

# LC05711ARA

## Battery Protection IC, Integrated Power MOSFET, 1-Cell Lithium-Ion Battery

### Overview

The LC05711ARA is a protection IC for 1-cell lithium-ion secondary batteries with integrated power MOS FET. Also it integrates highly accurate detection circuits and detection delay circuits to prevent batteries from over-charging, over-discharging, over-current discharging and over-current charging. A battery protection system can be made by only LC05711ARA and few external parts.

### Features

- Charge-and-discharge power MOSFET are integrated at  $T_a = 25^{\circ}\text{C}$ ,  $V_{CC} = 4.0\text{V}$   
ON resistance (total of charge and discharge )  $4.8\text{m}\Omega$  (typ)
- Highly accurate detection voltage/current at  $T_a = 25^{\circ}\text{C}$ ,  $V_{CC} = 3.7\text{V}$ 

Over-charge detection	$\pm 25\text{mV}$
Over-discharge detection	$\pm 50\text{mV}$
Charge over-current detection	$\pm 0.7\text{A}$
Discharge over-current detection	$\pm 0.7\text{A}$
- Delay time for detection and release (fixed internally)
- Discharge/Charge over-current detection is compensated for temperature dependency of power FET
- 0V battery charging : "Permission"
- Auto wake-up function battery charging : "Permission"

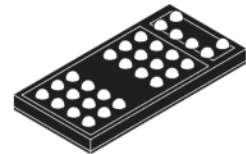
### Typical Applications

- Smart phone
- Tablet
- Wearable device



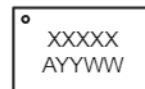
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ECP30 (1.97×4.01, 0.4Pitch)

### GENERIC MARKING DIAGRAM



A = Assembly Location  
YY = Year  
WW = Work Week

## Specifications

**Absolute Maximum Ratings** at Ta = 25°C (Notes 1, 2, 3, 4, 6)

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	VCC	Between PAC+ and VCC : R1=680Ω	-0.3 to 12.0	V
S1 - S2 voltage	VS1-S2		20.0	V
CS terminal Input voltage	CS		VCC-20.0 to VCC+0.3	V
TST terminal input voltage	TST		-0.3 to 7	V
Storage temperature	Tstg		-55 to +125	°C
Operating ambient temperature	Topr		-40 to +100	°C
Allowable power dissipation	Pd	(Note 5)	800	mW
Junction temperature	Tj		125	°C

1. Stresses exceeding those listed in the Maximum Rating 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.

2. Absolute maximum ratings represent the values which cannot be exceeded at any given time

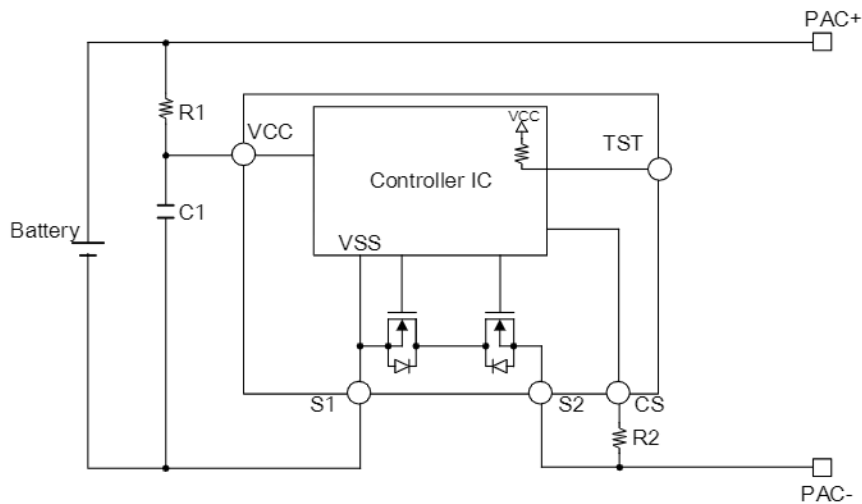
3. If you intend to use this IC continuously under high temperature, high current, high voltage, or drastic temperature change, even if it is used within the range of absolute maximum ratings or operating conditions, there is a possibility of decrease reliability. Please contact us for confirmation

4. This device is made for power applications.

5. JESD 51-3 (1S)

6. Please execute appropriate test and take safety measures on your board.

## Example of Application Circuit



Components	Recommended value	MAX	unit	Description
R1	680	1k	Ω	
R2	1k	2k	Ω	
C1	1.0μ	-	F	

\* We don't guarantee the characteristics of the circuit shown above.

