AMETEK, Inc.

Dynamic Fluid Solutions Division

100 E. Erie St.
Kent, Ohio 44240

User's Guide
4930721

INTEL2 PRODUCTS

Windjammer 5.7″	**120 Volt, 240 Volt, Universal 100V-240V**
Nautilair 7.6″	**120 Volt, 240 Volt, Universal 100V-240V**
Nautilair 8.9″	**120 Volt, 240 Volt, Universal 100V-240V**

Brushless Motor Drive Electronics

November 2018

Introduction

The brushless drive electronics module is used to power a variety of brushless DC motors and blower systems in the AMETEK Windjammer 5.7" (145 mm) and Nautilair 7.6” (193mm), 8.9” (226mm) families. The input power designation refers to a nominal mid-range operating point; actual power input will depend upon the application.

The Printed Circuit Board (PCB) electronics provides: Conversion of the AC input to a DC bus voltage, a small signal power source for the analog and digital components, commutation and power electronics, input command, and velocity sensing and feedback.

When used in blower products, the PCB also supports the motor stator and Hall Effect Rotor Position Sensors, providing a compact and reliable package.

The electronics module implements uni-directional, single quadrant speed control. Motor speed is monitored by converting the frequency of the signals from the Rotor Position Sensors to an analog DC voltage. This voltage is compared to the User's Input Command. The compensated error between actual speed and commanded speed is used to control the voltage applied to the motor windings in a manner to minimize the speed error. The Command Input is optically isolated from the AC source and all internal power circuits. A variety of speed control options are available.

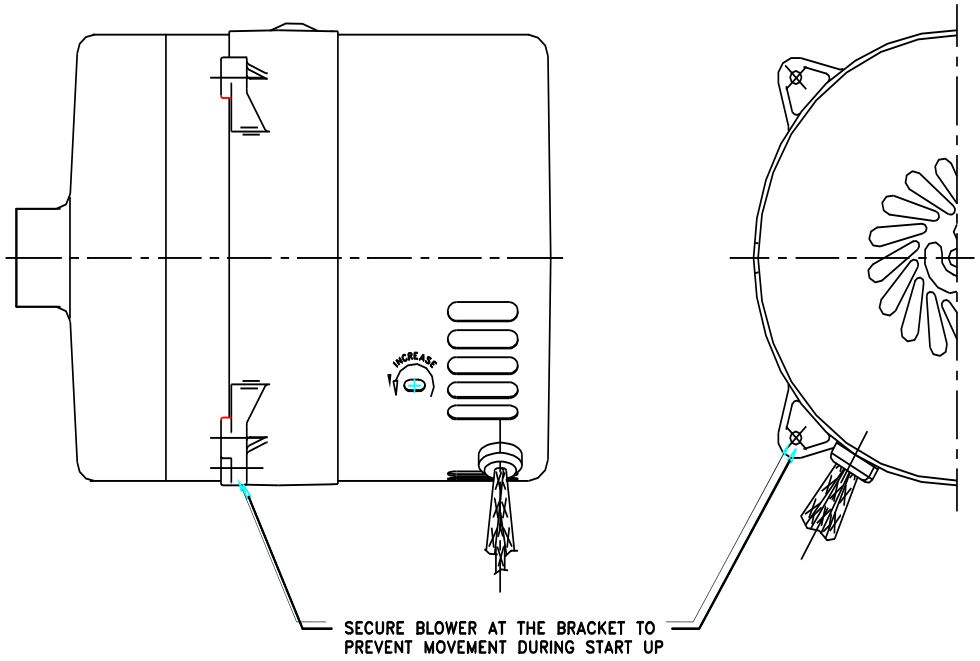
Protection features include over temperature and over current sensing and shutdown. A fuse, in-rush current limiter, and MOV voltage transient protector are connected to the AC source.

This User's Guide will provide information on the use and operation of the electronics module and its interfaces. Actual blower performance will depend upon the blower characteristics and the User's application.

