Battery Protection IC, OTP Function, 1-Cell Lithium-Ion Battery

LC06511FMX

Overview

LC06511FMX is a protection IC for 1 cell lithium−ion or lithium−polymer battery. It provides highly accurate over−charge, over−discharge, over−current protection. Current is detected by high precision external chip resistor. Which realizes accurate current detection over temperature.

Function

- Highly Accurate Detection Voltage/Current at Ta = 25°C, VCC = 3.8 V
- Over Charge Detection Voltage
  - 4.276 V, 4.426 V, 4.476 V
- Over Charge Release Hysteresis
  - 0.2 V
- Over Discharge Detection Voltage
  - 2.3 V, 2.5 V, 2.8 V
- Over Discharge Release Hysteresis2
  - 0.2 V
- Discharge Over Current Detection Voltage1
  - 6.3 mV, 7.5 mV
- Short Current Detection Voltage
  - 30 mV
- Charge Over Current Detection Voltage
  - 5.0 mV, 6.0 mV
- Over−discharge Detection Delay Time
  - 32 ms
- Discharge Over−current Detection Delay Time1
  - 16 ms
- 0 V Battery Charging
  - “Permit”
- Auto Wake−up Function
  - “Permit”
- This is a Pb−Free Device

Typical Applications

- Smart Phone
- Tablet
- Wearable Device

ON Semiconductor®

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X2DFN6 1.4x1.4, 0.5P
CASE 716AF

MARKING DIAGRAM

XX = Specific Device Code
M = Month Code
▪ = Pb−Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

Device	Package	Shipping†
LC06511FXXMXTBG	X2DFN6 (Pb−Free)	4000 / Tape & Reel

XX = 1A−9A, 1B−9B

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	VCC		−0.3 to 12.0	V
CS terminal Input voltage	VCS		−0.3 to 7	V
VM terminal Input voltage	VVM		VCC − 24.0 to VCC + 0.3	V
CO terminal voltage	VCO		VCC − 24.0 to VCC + 0.3	V
DO terminal voltage	VDO		VCC − 0.3 to VCC + 0.3	V
Storage temperature	Tstg		−55 to +125	°C
Operating ambient temperature	Topr		−40 to +85	°C
Junction temperature	Tj		125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

EXAMPLE OF APPLICATION CIRCUIT

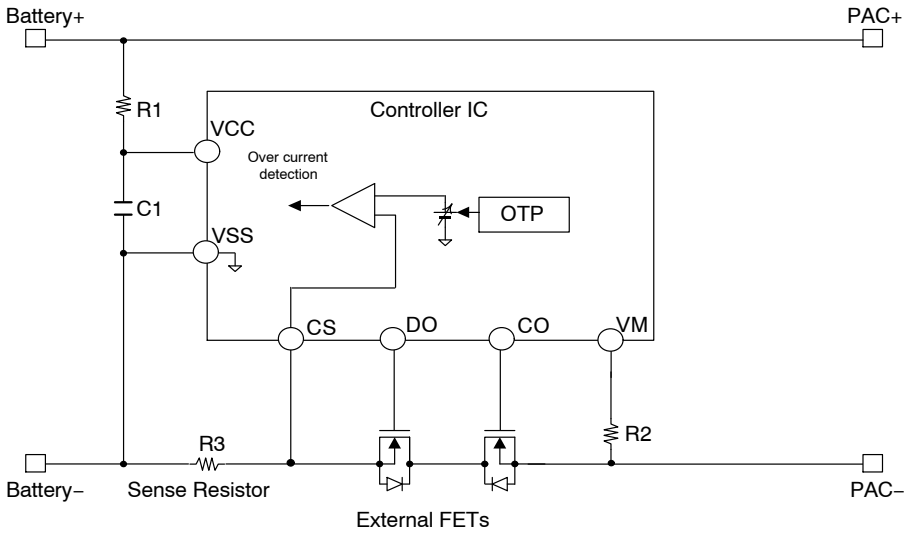


Figure 1. Example of Application Circuit

Table 2.

Components	Min	Recommended Value	Max	Unit	Description
R1	0.1	0.33	1	kΩ	Battery+ is filtered to VCC by R1 and C1
R2	0.1	1	2	kΩ	Protection from reverse connection of charger
C1	0.01	0.1	1.0	μF	Battery+ is filtered to VCC by R1 and C1
R3	1		20	mΩ	Sence resistor for over−current detection

Table 3. ELECTRICAL CHARACTERISTICS (R1 = 0.33 kΩ, R2 = 1 kΩ, VCC = 3.8 V (Note 1))

