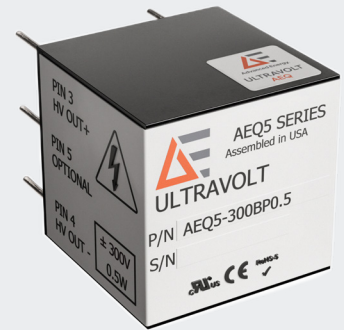


# ULTRAVOLT AEQ SERIES

## APPLICATION NOTE - 02



This application document, in conjunction with the product specification sheet is intended to provide technical information on the operation of the AEQ series of ultra-miniature DC to DC power converters, this includes pin assignments, input requirements, and output characteristics.

The AEQ family of ultra-miniature UL approved, isolated single or dual output DC to DC converters, supplying up to 600 VDC at 0.5 W (1.25 W extended models) of output power from an input voltage of +5 VDC or +12 VDC, the converters are packaged in a housing measuring 1/2" [0.5" x 0.5" x 0.5"] cube.

### Note:

- All specifications are after a 30-minute warm-up at full load at 25°C unless otherwise noted.
- Maximum output load is available at the maximum rated output voltage, the load derates linearly as control pin voltage is decreased.
- The AEQ output voltage is load dependent, under light load conditions it may be necessary to adjust the control pin, so the maximum rated output voltage is not exceeded.
- Good thermal management techniques must be used to maintain the maximum case temperature when operating the AEQ at maximum load.

### SAFETY WARNING

High voltage power converters present a serious risk of personal injuries if not used by qualified personal and/or used in designs or applications the converters were not designed for.



FUNCTIONAL DIAGRAM

Simplified functional diagram of a dual output

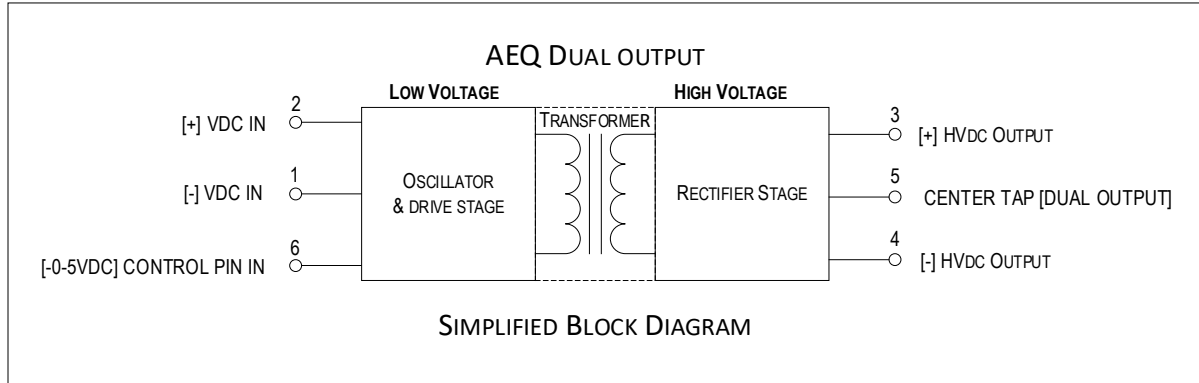


Figure 1

Simplified functional diagram of a single output

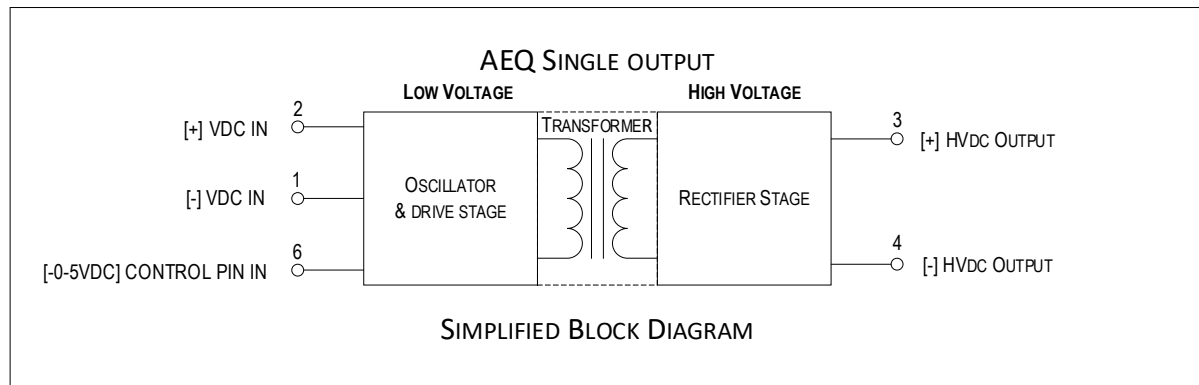


Figure 2

## PIN FUNCTION OVERVIEW

Please refer to the above functional diagrams for reference.

### Pin 1 - INPUT POWER RETURN (-IN)

Pin 1 is located on the low voltage side of the AEQ module, this pin is the ground return to the DC input source powering the AEQ module. This pin is also used as the return path for the voltage control programming signal.

Please Note: The input voltage is isolated from the output voltage; this pin is not the same as the high voltage return path.

