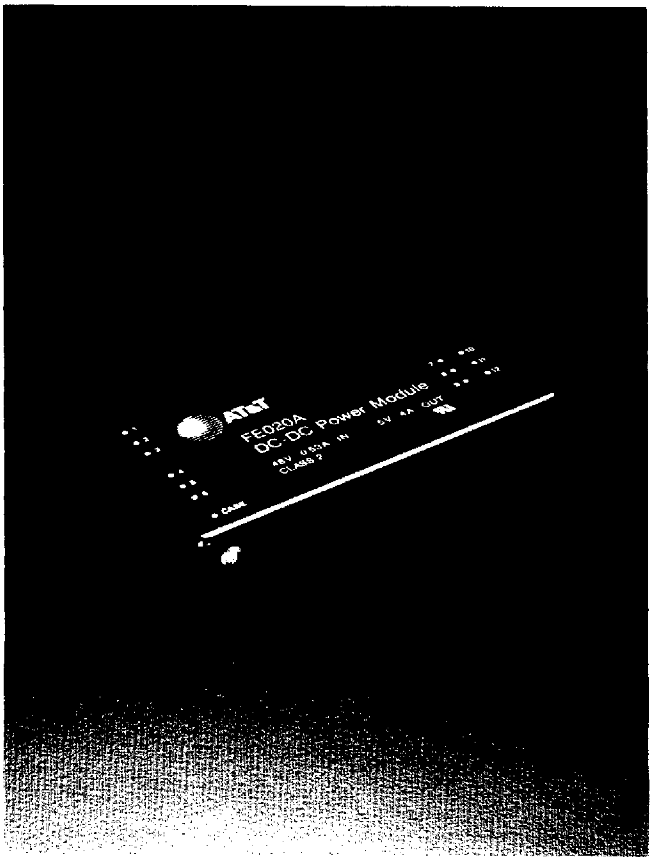
Data Sheet

AT&T
Microelectronics

FE020-Series Power Modules: dc-dc Converters; 48 Vdc Input, 20 W



The FE020-Series Power Modules use advanced surface-mount technology and deliver high-quality, compact dc-dc conversion at an economical price.

Features

- Low profile: 0.5 in.
- High power-density: 6 W/in.^{3}
- Output overvoltage clamp
- No minimum load
- Short-circuit protection
- Parallel operation with load sharing
- Input-to-output isolation
- Synchronization
- Remote sense
- Remote on/off

Applications

- Telecommunications 48 V systems
- Local power distribution
- Digital circuits
- Distributed power architectures
- Redundant power

Description

The FE020A, B, and C Power Modules are 20 W, isolated, dc-dc converters that operate from nominal 48 Vdc inputs and provide 5 Vdc, 12 Vdc, and 15 Vdc outputs respectively. The power modules incorporate peak-current control circuitry and power trains that combine high-efficiency power conditioning with precisely regulated output voltages.

State-of-the-art packaging techniques are combined with high-frequency switching technology to produce low-profile, high power-density power units. The modules, which mount on printed-circuit boards, are 3.6 in. long, 1.9 in. wide, and 0.5 in. high. In a natural convection environment, the devices operate up to 85 °C with no heat sink.

0050026 0025735 923

Absolute Maximum Ratings

Ratings apply to all devices.

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 Ambient Temperature* (natural convection)	T_A	–40	85	°C
Storage Temperature	T_{stg}	–40	100	°C

* See Thermal Management section, page 13.

Electrical Specifications

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

Table 1. Input Specifications

Specifications apply to all devices.

Parameter	Symbol	Min	Typ	Max	Unit
Operating Input Voltage	V_I	40	48	60	V
Maximum Input Current (V_I = 0 V to 60 V) (See Figure 1.)	$I_{I,\,max}$	—	—	1.0	A
Inrush Transient	i^2t	—	—	0.6	A^2s
Input Reflected-Ripple Current, Peak-to-Peak (5 Hz to 20 MHz, 12 µH source impedance) (See Figure 20.)	—	—	75	—	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 with a maximum rating of 5 A in series with the input. 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. However, for UL recognition, the dc rating of the fuse must not exceed 5 A. 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)	FE020A	V_O	4.85	—	5.15	Vdc
	FE020B	V_O	11.4	—	12.60	Vdc
	FE020C	V_O	14.25	—	15.75	Vdc
Output Voltage Set Point (V_I = 48 V; $I_O = I_{O,\,max}$; T_A = 25 °C)	FE020A	$V_{O,\,set}$	4.93	5.00	5.07	Vdc
	FE020B	$V_{O,\,set}$	11.75	12.00	12.25	Vdc
	FE020C	$V_{O,\,set}$	14.70	15.00	15.30	Vdc
Output Regulation:						
Line (V_I = 40 V to 60 V)	all	—	—	—	0.1	%
Load ($I_O = I_{O,\,min}$ to $I_{O,\,max}$)	all	—	—	—	0.2	%
Temperature (T_A = 0 °C to 70 °C)	FE020A	—	—	—	50	mV
(See Figures 2 to 4.)	FE020B, C	—	—	—	100	mV
Output Ripple and Noise:						
RMS	FE020A	—	—	—	20	mV rms
	FE020B	—	—	—	25	mV rms
	FE020C	—	—	—	30	mV rms
Peak-to-Peak (5 Hz to 20 MHz)	FE020A	—	—	—	150	mV p-p
	FE020B	—	—	—	200	mV p-p
	FE020C	—	—	—	250	mV p-p
Output Current*	FE020A	I_O	0	—	4.0	A
	FE020B	I_O	0	—	1.7	A
	FE020C	I_O	0	—	1.35	A
Output Current-Limit Inception:						
V_O = 4.5 V (See Figure 5.)	FE020A	—	—	4.8	—	A
V_O = 10.8 V (See Figure 6.)	FE020B	—	—	2.1	—	A
V_O = 13.5 V (See Figure 7.)	FE020C	—	—	1.7	—	A
Output Current Limit (V_I = 60 V, V_O = 1.0 V)(See Figures 5 to 7.)	FE020A	—	4.5	—	7.5	A
	FE020B	—	2.3	—	5.0	A
	FE020C	—	2.0	—	5.0	A
Output Short-Circuit Current (V_O = 250 mV)(See Figures 5 to 7.)	FE020A	—	—	8.0	—	A
	FE020B, C	—	—	6.0	—	A

* The FE020A Power Module can provide 4.5 A at T_A = 0 °C and 4.2 A at T_A = 50 °C.

