



The following document contains information on Cypress products. The document has the series name, product name, and ordering part numbering with the prefix “MB”. However, Cypress will offer these products to new and existing customers with the series name, product name, and ordering part number with the prefix “CY”.

How to Check the Ordering Part Number

1. Go to www.cypress.com/pcn.
2. Enter the keyword (for example, ordering part number) in the **SEARCH PCNS** field and click **Apply**.
3. Click the corresponding title from the search results.
4. Download the Affected Parts List file, which has details of all changes

For More Information

Please contact your local sales office for additional information about Cypress products and solutions.

About Cypress

Cypress is the leader in advanced embedded system solutions for the world's most innovative automotive, industrial, smart home appliances, consumer electronics and medical products. Cypress' microcontrollers, analog ICs, wireless and USB-based connectivity solutions and reliable, high-performance memories help engineers design differentiated products and get them to market first. Cypress is committed to providing customers with the best support and development resources on the planet enabling them to disrupt markets by creating new product categories in record time. To learn more, go to www.cypress.com.

Energy Calculation for Energy Harvesting

Associated Part Family: MB39C811/831

This Application Note describes the energy harvesting and the system design. The system performing low power operation should be designed since the amount of energy from harvester is very small. In such cases, the energy budget calculation is necessary.

Contents

1	Introduction.....	1	A.2	Amorphous silicon solar cell (for MB39C811)	8
1.1	Energy harvesting system.....	1	A.3	Amorphous silicon solar cell in series (for MB39C811)	10
2	Energy Calculation	2	A.4	Piezo (for MB39C811)	12
2.1	Energy requirement in application block	2	A.5	Single crystal silicon solar cell -1- (for MB39C831).....	14
2.2	Sizing of Cin and Cout (for MB39C811).....	3	A.6	Single crystal silicon solar cell -2- (for MB39C831).....	15
2.3	Charging time of Cin and Cout (for MB39C811)	4	A.7	Peltier (for MB39C831)	16
2.4	Sizing of Cin and Cout (for MB39C831).....	5	3	Document History.....	17
2.5	Charging time for Cin and Cout (for MB39C831)	6			
A	Appendix	7			
A.1	Power generation capability.....	7			

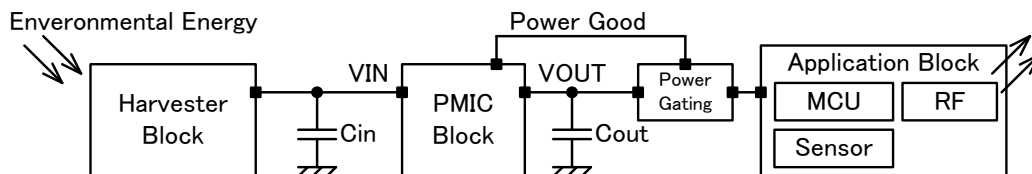
1 Introduction

For the energy harvesting, the system design is very important. The system performing low power operation should be designed since the amount of energy from harvester is very small. In such cases, the energy budget calculation is necessary

1.1 Energy Harvesting System

Figure 1 shows the popular energy harvesting system.

Figure 1. Popular Energy Harvesting System



Low power consumption devices are needed to design the energy harvesting system. Select low power PMIC and ICs for the application block because the energy from harvester is limited.

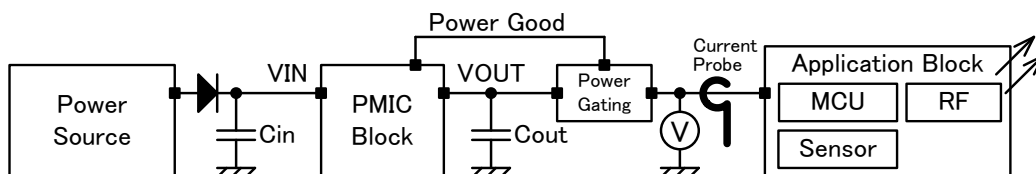
Also, energy from harvester should be stored on the Cin and Cout to operate the application block. If the size of these capacitors were too big, it would take too much time to charge energy into these capacitors, and the system cannot be operated frequently. On the other hand, if these capacitors were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

2 Energy Calculation

2.1 Energy Requirement in Application Block

Once the system is designed, make the prototype. The Figure 2 shows the measurement method of the energy requirement in application block.

Figure 2. Measurement of Energy Requirement

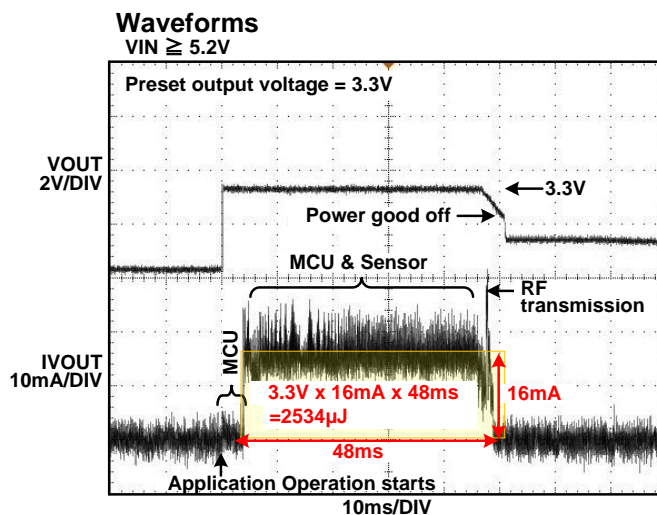


To calculate the necessary energy for the application, measure the voltage and current of VOUT. After the measurement, apply the following equation to calculate the energy requirement.

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

The Figure 3 shows actual measurement waveform of the energy harvesting system. In this example, the energy requirement for the application block is roughly calculated at 2,534μJ.