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
DETECTION VOLTAGE								
Over−charge Detection Voltage	Vov	R1 = 0.33 kΩ	Ta = 25°C	Vov_set − 10	Vov_set	Vov_set + 10	mV	B
			Ta = −20 to 60°C	Vov_set − 15	Vov_set	Vov_set + 15		
Over−charge Release Voltage	Vovr1	R1 = 0.33 kΩ VM < Vcocr& CS = 0 V	Ta = 25°C	Vovr_set − 30	Vovr_set	Vovr_set + 30	mV	B
			Ta = −20 to 60°C	Vovr_set − 55	Vovr_set	Vovr_set + 40		
	Vovr2	R1 = 0.33 kΩ VM > Vcocr& CS = 0 V	Ta = 25°C	Vov_set − 15	Vov_set	Vov_set + 10	mV	I
			Ta = −20 to 60°C	Vov_set − 20	Vov_set	Vov_set + 15		
Over−discharge Detection Voltage	Vuv	R1 = 0.33 kΩ	Ta = 25°C	Vuv_set − 35	Vuv_set	Vuv_set + 35	mV	B
			Ta = −20 to 60°C	Vuv_set − 55	Vuv_set	Vuv_set + 55		
Over−discharge Release Voltage1	Vuvr1	R1 = 0.33 kΩ VM = 0 V	Ta = 25°C	Vuv_set − 35	Vuv_set	Vuv_set + 50	mV	B
			Ta = −20 to 60°C	Vuv_set − 55	Vuv_set	Vuv_set + 80		
Over−discharge Release Voltage2	Vuvr2	R1 = 0.33 kΩ VM = OPEN	Ta = 25°C	Vuvr_set − 100	Vuvr_set	Vuvr_set + 100	mV	D
			Ta = −20 to 60°C	Vuvr_set − 110	Vuvr_set	Vuvr_set + 110		
Discharge Over−current Detection Voltage (Primary Protection)	Vdoc	R2 = 1 kΩ VCC = 3.8 V	Ta = 25°C	Vdoc_set − 1.0	Vdoc_set	Vdoc_set + 1.0	mV	F
			Ta = −20 to 60°C	Vdoc_set − 1.8	Vdoc_set	Vdoc_set + 1.8		
Discharge Over−current Detection Voltage (Short Circuit)	Vshrt	R2 = 1 kΩ VCC = 3.8 V	Ta = 25°C	Vshrt_set − 10	Vshrt_set	Vshrt_set + 10	mV	F
			Ta = −20 to 60°C	Vshrt_set − 12	Vshrt_set	Vshrt_set + 12		
Discharge Over−current (Short Circuit) Release Voltage	Vdocr	R2 = 1 kΩ VCC = 3.8 V CS = 0 V	Ta = 25°C	VCC − 1.1	VCC−0.65	VCC − 0.2	V	A
			Ta = −20 to 60°C	VCC − 1.2	VCC−0.65	VCC − 0.1		
Charge Over−current Detection Voltage	Vcoc	R2 = 1 kΩ VCC = 3.8 V	Ta = 25°C	Vcoc_set − 1.0	Vcoc_set	Vcoc_set + 1.0	mV	F
			Ta = −20 to 60°C	Vcoc_set − 1.8	Vcoc_set	Vcoc_set + 1.8		
Charge Over−current Release Voltage	Vcocr	R2 = 1 kΩ VCC = 3.8 V CS = 0 V	Ta = 25°C	0.08	0.2	0.32	V	A
			Ta = −20 to 60°C	0.05	0.2	0.35		
INPUT VOLTAGE								
0 V Battery Charge Permission Charger Voltage	Vchg	VCC − VM VCC = VSS = 0 V	Ta = 25°C			1.4	V	A
CURRENT CONSUMPTION								
Operating Current	Icc	At normal state	Ta = 25°C VCC = 3.8 V		3	6	μA	J
