Solar Development Kit with Nordic BLE (DEV-BLE-NS) Operation Guide.

Introduction

The Solar Development Kit with Nordic BLE (DEV-BLE-NS) is a complete energy harvesting power management solution and Nordic nRF52832 BLE development platform. It is perfect for developers looking to design or add PowerFilm's flexible solar to Nordic BLE products. With both Indoor Light and Classic Application series panels, the kit works out of the box and under direct sunlight down to 200 lux dim indoor environments.

The kit is able to efficiently extract power, charge a variety of storage elements, and supply power to the BLE circuit. It includes two user selectable energy harvesting modules, one implementing the BQ25570 PMIC and the other being a dedicated 'Cap-Charger' for batteryless applications.

Fully compatible with Nordic's development tools, the kit comes programmed with a low power optimized HRM demo.

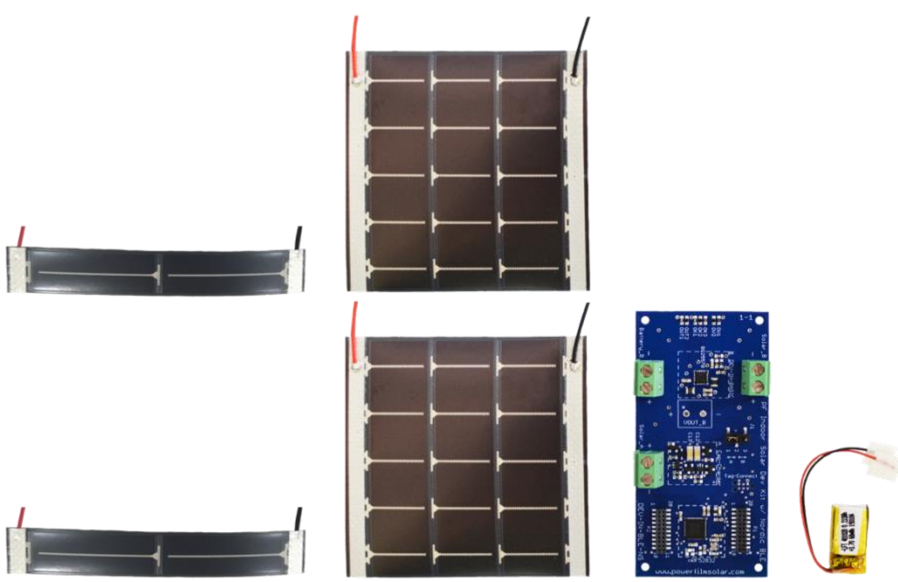

Figure 1, DEV-BLE-NS Indoor Solar Development Kit with Nordic BLE.

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Use Cases

Wireless connectivity is now standard in modern electronics and the growing IoT and sensing industries. Many applications in this area are very low power and can run completely using a solar energy harvested from indoor artificial lighting or outdoor sunlight.

Sensing Applications

Temperature	Humidity	Pressure
Light Level	Vibration	Motion
Acoustic	Air Flow	Water Flow
Strain	Moisture	Air Quality
Occupancy	Acceleration	Water Level

IoT Applications

Home Automation	Wearables	Smart Buildings
Smart City	Smart Agriculture	Wireless Nodes
Asset Tracking	Smart Transportation	Gateways
Beacons	Equipment Monitoring	Industrial Automation

Included in Kit

- DEV-BLE-NS circuit board
- (2) LL200-3.6-75 Indoor Solar Panel with 6″ leads
- (2) ONP2.4-15x94 Solar Panel with 6″ leads
- 60mAh rechargeable Li-Polymer battery

- Instructions, hardware and software files, and product documentation

System Overview

The DEV-BLE-NS consists of two main components; the energy harvesting and the BLE modules.

nRF52832 Nordic BLE Module

Fully functional BLE module configured for ultra-low power operation. It connects to iOS and Android devices through Nordic's Heart Rate Sensor example in the nRF Toolbox Mobile App. Simulated heart rate sensor data is sent approximately once per second to the connected device.

The nRF52832 IC can be reprogrammed via the 6-pin Tag-Connect programming interface or using the programming pins in the IO breakout headers.

