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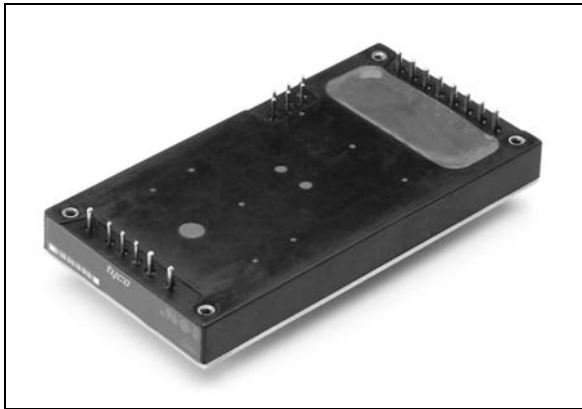
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**FC250A1 Power Module: dc-dc Converter;  
18 Vdc to 36 Vdc Input, 5 Vdc Output; 50 W**

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The FC250A1 Power Modules use advanced, surface-mount technology and deliver high-quality, compact dc-dc conversion at an economical price.

## Applications

- Redundant and distributed power architectures

## Options

- Heat sinks available for extended operation

## Features

- Small size: 61.0 mm x 116.8 mm x 13.5 mm (2.40 in. x 4.60 in. x 0.53 in.)
- Wide input voltage range
- High efficiency: 81% typical
- Parallel operation with load sharing
- Adjustable output voltage
- Thermal protection
- Synchronization
- Power good signal
- Current monitor
- Output overvoltage and overcurrent protection
- Constant frequency
- Case ground pin
- Input-to-output isolation
- Remote Sense
- Remote on/off
- Short-Circuit protection
- Output overvoltage clamp
- UL\* Recognized, CSA† Certified, VDE Licensed

\* UL is a registered trademark of Underwriters Laboratories, Inc.

† CSA is a registered trademark of Canadian Standards Association.

## Description

The FC250A1 Power Module is a dc-dc converters that operate over an input voltage range of 36 Vdc to 75 Vdc and provide a precisely regulated dc output. The outputs are fully isolated from the inputs, allowing versatile polarity configurations and grounding connections. The modules have maximum power ratings of 100 W at a typical full-load efficiency of 85%.

The sealed modules offer a metal baseplate for excellent thermal performance. Threaded-through holes are provided to allow easy mounting or addition of a heat sink for high-temperature applications. The standard feature set includes remote sensing, output trim, and remote on/off for convenient flexibility in distributed power applications.

## Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

Parameter	Symbol	Min	Max	Unit
Input Voltage: Continuous	$V_I$	—	80	Vdc
Transient (100 ms)	$V_{I, trans}$	—	100	V
Operating Case Temperature (See Thermal Considerations section.)	$T_C$	-40	100	°C
Storage Temperature	$T_{stg}$	-55	125	°C
I/O Isolation Voltage (for 1 minute)	—	—	1500	Vdc

## Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions.

**Table 1. Input Specifications**

Parameter	Symbol	Min	Typ	Max	Unit
Operating Input Voltage	$V_I$	36	48	75	Vdc
Maximum Input Current: $V_I = 0 \text{ V to } 75 \text{ V}; I_O = I_{O, max}$ (See Figure 1.)	$I_{I, max}$	—	—	3.8	A
$V_I = 36 \text{ V to } 75 \text{ V}; I_O = I_{O, max}$	$I_{I, max}$	—	—	3.3	A
Inrush Transient	$i^2t$	—	—	1	A <sup>2</sup> s
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 $\mu$ H source impedance; see Figure 7.)	$I_i$	—	10	—	mAp-p
Input Ripple Rejection (120 Hz)	—	—	60	—	dB

## Fusing Considerations

**CAUTION: This power module is not internally fused. An input line fuse must always be used.**

This encapsulated power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of a sophisticated power architecture. To preserve maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a normal-blow fuse with a maximum rating of 15 A (see Safety Considerations section). Based on the information provided in this data sheet on inrush energy and maximum dc input current, the same type of fuse with a lower rating can be used. Refer to the fuse manufacturer's data for further information.

