BENCHMARK™
COMPRESSION SOLUTIONS

# VStar

## V80J Series
## Variable Speed Compressor

Bristol Compressors International Inc.

# Application Bulletin

Variable Speed BENCHMARK
Compressor with Refrigerant R410A

# Application Bulletin

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Subject: BENCHMARK V80J Series Variable Speed Compressor

***This document covers key application information for the three main components that make up the new VStar product***

- ***V80J Compressor***
- ***Variable Speed Drive (VSD)***
- ***Line Inductor***

***If additional assistance is needed, please contact:***
***Bristol Compressors International • Applications Engineering Department • (276) 466-4121***

## Table of Contents

# 1.0 Component Definition

## 1.1 V80J Compressor

- The VStar V80J compressor is the same as the proven Benchmark series products but with enhancements to the lubrication system for lower speed operation and a permanent magnet motor for higher efficiency.
- See attached Supplement A for compressor pictorials/drawings/dimensions.
- All models use Benchmark H82J 5 ton compression hardware for maximum reliability.
- All models employ insertion-type PTCR crankcase heaters.
- All models require an external discharge muffler (reference Supplement A).
- Heat pump applications require an accumulator.

## 1.2 V80J Variable Speed Drive (VSD)

- The proprietary variable speed drive (VSD) is manufactured by Vacon Inc. and was developed using their Vacon 10 industrial drive platform.
- Utilizes Pulse Width Modulation (PWM) voltage output to produce a near-sinusoidal current waveform to the compressor's high efficiency 3-phase permanent magnet motor.
- See Supplement B for instrument requirements in measuring the non-sine input/output voltages and currents.
- See Supplement C for VSD pictorials. drawings, and recommended panel cutout dimensions.
- There are two (2) versions of the VSD, V0 and V1. The version V0 of the VSD is the development platform and will be available in limited quantities only.
- Version V1 is the production platform and the differences between version V0 and V1 as well as pictorials can be found in Supplement D.

## 1.3 V80J Compressor / Variable Speed Drive (VSD) Combination

- Four (4) compressors (18, 30, 40, and 50 thousand BTU/hr. displacements) and two (2) VSD platforms cover the entire 208-230v 1-phase and 3-phase product offering.
- One VSD platform covers all 460v applications using the same 4 compressors.
- Currently, no 575v product is included.
- Compressors must be matched with specified VSDs:

  Small platform
  - 3 Ton 1-phase VSD covers 18 and 30 1-phase (same drive, different protection settings)

  Large platform
  - 5 Ton 1-phase VSD covers 40 and 50 1-phase (same drive, different protection settings)
  - 5 Ton 230v 3-phase VSD covers 18 thru 50 (same drive, different protection settings)
    - One part number with protection set for 40 and 50
    - Different part number with lower protection settings for 18 and 30
  - 5 Ton 460v 3-phase VSD covers 18 thru 50 (same drive, different protection settings)
    - One part number with protection set for 40 and 50
    - Different part number with protection set for 18 and 30
- VSDs will be 60 and 50 Hz rated (expect voltage ratings the same as historic single and 3-phase 60/50 Hz products).

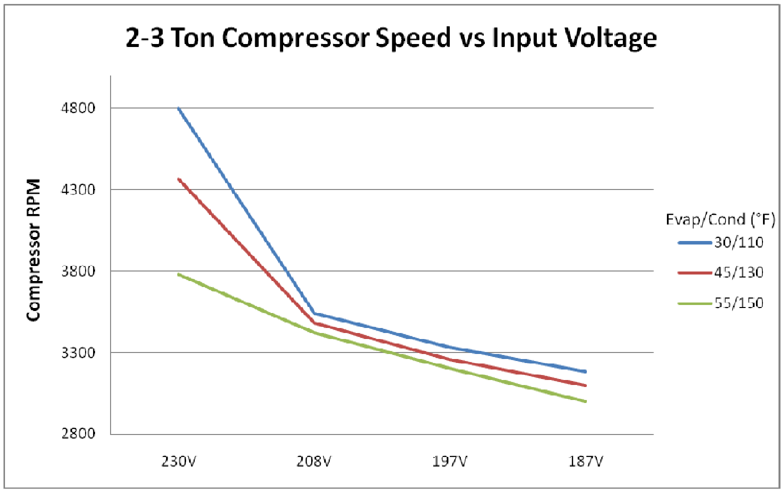
## 1.4 Line Inductor

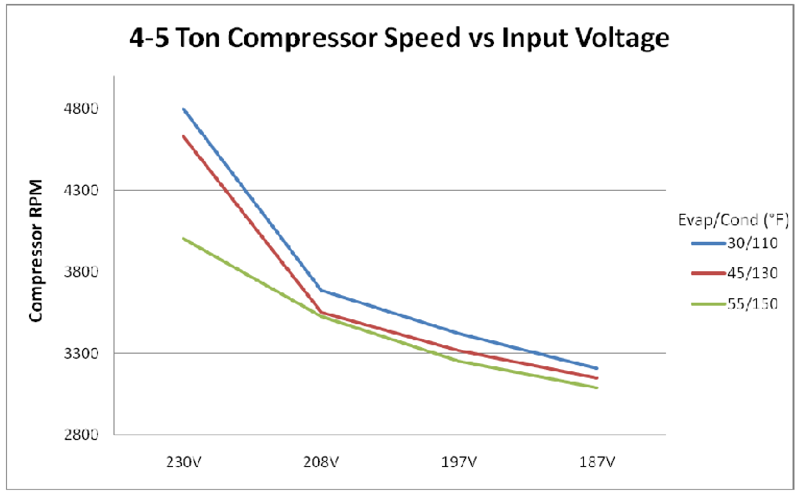
- Function:
  - Reduce input peak-to-peak current.
  - Reduce total RMS line current.
  - Improve power factor (especially at high loads during peak demand periods).
  - Limit the associated line input voltage/current harmonics.
  - Inductor (reactor) is installed in series with line power to VSD.

➢ Mounting/securement is critical with respect to potential vibration noise.
➢ Bristol supplies inductors with thermo-couples (Type T) for customer testing at worst case conditions (i.e., desert test).
➢ See Supplement E for more detail on the inductors.

## 2.0 Performance Information and Operating Envelope

- Contact Bristol Compressors International Engineering for performance tables.
- Performance tables display V-Star efficiencies at various loads and speeds.
- The tables are generated at nominal input voltage (i.e., 230v for a 208-230v product).
- The tables also define the compressor operating envelope.
- The tables represent the 1200 to 3600 RPM operating envelope limits at the allowed input voltage extremes (i.e., 187v to 253v for 208-230v product).
- VSD operation above 3600 rpm may be limited by input voltage and/or output power, causing the VSD to fold back (reduce) compressor speed. Since the “boost speed” envelopes do not reflect low voltage operation, refer to the following graphs which represent the limitations:




## 3.0 Connectivity

### 3.1 General Wiring

- See Supplement F for a system block diagram, schematics and wiring.

### 3.2 Grounding (Earthing) the VSD

- Provisions have been made to ground the drive directly if the mounting does not inherently satisfy the requirements, (see Supplement F).

### 3.3 Power to VSD

- All power connections are .250 inch (.6cm) standard male quick connect (QC) spades.
- Drive must be continuously line powered (no system contactor needed).
- 5-ton single-phase drives require two 10 AWG conductors for each line input in order to limit the current thru each circuit board connector to less than 25 amps. Refer to Supplement G, Wiring Guides.
- Drive power consumption during the off-cycle (no power to motor) is less than 10 watts.

## 3.4 VSD Fuse Requirements

- UL requires line input fuses on all power legs, presently required to be located in the unit controls cabinet.
- Fuses are Class T (Non time delay) - supplied by Bristol with VSD samples (see Supplement G for fuse recommendations and more info).

## 3.5 VSD to Compressor Connections

- 36 inches (.9m) minimum wire length is required from the VSD to the compressor terminals (max 50 ft. or 15 meters).
- Correct phasing (drive to compressor wiring) is required for proper operation.
- Connections allowed per Supplement F wiring diagrams only.

## 3.6 Condenser Fan Output Relay

- VSD provides condenser fan control via an on board T9A-style single-pole normally open relay.
- Relay contacts are closed when the drive is supplying power to the compressor motor.
- The standard relay is rated 11 amps (FLA) and 30 amps (LRA) for control of up to 1 HP induction motors.
- To control ECM motors, a signal-level relay (rated down to 1mA) is available.

## 3.7 VSD "Control" Wiring via Phoenix Type Connectors

- V0 – Screw-type terminal block for all control inputs.
- V1 – Dual-function connector interface to allow plug-on of either an OEM harness or a screw-type terminal block for OEM/field direct connect. Reference below part number listing which are customer-supplied Phoenix Contact connectors that plug onto the drive printed circuit board male pin receptacles (headers):
  - Analog Input (6 pin)
    - Screw type PN 1912773 (MVSTBW 2.5 HC/6-ST)
    - Harness type PN 1809543 (MSTBC 2.5/6-STZ-5.08)
  - Digital Input (4 pin)
    - Screw type PN 1912757 (MVSTBW 2.5 HC/4-ST)
    - Harness type PN 1809527 (MSTBC 2.5/4-STZ-5.08)
- See Supplement D for pictorials and V0 vs. V1 differences.
- RS-485 communicating input for programming/monitoring/speed control:
  - PC interface – WintrAC (see Supplement B for detail).
  - Modbus compatibility for programming.
  - Modbus/ClimateTalk speed control (see Supplement B for detail).

# 4.0 Speed Control

## 4.1 Available Speed Ranges

- OEM-defined cooling speeds 1200 to 3600 RPM (40 Hz to 120 Hz).
- OEM-defined heating speeds 1200 to 3600 RPM (40 Hz to 120 Hz).
- OEM-defined "boosted" heating speeds 3600 to 4800 RPM (120 Hz to 160 Hz), available when less than 35°F (1.7°C) outdoor on air-to-air applications.
- All applications other than air-to-air may operate at OEM-defined speeds above 3600 RPM but the application envelope is limited (refer to Section 2.0 graphs), as compared to the published air-to-air envelope.

## 4.2 Multispeed via Three (3) Digital 24 vac Inputs (LO, HI, SELect)

- Two (2) cooling speeds and 2 heating speeds (4 different preset speeds) or…
- Two (2) cooling and heating speeds (same) plus heat boost to 4800 RPM (3 different preset speeds).
- SELect input provides boost heat speed provision of 3600 to 4800 RPM when the compressor is operated within performance table limits.
- Up to seven (7) speeds with a user control interface that provides binary inputs to the three digital inputs (i.e., 001, 010, 011 etc.).
- Reference Supplement B for additional detail.

## 4.3 Full Variable Speed via 0-10Vdc Analog Input (V1 only)

- Approximately 5 RPM resolution control via the 0-10vdc analog input.
- Start / Stop control enabled via 24V AC/DC signal to LO input.
- Reference Supplement B for additional detail.

## 4.4 Full Variable Speed via RS-485 Communicating Input

- 0.01 Hz (0.3 RPM) resolution control via the RS-485 communicating input.
- Modbus (V0 or V1) or ClimateTalk (V1) compatible.
- Reference Supplement B for additional detail.

## 4.5 Skipping/Blocking Speeds

- Compressor speed will be held outside of predefined skip bands, even during VSD foldback.
- All drives factory-programmed to skip compressor resonance speeds of 86-94Hz (2580 - 2820 RPM).
- Customer may program up to 5 additional speed bands to block system resonances or other unwanted speeds.
- Reference Supplement B for parameter information.

# 5.0 Variable Speed Drive (VSD) Environment

## 5.1 Printed Circuit Board (PCB)

- Max application temperature 158°F (70°C ) surrounding ambient, e.g. control compartment. However, UL may enforce a lower max ambient of 140°F (60°C) due to the bus capacitor temperature restrictions noted below.
- No forced air required, but sufficient air flow must be provided to keep capacitors within temperature limits and to meet agency requirements for approval. Optimum life is based on PCB ambient temperature.
- Conformal coated for 99% non-condensing relative humidity.

## 5.2 Bus Capacitors

- Max surface temperature 185°F (85°C) for version V0 and 221°F (105°C) for version V1.
- TC'd drive provided to perform worst case conditions to assure adequate cooling in end use application.

## 5.3 Heatsink

- Max application temperature 176°F (80°C) air thru the fins.
- 300 FPM minimum air velocity thru fins recommended.

- TC'd drive provided to perform worst case conditions to assure adequate cooling in end use application.
- Heatsink fins should be installed vertical for best heat convection but application air flow may dictate angled or horizontal installation for optimum cooling (i.e. fan blades same plane as the heat sink fins).
- Bypassing condenser inlet air (or a mixture of inlet and discharge air) over heatsink fins may provide additional application margin.
- Heatsink has a machined groove to apply an o-ring weather seal, if required.

### 5.4 Package Unit and Ground/Water Source Cooling Options

- Place heatsink in indoor return airstream w/PCB in the controls compartment (preferred).
- Place entire VSD in indoor return airstream.
- Place heatsink in the supply airstream w/PCB in the controls compartment. Even though heating and cooling air temps should provide acceptable cooling, mixing ambient or return air to reduce temp extremes is recommended.
- Due to condensation concerns, it is not recommended to place the open VSD in the supply air. However, it may be acceptable to place it in a separate air-tight enclosure (heatsink exposed) and mount enclosure assembly in the blower compartment (supply air) for cooling applications. Heating applications may produce excessive temps within the enclosure.
- Plate heatsink option (no fins) for water or refrigerant cooling will be considered in the future. Requires qualification due to temp extremes and condensation concerns.

## 6.0 Variable Speed Drive (VSD) Cover Requirements

- It is required that a cover be installed by the OEM to shield the VSD bus capacitors due to the unlikely venting of a capacitor, and other hazards, when the VSD is operating with the unit service panel removed.
- Drives may also be purchased with an integral cover (see Supplement C for drawings).
- Covers can also be used to provide additional warning labels to alert technicians of the potential hazards of high voltage (AC and DC), hot components, and that safety glasses must be worn when servicing the equipment.
- Any cover may affect the PCB temperatures and must be installed during system qualification testing.

## 7.0 Compressor Protection

- Compressor employs an on-winding 1-phase line-break thermal overload protector (OLP) for protection against motor over-temperature.
- VSD protects the compressor against the following scenarios:
  - Improper phasing (i.e., drive output wires crossed results in no start if pressures are not equalized).
  - Loss of phase (includes thermal OLP trip).
  - Output current overload (including failure to start).
  - Input voltage out of range (low or high).
  - Excessive start/stop cycling.

## 8.0 VSD Faults and the Fault/Status LED

- Seventeen individual fault codes via red LED flash count (LED is green on V0).
- Most faults are sent thru the Auto-reset routine, allowing 3 restarts within a rolling 6-hour time period.
- Refer to Supplement B…. "VSD Operation Guide" for individual fault detail, including fault detection and response.

## 9.0 Programmable Anti Short Cycle Delay (ASCD)

- Independent parameter, can be disabled if necessary,
- Drive will not allow excessive cycling per hour (6 cycles/hour maximum - rolling time totalizer limited).
- Can temporarily bypass ASCD, for troubleshooting. Once initiated, the bypass lasts 30 minutes.
  - V0 - Rapidly touch R (i.e., 24vac supply) to SEL (i.e. 6 signal edges, or 3 OFF-ON-OFF transitions, in 10 seconds).
  - V1 - shorting pins provided (see photos in Supplement B and drawing in Supplement F) - momentarily short pins for two (2) seconds.

## 10.0 Testing of Compressor/Drive Samples

- Bristol will provide thermo-coupled (TC'd) drives and inductors for system qualification testing per the following guidelines:

- **VSD Heat Sink**
  - The drive power module has inherent thermal protection via an on board sensor which is set to trip at 239°F (115°C). A sensor temp of 115°C correlates to a heat sink temperature of 230°F (110°C), therefore we recommend a **max heat sink TC temp** of 212°F (100°C) to prevent nuisance trips or lockouts.
  - Note: As the first line of defense, the VSD will fold back on switching frequency (PWM output voltage waveform generation) if the drive power module sensor exceeds 176°F (80°C).

- **Bus Capacitors**
  - The bus caps must not exceed the max allowed surface TC temperature.

- **Recommended Testing**
  - Maximum Load (230v and 208v input)
    - Worst expected saturated evaporator and condenser temperatures with….
    - Highest expected air temperatures over the VSD heatsink and ….
    - Highest expected controls compartment temperature (i.e. component side of the VSD)
  - System tubing/cabinet vibration and sound through all operational speeds
  - EMI (conducted and radiated) evaluations with all system panels and shielding/mitigation in place
  - Sound and vibration evaluations to determine if additional skip frequencies (speeds) are required

- **1200 to 1800 RPM Oil Return Testing**
  Bristol will provide compressor samples fitted with a sight tube and/or sight glass for system testing at the worst case lowest mass flow conditions expected in order to determine line set recommendations considering the following:
  - **Heat Pump Mode** - low outdoor ambient and/or iced coil conditions are especially critical with extended operation at speeds below 1800 RPM.
    <u>Any vertical line set length</u>, with the indoor coil above the outdoor unit in heating, must be properly sized to maintain proper refrigerant velocity to assure the circulating oil will not collect in the suction (hot gas) line.
  - **Air Conditioning Mode** - high outdoor ambient conditions with the lowest expected mass flow are the most critical with extended operation at speeds below 1800 RPM.
    <u>Any vertical line set length</u>, with the outdoor coil above the indoor coil in cooling, must be properly sized to maintain proper refrigerant velocity to assure the circulating oil will not collect in the suction line.
  - **Horizontal Line Sets** - Normally, extended horizontal line sets are not a concern, especially if the guidelines as noted above are used. However, system confirmation testing is recommended for extreme lengths exceeding 100 ft.(30m).
  - **Mitigation Methods** - The following may be considered to augment the line set requirements:
    - Increase compressor speed (and air flow) after operating for specific periods at speeds less than 1800 RPM.

– Increase compressor speed (and air flow) based on combination of OD ambient and operating periods below 1800 RPM.
– Initiate a high speed defrost after specific periods of low speed operation.
– Cycle compressor off and back on after specific periods of low speed operation.

