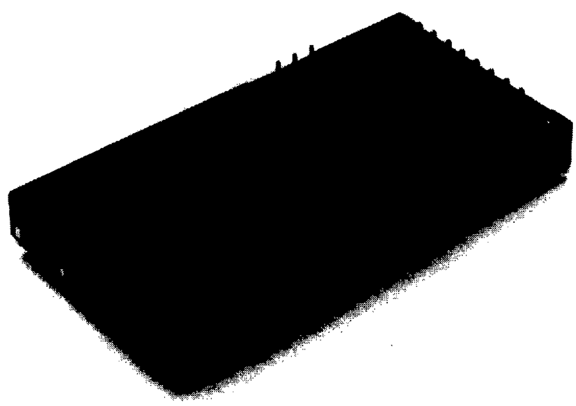
microelectronics group

Lucent Technologies
Bell Labs Innovations

FW250-Series Power Modules: 36 Vdc to 75 Vdc Input; 250 W



The FW250-Series 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
- Private branch exchange (PBX)
- Telecommunications

Features

- Size: 61.0 mm (2.40 in.) x 116.8 mm (4.60 in.) x 13.5 mm (0.5 in.)
- Operating case temperature range: –40 °C to +100 °C
- Remote sense
- Parallel operation with forced load sharing
- Remote on/off (primary side referenced)
- Adjustable output voltage: 60% to 110% of $V_{O,\,nom}$
- *UL** Recognized, *CSA*† Certified, and VDE Licensed
- CE mark meets 73/23/EEC and 93/68/EEC directives‡
- 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 ms)
- Nonthreaded through mounting holes

* *UL* is a registered trademark of Underwriters Laboratories, Inc.
† *CSA* is a registered trademark of the Canadian Standards Association.
‡ This product is intended to be integrated into end-use equipment. All the required procedures for CE marking of end-use equipment should be followed. (The CE mark is placed on selected products.)

Description

The FW250-Series Power Modules are dc-dc converters that operate over an input voltage range of 36 Vdc to 75 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 84% for a 5 V output.

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.

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	V
I/O Isolation Voltage	—	—	1500	V
Operating Ambient Temperature (See Thermal Considerations section.)	T_C	–40	100	°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	36	48	75	Vdc
Maximum Input Current (V_I = 0 V to 75 V)	$I_{I, max}$	—	—	9	A
Inrush Transient	i^2t	—	—	2.0	A^2s
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 µH source impedance; see Figure 1.)	—	—	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, dc fuse with a maximum rating of 20 A. (See Safety Considerations section.) 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 (Over all operating input voltage, resistive load, and temperature conditions until end of life; see Figure 3.)	FW250A1	V_O	4.85	—	5.15	Vdc
	FW250B1	V_O	11.64	—	12.36	Vdc
	FW250C1	V_O	14.55	—	15.45	Vdc
	FW250F1	V_O	3.20	—	3.40	Vdc
Output Voltage Set Point: (V_I = 48 V; $I_O = I_{O,\,max}$; T_C = 25 °C):	FW250A1	$V_{O,\,set}$	4.92	—	5.08	Vdc
	FW250B1	$V_{O,\,set}$	11.82	—	12.18	Vdc
	FW250C1	$V_{O,\,set}$	14.77	—	15.23	Vdc
	FW250F1	$V_{O,\,set}$	3.25	—	3.35	Vdc
Output Regulation:						
Line (V_I = 36 V to 75 V)	All	—	—	0.01	0.1	%V_O
Load ($I_O = I_{O,\,min}$ to $I_{O,\,max}$)	All	—	—	0.05	0.2	%V_O
Temperature (T_C = –40 °C to +100 °C)	FW250A1	—	—	15	50	mV
	FW250B1	—	—	50	100	mV
	FW250C1	—	—	50	100	mV
	FW250F1	—	—	15	50	mV
Output Ripple and Noise Voltage (See Figure 2.):						
RMS (V_I = 48 V; $I_O = I_{O,\,max}$)	FW250A1	—	—	—	40	mVrms
	FW250B1	—	—	—	50	mVrms
	FW250C1	—	—	—	60	mVrms
	FW250F1	—	—	—	40	mVrms
Peak-to-peak (5 Hz to 20 MHz)	FW250A1	—	—	—	50	mVp-p
	FW250B1	—	—	—	100	mVp-p
	FW250C1	—	—	—	150	mVp-p
	FW250F1	—	—	—	50	mVp-p
Output Current (At $I_O < I_{O,\,min}$ the modules may exceed output ripple specifications)	FW250A1	I_O	0.5	—	50	A
	FW250B1	I_O	0.3	—	20.8	A
	FW250C1	I_O	0.3	—	16.7	A
	FW250F1	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 (V_I = 48 V; $I_O = I_{O,\,max}$; T_C = 70 °C; see Figure 3.)	FW250A1	η	—	84	—	%
	FW250B1	η	—	87	—	%
	FW250C1	η	—	87	—	%
	FW250F1	η	—	79	—	%
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	—	—	2%*	—	$V_{O,\,set}$
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	—	—	2%*	—	$V_{O,\,set}$
Settling Time (V_O < 10% of peak deviation)	All	—	—	200	—	µs

