

**AP2200B****Step-Up DC-DC Converter IC Supporting Dye-sensitized Solar Cell****1. General Description**

The AP2200B is a voltage step-up DC-DC converter that uses a synchronous rectification method to be activated with a dye-sensitized solar cell. It is ideal for charging lithium-ion capacitors and outputting 3V.

2. Features

- Input voltage range 0.3V to 1.6V
- MPP input setting voltage 0.4V
- Operating temperature range -30 to 85 °C
- Input power Up to 400mW
- Output voltage 3.0V($\pm 2.0\%$) (SEL pin = "L")
3.8V($\pm 5.0\%$) (SEL pin = "H")
- Control method Comparator control method
- Rectification method Synchronous rectification method
- Standby function When the STBY pin is "H", the LC pin is fixed to "H"
- No battery detect function When the VB pin voltage decreases, the LC pin is fixed to "H".
- Efficiency 70% (3.8V, 50mA output)
- Package 16-pin QFN
- Application For outputting and charging 3V with a dye-sensitized solar cell, charging a lithium-ion capacitor

3. Table of Contents

1. General Description	1
2. Features	1
3. Table of Contents	2
4. Block Diagram	3
■ Block Diagram	3
5. Ordering Information	3
6. Pin Configurations and Functions	4
■ Pin Configurations	4
■ Pin Functions	4
7. Absolute Maximum Ratings	5
8. Recommended Operating Conditions	5
9. Electrical Characteristics	6
10. Functional Descriptions	7
■ Operation Overview	7
■ Target Voltage Setting	8
■ Constant input voltage control and Output voltage control	8
■ Timing Chart	9
11. Recommended External Circuits	13
■ When Setting the Output Voltage to 3.0V or 3.8V	13
■ Recommended Parts	13
12. Package	14
■ Outline Dimensions	14
■ Marking	14
13. Revise History	15
IMPORTANT NOTICE	16