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## Electrical Characteristics (Note 4, 6, 7, 8)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Detection voltage						
Over-charge detection voltage	Vov	R1=680Ω	Ta=25°C Ta=-30 to 70°C	Vov_set -25 Vov_set -30	Vov_set Vov_set +30	mV
Over-charge release voltage	Vovr	R1=680Ω	Ta=25°C Ta=-30 to 70°C	Vovr_set -40 Vovr_set -70	Vovr_set Vovr_set +70	mV
Over-discharge detection voltage	Vuv	R1=680Ω	Ta=25°C Ta=-30 to 70°C	Vuv_set -50 Vuv_set -80	Vuv_set Vuv_set +80	mV
Over-discharge release voltage	Vuvr	R1=680Ω CS=0V	Ta=25°C Ta=-30 to 70°C	Vuvr_set -100 Vuvr_set -120	Vuvr_set Vuvr_set +120	mV
Over-discharge release voltage2	Vuvr2	R1=680Ω CS=Open	Ta=25°C Ta=-30 to 70°C	Vuvr2_set -100 Vuvr2_set -120	Vuvr2_set Vuvr2_set +120	mV
Discharge over-current detection current	loc	R2=1kΩ	Ta=25°C VCC=3.7V Ta=-30 to 70°C	loc_set -0.7 loc_set -1.2	loc_set loc_set +0.7	A
Discharge over-current detection currnt2 (Short circuit)	loc2	R2=1kΩ	Ta=25°C VCC=3.7V Ta=-30 to 70°C	loc2_set*0.8 loc2_set*0.6	loc2_set loc2_set +1.2	A
Charge over-current detection current	loch	R2=1kΩ	Ta=25°C VCC=3.7V Ta=-30 to 70°C	loch_set -0.7 loch_set -1.2	loch_set loch_set +0.7	A
Input voltage						
Operating Voltage for 0V charging	Vchg	VCC-CS VCC-S1=0V	Ta=25°C		1.4	V
Current consumption						
Operating current	Icc	At normal state	Ta=25°C VCC=3.7V		3	μA
Standby current	Istb	At standby state	Ta=25°C VCC=2.0V		0.95	μA
Resistance						
ON resistance 1 of integrated power MOS FET	Ron1	VCC=3.1V I=±2.0A	Ta=25°C	4.4	5.4	mΩ
ON resistance 2 of integrated power MOS FET	Ron2	VCC=3.8V I=±2.0A	Ta=25°C	4	4.9	mΩ
ON resistance 3 of integrated power MOS FET	Ron3	VCC=4.0V I=±2.0A	Ta=25°C	3.9	4.8	mΩ
ON resistance 4 of integrated power MOS FET	Ron4	VCC=4.5V I=±2.0A	Ta=25°C	3.8	4.7	mΩ
Internal resistance (VCC-CS)	Rcsu	VCC=Vuv_set CS=0V	Ta=25°C		300	kΩ
Internal resistance (VSS-CS)	Rcsd	VCC=3.7V CS=0.1V	Ta=25°C		10	kΩ
Forward Source to Source Voltage	Vf(s-s)	VCC=2.0V Is=0.25A	Ta=25°C		0.67	V

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Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit	
Detection and Release delay time							
Over-charge detection delay time	Tov		Ta=25°C	0.8	1	1.2	s
			Ta=-30 to 70°C	0.6	1	1.5	
Over-charge release delay time	Tovr		Ta=25°C	12.8	16	19.2	ms
			Ta=-30 to 70°C	9.6	16	24	
Over-discharge detection delay time	Tuv		Ta=25°C	14	20	26	ms
			Ta=-30 to 70°C	12	20	30	
Over-discharge release delay time	Tuvr		Ta=25°C	0.9	1.1	1.3	ms
			Ta=-30 to 70°C	0.6	1.1	1.5	
Discharge over-current detection delay time 1	Toc1	VCC=3.7V	Ta=25°C	9.6	12	14.4	ms
			Ta=-30 to 70°C	7.2	12	18	
Discharge over-current release delay time 1	Tocr1	VCC=3.7V	Ta=25°C	3.2	4	4.8	ms
			Ta=-30 to 70°C	2.4	4	6	
Discharge over-current detection delay time 2 (Short circuit)	Toc2	VCC=3.7V	Ta=25°C	230	300	420	µs
			Ta=-30 to 70°C	200	300	450	
Charge Over-current detection delay time	Toch	VCC=3.7V	Ta=25°C	12.8	16	19.2	ms
			Ta=-30 to 90°C	9.6	16	24	
Charge Over-current release delay time	Tochr	VCC=3.7V	Ta=25°C	3.2	4	4.8	ms
			Ta=-30 to 90°C	2.4	4	6	

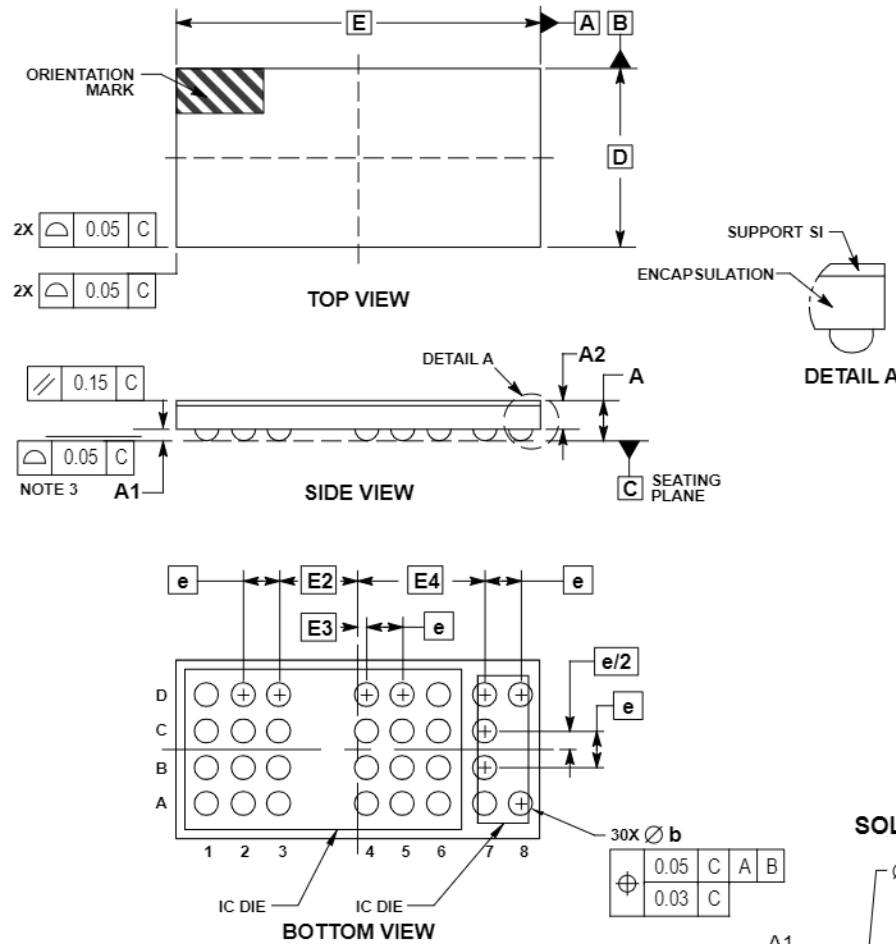
7. Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