### Pin 2 - INPUT POWER (+IN)

Pin 2 is located on the low voltage side of the AEQ module. The pin is the power input to the AEQ module and is supplied by the DC source powering the AEQ. The DC source must be capable of providing the full input voltage and the maximum input current necessary for the correct operation of the AEQ module. These input requirements vary by module/series and can be found on the product data/specification sheet.

### Pin 3 - HIGH VOLTAGE OUTPUT (+)

Pin 3 is located on the high voltage side of the AEQ module. This pin provides the high voltage positive output of the module and provides a voltage of up to 600 VDC at a maximum power output power of 0.5 Watts. The output is adjustable via the control pin. Refer to the datasheet/product specification sheet for the specific model maximum ratings.

### Pin 4 - HIGH VOLTAGE RETURN (-)

Pin 4 is located on the high voltage side of the AEQ module. It provides the AEQ modules high voltage return path. Please note, the high voltage return path is not internally connected to the input power return path (Pin 1). The high voltage output (Pin 3) is referenced to Pin 4.

### Pin 5 - CENTER TAP (BP CONFIGURATION ONLY)

Pin 5 is located on the high voltage side of the AEQ module. This optional pin provides center tap allowing for a  $\pm$ dual high voltage output configuration when referenced to this pin.

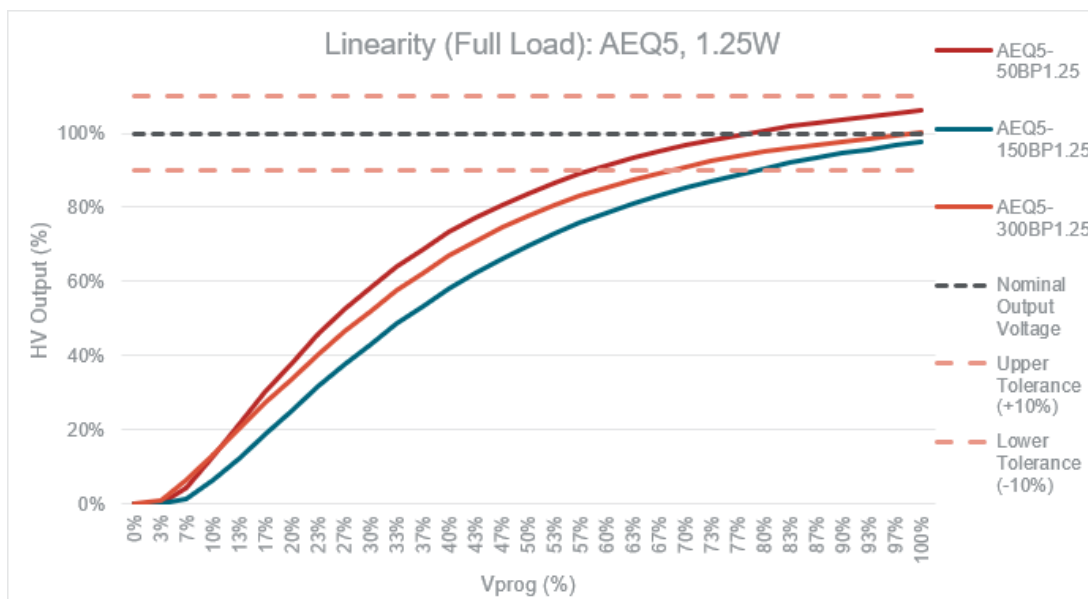
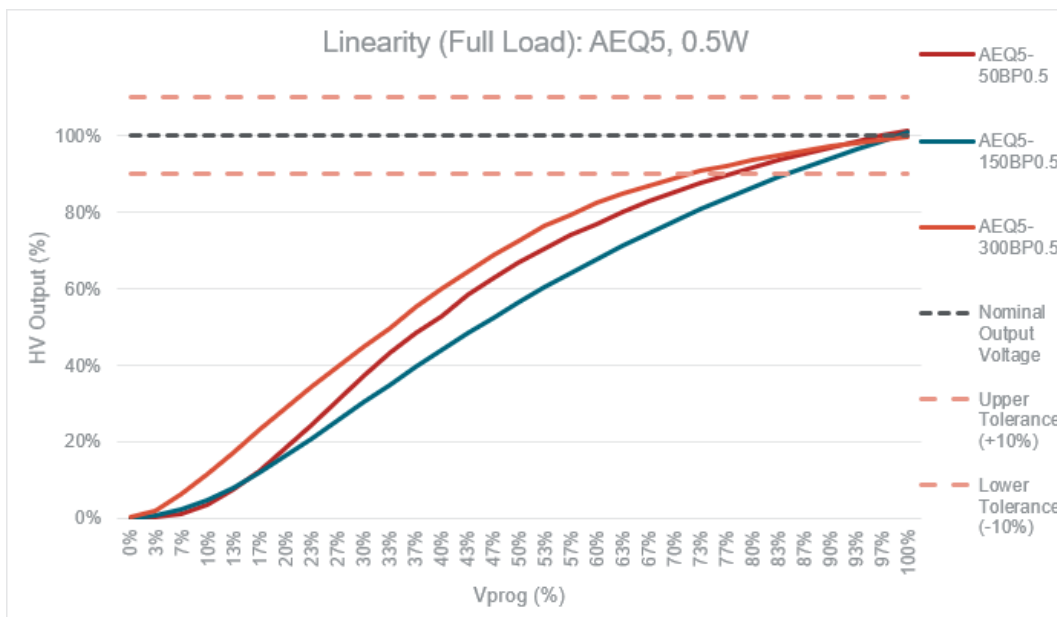
### Pin 6 - CONTROL PIN

Pin 6 is located on the low voltage side of the AEQ module. The pin is used to control the high voltage output of the module. Applying a low voltage analog signal of 0 VDC to +5 VDC to the pin will control the high voltage output from 0% to 100% of the maximum rated output as described in the product specification sheet. The input is high impedance. A wide variety a programming signal sources to be utilized. Any signal source used must have a common ground return to Pin 1 of the AEQ module. This is also true if digital to analog converters are used, operational amplifiers, microprocessors, potentiometers etc.

