

XIDAS IOT

# High Efficiency Energy Harvesting & Power Management Module

(EHM-UNIV-1)

# OVERVIEW

The Xidas EHM-UNIV-1 is a small, turn-key surface mount module designed to capture small amounts of harvested energy from sources such as photovoltaic cells, piezoelectric, electro-mechanical and thermoelectric generators, and continuously trickle charges storage elements like rechargeable Li-Ion batteries, thin film batteries, or conventional capacitors. This module is especially useful to power small electronic devices and battery free systems.

As leading sensor manufacturers have started to introduce wireless versions of their sensors, the EHM-UNIV-1 is directly optimized for these applications. Additionally, emerging IoT companies are leveraging advancements in MEMS transducers that are coupled with edge intelligence and data analytics to provide application specific solutions. These wireless devices must balance what the edge device does with the amount of power capacity the battery can provide. Wireless sensor lifetime, or the battery lifetime, becomes the most critical portion for the Wireless IoT products, particularly for industrial or B2B applications as the cost of replacing batteries is substantial. Hence the need to incorporate energy harvesting solutions.



The EHM-UNIV-1 leverages Xidas' experience in being the leader in vibration-based energy harvesting and the company's ongoing research into other energy harvesting solutions for IoT. When utilized with the Xidas's RHB-1530 small hybrid supercapacitor/lithium battery, this provides the ideal solution for driving wireless sensors.

# TECHNICAL DESCRIPTION

## Input

The EHM-UNIV-1 combines a state-of-the-art power management integrated circuit (PMIC) with supporting circuitry that reduces the number of required external components, and thus development cost. As inputs, the module offers both AC or DC input pins to allow connectivity to a variety of energy harvesters available. The signal conditioning provides a direct input for DC input sources (e.g. photovoltaic cells) or built-in voltage doubler circuitry for AC sources (e.g. electromagnetic transducers). This input conditioning and PMIC allow for energy harvesting from signals as low as 380mV. Minimal external components allow for maximum power-point tracking (MPPT) of the input signal source.

## Output

The EHM-UNIV-1 provides two independent output voltages: a tunable regulated output voltage (VREG) as well as an unregulated system voltage (VSYS), proportional to the energy storage level. VREG stems from a low drop-out regulator with up to 150mA, whose output voltage can be set to nine distinct levels by a single external resistor, across the range from 1.5V to 3.6V. The system output voltage allows for even higher output current (up to 1A), protected by a resettable fuse. This output becomes ideal for wireless devices that require higher surges in current when transmitting or receiving, such as Wifi or cellular. Both output voltages can be disconnected if the system voltage falls below an acceptable value. This value, set by external resistors, defines the lower limit as well as the hysteresis threshold before resumption of power. The module provides an output monitor pin indicating the state of the output voltages.

## Energy Storage and Protection

The module is optimized for use with the Xidas RHB-1530, which is a small combined supercapacitor and rechargeable lithium battery, making it ideal for wireless devices. Other supercaps or batteries can also be connected if desired.

The EHM-UNIV-1 is also designed to protect and maximize battery longevity, by simply setting the ideal charge and discharge voltages of the external

storage device through external resistors. When the battery voltage exceeds the battery charging termination threshold, the boost operation terminates to prevent battery overcharging. To prevent overdischarge, a shutdown charging threshold will switch the battery and high-current system voltage output pin to the off state and boost operation is performed asynchronously. Additionally, the EHM-UNIV-1 provides an on-board charge management IC, containing constant-current/constant-voltage control, allowing the user to externally charge the battery from a single 5V input.

The module can withstand operating temperatures ranging from -40°C to 125°C, providing more versatility. In the event that the temperature rises above the rated specification, the module has thermal shutdown circuitry that will terminate boost operation and prevent damage to the energy storage unit.

To get started with energy harvesting, Xidas recommends purchasing the EHM-UNIV-1 module, the RHB-1530 energy storage unit, and one of our vibration energy harvesting generators from the VEG line of products.