Precautions for Use

WARNING: THIS PRODUCT OPERATES FROM AND USES VOLTAGES THAT ARE POTENTIALLY DANGEROUS! FAILURE TO OBSERVE APPROPRIATE SAFETY PRECAUTIONS COULD RESULT IN SERIOUS BODILY INJURY, INCLUDING DEATH IN EXTREME CASES. We recommend that adequate instructions and warnings by the Original Equipment Manufacturer (OEM) include labels clearly stating the precautions necessary for this type of equipment in the application.

WARNING: Secure blower prior to initial start to prevent sudden movement and possible damage.



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Blower Safety Precaution

In the application of Ametek, Inc. blowers are considered as a component in your product, you must exercise the following minimum precautions:

THE FAILURE TO OBSERVE THE FOLLOWING SAFETY PRECAUTIONS COULD RESULT IN SERIOUS BODILY INJURY, INCLUDING DEATH IN EXTREME CASES. *We recommend that adequate instructions and warnings by the original equipment manufacturers (OEM) include labels setting forth the precautions listed below to the end user.*

The blowers must be connected to a proper and effective ground or mounted in a manner that will guarantee electrical isolation and insulate the user and others from electric shock. End product design should not rely solely on the primary insulation of the motor.

Standard blowers are not designed to handle volatile or flammable materials through the fan system unless specifically designed. Passing combustible gases or other flammable materials through the fan system could result in leakage which could cause a fire or explosion.

These products must not be used in an area contaminated by volatile or flammable materials since sparking is predictable in the normal operation of the motor and may ignite the volatile causing a dangerous explosion.

Other Division**s** of AMETEK, Inc. can supply specifically designed motors and blowers for use in handling combustible gases or for use in hazardous duty locations. These specially designed units should only be used in conjunction with combustible gases, which they were specifically designed to handle. The type of gases must be so noted on the product label and in the instructions.

The rotation of the blower is a potential source of injury and must be taken into account in the design of your end product. You must provide the necessary guarding or housing as required by the finished product. Do not remove guard as severe bodily injury may occur to fingers or appendages.

Products incorporating vacuum blowers must be designed so as to prevent the vacuum or air pressure from being concentrated in a manner that can expose the user to injury by coming into contact with any body area, such as eyes, ears, mouth, etc.

The blowers must not be exposed to moisture or liquid or used outdoors, except in equipment which is specifically designed for outdoor use and meets the appropriate regulatory agency requirements for outdoor use. Moisture or liquid can damage the blower and defeat the electrical insulation resulting in a severe electrical shock to the user.

Ametek blowers must not be operated above the design voltage. Over voltage conditions can cause excessive speed of the motor and can result in severe electrical shock and/or other traumatic injury to the operator.

Precautions must be exercised to ensure blower leads are properly routed and connected in your equipment. Lead wires must be routed and retained to ensure that they do not become pinched or come in contact with rotating parts during

assembly or subsequent operations. Connections must be designed so that proper electrical contact is established and the connections must be properly insulated.

Disassembly or repairs of AMETEK products should not be attempted. If accomplished incorrectly, repairs can create an electrical shock and/or operational hazard. It is recommended that repairs be made only by AMETEK and not by others.

In the event that the motor or blower ceases to operate, power must be disconnected before examination and/or removal from the system.

Contact AMETEK, Inc. to discuss any questionable application before selecting a blower. In setting forth the above listed recommendations with regards to precautionary steps that must be considered, we in no way intend to imply that if these steps are taken a product will meet the applicable safety standards. We, at AMETEK, are not sufficiently conversant with the specific safety hazards which may be associated with particular products. We can only advise precautions to be employed generally for the safe use of AMETEK products as components. For testing specifically related to the safety of the product, we recommend that you contact the appropriate regulatory agency as indicated by the type of product being manufactured.

Installation

Interface:
Please refer to the Block Diagram. All electrical connections are made through J1. Safety ground connections should be made to J1 pin 3.