4. Block Diagram

■ Block Diagram

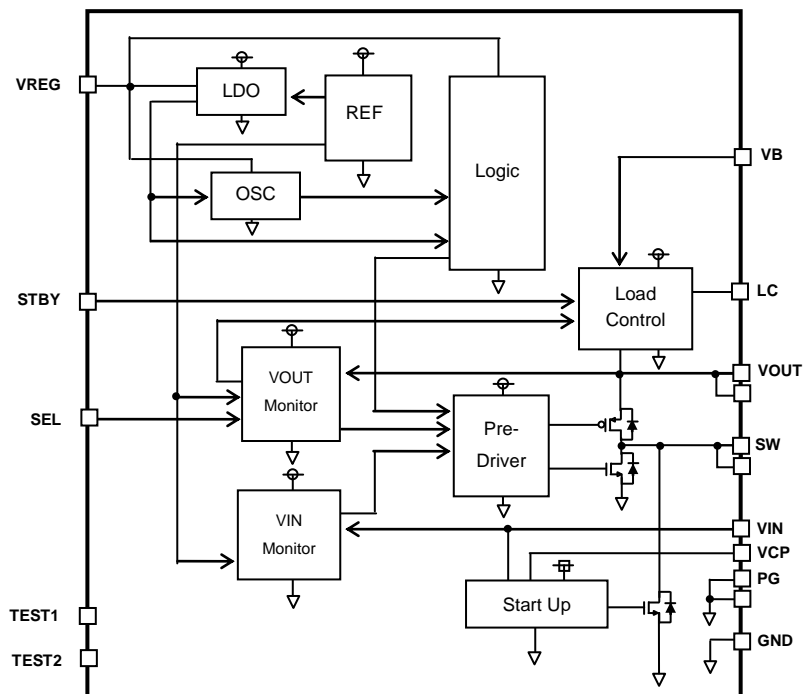


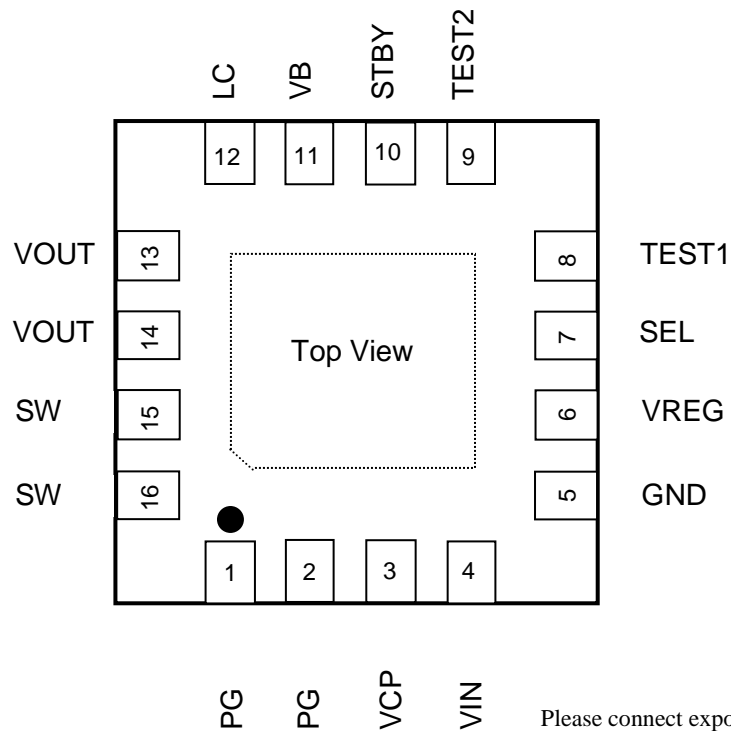
Figure 1. AP2200B Block Diagram

5. Ordering Information

AP2200B $T_a = -30 \sim +85\text{ }^{\circ}\text{C}$ 16-pin QFN

6. Pin Configurations and Functions

■ Pin Configurations



Please connect exposed pad to GND or leave OPEN.

■ Pin Functions

Pin No	Pin name	Type (Note 1)	I/O (Note 2)	Function	Description
1	PG	GND	-	DC-DC ground pin	
2	PG	GND	-	DC-DC ground pin	
3	VCP	A	IO	Charge pump pin	
4	VIN	PWR	-	Power input pin	
5	GND	GND	-	Ground pin	
6	VREG	A	IO	Internal regulator output pin	
7	SEL	D	I	Output voltage switch input pin	“L” = 3V, “H” = 3.8V
8	TEST1	-	-	Test pin	(Note 3)
9	TEST2	-	-	Test pin	(Note 3)
10	STBY	D	I	Standby input pin	“H” : standby
11	VB	A	I	Battery monitoring input pin	
12	LC	D	O	External switch control pin	
13	VOUT	A	IO	DC-DC output pin	
14	VOUT	A	IO	DC-DC output pin	
15	SW	A	IO	Inductor connect pin	
16	SW	A	IO	Inductor connect pin	
EP	GND	GND	-	Tab pin	

Note 1. A: analog pin, D: digital pin, GND: ground pin, PWR: power pin.

Note 2. I: input pin, O: output pin, IO: input and output pin.

Note 3. Test pins should be connected to GND.

7. Absolute Maximum Ratings

Parameter	Symbol	min	max	Unit	Conditions
Pin voltage Range (Note 4)	V _{VIN1}	-0.3	1.98	V	(Note 5)
	V _{VIN2}	-0.3	5.5	V	(Note 6)
Input power	P _{IN}	-	0.8	W	
Storage temperature Range	T _{stg}	-40	150	°C	
Junction temperature	T _j	-30	150	°C	
Power dissipation	P _d	-	0.8	W	

Note 4. All voltages with respect to ground.

Note 5. VIN pin and VREG pin

Note 6. VCP pin, SEL pin, STBY pin, VB pin, LC pin, VOUT pin and SW pin

WARNING: Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

8. Recommended Operating Conditions

Parameter	Symbol	min	typ	max	Unit	Conditions
Supply voltage range	V _{VIN}	0.3		1.6	V	(Note 7)
Operational temperature	T _a	-30		85	°C	

Note 7. All voltages with respect to ground.

9. Electrical Characteristics

(Ta = 25 °C, except as otherwise noted)

Parameter	Symbol	min	typ	max	Unit	Condition
Startup circuit						
Supply voltage on startup	V _{VINSTUP}		-	0.5	V	-30°C < Ta < -10°C
			0.3	0.4	V	-10°C < Ta < 85°C
DC-DC converter						
V _{VOUT} voltage	V _{TGT}	2.84	2.92	3.0	V	Ta = -30 ~ 85°C, SEL = “L”
		3.64	3.72	3.8	V	Ta = -30 ~ 85°C, SEL = “H”
V _{VOUT} hysteresis	V _{TGTHYS}	0.16	0.38	0.60	%	
High-side on resistance	R _{ONTOP}	-	0.2	-	Ω	
Low-side on resistance	R _{ONBOT}	-	0.1	-	Ω	
Switching frequency	f _{OSC}	450	500	550	kHz	
Low-side current limit	I _{LIM}	0.90	1.2	1.50	A	
MPP circuit						
Input voltage setting target	V _{VINMPP}	0.36	0.40	0.44	V	
Monitoring circuit						
No battery detect voltage	V _{BLOW}	1.0	-	2.5	V	
Low V _{VOUT} detect voltage	V _{OL}	2.35	2.65	2.90	V	
Logic I/O						
External switch driving voltage	V _{OLLC}	-	-	GND+0.1	V	I _{LC} = -1 μA
	V _{OHLC}	V _{VOUT} -0.45	-	-	V	V _{VOUT} > V _B (@I _{LC} = 1 μA)
		V _B -0.45	-	-	V	V _{VOUT} < V _B (@I _{LC} = 1 μA)
Standby input voltage	V _{ILSTB}	-	-	0.3	V	
	V _{IHSTB}	1.0	-	-	V	
Output voltage switching input voltage (Note 9)	V _{ILSEL}	-	-	V _{VOUT} *0.3	V	
	V _{IHSEL}	V _{VOUT} *0.7	-	-	V	
Control part						
Internal regulator voltage	V _{REG}	1.62	1.8	1.98	V	
Operating frequency	f _{CK}	0.9	1.0	1.1	MHz	
Pin current						
VIN pin current	I _{VIN}	-	-	50	μA	During DC-DC operation after Start-up
VB pin current	I _{VB}		10	20	μA	
Internal pull-down resistance						
STBY pin	R _{PDSTBY}	0.5	-	1.5	MΩ	
SEL pin	R _{PDSEL}	0.5	-	1.5	MΩ	

