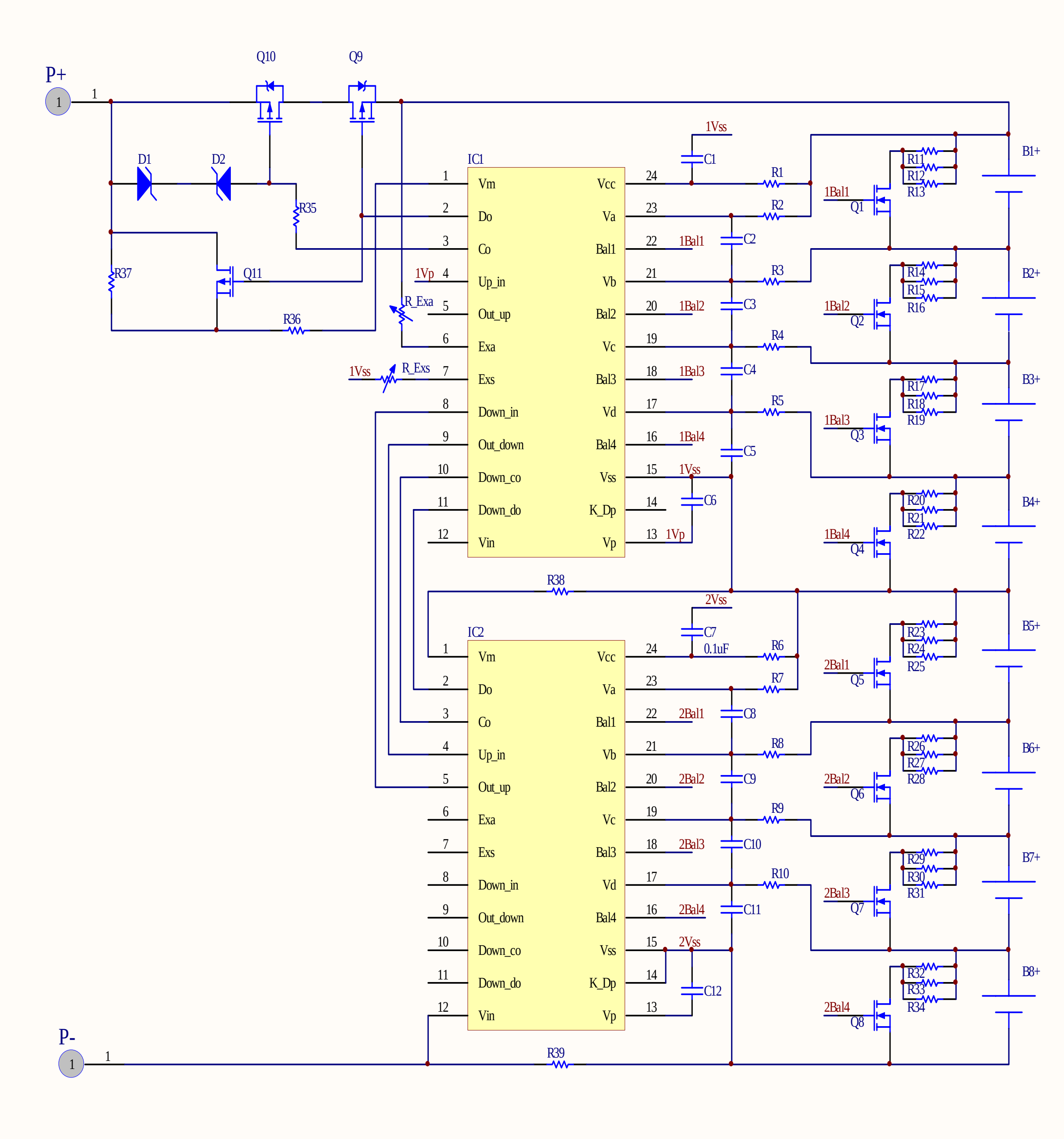
NOTE:

(1) Pin Down_co, Down_do can be used to control Co and Do, the priority is higher than protection circuits.

(2) Pin Vin and Vm have the same priority in the state as Excess current 1, so either can be selected to realize the Excess current 1 protect .

(3) The serial number of resistors and capacitors in the table is only applicable to 4-cell application circuit .

used in extended condition



Application in 8-cell battery pack

Recommended value of the resistors and capacitors is as followed:

symbol	TYP	Range	Unit
R1、R6	100	100~1000	Ω
R2、R3、R4、R5	200	100~1000	Ω
R7、R8、R9、R10	200	100~1000	Ω
R11、R12、R13	100	10~	Ω
R14、R15、R16	100	10~	Ω
R17、R18、R19	100	10~	Ω
R20、R21、R22	100	10~	Ω
R23、R24、R25	100	10~	Ω
R26、R27、R28	100	10~	Ω
R29、R30、R31	100	10~	Ω
R32、R33、R34	100	10~	Ω
R35	200	10~1000	KΩ
R36	2	1~10	KΩ
R37	1	0.5~2	MΩ
R_Exa	60	10~100	KΩ
R_Exs	80	70~85	KΩ
R38	2	1~10	KΩ
R39	—	0~100	mΩ
C1、C2、C3、 C4、C5、C6 C7、C8、C9、 C10、C11、C12	0.1	0.01~2.2	uF

NOTE:

(1) Must pay attention to the proper ratio between R35 and R36, recommend value of R35:R36=100:1; D1 and D2 are used to protect P-MOSFET, recommend value of inverting breakdown voltage is 18V.

(2) Pin Down_co, Down_do can be used to control Co and Do, the priority is higher than protection circuits.

(3) Pin Vin and Vm have the same priority in the state as Excess current 1, so either can be selected to realize the Excess current 1 protect .

(4) The serial number of resistors and capacitors in the table is only applicable to 8-cell application circuit .

Absolute Maximum Ratings

symbol	Description	Range	Unit
Vcc	Power supply voltage	5.5-40	V
V_charger	Charger input voltage	max.Vcc+40	V
Vpins	Pins' high level and low level	Vss-0.3~Vdd+0.3	V
Topr	Operation ambient temperature	-40~85	℃
Tstg	Storage temperature	-40~125	℃

NOTE: The value of Vcc must higher than 5.5V, or else the chip can not work normally.