## 11.0 UL Recognition

### 11.1 Compressor

- All models are recognized under Bristol's UL file SA5470, Section 12
  - V80J183MB2*
  - V80J303MB2*
  - V80J403MB2*
  - V80J503MB2*

  *Designates the mounting foot configuration

### 11.2 Variable Speed Drive

- All models are recognized under Vacon's UL file E132978
- Recognized via UL508C as a protection device

## 12.0 Supplements

A. Compressor Pictorials, Drawings, Discharge Muffler Requirements

B. VSD Operation - Interface Guide (WintrAC)

C. VSD Drawings (with and without cover), Pictorials, Mounting/Panel Cutout Dimensions

D. V0 vs. V1 Differences, Connector Details and Interface

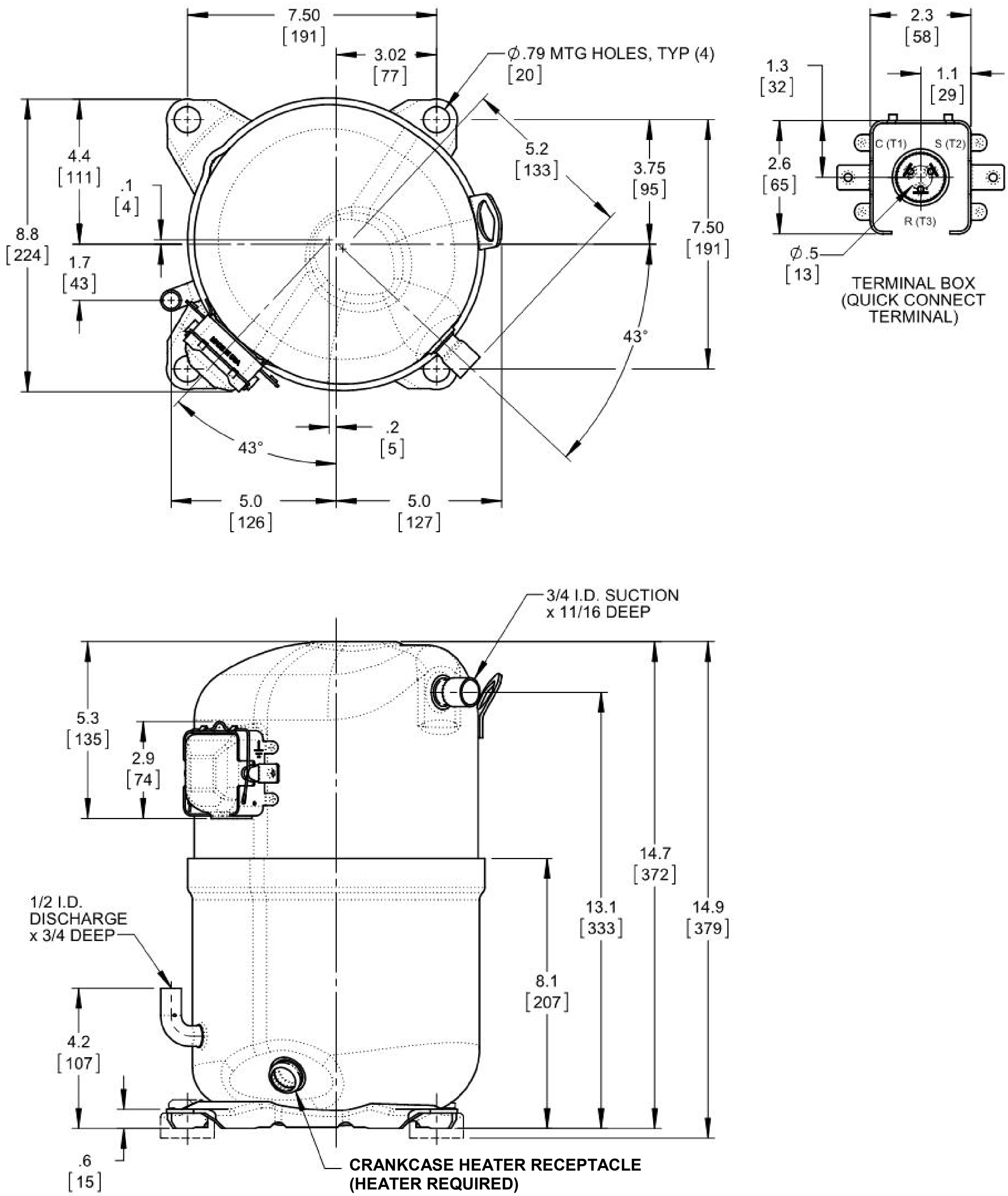
E. Inductor Operation - Application Guide

F. Block Diagrams, Schematics, Wiring

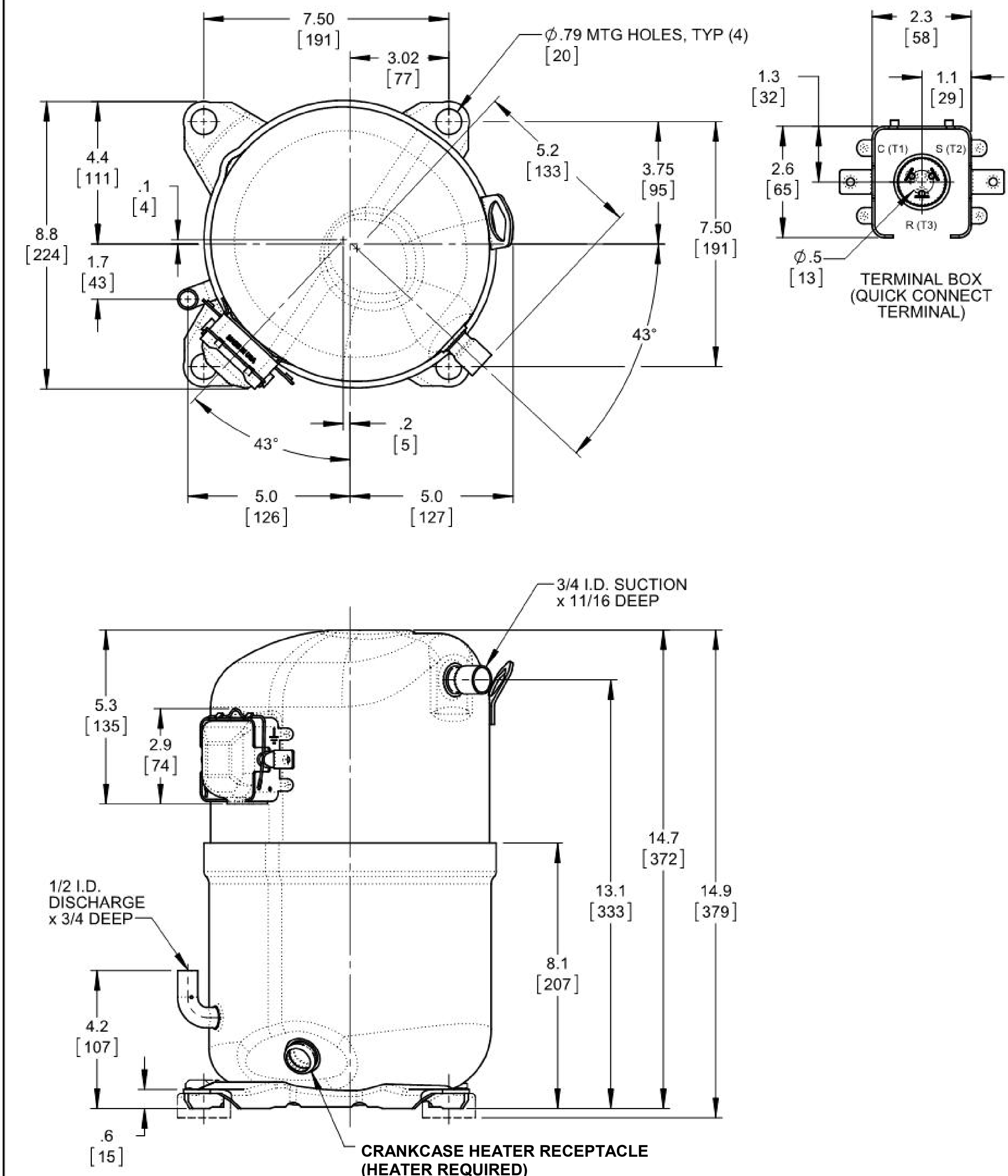
G. System Line Fuse Requirements/Info

H. Compressor and VSD Model Number Breakdown

# Compressor Pictorials, Drawings, Discharge Muffler Requirements




| | | | | | |
|---|---|---|---|---|---|
| MODEL: **V80J183MB2A** | | E/N RELEASE: **T23004** | | | Bristol Compressors International Inc. |
| VOLTAGE: **230** PH: **3** Hz: **120** | **REQUIRES VARIABLE SPEED DRIVE** | REVISIONS | | | |
| | | A | V04005 | BAM | |
| **TOLERANCES UNLESS SPECIFIED** | MARKETING REQ: | B | V14501 | LBW | |
| ONE PLACE DECIMAL: ±.125 (3.158mm)<br>TWO PLACE DECIMAL: ±.06 (1.5mm)<br>ANGULAR: ±5° | CHKD: BAM 4-27-11 | C | V25202 | JH | B/M NO: **775000** |
| | DRWN: LBW 4-21-11 | D | V28003 | BAM | |




| | | | |
|---|---|---|---|
| MODEL: **V80J303MB2A** VOLTAGE: **230** PH: **3** Hz: **120** | **REQUIRES VARIABLE SPEED DRIVE** | E/N RELEASE: **T23004** | Bristol Compressors International Inc. |

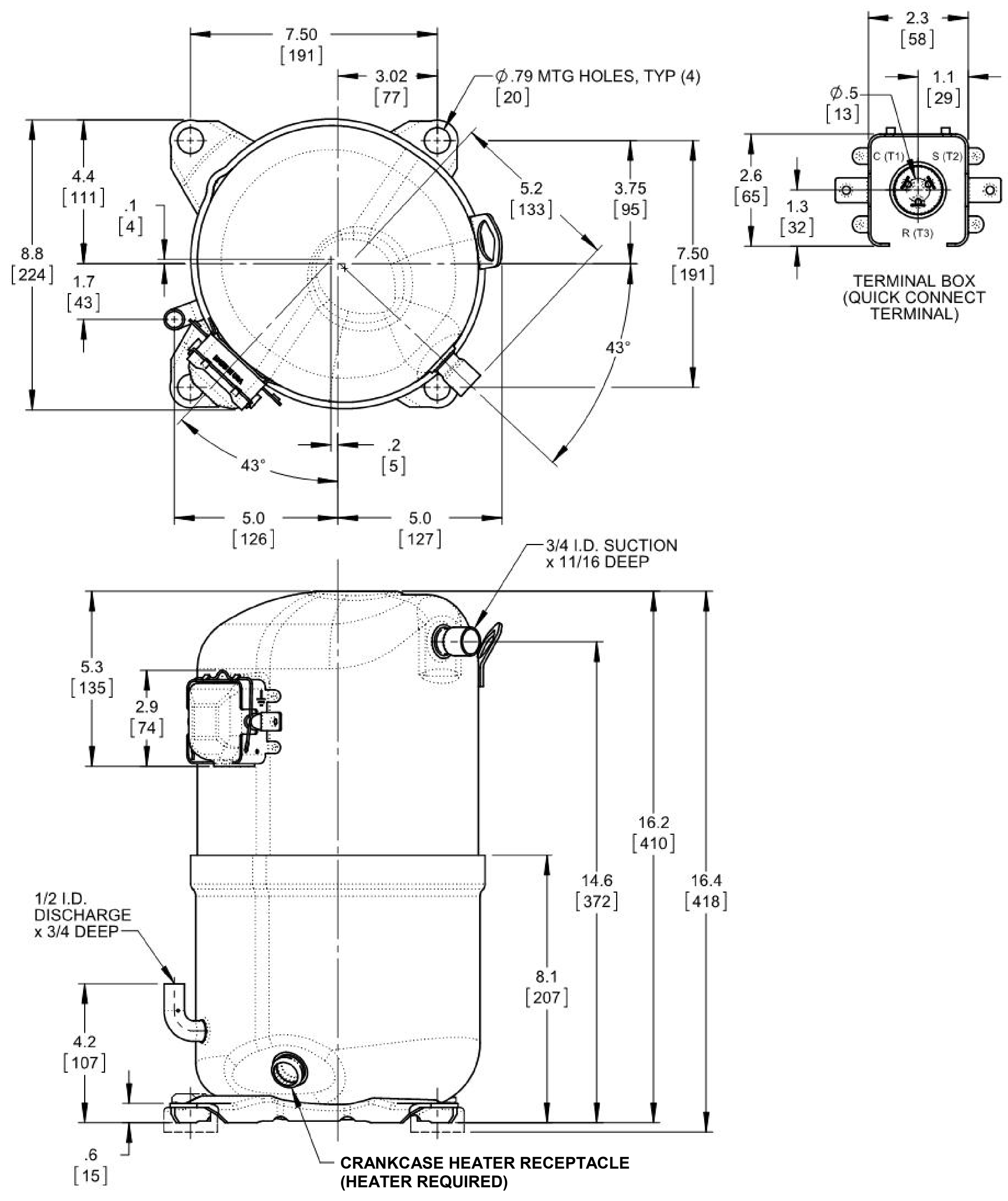
| REVISIONS | | |
|---|---|---|
| B | V04005 | BAM |
| C | V14501 | LBW |
| D | V25202 | JH |
| E | V28003 | BAM |

**TOLERANCES UNLESS SPECIFIED**

ONE PLACE DECIMAL: ±.125 (3.158mm)
TWO PLACE DECIMAL: ±.06 (1.5mm)
ANGULAR: ±5°

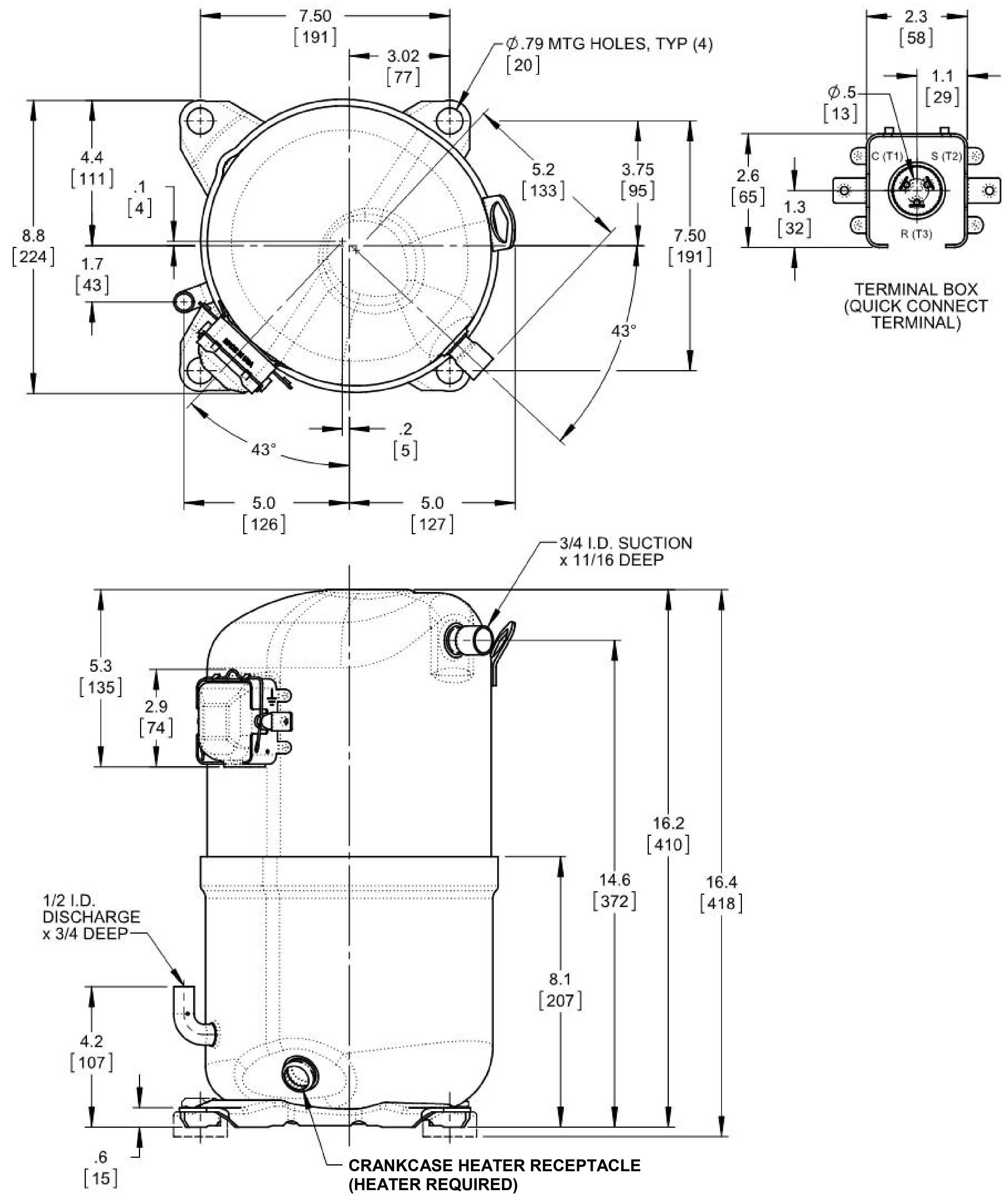
| | | |
|---|---|---|
| MARKETING REQ: | | |
| CHKD: | BAM | 4-27-11 |
| DRWN: | LBW | 4-26-11 |

B/M NO: **775001**




| | | | | |
|---|---|---|---|---|
| MODEL: **V80J403MB2A** VOLTAGE: **230** PH: **3** Hz: **120** | **REQUIRES VARIABLE SPEED DRIVE** | E/N RELEASE: **T23004** | | Bristol Compressors International Inc. |
| | | REVISIONS | | |
| | | **B** | V04005 | BAM |
| **TOLERANCES UNLESS SPECIFIED** | MARKETING REQ: | **C** | V14501 | LBW |
| ONE PLACE DECIMAL: ±.125 (3.158mm) | CHKD: BAM 4-27-11 | **D** | V25202 | JH |
| TWO PLACE DECIMAL: ±.06 (1.5mm) ANGULAR: ±5° | DRWN: LBW 4-26-11 | **E** | V28003 | BAM |

B/M NO: **775002**




| | | | | |
|---|---|---|---|---|
| MODEL: **V80J503MB2A** VOLTAGE: **230** PH: **3** Hz: **120** | **REQUIRES VARIABLE SPEED DRIVE** | E/N RELEASE: **T23004** | | |
| | | REVISIONS | | |
| | | B | V04005 | BAM |
| **TOLERANCES UNLESS SPECIFIED** | MARKETING REQ: | C | V14501 | LBW |
| ONE PLACE DECIMAL: ±.125 (3.158mm) | CHKD: BAM 4-27-11 | D | V25202 | JH |
| TWO PLACE DECIMAL: ±.06 (1.5mm) ANGULAR: ±5° | DRWN: LBW 4-26-11 | E | V28003 | BAM |

Bristol Compressors International Inc.

B/M NO: **775003**

## Supplement A: Compressor Pictorials, Drawings, Discharge Muffler Requirements

### A.1 Pictorials

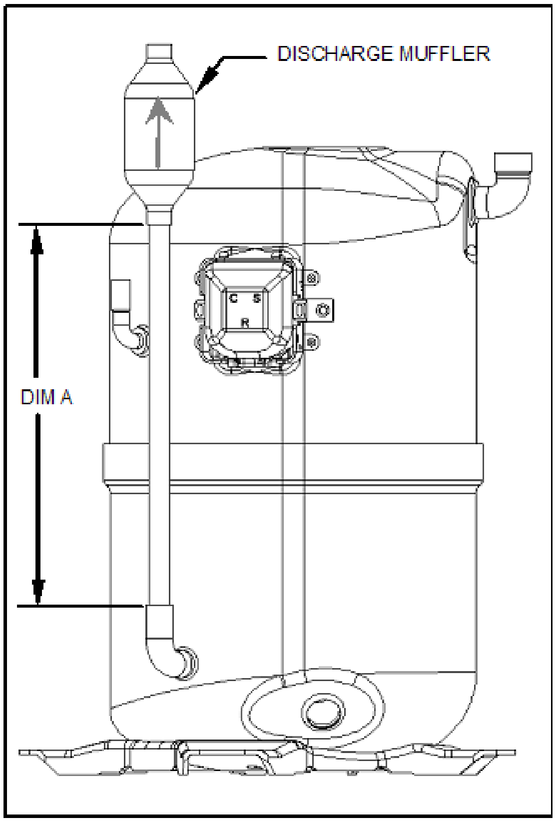



FIGURE A.1

### A.2 Discharge Muffler Requirements

- An external muffler is required for the V80J compressor to control discharge pulsations over the entire speed range.
- The Sporlan M-164-S muffler (formerly M-16E32) is preferred. If not selected, an external muffler design of similar diameter, volume and length is recommended.
- The external muffler should be installed in the discharge tubing assembly as close as possible to the compressor discharge connection, preferably with a straight length of tubing (Dim "A") between 6 and 15 inches long (15 and 38cm).
- It is preferable that the muffler be installed as shown in Figure A.1 with use of the muffler shown in Table A.1. However, if it is necessary that bends be placed in the tube between the compressor and the muffler, both indoor and outdoor sound evaluations must be performed to confirm acceptance of the final configuration. Bristol field testing indicates any bends prior to the muffler can result in increased sound and tubing vibration.

