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FUJITSU SEMICONDUCTOR
DATA SHEET

DS405-00014-0v01-E

Ultra Low Voltage Boost Power management IC for Solar/Thermal Energy Harvesting

MB39C831

■ DESCRIPTION

The MB39C831 is the high-efficiency synchronous rectification boost DC/DC converter IC which efficiently supplies energy getting from the solar cell with the single cell or multiple cells, or from the thermoelectric generator (TEG) to the the Li-ion battery.

It contains the function to control the DC/DC converter output following the maximum power point of the solar cell (MPPT) and the protection function to charge the Li-ion battery safely.

It is possible to start-up from 0.35 V using the low-voltage process and adapts the applications which the single cell solar cell is treated as the input.

■ FEATURES

- Operation input voltage range : 0.3 V to 4.75 V
- Output voltage adjustment range : 3.0 V to 5.0 V
- Minimum input voltage at start-up : 0.35 V
- Quiescent Current (No load) : 41 µA
- Input peak current limit : 200 mA
- Built-in MPPT
- Charge voltage to the Li-ion battery/current protection function built in
- Improvement of the efficiency during the low-output power according to the auto PFM/PWM switching mode

■ APPLICATIONS

- Solar energy harvesting
- Thermal energy harvesting
- Li-ion battery using the single cell or multiple cells' solar cell/Super Capacitor Charger
- Portable audio players
- Cellular phone
- eBook
- Electronic dictionary
- Wireless remote controllers
- Sensor node