Electrical Specifications (continued)

Table 2. Output Specifications (continued)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Efficiency (V_I = 48 V; I_O = $I_{O,max}$; T_A = 25 °C)	FE020A	η	78	82	—	%
(See Figures 8 to 10 and 21.)	FE020B, C	η	78	83	—	%
Dynamic Response						
($\Delta I_O/\Delta t$ = 1 A/µs, V_I = 48 V, T_A = 25 °C):						
Load Change from I_O = 50% to 75% of $I_{O,max}$						
(See Figures 11 to 13.):						
Peak Deviation	FE020A	—	—	150	—	mV
	FE020B, C	—	—	200	—	mV
Settling Time (V_O < 10% peak deviation)	all	—	—	400	—	µs
Load Change from I_O = 50% to 25% of $I_{O,max}$						
(See Figures 14 to 16.):						
Peak Deviation	FE020A	—	—	150	—	mV
	FE020B, C	—	—	200	—	mV
Settling Time (V_O < 10% peak deviation)	all	—	—	400	—	µs

Table 3. Isolation Specifications

Specifications apply to all devices.

Parameter	Min	Typ	Max	Unit
Isolation Capacitance	—	1200	—	pF
Isolation Resistance	1	—	—	MΩ

General Specifications

Parameter	Device	Min	Typ	Max	Unit
Calculated MTBF (I_O = 80% of $I_{O,max}$; T_C = 40 °C)	FE020A		820,000		hours
	FE020B		735,000		hours
	FE020C		736,000		hours
Weight	all	—	—	3.5(99)	oz.(g)

Feature Specifications

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

Parameter	Device	Symbol	Min	Typ	Max	Unit
Remote On/Off						
(0 V < V_I < 60 V; open collector or equivalent compatible; signal referenced to $V_I(-)$ terminal; see Feature Descriptions, page 11.):						
Logic Low — Module Off						
Logic High — Module On						
Module Specifications:						
On/Off Current — Logic Low	all	$I_{on/off}$	—	—	500	µA
On/Off Voltage:						
Logic Low	all	$V_{on/off}$	0	—	0.4	V
Logic High ($I_{on/off}$ = 0)	all	$V_{on/off}$	—	—	11	V
Open Collector Switch Specifications:						
Leakage Current during Logic High ($V_{on/off}$ = 11 V)	all	$I_{on/off}$	—	—	10	µA
Output Low Voltage during Logic Low ($I_{on/off}$ = 500 µA)	all	$V_{on/off}$	—	—	0.4	V
Turn-on Time (@ 80% of full load, T_A = 25 °C, V_O within ±1% of steady state)	all	—	—	1.5	2.5	ms
Output Voltage Overshoot (See Figures 17 to 19.)	all	—	—	—	5	%
Output Voltage Sense Range	all	—	—	—	0.5	V
Output Voltage Set Point Adjustment Range	all	—	—	—	0.25	V
Parallel Operation Load Sharing	FE020A	—	—	0.2	0.6	A
(Current deviation of the unit with respect to the average load current distributed among other units)	FE020B, C	—	—	0.2	0.4	A
Output Overvoltage Clamp	FE020A	$V_{O,\ clamp}$	5.4	—	7.0	V
	FE020B	$V_{O,\ clamp}$	13	—	16	V
	FE020C	$V_{O,\ clamp}$	16	—	20	V
Synchronization (50% duty cycle):						
Synchronization Voltage	all	—	4.85	—	5.1	V
Required Source Current	all	—	—	—	6	mA
Synchronization Frequency	all	—	325	—	345	kHz
Required Output Load for Synchronization	FE020A	I_O	0.3	—	—	A
	FE020B, C	I_O	0.15	—	—	A

Characteristic Curves

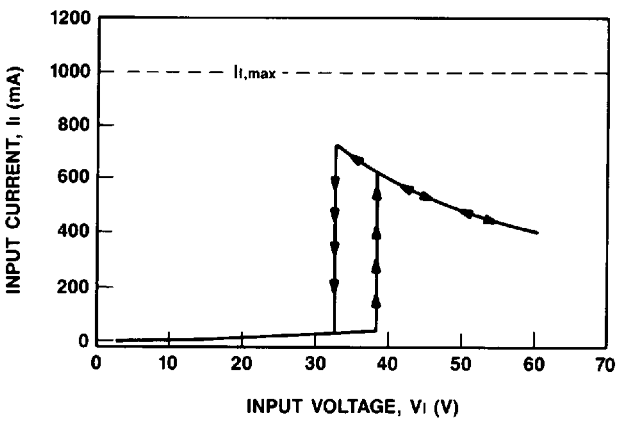


Figure 1. FE020-Series Typical Input Characteristic with a Resistive Load of Io = Io, max; TA = 25 °C (Arrows indicate hysteresis.)

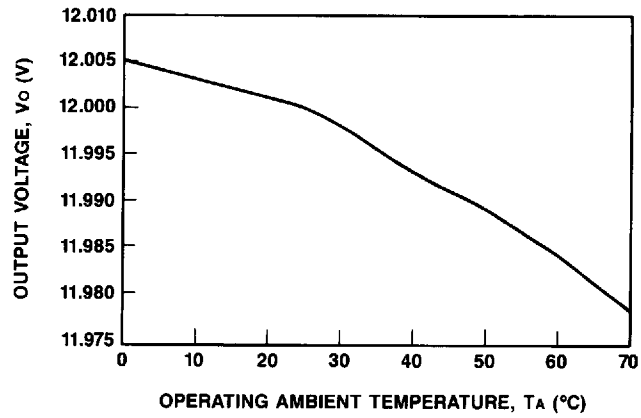


Figure 3. FE020B Typical Output Voltage Variation over Operating Ambient Temperature Range at Io = Io, max; VI = 48 V

