BYD Microelectronics Co., Ltd.

3 Cells Battery Professional Protectors

General Description

The BM3452 is a professional protection IC for 3 cells rechargeable battery pack; it is highly integrated, and generally used in power tools, electric bicycles and UPS applications.

The BM3452 works constantly to monitor each cell's voltage, the current of charge or discharge, and the temperature of the environment to provide overcharge, over-discharge, discharge overcurrent, short circuit, charge overcurrent and over-temperature protections, etc. Besides, it also can change the protection delay time of overcharge, over-discharge and discharge overcurrent by setting the external capacitors.

Features

(1) High-accuracy voltage detection for each cell

·overcharge threshold	3.6V~4.6V	accuracy: ±25 mV (+25℃)
		accuracy: ±40 mV (-40℃ to +85℃)
·overcharge hysteresis	0.1V	accuracy: ±50 mV
·over-discharge threshold	1.6V~3.0V	accuracy: ±80 mV
·over-discharge hysteresis	0V / 0.2V / 0.4V	accuracy: ±100 mV

(2) Three grades voltage detection of discharge overcurrent

·discharge overcurrent 1	0.025 V ~ 0.30 V	(50 mV step)
·discharge overcurrent 2	0.2 V / 0.3V / 0.4V / 0.6 V	
·short circuit	0.8V / 1.2 V	

(3) Charge overcurrent detection

·detection voltage	-0.03V / -0.05V / -0.1V / -0.15V / -0.2 V

(4) Setting of output delay time

·overcharge, over-discharge, discharge overcurrent 1 and discharge overcurrent 2 protection delay time can be set by external capacitors

(5) Controlling the state of charge or discharge by external signals

(6) The maximum output voltage of CO / DO: 12V

(7) Over-temperature protection

(8) Wide operation Temp Range: -40℃~85℃

(9) Breaking Wire Protection

(10) Low power consumption

·operation mode（with Temp protection）	25 µA	typical
·operation mode（without Temp protection）	15 µA	typical
·sleeping mode	6 µA	typical

Applications

·Power tool

·Electric bicycle

·UPS backup battery

Packages

SOP 16

Block Diagram
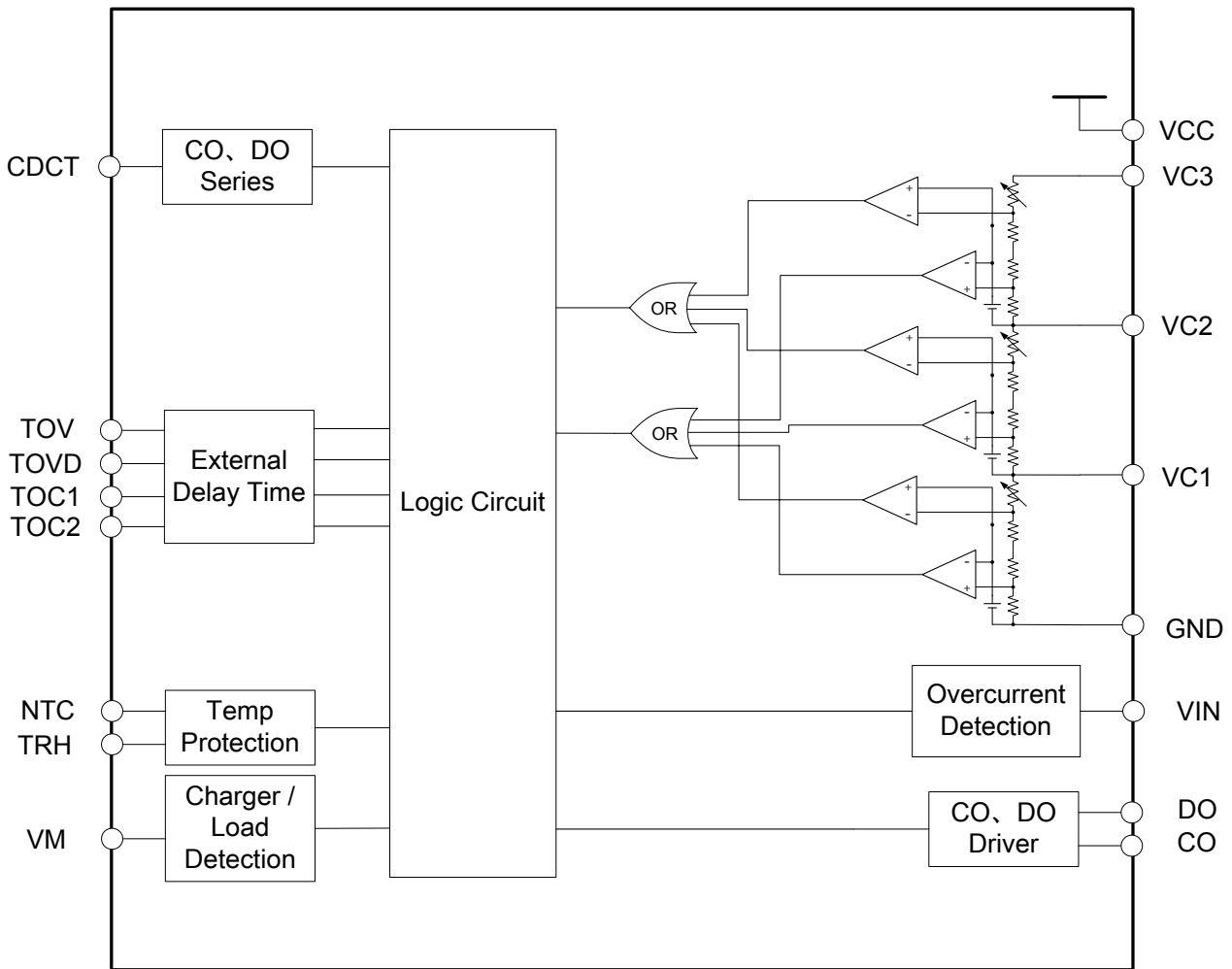
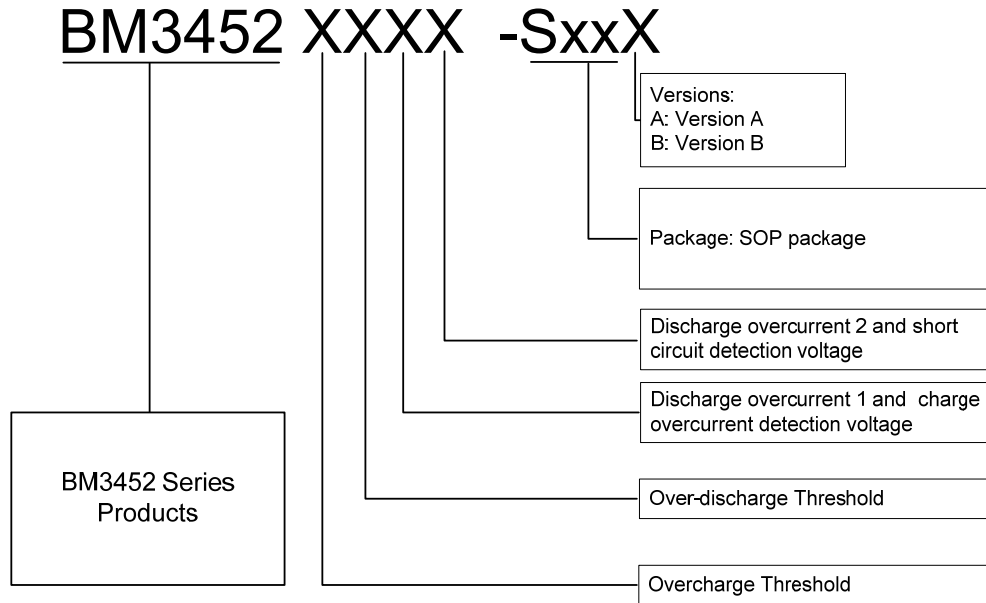