2013.6

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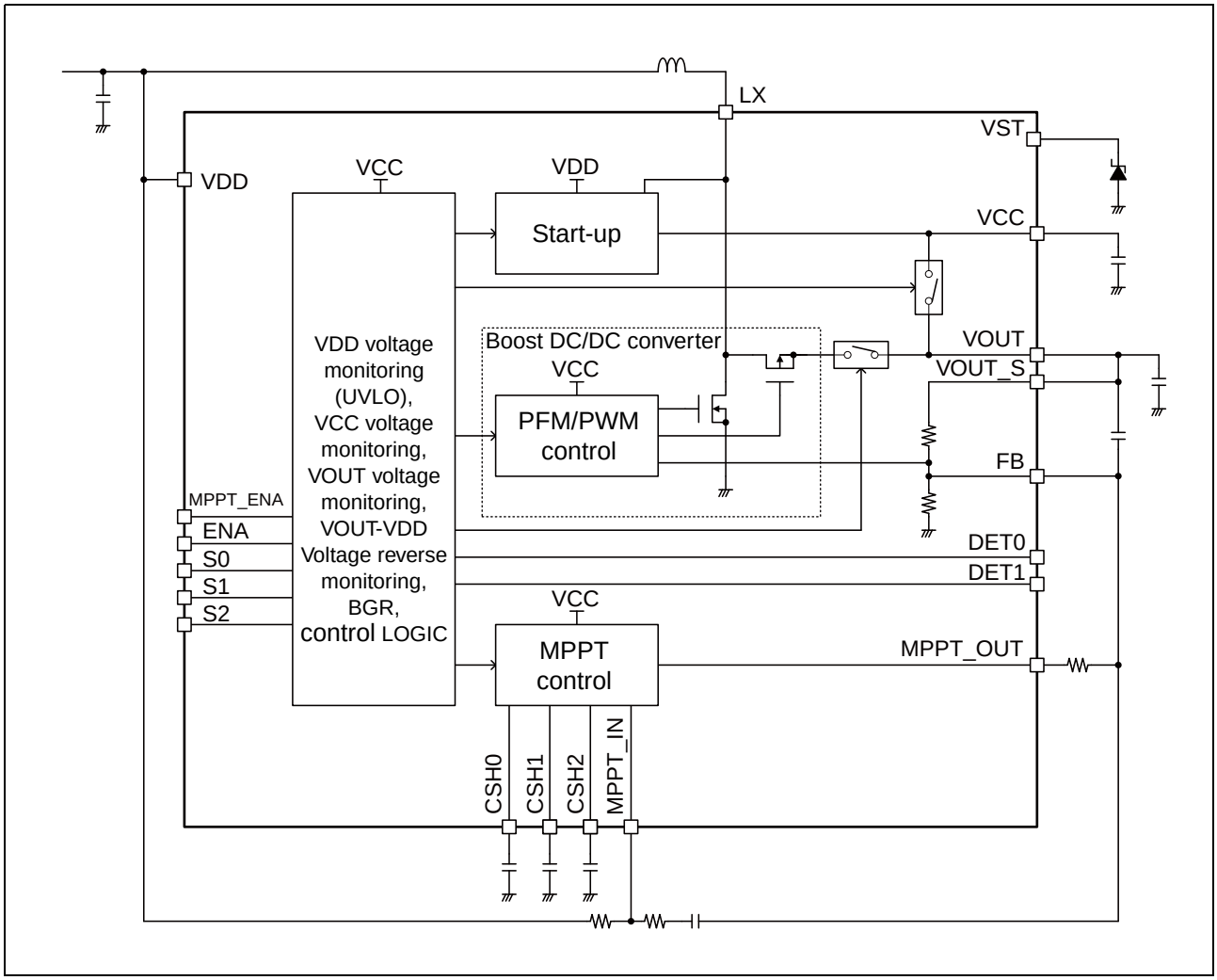
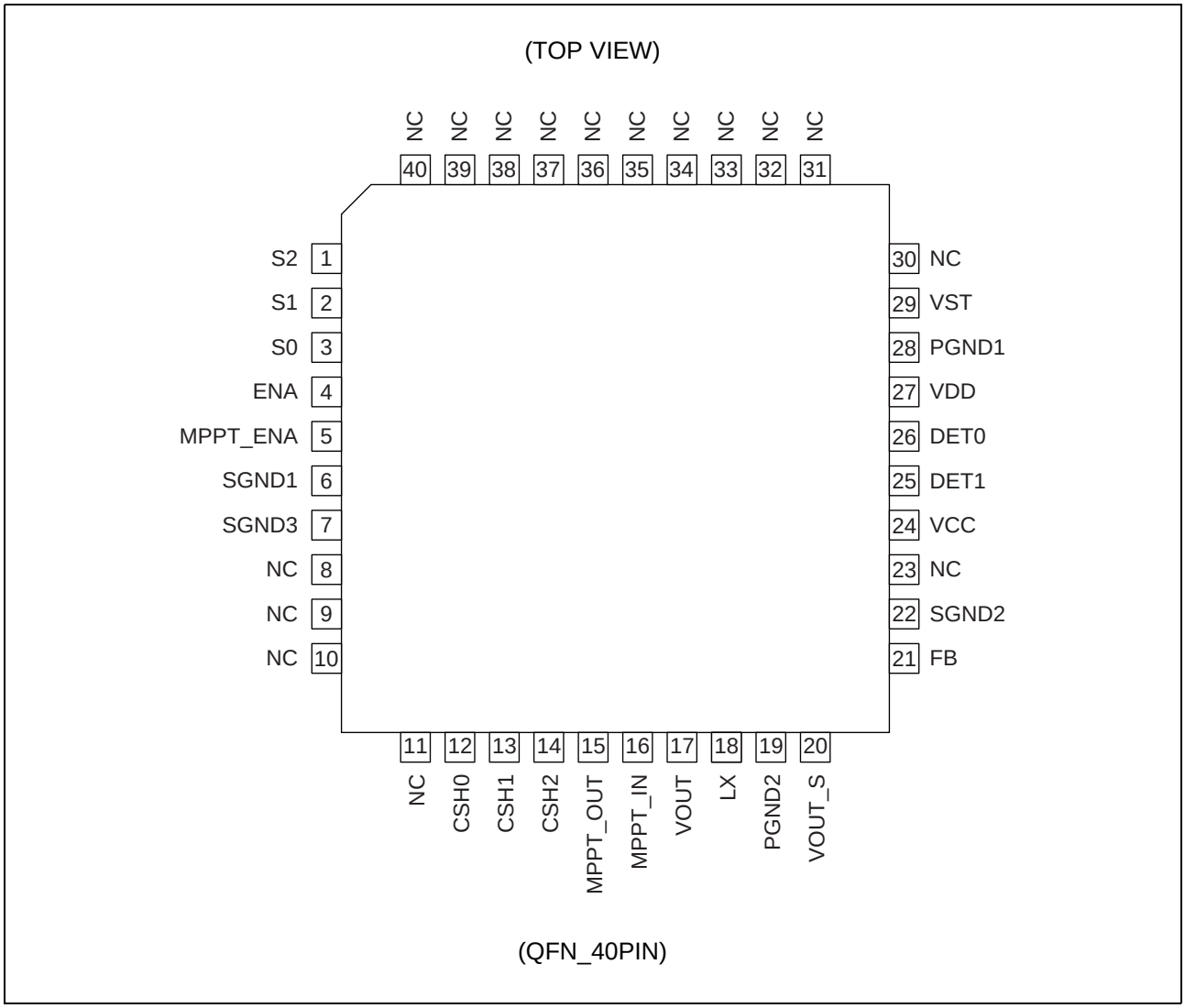
■ BLOCK DIAGRAM



