ATM3330e PV Keyboard

User Guide

SUMMARY: This document describes the features and usage of the ATM3330e based Photovoltaic (PV) Bluetooth LE Keyboard reference design. The PV Keyboard is powered by up to two PV cells and is available in battery-free configuration.

Atmosic™

Doc. No. ATM3330e-UGPVKB-P052

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Acronyms and Abbreviations

Acronyms	Definition
HSC	Hybrid Supercapacitor
KBD	Keyboard
OTA	Over-The-Air
PMU	Power Management Unit
PV	Photovoltaic
RPB	Reference Design Programming Board
SoC	System-on-Chip
RDK	Reference Design Kit

1. Overview

The ATM3330e PV Keyboard is a Bluetooth LE Keyboard reference design that demonstrates the low power consumption of the Atmosic Bluetooth LE ATM3330e and how the addition of PV cells to a keyboard can reduce or eliminate the need for batteries in the device.

This document covers the features, operation, performance, and upgrade procedure for the ATM3330e PV Keyboard.

The ATM3330e PV Keyboard supports HSC(Hybrid Supercapacitor) configuration to harvest energy to store in the device. The ATMKBD_3330e_HSC stores harvested energy in a hybrid supercapacitor that can also be recharged via a USB connector on the device.

The ATM3330e SoC solution combines an ultra-low power Bluetooth LE 5.3 solution with an integrated PMU that supports the direct connection of PV cells.

The direct connection of PV cells to the ATM3330e PMU has multiple benefits, both reducing the overall cost of adding energy harvesting and improving the efficiency of harvested energy usage. In addition, the low power consumption of the ATM3330e means less energy needs to be harvested, so a smaller PV cell can be used in the design, further reducing both the cost and area required for the PV cell.

The ATM3330e PV Keyboard is designed to operate at indoor light levels with excess harvested energy stored in the hybrid supercapacitor.

The Atmosic PV Keyboard is provided for demonstration and evaluation purposes only and is not for commercial sale. See References section for related information.

Reference Design	SoC Package	SoC Part Number	Reference Design Part Number
ATM3330e PV Keyboard with Hybrid Supercapacitor	56-pin 7x7 mm QFN	ATM3330E-5DCAQN	ATMKBD_3330e_HSC-3

Table 1 - ATM3330e PV Keyboard Part Number

2. PV Keyboard

The Atmosic PV Keyboard is shown in Figure 1. A commercially available PV Keyboard was used for the housing with an Atmosic designed circuit board completely replacing the internal electronics. The two PV cells used in the commercially available version can be supported in the Atmosic PV Keyboard reference design.

Figure 1 - Atmosic PV Keyboard

A simplified hardware block diagram is shown in Figure 2. The hardware design is centered around the Atmosic ATM3330e SoC.