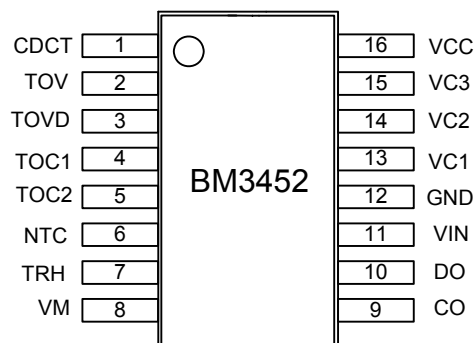Figure 1

Selection Guides

1.   **Products name structure**

$$\text{BM3452 XXXX -SxxX}$$

Versions:
A: Version A
B: Version B

Package: SOP package

Discharge overcurrent 2 and short circuit detection voltage

Discharge overcurrent 1 and charge overcurrent detection voltage

BM3452 Series Products

Over-discharge Threshold

Overcharge Threshold

Figure 2

2.   **Products catalogue**

Type/Item	Overcharge protection voltage [V_{DET1}]	Overcharge release voltage [V_{REL1}]	Over-discharge protection voltage [V_{DET2}]	Over-discharge release voltage [V_{REL2}]	Discharge overcurrent 1 detection voltage [V_{OC1}]	Discharge overcurrent 2 detection voltage [V_{OC2}]	Short circuit detection voltage [V_{SHORT}]	Charge overcurrent detection voltage [V_{OVCC}]
BM3452VJDC-S16A	4.300V	4.200V	2.500V	2.700V	0.100V	0.400V	0.800V	-0.100V
BM3452SMDC-S16A	4.225V	4.125V	2.800V	3.000V	0.100V	0.400V	0.800V	-0.100V
BM3452HEDC-S16A	3.850V	3.750V	2.000V	2.500V	0.100V	0.400V	0.800V	-0.100V

Table 1

Pin Configurations

		BM3452		
CDCT	1		16	VCC
TOV	2		15	VC3
TOVD	3		14	VC2
TOC1	4		13	VC1
TOC2	5		12	GND
NTC	6		11	VIN
TRH	7		10	DO
VM	8		9	CO

Top View

Figure 3

Pin Definition

Pin number	Name	Description
1	CDCT	CO ,DO controller for extended application
2	TOV	Connect to a capacitor for setting the delay time of overcharge protection
3	TOVD	Connect to a capacitor for setting the delay time of over-discharge protection
4	TOC1	Connect to a capacitor for setting the delay time of discharge overcurrent 1 protection
5	TOC2	Connect to a capacitor for setting the delay time of discharge overcurrent 2 protection
6	NTC	Cell temperature detection
7	TRH	Temperature protection reference
8	VM	Voltage detection terminal 1 for detecting load or charger
9	CO	Charge power mosfet control terminal, Open-Drain output
10	DO	Discharge power mosfet control terminal, CMOS output
11	VIN	Charge and Discharge overcurrent Voltage detection terminal 2
12	GND	Ground pin of the IC, Cell1 negative input
13	VC1	Cell1 positive input, Cell2 negative input
14	VC2	Cell2 positive input, Cell3 negative input
15	VC3	Cell3 positive input
16	VCC	Power supply,Cell3 positive input

Table 2

Absolute Maximum Ratings

Item	Symbol	Description	Ratings	Unit
Power supply voltage	VCC	-	GND-0.3 ~ GND+30	V
Single cell input voltage	V_{CELL}	Vcell3 Vcell2,Vcell1	GND-0.3 ~ GND+6	V
VM input voltage	VM	VM	GND-20 ~ GND+30	V
DO output voltage	V_{DO}	DO	GND-0.3 ~ VCC+0.3	V
CO output voltage	V_{CO}	CO	GND-20 ~ VCC+0.3	V
Operating temperature	T_A	-	-40 ~ 85	℃
Storage temperature	T_{STG}	-	-40 ~ 125	℃

Table 3

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.

