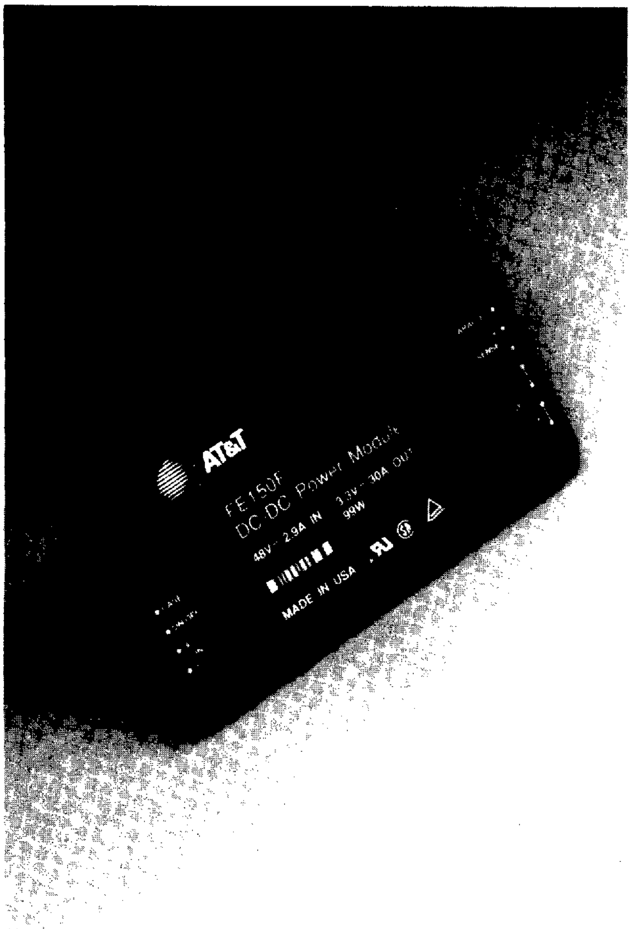
Data Sheet
June 1993

AT&T Microelectronics

FE050F, FE100F, FE150F Power Modules: dc-dc Converters; 48 Vdc Input, 3.3 Vdc Output, 33 W to 99 W



The FE050F, FE100F, and FE150F Power Modules use advanced, surface-mount technology and deliver high-quality, compact, dc-dc conversion at an economical price.

Features

- High efficiency: 75% typical
- Parallel operations with load sharing
- Low profile: 0.5 in.
- Complete input and output filtering
- Input-to-output isolation
- Remote sense
- Remote on/off
- Short-circuit protection
- Output overvoltage clamp: Vo < 5.0 V
- Within FCC requirements for telecom
- UL, CSA, and TUV recognized
- Output voltage adjustment

Options

- Trim pin

Applications

- Distributed power architectures
- Telecommunications

Description

The FE050F, FE100F, and FE150F Power Modules are members of a new line of high-efficiency, dc-dc converters. Operating from standard 38 Vdc to 60 Vdc inputs, these modules provide precisely regulated and fully isolated 3.3 Vdc outputs.

Built-in filtering, for both the input and output of each device, eliminates the need for external filters. Two or more modules may be paralleled with forced load sharing for redundant or enhanced power applications. The package, which mounts on a printed-circuit board, accommodates a heat sink for high-temperature 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	V_I	—	60	V
I/O Isolation Voltage	—	—	500	V
Operating Case Temperature (See Thermal Considerations section.)	T_C	0	90	°C
Storage Temperature	T_{stg}	–40	125	°C

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	38	48	60	Vdc
Maximum Input Current (V_I = 0 V to 60 V)					
FE050F	$I_{I, max}$	—	—	1.4	A
FE100F	$I_{I, max}$	—	—	2.8	A
FE150F	$I_{I, max}$	—	—	4.2	A
Inrush Transient	i^2t	—	—	1.0	A^2s
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 µH source impedance) (See Figure 9.)	—	—	20	—	mA p-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 *Underwriters Laboratories Conditions of Acceptability* requires a normal-blow, dc fuse. A dc fuse with a maximum rating of 6 A is recommended. 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 (Over all operating input voltage, resistive load, and temperature conditions until end of life; see Figure 10 and Feature Descriptions.)	V_O	3.140	—	3.460	Vdc
Output Voltage Set Point (V_I = 48 V; $I_O = I_{O,\,max}$; T_C = 25 °C):					
Unit Operating in Parallel or Parallel Pin Shorted to SENSE(–) (See Figure 10 and Feature Descriptions.)	$V_{O,\,set}$	3.230	3.300	3.370	Vdc
Parallel Pin Open	$V_{O,\,set}$	3.230	3.300	3.432	Vdc
Output Regulation:					
Line (V_I = 38 V to 60 V)	—	—	0.05	0.2	%
Load ($I_O = I_{O,\,min}$ to $I_{O,\,max}$)	—	—	0.1	0.4	%
Temperature (T_C = 0 °C to 90 °C)	—	—	10	50	mV
Output Ripple and Noise Voltage: (See Figure 5.)					
RMS	—	—	—	35	mV rms
Peak-to-peak (5 Hz to 20 MHz)	—	—	—	100	mV p-p
Output Current:					
FE050F	I_O	1.0	—	10	A
FE100F	I_O	1.0	—	20	A
FE150F	I_O	1.0	—	30	A
Output Current-limit Inception (V_O = 2.97 V) (See Figure 2 and Feature Descriptions.)	—	103	—	130	% $I_{O,\,max}$
Output Short-circuit Current (V_O = 250 mV; see Figure 2.)	—	—	135	170	% $I_{O,\,max}$
External Load Capacitance	—	—	—	4000	µF
Efficiency (V_I = 48 V; $I_O = I_{O,\,max}$; T_C = 25 °C) (See Figure 10.)	η	72	75	—	%
Dynamic Response: (See Figures 6 and 7.) ($\Delta I_O/\Delta t$ = 1 A/10 µs, V_I = 48 V, T_C = 25 °C)					
Load Change from I_O = 50% to 75% of $I_{O,\,max}$:					
Peak Deviation	—	—	150	—	mV
Settling Time (V_O < 10% of peak deviation)	—	—	300	—	µs
Load Change from I_O = 50% to 25% of $I_{O,\,max}$:					
Peak Deviation	—	—	150	—	mV
Settling Time (V_O < 10% of peak deviation)	—	—	300	—	µs

