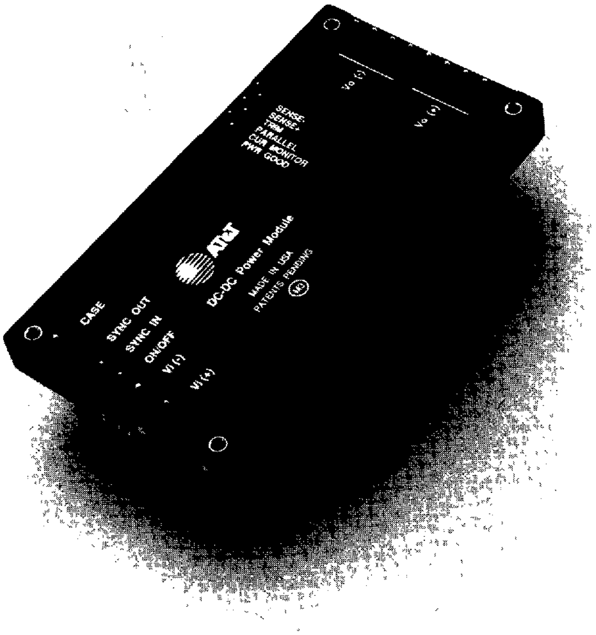
Advance Data Sheet
September 1994

AT&T Microelectronics

FC250-Series Power Modules: 18 Vdc to 36 Vdc Input: 250 W



The FC250-Series Power Modules use advanced, surface-mount technology and deliver high-quality, compact, dc-dc conversion at an economical price.

Features

- Size: 2.40 in. x 4.60 in. x 0.5 in.
- Operating case temperature range: –40 °C to +90 °C
- Remote sense
- Parallel operation with forced load sharing
- Remote on/off (primary and secondary side referenced)
- Adjustable output voltage: 60% to 110% of $V_{O,\,nom}$
- *UL**, *CSA*†, VDE pending
- Thermal shutdown
- Synchronization
- Power good pin
- Current monitor
- Output voltage and output current protection
- Case ground pin

Options

- Heat sink available for extended operation
- Input voltage transient (100 V for 100 m/s)
- Non-threaded through mounting holes

Applications

- Redundant and distributed power architectures
- Private branch exchange (PBX)
- Telecommunications

Description

The FC250-Series Power Modules are dc-dc converters that operate over an input voltage range of 18 Vdc to 36 Vdc input and provide precisely regulated dc outputs. The outputs are fully isolated from the inputs, allowing versatile polarity configurations and grounding connections. The modules have a maximum power rating of 250 W with a typical full load efficiency of 81%.

These 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.

* *UL* is a registered trademark of the Underwriters Laboratories, Inc.
† *CSA* is a registered trademark of the Canadian Standards Association.

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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	—	50	V
I/O Isolation Voltage	—	—	500	V
Operating Case Temperature (See Thermal Considerations section.)	T_C	–40	90	°C
Storage Temperature	T_{stg}	–40	110	°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	18	28	36	Vdc
Maximum Input Current (V_I = 0 V to 36 V)	$I_{I, max}$	—	—	22	A
Inrush Transient	i^2t	—	—	4.0	A^2s
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 µH source impedance; see Figure 1.)	—	—	—	TBD	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. To aid in the proper fuse selection for the given application, information on inrush and maximum dc input current is provided. Refer to the fuse manufacturer's data for further information.

Electrical Specifications (continued)

