PowerBlok®

User and Installation
Manual

MTS Systems Corporation
Automation Division

2101 North Broadway

New Ulm, MN 56073

Telephone: 507-354-1616

Fax: 507-354-1611

Part Number :575-00039 Rev 03/17/03

1 INTRODUCTION

Application

This manual is designed to help you install the PowerBlok servo drive.

Unpacking and Inspection

Carefully unpack the drive and inspect it for visible damage. Check items against the packing list. Report any missing or damaged items to your supplier.

Warranty and Service

The servo drive is warranted to be free from defects in workmanship and materials for a period of two years from the original shipment by MTS Automation.

During the warranty period, a defective unit will be repaired or replaced as outlined below.

Before requesting return authorization, please try to verify that the problem is within the drive, and not with external devices.

To arrange for repair or replacement, please contact:

MTS Automation Customer Service
(507) 354-1616
(800) 967-1785
Monday–Friday, 8:00–4:30 Central Time

- You must provide the model and serial number from the labels on the drive.
- You must provide an explanation as to why the unit is being returned.
- You will be issued a return authorization number which must be marked on the return shipment and on all correspondence.

Continued on next page

Warranty and Service (continued)

Service Under Warranty

- Return your defective unit, freight prepaid, and it will be repaired and returned within two weeks of receipt via regular UPS, freight prepaid.
- Upon request, a factory-repaired replacement unit will be sent via regular prepaid UPS, within 4 working days. Next day shipment for overnight delivery, freight collect, is available at an expediting charge of $100. The defective unit is to be returned via regular UPS, freight prepaid, upon your receipt of the replacement.

Non-Warranty Service

- Return your defective unit, freight prepaid, and it will be repaired on a time and material basis and returned within three weeks of receipt.
- OR contact your local distributor or MTS Automation Customer Service for a factory-repaired exchange unit, which is available at a flat rate price, assuming the defective unit is in repairable condition and is returned freight prepaid. Next day shipment for overnight delivery, freight collect, is available at an expediting charge of $100.

General Provisions

Except as specifically modified by this warranty statement, all MTS Automation Conditions of Sale and Warranty shall apply.

Introduction

The PowerBlok is an all digital, direct PWM controlled servo drive suitable for driving brushless permanent magnet rotary servo motors, brushless permanent magnet linear servo motors, and AC inverter duty induction motors. The PowerBlok Integrated Drive Module (IDM) is available as a stand-alone product, or can be combined with an MTS Automation supplied CapBlok and heatsink to form a packaged drive solution. The PowerBlok IDM is available in 240 and 480 Vac offline packages with peak current ratings up to 56 Arms. Detailed product selection information can be found in the PowerBlok Product Specification.

This manual contains detailed instructions on installing, wiring, and configuring a PowerBlok system. The manual is divided into three major sections. The first contains detailed installation and wiring requirements. It includes details on fusing, AC input wiring, dynamic brake wiring, and motor output wiring.

The second major section details the software setup required for PMAC2 or PMACTurbo from Delta Tau Data Systems to control a PowerBlok. While the digital, direct PWM control required by a PowerBlok is an open standard, at the time of this printing, Delta Tau Data Systems is the only company shipping products that support this standard. As more servo control vendors add support for this standard, this section will be expanded to support the easy integration of the PowerBlok into these systems.

Finally, the last section contains detailed mounting dimensions and a number of appendixes detailing application specific requirements and guidelines. These appendixes include CE EMC installation guidelines, multi-axis application considerations, and formulas for calculating DC bus capacitor and regenerative resistor sizing.

If there are any questions or comments, please contact MTS Automation.

Telephone: 507 354 1616
Fax: 507 354 1611

Features

Operation Features

- Direct Offline operation 200-480 VAC ±10% 47-66 Hz
- 1 to 21.5 kw continuous drive power output
  Up to 28 Arms continuous
  Up to 56 Arms Peak (3 sec)
  150% of continuous rating for 1 minute

Protection Features

- Short circuit and ground fault
- Instantaneous over-current protection
- Over-voltage, under-voltage protection
- Base plate over temperature
- Serial fault status feedback

Command Interface Features

- Optically isolated PWM commands
- Adjustable PWM frequency to 10kHz
- “Dead Time” logic to prevent shoot-through
- Serial A/D motor current feedback
- 12VDC power for external fan
- 7-segment fault/status display

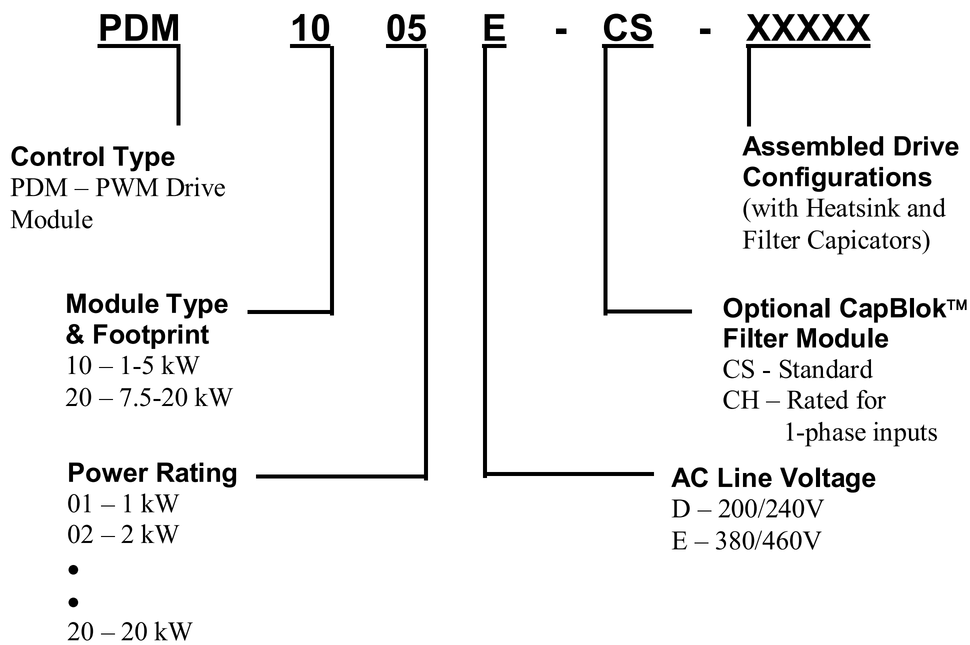
Environmental Features

- UL recognition
- CE certification
- Max operating temp: -20 to +70°C (module)
  -20 to +50°C (assembled configuration)
- Enclosure: IP-20
- Efficiency 95-97%

Ordering Information

Part Numbering System

The following information explains how a PowerBlok part number is established.



PowerBlok Module Only

The first 9 digits of the ordering part number identify the basic PowerBlok module.

PowerBlok with CapBlok™ DC Bus Filter Capacitor

By including the additional capacitor assembly part number to the module ordering number, the module would be supplied with the appropriately rated electrolytic filter CapBlok capacitor assembly. The capacitor assembly and PowerBlok are shipped together in the same box, however final assembly is required. Assembly instructions are provided later in this manual.

Assembled PowerBlok Configurations

MTS Automation offers standard assembled drive configurations that include the CapBlok, heat sink, fan and other options. Refer to the section later in this manual or contact the factory for availability and form factor specifications.

2 WIRING AND INSTALLATION

The first step in setting up and configuring a PowerBlok driven motion control system is properly wiring and installing the PowerBlok.

Wiring a PowerBlok can be divided into four steps. Details on connecting AC Power, a regenerative resistor, if necessary, motor power leads, and the PWM command signal are given below. Please note that with the properly designed system, the PowerBlok can be powered off of an appropriate DC bus. (Vdc > 200). Consult the factory for details on designing this bus.

Common Wiring Specifications

Model	**Recommended Wire Gauge Size**
PDM1000 type modules	#8 AWG (8mm^2)
PDM2000 type modules	#4 AWG (19mm^2)
PDM1001C/D/E	#14 AWG (2mm^2)
PDM1002C/D/E	#14 AWG (2mm^2)
PDM1005E	#14 AWG (2mm^2)
PDM2007E	#14 AWG (2mm^2)
PDM1005D	#12 AWG (3mm^2)
PDM2010E	#12 AWG (3mm^2)
PDM2007D	#10 AWG (5mm^2)
PDM2015E	#10 AWG (5mm^2)
PDM2010D	#8 AWG (8mm^2)
PDM2020E	#8 AWG (8mm^2)

Table 1: Recommended Wire Gauge Size

Tightening torque range is 16-18 in. lbs. on the power terminals for both the PDM1000 and 2000 Series of PowerBloks (including L1, L2, L3, T1, T2, T3, and the ground lugs).

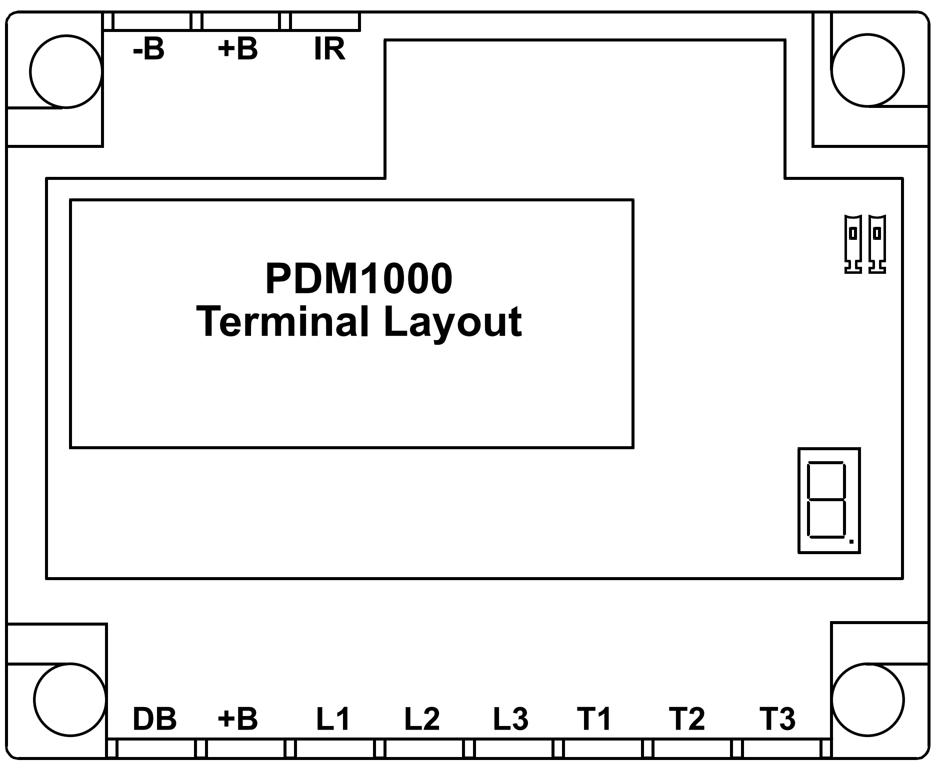
Since the drive module is IP-20 (PDM1000 Series) or Open-Frame (PDM2000 Series) the unit is not suitable for stand-alone operation. It is intended to be mounted in a panel, which provides the primary safety enclosure to protect the operator of the machine from the hazards of electrical shock that these drives will expose the user to. Detailed mounting dimensions for the modular and packaged versions of the drive can be found at the end of this manual.

PDM1000 Series Wiring

The following table gives connection descriptions for models PDM1000C/D/E through PDM1005D/E 120 VAC, 200/240 Vac and 380/480 Vac.

