



Energy Harvesting NanoBeacon™ IN100 Development Kit User Manual



NanoBeacon™

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About Documentation

Document name	Energy Harvesting NanoBeacon™ IN100 Development Kit user manual	
Part number	IN1BN-DKA0-AEM100-C1	
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Document status	Document content	Data status
In development	Target specification / MRD	Initial release
Engineering Document	Main functions and features description	Preliminary version
Official release document	Description of all functional features	Subject to revision and updates

This document applies to the following products:

Document	Applicable products	Document status
Energy Harvesting NanoBeacon™ IN100 Development Kit User Manual	IN1BN-DKA0-AEM100-C1	Engineering Document

Introduction and General Description

IN1BN-DKA0-AEM100-C1 is a partner board between e-peas and InPlay Inc. It is a InPlay NanoBeacon™ development kit that includes one energy harvesting IN100 development boards and one programmer board. The development board includes the e-peas AEM10330, an integrated energy management circuit that extracts DC power from an ambient energy harvesting source.

The development kit provides two Connectors (green) for connecting an energy source and storage device to the AEM10330. This allows quick testing of battery free and energy harvesting solutions. Additionally, all the I/Os available on IN100 (QFN18 package) that allow users to easily connect peripheral devices such as sensors, and by connecting the RF cables using SMA, users can evaluate the RF performance more accurately. In addition, an external power supply can be selected to provide a wide range of voltages for the IN100 device or system evaluation.

A kit contains one development board and one programmer board as shown in

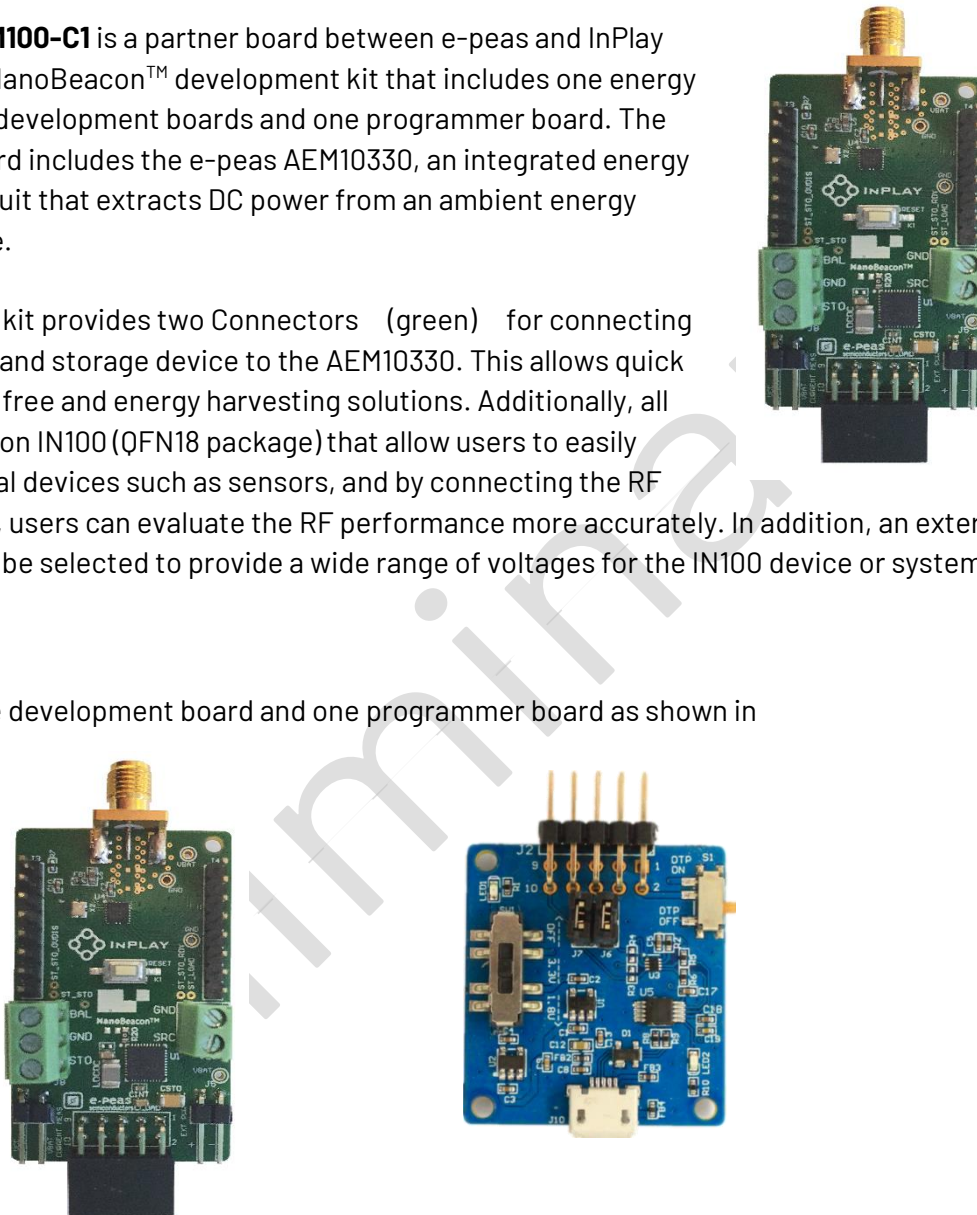


Figure 1: Energy Harvesting IN100 Development Kit

Energy Harvesting IN100 Development Board

- NanoBeacon™ IN100 SoC device
- e-peas AEM10330 PV Energy Harvester
- Source and storage element screw connectors
- 3.5mm SMA female RF connector
- Device I/O pins
- Reset button
- Power supply source selection switch: On-board energy harvester storage element/ External power supply / Programmer board power supply
- System current measurement jumper provision
- Programming interface female connector



Figure 2 : Energy Harvesting Development board

Programmer Board

- Programming interface male connector
- OTP (eFuse) memory programming power switch
- Programmer board output power selection switch : 1.8V / 3.3V / No connect
- OTP memory (eFuse) burning LED indicator
- On-board USB to UART convertor
- Micro USB female connector