Electrical Specifications (continued)

Table 3. Isolation Specifications

Parameter	Min	Typ	Max	Unit
Isolation Capacitance	—	1700	—	pF
Isolation Resistance	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (I_O = 80% of $I_{O,\,max}$; T_C = 40 °C)		920,000		hours
Weight	—	—	7 (200)	oz. (g)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions and Design Considerations for further information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off (V_I = 38 V to 60 V; open collector or equivalent compatible; signal referenced to $V_I(-)$ terminal; see Figure 16 and Feature Descriptions.):					
Logic Low — Module On					
Logic High — Module Off					
Module Specifications:					
On/Off Current — Logic Low	$I_{on/off}$	—	—	1.0	mA
On/Off Voltage:					
Logic Low	$V_{on/off}$	0	—	1.2	V
Logic High ($I_{on/off}$ = 0)	$V_{on/off}$	—	—	18	V
Open Collector Switch Specifications:					
Leakage Current During Logic High ($V_{on/off}$ = 18 V)	$I_{on/off}$	—	—	50	µA
Output Low Voltage During Logic Low ($I_{on/off}$ = 1 mA)	$V_{on/off}$	—	—	1.2	V
Turn-on Time (I_O = 80% of $I_{O,\,max}$; V_O within ±1% of steady state)	—	—	5	10	ms
Output Voltage Adjustment (See Feature Descriptions.):					
Output Voltage Sense Range	—	—	—	0.6	V
Output Voltage Set Point Adjustment Range	—	—	—	10	$\%V_{O,\,nom}$
Output Voltage Trim Range	V_O	3.0	—	4.0	V
Parallel Operation Load Sharing (See Feature Descriptions.)	—	—	—	20	$\%\,I_{O,\,max}$
Output Overvoltage Clamp	$V_{O,\,clamp}$	4.0	4.5	5.0	V

Characteristic Curves

The following figures provide typical characteristics for the FE150F Power Module. The FE050F and FE100F characteristics are similar to the FE150F characteristics provided here, scaled by power level where appropriate.

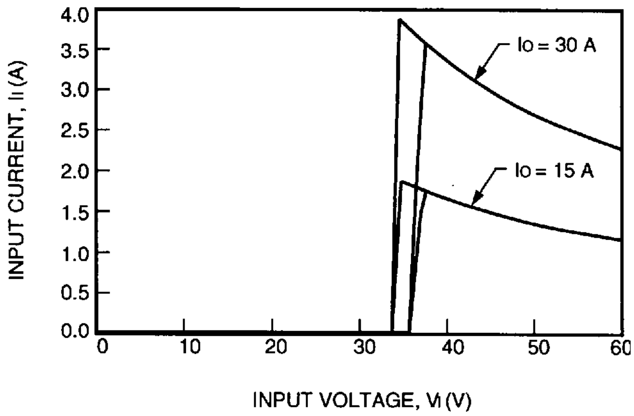


Figure 1. Typical FE150F Input Characteristics at Room Temperature

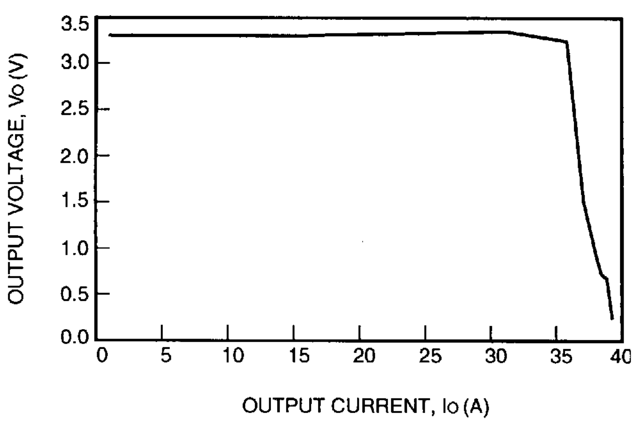


Figure 2. Typical FE150F Output Characteristics at Room Temperature and 48 V Input