Table 2. Output Specifications

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage	FC250A	V_O	4.85	—	5.15	Vdc
(Over all operating input voltage, resistive load,	FC250B	V_O	11.64	—	12.36	Vdc
and temperature conditions until end of life;	FC250C	V_O	14.55	—	15.45	Vdc
see Feature Descriptions section.)	FC250F	V_O	3.20	—	3.40	Vdc
Output Voltage Set Point:	FC250A	$V_{O,\,set}$	4.92	—	5.08	Vdc
(V_I = 48 V; $I_O = I_{O,\,max}$; T_C = 25 °C):	FC250B	$V_{O,\,set}$	11.82	—	12.18	Vdc
	FC250C	$V_{O,\,set}$	14.77	—	15.23	Vdc
	FC250F	$V_{O,\,set}$	3.25	—	3.35	Vdc
Output Regulation:						
Line (V_I = 18 V to 36 V)	all	—	—	0.01	0.1	%V_O
Load ($I_O = I_{O,\,min}$ to $I_{O,\,max}$)	all	—	—	0.5	0.2	%V_O
Temperature (T_C = –40 °C to +100 °C)	FC250A	—	—	15	50	mV
	FC250B	—	—	50	100	mV
	FC250C	—	—	50	100	mV
	FC250F	—	—	15	50	mV
Output Ripple and Noise Voltage (See Figure 2.):						
RMS	FC250A	—	—	—	40	mV rms
	FC250B	—	—	—	50	mV rms
	FC250C	—	—	—	60	mV rms
	FC250F	—	—	—	40	mV rms
Peak-to-peak (5 Hz to 20 MHz)	FC250A	—	—	—	50	mV p-p
	FC250B	—	—	—	100	mV p-p
	FC250C	—	—	—	150	mV p-p
	FC250F	—	—	—	50	mV p-p
Output Current	FC250A	I_O	0.5	—	50	A
	FC250B	I_O	0.3	—	20.8	A
	FC250C	I_O	0.3	—	16.7	A
	FC250F	I_O	0.5	—	50	A
Output Current-limit Inception (V_O = 90% of $V_{O,\,set}$; see Feature Descriptions section.)	all	I_O	103	—	130	%$I_{O,\,max}$
Output Current-limit (V_O = 1.0 V; indefinite duration, no hiccup mode.)	all	I_O	—	—	150	%$I_{O,\,max}$
Efficiency	FC250A	η	—	81	—	%
(V_I = 48 V; $I_O = I_{O,\,max}$; T_C = 70 °C; see Figure 3.)	FC250B	η	—	84	—	%
	FC250C	η	—	84	—	%
	FC250F	η	—	77	—	%
Dynamic Response:						
($\Delta I_O/\Delta t$ = 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	all	—	—	50	—	mV
Settling Time (V_O < 10% of peak deviation)	all	—	—	200	—	µs
Load Change from I_O = 50% to 25% of $I_{O,\,max}$:						
Peak Deviation	all	—	—	50	—	mV
Settling Time (V_O < 10% of peak deviation)	all	—	—	200	—	µs

Electrical Specifications (continued)

Table 3. Isolation Specifications

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

General Specifications

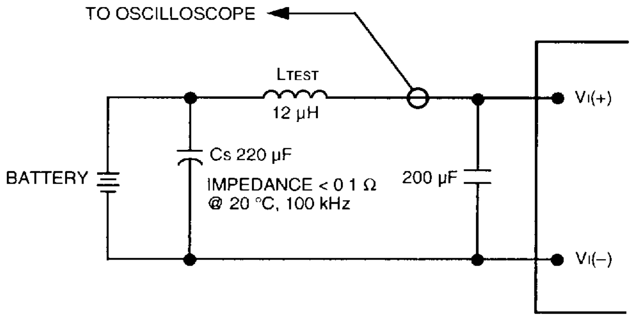
Parameter	Min	Typ	Max	Unit
Calculated MTBF (I_O = 80% of $I_{O,\,max}$; T_C = 40 °C)		1,000,000		hr
Weight	—	—	7(200)	oz.(g)