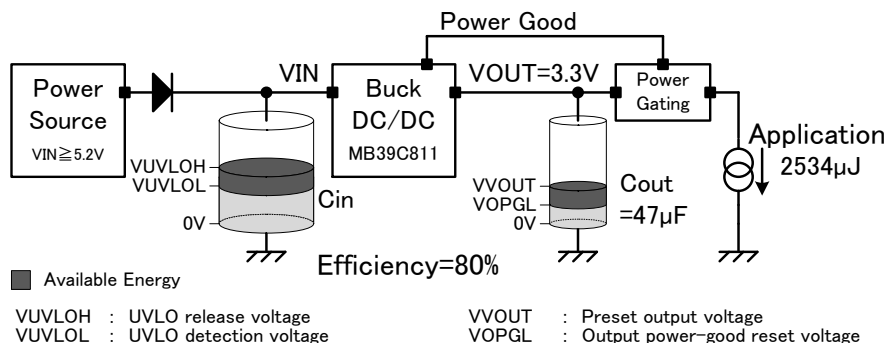
Figure 3. Waveform of VOUT and IVOUT



2.2 Sizing of Cin and Cout (for MB39C811)

The Cin and Cout should be sized. The Figure 4 shows the image of the capacitors with the buck DC/DC converter, MB39C811.

Figure 4. Stored Image of Capacitors (for MB39C811)



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

$$E_{\text{capacitor}}[\text{J}] = \frac{1}{2} CV^2$$

Because the energy in a capacitor is proportional to the square of the voltage, it is energetically advantageous for the buck DC/DC converter to make the Cin larger. On the other hand, for the boost DC/DC converter, it is energetically advantageous to make the Cout larger. In the example with MB39C811 of the Figure 4, adjust the Cin, and keep the Cout = 47μF (refer to the MB39C811 datasheet).

Calculate the available energy in Cout

The output power-good reset voltage (minimum voltage of the Cout) is 70 % of the preset output voltage (VOUT voltage), VOPGL is 2.31V (refer to the MB39C811 datasheet).

$$\begin{aligned} \text{Available energy in Cout } [\mu\text{J}] &= \frac{1}{2} \times \text{Cout} \times (\text{VVOUT}^2 - \text{VOPGL}^2) \\ &= \frac{1}{2} \times 47[\mu\text{F}] \times (3.3[\text{V}]^2 - 2.31[\text{V}]^2) = 131[\mu\text{J}] \end{aligned}$$

In the Figure 3, the energy requirement for the application block was calculated at 2,534[μJ]. The available energy stored on the Cout was found 131μJ, so that the remaining energy requirement is

$$\text{Remaining energy requirement } [\mu\text{J}] = 2,534[\mu\text{J}] - 131[\mu\text{J}] = 2,403[\mu\text{J}]$$

The remaining energy requirement should be stored on the Cin.

Calculate the size of the Cin

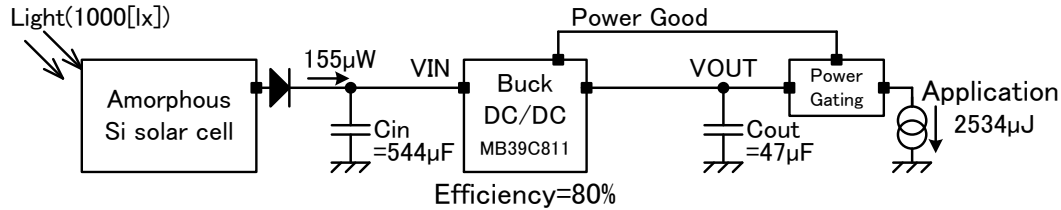
For the Cin calculation, it is necessary to take the efficiency of PMIC into account. According to the datasheet, the efficiency is about 80% in the 16mA load current. (The “η” is the efficiency of PMIC.)

$$\begin{aligned} \text{Available energy in Cin } [\mu\text{J}] &= \frac{1}{2} \times \eta \times \text{Cin} \times (\text{VUVLOH}^2 - \text{VUVLOL}^2) \\ 2403 [\mu\text{J}] &= \frac{1}{2} \times 80[\%] \times \text{Cin}[\mu\text{F}] \times (5.2[\text{V}]^2 - 4.0[\text{V}]^2) \\ \text{Cin } [\mu\text{F}] &= 544[\mu\text{F}] \end{aligned}$$

2.3 Charging Time of Cin and Cout (for MB39C811)

In order to calculate the charging time, the power generation capability is needed. (Refer to the Appendix, e.g. a solar cell has 155 μ W generation capability at the 1000[lx]). The Figure 5 shows the example of energy harvesting system focused on the charging time with a harvester.

Figure 5. Charging Time of Cin and Cout (for MB39C811)



Step1 for Initial charging time

Before calculating the initial charging time, calculate the total energy stored on both Cin and Cout.

$$\text{Total energy of Cin } [\mu\text{J}] = \frac{1}{2} \times \text{Cin} \times (\text{VUVLOH}^2) = \frac{1}{2} \times 544[\mu\text{F}] \times 5.2[\text{V}]^2 = 7355[\mu\text{J}]$$

$$\text{Total energy of Cout } [\mu\text{J}] = \frac{1}{2} \times \text{Cout} \times (\text{VVOUT}^2) = \frac{1}{2} \times 47[\mu\text{F}] \times 3.3[\text{V}]^2 = 256[\mu\text{J}]$$