Note 8. All voltages with respect to ground.

Note 9. Connect the SEL pin to the VOUT or the GND pin.

10. Functional Descriptions

■ Operation Overview

When the output voltage is input to the VIN pin from the solar cell(s), the low voltage startup circuit starts to step up the output voltage (V_{VOUT}). When V_{VOUT} reaches the voltage required operating the step-up converter, the low voltage startup circuit stops operation and the step-up converter starts operation.

The input voltage is regulated to reach V_{VINMPP} .

After that, the step-up converter increases V_{VOUT} to the target voltage (V_{TGT}) and controls V_{VOUT} so that it will be stabilized at V_{TGT} . The step-up converter also decreases the LC pin voltage to a low level when V_{VOUT} reaches V_{TGT} . For the application where an external PMOS load switch is connected to the LC pin of the AP2200B, the external switch is turned ON to start power supply by the LC pin = "L". However, if a one of conditions below is met, the external load switch will be turned OFF to stop power supply.

Table 1. Stop power supply

1	The STBY pin is set to a high level:	The AP2200B has a standby function. When the STBY pin is set to a high level (V_{IHSTB}), the external load switch is turned OFF to stop power supply. In this case, the step-up converter is still running even in a standby state. When the STBY pin is set to a low level (V_{ILSTB}), the standby mode is released and the power supply is resumed.
2	The VB pin voltage is less than or equal to V_{BLOW} :	The AP2200B has a battery monitoring function. When the VB pin voltage decrease to V_{BLOW} or lower, it is assumed that the battery is removed, and the external load switch is turned OFF to stop power supply. When the VB pin voltage increases to V_{BLOW} or higher, it is assumed that the battery is reinserted, and the external load switch is turned ON to start power supply. To disable this function, connect the VB pin to the VOUT pin.
3	The VOUT pin voltage is less than or equal to V_{OL} :	When the VOUT pin voltage decreases to V_{OL} and lower, the external load switch is turned OFF to stop power supply. In this case, the step-up converter is still running. When V_{VOUT} reaches V_{TGT} again, the power supply is resumed.
4	Every tPV Period (solar condition checking):	The AP2200B turns OFF the external load switch as well as stopping the voltage step-up operation by each tPV period. The voltage step-up operation is resumed after a certain period of time. However, unless V_{VOUT} reaches V_{TGT} again, the external load switch is not turned ON. This prevents back flow from the battery to V_{VOUT} to minimize the battery consumption when the power supply from the solar cell(s) decreases and the step-up converter cannot increase the voltage sufficiently.

■ Target Voltage Setting

The target voltage (V_{TGT}) is selectable by the SEL pin.

Table 2. Target voltage

SEL pin level	Target voltage (V_{TGT}) setting
“L”	3.0 V
“H”	3.8 V

■ Constant input voltage control and Output voltage control

The step-up converter always monitors V_{VOUT} and regulates the input voltage to be V_{VINMPP} . As soon as V_{VOUT} reaches the target voltage (V_{TGT}), the converter stops step-up operation. When the voltage step-up operation is stopped, V_{VOUT} decreases due to load consumption. When V_{VOUT} drops by V_{TGTHYS} or more from the V_{TGT} level, the step-up operation is restarted.

