

## EH300/301 EPAD® ENERGY HARVESTING™ MODULES

### GENERAL DESCRIPTION

EH300/EH301 Series EPAD® Energy Harvesting™ Modules can accept energy from many types of electrical energy sources and store this energy to power conventional 3.3V and 5.0V electrical circuits and systems. EH300/EH301 Series modules are completely self-powered and always in the active mode. They are intended for low power intermittent duty cycle sampled data or condition-based monitoring/ extreme lifespan applications. These modules can accept instantaneous input voltages ranging from 0.0V to +/-500V AC or DC, and input currents from 200nA to 400mA from energy harvesting sources that produce electrical energy in either a steady or an intermittent and irregular manner with varying source impedances. EH300/EH301 Series modules condition the stored energy to provide power at output voltage and current levels that are within the limits of a particular electronic system power supply specifications. For example, 1.8V and 3.6V is a useful voltage range for many types of IC circuits, such as microprocessors.

EH300/EH301 Series modules are designed to continuously and actively operate to capture, accumulate, and conserve energy from an external energy source. Each individual EH300/EH301 Series module is set to operate between two supply voltage thresholds, +V\_low DC and +V\_high DC, corresponding to the minimum ( $V_L$ ) and maximum ( $V_H$ ) supply voltage values for the intended application. When an energy source starts to inject energy into the inputs of an EH300/EH301 Series module in the form of electrical charge impulses, these charge packets are collected, accumulated and stored onto an internal storage capacitor bank. For most common energy harvesting applications, the electrical energy charge packets arrives in the form of input voltage spikes that are uncontrolled and unpredictable. Often these cover a wide range of voltages, currents and timing waveforms. EH300/EH301 Series modules are designed to accommodate such conditions with exceptional efficiency and effectiveness. As an example, a EH300 module can cycle within 4 minutes at an average input current of 10 $\mu$ A and within 40 minutes at an average input current of just 1.0 $\mu$ A.

### ORDERING INFORMATION

| Part Number     | Description   |
|-----------------|---|
| EH300<br>EH300A | 4.6 mJ Module / 1.8V to 3.6V operation<br>30 mJ Module / 1.8V to 3.6V operation |
| EH301<br>EH301A | 8.3 mJ Module / 3.1V to 5.2V operation<br>55 mJ Module / 3.1V to 5.2V operation |
| EHJ1C<br>EHJ2C  | 6 inch cable / J1 connector (Input)<br>6 inch cable / J2 connector (Output)     |

Note: EH300A and EH301A are high energy output versions

### BENEFITS

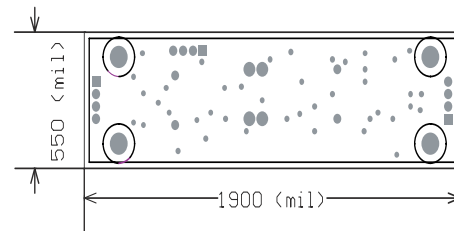
- Eliminates manual and elaborate system trimming procedures
- Remote controlled automated trimming
- In-System Programming capability
- No external components
- No internal clocking noise source

### APPLICATIONS

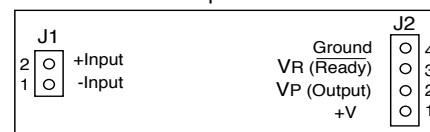
- Sensor interface circuits
- Transducer biasing circuits
- Capacitive and charge integration circuits
- Biochemical probe interface
- Signal conditioning
- Portable instruments

### MECHANICAL SPECIFICATIONS

- Outline Dimensions:  
W x L x H : 0.55 in. x 2.00 in. x 0.70 in.
- 4 Mounting Holes: 0.085 in. diameter
- Weight: 0.5 ounce (14 grams) nominal



Top View



Socket Adapter Cable:

J1: Hirose Socket, 2 Position P/N : DF13-2S

J2: Hirose Socket, 4 Position P/N : DF13-4S

## FUNCTIONAL DESCRIPTION

The EH300/EH301 Series module's voltage on the onboard storage capacitor bank is +V, which is also the positive supply voltage switched to power the output power load. Initially, +V voltage on an EH300/EH301 Series module starts at 0.0V. During the initial charge period, +V starts charging from 0.0V. The module's internal circuit monitors and detects this +V voltage. When +V reaches  $V_H$ , the module output ( $V_P$ ) is enabled and turned to the ON state and is then able to supply power to a power load, such as a micro-processor and/or a sensor circuit. The amount of useful energy available is a function of the capacity of the storage capacitor bank. Meanwhile, an EH300/EH301 Series module continues to accumulate any energy generated by external energy sources. If external energy input availability is high, output  $V_P$  remains in an ON state continuously, until such time that external energy availability is lower than the power demand required by the power load. As external energy input exceeds power loading, +V increases until internal voltage clamp circuits limit it to a maximum clamp voltage.

During normal operation, as power is drawn from an EH300/EH301 Series module, +V decreases in voltage. When +V reaches  $V_L$ , output  $V_P$  switches to an OFF state and stops supplying any further power to the power load. With built-in hysteresis circuits within the module,  $V_P$  now remains in the OFF state, even when the external energy source starts charging the capacitor bank again by importing fresh new impulses of electrical energy. Once  $V_H$  level is reached again, output  $V_P$  is then turned to the ON state again. Hence +V voltage cycles between  $V_H$  to  $V_L$  voltage levels and then to the OFF state. When in the ON state,  $V_P$  can supply up to 1A of current for a limited time period as determined by the stored useful energy and the energy demand by the power load. An optional input/output pin  $V_R$  functions as  $V_P$  on/off control (external input through 1K $\Omega$ ) or as READY logical control (output) signal preceding output  $V_P$  switching.

Input energy charging times  $t_1$  and  $t_2$  are limited by input energy available minus energy loss by an EH300/EH301 Series module. The energy output time period  $t_3$  is determined by the rate of energy used by the power load as a function of energy stored. Low input energy hold time  $t_4$  is typically many orders of magnitude greater than the sum of  $t_1$ ,  $t_2$  and  $t_3$ .

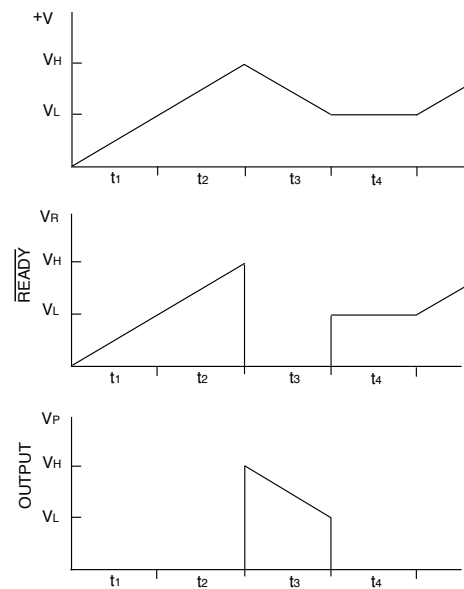
## ENVIRONMENTAL SPECIFICATIONS

- Leadfree (ROHS) compliant
- Operating Temperature Range: 0 to 70° C
- Max. Average Operating Temperature : 50° C
- Storage Temperature: -40 to +85° C
- Humidity: To 90% (no condensation)
- Protection: Conformal and Epoxy coated

## INITIAL SETUP & CALIBRATION

EH300/EH301 Series modules are setup and calibrated at the factory to standard specifications and settings. No user setup is required. Optional user control signal and connection to external capacitor or battery storage banks are available at the output port. All EH300/EH301 Series modules are shipped ready to use.