Step2 for Initial charging time

$$\text{Initial charging time of Cin } [\text{s}] = \frac{\text{Total energy of Cin } [\mu\text{J}]}{\text{Power of solar cell } [\mu\text{W}]} = \frac{7355 [\mu\text{J}]}{155 [\mu\text{W}]} = 49.5[\text{s}]$$

$$\text{Initial charging time of Cout } [\text{s}] = \frac{\text{Total energy of Cout } [\mu\text{J}]}{\text{Power of solar cell } [\mu\text{W}] \times 80[\%]} = \frac{256 [\mu\text{J}]}{155 [\mu\text{W}] \times 0.8} = 2[\text{s}]$$

$$\begin{aligned} \text{Initial charging time } [\text{s}] &= \text{Initial charging time of Cin } [\text{s}] + \text{Initial charging time in Cout } [\text{s}] \\ &= 49.5 [\text{s}] + 2 [\text{s}] = 51.5 [\text{s}] \end{aligned}$$

Repeat charging time

$$\text{Repeat time for charging time of Cin } [\text{s}] = \frac{\text{Available energy in Cin } [\mu\text{J}]}{\text{Power of solar cell } [\mu\text{W}]} = \frac{2403 [\mu\text{J}]}{155 [\mu\text{W}]} = 15.5[\text{s}]$$

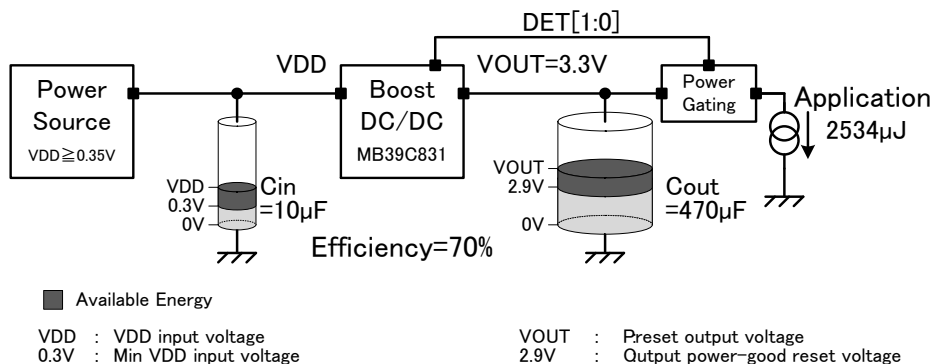
$$\text{Repeat charging time of Cout } [\text{s}] = \frac{\text{Available energy in Cout } [\mu\text{J}]}{\text{Power of solar cell } [\mu\text{W}] \times 80[\%]} = \frac{131 [\mu\text{J}]}{155 [\mu\text{W}] \times 0.8} = 1[\text{s}]$$

$$\begin{aligned} \text{Repeat charging time } [\text{s}] &= \text{Repeat charging time of Cin } [\text{s}] + \text{Repeat charging time of Cout } [\text{s}] \\ &= 15.5 [\text{s}] + 1 [\text{s}] = 16.5 [\text{s}] \end{aligned}$$

2.4 Sizing of Cin and Cout (for MB39C831)

The Figure 6 shows the image of the capacitors with the boost DC/DC converter, MB39C831.

Figure 6. Stored Image of Capacitors (for MB39C831)



Because the energy in a capacitor is proportional to the square of the voltage, it is energetically advantageous for the boost DC/DC converter to make the Cout larger. In the example with MB39C831 of the Figure 6, only adjust the Cout. Although the Cin = 10μF is used as the input capacitor, the Cin is excluded from the energy calculation because the stored energy on the Cin is very small.

In the Figure 3, the energy requirement for the application block was calculated at 2,534[μJ]. The energy requirement should be stored on the Cout.

Calculate the size of the Cout

The output power-good reset voltage (minimum voltage of the Cout) is set by 2.9V in MB39C831. (Refer to the MB39C831 datasheet).

$$\text{Available energy in Cout } [\mu\text{J}] = \frac{1}{2} \times \text{Cout} \times (\text{VOUT}^2 - 2.9[\text{V}]^2)$$

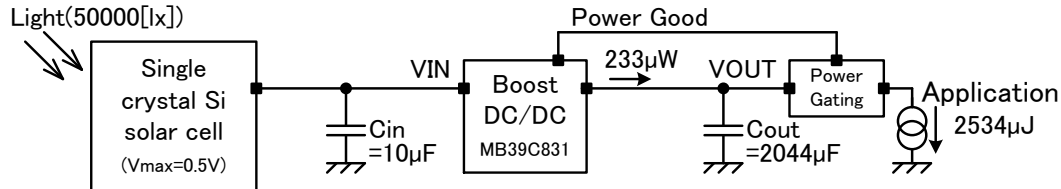
$$2534 [\mu\text{J}] = \frac{1}{2} \times \text{Cout}[\mu\text{F}] \times (3.3[\text{V}]^2 - 2.9[\text{V}]^2)$$

$$\text{Cout } [\mu\text{F}] = 2044[\mu\text{F}]$$

2.5 Charging Time for Cin and Cout (for MB39C831)

In order to calculate the charging time, the power generation capability is needed. (Refer to the Appendix, e.g. the single crystal silicon solar cell ($V_{max}=0.5V$) has $233\mu W$ generation capability including the MB39831's consumption at the $50000[lx]$). The Figure 7 shows the example of energy harvesting system focused on the charging time with a harvester.

