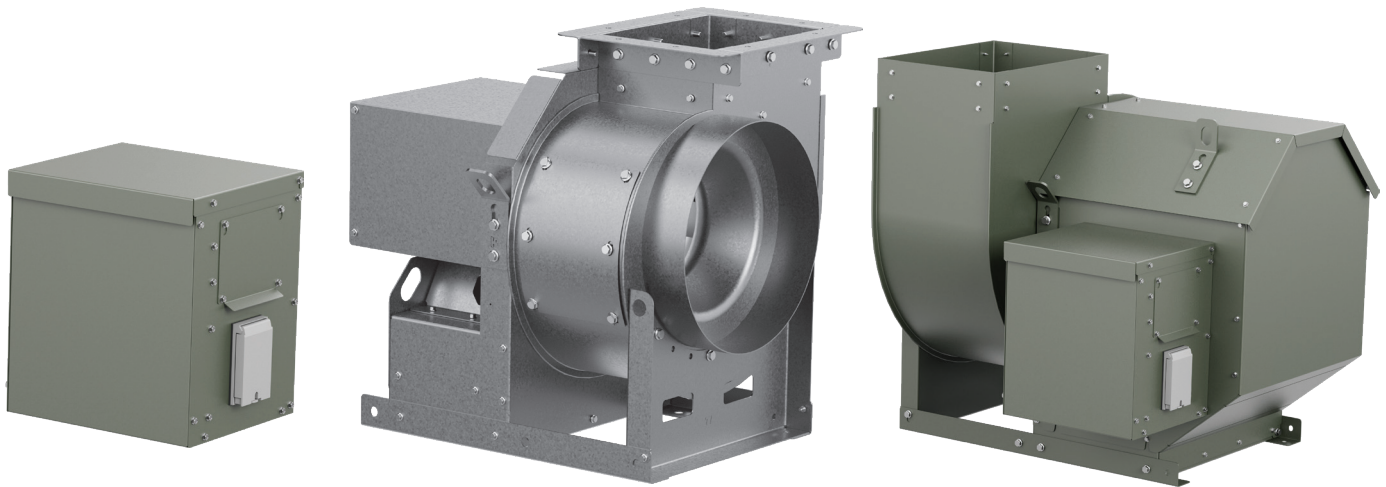


## Installation, Operation and Maintenance Manual

Please read and save these instructions for future reference. Read carefully before attempting to assemble, install, operate or maintain the product described. Protect yourself and others by observing all safety information. Failure to comply with these instructions will result in voiding of the product warranty and may result in personal injury and/or property damage.



Ship Loose VFD  
Control Package

VG-BLDC

VG-SynRM or  
Induction Motor with  
Mounted and Wired VFD

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#### DANGER

Always disconnect, lock and tag power source before installing or servicing. Failure to disconnect power source can result in fire, shock, serious injury or death.

#### CAUTION

When servicing the fan, motor may be hot enough to cause pain or injury. Allow motor to cool before servicing.

#### CAUTION

Precaution should be taken in explosive atmospheres.

#### DANGER

Pour écarter les risques d'incendie, de choc électrique ou de blessure grave, veiller à toujours débrancher, verrouiller et étiqueter la source de courant avant l'installation ou l'entretien.

#### ATTENTION

Lors de toute intervention sur la soufflante, le moteur peut être suffisamment chaud pour provoquer une douleur voire une blessure. Laisser le moteur refroidir avant toute maintenance.

#### ATTENTION

Faire preuve de précaution dans les atmosphères explosives.

## General Safety Information

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Only qualified personnel should install this unit. Personnel should have a clear understanding of these instructions, the VFD manufacturer instructions, and be aware of general safety precautions. Improper installation can result in electric shock, possible injury from contact with moving parts, as well as other potential hazards, including death. Other considerations may be required if high winds or seismic activity is present. If more information is needed, contact a licensed professional engineer before moving forward.

1. Follow all local electrical and safety codes, as well as the National Electrical Code (NEC) and the National Fire Protection Agency (NFPA), where applicable. Follow the Canadian Electric Code (CEC) in Canada.
2. Do not allow the power cable to kink or come in contact with oil, grease, hot surfaces or chemicals. Replace cord immediately if damaged.
3. Verify that the power source is compatible with the equipment.
4. For liquid tight applications, use appropriately sized liquid tight conduit.