EH300/EH301 Waveforms



**ABSOLUTE MAXIMUM and MINIMUM RATINGS**

|                                  |       |              |
|----------------------------------|-------|--------------|
| Max. instantaneous input voltage | _____ | +/- 500V     |
| Max. instantaneous input current | _____ | 400mA        |
| Max. input/output power          | _____ | 500 mW       |
| Operating temperature range      | _____ | 0°C to +70°C |
| Min. input                       | _____ | 0.0V@1nA     |
| Internal voltage clamp           | _____ | 7.0V@10mA    |
| Max. output current              | _____ | 1A           |

**CAUTION:** ESD Sensitive Device. Use static control procedures in ESD controlled environment.

**OPERATING ELECTRICAL CHARACTERISTICS**

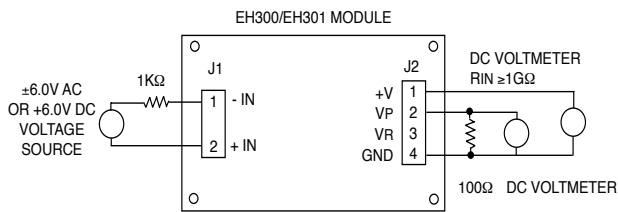
**T<sub>A</sub> = 25°C, V<sub>IN</sub> = 4.0V unless otherwise specified**

| Parameter                            | Symbol               | EH300   |       |     | EH300A  |        |     | Unit    | Test Conditions                              |
|--------------------------------------|----------------------|---------|-------|-----|---------|--------|-----|---------|--|
|                                      |                      | Min     | Typ   | Max | Min     | Typ    | Max |         |  |
| Output Low Level                     | V <sub>L</sub>       |         | 1.9   |     |         | 1.9    |     | V       |  |
| Output High Level                    | V <sub>H</sub>       |         | 3.5   |     |         | 3.5    |     | V       |  |
| Charging Input                       | V <sub>in</sub>      | 4.0/200 |       |     | 4.0/200 |        |     | V@nA    |  |
| Power Dissipation                    | P <sub>D</sub>       |         | 0.4   | 0.8 |         | 1      | 2   | μW      |  |
| Useful Energy Output                 | E                    |         | 4.6   |     |         | 30     |     | mJ      | 1 cycle                                      |
| Output On-time Rating                | t * I                |         | 68/25 |     |         | 75/150 |     | msec@mA | 1 cycle                                      |
| V <sub>P</sub> Output Resistance     | R <sub>VP</sub>      |         | 0.15  |     |         | 0.15   |     | Ω       | V <sub>P</sub> = 3.5V                        |
| V <sub>R</sub> Output Sink Current   | I <sub>Rsink</sub>   |         | 2.5   |     |         | 2.5    |     | mA      | V <sub>P</sub> = 3.5V, V <sub>R</sub> = 3.5V |
| V <sub>R</sub> Output Source Current | I <sub>Rsource</sub> |         | -1.0  |     |         | -1.0   |     | mA      | V <sub>P</sub> = 3.5V, V <sub>R</sub> = 0.0V |
| Output Load                          | R <sub>load</sub>    | 3.5     |       |     | 3.5     |        |     | Ω       | I <sub>out</sub> = 1A                        |
| Output Current                       | I <sub>out</sub>     |         |       | 1   |         |        | 1   | A       | R <sub>load</sub> = 3.5Ω                     |

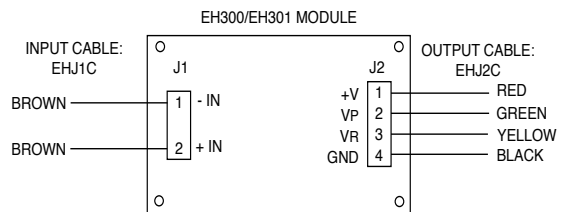
**T<sub>A</sub> = 25°C, V<sub>IN</sub> = 6.0V unless otherwise specified**