Figure 7. Charging Time of Cin and Cout (for MB39C831)



Step1 for Initial charging time

Before calculating the initial charging time, calculate the total energy stored on the Cout.(excluding the Cin because the stored energy on the Cin is very small.)

$$\text{Total energy of Cout } [\mu J] = \frac{1}{2} \times \text{Cout} \times (V_{OUT})^2 = \frac{1}{2} \times 2044[\mu F] \times 3.3[V]^2 = 11127[\mu J]$$

Step2 for Initial charging time

$$\text{Initial charging time of Cout } [s] = \frac{\text{Total energy of Cout } [\mu J]}{\text{generation capability including IC}[\mu W]} = \frac{11127 [\mu J]}{233 [\mu W]} = 44.8[s]$$

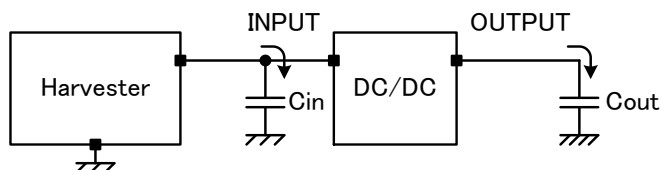
Repeat charging time

$$\text{Repeat charging time of Cout } [s] = \frac{\text{Available energy in Cout } [\mu J]}{\text{generation capability including IC}[\mu W]} = \frac{2534 [\mu J]}{233 [\mu W]} = 11[s]$$

A Appendix

A.1 Power Generation Capability

Figure 8. Power Generation Capability



To make it simple to calculate charging time at the section 2.3 and the section 2.5, the power generation capability is calculated based on the measured charging time of capacitors.

Table 1. Examples of Power Generation Capability (for MB39C811)

Generator	Type	Size [mm]	Vmax [V]	I _{max} [mA]	condition	Power generation capability [μW]
Solar	Amorphous Si	46×30	6.68 (6.4 + 0.28)	---	1000[lx]	155 [μW]
Solar	Amorphous Si	46×30 (2 series)	13.08 (12.8 + 0.28)	---	1000[lx]	193 [μW]
Piezo	Polymer	80×30	80(V _{pp})	---	3Hz hand push	578 [μW]

The MB39C831 is designed for harvesters that have a high power generation capability, such as an outdoor solar cell. It is not possible to start up with a small indoor solar cell

Table 2. Examples of Power Generation Capability (for MB39C831)

Generator	Type	Size [mm]	Vmax [V]	I _{max} [mA]	condition	Power generation capability [μW]
Solar	Single crystal Si	50×50	0.5	500	50000[lx]	233 [μW] (*1)
Solar	Single crystal Si	82×68	1.5	500	50000[lx]	1706 [μW] (*1)
Peltier	---	10×10 (2 series)	0.704	117	Δ T=30°C	Larger than 44000 [μW] (*2)

1. The value including the MB39C831's consumption.
2. The value from a peltier's datasheet

Table 3. Characteristics of Amorphous Silicon Solar Cell

Generator	Type	Size [mm]	Vmax [V]	Imax [mA]	condition	Power generation capability [μ W]
Solar	Amorphous Si	46×30	6.68	---	1000[lx]	155 [μ W]

Figure 9. Block Diagram with Amorphous Silicon Solar Cell

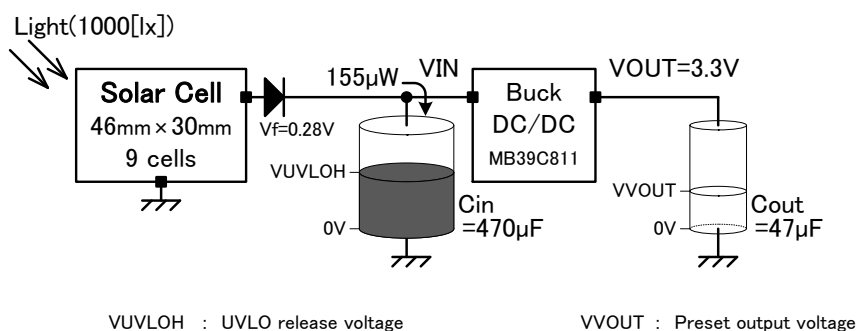
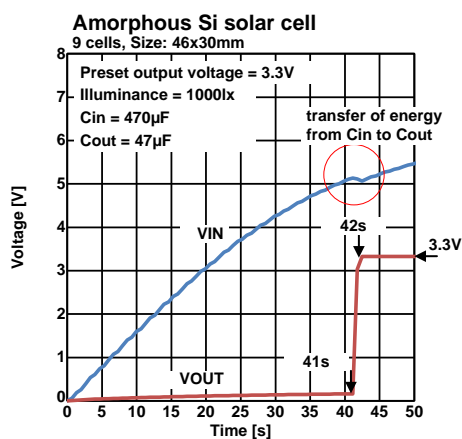


Figure 10. Charging time for Cin and Cout


$$\text{Charging energy}[\mu\text{J}] = \frac{1}{2} \times C_{in} \times (V_{UVLOH^2}) = \frac{1}{2} \times 470[\mu\text{F}] \times 5.2[\text{V}]^2 = 6354[\mu\text{J}]$$

Charging time[s] = 41 [s]

$$\text{Power generation capability}[\mu\text{W}] = \text{Charging energy}[\mu\text{J}] \div \text{Charging time}[\text{s}]$$

$$= 6354 \text{ [}\mu\text{J]} \div 41 \text{ [s]} = 155 \text{ [}\mu\text{W]}$$

After the voltage of the Cout becomes the preset output voltage, more energy is charged into the Cin until the open circuit voltage of the solar cell. The power generation capability during the period is calculated.