8. The specification in this parameter and all specification at high and low temperature are guaranteed by design.

## Package Dimensions

unit : mm

ECP30, 1.97x4.01  
CASE 971BC  
ISSUE A

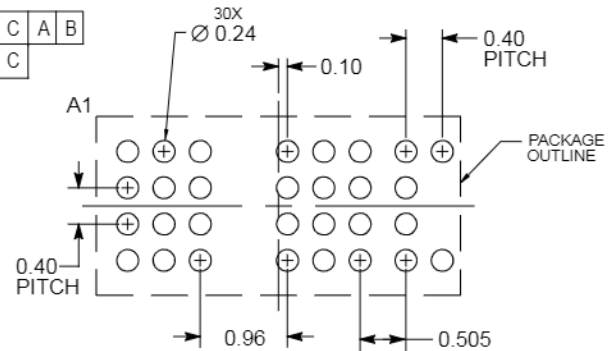


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO THE SPHERICAL CROWNS OF THE SOLDER BALLS.
4. DIMENSION b IS MEASURED AT THE MAXIMUM BALL DIAMETER PARALLEL TO DATUM C.

MILLIMETERS		
DIM	MIN	MAX
A	0.545	0.625
A1	0.165	0.205
A2	0.380	0.420
b	0.245	0.285
D	1.970 BSC	
E	4.010 BSC	
E2	0.860 BSC	
E3	0.100 BSC	
E4	1.405 BSC	
e	0.400 BSC	

### RECOMMENDED SOLDERING FOOTPRINT\*

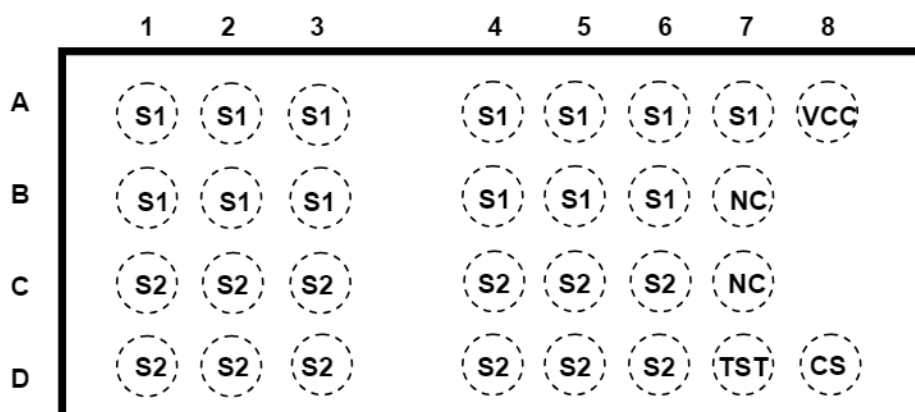


DIMENSIONS: MILLIMETERS

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

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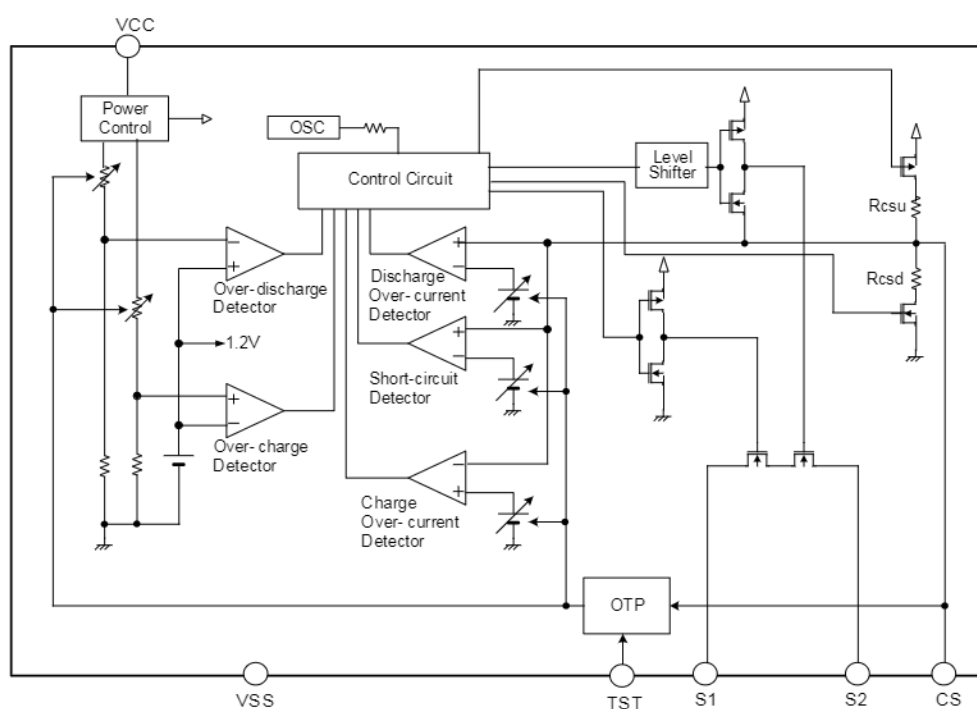
## Pin Functions