### Receiving

Upon receiving the product, check to ensure all items are accounted for by referencing the delivery receipt or packing list. Inspect each crate or carton for shipping damage before accepting delivery. Alert the carrier of any damage detected. The customer will make a notation of damage (or shortage of items) on the delivery receipt and all copies of the bill of lading which is counter signed by the delivery carrier. If damaged, immediately contact your local representative. Any physical damage to the unit after acceptance is not the responsibility of manufacturer.

### Unpacking

Verify that all required parts and the correct quantity of each item have been received. If any items are missing, report shortages to your local representative to arrange for obtaining missing parts. Sometimes it is not possible that all items for the unit be shipped together due to availability of transportation and truck space. Confirmation of shipment(s) must be limited to only items on the bill of lading.

### Handling

Handle in such a manner as to keep from scratching or chipping the coating. Damaged finish may reduce the ability of the fan to resist corrosion.

### Storage

Units are protected against damage during shipment. If the unit cannot be installed and operated immediately, precautions need to be taken to prevent deterioration of the unit during storage. The user assumes responsibility of the fan and accessories while in storage. The manufacturer will not be responsible for damage during storage. These suggestions are provided solely as a convenience to the user.

The ideal environment for the storage of units and accessories is indoors, above grade, in a low humidity atmosphere which is sealed to prevent the entry of blowing dust, rain or snow. Temperatures should be evenly maintained between 30° to 110°F (-1° to 43°C), as wide temperature swings may cause condensation and “sweating” of metal parts. All accessories must be stored indoors in a clean, dry atmosphere.

Remove any accumulations of dirt, water, ice, or snow and wipe dry before moving to indoor storage. To avoid “sweating” of metal parts, allow cold parts to reach room temperature. Use a portable electric heater to dry parts and remove moisture build up. Leave coverings loose to permit air circulation and to allow for periodic inspection. The unit should be stored at least 3-1/2 inches (89 mm) off the floor on wooden blocks covered with moisture proof paper or polyethylene sheathing. Aisles between parts and along all walls should be provided to permit air circulation and space for inspection.

### Inspection and Maintenance During Storage

While in storage, inspect equipment once per month. Keep record of inspection and maintenance performed. Clean if moisture or dirt accumulations are found on parts; then source should be located and eliminated. Refer to the fan IOM for additional information on the fan and motor.

### Removing from Storage

As units are removed from storage to be installed in the final location, the units should be protected and maintained in a similar fashion until the equipment goes into operation.

Prior to assembly and installation of the unit and system components, inspect the assembly to make sure it is in working order. Check all fasteners and accessories for tightness.

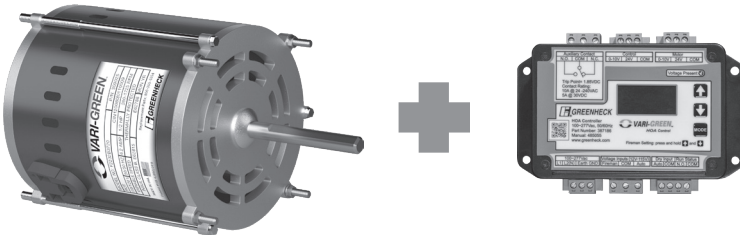
## USF Controls Overview

The purpose of this document is to provide additional information on the different types of motors and controls offered on the model USF fan. The USF is a configurable product, available with the following motor technologies:

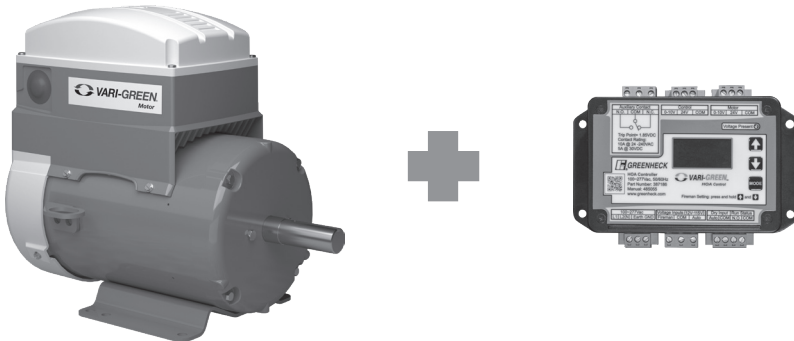
1. AC Induction motor only
2. Vari-Green® Brushless Direct Current Motor (BLDC) and potentiometer (dial)