Figure 11. Block Diagram with Amorphous Silicon Solar Cell

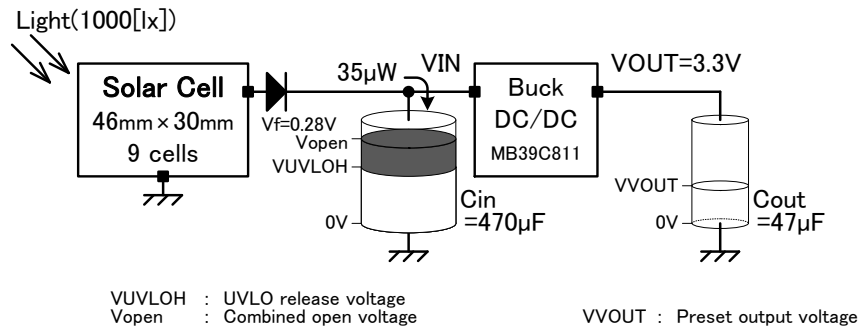
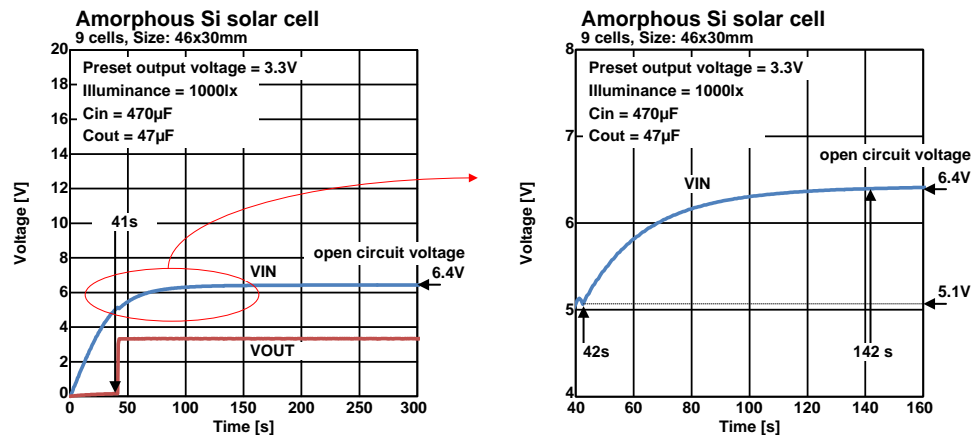


Figure 12. After the Charging time of Cin and Cout



1. Charging more energy in Cin

$$\text{Charging energy}[\mu\text{J}] = \frac{1}{2} \times 80[\%] \times 470[\mu\text{F}] \times (6.4[\text{V}]^2 - 5.1[\text{V}]^2) = 3513[\mu\text{J}]$$

2. Charging time in Cin (measured value)

$$\text{Charging time}[\text{s}] = 100[\text{s}]$$

3. Power generation capability

$$\text{Power generation capability}[\mu\text{W}] = \text{Charging energy}[\mu\text{J}] \div \text{Charging time}[\text{s}]$$

$$= 3513[\mu\text{J}] \div 100[\text{s}] = 35[\mu\text{W}]$$

The power generation capability is much smaller than that until the Cin become the preset output voltage. That is because of the characteristics of the solar cell. This solar cell acts as a current source until around 5V (see Figure 13). However, the current supply suddenly decrease after the voltage goes over 5V.

Amorphous Si characteristics
 9 cells, Size: 46x30mm
 Illuminance = 1000lx

Current [μ A]

Voltage [V]

Vf of diode 0.28V

6.4V

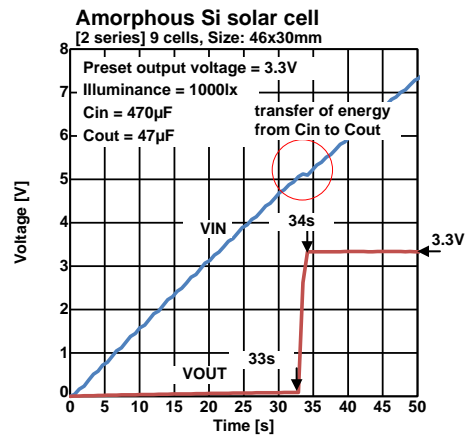
Table 4. Characteristics of 2 Series Amorphous Silicon Solar Cells

Generator	Type	Size [mm]	Vmax [V]	Imax [mA]	Condition	Power generation capability [μ W]
Solar	Amorphous Si	46 \times 30 (2 series)	13.8	---	1000[lx]	193 [μ W]

VUVLOH : UVLO release voltage

VVOUT : Preset output voltage

Figure 15. Measured Graph Using Amorphous Silicon Solar Cells in Series



1. Charging energy in Cin

$$\text{Charging energy}[\mu\text{J}] = \frac{1}{2} \times C_{in} \times (V_{UVLOH})^2 = \frac{1}{2} \times 470[\mu\text{F}] \times 5.2[\text{V}]^2 = 6354[\mu\text{J}]$$

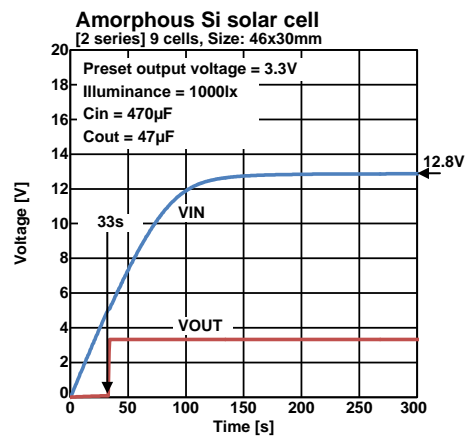
2. Charging time in Cin (measured value)

$$\text{Charging time [s]} = 33 \text{ [s]}$$

3. Power generation capability

$$\begin{aligned} \text{Power generation capability}[\mu\text{W}] &= \text{Charging energy}[\mu\text{J}] \div \text{Charging time[s]} \\ &= 6354 [\mu\text{J}] \div 33 \text{ [s]} = 193 [\mu\text{W}] \end{aligned}$$