Electrical Characteristics[1*](25 ℃)

(T_{OPT}=25℃ unless otherwise specified)

Power Supply(Test circuit1)

Symbol	Item	Test conditions	MIN	TYP	MAX	Unit
Vcc	Supply Voltage		5.5		40	V
Vp		V1=V2=V3=V4=3.70V	3.0	3.4	3.7	V
Iope	Supply Current	V1=V2=V3=V4=3.70V		40	70	uA
Istandby		V1=V2=V3=V4=2.20V		10	15	uA

Overcharge(OC) And Over-discharge(OD) Protection(Test circuit2)

Symbol	Item	Test conditions	MIN	TYP	MAX	Unit
Vdet1[2*]	OC Threshold	V2=V3=V4=3.70V, V1=3.70V→4.40V	Vdet1-0.050	Vdet1	Vdet1+0.050	V
Tdet1	OC Delay	V2=V3=V4=3.70V, V1=3.70V→4.40V	0.6	1.2	2.4	s
Treset	OC Reset Delay	V2=V3=V4=3.70V, V1=3.70V→4.40V→3.70V	8	15	30	ms
Vrel1[3*]	OC Release Threshold	V2=V3=V4=3.70V, V1=4.40V→3.70V	VDET1-0.300	VDET1-0.200	VDET1-0.100	V
Trel1	OC Release Delay	V2=V3=V4=3.70V, V1=4.40V→3.70V	12	21	40	ms
Vdet2[2*]	OD Threshold	V2=V3=V4=3.70V, V1=3.30V→2.20V	Vdet2-0.100	Vdet2	Vdet2+0.100	V
Tdet2	OD Delay	V2=V3=V4=3.70V, V1=3.30V→2.20V	18	36	72	ms
Vrel2[3*]	OD Release Threshold	V2=V3=V4=3.70V, V1=2.20V→3.30V	VDET2+0.300	VDET2+0.500	VDET2+0.700	V
Trel2	OD Release Delay	V2=V3=V4=3.70V, V1=2.20V→3.30V	2	6	12	ms

Excess Current(EX) & Short Circuit(SC) And Abnormal Charge(AB) Protection(Test circuit3)

Symbol	Item	Test conditions	MIN	TYP	MAX	Unit
Vdet3[4*]	EX1 Threshold	V1=V2=V3=V4=3.70V	Vcc-0.170	Vcc-0.200	Vcc-0.230	V
Tdet3	EX1 Delay	V1=V2=V3=V4=3.70V	13	27	54	ms

Vdet4[4*]	EX2 Threshold	V1=V2=V3=V4=3.70V	Vcc-0.500	Vcc-0.600	Vcc-0.700	V
Tdet4	EX2 Delay	V1=V2=V3=V4=3.70V	5	9	18	ms
Vshort	SC Threshold	V1=V2=V3=V4=3.70V	Vcc-1.200	Vcc-1.800	Vcc-2.400	V
Tshort	SC Delay	V1=V2=V3=V4=3.70V			0.4	ms
Trex	EX & SC Release Delay	V1=V2=V3=V4=3.70V	2	4	8	ms
Vab	AB Threshold	V1=V2=V3=V4=3.70V	Vcc+0.170	Vcc+0.200	Vcc+0.230	V
Tab	AB Delay	V1=V2=V3=V4=3.70V	9	18	36	ms
Vcha	Charger detection threshold	V1=V2=V3=3.70V V4=2.20V	Vcc+0.170	Vcc+0.200	Vcc+0.230	V
Vin[5*]	Discharge current detection threshold	V1=V2=V3=V4=3.70V	0.170	0.200	0.230	V

Cell Balance And 0V Charge(Test circuit4)

Symbol	Item	Test conditions	MIN	TYP	MAX	Unit
Vbal1	Cell Balance threshold1	V2=V3=V4=3.70V V1=3.70V→4.20V	Vbal1-0.100	Vbal1	Vbal1+0.100	V
Vbal2	Cell Balance threshold2	V2=V3=V4=3.70V V1=3.70V→2.60V	Vbal2-0.100	Vbal2	Vbal2+0.100	V

Over Temperature(OT) Protection

Symbol	Item	Test conditions	MIN	TYP	MAX	Unit
Tot	OT Threshold	V1=V2=V3=V4=3.70V	105	115	125	°C
Totr	OT Release Threshold	V1=V2=V3=V4=3.70V	85	95	105	°C

Pin drive capacity(Test circuit5、6、7、8)

Symbol	Item	Test conditions	MIN	TYP	MAX	Unit
RCo	Co output resistance	normal state, Co"L"	0.8	1.5	2.2	kΩ
		protection state, Co"H"	0.8	1.5	2.2	kΩ

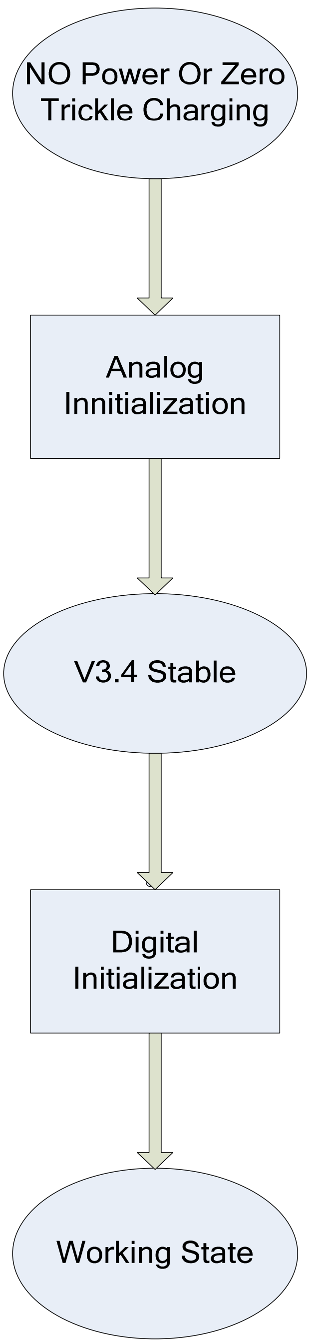
RDo	Do output resistance	normal state, Do"L"	0.8	1.5	2.2	kΩ
		protection state, Do"H"	0.8	1.5	2.2	kΩ
RBal1	RBleed1 output resistance	on state,"H"	1.3	2.7	4.1	kΩ
		off state,"L"	1.5	3.0	4.5	kΩ
RBal2	RBleed2 output resistance	on state,"H"	1.5	3.0	4.5	kΩ
		off state,"L"	1.0	2.0	3.0	kΩ
RBal3	RBleed3 output resistance	on state,"H"	1.5	3.0	4.5	kΩ
		off state,"L"	1.0	2.0	3.0	kΩ
RBal4	RBleed4 output resistance	on state,"H"	0.9	1.7	2.5	kΩ
		off state,"L"	0.4	0.7	1.0	kΩ
Idrive	Current drive capacity of Vp	V1=V2=V3=V4=3.70V	200	400	600	uA
RVMC	Resistance between Vm and VCC	V1=V2=V3=V4=3.70V	200	500	1000	KΩ
RVMS	Resistance between Vm and VSS	V1=V2=V3=V4=2.20V	200	400	800	KΩ
Down_co	Co from under chip	V1=V2=V3=V4=3.70V	500	900	2000	nA
Down_do	Do from under chip	V1=V2=V3=V4=3.70V	500	900	2000	nA
Down_in	Cell balance 2 among chips	V1=V2=V3=V4=3.70V	40	80	200	nA
Out_down	Cell balance 4 among chips	V1=V2=V3=V4=3.70V	10	20	30	KΩ
Up_in	Cell balance 1 among chips	V1=V2=V3=V4=3.70V	40	80	200	nA
Out_up	Cell balance 3 among chips	V1=V2=V3=V4=3.70V	12	24	36	KΩ
K_Dp	Spread & TRIM control	V1=V2=V3=V4=3.70V		1.6	2	uA

1* The Electrical parameters for this temperature range is guaranteed by design, not tested in production.
2* See "Selection Guide" section.
3* VDET1 and VDET2 are the overcharge and over-discharge threshold voltage of actual testing.
4* In the condition of R_Exa=60 KΩ,R_Exs=80 KΩ,VDET3 and VDET4 are guaranteed by design.
5* Vin is used to detect Excess current 1 by the sense-resistor which connected between B- and P-.