■ Timing Chart

Normal Operation (the voltage increases to V_{VOUT} after startup)

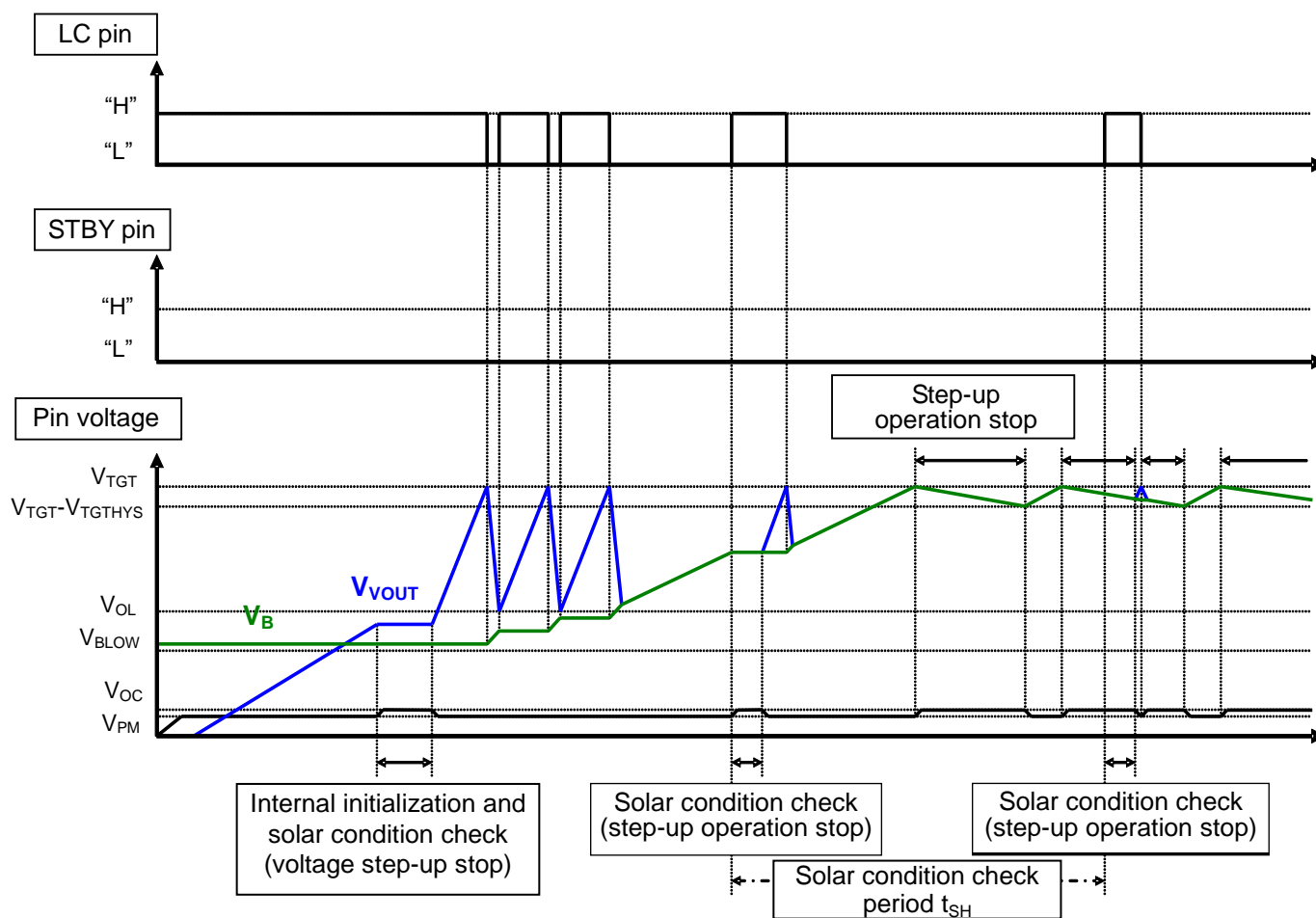


Figure 2. Normal Operation

Behavior of When Solar Cell Output Decreases

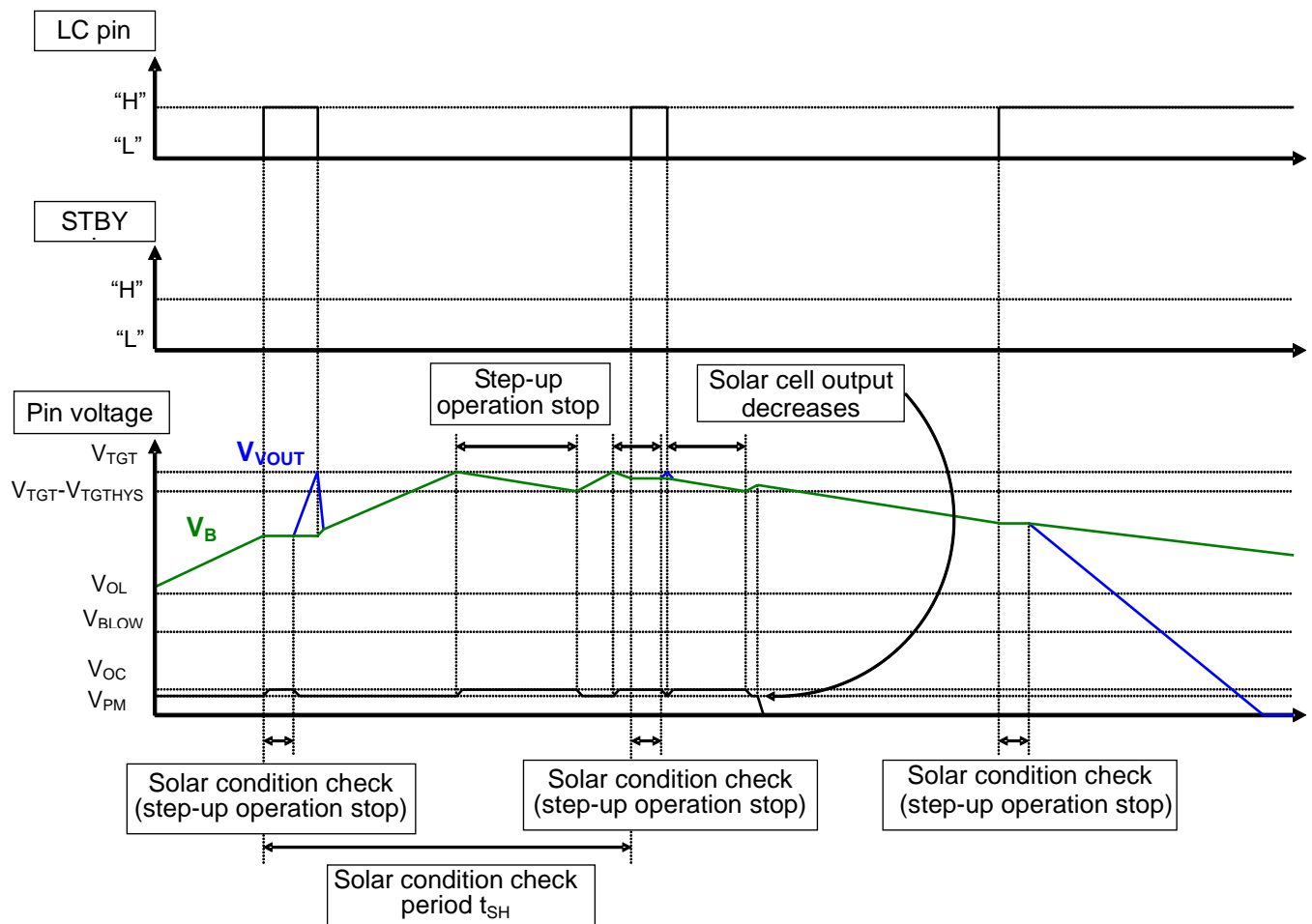


Figure 3. Behavior of When Solar Cell Output Decreases

