

# **AMETEK, Inc.**

## **Dynamic Fluid Solutions Division**

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### **User's Guide**

**Number 4930712**

**240 Volt, 400 Watt Brushless Motor Drive Electronics**

**5.7" (145 mm) Windjammer Products**

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## 1 Introduction

The 240 VAC, 400 Watt brushless drive electronics module is used to power a variety of brushless DC motors and blower systems in the Ametek 5.7" (145 mm) Windjammer family. The 400 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 240 VAC input to a DC bus of approximately 320 VDC; 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" (145 mm) 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 240 VAC 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. An in-rush limiter and a fuse are in series with the 240 VAC 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.

### THRU-FLOW BLOWERS

The motor and control are cooled by the air flow through the blower. This type of unit is suitable for handling breathing quality air only. Do not operate sealed at maximum speed.

### BY-PASS BLOWERS

The motor and control are not in the working air but breathing quality air must be available for the separated motor/control cooling function.

## 2 Electrical Performance Characteristics

### 2.1 AC Input

180 to 264 VAC RMS, 50/60Hz, single phase; maximum input current 4.0 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 180 VAC RMS. Also, the maximum blower performance changes with applied line voltage.

## 2.2 Isolated Speed Control Input

Analog Input Voltage Range: 0 to +10 VDC nominal, -3 to +20 VDC maximum.

Digital Pulse Input: 150 Hz to 400 Hz, 0 to +10 Volt pulse nominal, -3 to +20 Volt maximum. (It is possible to use higher frequencies, however, the user must find a frequency for the specific application that is free of noise and that will operate in a stable environment).

Speed Control Input Current: Less than 12 mA at 10 volts input with multi-turn internal potentiometer set to minimum (fully counter-clockwise).

Speed Control Drift with Temperature:

Analog Mode: Typ.  $\pm 10\%$  from nominal speed at +23°C

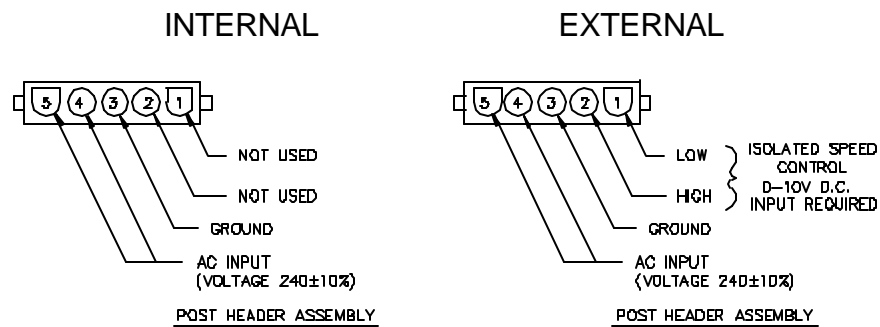
Digital or

Direct Mode: Typ.  $\pm 4\%$  from nominal speed at +23°C

## 2.3 Connector

5-Pin nylon PCB mount connector.

AMP plug Part Number 350809-1 or equivalent may be used for mating connector.



**Please observe the above conventions.**

## 2.4 Ambient Temperature

Operational: 0°C to +50°C

Storage: -40°C to +85°C

## 2.5 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.

## 2.6 Regulatory Agency Certification

TÜV Rheinland Bauart Certification, qualified per EN60950.

Underwriters Laboratories Inc., qualified per UL507.

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

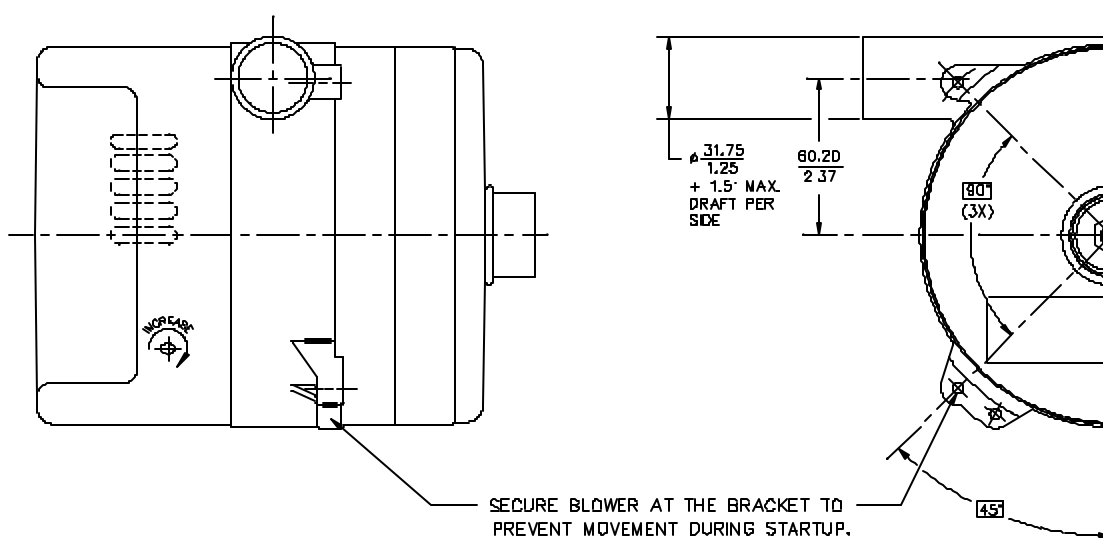
The Isolated Speed Control Input is a "Safety Extra-Low Voltage Circuit" per EN60950.

