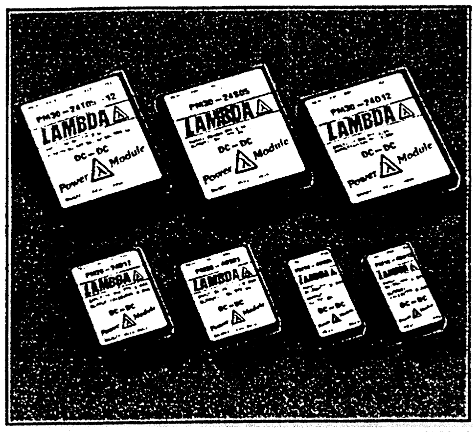

Lambda's new PM Series of Bellcore and ETSI compliant DC-DC converters are specifically designed for telecom, datacom and computer applications. They offer industry standard pin-outs, SMT technology, and the fastest delivery time in the industry.

Application Note

PM Series of Power Modules

Lambda Error-free Action Process

Lambda Electronics Inc.
515 Broad Hollow Rd. • Melville, NY 11747
Tel: 516-694-4200 • 1-800-LAMBDA-4/5 • Fax: 516-293-0519

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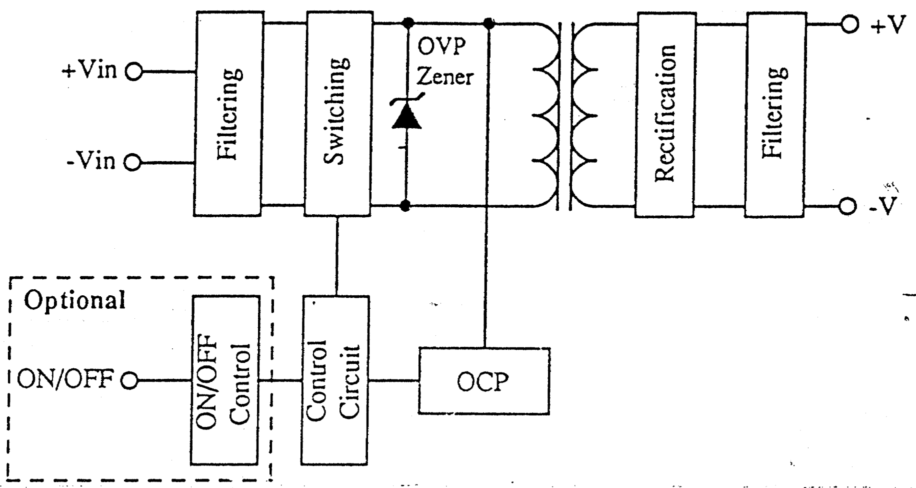
ANPM

Table of Contents

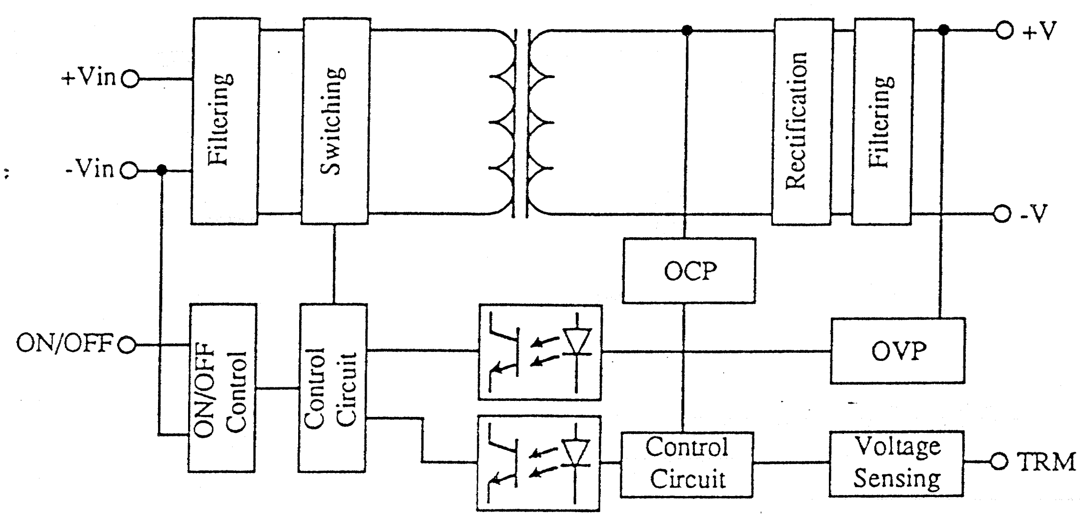
Typical Block Diagrams

- Topology
  PM10 Series: Flyback topology
  PM20, PM30 Series: Fly Forward topology
  Switching Frequency: 350KHz for the entire PM Series