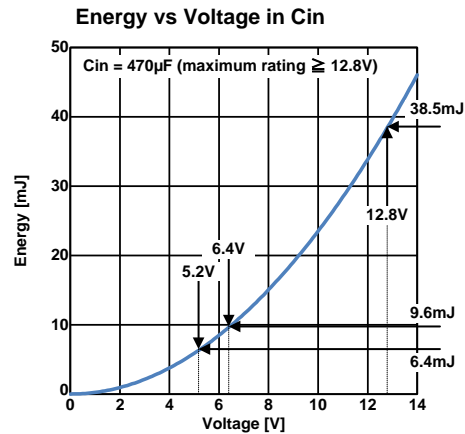
Figure 16. Measured Graph Using Amorphous Silicon Solar Cell in Series



The more energy from a harvester can be stored on a capacitor because the energy in a capacitor is proportional to the square of the voltage.

$$\text{Energy}[\mu\text{J}] = \frac{1}{2} \times 470[\mu\text{F}] \times \text{Voltage}^2$$

Figure 17. Energy vs Input Voltage in Capacitor



A.4 Piezo (for MB39C811)

Table 5. Characteristics of Piezo

Generator	Type	Size [mm]	Vmax [V]	I _{max} [mA]	Condition	Power generation capability [μ W]
Piezo	Polymer	80 × 30	80(V _{pp})	---	3Hz, hand push	578 [μ W]

Figure 18. Testing Method Using Piezo

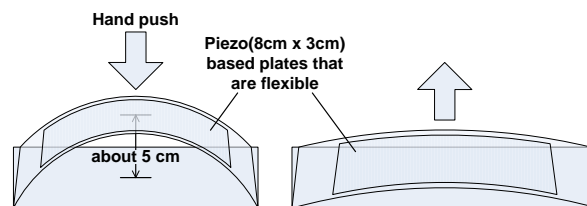
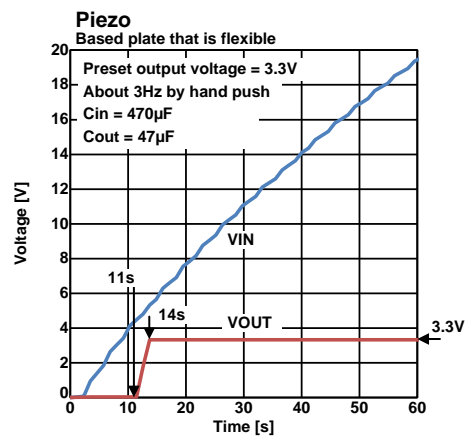


Figure 19. Measured Graph Using Piezo



1. Charging energy in Cin

$$\text{Energy for charging}[\mu\text{J}] = \frac{1}{2} \times C_{in} \times (V_{UVLOH})^2 = \frac{1}{2} \times 470[\mu\text{F}] \times 5.2[\text{V}]^2 = 6354[\mu\text{J}]$$

2. Charging time in Cin (measured value)

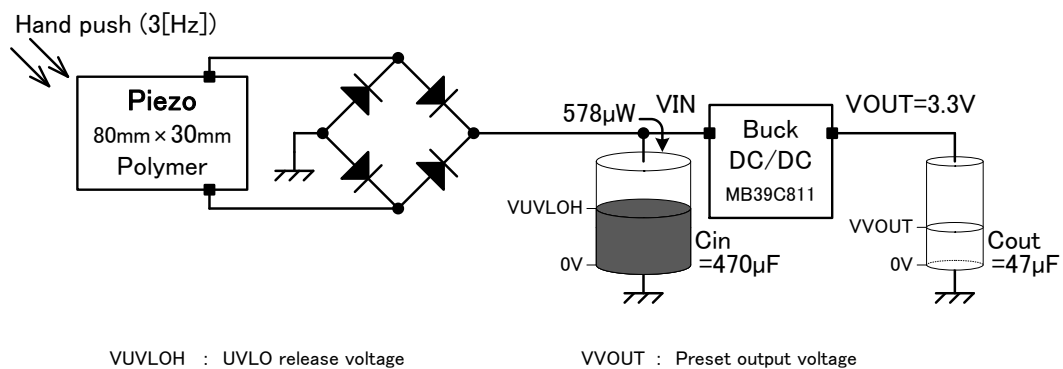
$$\text{Charging time}[\text{s}] = 11 [\text{s}]$$

3. Power generation capability

$$\text{Power generation capability}[\mu\text{W}] = \text{Charging energy}[\mu\text{J}] \div \text{Charging time}[\text{s}]$$

$$= 6354[\mu\text{J}] \div 11 [\text{s}] = 578 [\mu\text{W}]$$

Figure 20. Block Diagram with Single Crystal Silicone Solar Cell -1



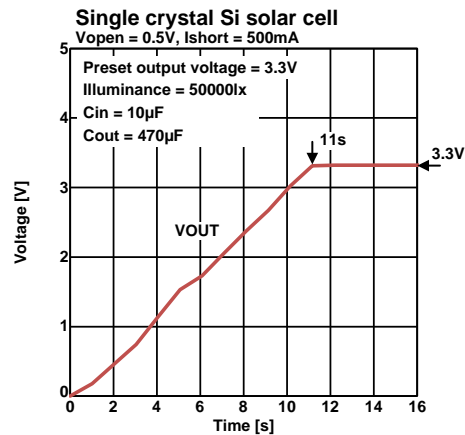
A.5 Single Crystal Silicon Solar Cell -1 (for MB39C831)

Table 6. Characteristics of Single Crystal Silicone Solar Cell -1

Generator	Type	Size [mm]	Vmax [V]	Imax [mA]	condition	Power generation capability [μW]
Solar	Single crystal Si	50×50	0.5	500	50000[lx]	233 [μW] (*1)

1. The value including the MB39C831's consumption

Figure 21. Measured Graph Using Single Crystal Silicone Solar Cell -1



The Cin is excluded from the energy calculation because the input voltage (VDD) is not stable in the start-up and the stored energy is very small.