Electrical Characteristics

（T_A=25℃ unless otherwise specified）

Item		Symbol	Test conditions*[1]	Min.	Typ.	Max.	Unit	Test circuit
Power supply voltage		VCC	-	5	-	30	V	
Operating consumption		I_{CC}	V1=V2=V3=3.5V	-	-	25	µA	1
Sleeping consumption		I_{SLP}	V1=V2=V3=2.0V	-	-	10	µA	
Overcharge	Protection threshold	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	T_{OV}	V1=V2=3.5V C_{OV}=0.1µF V3=3.5V→4.4V	0.5	1.0	1.5	s	
	Release threshold	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	T_{REL1}	V1=V2=3.5V V3=4.4V→3.5V	10	20	30	ms	
	Temperature factor(1)	K_{U1}	Ta= -40℃ to 85℃	-0.6	0	0.6	mV/℃	
Over-discharge	Protection threshold	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	T_{OVD}	V1=V2=3.5V C_{OVD}=0.1µF V3=3.5V→2.0V	0.5	1.0	1.5	s	
	Release threshold	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	T_{REL2}	V1=V2=3.5V V3=2.0V→3.5V	10	20	30	ms	
Discharge overcurrent 1	Protection threshold	V_{OC1}	V1=V2=V3=3.5V V4=0V→0.12V	V_{OC1} *85%	V_{OC1}	V_{OC1} *115%	V	3
	Protection delay time	T_{OC1}	V1=V2=V3=3.5V C_{OC1}=0.1µF V4=0V→0.12V	100	200	300	ms	
	Release delay time	T_{ROC1}	V1=V2=V3=3.5V V4=0V→0.12V→0V	100	200	300	ms	
	Resistance between VM and GND	R_{VMS}	V1=V2=V3=3.5V V4=0V→0.12V	100	300	500	kΩ	
	Temperature factor(2)	K_{U2}	Ta= -40℃ to 85℃	-0.1	0	0.1	mV/℃	
Discharge overcurrent 2	Protection threshold	V_{OC2}	V1=V2=V3=3.5V V4=0V→0.5V	V_{OC2} *80%	V_{OC2}	V_{OC2} *120%	V	

	Protection delay time	T_{OC2}	V1=V2=V3=3.5V C_{OC2}=0.1µF V4=0V→0.5V	10	20	30	ms	
Short circuit	Protection threshold	V_{SHORT}	V1=V2=V3=3.5V V4=0V→1.2V	V_{SHORT} *80%	V_{SHORT}	V_{SHORT} *120%	V	3
	Protection delay time	T_{SHORT}	V1=V2=V3=3.5V V4=0V→1.2V→0V	100	300	600	µs	
Charge overcurrent	Protection threshold	V_{OVCC}	V1=V2=V3=3.5V V4=0V→-0.2V	V_{OVCC} -0.03	V_{OVCC}	V_{OVCC} +0.03	V	4
	Protection delay time	T_{OVCC}	V1=V2=V3=3.5V V4=0V→-0.2V	10	20	30	ms	
Output resistances	CO	R_{CO}	Normal time, Co "H" (12V)	3	5	8	kΩ	5
	DO	R_{DO}	Normal time, Do "H" (12V)	3	5	8	kΩ	6
			Protecting time, Do "L"	0.20	0.35	0.50		

Table 4

*1: All the test condition parameters above are designed based on Li+ parameters, other grade parameters can adjust by their own actual voltages.

Function Description

1. Overcharge

During charging, VIN >V_{OVCC} when IC doesn't work in the state of charge overcurrent, If any of VC1, (VC2-VC1), (VC3-VC2) is higher than V_{DET1} and lasts longer than $T_{OV,}$ BM3452 chip considers that the batteries work in the state of overcharge, the output voltage of CO will become to 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.

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

(1) All cells' voltage is less than the Overcharge release threshold V_{REL1} and stays a period of time $T_{REL1.}$

(2) VM> 100mV (connecting to the load), Battery voltage is lower than V_{DET1} and stays a period of time $T_{REL1.}$

2. Over-discharge

During discharging, VIN<V_{OVCC} when IC doesn't work in the state of discharge overcurrent. If any of VC1, (VC2-VC1), (VC3-VC2) is less than V_{DET2} and lasts longer than T_{OVD}. BM3452 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.

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

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

(2) VM <-100mV (connecting to the charger), all cells' voltage is higher than V_{DET2} and stays a period of time $T_{REL2.}$

3. Discharge Overcurrent

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 over-current discharge. Usually $V_{OC1} < V_{OC2} < V_{SHORT}$, $T_{OC1} > T_{OC2} > T_{SHORT}$. When IC works in discharge overcurrent, the output voltage of DO is locked in low level. The discharge overcurrent protection state will be released when disconnect the load.