- **PM10-12S, PM10-24S, PM10-48S**

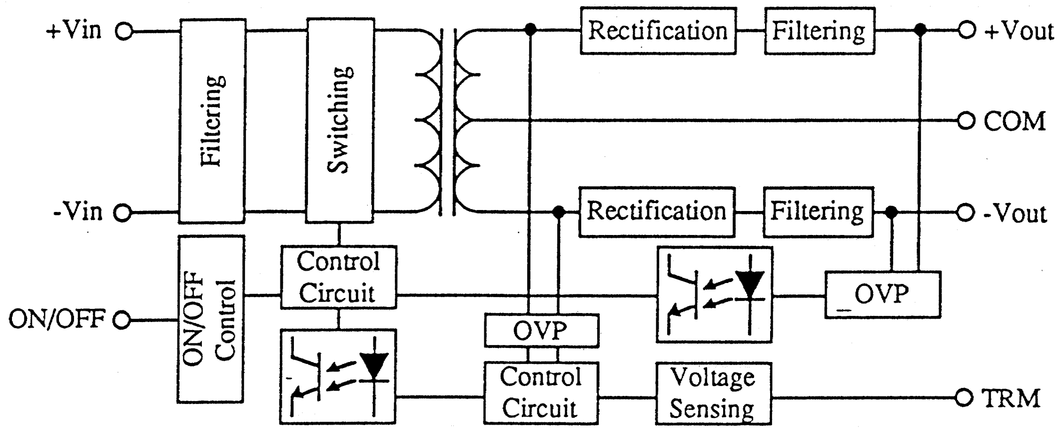


- PM20-12S, PM20-24S, PM20-48S, PM30-12S, PM30-24S, PM30-48S

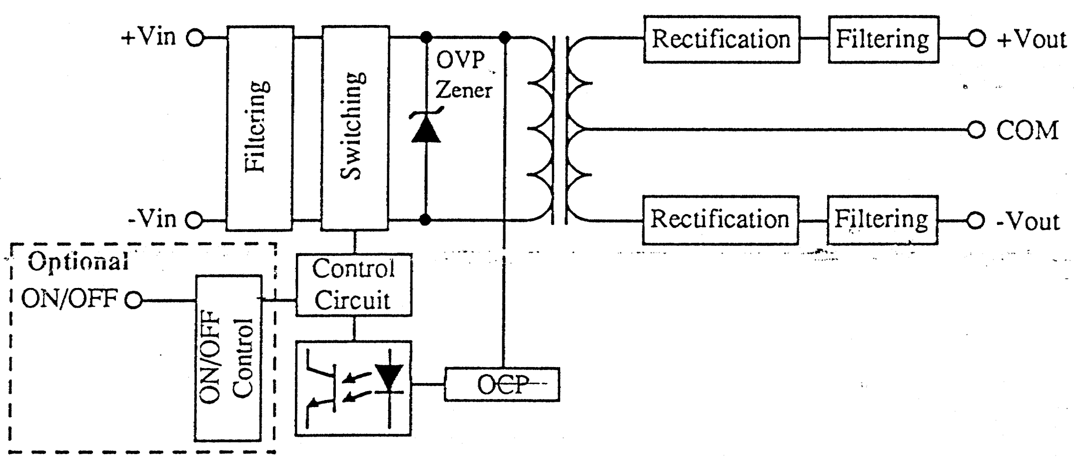


PM Series Input Range
Typical Block Diagrams, cont'd.

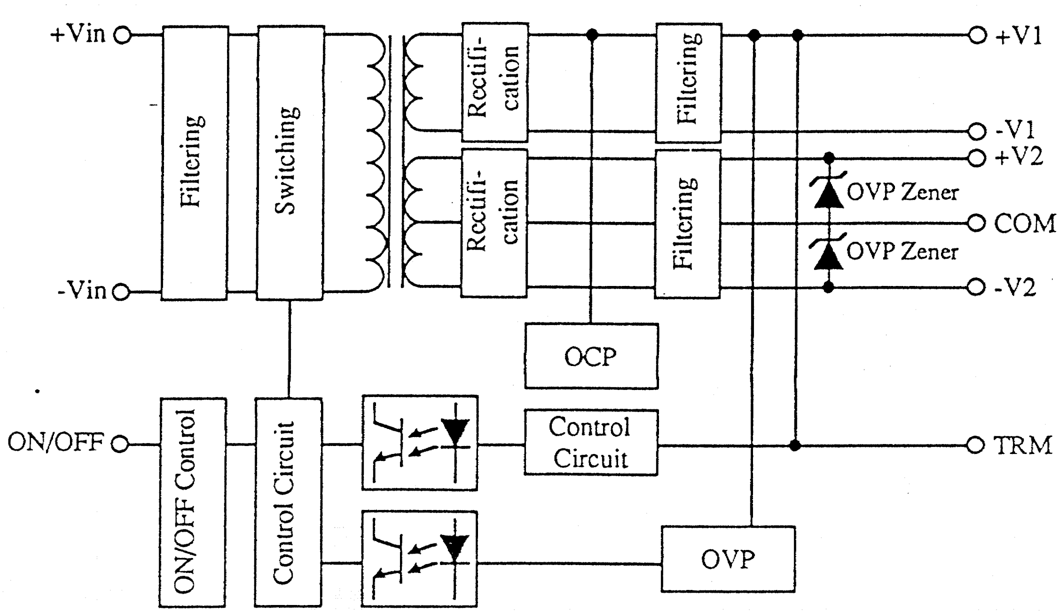
- **PM20-12D, PM20-24D, PM20-48D, PM30-12D, PM30-24D, PM30-48D**



- **PM10-12D, PM10-24D, PM10-48D**



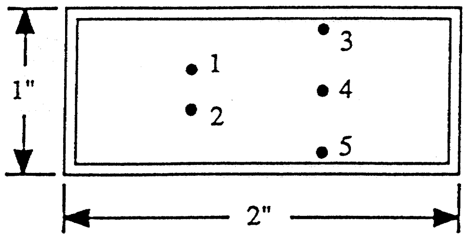
- **PM30-12T, PM30-24T, PM30-48T**



Pinout Description - Mechanical Layouts

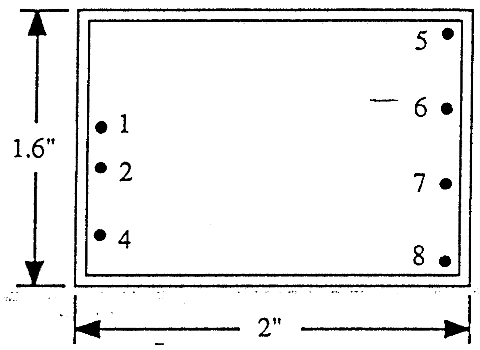
Note: Case height on all models - 0.33"

• PM10 Series



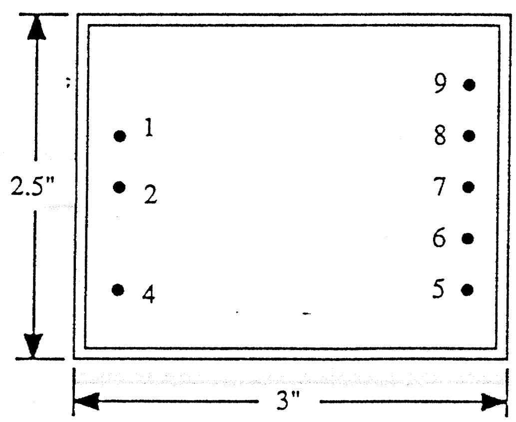
Connections		
Pin No.	Function	
	Single	Dual
1	+Vin	+Vin
2	-Vin	-Vin
3	+Vo	+Vo
4	No Pin	Common
5	-Vo	-Vo

• PM20 Series



Connections		
Pin No.	Function	
	Single	Dual
1	+Vin	+Vin
2	-Vin	-Vin
3	No Pin	No Pin
4	ON/OFF	ON/OFF
5	No Pin	+Vo
6	+Vo	Common
7	-Vo	-Vo
8	TRIM	TRIM