Stand−by Current	Istb	At stand−by state	Ta = 25°C VCC = 2.0 V			0.95	μA	J
		Auto wake−up = enable						

Table 3. ELECTRICAL CHARACTERISTICS (R1 = 0.33 kΩ, R2 = 1 kΩ, VCC = 3.8 V (Note 1)) (continued)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
RESISTANCE								
Internal Resistance (VCC−VM)	Rvmu	VCC = 2.0 V VM = 0 V	Ta = 25°C	150	300	600	kΩ	E
Internal Resistance (VSS−VM)	Rvmd	VCC = 3.8 V VM = 0.1 V	Ta = 25°C	5	10	20	kΩ	E
CO Output Resistance (High)	Rcoh	VCC = 3.8 V CO = 3.3 V CS = 0 V	Ta = 25°C	6	12	24	kΩ	H
CO Output Resistance (Low)	Rcol	VCC = 4.5 V CO = 0.5 V CS = 0 V	Ta = 25°C	0.5	0.7	2.0	kΩ	H
DO Output Resistance (High)	Rdoh	VCC = 3.8 V DO = 3.3 V CS = 0 V	Ta = 25°C	0.5	1.0	2.0	kΩ	G
DO Output Resistance (Low)	Rdol	VCC = 2.0 V CS = 0 V DO = 0.5 V	Ta = 25°C	0.2	0.3	0.8	kΩ	G
DETECTION AND RELEASE DELAY TIME								
Over−charge Detection Delay Time	Tov	VCC = 3 V to 4.6 V VM = CS = 0 V	Ta = 25°C	819	1024	1229	ms	B
			Ta = −20 to 60°C	717	1024	1331		
Over−charge Release Delay Time	Tovr	VCC = 4.6 V to 3 V VM = CS = 0 V	Ta = 25°C	12.8	16	19.2	ms	B
			Ta = −20 to 60°C	11.2	16	20.8		
Over−discharge Detection Delay Time	Tuv	VCC = 3.5 V to 1.8 V VM = CS = 0 V	Ta = 25°C	Tuv_set * 0.8	Tuv_set	Tuv_set * 1.2	ms	B
			Ta = −20 to 60°C	Tuv_set * 0.65	Tuv_set	Tuv_set * 1.35		
Over−discharge Release Delay Time	Tuvr	VCC = 1.8 V to 3.5 V VM = CS = 0 V	Ta = 25°C	0.84	1.05	1.26	ms	B
			Ta = −20 to 60°C	0.68	1.05	1.42		
Discharge Over−current Detection Delay Time 1	Tdoc1	CS = 0 V to VdocMAX VM = 0 V	Ta = 25°C	Tdoc1_set * 0.8	Tdoc1_set	Tdoc1_set * 1.2	ms	F
			Ta = −20 to 60°C	Tdoc1_set * 0.7	Tdoc1_set	Tdoc1_set * 1.3		
Discharge Over−current Release Delay Time	Tdocr	VM = 3.8 V to 2.65 V CS = 0 V	Ta = 25°C	3.2	4	4.8	ms	A
			Ta = −20 to 60°C	2.8	4	5.2		
Short−current Detection Delay Time	Tshrt	CS = 0 V to VshrtMAX VM = 0	Ta = 25°C	175	250	325	μs	F
			Ta = −20 to 60°C	150	250	350		
Charge Over−current Detection Delay Time	Tcoc	CS = 0 V to VcocMIN VM = 0	Ta = 25°C	12.8	16	19.2	ms	F
			Ta = −20 to 60°C	11.2	16	20.8		
Charge Over−current Release Delay Time	Tcocr	VM = 0 V to VcocrMAX CS = 0 V	Ta = 25°C	3.2	4	4.8	ms	F
			Ta = −20 to 60°C	2.8	4	5.2		