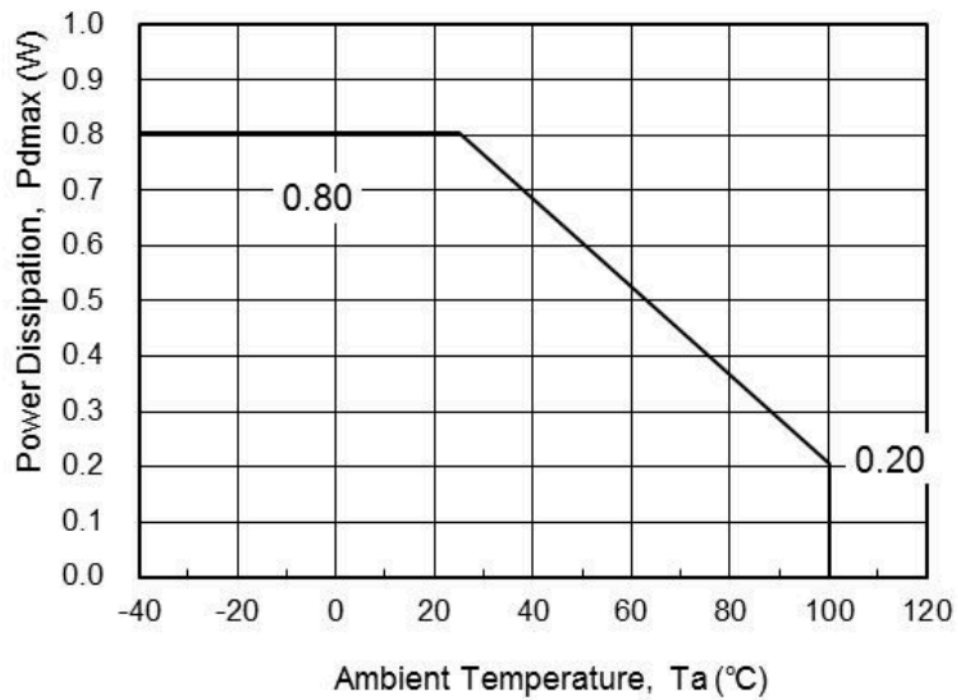
TOP VIEW

Pin No.	Symbol	Pin Function	Description
A1-7 B1-6	S1	Source 1	Negative power input
A8	VCC	VCC terminal	
C1-6 D1-6	S2	Source 2	
D7	TST	Test terminal	Connected to VCC with 100kΩ
D8	CS	Charger minus voltage input terminal	
B7,C7	NC	Non connection	

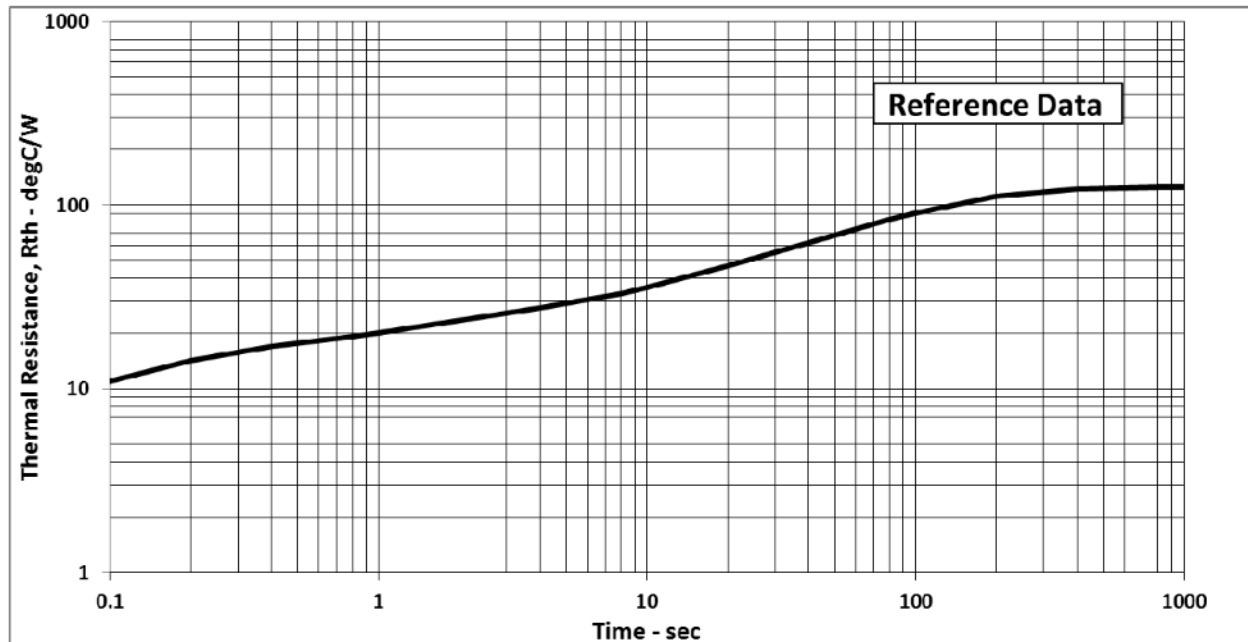
## Block Diagram



Pdmax vs Ta



Thermal Resistance vs Time



## Description of operation

### (1) Normal mode

- LC05711ARA controls charging and discharging by detecting cell voltage (VCC) and controls S2-S1 current. In case that cell voltage is between over-discharge detection voltage (Vuv) and over-charge detection voltage (Vov), and S2-S1 current is between charge over-current detection current (Ioch) and discharge over-current detection current (Ioc), internal power MOS FETs as CHG\_SW, DCHG\_SW are both turned ON. This is the normal mode, and it is possible to be charged and discharged.