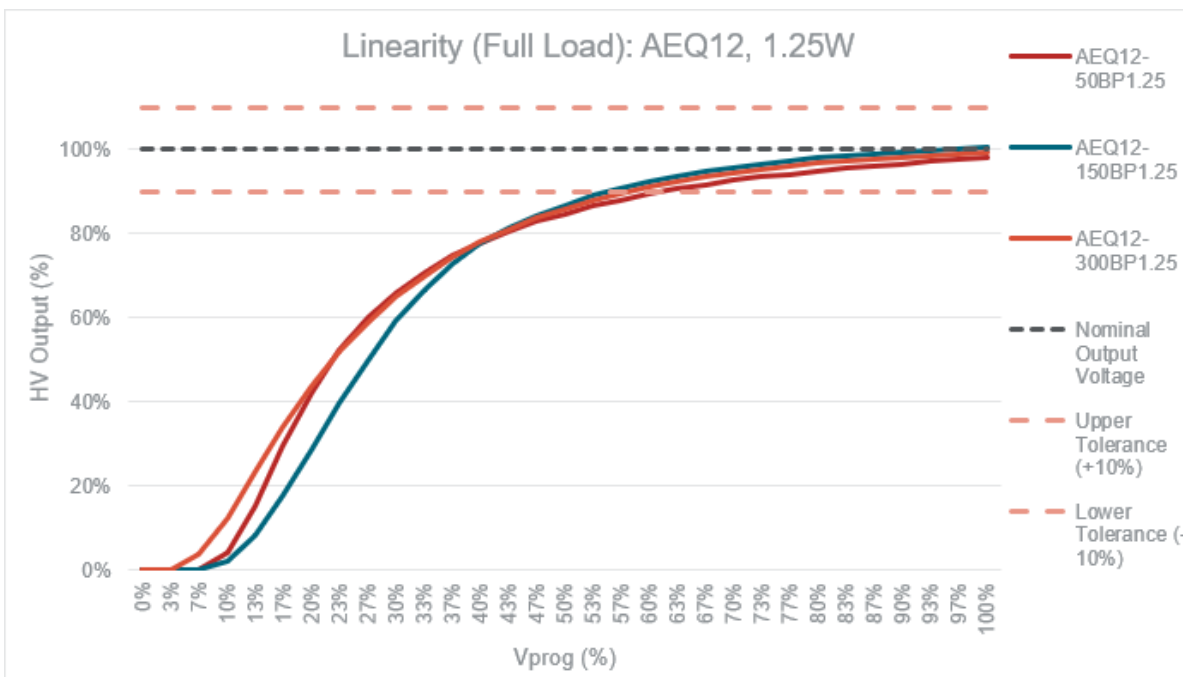
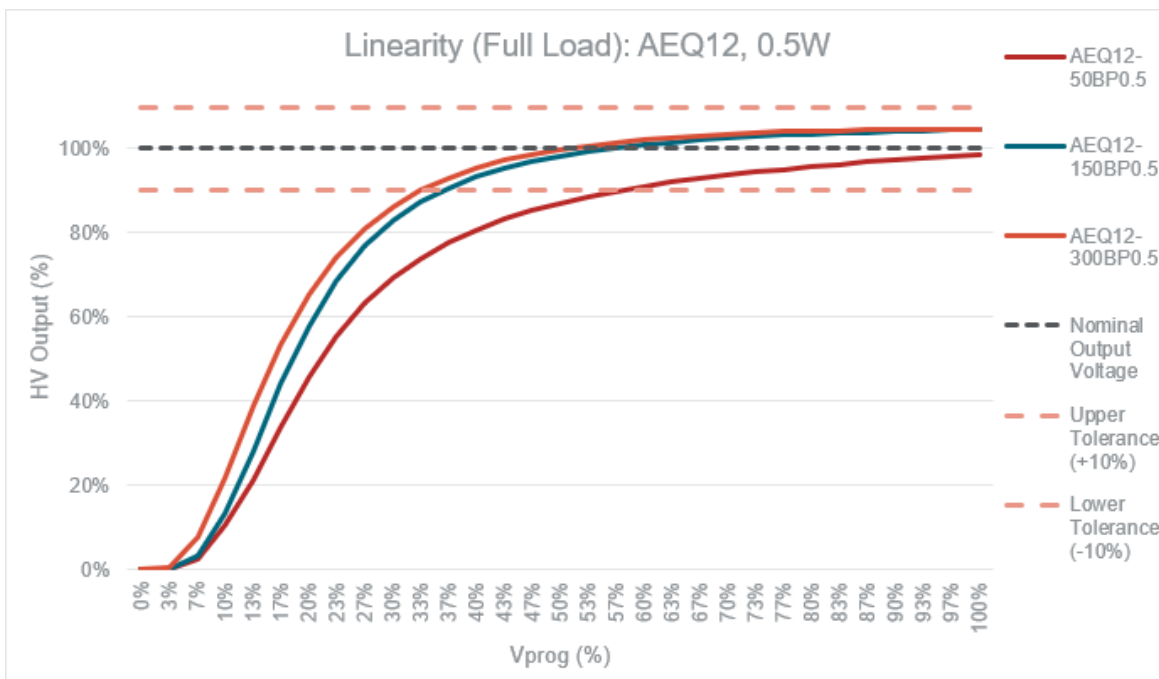
**OUTPUT VOLTAGE LINEARITY**