Terminal	Name	Functional Description
1	DB	Switched end of external braking resistor.
2	+B	DC link end of external braking resistor.
3	L1	AC line 1 input
4	L2	AC line 2 input
5	L3	AC line 3 input
6	T1	Motor phase A output
7	T2	Motor phase B output
8	T3	Motor phase C output

Table 2: PDM1000 Terminal Connections



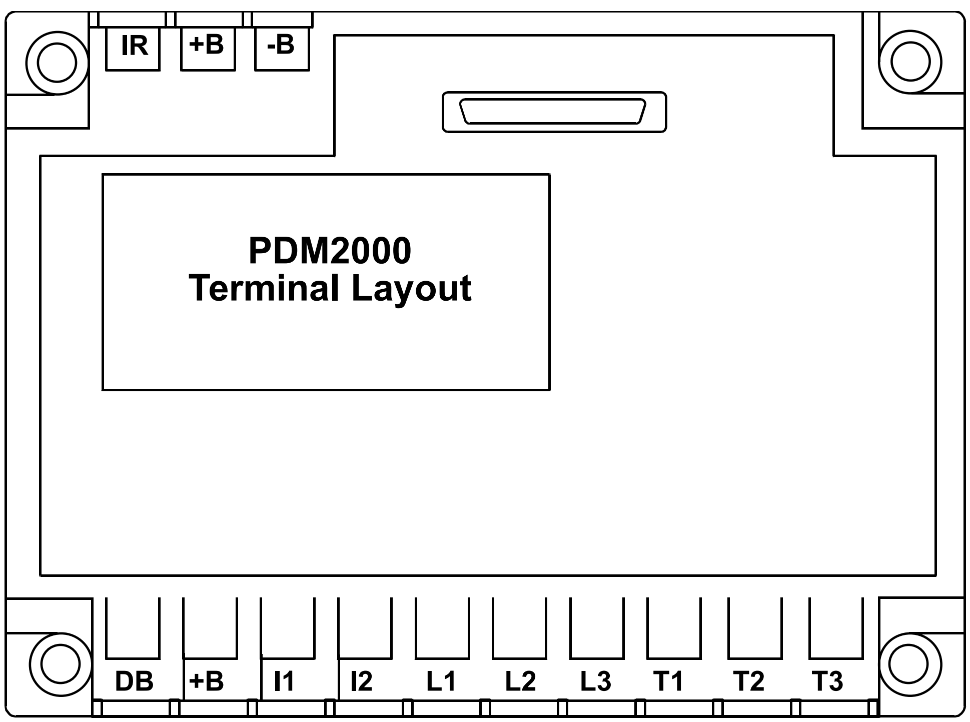
PDM2000 Series Wiring

The following table gives connection descriptions for models PDM2007 through PDM2020 200/240 volt and 7.5 – 20 HP 380/480 volt drives.

Terminal	Name	Functional Description
1	DB	Switched end of external braking resistor.
2	+B	DC link end of external braking resistor.
3	I1	Capacitor filter bank input – should be connected to I2*
4	I2	Bridge rectifier output – should be connected to I1*
5	L1	AC line 1 input
6	L2	AC line 2 input
7	L3	AC line 3 input
8	T1	Motor phase A output
9	T2	Motor phase B output
10	T3	Motor phase C output

Table 3: PDM2000 Terminal Connections

Note: A DC link inductor, external to the drive enclosure, may be installed between I1 and I2 to increase the apparent line impedance, improving the input power factor and reducing Bus Capacitor Assembly ripple currents. More information on the use of a DC link inductor can be found later in this manual.



AC Input Voltage

All wiring, including the motor power cables, the regenerative brake, and the DC bus capacitor assembly should be completed before applying power to the PowerBlok.

Model #	Voltage Class	Rating	Frequency
PDM1000C	120 V ± 10%	105 – 132 Vac, 1-ph	47 – 66 Hz
PDM1000D PDM2000D	200/240 V ± 10%	180 – 264 Vac_{RMS} 3-ph 180 – 264 Vac_{RMS} 1-ph	47 – 66 Hz
PDM1000E PDM2000E	380/480 V ± 10%	340 – 530 Vac_{RMS} 3-ph 360 – 530 Vac_{RMS} 1-ph	47 – 66 Hz

Table 4: AC Input Voltage

AC Input Fusing

External fusing is required in all installations.

Module Type	Volts 1-ϕ or 3-ϕ	Line Fuse	Fuse Class	Branch Circuit Breaker
PDM1001C	120	KTK-20	KTK	15
PDM1002C	120	KTK-20	KTK	15
PDM1003C	120	KTK-25	KTK	20
PDM1001D	200-240	KTK-20	KTK	15
PDM1002D	200-240	KTK-20	KTK	15
PDM1003D	200-240	KTK-25	KTK	20
PDM1005D	200-240	JJN-40	300V T	30
PDM2007D	200-240	JJN-50	300V T	40
PDM2010D	200-240	JJN-60	300V T	60
PDM1001E	380-480	KTK-10	KTK	15
PDM1002E	380-480	KTK-10	KTK	15
PDM1003E	380-480	KTK-15	KTK	15
PDM1005E	380-480	KTK-20	KTK	15
PDM2007E	380-480	JJS-25	600V T	20
PDM2010E	380-480	JJS-35	600V T	30
PDM2015E	380-480	JJS-50	600V T	40
PDM2020E	380-480	JJS-60	600V T	60

Table 5: Recommended Fuses

Earth Ground

The input power line ground wire should be attached to the heatsink on which the PDM is mounted. A separate ground wire should be connected between the PDM Module heatsink and the motor frame, bundled with the motor phase output leads for the return of induced ground currents in the motor frame and cable tray. When using an MTS Automation supplied heatsink package, there are two tapped holes on the heatsink for this purpose.

Single Phase Operation

For single-phase operation, connect AC line and neutral to inputs L1 and L2 on the PowerBlok module. Connect the AC ground as specified above.

All PDMs are rated for single-phase operation, and if applied properly, can operate at full rating on a single-phase input. Finished drives built from the PDM family, which were designed for three-phase operation, must be derated for single-phase operation to prevent damage to the Bus Filter Capacitor Assembly. Care should be exercised to prevent premature capacitor failure.

A fully functional, reliable drive can be built with the PDM module if the capacitor bank is designed with a single-phase application in mind. The DC link instantaneously drops too low if too much power is drawn for the capacitors to provide during single-phase operation. This can shut off the power supply, causing the drive to report a low voltage fault. Voltage ripple on the bus causes current ripple in the phase current, causing torque and/or velocity ripple, and can limit the maximum output voltage that can be applied, reducing maximum speed under heavy loads. Motor Kv must be specified with full knowledge of worst case minimum DC link voltage including the effects of ripple.

Line Impedance

The PDM is capable of operation from a power system with a short circuit rating not to exceed 65,000 RMS symmetrical amperes at the PDM AC input. A 1% line impedance, not to exceed 5%, should be provided upstream of the PDM AC input terminals. Operation above 5% line impedance does not harm the PDM, but full output voltage and power cannot be guaranteed. Operation below 1% line impedance does not harm the PDM Module itself, but could compromise the long-term life of the bus filter capacitor bank.

DC Link Inductors

Optionally, the PDM2000 series provides terminals for a DC Link inductor. This component, if installed, replaces the need for an AC Line reactor and provides better performance, but must be shunted with an MOV assembly for proper operation.

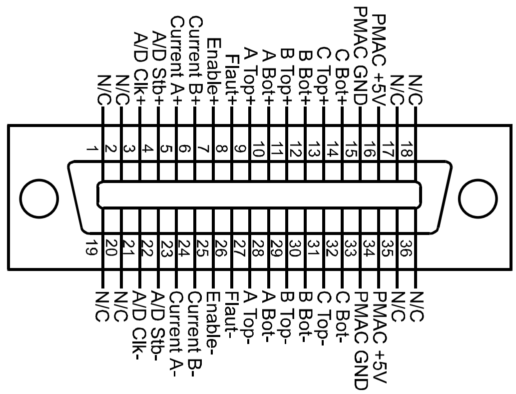
Additionally, operation of high power 460V rated inverters at the minimum line impedance may require some EMI filtering to eliminate the effects of noise in the control system. Low line impedance combined with poor grounding practices may disturb the internal switching power supply, which will cause a logic supply fault nuisance trip (fault code “b”). Motor output reactors can usually solve this problem if they are placed close to the PDM, and if their frames are returned to the PDM heatsink common.

PowerBlok Model Number	**DC Link Inductor**	
	Inductance	**Current Rating A (DC)**
PDM2007D	430µH	23
PDM2010D	320µH	30
PDM2007E	1750µH	11.5
PDM2010E	1300µH	15 A
PDM2015E	650µH	23
PDM2020E	500µH	30

Table 6: DC Link Inductors

PWM Interface

This 36-pin connector contains all the logic level control and feedback signals used in the Delta Tau defined PMAC2 PWM specification. (View from the cable end, shown below).



36-pin Mini-D Connector

This is a standard IEEE-1284-E connector. The mating cable is made by a number of companies including 3M, Honda, Centronics, and L-com. A good online reference to these cables can be found at www.l-com.com

DC Supply for External Fan

Provision is made to power external 12Vdc fan(s) to provide forced air cooling of the heatsink that the PDM is mounted on. One post of the two-post connector is held at 12Vdc. The other post is connected to ground when the heatsink temperature exceeds approximately 55°C to start the fan. The fan turns off when the heatsink temperature falls below approximately 55°C.

Drive Types	**Allowable Fan Start Current**	**Allowable Fan Run Current**	**Voltage**
PDM1000	600mA	300mA	12V
PDM2007 and 2010	1.2A	600mA	12V
PDM2015 and 2020	1.2A	950-1000mA	12V

Table 7: External Fan Specs

The fan switch includes a soft-start provision to reduce stalled fan start inrush current. A removable, locking post header is available to attach the fan. One header is provided on the PDM1000 module, and two headers are provided on the PDM2000 module. The connector is an AMP .100 MTA type.

Regenerative Braking Resistor

Provisions are made for the connection of an external regen resistor for applications that require it. There is no internal regen resistor. The regen transistor output is protected from ground faults and short circuits. When no braking resistor is provided, the amount of load energy that can be dissipated is limited to the power consumed internally by the drive and the power dissipated by the mechanical transmission. Braking transistor duty cycle and frequency vary with the rate of load deceleration, total kinetic energy of the load, the bus capacitance, the line voltage, and the brake circuit inductance. The external regen circuit activates at a DC bus voltage of 410 Vdc for 200/240 Vac drives and 820 Vdc for 380/480 Vac drives. The regen resistor value can be no lower than the minimum specified value. The inductance of the regen resistor (and associated wiring) can be no larger than the maximum value specified.

The PDM does not measure the temperature of the external braking resistor or protect it from excessive power dissipation. Some form of external protection must be applied to prevent damage if the resistor is undersized for the application, or if the PDM braking circuit fails.

PDM Model	**Voltage Class**	**Minimum R (Ω)**	**Maximum Inductance of R (mH)** (Including wiring)
PDM1001C	120 Vac	25	4.6
PDM1002C	120 Vac	25	4.6
PDM1003C	120 Vac	18	3.0
PDM1001D	200 / 240 Vac	50	2.3
PDM1001E	380 / 480 Vac	200	9
PDM1002D	200 / 240 Vac	50	2.4
PDM1002E	380 / 480 Vac	200	9
PDM1003D	200 / 240 Vac	35	1.5
PDM1003E	380 / 480 Vac	140	6
PDM1005D	200 / 240 Vac	20	0.9
PDM1005E	380 / 480 Vac	80	3.6
PDM2007D	200 / 240 Vac	15	0.6
PDM2007E	380 /480 Vac	60	2.4
PDM2010D	200 / 240 Vac	10	0.5
PDM2010E	380 / 480 Vac	40	1.8
PDM2015E	380 / 480 Vac	30	1.2
PDM2020E	380 / 480 Vac	20	0.9

Table 8: External Regen Resistors

Regen Resistor Specification and Sizing

Most servo positioning applications do NOT require a regen resistor. In most applications, the maximum deceleration rate is limited mechanically (i.e. something will break if the load is stopped too quickly) or by the available motor torque. In applications with highly efficient transmissions and large inertial loads, your maximum deceleration rate may be limited by the drive’s ability to dissipate the load’s energy. In this case, adding a regen resistor will allow your system to decelerate at a higher rate. If you try to decelerate at too high a rate without a regen resistor, the PowerBlok will shut down with an over-voltage fault (Fault Code A). If this happens, you must lower the deceleration rate or add a regen resistor to stop the load under control.