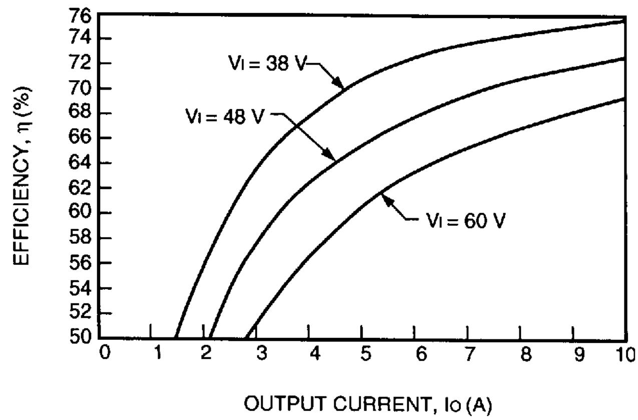


Figure 3. Typical FE050F Efficiency vs. Output Current at Room Temperature

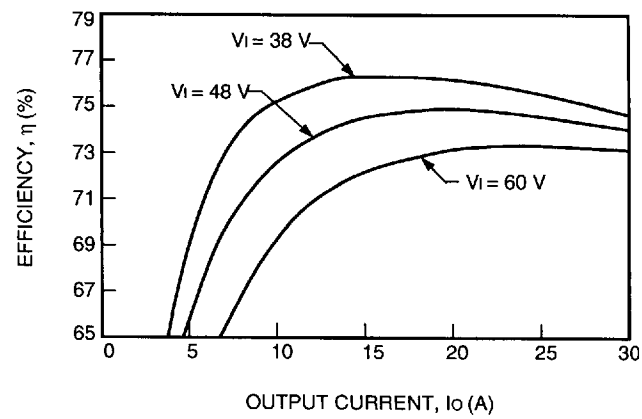


Figure 4. Typical FE150F Efficiency vs. Output Current at Room Temperature

Characteristic Curves (continued)

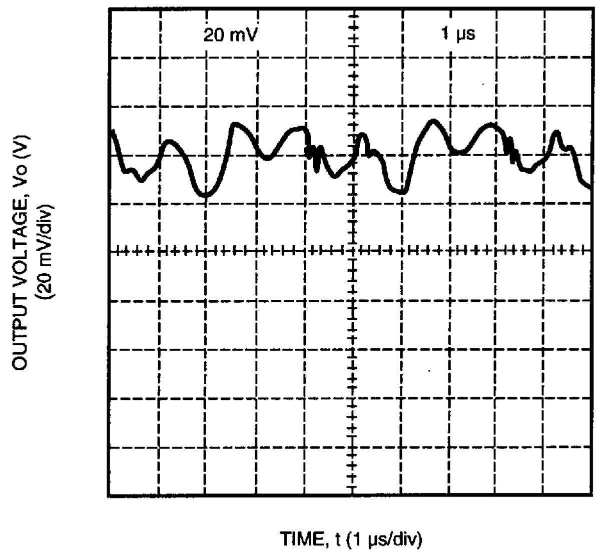


Figure 5. Typical FE150F Output Ripple Voltage at Room Temperature, 48 V Input, and 30 A Output

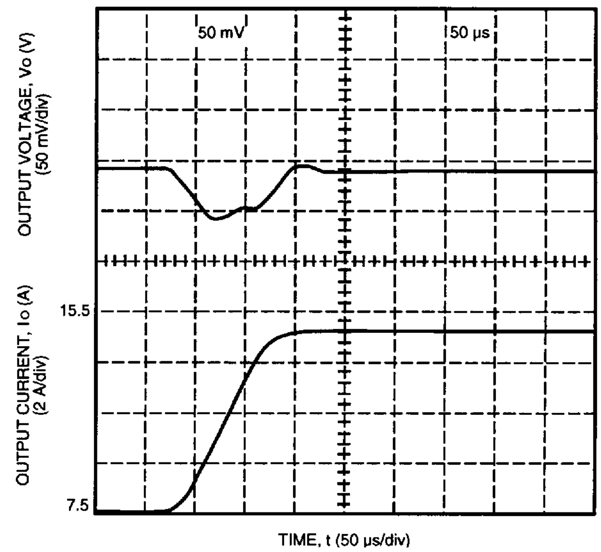


Figure 7. Typical FE150F Transient Response to Step Increase in Load from 50% to 75% of Full Load at Room Temperature and 48 V Input (Waveform averaged to eliminate ripple component.)