Warning! Use care when making initial power connections. Application of main power to the User Speed Command Input pins will result in destruction of the velocity control circuit. Check all connections before applying power!

Power Input:
The 50/60 Hz AC power source is connected to J1, pins 5 and 4.

Speed Command Input (when applicable):
The Speed Command is connected to J1, pin 2 (positive) and pin 1 (negative).

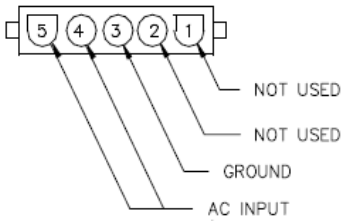
Note: Application of opposite polarity voltages to input pins 1 & 2 will not destroy the unit unless the input voltage exceeds 45VDC.

Connector:

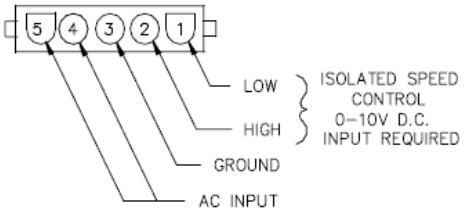
Refer to the outline drawing of the specific blower model for the required connector type.

Windjammer 5.7" and 7.6"

INTERNAL Mechanical Speed Control



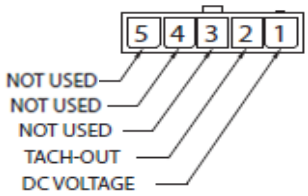
EXTERNAL Speed Control



POST HEADER ASSEMBLY

Windjammer 5.7

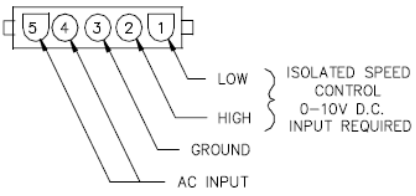
Option- Status or Tach-Out

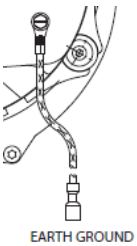


POST HEADER ASSEMBLY

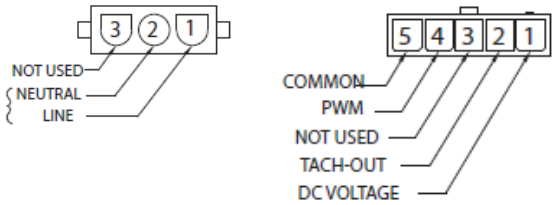
Nautilair 7.6" and 8.9"

0-10V speed control





PWM speed control and/or Tach out



POST HEADER ASSEMBLY

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Ambient Temperature:

Operational: **-20°C** to +50°C
Storage: -40°C to +85°C

High Voltage Testing:

AC input and ground:
3000 VAC RMS (50/60Hz) applied for one minute, 2 mA leakage maximum.

AC input and Isolated Speed Control Input:
3000 VAC RMS (50/60 Hz) applied for one minute between AC input and Isolated Speed Control Input, 1 mA leakage maximum.

AC input and Isolated Status or Tach Output:
3000 VAC RMS (50/60 Hz) applied for one minute between AC input and Isolated Speed Control Input, 1 mA leakage maximum.

Electrical Performance Characteristics

AC Input:

240VAC Models:
180 to 264 VAC RMS, 50/60Hz, single phase

120VAC Models:
90 to 132 VAC RMS, 50/60Hz, single phase

Universal Models:
90 to 264 VAC RMS, 50/60Hz, single phase

Note: Although the unit contains a lock-out feature that detects low voltage conditions, the electronics should not be operated continuously with the AC Input lower than 180V FOR 240V models OR 90V for 120v / Universal models. Also, the blower performance changes with applied line voltage.

AC-Inrush Current:

With the blower connected to AC Power Line, there will be a high Inrush Current for approx. 50ms until the internal capacitors are charged. The inrush current is limited by a NTC-Thermistor.

