■ Description

The CM1004-BWD is a protection IC for lithium-ion / lithium polymer rechargeable batteries and includes high-accuracy voltage detection circuits and delay circuits. It is suitable for protecting 1-cell lithium-ion / lithium polymer rechargeable battery packs from overcharge, overdischarge, and overcurrent.By using an external overcurrent detection resistor, the CM1004-BWD realizes high-accuracy overcurrent protection with less effect from temperature change.

■ Features

1) **High accuracy voltage detection**

• Overcharge detection voltage	4.525 V	Accuracy ±20 mV
• Overcharge release voltage	4.425 V	Accuracy ±50 mV
• Over discharge detection voltage	2.300 V	Accuracy ±50 mV
• Over discharge release voltage	2.700 V	Accuracy ±75 mV
• Discharging overcurrent detection voltage 1	0.0075 V	Accuracy ±1.5 mV
• Discharging overcurrent detection voltage 2	0.018 V	Accuracy ±3.0 mV
• Load short-circuit detection voltage 1	0.033 V	Accuracy ±5.0 mV
• Load short-circuit detection voltage 2	VDD-1.0 V	Accuracy ±0.3 V
• Charging overcurrent detection voltage	-0.010 V	Accuracy ±1.5 mV

2) **Detection delay times are generated only by an internal circuit (external capacitors are unnecessary)**

3) **0V battery charge function** Available

4) **Power-down function** Unavailable

5) **Release condition of discharge overcurrent status** Load disconnection

6) **Discharge overcurrent release voltage** V_{RIOV}

7) **Ultra-low power dissipation**

• Normal mode 1.8 μA (Typ.) (Ta = +25°C)

• Overdischarge mode 0.5 μA (Typ.) (Ta = +25°C)

8) **RoHS, PB-Free, HF**

■ Application

• Lithium-ion/lithium-polymer rechargeable battery

■ Packages

• DFN1.9*1.6-6L

■ Block Diagram

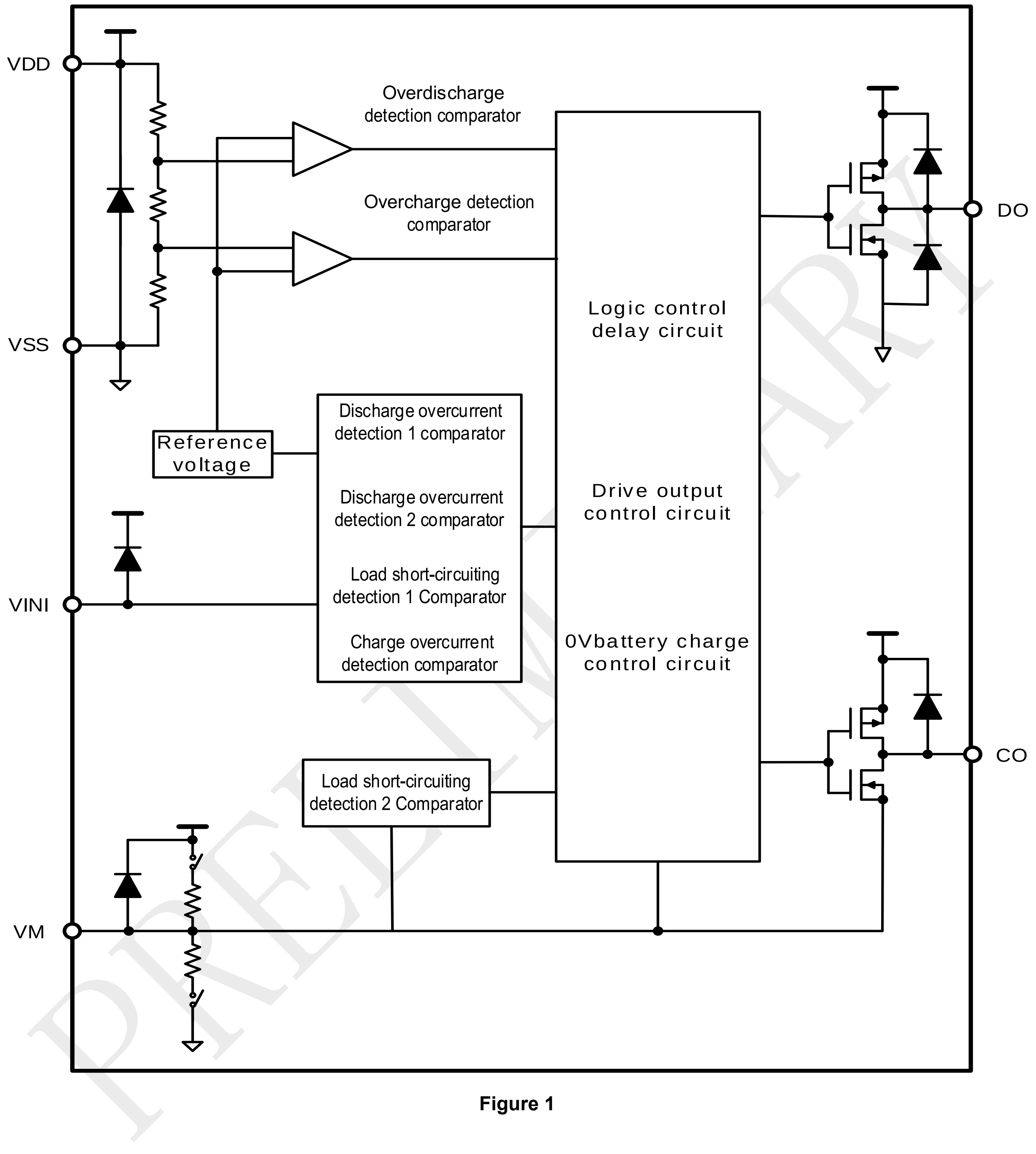


Figure 1

■ Pin Configurations

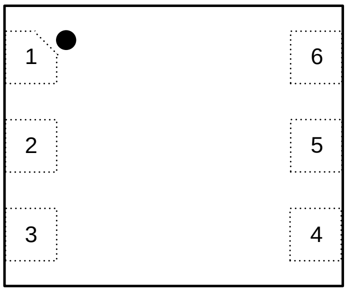


Figure 2 Top view

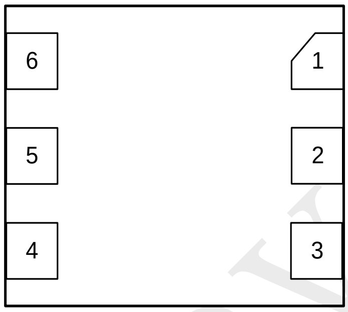


Figure 3 Bottom view

Pin No.	Symbol	Description
1	VM	Input pin for external negative voltage
2	CO	Connection pin of charge control MOSFET gate
3	DO	Connection pin of discharge control MOSFET gate
4	VSS	Input pin for negative power supply
5	VDD	Input pin for positive power supply
6	VINI	Overcurrent detection pin

