POWERSTAX FP Series
Power Factor Correction Converters

APPLICATION NOTES

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The Powerstax FP Series of Power Modules are a range of high performance Power Factor Correction AC- DC Converters. The converters have been developed to provide front-end power conditioning for High Input Voltage DC/DC Modules. Wherever used the Powerstax Power Modules are a cost effective alternative to designing power supplies with discrete components.

The FP Series of Power Modules incorporate surface mount technology to achieve high power density and reliability. The converters are available with universal input voltage range for worldwide application or high-line (230Vrms) only, with an output voltage of 380V.

The ENABLE output can be used to control the load DC-DC converters. DCOK and VAUX outputs are available to provide monitoring to the system if required. The modules have inrush current limiting, thermal shut down, output over-voltage and input under-voltage protection. In addition, a SYNC input pin allows the synchronising of units to an external system clock for particularly noise sensitive applications.

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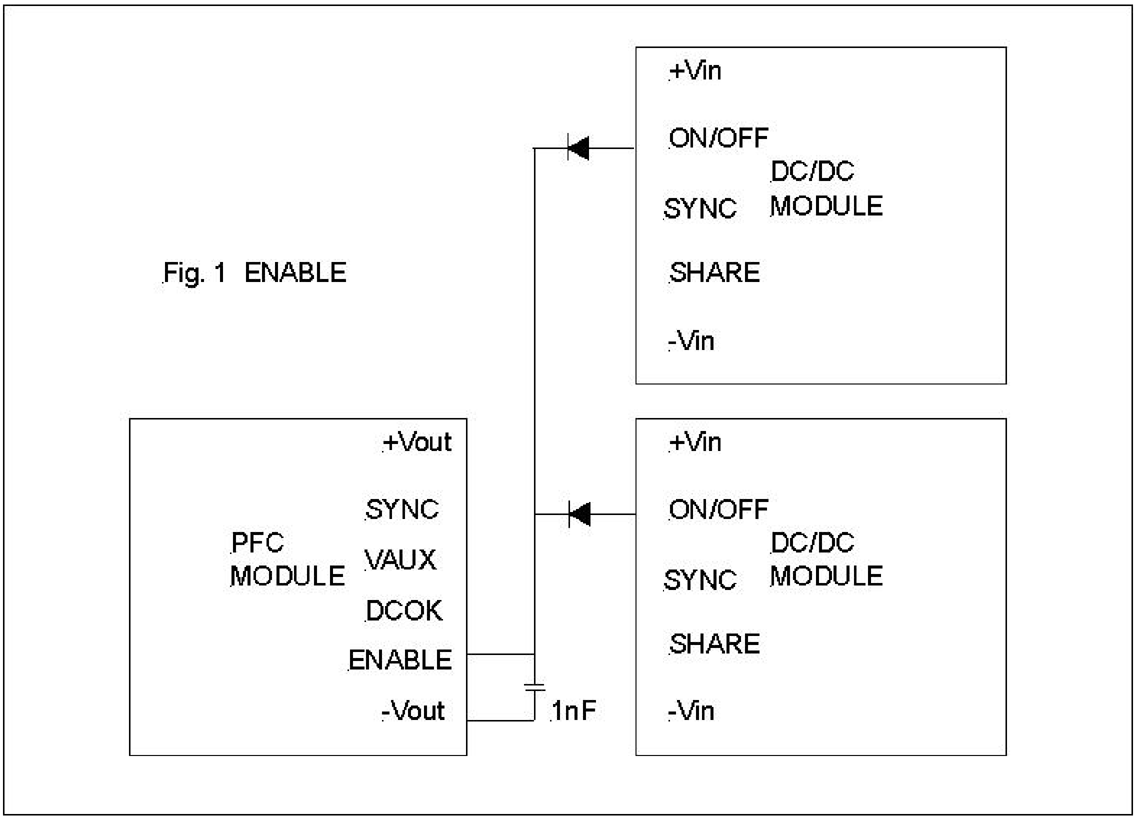
ENABLE

The ENABLE output of the Module is an open-drain signal, referenced to –Vout, which is designed to control the load DC/DC converters. The logic is Low = Off. When using a single DC/DC module as load, all that is required is a single wire connection to its' ON/OFF input. When using more than one load module, connect a small-signal diode from each ON/OFF input to the ENABLE output (see Fig.1).