Power resistors are specified by four characteristic ratings: *Resistance*, *Power* (average power rating in Watts), *Peak Power* or *Energy* (maximum short duration power handling in Joules), and *Rated Working Voltage* (rated operating terminal voltage in Volts). In addition, the thermal time constant of the resistor must be known to properly evaluate its suitability as a regen resistor and to protect it in the application.

1. Resistance Value

First, in selecting the correct regen resistor, the required resistance value must be determined. The motor peak torque rating (given by horsepower and speed for an AC motor or current and Kt for a BLDC motor) and the maximum speed in the application must be known. Peak motor torque times maximum speed will provide the peak braking power. The maximum resistance value that we can use is given by:

$Resistance_{maximum} = Voltage_{braking}^2 / Power_{maximum\ braking}$, where

$Power_{maximum\ regen} = Torque_{rated\ motor} * Speed_{maximum}$

[Note: For $Voltage_{braking}$, use 210 Vdc for a 230 Vac drive and 820 Vdc for a 480 Vac drive.]

Remember that this value is a maximum resistance when hot. Therefore, select a convenient value less than this, but never select a resistor value smaller than the minimum braking resistor value specified in the table above. Selecting the largest resistance value possible will minimize the current needed to dissipate the load's energy. Keeping this current as small as possible will extend the life of the PowerBlok and the resistor, as well as to help reduce EMI problems.

There is one complication in the resistance calculation for AC motors. If maximum speed exceeds the speed at which the motor enters field weakening, then the speed at which the motor enters field weakening should be used in place of the actual "maximum speed" to calculate the resistor value. Typically, this speed is about 120% the motor rated speed.

2. Average Power Rating

Next, the regen resistor's power rating must be determined. The power rating of the resistor can ***only*** be calculated if the ***frequency*** of how often the PowerBlok decelerates and the ***time duration*** of this deceleration. The average power during braking the load from maximum speed to zero speed is equal to half the peak power that you calculated above. If the application decelerates in $Time_{stop}$ seconds and does this every $Time_{repeat}$ seconds then, the duty cycle is:

$Duty\ Cycle = Time_{stop} / Time_{repeat}$

$Power_{minimum\ rating} = Duty\ Cycle * (Power_{maximum\ braking}/2)$

Example 1:
A drive is controlling a 5 Hp, 4-pole, 230 Vac induction motor. The motor is to decelerate from 1800 rpm to 0 rpm in 1 second and repeats this deceleration five times per minute. What is the required resistance and power rating of the braking resistor for this application?

$Torque_{rated\ motor} = (Power_{rated\ motor})/(Speed_{rated\ motor})$
= (5 Hp * 746 Watts/Hp)/(1800 RPM * 2π rad/rev * (1 min/60 sec))
= 19.8 N-m
~ 20 N-M

$Power_{maximum\ braking} = Torque_{rated\ motor} * Speed_{maximum}$
= 20 N-m * (1800 RPM * 2π rad/rev * (1 min/60sec))
= 3770 Watts

$Resistance_{maximum} = Voltage_{braking}^2/Power_{maximumbraking}$
= $(410\ VDC)^2$/3770 Watts
= 44.5 Ohms

Next, $Power_{average\ resistor}$ must be determined.

Duty Cycle = $Time_{stop}/Time_{repeat}$
= 1 sec/(60 sec/5)
= 0.0833

$Power_{minimum\ rated} = Duty\ Cycle * (Power_{maximum\ braking}/2)$
= 0.0833 * (3770 Watts/2)
= 157 Watts

For most applications, sizing can stop at this point because there is enough information to order a braking resistor. For more information on Power Resistor sizing and application, go to www.postglover.com

3. Peak Power Rating

The peak power or energy ratings of a resistor depend on its internal construction. A typical power wire-wound resistor consists of a resistance wire wound on a hollow ceramic core and welded to the electrical terminations (e.g., wiring lugs or leads) at each end. If this type of resistor is hit with a large pulse of power, despite a short duration, mechanical stresses at these terminations will be produced that will cause the resistor to fail prematurely in your machine. Typically, a wire-wound resistor can tolerate 3:1 to 5:1 peak to average power for very short power pulses.

In the example above, a wire-wound resistor would be a poor choice. Peak to average power is 3770/157 = 24:1. If the wire-wound resistor can be used, buy it. It is usually less expensive and more readily available.

If a higher peak to average power ratio is required, speak with your wire-wound resistor vendor. Several vendors make specially constructed wire-wound resistors that have a higher Peak Power rating, but it is unlikely that these resistors will be found in the catalog. Contact technical support of the resistor manufacturer.

Another alternative is to choose a resistor constructed to handle peak power. Several vendors specialize in resistors constructed specifically for pulse power applications. Carborundum, and HVR Advanced Power Components are two of the best vendors. Each vendor manufactures a line of solid ceramic resistance elements that heat uniformly during the power pulse, thus eliminating the termination problem inherent in wire-wound resistor construction. Basically, these resistors can handle ANY peak power, as long as it does not overheat the entire resistive element. Therefore, they are typically rated in Joules (i.e., the number of Watt-seconds that can be delivered without raising the temperature too high in a single pulse).

The energy rating required in our application, assuming $Time_{stop}$ is short with respect to the thermal time constant of the resistor is:

$Energy_{minimum}$ rated = $Time_{stop}$ * ($Power_{maximum\ braking}$/2)

In the example, a ceramic resistor capable of at least 1 sec * 3770/2 = 1885 J in addition to the 157 W average power rating would be needed.

4. Working Voltage

The rated voltage of a resistor used by a 240 Vac rated PowerBlok needs to be at least 500 Vdc. The rated voltage of a resistor used by a 480 Vac rated PowerBlok needs to be at least 1000 Vac.

3 SOFTWARE CONFIGURATION

Overview

While there are no software or hardware settings on the PowerBlok module, there are a substantial number of parameters that must be correctly set in the servo control providing the PWM control to the PowerBlok. These parameters specify peak and continuous current ratings and PWM dead-time specifications among other things. The following information assumes that the PowerBlok is being integrated in a system controlled by a Delta Tau PMAC2 or PMACTurbo servo controller. It further assumes the use of the 32-bit version of Delta Tau's PMAC2 Setup software (3/16/98 or later), and PMAC2 firmware version 1.16 or later. Though it is possible to correctly configure a PMAC based controller without using the 32-bit version of Delta Tau's set up software, MTS Automation highly recommends its use, especially for first time users of direct PWM control systems.

The information that follows is applicable to all direct PWM controllers utilizing digital current feedback. As other control vendors release products that support this standard, their setup and application will be documented here. Please contact MTS Automation [(507) 354 1616] for more information on the all digital PWM control standard.

There are three major steps in setting up a controller in direct PWM dead-time, and current sensor calibration. Secondly, application specific safety limits must be set. These include the PowerBlok fault polarity, and the peak and continuous current limits of the system being configured. While the PowerBlok can prevent an over-current condition from damaging its power output stage, it has no provisions for protecting a motor from a peak or continuous over-current condition. Finally, the current loop gains and motor phasing must be set up. At this point, the traditional velocity and position loop gains can be set up.

PWM Control Setup

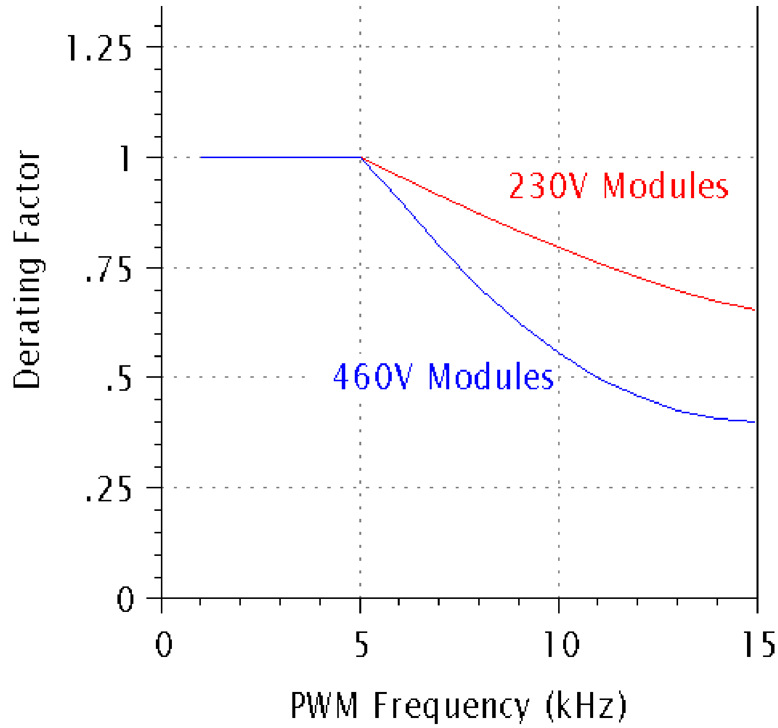
Current Control

If your controller supports different current loop control options, select digital current control. The Delta Tau controllers support digital current control for linear servo motors, rotary servo motors, and AC induction motors equipped with encoder feedback.

PWM Frequency

The PowerBlok accepts PWM control frequencies up to 10kHz. It will report an error if frequencies above this are detected. The default PWM frequency when using a Delta Tau controller is 4.53 kHz. Please note that when this frequency is changed, appropriate changes must also be made to the servo update rate, and the servo calculation rate. Please contact Delta Tau for more information on changing these parameters.

In some applications, using a higher PWM frequency will result in a higher frequency current loop and allow the use of higher gains in the position and velocity loops. For most applications though, the thermally efficient default PWM frequency will give more than adequate current loop bandwidth. Higher PWM frequencies can reduce motor heating in low inductance motors, at the expense of increased amplifier heating. If frequencies about 5kHz are required, please use the following graph to de-rate the PowerBlok appropriately.



Example: A PDM1005E has a continuous current rating of 7.6 amps and a peak current rating of 15.2 amps when used with PWM frequencies below 5kHz. At a PWM frequency of 8kHz, the PDM1005E would have a continuous current rating of .75 * 7.6 = 5.7 arms. The peak current and peak power ratings remain unchanged.

PWM Dead-time

Dead time is the term used to describe the time between turning the top IGBT of a phase off and turning on the bottom IGBT of the same phase. Since IGBT's start to conduct current faster than they stop conducting current, this latency is required to prevent connecting the high side of the DC bus directly to ground. The default dead time used by the PMAC2 and PMACTurbo controllers is appropriate for most applications. The interface logic in the PowerBlok also inserts a dead time of 2 μsec in the event that the dead time parameter in the controller is inadvertently set to zero.

PMAC2 Setup does not give the user the option of changing the default dead time, but it can be changed by directly modifying the appropriate parameter.

Current Sensor Calibration

The PMAC2 setup program conducts a series of tests to check the polarity of the current sensors. When selecting the level of current to use in these tests, please be aware that the scale is based on the ADC full scale reading of 32768. The default choices may be enough to damage some motors. Always use the minimum current necessary to get a proper reading. These tests confirm that the drive output IGBTs, current sensors, current feedback ADCs, and the control cable are connected and working properly. If these tests are not completed successfully, please check the troubleshooting section of this manual, or contact MTS Automation for assistance.

Six-Step Voltage Test

During the six-step voltage test, the PMAC2 setup utility P2Setup makes a series of open-loop step moves to determine encoder and motor phasing (direction of rotation). These moves are made before P2Setup has asked for any information on the attached amplifier or stabilized the current loops – at this point, **all PMAC2 current protection features are disabled**.

