



CC9016

Battery Protection IC for 1-Cell Pack

Features

- Overcharge Detection Voltage
 - Range 3.650V~4.600V, Accuracy $\pm 25\text{mV}$
- Overdischarge Detection Voltage
 - Range 2.000V~3.300V, Accuracy $\pm 50\text{mV}$
- Overcurrent Detection
 - Discharge Overcurrent Detection Voltage, Range 20mV~250mV, Accuracy $\pm 10\text{mV}$
 - Load Short-circuiting Detection Voltage, Accuracy $\pm 100\text{mV}$
 - Charge Overcurrent Detection Voltage, Range -200mV~-15mV, Accuracy $\pm 10\text{mV}$
- Detection Delay Times Are Generated Only by Internal Circuits
- VM Pin and CO Pin Can Withstand Max. 28V
- 0V Battery Charge is selectable
- Low Current Consumption:
 - Operation mode 2.0uA Typ.
 - Low power mode 0.5uA Max
 - Sleep mode 50nA Typ.

Package

- SOT23-6

Application

- Lithium-ion Rechargeable Battery Pack
- Lithium Polymer Rechargeable Battery Pack

General Description

The CC9016 Series is a protection IC for lithium-ion / lithium polymer rechargeable batteries, which 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.

Typical Application

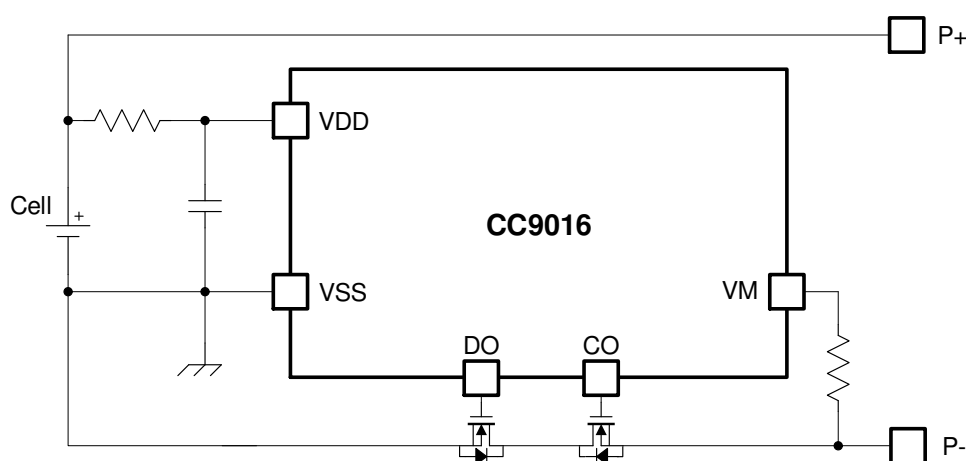


Figure1. Typical Application

Ordering Information

Part Number	Temperature Range	Package and Pin	Shipping	Environmental Info
CC9016	-40 °C to 85 °C	SOT23-6	Tape & Reel 3000	RoHS & HF

Product List

SOT23-6

Table 1. (1/2)

Product Name	Overcharge Detection Voltage [V _{OV} P]	Overcharge Release Voltage [V _{OV} PR]	Over-discharge Detection Voltage [V _{UV} P]	Over-discharge Release Voltage [V _{UV} PR]	Discharge Overcurrent Detection Voltage [V _{DOC}]	Load Short- circuiting Detection Voltage [V _{SHR}]	Charge Overcurrent Detection Voltage [V _{COC}]
CC9016ALBS	4.225V	4.025V	2.800V	3.000V	0.150V	0.500V	-0.150V
CC9016ALCS	4.275V	4.075V	2.500V	2.900V	0.150V	0.500V	-0.150V
CC9016ALDS	4.475V	4.275V	2.800V	3.000V	0.150V	0.500V	-0.150V
CC9016ALES	4.280V	4.080V	2.800V	3.000V	0.150V	0.500V	-0.150V
CC9016CLAS	4.225V	4.025V	2.800V	3.000V	0.150V	0.500V	-0.100V
CC9016AFAS	3.625V	3.475V	2.185V	2.485V	0.150V	0.500V	-0.150V
CC9016CLCS	4.425V	4.225V	2.500V	2.900V	0.150V	0.500V	-0.150V
CC9016CLDS	4.250V	4.025V	2.500V	2.900V	0.150V	0.500V	-0.150V
CC9016CLFS	4.475V	4.275V	2.500V	2.900V	0.200V	0.700V	-0.200V
CC9016ALRS	4.225V	4.025V	3.000V	3.000V	0.080V	0.350V	-0.080V
CC9016CLGS	4.225V	4.025V	2.400V	2.500V	0.250V	0.700V	-0.100V

Table 1. (2/2)

Product Name	Delay Time Combination*1	0V Battery Charge	Overcharge Release Latch	Release Voltage of Discharge Overcurrent	Sleep Function	Mark*2
CC9016ALBS	1	Inhibition	Disable	V _{DOC}	Enable	9016ALBSxxxx
CC9016ALCS	1	Inhibition	Disable	V _{DOC}	Enable	9016ALCSxxxx
CC9016ALDS	2	Inhibition	Enable	V _{DOCR}	Enable	9016ALDSxxxx
CC9016ALES	1	Inhibition	Disable	V _{DOC}	Enable	9016ALESxxxx
CC9016CLAS	3	Permission	Enable	V _{DOC}	Enable	9016CLASxxxx
CC9016AFAS	1	Inhibition	Disable	V _{DOCR}	Enable	9016AFASxxxx
CC9016CLCS	1	Permission	Disable	V _{DOCR}	Enable	9016CLCSxxxx
CC9016CLDS	1	Permission	Disable	V _{DOCR}	Enable	9016CLDSxxxx
CC9016CLFS	3	Permission	Disable	V _{DOCR}	Enable	9016CLFSxxxx
CC9016ALRS	1	Inhibition	Disable	V _{DOC}	Enable	9016ALRSxxxx
CC9016CLGS	1	Permission	Disable	V _{DOC}	Enable	9016CLGSxxxx

Note:

*1 Delay time combination details, please refer to Table 2.

*2 xx... stands for manufacture information.

Table 2. Delay Time Combination

Delay Time Combination #	Overcharge Detection Delay Time [t _{ovp}]	Overdischarge Detection Delay Time [t _{uvp}]	Discharge Overcurrent Detection Delay Time [t _{doc}]	Load Short-circuiting Detection Delay Time [t _{shr}]	Charge Overcurrent Detection Delay Time [t _{coc}]
1	1s	128ms	8ms	280μs	8ms
2	1s	32ms	8ms	280μs	8ms
3	1s	128ms	16ms	280μs	8ms

Pin Configuration

SOT23-6

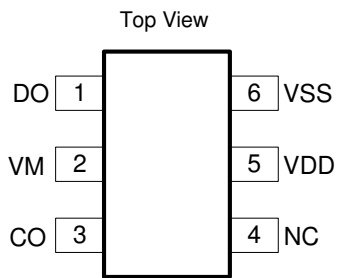


Figure 2

Pin No.	Symbol	Description
1	DO	Connection pin of discharge control FET gate (CMOS output)
2	VM	Input pin for external negative voltage
3	CO	Connection pin of charge control FET gate (CMOS output)
4	NC	No connection
5	VDD	Input pin for positive power supply
6	VSS	Input pin for negative power supply