Features:

- iOS and Android Bluetooth connectivity
- IO Break-out connectors for additional sensors or components
- Segger Embedded Studio project solution files
- Small footprint with few components and compact meandering antenna design

Energy Harvesting Modules

The Solar Development Kit with Nordic BLE comes with the two charging circuits detailed below. The first is a custom battery-free capacitor charger ("Cap-Charger") and the second implements TI's BQ25570 energy harvesting/power management IC and is identical to the Solar Development Kit (DEV-BASIC). The desired charging circuit can be chosen with jumper J1.

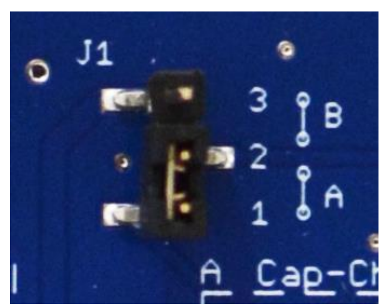
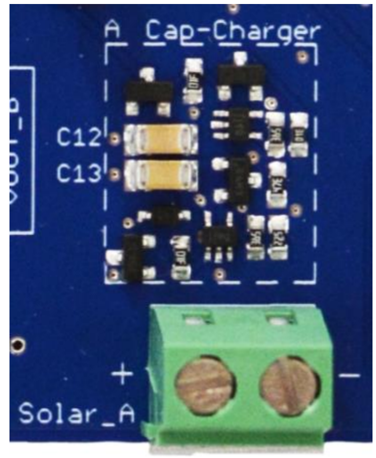


Figure 2, Jumper J1 charge control circuitry selection.

Cap-Charger: (default)



This custom circuit allows the Solar Development Kit with Nordic BLE to operate without a storage element connected, instead using two 220uF surface mount capacitors. From a fully discharged state, this circuit will charge up and begin advertising in under 30 seconds at 200 lux.

The Cap-Charger implements a low voltage load disconnect with a wide hysteresis (1.5V – 2.9V), which prevents the load from getting stuck in a turn-on loop.

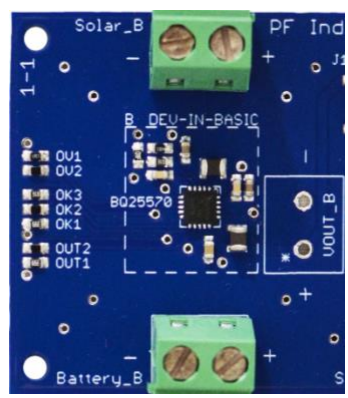
Figure 3, Cap-Charger charge control circuit 'A'.

It also implements charge termination to prevent the capacitors from charging past the safe operating voltage of the nRF52832 module (3.6V).

Features:

- Up to 2x harvesting performance vs standard energy harvesting IC solutions
- Rapid charging during initial off state (0-2V)
- Low voltage load disconnect with hysteresis and high voltage charge termination
- Low cost and small footprint

BQ25570 Energy Harvesting and Power Management IC:



This module is identical to the DEV-BASIC Solar Development Kit. The BQ25570 IC uses nano-power boost charging technology to efficiently extract energy from the Photovoltaic (PV) modules, while the integrated power management can be configured to charge a connected storage element, such as a rechargeable Li-Ion battery, and also provides a power output to connect external electronics.

Figure 4, DEV-BASIC charge control circuit 'B'.

Features:

- MPPT Input with low voltage boost converter
- Integrated battery charger (default 4.2V Li-ion) with low voltage load disconnect and high voltage charge termination
- Regulated power output (default 3V)

Quick Setup Instructions

The DEV-BLE-NS has two setup options for the two available charging circuits.

Option A (default), uses the custom “Cap-Charger” and does not require an external storage element.

Option B uses the BQ25570 energy harvesting/power management IC which is configured to recharge the 60mAh Li-Po battery included in the kit.

Equipment

- DEV-BLE-NS Indoor/Outdoor Solar Development Kit with Nordic BLE
- Android Device with Bluetooth Low Energy capability
- Small flathead Screwdriver

Setup

Option A: Cap-Charger

1. Connect Solar Panel Leads to Solar_A Input*.

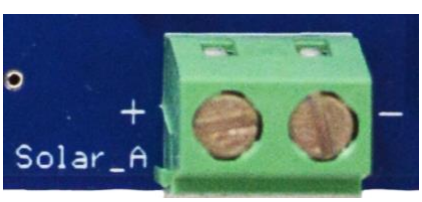


Figure 5, Solar input for charge control circuit ‘A’, Cap-Charger.