Table 1

Marking

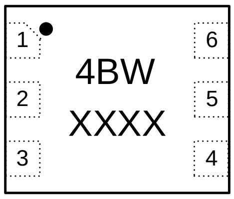
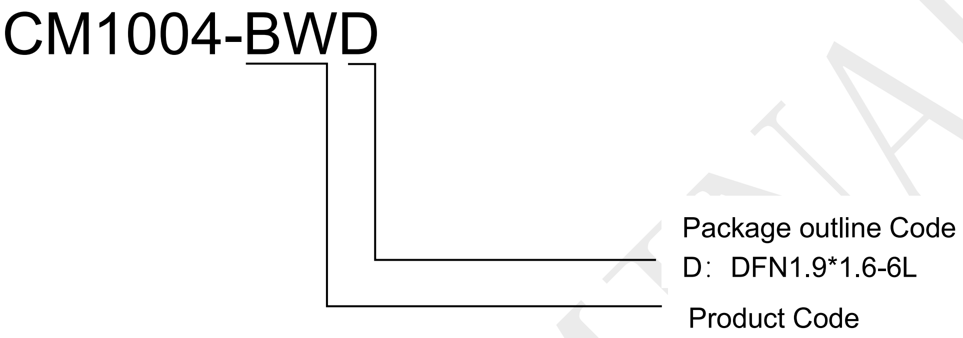


Figure 4

The first line: “4” is the product family code,“BW” is the Product Code
The second line: lot number

Naming rules



Products Catalogue

1. Detect Voltage List

Part No.	Overcharge detection voltage [V_{OC}]	Over-charge release voltage [V_{OCR}]	Over-discharge detection voltage [V_{OD}]	Over-discharge release voltage [V_{ODR}]	Discharge overcurrent detection [V_{EC1}]	Discharge overcurrent detection [V_{EC2}]	Short-circuit current detection [V_{SHORT}]	Charge overcurrent detection [V_{CHA}]
CM1004-BWD	4.525 V	4.425 V	2.300 V	2.700 V	0.0075 V	0.018 V	0.033 V	-0.010 V

Table 2

2. Product Function List

Part No.	0V Battery Charge Function	Release condition of discharge overcurrent status	Release Voltage of Discharge Overcurrent Status	Power-down Function
CM1004-BWD	Available	Load disconnection	V_{RIOV}	Unavailable

Table 3

3. Delay Time

Overcharge detection delay time [T_{OC}]	Over discharge detection delay time [T_{OD}]	Discharge overcurrent detection delay time [T_{EC1}]	Discharge overcurrent detection delay time [T_{EC2}]	Charge overcurrent detection delay time [T_{CHA}]	Load short-circuiting detection delay time [T_{SHORT}]
1024 ms	128 ms	3584 ms	32 ms	32 ms	512 μs

Table 4

Remark: For more product info, please contact iCM marketing department.

Absolute Maximum Ratings

(Unless otherwise specified: Ta = +25°C)

Item	Symbol	Ratings	Unit
Power supply voltage	VDD	VSS-0.3 ~ VSS+8.0	V
Input pin voltage for VM	V_{VM}	VDD-28 ~ VDD+0.3	V
CO output voltage	V_{CO}	VDD−28 ~ VDD+0.3	V
DO output voltage	V_{DO}	VSS-0.3 ~ VDD+0.3	V
Operating temperature	T_{OPR}	-40 ~ +85	°C
Storage temperature	T_{STG}	-55 ~ +125	°C

Table 5

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

(Unless otherwise specified: Ta = +25°C)

Item	Symbol	Test conditions	Min.	Typ.	Max.	Unit
[Consumption]						
Operating consumption	I_{OPE}	VDD=3.5V, V_{VM}=0V	0.9	1.8	3.5	μA
Overdischarge consumption	I_{OPED}	VDD=V_{VM}=1.5V	-	0.5	0.8	nA
[Detection Voltage]						
Overcharge detection voltage	V_{OC}	VDD=3.5 → 4.8V	4.505	4.525	4.545	V
Overcharge release voltage	V_{OCR}	VDD=4.8 → 3.5V	4.375	4.425	4.475	V
Over discharge detection voltage	V_{OD}	VDD=3.5 → 2.0V	2.250	2.300	2.350	V
Over discharge release voltage	V_{ODR}	VDD=2.0 → 3.5V	2.625	2.700	2.775	V
Discharge overcurrent detection voltage 1	V_{EC1}	-	0.0060	0.0075	0.0090	V
Discharge overcurrent detection voltage 2	V_{EC2}	-	0.015	0.018	0.021	V
Load short-circuiting detection voltage	V_{SHORT}	-	0.028	0.033	0.038	V
Charge overcurrent detection voltage	V_{CHA}	-	0.0085	0.0100	0.0115	V
Discharge overcurrent release	V_{RIOV}	VDD=3.5V	V_{VDD} − 1.3	V_{VDD} − 1.0	V_{VDD} − 0.7	V
[Delay Time]						
Overcharge detection delay time	T_{OC}	VDD=3.5 → 4.8V	717	1024	1331	ms
Over discharge detection delay	T_{OD}	VDD=3.5 → 2.0V	89.6	128.0	166.4	ms
Discharge overcurrent detection delay time 1	T_{EC1}	VINI-VSS=0→0.120V	2509	3584	4659	ms
Discharge overcurrent detection delay time 2	T_{EC2}	VINI-VSS=0→0.120V	22.4	32.0	41.6	ms
Charge overcurrent detection delay time	T_{CHA}	VSS-VINI=0→0.120V	22.4	32.0	41.6	ms
Load short-circuiting detection	T_{SHORT}	VINI-VSS=0→0.120V	307	512	717	μs
[Internal Resistance]						
Resistance between VDD pin and VM pin	R_{VMD}	VDD=1.8V, V_{VM}=0V	150	300	600	kΩ
Resistance between VM pin and VSS pin	R_{VMS}	VDD=3.4V, V_{VM}=1.0V	5	10	15	kΩ
[Output Resistance]						
CO pin resistance "H"	R_{COH}	-	5	10	20	kΩ
CO pin resistance "L"	R_{COL}	-	5	10	20	kΩ
DO pin resistance "H"	R_{DOH}	-	5	10	20	kΩ
DO pin resistance "L"	R_{DOL}	-	1	2	4	kΩ
[0V Battery Charge Function]						
0V battery charge “Available” starting charge voltage	V_{0CH}	0V battery charging “Available”	0.7	1.1	1.5	V

Table 6

Electrical Characteristics

(Unless otherwise specified: Ta =-25°C ~ +70°C*1)