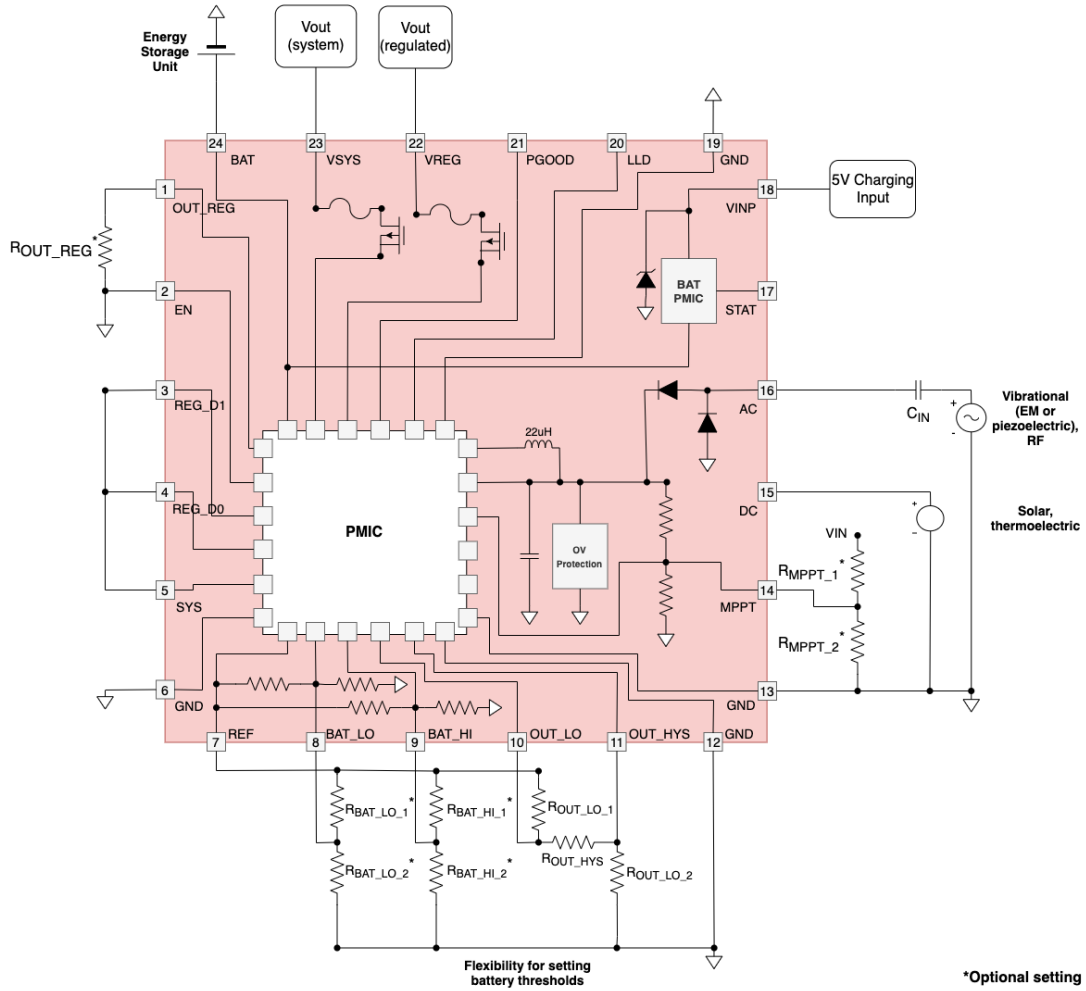


# FEATURES & SPECIFICATIONS

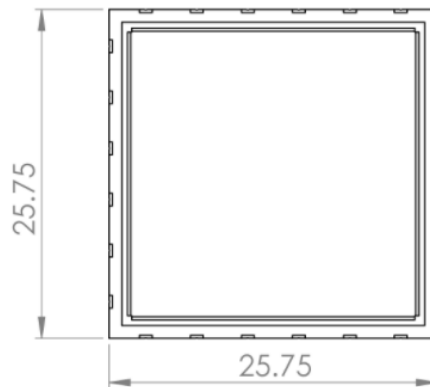
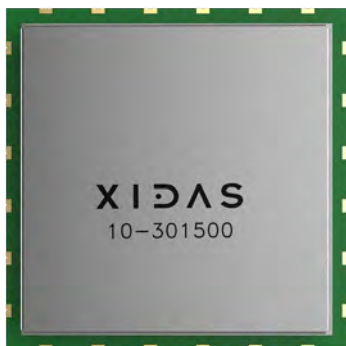
- ✓ User-selectable DC or AC input sources (with built-in voltage doubling)
- ✓ Configurable maximum power-point tracking (MPPT)
- ✓ High- and low-current output voltages with short-circuit and ESD protection
- ✓ Over-charge and discharge protection
- ✓ Built-in charge controller for Li-Ion batteries and supercapacitor
- ✓ Compact footprint, plug-and-play design

|   |  |              |
|---|--|--------------|
| Startup Threshold w/ Xidas RHB-1530 battery | 380 mV                                   | 6 $\mu$ W    |
| Maximum Input Voltage (VIN)                 | 3.6 V                                    |              |
| Configurable Regulated Output (VREG)        | 1.5 V to 3.6 V                           | up to 150 mA |
| High current system voltage output (VSYS)   | up to 1 A (protected by resettable fuse) |              |
| Operating quiescent current                 | 510 nA                                   |              |
| Sleeping quiescent current                  | 390 nA                                   |              |
| Operating junction temperature range        | -40°C to 125°C                           |              |
| Storage temperature range                   | -65°C to 150°C                           |              |