The AEQ output voltage is proportional to the > 0.1 VDC to +5 VDC applied to the control pin and is independent of the power converter supply voltage. With the +5 VDC power converter voltage present on Pin 2, the output turns on when approximately 0.1 VDC is applied to the control pin (Pin6). As the voltage increases on the control pin so does the output high voltage, likewise as the control pin voltage decreases so does the high voltage output. At light or no-load conditions, the control pin must be compensated to allow the high voltage output to remain in the maximum rated output. See specification sheet for individual modules.

ALL DATA TAKING AFTER 30 MINUTES WARM-UP PERIOD



OUTPUT VOLTAGE LINEARITY



**DESIGN CONSIDERATIONS**

**PCB Layout (Always use best practices when designing PCB boards)**

The AEQ family of miniature high voltage converters are designed to be PCB mounted. It is highly recommended that the low voltage input side of the AEQ module and the high voltage output side traces be separated and all recommended creepage and clearances must be observed (IPC-2221 standard for reference).

Ground planes and power planes are recommended where possible but must follow the same rules as above. Do not rout traces directly under the module, care should be taken when routing critical traces to avoid noise pickup.

**Module Cleaning**

Recommended Pre-soldering: The module should be generally checked for contaminants paying particular attention to the high voltage pin area.

Recommended post soldering: Local spot cleaning by hand only (using alcohol or similar chemistry). The AEQ Power converter family cannot be subjected to batch immersion cleaning, aqueous, or any other methods/chemistry.

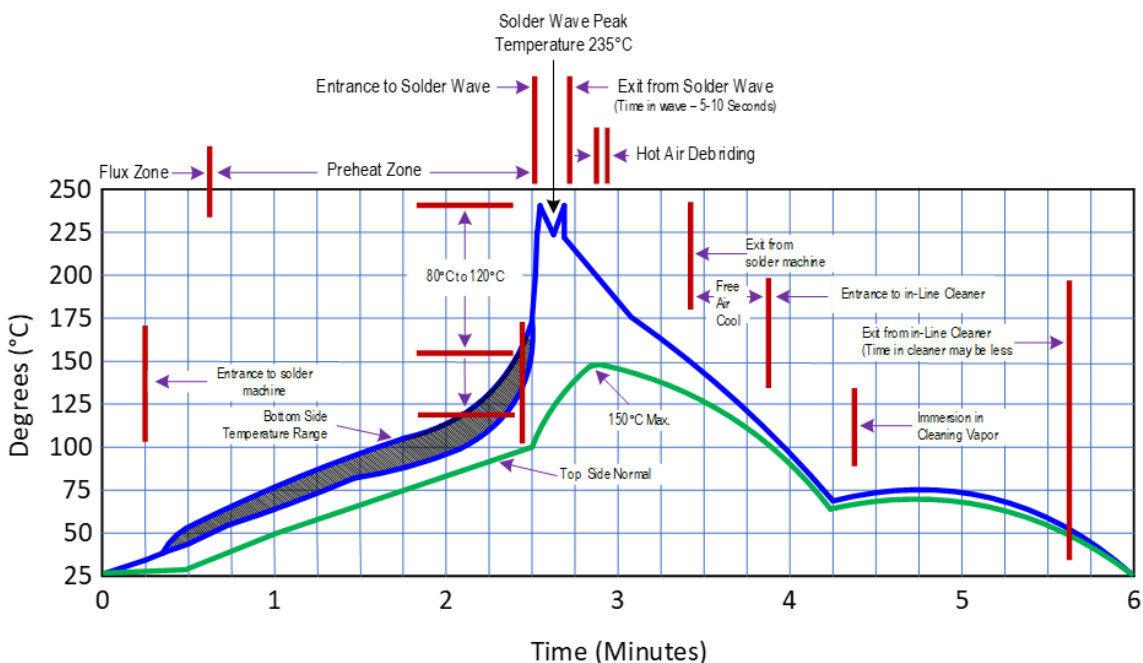
**Soldering**

**Hand Soldering:** Recommended and preferred. Solder iron temperature should be 350°C (662°F) ±5% (application Variable). Dwell time ≤ 4 seconds per pin using a suitable tip and soldering iron.

**Preheating:** Not recommended or preferred. However, preheat can be applied up to the datasheet maximum storage case temperature. (105°C)

**Wave or Flow Soldering:** Not recommended, but possible without TOP preheat. The temperature should be 270°C (518°F) ±5% and the dwell time should be ≤8 seconds with the AEQ mounted on top of the circuit board. The AEQ case temperature should not exceed the datasheet storage temperature. (Check AEQ datasheet)

**Wave Soldering Profile:** The wave soldering profile below is for thru-hole assemblies or type II/III SMT assemblies VOC free no clean flux.