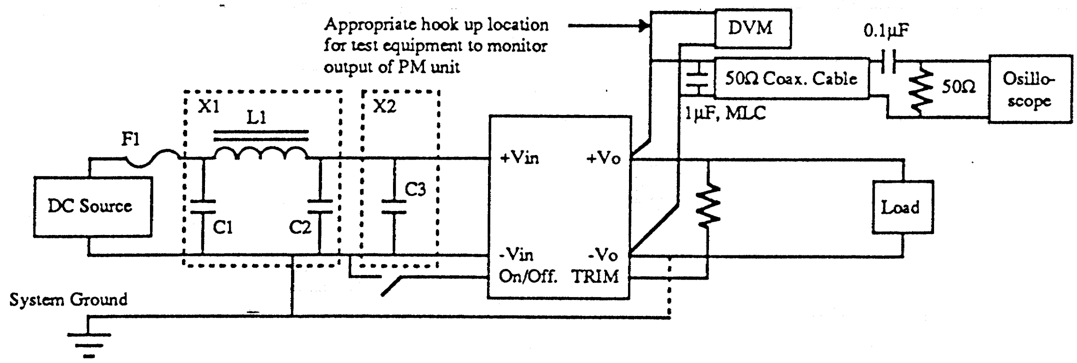
• PM30 Series



Connections			
Pin No.	Function		
	Single-	Dual	Triple
1	-Vin	-Vin	-Vin
2	+Vin	+Vin	+Vin
3	No Pin	No Pin	No Pin
4	ON/OFF	ON/OFF	ON/OFF
5	TRIM	TRIM	TRIM
6	+Vo	+Vo	+5 / +3.3
7	-Vo	Common	Common
8	No Pin	No Pin	+12
9	No Pin	-Vo	-12

Basic Connections - Recommended Circuit Hook up

- **For optimal performance, the following circuit hookup is recommended.**



1.0 Input Voltage Range

The input voltage range for the PM Series of modules differs for each nominal input voltage, as shown in the following:

- For the 12 Volt Input Series : 9 to 18 volt input range
- For the 24 Volt Input Series : 18 to 36 volt input range
- For the 48 Volt Input Series : 36 to 75 volt input range

Input voltage is comprised of both the DC voltage (average rectified voltage) and the peak to peak ripple voltage, and is dependent upon the input source and capacitance. Peak to peak ripple voltage should be minimized to 4V p-p for optimum output ripple performance. Above 4V p-p, output ripple performance will degrade without damage to the DC-DC converter.

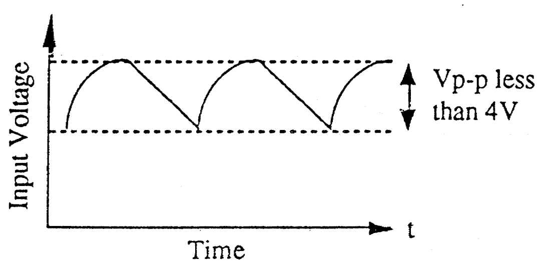


Figure 1-1

1.1 Input Fuse (F1)

An external input fuse is not provided in the power module. To ensure safe operation and protection to the module, an external fuse (fast blow type) is recommended. The fuse should be installed in the +Vin line to the power module.

1.2 Recommended Fuse Ratings

+12V Input	
Model	Fuse
PM10	2A
PM20	6A
PM30	8A

+24V Input	
Model	Fuse
PM10	1A
PM20	3A
PM30	4A

+48V Input	
Model	Fuse
PM10	0.5A
PM20	1.5A
PM30	2.0A

1.3 LC Input Circuitry (X_1 and X_2)

Input filter components in X_1 (C1, C2, L1) are used to achieve European Conducted Emissions compliance to EN55022 level B , VDE0871 Curve B , FCC Part 15 Subpart J Class B, and MIL-STD-461D CE102. These components are only used on the PM10 and PM20 48 Volt input series. For the PM30 48 Volt input series, a 39μF, 100V electrolytic capacitor is used as shown in input circuitry X_2 (C3) to meet EN55022 (level B) compliance. Without these components, the PM module will meet level A compliance.

The following is a list of recommended values and part numbers for input filter components. These components should be mounted as close as possible to the PM module; and all leads should be minimized to decrease radiated noise.

Table 1-1 LC Input Circuitry Components

PM Series	X1			X2
	C1	L1	C2	C3
PM10	22μF, 100V Electrolytic	3.3μH	22μF, 100V Electrolytic	---------
PM20	1μF, MLC	5.5μH	39μF, 100V	---------
PM30	---------	---------	---------	39μF, 100V Electrolytic

An optional low impedance capacitor in parallel with C3 can be added to the input terminals to reduce reflected ripple current to the DC source. A recommended value for the low impedance capacitor is 49μF with a low ESR value (typically 50mΩ).

2.0 Remote ON/OFF Control (ON/OFF Terminal)

PM20 and PM30 models offer a remote ON/OFF feature that can enable or disable the output from the primary (input) side of the power module. This feature is useful in timing sequences, where the input voltage does not need to be recycled to turn on the module, therefore avoiding unwanted inrush currents. The remote ON/OFF feature is controlled via the ON/OFF terminal, which is referenced to the -Vin terminal for converter modules. Standard PM10 modules are not available with the remote ON/OFF feature, but may be ordered with this option.

1) The maximum voltage applied to the ON/OFF terminal is 5V, with a maximum reverse voltage of 0.7V. The sink current at the ON/OFF terminal is approximately 0.5mA.

2) Remote ON/OFF control can also be exercised by opening o closing the contacts of a switch or relay, or by operating a transistor a a switch in series with the ON/OFF terminal.

3) A standard remote ON/OFF control circuit is provided in the primary circuit. For secondary control, isolation can be achieved through the use of an optocoupler or relay.

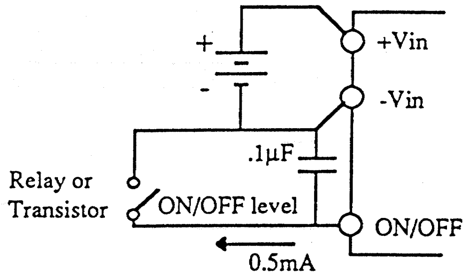


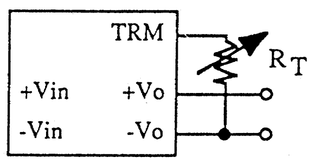
Figure 2-1 CNT Terminal Connection

Table 2-1 ON/OFF Control Mode

Remote ON/OFF Level for INPUT - SG	OUTPUT
H (more than 4V) or open	ON
L (less than 0.7V) or short	OFF

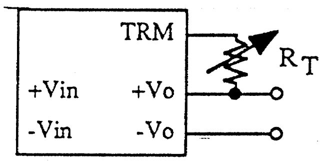
3.0 Output Voltage Adjustment

Both the PM20 and PM30 Series outputs are adjustable to ±10% of Vout nominal. Output voltage adjustment is obtained via the combination of the internal programming string circuit and an external resistance (RT). The formulas below were derived from the two circuits below. Please refer to them or the graphs for output adjustment. A resistor is placed from the trim pin to -Vo for positive voltage adjustment, and to +Vo for negative voltage adjustment.