# EHM BLOCK DIAGRAM



## Dimensions (mm)

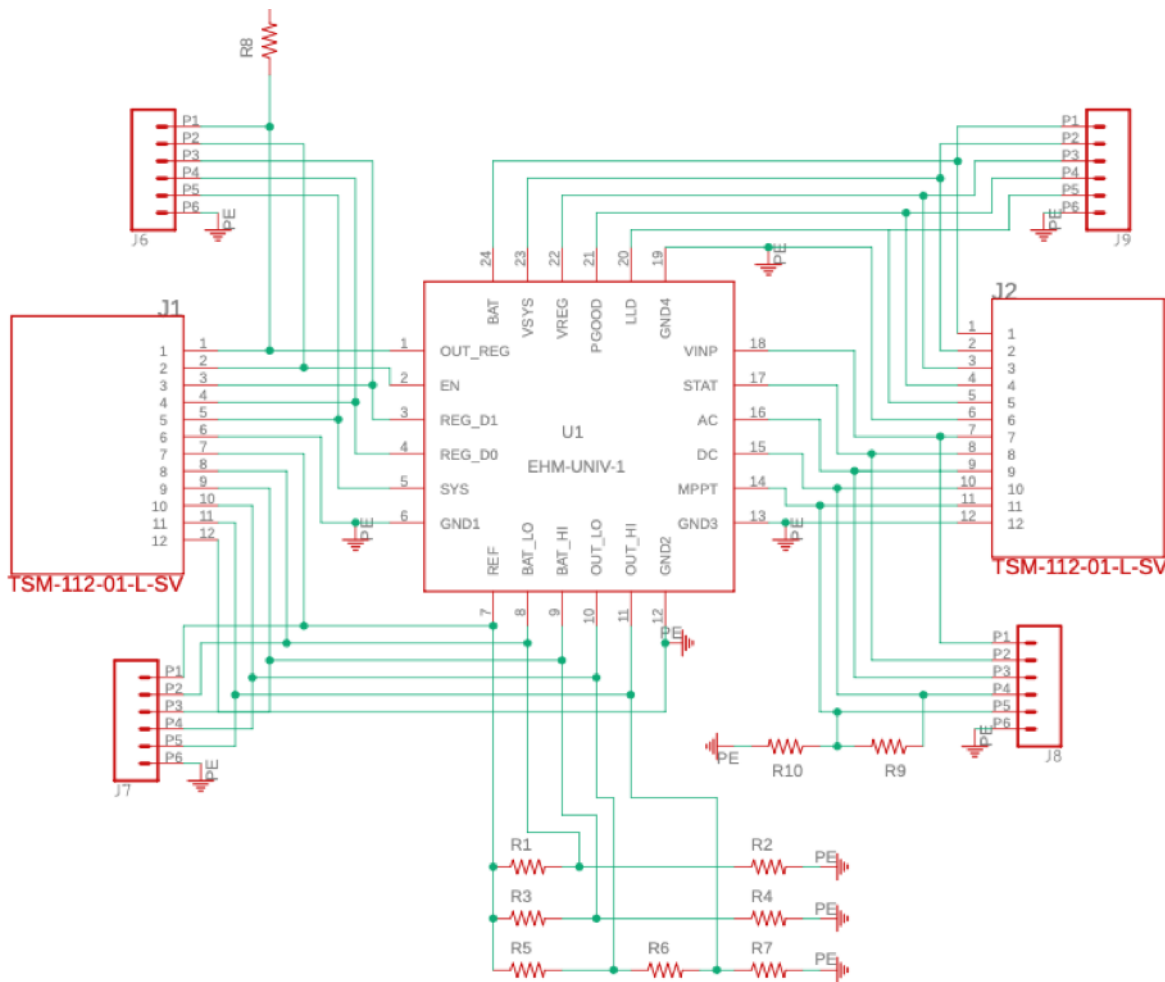


# EHM-UNIV-1-ADPT Adapter Board

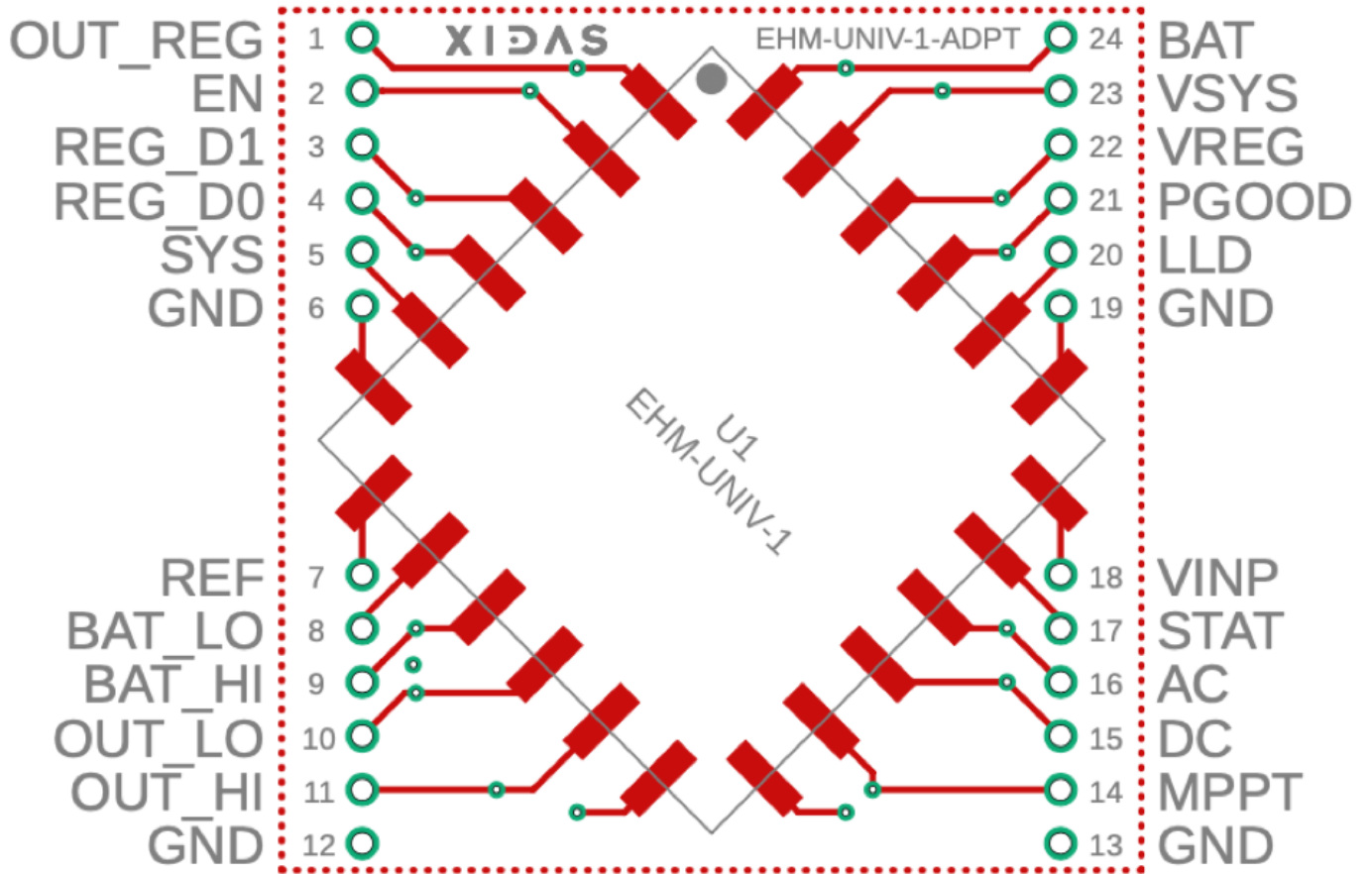
The purpose of this board is to simplify the development phase for a user by providing an option to connect the EHM onto a solderless breadboard. Furthermore, this adapter board provides header pins to act as test or connection points for the 24 pins found on the module. The back of the adapter board also allows the user to solder on surface-mount 0603 resistors.

The EHM-UNIV-1 comes with one adapter board, four 6-pin through-hole headers and two 12-pin surface-mount headers. The headers and the EHM-UNIV-1 can be soldered onto