Warning – If your motor resistance is lower than listed here:

PowerBlok Model	120 VAC Motor Resistance Phase-to-Phase	200/240 VAC Motor Resistance Phase-to-Phase	400/480 VAC Motor Resistance Phase-to-Phase
PDM1001	2.4Ω	4.8Ω	19Ω
PDM1002	1.2Ω	2.4Ω	9.6Ω
PDM1003	0.85Ω	1.7Ω	6.8Ω
PDM1005	N/A	1Ω	4.3Ω
PDM2007	N/A	0.75Ω	3.0Ω
PDM2010	N/A	0.6Ω	2.3Ω
PDM2015	N/A	Not Available	1.6Ω
PDM2020	N/A	Not Available	1.2Ω

Table 9: Motor Resistance

Then you must enter the correct safe PWM duty cycle value in the Six-Step Voltage Test step in P2Setup or risk damage to the PowerBlok.

The PowerBlok has a layered overload protection design. First, actual short circuits are detected by a desaturation detection system that continuously monitors the status of every power device and trips off whenever a device that was commanded ON appears to be OFF. This protects from errors that could destroy the devices in 10μs ("4" Fault). Next, an instantaneous overcurrent trip shuts down whenever the measured current exceeds the 1ms capability of the IBGTs, typically 5-6x rated current ("3" Fault). Next, a longer time constant, lower threshold current limit protects from longer duration uncontrolled overloads ("1" Fault). Next, the PMAC will not command currents greater than the PowerBlok rating once you tell it what that current limit is, and finally the PMAC has an I^2T function that protects from longer duration overloads. **Without these protections from the PMAC, excessive currents above the module rating would flow unchecked, and the PowerBlok could be damaged.**

Calculating the PWM Step Size values in P2Setup:

PWM percent Duty Cycle ≤ (PowerBlok Rated Current * Stator phase-phase Resistance) / (1.414 * VAC) for example, for a 10Hp 460V PowerBlok on a 480V line with a 0.6 Ohm per-phase stator resistance, PWM percent Duty Cycle ≤ (14 * 2 * .6) / (1414 * 480) = 2.47%. In this case, you must select 2% from the pick list for this parameter to avoid damage to the PowerBlok.

Current Loop Tuning

The purpose of current loop tuning is to optimize the gains in the algorithm that controls the current in the motor. These gains will vary with bus voltage, motor resistance, motor inductance, and PWM switching frequency. The current loop tuning section of the P2Setup program will lead you through a series of steps that apply a current step command to the motor. The current loop gains should be adjusted to make the current loop step rise as fast as possible, with a minimum amount of overshoot. A high bandwidth current loop allows high gains to be used in the position and velocity loops, resulting in a more responsive servo system. Kp1, the proportional gain in the feedback path, controls how quickly the current step rises for the first half of the step magnitude. Ki, the integral gain, controls how much the step overshoots, AND how quickly the actual current approaches the commanded current value during the 2^{nd} half of the step moves. Using Kp2, the proportional gain in the feedforward path, can increase the response of the current loop, but does make the system less intuitive to tune.

Please be aware that the 5000-bit default step size may be too high for some motors. The “amp/bit” value of each PowerBlok is equal to the “Full Scale ADC Value” divided by 32,768. The Full Scale ADC Value for each PowerBlok is shown in the *Current Limit* section of this manual.

Please consult Delta Tau for more information on using Delta Tau’s current loop gains and current loop auto-tuning.

Amplifier Fault Polarity

The PowerBlok has a “High – True” Fault signal. When using Delta Tau’s PMAC2 Setup program, this setting is made from the Input Channel Selection screen. Please note that the program defaults to a “Low – True” setting.

Motor Current Limit Parameters

System Current Limits

The PMAC2 Setup program will prompt you to enter the current limits for your system. MTS Automation technical marketing documentation shows the motor current ratings for the various PowerBlok modules in units of continuous and peak RMS Amps, while all of Delta Tau's current limits are in units of 0 to Peak Amps. In addition to the square root of 2 factor between the two rating systems, there is a cos(30) factor used to calculate the correct value of Ix57, Ix58 and Ix59. PMAC2 setup does NOT include this factor. This table lists the proper value of Ix57, Ix58, and Ix69. (Ixx57, 58 and 69 in the Turbo version of the PMAC2) Please note that if the motor you are using has a lower peak or continuous current rating that the PowerBlok, the motor's current limits should be entered to prevent motor winding damage. Also note that the continuous current limits listed here are based on a MTS Automation supplied heatsink and fan assembly. The PowerBlok may be thermally limited to a lower continuous current output if a different heatsink is used. The PowerBlok has two peak current ratings. Which rating you use is application dependent. Most point to point applications will use the "3 sec" peak rating to optimize acceleration and deceleration. In other applications, particularly clamping and machining operations, it may be more useful to specify the PowerBlok at its 60 seconds rating. All modules are rated at 150% of continuous current for 60 seconds provided that frequency output to the motor exceeds 1Hz.

It is critically important to note the whether your PowerBlok is a Standard Resolution (-S) or a High Resolution (-H) product. Using the wrong table for your PowerBlok can result in permanent damage to your product. If your are unsure of which table to use, for example if your model number does not end in either –S or –H, please call the factory for clarification before using the information in Tables 10a and 10b.

120VAC Modules	Full Scale ADC Value	I_{cont}(rms) Rating	I_{cont}(pk) Rating	Ix57	Ix58*	I_{peak}(rms)	I_{peak} (pk)	Ix69
PDM-1001-C	12.7	4	5.6568	12,639	3024	8	11.3136	25,279
PDM-1002-C	25.4	7.2	10.18224	11,375	2450	14.4	20.36448	22,751
PDM-1003-C	38.1	10.4	14.70768	10,954	2272	20.8	29.41536	21,908
230VAC Modules								
PDM-1001-D	12.7	3.4	4.81	10,743	2185	6.8	9.61656	21,487
PDM-1002-D	25.4	6.8	9.62	10,743	2185	13.6	19.23312	21,487
PDM-1003-D	38.1	9.6	13.58	10,111	1936	19.2	27.15264	20,223
PDM-1005-D	50.1	15.2	21.50	12,175	2806	30.4	42.99168	24,350
PDM-2007-D	67.7	22	31.11	13,041	3220	44	62.2248	26,081
PDM-2010-D	101.6	28	39.60	11,059	2316	56	79.1952	22,119
460 VAC Modules								
PDM-1001-E	6.3	1.7	2.40	10,829	2220	3.4	4.80828	21,657
PDM-1002-E	12.7	3.4	4.81	10,743	2185	6.8	9.61656	21,487
PDM-1003-E	19	4.8	6.79	10,138	1946	9.6	13.57632	20,276
PDM-1005-E	25.4	7.6	10.75	12,007	2730	15.2	21.49584	24,015
PDM-2007-E	38.1	11	15.56	11,586	2541	22	31.1124	23,172
PDM-2010-E	50.8	14	19.80	11,059	2316	28	39.5976	22,119
PDM-2015-E	67.7	21	29.70	12,448	2934	42	59.3964	24,896
PDM-2020-E	101.6	27	38.18	10,664	2153	54	76.3668	21,329

*3 second peak rating, Brushless Permanent Magnet motor only when PWM freq @4.5173kHz, and I900, I901, I902, and I10 are at default settings. Please see the PMAC2 Family Addendum to User's Manual and Software reference for more information on how to calculate the correct setting for Ix58 when using AC induction motors, or when operating at PWM frequencies other than 4.5kHz.

Table 10a: System Current Limits for –H PowerBloks **

**The "-H" is determined by the last digit of the PowerBlok model number.
Example: PDM2007ECSWE00H (as compared to PDM2007ECSWE00S)

120VAC Modules	Full Scale ADC Value	I_{cont}(rms) Rating	I_{cont}(pk) Rating	Ix57	Ix58*	I_{peak}(rms)	I_{peak} (pk)	Ix69
PDM-1001-C	39	4	5.6568	4,116	320.7176	8	11.3136	8,232
PDM-1002-C	39	7.2	10.18224	7,409	1039.125	14.4	20.36448	14,817
PDM-1003-C	39	10.4	14.70768	10,701	2168.051	20.8	29.41536	21,402
230VAC Modules								
PDM-1001-D	39	3.4	4.80828	3,498	231.7185	6.8	9.61656	6,997
PDM-1002-D	39	6.8	9.61656	6,997	926.8738	13.6	19.23312	13,994
PDM-1003-D	39	9.6	13.57632	9,878	1847.333	19.2	27.15264	19,756
PDM-1005-D	78	15.2	21.49584	7,820	1157.79	30.4	42.99168	15,640
PDM-2007-D	104	22	31.1124	8,489	1364.303	44	62.2248	16,978
PDM-2010-D	156	28	39.5976	7,203	982.1976	56	79.1952	14,406
460 VAC Modules								
PDM-1001-E	19.5	1.7	2.40414	3,498	231.7185	3.4	4.80828	6,997
PDM-1002-E	19.5	3.4	4.80828	6,997	926.8738	6.8	9.61656	13,994
PDM-1003-E	19.5	4.8	6.78816	9,878	1847.333	9.6	13.57632	19,756
PDM-1005-E	39	7.6	10.74792	7,820	1157.79	15.2	21.49584	15,640
PDM-2007-E	78	11	15.5562	5,659	606.3567	22	31.1124	11,319
PDM-2010-E	78	14	19.7988	7,203	982.1976	28	39.5976	14,406
PDM-2015-E	104	21	29.6982	8,103	1243.094	42	59.3964	16,206
PDM-2020-E	156	27	38.1834	6,946	913.2934	54	76.3668	13,891

*3 second peak rating, Brushless Permanent Magnet motor only when PWM freq @4.5173kHz, and I900, I901, I902, and I10 are at default settings. Please see the PMAC2 Family Addendum to User's Manual and Software reference for more information on how to calculate the correct setting for Ix58 when using AC induction motors, or when operating at PWM frequencies other than 4.5kHz.

Table 10b: System Current Limits for –S PowerBloks **

**The "-S" is determined by the last digit of the PowerBlok model number.
Example: PDM2007ECSWE00S (as compared to PDM2007ECSWE00H)

Motor Phasing and Tuning

The rest of the steps involved with setting up an MTS Automation PowerBlok/Delta Tau PMAC2 system are completely dependent upon your application, and feedback device(s). There are no more drive-specific parameters to set. Please consult your Delta Tau documentation for the latest information on tuning your velocity and position loops.

4 TROUBLESHOOTING

LED Fault Code

A seven-segment LED indicates the following fault and status conditions:

Indication	Fault/Warning
0	No Fault
1	Over Current
2	Watchdog Time Timeout
3	Motor Short/Ground Short
4	IGBT Saturation Fault
5	Substrate Over Temperature
6	PWM Frequency Fault
7	Substrate Temp Sensor Fault
8	Control Mode Fault
9	DC Link Undervoltage
A	DC Link Overvoltage
b	DC Logic Power Supply Fault
C	Reserved
d	Reserved
E	Reserved
F	Reserved

Table 11: 7-Segment Display Decode

On power up, before the PMAC2 establishes communication with the drive, any fault code can be present. Normally fault code "9" – undervoltage, is displayed. After the PMAC2 enables the drive, all power up fault conditions are cleared. Any subsequent fault codes are valid.

All faults are latched. A power cycle clears the fault if the condition is no longer true. The servo controller can clear the fault by toggling the servo enable line. The fault will clear when the PowerBlok is re-enabled.

The "decimal point" of the seven-segment LED turns on when the amplifier is enabled. When the seven segment display shows a zero, and the decimal point is on, no error conditions exist, the amplifier is enabled, the motor is energized and servoing.

In addition to the fault code being displayed on the PowerBlok module, it is also embedded in the current feedback serial word. When a fault occurs, the PowerBlok output shuts down, the digital fault output goes high, and the fault is encoded in 4 bits of the current feedback word. The 12 MSB of the current feedback word contain actual motor phase current phase information. The next 4 MSB contain the latched fault code displayed on the seven-segment display. This fault code can be read via M-variable mapping and used in user-written PLCs just like any other I/O point. Please see Delta Tau's PMAC2 documentation for more information.