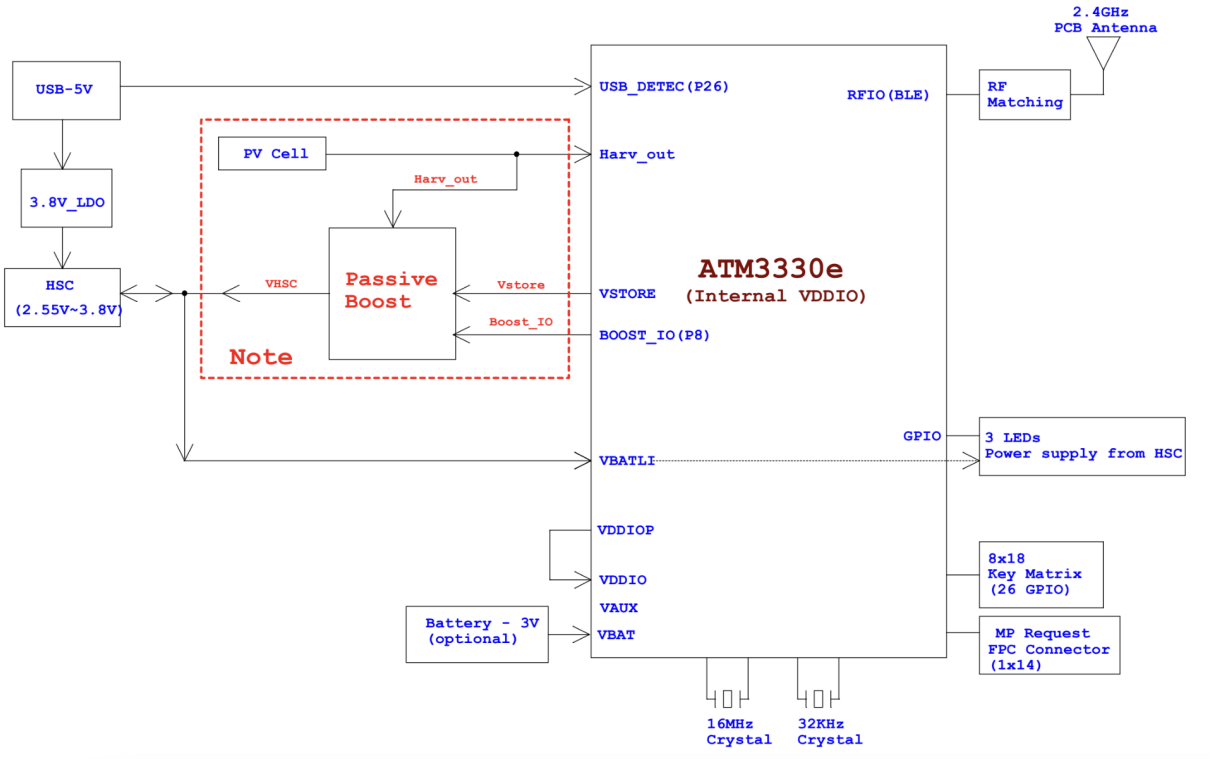
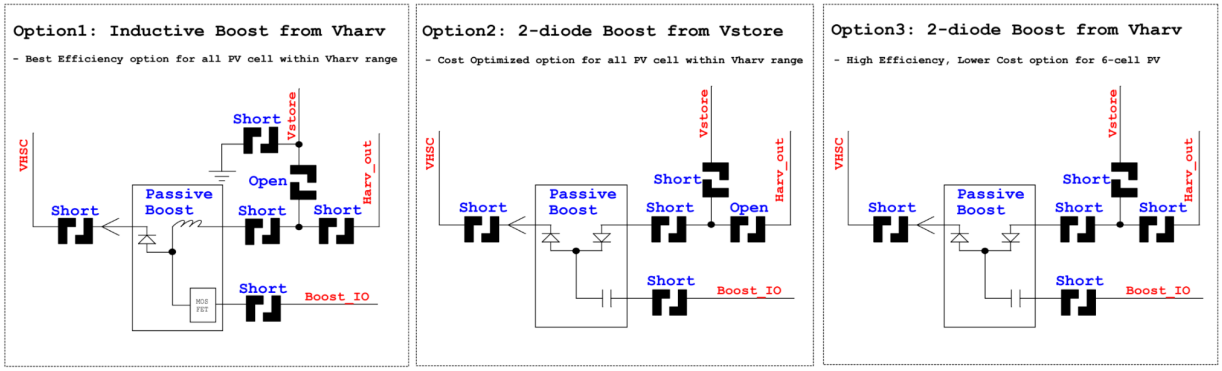


Figure 2 - Atmosic PV Keyboard Block Diagram (Internal VDDIO)

Different boost circuits depending on the type of PV cell & efficiency



Boost IO: P8 CanHarv&MustHarv **Boost IO: P8 Hardware Control** **Boost IO: P8 Hardware Control**

Note:
Open is no connection, Short is connection

Figure 3 - Different passive boost circuits

The battery-free configuration integrates two 50 F hybrid supercapacitors (see References section for more information) and supports up to two PV cells. These two 50 F hybrid supercapacitors can be used to power the device when ambient light is unavailable. The ATM3330e will always use energy from the PV cell as a primary power source and use excess harvested energy that has been stored on the hybrid supercapacitors when the amount of harvested energy is insufficient. If the ambient light is unavailable and the energy of the hybrid supercapacitors are also insufficient, the USB connector can charge the hybrid supercapacitors directly.

The key matrix on this keyboard is 8 x 18 and is supported by the I/O pins on the ATM3330e.