### (2) Over-charging mode

- Internal poer MOS FET CHG\_SW turns off if cell voltage becomes greater than or equal to over-charge detection voltage (Vov) over the delay time of over-charging (Tov). This is the over-charging detection mode.
- The recovery from over-charging will be made after the following two conditions are satisfied.
  1. Charger is removed from IC.
  2. Cell voltage decreases under over-charge release voltage (Vovr) over the delay time of over-charging releasing (Tovr) due to discharging through a load.

Consequently, internal power MOS FET as CHG\_SW will be turned on and normal mode will be resumed.

- In over-charging mode, discharging over-current detection is made only when CS pin increases more than discharging over-current detection current 2 (Ioc2), because discharge current flows through parasitic diode of CHG\_SW FET. If CS pin voltage increases more than discharging over-current detection current 2 (Ioc2) over the delay time of discharging over-current 2 (Toc2), discharging will be shut off, because internal power FETs as DCHG\_SW is turned off. (short-circuit detection mode)  
After detecting short-circuit, CS pin will be pulled down to Vss by internal resistor Rcsd.

The recovery from short circuit detection in over-charging mode will be made after the following two conditions are satisfied.

1. Load is removed from IC.
2. CS pin voltage becomes less than or equal to discharging over-current detection current 2 (Ioc2) due to CS pin pulled down through Rcsd.

Consequently, internal power MOS FET as DCHG\_SW will be turned on, and over-charging

detection mode will be resumed.

### (3) Over-discharging mode with Auto Wake Up function

- If cell voltage drops lower than over-discharge detection voltage (Vuv) over the delay time of over-discharging (Tuv), discharging will be shut off, internal power FETs as DCHG\_SW is turned off.

This is the over-discharging mode.

After detecting over-discharging, CS pin will be pulled up to Vcc by an internal resistor Rcsu and the bias of internal circuits will be shut off. (Shut-down mode)

In shut-down mode, operating current is suppressed under 0.1uA (max).

- The recovery from stand-by mode will be made by internal circuits biased after the following two conditions are satisfied.
  1. Charger is connected.
  2. VCC level rise more than Over-discharge release voltage2 (Vuvr2) without charger.(Auto wake-up function)

- By continuing to be charged, if cell voltage increases more than over-discharge detection voltage (Vuvr) over the delay time of over-discharging (Tuvr), internal power MOS FETs as DCHG\_SW is turned on and normal mode will be resumed.

- In over-discharge detection mode, charging over-current detection does not operate.  
By continuing to be charged, charging over-current detection starts to operate after cell voltage goes up more than over-discharge release voltage (Vuvr).

### (4) Discharging over-current detection mode 1

- Internal power MOS FET as DCHG\_SW will be turned off and discharging current will be shut off if CS pin voltage becomes greater than or equal to discharging over-current detection current (Ioc) over the delay time of discharging over-current (Toc1).

This is the discharging over-current detection mode 1.

In discharging over-current detection mode 1, CS pin will be pulled down to Vss with internal resistor Rcsd.

- The recovery from discharging over-current detection mode will be made after the following two conditions are satisfied.
  1. Load is removed from IC.
  2. CS pin voltage becomes less than or equal to discharging over-current release current (Iocr) over the delay time of discharging over-current release (Tocr1) due to CS pin pulled down



through Rcsd.

Consequently, internal power MOS FET as DCHG\_SW will be turned on, and normal mode will be resumed.

#### (5) Discharging over-current detection mode 2 (short circuit detection)

- Internal power MOS FET as DCHG\_SW will be turned off and discharging current will be shut off if CS pin voltage becomes greater than or equal to discharging over-current detection current2 (Ioc2) over the delay time of discharging over-current 2 (Toc2).

This is the short circuit detection mode.

- In short circuit detection mode, CS pin will be pulled down to Vss by internal resistor Rcsd. The recovery from short circuit detection mode will be made after the following two conditions are satisfied.
  - a. Load is removed from IC.
  - b. CS pin voltage becomes less than or equal to discharging over-current release current (Iocr) over the delay time of discharging over-current release (Tocr1) due to CS pin pulled down through Rcsd.

Consequently, internal power MOS FET as DCHG\_SW will be turned on, and normal mode will be resumed.

#### (6) Charging over-current detection mode

- Internal power MOS FET as CHG\_SW will be turned off and charging current will be shut off if CS pin voltage becomes less than or equal to charging over-current detection current (Ioch) over the delay time of charging over-current (Toch).

This is the charging over-current detection mode.

- The recoveries from charging over-current detection mode will be made after the following two conditions are satisfied.
  1. Charger is removed from IC and CS pin will increase by load connection.
  2. CS pin voltage becomes greater than or equal to charging over-current release current (Iochr) over the delay time of charging over-current release (Tochr).

Consequently, internal power MOS FET as CHG\_SW will be turned on, and normal mode will be resumed.

\*Internal current flows out through CS and S2 terminals.

After charger is removed, it flows through

parasitic diode of CHG\_SW FET.