$$R_T = \left[\frac{V_{ref}}{\left[\frac{V_{out} - V_{ref}}{R1} - \frac{V_{ref}}{R2} \right]} - R3 \right]$$

Figure 3-1 Adjustment for Positive Voltage



$$R_T = \left[\frac{V_{out} - V_{ref}}{\left[\frac{V_{ref}}{R2} - \frac{V_{out} - V_{ref}}{R1} \right]} - R3 \right]$$

Figure 3-2 Adjustment for Negative Voltage

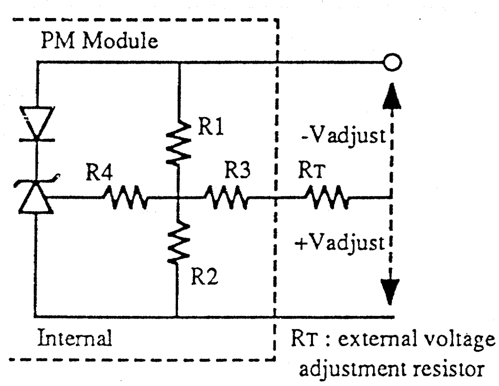


Figure 3-3

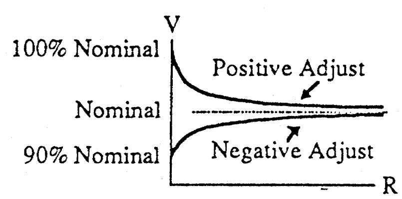


Figure 3-4

Output Voltage	R1		R3
3.3V	787		7.5k
5V	2.49k		9.42k
	Single	Dual	
12V	9.42k	21.3k	21.3k
15V	12.4k	27.4k	21.3k

Table 3-1 Resistor Values

* For all PM Modules, the value for R2 is 2.49KΩ, and the reference voltage (Vref) is 2.5V.

4.0 Ripple Measurement

The following circuit is recommended to measure the output ripple voltage for all PM Modules.

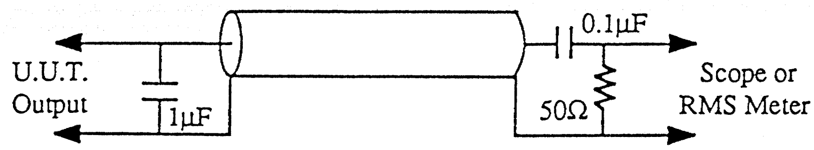


Figure 4-1 Output Ripple Measurement Circuit

4.1 Minimized Leads

This diagram is the basic representation of an oscilloscope probe. To avoid radiated noise, be sure to make all leads as short as possible. The tip of most oscilloscope probes can be manipulated to do this as follows. The bandwidth on the oscilloscope should be set to 20MHz.

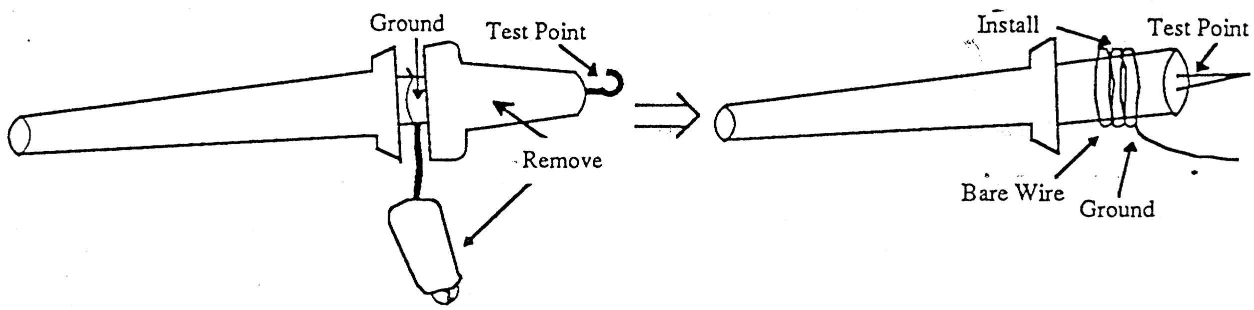


Figure 4-2 Minimized Probe Leads

Typical output ripple is 100mVp-p, but can be improved with additional electrolytic caps and layout considerations. Some considerations for layout (to improve output ripple) design are to make all connections as short as possible, large ground planes, and to place the load as closely as possible to the PM module.

5.0 Temperature Considerations

5.1 Thermal Design

Thermal conditions are critical in the design of a power converter application. Excessive heat is the primary cause for failure of DC-DC converters. This heat must be removed effectively in order to prolong the unit's life.

There are three basic relationships required for practical thermal design of DC-DC converters. These include efficiency, power dissipation and thermal resistance relationships.

$$\text{Efficiency} = \eta = \frac{\text{Pout}}{\text{Pin}}$$

The internal power dissipated is given by the following equation:

$$\text{Pdiss} = \text{Pout}\left[\frac{1-\eta}{\eta}\right]$$ where η = efficiency, Pout = Vout x Iout

$P_{DISS} = P_{IN} - P_{OUT}$

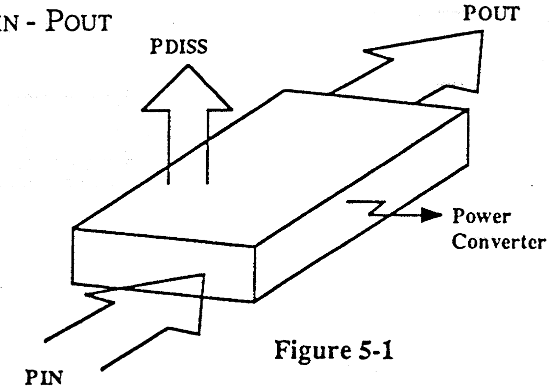
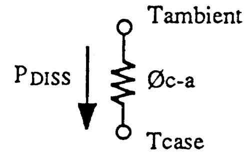


Figure 5-1



$$Øc\text{-}a = \frac{\text{Tambient} - \text{Tcase}}{\text{PDISS}}$$

Figure 5-2 Basic Thermal Impedance Relationship

Dissipation in a PM module can be modeled similarly to an electrical circuit where P_{DISS} (dissipated power) relates to current, Øc-a (thermal impedance) relates to resistance and Tambient and Tcase (temperatures) relate to voltages. The maximum case temperature for the PM modules is 105°C.

Baseplate temperature and thermal impedance are both a function of airflow. These characteristics can be seen in the following diagrams.

