MB39C831

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

Data Sheet (Full Production)

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

Data Sheet (Full Production)

1. 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 Li-ion battery.

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

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

2. Features

- Operation input voltage range : 0.3V to 4.75V
- Output voltage adjustment range : 3.0V to 5.0V
- Minimum input voltage at start-up : 0.35V
- Quiescent Current (No load) : 41µA
- Input peak current limit : 200mA
- 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

3. 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

Power Supply online Design Simulation
Easy DesignSim

This product supports the web-based design simulation tool.
It can easily select external components and can display useful information.
Please access from the following URL.

http://www.spansion.com/easydesignsim/

Publication Number MB39C831_DS405-00014 Revision 3.0 Issue Date October 10, 2014

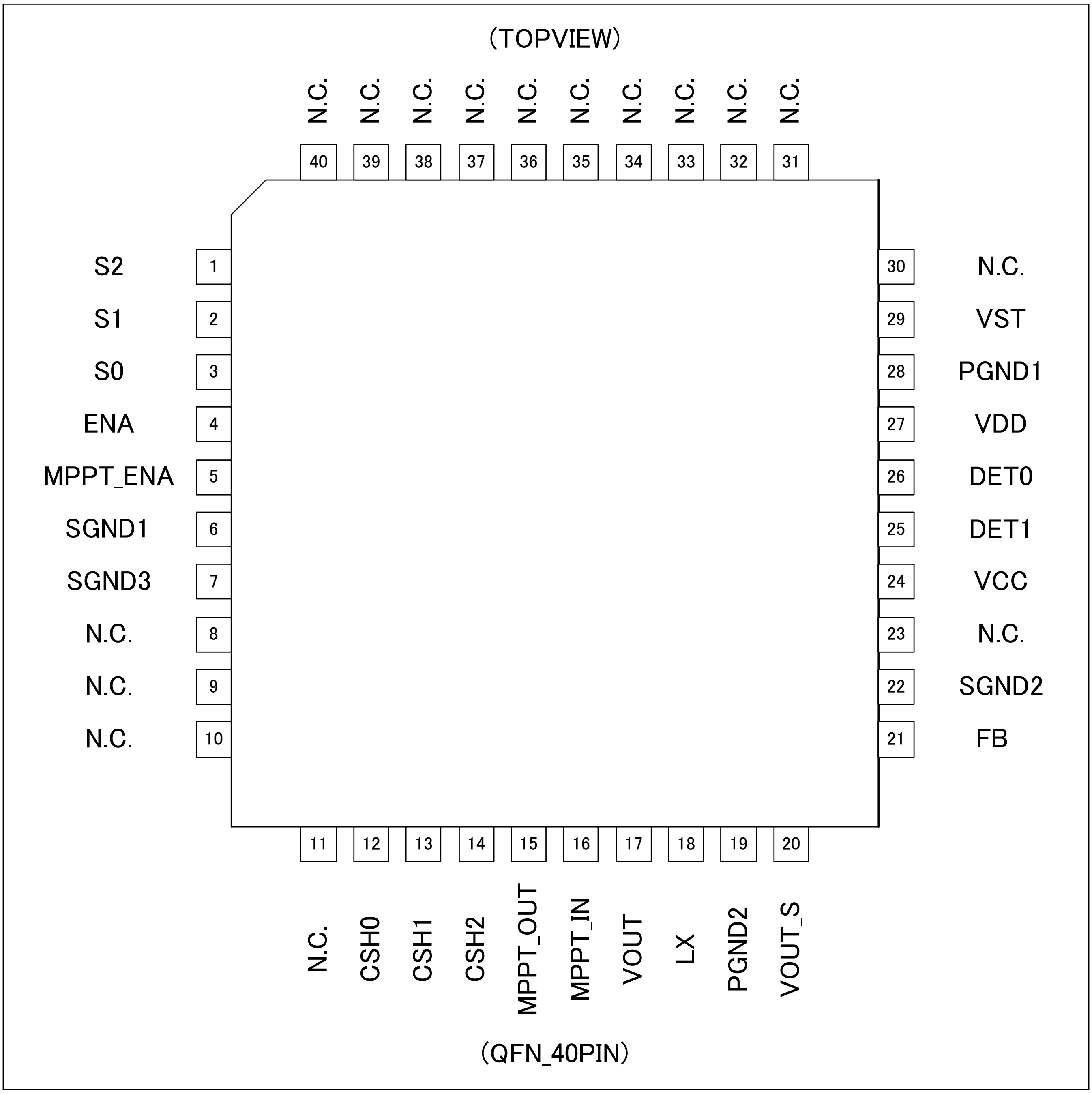
Table of contents

Figures

Tables

4. Pin Assignments

Figure 4-1 Pin assignments



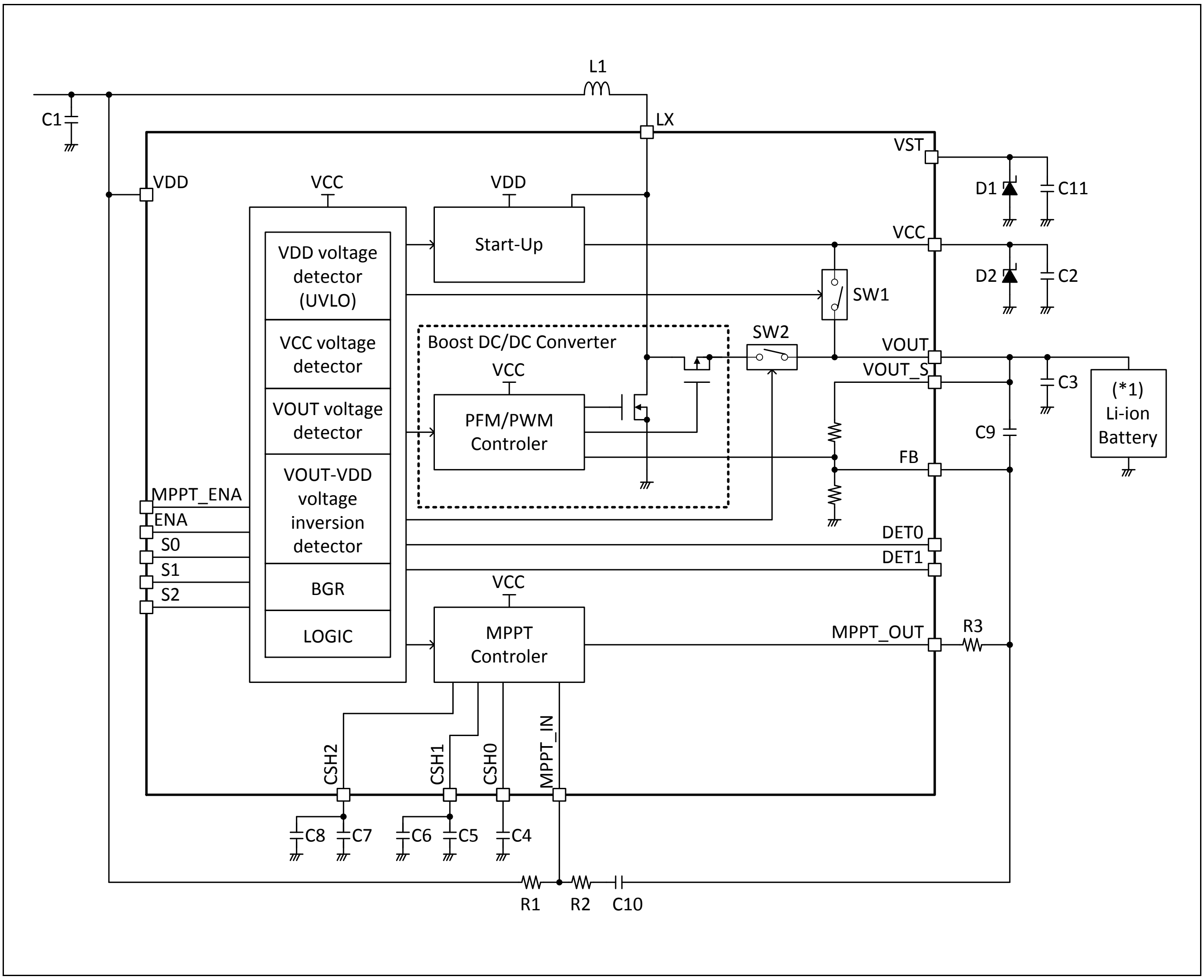
5. Pin Descriptions

Table 5-1 Pin descriptions

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, 9, 10, 11	N.C.	-	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	N.C.	-	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, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40	N.C.	-	Non connection pins

6. Block Diagram

Figure 6-1 Block diagram



*1: Connect the Li-ion battery in the charge mode (refer to Figure 11-2)

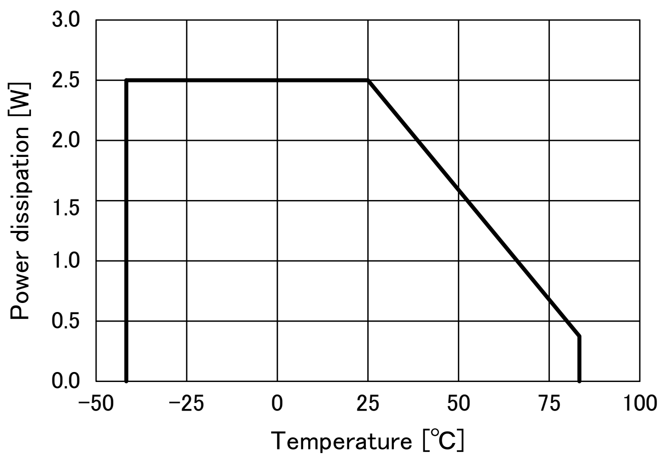
7. Absolute Maximum Ratings

Table 7-1 Absolute maximum ratings

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
VDD input voltage	VDDMAX	VDD pin	-0.3	+7.0	V
VOUT input voltage	VOUTMAX	VOUT, VOUT_S pins	-0.3	+7.0	V
Input pin input voltage	VINPUTMAX	MPPT_ENA, ENA, S2, S1, S0, DET0, DET1, CSH0, CSH1, CSH2, MPPT_IN, MPPT_OUT pins	-0.3	VCC pin voltage +0.3 (≤ +7.0)	V
Power dissipation	PD	Ta ≤ +25°C	-	2500(*1)	mW
Storage temperature	TSTG	-	-55	+125	°C
ESD voltage1	VESDH	Human Body Model	-2000	+2000	V
ESD voltage2	VESDM	Machine Model	-200	+200	V

*1: In the case of θ ja (wind speed 0m/s) +28°C/W

Figure 7-1 Power dissipation – Operating ambient temperature



WARNING:

1. *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.*

8. Recommended Operating Conditions

Table 8-1 Recommended operating conditions

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

WARNING:

1. *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.*
2. *Any use of semiconductor devices will be under their recommended operating condition.*
3. *Operation under any conditions other than these conditions may adversely affect reliability of device and could result in device failure*
4. *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*

9. Electrical Characteristics

9.1 Electrical characteristics of constant voltage mode

Table 9-1 Electrical characteristics of constant voltage mode (MPPT_ENA = L, ENA = H)

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

Parameter	Symbol	Condition			Value			Unit
		MPPT_ENA	ENA	Other	Min	Typ	Max	
Minimum input voltage at start-up	VSTART	L	H	VDD pin, Ta = +25°C	-	0.35	0.5	V
Preset output voltage	VOUT	L	H	S2=L, S1=L, S0=L	2.940	3.000	3.060	V
		L	H	S2=L, S1=L, S0=H	3.234	3.300	3.366	V
		L	H	S2=L, S1=H, S0=L	3.528	3.600	3.672	V
		L	H	S2=L, S1=H, S0=H	4.018	4.100	4.182	V
		L	H	S2=H, S1=L, S0=L	4.410	4.500	4.590	V
		L	H	S2=H, S1=L, S0=H	4.900	5.000	5.100	V
Input power supply current	IQIN	L	H	VDD, LX pin input current, VDD=0.6V, VOUT=3.3V, IOUT=0	-	0.75	5(*1)	mA
Current dissipation	IQOUT	L	H	VOUT pin input current, VOUT=3.3V, IOUT=0	-	32	64	μA
VCC detection voltage 1	VCCDETH1	L	H	Upper threshold	2.8	2.9	3	V
	VCCDETL1	L	H	Lower threshold	2.5	2.6	2.7	V
VOUT detection voltage 1	VOUTDETH1	L	H	Upper threshold	2.8	2.9	3	V
	VOUTDETL1	L	H	Lower threshold	2.5	2.6	2.7	V

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

9.2 Electrical characteristics of charge mode

Table 9-2 Electrical characteristics of charge mode (MPPT_ENA = H, ENA = H)