During start-up, the ENABLE signal will allow the loads to start only when the output has reached 360V (typically). This prevents any current from the loads activating the foldback current limit of the PFC Module during inrush, which may cause the system to oscillate. Therefore, Powerstax strongly recommend using this feature.

During shut-down, the ENABLE signal goes low when the output has fallen to 225V (typically). This allows the system to continue working during an input drop-out.

In noisy environments, it may be necessary to add a small ceramic capacitor on the ENABLE output. (A typical value would be 1nF.)



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DCOK AND VAUX

The DCOK output is an open-drain output intended, with the VAUX output, to drive an optocoupler (or similar). Low = Output OK, Open = Output Low. The signal is referenced to the –Vout. The rising threshold is 360V (typically) and the falling threshold is 350V (typically). The VAUX output is a nominal 14.5V supply fed through a 660Ω resistor.

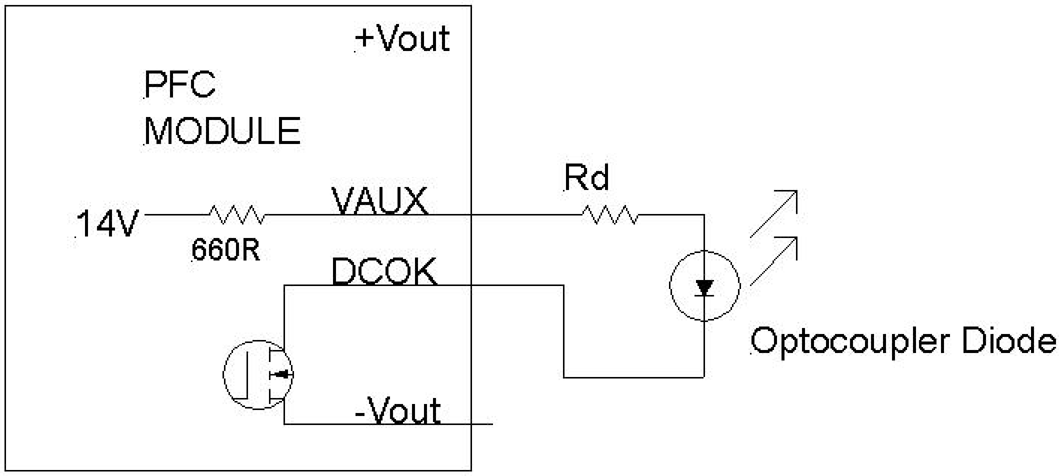
The opto-diode and series resistor Rd should be connected as shown in Fig. 2. For a desired diode current Id, Rd can be calculated using the following formula:

Rd = (Vaux – Vd)/Id - 660

For example, for 10mA current:

Rd = (14.5 – 1.2)/10m - 660 = 670Ω

Fig. 2 DCOK



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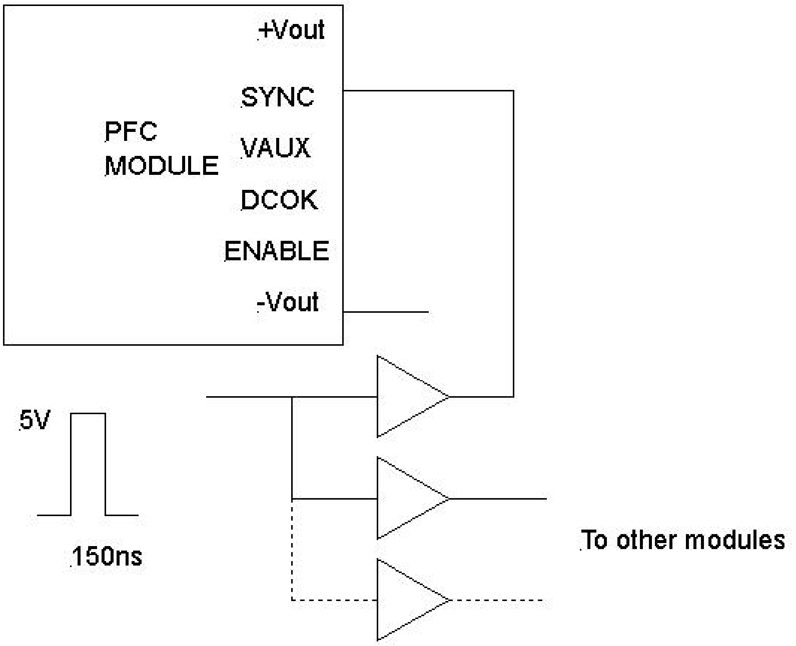
SYNCHRONISATION

When used for particularly noise sensitive applications one or more Power Modules can be synchronised to an external clock frequency. The external 5V TTL compatible driving signal drives the SYNC pin of the Power Module directly.