Locked Rotor test per UL507, condition 8.

### 3 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 Ametek Safety Bulletin, number 4930700.

### 4 Installation

#### 4.1 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!

#### 4.2 Power Input

The 240 VAC, 50/60 Hz 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 opto-coupler.

## 5 Operation

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

### 5.1 Speed Control

Depending upon the option jumpers set at the factory, various speed control modes are available. The control electronics has a built-in multi-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.

#### 5.1.1 Direct (Internal) 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

#### 5.1.2 Analog (External) 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 multi-turn potentiometer is wired such that fully counter-clockwise represents minimum resistance (1K Ohms) in line with the opto-coupler photodiode. With the potentiometer fully clockwise, the resistance is maximum (21K Ohms). With the potentiometer fully counter-clockwise:

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

#### 5.1.3 Digital (External) Control

In this mode, the internal potentiometer must be set fully counter-clockwise (minimum resistance) to ensure saturation of the opto-coupler. 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. The Filter and Compensation circuit (see the Block Diagram) on the Command Input will convert the pulse width duty cycle to a DC voltage.

J1-1,2 100% Duty Cycle: Maximum RPM  
J1-1,2 0% Duty Cycle: Motor Off

### 5.2 Operation Notes

In the Analog and Digital Modes, due to the use of the opto-coupler for isolation, the motor will not begin to rotate until a threshold voltage is reached. In the Analog mode, this threshold voltage will 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 10 Volt Speed Command Input (100% duty cycle) will saturate the velocity error amplifier; the actual motor speed achieved will depend on the magnitude of the AC input power and the load.

In the Direct mode, the motor will start running slowly even with the potentiometer set fully clockwise (maximum resistance).

Ametek may pre-set the potentiometer or the opto-coupler saturation voltage for specific user applications during final factory test.

NOTE: Ametek recommends the use of the Digital or Direct Modes for speed control in order to minimize variance due to the opto-coupler characteristics. In the Digital Mode, the opto-coupler is saturated by the 10 VDC pulse and accurate control with minimum drift is possible. In the direct mode, the opto-coupler is removed from the control circuit. Analog is not recommended due to variations in the opto-coupler initial gain characteristics and to variations in temperature.

### 5.3 Start Up

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 power (nominal 240 VAC) 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.

The simplest way to set the internal potentiometer is to apply the nominal Speed Command Input voltage or duty cycle (established by the application or user's control scheme) and adjust the potentiometer to yield the desired motor speed, or blower flow and pressure.

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!

## 6 Detailed Operation

Refer again to the Block Diagram. Input AC power is rectified and filtered to provide an internal DC bus of approximately 320 VDC. In-rush current is limited to approximately 15 Amps using a Negative Temperature Coefficient (NTC) device in series with the Filter Capacitors. 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 30 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, the voltage applied to the opto-coupler diode through the internal potentiometer is translated into a velocity command voltage. When the Digital Mode is used, the PWM duty cycle is converted to the velocity command through the use of a filter. In the Direct Mode, the opto-coupler is bypassed 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 command and the actual motor speed is 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 improve velocity step response. 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 pulse 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 heatsink temperature exceeds approximately +85°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 +85°C.

## **7 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.

## **8 Troubleshooting**

### **8.1 Unit Will Not Start**

- a) AC Power not applied;
- b) Connector is mis-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;
- f) Power Output Stage heatsink temperature still exceeds +85°C due to operating point, ambient temperature, or both.
- h) Fuse has blown.

## **8.2 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.

## **9.0 Block Diagram**