* Greater of 2% or 100 mV.

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	—	—	200 (7)	g (oz.)

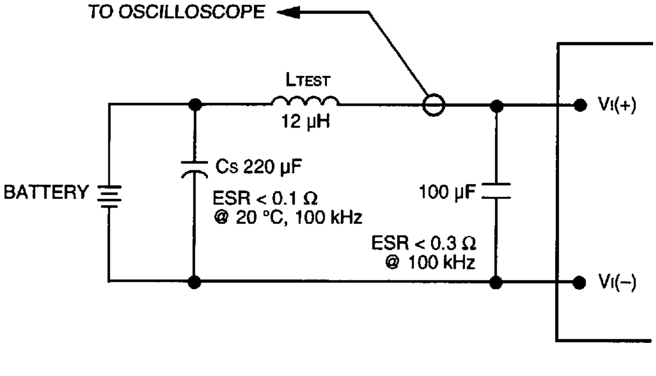
Feature Specifications

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 (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(–) terminal. See Figure 7 and 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	$V_{on/off}$	—	—	15	V
Open Collector Switch Specifications: Leakage Current During Logic High ($V_{on/off}$ = 15 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 (IO = 80% of $I_{O,\,max}$; VO within ±1% of steady state)	All	—	—	30	—	ms
Output Voltage Sense Range	FW250A1, F1	V_{sense}	—	—	0.5	Vdc
	FW250B1	V_{sense}	—	—	1.2	Vdc
	FW250C1	V_{sense}	—	—	0.5	Vdc
Output Voltage Trim Range	All	—	60	—	110*	$\%V_{O,\,nom}$
Output Voltage Set Point Adjustment Range	FW250A1, B1	—	60	—	110	$\%V_{O,\,nom}$
	FW250C1	—	60	—	100	$\%V_{O,\,nom}$
	FW250F1	—	60	—	115	$\%V_{O,\,nom}$
Output Overvoltage Shutdown	FW250A1	—	5.6	—	7.0	Vdc
	FW250B1	—	13.5	—	16.0	Vdc
	FW250C1	—	17.0	—	20.0	Vdc
	FW250F1	—	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	Vp-p
Duty	All	—	—	50	—	%
Frequency	All	—	450	—	550	kHz
Overtemperature Shutdown	All	T_{case}	—	110	—	°C
Current Monitor (IO = $I_{O,\,max}$; TC = 70 °C)	FW250A1, F1	$I_{O,\,mon}$	—	0.065	—	V/A
	FW250B1	$I_{O,\,mon}$	—	0.18	—	V/A
	FW250C1		—	0.25	—	V/A
PWR GOOD Signal Interface (See Feature Descriptions.)						
Low Impedance—Module Operating	All	$R_{pwr/good}$	—	—	100	Ω
		$I_{pwr/good}$	—	—	1	mA
High Impedance—Module Off	All	$R_{pwr/good}$	1	—	—	MΩ
		$V_{pwr/good}$	—	—	40	V

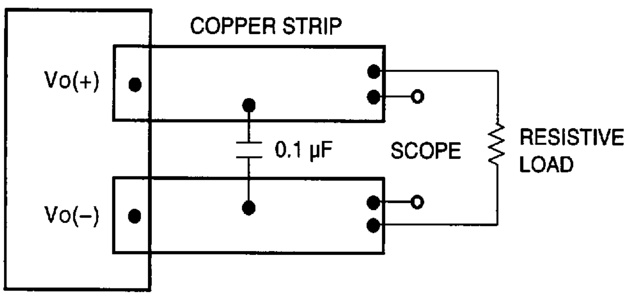
*Greater than 110% of $V_{O,\,nom}$ or 0.5 V