2. Place jumper across pins 1 and 2 on J1.

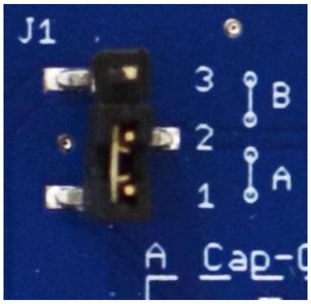


Figure 6, Jumper J1 charge controller selection

3. Go to Option B, step 3.

Option B: BQ25570

1. Connect Battery Lead to Battery_B Input*.

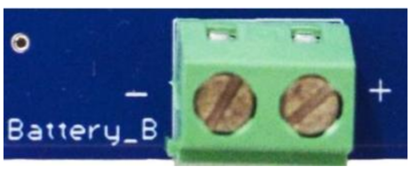


Figure 7, Battery input for charger control circuit 'B', DEV-BASIC.

2. Connect Solar Panel Leads to Solar_B Input*.

Figure 8, Solar input for charge control circuit 'B', DEV-BASIC.

3. Download and open the nRF Toolbox mobile app on a compatible iOS or Android device.

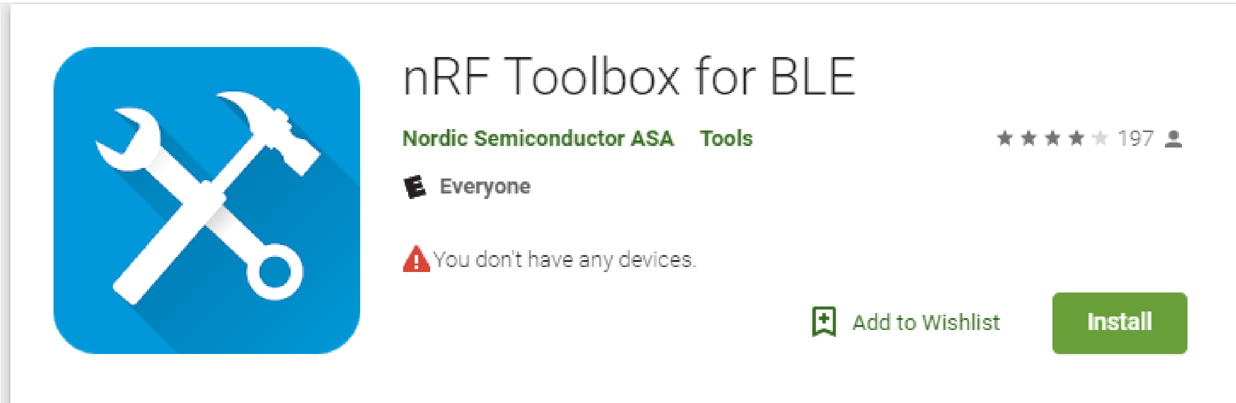


Figure 9, nRF Toolbox app for Android and iOS mobile devices.

4. Run the HRM demo and scan for "Solar_HRM" by clicking "Connect".

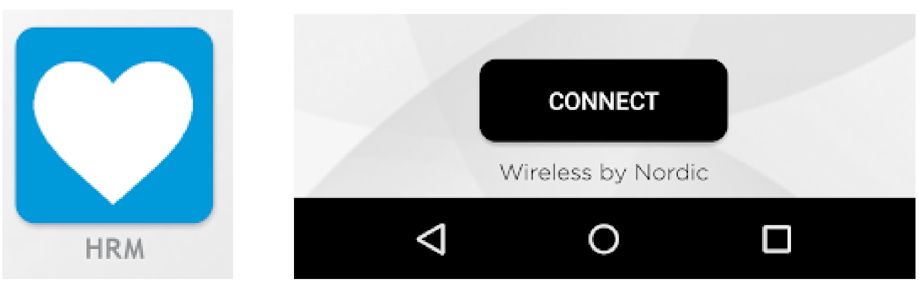


Figure 10, Heart Rate Monitor demo application (left) and the Bluetooth 'CONNECT' button (right).