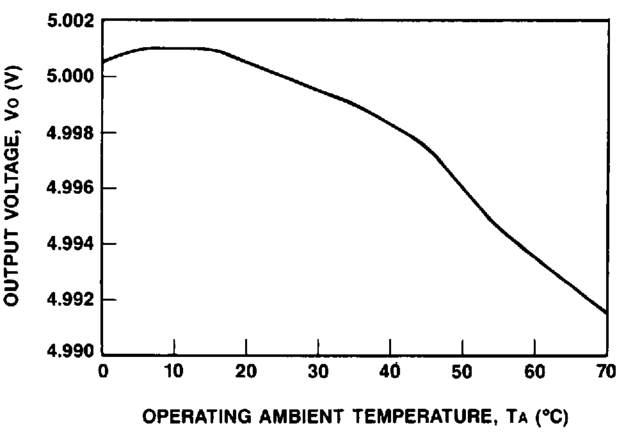


Figure 2. FE020A Typical Output Voltage Variation over Operating Ambient Temperature Range at Io = Io, max; VI = 48 V

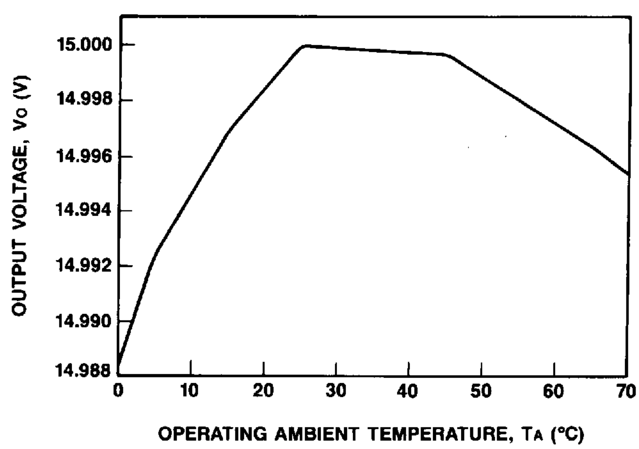


Figure 4. FE020C Typical Output Voltage Variation over Operating Ambient Temperature Range at Io = Io, max; VI = 48 V

Characteristic Curves (continued)

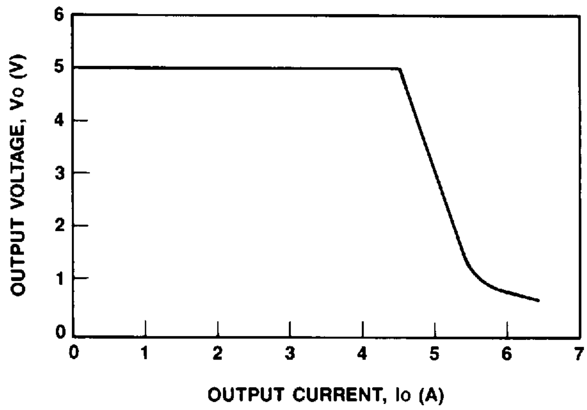


Figure 5. FE020A Typical Output Characteristic with V_I = 48 V; T_A = 25 °C

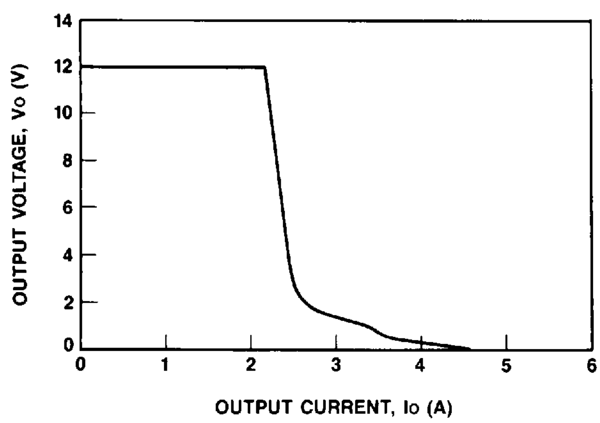


Figure 6. FE020B Typical Output Characteristic with V_I = 48 V; T_A = 25 °C

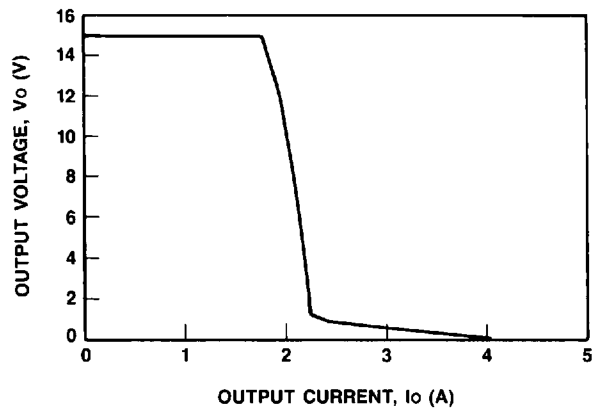


Figure 7. FE020C Typical Output Characteristic with V_I = 48 V; T_A = 25 °C

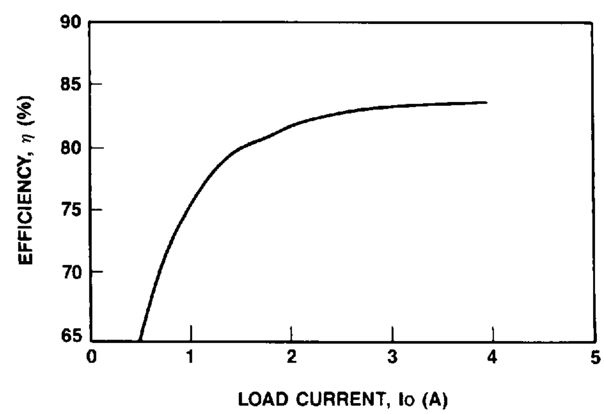


Figure 8. FE020A Typical Converter Efficiency as a Function of Output Current with V_I = 48 V; T_A = 25 °C

Characteristic Curves (continued)