■ PIN ASSIGNMENTS



■ PIN DISCRIPTIONS

Pin No.	Pin Name	I/O	Description
1	S2	I	Input pin for preset output voltage setting and MPPT setting
2	S1	I	Input pin for preset output voltage setting and MPPT setting
3	S0	I	Input pin for preset output voltage setting and MPPT setting
4	ENA	I	DC/DC converter control input pin
5	MPPT_ENA	I	MPPT control input pin
6	SGND1	—	COMMON, MPPT block control system ground pin
7	SGND3	—	Control system ground pin for BGR
8 to 11	NC	—	Non connection pins
12	CSH0	O	Capacitor connection pin for MPPT, used only at the charge mode
13	CSH1	I	Capacitor connection pin for MPPT, used only at the charge mode
14	CSH2	I	Capacitor connection pin for MPPT, used only at the charge mode
15	MPPT_OUT	O	MPPT output pin, used only at the charge mode
16	MPPT_IN	I	MPPT input pin, used only at the charge mode
17	VOUT	O	Output pin of DC/DC converter
18	LX	I	Inductor connection pin
19	PGND2	—	DC/DC converter power system ground pin
20	VOUT_S	I	Input pin for DC/DC converter FB
21	FB	I	Feedback input pin of DC/DC converter
22	SGND2	—	DC/DC control system ground pin
23	NC	—	Non connection pin
24	VCC	O	Control system power supply output pin
25	DET1	O	Output pin for state notification
26	DET0	O	Output pin for state notification
27	VDD	I	External power supply input pin
28	PGND1	—	Start-up ground pin
29	VST	O	Start-up power supply output pin
30 to 40	NC	—	Non connection pins

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
VDD input voltage	V_{VDDMAX}	VDD pin	– 0.3	+ 7.0	V
VOUT input voltage	$V_{VOUTMAX}$	VOUT, VOUT_S pins	– 0.3	+ 7.0	V
Input pin input voltage	$V_{VINPUTMAX}$	MPPT_ENA, ENA, S0, S1, S2, CSH0, CSH1, CSH2, MPPT_IN, MPPT_OUT pins	– 0.3	VCC pin voltage + 0.3 (≤ + 7.0)	V
Power dissipation	P_D	Ta = + 85 °C	TBD	TBD	mW
Storage temperature	T_{STG}	—	– 55	+ 125	°C
ESD voltage1	V_{ESDH}	Human Body Model	– 2000	+ 2000	V
ESD voltage2	V_{ESDM}	Machine Model	– 200	+ 200	V

WARNING: Semiconductor devices may be permanently damaged by application of stress (including, without limitation, voltage, current or temperature) in excess of absolute maximum ratings.
Do not exceed any of these ratings.

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
VDD input voltage	V_{VDD}	VDD pin	0.3	—	4.75	V
VOUT input voltage	V_{VOUT}	VOUT pin MPPT_ENA = H	2.55	3	5.5	V
Input pin input voltage	V_{INPUT}	MPPT_ENA, ENA, S0, S1, S2 pins	0	—	VCC pin voltage	V
Operating ambient temperature	Ta	—	– 40	—	+ 85	°C

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated under these conditions.

Any use of semiconductor devices will be under their recommended operating condition.
Operation under any conditions other than these conditions may adversely affect reliability of device and could result in device failure.

No warranty is made with respect to any use, operating conditions or combinations not represented on this data sheet. If you are considering application under any conditions other than listed herein, please contact sales representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

(Ta = − 40 °C to + 85 °C, irrespective of MPPT_ENA, VDD ≤ VOUT − 0.25 V, L = 4.7 µH, Cout = 10 µF)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
Minimum input voltage at start-up	V_{START}	VDD pin, Ta = + 25 °C	—	0.35	0.5	V
Preset output voltage	V_{OUT}	MPPT_ENA = L, S2 = L, S1 = L, S0 = L	2.940	3.000	3.060	V
		MPPT_ENA = L, S2 = L, S1 = L, S0 = H	3.234	3.300	3.366	V
		MPPT_ENA = L, S2 = L, S1 = H, S0 = L	3.528	3.600	3.672	V
		MPPT_ENA = L, S2 = L, S1 = H, S0 = H	4.018	4.100	4.182	V
		MPPT_ENA = L, S2 = H, S1 = L, S0 = L	4.410	4.500	4.590	V
		MPPT_ENA = L, S2 = H, S1 = L, S0 = H	4.900	5.000	5.100	V
MPPT setting	MPPTSET	MPPT_ENA = H, S2 = L, S1 = L, S0 = L	45	50	55	%
		MPPT_ENA = H, S2 = L, S1 = L, S0 = H	50	55	60	%
		MPPT_ENA = H, S2 = L, S1 = H, S0 = L	55	60	65	%
		MPPT_ENA = H, S2 = L, S1 = H, S0 = H	60	65	70	%
		MPPT_ENA = H, S2 = H, S1 = L, S0 = L	65	70	75	%
		MPPT_ENA = H, S2 = H, S1 = L, S0 = H	70	75	80	%
		MPPT_ENA = H, S2 = H, S1 = H, S0 = L	75	80	85	%
		MPPT_ENA = H, S2 = H, S1 = H, S0 = H	80	85	90	%
LX peak current	I_{LIMIN_A}	LX pin input current	—	200	—	mA
Maximum output current	I_{OUT}	VDD = 0.6 V, VOUT = 3.3 V	8	—	—	mA
		VDD = 3.0 V, VOUT = 3.3 V	80	—	—	mA
Oscillation frequency	F_{OSC}	PWM mode	0.87	1	1.13	MHz
Line regulation	V_{LINE}	0.4 V ≤ VDD ≤ VOUT − 0.25 V, IOUT = 0	—	—	0.5	%
Load regulation	V_{LOAD}	VDD = 0.6 V, VOUT = 3.3 V, IOUT = 0 mA to 8 mA	—	—	0.5	%
Input power supply current	I_{QIN}	VDD pin input current , VDD = 0.6 V, VOUT = 3.3 V, IOUT = 0	—	0.75	5	mA
Current dissipation	I_{QOUT}	VOUT pin input current , MPPT_ENA = H, VOUT = 3.3 V , IOUT = 0	—	41	82	µA
		VOUT pin input current , MPPT_ENA = L, VOUT = 3.3 V, IOUT = 0	—	32	64	µA
UVLO release voltage	V_{UVLOH}	—	0.2*	0.3*	0.4*	V
UVLO detection voltage	V_{UVLOL}	—	0.1	0.2	0.3	V
VCC low-voltage detection 1	$V_{VCCDETH}$	MPPT_ENA = L	2.8	2.9	3	V
VCC low-voltage detection release 1	$V_{VCCDETL}$	MPPT_ENA = L, release voltage after detection	2.5	2.6	2.7	V
VCC low-voltage detection 2	$V_{VCCDETH2}$	MPPT_ENA = H	2.5	2.6	2.7	V
VCC low-voltage detection release 2	$V_{VCCDETL2}$	MPPT_ENA = H, release voltage after detection	2.45	2.55	2.65	V
VOUT low-voltage detection 1	$V_{VOUTDETH}$	MPPT_ENA = L	2.8	2.9	3	V