**TABLE A.1**

**EXTERNAL MUFFLERS**

| Bristol Part Number | Manufacturer | Material | Manufacturer Part Number | Muffler OD (inch/cm) | Length (inch/ cm) | Inlet and Outlet ID (inch/cm) | Internal Free Volume (inches$^3$/cc) |
|---|---|---|---|---|---|---|---|
| 302169 | Sporlan | Steel | M-164-S or M-16E32 | 3.0 / 7.6 | 6.0 / 15.0 | .50 / 1.3 | 24 / 393.0 |

Note: Direct muffler orders to Sporlan should reference their manufacturer part number.

# Supplement A: Compressor Pictorials, Drawings, Discharge Muffler Requirements

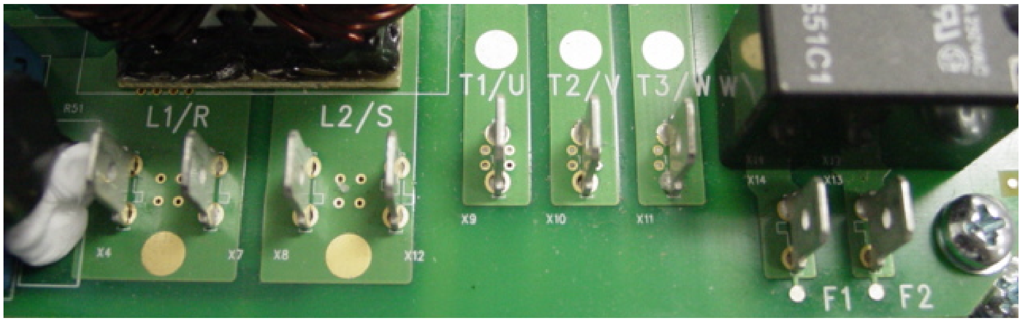
## A.3 Tubing Design Guidelines

- The tubing design between the compressor and the condensing unit coil is very important in regard to both sound performance and reliability. The length, number of bends, geometry, and method of attachment can have a significant impact on acoustic performance of the muffler and tube vibration levels. **The system tubing vibration should be thoroughly evaluated using accelerometers.** Discharge tube total displacement (peak-to-peak) needs to be kept below 0.011 inches (0.028cm), as measured 3.5 inches (8.9cm) from the top of the compressor discharge elbow, to avoid premature tubing failure due to excessive vibration.

# VSD Operation—Interface Guide (WintrAC)

# Bristol Compressors International
# Permanent Magnet Motor Drive
# General Setup

## High-Voltage Connections




**Voltage In**
Connect L1/R and L2/S to a single-phase, 187-253 Vac 50/60 Hz supply. For the 5 ton drive, both L1/R terminals must be connected to L1 and both L2/S terminals must be connected to L2 for current sharing through the terminals. Since the drive input current is non-sinusoidal (see "Current In" description below), the input voltage may become distorted as the drive's power demand goes up. Thus, when measuring Voltage In, use voltage measurement devices that are designated as capable of measuring "True RMS" voltage.

**Current In**
The drive input circuitry contains a full-wave-rectified power supply, thus input current is non-sinusoidal. Current flows into the drive during the peaks of the input voltage. It is imperative to use current measurement devices that are designated as capable of measuring "True RMS" current. Secondly, the input current waveform will change shape dependent upon the "stiffness" of the power source - reflected by the kAIC (kiloAmp Interrupting Capacity) or impedance rating of the source. A stiffer source will provide a "tall and narrow" current pulse, while a softer source will provide a "short and wide" current pulse (see Supplement E). Although the overall power consumption is the same, the "tall and narrow" pulse has a higher RMS current value. **Input current shall not exceed the drive input RLA** (i.e., 21.8A RMS for the 3 ton single phase drive). If this value is exceeded during test, a higher mH (milli-Henry) line inductor must be utilized to ensure the input current remains below this required value.

**Power In**
Since the drive input is non-sinusoidal (see Voltage In and Current In descriptions above), proper sampling must be done to capture the information held in the voltage and current waveforms. Instrumentation devices must state they are compatible with SCR controls, variable frequency drives, or PWM drives.

**Earth Ground**
The drive's heatsink must be connected to a viable earth ground. The electrical hardware receives its ground connection via the mounting bolts retaining the PCB to the heatsink.

**Voltage Out**
Connect **T1/U, T2/V,** and **T3/W** to compressor terminals **T1/C, T2/S, T3/R,** respectively. Each drive output phase is created using Pulse Width Modulation (PWM). PWM output voltages cannot be read by standard RMS voltmeters, even those designated as "True RMS". If measurement is required, a Fluke 87V multimeter has an integrated low-pass filter, designed for use with motor drives. Its circuitry can calculate the fundamental output voltage, which is indicative of how the motor will respond to the PWM waveform provided by the drive.

**Current Out**
With the drive's method of generating out put voltage (see Voltage Out description above), the current supplied to the motor is *generally* sinusoidal. Since the current is not *perfectly* sinusoidal, it is important to use current measurement devices that are designated as capable of measuring "True RMS" current.

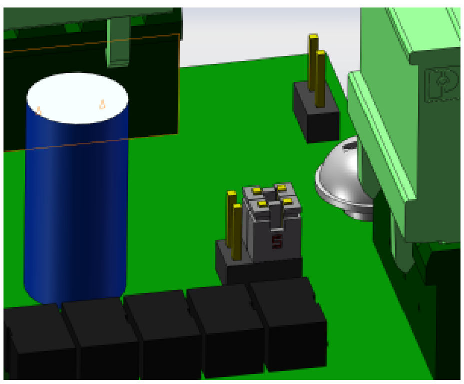
**Power Out**
Since the drive output is PWM-based (see the Voltage Out and Current Out descriptions above), it is difficult to accurately measure output power. Proper sampling must be done to capture the information held in the voltage and current, normally requiring high-end power analyzers to obtain correct values.

## Condenser Fan Relay

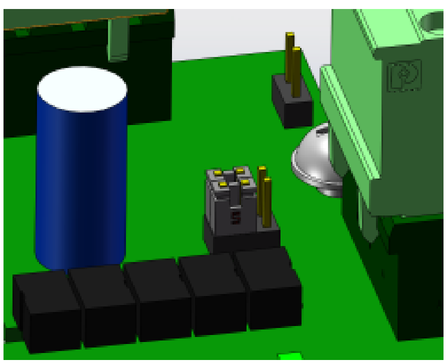
**Fan Relay Out**
The drive contains an on-board relay that can be used to operate a condenser fan motor. This is desirable when the drive is applied without a "main" contactor, or if it is otherwise a requirement to interlock fan operation with drive operation, as determined by the drive's operating state. To do so, connect **F1** and **F2** in series with the "common" side of the condenser fan motor, or in series with the low voltage enable of a variable speed fan motor controller if the signal level is at least 1 amp. The contacts are not rated for microprocessor control (low milliamp signals). An optional drive with a special signal level relay (rated down to 1mA) is available.

## Hardware Mode Selection (V1 Only)

The drive hardware can be configured for 3 digital inputs, referred to as "Digital Mode", or it can be configured for 1 analog input with 2 digital inputs, referred to as "Analog Mode". The hardware mode is determined by the location of 2 jumper connections located near the **C/LO/HI/SEL** connector.

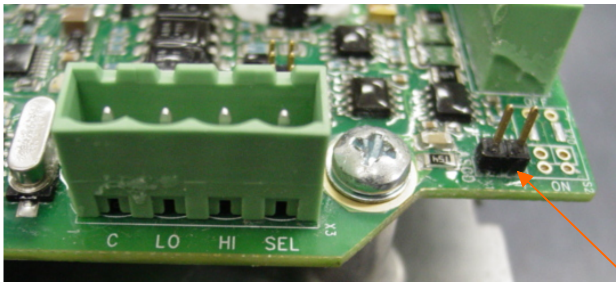


Configured for Digital Hardware Mode



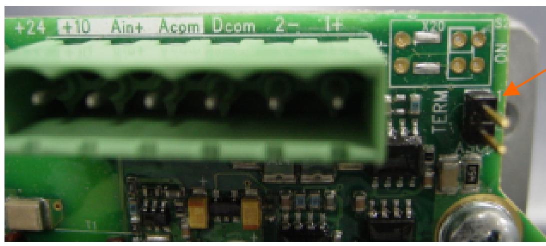
Configured for Analog Hardware Mode

## Control Inputs




**Right Side Terminal**

ASCD Bypass




**Upper Terminal Block**

## Control Inputs—Digital Hardware Mode (V0 and V1 Versions)

**C**
The common side of the system 24 Vac 50/60 Hz transformer should be connected here. The **LO/HI/SEL** logic inputs are referenced back to this connection. It is allowable for the system transformer to be earth grounded, as these inputs are opto-coupler isolated.

**LO**
Digital input for Stage 1 compressor operation. The input must be 24 Vac 50/60 Hz or 24 Vdc as referenced back to the **C** terminal. If desired, this input may be wired in series with system safeties (ex. high pressure switch) to disable compressor operation during an error state. (**Default operation** - contact BCI Engineering or see “Control Mode Options” in this Supplement.)

**HI**
Digital input for Stage 2 compressor operation. The input must be 24 Vac 50/60 Hz or 24 Vdc as referenced back to the **C** terminal. The **LO** input must be active prior to or simultaneous with a **HI** transition to the "ON" state. An active **HI** without an active **LO** is considered a fault. (**Default operation** - contact BCI Engineering or see “Control Mode Options” in this Supplement.)

**SEL**
Digital input that **SEL**ects between 2 groups of pre-defined compressor speeds. The input must be 24 Vac 50/60 Hz or 24 Vdc as referenced back to the **C** terminal. Based on the state of the **SEL** input, two discrete speeds are selectable with the **LO** input, and two separate discrete speeds are selectable with the **LO+HI** input, for a total of 4 discrete speeds. For example, when the reversing valve control signal is connected to SEL: Low Heat, High Heat, Low Cool, High Cool. (**Default operation** - contact BCI Engineering or see “Control Mode Options” for alternatives.)

**+10/Ain+/ACOM**
Not used in Digital Hardware Mode.

**<u>Control Inputs—Analog Hardware Mode (V1 Only)</u>**

**C**
The common side of the system 24 Vac 50/60 Hz transformer should be connected here. The **LO/HI** logic inputs are referenced back to this connection. It is allowable for the system transformer to be earth grounded, as these inputs are opto-coupler isolated.

**LO**
Digital input used to Stop/Start compressor operation. The input must be 24 Vac 50/60 Hz or 24 Vdc as referenced back to the **C** terminal. If desired, this input may be wired in series with system safeties (ex. high pressure switch) to disable compressor operation during an error state.

**HI**
Not used in the default setup. Can be utilized as a digital input to set and record a fault condition. The input must be 24 Vac 50/60 Hz or 24 Vdc as referenced back to the **C** terminal. Contact BCI Engineering for options.

**SEL**
Not used in Analog Hardware Mode.

**+10 (Upper Terminal Block)**
A 10 Vdc source that can be used by a system controller to generate the 1-9 Vdc for compressor speed control. This source is referenced back to the **ACOM** connection and is isolated from line and digital inputs but does have potential to ground. Ensure current draw does not exceed 150mA.

**Ain+ (Upper Terminal Block)**
The positive connection of the input that controls compressor speed. The input must be between 0.5 and 9.5Vdc as referenced back to the **ACOM** connection. If the input drops below 0.5Vdc or exceeds 9.5Vdc, the drive will fault. 1-9Vdc equates to 40-160Hz compressor speed, linearly. If provided with a valid analog in, the drive will start and run once the LO digital in goes active. Contact BCI engineering for additional setup options.

**ACOM (Upper Terminal Block)**
The negative connection of the analog input that controls compressor speed.

**<u>Communication/Programming—Either Hardware Mode</u>**

**1+ (Upper Terminal Block) or SIO+ on V0**
The Tx+ connection of the RS-485 communications link.

**2- (Upper Terminal Block) or SIO- on V0**
The Tx- connection of the RS-485 communications link.

**DCOM (Upper Terminal Block)**
The serial interface common connection of the RS-485 communications link (optional connection for cable shield)

# Bristol Compressors International
# Permanent Magnet Motor Drive
# Win-trAC Program Software Installation

**Win-trAC Installation**

1) Copy “Win-trAC_V2_1_9_Install.exe” to the hard drive.

2) Run “Win-trAC_V2_1_9_Install.exe” by double-clicking on the file.

3) Accept the default destination location.

4) Accept the default Start Menu folder.

5) Verify settings, click “Install”.

6) Click “Finish” to complete the basic software installation.

7) Navigate to the location that contains the additional setup detail for Win-trAC installation.

8) Copy “Bristol_standard_Vxxx_OEM.dpf” file to the clipboard. “xxx” is replaced by the current software revision number.

9) Navigate into “C:\Program Files\Vacon\Win-trAC\Dpf\” (drive letter and/or folder path may differ depending upon options selected during basic software installation).

10) Paste the new .dpf file into the \Dpf\ folder.

11) Run Win-trAC for the first time using the “Vacon\Win-trAC Pro” start menu or desktop.

12) In the “Select Win-trAC Workspace” pop-up window, click on the “Create new Workspace” button.

13) In the “Auto-Detect Network” pop-up window, click the “No” button.

14) In the “Workspace” drop-down menu, click the “Add Drive …” option.

15) In the “Configure New Drive Properties” pop-up window, click in the “Node Address:” text box and enter “1”, or the new node number if P2060 SIODropNum has been changed.

16) Click the “DPF Browse…” button below the “Select DPF File:” text box.

17) In the “Browse for DPF Files” pop-up window, double-click the “Bristol_standard_Vxxx_OEM.dpf” file.

18) In the “Configure New Drive Properties” pop-up window, click the “OK” button.

19) In the “File” drop-down menu, click the “Save Workspace” option, then close Win-trAC.

20) When re-opening Win-trAC, the Workspace can be retrieved without repeating steps 12—19.

21) Win-trAC is installed and ready for use. For faster access, a shortcut should be created on the desktop.

**Win-trAC Operation**

1) Ensure that the RS-485 communication adapter is connected to the computer and is functional.

2) Connect the Tx+ connection of the RS-485 communication adapter to the 1+(SIO+) and Tx- to the 2-(SIO-) terminals on the drive. Connect the adapter common to the DCOM terminal on the drive. The cable's shielding may also be connected to the DCOM terminal on the drive which will provide additional resilience to electrical noise.

3) Power-up the drive. (The RS-485 hardware could CAREFULLY be connected with the drive already powered, even when operating a compressor. If this is attempted, extra care should be taken to avoid inadvertent contact with "live" electrical components.)

4) Open the Win-trAC software.

5) Recall the Workspace created during Win-trAC installation.

6) Check the bottom right corner of the window and verify Win-trAC is accessing the proper COM port. If not, in the "Workspace" drop-down menu, click "Communication Properties…". This will open the "Configure Communication Properties" window where the proper selection can be made.

7) Click the icon that depicts a disconnected extension cord surrounded by a red circle. The icon will change to depict a connected extension cord and the red circle around the cord will change to green.

8) The "Drive Communication Check" pop-up window will appear. If the drive connection is good, and the drive's software version matches the loaded .dpf file, a green box will appear with the text "Valid Configured Node". If the drive connection is good, and the drive's software does not match the .dpf file, a red box will appear with the text "Error: Drive does not match DPF Configuration". Load the correct DPF file and reconnect. If the wrong COM port is selected, a yellow box will appear with the text "Warning: Drive is present but not able to be identified". Repeat step 6. If the drive connection is bad (mis-wired), if the RS-485 adapter is not functioning properly, if the drive is not powered or if the wrong COM port is selected, a yellow box will appear with the text "Warning: Cannot Detect a Drive".

9) In the "Tools" drop-down menu, click on "Parameter View/Edit..." option to access drive parameters. Parameters surrounded by grey are typically Read-access only, those in white typically have both Read and Write access.

10) To change a parameter value, double-click in the "Current Value" box for that parameter, change the value in the "Edit Parameter Value" pop-up window, and click "OK" to keep the change. Click "Cancel" or press "Esc" to retain the previous value. After entry, if a valid parameter adjustment was not kept in the parameter value, the user did not have access right to adjust that parameter. All parameters changes are written to non-volatile memory during power-down of the drive.

11) Click the "x" in the upper right corner of each open window to close Win-trAC.

# Bristol Compressors International
## Permanent Magnet Motor Drive
### Drive Parameters

**Parameter Detail**

| **SWV:** | 113 | Grey = READ ONLY | | |
|---|---|---|---|---|
| **Sub-Group** | **Number** | **Parameter Name** | **Default Value** | **Parameter Description** |
| System | 002 | OperatingTimeHigh | n/a | High byte in (value*65536) sec of the drive's powered-on time |
| | 003 | OperatingTimeLow | n/a sec | Low byte in sec of the drive's powered-on time (total time in sec = P002*65536 + P003) |
| | 043 | SystemSoftwareVersion | 113 | Revision level of the drive's operating software |
| | 512 | InterfaceFactoryReset | No Action | Store / Recall Customer Parameter Set (this set is auto-recalled after an EEPROM error) |
| Unit | 007 | UnitNomVoltage | n/a Vac | Rated nominal input voltage, in Vac |
| | 008 | DCNomVoltage | n/a Vdc | Rated nominal DC Bus value, in Vdc, when UnitNomVoltage is applied |
| | 009 | UnitVTCurrent | n/a A | Rated maximum drive output current, in A |
| | 011 | DCVoltage | n/a Vdc | Average voltage in Vdc of the DC Bus |
| | 012 | IGBTTemperature | n/a °C | IGBT temperature in C, as modeled from UnitTemperature and MotorCurrent |
| | 013 | UnitTemperature | n/a °C | Heatsink temperature in C, as measured by sensor in power module |
| | 017 | RealSwitchingFrequency | n/a kHz | Actual PWM switching frequency, will reduce if IGBTTemperature reaches 92 degC |
| | 521 | SwitchingFrequency | 7.0 kHz | Target PWM switching frequency (5k for lowest power, 7k for lowest sound) |
| Motor Control | 021 | FreqOut | n/a Hz | Actual motor output frequency in Hz |
| | 025 | MotorSpeed | n/a RPM | Estimated motor speed in rpm (calculated from FreqOut) |
| | 026 | MotorCurrent | n/a A | Average motor current in A |
| | 027 | MotorTorque | n/a % | Motor torque in %, calculated based on present operating conditions |
| | 028 | MotorPower | n/a % | Motor power in %, calculated based on present operating conditions |
| | 044 | MCStatus[1] | n/a | Bitwise representation of present operating status, see next section for definition |
| | 527 | StopFunction | Coasting | DO NOT MODIFY -- keep factory setting of "Coasting" |
| | 604 | FreqRef | n/a Hz | Target motor output frequency in Hz |
| Ramp | 545 | AccelerationTime2 | n/a sec | Acceleration rate -- used when increasing speed (larger value = slower ramp) |
| | 546 | DecelerationTime2 | n/a sec | Deceleration rate -- used when decreasing speed (larger value = slower ramp) |
| Protections | 039 | ActiveFault_1 | No Fault | The fault description if drive is presently faulted -- see "Fault List" for definition |
| Speed Reference | 2052 | SpeedPreset1 | 60 Hz | Frequency out target when "LO" input is active and "SEL" input is inactive **(Default)** |
| | 2053 | SpeedPreset2 | 120 Hz | Frequency out target when "HI+LO" are active and "SEL" is inactive **(Default)** |
| | 2056 | SpeedPreset3 | 60 Hz | Frequency out target when "LO" and "SEL" are active **(Default)** |
| | 2057 | SpeedPreset4 | 120 Hz | Frequency out target when "HI+LO" and "SEL" are active **(Default)** |
| | 2112/13/14 | SpeedPreset5/6/7 | 0 Hz | See Control Mode Options and/or contact BCI Engineering for options |
| Skip Bands | 2097-2106 | SkipFreq 1Lo/Hi - 5Lo/Hi | 0/0 Hz | 5 OEM-definable output frequency ranges that will be skipped by drive |
| | 2107/08 | SkipFreq6Lo/6Hi | 86/94 Hz | Bristol-defined output frequency range that will be skipped by drive |
| Timers | 2054 | TimerASCD | 30 sec | Anti-Short Cycle Delay, an OFF delay after power-up or compressor stop |
| | 2055 | TimerDwell | 0.0 sec | Minimum dwell time in a speed mode before a speed transition is permitted |
| | 2058 | TimerDwellStart | 0.1 sec | Factory use only, do not modify |
| | 2109 | TimerSkipBand | 300.0 sec | Dwell time when a limit function forces output to the bottom of a skip band |
| Modbus | 2060 | SIODropNum | 1 | CAUTION IF MODIFYING -- Node address for Modbus/Win-trAC serial communication |
| | 2061 | SIOBaudRate | 9600 Baud | CAUTION IF MODIFYING -- Baud rate for serial communication |
| | 2063 | SIO485Protocol | N81 | CAUTION IF MODIFYING -- Start bit, number of data bits, and number of stop bits |
| | 2116 | SIOTimer | 10.0 sec | CAUTION IF MODIFYING -- Timeout period for loss of communication fault |
| App General | 2062 | DISettleTime | 0.50 sec | Time period required for a valid digital input state change |
| | 2115 | ReferenceMode | 2-4 spd | Drive control mode, see next section or contact BCI Engineering for options |
| | 2117 | ActiveLogic | 0x0007 | Drive digital input logic setup -- contact BCI Engineering for options |
| | 2119 | AIFilterTime | 5.0 sec | Drive analog input logic setup -- contact BCI Engineering for options |
| | 2121/22 | AISpan/Offset | n/a | Factory use only |
| | 2123/24 | StartsPerHr/NumOfHrsThreshold | n/a | Factory use only |