Figure 5-3 PM10 delta T case vs. Airflow

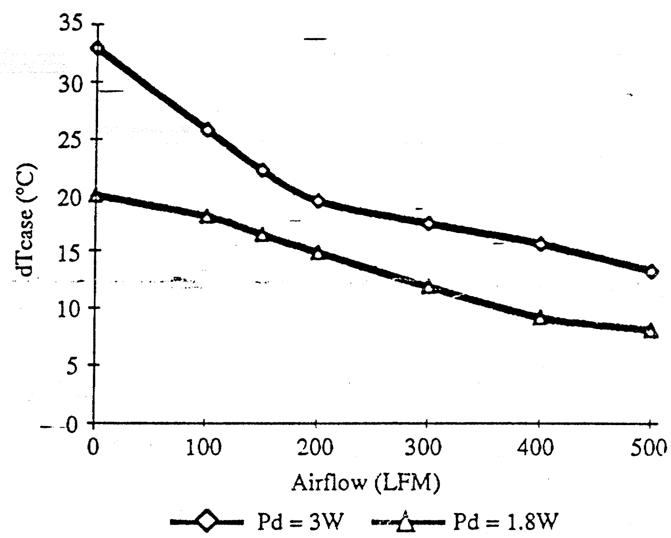


Figure 5-4 PM10 Thermal Impedance vs. Airflow

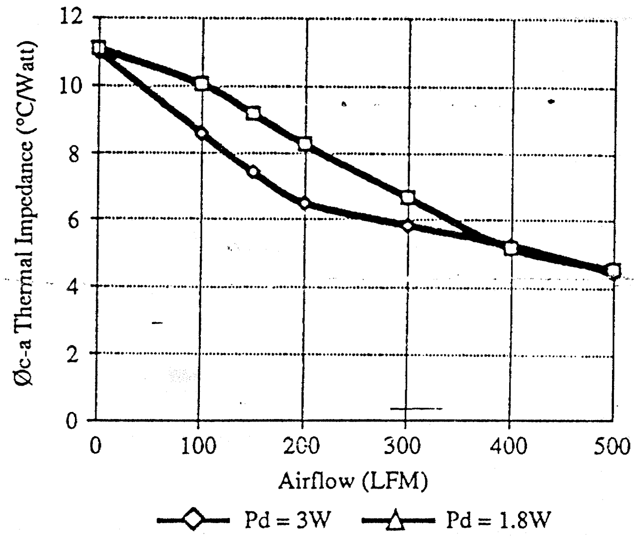


Figure 5-5 PM20 delta T case vs. Airflow

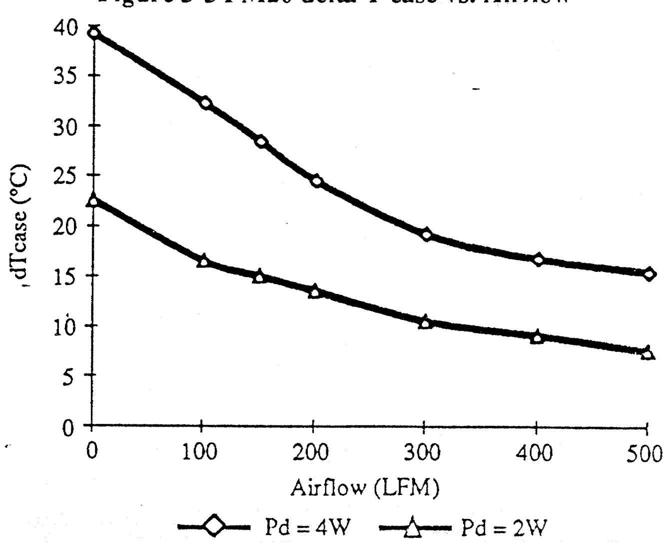


Figure 5-6 PM20 Thermal Impedance vs. Airflow

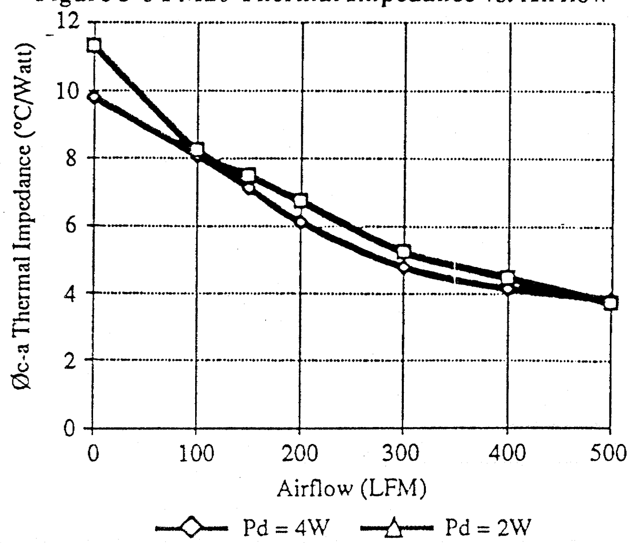


Figure 5-7 PM30 delta T case vs. Airflow

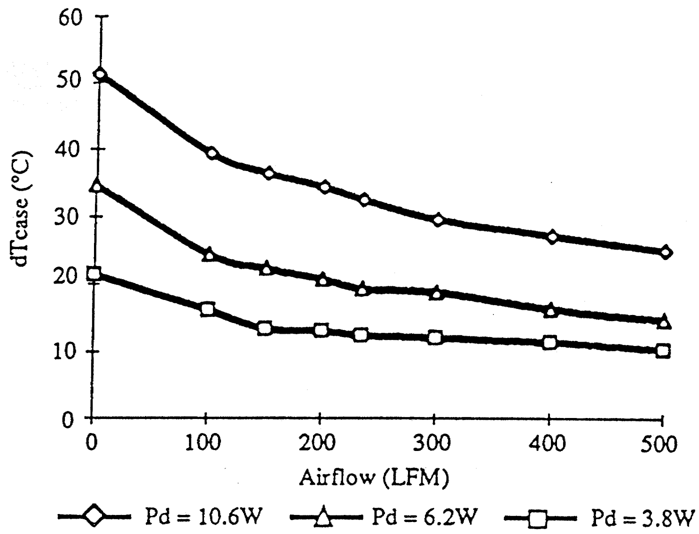
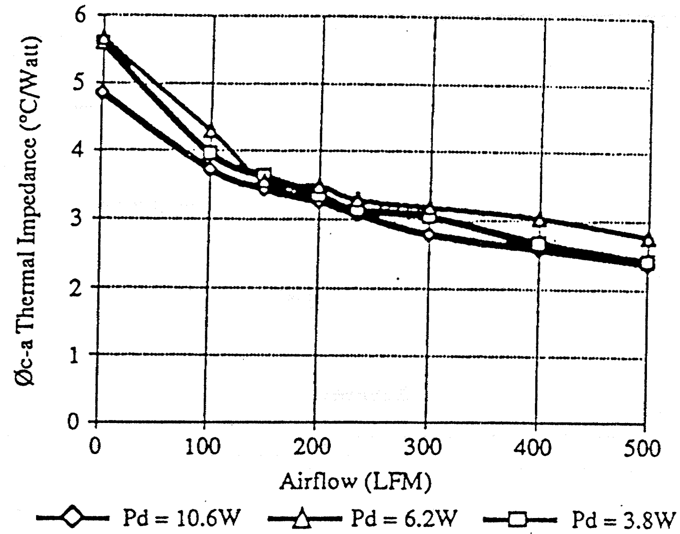