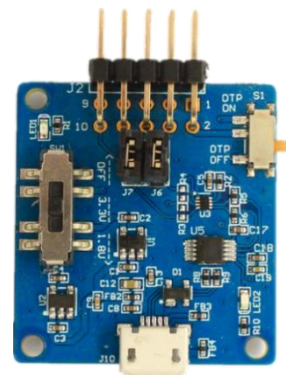


Figure 3 : Programmer board

Hardware Description

Development board front view

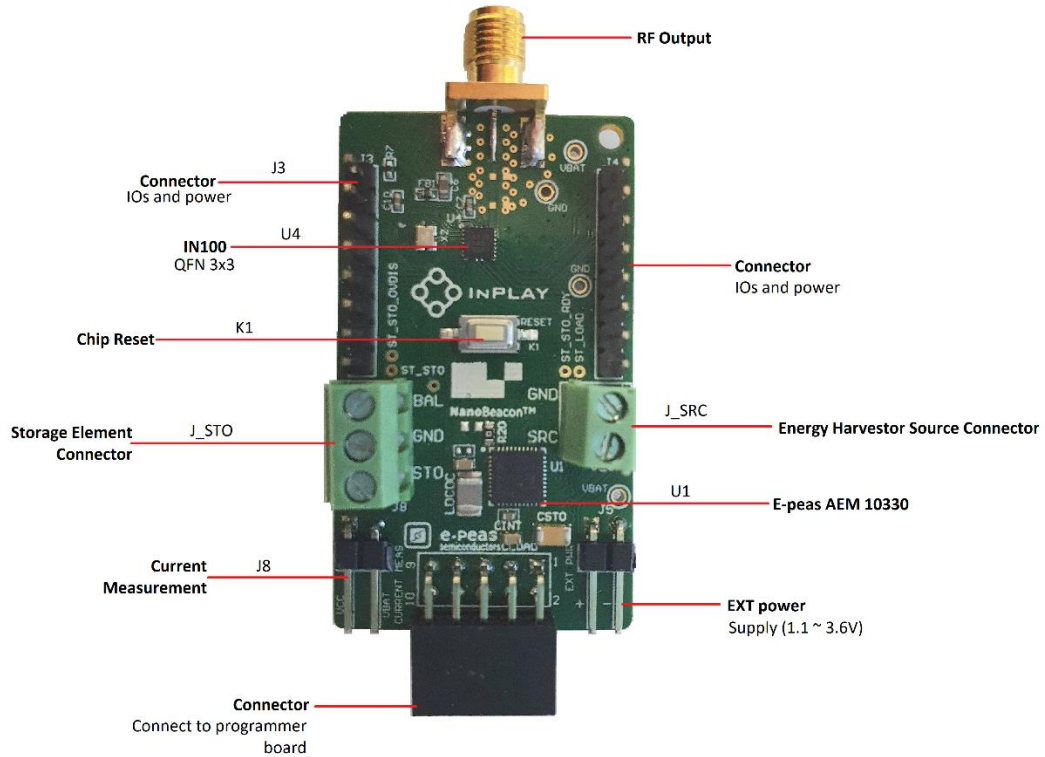


Figure 4 : Development board front view

Development board Connectors/Pins/Jumpers/Button Definition

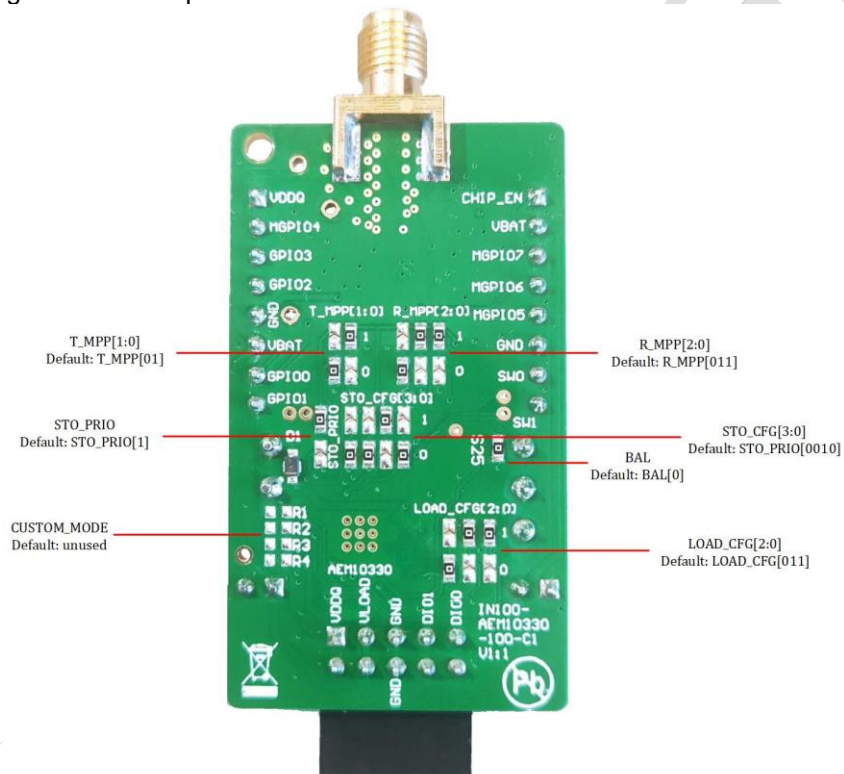
PRO

Designator	Function	Description		
J1	Connector (development board)	Pin #	Pin name	Description
		1	VDDQ	OTP (eFuse) memory programming power pin
		2	MGPI07	IN100 mixed-signal GPIO
		3	VBAT	System power supply, connected to the VCC pin of the IN100 through J8
		4	VBAT	System power supply, connected to the VCC pin of the IN100 through J8
		5	GND	Ground
		6	GND	Ground
		7	GPIO1	IN100 digital GPIO, Default is IN100 UART_TX
		8	MGPI05	IN100 mixed-signal GPIO
		9	GPIO0	IN100 digital GPIO, Default is IN100 UART_RX
10	MGPI04	IN100 mixed-signal GPIO		
J2	Connector (programmer board)	Pin #	Pin name	Description
		1	NC	No connect
		2	VDDQ	OTP (eFuse) memory programming power pin Power On/Off controlled by S1
		3	PWR	Power supply, controlled by SW1
		4	PWR	Power supply, controlled by SW1
		5	GND	Ground
		6	GND	Ground
		7	NC	No connect
		8	UART_RX	UART interface, connect to IN100 UART_TX
		9	NC	No connection
10	UART_TX	UART interface, connect to IN100 UART_RX		
J3	Connector for IOs and power	Pin #	Pin name	Description
		1	Reset	Connect to the Chip_EN pin of IN100 and pull low to disable the chip, pull high to enable the chip
		2	VBAT	System power supply, connect to IN100 VCC pin through J8
		3	MGPI07	IN100 mixed-signal GPIO
		4	MGPI06	IN100 mixed-signal GPIO
		5	MGPI05	IN100 mixed-signal GPIO
		6	GND	Ground
		7	SW0	IN100 built-in load switch for power supply
8	SW1	IN100 built-in load switch for grounding		

Designator	Function	Description																											
J4	Connector for IOs and power	<table border="1"> <thead> <tr> <th>Pin #</th> <th>Pin name</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>VDD0</td> <td>OTP (eFuse) memory programming power pin</td> </tr> <tr> <td>2</td> <td>MGPIO4</td> <td>IN100 mixed-signal GPIO</td> </tr> <tr> <td>3</td> <td>GPIO3</td> <td>IN100 digital signal GPIO</td> </tr> <tr> <td>4</td> <td>GPIO2</td> <td>IN100 digital signal GPIO</td> </tr> <tr> <td>5</td> <td>GND</td> <td>Ground</td> </tr> <tr> <td>6</td> <td>VBAT</td> <td>System power supply, connected to the VCC pin of the IN100 through J8</td> </tr> <tr> <td>7</td> <td>GPIO0</td> <td>IN100 digital GPIO, Default is IN100 UART_RX</td> </tr> <tr> <td>8</td> <td>GPIO1</td> <td>IN100 digital GPIO, Default is IN100 UART_TX</td> </tr> </tbody> </table>	Pin #	Pin name	Description	1	VDD0	OTP (eFuse) memory programming power pin	2	MGPIO4	IN100 mixed-signal GPIO	3	GPIO3	IN100 digital signal GPIO	4	GPIO2	IN100 digital signal GPIO	5	GND	Ground	6	VBAT	System power supply, connected to the VCC pin of the IN100 through J8	7	GPIO0	IN100 digital GPIO, Default is IN100 UART_RX	8	GPIO1	IN100 digital GPIO, Default is IN100 UART_TX
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J5	External power supply	External power supply (1.1~3.6V input). When this power supply is available, keep no coin cell battery installed and switch the programmer board SW1 to OFF.																											
J8	Current measurement	- For normal operation, a jumper needs to be installed - For current measurement <ul style="list-style-type: none"> Remove the jumper J8 on the board Power pin 1(VCC) of J8 with an external power supply with an ammeter. Initially, set the voltage same as the voltage presented on J8 pin 2 (VBAT) Press the K1 button to reset the device and run the user configuration in RAM (refer to the "Run in RAM" operation in the NanoBeacon™ Configuration Tool User Manual for details) Disconnect the programmer board from the development board Set the external power supply to the voltage at which you want to measure the current, and then measure the current. 																											
J9	RF TX output connector	The female 3.5mm SMA RF connector for connecting an external antenna (Note: antenna is not provided in the kit)																											
J_SRC	Connector for photovoltaic element	SRC connector for positive connection, GND for ground or negative connection. Don't exceed 4.5V; NEVER CONNECT FIRST to prevent damaging AEM10330- PMIC; ALWAYS DISCONNECT FIRST																											

Designator	Function	Description
J_STO	Connector for storage element	STO for positive connection, GND for negative or ground connection, and BAL for balancing dual cell storage element. Don't exceed 4.5V. ALWAYS CONNECT FIRST
P1	Chip_EN	- Chip_EN ON: Connect pin 1 and 2. This is to enable the device. - Chip_EN OFF: Connect pin 2 and 3. This is to disable the device.
K1	Chip reset	Chip reset button

Energy Harvesting IN100 development board back view


Figure 5: Developer Board Back View

Designator	Function	Description
T_MPP[1:0]	MPPT timing setting	Timing and duration of the MPP evaluation Default: 70.8 ms every 4.5s

Designator	Function	Description
R_MPP [2:0]	MPPT voltage ratio	Ratio between the source maximum power point voltage and the open circuit voltage Default: 75%
STO_PRI0	Storage element priority	Defines if the storage element charging has priority over the powering of the IN100 at startup on an empty storage element.
STO_CFG [3:0]	Storage element voltage levels	Defines the charging voltage of the storage element and at which storage voltage the AEM starts to supply the IN100 or cut-off power to protect the storage element. Default: Over discharge (1.85V), Charge ready (2.4V), Over charge (2.7V)
BAL	Dual-cell balancing	Used for balancing the center point of two storage element connected in series. S25 must be removed to use the BAL functionality
LOAD_CFG [2:0]	IN100 supply voltage	Defines the supply voltage of the IN100 Default: 1.2V For IN100 Tx power above 0dbm, it is recommended to use the configuration LOAD_CFG[001] (2.5V)
CUSTOM_MODE	Custom battery level voltages	Set custom battery voltages not covered by STO_CFG. To use the custom mode, STO_CFG[3:0] must be set to STO_CFG[0111]

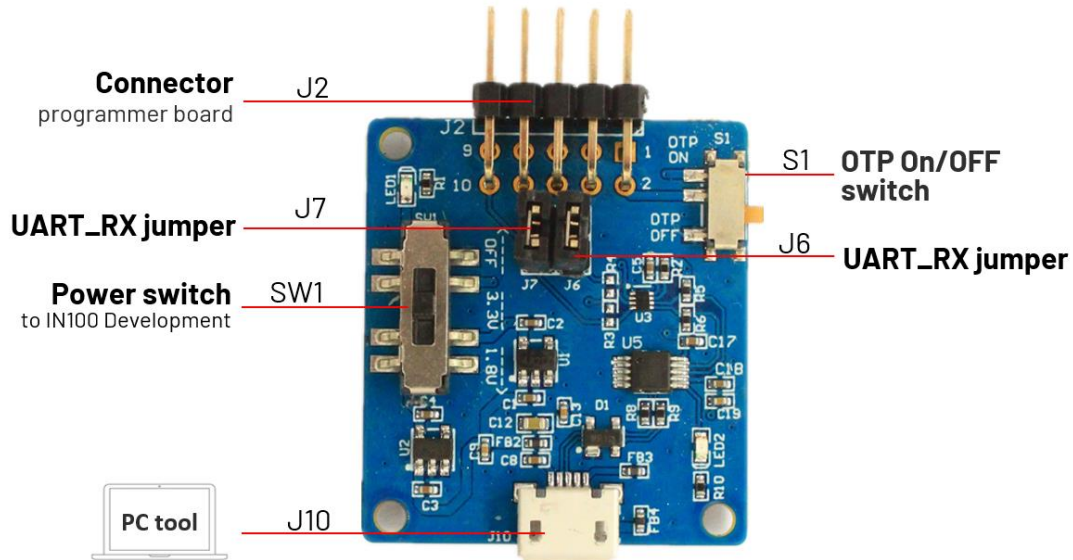
For further information on the characteristics and behaviors of the AEM10330, please refer to its datasheet:

https://e-peas.com/wp-content/uploads/2021/08/Datasheet_AEM10330_solar_energy_harvesting_IC_REV1.1.pdf

While the AEM is powering the IN100, it is possible to keep the IN100 running in RAM to test different applications without the need of burning the IN100 eFuse (OTP).