# Bristol Compressors International
## Permanent Magnet Motor Drive
### Drive Parameters

**Parameter Detail - con't**

| SWV: | 113 | Grey = READ ONLY | | |
|---|---|---|---|---|
| **Sub-Group** | **Number** | **Parameter Name** | **Default Value** | **Parameter Description** |
| Serial Access/Control | 904 | SIOControlWord[2] | 0x0000 | Bitwise control word used during Serial Control Mode. Also used to clear faults or fault history |
| | 905 | SIOSpeedRef | 0.00 Hz | Speed Reference used during Serial Control Mode |
| | 907 | SIOAccessCode | 0 | Factory use only |
| | 908 | Timer Status[3] | n/a | Bitwise representation of timer states AND hardware configuration |
| | 909 | DIStatus | n/a | Bitwise representation of digital inputs (only valid with digital hardware config) |
| | 910 | AIStatus | n/a | Analog input status, 0-10Vdc = 0-100% (only valid with analog hardware config) |
| Fault History | 787-825 | Faults 1-5 + data | n/a | Resettable fault history, 1-4 since last reset / 5th always updated, i.e. most recent |
| Fault Counters | 827-859 | Individual Fault Names | n/a | Non-resettable fault count for each individual fault |
| System Counters | 1446-1459 | Drive Lifetime Data | n/a | Non-resettable data documenting drive operation |

**Control Mode Options (Param 2115 ReferenceMode)**

**Board Config:** Digital
P908 Timer Status = 0x0040*

**RefMode:** **2-4 spd**

**Application:**
Up to 4 speeds, fault w/o LO,
2-stage stat control
0 RPM is not a valid preset speed

| LO | HI | SEL | Output |
|---|---|---|---|
| 0 | 0 | 0 | OFF |
| 1 | 0 | 0 | SpeedPreset1 |
| 0 | 1 | 0 | DI LO fault |
| 1 | 1 | 0 | SpeedPreset2 |
| 0 | 0 | 1 | OFF |
| 1 | 0 | 1 | SpeedPreset3 |
| 0 | 1 | 1 | DI LO fault |
| 1 | 1 | 1 | SpeedPreset4 |

**Board Config:** Digital
P908 Timer Status = 0x0040*

**RefMode:** **7 spd**

**Application:**
Up to 7 speeds, no DI faults
integration w/system controller
0 RPM is a valid preset speed

| LO | HI | SEL | Output |
|---|---|---|---|
| 0 | 0 | 0 | OFF |
| 1 | 0 | 0 | SpeedPreset1 |
| 0 | 1 | 0 | SpeedPreset2 |
| 1 | 1 | 0 | SpeedPreset3 |
| 0 | 0 | 1 | SpeedPreset4 |
| 1 | 0 | 1 | SpeedPreset5 |
| 0 | 1 | 1 | SpeedPreset6 |
| 1 | 1 | 1 | SpeedPreset7 |

**Board Config:** Analog
P908 Timer Status = 0x0020*

**RefMode:** **AI:0-10V**

**Application:**
Full analog variable speed
requires integration w/system controller
0-10Vdc is translated to 0-100% AIStatus

| LO | HI | AIStatus | Output |
|---|---|---|---|
| 0 | x | x | OFF |
| 1 | x | <5% | AI Range fault |
| 1 | x | >5% & <10% | 40Hz |
| 1 | x | 10 - 90% | 40 - 160Hz |
| 1 | x | >90% & <95% | 160Hz |
| 1 | x | >95% | AI Range fault |

**Board Config:** Analog
P908 Timer Status = 0x0020*

**RefMode:** **AI:0-10V+HI flt**

**Application:**
Full analog variable speed
same as above, adds fault w/HI input

| LO | HI | AIStatus | Output |
|---|---|---|---|
| x | 0 | x | Same as above |
| x | 1 | x | DI HI fault |

*** value if no timers are active**

**x = don't care**

**Definitions for Bit-based Parameters**

| [1]P044 MCStatus | Operation |
|---|---|
| Bit 2: | Ready |
| Bit 3: | Running |
| Bit 6: | In Current Limit |
| Bit 7: | In Voltage Limit |
| Bit 8: | In Power Limit |
| Bit 10: | Faulted |
| Bit 13: | At Reference Speed |
| Bit 14: | At Zero Speed |

| [2]P904 SIOControlWord | Function |
|---|---|
| Bit 0: | Serial Comm Active |
| Bit 2: | Compressor On/Off |
| Bit 9: | Fan Logic Override |
| Bit 10: | Fan Relay On/Off |
| Bit 14: | Reset Fault History |
| Bit 15: | Reset Active Fault |

| [3]P908 Timer Status | Timer Active |
|---|---|
| Bit 0: | Skip Band |
| Bit 1: | Speed Dwell |
| Bit 2: | Start Dwell |
| Bit 3: | Autoreset |
| Bit 4: | ASCD |
| Bit 5: | Analog hw config |
| Bit 6: | Digital hw config |
| Bit 7: | Accel4 |

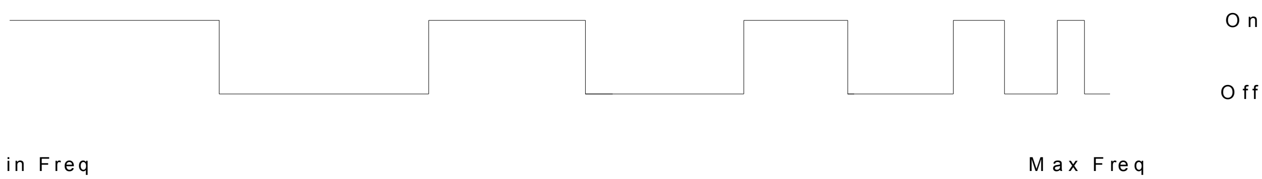
# Bristol Compressors International
# Permanent Magnet Motor Drive
# Fault List/LED Operation

Bristol Fault/LED Numbering (swv111 and later)

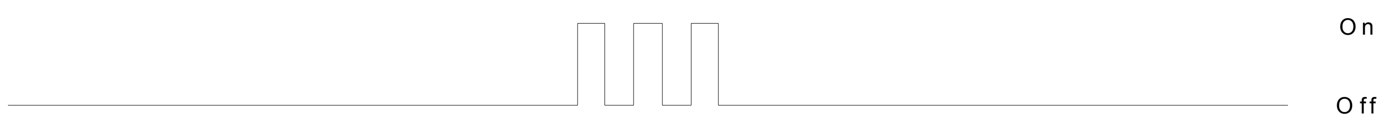
When powered, the status LED on the Bristol drive will blink 1 of 3 blink patterns: Ready, Run, or Faulted.

1) The Ready (heartbeat) state is indicated by a 5 second ON period, followed by a half second OFF period. It means that the drive is not faulted, has no run signal, but is enabled.


2) The Run state is indicated by an ON-OFF blink pattern with a frequency proportional to the drive’s output frequency.




3) The Faulted state is indicated by blinks at a time of 0.4 seconds ON and 0.4 seconds OFF, followed by a 3 second OFF period, after the number of ON blinks corresponding to the fault has been counted out. Fault codes 1-16 will show the corresponding blink count, and codes of 17 or higher will be represented by 17 blinks.




Example: Fault code 3

Note that Fault Code 1 is technically an exception, as it is the Not Ready state:
— The Not Ready state is signaled by a 1 blink count. This state signifies that that the drive is not faulted, but it is in a "wait" state, due to one of the following reasons: the drive has just powered-up and is awaiting a run request, the drive's DC bus voltage (thereby the input voltage) is too low; the drive's heatsink is below the allowed starting temperature; the drive's heatsink is above the allowed starting temperature; the drive did not detect all 3 phases of the PM motor; or the drive is waiting the ASCD. The drive may or may not have a run request from its hardware inputs or the serial link, and as soon as the condition causing the Not Ready state goes away, the drive will return to the Ready state or the Run state, dependent upon a run request.

# Bristol Compressors International
# Permanent Magnet Motor Drive
# Fault List/LED Operation

The following is a list of the most recent fault codes defined for the Bristol drive: Software version (SWV) 110 and above.

| Fault | | LED | Fault Description |
|---|---|---|---|
| 1) | Not Ready | 1 | See the "Not Ready" description (page 19) |
| 2) | DI LO input | 2 | "LO" input status is invalid (based on P2115 ReferenceMode selection) |
| 3) | DI HI input | 3 | "HI" input status is invalid (based on P2115 ReferenceMode selection) |
| 4) | Output Phase | 4 | Compressor motor phase was lost or OLP opened during a Run state |
| 5) | *Communication | 5 | Serial communication was established then lost for longer than P2116 |
| 6) | AI Range | 6 | 0-10V Analog Input is less than 0.5V or greater than 9.5V (if AI mode), or drive hardware mode does not support P2115 ReferenceMode selection |
| 7) | Over Current | 7 | Current output from drive exceeded hardware limit |
| 8) | Motor Stall | 8 | Compressor failed to start, or stalled while running due to excessive load |
| 9) | Underload | 9 | Compressor is operating at a continued light load, ex. loss of charge |
| 10) | *Heatsink (or IGBT) Over Temp | 10 | Drive temperature, per on-board sensor or IGBT calculation, was too high |
| 11) | Under voltage | 11 | Input voltage was too low, as detected by low DC Bus |
| 12) | Over voltage | 12 | Input voltage was too high, as detected by high DC Bus |
| 13) | Rotor Loss | 13 | Compressor failed to start |
| 14) | Motor temp | 14 | Compressor motor temperature, per drive calculation, was too high |
| 15) | *Ground fault | 15 | Drive detected excessive ground current in compressor motor phases |
| 16) | *Starts/Hr | 16 | Excessive start/stop commands - error in design or application |
| 17 & Up) | *Drive Internal Fault | 17 | Drive has encountered a non-serviceable drive error |

*fault does not Auto-reset

# Bristol Compressors International
# Permanent Magnet Motor Drive
# Fault List/LED Operation

Bristol Fault/LED Numbering (swv78 — swv110)

| Fault | | LED | Fault Description |
|---|---|---|---|
| 1) | Not Ready | 1 | See the "Not Ready" description (page 19) |
| 2) | DI LO input | 2 | "LO" input status is invalid (based on control mode) |
| 3) | DI HI input | 3 | "HI" input status is invalid (based on control mode) |
| 4) | Output Phase | 4 | Motor phase lost or OLP opened during a Run state |
| 5) | *Communication | 5 | Serial communication lost (based on control mode) |
| 6) | AI Range | 6 | 0-10V Analog Input is less than 0.5V or greater than 9.5V (if AI mode), or drive hardware mode does not support control mode selection |
| 7) | Over Current | 7 | Current output to motor exceeded hardware limit |
| 8) | Motor Stall | 8 | Motor failed to start, or stalled due to overload |
| 9) | Underload | 9 | Compressor is operating at a continued light load, ex. loss of charge |
| 10) | *Heatsink (or IGBT) Over Temp | 10 | Drive temperature, per on-board sensor or IGBT calculation, was too high |
| 11) | Under voltage | 11 | Input voltage was too low, as detected by low DC Bus |
| 12) | Over voltage | 12 | Input voltage was too high, as detected by high DC Bus |
| 13) | Rotor Loss | 13 | Motor failed to start |
| 14) | Motor temp | 14 | Motor temperature, per drive calculation, was too high |
| 15) | *Ground fault | 15 | Drive detected excessive ground current in motor phases |
| 16 & Up) | *Drive Internal Fault | 16 | Drive has encountered a non-serviceable drive error |

*fault does not Auto-reset

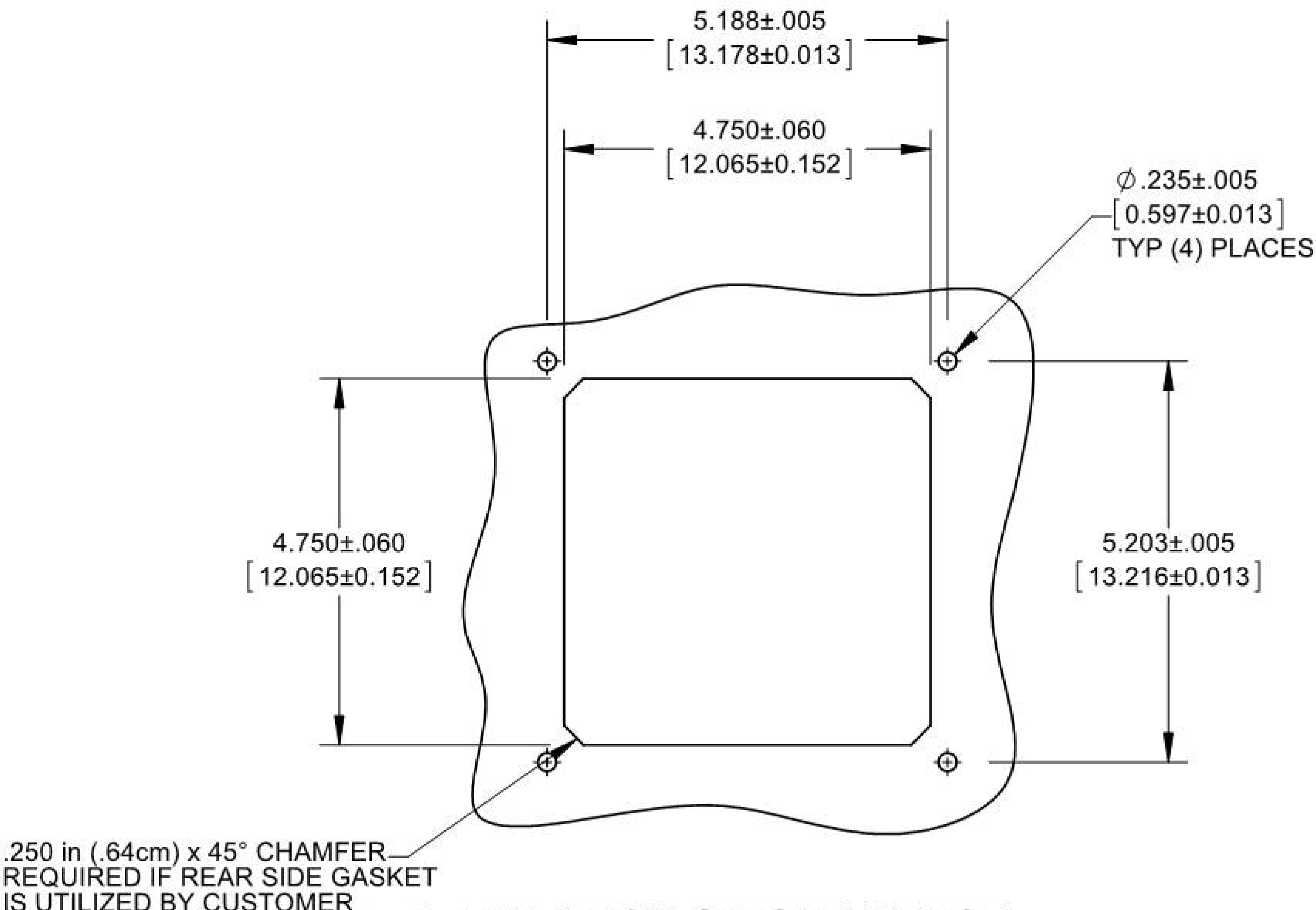
# Bristol Compressors International
# Permanent Magnet Motor Drive
# Fault List/LED Operation

Bristol Fault/LED Numbering (pre-swv78)

| Fault | | LED | Fault Description |
|---|---|---|---|
| 1) | Over Current | 1 | Current output to motor was too high |
| 2) | Over Voltage | 2 | Input voltage was too high, as detected by high DC Bus |
| 3) | Earth Fault | 3 | Drive detected excessive current imbalance in motor phases |
| 4) | DI Pressure | 4 | “HI” input was Active with “LO” input Inactive |
| 5) | Drive Under Temperature | 5 | Drive temperature, per on-board sense, was too low |
| 6) | Drive Over Temperature | 6 | Drive temperature, per on-board sense, was too high |
| 7) | Motor Stalled | 7 | Motor failed to start, or stalled due to overload |
| 8) | Motor Temperature | 8 | Motor temperature, per drive calculation was too high |
| 9) | Motor Underload | 9 | Motor lead(s) not connected, or compressor low on charge |
| 10) | Under Voltage | 10 | Input voltage was too low, as detected by low DC Bus |
| 11 & Up) | Drive Internal Faults | 12 | Drive has encountered a non-serviceable drive error |

**LED Fault Blink Rate**
1/2 sec ON, 1/2 sec OFF
Long off after end of series

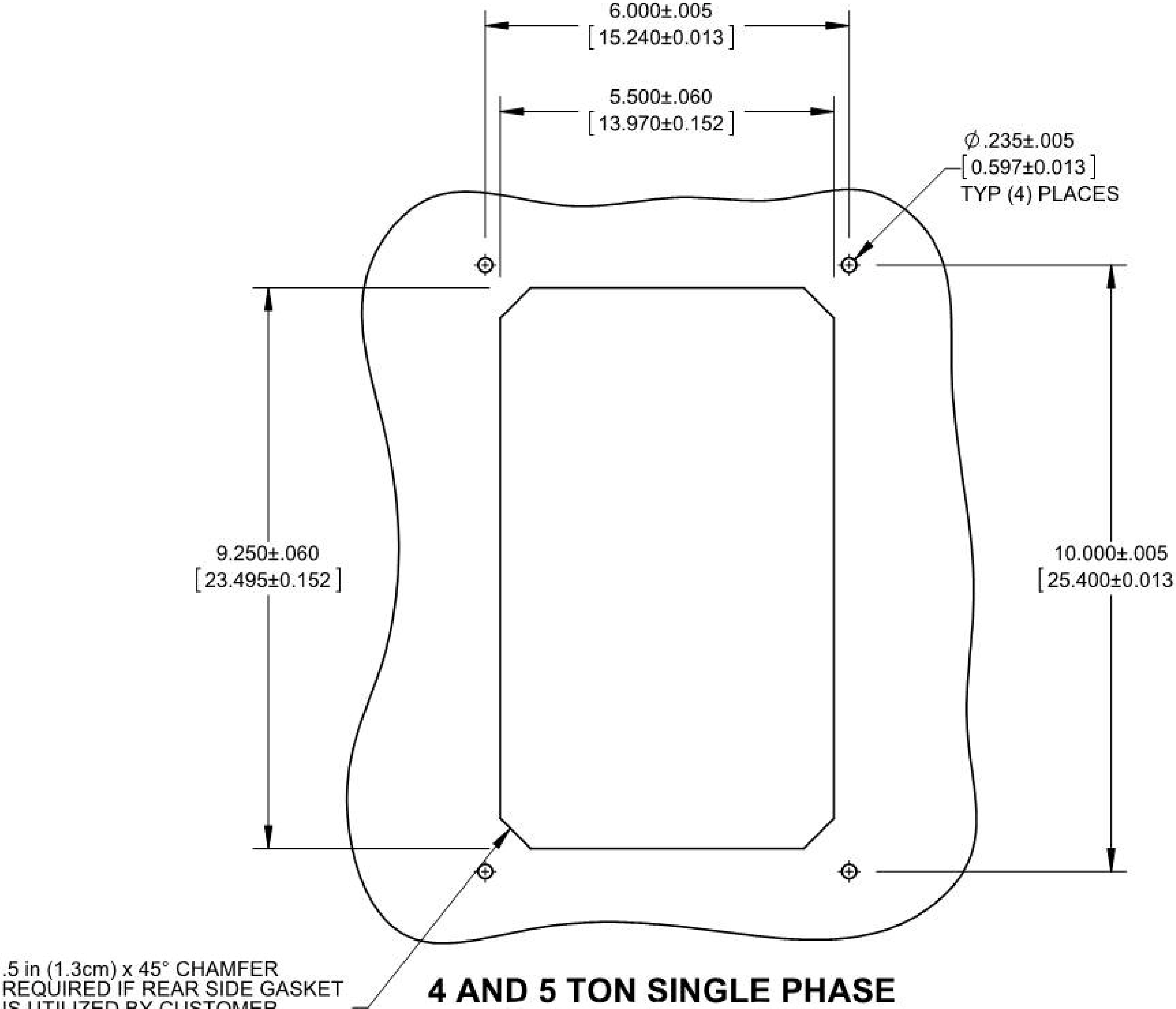
# VSD Drawings (With and Without Cover), Pictorials, Mounting/Panel Cutout Dimensions