Therefore, CS pin voltage will go up more than charging over-current release current (Iochr).

So CS pin voltage is not an indispensable condition for recovery from charging over-current detection.

#### (7) Available Voltage for 0V charging

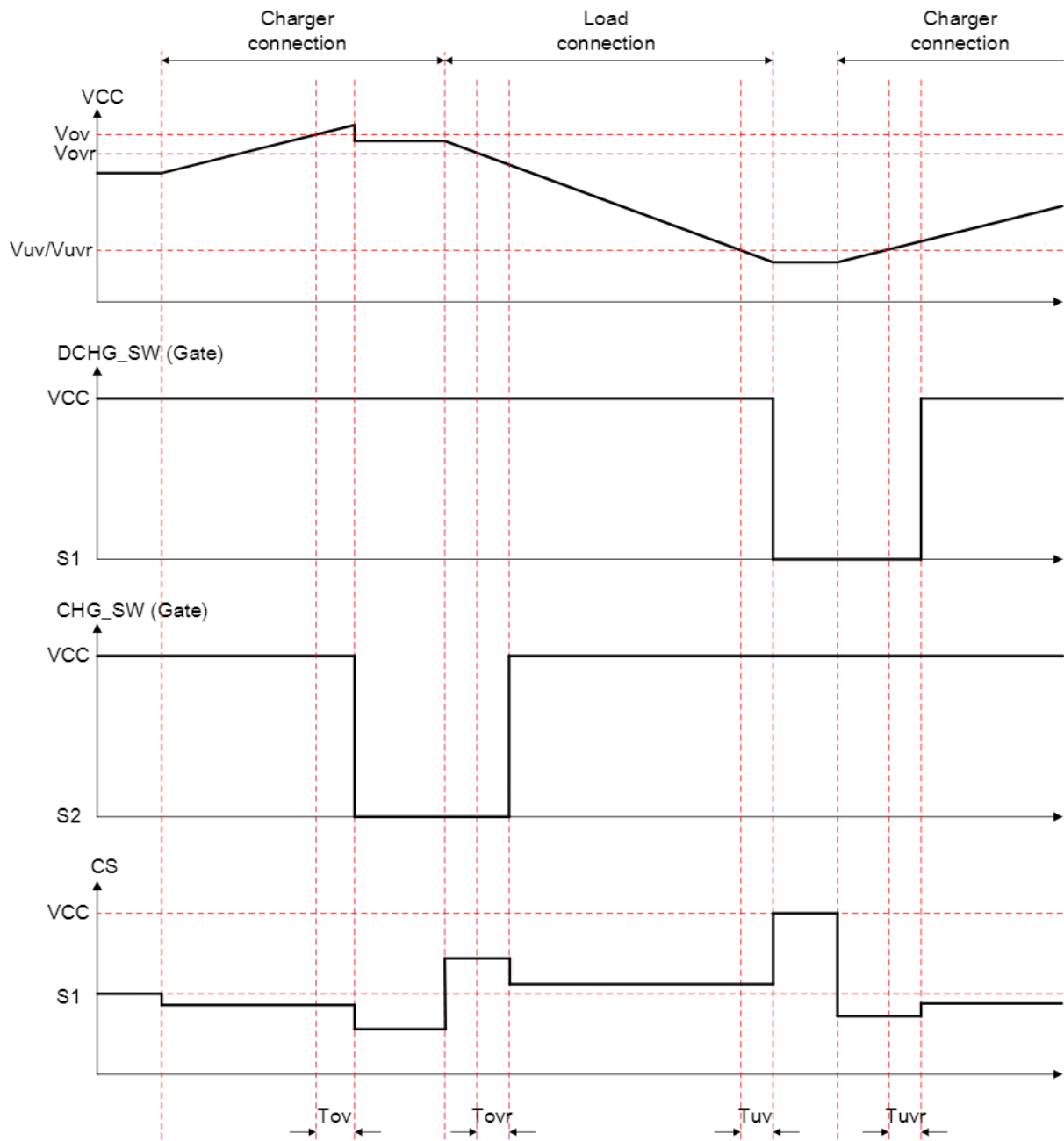
It is the function that the voltage of a connected battery can charge from the state that became 0V by self-discharge. The 0V battery charge start battery charger voltage (Vchg), it fix a gate of the charge system order FET to the VDD terminal voltage when it connect a battery charger of the above-mentioned voltage to PAC+ terminal between PAC- terminals.

Gate-source voltage of the charge control FET becomes equal to the turn-on voltage or more due to the charger voltage, the charging control FET To start charging row is turned on.

Discharge control FET is off at this time, the charge current flows through the internal parasitic diode in the discharging control FET. It is the normal state battery voltage becomes the overdischarge release voltage (Vuvr) or more.