Block Diagram

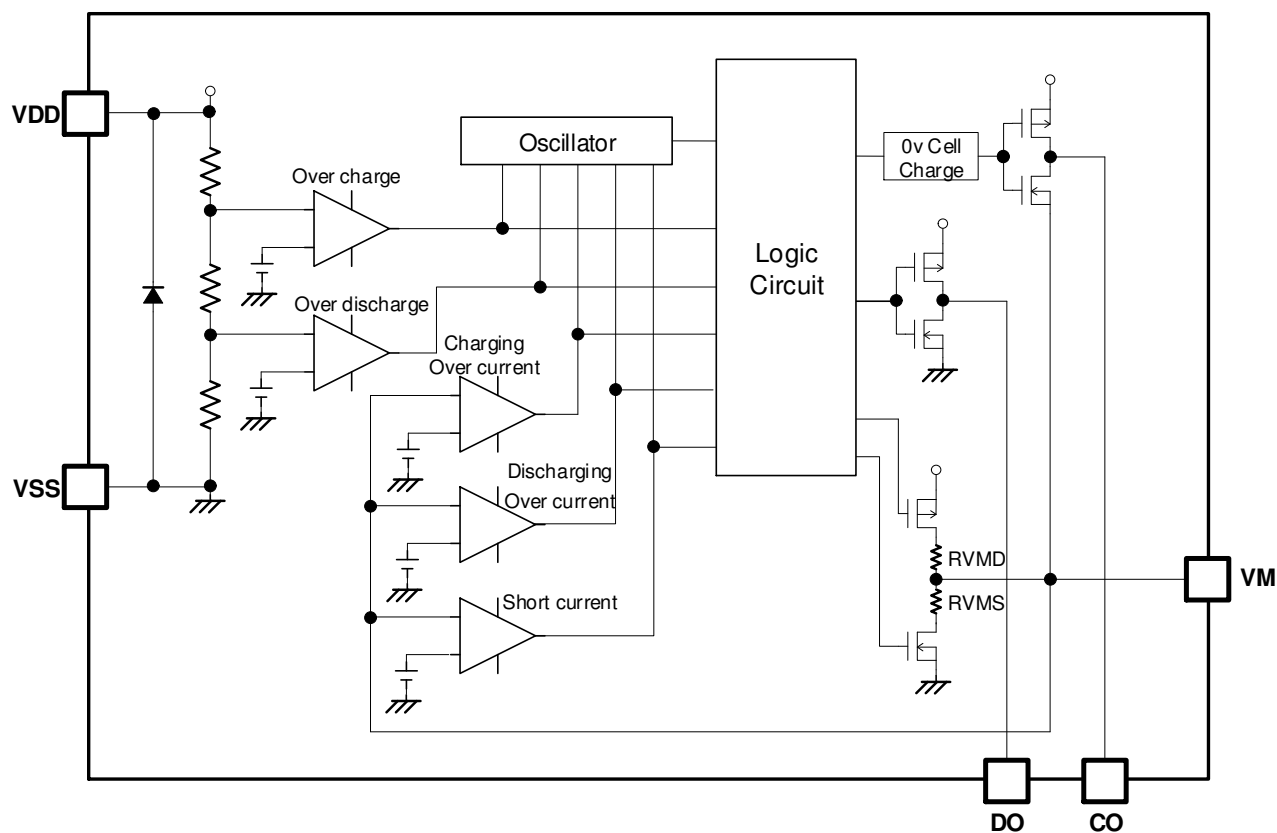


Figure 3. Block Diagram

Absolute Maximum Ratings

Ta=+25° unless otherwise specified

Item		Range		Unit
		Min.	Max.	
Pin input voltage	VDD	VSS-0.3	VSS+6	V
Pin input voltage	VM	VDD-28	VDD+0.3	V
Pin input voltage	CO	VM-0.3	VDD+0.3	V
Pin input voltage	DO	VSS-0.3	VDD+0.3	V
Operation ambient temperature	T1	-40	85	°C
Storage temperature	T2	-55	125	°C

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

Electrical Characteristics

Ta=+25° unless otherwise specified

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Recommended operating conditions							
Operating voltage	V _{DD}			1.5		5	V
Current consumption							
Current consumption during operation	I _{OPR}	V _{DD} =3.5V, Ta = 25° C			2.0	4	μA
		V _{DD} =3.5V, Ta = -40~85° C				4	μA
Current consumption during overdischarge (low-power mode)	I _{LP}	V _{DD} =V _{VM} =1.5V, Ta = 25° C			300	500	nA
		V _{DD} =V _{VM} =1.5V, Ta = -40~85° C				800	nA
Current consumption during overdischarge (sleep mode)	I _{SLEEP}	V _{DD} =V _{VM} =1.5V, Ta = 25° C				50	nA
		V _{DD} =V _{VM} =1.5V, Ta = -40~85° C				150	nA
Voltage protection limit							
Overcharge detection voltage	V _{OVDP}	V _{DD} = 3.5→4.6V	Ta=25° C	V _{OVDP} -0.025	V _{OVDP}	V _{OVDP} +0.025	V
			Ta=-20~60° C	V _{OVDP} -0.025		V _{OVDP} +0.025	
			Ta=-40~85° C	V _{OVDP} -0.045		V _{OVDP} +0.045	
Overcharge release voltage	V _{OVDP}	V _{DD} = 4.6→3.5V	Ta = 25° C	V _{OVDP} -0.045	V _{OVDP}	V _{OVDP} +0.045	V
			Ta=-40~85° C	V _{OVDP} -0.075		V _{OVDP} +0.075	
Overdischarge detection voltage	V _{UVP}	V _{DD} = 3.5→1.5V	Ta = 25° C	V _{UVP} -0.050	V _{UVP}	V _{UVP} +0.050	V
			Ta=-40~85° C	V _{UVP} -0.080		V _{UVP} +0.080	
Overdischarge release voltage	V _{UVP}	V _{DD} = 2.0→3.5V	Ta = 25° C	V _{UVP} -0.100	V _{UVP}	V _{UVP} +0.100	V
			Ta=-40~85° C	V _{UVP} -0.120		V _{UVP} +0.120	
Overcurrent protection limit							
Discharge overcurrent detection voltage	V _{DOC}	V _{DD} = 3.5V	Ta = 25° C	V _{DOC} -10	V _{DOC}	V _{DOC} +10	mV
			Ta=-40~85° C	V _{DOC} -15		V _{DOC} +15	
Charge overcurrent detection voltage	V _{COC}	V _{DD} = 3.5V	Ta = 25° C	V _{COC} -10	V _{COC}	V _{COC} +10	mV
			Ta=-40~85° C	V _{COC} -15		V _{COC} +15	
Load short-circuiting detection voltage	V _{SHR}	V _{DD} = 3.5V	Ta = 25° C	V _{SHR} -100	V _{SHR}	V _{SHR} +100	mV
			Ta=-40~85° C	V _{SHR} -110		V _{SHR} +110	