the adapter board using lead-free ROHS solder. Xidas recommends the following solder: AM-TECH Sn96.5/Ag3/Cu0.5 water-washable lead-free solder.

The following is the schematic for the adapter board connections



The following is the adapter board layout showing the pinout labels



**Example setup with the Xidas Energy Harvesting Products  
(includes RHB-1530 and VEG Generator)**

|  |                |                          |                         |
|--|----------------|--------------------------|-------------------------|
| <b>Threshold Resistors</b>                 | <b>BAT_LO</b>  | <b>BAT_LO_1=6.49 MΩ,</b> | <b>BAT_LO_2=3.57 MΩ</b> |
|  | <b>BAT_HI</b>  | <b>BAT_HI_1=6.34 MΩ,</b> | <b>BAT_HI_2=3.65 MΩ</b> |
|  | <b>OUT_LO</b>  | <b>OUT_LO_1=6.65 MΩ,</b> | <b>OUT_LO_2=3.32 MΩ</b> |
|  | <b>OUT_HYS</b> | <b>100 kΩ</b>            |                         |
|  | <b>OUT_REG</b> | <b>Floating</b>          |                         |
| <b>Set Minimum Operating Input Voltage</b> | <b>VMIN</b>    | <b>1 kΩ</b>              |                         |
| <b>Charge Limit Threshold</b>              | <b>BAT_MA</b>  | <b>20 kΩ</b>             |                         |
| <b>Maximum Power Point Tracking</b>        | <b>MPPT_1</b>  | <b>4.7 MΩ</b>            |                         |
|  | <b>MPPT_2</b>  | <b>18 MΩ</b>             |                         |