(Continued)

(Continued)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
VOUT low-voltage detection release 1	$V_{VOUTDETL}$	MPPT_ENA = L, release voltage after detection	2.5	2.6	2.7	V
VOUT low-voltage detection 2	$V_{VOUTDETH2}$	MPPT_ENA = H	2.5	2.6	2.7	V
VOUT low-voltage detection release 2	$V_{VOUTDETL2}$	MPPT_ENA = H, release voltage after detection	2.45	2.55	2.65	V
VOUT high-voltage detection	$V_{VOUTDETH3}$	MPPT_ENA = H	3.88	4	4.12	V
VOUT high-voltage detection release	$V_{VOUTDETL3}$	MPPT_ENA = H, release voltage after detection	3.58	3.7	3.82	V

*: This parameter is not be specified. This should be used as a reference to support designing the circuits.

■ OPERATION

The charge mode (MPPT_ENA = H) and the constant voltage mode (MPPT_ENA = L) are selected by the MPPT_ENA pin.

Charge mode : Follows the MPPT setting set at the S0, S1 and S2 pins and charges whilst letting VOUT be variable.

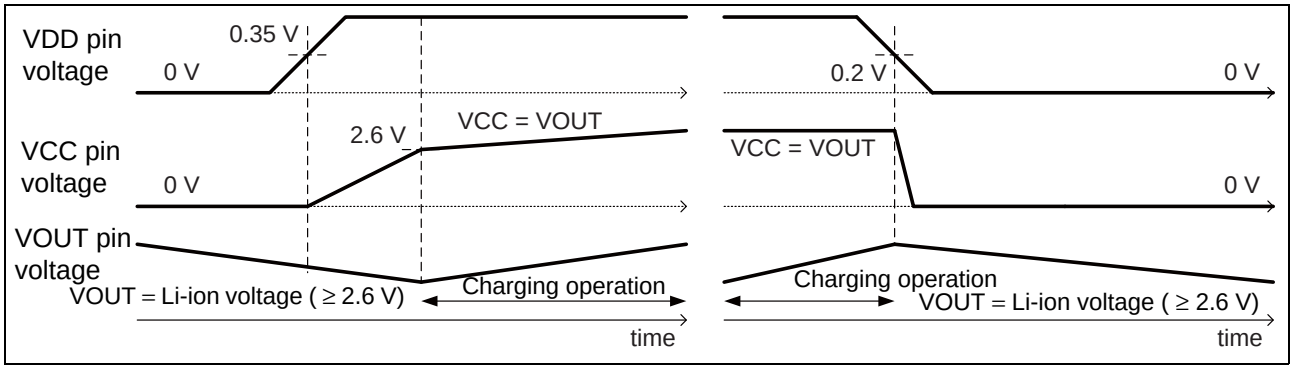
Constant voltage mode : Outputs VOUT set at the S0, S1 and S2 pins.

■ START-UP/SHUT-DOWN SEQUENCE

• When setting the charge mode

When 0.35 V or higher voltage which is the minimum input voltage at activation is applied to the VDD pin, the start-up circuit activates charging the VCC output. When VCC reaches 2.6 V, the DC/DC converter activates charging the VOUT output. At the same time, the start-up circuit stops operating. When VOUT reaches 2.9 V, the internal switch between VCC and VOUT is turned on and the charging starts connecting two outputs mutually.

When the VDD pin is equal to 0.2 V or less, the internal switch is turned off, and VOUT and VCC are disconnected.

