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Rotron Technical Products Division

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User's Guide

Number 4930720 Revision F

120 Volt, 800 Watt and 240 Volt, 1200 Watt

Brushless Motor Drive Electronics

5.7" (145 mm) and 7.2" (183 mm) Windjammer Products

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APP'D:							

Introduction

The brushless drive electronics module is used to power a variety of brushless DC motors and blower systems in the Ametek 5.7" (145 mm) and 7.2" (183 mm) Windjammer family. The 800 and 1200 Watt 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 of approximately 160 VDC (800 Watt) or 310 VDC (1200 Watt), 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 the 5.7"/7.2" 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 overtemperature and overcurrent 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.

Electrical Performance Characteristics

AC Input:

1200 Watt:
180 to 264 VAC RMS, 50/60Hz, single phase; maximum inrush current 15 AMPS RMS, maximum running current 10 AMPS RMS.

800 Watt:
90 to 132 VAC RMS, 50/60Hz, single phase; maximum inrush current 15 AMPS RMS, maximum running current 10 AMPS RMS.

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 90 VAC RMS. Also, the maximum blower performance changes with applied line voltage.

Isolated Speed Control Input:
Analog Input Voltage Range: 2 to +10 VDC nominal, 0 to +18 VDC maximum.

Isolated Speed Control Input: (continued)

Digital Pulse Input: 150 Hz to 400 Hz, 0 to +10 Volt pulse nominal, 0 to +18 Volt maximum, minimum duty cycle 10%.
(It is possible to provide a 10VDC, 12mA source to pin 2 and pulse the ground (sink) at pin 1.)

Speed Control Input Current: Less than 12 mA at 10 volts input.

Speed Control Drift with Temperature:

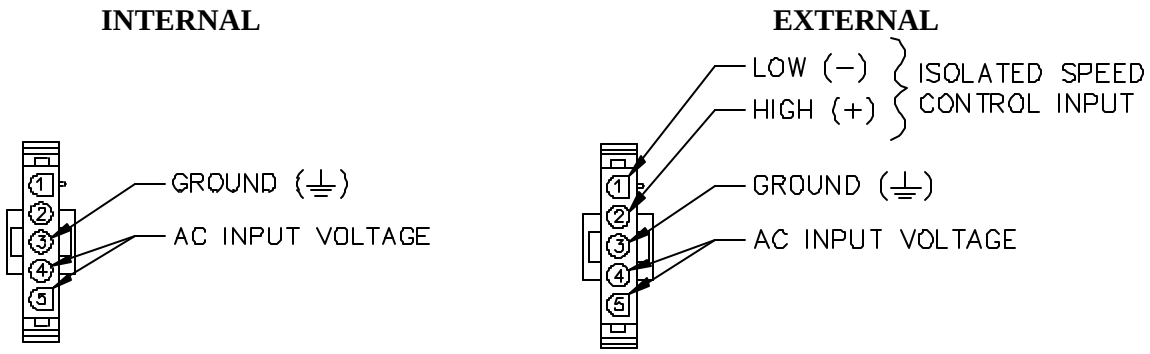
Analog Mode: Typ. ±15% from nominal speed at +23°C

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

Connector:

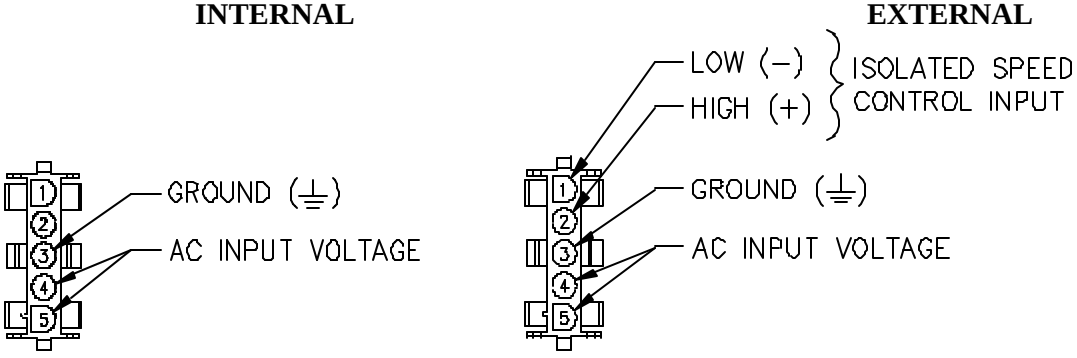
5-Pin nylon flying lead connector. The following AMP plug or equivalent may be used for mating connector:

800 Watt AMP 350810-1



POST HEADER ASSEMBLY

1200 Watt AMP 350809-1



Ambient Temperature:

Operational: $0^{o}C$ to $+50^{o}C$
Storage: $-40^{o}C$ to $+85^{o}C$

High Potential:

1500 VAC RMS (50/60Hz) applied for one second between AC input and ground, 2 mA leakage maximum. 1500 VAC RMS (50/60 Hz) applied for one second between AC input and Isolated Speed Control Input, 1 mA leakage maximum.

Electromagnetic Compatibility:

This Ametek family of blower products comply with electromagnetic interference requirements as defined by:

EN50082-1
IEC801-2
IEC801-3
IEC801-4
IEC801-5

Refer to TÜV Rheinland test report number P9571147.01 for severity levels & limits.

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 **IEC555-2** and **IEC555-3** line perturbation and flicker requirements consult the factory for assistance. Solutions are available depending on the application.

Regulatory Agency Certification:

TÜV Rheinland Bauart Certification, qualified per EN60950.

Underwriters Laboratories Inc., qualified per UL507.

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

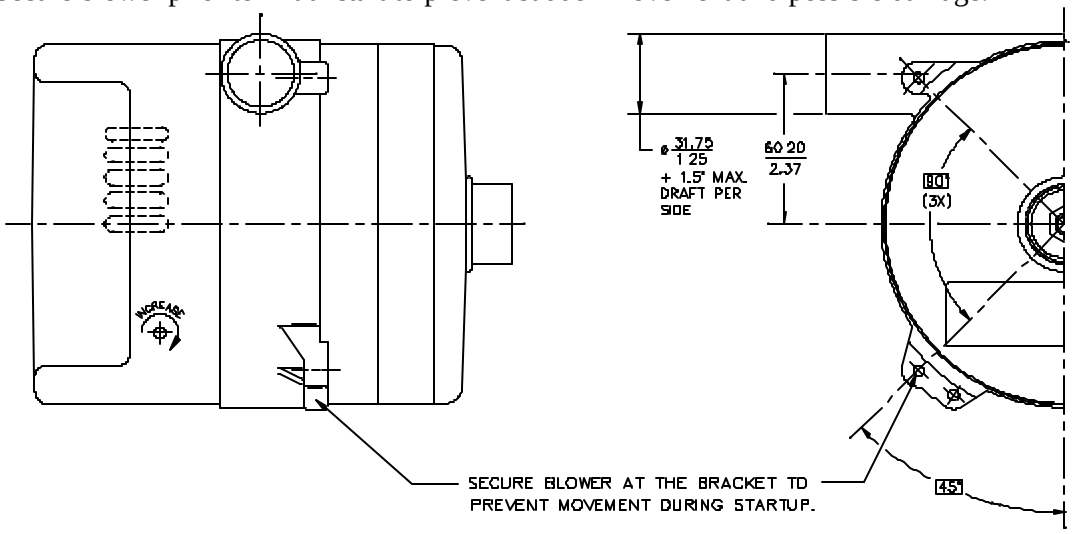
The Isolated Speed Control Input is a "Safety Extra-Low Voltage Circuit" per EN60950.

Locked Rotor test per UL507, condition 8.

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.



NOTE: Please refer to the Ametek Safety Bulletin, number 4930700, included with this User's Guide.

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 these input pins may destroy the unit.

Operation

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

Speed Control:

Depending upon the **option jumpers set at the factory**, 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.