5. Once connected, view simulated data sent from the BLE module.

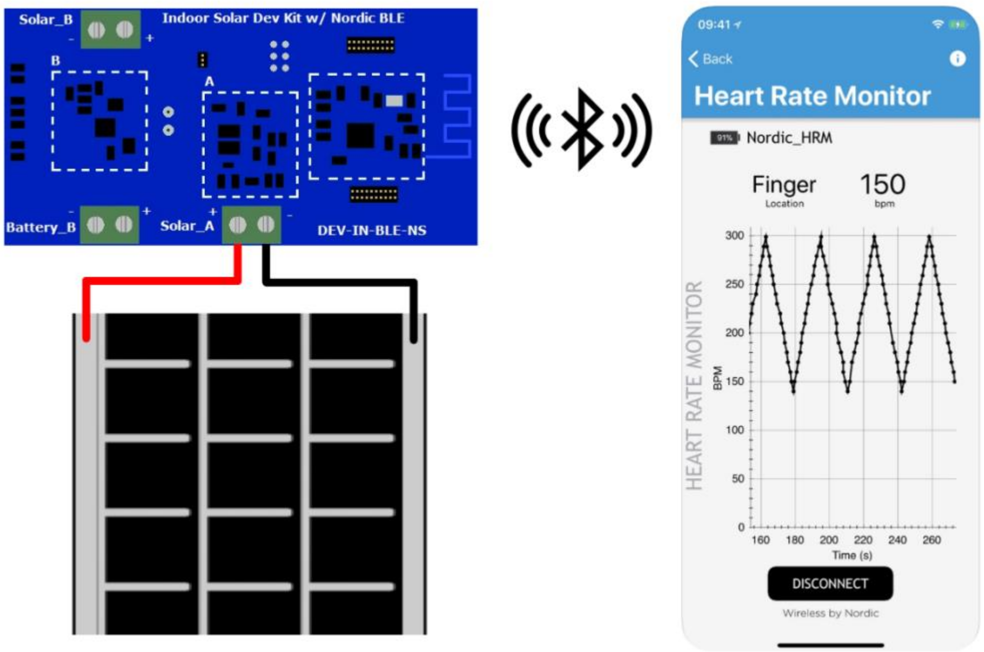


Figure 11, System diagram showing the DEV-BLE-NS powered with indoor solar and connected too a mobile device running the Nordic HRM demo application.

*Insert red leads into positive (+) terminals and black leads into negative (-) terminals.