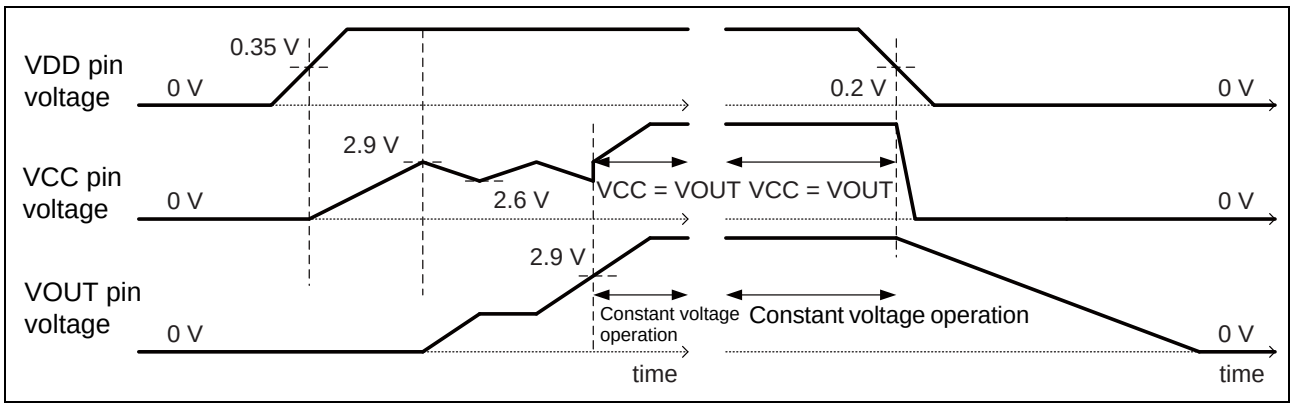


• When setting constant voltage mode

When 0.35 V or higher voltage which is the minimum input voltage at activation is applied to the VDD pin, the start-up circuit activates charging the VCC output. When VCC reaches 2.9 V, the DC/DC converter activates charging the VOUT output. At the same time, the start-up circuit stops the operation. When VCC becomes 2.6 V or less by the internal consumption current, the start-up circuit operates again, and this sequence is repeated till VOUT becomes the constant voltage. When VOUT reaches 2.9 V, the internal switch between VCC and VOUT is turned on and two outputs are connected mutually.

Afterwards, VOUT keeps rising, becomes the preset voltage set at the S0, S1 and S2 pins and outputs the constant voltage.

When the VDD pin becomes 0.2 V or less, the internal switch is turned off and VOUT and VCC are disconnected. As for VOUT, the output is gradually decreased by the leak current of the capacitor and so on.



■ MPPT

In general the solar cell, the voltage is fluctuated by the current which is the load. The voltage where the power becomes the maximum is called the power maximum voltage, and the voltage with no load is called the release voltage. The comparison between the power maximum voltage and release voltage is defined as the MPPT setting.

The DC/DC converter activates following the MPPT setting set at the S0, S1 and S2 pins for the charge mode.

When in use, please set this function after confirming the voltage dependency of the solar cell power.

■ FUNCTION

(1) Mode control

The mode is controlled by the MPPT_ENA pin. There are the charge mode and constant voltage mode, and the existence of the MPPT function, the UVLO function, the VDD, VCC, and VOUT voltage monitoring function is decided. Set the MPPT_ENA pin according to the application. The DC/DC operation is controlled by the ENA pin.

Input signal		Internal control	Function		
MPPT_ENA pin	**ENA pin**	**State**	**MPPT**	**UVLO, VCC low-voltage monitoring, VOUT low-voltage monitoring, state notification**	**VOUT high-voltage monitoring, VOUT-VDD voltage reverse monitoring**
L	L	Constant voltage mode, VOUT output stop	OFF	ON	OFF
L	H	Constant voltage mode, VOUT output enabled	OFF	ON	OFF
H	L	Charge mode, Charge stop	OFF	ON	ON
H	H	Charge mode, Charge enabled	ON	ON	ON

(2) Preset output voltage & MPPT setting

The state is controlled by the S0, S1 and S2 pins and the MPPT_ENA pin.

When MPPT_ENA pin is set to “L”, S0, S1, S2 pins are used for the preset output voltage setting because the MPPT function is not used.

When MPPT_ENA pin is set to “H”, S0, S1, S2 pins are used for MPPT setting.

Input signal				Control	
S2 pin	S1 pin	S0 pin	MPPT_ENA pin	Preset output voltage (V)	MPPT setting
L	L	L	L	3	Invalid
L	L	H	L	3.3	Invalid
L	H	L	L	3.6	Invalid
L	H	H	L	4.1	Invalid
H	L	L	L	4.5	Invalid
H	L	H	L	5	Invalid
H	H	L	L	Setting prohibited	Setting prohibited
H	H	H	L	Setting prohibited	Setting prohibited
L	L	L	H	Invalid	50%
L	L	H	H	Invalid	55%
L	H	L	H	Invalid	60%
L	H	H	H	Invalid	65%
H	L	L	H	Invalid	70%
H	L	H	H	Invalid	75%
H	H	L	H	Invalid	80%
H	H	H	H	Invalid	85%

(3) UVLO

This function is independent of MPPT_ENA.

It monitors the drop of the VDD input voltage, and prevents IC's malfunction.