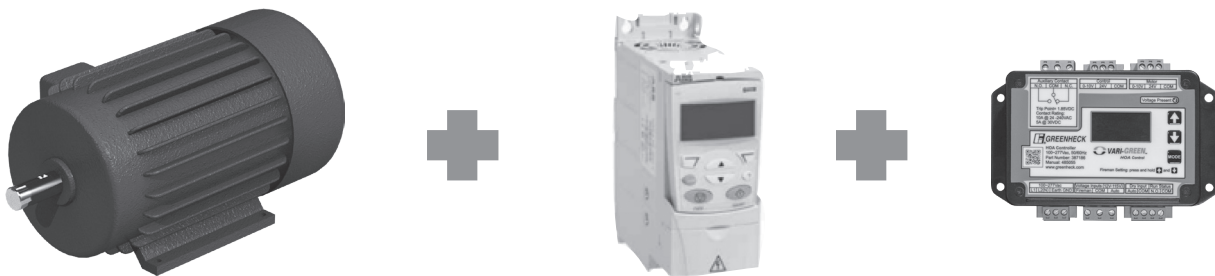
3. Vari-Green Brushless Direct Current Motor (BLDC) with Hands/Off/Auto (HOA) controller



4. Vari-Green Synchronous Reluctance Motor (SynRM) with HOA controller



5. Induction motor with VFD and Vari-Green HOA controller



Wiring diagrams and specific information about the selected configuration can be found in the submittal.

## USF Motor Technology Configuration

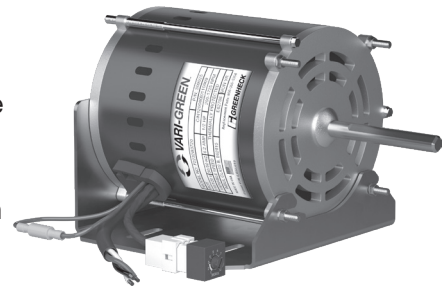
Not all motor technologies are available at every motor size and phase. Below is a general overview of motor technology via phase and horsepower.

USF Motor Technology Configuration				
HP	Vari-Green - EC Motor		Induction with VFD	
	Single Phase	Three Phase	Single Phase	Three Phase
0.25	BLDC	N/A	N/A	N/A
0.33	N/A	N/A	N/A	N/A
0.5	BLDC	N/A	Ind. with VFD	Ind. with VFD
0.75	BLDC	N/A	Ind. with VFD	Ind. with VFD
1	BLDC	SynRM	Ind. with VFD	Ind. with VFD
1.5	N/A	N/A	Ind. with VFD	Ind. with VFD
2	N/A	SynRM	Ind. with VFD	Ind. with VFD
3	N/A	SynRM	Ind. with VFD	Ind. with VFD
5	N/A	SynRM	N/A	Ind. with VFD
7.5	N/A	SynRM	N/A	Ind. with VFD
10	N/A	SynRM	N/A	Ind. with VFD
15	N/A	N/A	N/A	Ind. with VFD
20	N/A	N/A	N/A	Ind. with VFD
25	N/A	N/A	N/A	Ind. with VFD
30	N/A	N/A	N/A	Ind. with VFD
	VG-BLDC	VG-SynRM	1ph→3ph VFD	3ph VFD

## Vari-Green (VG) Brushless Direct Current Motor (BLDC)

The USF utility blower offers BLDC motors as part of its available configurations. These motors are available in horsepower from 0.25 to 1, in single phase voltages from 115 to 277, and provide up to 80% energy savings over traditional 1-phase induction motors. Their built-in electronics also provide the ability to adjust motor speed locally, as well as remotely with the purchase of additional accessories.