Block Diagram

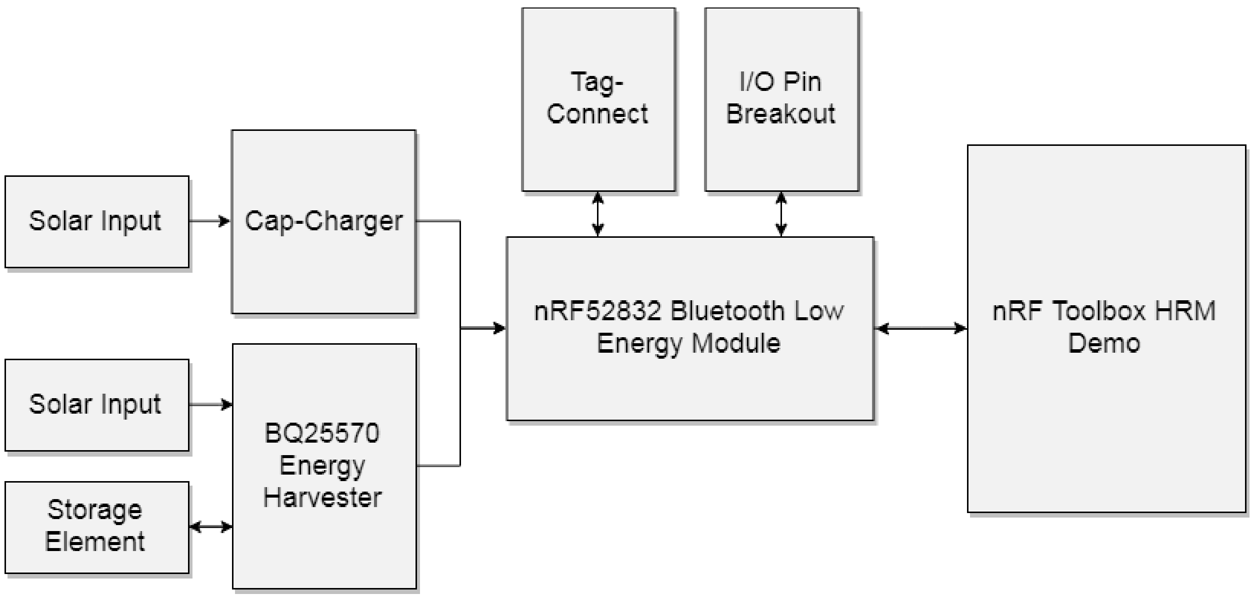


Figure 12, block diagram showing how the sub-components of the DEV-BLE-NS are connected.

Interfaces

Solar and Battery Inputs

Solar power can be connected to either Solar_A or Solar_B screw terminals, depending on which charge circuit is being used (see "Charge Circuit Selection" below).

A rechargeable Lithium based battery (4.2V max) or other compatible storage element can be recharged through the Battery_B screw terminals (must be using charging circuit "B", see details below).

See schematic and layout documents for details.

Charge Circuit Selection

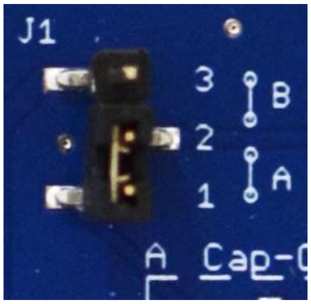


Figure 13, Jumper J1 charge control circuit selector.

Jumper J1 is used to select which charging circuit, A or B, to run the nRF52832 BLE module.

Move the jumper across pins 1 and 2 to use circuit A, Cap-Charger.

Move the jumper across pins 2 and 3 to use circuit B, DEV-BASIC.

See schematic and layout documents for details.

Tag-Connect

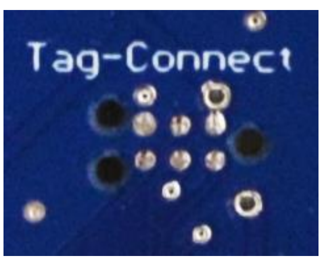


Figure 14, Tag-Connect nRF52832 programming interface.

The 6-pin Tag-Connect layout can be used to access and program the nRF52832 IC.

See schematic and layout documents for details.

IO Breakout

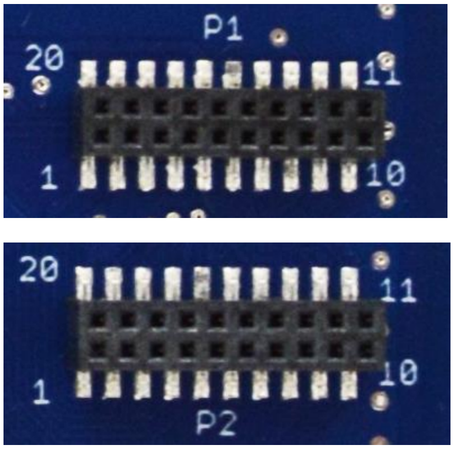


Figure 15, nRF52832 I/O breakout pin headers.

Female pin headers P1 and P2 provide access to nRF52832 IO pins, VDD, and Ground for development purposes.

See schematic and layout documents for details.

DEV-BLE-NS Application Notes

Power Consumption Optimization

The power consumption of the DEV-BLE-NS is heavily dependent on how the Bluetooth connection is configured in software. Advertising interval (1 second default) and connection interval (0.65 – 0.9 second default) will have the greatest impact on overall power consumption. Both parameters can be adjusted within the application. Using long connection intervals (16 seconds max) and long time periods between sensor measurements will allow the device to operate at very low light levels using minimum amount of PV material.

Hardware Configurations

Charge Control Configuration

The BQ25570 module is configured to charge a Li-ion type battery with max voltage of 4.2V, with the output supply voltage set to 3.0V. This configuration can be customized by modifying SMD resistor dividers per the BQ25570 datasheet specifications which can be found at http://www.ti.com/lit/ds/symlink/bq25570.pdf section 7.3.