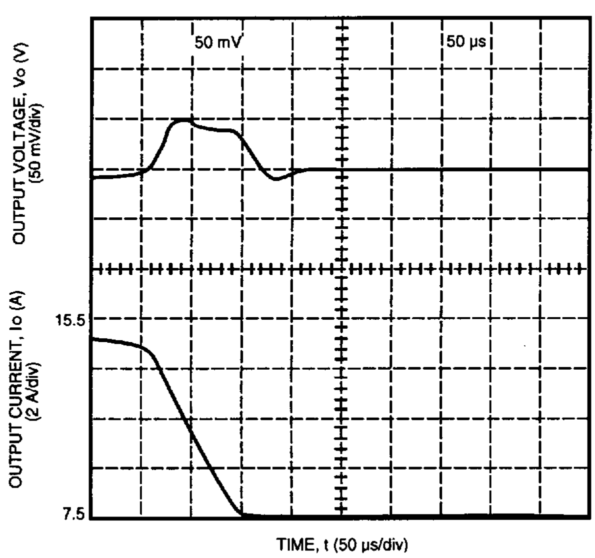


Figure 6. Typical FE150F Transient Response to Step Decrease in Load from 50% to 25% of Full Load at Room Temperature and 48 V Input (Waveform averaged to eliminate ripple component.)

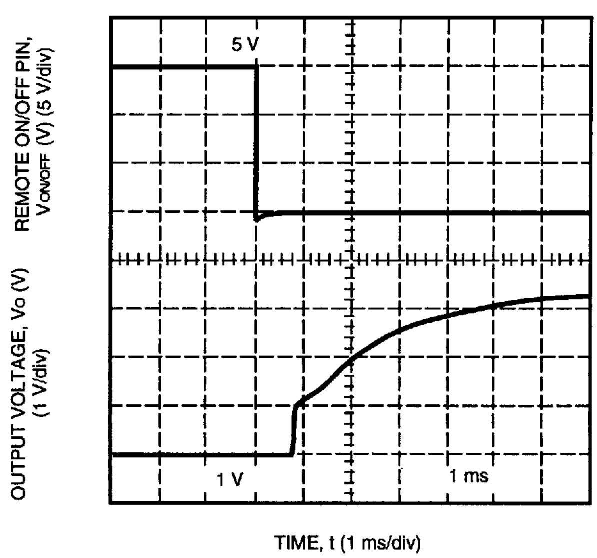
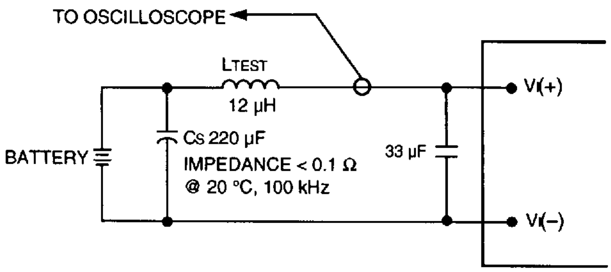


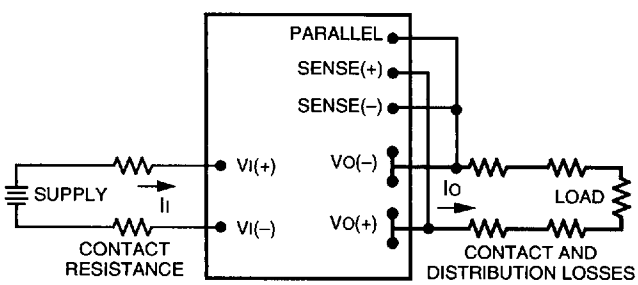
Figure 8. Typical FE150F Start-up Transient at Room Temperature, 48 V Input, and 30 A Output

Test Configurations



Note: Measure input reflected-ripple current with a simulated source impedance (LTEST) of 12 µH. Capacitor Cs offsets possible battery impedance. Measure current as shown above.

Figure 9. Input Reflected-Ripple Test Setup



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.

$$\eta = \left(\frac{[V_O(+) - (V_O(-))]I_O}{[V_I(+) - (V_I(-))]I_I}\right) \times 100$$

Figure 10. 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 9, a 33 µF electrolytic capacitor (ESR < 0.7 Ω 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 22.2-950, EN 60 950.

The power module outputs are safety extra low voltage (SELV) when all inputs are SELV and floating. If the input is SELV and grounded, the output must also be grounded to be SELV.

Feature Descriptions

Remote Sense

Remote sense minimizes the effects of distribution losses by regulating the voltage at the remote-sense connections. For single-unit operation, the parallel pin should be connected to SENSE(–). The voltage between the remote-sense pins and the output terminals must not exceed the output voltage sense range given in the Feature Specifications table, i.e.:

$$[V_O(+) - V_O(-)] - [SENSE(+) - SENSE(-)] \leq 0.6V$$

The voltage between the VO(+) and VO(–) terminals must not exceed 4.0 V. This limit includes any increase in voltage due to remote sense compensation, set point adjustment, and trim. See Figure 11.