The USF uses two different BLDC motor type assemblies: a basic configuration and an advanced assembly.



### NOTE

VG-BLDC motors are only available on USF-B7 selections.

## VG-BLDC Basic Assembly

The basic assembly includes the BLDC motor, shaft-mounted cooling fan, toggle-style disconnect, and NEMA-3R enclosure to protect the motor from weather. A potentiometer dial connected to the motor allows the motor rpm to be adjusted.

### Basic Assembly

- Motor
- Brackets
- Cooling fan
- Potentiometer
- Disconnect
- Enclosure

The power supply to the fan should be wired into the disconnect junction box. See wiring diagram included in fan submittal.

The basic VG-BLDC assembly has two control options:

1. Dial on motor
2. 0-10 VDC

Dial on Motor: features the motor assembly in its native form using the potentiometer to control the fan speed. The potentiometer (part number 385806) comes plugged into the 9-pin connector of the motor. To increase speed, rotate the dial clockwise. To decrease speed, rotate the dial counterclockwise.

0-10 VDC: uses the same native motor assembly. The dial is included for test and balance. From 0-1.9V, the motor will be off, and will operate in the 2-19V range. A low voltage wiring harness is necessary to supply the 0-10V signal to the motor. It is included when 0-10VDC is selected and shipped separately. The dial must be removed before the pigtail can be connected.

The pigtail can be purchased independently, as well:

Low Voltage Harness Part numbers		
Type	24 in. part number	35 in. part number
9-pin	385821	385822

0-10V Analog Input Connection	
Red	0-10 VDC
White	Common

### Replacement Basic VG-BLDC motor assemblies

The complete motor assembly can be purchased for easy servicing, should it be needed in the future. The assembly includes the VG motor, shaft mounted cooling fan, disconnect switch, dial fan control, and NEMA-3R rated motor enclosure.

Replacement Basic VG-BLDC Motor Assemblies								
Motor Assembly	Assembly Part Number	Includes VG Motor	HP	Voltage	Phase	RPM	Switch	Control
Basic	919288	357159	0.25	115/208-230/277	1	300 - 1750	NEMA-3R	Dial on motor (Potentiometer)
	919289	320588	0.50					
	919290	350589	0.75					
	919291	320590	1					

### VG-BLDC Advanced Assembly

The advanced assembly takes the basic version and adds a 24V transformer and Vari-Green Hand/Off/Auto (HOA) controller for additional capability. The motor RPM is then controlled either locally via the HOA or via a 0-10V signal sent to the unit via an external remote source.

#### Advanced Assembly

- Removes dial
- Adds HOA and transformer
- Larger enclosure

The power supply to the fan should be directed into the motor box and connected to the disconnect. See wiring diagram included in fan submittal.

The advanced VG-BLDC assembly has multiple control options:

1. Hand/Off/Auto
2. Remote Dial
3. Touch Remote
4. Constant Pressure
5. Constant Airflow
6. IAQ – Temp/Humidity
7. IAQ – VOC

### Replacement advanced VG-BLDC motor assemblies

The complete motor assembly can be purchased for easy servicing should it be needed in the future. The assembly includes the VG motor, shaft mounted cooling fan, disconnect switch, transformer, VG-HOA controller, and NEMA-3R rated motor enclosure.

Replacement Advanced VG-BLDC Motor Assemblies								
Motor Assembly	Assembly Part Number	Includes VG Motor	HP	Voltage	Phase	RPM	Switch	Control
Advanced	919292	357159	0.25	115/208-230/277	1	300 - 1750	NEMA-3R	Hand/Off/Auto
	919293	320588	0.50					
	919294	350589	0.75					
	919295	320590	1					

To get additional information on the Vari-Green BLDC motors, see the Vari-Green Motors and Controls IOM; Document 473681.





## Vari-Green Synchronous Reluctance Motor (SynRM)

Greenheck uses ABB EC Titanium motors as an additional expansion to the BLDC motors listed above. These motors expand the fractional HP selections typically offered in BLDC into larger integral horsepower selections.

The USF combines the Vari-Green motor and integrated drive with a mounted and wired NEMA-3R rated control box complete with Vari-Green HOA controller, transformer and toggle-style disconnect switch. This is a factory programmed, mounted, and wired control package which just requires supply power to the box.