Test Configuration



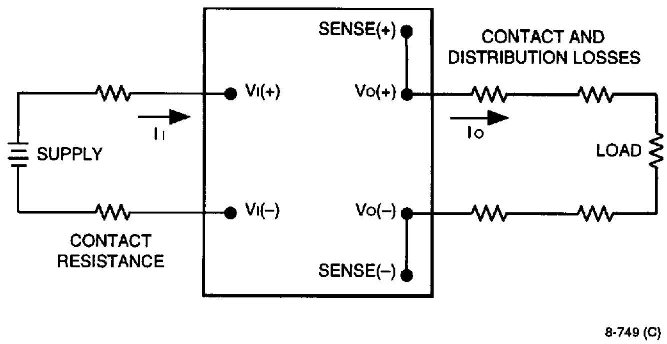
Note: Measure input reflected-ripple current with a simulated source impedance (LTEST) of 12 µH. Capacitor Cs offsets possible battery impedance. Measure current as shown above.

Figure 1. Input Reflected-Ripple Test Setup



Note: Use a 0.1 µF ceramic capacitor. Scope measurement should be made using a BNC socket. Position the load between 50 mm (2 in.) and 76 mm (3 in.) from the module.

Figure 2. Peak-to-Peak Output Noise Measurement 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 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 100 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.

EMI Filter

The power module has an internal input EMI filter. However, in EMI sensitive applications, an external, more efficient EMI filter is recommended. We recommend the Lucent Technologies FLTR100V10 or FLT100V20 which were specifically designed to work with Lucent Technologies dc/dc converters.

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, EN60950.

For the converter output to be considered meeting the requirements for safety extra low voltage (SELV), one of the following must be true:

- All inputs are SELV and floating, with all outputs also floating.
- All inputs are SELV and grounded, with the output also grounded.
- Any non-SELV input must be provided with reinforced insulation from any other hazardous voltages, including the ac mains, and must have an SELV reliability test performed on it in combination with the converters.

The output of the converter is considered extra-low voltage (ELV) if the input meets the requirements for ELV.

The inputs to these power units are to be provided with a maximum 20 A normal-blow fuse in the ungrounded lead.

Thermal Considerations

The FW250-Series 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 (Tc) occurs at the position indication in the Figure below.

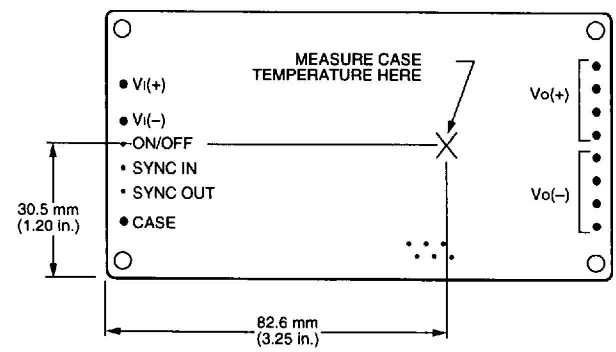


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Figure 4. Case Temperature Measurement Location

Note that the view in Figure 4 is the metal surface of the module—the pin locations shown are for reference. 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.

For further information on these modules, refer to the Lucent Technologies *Thermal Management for FC-FW-Series 250 W—300 W Board-Mounted Power Modules* Technical Note.

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.:

$[Vo(+) - Vo(-)] - [SENSE(+) - SENSE(-)] \leq V_{sense,\ max}$

This limit includes any increase in voltage due to remote-sense compensation, and output voltage set point adjustment (see Figure 5).

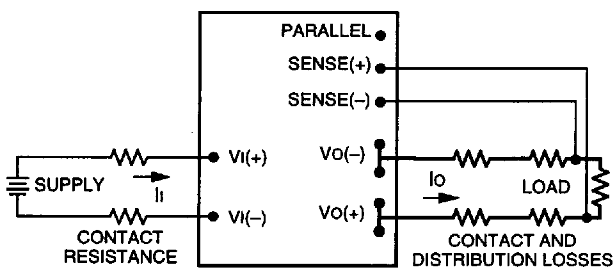


Figure 5. Effective Circuit Configuration for Single-Module Remote-Sense Operation

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 given in the Feature Specifications table. For example, on the FW250A1, the V/A ratio is set at 65 mV/A ± 10% @ 70 °C case. At a full load current of 50 A, the voltage on the current monitor pin is 3.25 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.

Feature Descriptions (continued)

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 6). For a typical redundant configuration, Schottky diodes or an equivalent should be used to protect against a shorted module output. 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.