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	Device	Symbol	Min	Typ	Max	Unit
Remote On/Off (V_I = 0 V to 36 V; open collector or equivalent compatible; signal referenced to $V_I(-)$ terminal; see Feature Descriptions.):						
Logic Low — Module On						
Logic High — Module Off						
Module Specifications:						
On/Off Current — Logic Low	all	$I_{on/off}$	—	—	1.0	mA
On/Off Voltage:						
Logic Low	all	$V_{on/off}$	0	—	1.2	V
Logic High ($I_{on/off}$ = 0)	all	$V_{on/off}$	—	—	18	V
Open Collector Switch Specifications:						
Leakage Current During Logic High ($V_{on/off}$ = 18 V)	all	$I_{on/off}$	—	—	50	µA
Output Low Voltage During Logic Low ($I_{on/off}$ = 1 mA)	all	$V_{on/off}$	—	—	1.2	V
Turn-on Time (I_O = 80% of $I_{O,\,max}$; V_O within ±1% of steady state)	all	—	—	50	100	ms
Output Voltage Sense Range	all	—	—	—	0.5	Vdc
Output Voltage Trim Range	all	—	60	—	110	%$V_{O,\,nom}$
Output Overvoltage Shutdown	FC250A	—	5.6	—	7.0	Vdc
	FC250B	—	13.5	—	16.0	Vdc
	FC250C	—	17.0	—	20.0	Vdc
	FC250F	—	4.0	—	5.0	Vdc
Current Share Accuracy—5 Units in Parallel	all	—	—	10%	—	%$I_{O,\,rated}$
Synchronization						
Clock Amplitude	all	—	TBD	4.0	5.0	V p-p
Duty	all	—	—	50	—	%
Overtemperature Shutdown	all	T_{case}	—	110	—	°C
Current Monitor (I_O = $I_{O,\,max}$; T_C = 70 °C)	all	$I_{O,\,mon}$	—	0.05	—	V/A

Test Configurations



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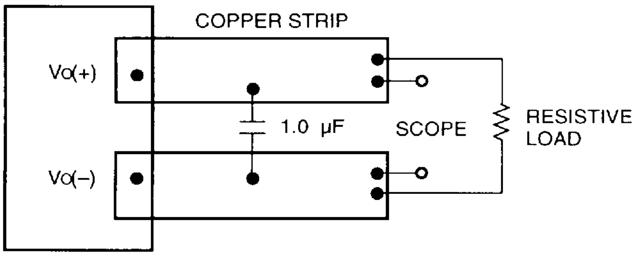
Note: Measure input reflected-ripple current with a simulated source impedance (LTEST) of 12 µH. Capacitor Cs offsets possible battery impedance. Measure current as shown above.

Figure 1. Input Reflected-Ripple Test Setup



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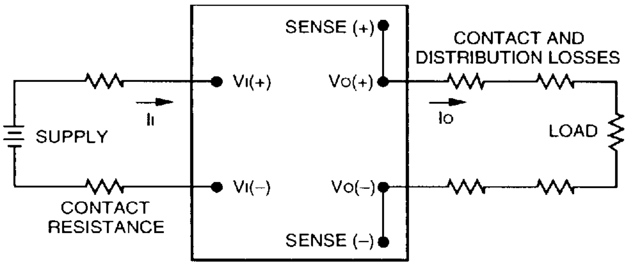
Note: Use a 1.0 µF ceramic capacitor. Scope measurement should be made using a BNC socket. Position the load between 2 in. and 3 in. from the module.

Figure 2. 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.

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

Figure 3. 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 1, a 200 µF electrolytic capacitor (ESR < 0.3 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.

Feature Descriptions

Remote Sense

Remote sense minimizes the effects of distribution losses by regulating the voltage at the remote-sense connections. 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.:

$$[V_O(+) - V_O(-)] - [\text{SENSE}(+) - \text{SENSE}(-)] \leq 10\%\ V_{O,\,nom}$$

This limit includes any increase in voltage due to remote-sense compensation, set point adjustment, and trim (see Figure 4).

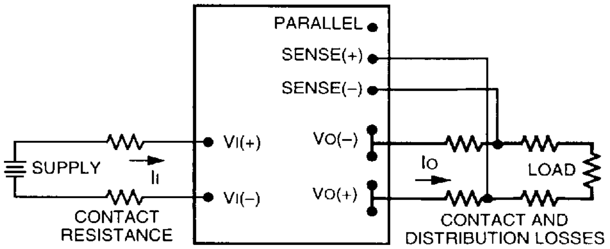

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Figure 4. Effective Circuit Configuration for Single-Module Remote Sense Operation

Feature Descriptions (continued)

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 Protection

The modules are designed with a latching overvoltage shutdown. Recovery from latched shutdown is accomplished by cycling the dc input power off for at least 1.0 s or toggling the primary referenced ON/OFF signal for at least 1.0 s.