Fault Code Explanation

Code 0: - No Fault

Code 1: - Over-current

The PDM is protected from short term, controller overcurrent conditions that exceed the thermal rating of the IGBTs, but are not long enough to heat the entire module and activate a thermal fault. This feature does not protect the motor. The PWM servo controller will include provisions for protecting a given motor from average overcurrent.

Code 2: - Watchdog Timer Timeout

Delta Tau's PMAC series of controllers query the PowerBlok for motor current information 4 times per PWM cycle. This motor current data is sent via a serial line back to the controller. The PowerBlok also uses the timing of this query to determine the presence of a noise free, properly configured PWM command signal. If this interface fails, due to electrical noise, or mechanical disconnection, the PowerBlok reports a timeout error.

Code 3: - Motor/Ground Short

The PDM is protected from short circuit and ground fault conditions by automatically shutting down without damage to any components. Any output phase can be shorted to ground. The PDM shall stop operating when the ground current reaches approximately 5 times the current rating of the inverter or brake IGBT. The PDM will report that a fault has occurred.

The PDM is protected from short circuit conditions by automatically shutting down without damage to components. Any output phase or dynamic brake lead may be shorted to another, or the positive or negative side of the DC bus. The PDM will stop operating when the phase current reaches approximately 5 times the current rating of the inverter or brake IGBT. The output fault must have an impedance such that the trip current is reached within 5μs. The PDM will report that a fault has occurred. If the impedance of the motor is such that the short circuit trip point is not reached within 5μs, or the duty cycle of the PWM input is very low, an over-current fault may be reported instead of a short circuit/ground fault. The module will display an error code of 3, and will report this condition to the servo control.

Code 4: - IGBT Saturation Fault

The PDM is protected from IGBT Saturation conditions by automatically shutting down without damage to any component. Normally, a fault code of 4 is a symptom of poor system grounding. If the fault cannot be cleared by cycling the enable input of the PowerBlok, the fault may indicate a hardware failure in the module. If so, the PowerBlok must be returned to MTS Automation for repair or replacement. Please see the beginning of this manual for return procedures.

Code 5: - Substrate Over-Temperature

The substrate temperature is monitored by the hardware. If the temperature exceeds 92°C, the PDM will stop operating and report fault condition “5”. Fan operation, via the 12 Vdc internal fan power supply, is controlled by measurement of the substrate temperature. Fan power is cycled automatically based on this temperature measurement.

Code 6: - PWM Frequency Fault

The PowerBlok's logic inserts a minimum dead time of 2μs into PWM signals. No fault condition is generated when this happens. If the PWM frequency exceeds 10.5kHz, the module will display an error code of "6", and will report this condition to the servo control. The power output of the PDM may need to be derated if the PWM frequency exceeds 4.5kHz. Please see the power derating graph in the software setup section of this manual for more information.

A "6" fault can also be a symptom of poor grounding or PWM command signal shielding. Make sure that the motor and AC power ground are both tied to the PowerBlok heatsink. Also check the routing and shielding of the 100-pin PMAC2 ribbon cable.

Code 7: - Substrate Temp Sensor Fault

If the substrate temp sensor fails, the module will display an error code of 7, and will report this conditions to the servo control. This is a hardware failure, and the PowerBlok module must be returned to MTS Automation for repair.

Code 8: - Control Mode Fault

If the servo controller is not properly configured to control a PowerBlok in PWM mode, or there is a cabling error, the module will display an error code of "8", and will report this condition to the servo control. Delta Tau's PMAC controller can be set up to control an amplifier with high speed DAC signals that would generate dangerous switching frequencies at the power output stage of the PowerBlok. The internal logic of the PowerBlok detects this software setup error and prevents any damage.

Code 9: - DC Link UnderVoltage

The PDM will report undervoltage conditions. If an undervoltage condition exists, the PDM will shut down the output and report fault condition "9". An undervoltage condition will not harm the PDM. Undervoltage trip point is 170Vdc for 230Vac drives and 340Vdc and 460Vac drives. These voltages are set in the hardware.

Undervoltage faults that occur during load acceleration are usually due to too high a bus inductance or too low a bus capacitance. Lowering the commanded acceleration rate or adding more capacitance will eliminate this fault.

Code A: - DC Link OverVoltage

The PDM will report overvoltage conditions. If an over-voltage condition exists, the PDM will shut down the output, and display an error code of "A". The PDM will trip at DC bus voltage of 450Vdc for 230Vac models and 900Vdc for 460Vac models. These voltages are set in the hardware.

Overvoltage faults typically occur when decelerating large inertial loads. Lowering the deceleration rate or adding an external regeneration resistor will eliminate this fault. See the Regeneration Resistor section of this manual for more details.

Code b: - Logic Power Supply Fault

If the 12Vdc or 5Vdc logic supplies, generated from the DC link, fall below 10.2 and 4.2 Vdc respectively, the module will display an error code of "b", and will report this condition to the servo control. Poor grounding practices can generate this condition. Assuming that there is not a hardware failure in the PowerBlok, look at the ground connection between the motor frame and the PowerBlok heatsink. A poor connection here can generate enough noise to cause this power supply to droop.

5 HARDWARE SPECIFICATIONS

The charts below contain hardware specifications that are common to all models of PowerBloks. Model specific current, voltage, and power specifications can be found in the PowerBlok Data Sheet specification guide, and in the appropriate section of this manual.

Environmental

Parameter	Rating	Notes
Enclosure	IP-20	Finger-safe modular package
Operating Ambient Temp	-20 to +65°C	
Operating Substrate Temp	-20 to +90°C	Sufficient heatsink required to maintain acceptable substrate temp during operation
Storage Temp	-20 to +100°C	
Humidity	10 - 95%	non-condensing
Altitude	1000 m (3300 ft) (typ)	Depends on heatsink
Altitude derating	2% for every 330m (1000 ft.) above 1000m (3300 ft.) (typ)	Depends on heatsink [Not rated for use above 4000m (13200 ft)]
Shock	TBD	
Vibration	IEC68-2	
Ambient Pollution	TBD	
Hazardous Environment	Not rated for “Hazardous (Classified) Location”	per NEC Article 500
Corrosive Environment	Not rated for corrosive environment	

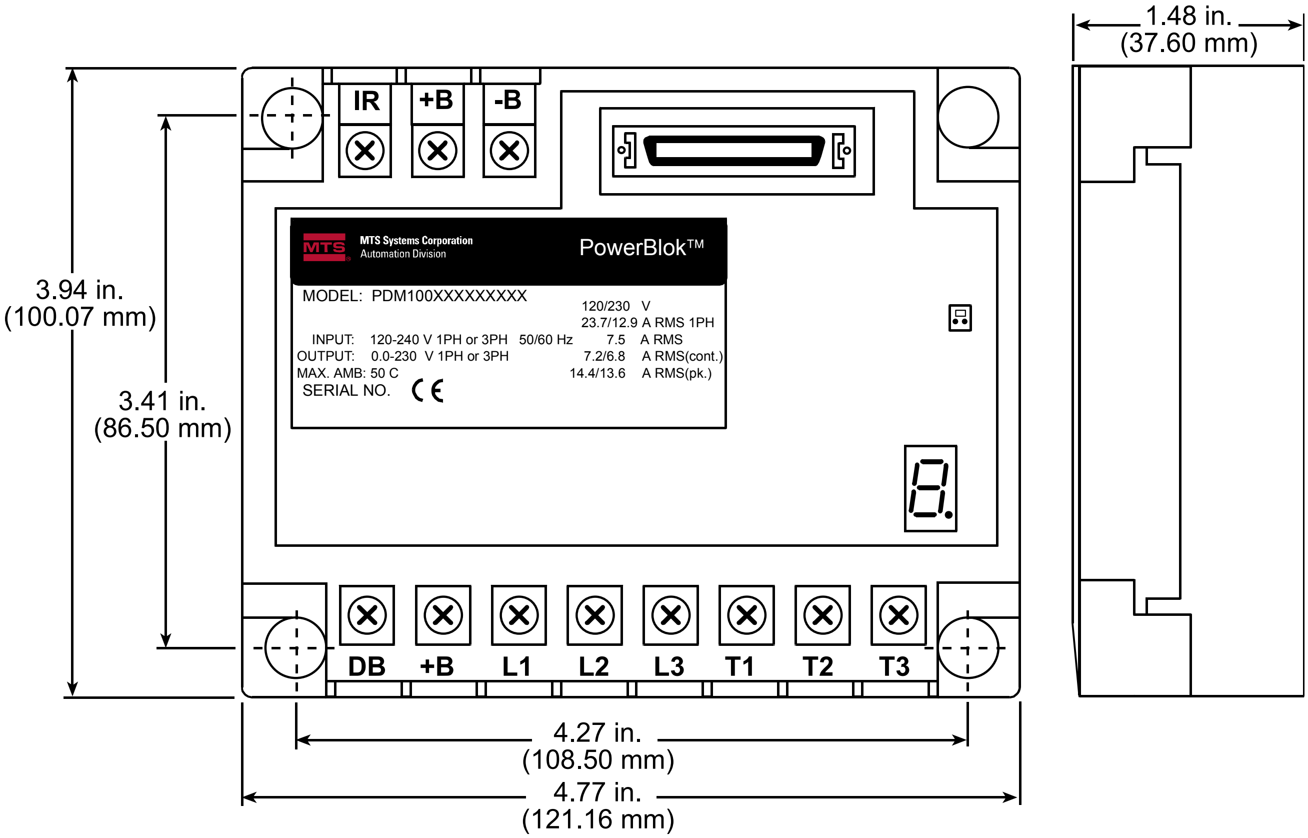
General PowerBlok Ratings

Parameter	Rating	Notes
Power factor (typical), 3-phase input	0.74 @ 1% line impedance 0.87 @ 3% line impedance 0.90 @ 5% line impedance	At nominal rated load when connected to a motor of assumed 88% efficiency.
Efficiency	> 97%, 5 – 20 Hp drives > 95%, 5 – 3 Hp drives	At Base Speed, 100% Rated Load