## Electrical Specifications (continued)

**Table 2. Output Specifications**

Parameter	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point ( $V_I = 48\text{ V}$ ; $I_O = I_{O, \text{max}}$ ; $T_C = 25\text{ }^\circ\text{C}$ )	$V_{O, \text{set}}$	2.46	2.5	2.54	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions until end of life. See Figure 9.)	$V_O$	2.425	—	2.575	Vdc
Output Regulation: Line ( $V_I = 36\text{ V}$ to $75\text{ V}$ )	—	—	0.01	0.1	% $V_O$
Load ( $I_O = I_{O, \text{min}}$ to $I_{O, \text{max}}$ )	—	—	0.05	0.2	% $V_O$
Temperature ( $T_C = -40\text{ }^\circ\text{C}$ to $+100\text{ }^\circ\text{C}$ )	—	—	15	50	mV
Output Ripple and Noise Voltage (See Figure 8.): RMS	—	—	—	40	mVrms
Peak-to-peak (5 Hz to 20 MHz)	—	—	—	150	mVp-p
External Load Capacitance	—	0	—	*	$\mu\text{F}$
Output Current	$I_O$	2	—	40	A
Output Overcurrent Protection	$I_O$	42	—	52 <sup>†</sup>	A
Output Short-circuit Current ( $V_O = 250\text{ mV}$ )	—	0	—	70	A
Efficiency ( $V_I = 48\text{ V}$ ; $I_O = I_{O, \text{max}}$ ; $T_C = 25\text{ }^\circ\text{C}$ ; see Figure 2 and Figure 9.)	$\eta$	—	85	—	%
Switching Frequency	—	—	330	—	kHz
Dynamic Response ( $\Delta I_O/\Delta t = 1\text{ A}/10\text{ }\mu\text{s}$ , $V_I = 48\text{ V}$ , $T_C = 25\text{ }^\circ\text{C}$ ; tested with a $10\text{ }\mu\text{F}$ tantalum and a $1\text{ }\mu\text{F}$ ceramic capacitor across the load.): Load Change from $I_O = 50\%$ to $75\%$ of $I_{O, \text{max}}$ : Peak Deviation	—	—	8	—	% $V_{O, \text{set}}$
Settling Time ( $V_O < 10\%$ of peak deviation)	—	—	0.2	—	ms
Load Change from $I_O = 50\%$ to $25\%$ of $I_{O, \text{max}}$ : Peak Deviation	—	—	9	—	% $V_{O, \text{set}}$
Settling Time ( $V_O < 10\%$ of peak deviation)	—	—	0.2	—	ms

\* Consult your sales representative or the factory.

† These are manufacturing test limits. In some situations, results may differ.

**Table 3. Isolation Specifications**

Parameter	Min	Typ	Max	Unit
Isolation Capacitance	—	2800	—	pF
Isolation Resistance	10	—	—	M $\Omega$

Parameter	Min	Typ	Max	Unit
Calculated MTBF ( $I_o = 80\%$ of $I_{o, \max}$ ; $T_C = 40\text{ }^{\circ}\text{C}$ )	2,500,000			hours
Weight	—	—	130 (4.6)	g (oz.)

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See the Feature Descriptions section for additional information.

<b>Parameter</b>	<b>Symbol</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
Remote On/Off Signal Interface ( $V_I = 0\text{ V}$ to $75\text{ V}$ ; open collector or equivalent compatible; signal referenced to $V_{I(-)}$ terminal): <b>JWxxxG1 Preferred Logic:</b> Logic Low—Module On Logic High—Module Off <b>JWxxxG Optional Logic:</b> Logic Low—Module Off Logic High—Module On <b>Logic Low:</b> At $I_{on/off} = 1.0\text{ mA}$ At $V_{on/off} = 0.0\text{ V}$ <b>Logic High:</b> At $I_{on/off} = 0.0\text{ }\mu\text{A}$ Leakage Current Turn-on Time (See Figure 6.) ( $I_O = 80\%$ of $I_{O,max}$ ; $V_O$ within $\pm 1\%$ of steady state)	               	               	               	               	               
Output Voltage Adjustment: Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	   	   	   	   	   
Output Overvoltage Protection	$V_{O,sd}$	3.0*	—	3.8*	V
Overtemperature Protection	Tc	—	105	—	°C

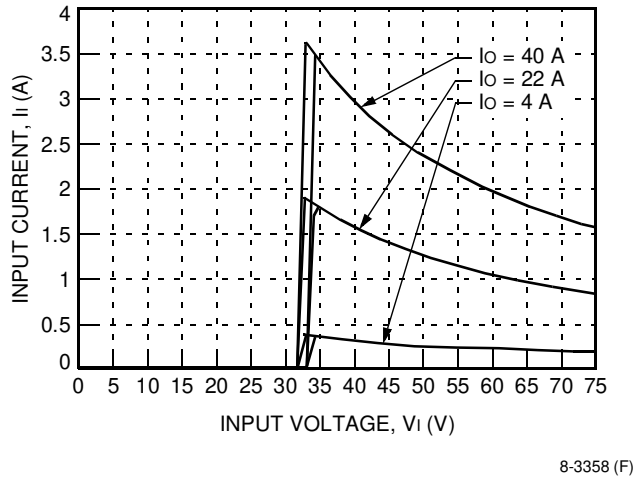
## Solder, Cleaning, and Drying Considerations