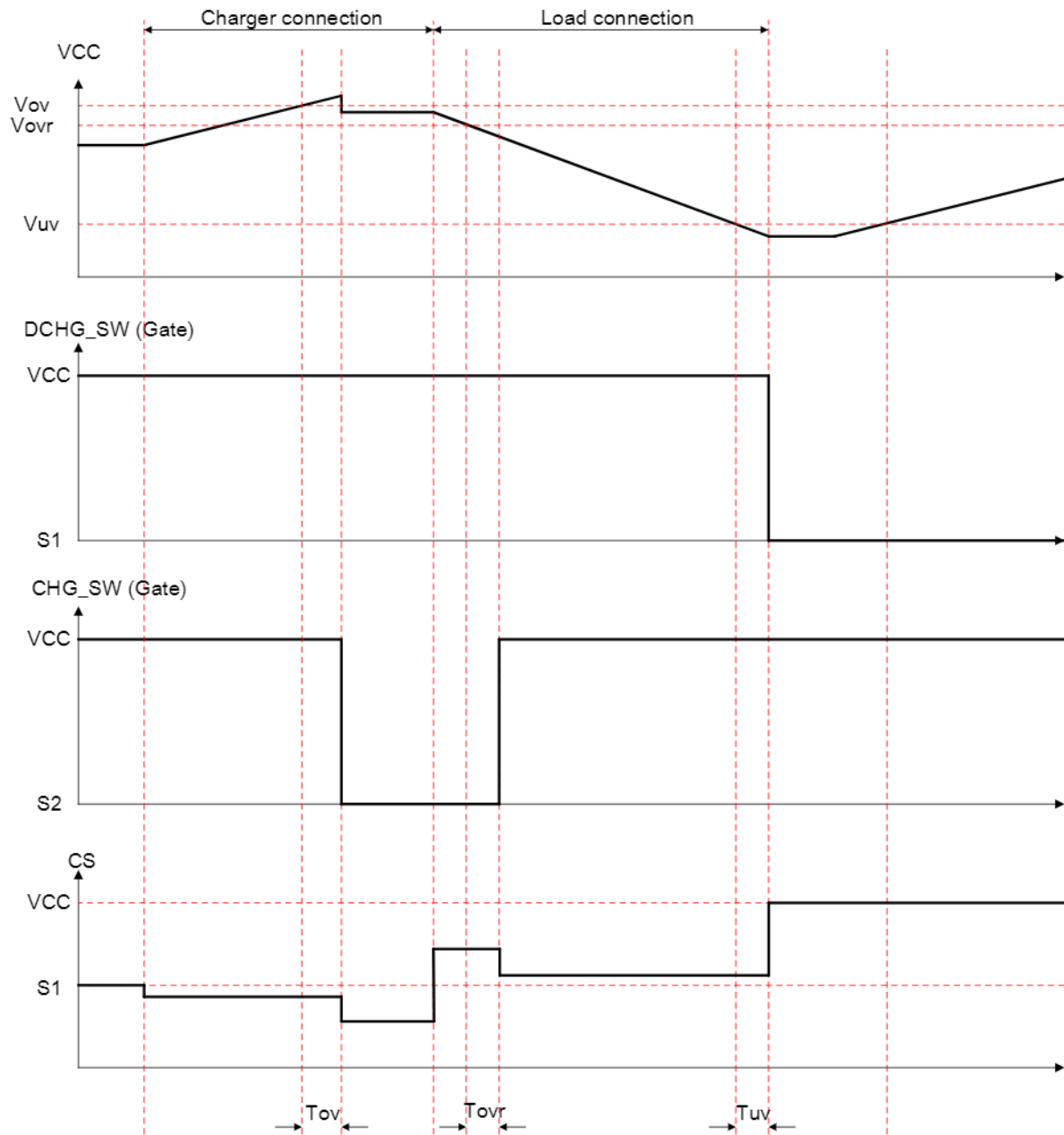
## Timing Chart

Over-charge detection/release, Over-discharge detection/release (Connect charger)