It has the hysteresis on the low-voltage side, and the detection state has been kept till the value becomes that voltage or less.

(4) VCC Under-voltage Monitoring

This function is independent of MPPT_ENA.

The detection that the VCC pin is equal to 2.9 V or higher is the source to start the operation of the DC/DC control part and to turn on the internal switch between VCC and VOUT. The undetected state is the VCC voltage undetected.

It has the hysteresis on the low-voltage side, and the detection state has been kept till the value becomes that voltage or less.

(5) VOUT Under-voltage Monitoring

This function controls the stop of charging when in the charge mode. The detection that the VOUT pin is equal to 2.6 V or less is the source to stop the DC/DC control part operation.

It has the hysteresis on the low-voltage side, and the detection state has been kept till the value becomes that voltage or less.

The function controls the internal switch between VCC and VOUT when in the constant mode.

The function detects that the VOUT pin is equal to 2.9 V or higher and then the internal switch between VCC and VOUT is turned on.

It has the hysteresis on the low-voltage side, and the detection state has been kept till the value becomes that voltage or less.

(6) VOUT Over-voltage Monitoring

This function operates in the charge mode (MPPT_ENA = H).

The detection that the VOUT pin is equal to 4.0 V or higher is the source to stop the DC/DC control part operation.

It has the hysteresis on the low-voltage side, and the detection state has been kept till the value becomes that voltage or less.

(7) VOUT-VDD Voltage Reverse Monitoring

This function operates in the charge mode (MPPT_ENA = H).

The detection that the VDD pin is equal to the VOUT pin's voltage or higher is the source to stop the DC/DC control block operation.

(8) State Notification

This function is independent of MPPT_ENA.

It outputs the results of the VCC voltage monitoring, VOUT voltage monitoring and VOUT-VDD voltage reverse monitoring.

Output singnal		State	
DET1 pin	DET0 pin	MPPT_ENA = L	MPPT_ENA = H
L	L	Running (VCC < 2.9 V, VOUT < 2.9 V)	During VCC or VOUT low-voltage detection
L	H	Running (VCC ≥ 2.9 V, VOUT < 2.9 V)	During VOUT-VDD voltage reverse detection*1
H	L	Normal (VCC ≥ 2.9 V, VOUT ≥ 2.9 V)	During VOUT high-voltage detection*2
H	H	Running (VCC < 2.9 V, VOUT ≥ 2.9 V)	Normal

*1 : The state during the VCC and VOUT low-voltage detection has the priority.

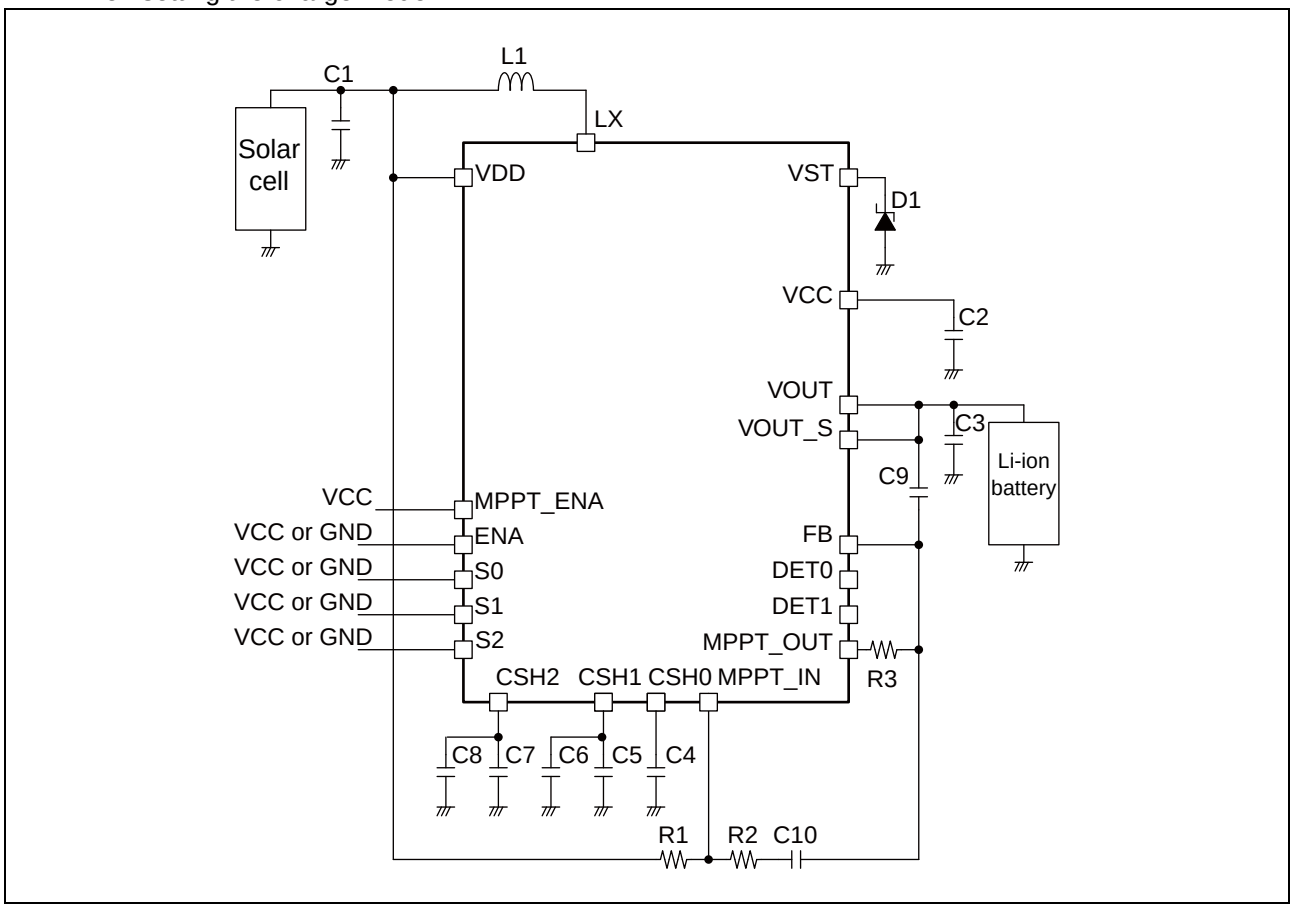
*2 : The states during the VCC and VOUT low-voltage detection and during the VOUT-VDD voltage reverse detection have the priority.

