AN90040

Designing an Energy Harvesting system using the NEH2000BY PMIC

Rev. 1.1 — 28 March 2023 application note

Document information

Information	Content
Keywords	Energy Harvesting, solar, PV, NEH2000BY
Abstract	This application note details a reference design for a typical solar energy harvesting application using the NEH2000BY Energy Harvesting Power Management IC from Nexperia.

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1. Introduction

This application note describes the design of a complete solar energy harvesting (EH) system using the NEH2000BY Power Management IC (PMIC) from Nexperia. Components will be presented and resulting harvested energy obtained for a certain ambient light condition will be discussed.

In describing a reference design for an energy harvesting application, the following topics will be discussed:

- Energy harvesting system
  - Solar harvesting: ambient source and harvester
  - NEH2000BY
  - Energy storage
- Battery protection
- Application circuit
- PCB layout and dimensions
- Bill of Materials

2. Energy harvesting system

Instead of supplying energy to devices through wires and batteries, energy harvesting enables these devices to use the energy already available at its location. In the system detailed in this application note, the energy harvesting system is based on the conversion of ambient light energy.

An application which makes use of an energy harvesting system mainly consists of five components as show in Fig. 1.

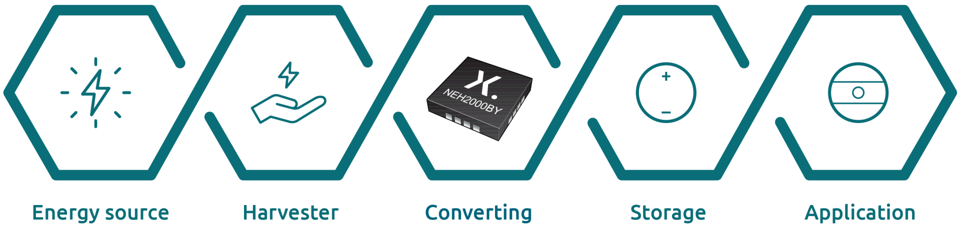


Fig. 1. Energy harvesting system diagram

Energy source: This is the ambient source, which in this case, is light and can be indoor or outdoor. In outdoor environments, the ambient source during the day is solar, and at night it is generated by a street light for example. For indoor environments the ambient source depends on the type of lamp (e.g. LED, halogen, incandescent).

Harvester: A photovoltaic (PV) cell that converts light into electricity. There are many different types of cells, each with different characteristics such as better indoor or outdoor performance. A few examples are amorphous silicon, monocrystalline silicon and dye-sensitized solar cells.

Converting: The PMIC converts the voltage generated by the harvester to a voltage that is suitable for charging the storage element.

Energy storage: To power the application, energy must be available from a re-chargeable element. Lithium-based batteries are a perfectly suited for this. Lithium batteries are available in many shapes and sizes such as lithium-ion coin cells or square lithium-polymer cells.

Application: Many applications are suitable for an energy harvesting systems, examples include TV remote controls and electronic shelf labels.

3. Physical system

This reference design takes certain conditions and components to present a complete energy harvesting system, see Fig. 2. In this system the PMIC is the NEH2000BY, designed by Nexperia, the remaining components are made by other manufacturers.

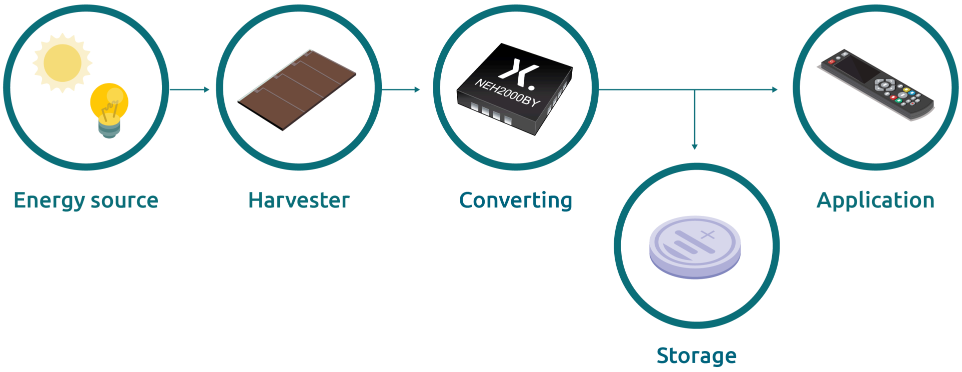
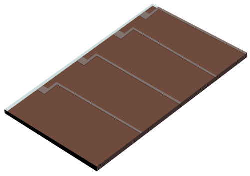


Fig. 2. Physical system

Energy source: Indoor environment where LED lighting is present at 600 lux for 8 hours per day. 600 lux is a common light intensity for office environments.