**Surface Mount Reflow Solder:** The AEQ family are not suited for reflow processes.

**CUSTOMIZATION**

The AEQ family can be manufactured with modifications if necessary. Contact Advanced Energy for information.

**PROTECTION**

Due to the extremely small nature of the AEQ series of modules, components found in larger converters have not been included in the AEQ family.

**Reverse Polarity Protection**

Reverse polarity is achieved by placing a series diode with the input to the converter (Figure 3). A schottky diode is preferred because it will introduce less of a voltage drop than a silicon diode (DC input source maybe adjusted to compensate for the voltage drop). The voltage rating of the diode should be higher than the highest reverse voltage the circuit might see. The AEQ Series only consumes about 250 mA under full load conditions, the diode should be rated for 400 mA to allow for inrush current, converter output short circuit or overload, and derating.

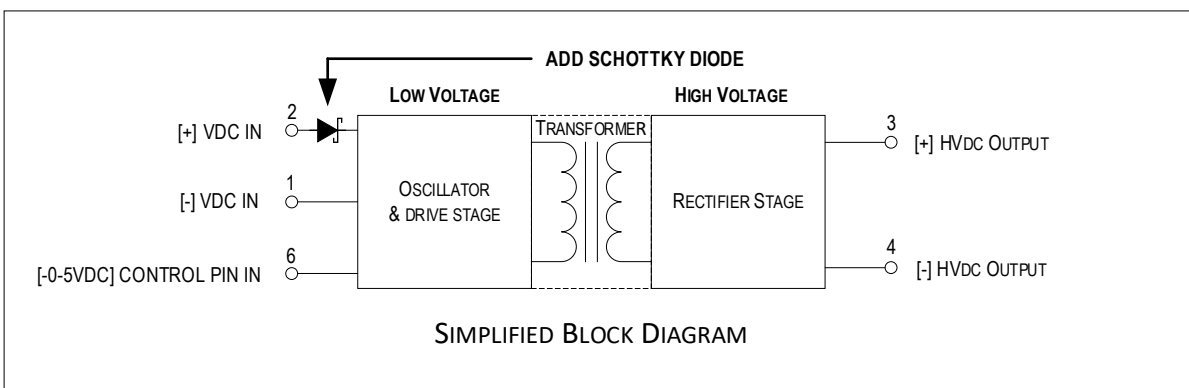


Figure 4

**Arc Protection**

If the application is prone to arcing a small series resistor placed on the high voltage output is recommended, the addition of a resistor will limit the peak current associated with an arc incident and will limit the stress on the high voltage capacitors internal to the converter. Load regulation requirements help dictate the maximum value of the protection resistor. If your load resistance is reasonable constant, pick a tolerable voltage drop across the resistor and your load current. To calculate the resistor value, use this Ohms law formula ( $R=V/I$ ). It is important to use the correct style of resistor, a carbon composition or similar type is recommended to survive repetitive arcs.

**Output Short Circuit / Overload Conditions**

The AEQ family of converters are designed to withstand intermittent output current overloads/short circuits. As the output load current increases beyond the operating specification the output voltage will drop. Operating the AEQ converters outside its operational window for extended time may result in thermal damage and converter failure.

**APPLICATION NOTE**

**Input Bypass Capacitor**

Internal to the AEQ series of converters there is a small input capacitor. We recommend adding a good quality low impedance electrolytic capacitor as close to the input pins of the converter as possible (Figure 4). This capacitor will work in parallel with the internal capacitor and will reduce reflected ripple on the input supply lines.

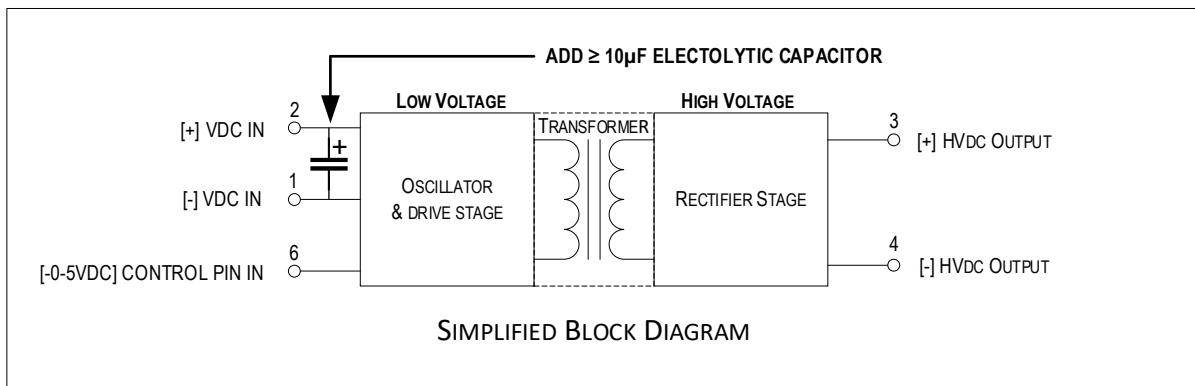


Figure 5

**Output Ripple Reduction Filter**

The AEQ has an output ripple of  $\leq 1\%$  (see specification sheet), if a further reduction of ripple is required on the high voltage output, a simple 1 stage (or several cascaded stages) RC filter network can be implemented (Figure 5). Using the load current to calculate the resistor and using high voltage ceramic capacitors in the value range of 0.001 to 0.01  $\mu\text{F}$ , very low levels of ripple can be achieved.