Function Description

BM309 Series Power Up Sequence

Fig.1 shows the BM309 Series' power up sequence. When the power supply is applied to Vcc, the bias and the reference circuit start first, followed by the 3.4V LDO. Then 8KHz oscillator works and initializes the digital section. Sampling circuits collect each battery's information and send it out for further processing. Finally BM309 Series can work normally.



Battery Protection

1. Overcharge

During charging, Vdet3＜Vm＜Vab, when (Va-Vb), (Vb-Vc), (Vc-Vd) or Vd increases to Overcharge Threshold Voltage (Vdet1) or higher and stays longer than Overcharge Delay Time (Tdet1), BM309 Series turn off the charge FET. If, within Tdet1, every cell's voltage becomes lower than Vdet1 and stays shorter than Overcharge Reset Delay Time (Treset) before rising up over Vdet1 again, this type of instantaneous falling of battery voltage will be ignored. Otherwise, the timing related to Tdet1 will be reset.

The overcharge protection state will be released when:

(1) All cells' voltage is less than the Overcharge release threshold Vrel1 and stays for Trel1, or

(2) Vm＜Vdet3 and battery voltage is lower than Vdet1.

Make sure Vm＞Vdet3 in the overcharge threshold test with a single chip or extended condition, otherwise, abnormal condition will occur.

2. Over-discharge

During discharging, Vdet3＜Vm＜Vab, when (Va-Vb), (Vb-Vc), (Vc-Vd) or Vd decreases to Over-discharge Threshold Voltage (Vdet2) or lower and stays longer than Over-discharge Delay Time (Tdet2), BM309 Series turn off the discharge FET. Thus, the chip enters sleep mode.

The Over-discharge protection state will be released in the following conditions:

(1) A charger is connected to the battery pack, and the battery supply voltage becomes higher than Vdet2 and stays longer than Trel2, and Vm is higher than the Charger Detection Threshold Voltage (Vcha); or

(2) Every cell's voltage becomes higher than the Over-discharge Release Voltage (Vrel2) and stays longer than Trel2, and Vm is between Vcha and Vdet3.

Make sure Vm＜Vcha in the overcharge threshold test with a single chip or extended condition, otherwise, abnormal condition will occur.

3. Excess current

When discharging, the current varies with the load, and Vm decreases with the discharging current increasing. Once Vm drops down to Excess Current 1 Threshold Voltage (Vdet3) or lower and stays longer than the Excess Current 1 Delay Time (Tdet3), Do pad switches to high, turning off the discharge FET. The excess current protection state will be released when Vm＞Vdet3 and it stays longer than EX & SC Release Delay (Trex).

When discharging, the current varies with the load, and Vm decreases when the discharging current increases. Once Vm drops down to Excess Current 2 Threshold Voltage (Vdet4) or lower and stays longer than the Excess Current 2 Delay Time (Tdet4), Do pad switches to high, turning off the discharge FET. The excess current protection state will be released when Vm＞Vdet3 and it stays longer than EX & SC Release Delay (Trex). The Excess Current 2 Threshold Voltage (Vdet4) is lower than the Excess Current 1 Threshold Voltage (Vdet3), and the Excess Current 2 Delay Time (Tdet4) is also shorter than the Excess Current 1 Delay Time (Tdet3).

Another way to detect discharge current is placing a small value sense-resistor between Vss and Vin. Vin takes the same priority and delay as Vm in the Excess current 1 state. The Excess Current 1 Threshold Voltage is 0.2V, and the excess current can be changed by sense-resistor with different values.

4. Short circuit

The principle of this function is just the same as the excess current protection. But, the delay time Tshort is much shorter than Tdet3 and Tdet4, and the threshold Vshort is much lower than Vdet3 and Vdet4. When the circuit is shorted, Vm decreases rapidly. Once Vm＜Vshort, Do pad switches to high, turning off the discharge FET. The Short circuit release condition is as same as Excess current, the current of short peak value is related to Vshort and discharge/charge FET by Ohm's law.

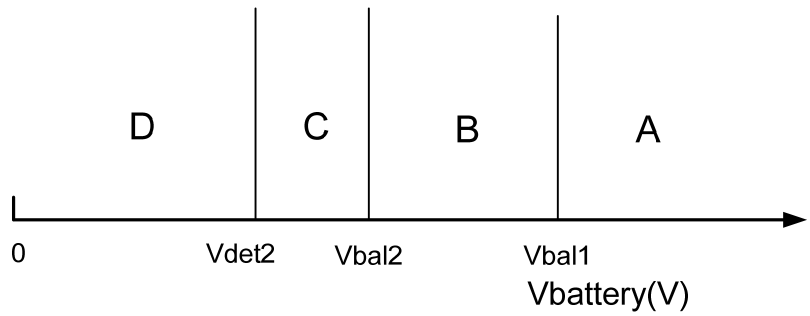
5. Abnormal charge and charger detection

When charging, if charging current exceeds pre-set threshold, Vm＞Vab, charge FET will be turned off after abnormal charge delay Tab. But for battery packs in over-discharge state, abnormal charge detection doesn't work. Instead, if Vm＞Vab due to voltage difference between battery and charger, charger detection works to turn on discharge FET as battery voltage goes up to Vdet2, not Vrel2. Abnormal charge state and charger detection is released when the Vm becomes lower than Vab.

6. External Bleeding

Cell balance is to balance the cells' capacity in a pack. When the (Va-Vb), (Vb-Vc), (Vc-Vd) and Vd all in t of the three ranges A, B, C ,or at least one of them is in range D, cell balance will not work. Otherwise there will be at least one bypass bleeding for cell balance. If four batteries' voltage separate in two of the three ranges A, B, C, external bleeding of those who is in range with higher voltage will be switched on. Else if A, B, C areas all have their own distributions, cells in area A, B, turn on their cell balance.

When charging, if one of the four cells enters overcharge state, charge FET will be turned off. Bleeding current makes the battery voltage falling down to overcharge release voltage Vrel1, charger detection stops for a while, turning on Co for continuing charging. Thus the voltage of all cells locate will reach to range A just in a cycle .



NOTE: D means over-discharge area.

Vbal2 means cell balance threshold2; Vbal1 means cell balance threshold1.

Excess current threshold adjustment

Adjustment of excess current threshold is available by external resistors R_Exa and R_Exs. Different values have their corresponding excess current threshold, R_Exs=80K. Small resistance can acquire high accuracy of excess current threshold at the price of power dissipation. Large resistance can reduce power dissipation, but the accuracy is not ideal.