Thermal Shutdown

To provide protection in a fault condition, the unit is equipped with a thermal shutdown circuit. The shutdown circuit will not engage unless the unit is operated above the maximum case temperature. Recovery from thermal shutdown is accomplished by cycling the dc input power off for at least 1.0 s or toggling the primary referenced ON/OFF signal for at least 1.0 s.

Current Monitor

The current monitor pin provides a dc voltage proportional to the dc output current of the module. The V/A ratio is set at 50 mV/A ±10% @ 70 °C case. For example, at a full load current of 50 A, the voltage on the current monitor pin is 3 V. The current monitor signal is referenced to the SENSE(–) pin on the secondary and is supplied from a source impedance of approximately 2 kΩ. It is recommended that the current monitor pin be left open when not in use, although no damage will result if the current monitor pin is shorted to secondary ground. Directly driving the current monitor pin with an external source will detrimentally affect operation of the module and should be avoided.

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 5). 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 must 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.

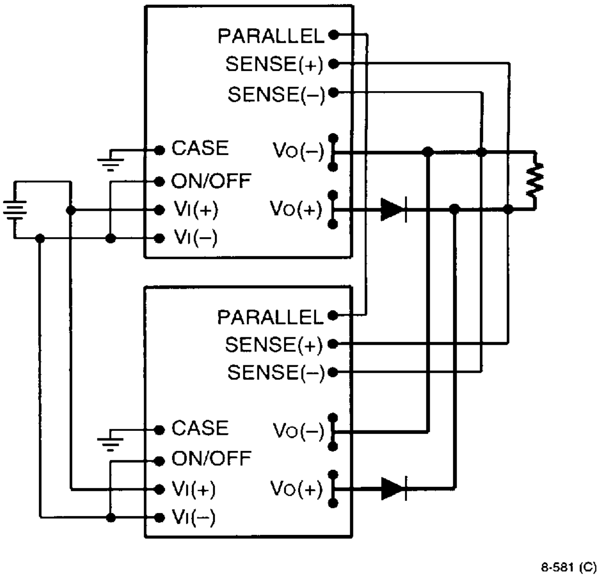


Figure 5. Wiring Configuration for Redundant Parallel Operation

Feature Descriptions (continued)

Power Good Pin

The PWR GOOD pin provides an open-drain signal (referenced to the SENSE(–) pin) that indicates the operating state of the module. A low impedance (<100 Ω) between PWR GOOD and SENSE(–) indicates that the module is operating. A high impedance (>1 MΩ) between PWR GOOD and SENSE(–) indicates that the module is off or has failed. The PWR GOOD pin can be pulled up through a resistor to an external voltage to facilitate sensing. This external voltage level must not exceed 40 V and the current into the PWR GOOD pin during the low-impedance state should be limited to 1 mA maximum.

Module Synchronization

Any module can be synchronized to any other module or to an external clock using the SYNC IN or SYNC OUT pins. The modules are not designed to operate in a master/slave configuration.

SYNC IN Pin

This pin can be connected either to an external clock or directly to the SYNC OUT pin of another Fx250 module.

If an external clock signal is applied to the SYNC IN pin, the signal must be a 500 kHz (±50 kHz) square wave with a 4 Vp-p amplitude. Operation outside this frequency band will detrimentally affect the performance of the module and must be avoided.

If the SYNC IN pin is connected to the SYNC OUT pin of another module, the connection should be as direct as possible, and the V_I(–) pins of the modules must be shorted together.

If no connection is made to the SYNC IN pin, the module will operate from its own internal clock.

When not in use, the SYNC IN pin should be shorted directly to the V_I(–) pin.

SYNC OUT Pin

This pin contains a clock signal referenced to the V_I(–) pin. The frequency of this signal will equal either the module's internal clock frequency or the frequency established by an external clock applied to the SYNC IN pin.