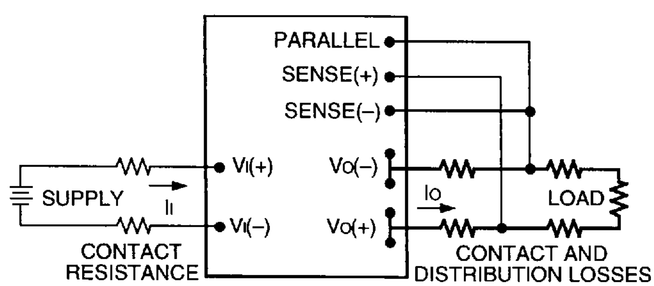


Figure 11. Effective Circuit Configuration for Single-Module Remote Sense Operation

Output Voltage Adjustment

Adjustment with Trim Pin

Output voltage adjustment allows the output voltage set point to be increased or decreased 10% of $V_{O, nom}$ by adjusting an external resistor connected between the TRIM pin and either the SENSE(+) or SENSE (–) pins (see Figures 12 and 13).

Feature Descriptions (continued)

Connecting the external resistor ($R_{trim\text{-}up}$) between the TRIM and SENSE(–) pins ($V_{O,\,adj}$) increases the output-voltage set point as defined in the following equation:

$$R_{trim\text{-}up} = \left(\frac{1.25 \times 3.320}{V_{O,\,adj} - 3.3}\right) k\Omega$$

Connecting the external resistor ($R_{trim\text{-}down}$) between the TRIM and SENSE(+) pins ($V_{O,\,adj}$) decreases the output voltage set point as defined in the following equation:

$$R_{trim\text{-}down} = \left[\frac{(V_{O,\,adj} - 1.25) \times 3.320}{3.3 - V_{O,\,adj}}\right] k\Omega$$

The combination of the output voltage adjustment range and the output voltage sense range given in the Feature Specifications table cannot exceed 4.0 V between the Vo(+) and Vo(–) terminals.

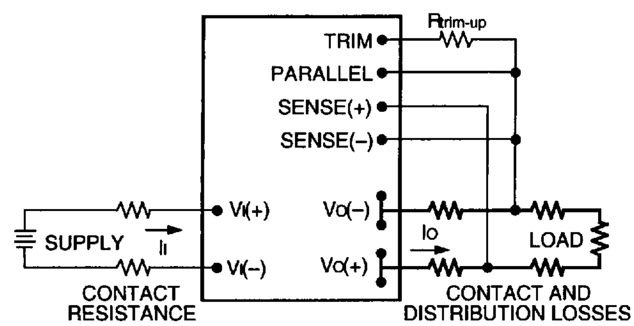


Figure 12. Circuit Configuration to Trim Up Output Voltage

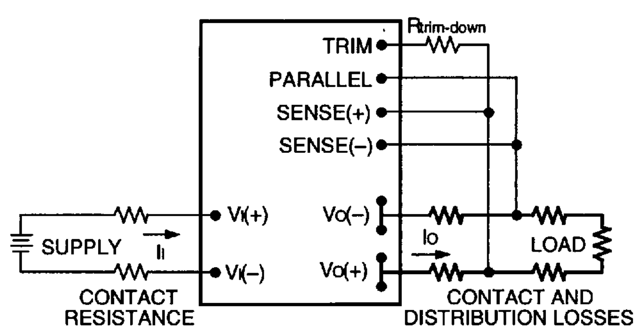


Figure 13. Circuit Configuration to Trim Down Output Voltage

Adjustment Without Trim Pin

The output voltage can be adjusted by placing an external resistor (R_{adj}) between the SENSE(+) and Vo(+) terminals (see Figure 14). By adjusting R_{adj}, the output voltage can be increased by 10% of the nominal output voltage. The following equation shows the resistance required to obtain the desired output voltage.

$$R_{adj} = (V_{O,\,adj} - V_{O,\,nom})\ 1.0\ k\Omega$$

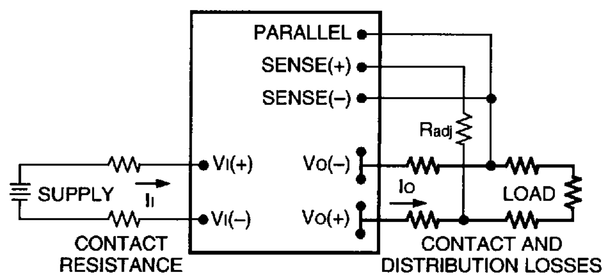


Figure 14. Circuit Configuration to Adjust Output Voltage

Parallel Operation

For either redundant operation or additional power requirements, the power modules can be configured for parallel operation with forced load sharing (see Figure 15). For a typical redundant configuration, Schottky diodes or an equivalent should be used to protect against short-circuit conditions. Because of the remote sense, the forward-voltage drops across the Schottky diodes do not affect the set point of the voltage applied to the load. For additional power requirements, where multiple units are used to develop combined power in excess of the rated maximum, the Schottky diodes are not needed.