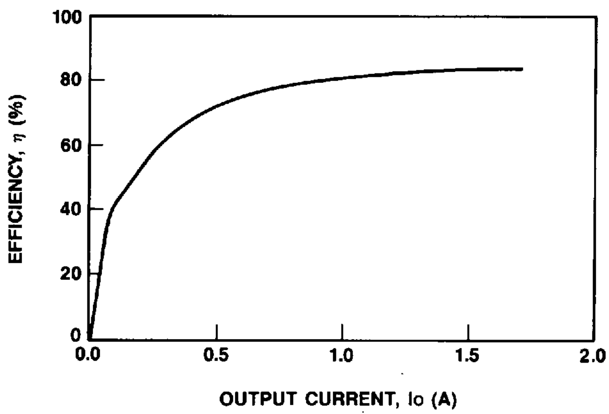


Figure 9. FE020B Typical Converter Efficiency as a Function of Output Current with V_I = 48 V; T_A = 25 °C

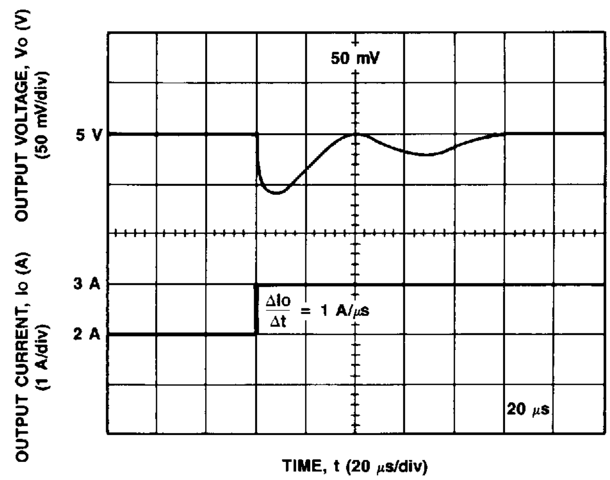


Figure 11. FE020A Typical Output Voltage Waveform for a Step Load Change from 50% to 75% of $I_{O,\,max}$; V_I = 48 V; T_A = 25 °C

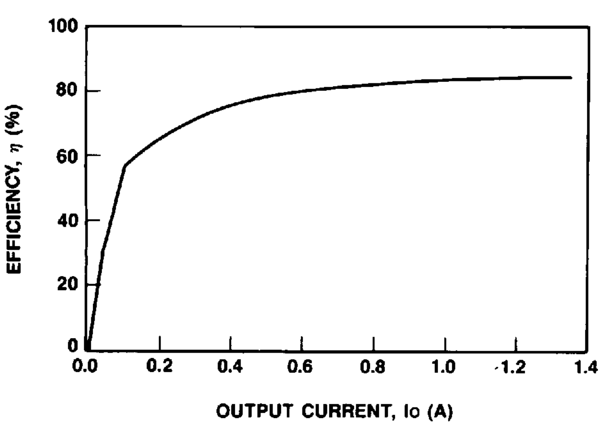


Figure 10. FE020C Typical Converter Efficiency as a Function of Output Current with V_I = 48 V; T_A = 25 °C

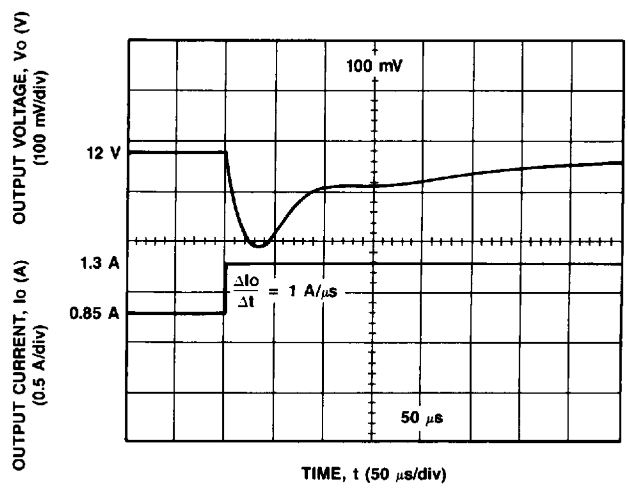


Figure 12. FE020B Typical Output Voltage Waveform for a Step Load Change from 50% to 75% of $I_{O,\,max}$; V_I = 48 V; T_A = 25 °C

Characteristic Curves (continued)

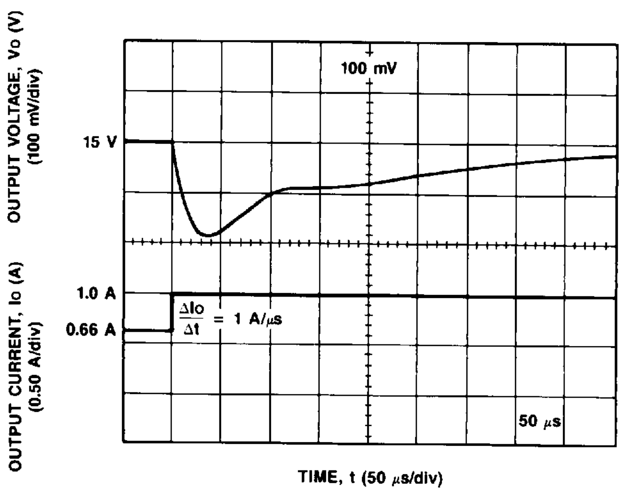


Figure 13. FE020C Typical Output Voltage Waveform for a Step Load Change from 50% to 75% of $I_{O, max}$; V_I = 48 V; T_A = 25 °C

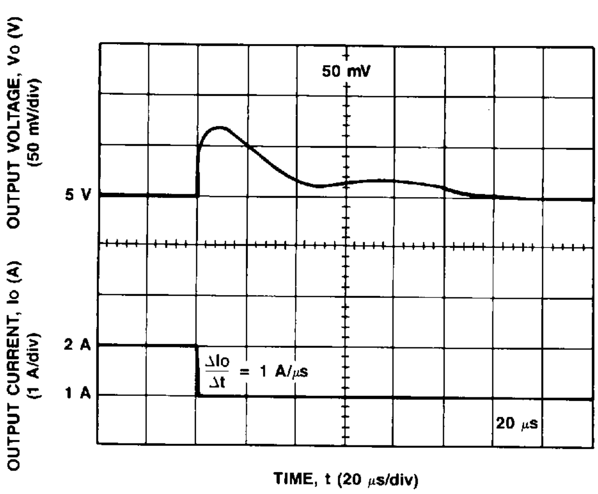


Figure 14. FE020A Typical Output Voltage Waveform for a Step Load Change from 50% to 25% of $I_{O, max}$; V_I = 48 V; T_A = 25 °C