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

Parameter	Symbol	Condition			Value			Unit
		MPPT_ENA	ENA	Other	Min	Typ	Max	
Minimum input voltage at start-up	VSTART	H	H	VDD pin, Ta = +25°C	-	0.35	0.5	V
MPPT setting	MPPTSET			S2=L, S1=L, S0=L	45	50	55	%
				S2=L, S1=L, S0=H	50	55	60	%
				S2=L, S1=H, S0=L	55	60	65	%
				S2=L, S1=H, S0=H	60	65	70	%
				S2=H, S1=L, S0=L	65	70	75	%
				S2=H, S1=L, S0=H	70	75	80	%
				S2=H, S1=H, S0=L	75	80	85	%
				S2=H, S1=H, S0=H	80	85	90	%
Input power supply current	IQIN			VDD, LX pin input current, VDD=0.6V, VOUT=3.3V, IOUT=0	-	0.75	5(*1)	mA
Current dissipation	IQOUT			VOUT pin input current, VOUT=3.3V, IOUT=0	-	41	82	μA
UVLO detection voltage (VDD detection voltage)	VUVLOH			Upper threshold	0.2(*1)	0.3(*1)	0.4(*1)	V
	VUVLOL			Lower threshold	0.1	0.2	0.3	V
VCC detection voltage 2	VCCDETH2			Upper threshold	2.5	2.6	2.7	V
	VCCDETL2			Lower threshold	2.45	2.55	2.65	V
VOUT detection voltage 2	VOUTDETH2			Upper threshold	2.5	2.6	2.7	V
	VOUTDETL2			Lower threshold	2.45	2.55	2.65	V
VOUT detection voltage 3	VOUTDETH3			Upper threshold	3.88	4	4.12	V
	VOUTDETL3			Lower threshold	3.58	3.7	3.82	V

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

9.3 Electrical characteristics of boost DC/DC converter

Table 9-3 Electrical characteristics of boost DC/DC converter

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

Parameter	Symbol	Condition			Value			Unit
		MPPT_ENA	ENA	Other	Min	Typ	Max	
LX peak current	ILIMIN_A	L or H	H	LX pin input current	-	200(*2)	-	mA
Maximum output current	IOUT			VDD=0.6V, VOUT=3.3V	8	-	-	mA
				VDD=3.0V, VOUT=3.3V	80	-	-	mA
Oscillation frequency	FOSC			PWM mode	0.87	1	1.13	MHz
Line regulation	VLINE			0.4V ≤ VDD ≤ VOUT - 0.25V, IOUT=0	-	-	0.5	%
Load regulation	VLOAD			VDD=0.6V, VOUT=3.3V, IOUT=0 to 8mA	-	-	0.5	%

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

10. Function

10.1 Outline of operation

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

Constant voltage mode: The output voltage is outputted as a constant voltage VOUT setting by the S2, S1 and S0 pins.

Charge mode: The input voltage (VIN) is adjusted by following the MPPT value setting by the S2, S1 and S0 pins, and a Li-ion battery can be charged.

10.2 Start-up/Shut-down sequence

Constant voltage mode: MPPT_ENA = L, ENA = H

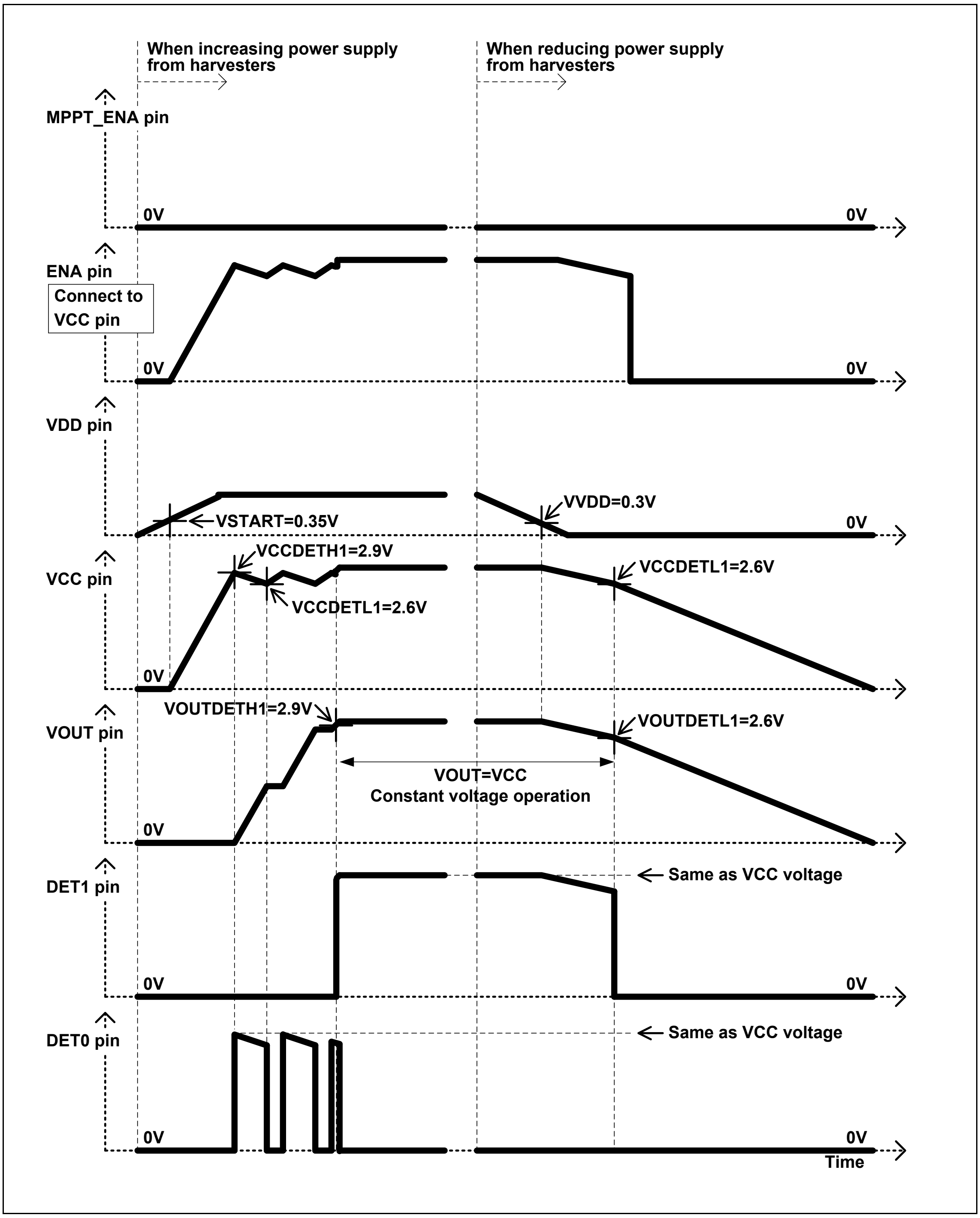
In order to operate the charge mode, it is necessary to set MPPT_ENA = L and ENA = H. MPPT_ENA pin is connected to GND, and ENA pin is connected to VCC pin.

When 0.35 V (Minimum input voltage at start-up: VSTART) or higher voltage is applied to the VDD pin, the start-up circuit activates charging the VCC capacitor C2 (see Figure 6-1). When the VCC reaches 2.9 V (upper threshold of VCC detection voltage 1: VCCDETH1), the operation of the start-up circuit stops, then the DC/DC converter activates charging the VOUT capacitor C3 (see Figure 6-1). While the DC/DC converter is continuously operated, charging the VOUT capacitor C3 to the preset voltage setting by S2, S1, and S0 pins is performed.

When the VCC reaches less than 2.6 V (lower threshold of VCC detection voltage 1: VCCDETL1) by the internal consumption current, the start-up circuit operates again, and this sequence is repeated until the VOUT becomes 2.9V (upper threshold of VOUT detection voltage 1: VOUTDETH1). When the VOUT reaches 2.9 V (upper threshold of VOUT detection voltage 1: VOUTDETH1), the internal switch SW1 (see Figure 6-1) between VCC and VOUT is turned on, and then the VCC and the VOUT are connected internally.

When the VDD falls and reaches 0.3V (Min. value of VDD input voltage: VVDD) or less, the charging ability into the VOUT capacitor C3 decreases. After that the VOUT voltage reaches 2.6V (lower threshold of VOUT detection voltage 1: VOUTDETL1) or the VCC voltage reaches 2.6V (lower threshold of VCC detection voltage 1: VCCDETL1), and then the internal switch SW1 between VCC and VOUT is turned off, and the VCC and the VOUT are disconnected internally.

Figure 10-1 Start-up/shut-down sequences of constant voltage mode (MPPT_ENA=L, ENA=H)



Charge mode: MPPT_ENA = H, ENA = H

In order to operate the charge mode, it is necessary to set MPPT_ENA = H and ENA = H. Both MPPT_ENA and ENA are connected to the VCC pin, and a Li-ion battery should be connected to the VOUT pin to make the VOUT ≧2.6V(upper threshold of VOUT detection voltage 2: VOUTDETH2).

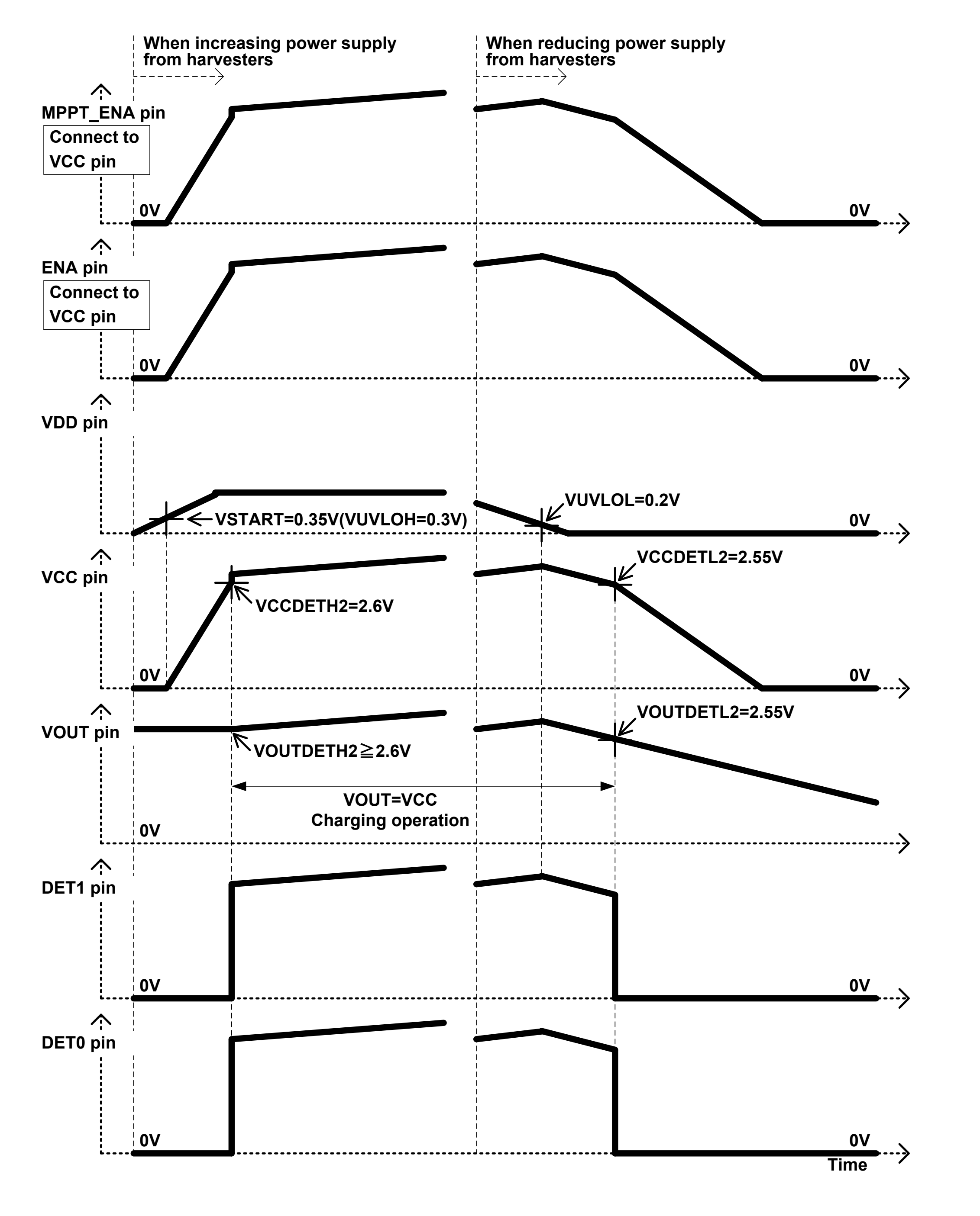
When 0.35 V (Minimum input voltage at start-up: VSTART) or higher voltage is applied to the VDD pin, the start-up circuit activates charging the VCC capacitor C2 (see Figure 6-1). When the VCC reaches 2.6 V (upper threshold of VCC detection voltage 2: VCCDETH2) and the VOUT is higher than 2.6 V (upper threshold of VOUT detection voltage 2: VOUTDETH2), the operation of the start-up circuit stops and the internal switch SW1 (see Figure 6-1) between VCC and VOUT is turned on. Then the DC/DC converter activates charging the Li-ion battery (see Figure 6-1), and the MPPT control starts at the same time. While the DC/DC converter is continuously operated, the voltage of VDD is controlled to the MPPT value setting by S0, S1, and S2 pins. (For more detail, refer to Chapter 10.3).

When the voltage of the Li-ion battery reaches 4V (upper threshold of VOUT detection voltage 3: VOUTDETH3), the charging of the Li-ion battery stops. When the voltage of the Li-ion battery drops and reaches 3.7V (lower threshold of VOUT detection voltage 3: VOUTDETL3), the charging of the Li-ion battery starts again.