Figure 5-8 PM30 Thermal Impedance vs. Airflow



5.2 Airflow Selection

The following calculations demonstrate a typical thermal design using DC-DC converters. For all modules, the maximum case temperature is 105°C. Assume the following efficiencies for the various PM Modules, and keep in mind that the air flow selection should be determined at worst case scenario, which is at full load (maximum output power):

Table 5-1 Efficiency

PM Module	Output	Efficiency
PM10	3.3V	72%
	5V, 12V, 15V	78%
PM20	3.3V	77%
	5V, 12V, 15V	82%
PM30	3.3V	71%
	5V, 12V, 15V	74%

Example: To calculate or verify the proper air flow to operate a PM20-48S05 at 70°C (ambient), the following procedures are performed.

Given:

Figure 5-9 PM20 delta T case vs. Airflow

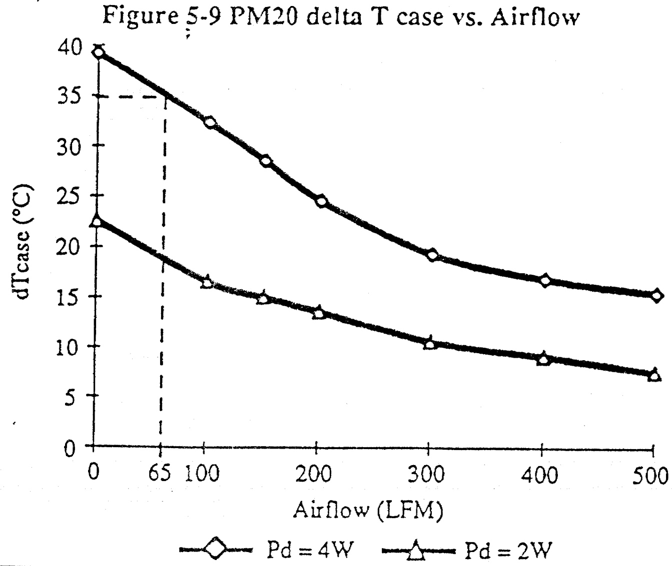
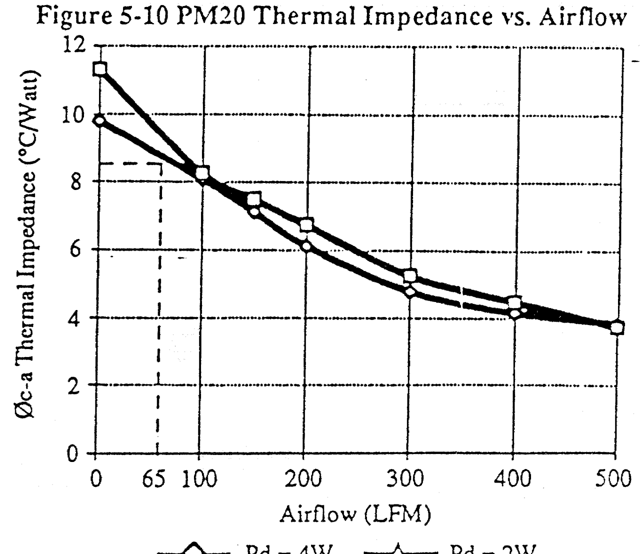


Figure 5-10 PM20 Thermal Impedance vs. Airflow



Pout = 20 Watts
Efficiency = 82% (see Efficiency chart on the previous page)
Max. Case Temperature = 105°C
Operating Temperature = 70°C (ambient)

- Formula for airflow determination on delta T case vs. Airflow diagram:

$$\eta = \text{Efficiency}$$

$$P_{diss} = \left(\frac{1-\eta}{\eta}\right) P_{out}$$

$$= \left(\frac{1-.82}{.82}\right) 20W = 4.4 \text{ Watts}$$

-From the delta T case vs. Airflow diagram, on the 4W line airflow is determined to be 65LFM.

- Formulas for airflow determination on the Thermal Impedance vs. Airflow diagram:

Tcase = Max. Case Temp. - Ambient Temp.
= 105°C - 70°C = 35°C

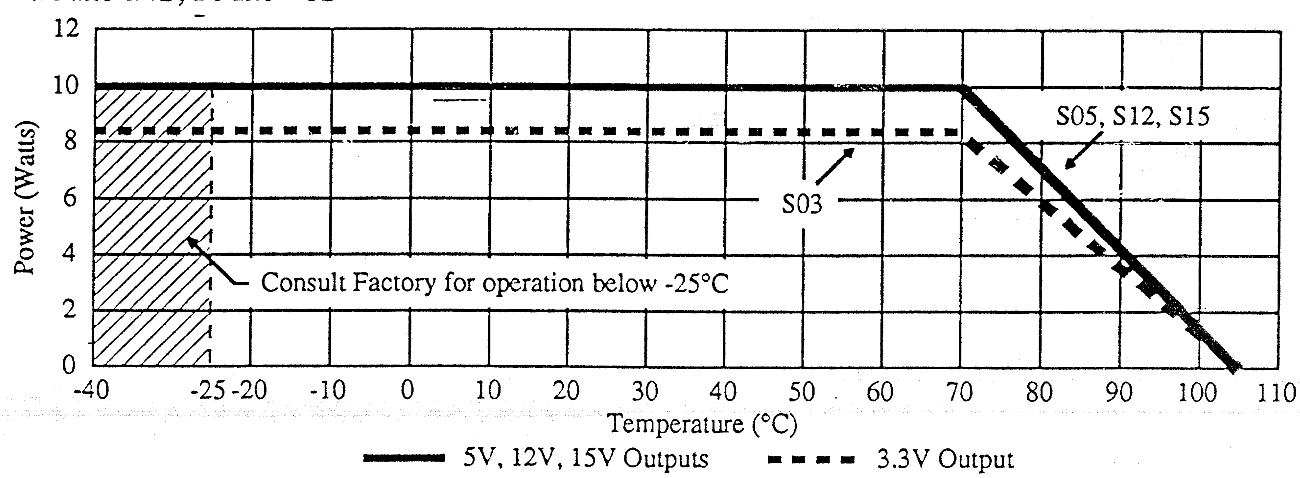
$$\theta_{CA} = \frac{T_{ambient} - T_{case}}{P_D}$$