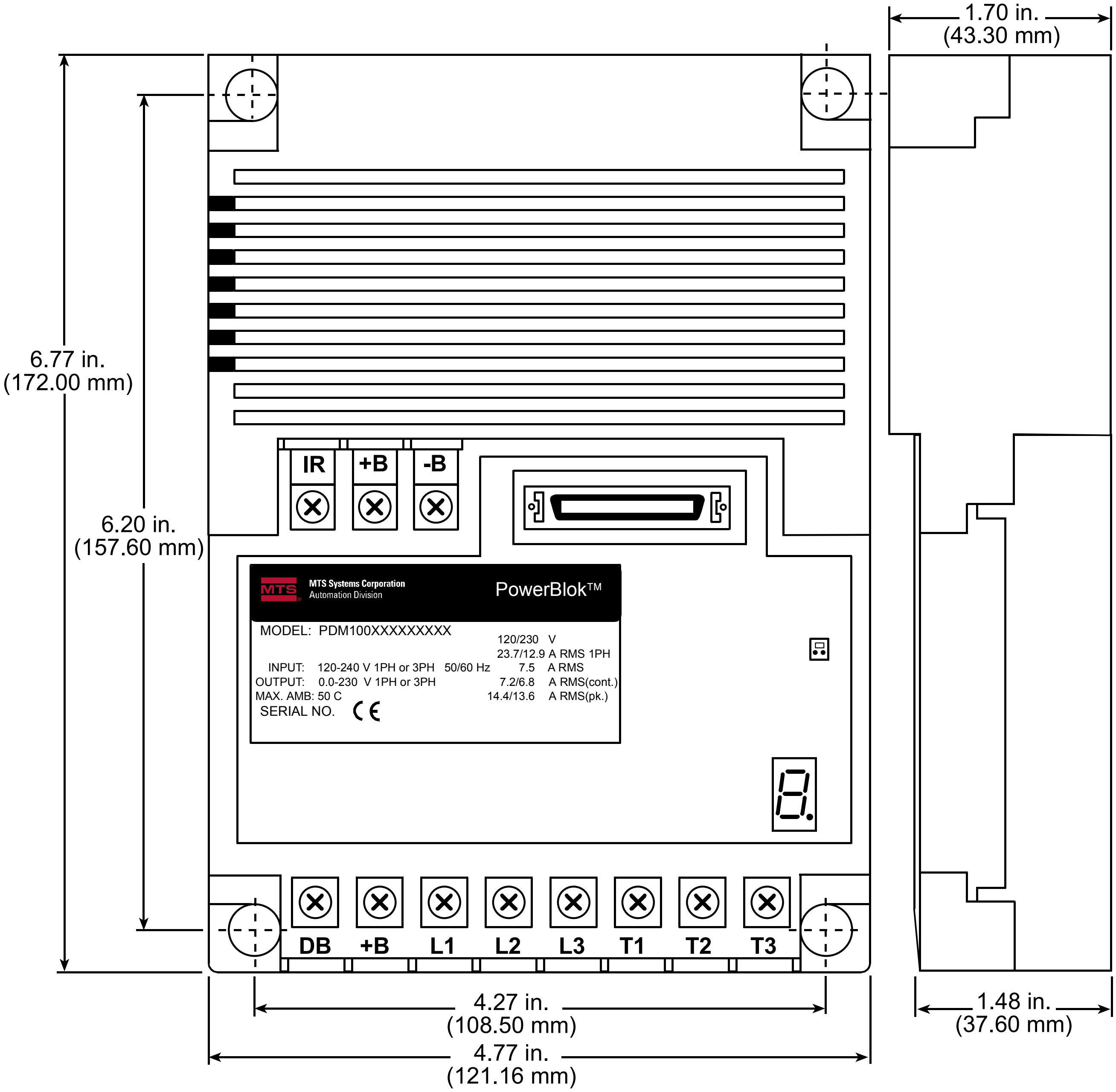
6 MOUNTING DIMENSIONS

PDM1000 Series Mounting Dimensions

PDM1000 Module Only

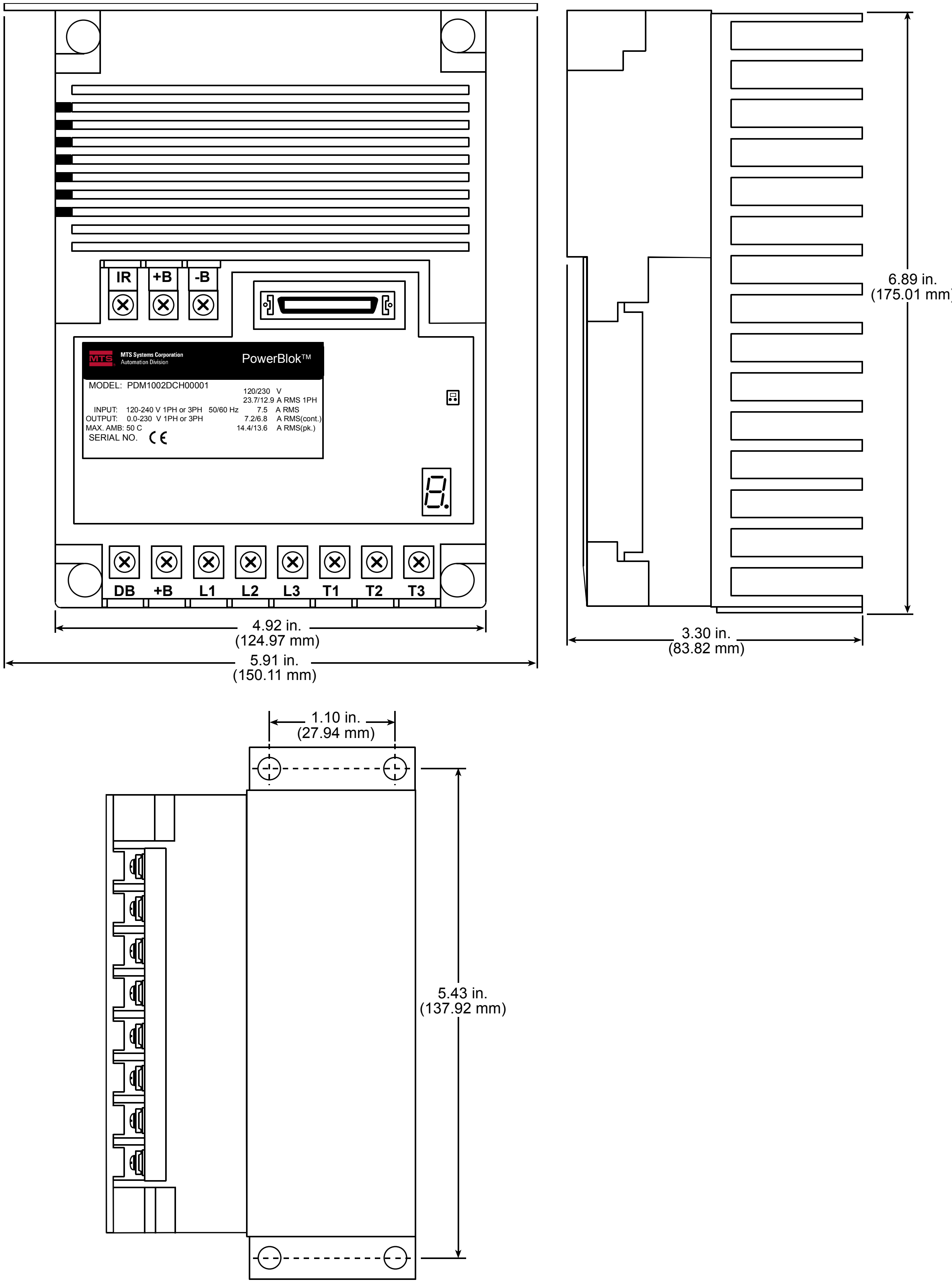


PDM1000 Module with CapBlok

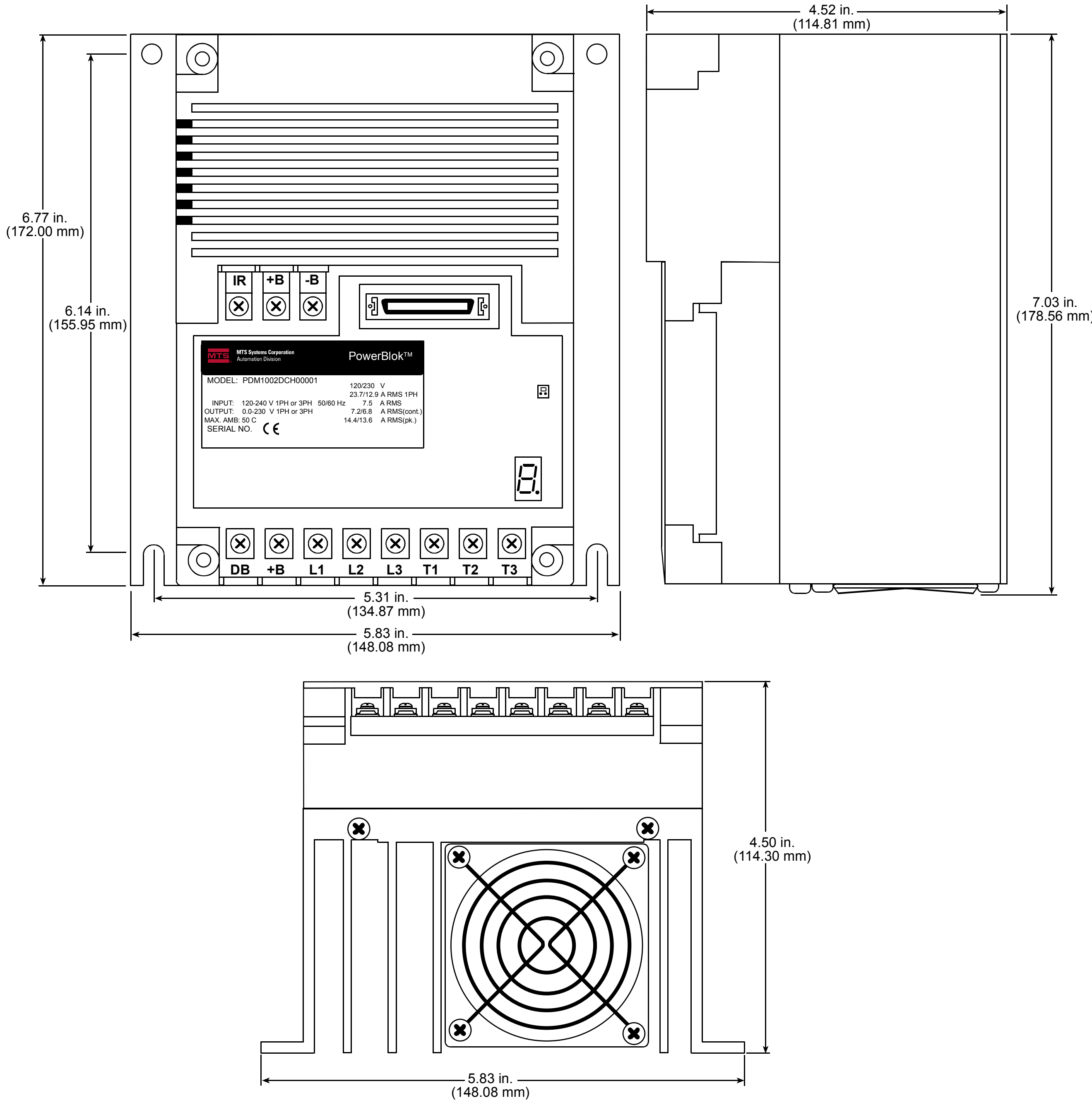


PDM1000 BB00S Drive Package

(PDM1001C, D, or E only)