There is no need to disconnect the PV cell or storage element while the evaluation board is connected to the programmer board (unless the LOAD_CFG is configured at a higher voltage than the programmer board output voltage)

To safely store the device while unused, simply remove the PV cell, followed by the storage element, then press the reset button.


Figure 6: Programming Board
Programmer board Connectors/Pins/Jumpers/Button Definition

Designator	Function	Description
J6, J7	PC UART interface jumpers	The UART between the device (IN100) and PC is disconnected when no jumpers are installed.
J10	USB interface	Micro USB female connector for connecting with a PC
S1	OTP ON/OFF	OTP memory power supply switch. - Switch On: eFuse (OTP) memory programming is enabled, J2 pin2(FUSE) output 3.3V and connected to the device's (IN100) VDDQ. - Switch OFF: eFuse (OTP) memory programming is disabled. J2 pin2 will be grounded and connected to VDDQ of the device (IN100).
SW1	Power supply source select switch	-1.8V: 1.8V output for the development board -3.3V: 3.3V output for the development board -OFF: No power is provided by the programmer board. The power is provided by the development board itself.

Schematic

3.1 Simplified Schematic View

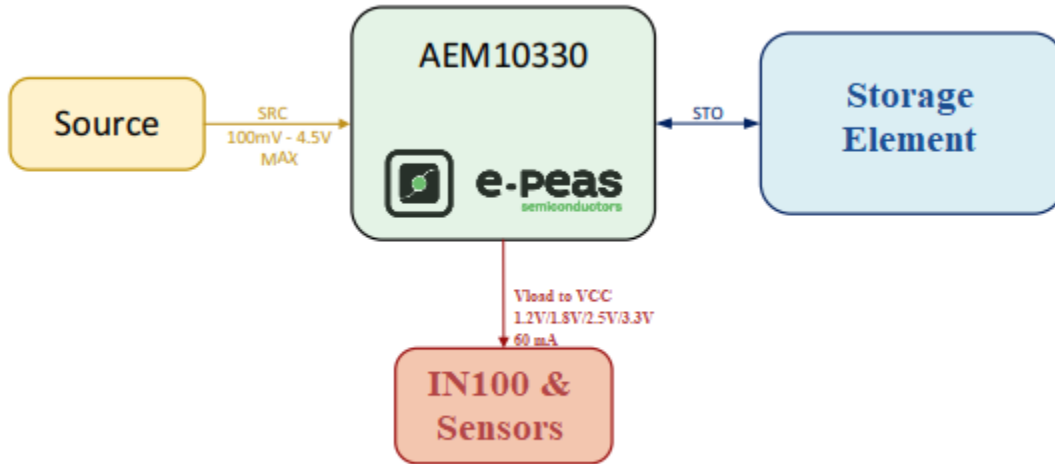
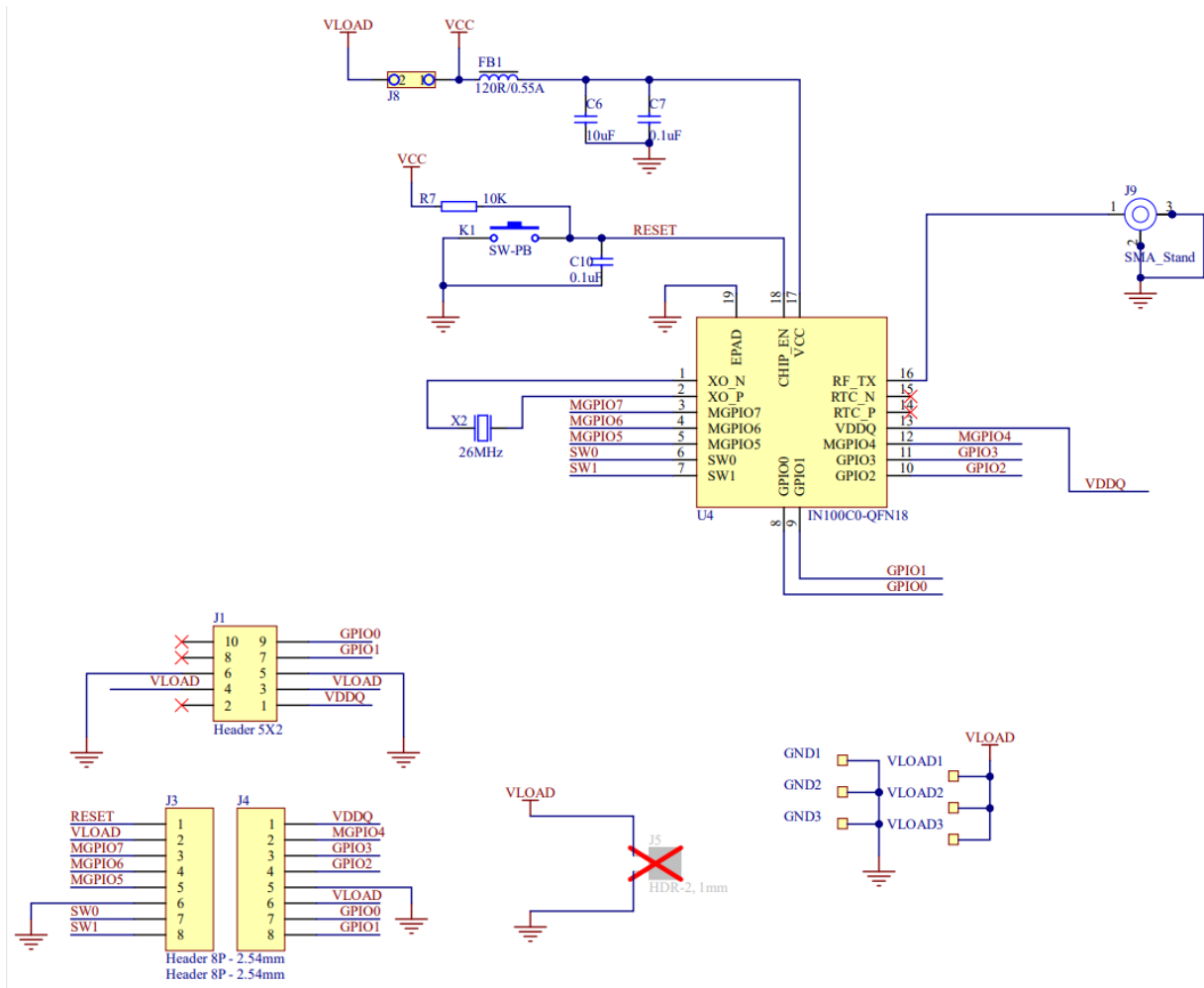
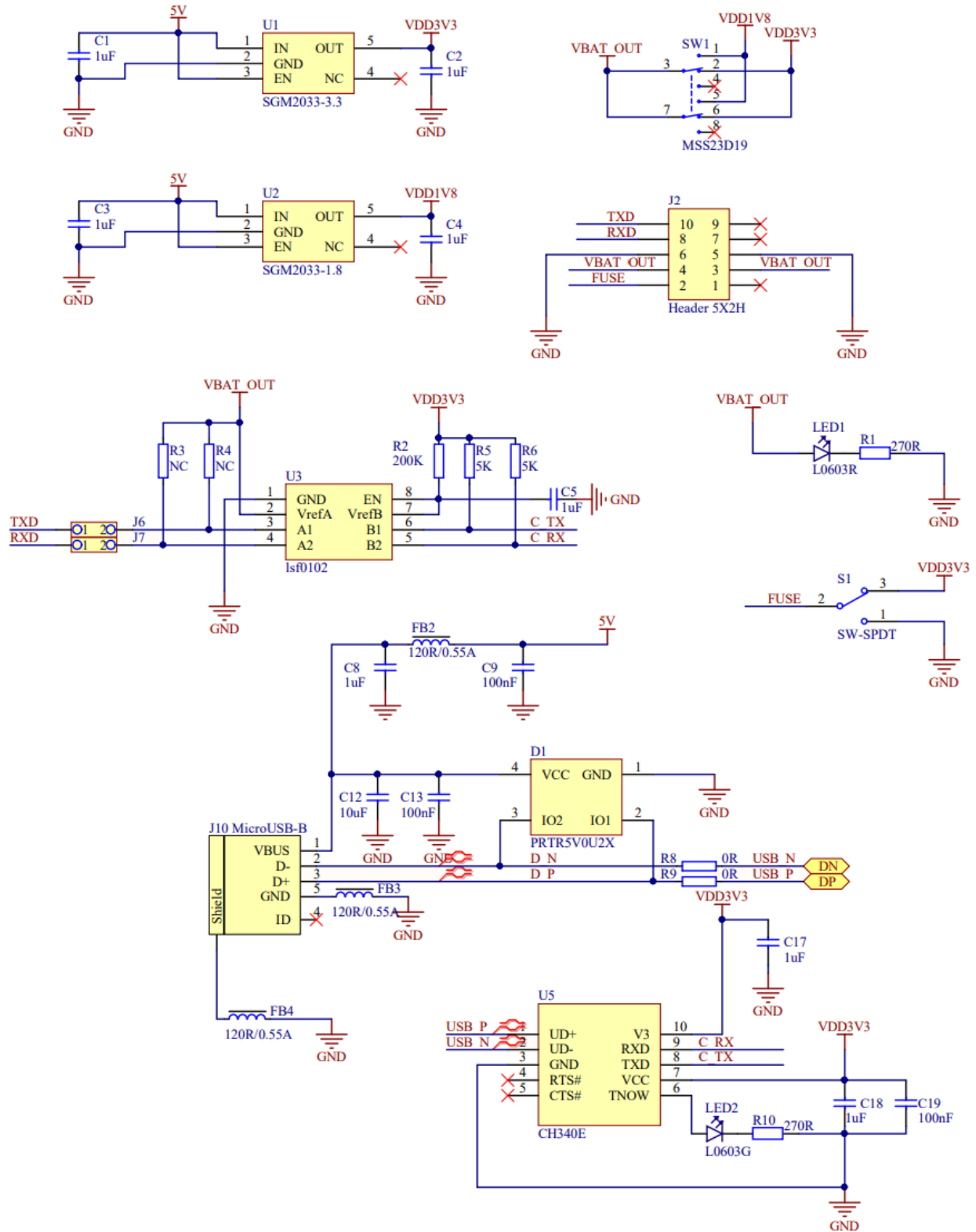