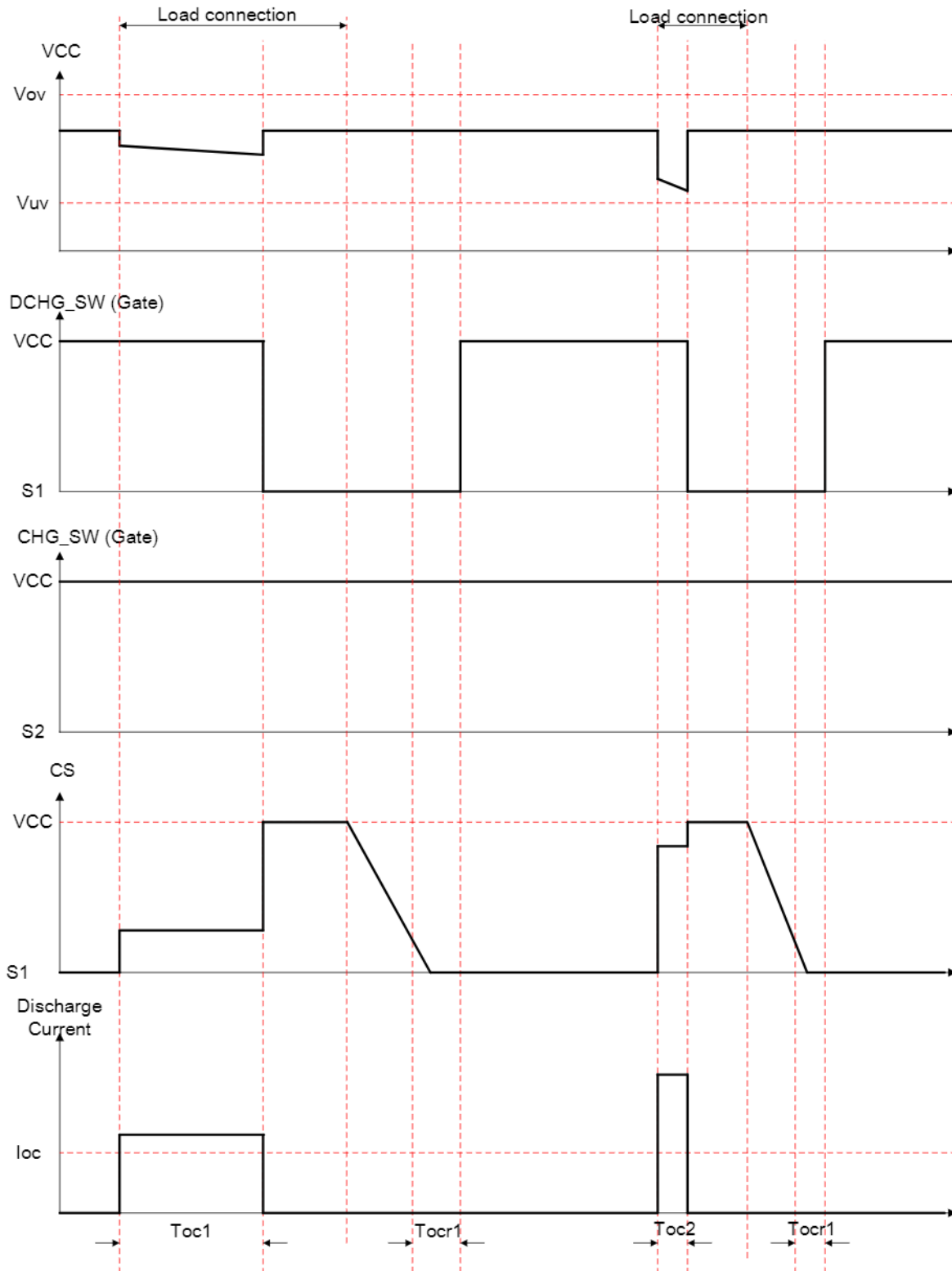
# LC05711ARA

Over-charge detection/release, Over-discharge detection/release (Non-connect charger)

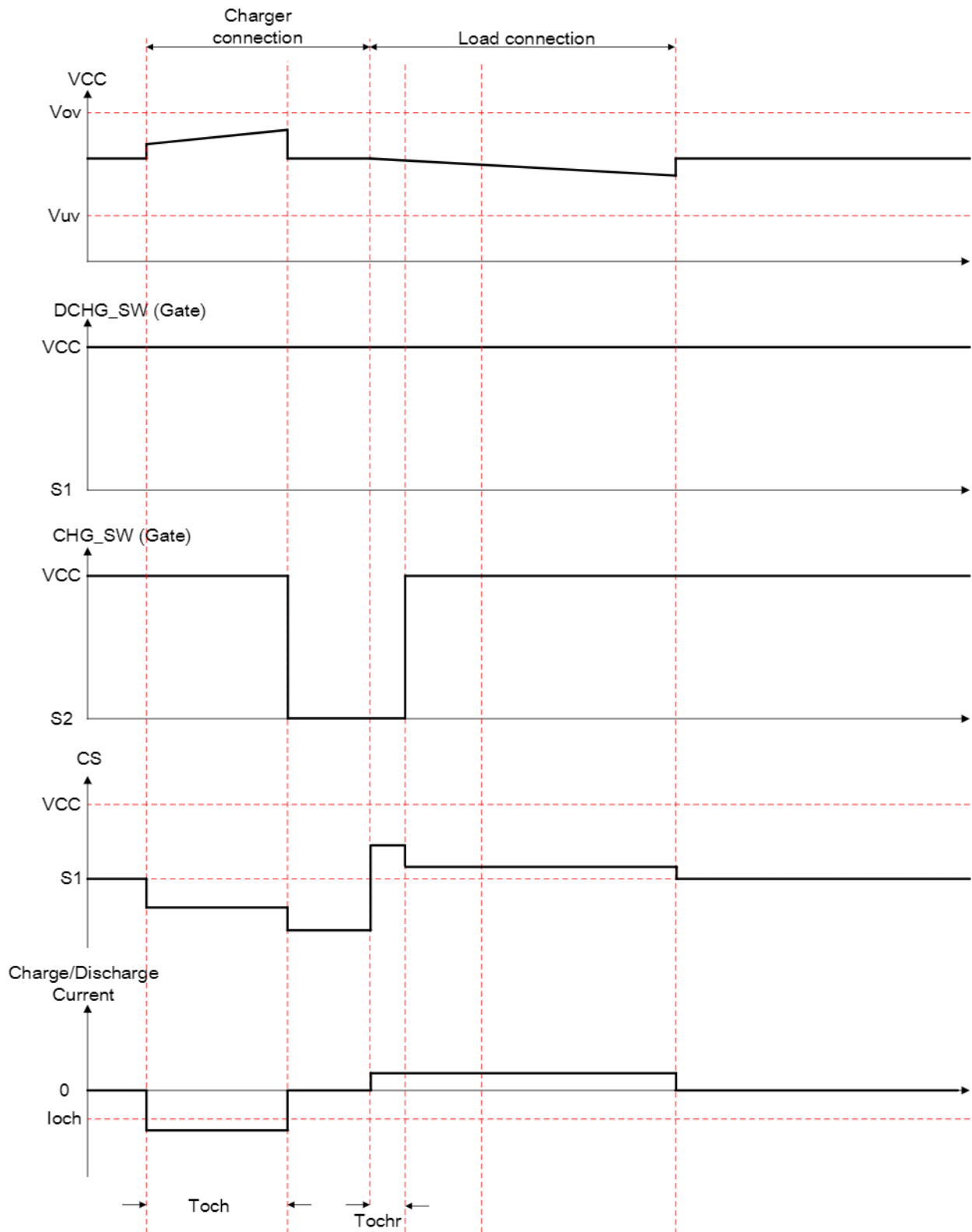


# LC05711ARA

Discharge over-current detection1, Discharge over-current detection2  
(Short circuit)



Charge over-current detection



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