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Release voltage from discharge overcurrent	V_{DOCR}	$V_{DD} = 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$	$V_{DD}-1.3$ $V_{DD}-1.5$	$V_{DD}-1$	$V_{DD}-0.7$ $V_{DD}-0.5$	V
Delay time							
Overcharge detection delay time	t_{OVP}	$V_{DD} = 3.5 \rightarrow 5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$	$0.7 \cdot t_{OVP}$ $0.5 \cdot t_{OVP}$	t_{OVP}	$1.3 \cdot t_{OVP}$ $1.5 \cdot t_{OVP}$	ms
Overcharge release delay time	t_{OVPR}	$V_{DD} = 5 \rightarrow 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$		1	2 3	ms
Overdischarge detection delay time	t_{UVP}	$V_{DD} = 3.5 \rightarrow 1.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$	$0.7 \cdot t_{UVP}$ $0.5 \cdot t_{UVP}$	t_{UVP}	$1.3 \cdot t_{UVP}$ $1.5 \cdot t_{UVP}$	ms
Overdischarge release delay time	t_{UVPR}	$V_{DD} = 1.5 \rightarrow 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$		4	8 10	ms
Discharge overcurrent detection delay time	t_{DOC}	$V_{DD} = 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$	$0.7 \cdot t_{DOC}$ $0.5 \cdot t_{DOC}$	t_{DOC}	$1.3 \cdot t_{DOC}$ $1.5 \cdot t_{DOC}$	ms
Load Short detection delay time	t_{SHR}	$V_{DD} = 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$	$0.6 \cdot t_{SHR}$ $0.5 \cdot t_{SHR}$	t_{SHR}	$1.4 \cdot t_{SHR}$ $2.0 \cdot t_{SHR}$	μs
Charge overcurrent detection delay time	t_{COC}	$V_{DD} = 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$	$0.7 \cdot t_{COC}$ $0.5 \cdot t_{COC}$	t_{COC}	$1.3 \cdot t_{COC}$ $1.5 \cdot t_{COC}$	ms
Discharge overcurrent release delay time	t_{DOCR}	$V_{DD} = 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$		1	3 5	ms
Charge overcurrent release delay time	t_{COCR}	$V_{DD} = 3.5V$	$T_a = 25^{\circ}C$ $T_a = -40 \sim 85^{\circ}C$		1	3 5	ms
VM pin							
Monitor voltage for the charger connection	V_{CHG}	$V_{DD} = 3.5V$		-0.1	0	0.1	V
Monitor voltage for the load connection	V_{LD}	$V_{DD} = 3.5V$		0.15	0.25	0.35	V
Resistance between VDD pin and VM pin	R_{VMD}	$V_{DD} = 1.8V, V_{VM} = 0V$		500	1000	1500	k Ω
Resistance between VM pin and VSS pin	R_{VMS}	$V_{DD} = 3.5V, V_{VM} = 1.0V$		7	10	15	k Ω
0V battery charge							
0V battery charge inhibition voltage	V_{0VINH}	0V battery charge inhibited		0.6	0.9	1.2	V
0V battery charge starting charger voltage	V_{0VCHA}	0V battery charge permissible		1.2			V
Output resistance							
CO pin resistance 'H'	R_{COH}	$V_{DD} = 3.5V, T_a = -40^{\circ}C \sim 85^{\circ}C$		2	3.6	5	k Ω
CO pin resistance 'L'	R_{COL}	$V_{DD} = 5V, T_a = -40^{\circ}C \sim 85^{\circ}C$		2	2.7	3.5	k Ω
DO pin resistance 'H'	R_{DOH}	$V_{DD} = 3.5V, T_a = -40^{\circ}C \sim 85^{\circ}C$		2	3.6	5	k Ω
DO pin resistance 'L'	R_{DOL}	$V_{DD} = 1.8V, T_a = -40^{\circ}C \sim 85^{\circ}C$		2	3.3	5	k Ω

Test Circuits

Caution:

Unless otherwise specified, the output voltage levels 'H' and 'L' at CO pin (V_{CO}) and DO pin (V_{DO}) are judged by the threshold voltage (1.0V) of the N-channel FET. Judge the CO pin level with respect to V_{VM} and the DO pin level with respect to V_{SS} .

1. Overcharge detection voltage, overcharge release voltage

(Test circuit 1)

Overcharge detection voltage (V_{OVP}) is defined as the voltage V_1 at which V_{CO} goes from 'H' to 'L' when the voltage V_1 is gradually increased after setting $V_1=3.5V$. Overcharge release voltage (V_{OVPR}) is defined as the voltage V_1 at which V_{CO} goes from 'L' to 'H' when the voltage V_1 is then gradually decreased.

2. Overdischarge detection voltage, overdischarge release voltage

(Test circuit 2)

Overdischarge detection voltage (V_{UVP}) is defined as the voltage V_1 at which V_{DO} goes from 'H' to 'L' when the voltage V_1 is gradually decreased after setting $V_1=3.5V$, $V_2=0V$.

Overdischarge release voltage (V_{UVPR}) is defined as the voltage V_1 at which V_{DO} goes from 'L' to 'H' when setting $V_2=0.01V$, and when the voltage V_1 is then gradually increased.

3. Discharge overcurrent detection voltage, discharge overcurrent release voltage

(Test circuit 2)

Discharge overcurrent detection voltage (V_{DOC}) is defined as the voltage V_2 whose delay time for changing V_{DO} from 'H' to 'L' is discharge overcurrent detection delay time (t_{DOC}) when V_2 voltage is increased after setting $V_1=3.5V$, $V_2=0V$.

Discharge overcurrent release voltage is defined as the voltage V_2 at which V_{DO} goes from 'L' to 'H' when setting $V_2=3.5V$, and when the voltage V_2 is then gradually decreased.

4. Load short-circuiting detection voltage

(Test circuit 2)

Load short-circuiting detection voltage (V_{SHR}) is defined as the voltage V_2 whose delay time for changing V_{DO} from 'H' to 'L' is load short detection delay time (t_{SHR}) when V_2 voltage is increased after setting $V_1=3.5V$, $V_2=0V$.

5. Charge overcurrent detection voltage

(Test circuit 2)

Charge overcurrent detection voltage (V_{COC}) is defined as the VM pin voltage whose delay time for changing V_{CO} from 'H' to 'L' is charge overcurrent detection delay time (t_{COC}) when the VM pin voltage is decreased after setting $V_1=3.5V$, $V_2=0V$.

6. Current consumption during operation

(Test circuit 3)

The current consumption during operation (I_{OPR}) is the current that flows through the VDD pin (I_{DD}) under the set conditions of $V1=3.5V$, $V2=0V$.

7. Current consumption during overdischarge

(Test circuit 3)

7. 1 Without sleep function

Set $V1=3.5V$, $V2=0V$, then set $V1=V2=1.5V$, the I_{DD} is the current consumption during overdischarge (I_{LP}).

7. 2 With sleep function

Set $V1=3.5V$, $V2=0V$, then set $V1=V2=1.5V$, the I_{DD} is the current consumption during overdischarge (I_{SLEEP}).

8. Resistance between VDD pin and VM pin

(Test circuit 3)

R_{VMD} is the resistance between VDD pin and VM pin under the set conditions of $V1=1.8V$, $V2=0V$.

$$R_{VMD} = V1 / I_{VM}$$

9. Resistance between VM pin and VSS pin

(Test circuit 3)

R_{VMS} is the resistance between VM pin and VSS pin when setting $V1=3.5V$, $V2=1.0V$.

$$R_{VMS} = V2 / I_{VM}$$

10. CO pin resistance 'H'

(Test circuit 4)

The CO pin resistance 'H' (R_{COH}) is the resistance between VDD pin and CO pin under the set conditions of $V1=3.5V$, $V2=0V$, $V3=3.0V$.

11. CO pin resistance 'L'

(Test circuit 4)

The CO pin resistance 'L' (R_{COL}) is the resistance between VM pin and CO pin under the set conditions of $V1=5.0V$, $V2=0V$, $V3=0.4V$.