# 2 AND 3 TON SINGLE PHASE PANEL CUTOUT

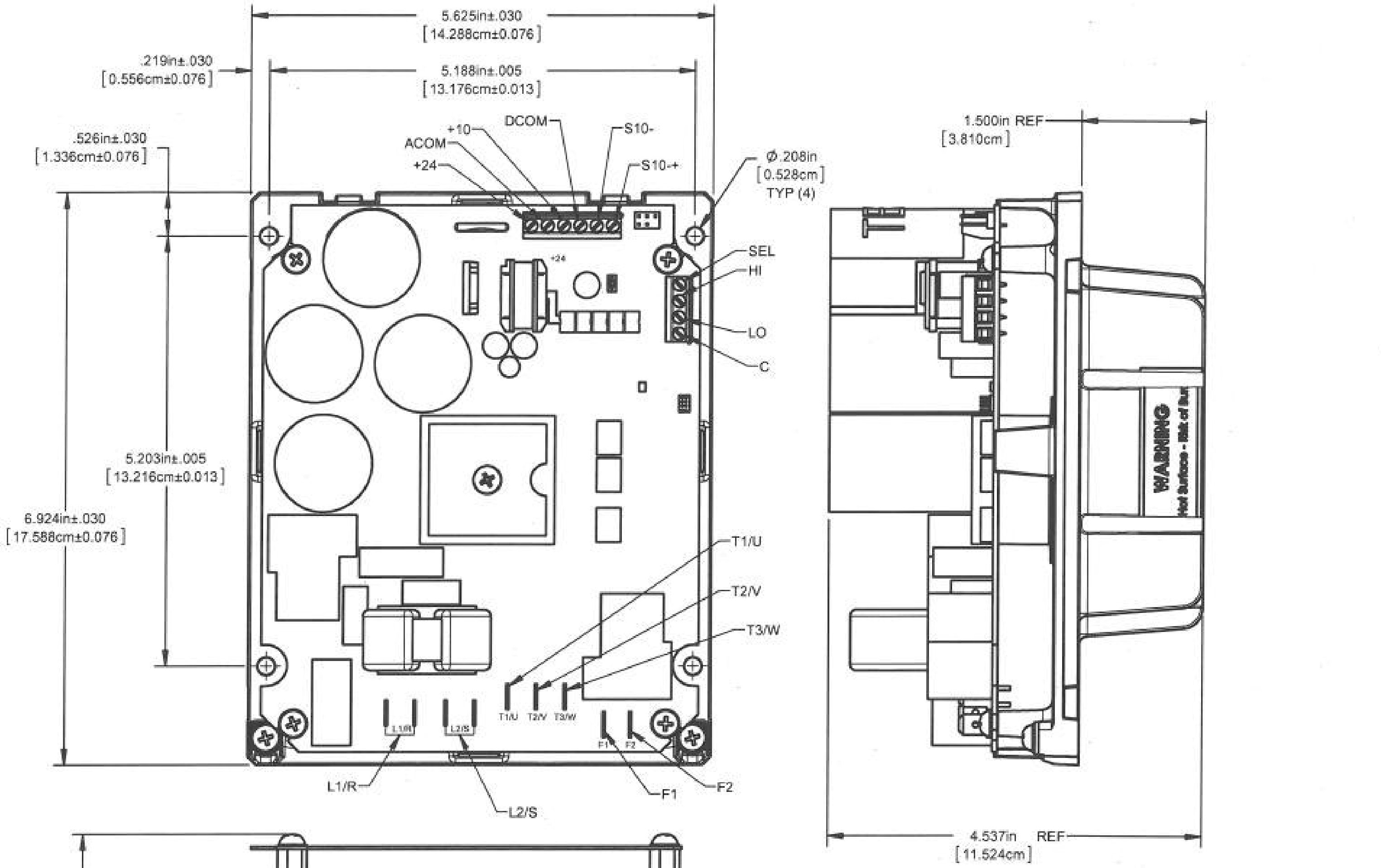
**VARIABLE SPEED DRIVE INSTALLATION**

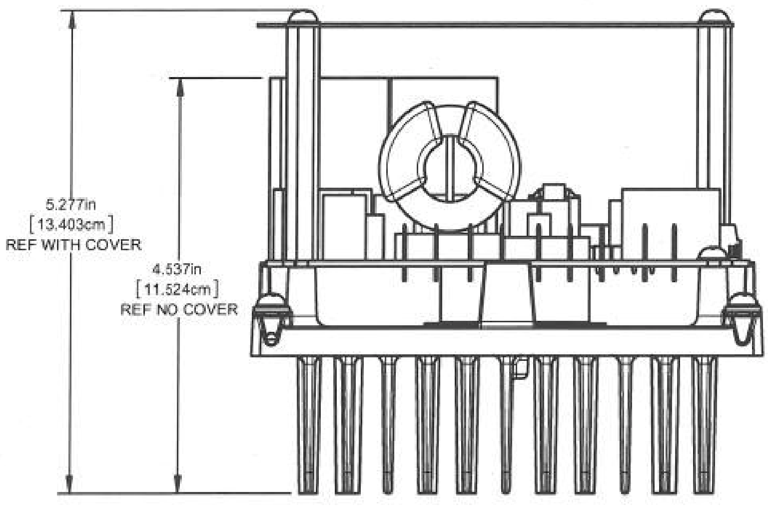
(VIEW IS NOT SCALED)
DIMENSIONS IN INCHES AND (cm)

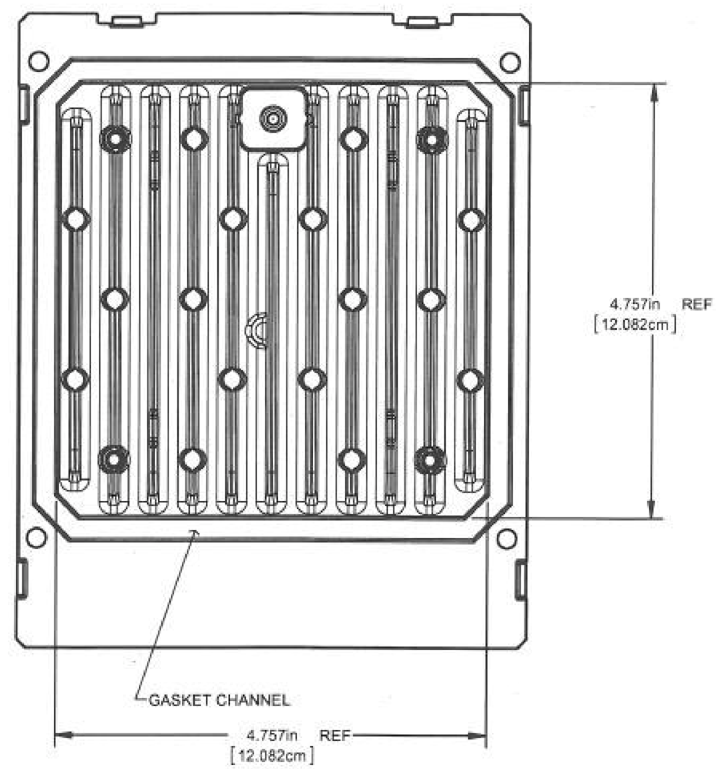



**4 AND 5 TON SINGLE PHASE**
**AND ALL THREE PHASE**
**PANEL CUTOUT**

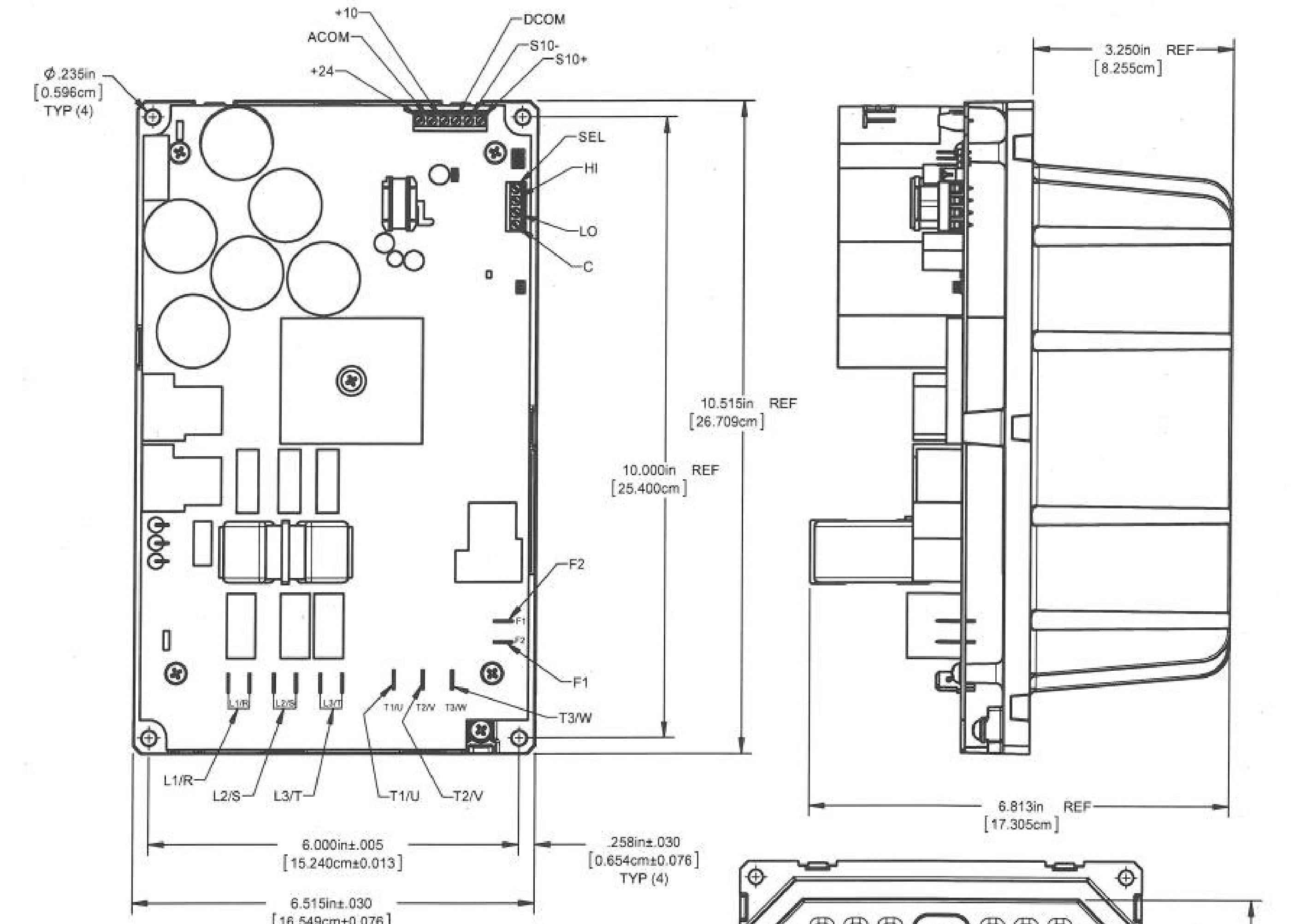
**VARIABLE SPEED DRIVE INSTALLATION**
(VIEW IS NOT SCALED)
DIMENSIONS IN INCHES AND (cm)