When parallel operation is not being utilized, leave the parallel pin open.

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.

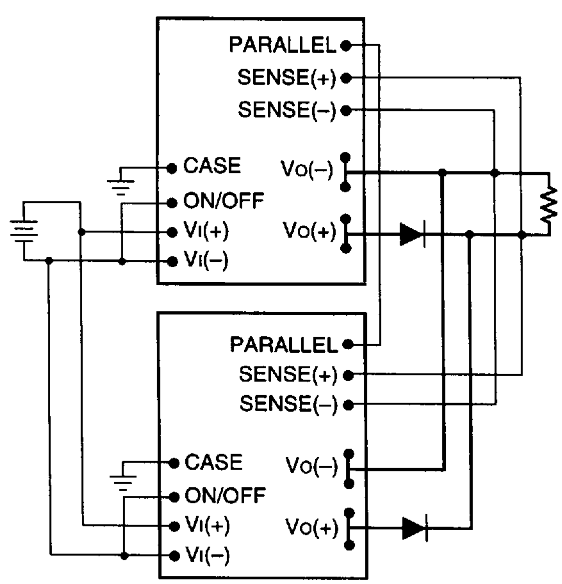


Figure 6. Wiring Configuration for Redundant Parallel Operation

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.

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. The switch can be an open collector or equivalent (see Figure 7). 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 15 V. The maximum allowable leakage current of the switch at $V_{on/off}$ = 15 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.

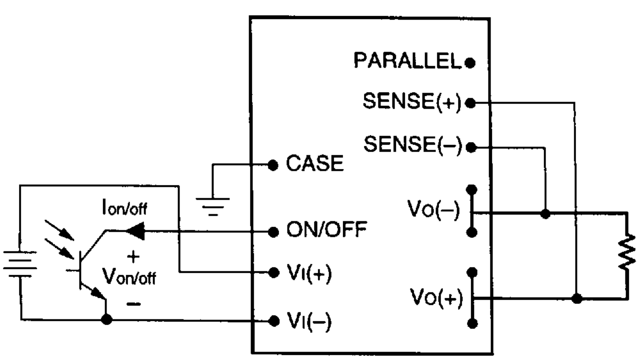


Figure 7. Remote On/Off Implementation

Feature Descriptions (continued)

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 FW250/FW300 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 Set Point Adjustment (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 ($R_{adj\text{-}down}$), between the TRIM and SENSE(–) pins the output voltage set point ($V_{O,\,adj}$) decreases (see Figure 8). The following equation determines the required external resistor value to obtain a percentage output voltage change of Δ%.

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

The test results for this configuration are displayed in Figure 9. This figure applies to all output voltages.

With an external resistor ($R_{adj\text{-}up}$) connected between the TRIM and SENSE(+) pins, the output voltage set point ($V_{O,\,adj}$) increases (see Figure 10).

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

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

The test results for this configuration are displayed in Figure 11.

Leave the TRIM pin open if not using the Trim feature.

Feature Descriptions (continued)

Output Voltage Set Point Adjustment (TRIM) (continued)

The combination of the output voltage adjustment and sense range and the output voltage given in the Feature Specifications table cannot exceed the greater of 110% of the nominal output voltage between the Vo(+) and Vo(–) terminals or 0.5 V.