4. Delay Time Setting

Overcharge and Over-discharge delay time can be calculated as follow:

Tov = 10^7 x C_{OV}; Tovd = 10^7 x C_{OVD}

Discharge overcurrent 1 delay time can be calculated as follow: Toc1 = 2 x 10^6 x C_{OC1}

Discharge overcurrent 2 delay time can be calculated as follow: Toc2 = 2 x 10^5 x C_{OC2}

5. Charge Overcurrent

During charging, if the current is biggish with VIN<V_{OVCC} and stays longer than T_{OVCC}, the BM3452 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.

6. Over-temperature

Usually, batteries should be prevented charging and discharging from over-temperature. The BM3452 chip has this over-temperature protection. The thermostat resistor connecting to NTC pad is used to induct the pack's temperature, the resistor connecting TRH pad is used to set the reference of over-temperature protection. Assuming the resistance of NTC is R_{NTC} when the pack gets to the temperature of charge over-temperature protection, and then we set the resistance R_{TRH} of TRH be R_{TRH} =2* R_{NTC}. The over-discharge protection temperature is the temperature when the resistance of NTC become to 0.54* R_{NTC}. We can set the temperature of charge and discharge protection by changing the value of R_{TRH}.

Take 103AT-4 for example, NTC resistance is 10KΩ in normal temperature (25℃), and the temperature of charge over-temperature protection is 55℃.When the temperature is 55℃ and chip works in the state of charging, R_{NTC} is 3.5KΩ, so R_{TRH} is equal to 7KΩ. We also know the NTC resistance is 0.54*R_{NTC}=1.89 KΩ when the pack arrive to the temperature of discharge over-temperature, the temperature is 75℃ in this condition. The hysteresial temperature of charge over-temperature is 5℃ and the hysteresial temperature of discharge over-temperature is 15℃. During charging, when the temperature is higher than 55℃, the output voltage of CO turns to high resistance, and will be pulled down to low level by external resistor, charge control MOSFET will be turned off and stops charging. And when the pack's temperature falls down to 50℃, CO changes to high level and charge control MOSFET be turned on again. During discharging, when the temperature is higher than 75℃, the output voltage of DO becomes to low level, discharge control MOSFET will be turned off and stop discharging, at the same time charge control MOSFET will also be turned off and stops charging. When pack's temperature falls down to 60℃, the output of CO and DO turn to high level, charge and discharge control MOSFET will both be turned on again.

7. Breaking wire protection

When one or multi wires of VC1, VC2, VC3 are detected cut from the batteries by the BM3452 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, then the IC enters low consumption state.

Operation Timing Charts
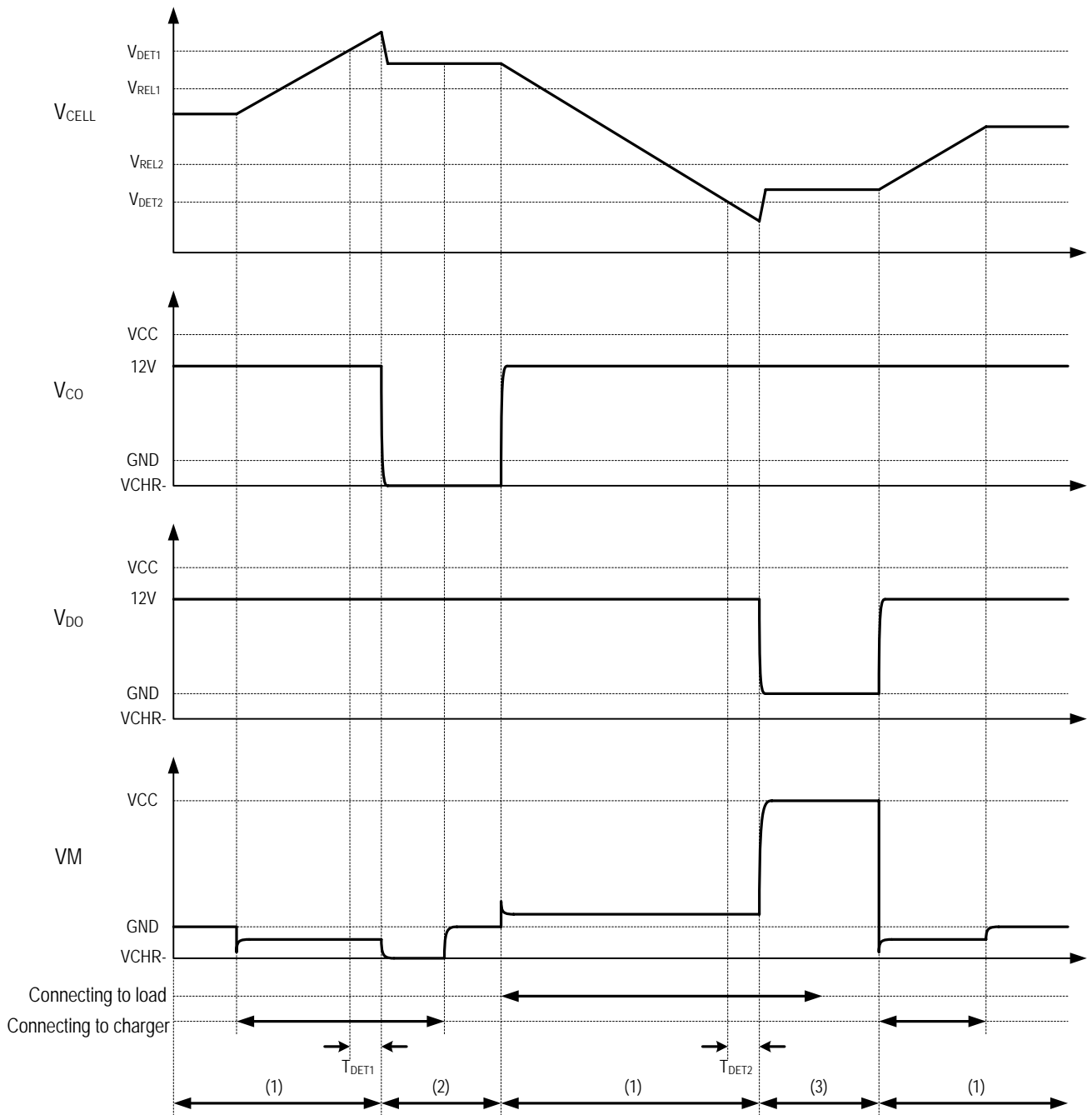
1. Overcharge/Over-discharge Protection