$$= \frac{70°C - 35°C}{4} = 8.75$$

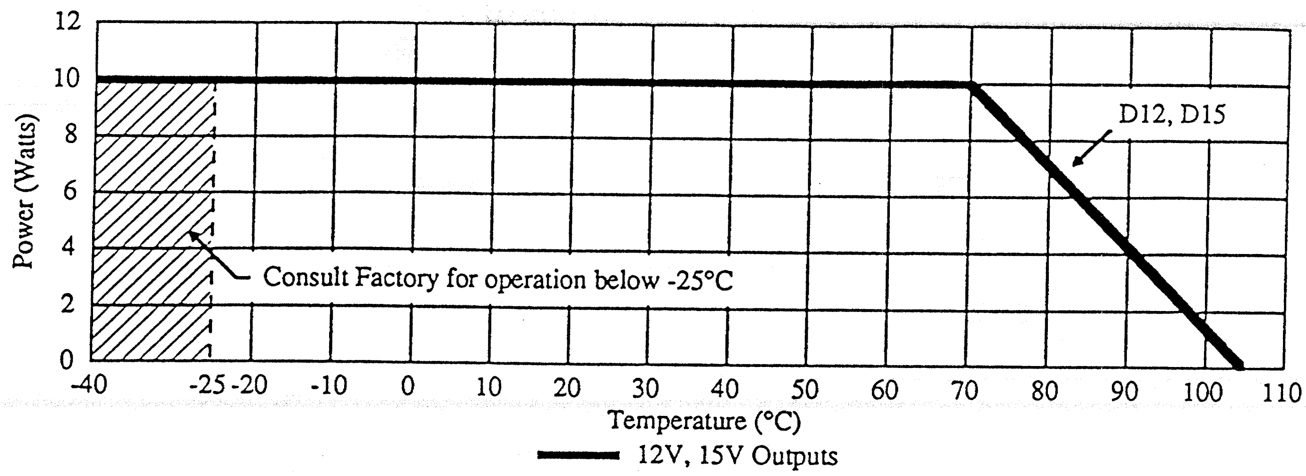
- From the Thermal Impedance vs. Airflow diagram, the same airflow of 65LFM is determined.