When synchronizing several modules together, the modules can be connected in a daisy chain fashion where the SYNC OUT pin of one module is connected to the SYNC IN pin of another module. Each module in the chain will synchronize to the frequency of the first module in the chain.

To avoid loading effects, ensure that the SYNC OUT pin of any one module is connected to the SYNC IN pin of only one module. Any number of modules can be synchronized in this daisy chain fashion.

Output Voltage Trim

Output voltage trim allows the user to increase or decrease the output voltage set point of a module. This is accomplished by connecting an external resistor between the TRIM pin and either the SENSE(+) or SENSE(–) pins. With an external resistor between the TRIM and SENSE(–) pins ($R_{adj\text{-}down}$), the output voltage set point ($V_{O,\,adj}$) decreases (see Figure 6). The following equation determines the required external resistor value to obtain a percentage output voltage change of Δ%.

$$R_{adj\text{-}down} = \left(\frac{205}{\Delta\%} - 2.255\right)\ k\Omega$$

The test results for this configuration are displayed in Figure 7. This figure applies to all output voltages.

With an external resistor connected between the TRIM and SENSE(+) pins ($R_{adj\text{-}up}$), the output voltage set point ($V_{O,\,adj}$) increases (see Figure 8).

The following equation determines the required external resistor value to obtain a percentage output voltage change of Δ%.

$$R_{adj\text{-}up} = \left(\frac{\left(V_{O,\,nom}\left(1 + \frac{\Delta\%}{100}\right) - 1.225\right)}{(1.225\Delta\%)} 205 - 2.255\right)\ k\Omega$$

The test results for this configuration are displayed in Figure 9.

Feature Descriptions (continued)

Output Voltage Trim (continued)

The combination of the output voltage adjustment and sense range and the output voltage given in the Feature Specifications table cannot exceed 110% of the nominal output voltage between the Vo(+) and Vo(–) terminals.