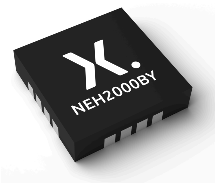
Harvester: The AM-1454 solar panel by Panasonic.

This PV is of the amorphous silicon type, which is efficient in indoor environments:



- Dimensions: 41.6 mm x 26.3 mm
- Open circuit voltage: 2.4 V
- Maximum power point (MPP) voltage: 1.85 V
- Maximum power at MPP: 67 μW @ 600 lux

Converting: NEH2000BY is one of Nexperia's Energy Harvesting Solutions, powered by Nowi technology. By perpetually powering consumer electronics and IoT devices with clean ambient energy, Nexperia's energy harvesting PMIC removes the need for battery swaps, allowing for more sustainable product designs. NEH2000BY combines the lowest BOM cost with the smallest PCB footprint and the best average harvesting performance with an industry-fast maximum Power Point Tracking (PPT) of under 1 second. Key features of the NEH2000BY include:



- Unique inductorless technology which implies a minimum need for external components
- Conversion efficiency up to 80%
- Voltage boosting: 2x
- Power range: 35 μW – 2 mW
- Compact QFN16 3 mm x 3 mm package
- Power: 54 μW at 600 lux with AM-1454 PV
- Energy: 1.3 mWh per day at 600 lux for 8 hours with AM-1454 PV

Energy storage: LIR2450, a lithium-Ion battery.

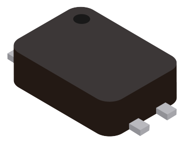
- Voltage: 3.6 V
- Capacity: 120 mAh
- 24 mm x 5 mm
- Peak current: 240 mA

4. Battery protection

Batteries should not be overcharged. When the battery is fully charged, harvesting should stop. A full battery can be detected by an Overvoltage Protection (OVP) device. Subsequently the output signal disables the harvesting. A high signal at the DISABLE pin of the NEH2000BY will disable the converter.

The OVP device used in this reference design is: S-1000C42-I4T1U by ABLIC, (data sheet link). Key features of the S-1000C42-I4T1U include:

- Voltage threshold: 4 V
- Low current consumption: 350 nA
- Output level high when above threshold
- Package: SNT-4A



5. Available energy for application

This reference design delivers 1.3 mWh. Given this harvested energy, a multitude of low-power applications could run autonomously, removing the need for costly and polluting battery swaps. Examples include electronic shelf labels for retail, and remote control units.

Electronic Shelf Label ~0.4 mWh

Remote Controls 1 - 2 mWh

Fig. 3. Low-power applications

6. Reference design

A reference design PCB has been built and tested. The schematic diagram, PCB design layout and Bill of Materials are included in this section.

6.1. Application circuit schematic

The reference design is based on the application schematic diagram shown in Fig. 4.