Fig 3 Synchronisation



Synchronisation pulses are nominally +5v and 150nSec long (±50nSec), with a pulse repetition frequency (p.r.f.) selected to be between 165 kHz and 180kHz. Higher switching frequencies can be accommodated if required. Powerstax application engineers are available to give advice on special requirements.

The input impedance is a resistive 90Ω to ground. There is negligible capacitive loading; the external stray pcb capacitance from the external drive to the Power Module is typically dominant and having a low duty cycle, (typically 5%), minimizes the drive power requirements to achieve synchronisation in a very efficient manner.

Typical of the devices to drive the synchronising pulse to the Power Modules are FET drivers supplied from a 5V power rail, a suggested example being the widely used 426 series.

Note: the 0V reference ground for the SYNC function is the –Vout terminal of the module

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SAFETY CONSIDERATIONS

The modules are intended for use within suitable enclosures and safety must be considered in positioning the modules.

- In order to give the designer flexibility with regard to grounding, the metal base plate of the power modules is isolated from the internal circuitry by single ("Basic") isolation. In Class I applications, where a safety ground is provided, the base plate must be connected to the safety ground. In Class II applications where no ground is provided, the base plate and any conductive parts to which it is connected must be isolated so they do not present a shock hazard in the event of insulation failure between the input circuitry and the base plate (giving double isolation).
- To ease grounding, the fixings are connected to the base plate and can be used to connect the base to ground.
- To prevent risk of fire in case of certain kinds of fault developing within the converter, the input circuit should be fitted with appropriately rated fuse (see below).
- The modules are designed to operate at temperatures that may be hazardous if touched. Care should be taken to prevent touching of metal parts.
- Modules may have a voltage across the Vin and Vout terminals after removing the power. The voltage, stored as a charge on capacitors, may not decay to low levels immediately. Users should take this into account when gaining access to the modules within the equipment.

FUSES

An external input fuse is needed for electrical safety (and to protect other circuits) in the unlikely event of catastrophic failure of a Power Module.

This fuse should be selected to withstand the maximum input current at low input voltage, with a safety margin (normally 20%). For example, for a PFC module driving two 200W modules, from a 230Vac input, the fuse would be rated at 3A. A HRC, slow blow/time-delay/antisurge (T) type fuse should be used to prevent blowing during inrush transients. The maximum fuse rating that should be used is 10A.

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OVERLOAD PROTECTION

The PFC Modules have an output current limit circuit for inrush/start-up. This circuit is in series with the positive output of the module. Since there is a large capacitor on the output, this circuit limits the charging current and therefore the inrush current, during start-up.

The current limit circuit has a foldback characteristic to prevent excessive dissipation in the series element as it charges the load capacitance. Due to the AC nature of the input, this means that the charging/inrush current varies as the input voltage changes.

The foldback characteristic means that the unit may not start into a resistive load. To start into a resistive load, ensure the resistance is greater than 2500 ohms. Higher loads may then be applied once the unit is running.

Once the ENABLE pin has gone open circuit, to enable the downstream converter(s), the series protection circuit is disabled. This allows for recharging of the output capacitor after a mains drop-out.

A sudden application of a short circuit on the output of the module, when running, may cause failure of the module. It may therefore be necessary to fuse the inputs of the load converters.

INPUT UNDERVOLTAGE SHUTDOWN

The PFC Module is protected against input undervoltage (brown-out) using a detector that monitors the peak input voltage. This is to prevent the module overheating in the unlikely event of the input voltage falling below the normal range.

On universal input versions, the thresholds are typically 121Vpk(on) and 112Vpk(off), which correspond to 86Vrms and 79Vrms respectively - provided the input is a sine wave. On high-line versions these are typically 237Vpk and 222Vpk (168Vrms and 157Vrms).