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1. The specifications in high temperature and low temperature are guaranteed by design.

TEST CIRCUITS

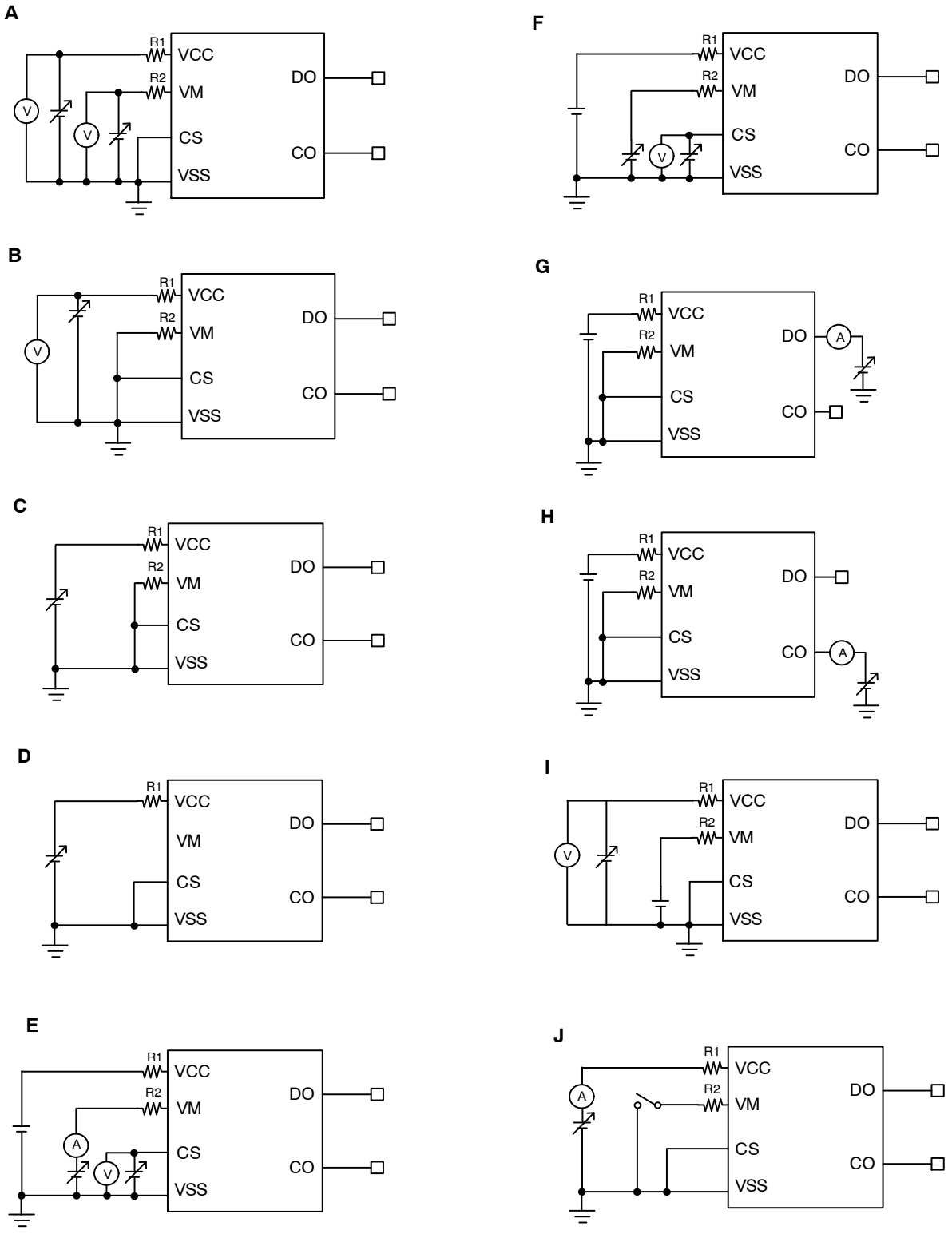


Figure 2. Test Circuits

Table 4. SELECTION GUIDE

Device	Vov (mV)	Vovr (mV)	Vuv (mV)	Vuvr2 (mV)	Vdoc (mV)	Vshrt (mV)	Vcoc (mV)	Tuv (ms)	Tdoc1 (ms)	Specific Device Code
LC06511F1AMX	4276	4076	2300	2500	6.3	30	−5	32	16	LL
LC06511F1BMX	4276	4076	2300	2500	7.5	30	−6	32	16	LW
LC06511F2AMX	4426	4226	2300	2500	6.3	30	−5	32	16	LM
LC06511F2BMX	4426	4226	2300	2500	7.5	30	−6	32	16	LX
LC06511F3AMX	4476	4276	2300	2500	6.3	30	−5	32	16	LN
LC06511F3BMX	4476	4276	2300	2500	7.5	30	−6	32	16	LY
LC06511F4AMX	4276	4076	2500	2700	6.3	30	−5	32	16	LP
LC06511F4BMX	4276	4076	2500	2700	7.5	30	−6	32	16	LZ
LC06511F5AMX	4426	4226	2500	2700	6.3	30	−5	32	16	LQ
LC06511F5BMX	4426	4226	2500	2700	7.5	30	−6	32	16	L2
LC06511F6AMX	4476	4276	2500	2700	6.3	30	−5	32	16	LR
LC06511F6BMX	4476	4276	2500	2700	7.5	30	−6	32	16	L3
LC06511F7AMX	4276	4076	2800	3000	6.3	30	−5	32	16	LT
LC06511F7BMX	4276	4076	2800	3000	7.5	30	−6	32	16	L4
LC06511F8AMX	4426	4226	2800	3000	6.3	30	−5	32	16	LU
LC06511F8BMX	4426	4226	2800	3000	7.5	30	−6	32	16	L5
LC06511F9AMX	4476	4276	2800	3000	6.3	30	−5	32	16	LV
LC06511F9BMX	4476	4276	2800	3000	7.5	30	−6	32	16	L6

Table 5. SENSE RESISTOR SELECTION GUIDE

		LC06511F 1A−9A MX			LC06511F 1B−9B MX		
		Vcoc −5.0 mV	Vdoc 6.3 mV	Vshrt 30 mV	Vcoc −6.0 mV	Vdoc 7.5 mV	Vshrt 30 mV
		Charge Over Current [A]	Discharge Over Current [A]	Short Current [A]	Charge Over Current [A]	Discharge Over Current [A]	Short Current [A]
Sense Resistor [mΩ]	2	2.5	3.2	15	3	3.8	15
	3	1.7	2.1	10	2	2.5	10
	4	1.3	1.6	7.5	1.5	1.9	7.5
	5	1	1.3	6	1.2	1.5	6
	6	0.8	1.1	5	1	1.3	5
	7	0.7	0.9	4.3	0.9	1.1	4.3
	8	0.6	0.8	3.8	0.8	0.9	3.8
	9	0.6	0.7	3.3	0.7	0.8	3.3
	10	0.5	0.6	3	0.6	0.8	3

Table 6. PIN FUNCTION

Pin No.	Symbol	Pin Function
1	VM	Charger negative voltage input terminal
2	CO	Charge FET control terminal
3	DO	Discharge FET control terminal
4	VSS	VSS terminal
5	VCC	VCC terminal
6	CS	Over−current detection input terminal