### 3-phase VG (EC Titanium)

- Arrangement 4 only
- 1 – 10 HP
- 1200, 1800 rpm
- 208/230, 460V
- Requires:
  - Motor cover
  - Mounted control box
    - NEMA-3R enclosure
    - Disconnect switch
    - HOA

The VG-SynRM configuration has multiple control options:

1. Hand/Off/Auto
2. Remote Dial
3. Touch Remote
4. Constant Pressure
5. Constant Airflow
6. IAQ – Temp/Humidity
7. IAQ – VOC

Vari-Green EC Titanium Motors (SynRM)							
Motor RPM	HP	Voltage/Cycle/Phase	VG Motor	Voltage/Cycle/Phase	VG Motor	Switch	Control
1200	1	208-230/60/3	356578	460/60/3	356583	NEMA-3R	Hand/Off/Auto
	2		356579		356584		
	3		356581		356586		
	5		-		329837		
	7.5		-		356588		
1800	1	208-230/60/3	329879	460/60/3	329884	NEMA-3R	Hand/Off/Auto
	2		329880		329885		
	3		329881		329887		
	5		329883		329888		
	7.5				329890		
	10				329891		

### NOTE

VG motor part numbers above do not include the control box, disconnect switch, transformer, or HOA control.

See IOM Documents for additional information on Vari-Green EC Titanium (SynRM) motors:

ABB IOM:

[https://content.greenheck.com/public/DAMProd/Original/10012/Single\\_ThreePhase\\_VariGreenMotor\\_IOM.pdf](https://content.greenheck.com/public/DAMProd/Original/10012/Single_ThreePhase_VariGreenMotor_IOM.pdf)

Document 484390 Quick Start Guide:

[https://content.greenheck.com/public/DAMProd/Original/10011/484390VG-MotorQuickStart\\_iom.pdf](https://content.greenheck.com/public/DAMProd/Original/10011/484390VG-MotorQuickStart_iom.pdf)

ABB User Manual:

[https://content.greenheck.com/public/DAMProd/Original/10012/Single\\_ThreePhase\\_VariGreenMotor\\_UserManual.pdf](https://content.greenheck.com/public/DAMProd/Original/10012/Single_ThreePhase_VariGreenMotor_UserManual.pdf)

## Induction Motors with VFD

The USF offers a complete programmed and wired controls solution for AC induction motors with variable frequency drive (VFD). In this setup, we supply a NEMA-3R control box, disconnect switch, transformer, VFD and VG-HOA controller as an accessory to the fan. This package comes as an option to be mounted and wired to the fan on direct drive (arrangement 4) configurations or shipped loose on all arrangements, including arrangement 4.

### VFD Options

Model USF uses two VFD models. The manufacturer is ABB for both, and the models used are the ACS-255 and ACS-320. These different models were used to handle different voltages and phases.



The ACS-255 is used on 115V, 1-phase and 575V, 3-phase offerings. This option is supplied in a ship loose control box only.

The ACS-320 is used on 208-230V, 1-phase and 3-phase. It is also offered on 460V, 3-phase. This option is supplied in either a ship loose control box for any arrangement or also as a mounted and wired version if the fan is an arrangement 4 direct drive.



When a VFD option is used, induction motors are always 3-phase, no matter the fan input phase. When a single phase VFD is used, the drive converts the phase from one to three upon outputting to the motor.

VFD Options					
Voltage	115	208, 230	208, 230	460	575
Phase	1		3		
Horsepower	1/2 - 1	1/2 - 3	1/2 - 10	1/2 - 30	1/2 - 20
VFD Model	ACS-255	ACS-320	ACS-320	ACS-320	ACS-255
Control Box Mounting	Ship Loose	Mounted & Wired, Ship Loose	Mounted & Wired, Ship Loose	Mounted & Wired, Ship Loose	Ship Loose