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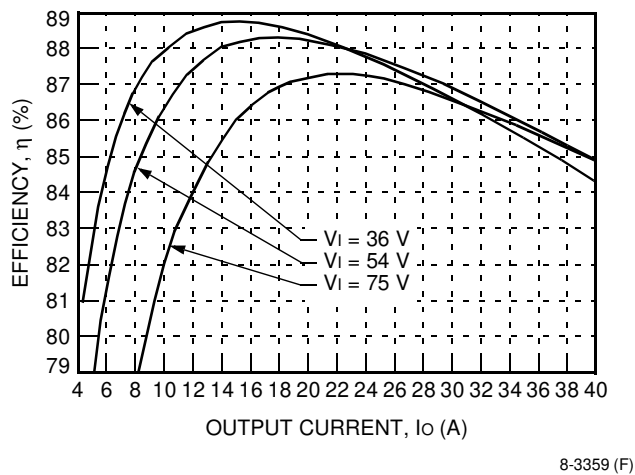


## Characteristic Curves

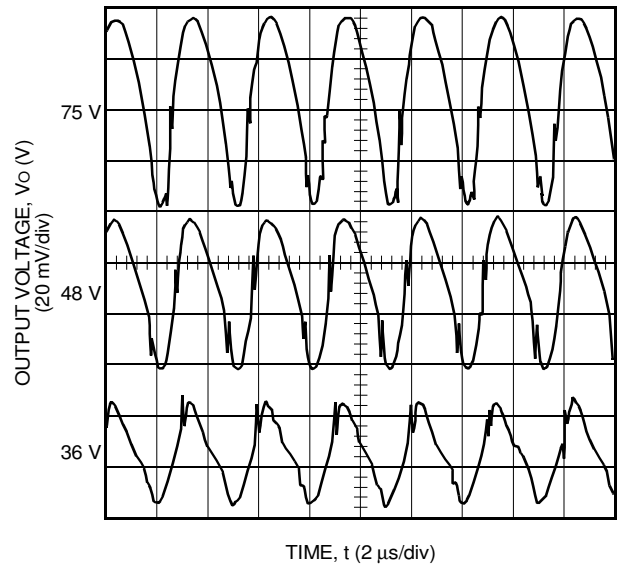
The following figures provide typical characteristics for the power modules. The figures are identical for both on/off configurations.



**Figure 1. Typical FC250A1 Input Characteristics at 25 °C**

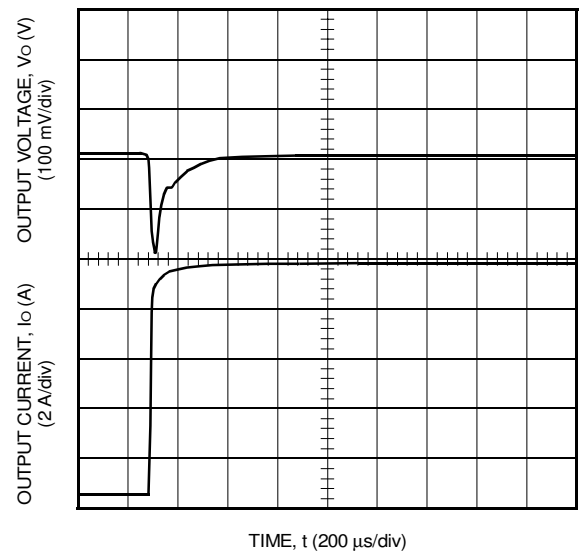


**Figure 2. Typical FC250A1 Efficiency vs. Output Current at 25 °C**



Note: See Figure 8 for test conditions.

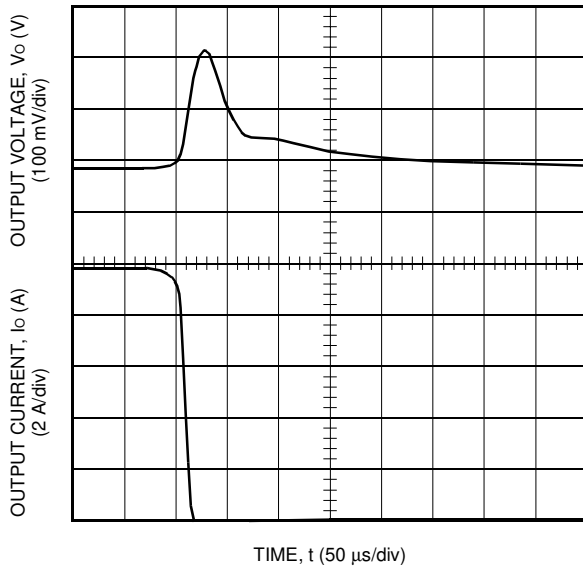
**Figure 3. Typical FC250A1 Output Ripple Voltage at Room Temperature,  $I_o = I_{o, max}$**



Note: Tested with a 10  $\mu$ F tantalum and a 1  $\mu$ F ceramic capacitor across the load.