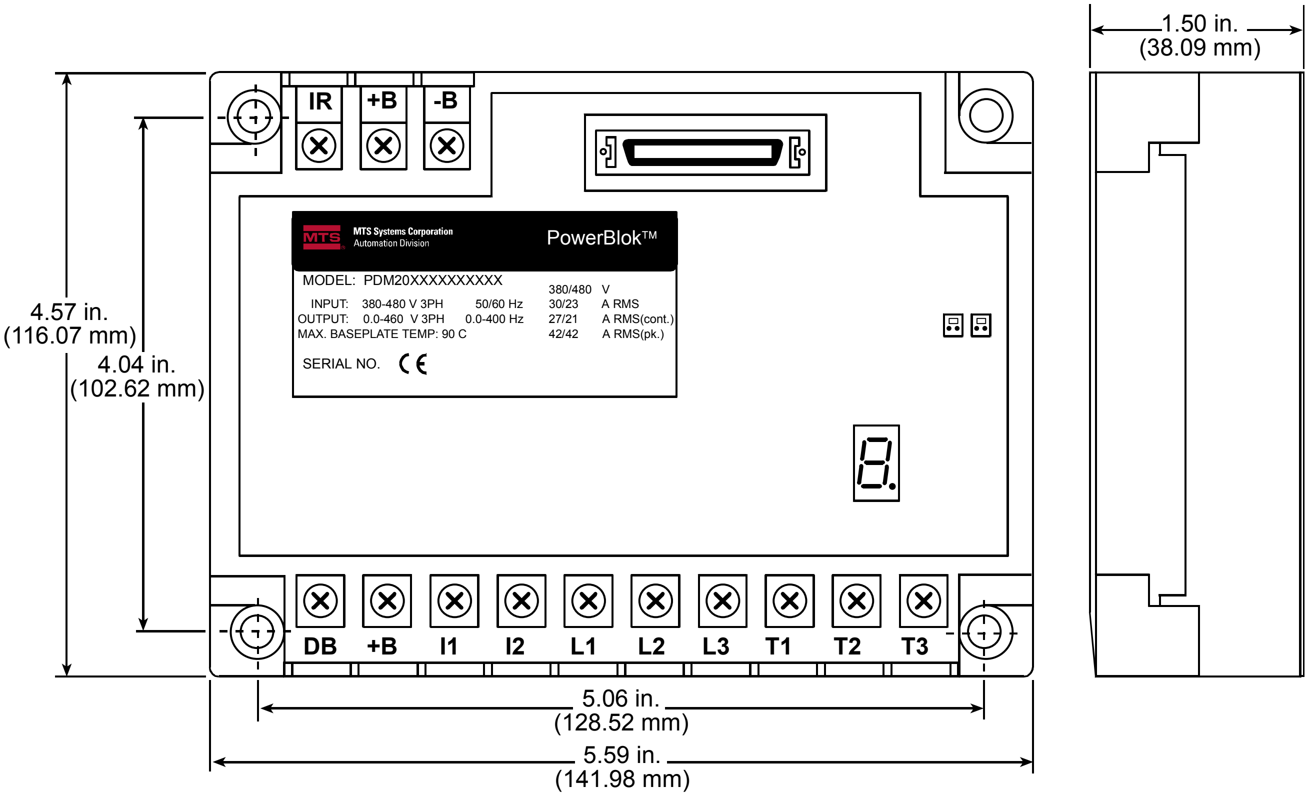


PDM1000 WC00S Drive Package

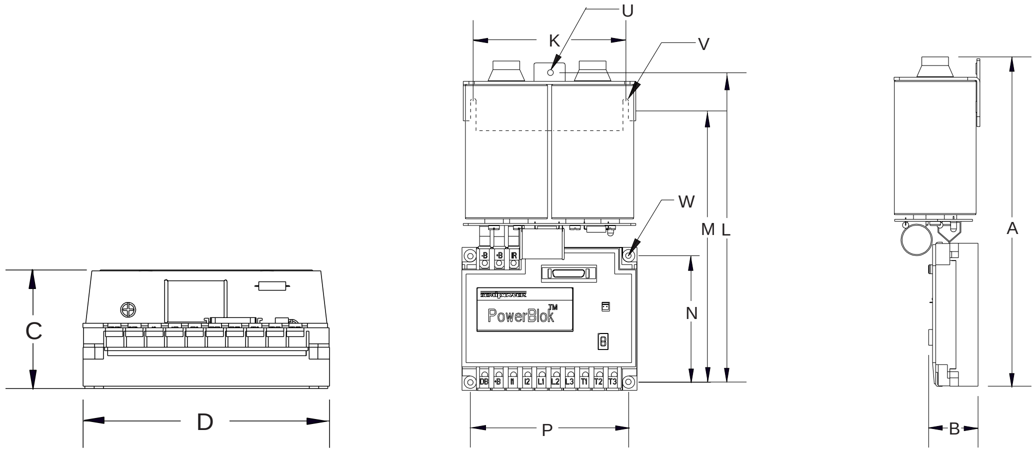


PDM2000 Series Mounting Dimensions

PDM2000 Module Only

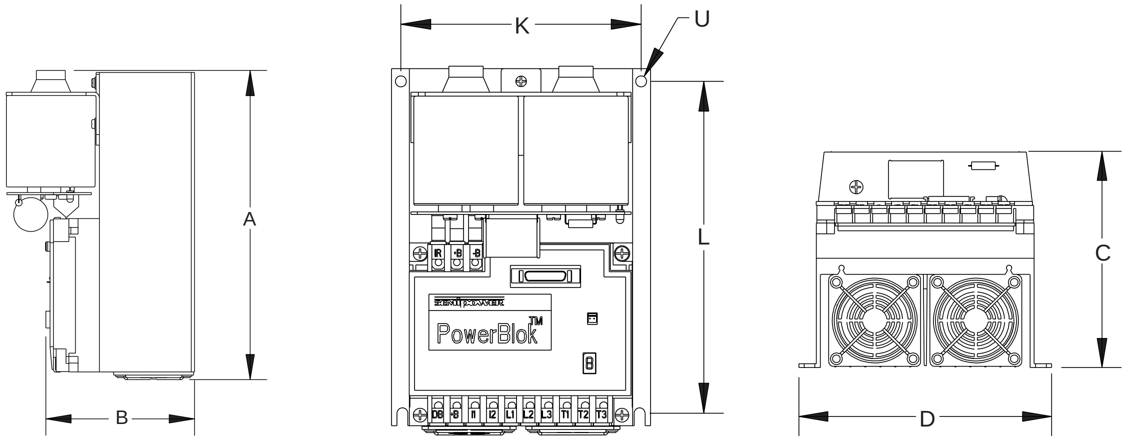


PDM2000 Module with CapBlok



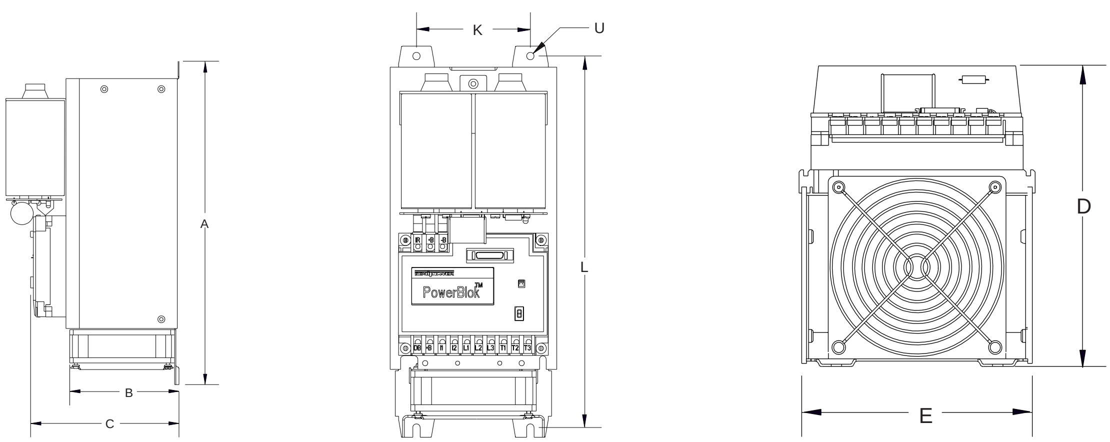
	7.5-10 kW		15-20kW	
Dim	Inches	mm	Inches	mm
A	8.98	228.0	10.52	267.2
B	1.59	40.3	1.59	40.3
C	2.76	70.0	2.76	70.0
D	5.59	142.0	5.59	142.0
K	4.88	124.0	4.88	124.0
L	8.32	221.4	9.88	250.9
M	7.10	180.4	8.66	219.9
N	4.05	102.5	4.05	102.5
P	5.06	128.5	5.06	128.5
U	∅0.197	∅5.0	∅0.197	∅5.0
V	∅0.197	∅5.0	∅0.197	∅5.0
W	∅0.209	∅5.3	∅0.209	∅5.3

PDM2000 WE00S Drive Package



Dim	Inches	mm
A	9.21	233.9
B	4.40	111.8
C	5.57	141.5
D	6.50	165.0
K	6.02	153.0
L	8.29	210.5
U	∅.276	∅7.0

PDM2000 WG00S Drive Package

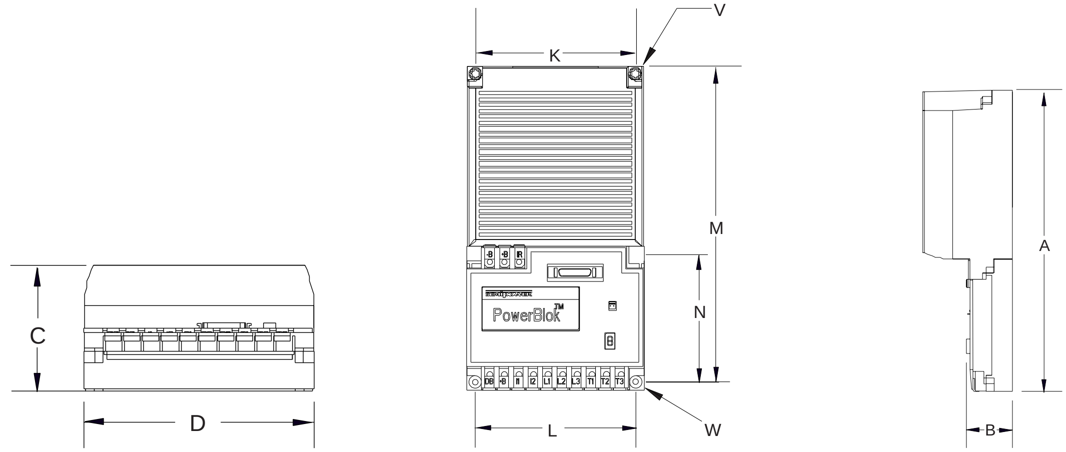


Dim	Inches	mm
A	14.61	371.0
B	4.90	124.4
C	6.65	169.0
D	7.82	198.7
E	6.08	154.4
K	4.25	108.0
L	13.87	352.4
U	∅.276	∅7.0

PDM2000 Package Dimensions

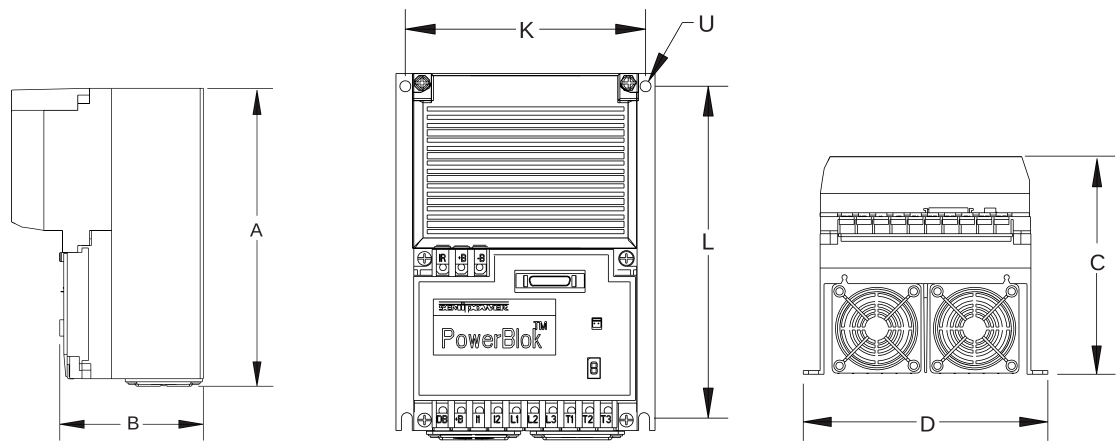
(these drawings reflect a new IP-20 CapBlok that will be available during Q3 '99. Please call the factory for availability)

PDM2000 Module with CapBlok



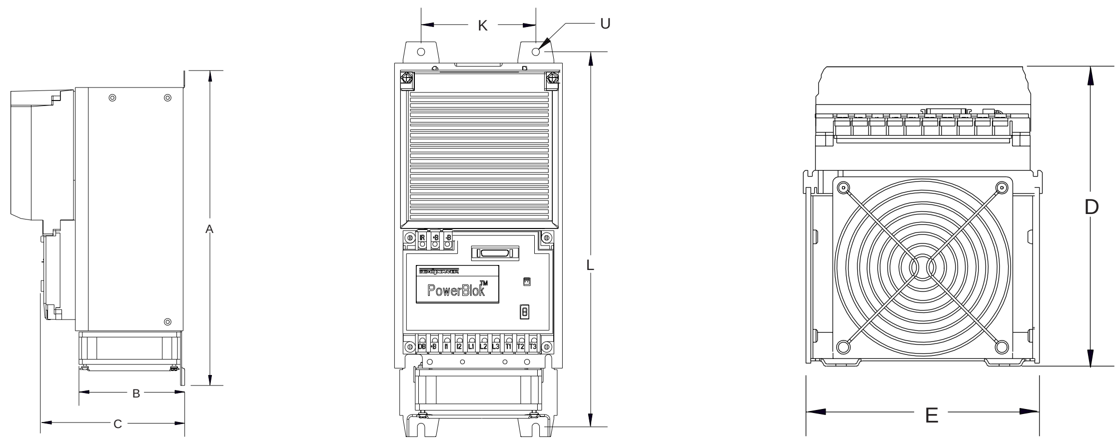
	7.5-10 kW		15-20kW	
Dim	Inches	mm	Inches	mm
A	8.98	228.0	10.52	269.2
B	1.59	40.3	1.59	40.3
C	3.05	77.2	3.04	77.2
D	5.59	142.0	5.59	142.0
K	5.12	130.0	5.12	130.0
L	5.06	128.5	5.06	128.5
M	8.39	213.2	9.88	250.5
N	4.05	102.5	4.05	102.5
V	∅0.197	∅5.0	∅0.197	∅5.0
W	∅0.209	∅5.3	∅0.209	∅5.3