Stand By Power Consumption:

240VAC 50/60 Hz version	50mA typical
120VAC 50/60 Hz version	65mA typical
100-264VAC 50/60 Hz version	65mA typical (120VAC)

Isolated Speed Control Input:

0..10V Analog Signal Input

Voltage Range: 0 to +10 VDC nominal,
Absolute maximum of 45 VDC

PWM Digital Pulse Input:

PWM Frequency Input range: 400 Hz to 10 KHz
Duty Cycle 0..100%
0 to +10 Volt pulse nominal,
0 to +45 Volt absolute maximum

(It is possible to provide a 10VDC, 12mA source to pin 2 and pulse the ground (sink) at pin 1.)

0..20mA Speed Control Current Input:

Current Range: 0 to 20mA
Absolute maximum 44mA (22V, 500Ω)

Speed Control Drift with Temperature:

Analog Mode: Typ. ±4% from nominal speed at +23°C

PWM or
Mechanical Mode: Typ. ±4% from nominal speed at +23°C

Operation

Prior to initial application of power, check all connections and grounds.

Speed Control:

Various speed control modes are available. The control electronics has a built in 25 turn potentiometer that may be used to directly control speed or to adjust motor speed in response to the signals on the Speed Command Input.

Mechanical Direct Speed Control:

In this mode, no input is required at the Speed Command Input; J1 pins 1 and 2 must be left open. The internal potentiometer is connected to the drive electronics and may be used to directly control motor speed over the design range.

Potentiometer Fully Clockwise: Motor RPM Maximum
Potentiometer Fully Counter-Clockwise: Motor RPM Minimum

Analog Speed Control:

In this mode, an analog signal between 0 to 10 VDC is used to control motor

speed. The internal potentiometer is wired to provide scaling of the input voltage. The analog voltage is applied between J1 pin 2(+) and pin 1(-). The analog input is used both for powering the velocity error amplifier and providing the speed command, therefore , a minimum voltage must be present at J1 pin 2 (+) and pin 1 (-) for proper operation. This minimum voltage threshold ensures that the controller will be "OFF" for voltages under 1.0 volts. The command scaling potentiometer is wired such that fully clockwise provides maximum command gain. With the potentiometer fully clockwise:

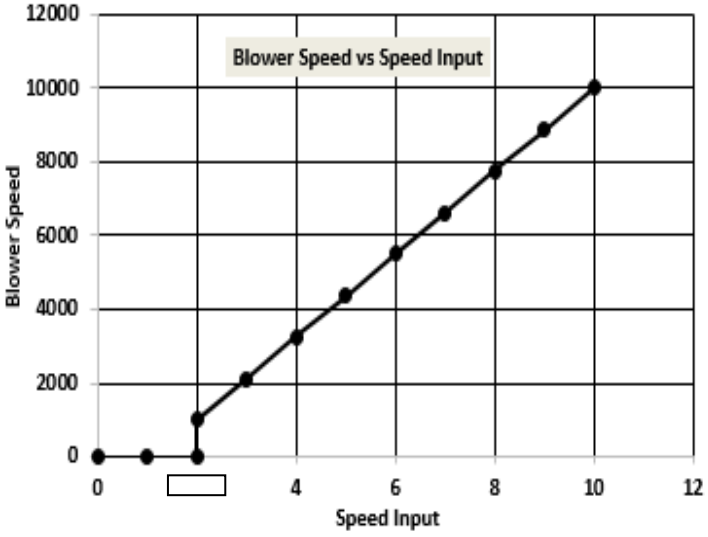
J1-1,2 10 Volts:	Maximum RPM
J1-1,2 <1 Volt:	Motor Off