When the VDD voltage drops and reaches 0.3V (upper threshold of UVLO detection voltage: VUVLOH) or less, the charging ability into the Li-ion battery decreases. Thereafter, when the VDD voltage drops and reaches 0.2V (lower threshold of UVLO detection voltage: VUVLOL), the operation of the DC/DC converter stops.

The VOUT voltage reaches 2.55V (lower threshold of VOUT detection voltage 2: VOUTDETL2) or the VCC voltage reaches 2.55V (lower threshold of VCC detection voltage 2: VCCDETL2, and then the internal switch SW1 between VCC and VOUT is turned off, and the VCC and the VOUT are disconnected internally to protect the Li-ion battery from an over-discharge.

Figure 10-2 Start-up/shut-down sequences (Charge mode: MPPT_ENA = H, ENA=H)



10.3 MPPT control

MPPT setting

In general, the voltage of a solar cell varies depending on the load current. 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 the release voltage is defined as the MPPT setting.

In the charge mode, the input voltage (VIN) is adjusted and the DC/DC converter operates while tracking the MPPT value setting by the S2, S1 and S0 pins.

When in use, set the MPPT value after confirming the voltage dependency of the solar cell power.

MPPT control

When setting the charge mode, the internal pulse frequency is determined by the values of the capacitors C5/C6 and C7/C8 (see Figure 6-1), which are connected to the CSH1 pin, and the CSH2 pin.

During the period of high level of the internal pulse setting by the capacitors C5/C6 connected to the CHS1 pin, the release voltage is measured. The capacitors C5/C6 latch the measured voltage level, the release voltage.

During the period of low level of the internal pulse setting by the capacitors C7/C8 connected to the CSH2 pin, the charge current is determined in order to make the VDD pin's voltage equal to the MPPT setting voltage, then the charging operation starts up. The MPPT setting voltage is calculated by the following equation.

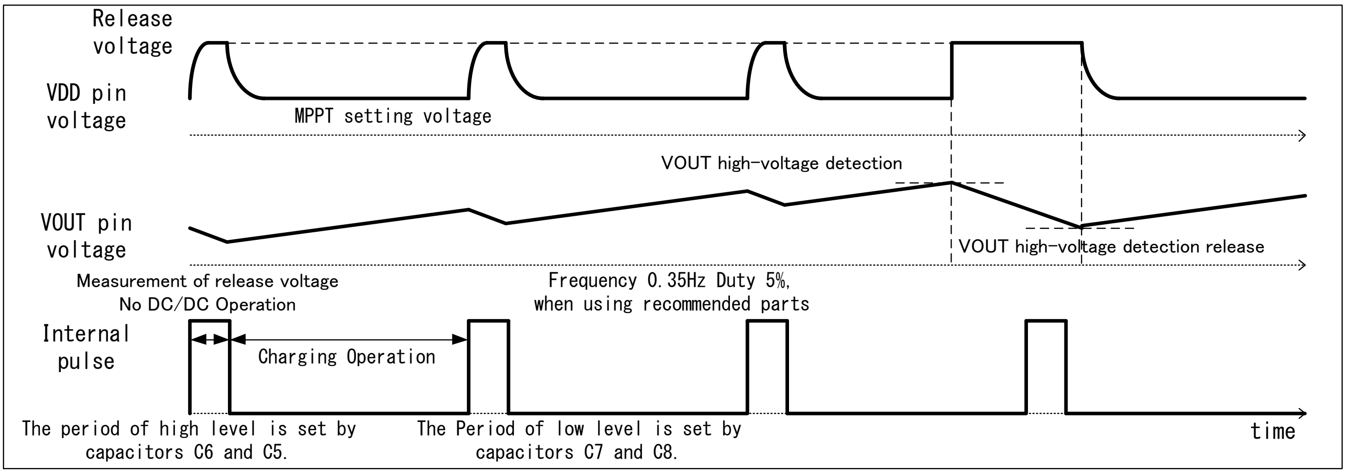
$$\text{MPPT setting voltage} = \text{Release voltage} \times \text{MPPT value}$$ (refer to Table 10-3 MPPT control)

When using the recommended pars, the frequency is set to 0.35Hz with 5% duty.

If not using the recommended parts, please be aware of the following points.

1. In general, laminated capacitances have leak current. If the inside pulse cycle setting by the capacitors C7/C8 were set too long, the voltage level of the capacitors C5/C6 would drop. There is a possibility that the MPPT value cannot be set correctly.
2. If the period of high level of inside pulse is set too short, setting by the capacitors C5/C6, the MPPT value cannot be set correctly due to a lack of the measurement time of the release voltage.

Figure 10-3 MPPT control



10.4 Function description

Mode control

The mode is controlled by the MPPT_ENA pin. There are the charge mode and constant voltage mode, which also determine the presence or absence of The MPPT, the UVLO, the VDD detecting, the VCC detecting, and the VOUT detecting functions. Set the MPPT_ENA pin according to an application.

The DC/DC operation is controlled by the ENA pin.

Table 10-1 Mode control

Input signal		Internal control		Function		
MPPT_ENA pin	ENA pin	Mode stage	Stage	MPPT, UVLO	VCC detection 1 & 2, VOUT detection 1 & 2	VOUT detection 3, VOUT-VDD voltage reverse detection
L	L	Constant voltage	VOUT output stop	OFF	ON	OFF
	H		VOUT output enabled	OFF	ON	OFF
H	L	Charge	Charge stop	OFF	ON	ON
	H		Charge enabled	ON	ON	ON

Changing setting method of preset output voltage & MPPT setting

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

The preset output voltage can be set in the constant voltage mode, set the MPPT_ENA = L and the ENA =H, and then set it by the S2, S1, and S0 pins.

The MPPT value can be set in the charge mode, set the MPPT_ENA = H and the ENA =H, and then set it by the S2, S1, and S0 pins.

Table 10-2 Changing preset output voltage in constant voltage mode (MPPT_ENA = L, ENA = H)

Input signal					Control
MPPT_ENA pin	ENA pin	S2 pin	S1 pin	S0 pin	Preset output voltage (V)
L	H	L	L	L	3
		L	L	H	3.3
		L	H	L	3.6
		L	H	H	4.1
		H	L	L	4.5
		H	L	H	5
		H	H	L	Setting prohibited
		H	H	H	Setting prohibited

Table 10-3 Changing MPPT setting in charge mode (MPPT_ENA = H, ENA = H)

Input signal					Control
MPPT_ENA pin	ENA pin	S2 pin	S1 pin	S0 pin	MPPT values
H	H	L	L	L	50%
		L	L	H	55%
		L	H	L	60%
		L	H	H	65%
		H	L	L	70%
		H	L	H	75%
		H	H	L	80%
		H	H	H	85%

VCC detection 1 and 2 (VCC detection voltage 1 and 2)

This function works with both the constant voltage mode (MPPT_ENA =L) and the charge mode (MPPT_ENA =H).

The main purpose of the VCC detection 1 and 2 is to stop the charging of the VOUT capacitor C3 or Li-ion battery, when the VCC voltage becomes low.

When the VCC voltage becomes higher than the upper threshold of the VCC detection voltage 1 and 2 (VCCDETH1 = 2.9V or VCCDETH2=2.6V), The DC/DC converter operation is started and then the internal switch SW1 between VCC and VOUT is turned on.

Since the VCC detection 1 and 2 have the hysteresis, the VCC detection state has been kept until the VCC voltage becomes the lower threshold of the VCC detection voltage (VCCDETL1 = 2.6V or VCCDETL2=2.55V) or less.

VOUT detection 1 and 2 (VOUT detection voltage 1 and 2)

This function works with both the constant voltage mode (MPPT_ENA =L) and the charge mode (MPPT_ENA =H).

The main purpose of the VOUT detection 1 and 2 is to stop the charging of the VOUT capacitor C3 or Li-ion battery, when the VOUT voltage becomes low.

When the VOUT voltage becomes higher than the upper threshold of the VOUT detection voltage (VOUTDETH1 = 2.9V or VOUTDETH2=2.6V), The DC/DC converter operation is started and then the internal switch SW1 between VCC and VOUT is turned on.

Since the VOUT detection 1 and 2 have the hysteresis, the VOUT detection state has been kept until the VOUT voltage becomes the lower threshold of the VOUT detection voltage (VOUTDETL1 = 2.6V or VOUTDETL2 = 2.55V) or less.

VOUT detection 3 (VOUT detection voltage 3)

This function works with the charge mode (MPPT_ENA =H).

The main purpose of the VOUT detection 3 is to stop the charging of the Li-ion battery, when the VOUT voltage becomes high.

When the VOUT voltage becomes higher than the upper threshold of the VOUT detection voltage 3 (VOUTDETH3 = 4V), The DC/DC converter operation stop.

Since the VOUT detection 3 has the hysteresis, the VOUT detection 3 state has been kept until the VOUT voltage becomes the lower threshold of the VOUT detection voltage 3 (VOUTDETL3 = 3.7V) or less.

UVLO (VDD detection)

This function works with the charge mode (MPPT_ENA =H).

The main purpose of the UVLO is to stop the circuit operation when the VDD voltage becomes low.

When the VDD voltage becomes higher than the upper threshold of the UVLO detection voltage (VDDDETH = 0.3V), the DC/DC converter operation is started.

Since the UVLO has the hysteresis, the UVLO state has been kept until the VDD voltage becomes the lower threshold of the UVLO (VUVLOL = 0.2V) or less.

VOUT-VDD Voltage Reverse detection

This function works with the charge mode (MPPT_ENA =H).

The main purpose of the VOUT-VDD voltage reverse detection is to stop the charging of the Li-ion battery, when the VDD voltage becomes higher than the VOUT voltage.

When the VDD voltage becomes higher than the VOUT voltage, the DC/DC converter operation stops.

State notification

This function is independent of the MPPT_ENA setting.

The VCC voltage stage, the VOUT voltage state, and the VOUT-VDD voltage reverse state are notified by the DET[1:0] signals.

The state notification is not a power good function.

Table 10-4 Stage notification of constant voltage mode (MPPT_ENA = L, ENA = H)

Output signal		State
DET1 pin	**DET0 pin**	**Constant voltage mode (MPPT_ENA = L, ENA = H)**
L	L	During start-up
L	H	During start-up
H	L	Normal operation
H	H	During start-up

Table 10-5 Stage notification of charge mode (MPPT_ENA = H, ENA = H)

Output signal		State
DET1 pin	**DET0 pin**	**Charge mode (MPPT_ENA = H, ENA = H)**
L	L	During start-up: VCC voltage is less than Or Abnormal stage: Stage that VOUT does not reach 2.6V
L	H	Abnormal stage: Stage that VDD voltage is higher than VOUT voltage (VOUT < VDD) (*1)
H	L	Abnormal stage: During the period VOUT drop from 4V to 3.7V, after VOUT reach VOUT detection voltage 3 (VOUTDETH3 = 4V) (*2)
H	H	Normal operation

*1: DET[1:0]=[L:L] has the highest priority.

*2: DET[1:0]=[L:H] has the highest priority.

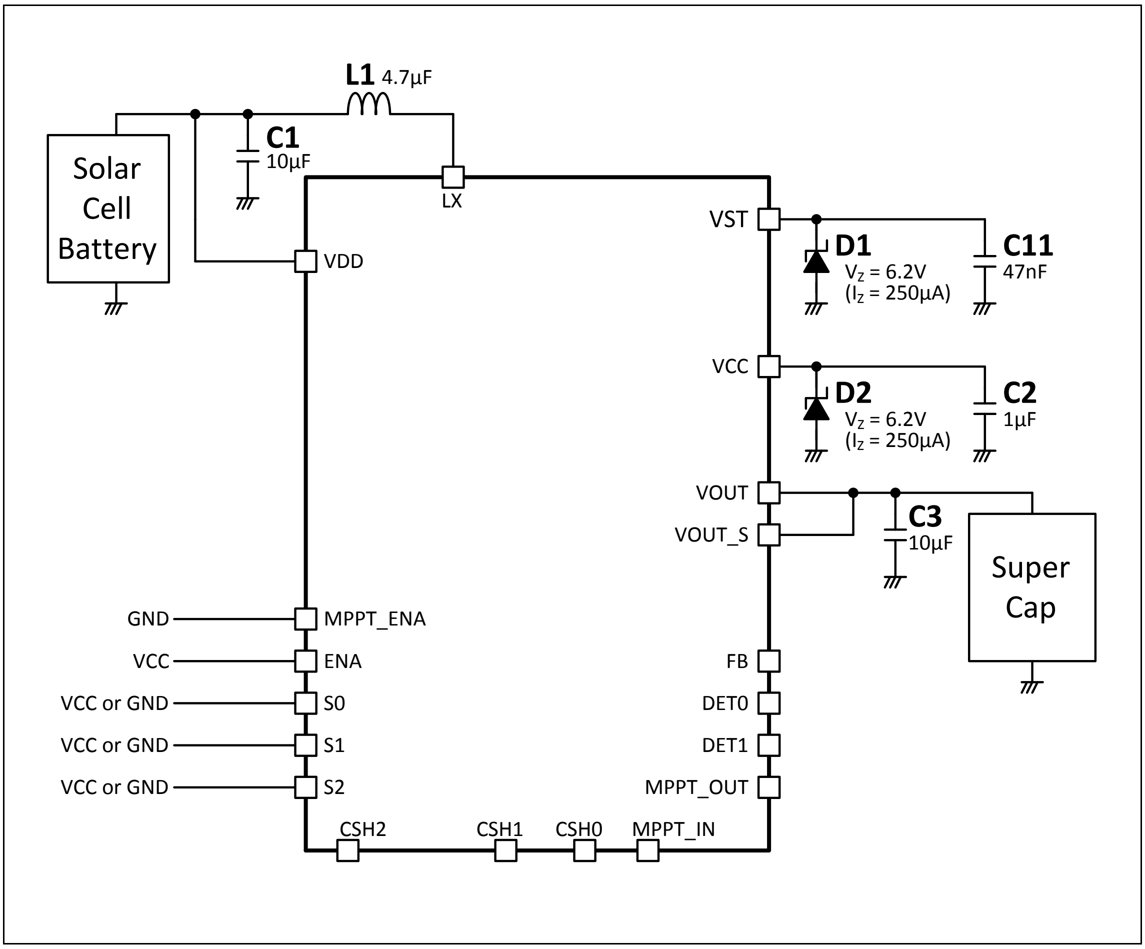
Boost DC/DC converter

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.