1. Charging energy in Cout

$$\text{Charging energy}[\mu\text{J}] = \frac{1}{2} \times \text{Cout} \times (\text{VOUT}^2) = \frac{1}{2} \times 470[\mu\text{F}] \times 3.3[\text{V}]^2 = 2559[\mu\text{J}]$$

2. Charging time in Cout (measured value)

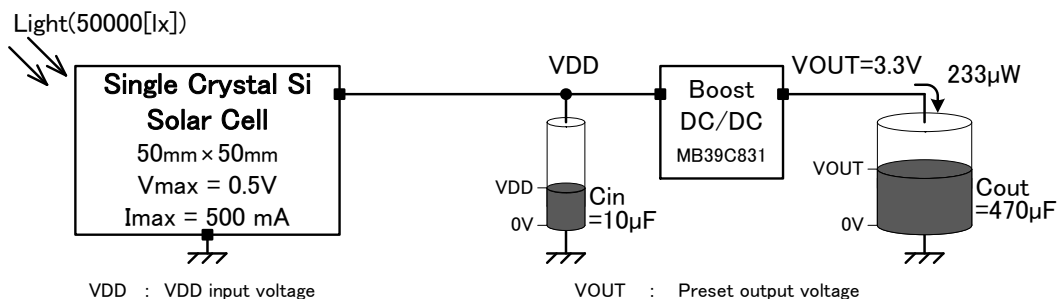
$$\text{Time for charging}[\text{s}] = 11[\text{s}]$$

3. Power generation capability

$$\text{Power generation capability}[\mu\text{W}] = \text{Charging energy}[\mu\text{J}] \div \text{Charging time}[\text{s}]$$

$$= 2559[\mu\text{J}] \div 11[\text{s}] = 233[\mu\text{W}]$$

Figure 22. Block Diagram with Single Crystal Silicone Solar Cell -1



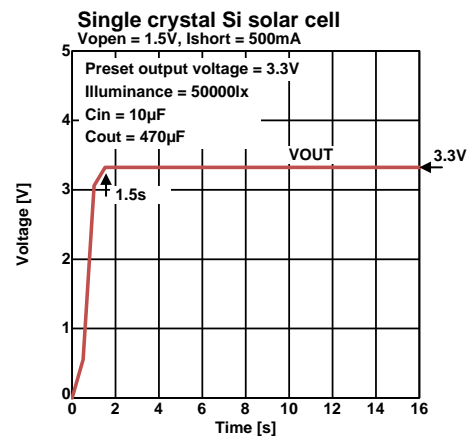
A.6 Single Crystal Silicon Solar Cell -2 (for MB39C831)

Table 7. Characteristics of Single Crystal Silicone Solar Cell -2

Generator	Type	Size [mm]	Vmax [V]	Imax [mA]	Condition	Power generation capability [μW]
Solar	Single crystal Si	80×70	1.5	500	50000[lx]	1706 [μW] (*1)

1. The value including the MB39C831's consumption

Figure 23. Measured Graph Using Single Crystal Silicone Solar Cell -2



The Cin is excluded from the energy calculation because the input voltage (VDD) is not stable in the start-up and the stored energy is very small.

1. Charging energy in Cout

$$\text{Charging energy}[\mu\text{J}] = \frac{1}{2} \times \text{Cout} \times (\text{VOUT}^2) = \frac{1}{2} \times 470[\mu\text{F}] \times 3.3[\text{V}]^2 = 2559[\mu\text{J}]$$

2. Charging time in Cout (measured value)

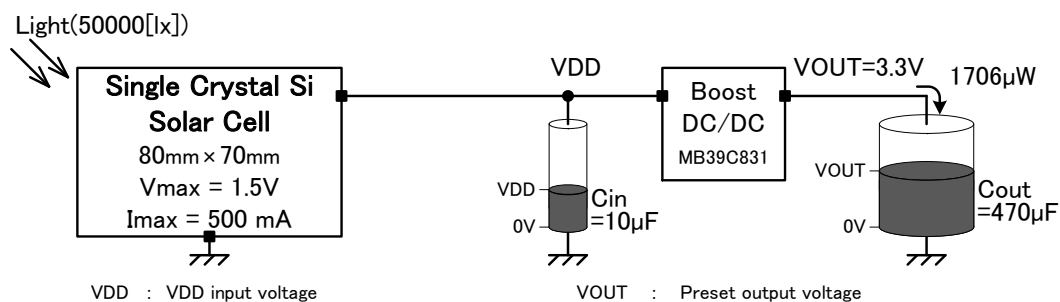
$$\text{Time for charging}[\text{s}] = 1.5 [\text{s}]$$

3. Power generation capability

$$\text{Power generation capability}[\mu\text{W}] = \text{Charging energy}[\mu\text{J}] \div \text{Charging time} [\text{s}]$$

$$= 2559 [\mu\text{J}] \div 1.5 [\text{s}] = 1706 [\mu\text{W}]$$

Figure 24. Block Diagram with Single Crystal Silicone Solar Cell -2



A.7 Peltier (for MB39C831)

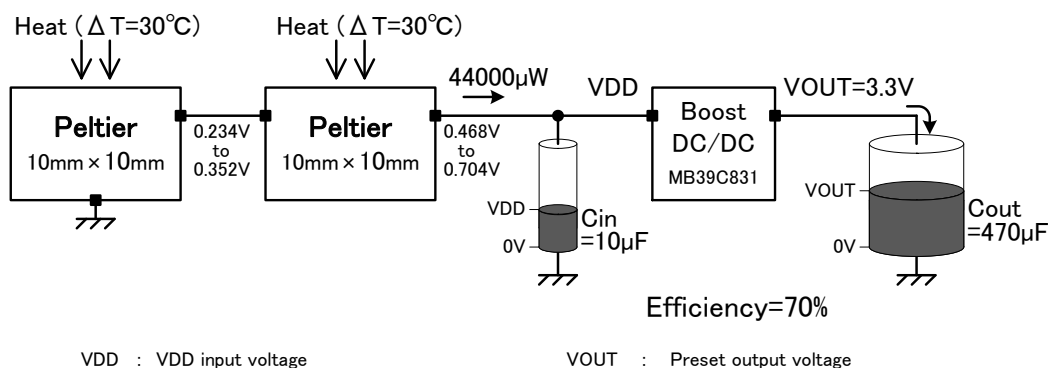
Peltier elements provide relatively large amount energy upon being given temperature difference. However, they do not supply high voltage. The peltier element shown in Table 8 supplies up to 0.352V. To meet the minimum start-up input voltage of MB39C831, use the peltier elements connected in series.