**Figure 4. Typical FC250A1 Transient Response to Step Increase in Load from 50% to 75% of  $I_{o, max}$  at Room Temperature and 48 Vdc Input (Waveform Averaged to Eliminate Ripple Component.)**

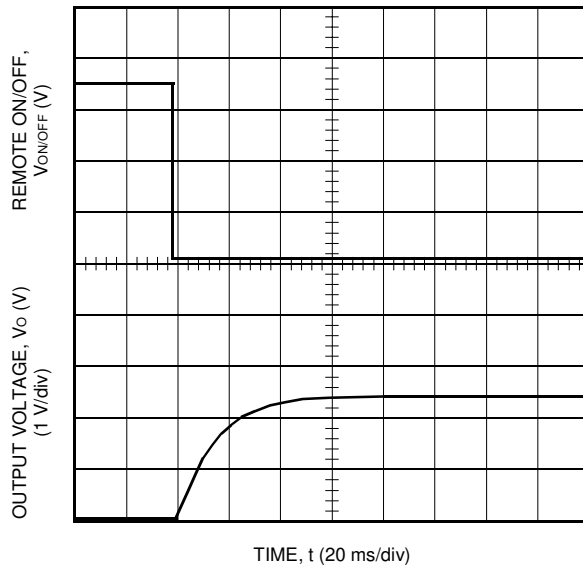
## Characteristic Curves (continued)



8-3362 (F)

Note: Tested with a 10  $\mu$ F tantalum and a 1  $\mu$ F ceramic capacitor across the load.

**Figure 5. Typical FC250A1 Transient Response to Step Decrease in Load from 50% to 25% of  $I_{o, max}$  at Room Temperature and 75 Vdc Input (Waveform Averaged to Eliminate Ripple Component.)**

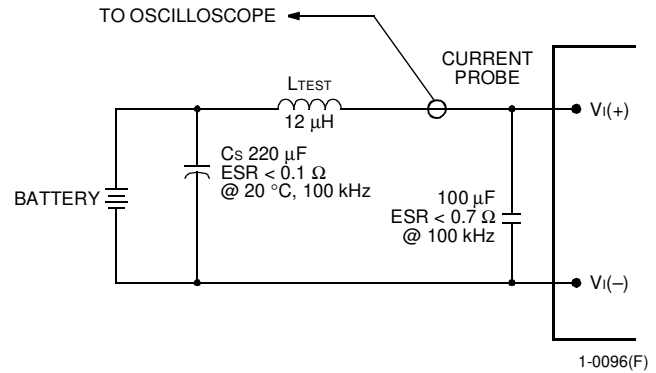


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Note: Tested with a 10  $\mu$ F tantalum and a 1  $\mu$ F ceramic capacitor across the load.

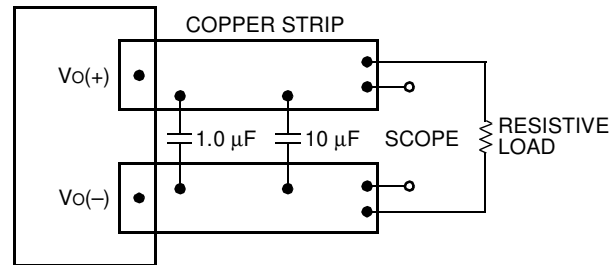
**Figure 6. Typical Start-Up from Remote On/Off;**  
 $I_o = I_{o, max}$

## Test Configurations



Note: Measure input reflected-ripple current with a simulated source inductance ( $L_{TEST}$ ) of 12  $\mu$ H. Capacitor  $C_s$  offsets possible battery impedance. Measure current as shown above.

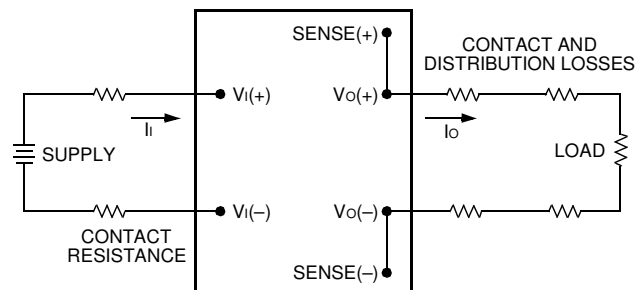
**Figure 7. Input Reflected-Ripple Test Setup**



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Note: Use a 1.0  $\mu$ F ceramic capacitor and a 10  $\mu$ F aluminum or tantalum capacitor. Scope measurement should be made using a BNC socket. Position the load between 51 mm and 76 mm (2 in. and 3 in.) from the module.

**Figure 8. Peak-to-Peak Output Noise Measurement Test Setup**



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Note: All measurements are taken at the module terminals. When socketing, place Kelvin connections at module terminals to avoid measurement errors due to socket contact resistance.

$$\eta = \left( \frac{[V_o(+)-V_o(-)]I_o}{[V_i(+)-V_i(-)]I_i} \right) \times 100 \quad \%$$

**Figure 9. Output Voltage and Efficiency Measurement Test Setup**

## Design Considerations

### Input Source Impedance

The power module should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the power module. For the test configuration in Figure 7, a 100  $\mu$ F electrolytic capacitor ( $ESR < 0.7 \Omega$  at 100 kHz) mounted close to the power module helps ensure stability of the unit. For other highly inductive source impedances, consult the factory for further application guidelines.

### Safety Considerations

For safety-agency approval of the system in which the power module is used, the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standard, i.e., *UL* 1950, *CSA* C22.2 No. 950-95, and *VDE* 0805 (EN60950, IEC950).