Preset value		**Real value**		
Vcc-Vdet3	Vcc-Vdet4	R_Exa (ohms)	Vcc-Vdet3	accuracy
0.10V	0.30V	30K	0.102V	±15%
0.15V	0.45V	45K	0.151V	±15%
0.20V	0.60V	60K	0.200V	±15%

0.25V	0.75V	75K	0.247V	±15%
0.30V	0.90V	90K	0.294V	±15%
0.35V	1.05V	105K	0.340V	±15%
0.40V	0.20V	120K	0.385V	±15%
0.45V	1.35V	135K	0.430V	±15%
0.50V	1.80V	150K	0.475V	±15%

The Excess current 1 threshold calculate： $\mathrm{Vdet3} \approx \mathrm{Vcc}\text{-}\frac{0.8}{3} \times \frac{\mathrm{R\_Exa}}{\mathrm{R\_Exs}}$, $\mathrm{Vdet4} = \mathrm{Vcc}\text{-}3(\mathrm{Vcc}\text{-}\mathrm{Vdet3})$

Power MOSFET Drive Control

In BM309 Series application circuit, two P-MOSFETs control on/off of charge and discharge current. Do and Co are CMOS outputs. BM309 Series utilize several buffers to level up the output drive capacity.

Two P-MOSFETs in series is only one pattern of the control of charge and discharge loops. BM309 Series also support different charge and discharge loops.

Auto-fit between 3/4 cell

BM309 Series can be used in either a three-cell or a four-cell pack. In a three-cell pack's application, the Vc must be shorted to Vd. Built-in circuits can distinguish this condition from four-cell application.

Extended Application

As mentioned above, BM309 Series provide an easy way for extended application in more-cell-packs' protection.by additional module..

When used in extended condition, each IC transfers Do and Co information upward. For example as 8-cell, the information from Co and Do of the nether one will be transferred to Down_co and Down_do, then the upper one will get this information.By analogy the top IC collects all ICs' information and sends proper instructions to final Co and Do, controlling external MOSFETs. Once one of the ICs enters abnormal state, the whole system enters abnormal state, the protection is performed. Apparently, the top IC differes from the others. Pin K_DP is used to distinguish them. When K_DP is "0", outputs of the corresponding IC's Do and Co are "0" and "X"（high resistance）, when K_Dp is floating, the outputs of the corresponding IC's Do and Co are CMOS level.

Cell balance function goes on working in extended condition. To assure cell balance between ICs, BM309 Series use Down_in, Up_in, Out_down, Out_up to transfer each IC's balance information upward and downward. Each IC will get other ICs' balance information and choose whether to open its balance function or not. The upward and downward transmission of balance information forms a loop.

The sleep mode is unavailable in extended condition. After over-discharge protection occurs, discharge FET will turn off but control circuits won't enter sleep mode.

A steady current source are embedded in K_Dp, the output is 1.6 uA.

A steady current source are embedded in Down_do, Down_co, the output is 0.8 uA.

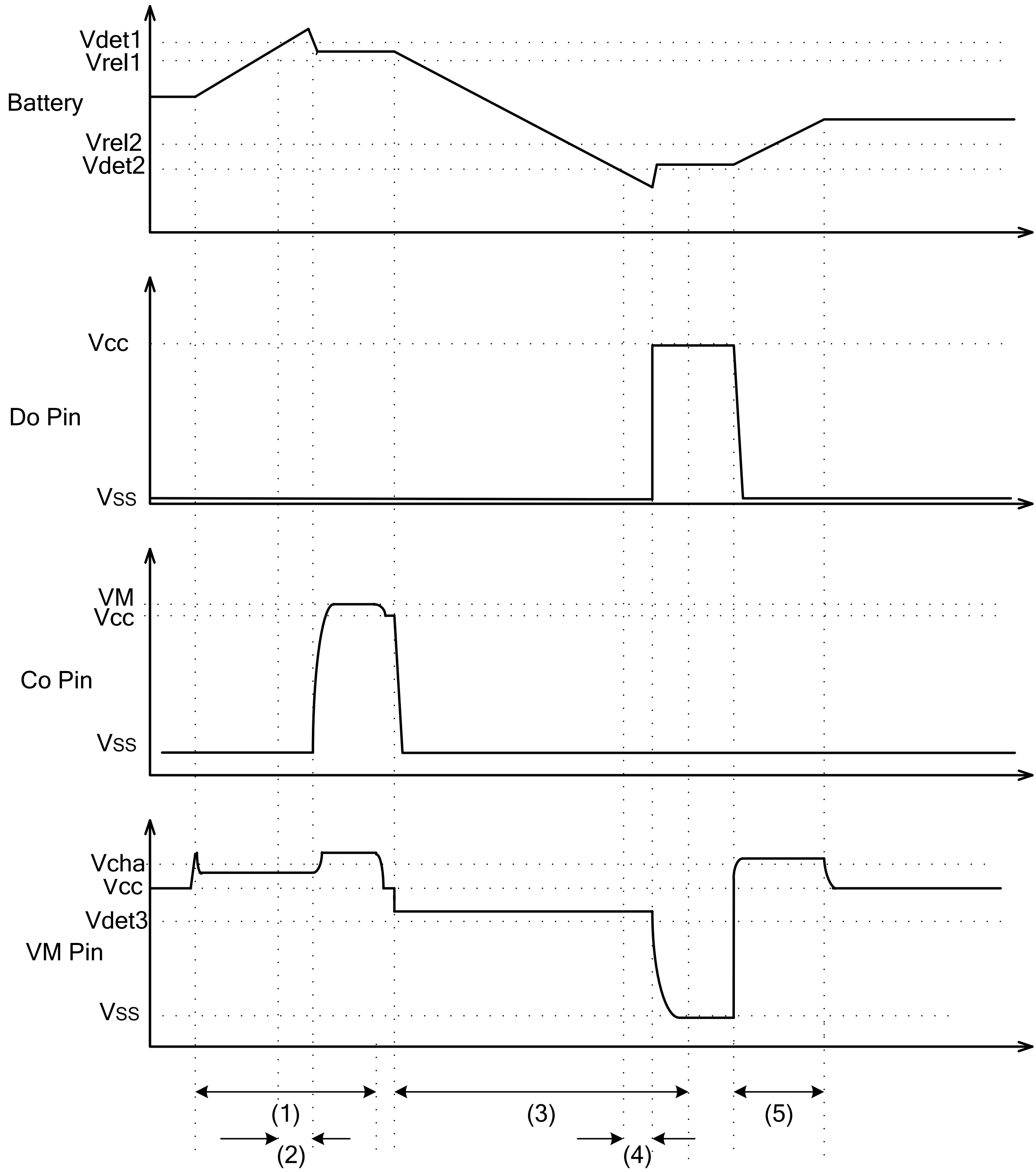
A steady current source are embedded in Down_in, Up_in, the output is 80nA.

Out_down pin is Nch open-drain output, the output resistance is 20K.

Out_up pin is Pch open-drain output, the output resistance is 24K.