Behavior of When the STBY Pin Is Asserted

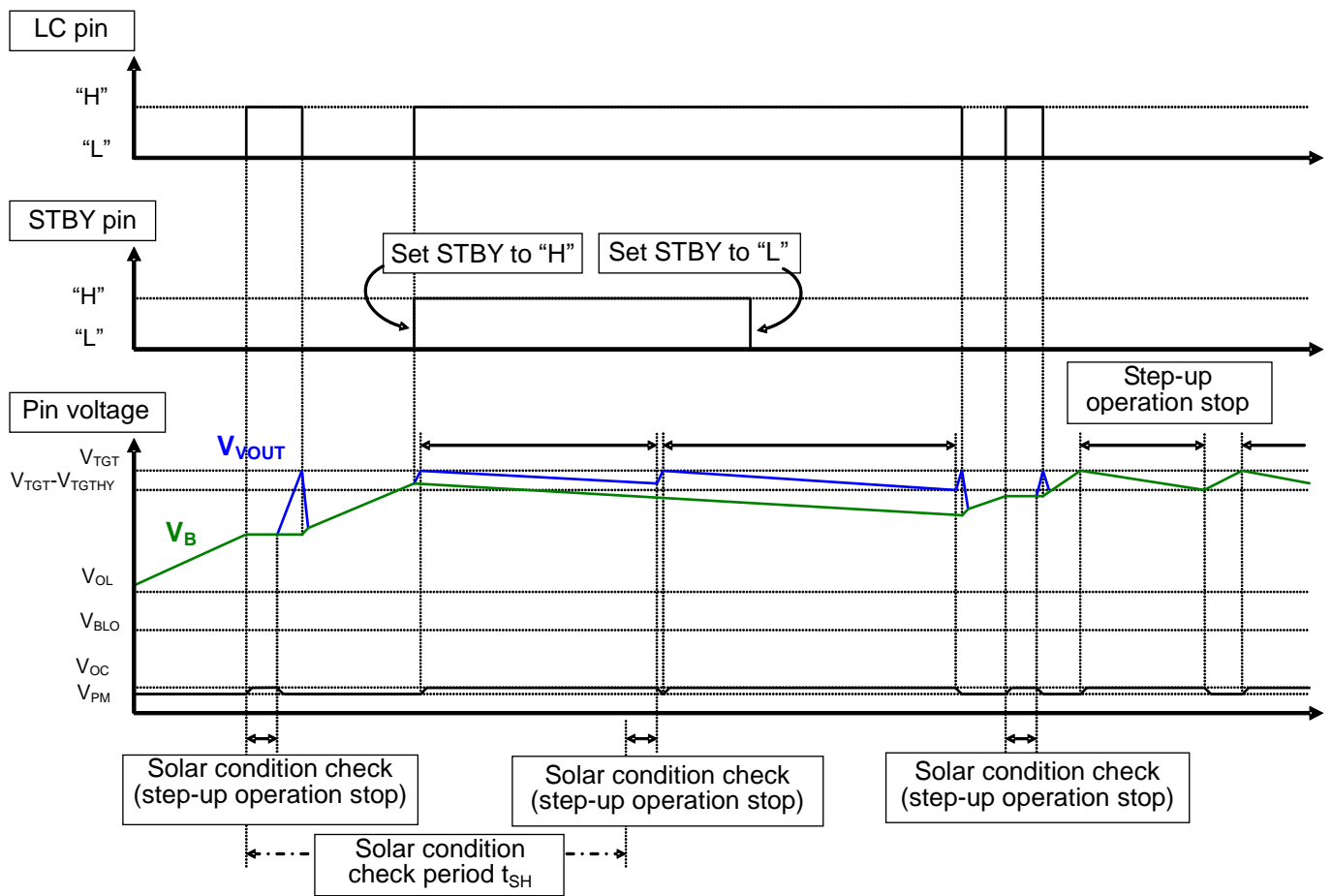


Figure 4. Behavior of When the STBY Pin Is Asserted

Behavior of When No Battery Is Connected

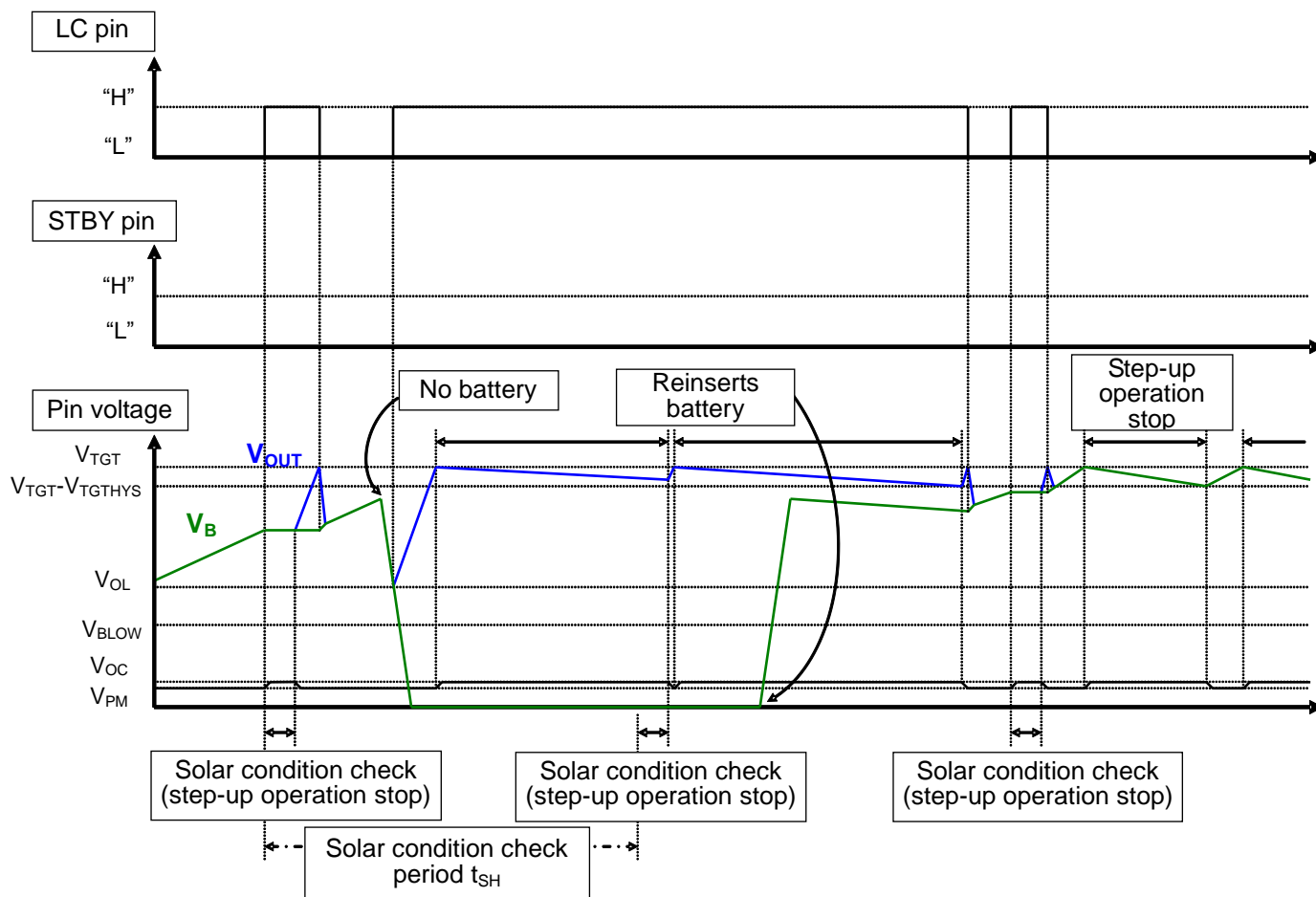