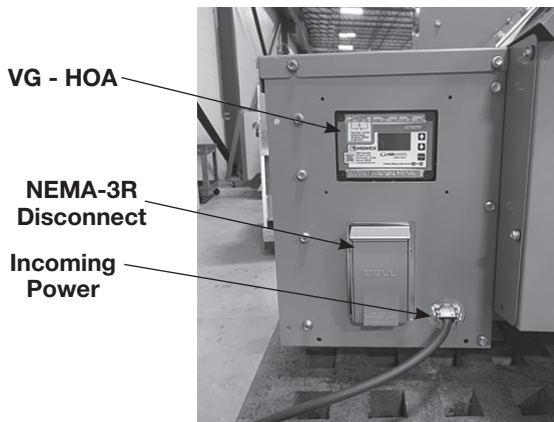
For more information on the ACS-255 including manuals, see ABB website:  
<https://new.abb.com/drives/low-voltage-ac/micro/acs255>

For more information on the ACS-320 including manuals, see ABB website:  
<https://new.abb.com/drives/low-voltage-ac/industry-specific-drives/acs320>

### NOTE

VFD models may be subject to change without notice based on manufacturer availability.

## Control Box (Vari-Green: SynRM, Induction with VFD)



For motor technologies Vari-Green SynRM, and Induction with VFD, a control box would be provided.

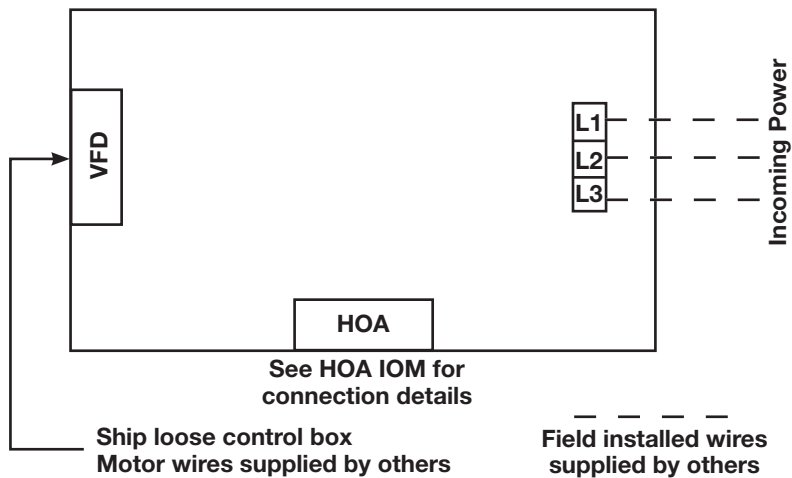
This control box can be mounted and wired (arrangement 4 only) or shipped loose (all arrangements, induction only).

The control box features a NEMA-3R disconnect and Vari-Green Hand/Off/Auto (HOA) controller.

Incoming power should be wired through the side of the control box and terminated at the provided terminal blocks. See wiring diagram included in fan submittal.

For ship loose control boxes, motor wiring shall be provided by others.

### CONTROL BOX



### NOTE

XHHW motor wire is recommended when VFD installed in distances greater than 25 feet from motor.

The Induction motor control box configuration has multiple control options:

1. Hand/Off/Auto
2. Remote Dial
3. Touch Remote
4. Constant Pressure
5. Constant Airflow
6. IAQ – Temp / Humidity
7. IAQ – VOC



## Vari-Green Controls

Motor on Dial and 0-10VDC control options are only available on the basic VG-BLDC motor technology and more information on these controls can be found in that section of the IOM.

The following controls are available on any motor technology option that uses a Vari-Green HOA:

**Hand/Off/Auto:** this is the basis of the VG-BLDC advanced motor assembly or Control Box (VG-SynRM or Induction motor with VFD controls). There are no additional ship loose controls included in this option (other than the control box may ship loose). This option comes defaulted to look for a remote 0-10VDC signal from an external source (auto remote). If this fan is desired to operate at a single speed without an additional external signal, press the mode button until HAND mode appears. To change speed, press the up or down arrows until the desired speed is acquired. To save the new speed, press the MODE button again.

Adding external or remote 0-10VDC signal to HOA:

When connecting ship loose Vari-Green or other 0-10VDC controls, you must wire them back to the HOA. The location of connections is shown on the image to the right.

See fan submittal for more details on the controls and wiring as configured.