Item	Symbol	Test conditions	Min.	Typ.	Max.	Unit
[Consumption]						
Operating consumption	I_{OPE}	VDD=3.5V, V_{VM}=0V	0.9	1.8	4.0	μA
Overdischarge consumption	I_{OPED}	VDD=V_{VM}=1.5V	-	0.5	1.0	nA
[Detection Voltage]						
Overcharge detection voltage	V_{OC}	VDD=3.5 → 4.8V	4.485	4.525	4.555	V
Overcharge release voltage	V_{OCR}	VDD=4.8 → 3.5V	4.355	4.425	4.480	V
Over discharge detection voltage	V_{OD}	VDD=3.5 → 2.0V	2.230	2.300	2.355	V
Over discharge release voltage	V_{ODR}	VDD=2.0 → 3.5V	2.600	2.700	2.800	V
Discharge overcurrent detection voltage 1	V_{EC1}	-	0.0055	0.0075	0.0095	V
Discharge overcurrent detection voltage 2	V_{EC2}	-	0.014	0.018	0.022	V
Load short-circuiting detection voltage	V_{SHORT}	-	0.028	0.033	0.038	V
Charge overcurrent detection voltage	V_{CHA}	-	0.008	0.010	0.012	V
Discharge overcurrent release	V_{RIOV}	VDD=3.5V	V_{VDD} − 1.5	V_{VDD} − 1.0	V_{VDD} − 0.5	V
[Delay Time]						
Overcharge detection delay time	T_{OC}	VDD=3.5 → 4.8V	614	1024	1434	ms
Over discharge detection delay	T_{OD}	VDD=3.5 → 2.0V	76.8	128.0	179.2	ms
Discharge overcurrent detection delay time 1	T_{EC1}	VINI-VSS=0→0.120V	2150	3584	5018	ms
Discharge overcurrent detection delay time 2	T_{EC2}	VINI-VSS=0→0.120V	19.2	32.0	44.8	ms
Charge overcurrent detection delay time	T_{CHA}	VSS-VINI=0→0.120V	19.2	32.0	44.8	ms
Load short-circuiting detection	T_{SHORT}	VINI-VSS=0→0.120V	256	512	768	μs
[Internal Resistance]						
Resistance between VDD pin and VM pin	R_{VMD}	VDD=1.8V, V_{VM}=0V	100	300	700	kΩ
Resistance between VM pin and VSS pin	R_{VMS}	VDD=3.4V, V_{VM}=1.0V	3.5	10	20	kΩ
[Output Resistance]						
CO pin resistance "H"	R_{COH}	-	2.5	10	30	kΩ
CO pin resistance "L"	R_{COL}	-	2.5	10	30	kΩ
DO pin resistance "H"	R_{DOH}	-	2.5	10	30	kΩ
DO pin resistance "L"	R_{DOL}	-	0.5	2	6	kΩ
[0V Battery Charge Function]						
0V battery charge “Available” starting charge voltage	V_{0CH}	0V battery charging “Available”	0.5	1.1	1.7	V

Table 7

***1: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.**

■ Electrical Characteristics

(Unless otherwise specified: Ta =-40°C ~ +85°C*1)

Item	Symbol	Test conditions	Min.	Typ.	Max.	Unit
[Consumption]						
Operating consumption	I_{OPE}	VDD=3.5V, V_{VM}=0V	0.9	1.8	4.0	μA
Overdischarge consumption	I_{OPED}	VDD=V_{VM}=1.5V	-	0.5	1.0	nA
[Detection Voltage]						
Overcharge detection voltage	V_{OC}	VDD=3.5 → 4.8V	4.475	4.525	4.555	V
Overcharge release voltage	V_{OCR}	VDD=4.8 → 3.5V	4.345	4.425	4.480	V
Over discharge detection voltage	V_{OD}	VDD=3.5 → 2.0V	2.220	2.300	2.355	V
Over discharge release voltage	V_{ODR}	VDD=2.0 → 3.5V	2.590	2.700	2.800	V
Discharge overcurrent detection voltage 1	V_{EC1}	-	0.0055	0.0075	0.0095	V
Discharge overcurrent detection voltage 2	V_{EC2}	-	0.014	0.018	0.022	V
Load short-circuiting detection voltage	V_{SHORT}	-	0.028	0.033	0.038	V
Charge overcurrent detection voltage	V_{CHA}	-	0.008	0.010	0.012	V
Discharge overcurrent release	V_{RIOV}	VDD=3.5V	V_{VDD} − 1.5	V_{VDD} – 1.0	V_{VDD} − 0.5	V
[Delay Time]						
Overcharge detection delay time	T_{OC}	VDD=3.5 → 4.8V	512	1024	1536	ms
Over discharge detection delay	T_{OD}	VDD=3.5 → 2.0V	64.0	128.0	192.0	ms
Discharge overcurrent detection delay time 1	T_{EC1}	VINI-VSS=0→0.120V	1792	3584	5376	ms
Discharge overcurrent detection delay time 2	T_{EC2}	VINI-VSS=0→0.120V	16	32	48	ms
Charge overcurrent detection delay time	T_{CHA}	VSS-VINI=0→0.120V	16	32	48	ms
Load short-circuiting detection	T_{SHORT}	VINI-VSS=0→0.120V	205	512	819	μs
[Internal Resistance]						
Resistance between VDD pin and VM pin	R_{VMD}	VDD=1.8V, V_{VM}=0V	100	300	700	kΩ
Resistance between VM pin and VSS pin	R_{VMS}	VDD=3.4V, V_{VM}=1.0V	3.5	10	20	kΩ
[Output Resistance]						
CO pin resistance "H"	R_{COH}	-	2.5	10	30	kΩ
CO pin resistance "L"	R_{COL}	-	2.5	10	30	kΩ
DO pin resistance "H"	R_{DOH}	-	2.5	10	30	kΩ
DO pin resistance "L"	R_{DOL}	-	0.5	2	6	kΩ
[0V Battery Charge Function]						
0V battery charge “Available” starting charge voltage	V_{0CH}	0V battery charging “Available”	0.5	1.1	1.7	V

Table 8

***1: Since products are not screened at high and low temperature, the specification for this temperature range is guaranteed by design, not tested in production.**

Function Description

1. Normal Condition

The CM1004-BWD monitors the voltage of the battery connected between VDD pin and VSS pin, the voltage between VINI pin and VSS pin to control charging and discharging. When the battery voltage is in the range from the over discharge detection voltage (V_{OD}) to the overcharge detection voltage (V_{OC}), and the VINI pin voltage is in the range from charging overcurrent detection voltage (V_{CHA}) to discharging overcurrent detection voltage 1 (V_{EC1}), the IC turns both the charging and discharging control MOSFETs on. This status is called the normal condition.

The resistance between VDD pin and VM pin (R_{VMD}), and the resistance between VM pin and VSS pin (R_{VMS}) are not connected in the normal status.

Note: When connecting the cell for the first time, there will be the possibility of not discharging. At this time, short connect the VM pin and VSS pin, or connect the charger, can be restored to normal working condition.

2. Overcharge Condition

When the battery voltage becomes higher than V_{OC} during charging in the normal status and the condition continues for the overcharge detection delay time (T_{OC}) or longer, the output voltage of IC CO pin changes from high level to low level, and the MOSFET used for charging control is turned off, charging is stopped. This condition is called the overcharge status.

The overcharge status is released in the following two cases.

(1) In the case that the VM pin voltage is lower than 0.25 V typ., the overcharge state is released when the battery voltage falls below overcharge release voltage (V_{OCR}).

(2) In the case that the VM pin voltage is equal to or higher than 0.25 V typ., the overcharge state is released when the battery voltage falls below V_{OC}.

When the discharge is started by connecting a load after the overcharge detection, the VM pin voltage rises by the Vf voltage of the parasitic diode than the VSS pin voltage, because the discharge current flows through the parasitic diode in the charge control MOSFET. If this VM pin voltage is equal to or higher than 0.25 V typ., the IC releases the overcharge status when the battery voltage is equal to or lower than V_{OC}.

Note: If the battery is charged to a voltage higher than Voc and the battery voltage does not fall below Voc even when a heavy load is connected, discharge overcurrent detection and load short-circuiting detection do not function until the battery voltage falls below Voc. Since an actual battery has an internal impedance of tens of mΩ, the battery voltage drops immediately after a heavy load that causes overcurrent is connected, and discharge overcurrent detection and load short-circuiting detection function.

3. Over discharge Condition

When the battery voltage falls below V_{OD} during discharging in the normal status and the condition continues for the overdischarge detection delay time (T_{OD}) or longer, The output voltage of DO will reverse. The discharge MOSFET will be turned off and stop discharging. This condition is called the overdischarge status.Under the overdischarge status, VDD pin and VM pin are shorted by R_{VMD} in the chip. The VM pin voltage is pulled up by R_{VMD}.