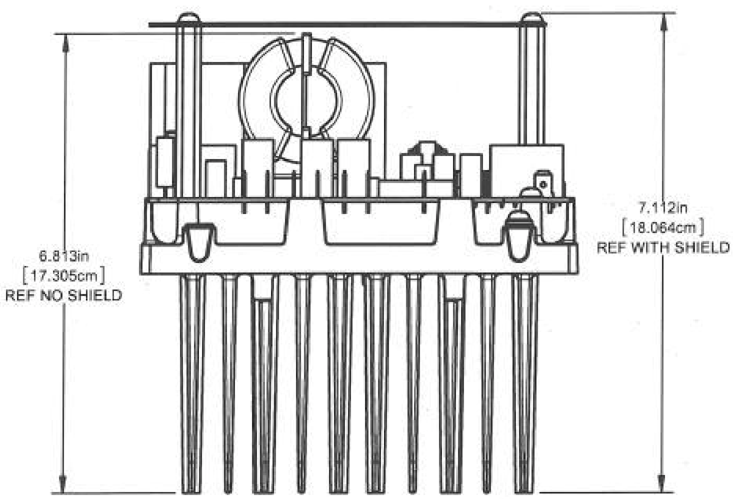


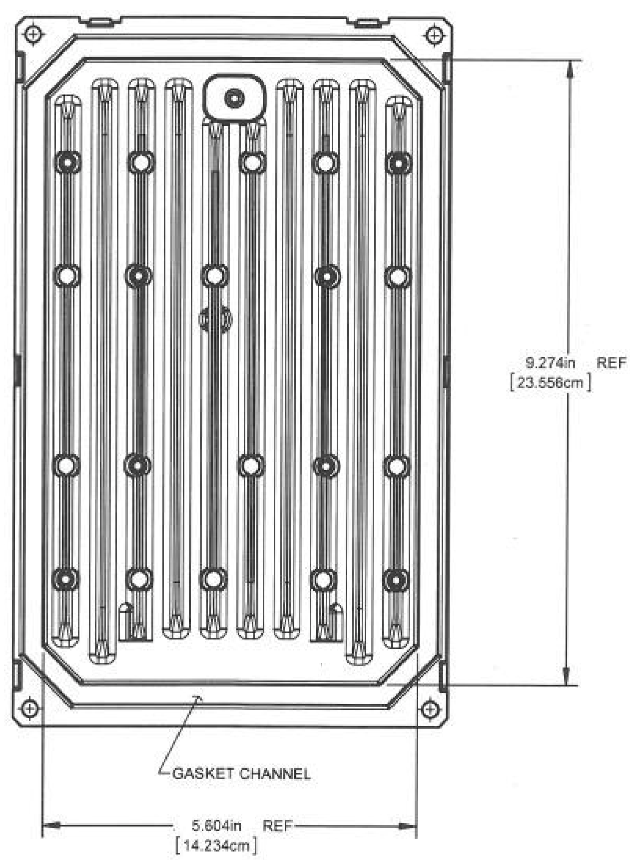



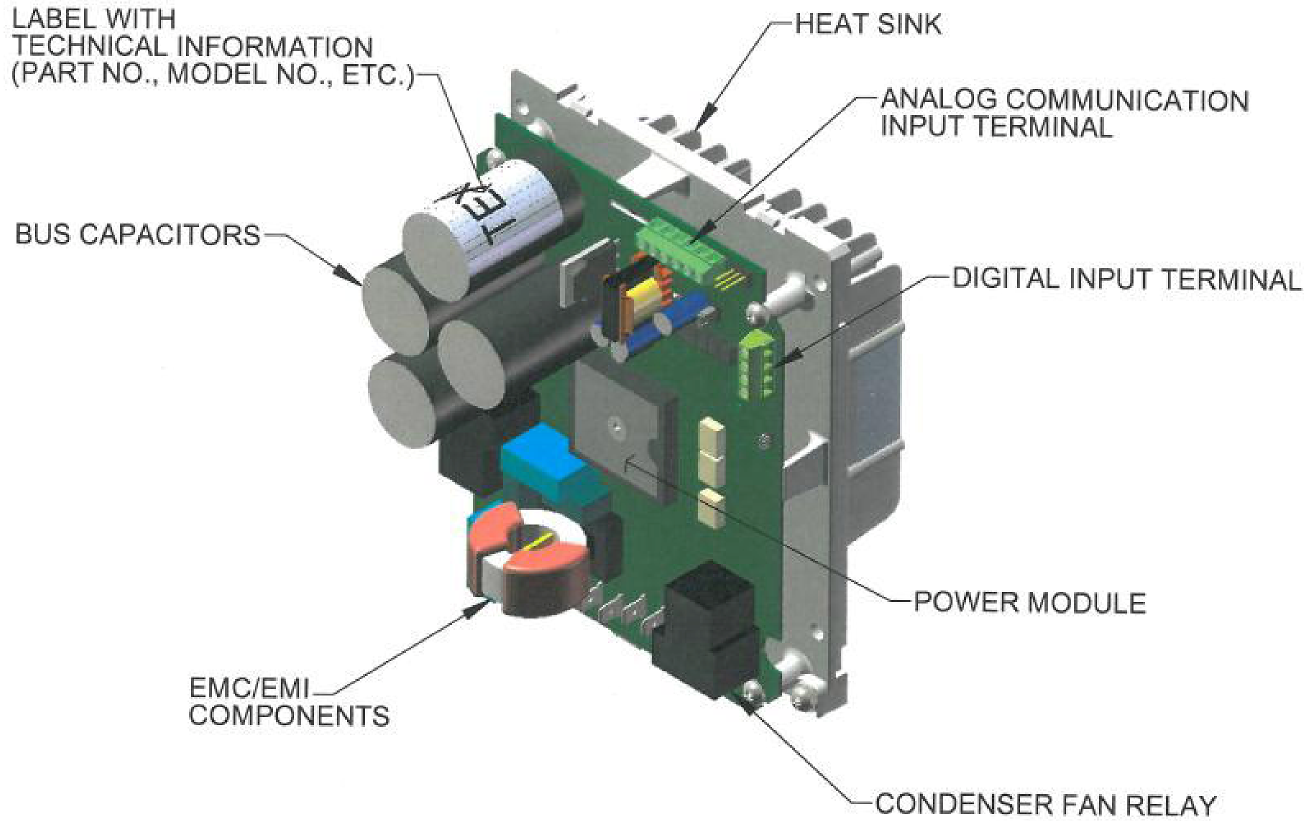

**V0 VERSION**
**2 AND 3 TON SINGLE PHASE**
**VARIABLE SPEED DRIVE**
(VIEW IS NOT SCALED)
DIMENSIONS IN INCHES AND (cm)

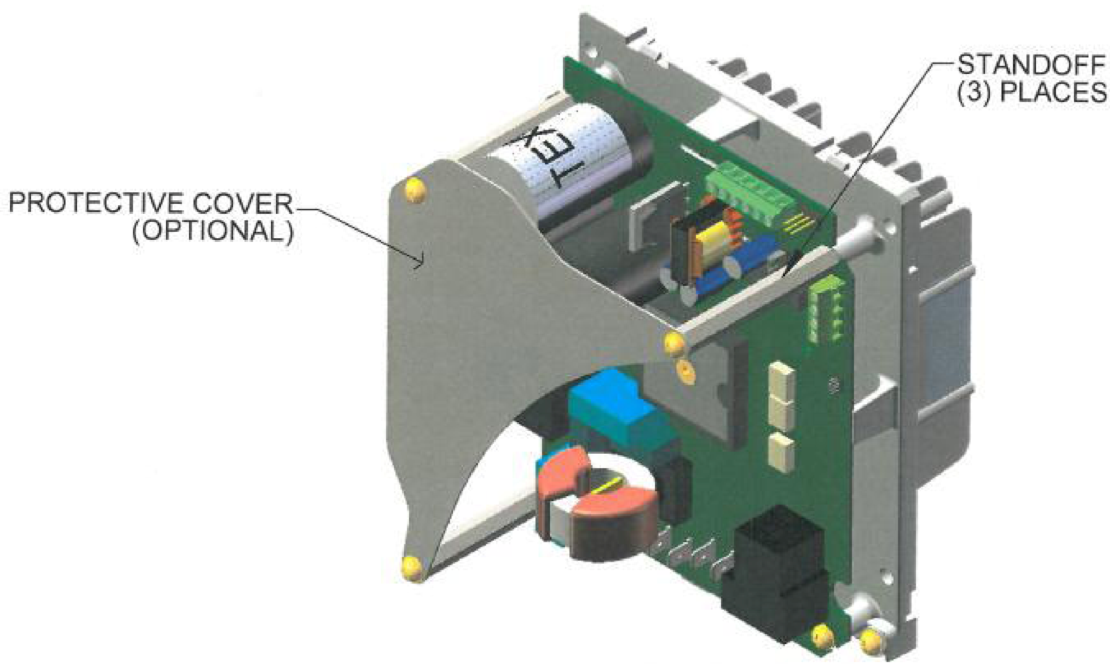


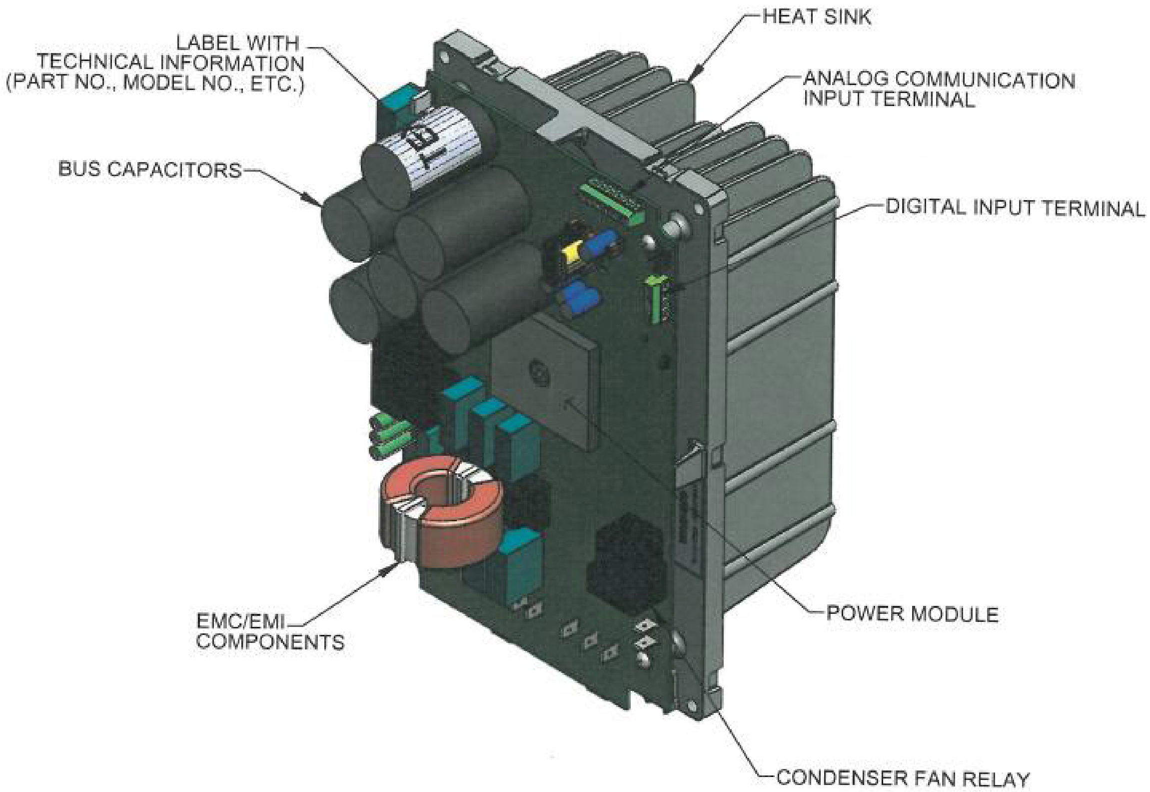

**V0 VERSION**
**4 AND 5 TON SINGLE PHASE**
**AND ALL THREE PHASE**
**VARIABLE SPEED DRIVE**
(VIEW IS NOT SCALED)
DIMENSIONS IN INCHES AND (cm)

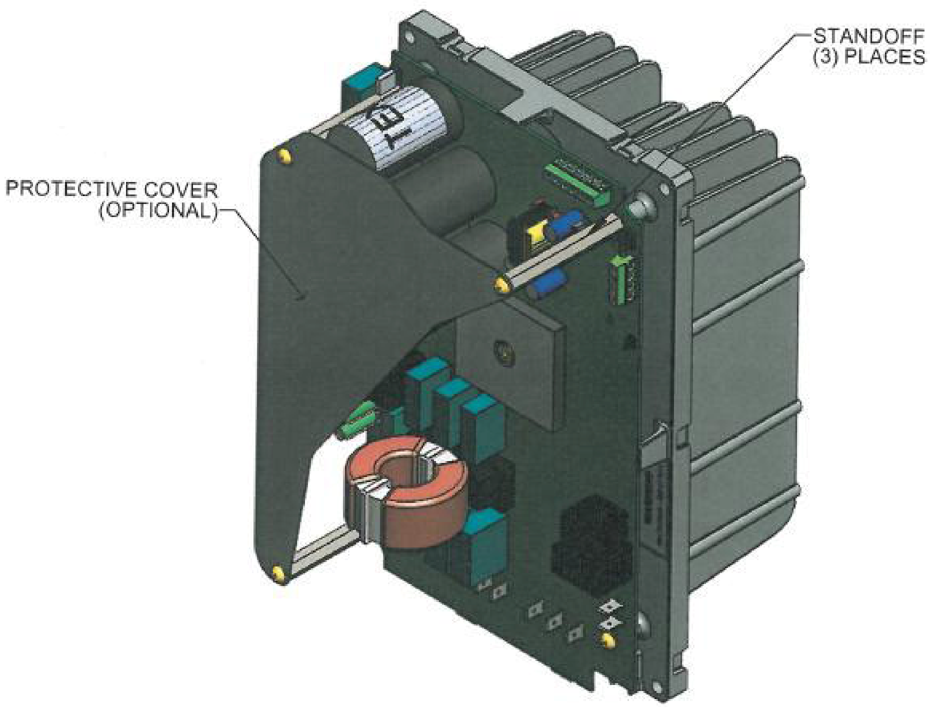



**VIEW WITH COVER INSTALLED**

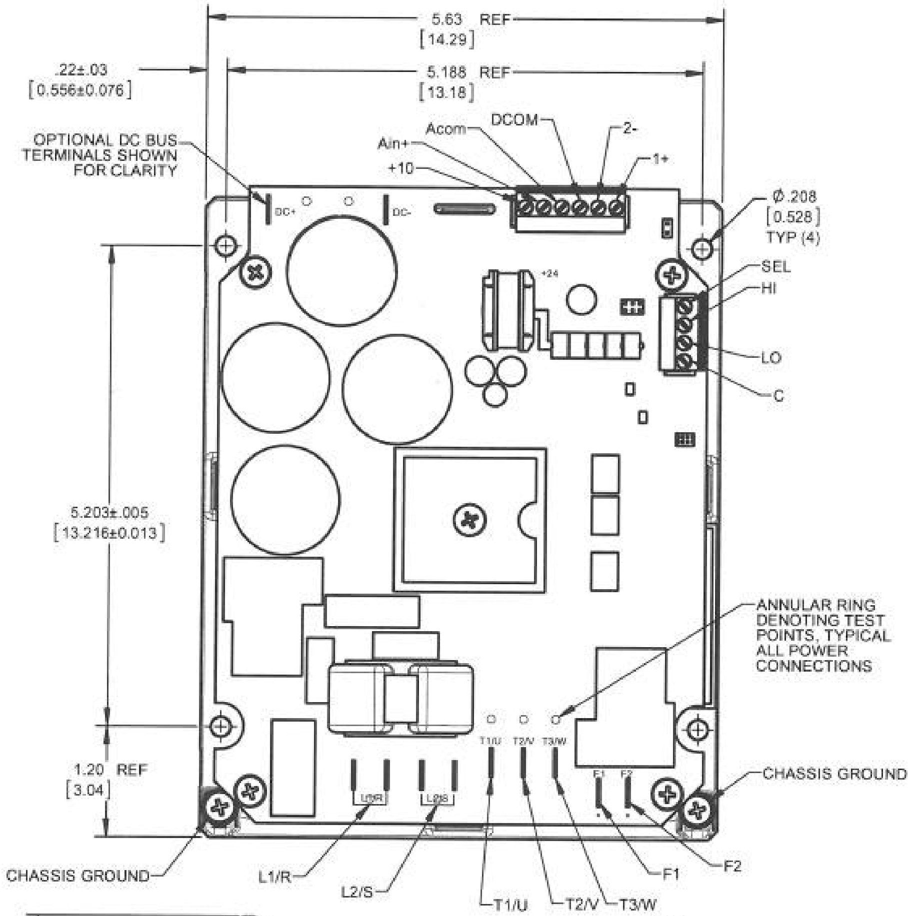
**V0 VERSION**
**2 AND 3 TON SINGLE PHASE**
**VARIABLE SPEED DRIVE**