Figure 5. Behavior of When No Battery Is Connected

11. Recommended External Circuits

■ When Setting the Output Voltage to 3.0V or 3.8V

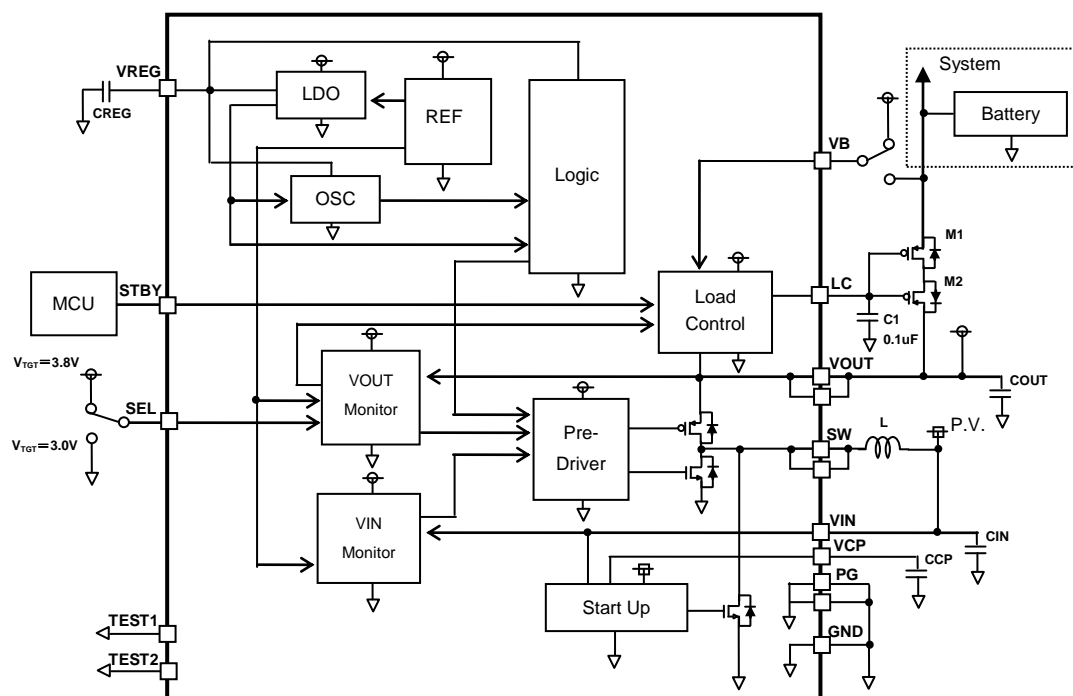


Figure 6. When Setting the Output Voltage to 3.0/3.8V

Note 10. ∇ : Power supply of the startup circuit. The supply source is P.V.

∇ : Power supply of the Internal circuits, VB pin and SEL pin for pull up.

Note 11. Select the C1 value to prevent the LC pin voltage from exceeding the absolute maximum rating due to the current through parasitic capacitance of the external load switch.