The ATM3330e PV keyboard supports three boost options of energy harvesting for different applications as described in Table 3.

- Boost option 1: Inductive boost from Vharv (ATMKBD_3330e_HSC_3_IB_VH)
- Boost option 2: 2-diode boost from Vstore (ATMKBD_3330e_HSC_3_DB_VS)
- Boost option 3: 2-diode boost from Vharv. This option only supports Li-battery on VBATLI (ATMKBD_3330e_HSC_3_DB_VH)

3. Keyboard Operation

3.1 General Operation

The state machine for the PV Keyboard is depicted in Figure 4. Upon power-up, the PV Keyboard will automatically enter the pairing state if it has not already been paired. If previously paired, it will attempt to reconnect and enter hibernation if it cannot connect in 60 seconds. From the pairing state, it will time out after 60 seconds if the pairing is not completed. A keypress on the PV Keyboard is required to exit the hibernation state and restart the reconnection or pairing process.

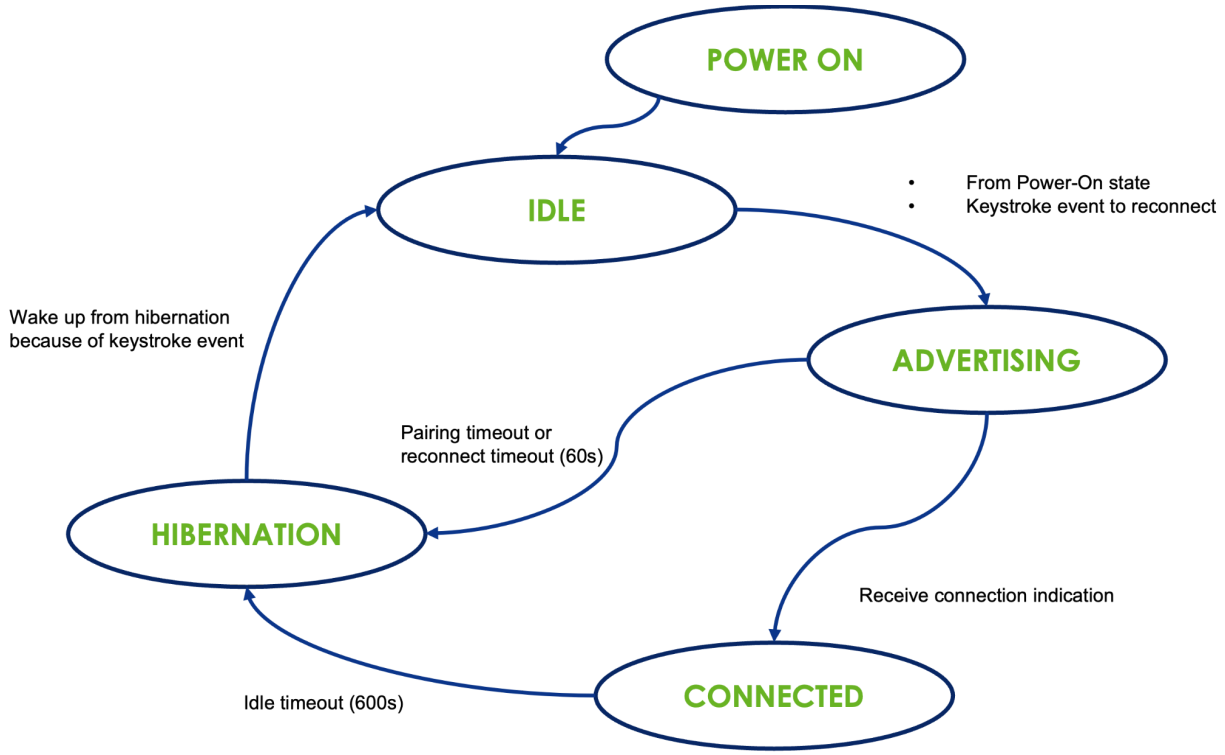


Figure 4 - Atmosic PV Keyboard State Machine

For the PV harvested energy, the ATM3330e PV Keyboard has a voltage monitoring function that operates continuously except when the keyboard is in the SoC Off state. If the voltage of the VBATLI is higher than the VBAT_BOOST voltage level (see Table 2), the system will enable external boost charger operation. For the PMU-bypass option (boost from Vharv, options 1 & 3), the external boost would be enabled without detecting VBAT_BOOST. If the voltage of the VBATLI is higher than VBAT_OV, the system will stop the boost charger operation.