To implement forced load sharing, the following connections must be made, and good layout techniques should be observed for noise immunity:

- The parallel pins of all units must be connected together. The paths of these connections should be as direct as possible.
- All remote-sense pins should be connected to the power bus at the same point, i.e., connect all remote-sense (+) pins to the (+) side of the power bus at the same point and all remote-sense (–) pins to the (–) side of the power bus at the same point. Close proximity and directness are necessary for good noise immunity.

Feature Descriptions (continued)

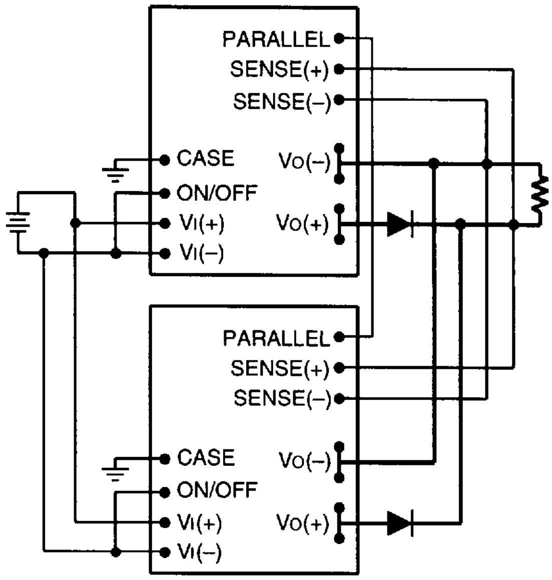


Figure 15. Wiring Configuration for Redundant Parallel Operation

Remote On/Off

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 16). A logic low is $V_{on/off}$ = 0 V to 1.2 V, during which the module is on. The maximum $I_{on/off}$ during a logic low is1 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 18 V. The maximum allowable leakage current of the switch at $V_{on/off}$ = 18 V is 50 µA.

Note: A PWB trace between the on/off terminal and the $V_I(-)$ terminal can be used to override the remote on/off.

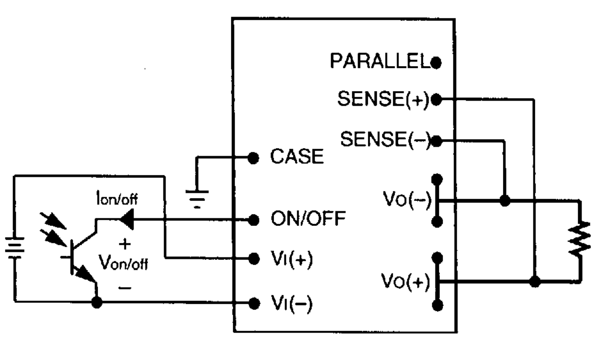


Figure 16. Remote On/Off Implementation

Current Limit

To provide protection in a fault (output overload) condition, the unit is equipped with internal current-limiting circuitry and can endure current limiting for an unlimited duration. 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). The unit operates normally once the output current is brought back into its specified range.

Output Overvoltage Clamp

The output overvoltage clamp consists of control circuitry, which is independent of the primary regulation loop, that monitors the voltage on the output terminals. The control loop of the clamp has a higher voltage set point than the primary loop (see Feature Specifications table). This provides a redundant voltage-control that reduces the risk of output overvoltage.

Thermal Considerations

Introduction

The FE150F Power Module operates 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 occurs at the position indicated in Figure 17. The temperature at this location should not exceed 95 °C. The average case temperature under these conditions is approximately 90 °C. The output power of the module should not exceed the rated power for the module as listed in the Ordering Information table.

Thermal Considerations

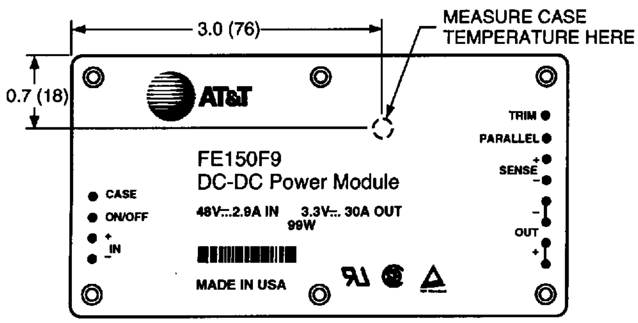


Figure 17. Case Temperature Measurement Location

Heat Sink Selection

To choose a heat sink, determine the power dissipated as heat by the unit for the particular application. Figure 18 shows typical heat dissipation for the FE150F over a range of output currents. With the known heat dissipation and a given local ambient temperature, the appropriate heat sink size can be chosen from the derating curves in Figure 19. For example, with 25 W of heat dissipation and a 30 °C ambient temperature, the heat sink should have a thermal resistance of about 3.5 °C/W. Thermal resistances shown are for vertically oriented heat sinks having a centrally located heat source with a temperature rise of 75 °C.

Placing a thermally conductive dry pad between the case and the heat sink minimizes contact resistance between the two. The six #4-40 fasteners used to mount the heat sink should be torqued to 5 in.-lb.