Figure 4

Assuming the charging current is constant, VCHR- is the voltage of the charger's negative terminal:

（1）Normal condition;

（2）Overcharge protection state;

（3）Over-discharge protection state.

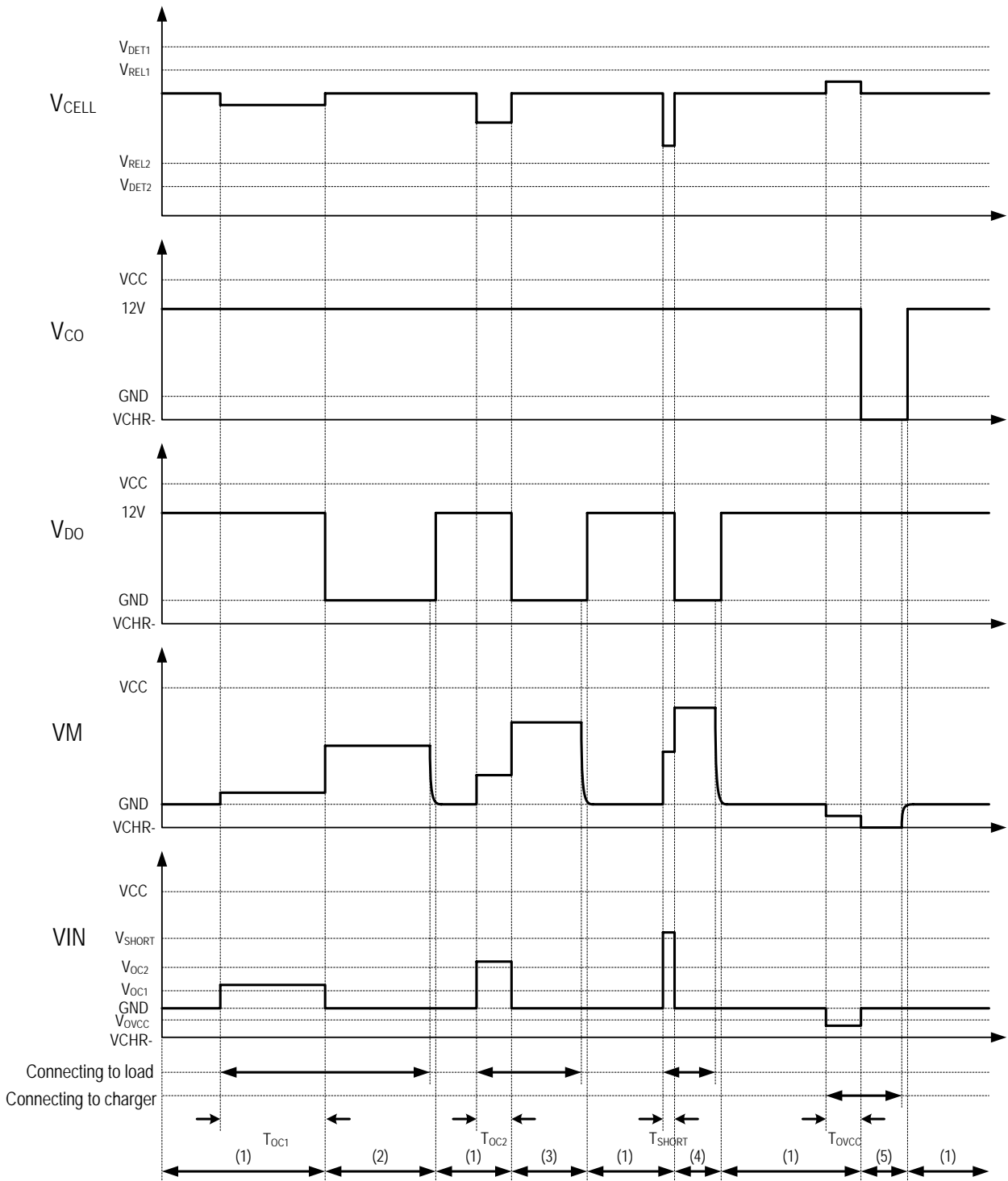## 2. Discharge Overcurrent / Short Circuit / Charge Overcurrent Protection

Figure 5

Assuming the charging current is constant, VCHR- is the voltage of the charger's negative terminal:

（1） Normal condition;

（2） Discharge overcurrent 1 protection state;

（3） Discharge overcurrent 2 protection state;

（4） Short circuit protection state;

（5） Charge overcurrent protection state.