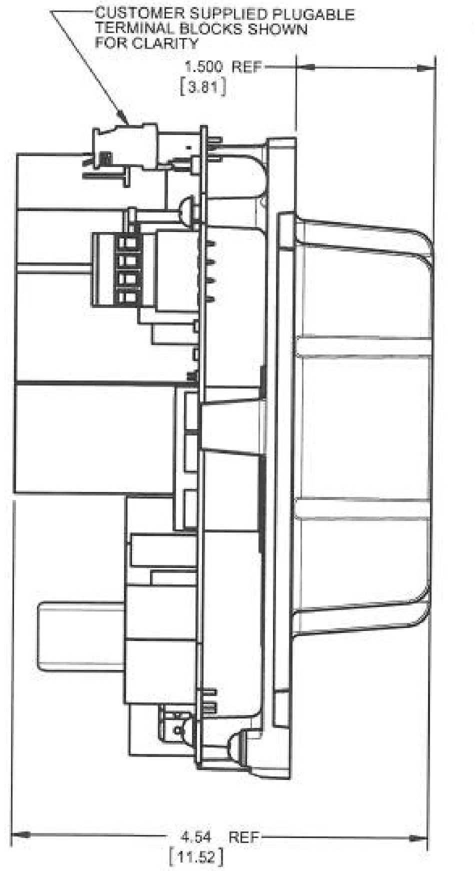


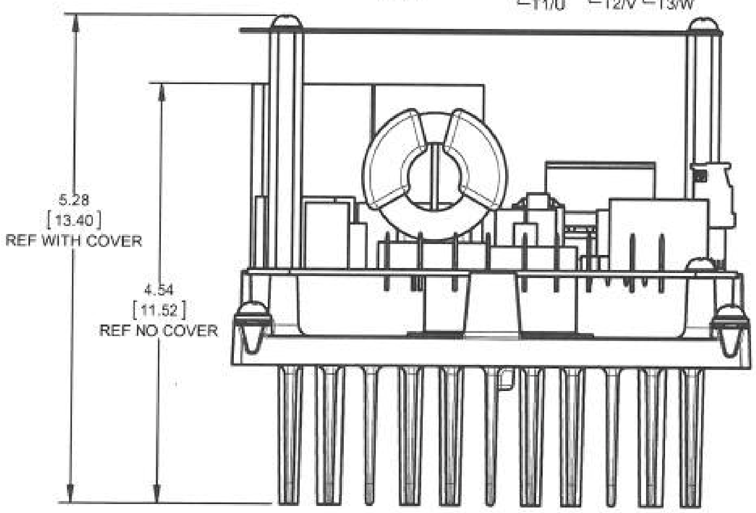



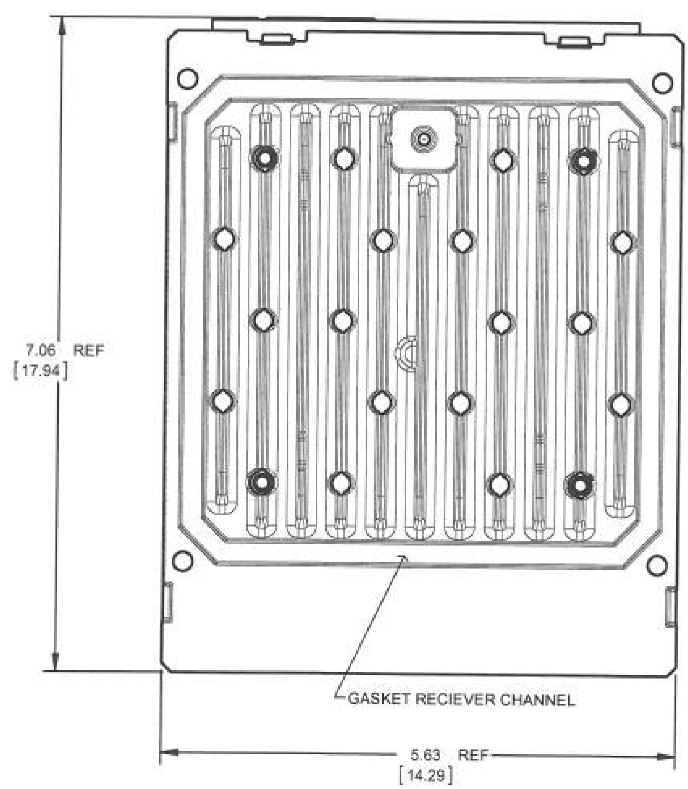

**VIEW WITH COVER INSTALLED**

| |
|---|
| **V0 VERSION**<br>**4 AND 5 TON SINGLE PHASE**<br>**AND ALL THREE PHASE**<br>**VARIABLE SPEED DRIVE** |

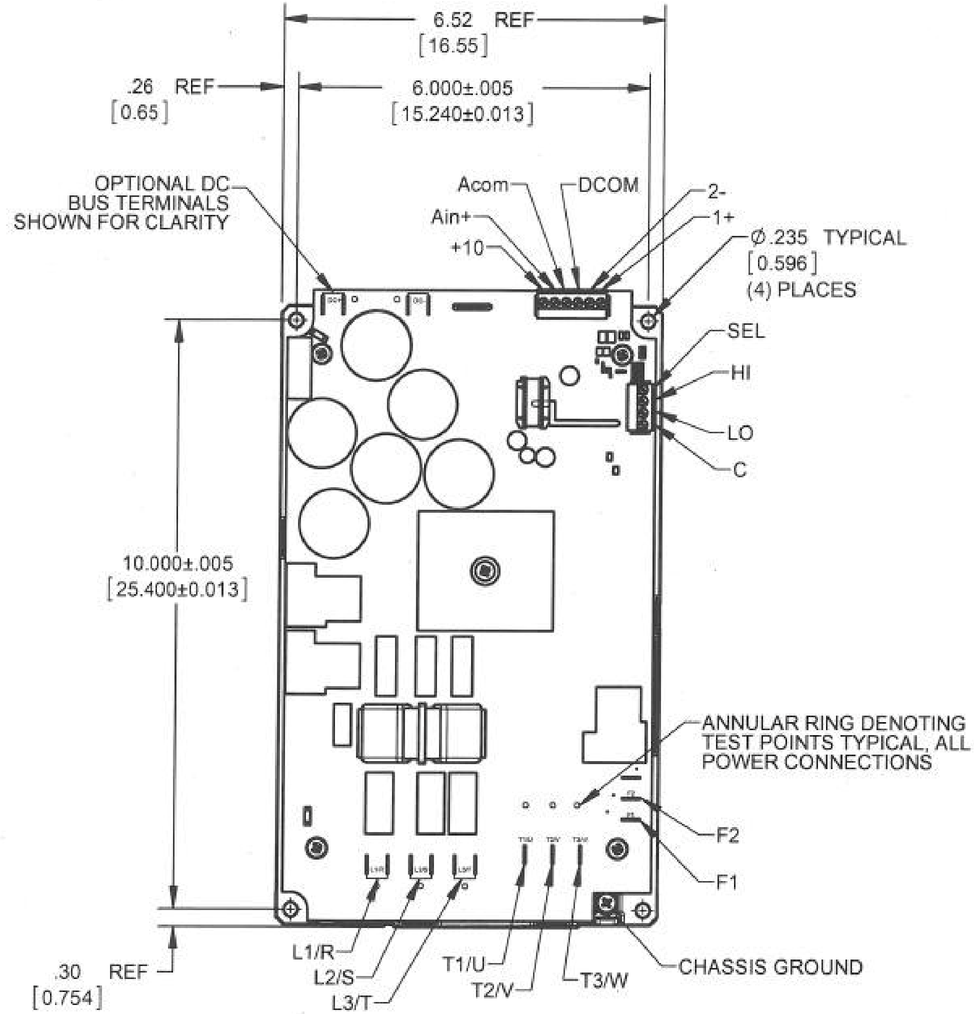


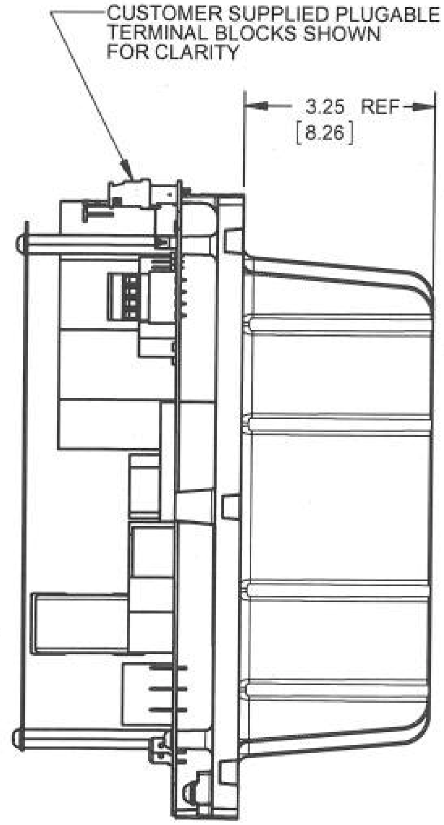



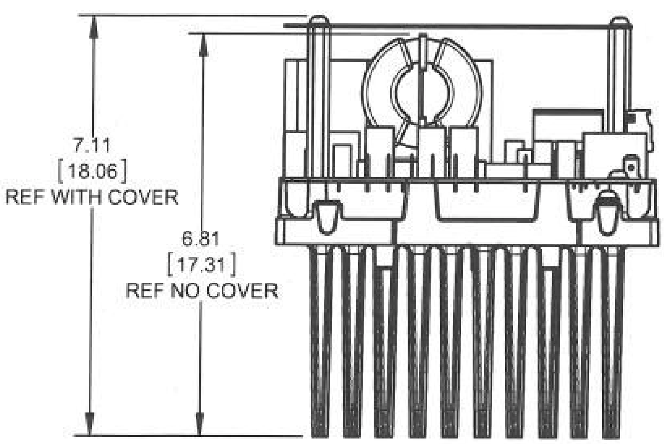



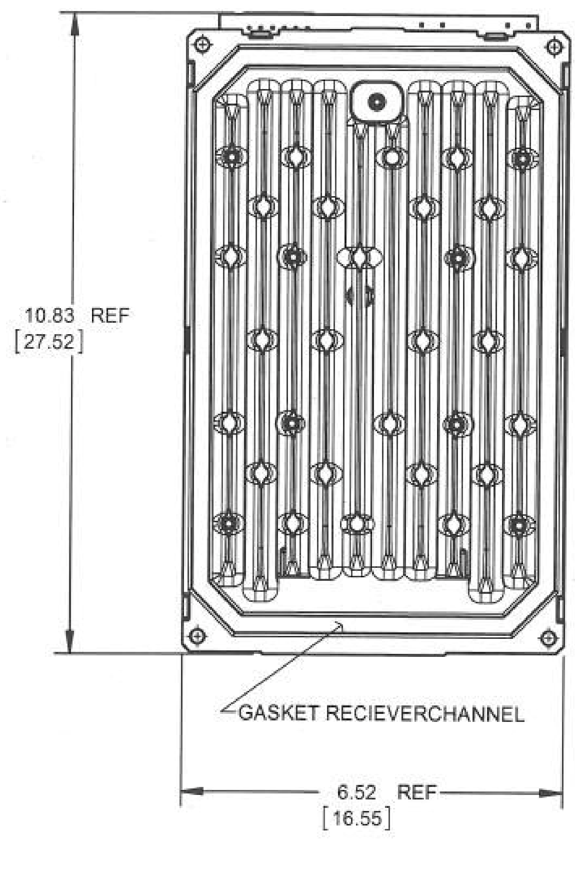




**V1 VERSION**
**2 AND 3 TON SINGLE PHASE**
**VARIABLE SPEED DRIVE**
**DIMENSIONS IN INCHES AND (cm)**

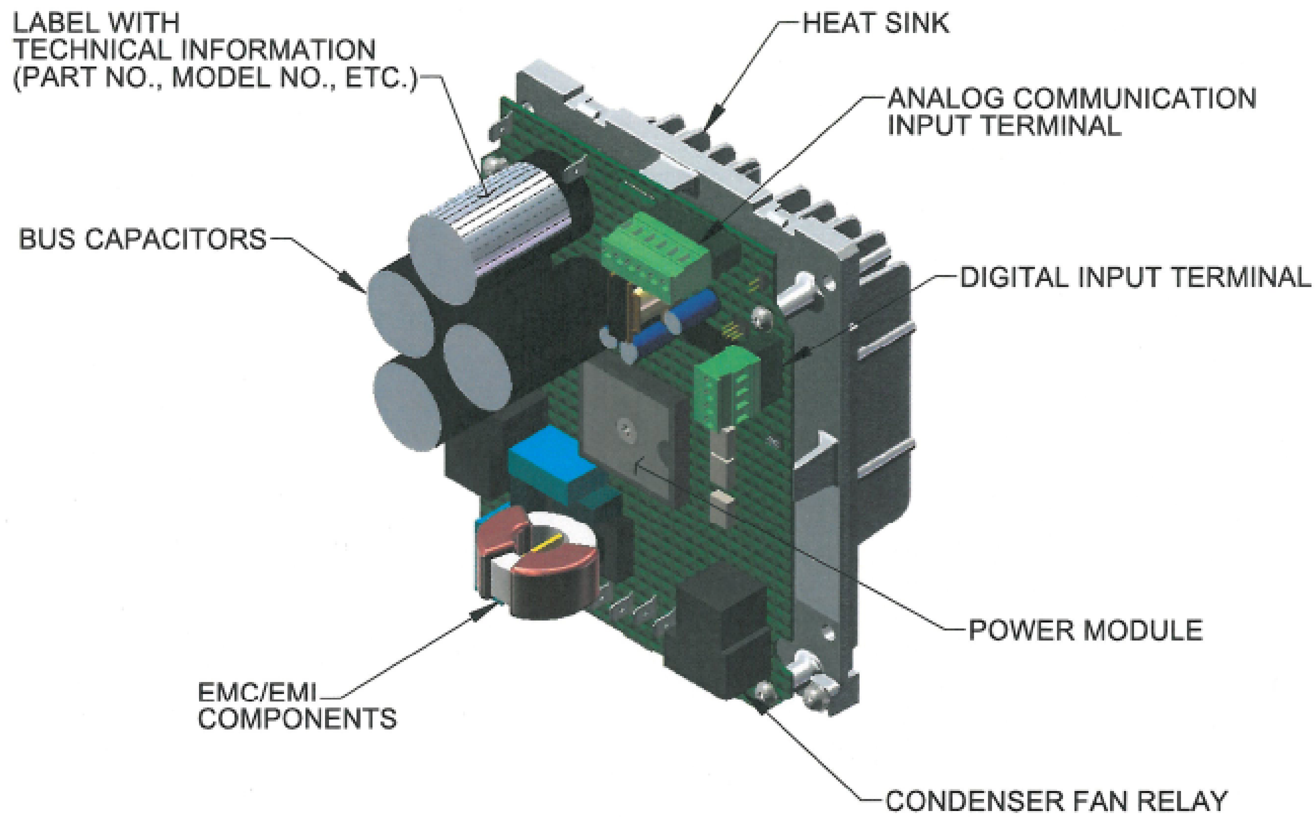


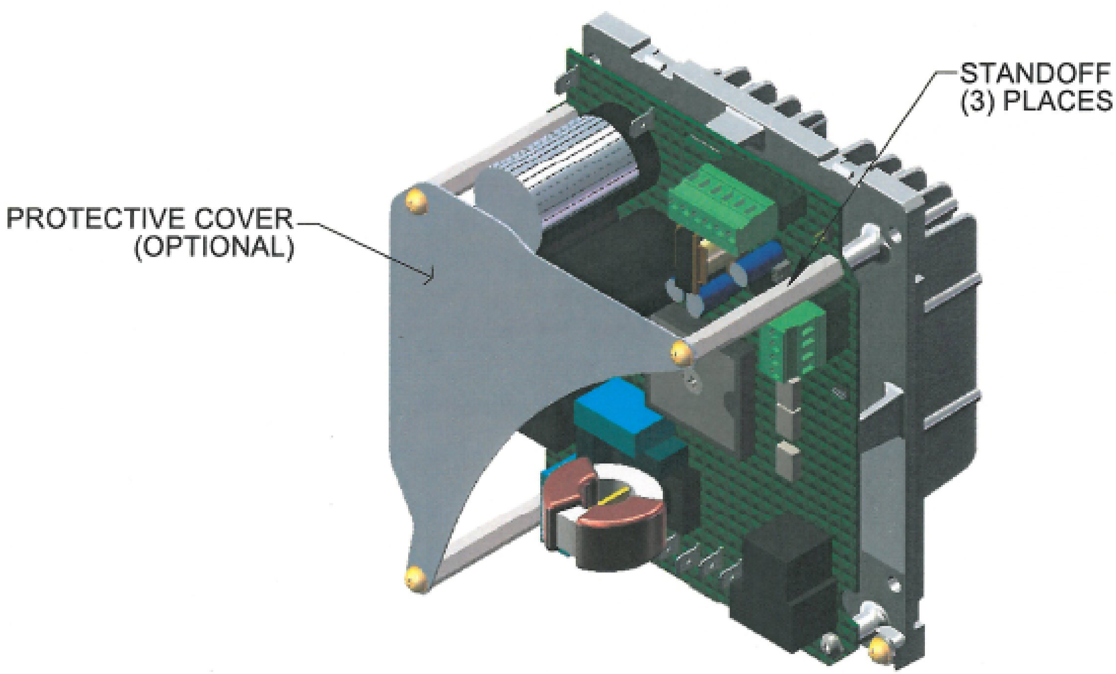



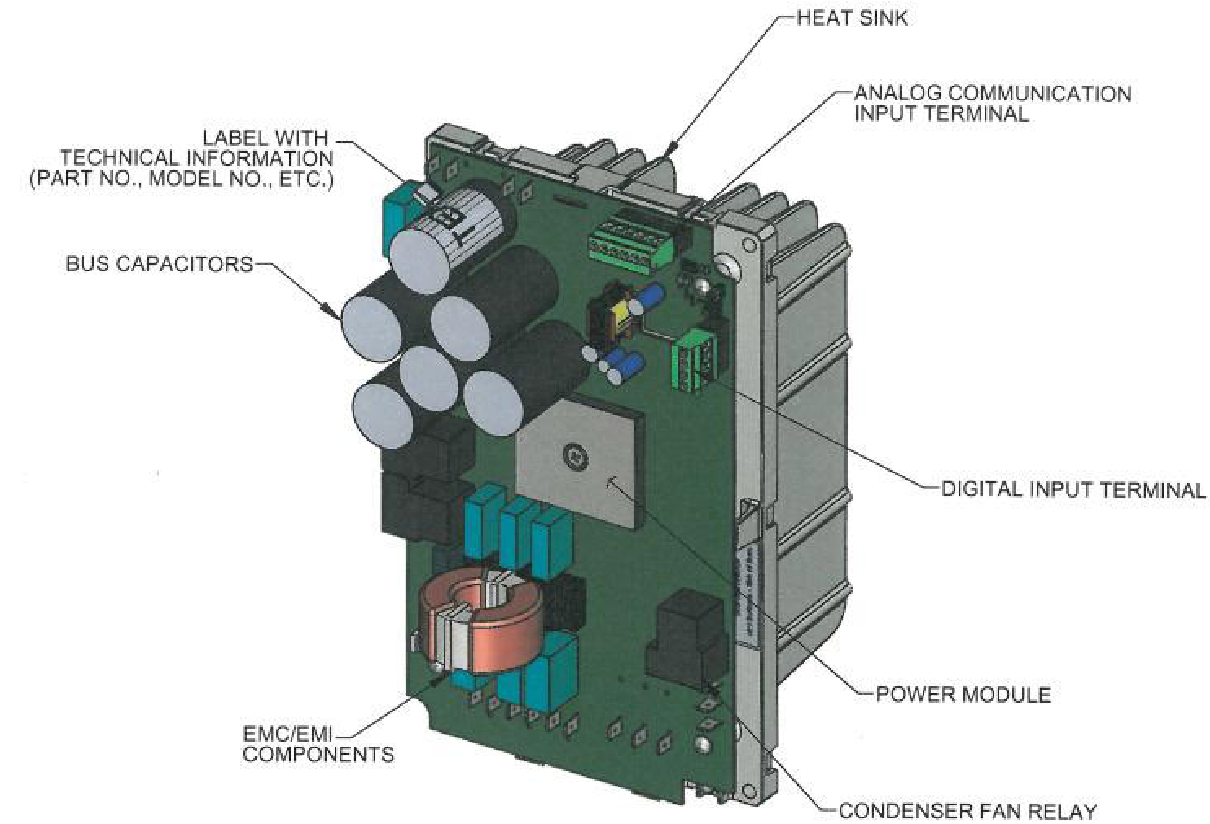

**V1 VERSION**
**4 AND 5 TON SINGLE PHASE**
**AND ALL THREE PHASE**
**VARIABLE SPEED DRIVE**
**(VIEW IS NOT SCALED)**
**DIMENSIONS IN INCHES AND (cm)**

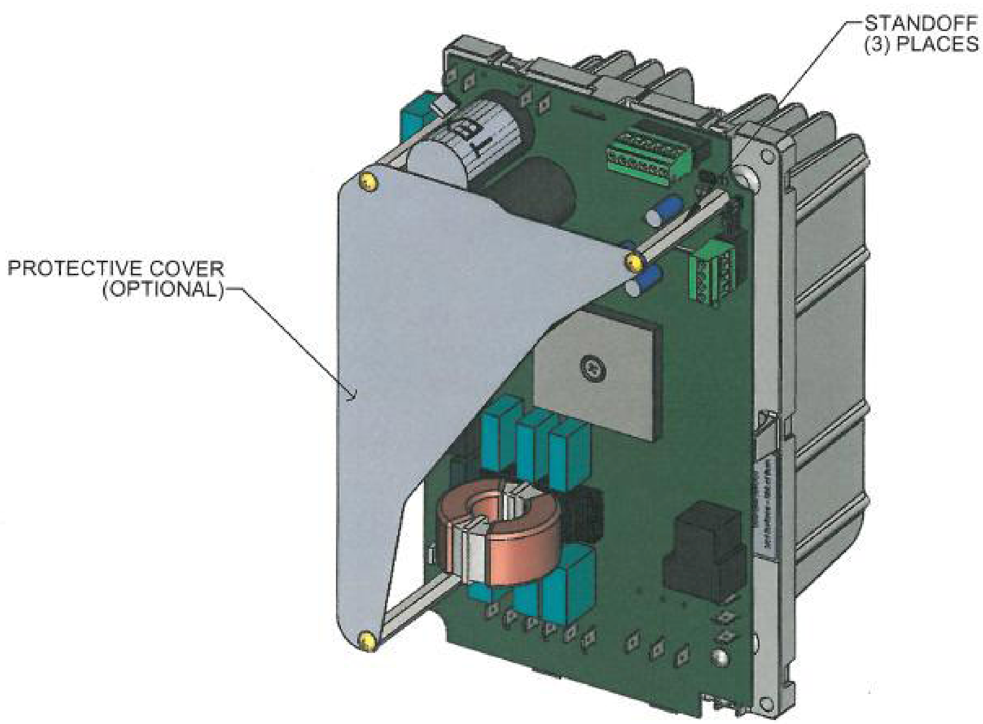



**VIEW WITH COVER INSTALLED**

**V1 VERSION**
**2 AND 3 TON SINGLE PHASE**
**VARIABLE SPEED DRIVE**



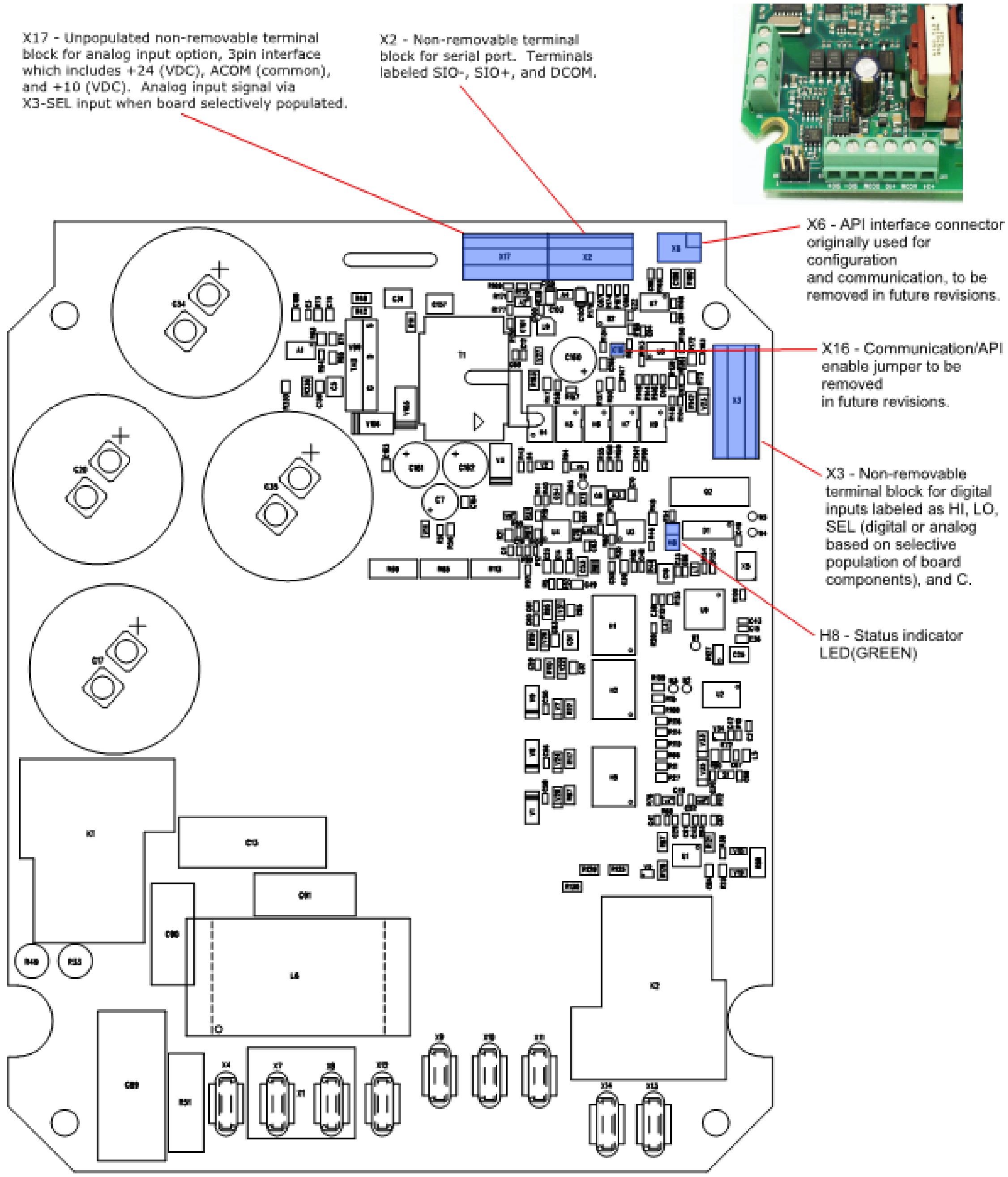




**VIEW WITH COVER INSTALLED**

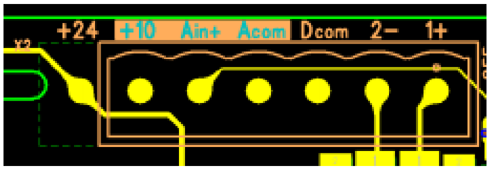
**V1 VERSION**
**4 AND 5 TON SINGLE PHASE**
**AND ALL THREE PHASE**
**VARIABLE SPEED DRIVE**

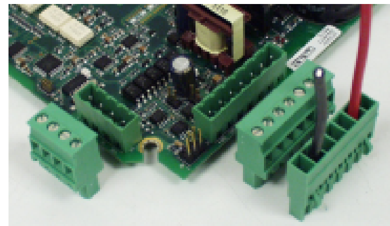
# V0 vs. V1 Differences, Connector Details and Interface

Note: The following pages detail the differences between versions V0 and V1 printed circuit boards.