(9) Boost DC/DC converter

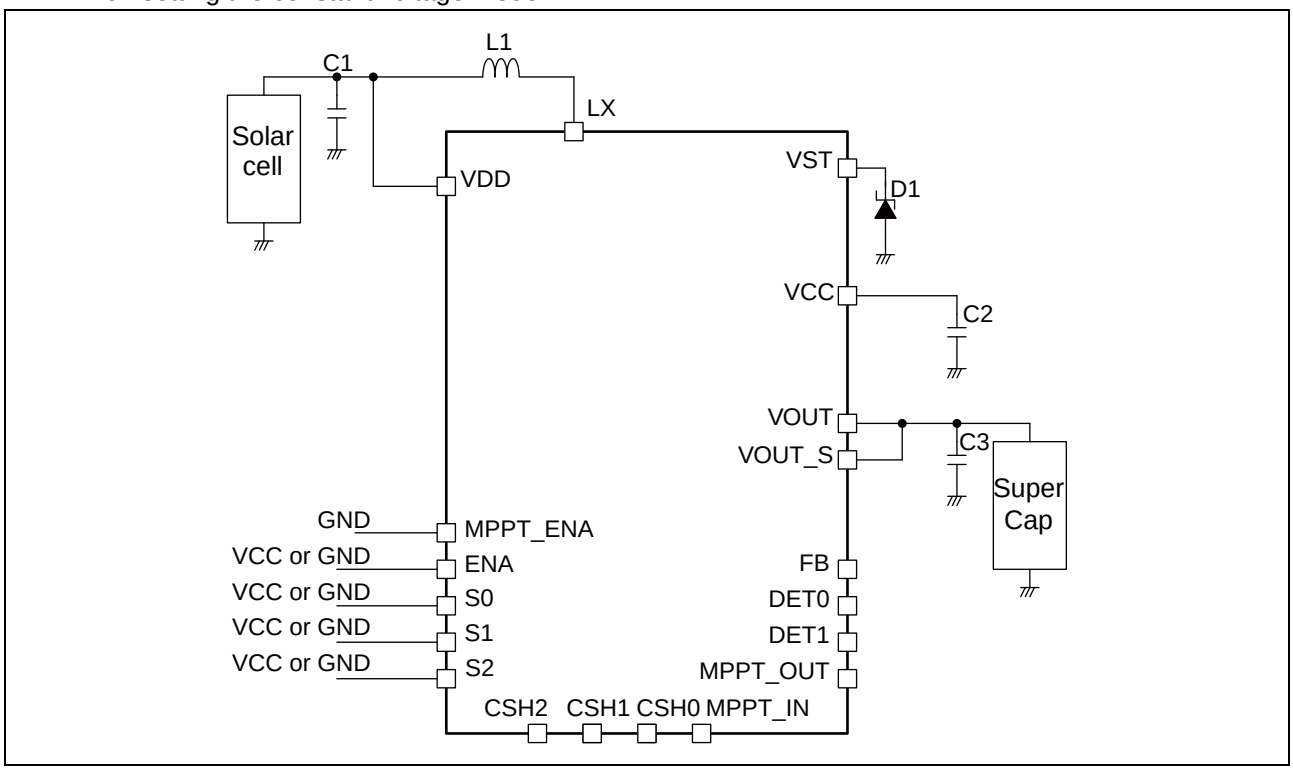
The function controls for the synchronous rectification operation of the main FET and synchronous FET using the frequency set by the built-in oscillator. The PFM operation is executed at the light load time. It has the output current limitation function to protect the circuit during the over load current. When the output current is excessive, the output voltage drops not to exceed the over current protection operation current, in order to prevent the IC destruction.