Application Circuits
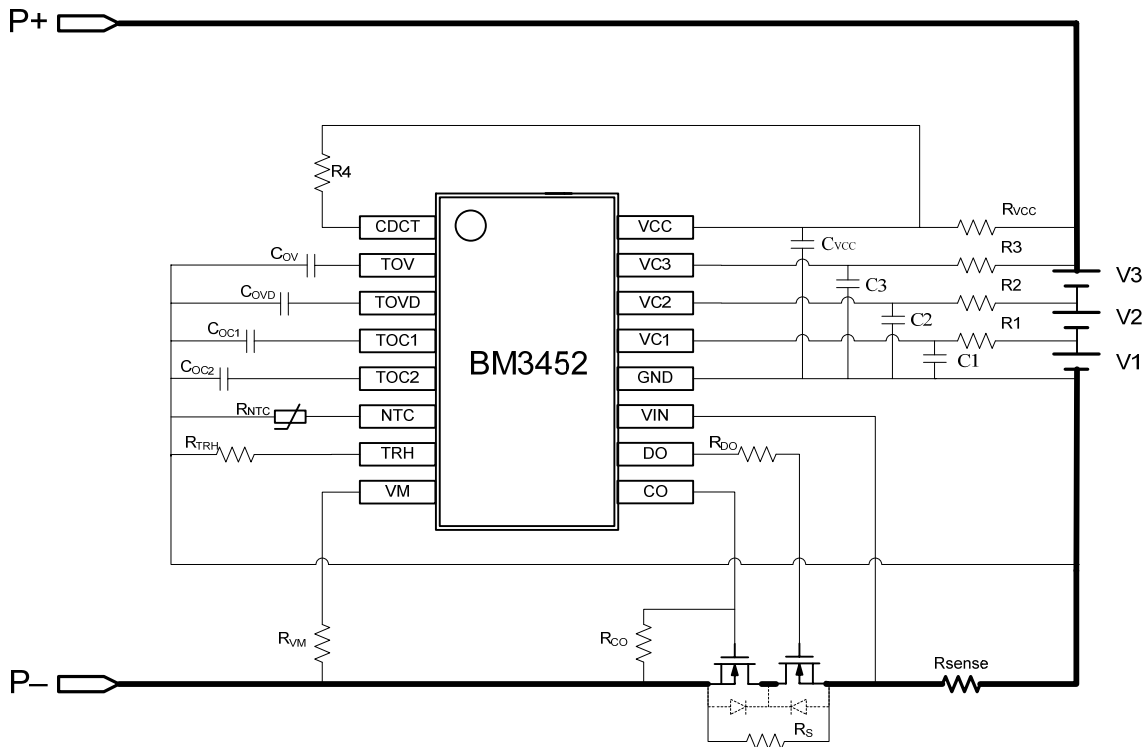
Figure 6（a-1）**3-cell application**

---charge and discharge circuits together
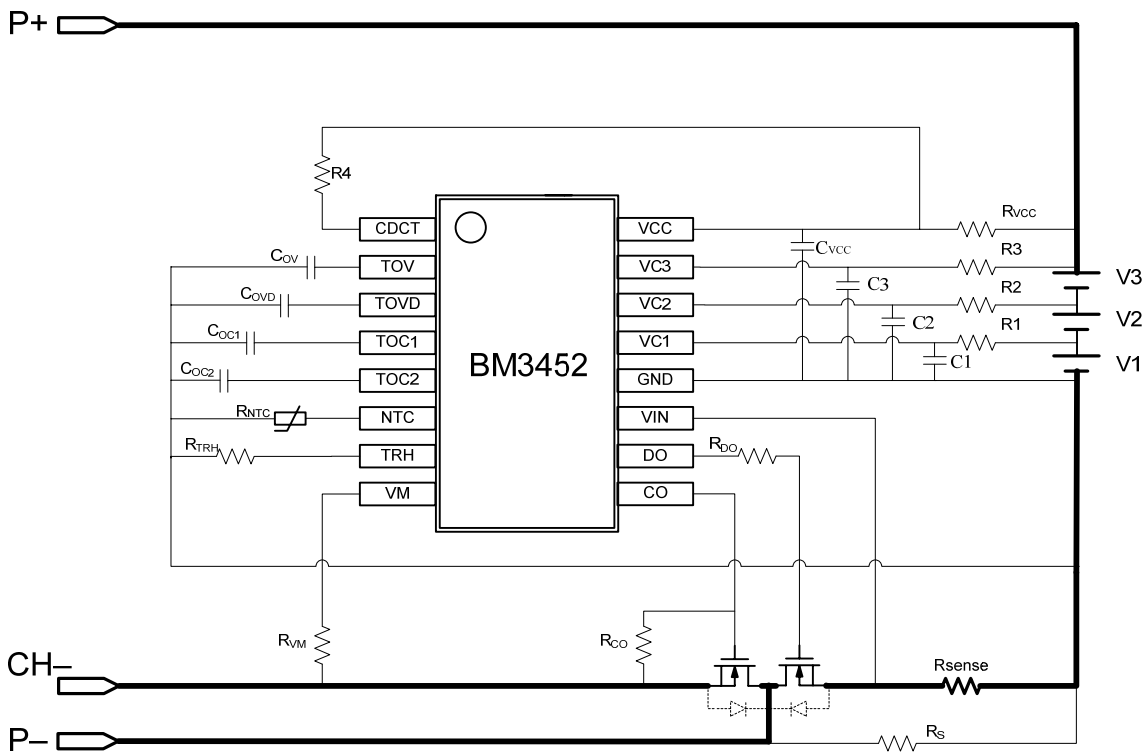
Figure 6（a-2）**3-cell application**

---charge and discharge circuits separated

Constants for External Components：

Component Symbol	Typ.	Range		Unit
R1, R2, R3	1000	100 ~ 1000		Ω
R_{VCC}	1000	100 ~ 1000		Ω
R4	1	1 ~ 2		MΩ
R_{NTC}	10	-		kΩ
R_{TRH}	7	-		kΩ
R_{VM}	220	10-500		kΩ
R_{CO}, R_S	10	5~15		MΩ
R_{DO}	2	1~10		kΩ
R_{sense}	5	1 ~ 20		mΩ
C_{VCC}	10	10 ~ 100		μF
C1, C2, C3	1.0	0.1 ~ 10	Maximum endurable voltage >50V	μF
C_{OV}, C_{OVD}, C_{OC1}, C_{OC2}	0.1	-		μF

Table 6

Test Circuits

1. Normal and Sleeping Current Consumption
Test circuit 1

(1) Set V1=V2=V3=3.50V, the current flowing to GND is the normal operating current consumption.