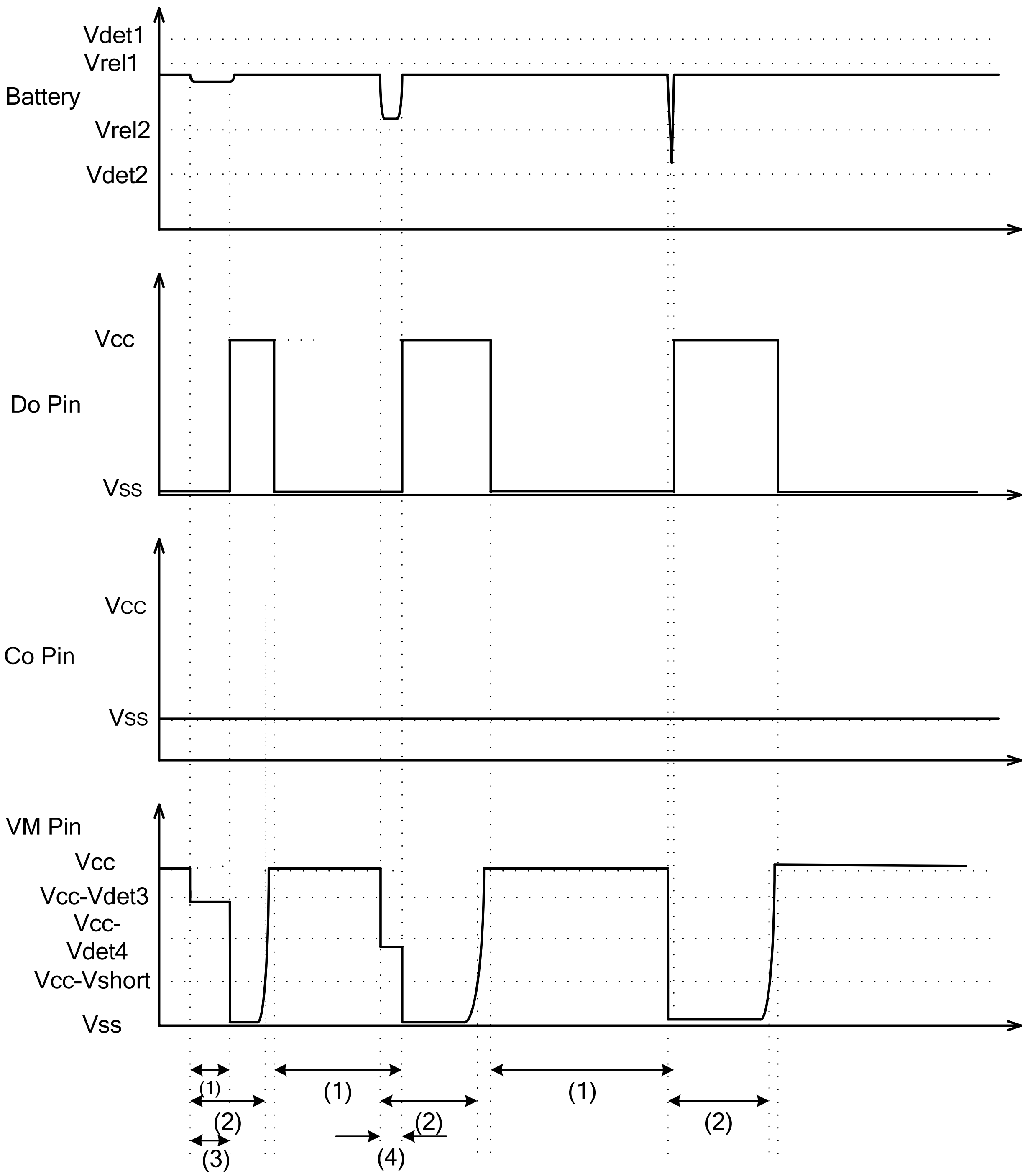
Operation Timing Charts

Overcharge/Over-discharge Detection



(1) Charger connected
(2) Overcharge Detection Delay Time (Tdet1)
(3) Load connected
(4) Over-discharge Detection Delay Time (Tdet2)
(5) Normal charging

Excess Current and Short Protection



(1) Normal condition
(2) Load connection
(3) Excess Current 1 Delay Time (Tdet3)
(4) Excess Current 2 Delay Time (Tdet4)

Test Circuits

1. Normal and standby current consumption

Test circuit 1

(1) Set V1=V2=V3=V4=3.70V, K1 on, the current flowing to Vss is the normal operating current consumption.

(2) Set V1=V2=V3=V4=3.70V, K1 on, then set V1=V2=V3=V4=2.20V, K1 off, the current flowing to Vss is the standby current consumption.

2. Overcharge threshold (Vdet1) and Overcharge release threshold (Vrel1)

Test circuit 2

Set V1=V2=V3=V4=3.70V, make sure Do and Co are “L”. Increase V1 gradually, monitor Co voltage and keep the condition not shorter than Tdet1, the V1, when Co turns from “L” to “H”, is the overcharge threshold voltage. Decrease V1, the V1, when Co returns to “L” again, is the overcharge release threshold.

3. Over-discharge threshold (Vdet2) and Over-discharge release threshold (Vrel2)

Test circuit 2

Set V1=V2=V3=V4=3.70V, make sure Do and Co are “L”. Decrease V1 gradually, monitor Do voltage and keep the condition not shorter than Tdet2, the V1, when Do turns from “L” to “H”, is the over-discharge threshold voltage. Increase V1, the V1 when Do returns to “L” again, is the over-discharge release threshold.

4. Balance threshold (Vbal1、Vbal2)

Test circuit 4

(1) Set V1=V2=V3=V4=3.70V, make sure Bal4 is 0V and Bal3 is 3.70V. Increase V4 gradually, monitor Bal4 voltage, when Bal4 turns from 0V to V4, the value of V4 is the balance threshold voltage (Vbal1).

(2) Set V1=V2=V3=V4=3.70V, make sure Bal4 is 0V and Bal3 is 3.70V. Decrease V4 gradually, monitor Bal3 voltage, when Bal3 turns from V4 to V4+3.70V, the value of V4 is the balance threshold voltage (Vbal2).

5. Excess current threshold (Vin, Vdet3, Vdet4) ,short circuit threshold (Vshort)

Test circuit 3

(1) Set V1=V2=V3=V4=3.70V, V5=14.80V, V6=0V, KI,K2 on, R_Exa＝60KΩ, R_Exs＝80KΩ, make sure Do and Co are “L”. Decrease V5 gradually, monitor Do voltage and keep the condition for some time, the V5, when Do turns from “L” to “H”, is the excess current 1 threshold (Vdet3). Increase V5, the excess current 1 will be released. Vdet4 and Vshort can also be tested, but V5 has a larger change.

(2) Set V1=V2=V3=V4=3.70V, V5=14.80V, V6=0V, KI, K2 off, make sure Do and Co are “L”. Increase V6 gradually, monitor Do voltage and keep the condition for some time, the V6, when Do turns from “L” to “H”, is discharge current detection threshold.