If the input source is non-SELV (ELV or a hazardous voltage greater than 60 Vdc and less than or equal to 75 Vdc), for the module's output to be considered meeting the requirements of safety extra-low voltage (SELV), all of the following must be true:

- The input source is to be provided with reinforced insulation from any other hazardous voltages, including the ac mains.
- One  $V_I$  pin and one  $V_O$  pin are to be grounded, or both the input and output pins are to be kept floating.
- The input pins of the module are not operator accessible.
- Another SELV reliability test is conducted on the whole system, as required by the safety agencies, on the combination of supply source and the subject module to verify that under a single fault, hazardous voltages do not appear at the module's output.

**Note:** Do not ground either of the input pins of the module without grounding one of the output pins. This may allow a non-SELV voltage to appear between the output pins and ground.

The power module has extra-low voltage (ELV) outputs when all inputs are ELV.

The input to these units is to be provided with a maximum 15 A normal-blow fuse in the ungrounded lead.

## Feature Descriptions

### Overcurrent Protection

To provide protection in a fault (output overload) condition, the unit is equipped with internal current-limiting circuitry and delayed overcurrent shutdown.

At the point of current-limit inception, the unit shifts from voltage control to current control. If the output voltage is pulled very low during a severe fault, the current-limit circuit can exhibit either foldback or tailout characteristics (output current decrease or increase). If the overcurrent persists for more than 50 ms, the unit will latch off.

### Remote On/Off

Two remote on/off options are available. Positive logic remote on/off turns the module on during a logic-high voltage on the ON/OFF pin, and off during a logic low. Negative logic remote on/off turns the module off during a logic high and on during a logic low. Negative logic, device code suffix "1," is the factory-preferred configuration.

To turn the power module on and off, the user must supply a switch to control the voltage between the on/off terminal and the  $V_I(-)$  terminal ( $V_{on/off}$ ). The switch can be an open collector or equivalent (see Figure 10). A logic low is  $V_{on/off} = 0$  V to 1.2 V. The maximum  $I_{on/off}$  during a logic low is 1 mA. The switch should maintain a logic-low voltage while sinking 1 mA.

During a logic high, the maximum  $V_{on/off}$  generated by the power module is 15 V. The maximum allowable leakage current of the switch at  $V_{on/off} = 15$  V is 50  $\mu$ A.

If not using the remote on/off feature, do one of the following to turn the unit on:

- For negative logic, short the ON/OFF pin to  $V_I(-)$ .
- For positive logic, leave the ON/OFF pin open.



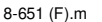
## Remote On/Off (continued)

### Figure 10. Remote On/Off Implementation

## Output Voltage Set-Point Adjustment (Trim) (continued)



The amount of power delivered by the module is defined as the voltage at the output terminals multiplied by the output current. When using remote-sense and trim, the output voltage of the module can be increased, which at the same output current would increase the power output of the module. Care should be taken to ensure that the maximum output power of the module remains at or below the maximum rated power.



## Remote Sense

## Output Overvoltage Protection

The output overvoltage protection consists of circuitry that monitors the voltage on the output terminals. If the voltage on the output terminals exceeds the overvoltage protection threshold, then the module will shut down and attempt to restart.

## Overtemperature Protection

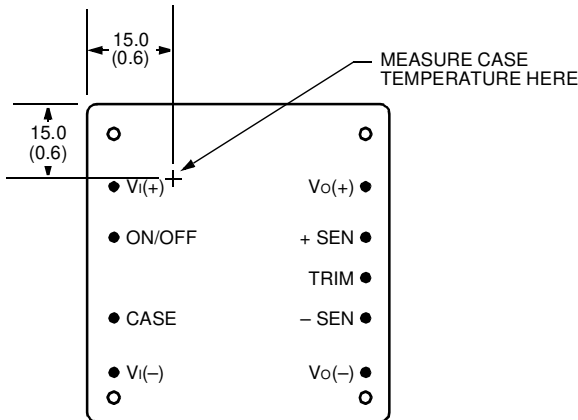
To provide protection in a fault condition, the unit is equipped with an overtemperature protection circuit. This circuit will not engage unless the case temperature exceeds the maximum limit. When activated, the overtemperature protection circuit temporarily shuts down the unit. Recovery from the overtemperature protection is automatic after the unit cools below the overtemperature protection threshold.

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## Thermal Considerations

### Introduction

The power modules operate in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat-dissipating components inside the unit are thermally coupled to the case. Heat is removed by conduction, convection, and radiation to the surrounding environment. Proper cooling can be verified by measuring the case temperature. Peak temperature ( $T_c$ ) occurs at the position indicated in Figure 14.



8-716 (F).k

Note: Top view, pin locations are for reference only. Measurements shown in millimeters and (inches).

**Figure 14. Case Temperature Measurement Location**

The temperature at this location should not exceed 100 °C. The output power of the module should not exceed the rated power for the module as listed in the Ordering Information table.