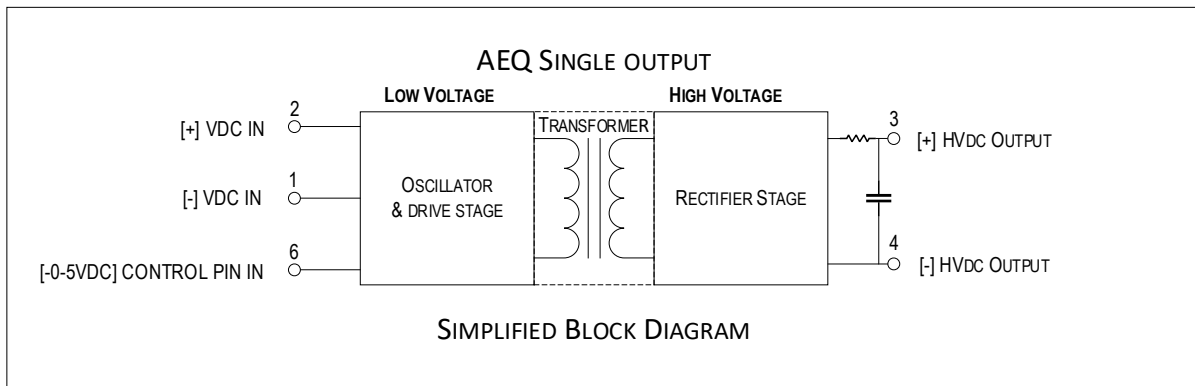


Figure 6



APPLICATION NOTE

Reversible

The AEQ family of high voltage converter have an isolated and floating output. If isolation is **not** required the following configuration methods can be utilized.

Dual output with the center tap (CT Pin 5) connected to [-] VDC IN.

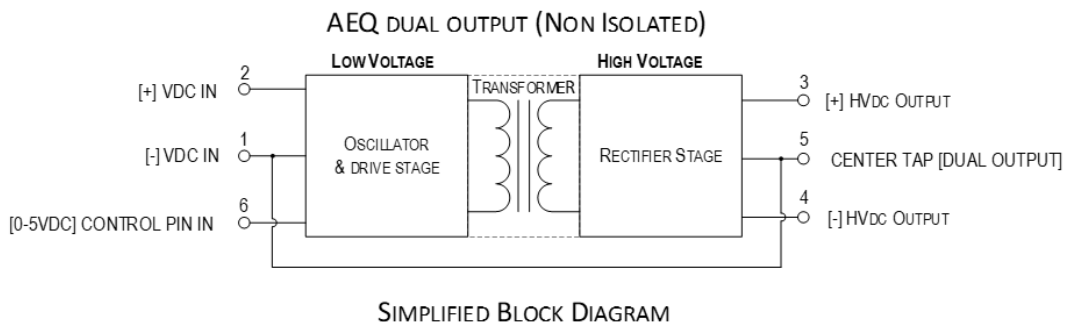


Figure 7

Positive output with [-] HVDC connected to [-] VDC IN.

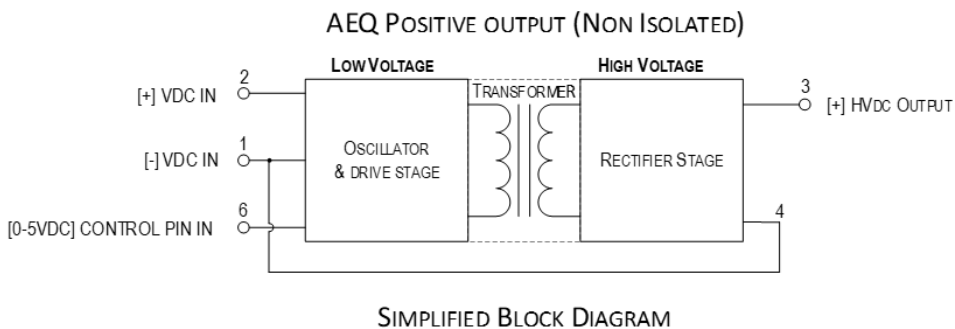


Figure 8

Negative output with [+] HVDC connected to [-] VDC IN.

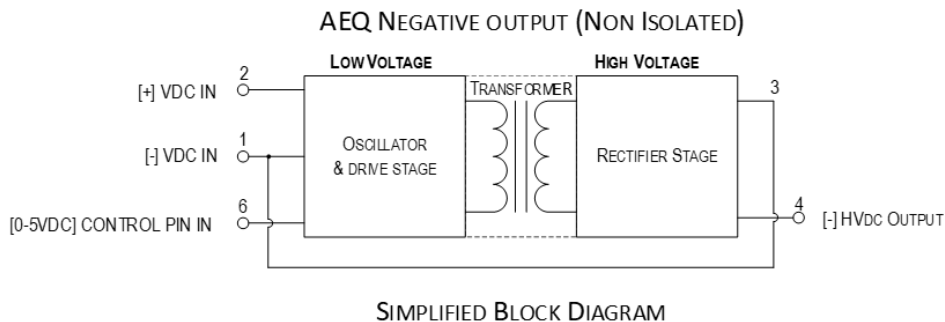


Figure 9

APPLICATION NOTE

Negative or Positive outputs with [-] HVDC connected to [-] VDC IN.