12. DO pin resistance 'H'

(Test circuit 4)

The DO pin resistance 'H' (R_{DOH}) is the resistance between VDD pin and DO pin under the set conditions of $V1=3.5V$, $V2=0V$, $V4=3.0V$.

13. DO pin resistance 'L'

(Test circuit 4)

The DO pin resistance 'L' (R_{DOL}) is the resistance between VSS pin and DO pin under the set conditions of $V1=1.8V$, $V2=0V$, $V4=0.4V$.

14. Overcharge detection delay time**(Test circuit 5)**

After setting $V1=3.5V$, $V2=0V$, the voltage $V1$ is increased. The time interval from when the voltage $V1$ exceeds V_{OVP} until V_{CO} goes to 'L' is the overcharge detection delay time (t_{OVP}).

15. Overdischarge detection delay time**(Test circuit 5)**

After setting $V1=3.5V$, $V2=0V$, the voltage $V1$ is decreased. The time interval from when the voltage $V1$ falls below V_{UVP} until V_{DO} goes to 'L' is the overdischarge detection delay time (t_{UVP}).

16. Discharge overcurrent detection delay time**(Test circuit 5)**

After setting $V1=3.5V$, $V2=0V$, the VM pin voltage is increased. The time interval from when the voltage $V2$ exceeds V_{DOC} until V_{DO} goes to 'L' is the discharge overcurrent detection delay time (t_{DOC}).

17. Load short-circuiting detection delay time**(Test circuit 5)**

After setting $V1=3.5V$, $V2=0V$, the VM pin voltage is increased. The time interval from when the voltage $V2$ exceeds V_{SHR} until V_{DO} goes to 'L' is the load short-circuiting detection delay time (t_{SHR}).

18. Charge overcurrent detection delay time**(Test circuit 5)**

After setting $V1=3.5V$, $V2=0V$, the VM pin voltage is decreased. The time interval from when the voltage $V2$ falls below V_{COC} until V_{CO} goes to 'L' is the charge overcurrent detection delay time (t_{COC}).

19. Monitor voltage for the charger connection**(Test circuit 5)**

In the charging overcurrent status, the monitor voltage for the charger connection (V_{CHG}) is defined as the voltage $V2$ at which V_{CO} goes to 'H' when the voltage $V2$ is gradually increased after setting $V1=3.5V$, $V2=-0.4V$.

20. 0V battery charge inhibition battery voltage (0V battery charge inhibited)**(Test circuit 2)**

The 0V battery charge inhibition battery voltage (V_{OVINH}) is defined as the voltage $V1$ at which V_{CO} goes to 'L' when the voltage $V1$ is gradually decreased after setting $V1=2V$, $V2=-2V$.

21. 0V battery charge starting charger voltage (0V battery charge permissible)**(Test circuit 6)**

The 0V battery charge starting charger voltage (V_{OVCHA}) is defined as the absolute value of voltage $V2$ at which V_{CO} reaches to 'H' when the voltage $V2$ is gradually decreased from the starting condition of $V1=V2=0V$.

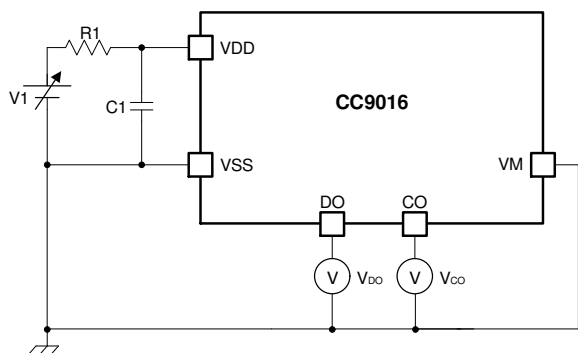


Figure 4. Test Circuit 1

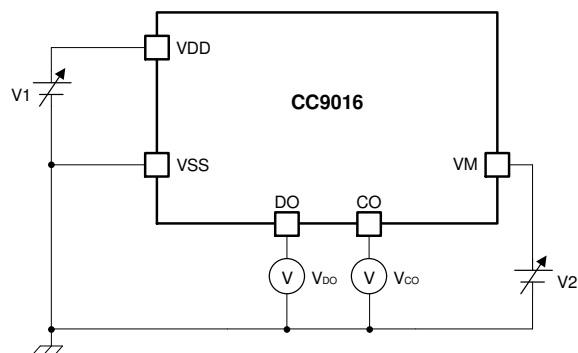


Figure 5. Test Circuit 2

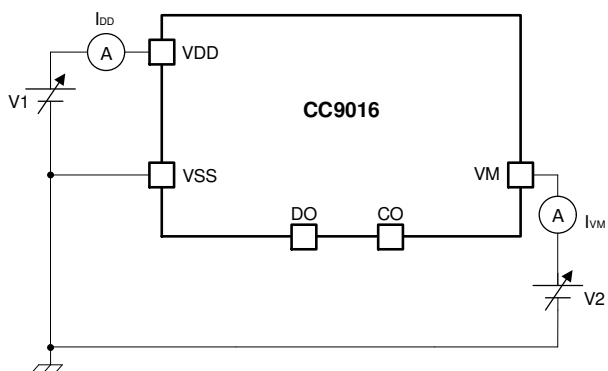


Figure 6. Test Circuit 3

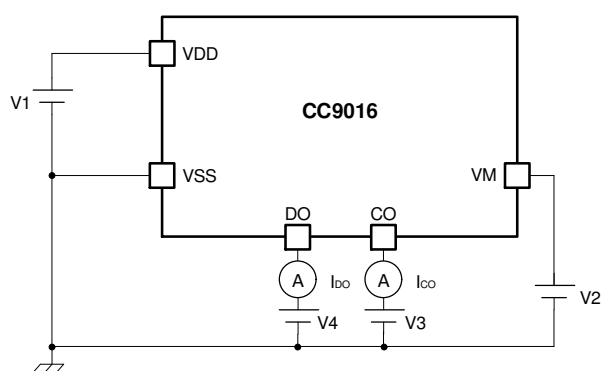


Figure 7. Test Circuit 4

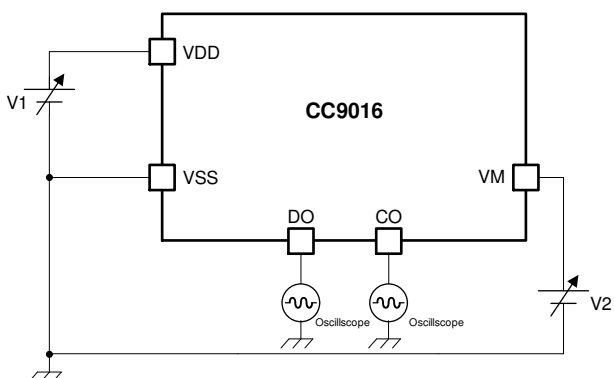


Figure 8. Test Circuit 5

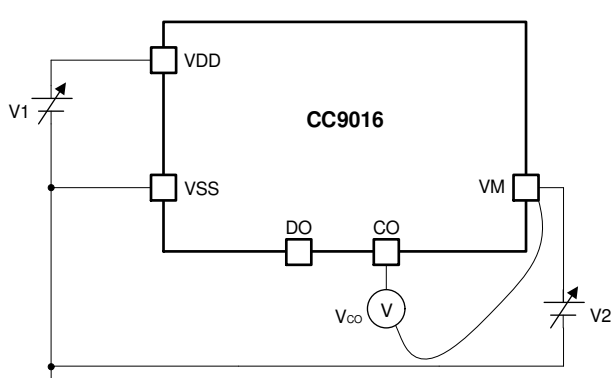


Figure 9. Test Circuit 6

Operation

Normal Status

The CC9016 Series monitors the voltage of the battery connected between VDD pin and VSS pin, the voltage between VM pin and VSS pin to control charging and discharging. When the battery voltage is in the range from overdischarge detection voltage (V_{UVP}) to overcharge detection voltage (V_{OVP}), and the VM pin voltage is in the range from charge overcurrent detection voltage (V_{COC}) to discharge overcurrent detection voltage (V_{DOC}), the CC9016 Series turns both the charge and discharge control FETs on. This status is called the normal status, and in this condition charging and discharging can be carried out freely. 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: After the battery is connected, discharging may not be carried out. In this case, the IC returns to the normal status by connecting a charger.