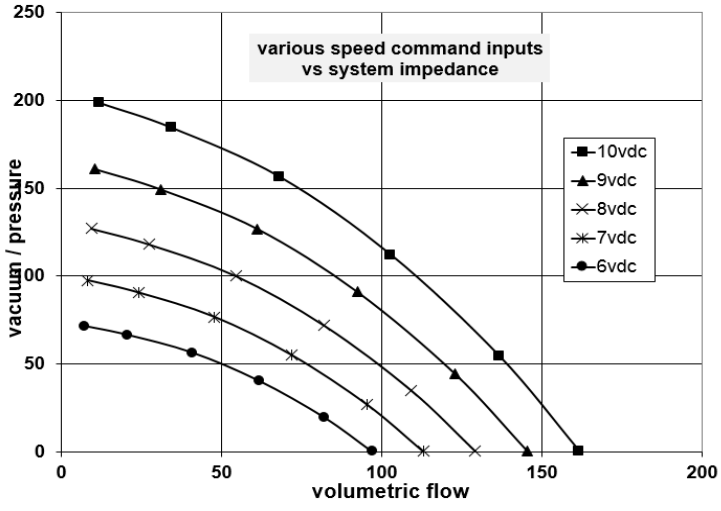
Digital PWM Speed Control:

In this mode, the internal potentiometer must be set fully clockwise. The User then supplies a Pulse Width Modulated (PWM) signal switching between 15 and 45 volts to the Speed Command Input, J1 pin 2(+) and pin 1(-). The PWM signal must have a base frequency between 400 Hz to 10 KHz. The motor may rotate slowly at any duty cycle greater than 10%. The Velocity Error amplifier and Filter and Compensation circuits (see the Block Diagram) will convert the pulse width duty cycle to a DC voltage for use by the Commutation and Control circuits.

J1-1,2 100% Duty Cycle:	Maximum RPM
J1-1,2 <10% Duty Cycle:	Motor Off

Speed Input Functions





In the Analog and Digital Modes the motor will not begin to rotate until a threshold voltage or threshold duty cycle is reached. In the Analog mode, this threshold voltage will also depend upon the setting of the potentiometer. This

feature allows the Speed Command Input to also be used as a logical "ON/OFF" signal.

AMETEK may pre-set the internal gain potentiometer for specific user applications during final factory test.

With the Speed Command Input voltage or duty cycle set to minimum, or, in Direct Mode, with the internal potentiometer set fully clockwise, apply AC appropriate to the unit. Increase the Speed Command Input voltage or duty cycle until rotation begins. In the Direct Mode, the motor will begin to rotate slowly; adjust the potentiometer to obtain the desired speed, pressure, or flow.

NOTE: For initial testing, or in order to check performance, the AC voltage may be brought up slowly using an adjustable AC voltage source or variable transformer with the Speed Command set to Maximum RPM. Prolonged operation at low line voltages under load is not recommended. The motor must never be allowed to stall when running under low line conditions! Use care when starting the motor with low line conditions!

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Detailed Operation

Refer again to the Block Diagram. Input AC power is rectified and filtered to provide an internal DC bus voltage. In-rush current is limited using a Negative Temperature Coefficient (NTC) device in series with the Bridge Rectifier. A pre-regulated low voltage power source supplies the analog and digital circuits.

The User Speed Command Input may be used in the three Modes described above. In Analog Mode, through the internal command scaling potentiometer, is compared to the velocity feedback, amplified, and translated into a velocity error voltage that controls the commutation circuits.

In the Direct Mode (Mechanical), the internal potentiometer directly controls the velocity command.

The electronics module implements six-step commutation of the brushless DC motor using Hall Effect devices to detect motor rotor position. The Hall Effect information is used to select which transistors in the Power Output Stage are turned ON to enable rotation in the desired direction. The Hall Effect signals are also used to provide motor velocity feedback. Velocity scaling is determined by the factory based on the motor winding and blower maximum speed.

The Analog, Digital, or Direct Mode velocity command voltage is amplified, and translated across the isolation interface using an analog opto-coupler. The velocity error is used as a current command that is compared to the Current Feedback. The output of this amplifier controls the duty cycle of an internal PWM Modulator. This PWM frequency is selected to ensure good bandwidth and minimum current ripple in the stator. A single sensing resistor in the lower bus supply line is used to measure current. The output of this resistor is used to set the Current Limit. In Current Limit, the duty cycle of the PWM Modulator is shortened in proportion to the over current condition.