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

Analog Control:

In this mode, an analog signal between 2 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 J1-2 and J1-1 for proper operation. This minimum voltage threshold ensures that the controller will be "OFF" for voltages under 0.8 volts. The command scaling potentiometer is wired such that fully counter-clockwise represents maximum command gain. With the potentiometer fully counter-clockwise:

J1-1,2 10 Volts: Maximum RPM
J1-1,2 0 Volts: Motor Off

Digital Control:

In this mode, the internal potentiometer must be set fully counter-clockwise. The User then supplies a Pulse Width Modulated (PWM) signal switching between 0 and 10 volts to the Speed Command Input, J1 pin 2(+) and pin 1(-). The PWM signal may have a base frequency of 150 to 400 Hz. Since the PWM input signal is also used to power the velocity error amplifier, the minimum duty cycle in Digital Mode control is 10%. The motor may rotate slowly at any duty cycle greater than 0%. 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 0% Duty Cycle: Motor Off

In the Analog and Digital Modes, due to the location of the Velocity Error Amplifier, 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. With the internal potentiometer set to minimum resistance (fully counter-clockwise), a 2 Volt Speed Command Input (10% duty cycle) will guarantee motor start.

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!**

Detailed Operation

Refer again to the Block Diagram. Input AC power is rectified and filtered to provide an internal DC bus of approximately 160 VDC (800 Watt) or 310 VDC (1200 Watt). 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 with approximately 15 VDC. The low voltage source allows operation with input AC voltages as low as 25 VRMS. The Commutation and Control chip further regulates the 15 VDC to provide a stable reference (Ref Voltage) of approximately 6.25 VDC.

The User Speed Command Input may be used in the three Modes described above. In Analog Mode (JP5 and JP6 installed), the voltage applied input powers the Velocity Error Amplifier and, 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.

When the Digital Mode is used (JP5 and JP6 installed), the PWM duty cycle is also converted to power the error amplifier. The internal Command Gain potentiometer may be used to alter the amplitude of the PWM input to the error amplifier. This signal is also converted to an error voltage that controls the commutation circuits.

In the Direct Mode (JP2 and JP3 installed), the Command Input is disconnected through the use of factory installed jumpers and 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 MOSFET transistors in the Power Output Stage are turned ON to enable rotation in the desired direction. Opto-isolated Level Shift circuits between the Commutation and Control circuits and the upper rail MOSFET's in the Power Output Stage ensure proper operation over a wide range of AC Power Inputs. The Hall Effect signals are also used by a Frequency to Voltage converter to provide motor velocity feedback. Velocity scaling is determined by the factory based on the motor winding and blower maximum speed.

The error between the Analog, Digital, or Direct Mode velocity error voltage is amplified, compensated and translated across the isolation interface using an opto-coupler. This method ensures that temperature variance of the opto-coupler characteristics will have minimal effect on performance. The velocity error is used as a current command which is compared to the Current Feedback and amplified and compensated by the Commutation and Control Error Amplifier. The

output of this amplifier controls the duty cycle of an internal PWM Modulator which operates at approximately 25 KHz. This frequency ensures 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 and is also fed back to the Commutation and Control Error Amplifier to close a single-quadrant current loop. In Current Limit, the duty cycle of the PWM Modulator is shortened in proportion to the overcurrent condition and the Fault Out signal goes low. The Fault Out signal is filtered and used to pull the Enable input low. The time constant of the filter ensures that the control electronics will "disable" approximately 2 seconds after a continuous overcurrent condition occurs. Overcurrent is a latched fault condition; power must be removed in order to restart the unit.

A Negative Temperature Coefficient (NTC) resistor is mounted on the Power Output Stage heatsink. This device will shut down the Commutation and Control logic if the internal temperature exceeds approximately +90^{o}C. Overtemperature is a latched fault condition; power must be removed in order to restart the unit. If the Overtemperature condition still exists, the unit will not return to normal operation until the heatsink temperature is less than +90^{o}C.

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 outer control loop. For example, the User may adjust motor speed to maintain constant pressure or temperature.

Troubleshooting

1) Unit Will Not Start

   a) AC Power not applied;

   b) Connector is miss-wired;

   c) Polarity of Speed Control Input is reversed;

   d) In Analog Mode, combination of internal potentiometer setting and input voltage prevents unit from starting;

   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, overcurrent condition exists;

   g) Controller internal temperature still exceeds +90^{o}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, then Stops

   Controller internal temperature still exceeds +90^{o}C due to operating point, ambient temperature, or both.

BLOCK DIAGRAM