11. Typical Applications Circuit

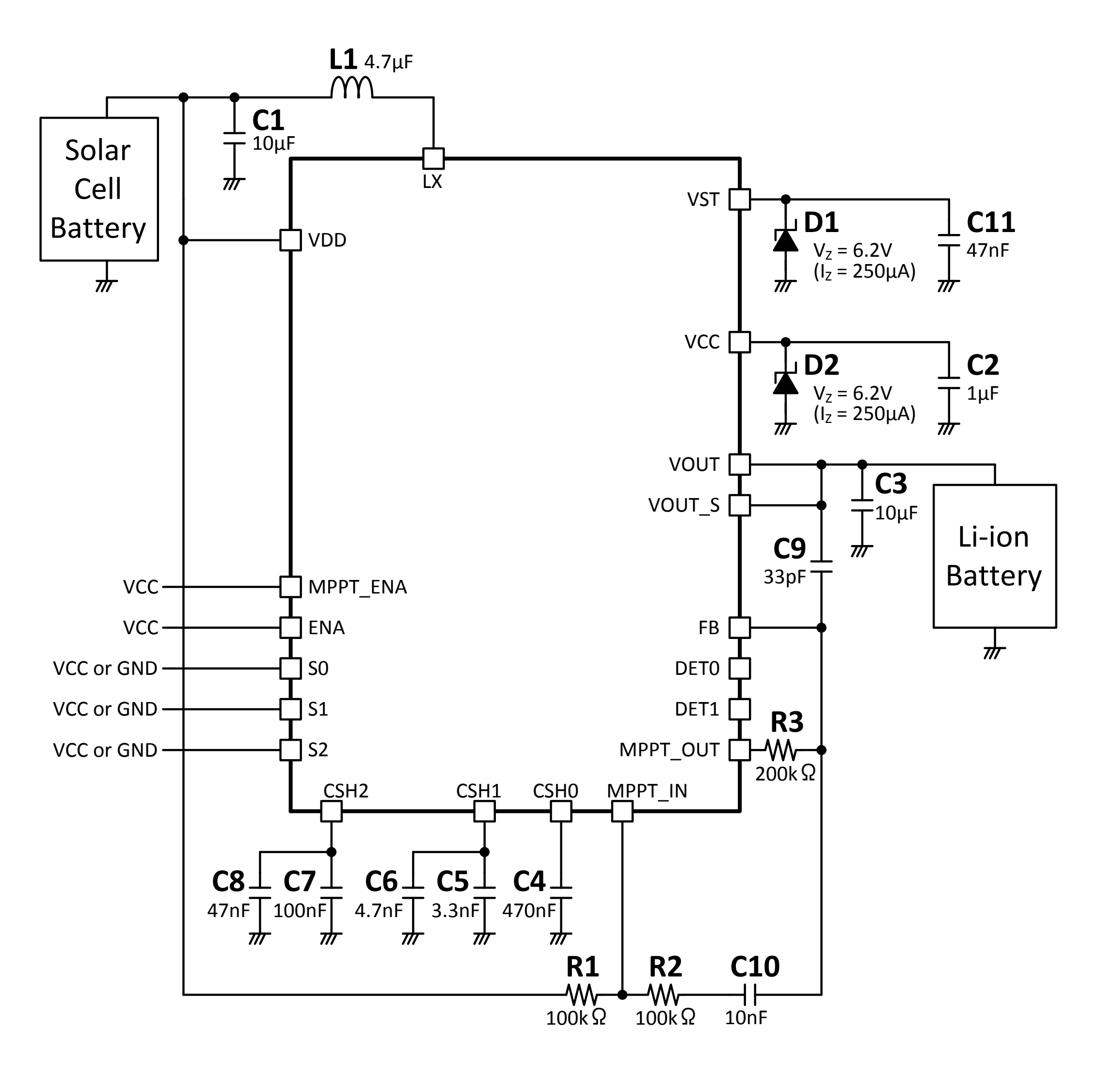
Constant voltage mode

Figure 11-1 Application circuit of constant voltage mode (MPPT_ENA = L, ENA = H)



Charge mode

Figure 11-2 Application circuit of charge mode (MPPT_ENA = H, ENA = H)



Parts list

Table 11-1 Parts list

Part number	Value	Description
C1	10μF	Capacitor
C2	1μF	Capacitor
C3	10μF	Capacitor
C4	470nF	Capacitor
C5	3.3nF	Capacitor
C6	4.7nF	Capacitor
C7	100nF	Capacitor
C8	47nF	Capacitor
C9	33pF	Capacitor
C10	10nF	Capacitor
C11	47nF	Capacitor
R1	100kΩ	Resistor
R2	100kΩ	Resistor
R3	200kΩ	Resistor
L1	4.7μH	Inductor
D1	V_Z=6.2V (L_Z=250μA)	Zener diode
D2	V_Z=6.2V (L_Z=250μA)	Zener diode

12. Application Notes

Inductor

The MB39C831 is optimized to work with an inductor in the range of 4.7µH. Also, since the peak switching current is up to 200mA, select an inductor with a DC current rating greater than 200mA.

Harvester (Photovoltaic power generator)

In case of photovoltaic (or solar) energy harvesting, use a solar cell with an open-circuit voltage less than 4.75V and the preset output voltage. Electric power obtained from a solar or light is increased in proportion to the ambient illuminance. Silicone-based solar cells are single crystal silicon solar cell, polycrystalline silicon solar cell, and amorphous silicon solar cell. Organic-based solar cells are dye-sensitized solar cell (DSC), and organic thin film solar cell. Crystal silicon and polycrystalline silicon solar cells have high energy conversion efficiency. Amorphous silicon solar cells are lightweight, flexible, and produced at low cost. Dye-sensitized solar cells are composed by sensitizing dye and electrolytes, and are low-cost solar cell. Organic thin film solar cells are lightweight, flexible, and easily manufactured.

Harvester (Temperature difference power generator)

Temperature difference power generators produce electric power keeping temperature difference between the high temperature side and the low temperature side. The temperature difference power generators include the peltier elements utilizing the Seebeck effect and thermopiles that made of thermocouples in series or in parallel.

Sizing of input and output capacitors

Energy from harvester should be stored on the Cin and Cout to operate the application block. If the size of these capacitors were too big, it would take too much time to charge energy into these capacitors, and the system cannot be operated frequently. On the other hand, if these capacitors were too small, enough energy cannot be stored on these capacitors for the application block. The sizing of the Cin and Cout is important.

Common capacitors are layered ceramic capacitor, electrolytic capacitor, electric double layered capacitor, and so on. Electrostatic capacitance of layered ceramic capacitors is relatively small. However, layered ceramic capacitors are small and have high voltage resistance characteristic. Electrolytic capacitors have high electrostatic capacitance from µF order to mF order. The size of capacitor becomes large in proportion to the size of capacitance. Electric double layered capacitors have high electrostatic capacitance around 0.5F to 1F, but have low voltage resistance characteristics around 3V to 5V. Be very careful with a voltage resistance characteristic. Also, leak current, equivalent series resistance (ESR), and temperature characteristic are criteria for selecting,

First of all, apply the following equation and calculate energy consumption for an application from voltage, current, and time during an operation.

$$E_{Appli.}[J] = V_{Appli.} \times I_{Appli.} \times t_{Appli.}$$

The energy stored on a capacitor is calculated by the following equation.

$$E_c[J] = \frac{1}{2}CV^2$$

Since the energy in a capacitor is proportional to the square of the voltage, it is energetically advantageous for the boost DC/DC converter, the input voltage, is less than the output voltage, to make the Cout larger.

An example of an application using the power gating by the DET1 signals is shown in the Figure 12-1. The Cin and the Cout are sized so as to satisfy the following equation. The η, the efficiency of the MB39C831, is determined from the current of application and the graph shown in Figure 13-1, Efficiency vs IOUT.

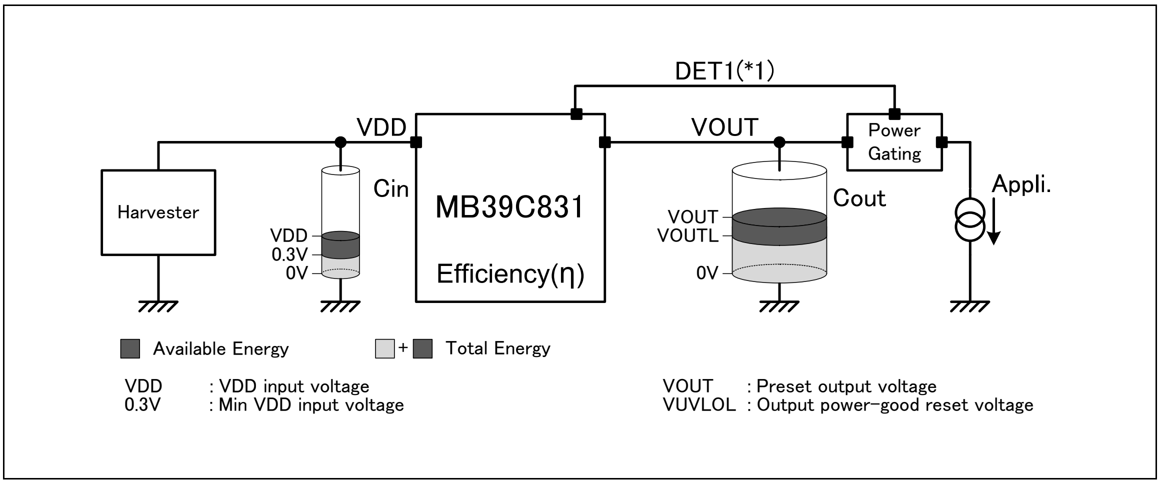
$$\mathrm{E_{Appli.}} \leq \mathrm{dE_{Cin}} \times \eta + \mathrm{dE_{Cout}}$$

dE_{Cin} and dE_{Cout} are the available energies for the application.

$$\mathrm{dE_{Cin}[J]} = \frac{1}{2}\mathrm{Cin}(\mathrm{VDD}^2 - 0.3^2)$$

$$\mathrm{dE_{Cout}[J]} = \frac{1}{2}\mathrm{Cout}(\mathrm{VOUT}^2 - \mathrm{VOUTL}^2)$$

Figure 12-1 Application example using the power gating



*1: When the output voltage settings are 3V or 3.3V, the DET1 signal can be used as a power good signal.

Before calculating the initial charging time ($T_{Initial}$), calculate the total energy (E_{Cin} and E_{Cout}) stored on both Cin and Cout.

$$\mathrm{E_{Cout}[J]} = \frac{1}{2}\mathrm{Cin} \times \mathrm{VDD}^2$$

$$\mathrm{E_{Cout}[J]} = \frac{1}{2}\mathrm{Cout} \times \mathrm{VOUT}^2$$

A $P_{Harvester}$ is a power generation capability of a harvester. An initial charging time ($T_{Initial}$) is calculated by the following equation.