Figure 7: Simplified Schematic View

3.2 Development Kit Schematic

Preliminary





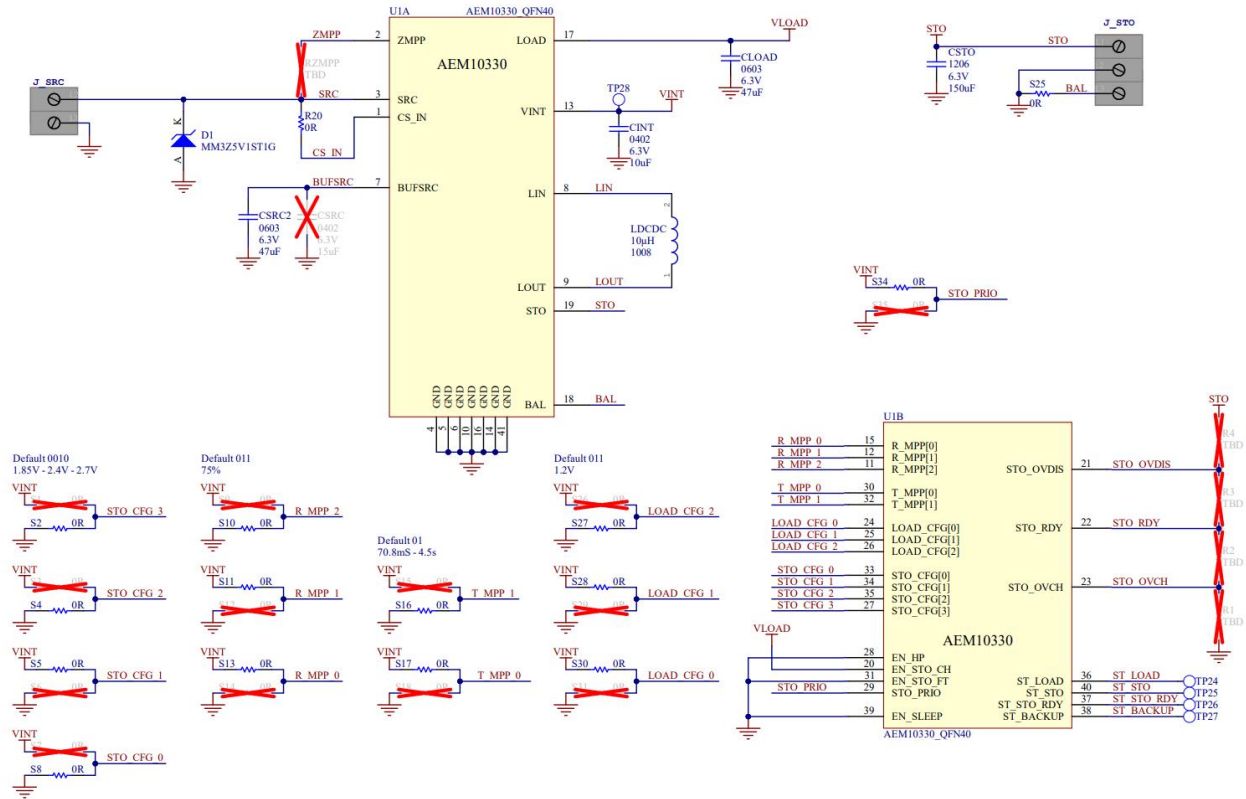


Figure 8 : Development Kit schematic

Recommended Peripheral Devices

The source and storage jumpers (J_SRC and J_STO) allow for testing various storage elements and energy harvesting solutions. The IN100 can operate from 1.1 to 3.6 V and the AEM10330 has a selectable load voltage from 1.2 to 3.3 V. This flexibility allows for multiple options for the source and storage elements. Below are the recommended peripheral devices for these purposes.

4.1 Solar Cells

For PV cells, InPlay recommends the following products:

Dracula Technologies LAYER

LAYER is a low cost, flexible, and printable solar cell technology developed by Dracula Technologies. The demo kit 6 product can produce up to 3 V, 210 micro-Amps, and 609 micro-Watts when exposed to 1000 Lumens. This allows for a quick charge of the storage element when testing applications that will be exposed to minimal light for long periods of time.

Powerfilm

Powerfilm provides a variety of low cost, indoor solar cells. The LL200-2.4-37 development sample 0.068 milli-Watts, 1.6 V operating voltage, 0.043 milli-Amps, and 200 Lux. This provides a lower voltage option from Dracula Technologies for testing battery free solutions with lower power requirements or a longer charging time for the storage element.

In case other PV cells are used please refer to the PV cell data sheet MPP characteristics , MPP section of the EVK as well as to AEM 10330 Data sheet .

4.2 Storage Elements

For the purpose of the storage element, InPlay recommends the following:

Nichicon

The Nichicon SLB03090LR801BT 2.4 V rechargeable Lithium battery operates at 2.4 V, with a 0.8 mAh capacity. This rechargeable battery is an effective option for low current consumption solutions.

Nichicon also has several options for super capacitors which vary in their capacitance and voltage rating. Exact specifications will be application dependent.

In case other storage elements are selected please refer to the storage element datasheet, STO Config section of EVK and AEM10330 DATASHEET.

AEM10330 System Configuration

The AEM 10330 is configurable through the configuration pins available on the device. The default configuration of the AEM10330 on the development kit is viewable on the Development Kit schematic and Developer Board Back.

1.1 High Power / Low Power Mode

When EN_HP is pulled to VINT, the DCDC converter is configured to HIGH POWER MODE. This allows higher currents to be extracted from the DCDC converter input (SRC or STO) to the DCDC converter output (LOAD or STO). Figure 9 shows the maximum current that the DCDC converter can supply to LOAD, depending on the storage voltage VSTO, for every available load voltage VLOAD, for both HIGH POWER MODE and LOW POWER MODE.