If additional information on the HOA is required, refer to the 24VAC/DC HOA Controller User and Service Manual, Document 485093.

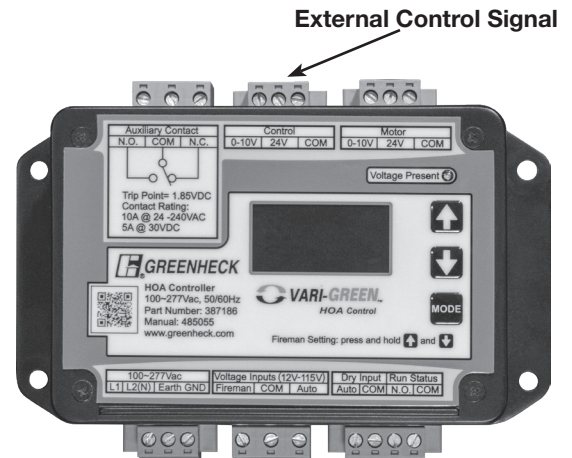
The following options include additional ship loose controls:

**Remote Dial:** This control option adds a ship loose Dial for a remote speed control installation. The Remote Dial mounts in a standard single gang 2x4 junction box and requires a 3-wire control cable to be wired back to the HOA controller.

To get additional information on the Vari-Green Remote Dial, see the Vari-Green Motor and Controls IOM, Document 473681.

**Touch Remote:** Like the Remote Dial option, the Touch Remote adds a ship loose push button control for remote installation. This control also mounts in a standard single gang 2x4 junction box and requires a 3-wire control cable to be wired back to the HOA controller.

To get additional information on the Vari-Green Touch Remote, see the Vari-Green Motor and Controls IOM, Document 473681.



**Constant Pressure:** The Constant Pressure control is designed to maintain a constant level of static pressure by automatically adjusting the speed of a fan. The Constant Pressure control is available with duct or room mounted probes for static pressure control.

To get additional information on the Vari-Green Constant Pressure control, see the Constant Pressure/Air Flow Control IOM, Document 479653.

**Constant Airflow:** the Constant Airflow control is designed to maintain a constant level of airflow by automatically adjusting the speed of a fan. The Constant Airflow control is available with a pitot tube for maintaining airflow.

To get additional information on the Vari-Green Constant Airflow control, see the Constant Pressure/Air Flow Control IOM, Document 479653.



**IAQ-Temp/Humidity:** The Temperature and Humidity controller is designed to sense the temperature and humidity in the space and will adjust the speed of the fan to maintain the set point accordingly.

To get additional information on the Vari-Green Temperature and Humidity control, see the Indoor Air Quality-Temp/Humidity Control IOM, Document 484777.



**IAQ-VOC:** The Volatile Organic Compounds controller is specifically designed to sense the level of volatile organic compounds (VOCs) in the space and automatically adjusts the speed of the fan to maintain the set point accordingly.

To get additional information on the Vari-Green Volatile Organic Compounds Control, see the Indoor Air Quality-VOC Control IOM, Document 458146.



## Electrical Installation Guidelines

### DANGER

Hazardous voltage present, work should be performed by a qualified electrician.

Disconnect all power sources before opening any electrical access panels. Personal protection equipment may be required for entry. After disconnecting power, wait 5 minutes for VFD capacitors to discharge before starting work inside the control box.

### WARNING

When servicing the unit, motor or VFD may be hot enough to cause pain or injury. Allow to cool before servicing.

- All wiring outside the control box is by others.
- Use wiring that has a temperature rating of at least 90°C.
- Any wiring deviations may result in personal injury or property damage. Manufacturer is not responsible for any damage to, or failure of the unit caused by incorrect field wiring.
- Use a dedicated ground wire for input power, motor power and control wiring. Do not ground one VFD to another in a “daisy chain” fashion.
- Keep the grounding wire connections as short as possible.
- Improper grounding may cause premature motor failure.
- All control boxes and VG-BLDC motor assemblies have dedicated disconnect switches.
- Incoming power should always be wired to the disconnect.
- Use appropriate sized wiring and conduit per NEC or local code authority.
- If fan motor is not thermally protected, remote overload protection must be installed having adequate rating as to voltage, frequency, horsepower, and full load current per phase. Where connected to a circuit protected by fuses, use time delay fuses.
- Use Class J type fuse or equivalent. VFDs may require fast acting fuses, refer to owner’s manual. Install in compliance with the National Electrical Code (NEC) and local and state building codes.