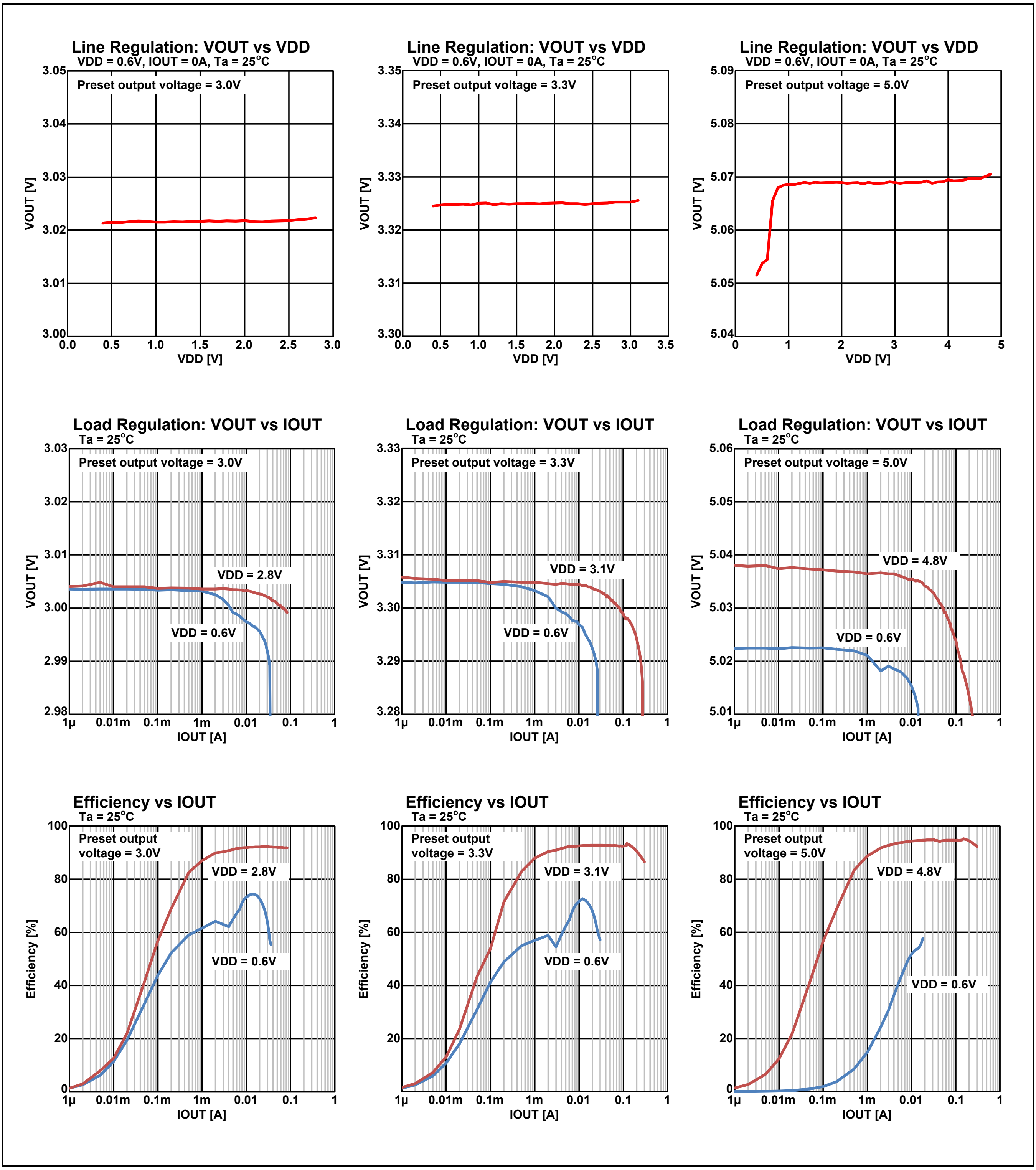
$$\mathrm{T_{Initial}} = \frac{\mathrm{E_{Cin}}}{\mathrm{P_{Harvester}}} + \frac{\mathrm{E_{Cout}}}{\mathrm{P_{Harvester}} \times \eta}$$

An repeat charging time (T_{Repeat}) is calculated by the following equation. The T_{Repeat} become shorter than $T_{Initial}$.

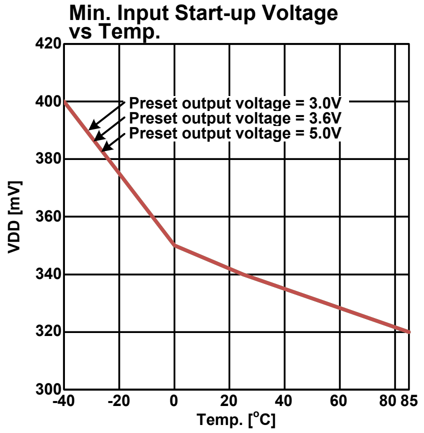
$$\mathrm{T_{Repeat}} = \frac{\mathrm{dE_{Cin}}}{\mathrm{P_{Harvester}}} + \frac{\mathrm{dE_{Cout}}}{\mathrm{P_{Harvester}} \times \eta}$$

13. Typical Characteristics

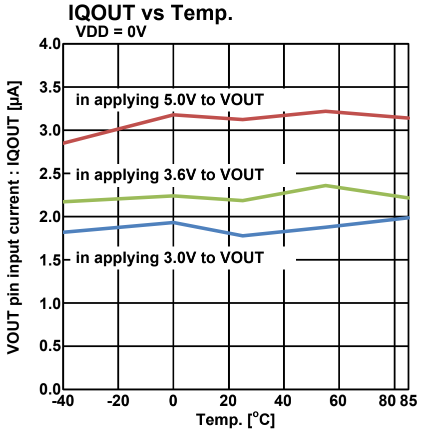
Figure 13-1 Typical characteristics of constant voltage mode (MPPT_ENA = L, ENA = H)



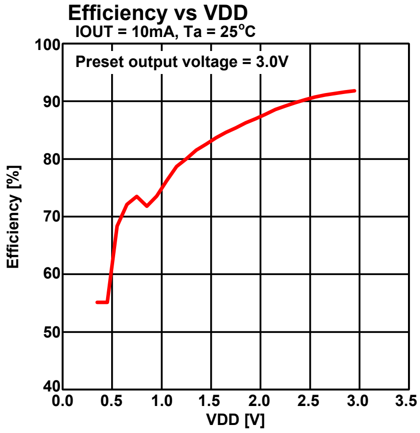
Min. Input Start-up Voltage vs Temp.



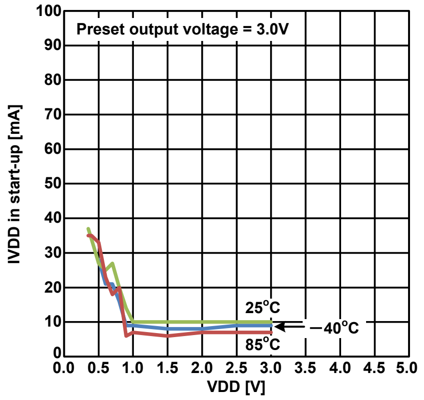
IQOUT vs Temp.



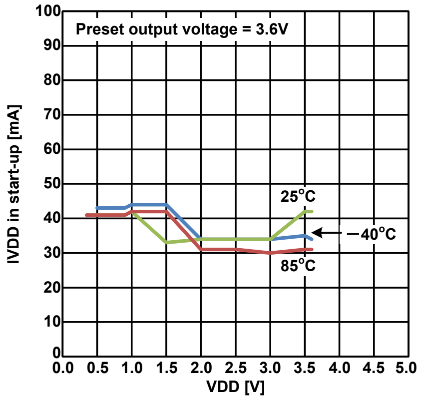
Efficiency vs VDD



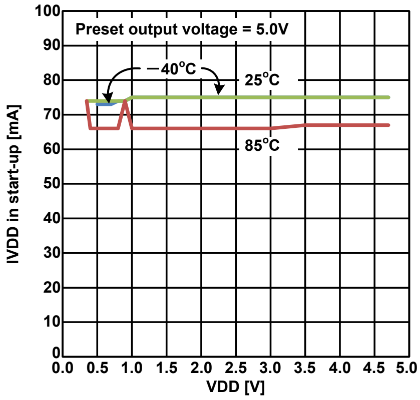
IVDD in start-up vs VDD



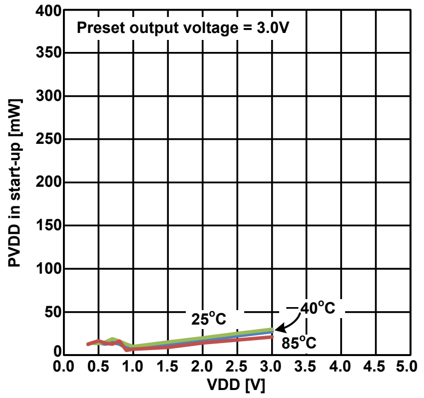
IVDD in start-up vs VDD



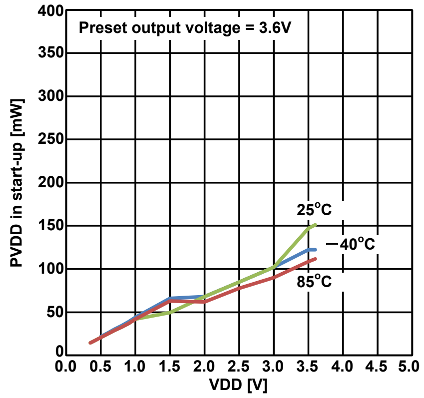
IVDD in start-up vs VDD



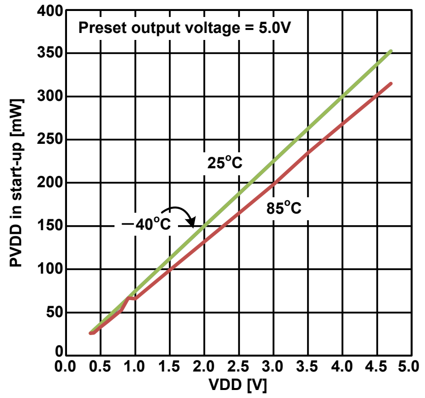
PVDD in start-up vs VDD

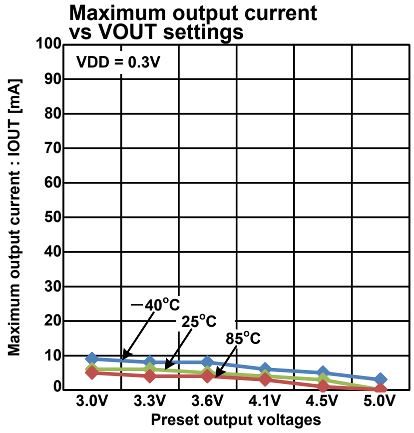


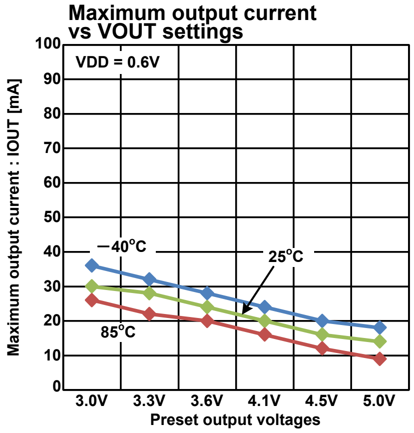
PVDD in start-up vs VDD

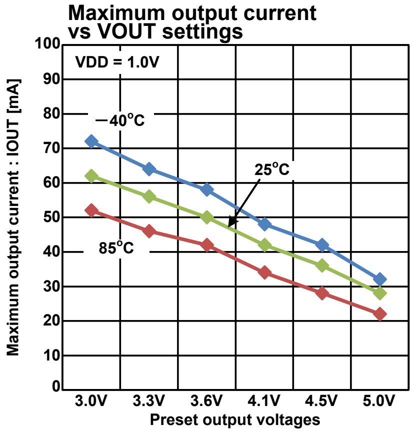


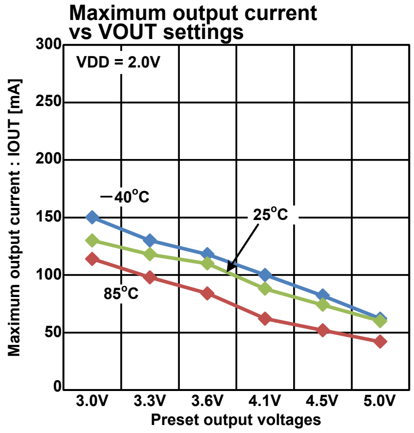
PVDD in start-up vs VDD

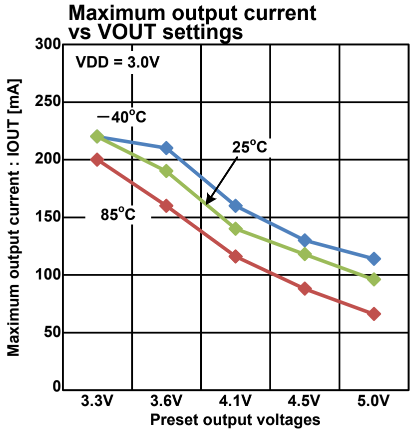


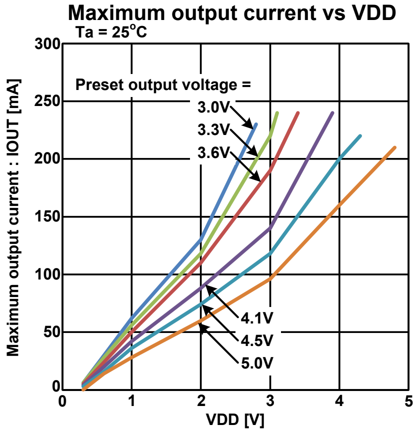

Maximum output current
vs VOUT settings
VDD = 0.3V
−40°C
25°C
85°C
Maximum output current : IOUT [mA]
Preset output voltages
3.0V
3.3V
3.6V
4.1V
4.5V
5.0V