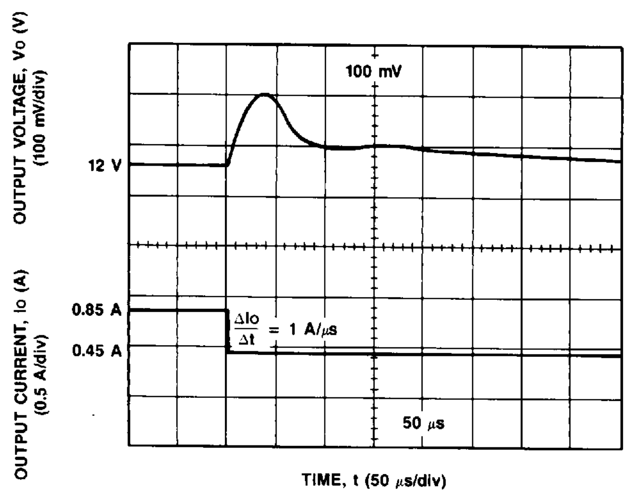


Figure 15. FE020B Typical Output Voltage Waveform for a Step Load Change from 50% to 25% of $I_{O, max}$; V_I = 48 V; T_A = 25 °C

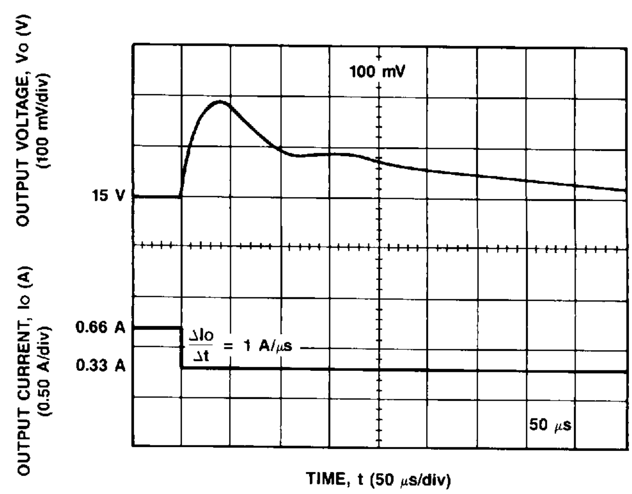


Figure 16. FE020C Typical Output Voltage Waveform for a Step Load Change from 50% to 25% of $I_{O, max}$; V_I = 48 V; T_A = 25 °C

Characteristic Curves (continued)

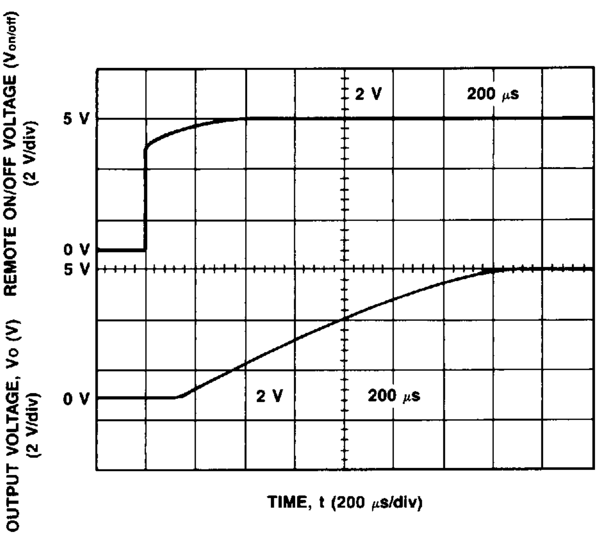


Figure 17. FE020A Typical Output Voltage Start-Up Waveform Once Remote On/Off Is Removed at V_I = 48 V; I_O = 80% of $I_{O, max}$; T_A = 25 °C

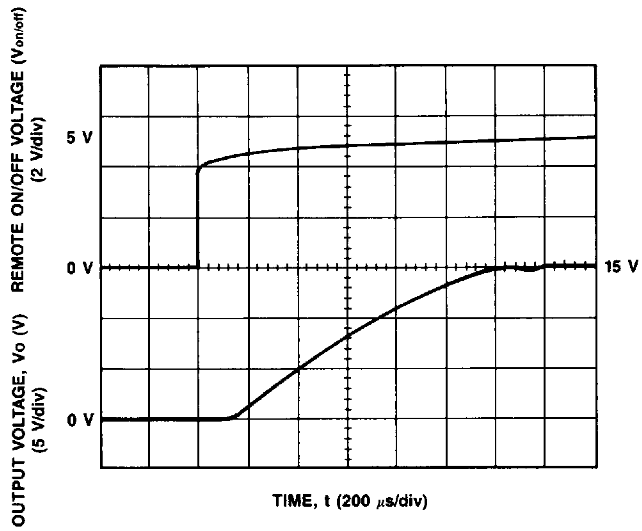


Figure 19. FE020C Typical Output Voltage Start-Up Waveform Once Remote On/Off Is Removed at V_I = 48 V; I_O = 80% of $I_{O, max}$; T_A = 25 °C

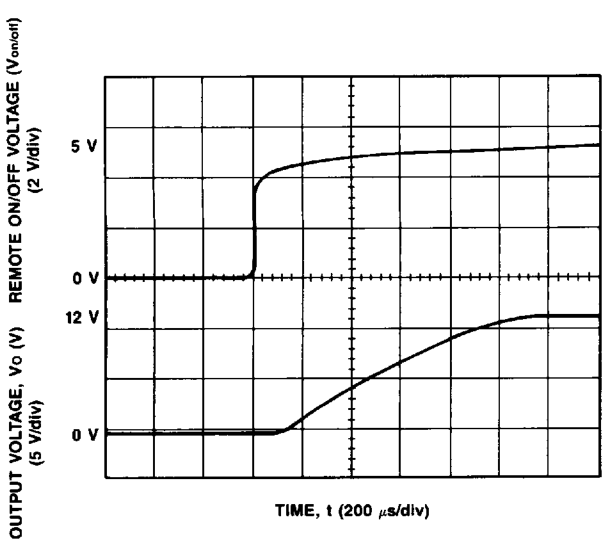
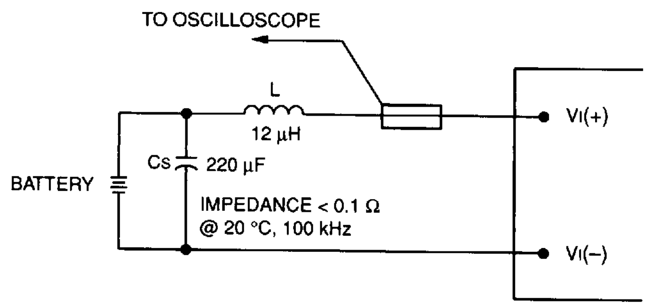