Overcharge status

When the battery voltage becomes higher than V_{OVP} during charging in the normal status and the condition continues for the overcharge detection delay time (t_{OVP}) or longer, the CC9016 Series turns the charge control FET off to stop charging. This status is called the overcharge status.

The overcharge status is released in the following two cases.

Overcharge without Latch function,

- If VM pin voltage is lower than 0.25V typ., the IC releases the overcharge status when the battery voltage falls below overcharge release voltage (V_{OVPR}) and continues for longer than overcharge release delay time(t_{OVPR}).
- If VM pin voltage is equal to or higher than 0.25V typ., the IC releases the overcharge status when the battery voltage falls below overcharge voltage (V_{OVP}), and continues for longer than overcharge release delay time(t_{OVPR}).

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

Noted,

If the CC9016 Series is in the overcharge status, and the battery voltage does not fall below V_{OVP} , even when a heavy load is connected, discharge overcurrent detection and load short-circuiting detection do not work until the battery voltage falls below V_{OVP} . Since an actual battery has an internal impedance, the battery voltage will drop immediately after a heavy load is connected, and discharge overcurrent detection and load short-circuiting detection start to work.

Overcharge with Latch function,

- If VM pin voltage is lower than 0.25V typ., the IC will not release the overcharge status even the battery voltage falls below overcharge release voltage (V_{OVPR}) and continues for longer than

overcharge release delay time(t_{OVPR}).

- If VM pin voltage is equal to or higher than 0.25V typ., the IC releases the overcharge status when the battery voltage falls below overcharge release voltage (V_{OVPR}), and continues for longer than overcharge release delay time(t_{OVPR}).

Noted,

If the CC9016 Series is in the overcharge status, and the battery voltage does not fall below V_{OVP} , even when a heavy load is connected, discharge overcurrent detection and load short-circuiting detection do not work until the battery voltage falls below V_{OVP} . Since an actual battery has an internal impedance, the battery voltage will drop immediately after a heavy load is connected, and discharge overcurrent detection and load short-circuiting detection start to work.

When a charger is connected when CC9016 Series is in the overcharge status, the overcharge status will not be released even if the battery voltage is below V_{OVPR} . The overcharge status will be released when the VM pin voltage is equal to or higher than 0.25V typ. by removing the charger and connecting a load.

Overdischarge status

When the battery voltage falls below V_{UVP} during discharging in the normal status and the condition continues for the overdischarge detection delay time (t_{UVP}) or longer, the CC9016 Series turns the discharge control FET off to stop discharging. This status is called the overdischarge status.

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

In the overdischarge status, charge and discharge overcurrent detection do not work.

The overdischarge status is released in the following two cases.

With sleep function,

- If VM pin voltage is higher than 0.9V typ., the IC will not release the overdischarge status even the battery voltage rises above overdischarge release voltage (V_{UVP}).
- If VM pin voltage is lower than 0.9V typ. and higher than 0V typ., the IC will release the overdischarge status when the battery voltage rises above overdischarge release voltage (V_{UVP}), and continues for longer than overdischarge release delay time(t_{UVP}).
- If VM pin voltage is lower than 0V typ., the IC releases the overdischarge status when the battery voltage rises above overdischarge voltage (V_{UVP}), and continues for longer than overdischarge release delay time(t_{UVP}).

Without sleep function,

- If VM pin voltage is equal to or higher than 0V typ., the IC releases the overdischarge status when the battery voltage rises above overdischarge release voltage (V_{UVP}), and continues for longer than overdischarge release delay time(t_{UVP}).
- If VM pin voltage is lower than 0V typ., the IC releases the overdischarge status when the battery voltage rises above overdischarge voltage (V_{UVP}), and continues for longer than overdischarge release delay time(t_{UVP}).

R_{VMS} is not connected in this status.

Discharge overcurrent status

Discharge overcurrent

When a battery in the normal status is in the status where the VM pin voltage is equal to or higher than V_{DOC} and continues for the discharge overcurrent detection delay time(t_{DOC}) or longer, the discharge control FET 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} , and VM pin is pulled down. However, the VM pin voltage is equal the VDD pin voltage as long as the load is connected. When the load is disconnected, the VM pin voltage returns to the VSS pin voltage.

The discharge overcurrent status is released in the following two cases.

Release condition: V_{DOC} - disconnect the load can release the discharge overcurrent status

- In the case that the VM pin voltage returns to lower than the discharge overcurrent voltage (V_{DOC}), and continues for longer than discharge overcurrent release delay time(t_{DOCR}), the IC releases the discharge overcurrent status.

Release condition: V_{DOCR} – A light load can release the discharge overcurrent status itself

- In the case that the VM pin voltage returns to lower than the release voltage from discharge overcurrent (V_{DOCR}), and continues for longer than discharge overcurrent release delay time(t_{DOCR}), the IC releases the discharge overcurrent status.

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

Load short-circuiting

When a battery in the normal status where a load causing discharge overcurrent is connected, and the VM pin voltage is equal to or higher than the load short-circuiting detection voltage (V_{SHR}) and the status continues for the load short-circuiting detection delay time (t_{SHR}) or longer, the discharge control FET is turned off and discharging is stopped. This status is called the short-circuiting status.

The IC releases the short-circuiting status in the same way as in Discharge overcurrent.

Charge overcurrent status

When a battery in the normal status is in the status where the VM pin voltage is equal to or lower than V_{COC} and continues for the charge overcurrent detection delay time (t_{COC}) or longer, the charge control FET is turned off and charging is stopped. This status is called the charge overcurrent status.

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

The charge overcurrent status is released in the following two cases.

- In the case that the VM pin voltage returns to higher than 0V typ., and continues for longer than charge overcurrent release delay time(t_{COCR}), the IC releases the charge overcurrent status.
- In the case that the VM pin voltage is higher than V_{SHR} , and continues for longer than 200 μ s typ., the IC releases the charge overcurrent status.

0V battery charge - permission

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_{0VCHA}) or a higher voltage is applied between the P+ and P– pins by connecting a charger, the charge control FET gate is fixed to the VDD pin voltage. When the voltage between the gate and source of the charge control FET becomes equal to or higher than the threshold voltage due to the charger voltage, the charge control FET is turned on to start charging. At this time, the discharge control FET is off and the charging current flows through its internal parasitic diode. When the battery voltage becomes equal to or higher than V_{UVP} , the IC returns to the normal status.

Note:

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.