(1) When a battery is not connected to a charger and the VM pin voltage ≥ 0.7 V typ., the battery voltage reaches V_{ODR} or higher and the over discharge state is released.

(2) When a battery is connected to a charger and 0.25 V typ. < the VM pin voltage < 0.7 V typ., the battery voltage reaches V_{ODR} or higher and the over discharge state is released.

(3) When a battery is connected to a charger. the VM pin voltage ≤ 0.25 V typ., the battery voltage reaches V_{OD} or higher and the over discharge state is released

4. Discharge overcurrent status (discharge overcurrent 1, discharge overcurrent 2, load short-circuiting, load short-circuiting 2)

4. 1 Discharge overcurrent 1, discharge overcurrent 2, load short-circuiting

When a battery in the normal status is in the status where the VINI pin voltage is equal to or higher than V_{EC1} because the discharge current is equal to or higher than the specified value and the status lasts for the discharge overcurrent detection delay time 1 (T_{EC1}) or longer, the discharge control MOSFET is turned off and discharging is stopped. This status is called the discharge overcurrent status.

Under the discharge overcurrent status, VM pin and VSS pin are shorted by R_{VMS} in the chip. However, the VM pin voltage is the VDD pin voltage due to the load as long as the load is connected. When the load is disconnected, the VM pin returns to the VSS pin voltage. When the VM pin voltage returns to V_{RIOV} or lower, the discharge overcurrent status is released.

R_{VMD} is not connected in the discharge overcurrent status.

4. 2 Load short-circuiting 2

When a battery in the normal status is in the status where a load causing discharge overcurrent is connected, and the VM pin voltage is equal to or higher than V_{SHORT2} and the status lasts for the load short-circuiting detection delay time (T_{SHORT}) or longer, the discharge control MOSFET is turned off and discharging is stopped. This status is called the discharge overcurrent condition.It releases the discharge overcurrent status in the same way as in "4. 1 Discharge overcurrent 1, discharge overcurrent 2, load short-circuiting".

5. Charging Overcurrent Condition

When a battery in the normal status is in the status where the VINI pin voltage is equal to or lower than V_{CHA} because the charge current is equal to or higher than the specified value and the status lasts for the charge overcurrent detection delay time (T_{CHA}) or longer, the charge control MOSFET is turned off and charging is stopped. This status is called the charge overcurrent status.

The charging overcurrent status is released. when the discharge current flows and the VM pin voltage is 0.25 V typ. or higher by removing the charger.

The charge overcurrent detection does not function in the overdischarge status.

6. 0V Battery Charging Function “Available”

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

Note: 1. Some battery providers do not recommend charging for a completely self-discharged lithium-ion rechargeable battery. Please ask the battery provider to determine whether to enable or inhibit the 0 V battery charge function.

2. The 0 V battery charge function has higher priority than the charge overcurrent detection function. Consequently, a product in which use of the 0 V battery charge function is enabled charges a battery forcibly and the charge overcurrent cannot be detected when the battery voltage is lower than V_{OD}.

Application Circuits

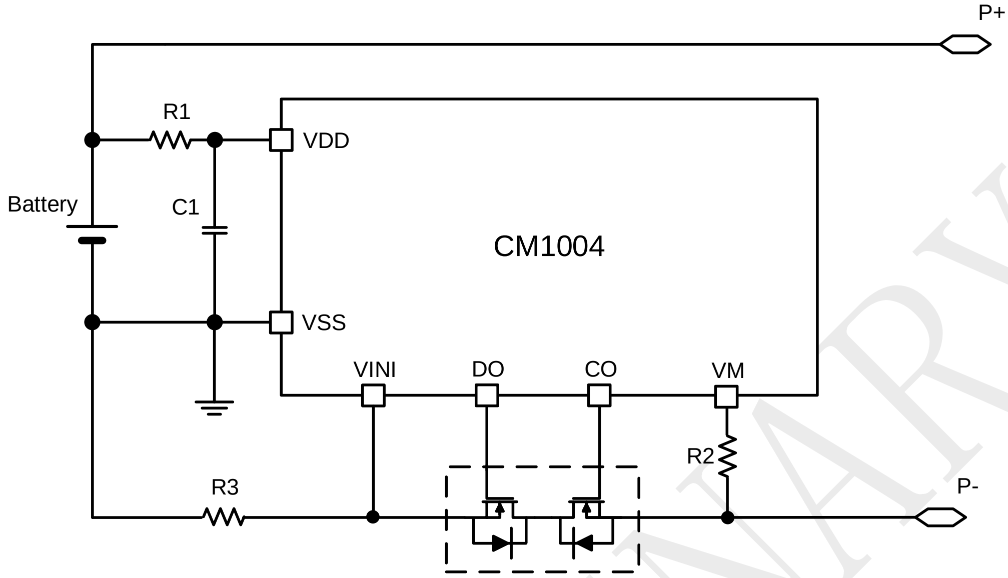


Figure 5

BOM List

Component Symbol	Type	Range	Unit
R1	330	270 ~ 1500	Ω
C1	0.1	0.068 ~ 2.2	μF
R2	1	0.3 ~ 3	kΩ
R3	1.5	-	mΩ

Table 9

Caution:

1. The above constants may be changed without notice.

2. The example of connection shown above and the constant do not guarantee proper operation. Perform thorough evaluation using the actual application to set the constant.