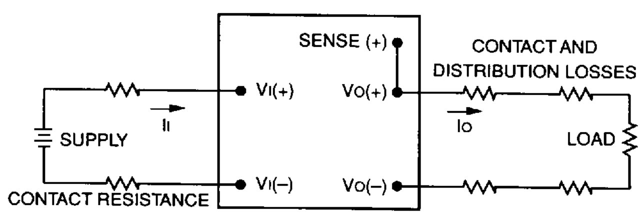
Figure 18. FE020B Typical Output Voltage Start-Up Waveform Once Remote On/Off Is Removed at V_I = 48 V; I_O = 80% of $I_{O, max}$; T_A = 25 °C

Test Configurations



Note: Input reflected-ripple current is measured with a simulated source impedance of 12 µH. Capacitor Cs offsets possible battery impedance. Current is measured at the input of the module.

Figure 20. 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.

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

Figure 21. Output Voltage and Efficiency Measurement Test Setup

Feature Descriptions

Remote On/Off

To turn the power module on and off, the user must supply a switch to control the voltage between pins 2 and 5. The switch can be an open collector or equivalent (see Figure 22). A logic low is $V_{on/off}$ = 0 V to 0.4 V, during which the module is off. The maximum $I_{on/off}$ during a logic low is 500 µA. The switch should maintain a logic low voltage while sinking 500 µA.

During a logic high, the maximum $V_{on/off}$ generated by the power module is 11 V. The maximum allowable leakage current of the switch at $V_{on/off}$ = 11 V is 10 µA.

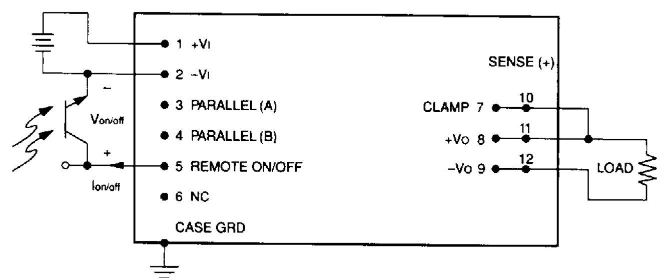


Figure 22. Remote On/Off Implementation for Single Unit Operation

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. The voltage clamp pin must be connected to the positive (+) side of the power bus.

Current Limit

To provide protection in a fault condition, the unit is equipped with internal current limiting 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. For a load resistance that results in an output voltage less than 1 Vdc, some tail-out or output current increase is exhibited. The unit operates normally once the output current is brought back into its specified range.

Feature Specifications (continued)

Remote Sense

Remote sense minimizes the effects of distribution losses by regulating the voltage at the remote-sense connections. The output voltage specifications refer to measurements taken 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.

Synchronization

The power module can by synchronized to an external clock for applications where synchronization is required. A square-wave voltage capable of delivering 6 mA must be placed between terminals 6 and 2. See Figures 23 and 24.

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 25). 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.

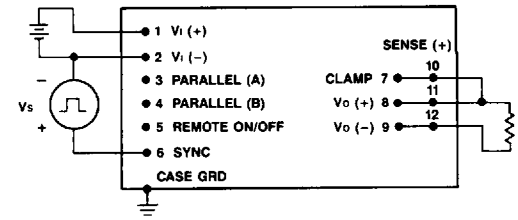


Figure 23. Connection Diagram for Synchronization

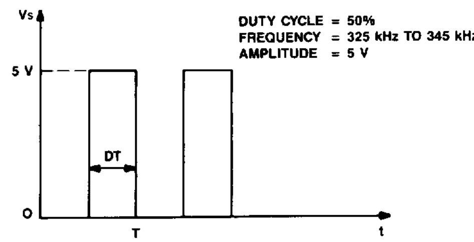


Figure 24. Synchronization Waveform

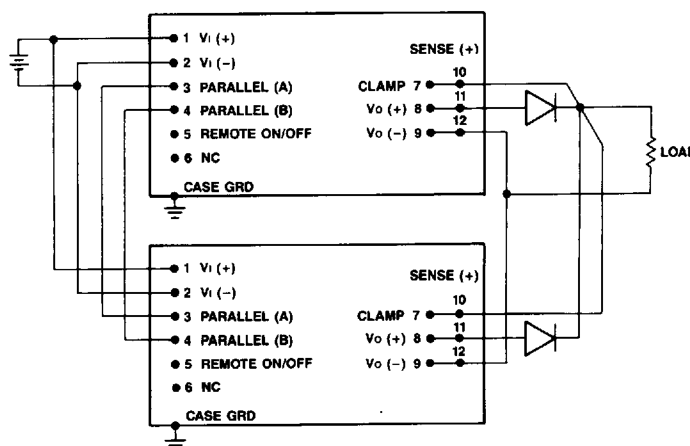


Figure 25. Wiring Configuration for Redundant Parallel Operation

Design Considerations

Input Reflected Ripple

An internal aluminum electrolytic input capacitor is used for filtering; therefore, input ripple increases as temperature decreases. There is approximately two times more ripple at 0 °C than at 25 °C and eight times more ripple at –40 °C than at 25 °C. The power module functions properly down to –40 °C with no additional filtering. If lower ripple is needed, an external capacitor across the input with an impedance of 0.5 Ω at 100 kHz over the desired temperature range is recommended.

Thermal Management

Figure 26 shows the output derating curves for units mounted vertically on boards spaced 3/4 in. apart with natural convection, 100 ft./min., and 200 ft./min. forced-air conditions. Air velocity is measured 0.5 in. above the unit in the center of the channel formed by the unit and the adjacent board (see Figure 27). To ensure proper operation in other environments, the user must not allow the case temperature to exceed 100 °C. Refer to Figure 28 for the location of the case temperature measurements.