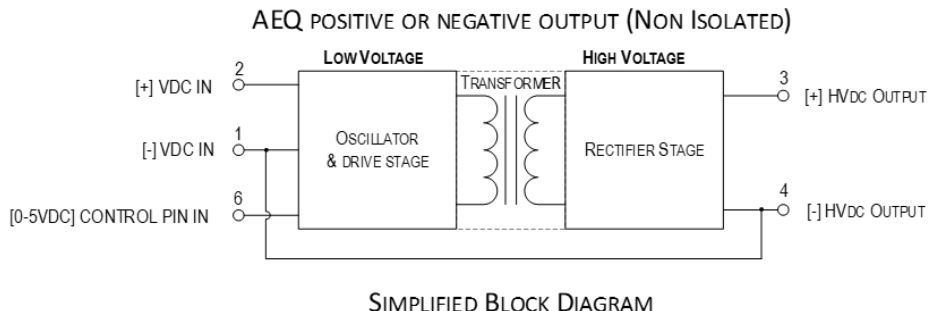


Figure 10

**Regulation**

Figure 11 below shows a design idea to achieve a regulated AEQ converter output. A resistor divider network connected to the high voltage output pin 3 and 4 is used to sample the high voltage output, the sampled voltage is feedback via the resistor divider network to an error amplifier. This technique can be used for achieving a regulated output across the operating range of the AEQ converter. The technique shown below is suitable for non-isolated applications requiring a higher level of high-voltage regulation.

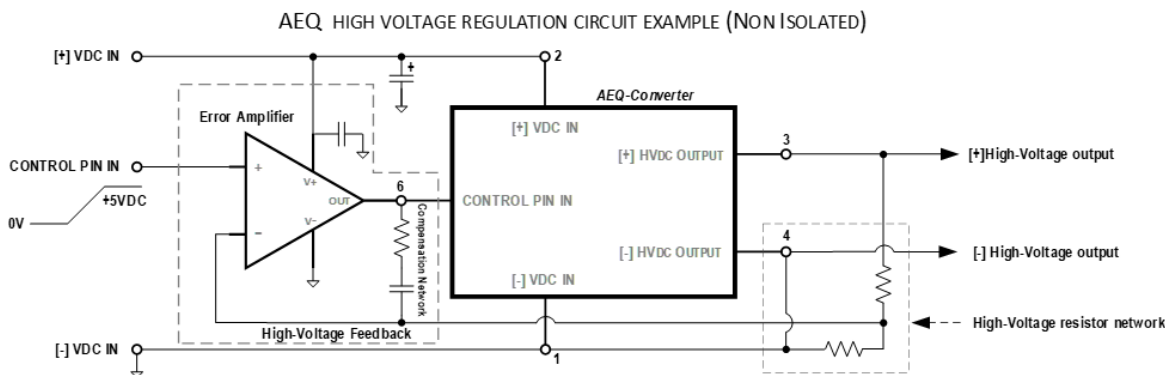


Figure 11

APPLICATION NOTE

Figure 12 below shows a design idea to achieve a regulated AEQ converter output at a fixed output voltage. A means of driving a correctly sized opto-coupler to provide the necessary galvanic isolation is provided by the network shown between the high-voltage output pins 3, 4 and 5, the network is used to sample the high voltage output, the sampled voltage is feedback via the opto-coupler to an error amplifier. This technique can be used for achieving a regulated output at a fixed output voltage of the AEQ converter. The technique shown below is suitable for **isolated** applications requiring a **fixed** output voltage and higher level of high-voltage regulation.