6. Charger detection threshold (Vcha) and abnormal charge threshold (Vab)

Test circuit 3

(1) Set V1=V2=V3=3.70V, V4=2.20, V5=13.30V, V6=0V, KI, K2 off, BM309 Series enter the over-discharge condition. Increase V4 gradually until it is between Vdet2 and Vrel2. Increase V5 gradually, the V5, when Do changes from “H” to “L”, is the Charger Detection threshold (Vcha).

(2) Set V1=V2=V3=V4=3.70V, V5=14.80V, V6=0V, KI,K2 off, make sure Do and Co are “L”, increase V5, the V5, when Co changes from “L” to “H”, is the abnormal charge threshold (Vab).

7. Delay parameters

(1) Overcharge detection delay(Tdet1)

Test circuit 2

Set V1=V2=V3=V4=3.70V, make sure Do and Co are “L”. Increase V1 transiently to 4.40V, monitor Co voltage, and keep the condition for some time. If Co changes to “H”, the “some time” is the overcharge detection delay (Tdet1).

(2) Over-discharge detection delay(Tdet2)

Test circuit 2

Set V1= V2=V3=V4=3.70V, make sure Do and Co are “L”, decrease V1 transiently to 2.20V, monitor Do voltage, and keep the condition for some time. If Do changes to “H”, the “some time” is the over-discharge detection delay (Tdet2).

(3) Excess current detection delay(Tdet3,Tdet4)

Test circuit 3

Set V1=V2=V3=V4=3.70V, V5=14.80V, KI, K2 on, make sure Do and Co are “L”, decrease V5 transiently to14V, monitor Do voltage, and keep the condition for some time. If Do changes to “H”, the “some time” is the excess current 1 detection delay (Tdet3). Increase V5, the excess current 1 will be released. Excess current 2 detection delay (Tdet4) can be tested using the same method. But V5 should decrease more and the delay is shorter.

8. Output/Input resistor drive capacity

8.1 Co, Do output resistor

Test Circuit 5

(1) Set V1=V2=V3=V4=3.70V, V5=0V, V6=0V, K1 on, increase V6 from 0V gradually, the V6 voltage, when A2 =50uA, is the CO 'L' voltage.

(2) Set V1=V2=V3=V4=4.40V, V5=0V, V6=17.60V, K1 on, decrease V6 from 17.60V gradually, the V6 voltage, when A2 =-50uA, is the CO 'H' voltage.

(3) Set V1=V2=V3=V4=3.70V, V5=0V, V6=0V, K2 on, increase V5 from 0V gradually, the V5 voltage, when A1 =50uA, is the DO 'L' voltage

(4) Set V1=V2=V3=V4=2.20V, V5=0V, V6=8.80V, and K2 on, decrease V5 from 8.80V gradually, the V5 voltage, when A2 =-50uA, is the DO 'H' voltage.

8.2 Vm resistance

Test Circuit 6

Test beginning condition: Set V1=V2=V3=V4=3.70V, V5=14.80V, make sure Do and Co are “L”,

(1) Set V1=V2=V3=V4=3.70V, V5=12.10V, the (14.80-V5)/I5 is the internal resistance RVMC which between VCC and Vm.

(2) Set V1=V2=V3=V4=2.20V, V5=3.70V, the V5/I5 is the internal resistance RVMS which between Vm and Vss.

8.3 Bleed1、Bleed2、Bleed3、Bleed4 resistance

Test Circuit 7

(1) Set V1=4.20, V2=V3=V4=3.70V, V5=15.30V, K1 on, K2, K3, K4 off, decrease V5 gradually from 15.30V, the V5, when A=-50uA, is the Bal1 ‘H’ voltage.

(2) Set V1=V2=V3=V4=3.70V, V5=11.10V, K1 on, K2, K3, K4 off, increase V5 gradually from 11.10V, the V5, when A=-50uA, is the Bal1 ‘L’ voltage.

(3) Set V2=4.20V, V1=V3=V4=3.70V, V5=11.60V, K2 on, K1, K3, K4 off, decrease V5 gradually from 11.60V, the V5, when A=-50uA, is the Bal2 ‘H’ voltage.

(4) Set V1=V2=V3=V4=3.70V, V5=7.40V, K2 on, K1, K3, K4 off, increase V5 gradually from7.40V, the V5, when A=50uA, is the Bal2 ‘L’ voltage.

(5) Set V3=4.20V, V1=V2=V4=3.70V, V5=7.90V, K3 on, K1, K2, K4 off, decrease V5 gradually from 7.90V, the V5, when A=-50uA, is the Bal3 ‘H’ voltage.

(6) Set V1=V2=V3=V4=3.70V, V5=3.70V, K3 on, K1, K2, K4 off, increase V5 gradually from 3.70V, the V5, when A=50uA, is the Bal3 ‘L’ voltage.

(7) Set V4=4.20V, V1=V2=V3=3.70V, V5=4.20V, K4 on, K1, K2, K3 off, decrease V5 gradually from 4.20V, the V5,

when A=-50uA, is the Bal4 'H' voltage.

(8) Set V1=V2=V3=V4=3.70V, V5=0V, K4 on, K1, K2, K3 off, increase V5 gradually from 0V, the V5, when A=50uA, is the Bal4 'L' voltage.

8.4 The output pin with extended application

Test circuit 8

(1) Set V1=V2=V3=V4=3.70V, V5=1.00V, K1 on, K2, K3, K4, K5, K6, K7 off, the reading of A1 is the output of K_Dp.

(2) Set V1=V2=V3=V4=3.70V, V7=1.00V, K4 on, K1, K2, K3, K5, K6, K7 off, the reading of A2 is the output of Up_in.

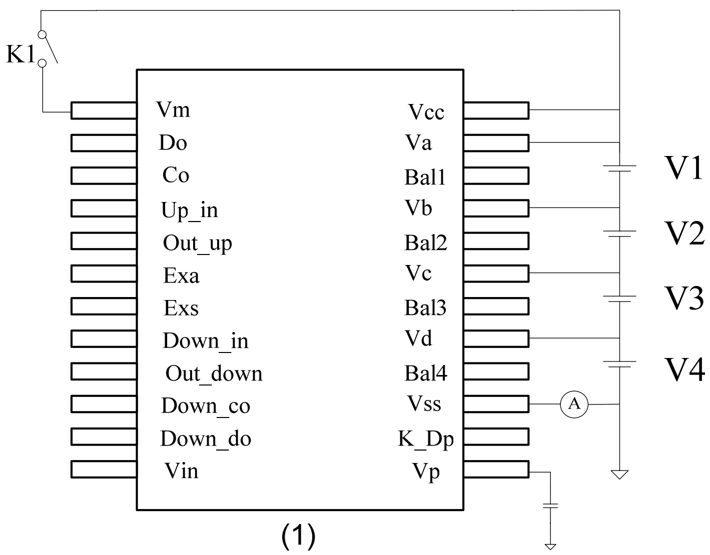
(3) Set V1=V2=V3=V4=3.70V, V7=1.00V, K5 on, K1, K2, K3, K4, K6, K7 off, the reading of A2 is the output of Down_in.

(4) Set V1=V2=V3=V4=3.70V, V7=1.00V, K6 on, K1, K2, K3, K4, K5, K7 off, the reading of A2 is the output of Down_co.