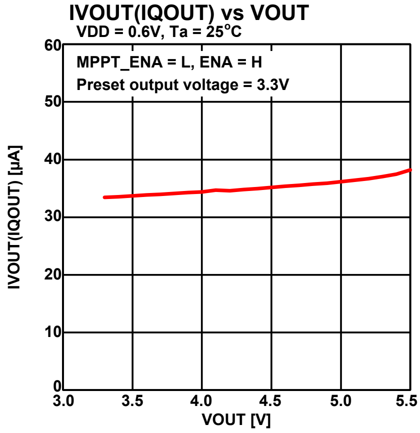

Maximum output current
vs VOUT settings
VDD = 0.6V
−40°C
25°C
85°C
Maximum output current : IOUT [mA]
Preset output voltages

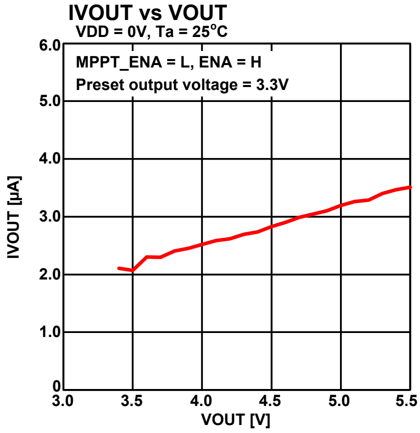

Maximum output current
vs VOUT settings
VDD = 1.0V
−40°C
25°C
85°C
Maximum output current : IOUT [mA]
Preset output voltages


Maximum output current
vs VOUT settings
VDD = 2.0V
−40°C
25°C
85°C
Maximum output current : IOUT [mA]
Preset output voltages


Maximum output current
vs VOUT settings
VDD = 3.0V
−40°C
25°C
85°C
Maximum output current : IOUT [mA]
Preset output voltages


Maximum output current vs VDD
Ta = 25°C
Preset output voltage =
3.0V
3.3V
3.6V
4.1V
4.5V
5.0V
Maximum output current : IOUT [mA]
VDD [V]


IVOUT(IQOUT) vs VOUT
VDD = 0.6V, Ta = 25°C
MPPT_ENA = L, ENA = H
Preset output voltage = 3.3V
IVOUT(IQOUT) [µA]
VOUT [V]


IVOUT vs VOUT
VDD = 0V, Ta = 25°C
MPPT_ENA = L, ENA = H
Preset output voltage = 3.3V
IVOUT [µA]
VOUT [V]

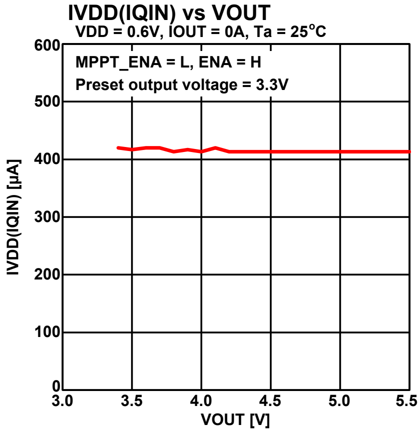

IVDD(IQIN) vs VOUT
VDD = 0.6V, IOUT = 0A, Ta = 25°C
MPPT_ENA = L, ENA = H
Preset output voltage = 3.3V
IVDD(IQIN) [µA]
VOUT [V]

Figure 13-2 Switching waveforms of constant voltage mode (MPPT_ENA = L, ENA = H)

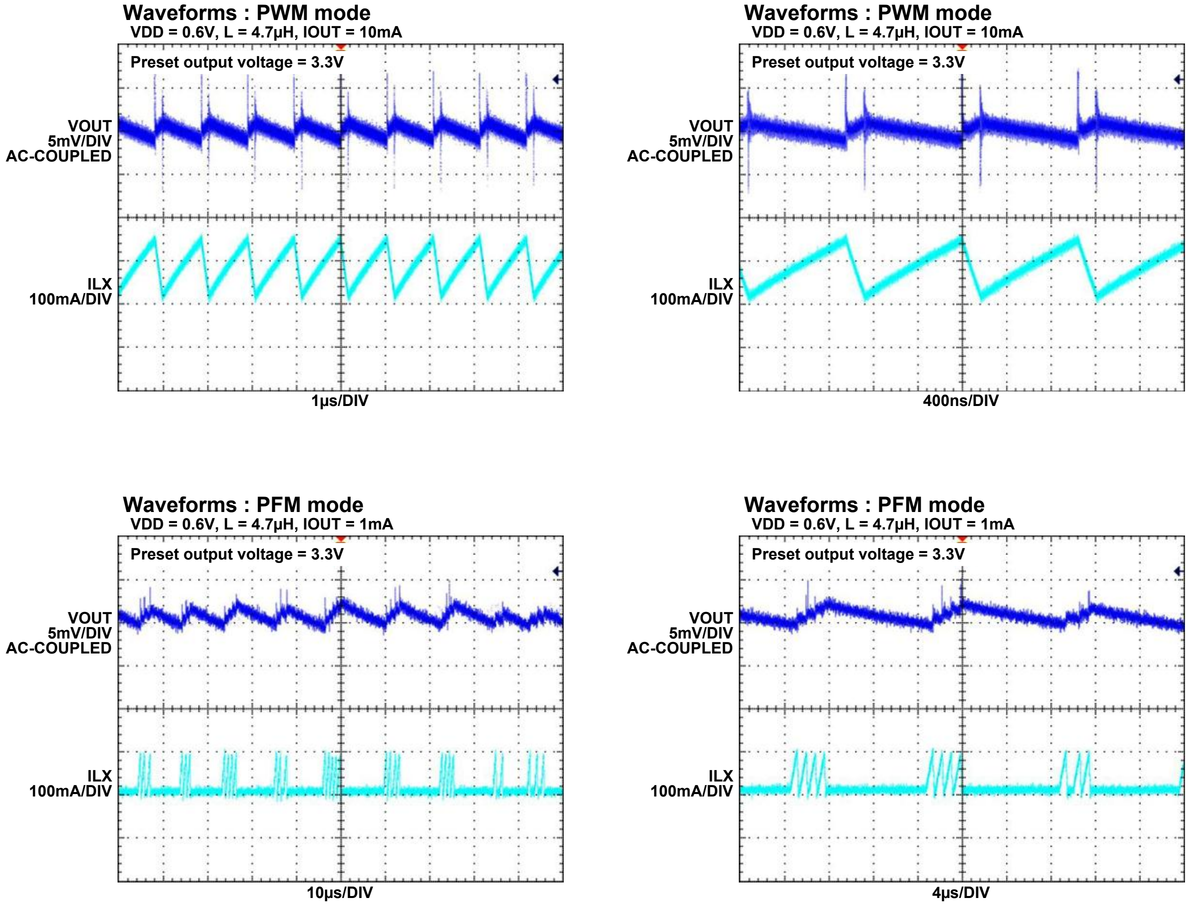


Figure 13-3 Typical characteristics of charge mode (MPPT_ENA = H, ENA = H)

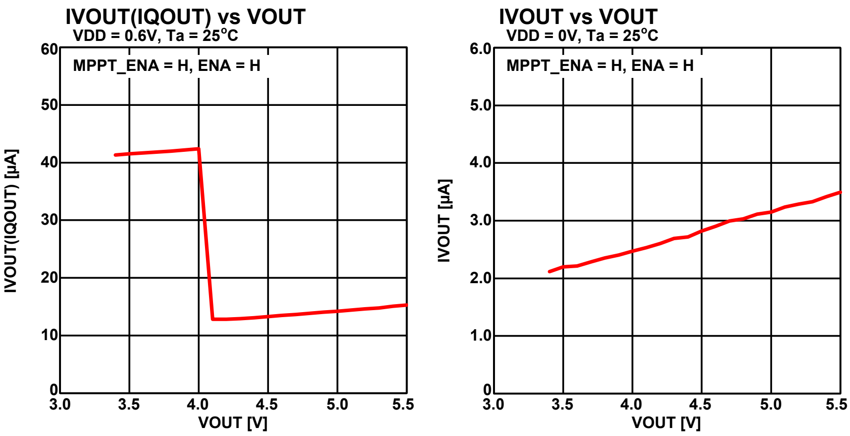
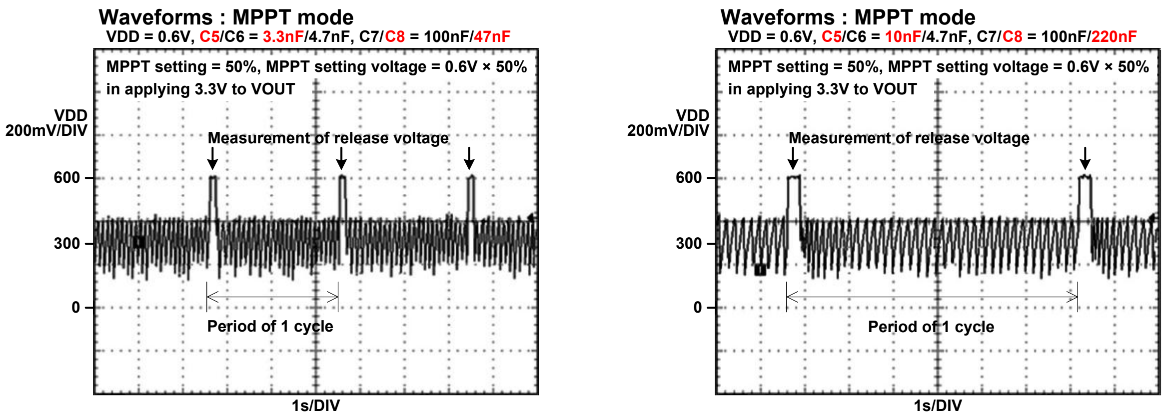


Figure 13-4 Waveforms of VDD pin voltage in charge mode (MPPT_ENA = H, ENA = H)



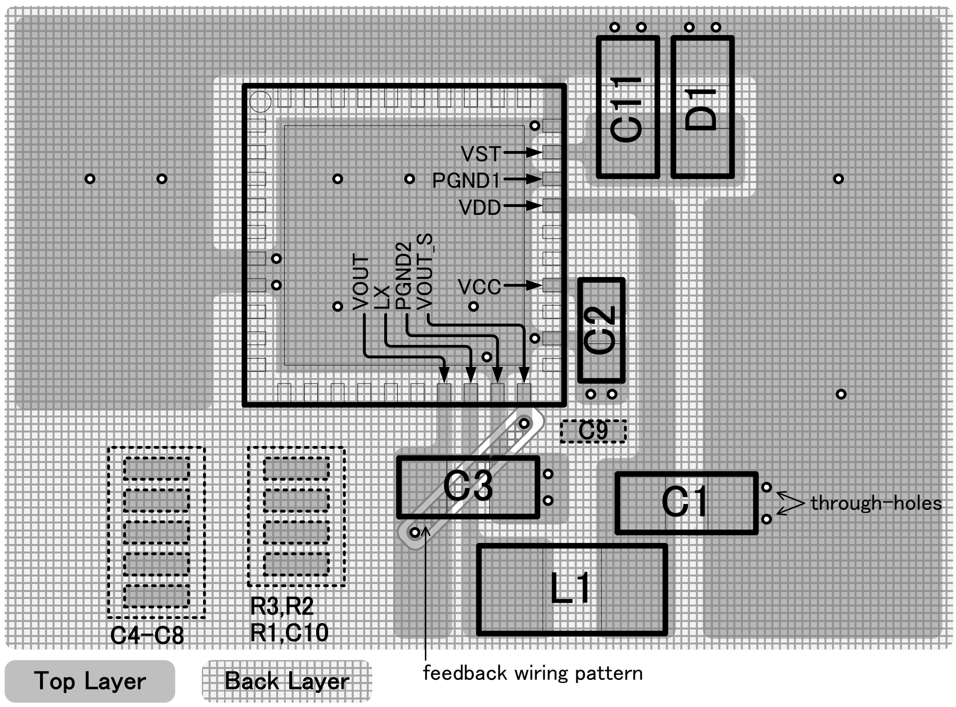
14. Layout for Printed Circuit Board

Note the points listed below in layout design

- Place the switching parts(*1) on top layer, and avoid connecting each other through through-holes.
- Make the through-holes connecting the ground plane close to the GND pins of the switching parts(*1).
- Be very careful about the current loop consisting of the output capacitor C3, the VOUT pin of IC, and the PGND2 pin. Place and connect these parts as close as possible to make the current loop small.
- The input capacitor C1 and the inductor L1 are placed adjacent to each other.
- Place the bypass capacitor C11 close to VST pin, and make the through-holes connecting the ground plane close to the GND pin of the bypass capacitor C11.
- Place the bypass capacitor C2 close to VCC pin, and make the through-holes connecting the ground plane close to the GND pin of the bypass capacitor C2.
- Draw the feedback wiring pattern from the VOUT_S pin to the output capacitor C3 pin. The wiring connected to the VOUT_S pin is very sensitive to noise so that the wiring should keep away from the switching parts(*1). Especially, be very careful about the leaked magnetic flux from the inductor L1, even the back side of the inductor L1.

*1: Switching parts: IC (MB39C831), Input capacitor (C1), Inductor (L1), Output capacitor (C3). Refer to Figure 6-1.

Figure 14-1 Example of a layout design



15. Usage Precaution

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.

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.

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

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 250kΩ to 1MΩ in series between body and ground.