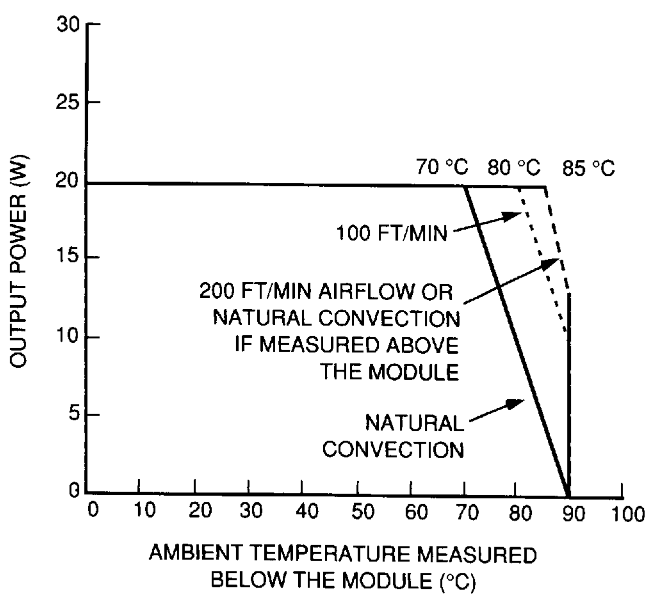


Figure 26. Thermal Derating Curves for FE020A Power Module

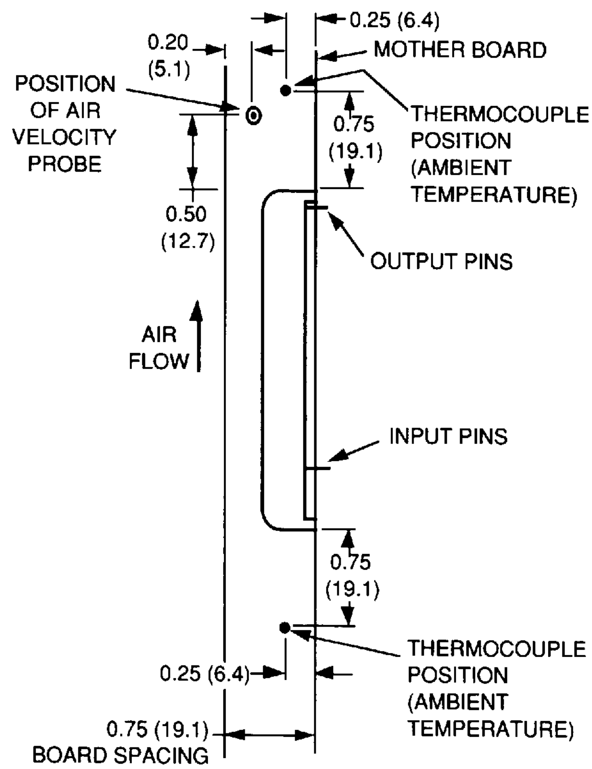


Figure 27. Power Module Orientation in Test Chamber

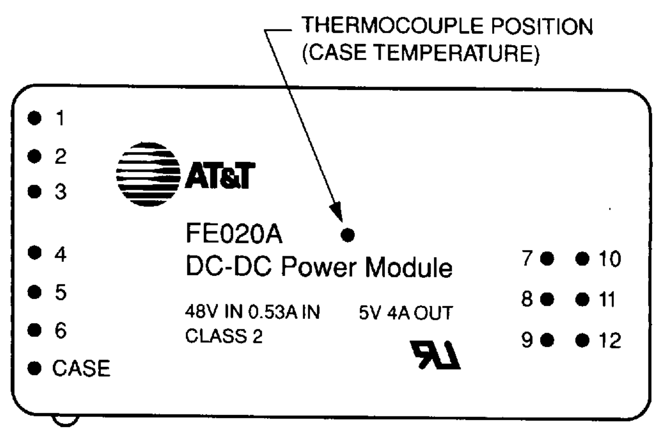


Figure 28. Thermocouple Location

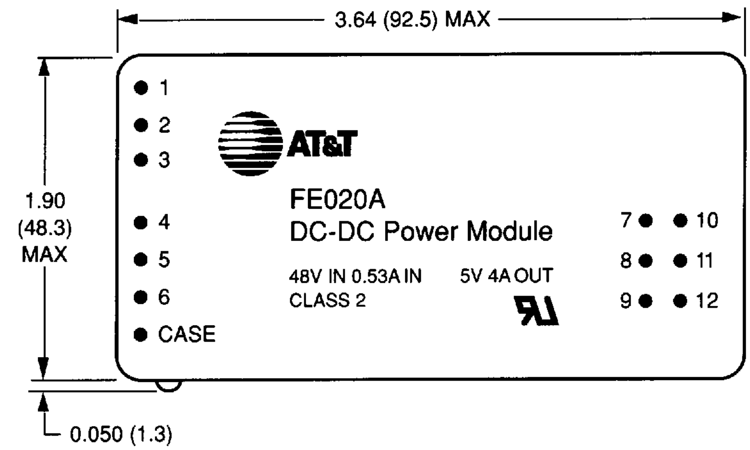
Outline Diagram

Dimensions are in inches and (millimeters).

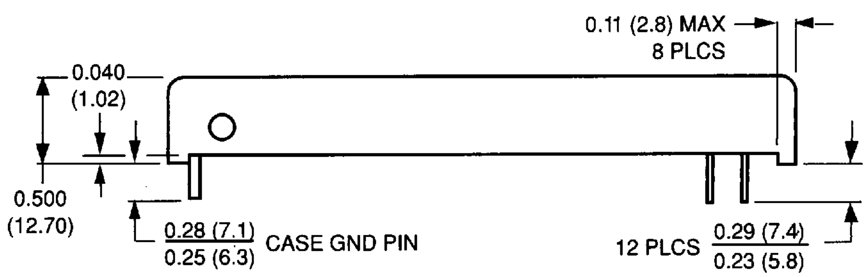
Copper paths must not be routed beneath the power module standoffs.