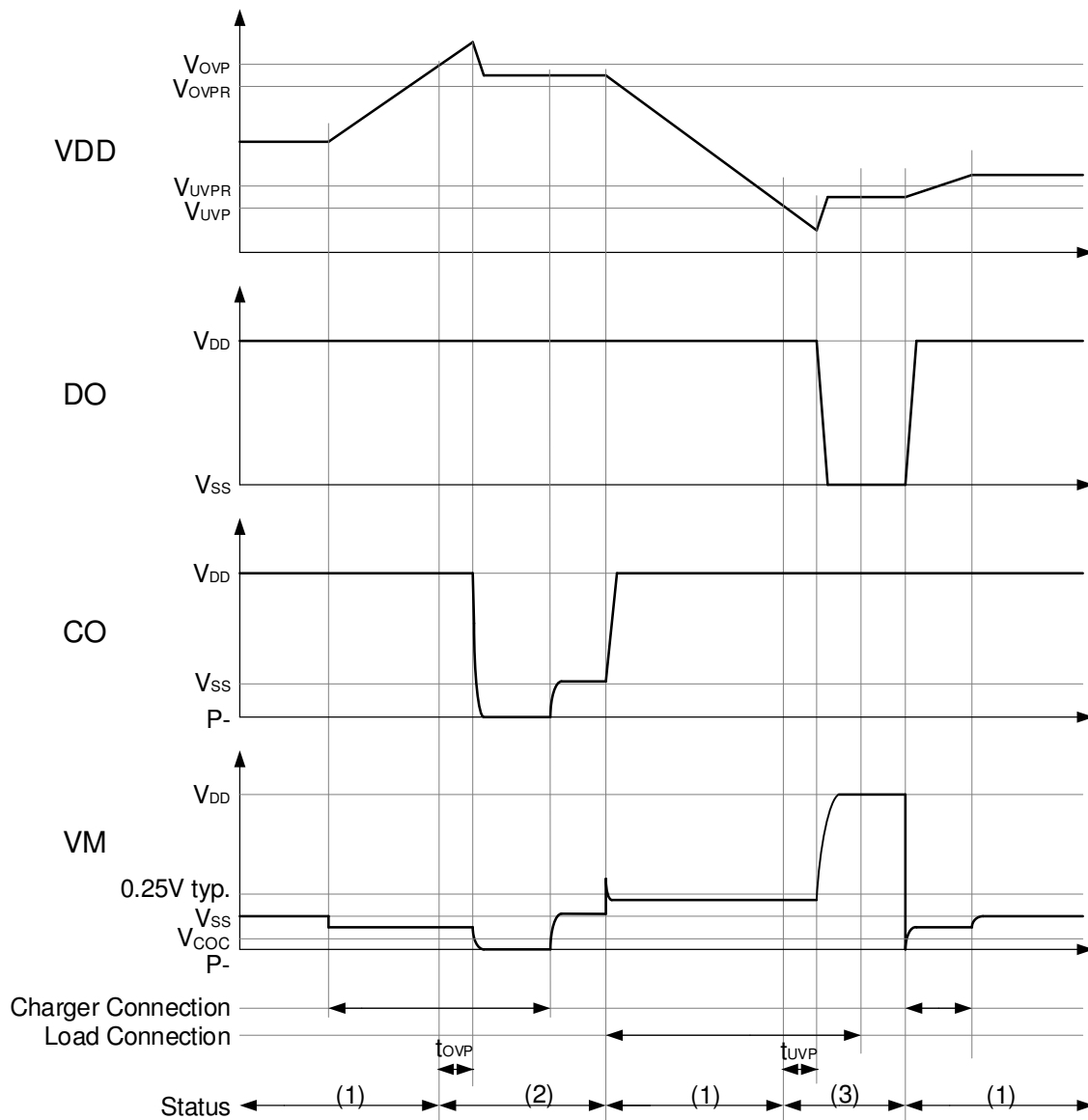
The 0V battery charge function has higher priority than the charge overcurrent detection function. Consequently, a product in which use of the 0V battery charge function is enabled charges a battery forcibly and the charge overcurrent cannot be detected when the battery voltage is lower than V_{UVP}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

0V battery charge - inhibition

This function inhibits recharging when a battery that is internally short-circuited (0V battery) is connected. When the battery voltage is lower than 0V battery charge inhibition voltage (V_{0VINH}), the charge control FET gate is fixed to the VM pin voltage to inhibit charging. When the battery voltage is high than V_{0VINH} , charging can be worked.

Timing Charts

1. Overcharge detection, overdischarge detection



Status:

(1) Normal Status

(2) Overcharge Status

(3) Overdischarge Status

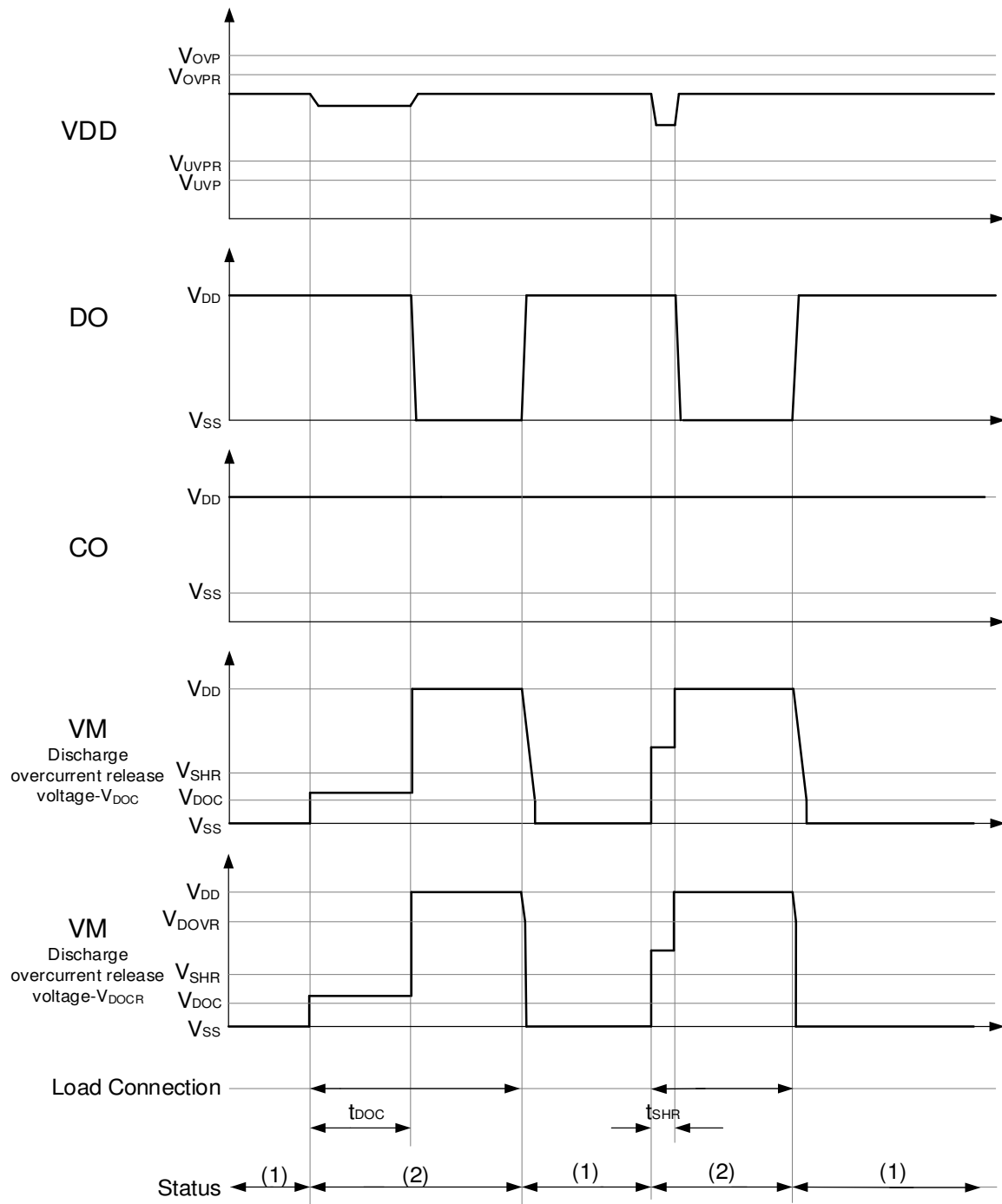
t_{OVP} : Overcharge Detection Delay Time