Do not apply negative voltages

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

16. Ordering Information

Table 16-1 Ordering information

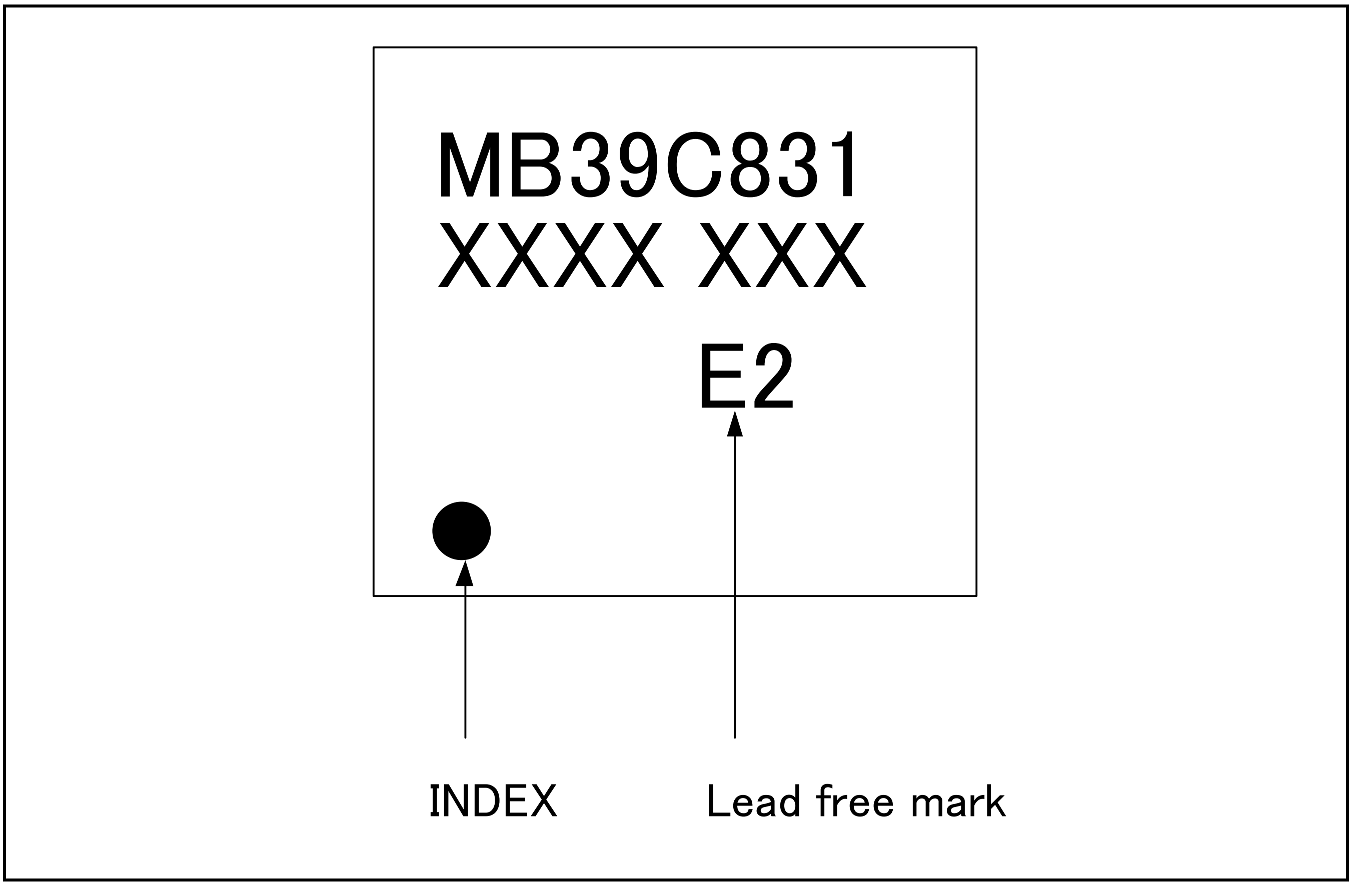
Part number	Package
MB39C831QN	40-pin plastic QFN (LCC-40P-M63)

Table 16-2 EVB Ordering information

EVB part number	EVB revision
MB39C831-EVB-02	Rev.1.0

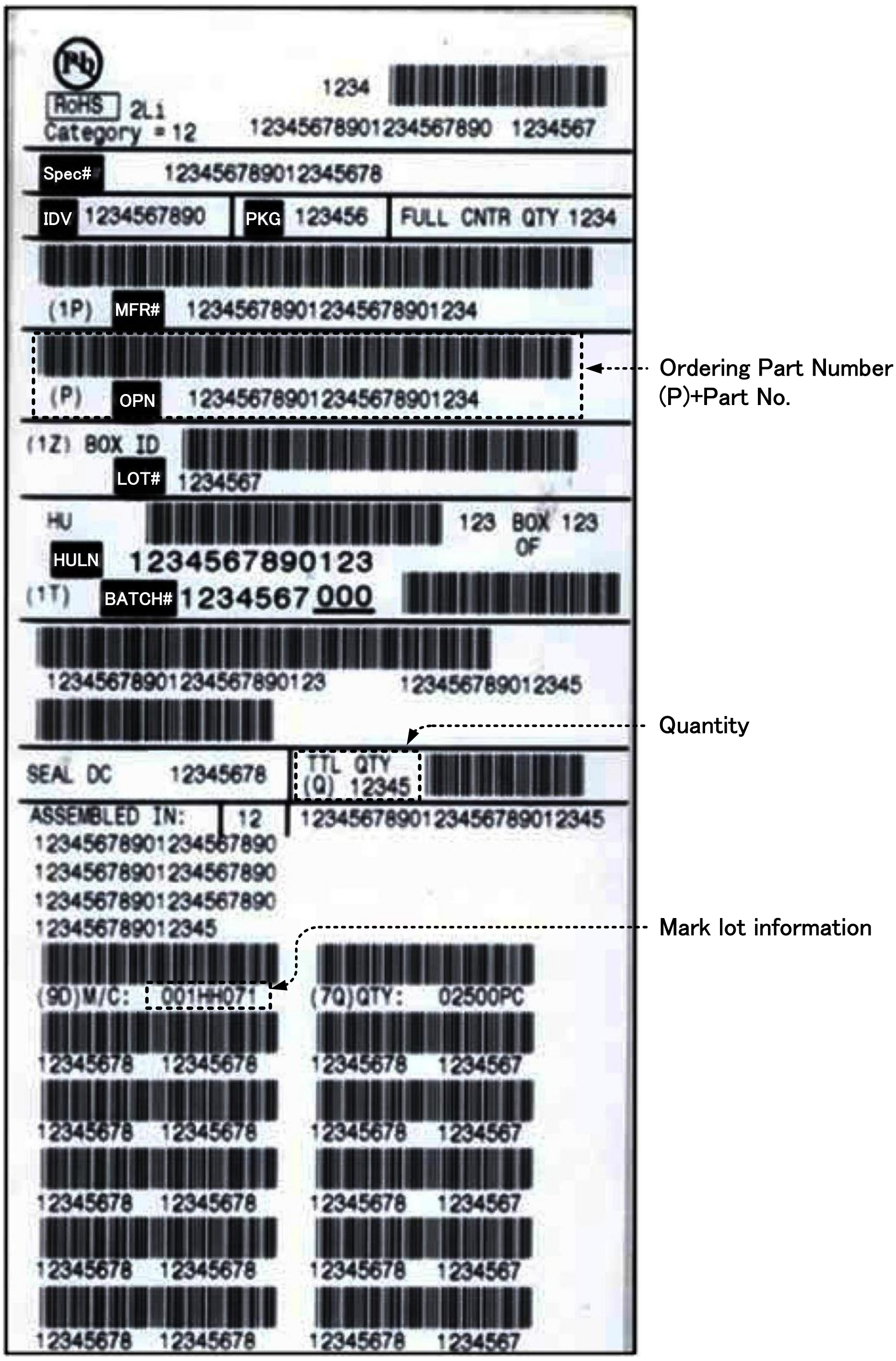
17. Marking

Figure 17-1 Marking



18. Product Label

Figure 18-1 Inner box label [Q-Pack label (4 × 8.5inch)]



Label spec : Conformable JEDEC
Barcode form : Code 39

Figure 18-2 Al bag label [2-in-1 label (4 × 8.5inch)]

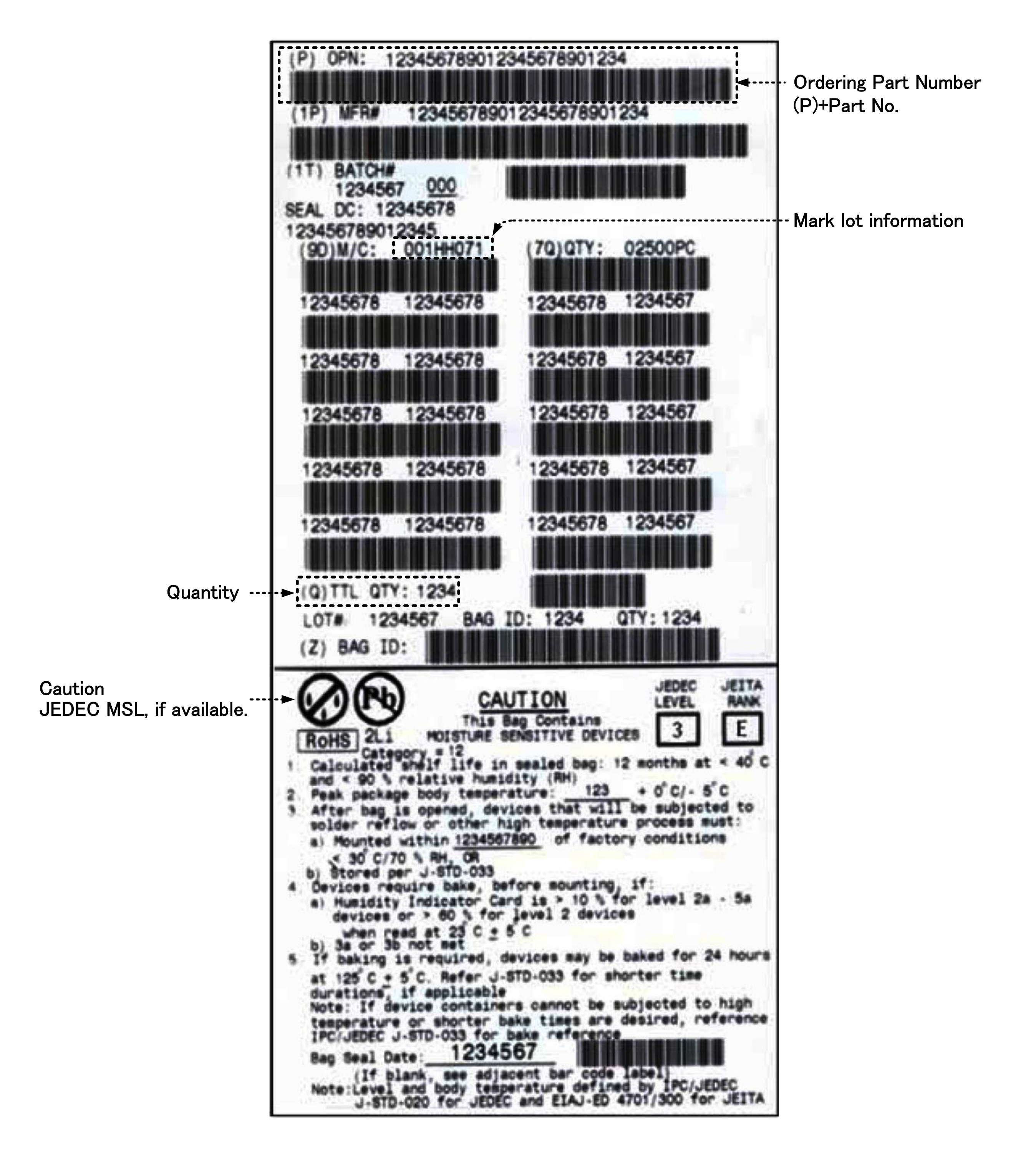


Figure 18-3 Reel label [Reel label (4 × 2.5inch)]