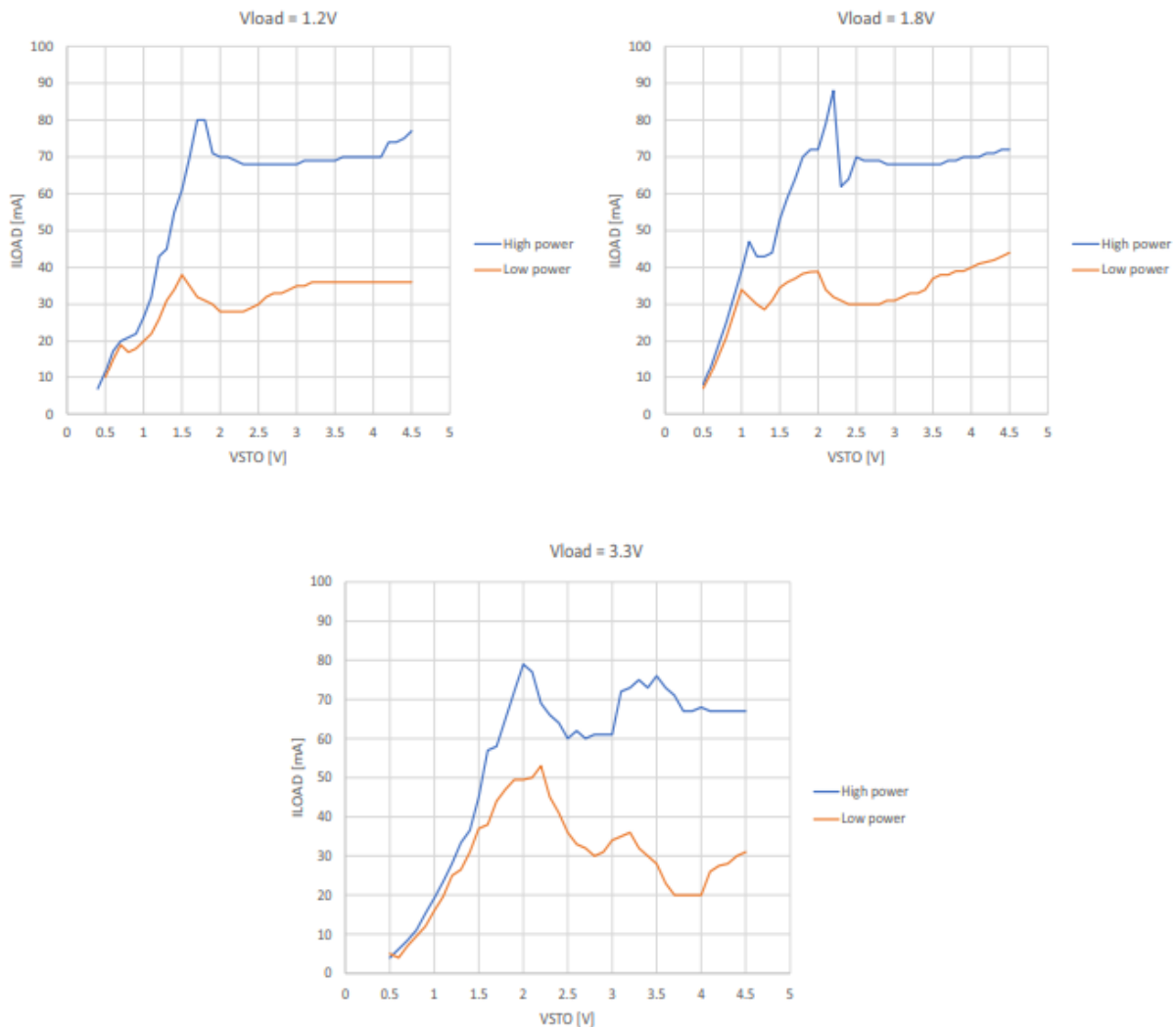


Figure 9: Maximum LOAD Current Depending on Vsto and on Vload

5.2 Storage Element Configuration

Through four configuration pins (STO_CFG[3:0]), the user can set a particular operating mode from a range that covers most application requirements, without any dedicated external component as shown in Table 1. The three threshold levels are defined as:

- VOVCH: maximum voltage accepted on the storage element before disabling its charging.
- VCHRDY: minimum voltage required on the storage element before starting to supply the LOAD (if STO_PRI0 is asserted) and entering supply state after start-up.
- VOVDIS: minimum voltage accepted on the storage element before considering the storage element as depleted resetting ST_STO.

A large-size storage element is not mandatory on STO:

- If the harvested energy source is permanently available and covers the application needs or
- If the application does not need to store energy when the harvested energy source is not available

The storage element may then be replaced by an external capacitor CSTO with a minimum value of 100 μ F.

CAUTION: running the AEM10330 without this 100 μ F minimum capacitance on STO will permanently damage the circuit.

Configuration pins				Storage element threshold voltages			Typical use
STO_CFG[3]	STO_CFG[2]	STO_CFG[1]	STO_CFG[0]	V _{OVDIS}	V _{CHRDY}	V _{OVCH}	
0	0	0	0	3.00 V	3.50 V	4.05 V	Li-ion battery
0	0	0	1	2.80 V	3.10 V	3.60 V	LiFePO4 battery
0	0	1	0	1.85 V	2.40 V	2.70 V	NiMH battery
0	0	1	1	0.20 V	1.00 V	4.65 V	Dual-cell supercapacitor
0	1	0	0	0.20V	1.00 V	2.60 V	Single-cell supercapacitor
0	1	0	1	1.00 V	1.20 V	2.95 V	Single-cell supercapacitor
0	1	1	0	1.85 V	2.30 V	2.60 V	NGK
0	1	1	1	Custom Mode			
1	0	0	0	1.10 V	1.25 V	1.50 V	Ni-Cd 1 cells
1	0	0	1	2.20 V	2.50 V	3.00 V	Ni-Cd 2 cells
1	0	1	0	1.45 V	2.00 V	4.65 V	Dual-cell supercapacitor
1	0	1	1	1.00 V	1.20 V	2.60 V	Single-cell supercapacitor
1	1	0	0	2.00 V	2.30 V	2.60 V	ITEN / Umal Murata
1	1	0	1	3.00 V	3.50 V	4.35 V	Li-Po battery
1	1	1	0	2.60 V	2.70 V	4.00 V	Tadiran TLI1020A
1	1	1	1	2.60 V	3.50 V	3.90 V	Tadiran HLC1020

Table 1: Storage Element Configuration Pins

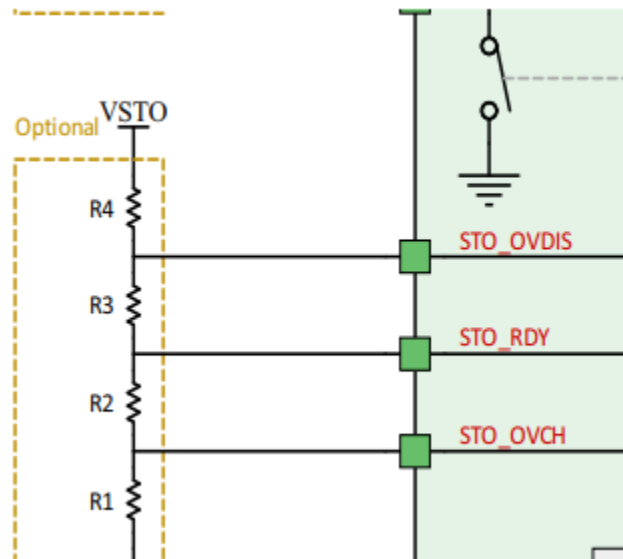
5.3 Load Configuration

The LOAD output voltage VLOAD can be configured thanks to the LOAD_CFG[2:0] configuration pins covering most application cases (see Table 10). VLOAD is regulated to VLOAD,TYP. However, if VLOAD falls below VLOAD,MID, the controller forces STO as an input of the DCDC converter to supply LOAD.

Configuration pins			LOAD output voltage			
LOAD_CFG[2]	LOAD_CFG[1]	LOAD_CFG[0]	V _{LOAD,MIN}	V _{LOAD,MID}	V _{LOAD,TYP}	V _{LOAD,MAX}
0	0	0	3.15 V	3.23 V	3.28 V	3.34 V
0	0	1	2.35 V	2.47 V	2.50 V	2.53 V
0	1	0	1.64 V	1.75 V	1.79 V	1.82 V
0	1	1	1.14 V	1.16 V	1.20 V	1.23 V
1	0	0	1.39 V	1.56 V	1.61 V	2.63 V
1	0	1	1.39 V	1.56 V	1.61 V	4.65 V
1	1	0	Reserved, do not use			
1	1	1				

Table 2: Load Configuration Pins

5.4 Custom Mode Configuration


Figure 10: Custom Mode Settings

When $STO_CFG[3:0] = 0111$, the custom mode is selected and all four configuration resistors must be wired as shown in Figure 10.

VOVCH, VCHRDY and, VOVDIS are defined thanks to R1, R2, R3 and R4, which can be determined within the following constraints:

- $RT = R1 + R2 + R3 + R4$
- $1\text{ M}\Omega \leq RT \leq 100\text{ M}\Omega$
- $R1 = RT(1\text{ V} / VOVCH)$
- $R2 = RT(1\text{ V} / VCHRDY - 1\text{ V} / VOVCH)$
- $R3 = RT(1\text{ V} / VOVDIS - 1\text{ V} / VCHRDY)$

$$R4 = RT(1 - 1V / VOVDIS)$$

The resistors should have high values to make the additional power consumption negligible. Moreover, the following constraints must be adhered to ensure the functionality of the chip:

- $VCHRDY + 0.05\text{ V} \leq VOVDIS \leq 4.5\text{ V}$
- $VOVDIS + 0.05\text{ V} \leq VCHRDY \leq VOVDIS - 0.05\text{ V}$
- $1V \leq VOVDIS$

5.5 Disabling Storage Element Charging

Pulling down EN_STO_CH pin to GND disables the charging of the storage element connected to STO from SRC. This can be done for example to protect the storage element when the system detects that the environment temperature is too low or too high to safely charge the storage element.

While EN_STO_CH is pulled down, VINT and LOAD can still be supplied either from SRC or from STO.