■ Operation Timing Chart

1. Overcharge and Charging Overcurrent Detection

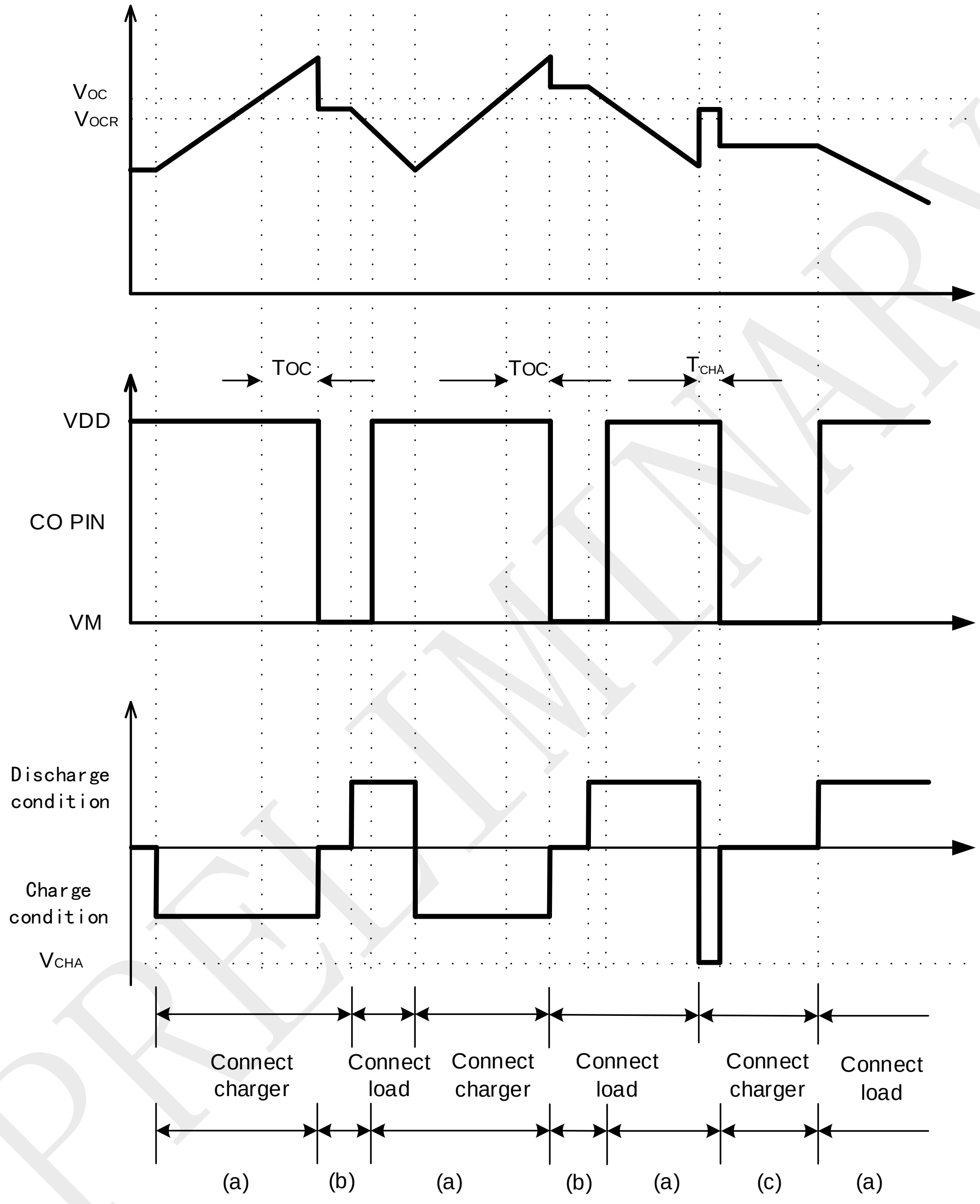


Figure 6

(a) Normal condition

(b) Overcharge condition

(c) Charging overcurrent condition

2. Over discharge and discharging Overcurrent Condition Detection

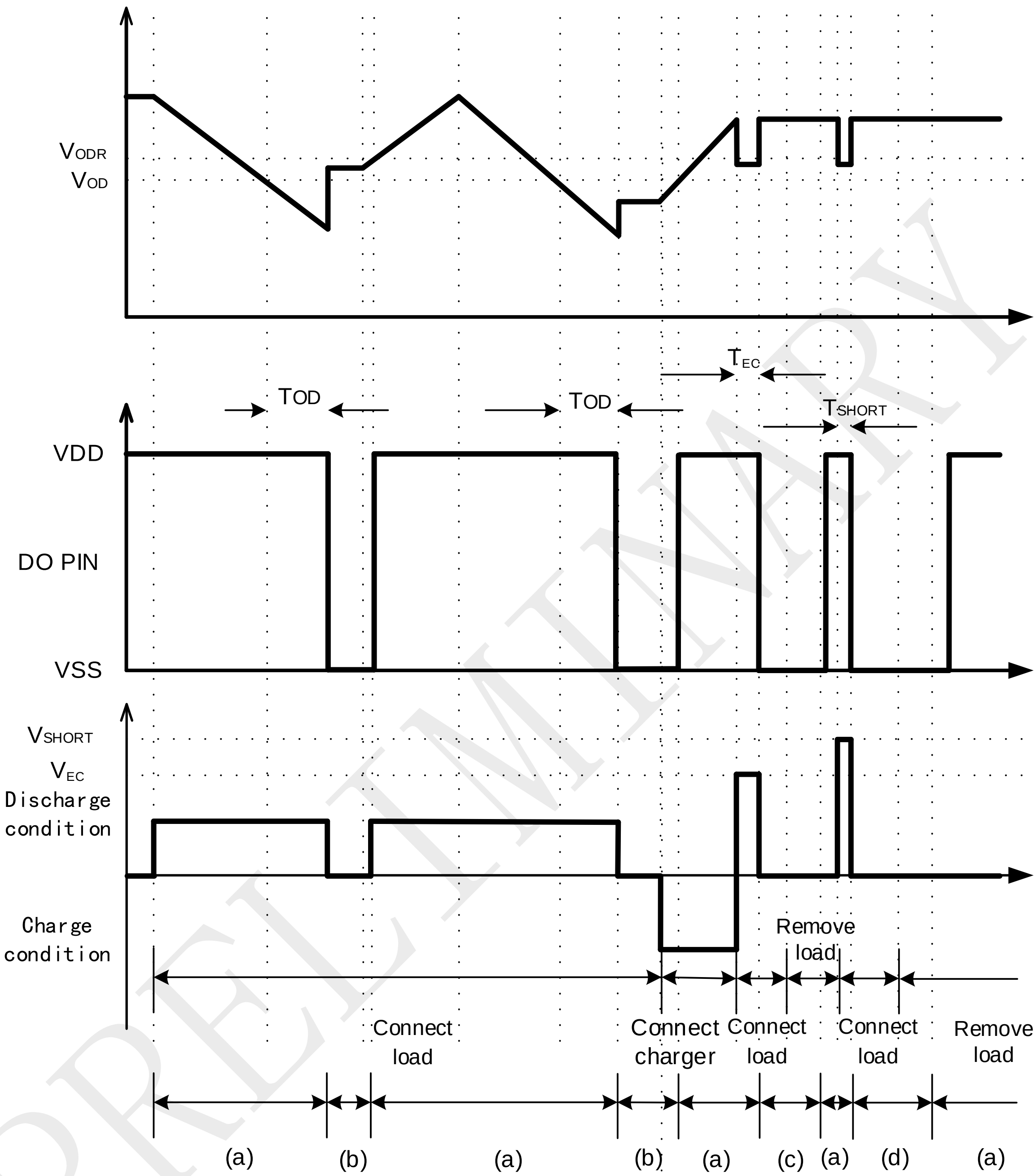


Figure 7

(a) Normal condition

(b) Over discharge condition

(c) Discharging overcurrent condition

(d) Load short circuit

■ Test Circuits

1. Overcharge protection voltage, Overcharge release voltage (Test Circuits 1)

Overcharge detection voltage (V_{OC}) is defined as the voltage V1 at which V_{CO} goes from "H" to "L" when the voltage V1 is gradually increased after setting V1 = 3.5 V. Overcharge release voltage (V_{OCR}) is defined as the voltage V1 at which V_{CO} goes from "L" to "H" when the voltage V1 is then gradually decreased.

2. Over discharge protection voltage, Over discharge release voltage (Test Circuits 2)

Overdischarge detection voltage (V_{OD}) is defined as the voltage V1 at which V_{DO} goes from "H" to "L" when the voltage V1 is gradually decreased after setting V1 = 3.5 V, V2 = V5 = 0 V. Overdischarge release voltage (V_{ODR}) is defined as the voltage V1 at which V_{DO} goes from "L" to "H" when setting V2 = 0.3 V, and when the voltage V1 is then gradually increased.

3. Discharge overcurrent protects voltage 1, Discharge overcurrent release voltage (Test Circuits 5)

Discharge overcurrent detection voltage 1 (V_{EC1}) is defined as the voltage V5 whose delay time for changing V_{DO} from "H" to "L" is discharge overcurrent detection delay time 1 (T_{EC1}) when the voltage V5 is increased after setting V1 = 3.5 V, V2 = 1.0 V, V5 = 0 V. Discharge overcurrent release voltage (V_{RIOV}) is defined as the voltage V2 at which V_{DO} goes from "L" to "H" when setting V2 = 3.5 V, V5 = 0 V and when the voltage V2 is then gradually decreased.When the voltage V2 falls below V_{RIOV}, V_{DO} will go to "H" after 1.0 ms typ. and maintain "H" during load short- circuiting detection delay time (T_{SHORT}).