5.3 Total Output Power vs. Ambient Operating Temperature

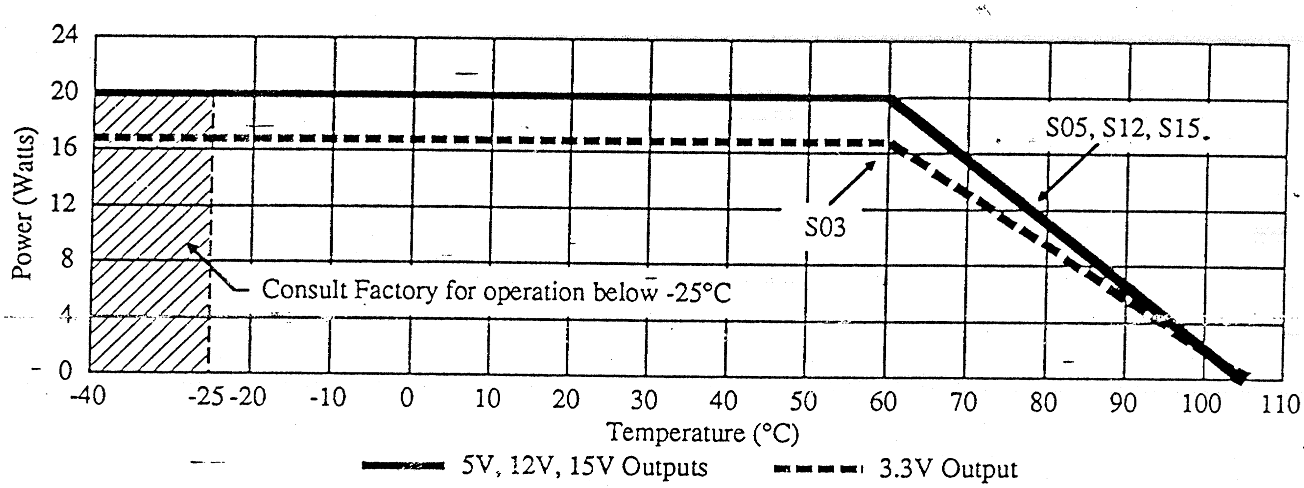
- **PM10-24S, PM10-48S**



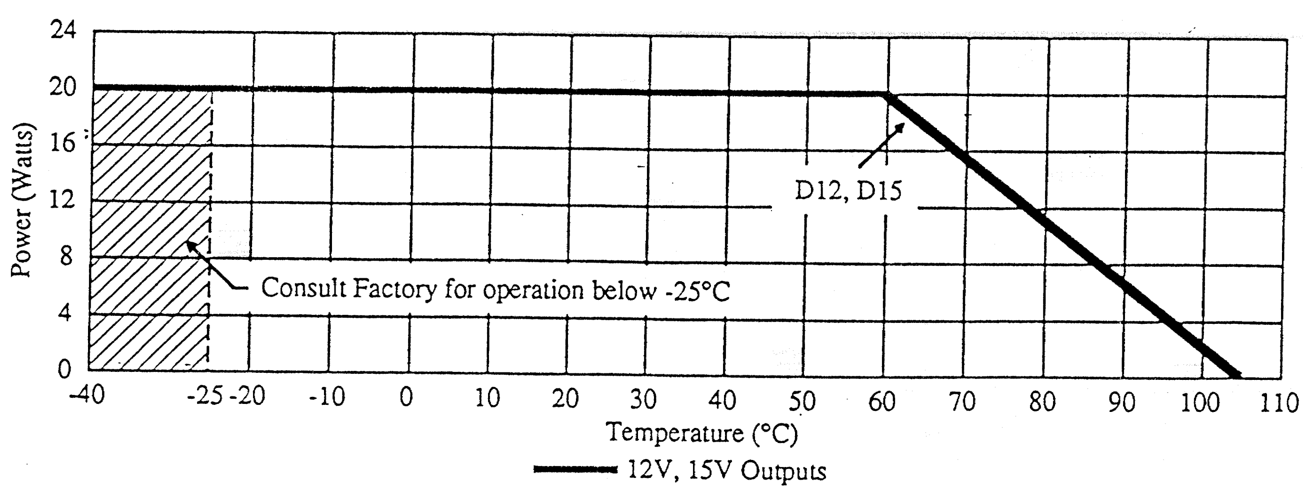
• PM10-24D, PM10-48D



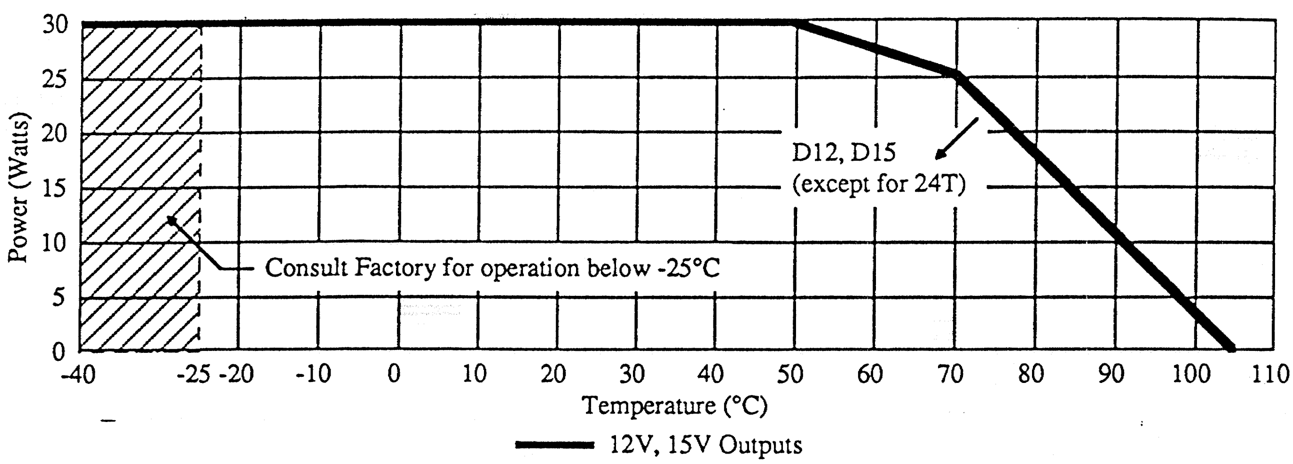
• PM20-24S, PM20-48S



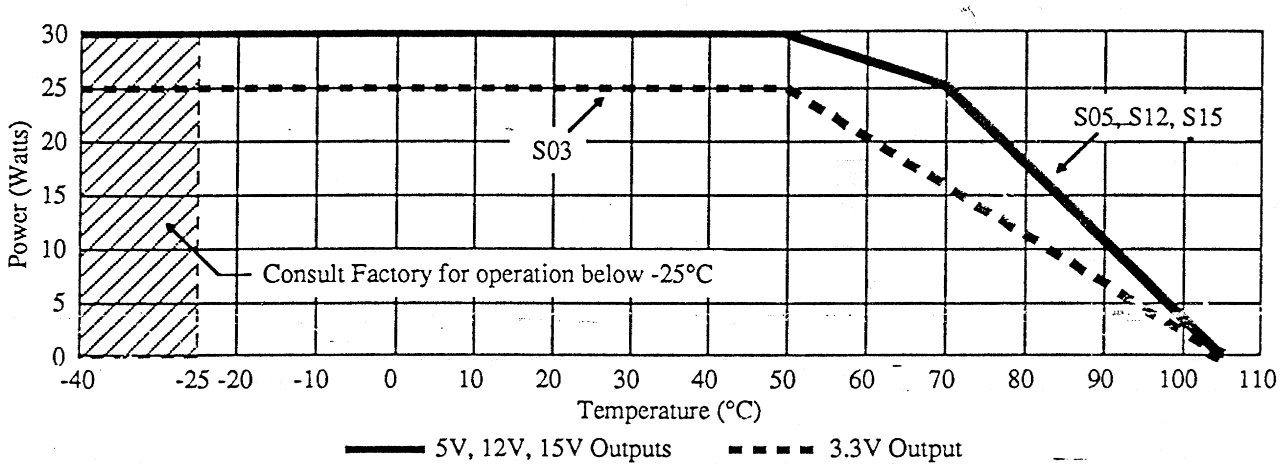
• PM20-24D, PM20-48D



• PM30-24D, PM30-48D, PM30-24T (no D12, D15 for -24T)



• PM30-24S PM30-48S



6.0 Overcurrent Protection

The PM Series is equipped with an over current protection circuit that provides a foldback characteristic. The current limit point is factory set from 110% to 175%, and cannot be changed.

If an output short or overcurrent condition occurs, the output voltage will automatically recover once the abnormal condition is cleared. It is not recommended to operate the power module continuously under an overcurrent or short circuit condition. These are both abnormal conditions where standard specifications and normal operation of the module do not apply.

7.0 Overvoltage Protection

All PM modules include a built-in overvoltage protection circuit which prevents damage to the load caused by an excessive power supply output voltage. This feature is a clamping-type effect. The overvoltage is a fixed value and cannot be changed. OVP is achieved via a clamping type circuit where DC input does not have to be recycled to clear an O.V. condition.

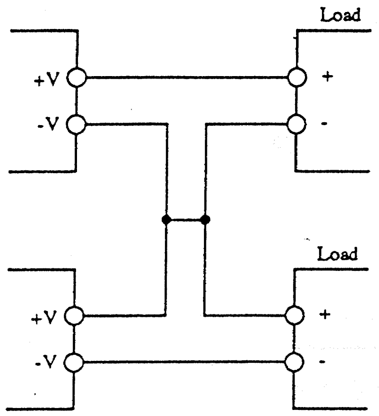
8.0 Series Operation

All PM modules allow for series operation with any combination of output voltages.
Example :
Vout desired = 30V
Iout desired = 2A

The maximum output voltage available with a standard PM module is 15V. Therefore two modules can be connected in series to provide 30V.

8.1 +/- Output Series Operation

When the load on the positive side is isolated from the load on the negative side, the following connection hookup is recommended. Note that bypassing diodes are not needed when operating in this mode.



8.2 Series Operation for High Output Voltage Applications

When using PM modules in a high output voltage configuration, external bypassing diodes need to be connected to prevent a reverse voltage from being applied to either module. Note that high voltage series operation can be used up to a maximum of 500Vdc.

1) Peak Reverse Voltage
VRRM > 2x the power module output voltage

2) Average Output Current
Io > twice the power module output current

3) Forward Voltage
VF = minimum (schottky barrier type recommended)