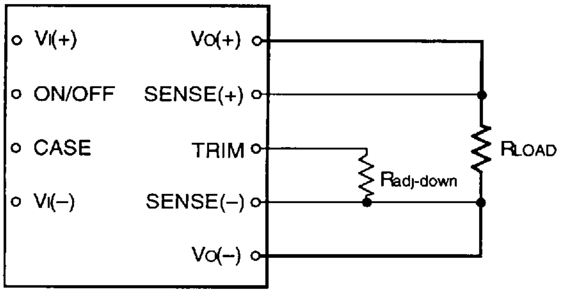


Figure 6. Circuit Configuration to Decrease Output Voltage

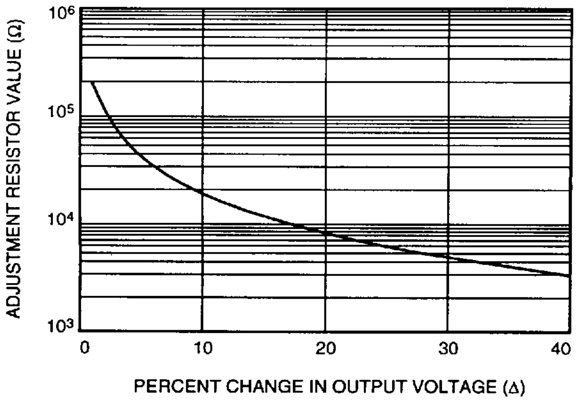


Figure 7. Resistor Selection for Decreased Output Voltage

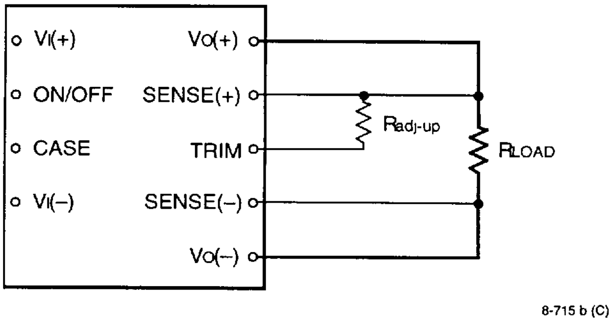


Figure 8. Circuit Configuration to Increase Output Voltage

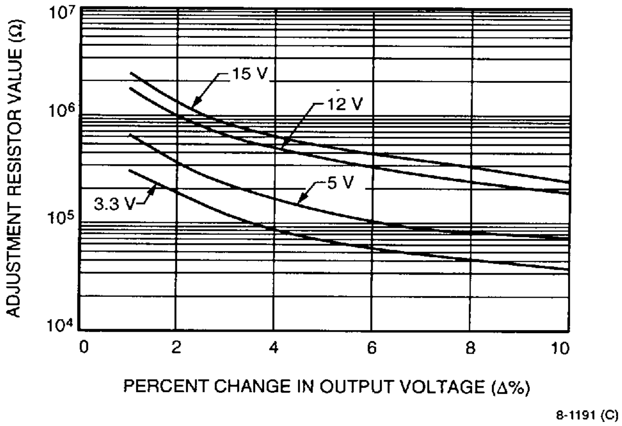


Figure 9. Resistor Selection for Increased Output Voltage

Feature Descriptions (continued)

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 10). 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 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 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.

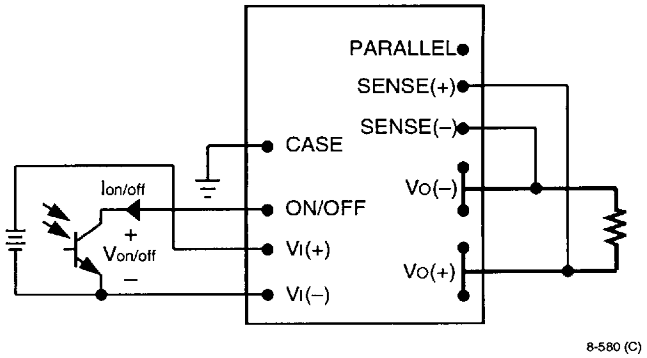


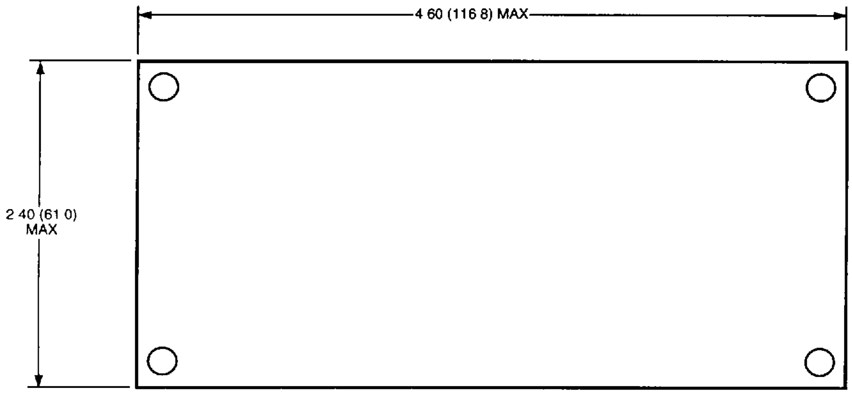
Figure 10. Remote On/Off Implementation

Outline Diagram

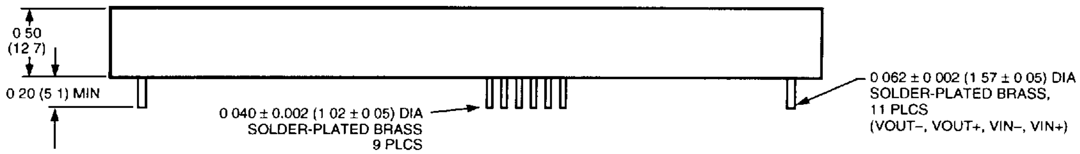
Dimensions are in inches and (millimeters).