OUTPUT OVER VOLTAGE PROTECTION

The output is also protected against over voltage by an internal over voltage protection circuit that shuts down the switching for the duration of the excessive voltage. The threshold is typically 415V.

Over voltage can occur during:

1. A major failure of the control circuit. In the unlikely event of this happening the PFC Module has to be replaced.

2. Start-up and large load changes, due to the (necessary) slow nature of the feedback circuit of the Module.

3. Input Over-Voltage (if the peak of the input exceeds the threshold).

DECOUPLING

The Powerstax PFC Modules have built in ceramic capacitors to absorb high frequency noise, but it is also necessary to add local input and output decoupling capacitors. A plastic capacitor, of at least 400V rating, should be connected close to the input pins of the module; typically 1uF is sufficient. An electrolytic capacitor, of at least 450V rating, should be connected close to the output pins of the module; at least 100µF is recommended. This capacitor also absorbs the twice-line-frequency ripple, the input ripple of the DC/DC converter and provides hold-up for mains drop-outs. For 20ms hold-up, 1µF per Watt of load is recommended.

THERMAL PROTECTION

A common failure mode in a power supply is overheating which may have been caused by inadequate thermal design, too high ambient temperature or failing forced cooling, sometimes caused by dirty air filters. Thus thermal protection and management is of prime importance for the reliability of a power supply.

The Power Modules are designed for mountingdirectly on to a heatsink with the flat metal base acting as the primary means of removing heat. Suitable heatsinks are available from Powerstax or other standard heatsinks can also be used. For good thermal contact between the Power Module's metal base and the heatsink a thermal pad should be used.

To obtain long life and a reliable performance the temperature rise within any power device cannot exceed certain values. For the Powerstax PFC Modules, the temperature of the metal base has to be controlled so that the maximum continuous temperature is 100^{o}C.

HEATSINK OPERATION

Some form of heatsinking is necessary to use the maximum output of the Power Modules and if space is not at a premium natural convection is normally used. The size and type of heatsink is determined by the available mounting space, ambient temperature, mounting orientation and output power requirements. Many standard heatsinks are available and sometimes the enclosure within which the power supply is located can be used for this purpose.

Powerstax can supply a specially designed heatsink for Power Modules mounted on a printed circuit board. This heatsink has a thermal resistance of 2.8^{o}C/W when mounted with the fins vertically. For maximum output power from the Power Module a fan is required to cool the assembly. The flow rate is dependent upon the required output power of the module and the maximum ambient air temperature. For high ambient temperatures a flow rate of up to 5m/s should suit most applications, reducing the thermal resistance to 0.6^{o}C/W

The ideal thermal resistance for full operation without a fan is 0.5^{o}C/W.

The metal base of the Power Modules is thermally coupled to the heat sources within the Power Module but is electrically isolated from its circuitry. It is very important that the mating surfaces of the heatsink and the Power Module are flat. The metal base of the Power Modules has a flatness of 0.2mm for this purpose.

Thermally conductive material should also be used to fill the voids between the mating surfaces. Powerstax recommends the use of a dry or phase change material. The thermal resistance between the two surfaces should be typically 0.1°C/W for materials obtained from most manufacturers.

Silicon compounds are greasy and have a tendency to creep along the surface of the heatsink with time. Other new “phase change” materials are designed to replace grease as a thermal interface. The phase change temperature are typically between 55°C to 65°C at which point the material changes from a solid to a thixotropic characteristic assuring total wet-out of the two surfaces reducing still further the thermal resistance.

Examples of dry thermally conducting material are Union Carbide “Grafoil”, Warth “KA150” and Bergquist “Hi Flow 105” for phase change materials, all are for non-isolated applications.

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EMI FILTERING

Like all power switching circuits, the modules generate high frequency noise in both series-mode and common-mode. In order to meet regulatory requirements, it is necessary to add an EMI filter between the module and the input line. This filter would typically have to be a dual-stage type. For further details see Application Note: Off-Line EMC Filtering.

It is normally necessary to include ceramic capacitors (e.g. 4.7nF, Y-type) from the –Vout (or +Vout) pin, and the AC input pins, to the base/heatsink/ground. They should be placed as close as possible to the module, with low impedance paths to the pins and the base.

NOTES

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TYPICAL APPLICATION CIRCUITS