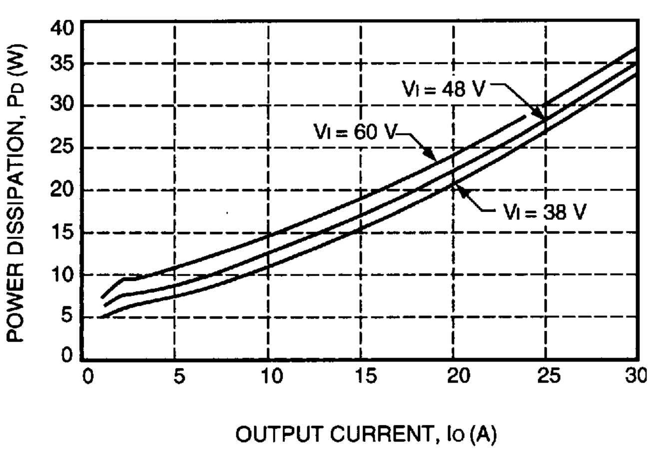


Figure 18. Power Dissipation as Heat vs. Output Current

Forced Convection Cooling

Derating curves for forced air cooling without a heat sink are shown in Figure 20. These curves can be used to determine the appropriate air flow for a given set of operating conditions. For example, if the unit dissipates 20 W of heat, the correct air flow in a 42 °C environment is 200 ft./min.

Forced convection lowers the thermal resistance of a heat sink. If the value is known for a given heat sink and air flow, the derating curves of Figure 19 can be used to estimate the thermal performance of the unit.

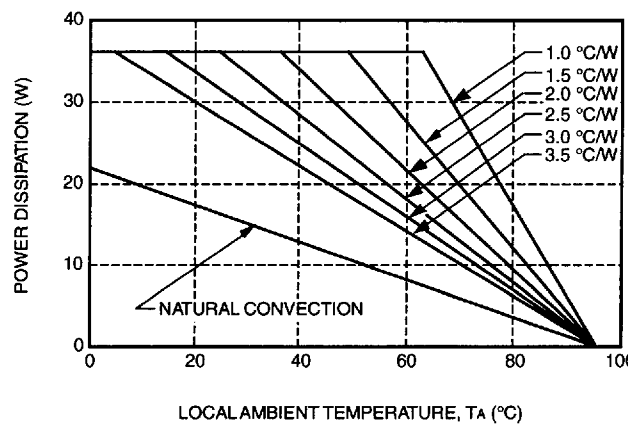


Figure 19. Power Derating vs. Local Ambient Temperature and Heat Sink Resistance

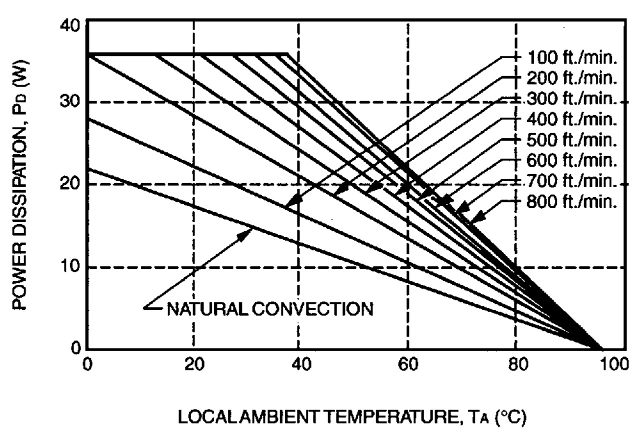


Figure 20. Power Derating vs. Local Ambient Temperature and Air Velocity

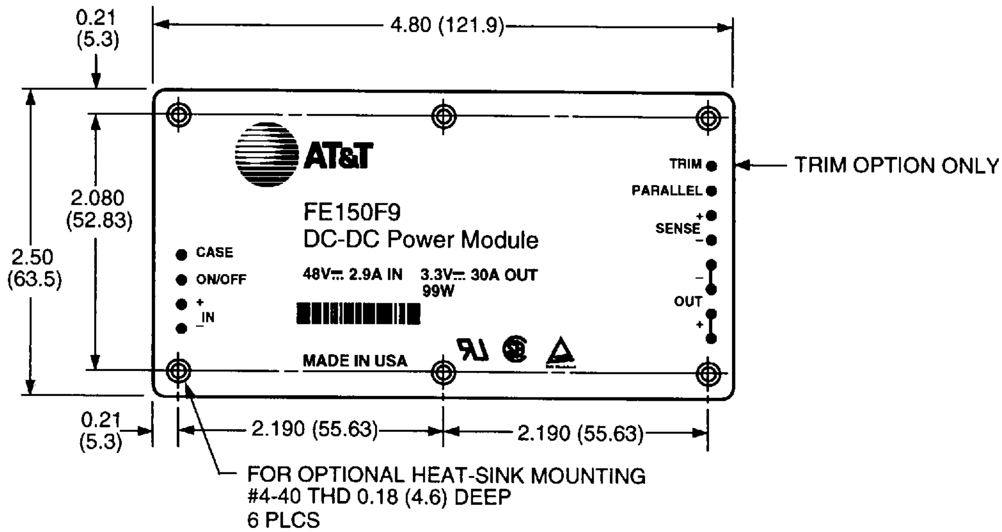
Outline Diagram

Dimensions are in inches and (millimeters).