BLOCK DIAGRAM

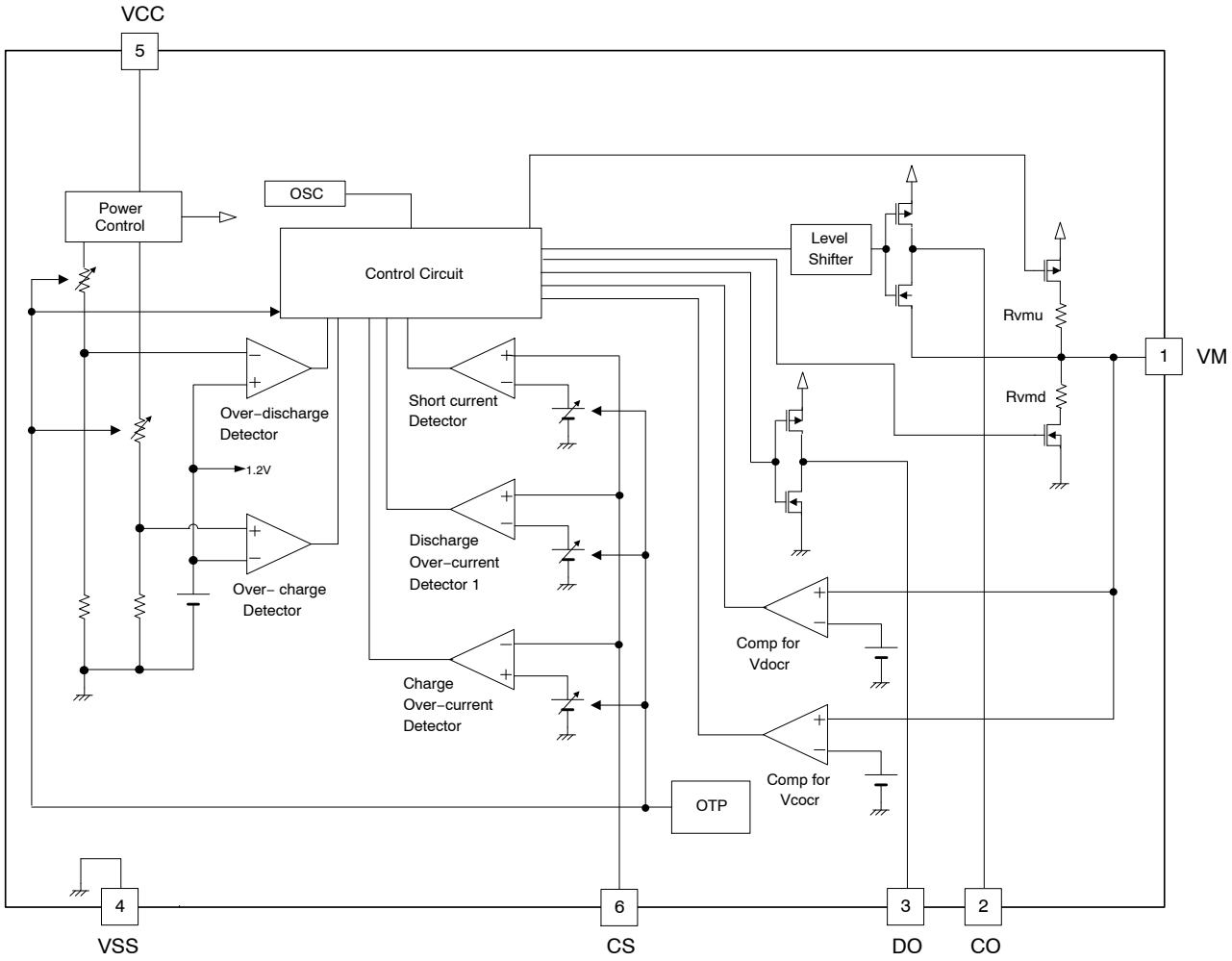


Figure 3. Block Diagram

DESCRIPTION OF OPERATION

- The battery voltage is detected between VCC pin and VSS pin and the battery current is detected between VSS pin and CS pin.

1. Normal State

- "VCC voltage" is between "over−discharge detection voltage (Vuv)", "over−charge detection voltage (Vov)", and "CS voltage" is between "charge over−current detection voltage (Vcoc)", "discharge over−current detection voltage (Vdoc)", and "VM voltage" is lower than "dicharge over−current (short) release voltage (Vdocr)".
  This is the normal state. Both CO and DO are high level output. Charge and discharge is allowed.

2. Over−charging State

- "VCC voltage" is higher than or equal to "over−charge detection voltage (Vov)" for longer than "over−charge detection delay time (Tov)".
  This is the over−charging state, CO is low level output. Charge is prohibited.
- **Release from Over−charging State 1**
  "VM voltage" is lower than "charge over−current (short) release voltage (Vcocr)". Then "VCC voltage" is lower than "over−charge release voltage (Vovr)" for longer than "over−charging release delay time (Tovr)".
- **Release from Over−charging State 2**
  "VM voltage" is higher than "charge over−current (short) release voltage (Vcocr)". Then "VCC voltage" is lower than "over−charge detection voltage (Vov) for longer than "over−charge release delay time (Tovr)".

3. Over−discharging State

- "VCC voltage" is lower than "over−discharge detection voltage (Vuv)" for longer than "over−discharge delay time (Tuv)".
  This is the over−discharging state, DO is low level output. Discharge is prohibited.
  During over−discharging state, VM pin is pulled up to Vcc by internal resistor (Rvmu) and circuits are shut down. The low power consumption is kept.
- **Release from Over−discharging State 1**
  Charger is connected, then "VCC voltage" goes higher than "over−discharge release voltage1 (Vuvr1)" for longer than "over−charge release delay time (Tuvr)".
- **Release from Over−discharging State (with Auto Wake−up Feature) 2**
  "VCC voltage" is higher than "over−discharge release voltage2 (Vuvr1)" without charger for longer than "over−charge release delay time (Tovr)".

4. Discharging Over−current State

- **Discharge Over−current Detection**
  CS terminal is higher than or equal to "discharge over−current detection voltage (Vdoc)" for longer than "discharge over−current detection delay time (Tdoc1)".
  DO is low level output. Discharge is prohibited.
- **Discharge Over−current Detection (Short Circuit)**
  CS terminal is higher than or equal to "discharge over−current detection voltage (Short circuit) (Vshrt)" for longer than "short−current detection delay time (Tshrt)".
  DO is low level output. Dischaege is prohibited.
  During discharging over−current state, VM pin is pulled down to Vss by internal resistor (Rvmd).
- **Release from Discharging Over−current State**
  "CS voltage" goes lower than "discharge over−current detection voltage (Vdoc)" and VM voltage goes lower than "discharge over−current (short) release voltage (Vdocr)" for longer than "discharge over−current release delay time (Tdocr)".