To enable charging the storage element on STO, EN_STO_CH must be pulled up to LOAD.

NOTE: STO will still be charged to VCHRDY during the START STATE

5.6 MPPT Configuration

There are two kinds of pins to configure the maximum point tracking. The first configuration pins allows for selecting the MPP tracking ratio based on the characteristic of the input power source. The configuration pins are R_MPP[2:0].

Configuration pins			MPPT ratio
R_MPP[2]	R_MPP[1]	R_MPP[0]	V_{MPP} / V_{OC}
0	0	0	60%
0	0	1	65%
0	1	0	70%
0	1	1	75%
1	0	0	80%
1	0	1	85%
1	1	0	90%
1	1	1	ZMPP

Figure 11: MPP Ratio Configuration Pins

The second kind of configuration pins allows for configuring the duration of an MPP evaluation and the time between two MPP evaluations. The configurations pins are T_MPP[1:0].

Configuration pins		MPPT timing	
T_MPP[1]	T_MPP[0]	Sampling duration	Sampling period
0	0	5.19 ms	280 ms
0	1	70.8 ms	4.5 s
1	0	280 ms	17.87 s
1	1	1.12 s	71.7 s

Figure 12: MPP Timing Configuration Pins

5.7 ZMPP Configuration

Instead of working at a ratio of the open-circuit voltage, the AEM10330 can regulate the input impedance of the DCDC converter so that it matches a constant impedance RZMPP connected to the ZMPP pin. In this case, the AEM10330 regulates VSRC at a voltage that is the product of the ZMPP resistance RZMPP and the current available at the SRC input.

- $10 \Omega \leq RZMPP \leq 100 \text{ K}\Omega$

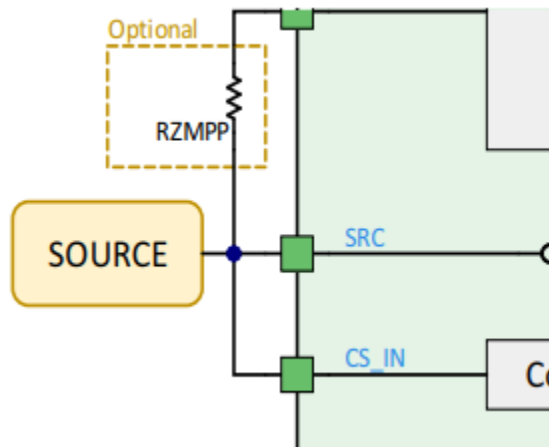


Figure 13: RZMPP Connection to the AEM10330

8.8 Source to Storage Element Feed Through

When the harvester connected to SRC delivers a high amount of power, the AEM might not be able to pull enough current to regulate VSRC to the MPP voltage. The voltage on SRC thus increases,

eventually above 5V. To maximize the energy extracted in that case, the AEM30330 can be configured to create a direct feed-through current path from SRC to STO when VSRC is above 5V. This is measured when the AEM is pulling current from the source (not during an MPP evaluation).

If the MPPT module detects that VSRC is higher than 4 V and EN_STO_FT is set, the SRC is monitored. From that moment, if the AEM10330 detects that VSRC rises above 5 V and if the storage element is not fully charged, the switch between the SRC and STO pins is closed until VSRC drops below 5 V or until the storage element is fully charged.

This feature is enabled by pulling up EN_STO_FT pin to VINT. However, it is disabled if the storage element is fully charged, or when a MPP evaluation is occurring. Therefore, the circuit must still be protected from any overshoot voltage on SRC above 5.5 V, for instance by a Zener diode.

5.9 External Components

Refer to Figure 8 to have an illustration of the external components wiring.

Nanobeacon Config Tool Introduction

InPlay NanoBeacon Configuration Tool is a PC GUI (Graphical User Interface) tool for chip firmware configuration. The PC application file is NanoBeacon Config.exe. Developers should have the flexibility to configure the peripherals, advertising data and advertising parameters of the NanoBeacon device (IN100) according to user's application requirements.

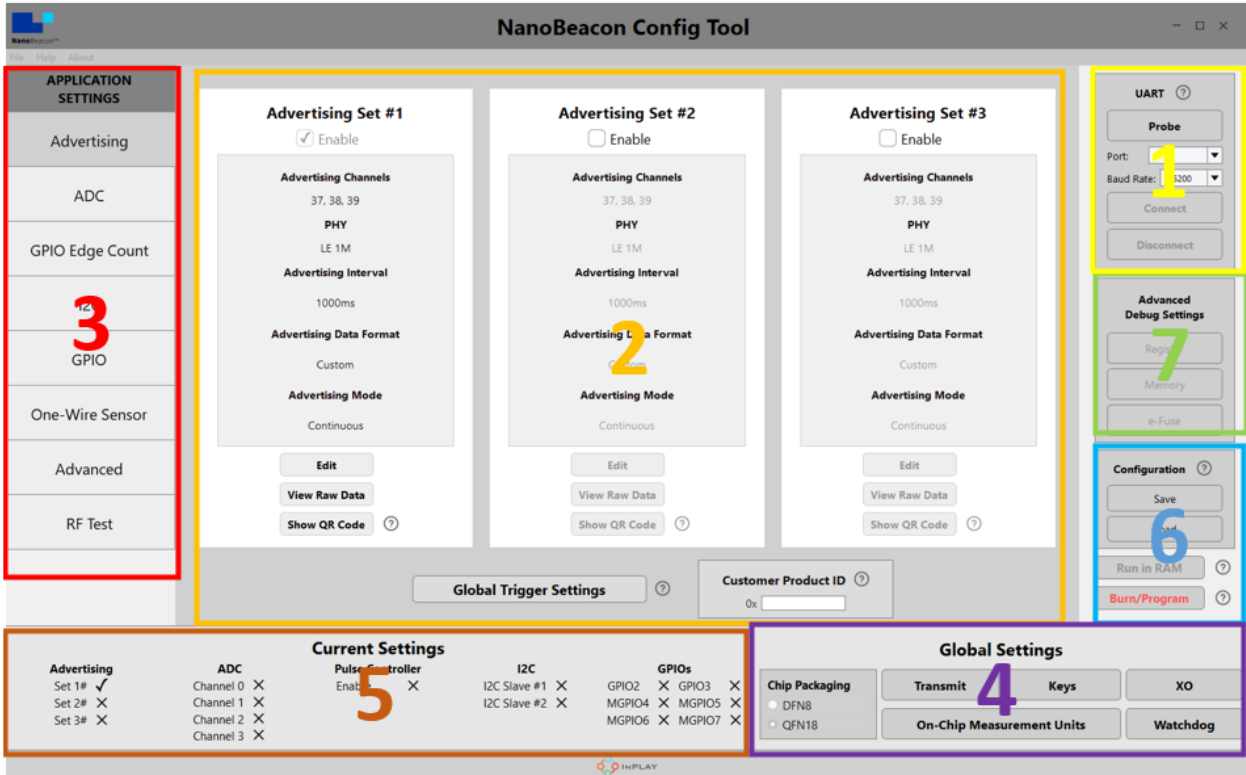


Figure 14 Overview of NanoBeacon configuration tool

Figure 14 shows the general look of the GUI software tools, which consists of:

- 1) **UART**, which is used for setting UART port and baud rate on the PC to communicate with the development kit. The default baud rate is 115200.
- 2) **Main window**, which provides a main configuration window for user to configure the device.
- 3) **Application Settings**, which includes all configurable option tabs including Advertising Settings, ADC, Plus Count Controller, I2C, GPIO and GPIO Edge Count. In addition, there is an advanced mode setting for using special device behavior settings not covered in the regular option settings. The RF Test tab provides an easy-to-use interface for users to run various RF tests, including BLE DTM mode test and carrier test.
- 4) **Global settings**, which provides settings to the device that applies to all advertising sets.
- 5) **Current Settings**, which provides an overview of device settings and configurations.
- 6) **Configuration**, which provides the user with a way to save the configuration to a file or load it from an existing configuration file. Once the configuration file is successfully loaded, the user has two options to try and test the configuration on the device. One is "Run in RAM", which provides a way to test and verify the user's configuration before it is permanently burned to the device. Whenever there are any changes to the

configuration, the user should always reset the device before operating "Run in RAM". The other is "Burn/Program" which will permanently burn the configuration file to the device, which is irreversible and should be performed as the last step.

- 7) **Advanced Debug Settings**, which provides a way to read/write device's register/memory/eFuse and this is used for debugging purposes only.