t_{UVP} : Overdischarge Detection Delay Time

Note: The charger is assumed to charge with a constant current

Figure 10.

2. Discharge overcurrent detection



Status:

(1) Normal Status

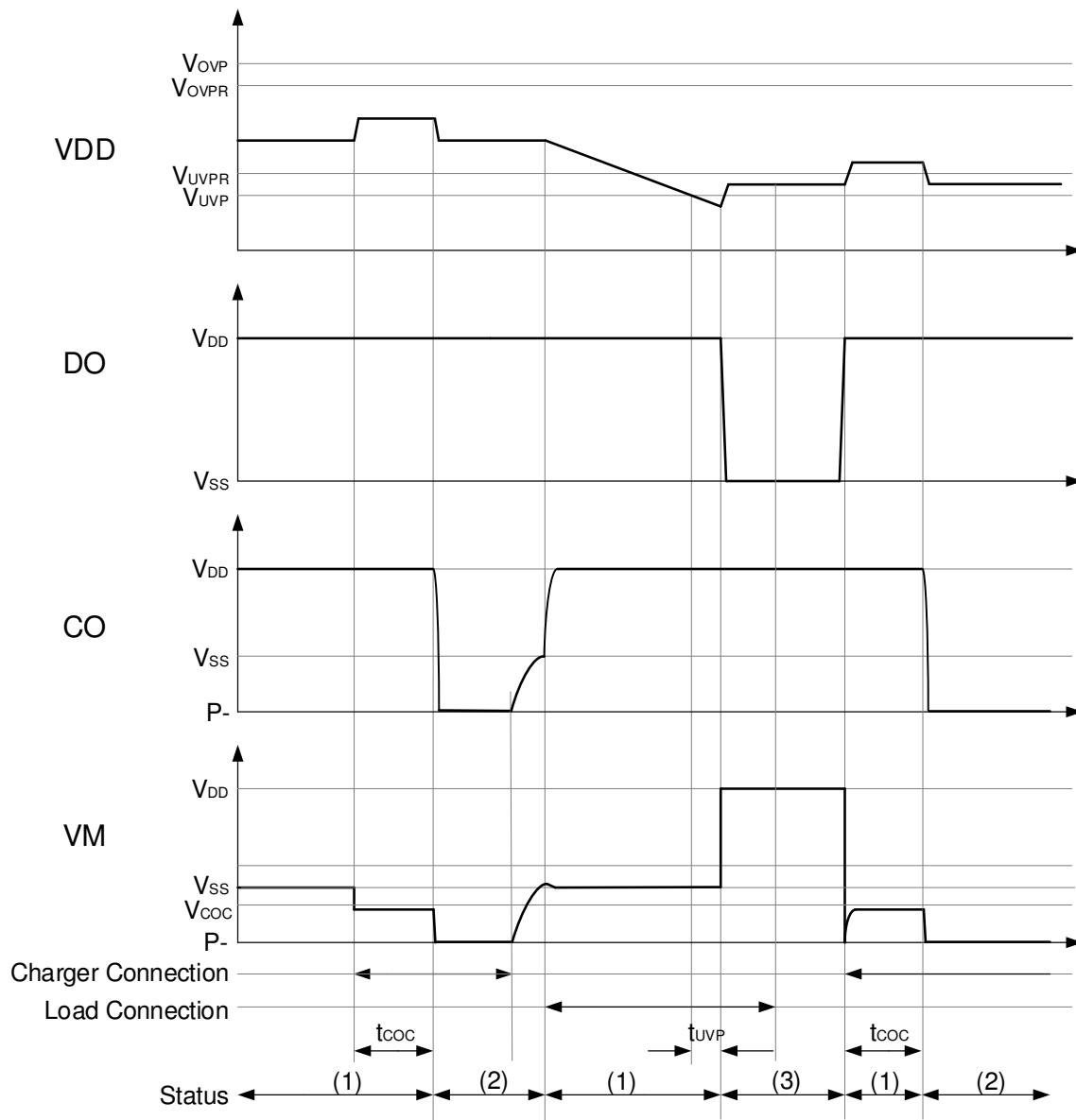
(2) Discharge Overcurrent Status

t_{DOC} : Discharge Overcurrent Detection Delay Time

t_{SHR} : Load Short-circuiting Detection Delay Time

Figure 11.

3. Charge overcurrent detection



Status:

(1) Normal Status

(2) Charge Overcurrent Status

(3) Overdischarge Status

t_{COC} : Charge Overcurrent Detection Delay Time

t_{UVP} : Overdischarge Detection Delay Time

Note: The charger is assumed to charge with a constant current

Figure 12.

Typical Application Circuit

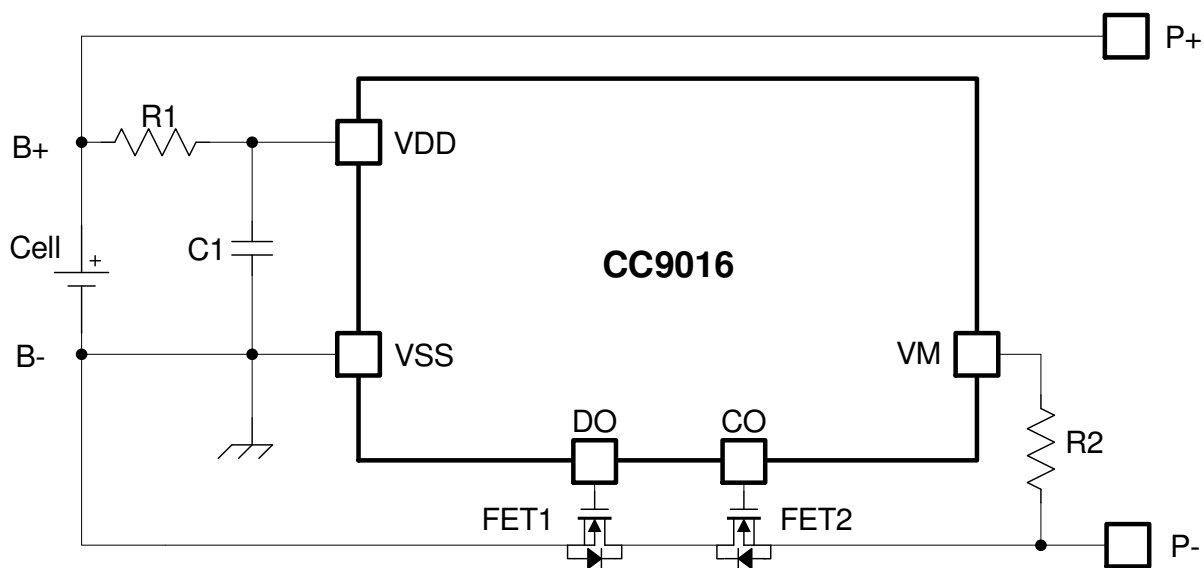
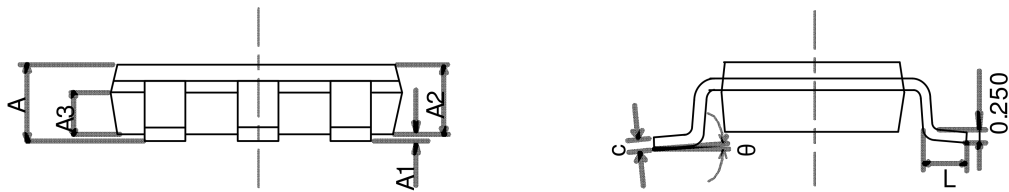