Table 8. Characteristics of Peltier

Generator	Type	Size [mm]	Vmax [V]	I _{max} [mA]	Condition	Power generation capability [μW]
Peltier	---	10×10	0.234 - 0.352	0.077 - 0.117	ΔT=30°C	Larger than 22000 [μW] (*1)
Peltier	---	10×10 (2 series)	0.468 - 0.704	0.077 - 0.117	ΔT=30°C	Larger than 44000 [μW] (*1)

1. The value from a peltier's datasheet

Figure 25. Block diagram with Peltier



3 Document History

Document Title: AN204360 - Energy Calculation for Energy Harvesting

Document Number: 002-04360

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	-	TAOA	01/18/2014	Initial Release
*A	5037823	TAOA	12/07/2015	Migrated Spansion Application Note from AN405-00001-1v0-E to Cypress format
*B	5790555	AESATMP8	06/29/2017	Updated logo and Copyright.

Worldwide Sales and Design Support

Cypress maintains a worldwide network of offices, solution centers, manufacturer's representatives, and distributors. To find the office closest to you, visit us at [Cypress Locations](#).

Products

ARM® Cortex® Microcontrollers	cypress.com/arm
Automotive	cypress.com/automotive
Clocks & Buffers	cypress.com/clocks
Interface	cypress.com/interface
Internet of Things	cypress.com/iot
Memory	cypress.com/memory
Microcontrollers	cypress.com/mcu
PSoC	cypress.com/psoc
Power Management ICs	cypress.com/pmic
Touch Sensing	cypress.com/touch
USB Controllers	cypress.com/usb
Wireless Connectivity	cypress.com/wireless

PSoC® Solutions

[PSoC 1](#) | [PSoC 3](#) | [PSoC 4](#) | [PSoC 5LP](#) | [PSoC 6](#)

Cypress Developer Community

[Forums](#) | [WICED IOT Forums](#) | [Projects](#) | [Videos](#) | [Blogs](#) | [Training](#) | [Components](#)

Technical Support

cypress.com/support

All other trademarks or registered trademarks referenced herein are the property of their respective owners.



© Cypress Semiconductor Corporation, 2014-2017. This document is the property of Cypress Semiconductor Corporation and its subsidiaries, including Spanion LLC ("Cypress"). This document, including any software or firmware included or referenced in this document ("Software"), is owned by Cypress under the intellectual property laws and treaties of the United States and other countries worldwide. Cypress reserves all rights under such laws and treaties and does not, except as specifically stated in this paragraph, grant any license under its patents, copyrights, trademarks, or other intellectual property rights. If the Software is not accompanied by a license agreement and you do not otherwise have a written agreement with Cypress governing the use of the Software, then Cypress hereby grants you a personal, non-exclusive, nontransferable license (without the right to sublicense) (1) under its copyright rights in the Software (a) for Software provided in source code form, to modify and reproduce the Software solely for use with Cypress hardware products, only internally within your organization, and (b) to distribute the Software in binary code form externally to end users (either directly or indirectly through resellers and distributors), solely for use on Cypress hardware product units, and (2) under those claims of Cypress's patents that are infringed by the Software (as provided by Cypress, unmodified) to make, use, distribute, and import the Software solely for use with Cypress hardware products. Any other use, reproduction, modification, translation, or compilation of the Software is prohibited.

TO THE EXTENT PERMITTED BY APPLICABLE LAW, CYPRESS MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARD TO THIS DOCUMENT OR ANY SOFTWARE OR ACCOMPANYING HARDWARE, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. To the extent permitted by applicable law, Cypress reserves the right to make changes to this document without further notice. Cypress does not assume any liability arising out of the application or use of any product or circuit described in this document. Any information provided in this document, including any sample design information or programming code, is provided only for reference purposes. It is the responsibility of the user of this document to properly design, program, and test the functionality and safety of any application made of this information and any resulting product. Cypress products are not designed, intended, or authorized for use as critical components in systems designed or intended for the operation of weapons, weapons systems, nuclear installations, life-support devices or systems, other medical devices or systems (including resuscitation equipment and surgical implants), pollution control or hazardous substances management, or other uses where the failure of the device or system could cause personal injury, death, or property damage ("Unintended Uses"). A critical component is any component of a device or system whose failure to perform can be reasonably expected to cause the failure of the device or system, or to affect its safety or effectiveness. Cypress is not liable, in whole or in part, and you shall and hereby do release Cypress from any claim, damage, or other liability arising from or related to all Unintended Uses of Cypress products. You shall indemnify and hold Cypress harmless from and against all claims, costs, damages, and other liabilities, including claims for personal injury or death, arising from or related to any Unintended Uses of Cypress products.

Cypress, the Cypress logo, Spanion, the Spanion logo, and combinations thereof, WICED, PSoC, CapSense, EZ-USB, F-RAM, and Traveo are trademarks or registered trademarks of Cypress in the United States and other countries. For a more complete list of Cypress trademarks, visit cypress.com. Other names and brands may be claimed as property of their respective owners.