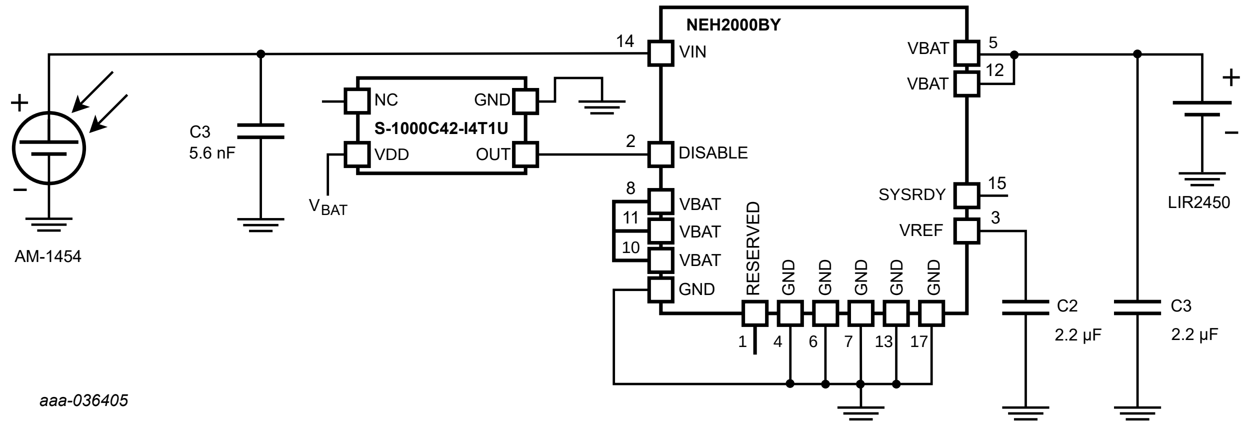


Fig. 4. Schematic

6.2. PCB layout and dimensions

Thanks to a unique inductorless and compact design, our energy harvesting solutions can be integrated on a PCB as small as 6 mm x 6 mm, see Fig. 5 and Fig. 6.

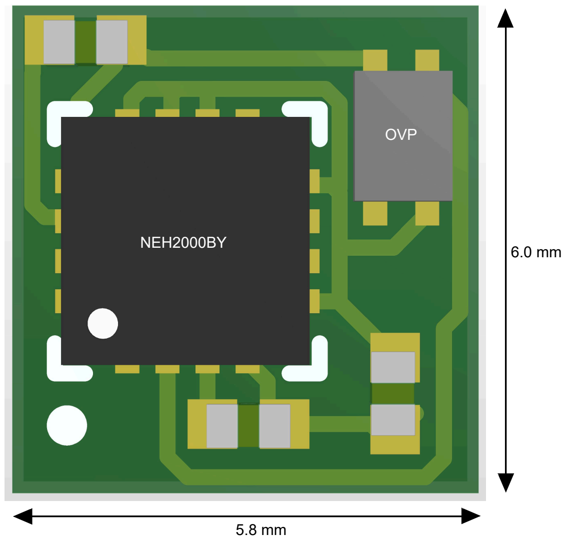


Fig. 5. PCB top view

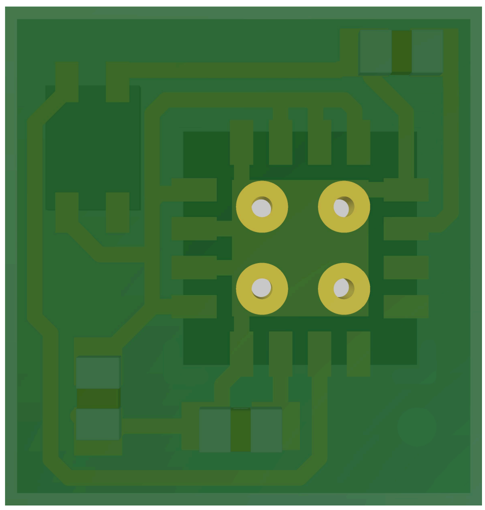


Fig. 6. PCB bottom view

6.3. Bill of materials

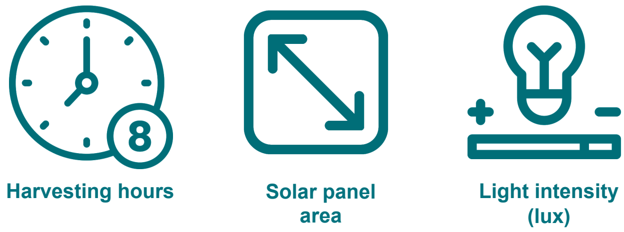
Table 1. Bill of material

Description	Type	Manufacturer	Quantity
Energy harvesting PMIC	NEH2000BY	Nexperia	1
2.2 µF capacitor	X7R / 6.3V	Murata	2
5.6 nF capacitor	X7R / 6.3V	Murata	1
OVP	S-1000C42-I4T1U	Ablic	1
Solar panel	AM-1454	Panasonic	1
Battery	LIR2450	multicomp	1

7. Customization

The reference design presented in this application note can be used as a starting point to develop energy harvesting systems.

Further enhancements can be done by adjusting:



8. Revision history

Table 2. Revision history

Revision number	Date	Description
1.1	2023-03-28	Pin names updated in Fig. 4.
1.0	2023-03-06	Initial version.

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