A Negative Temperature Coefficient (NTC) resistor is mounted on the Power Output Stage heat sink. This device will shut down the Commutation and Control logic if the internal temperature exceeds approximately +83°C ±5°C). Over temperature is a latched fault condition; power must be removed in order to restart the unit. If the Over temperature condition still exists, the unit will not return to normal operation until the heat sink temperature is less than +83°C (5°C Hysteresis).

NOTE: Constant cycling of the blower, by switching the main power, may cause damage to the blower if the blower will be restarted within less than 1 minute after being stopped. If the application requires constant ON/OFF the Speed Input should be used to start and stop the blower. If the Speed Input is used to start and stop the blower unlimited cycles are possible.
We recommend to disconnect the blower from the line voltage only if the machine will be switched off in general.

Blower Operation

As mentioned, the actual performance of the blower in the User's system will depend upon the application. The ability to control motor speed provides many benefits:

1) Adjusting speed varies the blower output, allowing the User to "tune" the blower to a particular application;

2) The blower may be part of an external control loop. For example, the User may adjust motor speed to maintain constant pressure or temperature.

Note: If the blower is part of an external control loop we recommend using the blower as an open loop version. Open loop means the internal speed control loop is not used and the speed is set to any value commanded by the speed input. If the blower is operated in a closed loop version and an external control loop is wired also, this may cause blower rpm oscillation.

Inlet Filter

Inlet Filter should be used whenever the working air or cooling air is polluted with dust or other air borne particles and contaminants larger than 2 microns. The filter system should be designed for minimal pressure drop and high efficiency. Contaminated air results in reduced operating life of the blower.

Error States

Following reasons will latch off the blower:

- locked rotor
- over current
- over temperature

The main power has to be switched off to restart the blower.

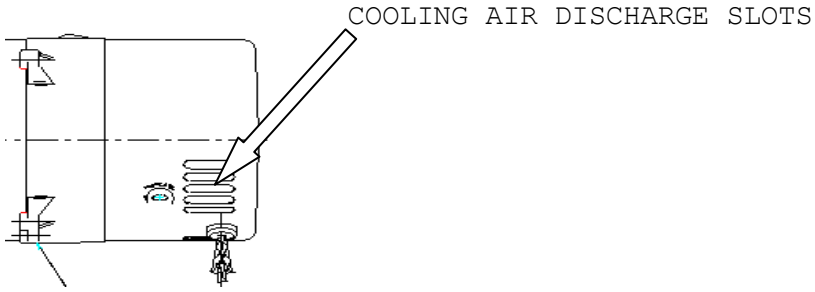
Following reasons will stop the blower:

- under voltage (for 240V it's 133**V** ; for 120V & Universal it's 83**V**)
- over voltage (for 240V & Universal it's **267V** ; (for 120V it's **150V**)

The motor will automatically restart when the voltage is again within design limits. Take precautions to insure nothing obstructs blower rotation.

Blower status and faults:

The Intelligen electronics provides external light indication of blower as long as main power is not switched off. The status LED is situated on the main control board and can be observed through the cooling air discharge slots of the blower.



Status and fault Table:

Blower status	Light status	Action	Resume operation
Powered in standby condition	OFF	N/A	N/A
Running	ON	N/A	N/A
Under voltage	1 blink slowly	Start with correct voltage	N/A
Over current	2 blinks and pause	Latched Shutdown	Power cycle
Stall motor	3 blinks and pause	Latched Shutdown	Power cycle
Over temperature	4 blinks and pause	Latched Shutdown	Power cycle
Over voltage	5 blinks and pause	Restart with correct voltage	N/A

..... Note: The latched error signal will stay until the main power is disconnected.