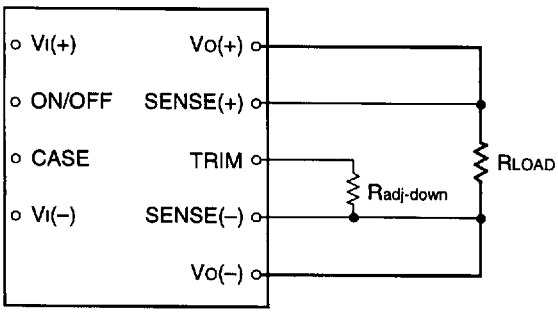


Figure 8. Circuit Configuration to Decrease Output Voltage

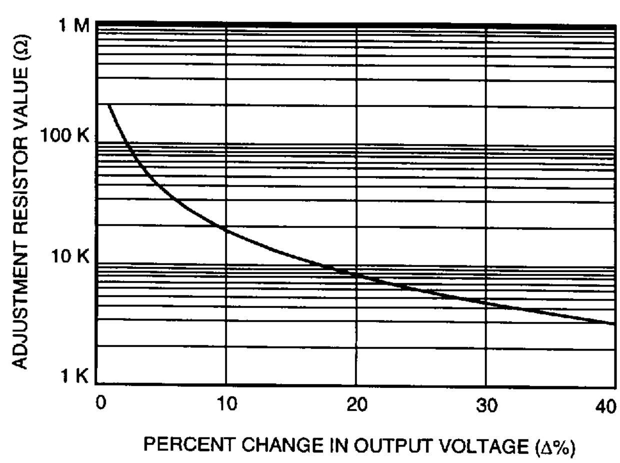


Figure 9. Resistor Selection for Decreased Output Voltage

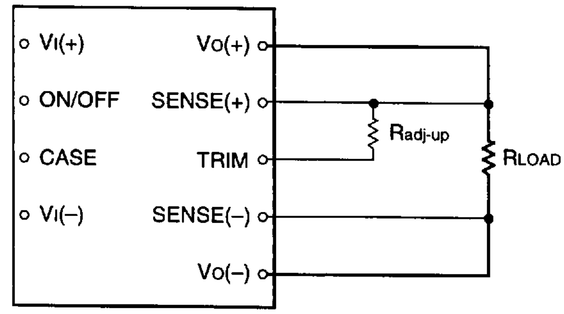


Figure 10. Circuit Configuration to Increase Output Voltage

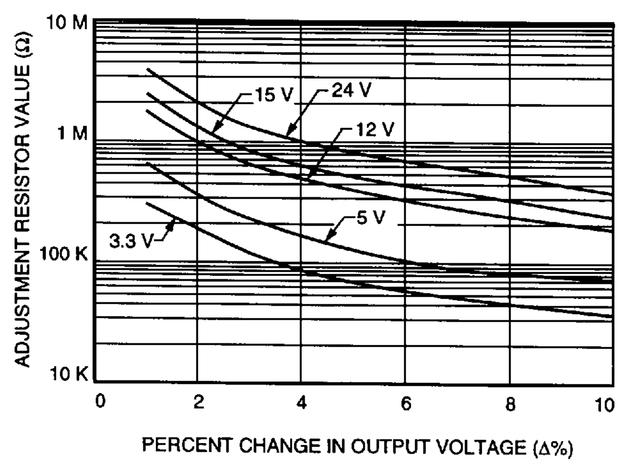


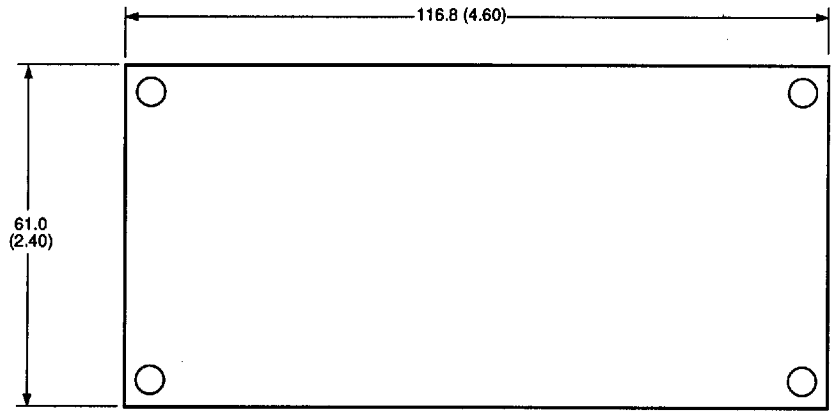
Figure 11. Resistor Selection for Increased Output Voltage

Outline Diagram

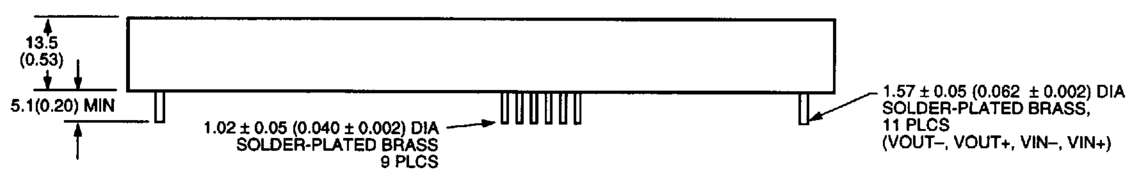
Dimensions are in millimeters and (inches).