Tolerances: x.xx ± 0.03 in. (0.76 mm), x.xxx ± 0.015 in. (0.38 mm)

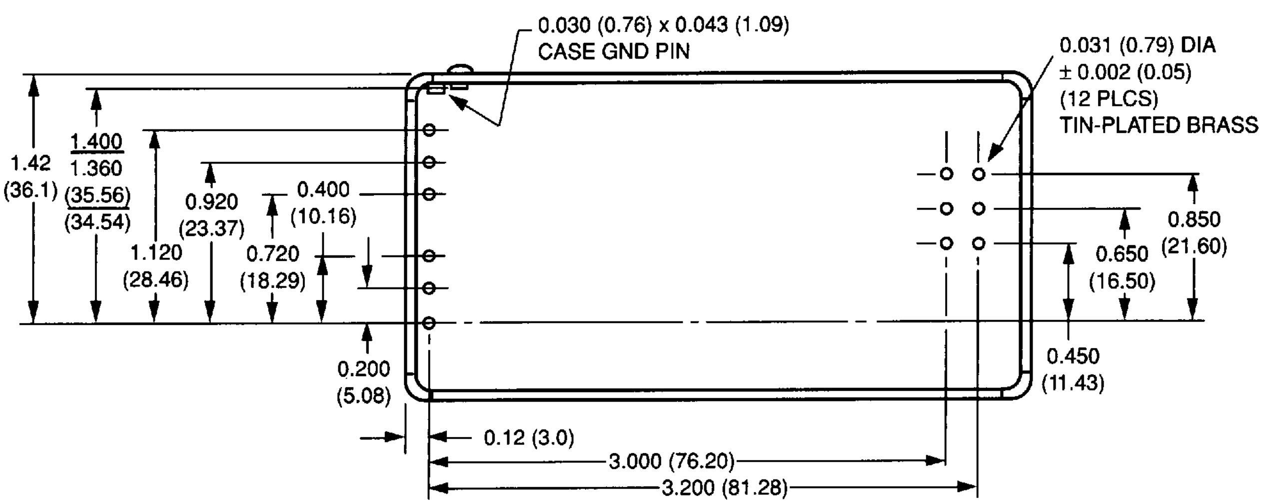
Top View



Side View



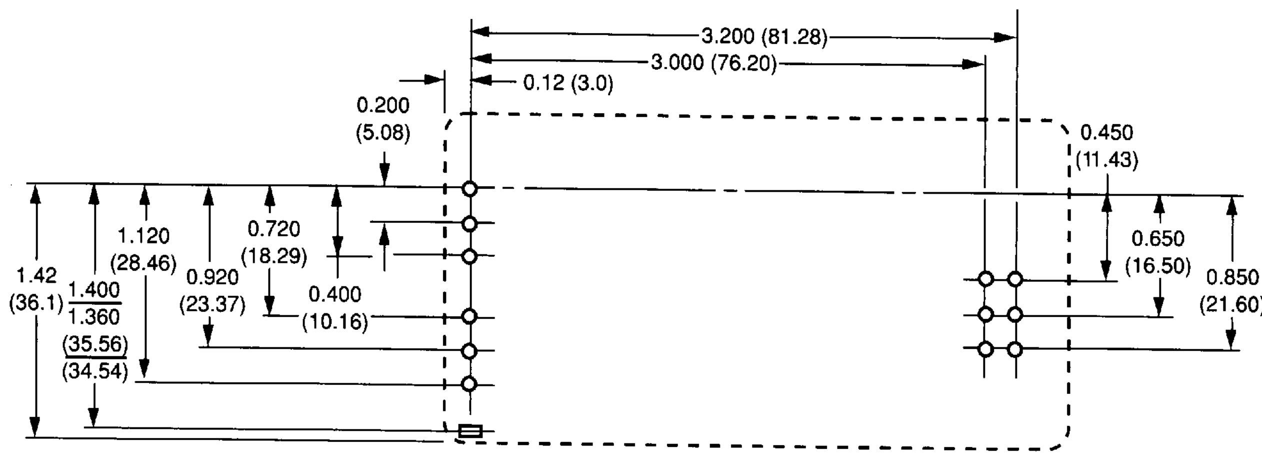
Bottom View



Recommended Hole Pattern

Component-side footprint.

Dimensions are in inches and (millimeters).



Pin Names

Pin	Name
1	VI(+)
2	VI(−)
3	Parallel (A)
4	Parallel (B)
5	Remote On/Off
6	Synchronization
7	Clamp
8	VO(+)
9	VO(−)
10	Remote Sense (+)
11	VO(+)
12	VO(−)

Ordering Information

Description			Device Code	Comcode
Input Voltage	Output Voltage	Output Power		
48 V	5 V	20 W	FE020A	105558233
48 V	12 V	20 W	FE020B	105558241
48 V	15 V	20 W	FE020C	105558258

For additional information, contact your AT&T Account Manager or the following:
U.S.A.: AT&T Microelectronics, Dept. 52AL040420, 555 Union Boulevard, Allentown, PA 18103
1-800-372-2447, FAX 215-778-4106 (In CANADA: **1-800-553-2448**, FAX 215-778-4106)
EUROPE: AT&T Microelectronics, AT&T Deutschland GmbH, Bahnhofstr. 24A, D-8043 Unterfoehring, Germany
Tel. 089/950 86-0, Telefax 089/950 86-111
ASIA PACIFIC: AT&T Microelectronics Asia/Pacific, 14 Science Park Drive, #03-02A/04 The Maxwell, Singapore 0511
Tel. (65)778-8833, FAX (65) 777-7495, Telex RS 42898 ATTM
JAPAN: AT&T Microelectronics, AT&T Japan Ltd., 31-11, Yoyogi 1-chome, Shibuya-ku, Tokyo 151, Japan
Tel. (03) 5371-2700, FAX (03) 5371-3556
SPAIN: AT&T Microelectronica de España, Poligono Industrial de Tres Cantos (Zona Oeste), 28770 Colmenar Viejo, Madrid, Spain
Tel. (34) 1-8071441, FAX (34) 1-8071420

June 1991
DS91-099EPS
(Replaces DS88-51POW, DS88-85POW, DS88-86POW, and DA90-003EPS)

AT&T Microelectronics