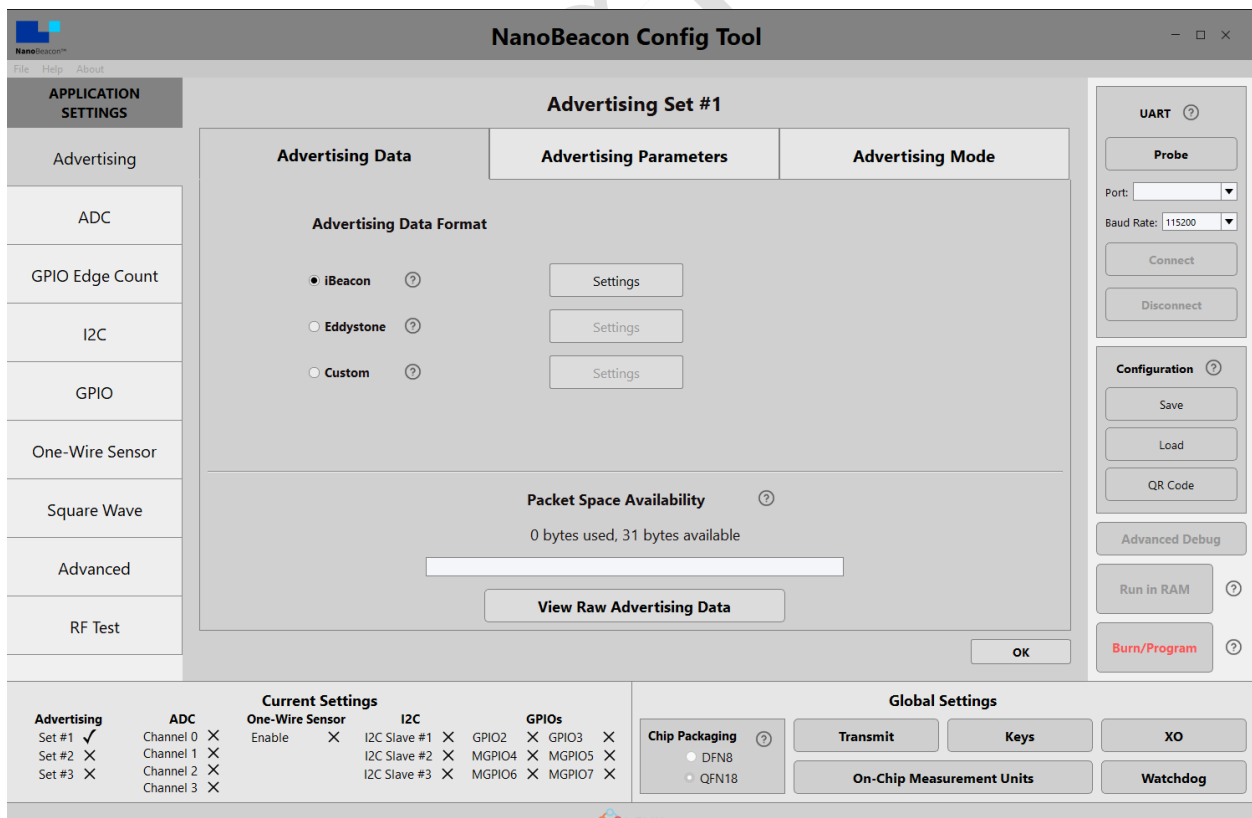
4.1 Battery Free Active RFID Use Case Examples

Because of the on-board AEM 10330, the development board can be used to accurately assess battery free solutions.

4.1.1 Example 1: Powerfilm Low Current Consumption iBeacon

Using the Nichicon SLB03090LR801BT 2.4 V rechargeable lithium battery and the Powerfilm LL200-2.4-37 indoor PV cell, the e-peas and IN100 development board can be made into an ultra-low power iBeacon.

In the Nanobeacon Config tool, advertising set #1 can be made into an iBeacon in the Advertising tab.



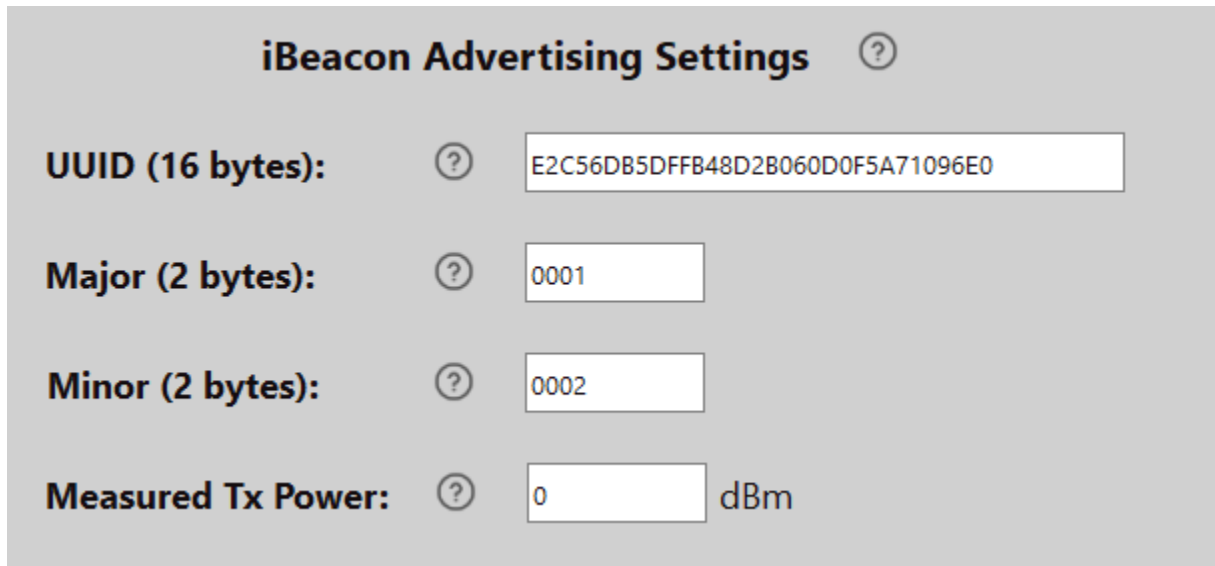
The screenshot shows the NanoBeacon Config Tool interface. The main window is titled "NanoBeacon Config Tool" and has a menu bar with "File", "Help", and "About". The interface is divided into several sections:

- APPLICATION SETTINGS**: A sidebar on the left with tabs for "Advertising", "ADC", "GPIO Edge Count", "I2C", "GPIO", "One-Wire Sensor", "Square Wave", "Advanced", and "RF Test".
- Advertising Set #1**: The main content area, divided into three sub-sections:
 - Advertising Data**: Contains "Advertising Data Format" with three radio button options: "iBeacon" (selected), "Eddystone", and "Custom". Each option has a "Settings" button next to it.
 - Advertising Parameters**: Currently empty.
 - Advertising Mode**: Currently empty.
- Packet Space Availability**: A section below the format options showing "0 bytes used, 31 bytes available" and a "View Raw Advertising Data" button.
- UART**: A sidebar on the right with "Probe", "Port:" (dropdown), "Baud Rate:" (115200 dropdown), "Connect", and "Disconnect" buttons.
- Configuration**: A sidebar on the right with "Save", "Load", and "QR Code" buttons.
- Advanced Debug**: A sidebar on the right with "Run in RAM" and "Burn/Program" buttons.
- Current Settings**: A bottom section with a table of settings:

Advertising	ADC	One-Wire Sensor	I2C	GPIOs
Set #1 ✓	Channel 0 ✗	Enable ✗	I2C Slave #1 ✗	GPIO2 ✗ GPIO3 ✗
Set #2 ✗	Channel 1 ✗		I2C Slave #2 ✗	MGPIO4 ✗ MGPIO5 ✗
Set #3 ✗	Channel 2 ✗		I2C Slave #3 ✗	MGPIO6 ✗ MGPIO7 ✗
	Channel 3 ✗			
- Global Settings**: A bottom section with "Chip Packaging" (DFN8, QFN18), "Transmit", "Keys", "XO", "On-Chip Measurement Units", and "Watchdog" buttons.

Figure 15: iBeacon Settings

To change the iBeacon parameters, click Settings from this tab and enter the desired UUID, major, minor, and reported Tx power level.



iBeacon Advertising Settings	
UUID (16 bytes):	<input type="text" value="E2C56DB5DFFB48D2B060D0F5A71096E0"/>
Major (2 bytes):	<input type="text" value="0001"/>
Minor (2 bytes):	<input type="text" value="0002"/>
Measured Tx Power:	<input type="text" value="0"/> dBm

Figure 16: iBeacon Advertising Settings

For the sake of example, the default UUID value and a simple major, minor, and measured Tx power level are selected.

In the Advertising parameters section, the advertising interval is changed to 5000 ms which is 5 seconds.