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

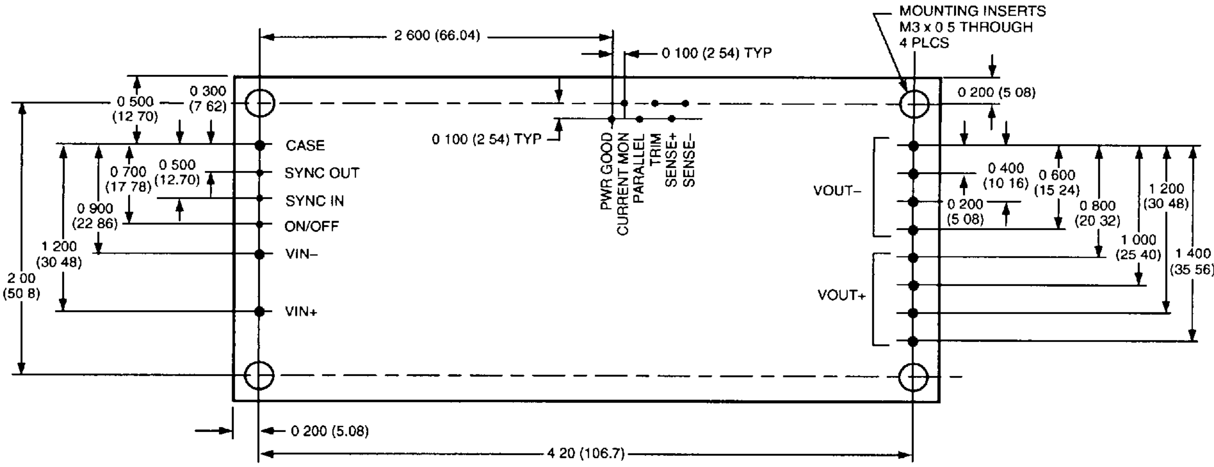
Top View



Side View



Bottom View



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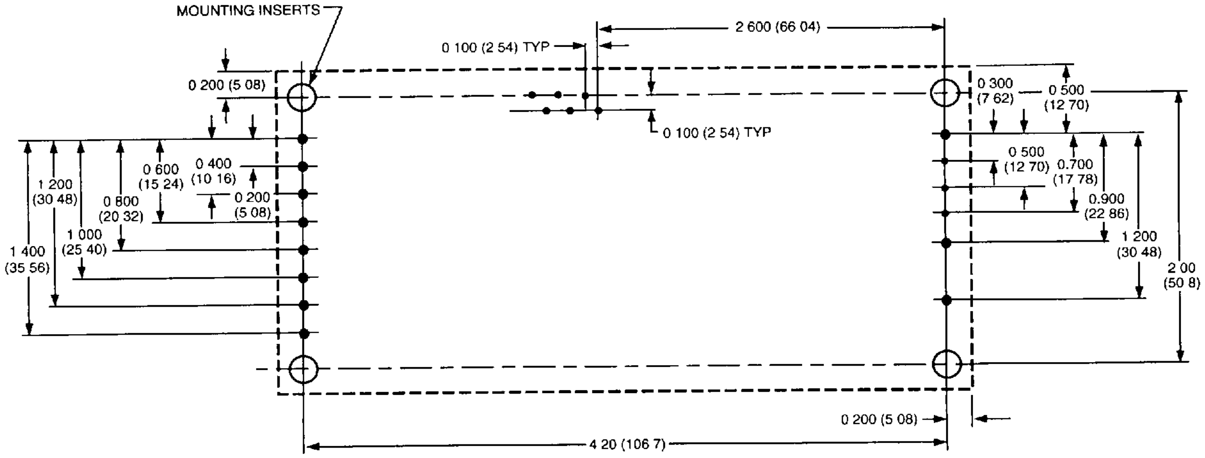
Recommended Hole Pattern

Component-side footprint.

Dimensions are in inches and (millimeters).



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Ordering Information

Input Voltage	Output Voltage	Output Power	Device Code	Comcode
48 V	5 V	250 W	FC250A	TBD
48 V	12 V	250 W	FC250B	TBD
48 V	15 V	250 W	FC250C	TBD
48 V	3.3 V	165 W	FC250F	TBD