Although the maximum case temperature of the power modules is 100 °C, you can limit this temperature to a lower value for extremely high reliability.

### Heat Transfer Without Heat Sinks

Increasing airflow over the module enhances the heat transfer via convection. Figure 15 shows the maximum power that can be dissipated by the module without exceeding the maximum case temperature versus local ambient temperature ( $T_a$ ) for natural convection through 4 m/s (800 ft./min.).

Note that the natural convection condition was measured at 0.05 m/s to 0.1 m/s (10 ft./min. to 20 ft./min.); however, systems in which these power modules may be used typically generate natural convection airflow rates of 0.3 m/s (60 ft./min.) due to other heat-dissipating components in the system. The use of Figure 15 is shown in the following example.

### Example

What is the minimum airflow necessary for a FC250A1 operating at  $V_i = 54$  V, an output current of 26 A, and a maximum ambient temperature of 60 °C?

### Solution

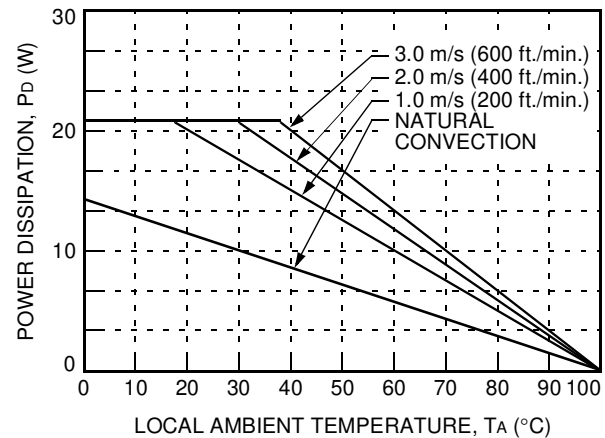
Given:  $V_i = 54$  V  
 $I_o = 26$  A  
 $T_a = 60$  °C

Determine  $P_D$  (Use Figure 16.):

$$P_D = 10 \text{ W}$$

Determine airflow ( $v$ ) (Use Figure 15.):

$$v = 1 \text{ m/s (200 ft./min.)}$$

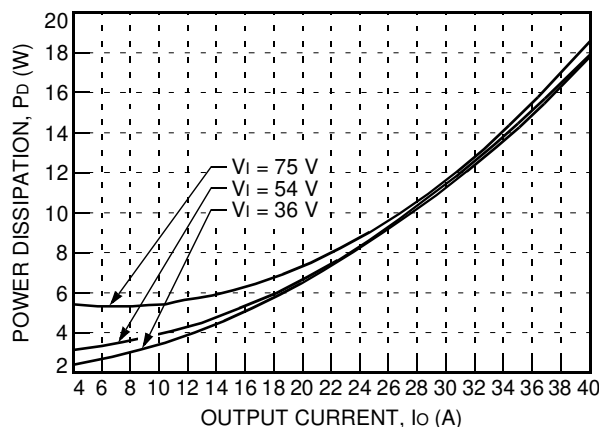


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**Figure 15. FC250A1 Forced Convection Power Derating with No Heat Sink; Either Orientation**

## Thermal Considerations (continued)

### Heat Transfer Without Heat Sinks (continued)



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Figure 16. FC250A1 Power Dissipation vs. Output Current at 25 °C

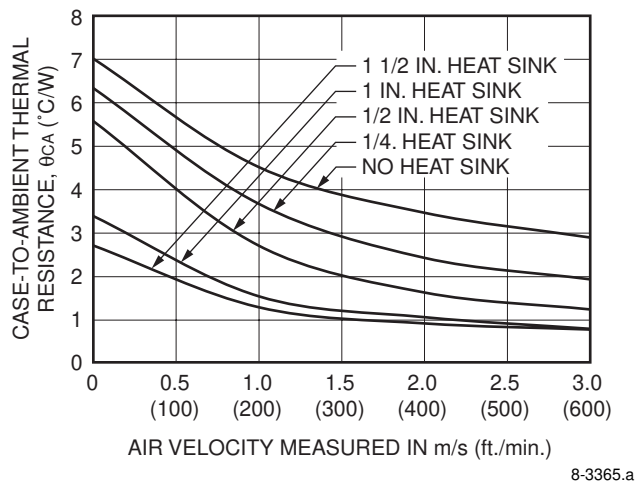
### Heat Transfer with Heat Sinks

The power modules have through-threaded, M3 x 0.5 mounting holes, which enable heat sinks or cold plates to attach to the module. The mounting torque must not exceed 0.56 N-m (5 in.-lb.).

Thermal derating with heat sinks is expressed by using the overall thermal resistance of the module. Total module thermal resistance ( $\theta_{ca}$ ) is defined as the maximum case temperature rise ( $\Delta T_{C, max}$ ) divided by the module power dissipation ( $P_D$ ):

$$\theta_{ca} = \left[ \frac{\Delta T_{C, max}}{P_D} \right] = \left[ \frac{(T_C - T_A)}{P_D} \right]$$

The location to measure case temperature ( $T_C$ ) is shown in Figure 14. Case-to-ambient thermal resistance vs. airflow is shown, for various heat sink configurations and heights, in Figure 17. These curves were obtained by experimental testing of heat sinks, which are offered in the product catalog.