If the voltage falls below BRWNOUT_THR_VBATLI (see Table 2), the ATM3330e PV Keyboard will enter SoC Off and will not be operable again until it reaches WAKEUP_THR_VBATLI via USB charging.

When the USB cable is plugged in for charging, a hardware reset will be triggered. The ATM3330e PV Keyboard will still work after the hardware reset.

The critical voltage levels are shown in Table 2.

	Option 1	Option 2	Option 3
VBATLI Charging Related Thresholds	**ATMKBD_3330e_HSC_3_IB_VH**	**ATMKBD_3330e_HSC_3_DB_VS**	**ATMKBD_3330e_HSC_3_DB_VH**
VBAT_OV	3.8V	3.8V	3.8V
VBAT_BOOST	Invalid	3V	Invalid
WAKEUP_THR_VBATLI	3.1V	3.1V	3.35 V
BRWNOUT_THR_VBATLI	2.8V	2.8V	3.25 V

Table 2 - Critical VBATLI Voltage Levels

3.1.1 Boost Options

To generate FW based on SDK (VER:5.5.0 with patch, or later), please set BOARD according to different boosting circuits. The make option uses BOARD to select each boost option.

```
make run_all BOARD=<board option>
```

Boost Option	Boosting Circuit	Board Option
Option 1	Inductive boost from Vharv	ATMKBD_3330e_HSC_3_IB_VH
Option 2	2-diode boost from Vstore	ATMKBD_3330e_HSC_3_DB_VS
Option 3	2-diode boost from Vharv	ATMKBD_3330e_HSC_3_DB_VH

Table 3 - Make options in SDK for different boost options

3.2 Pairing and Unpairing the Keyboard

Pressing the Function key + 0 simultaneously will delete all the pairing records and enter pairing mode (or Function key + U simultaneously will delete the current bond record). At this point, the keyboard is in the advertising (undirect) state shown in Figure 4.

It supports a maximum of 3 slots to store the bonding information. Once the specific slot is chosen, the bonding information will be stored in that slot. See below:

- Function key + 1: choose slot 1
- Function key + 2: choose slot 2
- Function key + 3: choose slot 3

3.3 Default Parameters

3.3.1 Advertising Parameters

By default the keyboard will operate with the following parameters when advertising:

- Advertising interval: 40 ms

3.3.2 Connection Parameters

By default the keyboard will operate with the following parameters after connection:

- Connection Interval: 7.5 ms
- Slave Latency: 66
- Connection Timeout: 3 s

3.3.3 Device Information Parameters

By default the keyboard will operate with the following parameters:

- Device name: KBD-101
- Tx power = 0 dBm

3.4 LED Indicator

The ATM3330e Keyboard supports LED indicators for the operating states listed in Table 4.

Operating State	LED Behavior
USB cable in and charging	Red LED on
USB cable in and charging battery voltage over 3.6V	Green LED on
Pairing	Green LED blinking at 250 ms interval
Fn Lock	Green LED on
Caps Lock	Green LED on
Reconnecting	Green LED blinking at 100 ms interval

Table 4 - LED Indicator Description

3.5 USB Type-C Connector

The USB Type-C connector is used to charge the hybrid supercapacitor. It is not necessary to remove the back cover for charging.

When plugging in the USB cable, it will trigger a hardware reset to the keyboard. The solid red LED is displayed until the hybrid supercapacitor is charged to a voltage over 3.6 V and the green LED turns on.

4. Power Consumption Measurement

This section introduces how to do the power consumption measurement of the keyboard reference design for the ATM3330e.

4.1 Application Options for Energy Boost

The ATM3330e PV Keyboard can support applications with different energy boost options as below:

- Application 1 - Inductive boost, bypass PMU, SCNE 6-cell PV.
- Application 2 - two diode boost, SCNE 6-cell PV.
- Application 3 - two diode boost, bypass PMU, SCNE 6-cell PV.
- Application 4 - Inductive boost, bypass PMU, specific PV cell (eg. single cell).