Figure 13. Typical Application Circuit

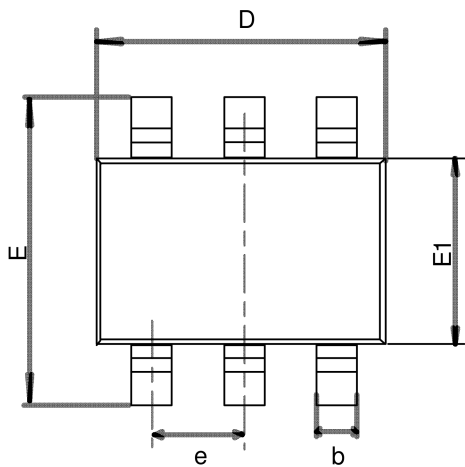
Symbol	Component	Description	Min.	Typ.	Max.
FET1	N-MOS	Discharge Control			
FET2	N-MOS	Charge Control			
R1*	Resistor	ESD protection, for power fluctuation	270Ω	330Ω	1.2kΩ
C1	Capacitor	For power fluctuation	68nF	100nF	2.2μF
R2	Resistor	ESD protection, Protection for reverse connection of a charger	300Ω	470Ω	1.5kΩ

Note: * Accuracy of overcharge detection voltage is guaranteed by $R1 = 330\Omega$. Connecting resistors with other values will worsen the accuracy, since the detection voltage rises by the current consumption of IC when R1 is too large.

Package Information (SOT23-6)



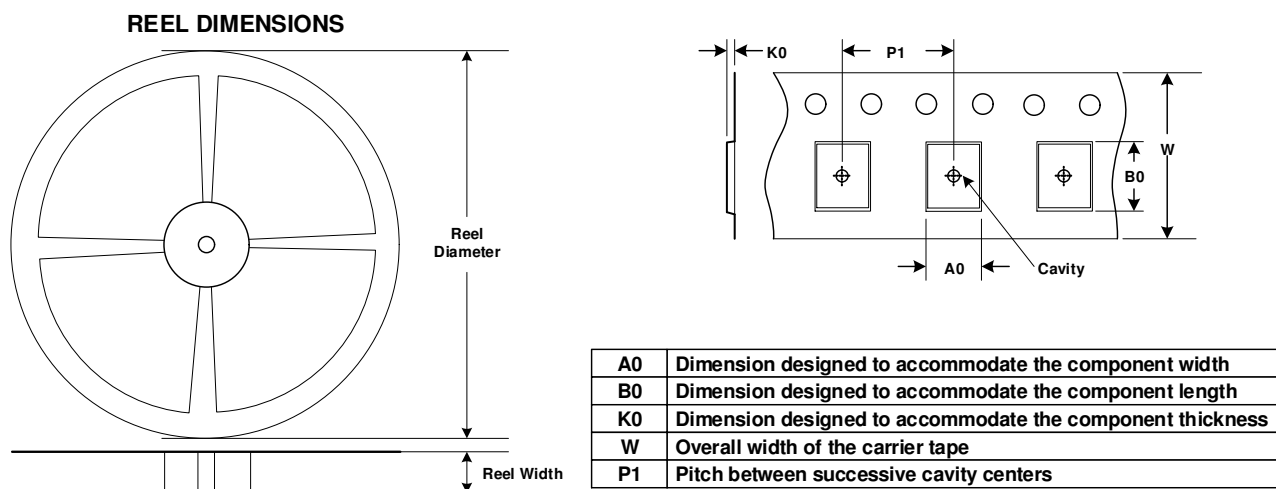
SIDE VIEW



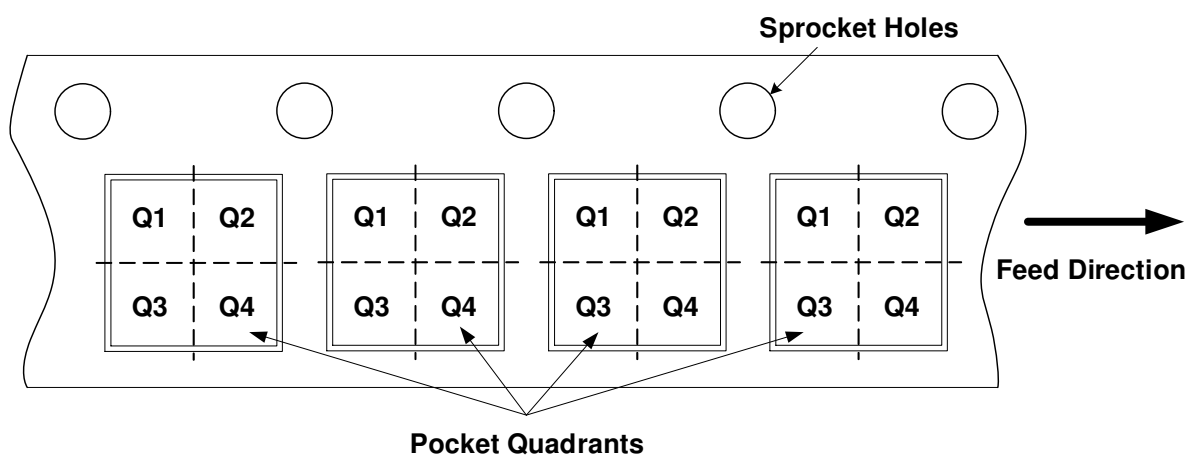
TOP VIEW

SYMBOL	MILIMETER		
	MIN	NOM	MAX
A	1.050	1.150	1.250
A1	0.000	0.060	0.100
A2	1.000	1.100	1.200
A3	0.550	0.650	0.750
b	0.300	0.400	0.500
c	0.100	0.152	0.200
D	2.820	2.920	3.020
E	2.650	2.800	2.950
E1	1.510	1.610	1.700
e	0.950BSC		
L	0.300	0.420	0.570
θ	0	4°	8°

Tape and Reel Information



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Package Type	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin 1 Quadrant
SOT23-6	180.00	8.60	3.22	3.25	1.38	4.00	8.00	Q3

Note: All dimensions are nominal.

Revision History

Date	Release No.	Revision Description
2024-11-07	1.0	V1.0 DS release
2025-07-03	1.1	Add part number CC9016CLAS
2025-11-10	1.2	Add part number CC9016AFAS, CC9016CLCS, CC9016CLDS, CC9016CLFS, CC9016ALRS, CC9016CLGS

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.