8-3365.a

Figure 17. FC250A1 Case-to-Ambient Thermal Resistance Curves; Either Orientation

These measured resistances are from heat transfer from the sides and bottom of the module as well as the top side with the attached heat sink; therefore, the case-to-ambient thermal resistances shown are generally lower than the resistance of the heat sink by itself. The module used to collect the data in Figure 17 had a thermal-conductive dry pad between the case and the heat sink to minimize contact resistance. The use of Figure 17 is shown in the following example.

### Example

If an 85 °C case temperature is desired, what is the minimum airflow necessary? Assume the FC250A1 module is operating at  $V_i = 54$  V and an output current of 26 A, maximum ambient air temperature of 55 °C, and the heat sink is 1/4 inch.

### Solution

Given:  $V_i = 54$  V  
 $I_o = 26$  A  
 $T_A = 55$  °C  
 $T_C = 85$  °C  
Heat sink = 1/4 inch

Determine  $P_D$  by using Figure 16:

$$P_D = 10 \text{ W}$$

## Thermal Considerations (continued)

### Heat Transfer with Heat Sinks (continued)

Then solve the following equation:

$$\theta_{ca} = \left[ \frac{(T_C - T_A)}{P_D} \right]$$

$$\theta_{ca} = \left[ \frac{(85 - 55)}{10} \right]$$

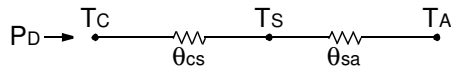
$$\theta_{ca} = 3 \text{ }^{\circ}\text{C/W}$$

Use Figure 17 to determine air velocity for the 1/4 inch heat sink.

The minimum airflow necessary for the FC250A1 module is 1.5 m/s (300 ft./min.).

### Custom Heat Sinks

A more detailed model can be used to determine the required thermal resistance of a heat sink to provide necessary cooling. The total module resistance can be separated into a resistance from case-to-sink ( $\theta_{cs}$ ) and sink-to-ambient ( $\theta_{sa}$ ) as shown in Figure 18.



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**Figure 18. Resistance from Case-to-Sink and Sink-to-Ambient**

For a managed interface using thermal grease or foils, a value of  $\theta_{cs} = 0.1 \text{ }^{\circ}\text{C/W}$  to  $0.3 \text{ }^{\circ}\text{C/W}$  is typical. The solution for heat sink resistance is:

$$\theta_{sa} = \left[ \frac{(T_C - T_A)}{P_D} \right] - \theta_{cs}$$

This equation assumes that all dissipated power must be shed by the heat sink. Depending on the user-defined application environment, a more accurate model, including heat transfer from the sides and bottom of the module, can be used. This equation provides a conservative estimate for such instances.

## EMC Considerations

For assistance with designing for EMC compliance, refer to the *FLTR100V10 Filter Module Data Sheet* (DS99-294EPS).

## Layout Considerations

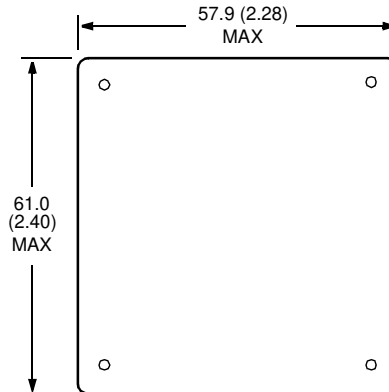
Copper paths must not be routed beneath the power module mounting inserts. This module is designed for solder interconnection between its terminal pins and the customer's board. For additional layout guidelines, refer to the *FLTR100V10 Filter Module Data Sheet* (DS99-294EPS).

## Outline Diagram

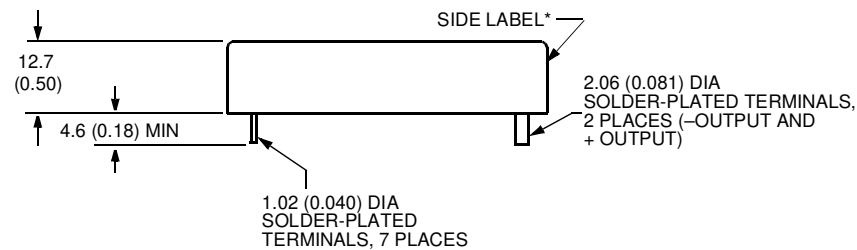
Dimensions are in millimeters and (inches).

Tolerances: x.x mm  $\pm$  0.5 mm (x.xx in.  $\pm$  0.02 in.)  
x.xx mm  $\pm$  0.25 mm (x.xxx in.  $\pm$  0.010 in.)