(2) On the condition of (1), then set V1=V2=V3=2.0V, the current flowing to GND is the sleeping current consumption.

2. Overcharge Protection Test
Test circuit 2

2.1 Overcharge threshold ($V_{DET1)}$) and Overcharge release threshold (V_{REL1})

Set V1=V2=V3=3.50V, 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 Tdet1, the value of V3 when CO turns from "H" to "L" is the overcharge threshold voltage. Decrease V3, the V3 when CO returns to "H" level again is the overcharge release threshold.

2.2 Overcharge protection delay time and Overcharge release delay time

(1) Set V1=V2=V3=3.50V, 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.

(2) Set V1=V2=3.50V, 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.

3. Over-discharge Protection Test
Test circuit 2

3.1 Over-discharge threshold (V_{DET2}) and Over-discharge release threshold (V_{REL2})

Set V1=V2=V3=3.50V, 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 Tdet2, the value of V3 when the output voltage of DO turns from "H" to "L" is the over-discharge threshold voltage. Increase V3, the value of V3 when DO returns to "H" level again is the over-discharge release threshold.

3.2 Over-discharge protection delay time and Over-discharge release delay time

(1) Set V1=V2=V3=3.50V, 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.

(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.

4. Discharge overcurrent and short circuit Protection Test
Test circuit 3

4.1 Discharge overcurrent1 and 2 threshold (V_{DET3}, V_{DET4}) and short circuit threshold (V_{SHORT})

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.

4.2 Discharge overcurrent protection delay time and release delay time

(1) Set V1=V2=V3=3.50V, 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.

(2) Set V1=V2=V3=3.50V, 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.

(3) Set V1=V2=V3=3.50V, V4=0V, make sure the voltages of DO and CO pins are "H". Increase V4 instantaneously with its value lager 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.

(4) Set V1=V2=V3=3.50V, 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.

5. Charge overcurrent Protection Test
Test circuit 4

5.1 Charge overcurrent threshold

Set V1=V2=V3=3.50V, V4=0V, make sure the output voltages of DO and CO pins are "H". Increase V4 gradually, monitor CO voltage and keep a period of time. The value of V4 when the output voltage of CO turns from "H" to "L" is the charge overcurrent threshold.

5.2 Charge overcurrent protection delay time

Set V1=V2=V3=3.50V, V4=0V, make sure the output voltages of DO and CO pins are "H". Increase V4 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.

6. Output/Input Resistance Test
7.1 The output resistances of CO and DO

(1) The output resistance when the output voltages of CO and DO pins are both "H".
Test circuit 5,6

Set V1=V2=V3=3.50V, V4=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 V4 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.

(2) The output resistance when the output voltage of DO pin is "L".
Test circuit 6