4. Discharge overcurrent protects voltage 2 (Test Circuits 2)

Discharge overcurrent detection voltage 2 (V_{EC2}) is defined as the voltage V5 whose delay time for changing V_{DO} from "H" to "L" is discharge overcurrent detection delay time 2 (T_{EC2}) when the voltage V5 is increased after setting V1 = 3.5 V, V2 = 1.0 V, V5 = 0 V.

5. Load short-circuit protection voltage (Test Circuits 2)

Load short-circuiting detection voltage (V_{SHORT}) is defined as the voltage V5 whose delay time for changing V_{DO} from "H" to "L" is T_{SHORT} when the voltage V5 is increased after setting V1 = 3.5 V, V2 = 1.0 V, V5 = 0 V.

6. Load short-circuit protection voltage 2 (Test Circuits 2)

Load short-circuiting detection voltage 2 (V_{SHORT2}) is defined as the voltage V2 whose delay time for changing V_{DO} from "H" to "L" is t_{SHORT} when the voltage V2 is increased after setting V1 = 3.5 V, V2 = V5 = 0 V

7. Charge overcurrent protection voltage (Test Circuits 2)

Charge overcurrent detection voltage (V_{CHA}) is defined as the voltage V5 whose delay time for changing V_{CO} from "H" to "L" is charge overcurrent detection delay time (T_{CHA}) when the voltage V5 is decreased after setting V1 = 3.5 V, V2 = V5 = 0 V.

8. Operating consumption current (Test Circuits 3)

When V1=3.5V and V2 = V5 = 0 V are set, the current I_{CC} flowing through the VDD pin is the current consumed while working (I_{OPE}).

9. Overdischarge consumption current（Test Circuits 3）

When V1=V2=1.5V and V5 = 0 V are set, the current I_{CC} flowing through the VDD pin is the current consumed while overdischage (I_{OPED}).

10. Resistance between VDD pin and VM pin（Test Circuits 3）

When V1=1.8V and V2=V5=0V are set, the resistance between VDD pin and VM pin is R_{VMD}

11. Resistance between VM pin and VSS pin（Test Circuits 3）

When V1=3.5V and V2=V5=1.0V are set, the resistance between VM pin and VSS pin is R_{VMS} when V5 is decreased to 0 V.

12. CO pin resistance "H"（Test Circuits 4）

When V1=3.5V, V2=V5=0V, and V3=3.0V are set, the resistance between VDD pin and CO pin is the CO pin resistance "H" (R_{COH}).

13. CO pin resistance "L"（Test Circuits 4）

When V1=4.7V, V2=V5=0V, and V3=0.4V are set, the resistance between VM pin and CO pin is the CO pin resistance "L" (R_{COL}).

14. DO pin resistance "H"（Test Circuits 4）

When V1=3.5V, V2=V5=0V, and V4=3.0V are set, the resistance between VDD pin and DO pin is the DO pin resistance "H" (R_{DOH}).

15. DO pin resistance "L"（Test Circuits 4）

When V1=1.8V, V2=V5=0V, and V4=0.4V are set, the resistance between VSS pin and DO pin is the DO pin resistance "L" (R_{DOL}).

16. Overcharge detection delay time（Test Circuits 5）

When V1=3.5V and V2=V5=0V are set, V1 is pulled up and the time from V1 exceeding V_{OC} to V_{CO} = "L" is the overcharge protection delay time (T_{OC}).

17. Over discharge detection delay time（Test Circuits 5）

When V1=3.5V and V2=V5=0V are set, V1 is lowered and the time from V1 exceeding V_{OD} to V_{DO} = "L" is the over discharge protection delay time (T_{OD}).

18. Discharge overcurrent detection delay time 1（Test Circuits 5）

When V1=3.5V, V2=1.0V and V5=0V are set, V5 is pulled up and the time from V5 exceeding V_{EC1} to V_{DO} = "L" is the discharge overcurrent protection delay time 1 (T_{EC1}).

19. Discharge overcurrent detection delay time 2（Test Circuits 5）

When V1=3.5V, V2=1.0V and V5=0V are set, V5 is pulled up and the time from V5 exceeding V_{EC2} to V_{DO} = "L" is the discharge overcurrent protection delay time 2 (T_{EC2}).

20. Load short-circuiting detection delay time（Test Circuits 5）

When V1=3.5V, V2=1.0V and V5=0V are set, V5 is pulled up and the time from V5 exceeding V_{SHORT} to V_{DO} = "L" is the Load short-circuiting detection delay time (T_{SHORT}).

21. Charge overcurrent detection delay time（Test Circuits 5）

When V1=3.5V and V2=V5=0V are set, V5 is lowered and the time from V5 is lower than V_{CHA} to V_{CO} = "L" is the charge overcurrent protection delay time (T_{CHA}).

22. The charger voltage for starting 0V battery charging (0V battery charge function "Available") (Test Circuits 4)

The 0 V battery charge starting charger voltage (V_{0CHA}) is defined as the absolute value of voltage V2 at which the current flowing through the CO pin (I_{CO}) exceeds 1.0 μA when the voltage V2 is gradually decreased after setting V1 = V5 = 0 V, V2 = V3 = −0.5 V.