5. Charging Over−current State

- "CS voltage" goes lower than or equal to "charge over−current detection voltage (Vcoc) for longer than "charge over−current detection delay time (Tcoc)".
  This is the charging over−current state, CO is low level output. Charge is prohibited.
- **Release from charging over−current state**
  "CS voltage" goes higher than "charge over−current detection voltage (Vcoc)" and "VM voltage" goes higher than "charge over−current release voltage (Vcocr)" for longer than "charge over−current release delay time (Tcocr)".

6. 0 V Battery Charging

- When the Battery voltage is lower than or equal to "0 V battery charge permission voltage (Vchg)", charge is allowed if charger voltage is higher than or equal "0 V battery charge permission voltage (Vchg)". CO is fixed by the "VCC voltage".

TIMING CHARTS

Over Charge Voltage and Charge Over Current

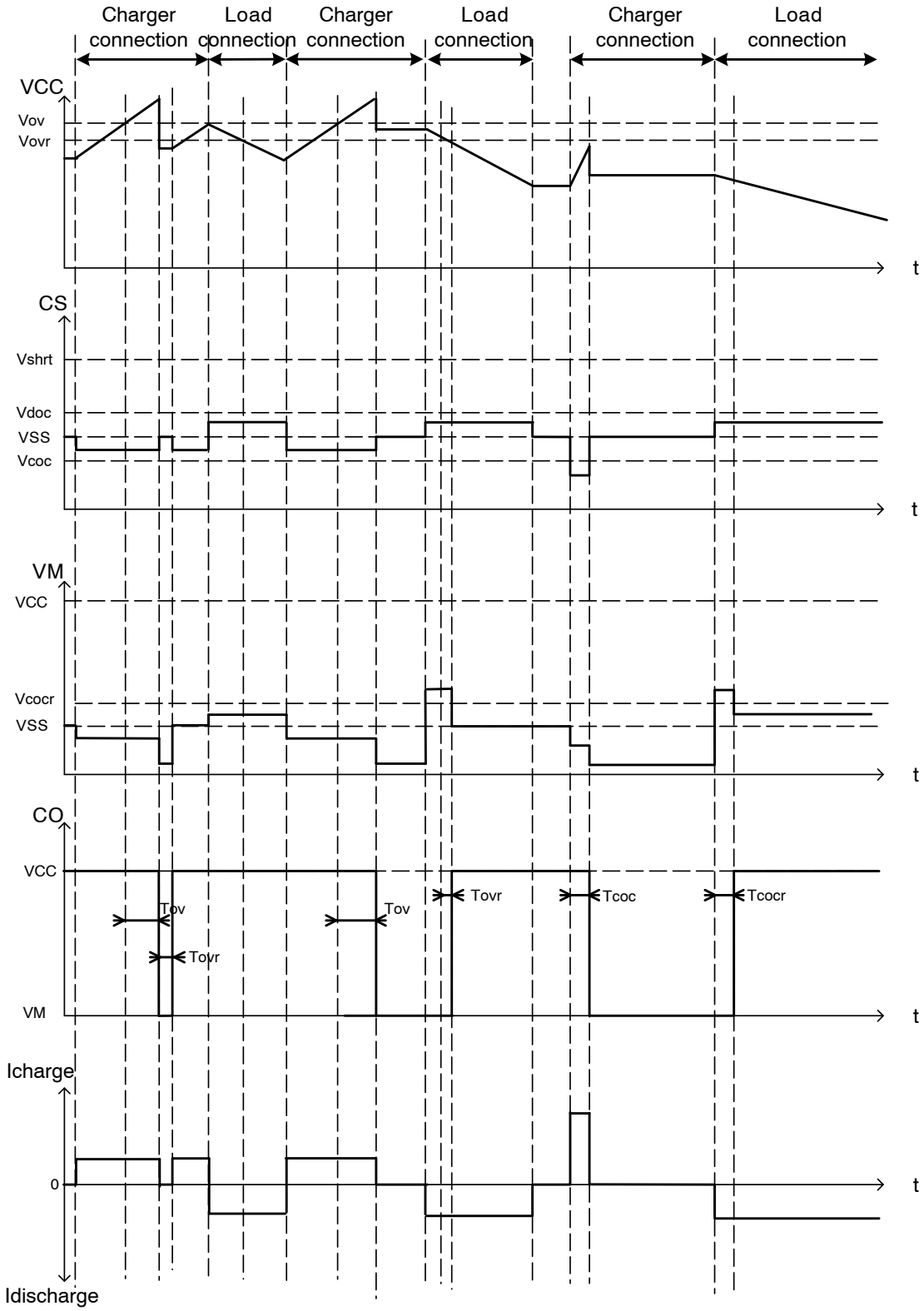


Figure 4. Over Charge Voltage and Charge Over Current

Over Discharge Detection and Release (with/without Charger)