# USER CONFIGURATION GUIDE

## REGULATED OUTPUT (VREG)

- ✔ Set by OUT\_REG pin and external resistor
- ✔ Gives user flexibility of adjusting the output voltage ranging from 1.5 V to 3.6 V and up to 150 mA
- ✔ The on-board PMIC allows eight fixed output voltage options in that range, detailed below in Table 3.

| OUT_REG Configuration (Short to GND) | Set VREG Voltage (V) |
|--------------------------------------|----------------------|
| Floating                             | 2.5 V                |
| 7 k $\Omega$                         | 1.5 V                |
| 14 k $\Omega$                        | 1.8 V                |
| 27.7 k $\Omega$                      | 3.6 V                |
| 55.6 k $\Omega$                      | 3.3 V                |
| 111 k $\Omega$                       | 2.0 V                |
| 221 k $\Omega$                       | 3.0 V                |
| 442 k $\Omega$                       | 2.8 V                |

Table 3. Regulated Output Voltage (VREG) Set Configuration.

Regulated Output Voltage (VREG) Set Configuration.

It is recommended to use a large resistance value to minimize quiescent current

## REGULATED OUTPUT (VREG) BOOST AND LOW DROPOUT (LDO)

- ✔ Boost and LDO mode configurations are set by the REG\_D0 and REG\_D1 pins
- ✔ The configurable modes are listed below in Table 4.

| Working Mode  | REG_D0     | REG_D1     |
|---------------|------------|------------|
| Boost Disable | LOW (GND)  | N/A        |
| Boost Enable  | HIGH (SYS) | N/A        |
| LDO Disable   | N/A        | LOW (GND)  |
| LDO Enable    | N/A        | HIGH (SYS) |

Regulated Output (VREG) Working Mode Configuration.

## DISABLING BOOST SWITCHING

- For applications that are noise or electromagnetic interference (EMI) sensitive, the boost control can be disabled using the EN pin.
- The EN pin can be pulled HIGH using a microcontroller or RF Transceiver to stop the boost switch
- Pull the EN pin LOW to resume boost switching

## OVERCHARGE PROTECTION

- To prevent the connected energy storage unit from overcharge and damage, the PMIC comes equipped with threshold resistors that are preset and allow an optional external threshold resistor in parallel  $R_{BAT\_HI,2}$ , if needed.
- This threshold can be calculated using the following equation:

$$V_{BAT\_HI} = \frac{3}{2} * V_{INT\_REF} * \left(1 + \frac{R_{BAT\_HI,1}}{R_{BAT\_HI,2}}\right)$$

$$R_{BAT\_HI,1} = 6.20M, R_{BAT\_HI,2} = 3.60M\Omega$$

- When the voltage at the BAT pin exceeds the  $V_{BAT\_HI}$  threshold, the main boost regulator disables.
- When input energy is excessive, the BAT pin voltage ripples between the  $V_{BAT\_HI}$  and hysteresis levels.

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## DISCHARGE PROTECTION

- To prevent the connected energy storage unit from damaging discharge, the PMIC comes equipped with threshold resistors that are preset and allow an optional external resistor in parallel with  $R_{BAT\_LO,2}$ , if needed.
- This threshold can be calculated using the following equation:

$$V_{BAT\_LO} = \frac{3}{2} * V_{INT\_REF} * \left(1 + \frac{R_{BAT\_LO,1}}{R_{BAT\_LO,2}}\right)$$

- Where  $R_{BAT\_LO,1} = 6.49M$ ,  $R_{BAT\_LO,2} = 3.57M\Omega$

## SYSTEM OUTPUT VOLTAGE

- The PMIC allows the user to configure the system output voltage threshold at the VSYS pin
- The chip is equipped with a monitoring pin, PGOOD, that monitors the VSYS pin, which can be set with OUT\_LO\_1, OUT\_LO\_2, and OUT\_HYS
- This threshold can be calculated using the following equation:

$$V_{OUT\_FALLING} = V_{INT\_REF} * \left( 1 + \frac{R_{OUT\_LO\_1}}{R_{OUT\_LO\_2} + R_{OUT\_HYS}} \right)$$