Option:

No input signal	7 blinks and pause	N/A	N/A

Option: The Failure/Fault output signal can be made available via a Solid State Relay contact. This feature is called Status Output.

Possible Stall Motor failure causes: Defect power stage, defective halls, defect driver circuit, improper stator phases, improper winding, locked bearing,

Possible Over Current failure causes: defect bearings, blower overload,

Possible Over Temperature failure causes: Ambient Temperature not within limits, cooling air and working air not kept separate, not enough exchange on cooling air, air contamination too high,

Hardware electronics protection features: Hardware Fuse – fast acting
(not accessible or replaceable)

Troubleshooting

1) Unit Will Not Start

a) AC Power not applied;

b) Connector wired incorrect;

c) Polarity of Speed Control Input is reversed;

e) In Digital Mode, Speed Control Input duty cycle is too low or base frequency is too low (<150 Hz);

f) Motor is stalled, blower impeller is blocked, over current condition exists;

g) Controller internal temperature still exceeds +83°C due to operating point, ambient temperature, or both.

h) Fuse has blown.

2) Unit Runs, but Will Not Reach Required Speed

a) Blower output capability is undersized for the application;

b) Line Voltage is outside normal range;

c) Internal pot is improperly adjusted;

d) Blower impeller or motor shaft is blocked;

e) Insufficient voltage at Speed Command Input.

3) Unit Starts, Runs Briefly and then Stops

Controller internal temperature still exceeds +83°C due to operating point, ambient temperature, or both.

4) Blower oscillates

a) Unstable speed input command;

b) If external control loop is used and the blower was supplied in closed loop configuration, the control loops may interfere with each other;

Maintenance & Service

Maintenance:

The blower d**oes** not require maintenance.
In the event of a fault, please do not open the blower.

Taking out of service:

The safety instructions must be read and observed prior to taking the unit out of service.

Disposal:

Take the blower out of service. Dismantle the drive ready for disposal and break it up into its individual components. Sort the individual parts according to material and forward to disposal. Adherence to the requirements of legislation governing disposal and environmental guidelines in the country of use must be ensured when disposing of electronic components.

Service & Support:

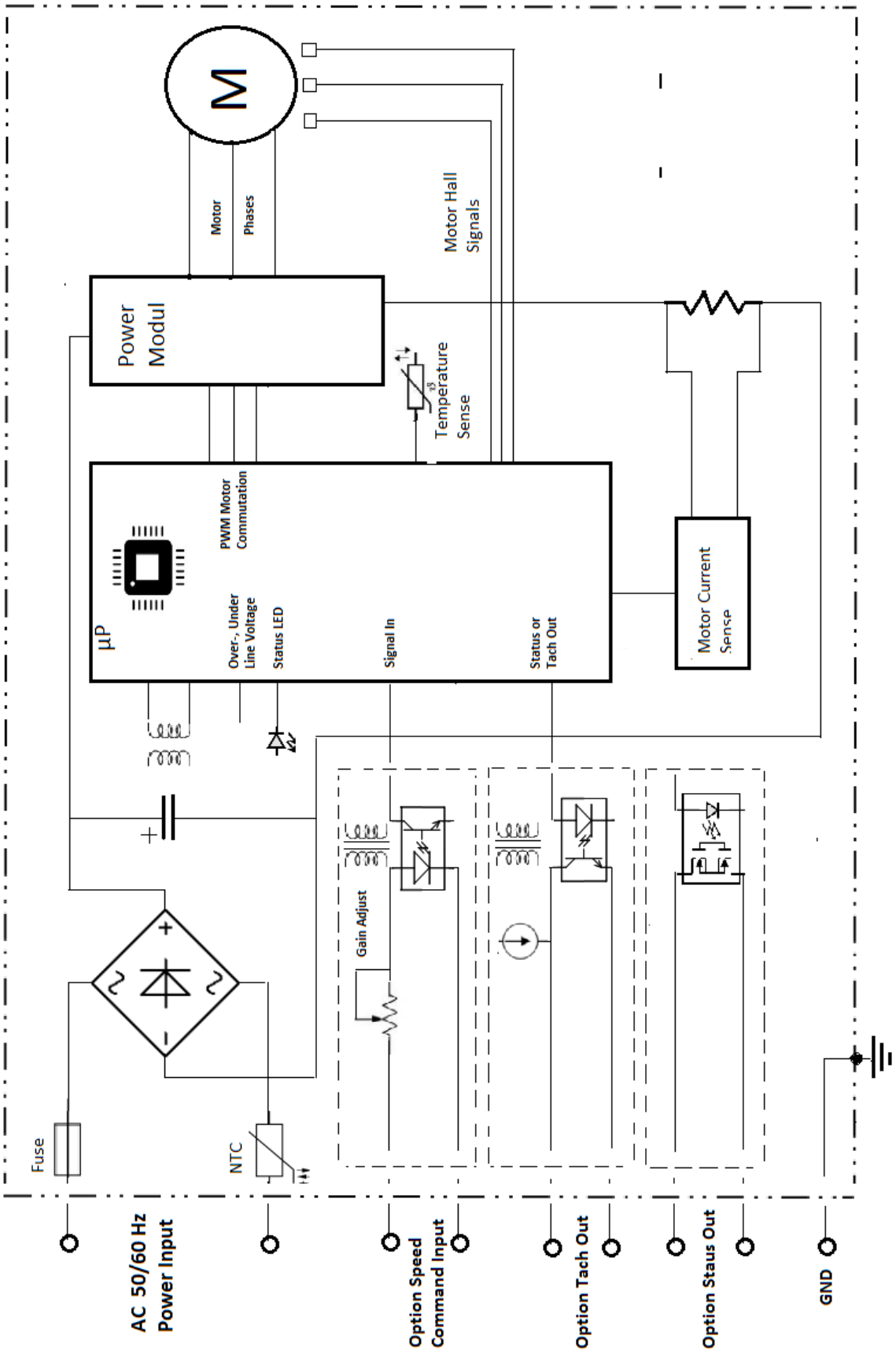
Should you have any questions or problems, please contact:

- Your local DFS sales outlet
- Your local DFS account manager
- Your local service center
- Our online YouTube channel

You can also visit our online web page for more information.

http://www.ametekpmc.com

Block Diagram



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Electromagnetic Compatibility:

This Ametek family of blower products complies with requirements as defined by:

EN61000-4-2 (2009)
EN61000-4-3 (2006)+A1(2008)+A2(2010)
EN61000-4-4 (2004)+A1(2010)
EN61000-4-5 (2006)
EN61000-4-11 (2004)

These AMETEK products are capable of causing conducted electromagnetic interference on the power mains. In applications where this is a concern, a suitable line filter should be used in the AC mains as near as possible to the blower AC power input.

In all cases, when performing associated leakage tests, the measurement circuit must be faithfully reproduced as specified in the applicable agency document.

For compliance with **IEC61000-3-2** and **IEC61000-3-3** line perturbation and flicker requirements consult the factory for assistance. Solutions are available depending on the application.

AMETEK Products also have the following ratings:
- Pollution Degree 3
- Software Class B
- Overvoltage Category III

Regulatory Agency Certification:

TÜV Rheinland Bauart Certification, qualified per EN60950.

Underwriters Laboratories Inc., qualified per UL507 , UL1004-1 , UL1004-3 , UL1004-7 , UL2111 , UL1998 , UL60730-1

Canadian Standards Association, qualified per C22.2 #113 , C22.2 #100 , C22.2 #77

The Isolated Speed Control Input is a "Safety Extra-Low Voltage Circuit" per EN60950.

Locked Rotor test per UL507, condition 8.

REV	A	B	C				
ECN	106626	106638	106651				

ISSUED BY: Guenter Morlok
APPROVED BY: Gene Bennington MARCH 2014