PDM2000 WE00S Drive Package



Dim	Inches	mm
A	9.21	233.9
B	4.40	111.8
C	5.85	148.6
D	6.50	165.0
K	6.02	153.0
L	8.29	210.5
U	∅.276	∅7.0

PDM2000 WG00S Drive Package

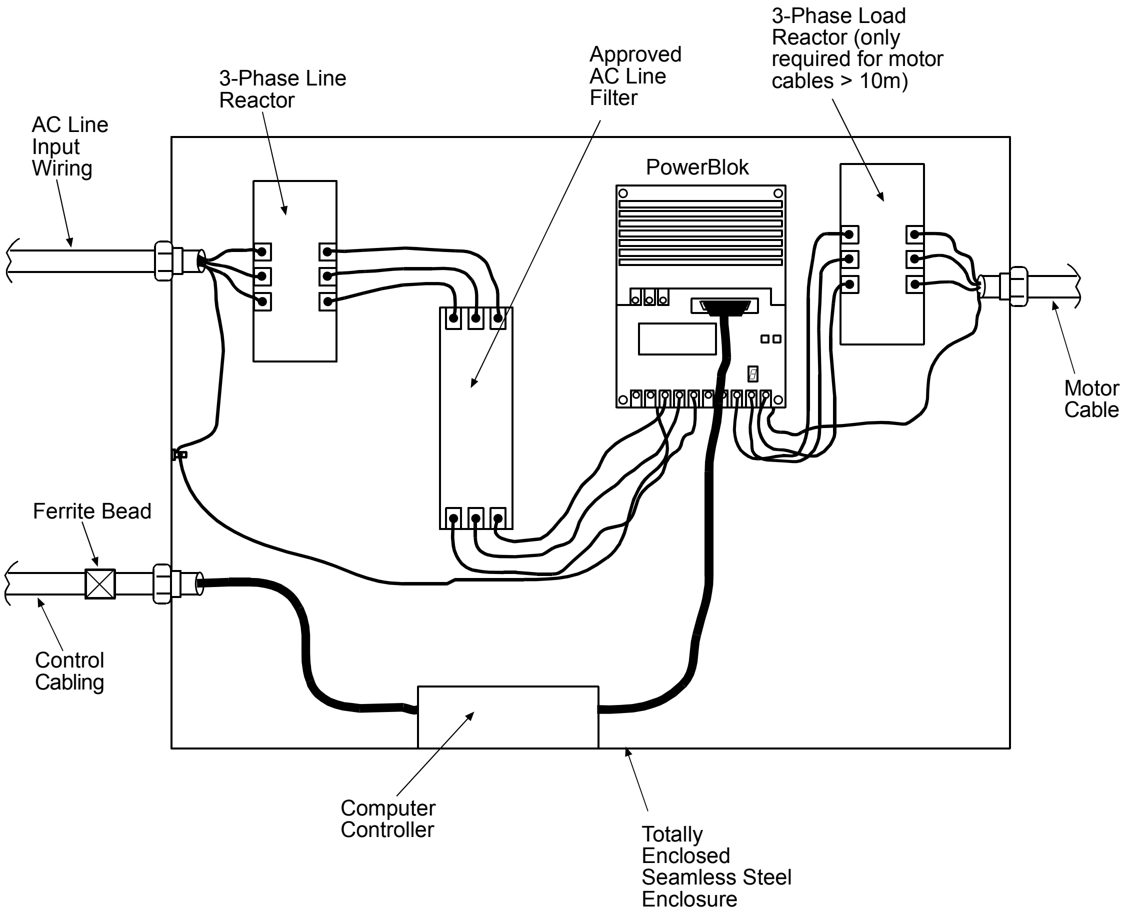


Dim	Inches	mm
A	14.61	371.0
B	4.90	124.4
C	6.65	169.0
D	8.11	205.9
E	6.08	154.4
K	4.25	108.0
L	13.87	352.4
U	∅.276	∅7.0

7 INSTALLATION GUIDELINES FOR EMC

EMC Directive

An Integrated Drive Module does not generally function independently. It is a component designed to be integrated with a machine control system, and is generally intended to be installed in such a manner. To assure compliance with the EMC Directive, the unit is tested in this configuration.



Suggested Installation for EMC Directive Compliance

Outline of Installation Requirements

1. Install the PowerBlok and EMC components within a totally enclosed seamless steel enclosure. A standard NEMA or IEC enclosure is adequate for this purpose. The door of the enclosure should be equipped with EMI/RFI gaskets.

2. Run AC Line Input wiring through a rigid or flexible metal-jacketed conduit, as required by applicable Electrical Code. Rigidly couple the conduit to the enclosure with a low impedance electrical connection (removing paint from the steel enclosure surface as required).

3. Run a separate ground conductor with the 2 or 3-wire AC Line input wires inside the conduit, and bond this separate conductor directly to a ground bonding stud on the enclosure surface.

4. Install a 1-ph or 3-ph 1% (minimum) line reactor, if required to raise the AC line impedance, in series with the incoming AC Line.

5. Install an appropriately rated 1-ph or 3-ph European Standard-compliant noise filter between the line reactor and the input terminals of the drive.

6. Run a separate ground conductor from the provided open-frame drive ground bonding screw (or in the case of an IDM module installation from immediately adjacent to the mounted PowerBlok module) to the enclosure ground bonding stud.

7. If required, install a 3-ph 1% (minimum) line reactor in series with the outgoing motor cable. This is normally only required for motor cables over 10 meters in length.

8. Use a shielded cable for wiring between the drive and motor (motor cable). Run a separate bonding conductor in the motor cable, connected directly to the PowerBlok heatsink ground bonding screw on one end, and the motor ground bonding screw in the motor junction box at the motor end. This cable may be run in a rigid conduit, but better EMC suppression is provided by a shielded cable with a braided shield.

9. Clamp a ferrite bead around all analog and digital control I/O and/or serial I/O cables as they exit the enclosure.

It is useful to note that the PowerBlok has passed all EMC emissions and susceptibility tests outside the enclosure described here, with the sole exception of the ESD directive. If the PowerBlok is protected from casual contact and therefore ESD susceptibility testing is not required, it should be possible with shielded cables to pass all other EMC Directives outside a sealed secondary enclosure.

Low Voltage Directive

A power electronic system is quite unique in its safety concerns and the methods used to ensure the safety of people, animals, plant, and equipment. The applicable standard for this product family is prEN50178-1995: Electronic Equipment for use in Power Installations. This standard details the design requirements and verification testing required for power electronic systems, including motor drive products, and we have self-certified compliance to the Low Voltage Directive according to this standard.

To ensure that your installation is safe, we recommend that the PowerBlok be installed in the following manner:

- The PowerBlok and CapBlok come in two voltage classes. The 230V class units achieve full rating at 230Vac ±10% 3-phase 50/60Hz. Operation at 200V must be derated – the drive current rating cannot be increased at 200V and so it can deliver less total output power under this condition. The 400V class units carry a dual rating – they are rated to deliver full power at 400Vac ±10% 3-phase 50/60Hz and 480Vac ±10% 3-phase 50/60Hz. This means that you can deliver higher output current at 380/400V operation to deliver the same shaft power from an appropriately rated motor. The CE mark applies to all 230V class applications, but for the 400V class only applications at 380/400Vac.
- On an Open-Frame Drive model, connect the heatsink ground bonding terminals to earth as shown in the wiring diagram above. Module customers must bond the earthing conductor as close to the mounted module as possible to provide a return path for currents injected into the IDM module baseplate. Even if EMC compliance is not required, the drive must be bonded to ground with suitable conductor rated for continuous current of at least the input current rating of the drive itself. Wire these connections separately – do not daisy chain ground connections.

- Do not use an earth leakage circuit breaker as an electric shock protector.
- Install current-limiting fuses on the incoming AC Line power leads to prevent damage to equipment and people in the event of a catastrophic failure of the power electronic circuits.
- While not normally required, it is generally a good practice to install a surge suppressor assembly at the input terminals of the drive. These assemblies are available from many sources.

APPENDIX A:

Warning: If your Motor Resistance is lower than listed here:

PowerBlok Type	200/240V	400/480V
PDM1001	4.8 Ohm	19 Ohm
PDM1002	2.4 Ohm	9.6 Ohm
PDM1003	1.7 Ohm	6.8 Ohm
PDM1005	1 Ohm	4.3 Ohm
PDM2007	0.75 Ohm	3.0 Ohm
PDM2010	0.6 Ohm	2.3 Ohm
PDM2015	x	1.6 Ohm
PDM2020	x	1.2 Ohm

You must enter the correct Safe PWM Duty Cycle value in the 6-Step Voltage Test step in P2Setup or risk damage to your new PowerBlok.

During the initial stages of system setup, the PMAC2 setup utility P2Setup makes a series of open-loop step moves to determine encoder and motor phasing (direction of rotation). These moves are made before P2Setup has asked for any information on the attached amplifier or stabilized the current loop – **at this point, all protection features are disabled.**

The PowerBlok has a layered overload protection design. First, actual short circuits are detected by a de-saturation detection system that continuously monitors the status of every power device and trips off whenever a device that was commanded ON appears to be OFF. This protects from errors that could destroy the in 10μs ("4" Fault). Next, an instantaneous overcurrent trip shuts down whenever the measured current exceeds the 1 ms capability of the IGBTs, typically 5-6x rated current ("3" Fault). Next, a longer time constant, lower threshold current limit protects from longer duration uncontrolled overloads ("1" Fault). Next, the PMAC will not command currents greater than the PowerBlok rating once you tell it what that current is, and finally the PMAC has an I^2t function that protects from longer duration overloads. **Without these protections from the PMAC, excessive currents above the module rating would flow unchecked, and the PowerBlok could be damaged.**

Calculating the PWM Step Size values in P2Setup:

PWM PerCent Duty Cycle ≤ (PowerBlok Rated Current * Stator phase-phase Resistance)/(1.414 * VAC)

For example, for a 10Hp 460V PowerBlok on a 480V line with a 0.6 Ohm per-phase stator resistance, PWM PerCent Duty Cycle ≤ (14 * 2 * .6)/(1.414 * 480) = 2.47%

In this case, you must select 2% from the pick list for this parameter to avoid damage to the PowerBlok.

Below is a listing of the available drives that can handle only 120 VAC input. Also, the table lists the capacitance of the CapBlok, the rated current, and rated power, respectively.

Module Type	Capacitance of CapBlok, μf	$Current_{rated}$ of module, A	Drive $Power_{rated}$, *kW*
PDM1001C	2800	4.0	0.75
PDM1002C	4200	7.2	1.40
PDM1003C	4200	10.4	2.00

Warning!!! The above module types are restricted to using an input voltage of 120 VAC ±10% without damaging the CapBlok.

Below is a listing of available drives that can handle both 120 or 240 Vac input. Also, the table lists the capacitance of the CapBlok and the rated current, respectively.

Module Type	Capacitance of CapBlok, μf	$Current_{rated}$ of module, A	Drive $Power_{rated}$, *kW*
PDM1001D-CH-xxx-001	2160	3.4	not rated