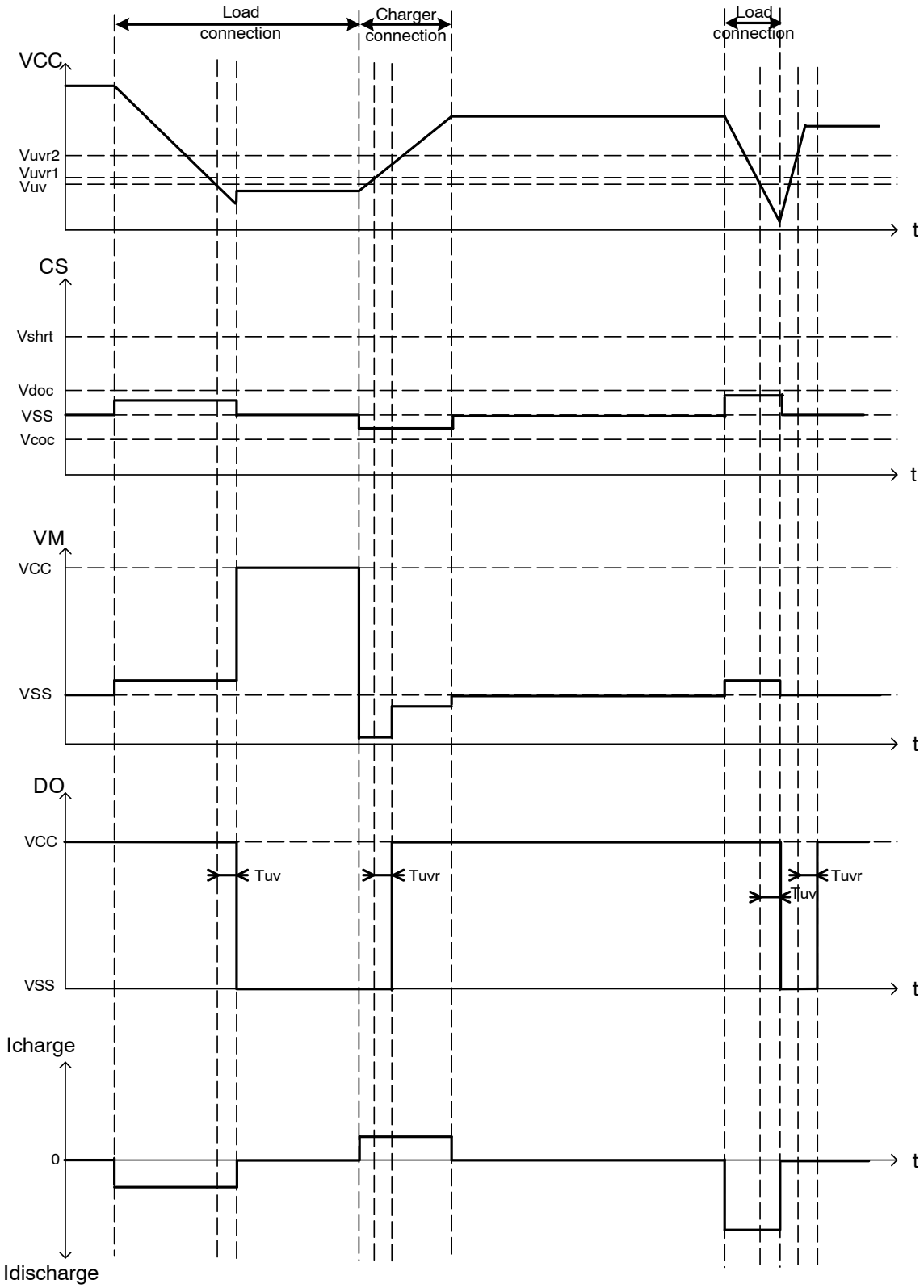


Figure 5. Over Discharge Detection and Release (with/without Charger)