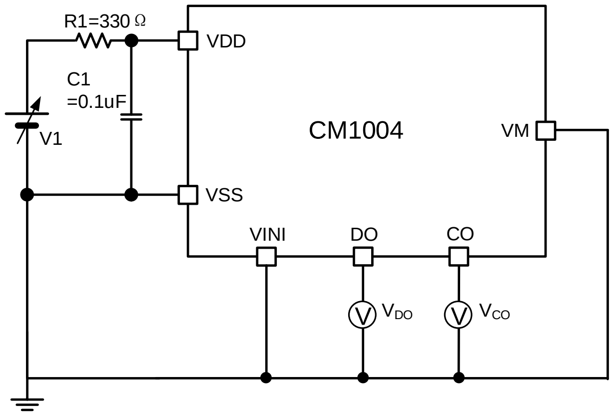


Figure 8 Test Circuits 1

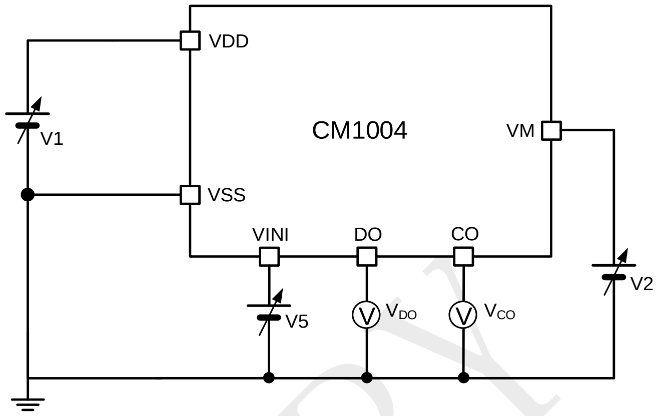


Figure 9 Test Circuits 2

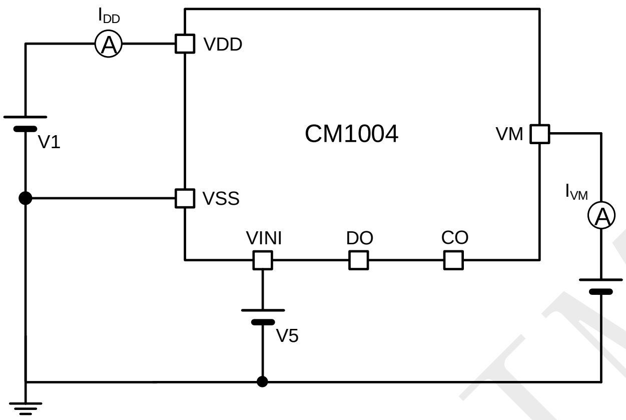


Figure 10 Test Circuits 3

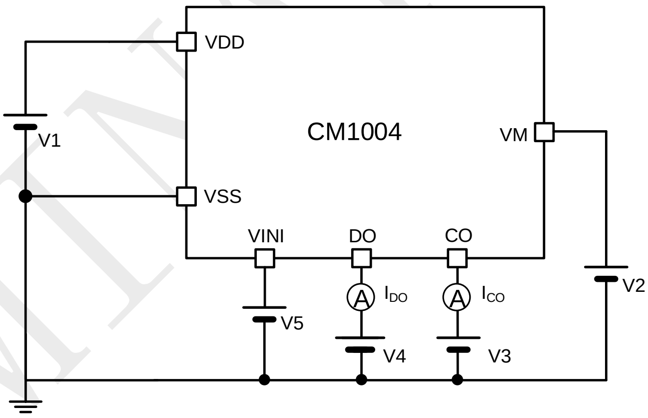


Figure 11 Test Circuits 4

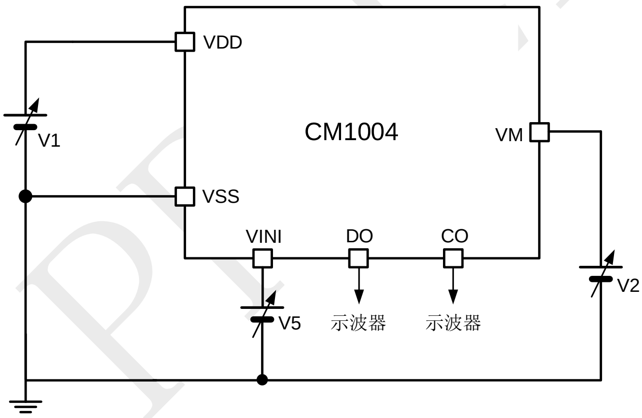


Figure 12 Test Circuits 5

■ Package

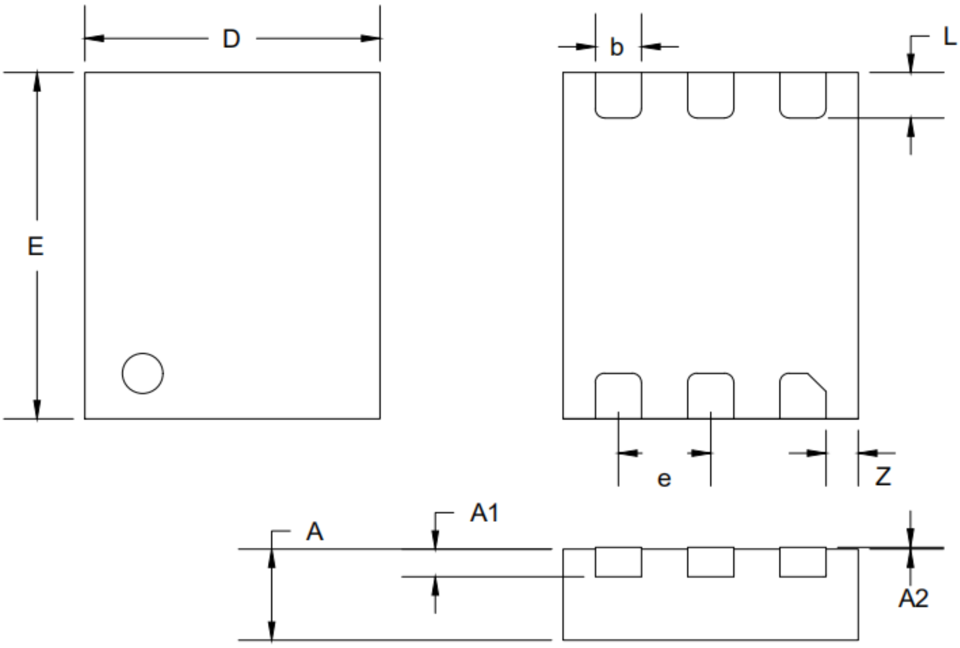


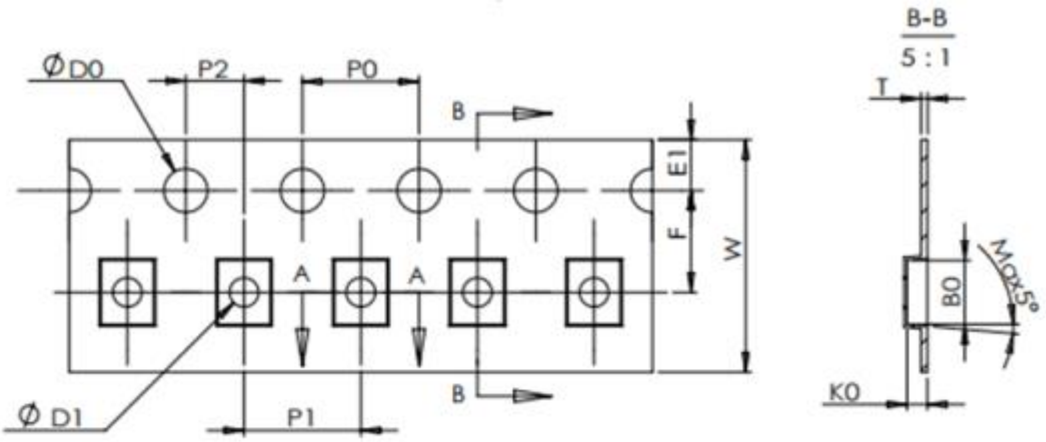
Figure 13

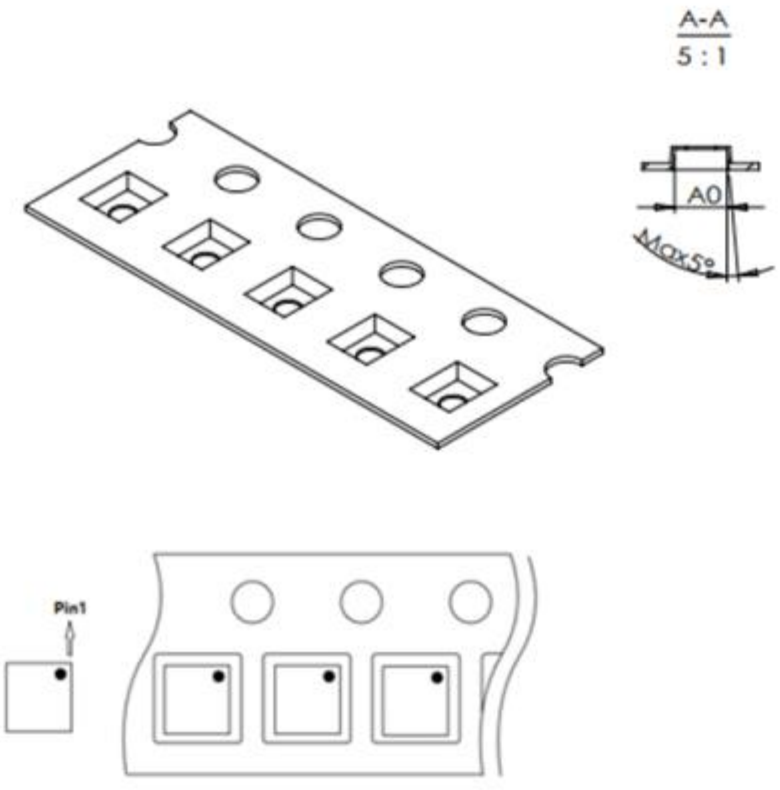
NOTE: ALL DIMENSIONS IN MM

SYMBOL	MIN	NOM	MAX
D	1.550	1.600	1.650
E	1.850	1.900	1.950
L	0.200	0.250	0.300
b	0.200	0.250	0.300
Z	0.125	0.175	0.225
e	0.500BSC		
A	0.450	0.500	0.550
A1	0.15REF		
A2	0.000	-	0.050

Table 10

■ Carrier Tape information





Item	Spec
W	8.00±0.20
P_1	4.00±0.10
E_1	1.75±0.10
F	3.50±0.05
D_0	1.50+0.10/0
D_1	1.00±0.10
P_0	4.00±0.10
$P_0$10	40.00±0.20
P_2	2.00±0.05
A_0	1.75±0.10
B_0	2.15±0.10
K_0	0.75±0.10
T	0.22±0.02
	Unit: mm

Figure 14

■ Reel information

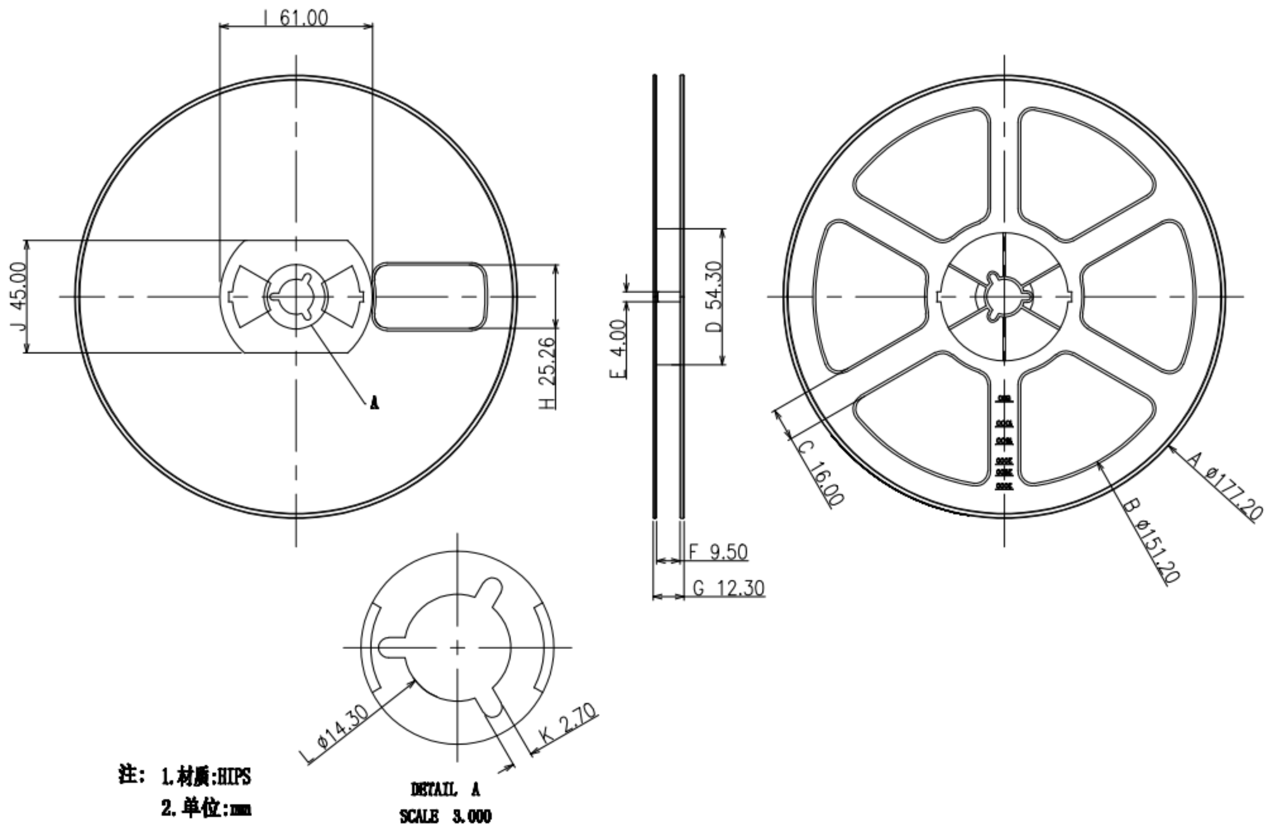


Figure 14

■ Package information

Reel	PCS/Reel	Reel /Inner Box	Inner Box/Carton
7”	3000	10	4

Precautions for use

1. The content in this manual may be changed without notice as the product improves. For more detailed content, please contact our company's marketing department.
2. The circuit examples, usage methods, etc. in this specification are for reference only, and are not designed to guarantee mass production. The company does not assume any responsibility for problems caused by third-party ownership.
3. When this specification is used alone, our company guarantees that its performance, typical applications and functions meet the conditions in the specification. When using the customer's products or equipment, we do not guarantee the above conditions, we recommend that customers do adequate evaluation and testing.
