

HDA 600W Single-Phase AC Front End With Active Power Factor Correction

General Description

The Rantec HDA Series single-phase AC active power factor correction unit permits operation of the Rantec HDM 270V Series of DC-DC Modules from a standard single phase AC power source. In addition to accepting a wide range of input voltages, the HDA Series offers the benefit of active Power Factor Correction (PFC) and has models for either 60 or 400 hertz operation.

Although the HDA Series performs many functions itself, it is intended to be used as a building block in a power system utilizing one or more Rantec HDM DC-DC converter modules in conjunction with additional external circuitry. Proper implementation with appropriate selection of external components provides the end-user with a flexible and effective means of creating a power system optimized for the specific needs of the application at hand. However, it is important to have a good understanding of what is required of the finished power system, and to observe the design guidelines presented herein, when determining what external components will be used to achieve that end.

The HDA Series accepts an input of 85 - 200 volts, 60 Hz. AC, or 400 Hz. with reduced specifications (see page 3). Special 400 Hz. optimized models are also available. The HDA models provide an output voltage of either 300 or 380 VDC and can deliver up to 600 watts of power to the converters. The higher output voltage allows for more holdup time for a given capacitor and load. Both are suitable for use in powering Rantec HDM 270Vin DC-DC Converters. The HDA Series also provides external, control-level functions as discussed in the following text.

The HDA Series utilizes Power Factor Correction (PFC) circuits to convert AC input power to DC output power with low input current distortion. The required output filter capacitors are not included in the HDA because of their bulk and the wide range of possible requirements. The minimum required

capacitance is a function of the total output power delivered by the HDM DC-DC modules, the desired hold-up time following brief interruptions of the input power, ripple and harmonic distortion requirements, and the line frequency of the input AC power source.

Output Capacitance Requirements

Output capacitance is required. Extensive testing has shown that the minimum output capacitance (see Figure 1) required to meet the output ripple and total harmonic distortion values specified in the datasheet is 800µF.

Capacitance for Ripple Voltage Concerns

The following formulas show the calculation of capacitance needed to limit the HDA's output ripple to a specified level. I_R , the primary ripple current at the output of the HDA, has a frequency, f_R , equal to twice the line frequency, f_L , and its magnitude is directly proportional to the DC load current, I_{DC} :

$$I_R(p-p) = \frac{4}{3} \times I_{DC}$$

The input ripple voltage, E_R , is related to the ripple current by the impedance of the filter capacitor, X_C , as follows:

$$E_R = I_R \times X_C$$

Also:

$$X_C = \frac{1}{2 \times \pi \times f_R \times C}$$

$$\text{and } f_R = 2 \times f_L$$

Substituting and rearranging to solve for C in terms of I_{DC} , E_R , and f_L :

$$C \geq \frac{I_{DC}}{3 \times \pi \times E_R \times f_L} \text{ Farads}$$

As an example, to keep the peak-to-peak ripple produced by an HDA-600-01 below 7.25V at full load ($I_{DC} = 1.6A$), the minimum capacitance necessary is: 468 μF for 50Hz; and 390 μF for 60Hz.

Capacitance for Hold Up

If the power system application under consideration requires the ability to continue operation for a period of time following an input power interruption, additional capacitance can be used to permit the HDM DC-DC Module(s) connected to the HDA to continue operation. The amount of storage capacitance required is given by the following equation:

$$C \geq \frac{2 \times P_{OUT} \times t_{HOLDUP}}{(V_{NOM})^2 - (V_{DROPOUT})^2}$$

Where

P_{out} = Power required for the HDM Module(s); Equals the delivered power to the loads divided by the efficiency of the HDM Module(s)

t_{holdup} = Desired holdup time in seconds

V_{nom} = The nominal output voltage of the HDA (380VDC)

$V_{dropout}$ = The low-line or dropout input voltage for HDM 270V Modules (220VDC)

Substituting the known values to find an expression in terms of P_{out} and t_{holdup} :

$$C \geq P_{OUT} \times t_{HOLDUP} \times (2.1 \times 10^{-5}) \text{ Farads}$$

As an example, to provide a holdup time of 50mS for a system comprising an HDA powering two HDM Modules, each delivering 5V @ 40A (200W) and having an efficiency of 80%:

$$P_{OUT} = 2 \times \left(\frac{200}{0.80} \right) = 500W$$

then

$$C \geq 500 \times 0.050 \times (2.1 \times 10^{-5}) = 525\mu F .$$

Implementing the Storage Capacitor

In selecting the storage capacitor or capacitors for use with the HDA, use only low ESR types with high ripple current ratings. Pay attention to the operating temperature range of the power supply, as most capacitors, especially electrolytics, will lose a significant percentage of their capacity at low temperatures.