Discharge Over Current and Short Current Detection and Release

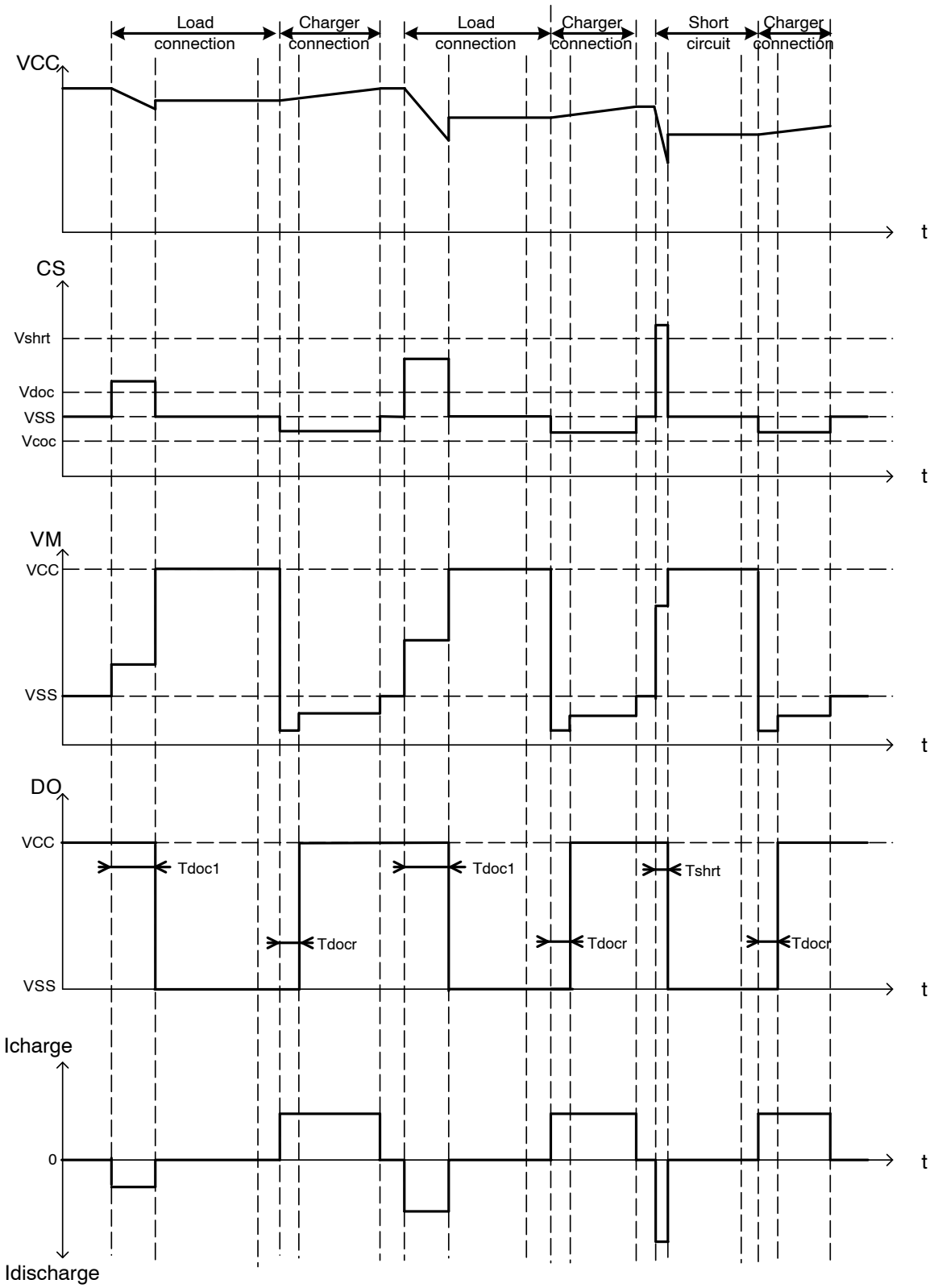


Figure 6. Discharge Over Current and Short Current Detection and Release

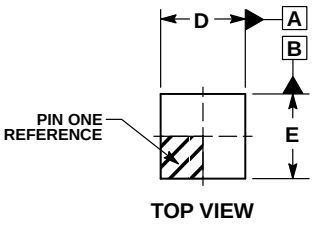
MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

ON Semiconductor®

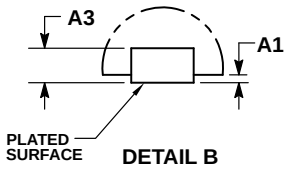
1
SCALE 4:1

X2DFN6 1.4x1.4, 0.5P
CASE 716AF
ISSUE A

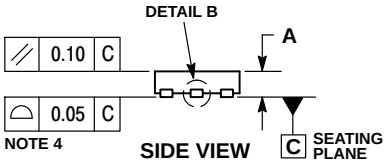
DATE 11 MAY 2018



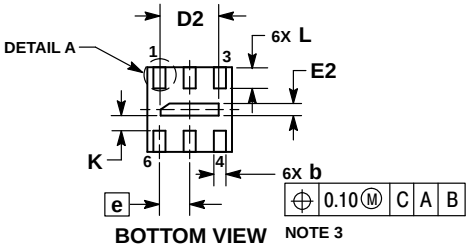
TOP VIEW



DETAIL B

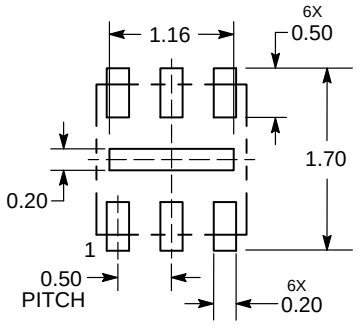


SIDE VIEW



BOTTOM VIEW NOTE 3

RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.10 AND 0.20 mm FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

	MILLIMETERS		
DIM	MIN	NOM	MAX
A	0.30	0.35	0.40
A1	−−−	−−−	0.05
A3		0.127 REF	
b	0.15	0.20	0.25
D	1.30	1.40	1.50
D2	0.86	0.96	1.06
E	1.30	1.40	1.50
E2	0.10	0.20	0.30
e		0.50 BSC	
K		0.25 REF	
L	0.30	0.35	0.40

GENERIC MARKING DIAGRAM*

XX = Specific Device Code
M = Month Code
▪ = Pb−Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “ ▪”, may or may not be present. Some products may not follow the Generic Marking.

DOCUMENT NUMBER:	**98AON79890G**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.	
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