(5) Set V1=V2=V3=V4=3.70V, V7=1.00V, K7 on, K1, K2, K3, K4, K5, K6 off, the reading of A2 is the output of Down_do.

(6) Set V1=V2=V3=V4=3.70V, V6=0V, K2 on, K1, K3, K4, K5 ,K6 ,K7 off, increase V6 gradually from 0V, the V6, when the reading of A3 is 50uA, is the output of Out_up.

(7) Set V1=V2=V3=V4=3.70V, V6=3.40V, K3 on, K1, K2, K4, K5 ,K6 ,K7 off, decrease V6 gradually from 3.40V, the V6, when the reading of A3 is -50uA, is the output of Out_down.



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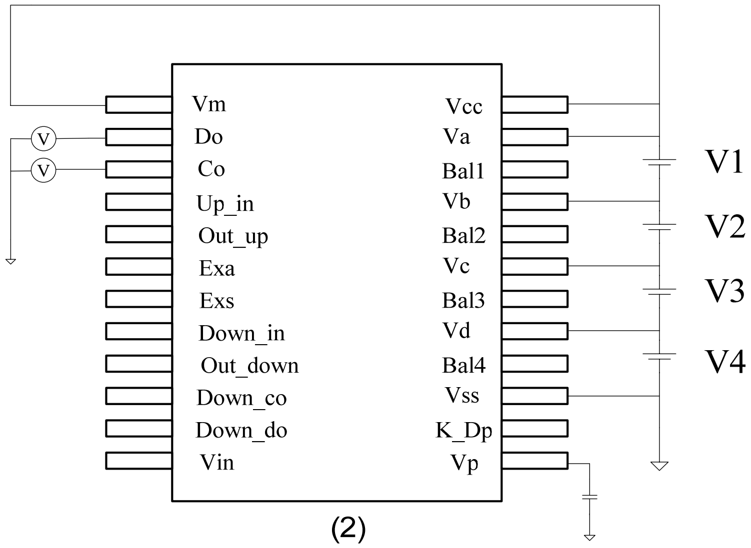
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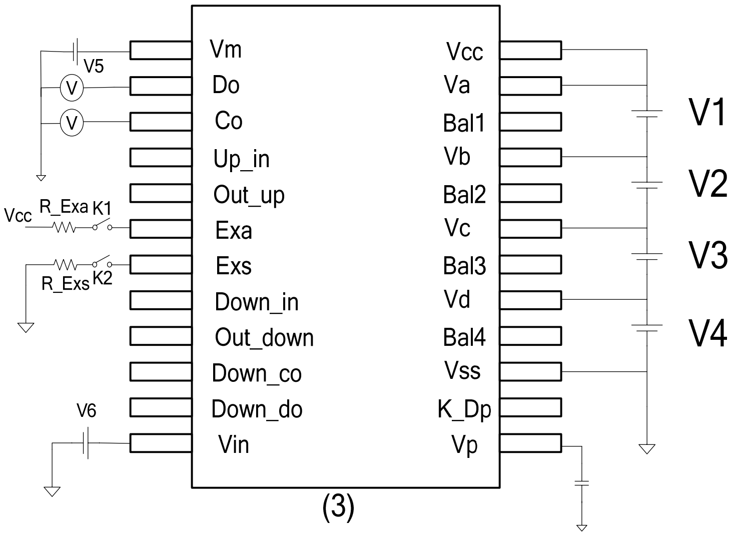
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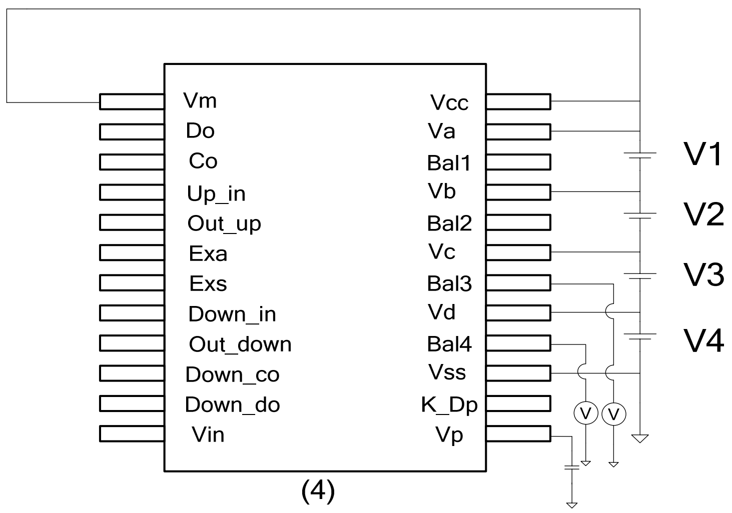
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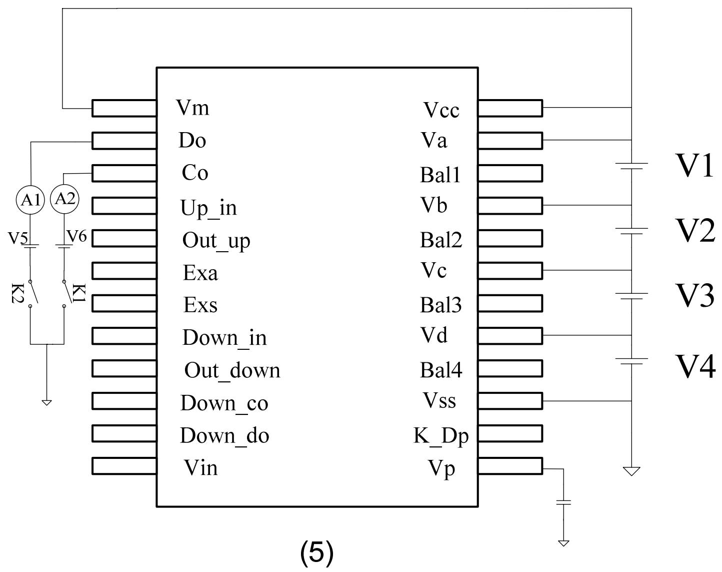