### NOTE

The purpose of this requirement is to protect electrical components from catastrophic failure and achieve the Short Circuit Current Rating labeled on the fan.

VFDs may require fast acting fuses because fuse clearing times vary depending on fuse type. Refer to VFD owner’s manual and verify installation compliance.

- Supply conductors and short circuit protection must be sized appropriately, refer to fan label for Minimum Circuit Ampacity (MCA) and Maximum Overcurrent Protection (MOP)
- For branch circuits containing a VFD for motor control, evaluated to UL 61800-5-1, and the VFD is listed as suitable for output motor conductor protection, the rating and type of protection shall be permitted to be determined by the VFD’s rated input current rather than motor full load current.
- Refer to specific manuals on individual components (VFD, controls, motor, etc.)
- Keep control wires as short as possible [100 ft. (30.5 m) or less] and separate from high power cables to minimize interference.
- XHHW motor wire is recommended for ship loose VFD applications when the fan is installed in distances greater than 25 feet from the control box.

## Additional Operating Information

Normal operating temperature is 14-104°F (-10-40°C).

Normal operating altitude is 0-6,600 ft above sea level (0-2,000 m).

Flipping the disconnect switch “ON” energizes power to the fan.

- If motor is installed with no additional controls, the motor will increase RPM until nameplate RPM is reached.
- If fan has local controls (no external control signal), the motor will increase RPM until set point is reached (either by motor dial or HOA preset).
- If fan is using an external control signal, motor will increase RPM until control signal set point is reached.

For additional details on adjusting motor RPM with the dial (VG only), refer to the section on VG-BLDC basic assembly.

All other motor technologies will utilize the Vari-Green HOA controller.

The HOA provides a common interface and wiring connection point for the operator. It takes either a local setting or remote signal and communicates to either the Vari-Green motor or the variable frequency drive (VFD) in order to control the motor speed.

The control box operates with the HOA providing two signals to the VFD.

1. HOA closes relay when control signal voltage is greater than 1.8V.
  - VFD will receive run enable signal.
  - Operational damper actuator: Fan will not receive run enable signal until damper actuator has fully opened and the actuator relay has closed.
2. VFD receives 2V-10V signal from HOA and the output frequency responds relative to programmed minimum and maximum frequency.

Calculation to determine 10V control signal to achieve desired fan RPM.

All VFDs have been programmed to operate on a 2-10V with a 10 Hz minimum and order specific Hz maximum.

$$\text{HOA Voltage} = \frac{(10\text{v} - 2\text{v}) \times (\text{Operating Hz} - \text{Minimum Hz})}{(\text{Maximum Hz} - \text{Minimum Hz})} + 2\text{v}$$

Example:

1360 rpm slower operating point

1622 selected fan rpm

1770 rpm motor

Operating Hz =  $1360/1770 \times 60 = 46 \text{ Hz}$     Maximum Hz =  $1622/1770 \times 60 = 55 \text{ Hz}$

$$\text{HOA Voltage} = \frac{(10\text{v} - 2\text{v}) \times (46 \text{ Hz} - 10 \text{ Hz})}{(55 \text{ Hz} - 10 \text{ Hz})} + 2\text{v} = 8.4\text{v}$$

\*Drive programming and scaling subject to change by factory.

## Our Commitment

*As a result of our commitment to continuous improvement, Greenheck reserves the right to change specifications without notice.*

Product warranties can be found online at [Greenheck.com](http://Greenheck.com), either on the specific product page or in the literature section of the website at [Greenheck.com/Resources/Library/Literature](http://Greenheck.com/Resources/Library/Literature).

Greenheck’s USF catalog provides additional information describing the equipment, fan performance, available accessories, and specification data.

AMCA Publication 410-96, Safety Practices for Users and Installers of Industrial and Commercial Fans, provides additional safety information. This publication can be obtained from AMCA International, Inc. at [www.amca.org](http://www.amca.org).