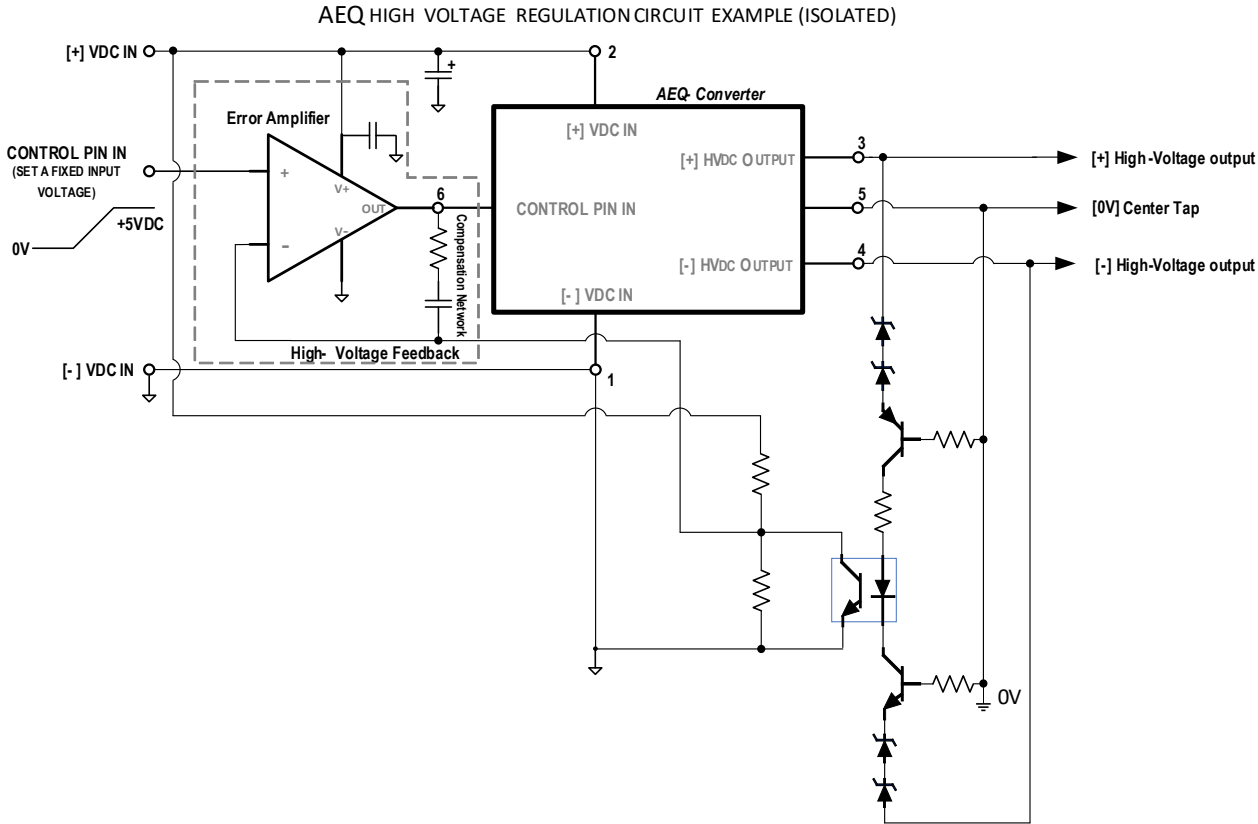
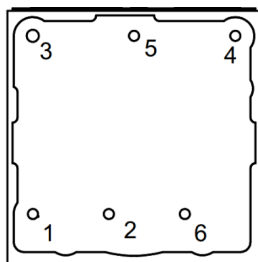


Figure 12

**MECHANICAL SPECIFICATIONS**

**Pin Assignment**

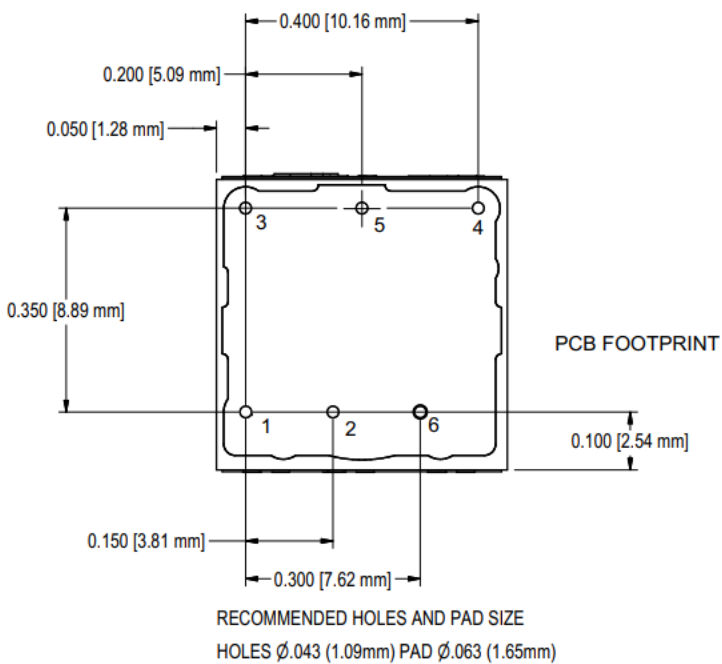


View from bottom

PIN ASSIGNMENT	
PIN 1	INPUT POWER RETURN (-IN)
PIN 2	INPUT POWER (+IN)
PIN 3	HIGH VOLTAGE OUTPUT (+)
PIN 4	HIGH VOLTAGE (-)
PIN 5	CENTER TAP (BP CONFIGURATION ONLY)
PIN 6	CONTROL PIN

**PCB Footprint**

Recommended printed circuit board footprint.





For international contact information,  
visit [advancedenergy.com](http://advancedenergy.com).

[powersales@aei.com](mailto:powersales@aei.com) (Sales Support)  
[productsupport.ep@aei.com](mailto:productsupport.ep@aei.com) (Technical Support)  
+1 888 412 7832

## ABOUT ADVANCED ENERGY

Since 1981, Advanced Energy (AE) has perfected how power performs for its customers. For both end users and OEMs, AE's comprehensive portfolio of standard and custom high voltage components precisely match system specifications to deliver unparalleled energy, quality, and performance. Through close customer collaboration, design expertise, application insight, and world-class support, AE creates successful partnerships and enables customers to push the boundaries of innovation and stay ahead of evolving market needs.

PRECISION | POWER | PERFORMANCE | TRUST



**CAUTION:**  
High Voltage

Read and understand all documentation before you install, operate, or maintain Advanced Energy high voltage power supplies. Follow all safety instructions and precautions to protect against property damage and serious or possibly fatal bodily injury. Never defeat safety interlocks or grounds.

Specifications are subject to change without notice. Not responsible for errors or omissions. ©2023 Advanced Energy Industries, Inc. All rights reserved. Advanced Energy®, AE®, and HiTek Power® are U.S. trademarks of Advanced Energy Industries, Inc.