Due to the relatively high voltage involved, it may be necessary to use two or more capacitors in a series or series-parallel configuration to accomplish the desired total capacitance (see Figure 1). Voltage bleeding resistors and reverse polarity protection diodes are also required, to prevent possible injury from stored charge, and to protect the capacitors from damage at turn-on and turn-off. See Figure 1 and Application Note HDMA-112 for more information.

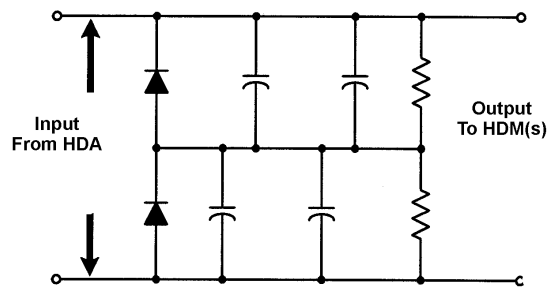


Figure 1 HDA Output Capacitance Implementation

DC OK Signal

The DC OK signal monitors the output of the HDA and provides a power fail warning that the DC output or AC input is going away. On turn-on, the DC OK pin is active low until the HDA output rises above ~362VDC for the HDA-600-01, and ~284VDC for the HDA-600-31. It then becomes an open drain. On turn-off, the DC OK pin remains an open drain until the output drops below ~352VDC for the 600-01, and ~278VDC for the 600-31. The DC OK pin is capable of sinking up to 40mA continuously and has a maximum voltage rating of 40V with respect to the -OUT pin of the HDA. It's active low voltage is less than 0.3V when sinking 10mA.



Load Enable Signal

The HDA module utilizes fold-back current limiting to safely and quickly start-up into large capacitive loads. Since non-capacitive loads can prevent the HDA from starting properly, the HDA modules have a load enable circuit that disables the load until the HDA can supply the rated current. The Load Enable should be used in all applications.

The HDA load enable circuit (see Figure 2) interfaces with the on/off control input of the load. It is designed for loads that are disabled when the control input is pulled low with respect to the -OUT pin of the HDA. Other loads may require an interface to work properly with the HDA.

On turn-on, the LD ENA pin is active low until the HDA output rises above ~345VDC for the 600-01, and ~273VDC for the 600-31. It then becomes an open drain. On turn-off, the LD ENA pin remains an open drain until the output drops below ~220VDC for the 600-01, and ~204VDC for the 600-31. The LD ENA pin is capable of sinking up to 40mA continuously and has a maximum voltage rating of 40V with respect to the -OUT pin of the HDA. Its active low voltage is less than 0.3V when sinking 10mA.

Care should be taken in system designs to prevent noise from affecting the operation of the module(s). The preferred method is to keep the load enable connection to the on/off pin as short as possible, opto-isolated, and shielded. A coax cable may be used with the shield tied to the -Vin of the modules. In a PC board layout, shield the on/off pin connection with the -Vin signal of the modules, and place the optocoupler(s) as close to the modules' on/off input pin as possible.

Auxiliary Output

The auxiliary output, "Vaux", is a regulated bias supply capable of powering logic or control circuitry. It provides ~16V at no load with respect to the -OUT pin. Vaux provides ~14V at 10mA. Vaux should not be loaded beyond 2mA at startup.

Connecting Multiple Modules to the HDA

In the event that the HDA is going to be providing input power for multiple Rantec HDM DC-DC Modules, an Enable interface circuit for each module is needed to ensure that no HDM Module starts operating before the HDA output voltage has fully come up. This is accomplished by connecting the HDA's Load Enable output to the HDM's parallel-on/off input through optocouplers (see Figure 2). For extended temperature conditions, PS2911 optocouplers may be used.

Common Mode Noise

Another issue that can be seen in systems using the HDA with multiple HDM DC-DC converters is common mode noise. This may cause erratic or unstable behavior to be seen in the DC-DC converters' control circuitry. This can be prevented by the use of common mode chokes on the input of each HDM as shown in Figure 2. A 10mH common mode choke is available from Rantec Power Systems for this purpose (Rantec P/N 30281).

Multiple PFC Systems

Multiple Rantec HDA PFC modules can be used when higher power is required. Please consult Rantec for your specific application support.

Precautions

Hazardous Voltages: Hazardous voltages may be present when implementing the PFC module, including the input AC potential and the 380V DC output. Care should be taken to provide insulation, protective covers, and warning labels.

PFC module is not isolated: The output of the PFC module is not electrically isolated from the input. Do not connect the output or status pins to earth ground either intentionally or accidentally (e.g. with a scope probe ground lead) unless proper precautions have been taken. Consider using an isolation transformer for testing purposes.

EMI Filter: An EMI filter may be required on the line side of the PFC module to filter the module's