By default, the PV keyboard is Application 1. There are some dummy (DM) pads (see Table 5) on the ATM3330e PV Keyboard for selecting different energy boost options. “1” means 0 ohm short on this dummy pad and “0” means open on this dummy pad. Please note that application 3 only supports Li-Ion battery on VBATLI.

	DM5	DM6	DM7	DM17	DM21	DM22	DM26	DM27	DM28	DM29
Application 1	0	1	1	1	1	0	1	1	0	0
Application 2	1	1	0	0	0	1	0	0	1	1
Application 3	1	1	0	1	0	1	0	0	1	1
Application 4	0	1	1	1	1	0	1	1	0	0

Table 5 - DM(dummy) pad selections for different application options.

4.2 VBATLI Current Consumption Measurement

After the energy boost option is decided according to the user application, the current consumption can be measured by the following steps:

1. Remove the energy input PV cells
    - Remove the PV cell connection on connectors CON2 and CON3 (see Figure 5), to cut off PV cells energy into ATM3330e.
2. Remove the power source of HSC
    - Remove the resistor R34 (see Figure 5), then the power source of ATM3330e SoC is cut off from the HSC.

3. Apply external DC voltage to ATM3330e
    - After the ATM3330e is cut-off from the HSC, users can apply the external DC voltage meeting the Recommended Operating Conditions as listed in ATM33 Series Datasheet (see References section) to the marked test points on TP12 VBATLI and TP15 GND (see Figure 6)

4. LEDs power sources
    - The default power source of the LEDs is connected to the VBATLI by resistor R3 (see Figure 5). If users want to cut off the LEDs' power, please remove R3.

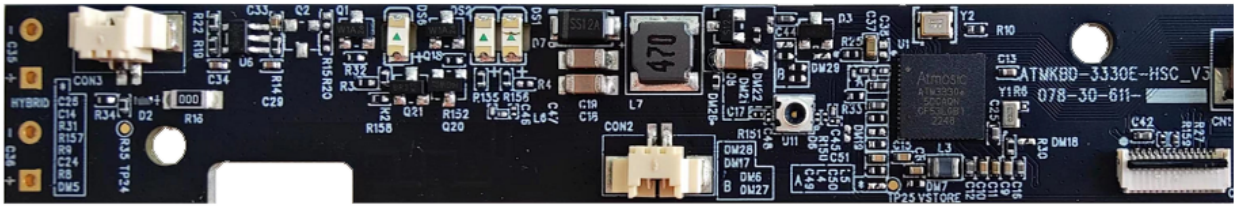


Figure 5 - Marked Positions on the Top Side of Keyboard PCB

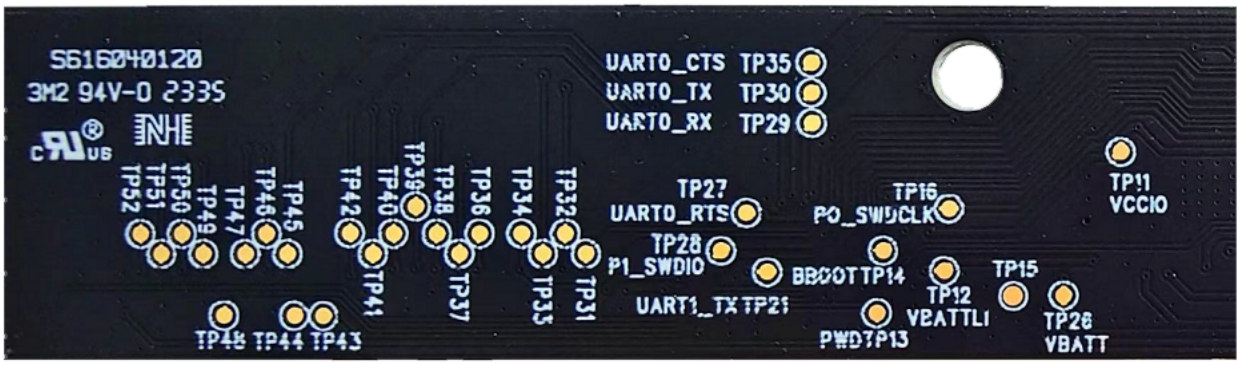


Figure 6 - Marked Position on the Bottom Side of Keyboard PCB

5. Keyboard Firmware Update

It is recommended that any firmware updates be done OTA with the Atmosic Mobile Application. Hardwired methods of updating the firmware are also available but require removal of the unit's back housing. For additional information, contact Atmosic support.