- Output voltage can be set using R_{OUT}_1 and R_{OUT}_2
- Max Battery Voltage can be set using R_{OV}_1 and R_{OV}_2
- The minimum battery voltage and output turn on voltage can be set using resistors R_{OK}_1,2,3

See DEV-BASIC customization guide for more details.

Capacitor Storage Element Operation Using BQ25570 Charger

The BQ25570 (Charger Option B) is also capable of charging a capacitor as the storage element instead of the li-ion battery. Except the capacitor, the hardware configuration of the board can remain the same.

Theory of Operation

A capacitor will behave similarly to a small capacity battery when used as a storage element. It will charge and discharge quicker and may not hold as much energy as a li-ion battery.

From a discharged state, the capacitor will begin to charge when the kit is illuminated. Once the voltage is above 3.2V the Bluetooth radio will be enabled and ready to connect to the nRF Toolbox HRM Demo Application.

The capacitor will maintain steady power to the system while light is available. If the lights are turned off, the capacitor will discharge. When it reaches 3V the radio will shut down.

Specifications

- Capacitor must be at least 440uF or greater
- Capacitor must be rated for 6V or greater

Charge and discharge rate will be greatly affected by the size of the capacitor. If the capacitor is completely discharged (0V) the charge rate will be slower because the harvester chip is not yet fully functional. Figures 63 and 64 show charge up times vs storage capacitance size for 0V-3V and 3V-4.2V.

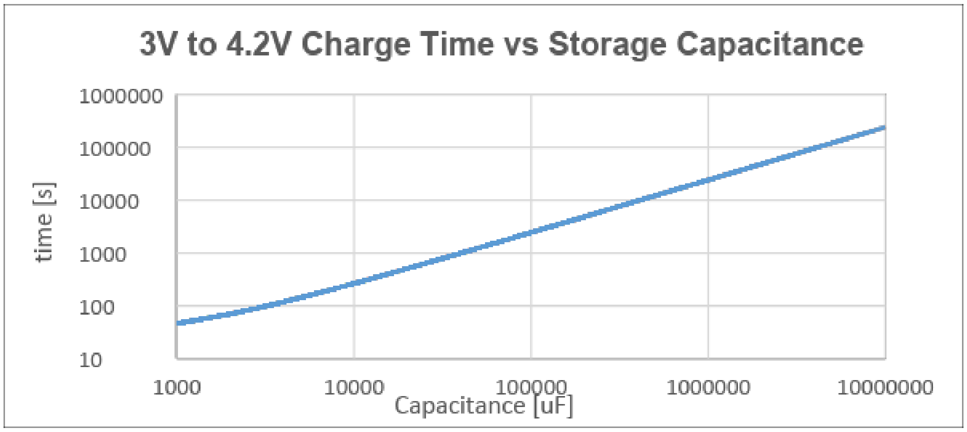


Figure 16, 3V to 4.2V charge time vs storage capacity at 300 lux.

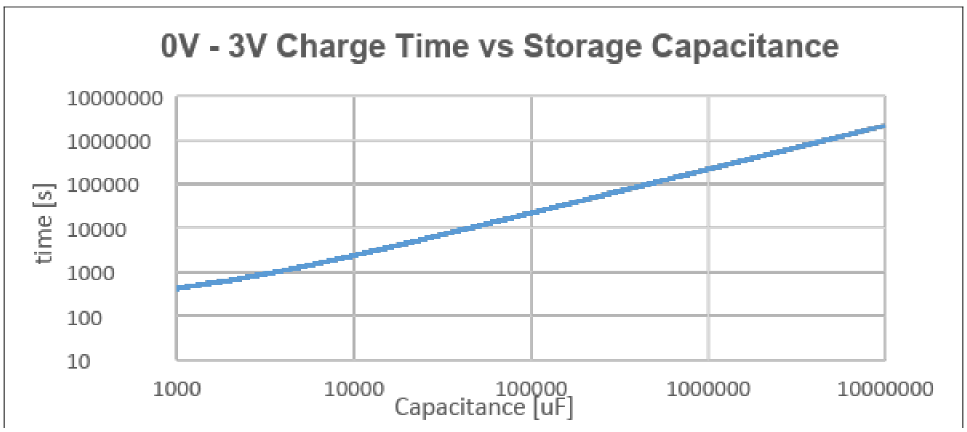


Figure 17, 0V-3V charge time vs storage capacitance at 300 lux.