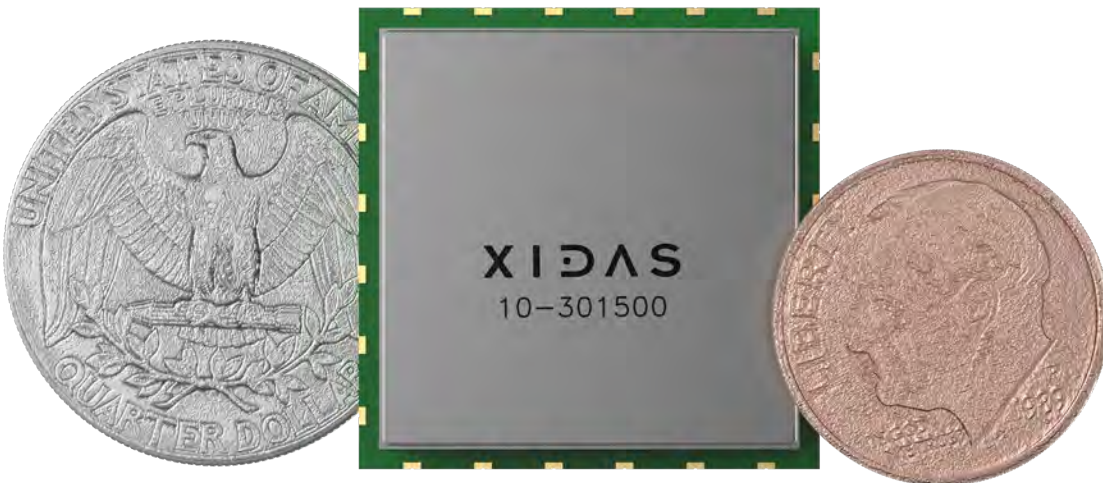
- The OUT\_HYS resistor and pin can externally program the hysteresis with the following equation:

$$V_{OUT\_FALLING} = V_{INT\_REF} * \left( 1 + \frac{R_{OUT\_LO\_1} + R_{OUT\_HYS}}{R_{OUT\_LO\_2}} \right)$$

- To ensure quiescent current consumption is taken into consideration, the sum of the three resistors must be

$$R_{OUT\_HYS} + R_{OUT\_LO\_1} + R_{OUT\_LO\_2} \geq 6 M \Omega$$

- The  $V_{OUT\_FALLING}$  threshold must be greater than the
- $V_{BAT\_LO}$  threshold.
- For best performance, use PGOOD to enable the system load.
- Please refer to the Threshold Resistors Configuration Table in the next page.