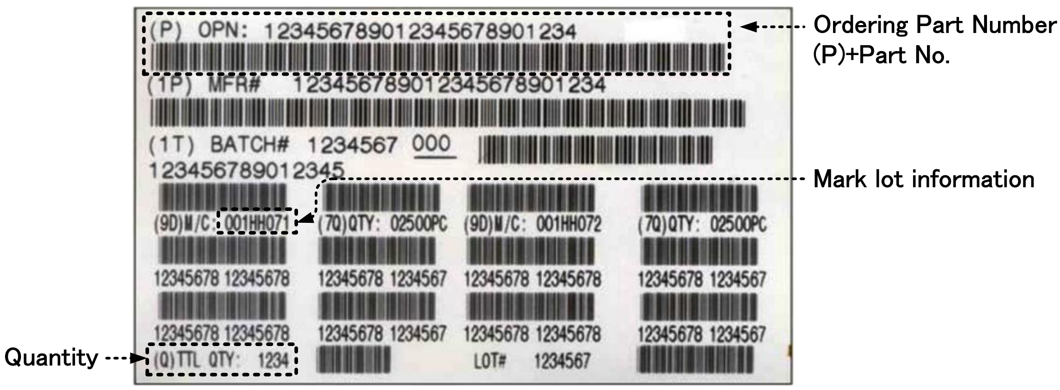
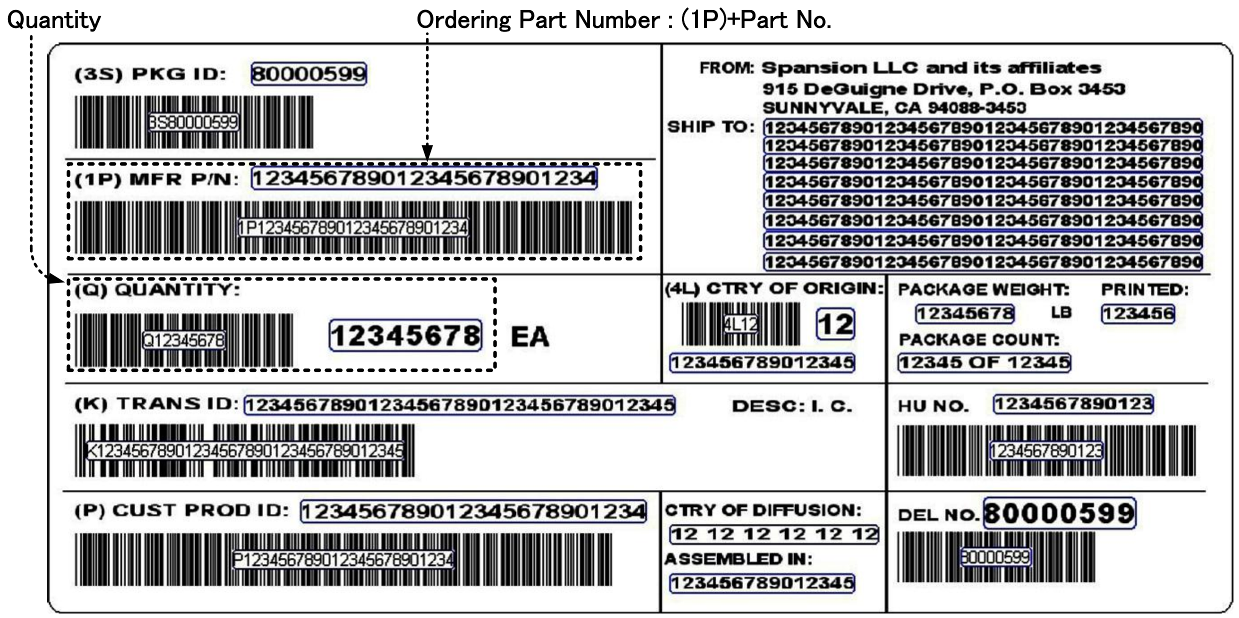


Figure 18-4 Reel label [Dry pack & Reel label (4 × 2.5inch)]

Figure 18-5 Outer box label [Shopping label (4 × 8.5inch)]



19. Recommended Mounting Conditions

Table 19-1 Recommended mounting conditions

Items	Contents	
Method	IR(Infrared Reflow) / Convection	
Times	3 times in succession	
Floor life	Before unpacking	Please use within 2 years after production.
	From unpacking to reflow	Within 7 days
	In case over period of floor life(*1)	Baking with 125°C+/-3°C for 24hrs+2hrs/-0hrs is required. Then please use within 7 days (Please remember baking is up to 2 times).
Floor life condition	Between 5°C and 30°C and also below 60%RH required. (It is preferred lower humidity in the required temp range.)	

*1: Concerning the Tape & Reel product, please transfer product to heatproof tray and so on when you perform baking. Also please prevent lead deforming and ESD damage during baking process.

Figure 19-1 Recommended mounting conditions

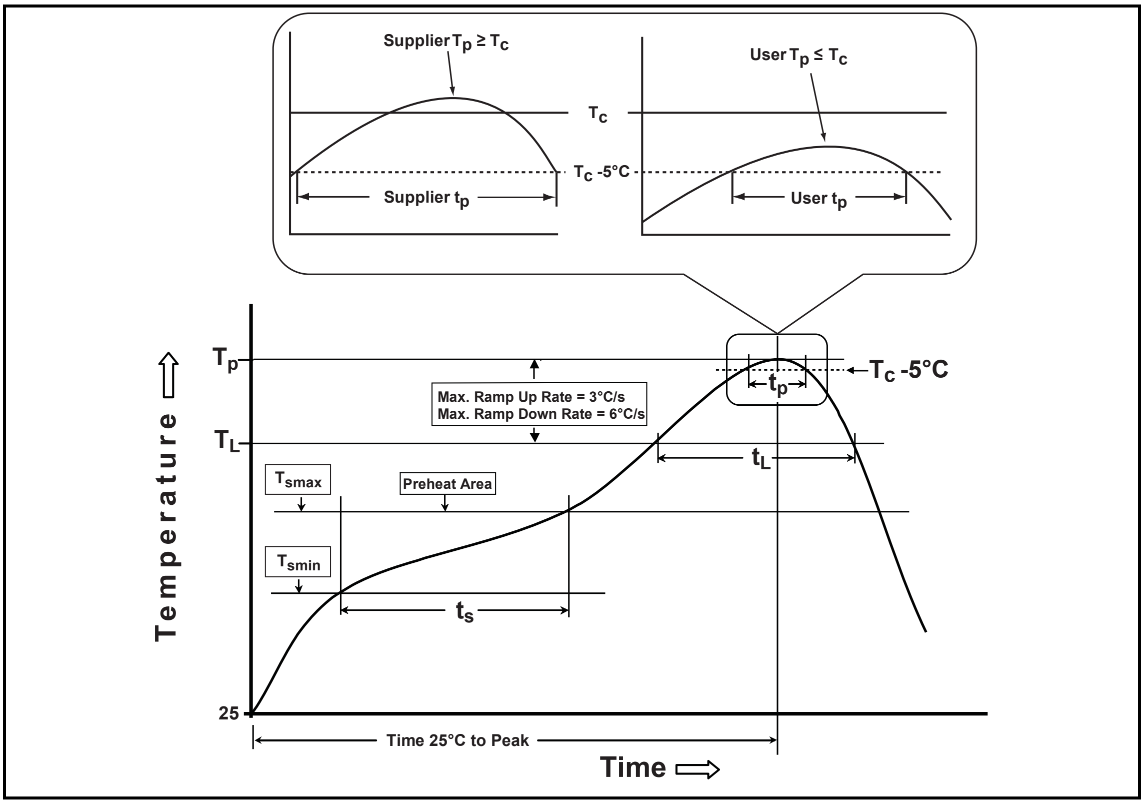


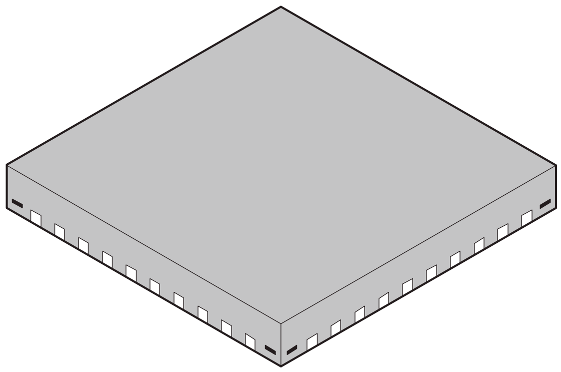
Table 19-2 Recommended mounting conditions (J-STD-020D)

(Temperature on the top of the package body is measured.)

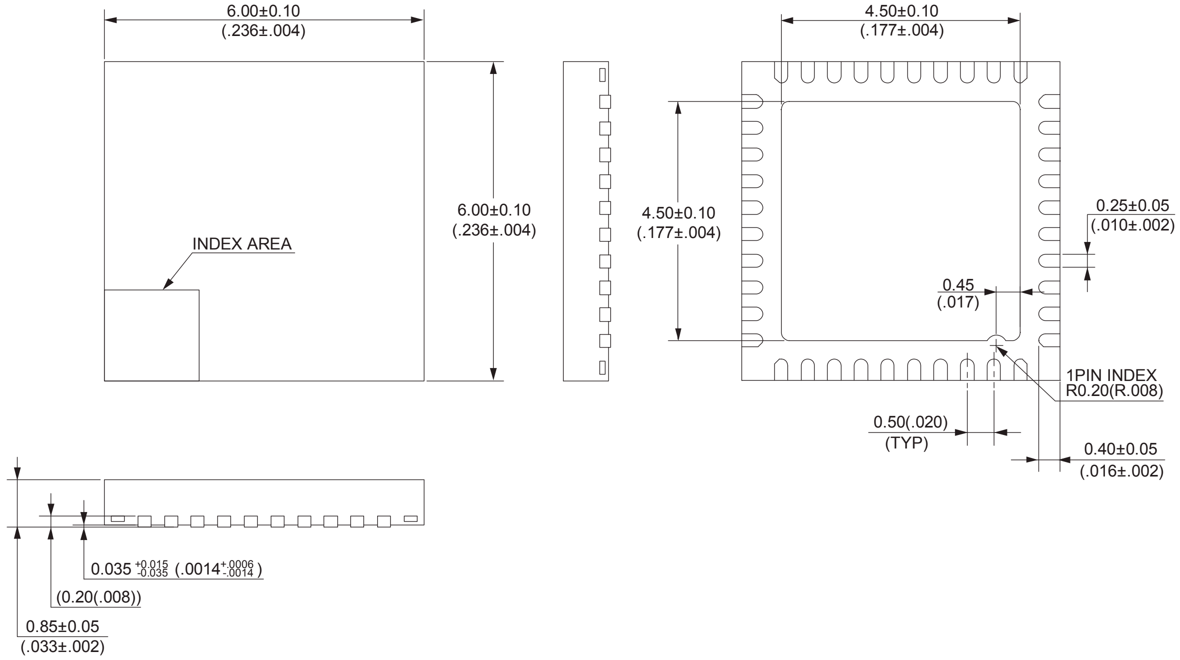
260°C Max.	
TL to TP: Ramp Up Rate	3°C/s Max.
TS: Preheat & Soak	150°C to 200°C, 60s to 120s
TP - tP: Peak Temperature	260°C Down, within 30s
TL – tL: Liquidous Temperature	217°C, 60s to 150s
TP to TL: Ramp Down Rate	6°C /s Max.
Time 25°C to Peak	8min Max.

20. Package Dimensions

Figure 20-1 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.

Please check the latest package dimension at the following URL.

http://edevice.fujitsu.com/package/jp-search/

21. Major Changes

Page	Section	Change results
Preliminary 0.1 [June 14, 2013]		
-	-	Initial release
Revision 1.0 [November 18, 2013]		
8	6.Block Diagram	Added capacitor
9	7.Absolute Maximum Ratings	Added the Rating and of Power dissipation and Figure 7-1
11, 12	9.Electrical Characteristics	Divided old table into system in general table and Boost DC/DC converter table. Added ENA=H into the condition on the table. Changed the Input power supply current condition
14	10.Function 10.3 MPPT control	Added more description
16	10.4 Function UVLO	Changed the sentence "This function is independent of MPPT_ENA." to" This function operates in the charge mode."
18	11.Example	Added standard example
19, 20	12.Typical Applications Circuit Circuit	Added D2 and C11
21	Parts list	Added D2 and C11
23	14.Ordering Information	Added "Figures 14-2 EVB ORDERING INFORMATION"
24	15.Marking	Added new
25	16.Product Label	Added new
26	17.Recommended Mounting Conditions	Added new
-	-	Company name and layout design change
Revision 2.0		
11, 12	9. Electrical Characteristics Table 9-1, Table 9-2	The table of the electrical characteristics was divided into that of the constant voltage mode and that of charge mode
15	10.2 Start-up/Shut-down sequence Figure 10-1	Added the sequences of MPPT_ENA, ENA, DET1, and DET0 pins.
17	10.2 Start-up/Shut-down sequence Figure 10-2	Added the sequences of MPPT_ENA, ENA, DET1, and DET0 pins.
19	10.4 Function description Table 10-2, Table 10-3	The table of the preset output voltage and the MPPT setting was divided into that of the preset output voltage and that of the MPPT setting.
21	10.4 Function description State notification Table 10-4, Table 10-5	The table of the state notification was divided into that of the constant voltage mode and that of charge mode
25, 26	12. Application Notes	Added the 12. Application Notes
27 to 31	13. Typical Characteristics	Added the 13. Typical Characteristics
32	14. Layout for Printed Circuit Board	Added the 14. Layout for Printed Circuit Board
36 to 39	18. Product Label	Changed the 18. Product Label
Revision 3.0		
3	1. Description	Made a change in the sentence. (MPPT) → (MPPT: Maximum Power Point Tracking)
21	10.4 Function description State notification	Added a following sentence. “The state notification is not a power good function”
24	11. Typical Applications Circuit Table 11-1 Parts list	Made a correction in the part number C6. 4.7pF → 4.7nF
26	12. Application Notes Figure 12-1	Added a note in the “Figure 12-1 Application example using the power gating”

Page	Section	Change results
40	19. Recommended Mounting Conditions Table 19-1	Made a correction in the floor life condition. 70%RH → 60%RH

Colophon

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