■ Recommended Parts

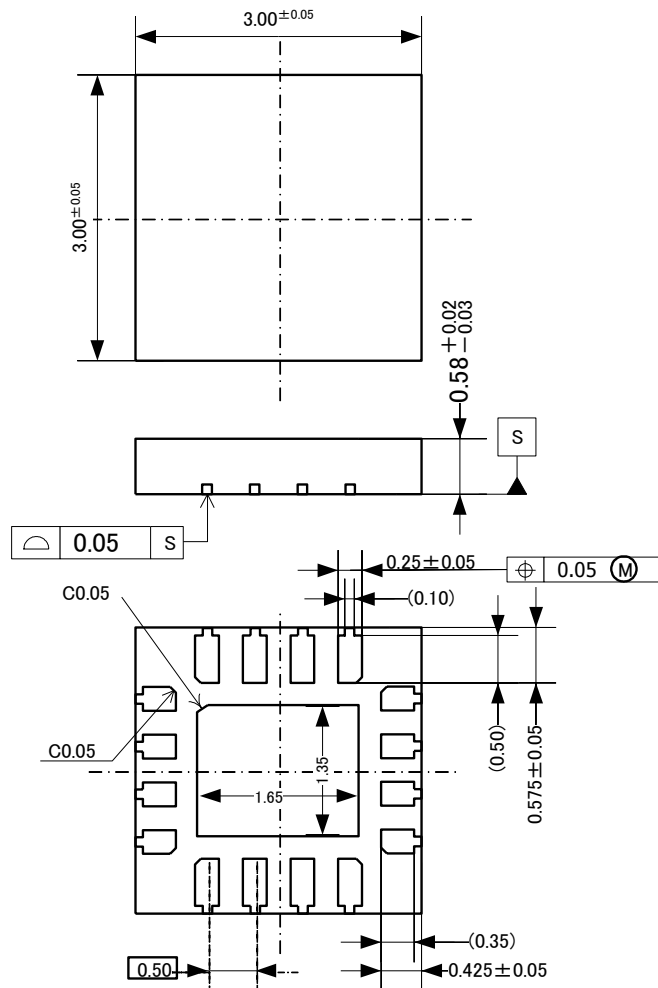
Table 3. Recommended Parts

Item	Symbol	Value	Type
Capacitors	CIN	10 μ F	Ceramic
	COUT	10 μ F	Ceramic
	CREG	1 μ F	Ceramic
	CCP	0.01 μ	Ceramic
	C1	0.1 μ F	Ceramic
Inductors	L	6.8 μ H	TDK: SLF6045T-6R8N2R0-3PF
Load switches	M1 M2	-	On Semiconductor: NTS2101P

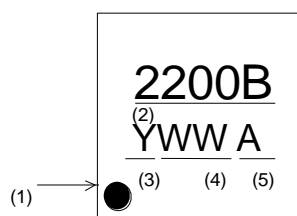
12. Package

■ Outline Dimensions

16-pin QFN (Unit mm)



■ Marking



- (1) Pin 1 Indication
- (2) Part No. : "2200B"
- (3) Year code (last 1 digit)
- (4) Week code
- (5) Management code

13. Revise History

Date (YY/MM/DD)	Revision	Page	Contents
14/02/28	00		First edition
14/04/28	01	8	Rewrite “Constant input voltage control and Output voltage control”.

IMPORTANT NOTICE

0. Asahi Kasei Microdevices Corporation (“AKM”) reserves the right to make changes to the information contained in this document without notice. When you consider any use or application of AKM product stipulated in this document (“Product”), please make inquiries the sales office of AKM or authorized distributors as to current status of the Products.
1. All information included in this document are provided only to illustrate the operation and application examples of AKM Products. AKM neither makes warranties or representations with respect to the accuracy or completeness of the information contained in this document nor grants any license to any intellectual property rights or any other rights of AKM or any third party with respect to the information in this document. You are fully responsible for use of such information contained in this document in your product design or applications. **AKM ASSUMES NO LIABILITY FOR ANY LOSSES INCURRED BY YOU OR THIRD PARTIES ARISING FROM THE USE OF SUCH INFORMATION IN YOUR PRODUCT DESIGN OR APPLICATIONS.**
2. The Product is neither intended nor warranted for use in equipment or systems that require extraordinarily high levels of quality and/or reliability and/or a malfunction or failure of which may cause loss of human life, bodily injury, serious property damage or serious public impact, including but not limited to, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. Do not use Product for the above use unless specifically agreed by AKM in writing.
3. Though AKM works continually to improve the Product’s quality and reliability, you are responsible for complying with safety standards and for providing adequate designs and safeguards for your hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of the Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption.
4. Do not use or otherwise make available the Product or related technology or any information contained in this document for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). When exporting the Products or related technology or any information contained in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. The Products and related technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
5. Please contact AKM sales representative for details as to environmental matters such as the RoHS compatibility of the Product. Please use the Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. AKM assumes no liability for damages or losses occurring as a result of noncompliance with applicable laws and regulations.
6. Resale of the Product with provisions different from the statement and/or technical features set forth in this document shall immediately void any warranty granted by AKM for the Product and shall not create or extend in any manner whatsoever, any liability of AKM.
7. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of AKM.