## THRESHOLD RESISTORS CONFIGURATION

Table below shows different configuration values for the voltage threshold

| THRESHOLD VOLTAGE (V) | RBAT_LO_1, ROUT_LO_1 (MΩ) | RBAT_LO_2, ROUT_LO_2 (MΩ) | RBAT_HI_1 (MΩ) | RBAT_HI_2 (MΩ) |
|-----------------------|---------------------------|---------------------------|----------------|----------------|
| 2                     | 5                         | 5                         | Not applicable | Not applicable |
| 2.1                   | 5.23                      | 4.75                      | Not applicable | Not applicable |
| 2.2                   | 5.49                      | 4.53                      | 3.2            | 6.81           |
| 2.3                   | 5.62                      | 4.32                      | 3.48           | 6.49           |
| 2.4                   | 5.9                       | 4.12                      | 3.74           | 6.2            |
| 2.5                   | 6.04                      | 4                         | 4              | 6.04           |
| 2.6                   | 6.19                      | 3.83                      | 4.22           | 5.76           |
| 2.7                   | 6.34                      | 3.74                      | 4.42           | 5.6            |
| 2.8                   | 6.49                      | 3.57                      | 4.64           | 5.36           |
| 2.9                   | 6.6                       | 3.48                      | 4.87           | 5.23           |
| 3                     | 6.65                      | 3.32                      | 5              | 5              |
| 3.1                   | 6.8                       | 3.24                      | 5.11           | 4.87           |
| 3.2                   | 6.81                      | 3.09                      | 5.36           | 4.7            |
| 3.3                   | 6.98                      | 3.01                      | 5.49           | 4.53           |
| 3.4                   | 6.98                      | 2.94                      | 5.6            | 4.42           |
| 3.5                   | 7.15                      | 2.87                      | 5.76           | 4.3            |
| 3.6                   | 7.15                      | 2.8                       | 5.9            | 4.12           |
| 3.7                   | 7.32                      | 2.7                       | 5.9            | 4.02           |
| 3.8                   | 7.32                      | 2.61                      | 6.04           | 3.92           |
| 3.9                   | 7.5                       | 2.55                      | 6.19           | 3.83           |
| 4                     | 7.5                       | 2.5                       | 6.2            | 3.74           |
| 4.1                   | 7.5                       | 2.43                      | 6.34           | 3.65           |
| 4.2                   | 7.68                      | 2.37                      | 6.49           | 3.57           |
| 4.3                   | 7.68                      | 2.32                      | 6.49           | 3.48           |
| 4.4                   | 7.68                      | 2.26                      | 6.6            | 3.4            |
| 4.5                   | 7.87                      | 2.21                      | 6.65           | 3.32           |
| 4.6                   | 7.87                      | 2.15                      | 6.8            | 3.24           |
| 4.7                   | 7.87                      | 2.15                      | 6.81           | 3.2            |
| 4.8                   | 7.87                      | 2.1                       | 6.81           | 3.09           |
| 4.9                   | 7.87                      | 2.05                      | 6.98           | 3.09           |
| 5                     | 8.06                      | 2                         | 6.98           | 3              |
| 5.1                   | 8.06                      | 1.96                      | 6.98           | 2.94           |
| 5.2                   | 8.06                      | 1.91                      | 7.15           | 2.87           |

## ORDERING INFORMATION

| Model Number | Part Number | Description                        |
|--------------|-------------|------------------------------------|
| EHM-UNIV-1   | 10-301500   | Energy Harvesting Module-Universal |

## COMPLIMENTARY PRODUCTS

The EHM-UNIV-1 works best with Xidas's Rechargeable High-Pulse Battery (RHB-1530) and Vibration Energy Harvesting Generator (VEG). Here is how to order:

### Vibration Energy Harvesting Generator



| Model Number | Part Number | Description                          |
|--------------|-------------|--------------------------------------|
| VEG-20       | 10-301000   | Designed for 20 Hz vibration sources |
| VEG-30       | 10-301100   | Designed for 30 Hz vibration sources |
| VEG-50       | 10-301200   | Designed for 50 Hz vibration sources |
| VEG-60       | 10-301300   | Designed for 60 Hz vibration sources |
| VEG-70       | 10-301400   | Designed for 70 Hz vibration sources |

### Rechargeable High-Pulse Battery



| Model Number | Part Number | Description                     |
|--------------|-------------|---------------------------------|
| RHB-1530     | 86000000    | Rechargeable High-pulse Battery |

### Vibration Perpetual Power Pod (all-in-one)



| Model Number | Part Number | Description                          |
|--------------|-------------|--------------------------------------|
| VP3-20       | 10-300400   | Designed for 20 Hz vibration sources |
| VP3-30       | 10-300100   | Designed for 30 Hz vibration sources |
| VP3-50       | 10-300300   | Designed for 50 Hz vibration sources |
| VP3-60       | 10-300200   | Designed for 60 Hz vibration sources |
| VP3-70       | 10-300500   | Designed for 70 Hz vibration sources |