5.1 OTA Update via Mobile App

The Atmosic DevTools App supports OTA updating of the keyboard firmware and is available on both Android and iOS. It can be downloaded from Google Play or Apple App Store.

Before updating, the keyboard must be put into pairing mode. See Pairing and Unpairing the Keyboard section of this document for details.

For detailed instructions, please refer to the Firmware Update OTA section of the appropriate User Guide listed in the References section.

5.2 Firmware Update Using Reference Design Programming Board RPB

The ATM3330e Keyboard reference design has one connector which can be used for flash programming and as a debug interface. To support the debug and programming function, additional required hardware available from Atmosic is listed below. See Figure 7 for a depiction of how this additional hardware is connected.

Please refer to the ATM33 RDK Firmware Update section in the **Reference Design Programming Board User Guide** (listed in References section) for detailed firmware update procedure.

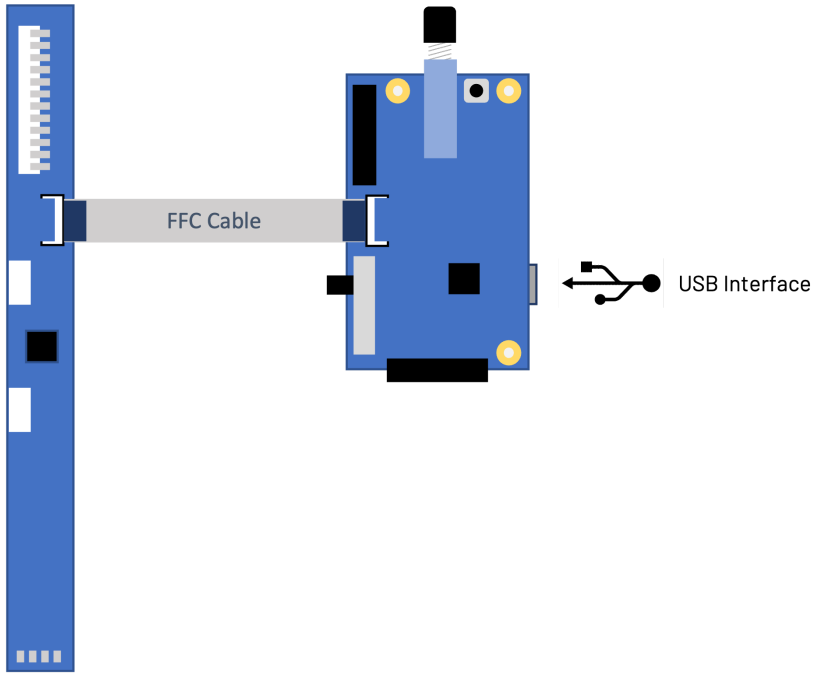


Figure 7 - Connection for Firmware Programming and Debug

References

Title	Document Number
ATM33e Series Datasheet	ATM33e-DS
ATM33/e Series OTA Update Service User Guide	ATM33_e-UGOTA
DevTools Mobile App User Guide	ATM-UGDTMA
ATM33/e Series Evaluation Kit User Guide	ATM33-e-UGEVK
RF Test Tool User Guide	ATM-UGRF
Reference Design Programming Board User Guide	ATM-UGRPB
SDK User Guide	ATM-UGSDK
Hardware	**Kit Order Number**
ATM3330e PV Keyboard Reference Design Battery free configuration	ATMKBD-3330e-HSC-3
Reference Design Programming Board	ATMRPB-FJ
Component	**Description/Link**
VINATech 50 F Hybrid Supercapacitor	Datasheet - contact VINATech for additional information

Revision History

Date	Version	Description
December 5, 2023	0.52	Reference design version has been updated to V3.
July 24, 2023	0.51	Format change, not content change.
June 7, 2023	0.50	Initial version created.

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