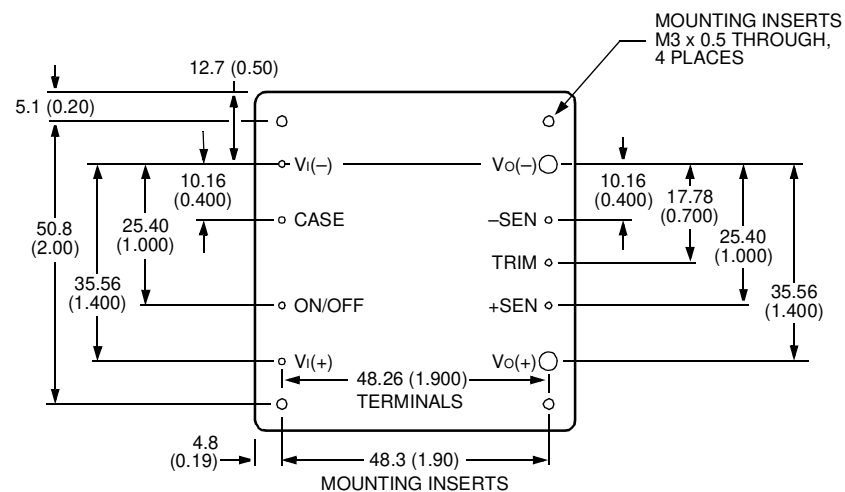
### Top View



### Side View



### Bottom View



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\* Side label includes Tyco name, product designation, safety agency markings, input/output voltage and current ratings, and bar code.



Dimensions are in millimeters and (inches).



#### Table 4. Device Codes

Input Voltage	Output Voltage	Output Power	Output Current	Remote On/Off Logic	Device Code	Comcode
48 Vdc	2.5 Vdc	100 W	40 A	Negative	FC250A11	108841099
48 Vdc	2.5 Vdc	100 W	40 A	Positive	FC250A1	TBD

## Ordering Information (continued)

Table 5. Device Accessories

Accessory	Comcode
1/4 in. transverse kit (heat sink, thermal pad, and screws)	407243989
1/4 in. longitudinal kit (heat sink, thermal pad, and screws)	407243997
1/2 in. transverse kit (heat sink, thermal pad, and screws)	407244706
1/2 in. longitudinal kit (heat sink, thermal pad, and screws)	407244714
1 in. transverse kit (heat sink, thermal pad, and screws)	407244722
1 in. longitudinal kit (heat sink, thermal pad, and screws)	407244730
1 1/2 in. transverse kit (heat sink, thermal pad, and screws)	407244748
1 1/2 in. longitudinal kit (heat sink, thermal pad, and screws)	407244755

Dimensions are in millimeters and (inches).

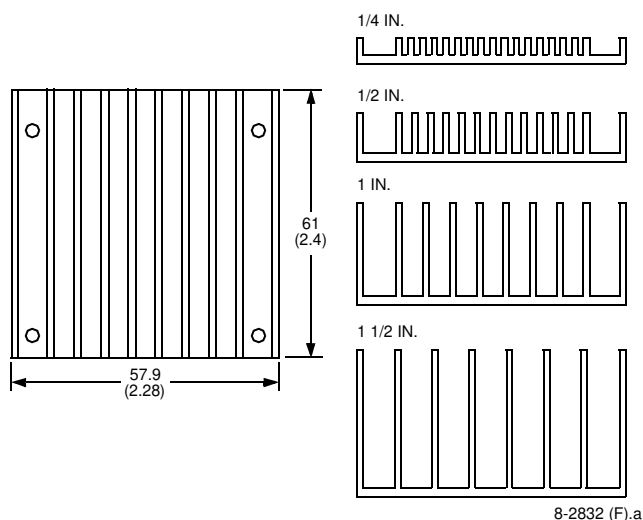


Figure 19. Longitudinal Heat Sink

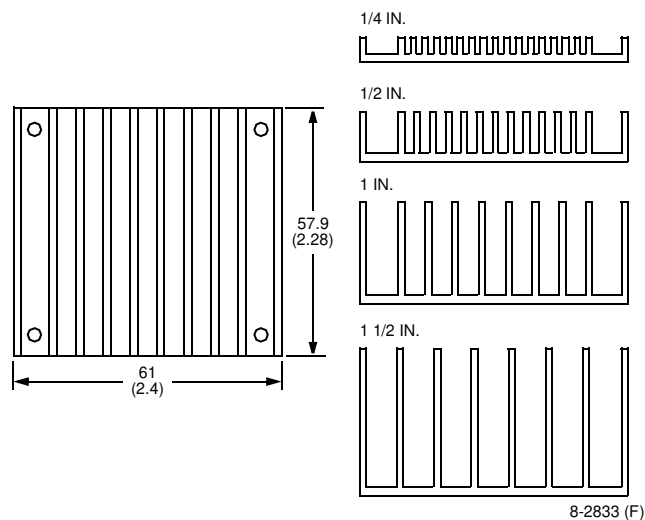


Figure 20. Transverse Heat Sink



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