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

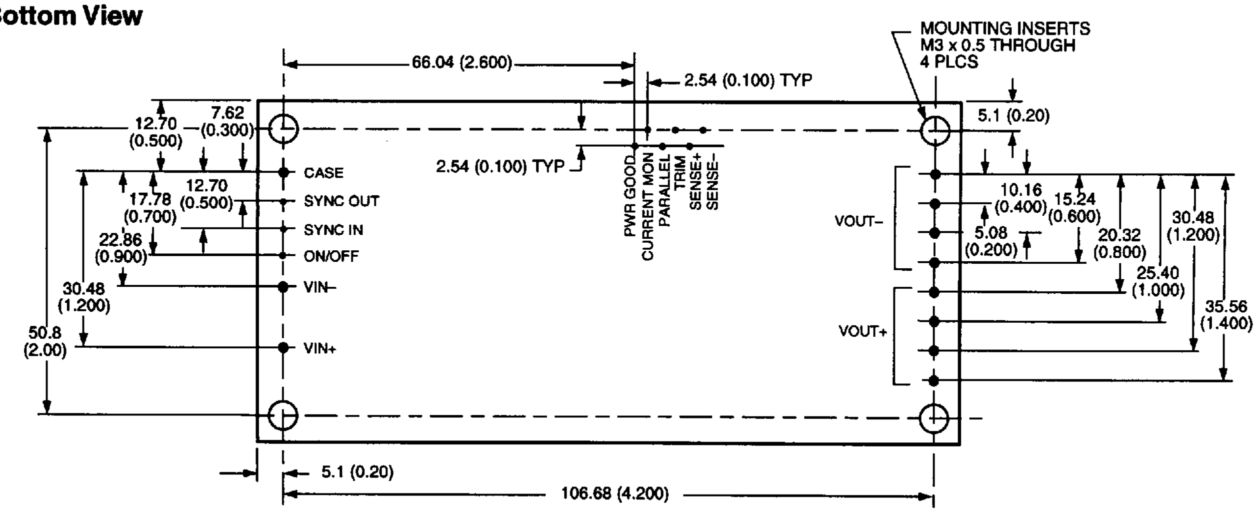
Top View



Side View



Bottom View



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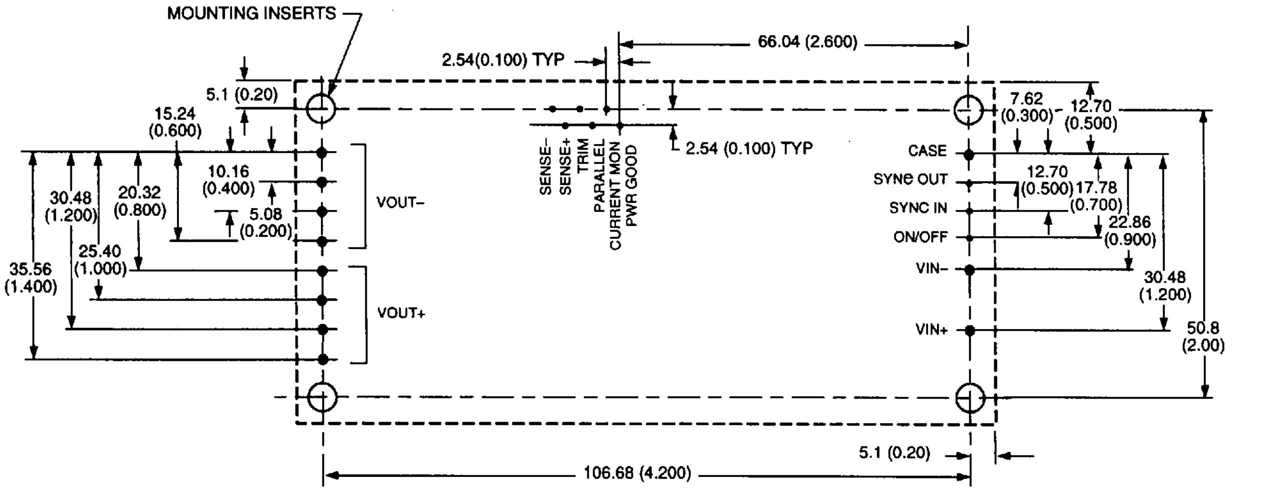
Recommended Hole Pattern

Component-side footprint.

Dimensions are in millimeters and (inches).



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Ordering Information

Input Voltage	Output Voltage	Output Power	Device Code	Comcode
48 V	5 V	250 W	FW250A1	107356735
48 V	12 V	250 W	FW250B1	107961492
48 V	15 V	250 W	FW250C1	107588345
48 V	3.3 V	165 W	FW250F1	107859886