| Parameter                            | Symbol               | EH301   |       |     | EH301A  |         |     | Unit    | Test Conditions                              |
|--------------------------------------|----------------------|---------|-------|-----|---------|---------|-----|---------|--|
|                                      |                      | Min     | Typ   | Max | Min     | Typ     | Max |         |  |
| Output Low Level                     | V <sub>L</sub>       |         | 3.1   |     |         | 3.1     |     | V       |  |
| Output High Level                    | V <sub>H</sub>       |         | 5.2   |     |         | 5.2     |     | V       |  |
| Charging Input                       | V <sub>in</sub>      | 6.0/300 |       |     | 6.0/300 |         |     | V@nA    |  |
| Power Dissipation                    | P <sub>D</sub>       |         | 0.9   | 1.8 |         | 1.5     | 3   | μW      |  |
| Useful Energy Output                 | E                    |         | 3.9   |     |         | 55      |     | mJ      | 1 cycle                                      |
| Output On-time Rating                | t * I                |         | 80/25 |     |         | 885/150 |     | msec@mA | 1 cycle                                      |
| V <sub>P</sub> Output Resistance     | R <sub>VP</sub>      |         | 0.1   |     |         | 0.1     |     | Ω       | V <sub>P</sub> = 5.0V                        |
| V <sub>R</sub> Output Sink Current   | I <sub>Rsink</sub>   |         | 5     |     |         | 5       |     | mA      | V <sub>P</sub> = 5.0V, V <sub>R</sub> = 5.0V |
| V <sub>R</sub> Output Source Current | I <sub>Rsource</sub> |         | -2    |     |         | -2      |     | mA      | V <sub>P</sub> = 5.0V, V <sub>R</sub> = 0.0V |
| Output Load                          | R <sub>load</sub>    | 5       |       |     | 5       |         |     | Ω       | I <sub>out</sub> = 1A                        |
| Output Current                       | I <sub>out</sub>     |         |       | 1   |         |         | 1   | A       | R <sub>load</sub> = 5.0Ω                     |

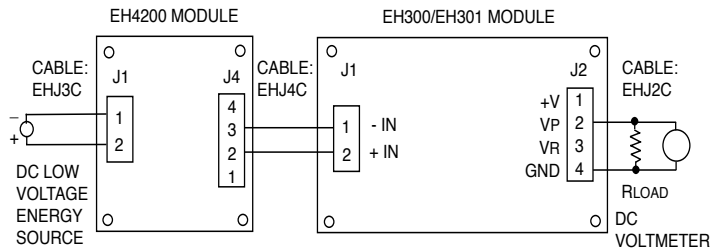
### EH300 TEST CIRCUIT



### TYPICAL CABLE CONNECTION



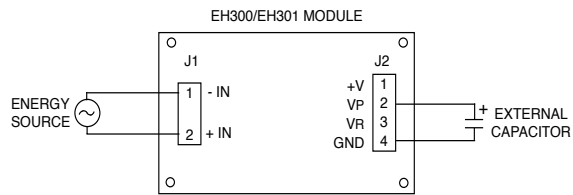
### EH4200\* CONNECTION TO EH300



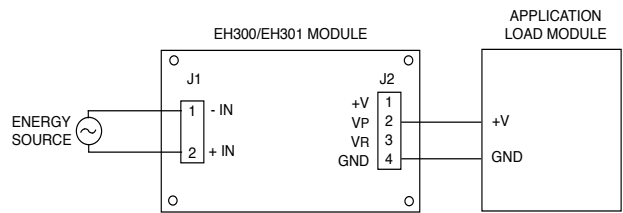
\* EH4200 Series of Micropower Step Up Low Voltage Booster Modules, e.g. EH4205, EH4295

### TYPICAL SYSTEM APPLICATIONS

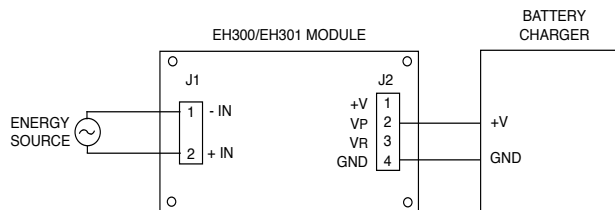
#### ADD EXTERNAL CAPACITOR



#### POWERING APPLICATION LOAD MODULE



#### TRICKLE CHARGE A BATTERY OR DRIVE A BATTERY CHARGER



#### IMPULSE POWER TO MICRO CONTROLLER WITH I/O HANDSHAKE