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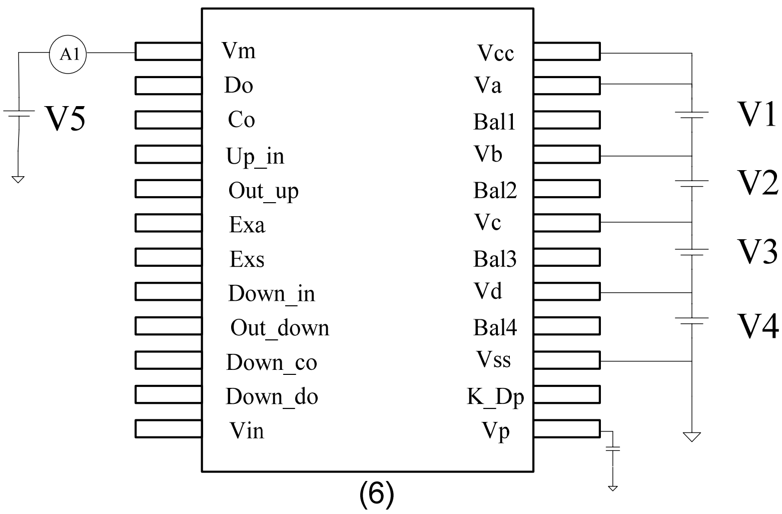
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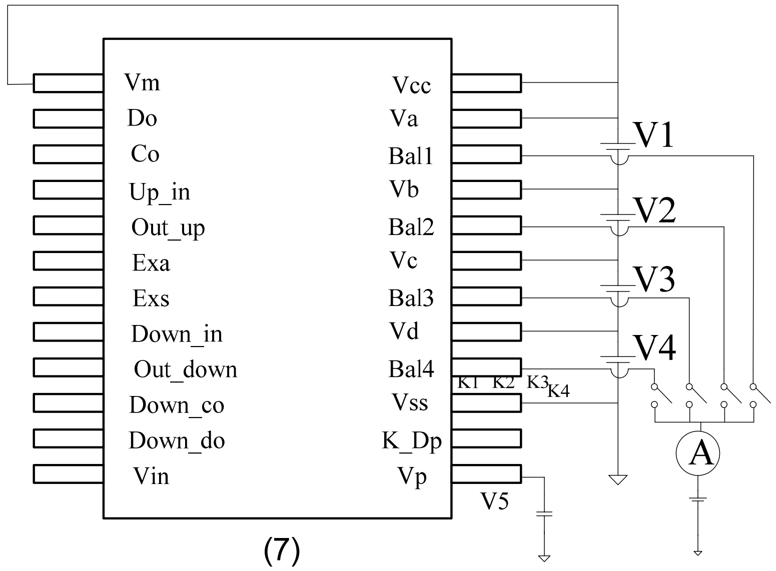
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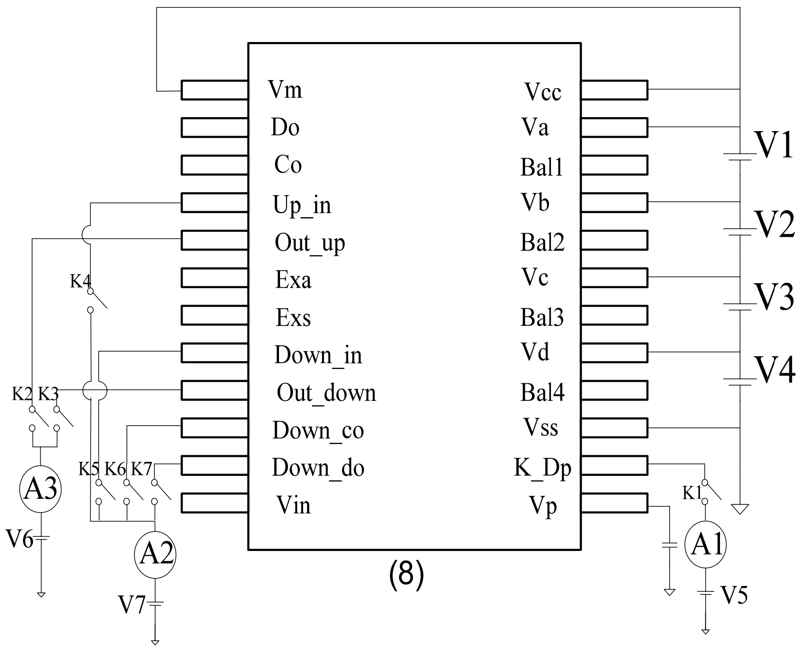
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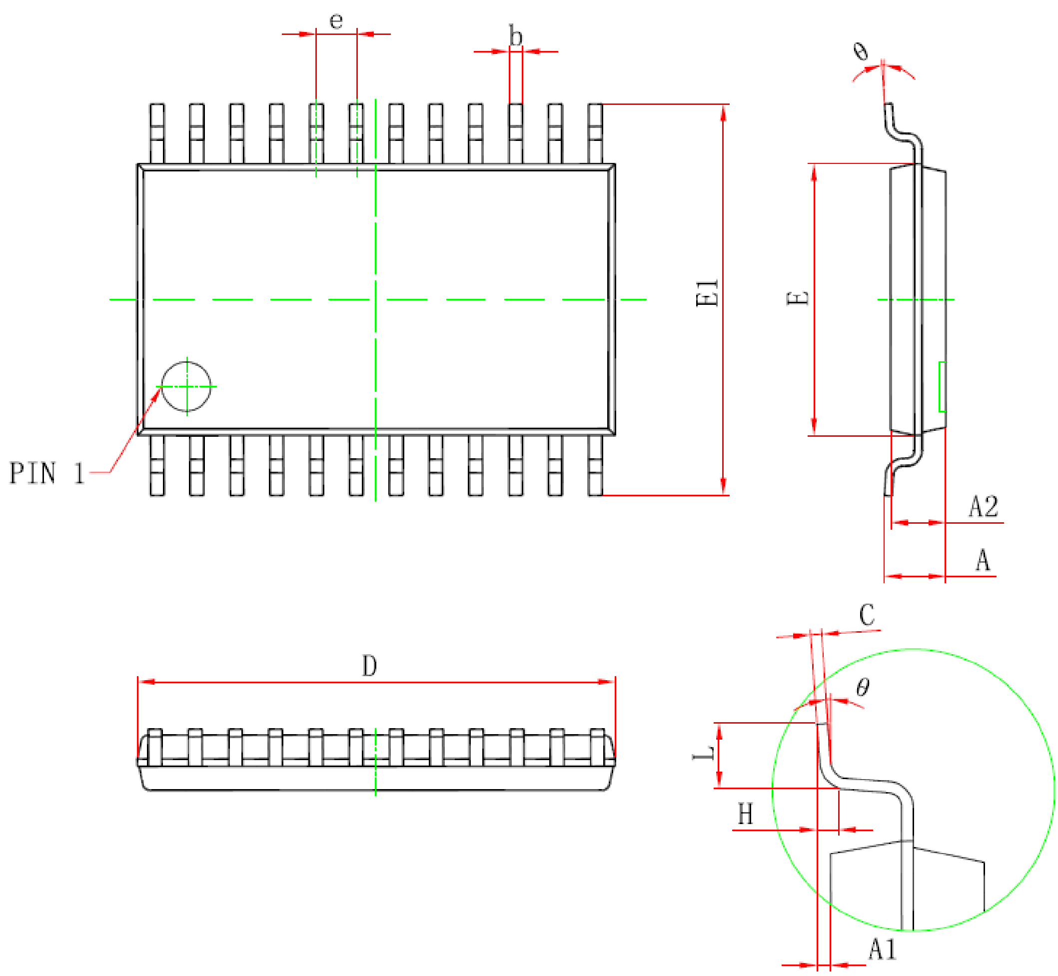
Package Information

- Package: TSSOP24



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	7.700	7.900	0.303	0.311
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.100		0.043
A2	0.800	1.000	0.031	0.039
A1	0.020	0.150	0.001	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.02	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

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