■ TYPICAL APPLICATIONS CIRCUIT

• When setting the charge mode



• When setting the constant voltage mode



• Parts list

Part number	Value	Description
C1	10 µF	Capacitor
C2	1 µF	Capacitor
C3	10 µF	Capacitor
C4	0.47 µF	Capacitor
C5	3300 pF	Capacitor
C6	4700 pF	Capacitor
C7	0.1 µF	Capacitor
C8	47000 pF	Capacitor
C9	33 pF	Capacitor
C10	10 nF	Capacitor
R1	100 kΩ	Resistor
R2	100 kΩ	Resistor
R3	200 kΩ	Resistor
L1	4.7 µH	Inductor
D1	—	Zener diode

■ USAGE PRECAUTION

1. Do not configure the IC over the maximum ratings

If the IC is used over the maximum ratings, the LSI may be permanently damaged.
It is preferable for the device to be normally operated within the recommended usage conditions. Usage outside of these conditions can have a bad effect on the reliability of the LSI.

2. Use the devices within recommended operating conditions

The recommended operating conditions are the recommended values that guarantee the normal operations of LSI.
The electrical ratings are guaranteed when the device is used within the recommended operating conditions and under the conditions stated for each item.

3. Printed circuit board ground lines should be set up with consideration for common impedance

4. Take appropriate measures against static electricity

- Containers for semiconductor materials should have anti-static protection or be made of conductive material.
- After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
- Work platforms, tools, and instruments should be properly grounded.
- Working personnel should be grounded with resistance of 250 kΩ to 1 MΩ in series between body and ground.

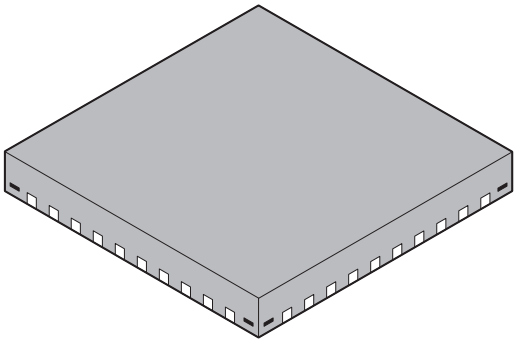
5. Do not apply negative voltages

The use of negative voltages below –0.3 V may cause the parasitic transistor to be activated on LSI lines, which can cause malfunctions.

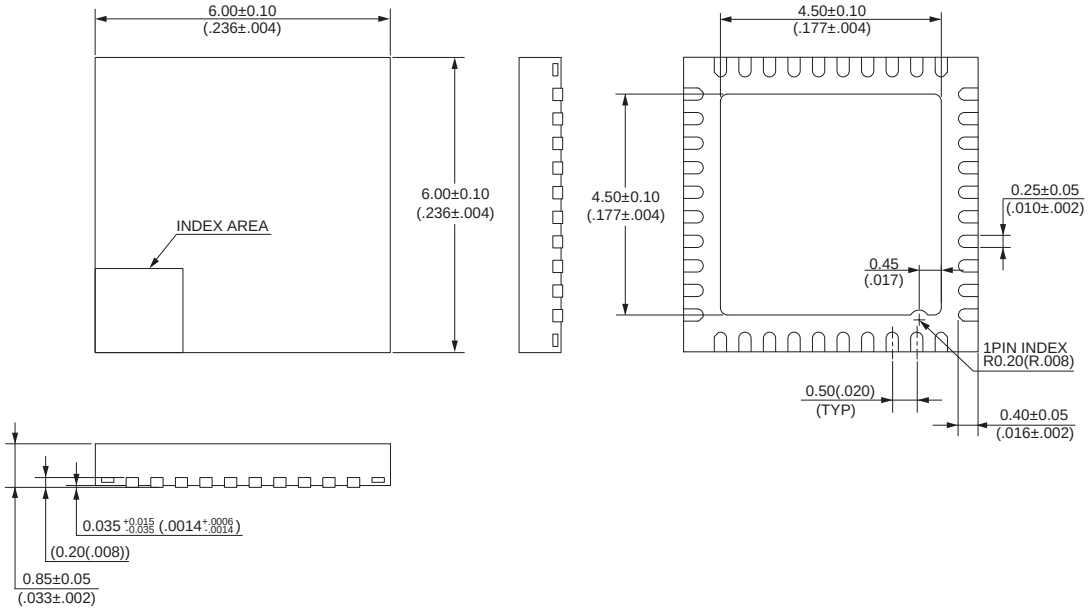
■ ORDERING INFORMATION

Part number	Package	Remarks
MB39C831QN	40-pin plastic QFN (LCC-40P-M63)	

■ PACKAGE DIMENSIONS

40-pin plastic QFN		
 (LCC-40P-M63)	Lead pitch	0.50 mm
	Package width × package length	6.00 mm × 6.00 mm
	Sealing method	Plastic mold
	Mounting height	0.90 mm MAX
	Weight	0.10 g

40-pin plastic QFN
(LCC-40P-M63)



Dimensions in mm (inches).
Note: The values in parentheses are reference values.

MEMO

MEMO

MEMO

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