Advertising Set #1

Advertising Data	Advertising Parameters	Advertising Mode															
<div style="border: 2px solid red; padding: 5px;"> Advertising Interval ? <input type="text" value="5000"/> ms </div>	PHY Selection ? <input checked="" type="radio"/> LE 1M PHY <input type="radio"/> LE Coded PHY(125Kbps)	CTE ? <input type="checkbox"/> Enable Duration (Unit is 8us, 2 ~ 20) <input type="text"/>															
Advertising Random Delay <input checked="" type="radio"/> 0 ~ 10ms <input type="radio"/> 0 ~ 20ms <input type="radio"/> 0 ~ 80ms <input type="radio"/> 0 ~ 160ms	Advertising Channels ? <input checked="" type="checkbox"/> Channel 37 <input checked="" type="checkbox"/> Channel 38 <input checked="" type="checkbox"/> Channel 39																
Bluetooth Device Address ? <input checked="" type="radio"/> Public/Static Address <input type="radio"/> Random Address																	
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;"> <table style="width: 100%; border: 1px solid gray; padding: 5px;"> <tr> <td style="text-align: center; font-size: small;">LSB</td> <td style="text-align: center; font-size: small;">MSB</td> </tr> <tr> <td style="text-align: center;"> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="23"/> <input type="text" value="22"/> <input type="text" value="22"/> </td> <td></td> </tr> </table> </td> <td style="width: 50%; border: none;"> <table style="width: 100%; border: 1px solid gray; padding: 5px;"> <tr> <td colspan="3" style="border: none;"> <input type="radio"/> Static <input type="radio"/> Private Resolvable <input checked="" type="radio"/> Private Non-Resolvable </td> </tr> <tr> <td style="border: none;">Private Address Renewal Interval</td> <td style="border: none;"><input type="text" value="90"/></td> <td style="border: none;">sec</td> </tr> <tr> <td style="border: none;">Private Resolvable Address Key</td> <td colspan="2" style="border: none;"><input type="text" value="key0"/> ▼</td> </tr> </table> </td> </tr> </table>			<table style="width: 100%; border: 1px solid gray; padding: 5px;"> <tr> <td style="text-align: center; font-size: small;">LSB</td> <td style="text-align: center; font-size: small;">MSB</td> </tr> <tr> <td style="text-align: center;"> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="23"/> <input type="text" value="22"/> <input type="text" value="22"/> </td> <td></td> </tr> </table>	LSB	MSB	<input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="23"/> <input type="text" value="22"/> <input type="text" value="22"/>		<table style="width: 100%; border: 1px solid gray; padding: 5px;"> <tr> <td colspan="3" style="border: none;"> <input type="radio"/> Static <input type="radio"/> Private Resolvable <input checked="" type="radio"/> Private Non-Resolvable </td> </tr> <tr> <td style="border: none;">Private Address Renewal Interval</td> <td style="border: none;"><input type="text" value="90"/></td> <td style="border: none;">sec</td> </tr> <tr> <td style="border: none;">Private Resolvable Address Key</td> <td colspan="2" style="border: none;"><input type="text" value="key0"/> ▼</td> </tr> </table>	<input type="radio"/> Static <input type="radio"/> Private Resolvable <input checked="" type="radio"/> Private Non-Resolvable			Private Address Renewal Interval	<input type="text" value="90"/>	sec	Private Resolvable Address Key	<input type="text" value="key0"/> ▼	
<table style="width: 100%; border: 1px solid gray; padding: 5px;"> <tr> <td style="text-align: center; font-size: small;">LSB</td> <td style="text-align: center; font-size: small;">MSB</td> </tr> <tr> <td style="text-align: center;"> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="23"/> <input type="text" value="22"/> <input type="text" value="22"/> </td> <td></td> </tr> </table>	LSB	MSB	<input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="22"/> <input type="text" value="23"/> <input type="text" value="22"/> <input type="text" value="22"/>		<table style="width: 100%; border: 1px solid gray; padding: 5px;"> <tr> <td colspan="3" style="border: none;"> <input type="radio"/> Static <input type="radio"/> Private Resolvable <input checked="" type="radio"/> Private Non-Resolvable </td> </tr> <tr> <td style="border: none;">Private Address Renewal Interval</td> <td style="border: none;"><input type="text" value="90"/></td> <td style="border: none;">sec</td> </tr> <tr> <td style="border: none;">Private Resolvable Address Key</td> <td colspan="2" style="border: none;"><input type="text" value="key0"/> ▼</td> </tr> </table>	<input type="radio"/> Static <input type="radio"/> Private Resolvable <input checked="" type="radio"/> Private Non-Resolvable			Private Address Renewal Interval	<input type="text" value="90"/>	sec	Private Resolvable Address Key	<input type="text" value="key0"/> ▼				
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<input type="radio"/> Static <input type="radio"/> Private Resolvable <input checked="" type="radio"/> Private Non-Resolvable																	
Private Address Renewal Interval	<input type="text" value="90"/>	sec															
Private Resolvable Address Key	<input type="text" value="key0"/> ▼																
<input type="button" value="Advanced Advertising"/>																	
<input type="button" value="OK"/>																	

Figure 17: Advertising Parameters Advertising Interval

After these parameters have been set in, the development kit being powered by the PV cell will result in an average current consumption of 3.21 micro-Amps. When powered by the Nichicon battery at 2.4 V, this results in a lifetime of 10 days, 9 hours, and 13 minutes. Increasing the advertising interval to 10 seconds from 5 results in an average current consumption of 1.88 micro-Amps and a resulting 17-and-a-half-day battery life.

To further increase battery life, strategies such as reducing the Tx power level or further increasing the advertising interval can result in battery lives up to a month or more in time.

4.1.2 Example 2: Low Power Temperature Sensor

In this example, the Sensirion SHT40 will be used as a low power pressure, temperature, and humidity sensor. Using this sensor with a super capacitor/rechargeable and PV cell allows for a maintenance free and high accuracy sensor. Uses can vary from monitoring plant soil, inventory condition, weather, or simpler use cases reducing the sensor's data to just one variable. To learn how to configure the SHT40 and the I2C commands needed, refer to the tutorials found on the [InPlay GitHub page](#).

Depending on the advertising interval, the battery lifetime will vary for this setup. For example, at a 1 second advertising interval and using the "low power" strategy discussed on the GitHub page, then the power consumption will be around 16.12 micro-Amps. For this power consumption the setup would last about 2 days and 1 and a half hours. If this setup was put outside or in a building

with the lights on regularly throughout the day, the setup could last well through the night or weekend before needing exposure to light again.

To configure this setup in the IN100 config tool, the SHT40 low power config file from the GitHub page will be used. For the advertising set, the sensor data will be added to the payload. More specifically, I2C slave #1 read data. Note that the I2C slave can be any of the three.

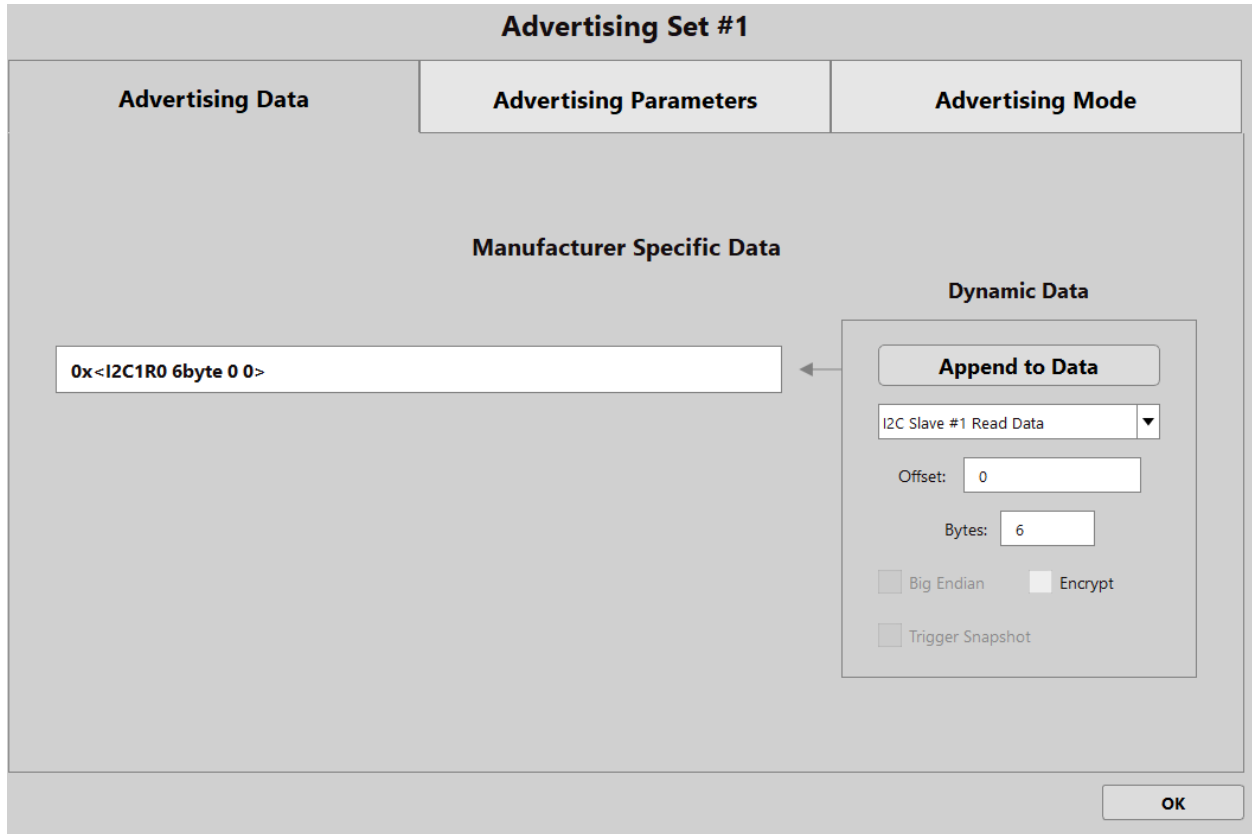


Figure 18: I2C Slave #1 Data

The previous mentioned use case of a soil monitor could measure the temperature, humidity, and relative pressure around the plant and soil through night, and recharged by the PV cell in the day. The low Lux requirement also means reliable use during overcast weather.

Revision History

Revision	Description	Update date	Owner
V0.6	Preliminary version	Jul-2023	A. Martens

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