Set V1=V2=V3=2.00V, V4=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 V4 gradually from 0V, monitor the value of I_A,
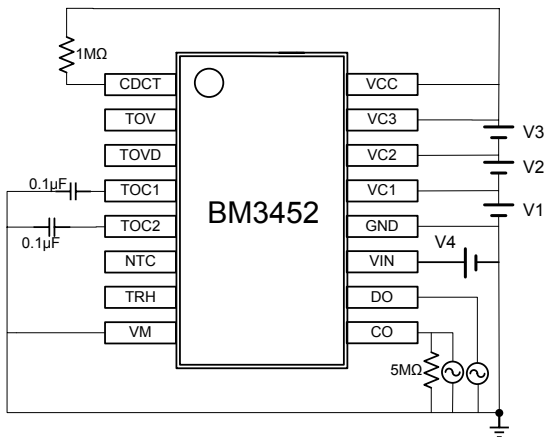
note down the output voltage V_{DO} of DO pin when the value of I_A is 50uA, then the output resistance of DO is calculated as follows: $R_{DOL} = V_{DO}/50$ (MΩ)
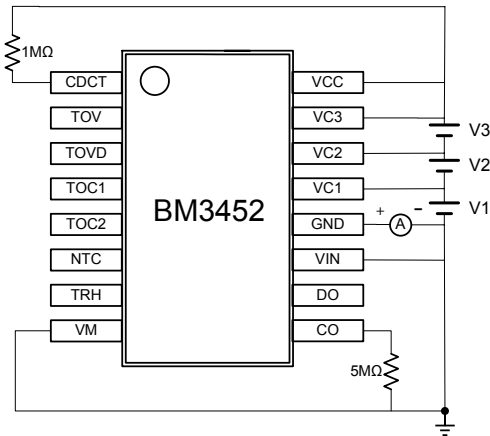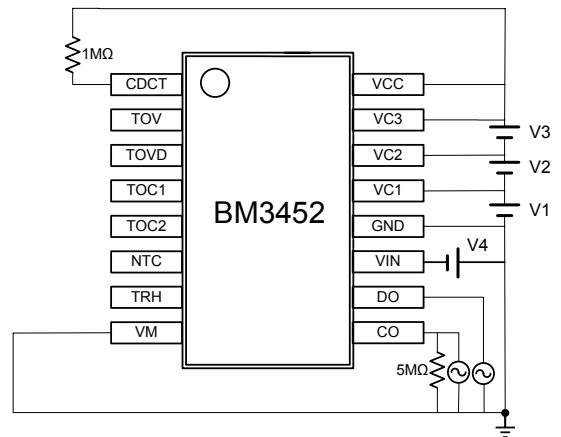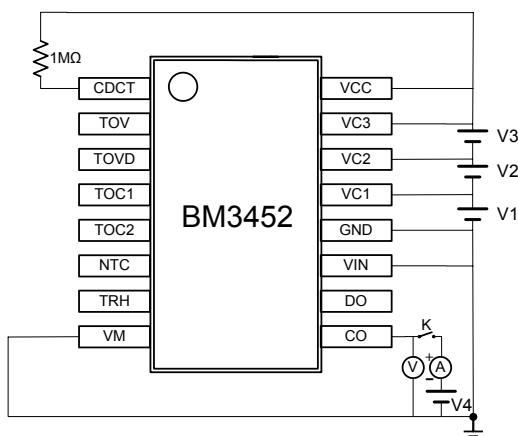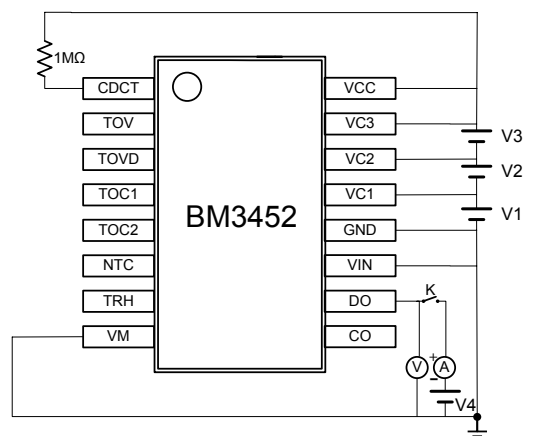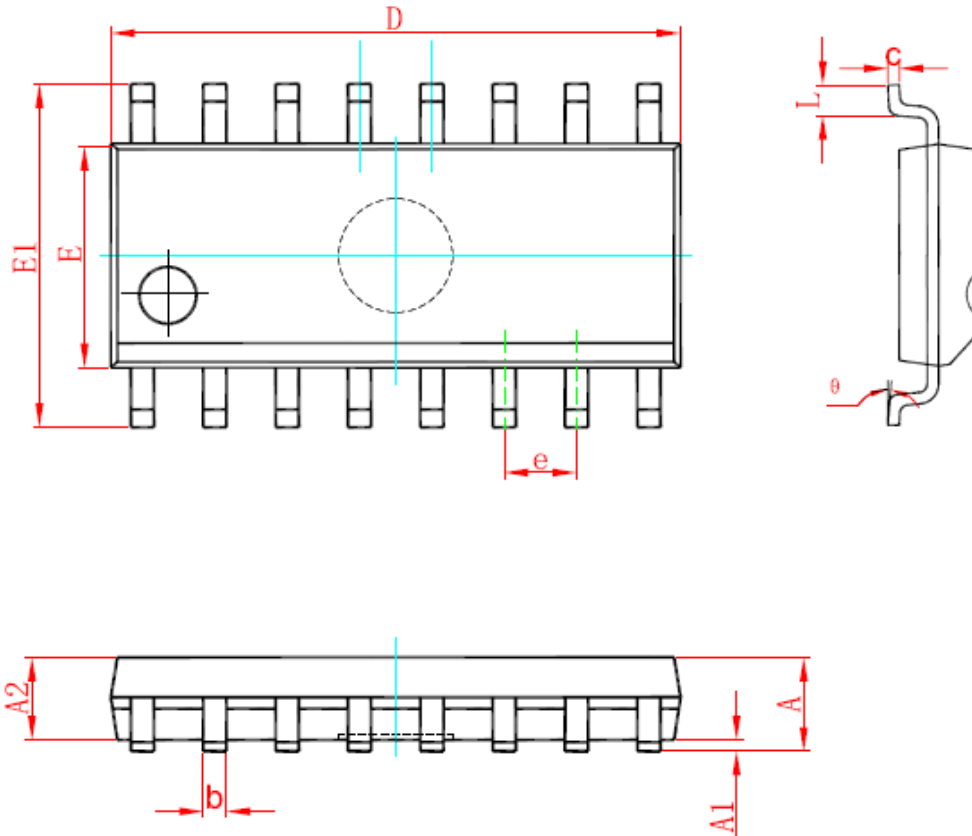

Test Circuit 1
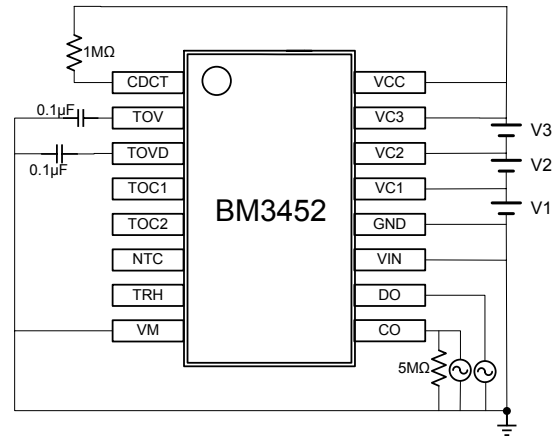
Test Circuit 2

Test Circuit 3

Test Circuit 4

Test Circuit 5

Test Circuit 6

Package Information

SOP16 PACKAGE OUTLINE DIMENSIONS

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Restrictions on Product Use