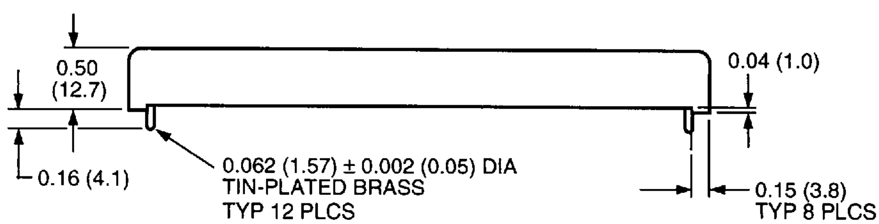
Copper paths must not be routed beneath the power module standoffs.

Tolerances: x.xx in. ± 0.02 in. (0.5 mm), x.xxx in. ± 0.010 in. (0.25 mm)

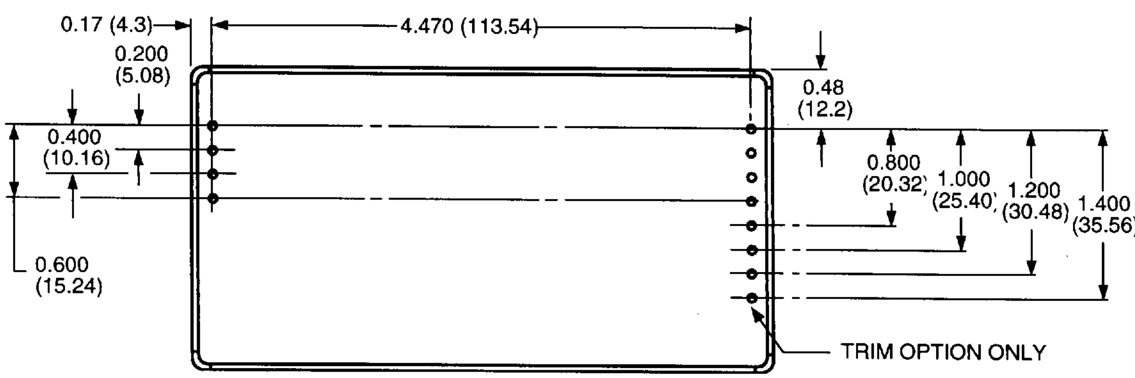
Top View



Side View



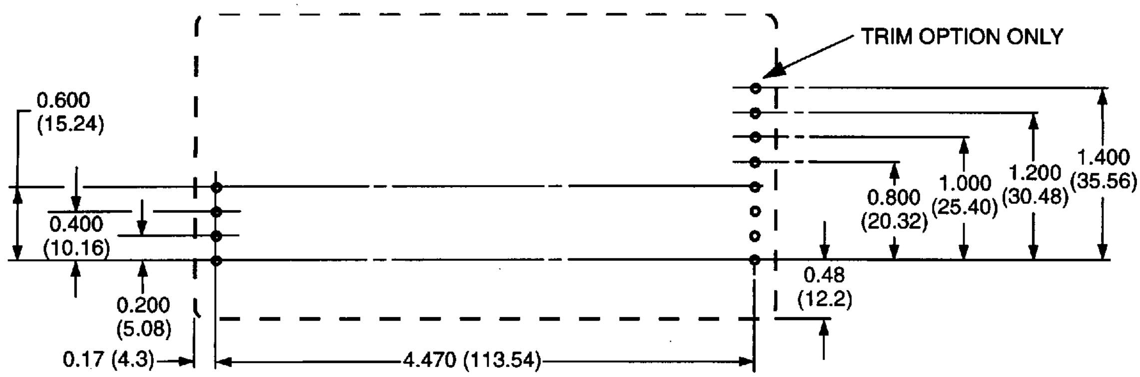
Bottom View



Recommended Hole Pattern

Component-side footprint.

Dimensions are in inches and (millimeters).



Ordering Information

Optional trim pin is designated by ending "9" in device code name. For assistance in ordering optional trim pin, please contact your AT&T Account Manager.

Input Voltage	Output Voltage	Output Power	Device Code	Comcode
48 V	3.3 V	33 W	FE050F	106378086
48 V	3.3 V	66 W	FE100F	106378110
48 V	3.3 V	99 W	FE150F	106291875
48 V	3.3 V	99 W	FE150F9	106892433

For additional information, contact your AT&T Account Manager or the following:
U.S.A.: AT&T Microelectronics, Dept. AL-500404200, 555 Union Boulevard, Allentown, PA 18103
1-800-372-2447, FAX 215-778-4106 (In CANADA: **1-800-553-2448**, FAX 215-778-4106)
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