4. Please pay attention to the use of the product within the conditions stated in the specification. Please pay special attention to the use conditions of input voltage, output voltage, and load current so that the power dissipation in the IC does not exceed the power dissipation of the package. The company will not be liable for any losses caused by customers using the product beyond the rated value specified in the specification, even if it is used instantaneously.
5. When using this product, please confirm the laws and regulations of the country, region and purpose of use, and test the ability and saMOSFETy performance of the product.
6. The products in this specification, without written permission, cannot be used in high-reliability circuits of equipment or devices that may cause damage to the human body, life and property, such as: medical equipment, disaster prevention equipment, vehicle equipment, and vehicle Equipment, aviation equipment, space equipment, nuclear energy equipment, etc., shall not be used as their parts.
7. The company does not assume any responsibility for damages caused by using the products described in this specification for purposes other than those specified by the company.
8. The company has been committed to improving the quality and reliability of products, but all semiconductor products have a certain probability of failure.
9. In order to prevent personal accidents, fire accidents, social damages, etc. caused by the probabilistic failure of this product, customers are requested to fully evaluate the entire system and be responsible for redundant design, measures to prevent fire spread, and saMOSFETy design to prevent mishandling, you can avoid accidents.
10. This product will not affect human health under normal conditions of use, but because it contains chemical substances and heavy metals, please do not put it in your mouth. In addition, the cracked surface of the package and chip may be sharp, so please protect it when touching it with bare hands to avoid injury.
11. When disposing of this product, please abide by the laws and regulations of the country and region of use and dispose of it reasonably.
12. The content in this specification is strictly prohibited from being reproduced or copied for other purposes without the permission of our company.