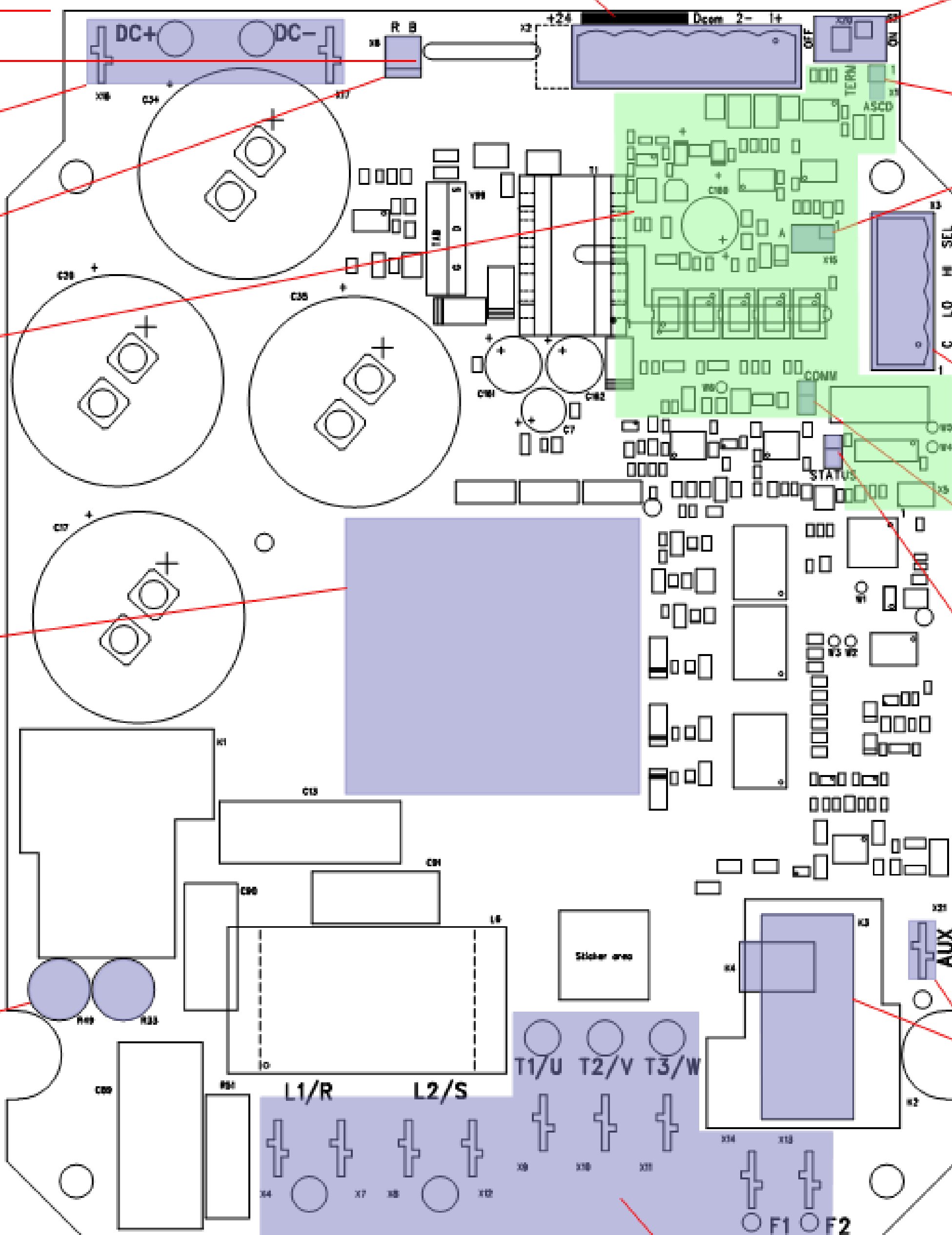



**3 Ton**
**Version - VO**
**(Top Side)**



X2 and X17 combined (X2) and changed to a 6 pin removable connector system. Serial port terminals labeled 1+, 2- and Dcom. Analog input terminals include Acom (common), Ain+ (0-10V analog input) and +10 (+10VDC reference). A seventh pin location not part of the connector for + 24VDC is for Vacon testing purposes. Representation of silkscreen and photo of connector system are shown.




Board length increased 7mm

S2, X20 - Future serial port terminating resistor options (not populated initially)

Added DC+ (X16) and DC- (X17) fastons and testpads to allow for meter access. (Not populated initially)

X1 - Shorting jumper to disable ASCD

X6 -Vacon optional power connections (Not populated initially)

X15 - I/O Select jumper (double pole) reconfigures hardware to allow third input to be either a 0-10VDC analog input (via X2 - Ain+) or a +24VAC digital input (via X3 - SEL).

Movement and addition of circuitry to accommodate changes such as Climatetalk compatible hardware and analog input configurable by hardware rather than circuit population.

X3 - Change to removable terminal block for digital inputs labeled as HI, LO, SEL (digital only), and C.

COMM - Serial Link Transmit (H10) Activity indicator LED (green). Compatibility with ClimateTalk.

Custom power module for increased lifetime

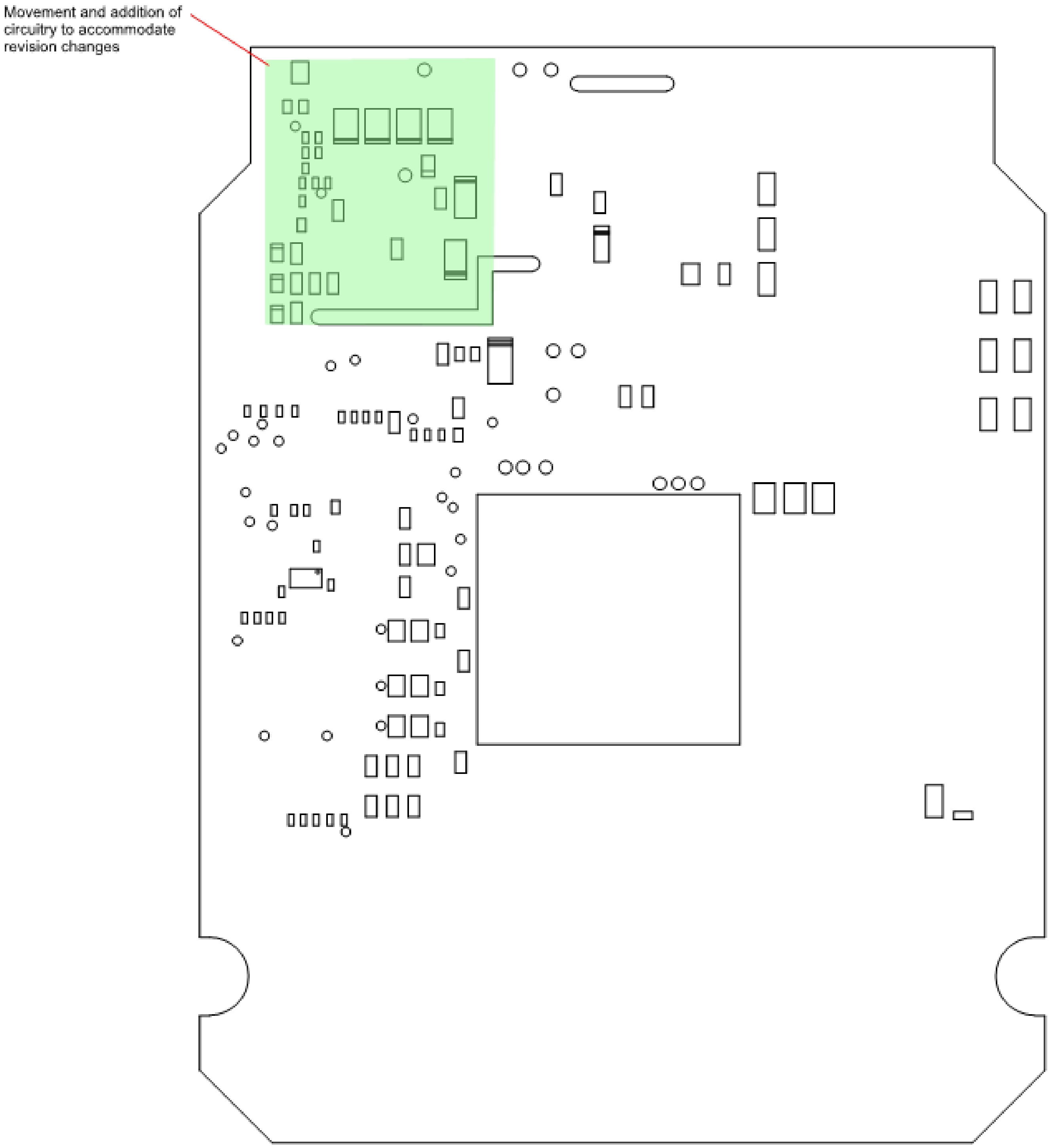
STATUS indicator LED (red). (H8)

Accommodation for larger precharge resistors

K3-4, X21 - Added relays and faston for future alternative relay options (Not populated initially)

Added testpads to allow meter access to input mains, motor connections, and aux fan relay outputs. Change to accommodate additional faston terminal type to provide better rigidity.

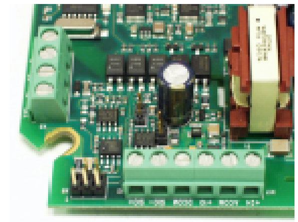
**3 Ton**
**Version - V1**
**(Top Side)**

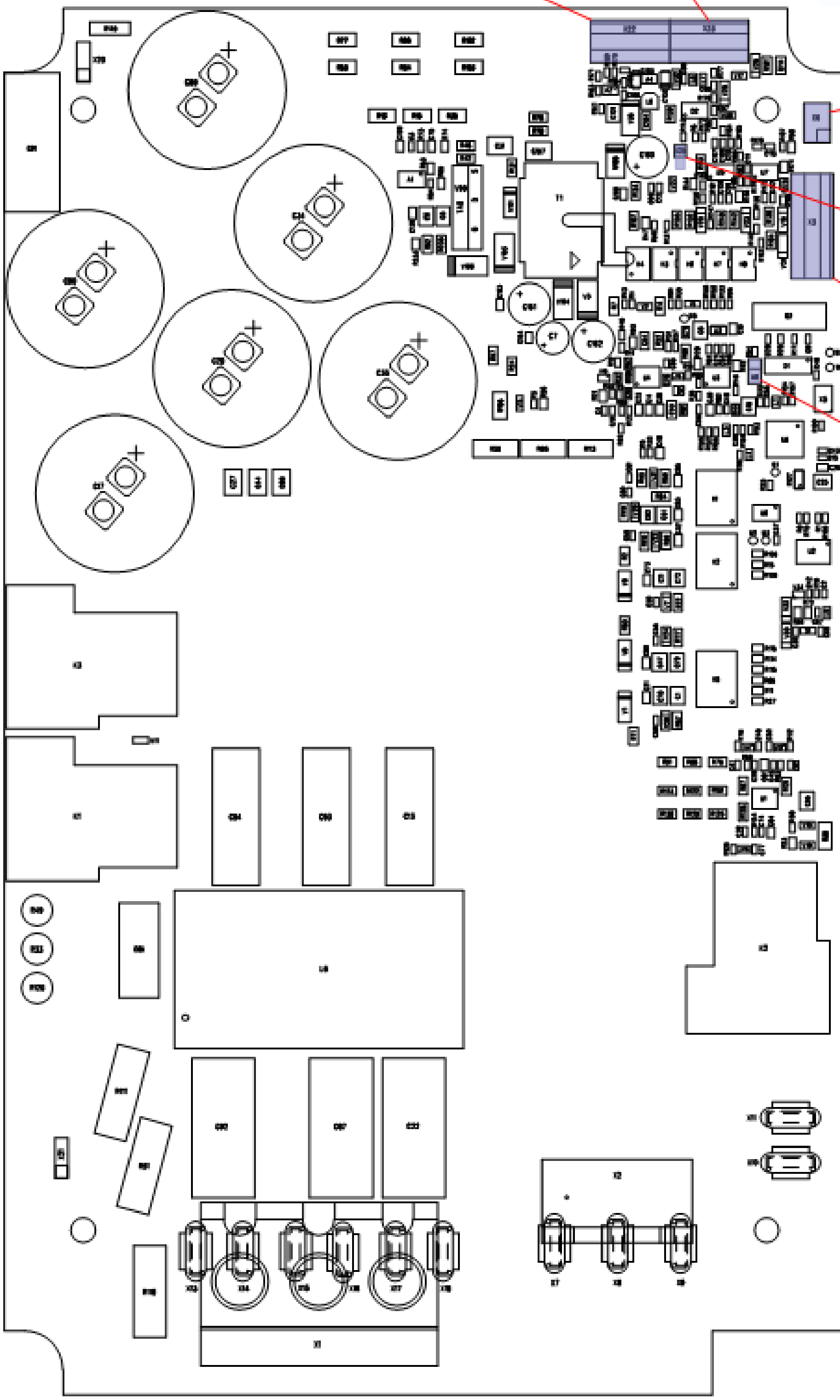



**3 Ton**
**Version - V1**
**(Bottom Side)**

X22 - Unpopulated non-removable terminal block for analog input option, 3 pin interface which includes +24 (VDC), ACOM (common) and +10 (VDC). Analog input signal via X3-SEL input when board selectively populated.

X23 - Non-removable terminal block for serial port. Terminals labeled SIO-, SIO+ and DCOM.





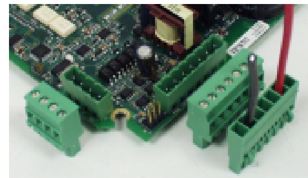
X6 - API interface connector originally used for configuration and communication, to be removed in future revisions.

X25 - Communication/API enable jumper, to be removed in future revisions.

X3 - Non-removable terminal block for digital inputs labeled as HI, LO, SEL (digital or analog based on selective population of board components) and C.

H8 - Status indicator LED (GREEN)

**5 Ton**
**Version - VO**
**(Top Side)**

X22 and X23 combined, renamed to X2 and changed to a 6 pin removable connector system. Serial port terminals are labeled 1+, 2- and Dcom. Analog input terminals include Acom (common), Ain+ (0-10V analog input) and +10 (+10VDC reference). A seventh pin location not part of the connector for +24VDC is for Vacon testing purposes. Representation of silkscreen and photo of connector system are shown.

S2,X27 - Future serial port terminating resistor option (Not populated initially)

Board length increased 8.4mm

X6 - Vacon optional power connections (Not populated initially)

Added DC+ (X22, X23) and DC- (X25, X26) fastons and testpads to allow for meter access. (Not populated initially)

X1 - Shorting jumper to disable ASCD

X20 - Hi-pot jumper and resistor moved to accommodate addition of DC+ and DC- fastons.

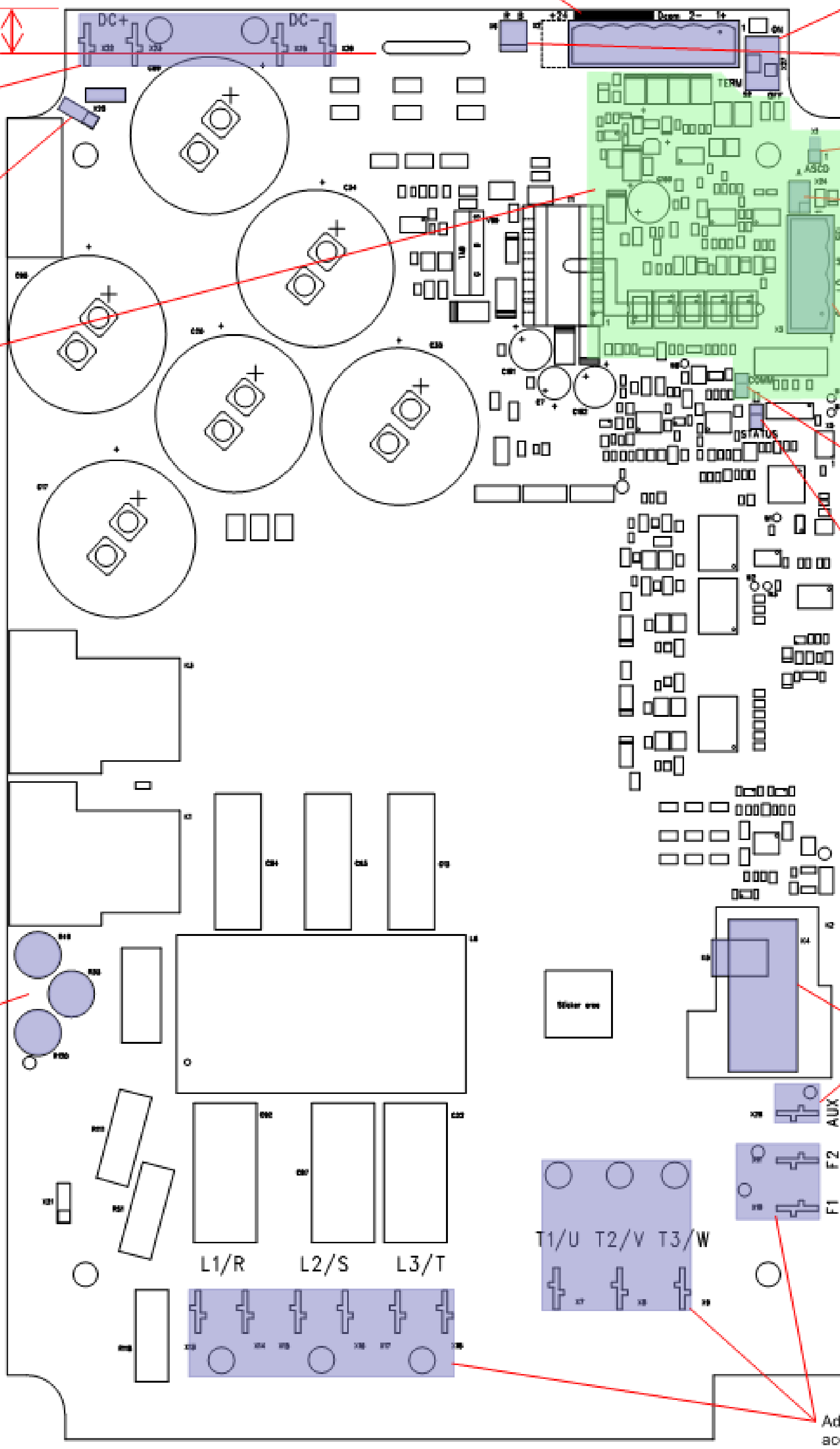
X24 - I/O Select jumper (double pole) reconfigures hardware to allow third input to be either a 0-10VDC analog input (via X2 - Ain+) or a +24VAC digital input (via X3 - SEL).

Movement and addition of circuitry to accommodate changes such as Climatetalk compatible hardware and analog input configurable by hardware rather than circuit population.

X3 - Change to removable terminal block for digital inputs labeled as HI, LO, SEL (digital only), and C.

COMM - Serial Link Transmit (H10) Activity indicator LED (green). Compatibilitiy with ClimateTalk.

STATUS indicator LED (red). (H8)




Accommodation for larger precharge resistors

K4-5, X28 - Added relays and faston for alternative options. (Not populated initially)

Added testpads to allow meter access to input mains, motor connections, and aux fan relay outputs. Change to accommodate additional faston terminal type to provide better rigidity.

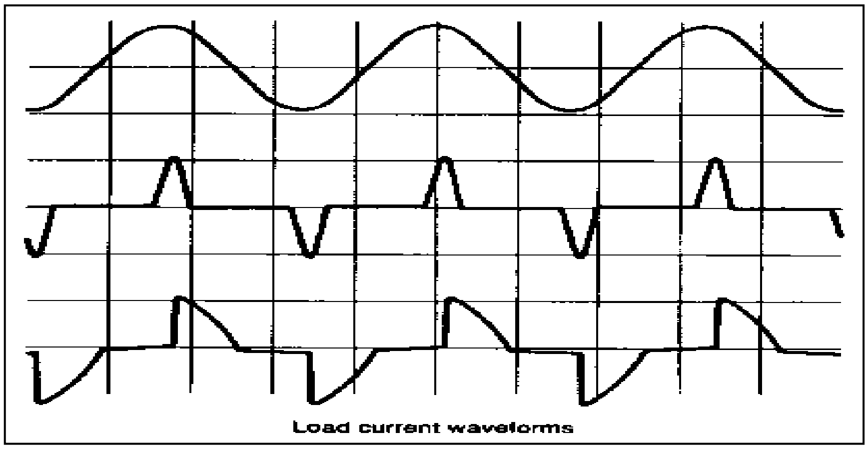
**5 Ton**
**Version - V1**
**(Top Side)**

# Inductor Operation—Application Guideline

# Supplement E
# Inductor Operation and Application Guide

## Linear and Non-linear Loads

Traditional electromagnetic devices such as induction motors provide a load that will draw both a sinusoidal current and voltage in a “linear” fashion. Electronic equipment which converts AC power to DC power does not draw current for the entire voltage waveform period resulting in a “non-linear” load. Examples of non-linear loads typically employ a form of rectification (such as used in a power supply), or some kind of arc discharge device such as a fluorescent lamp or electric welding machine.




(Top) **Motors and incandescent lights: Linear Load**
(Middle) **Computers electronic equipment and variable-speed drives: Non-linear Load**
(Bottom) **Dimmers and phase control devices: Non-linear Load**
**Figure 1**

Figure 2 shows the voltage (U1) and current (I1) waveforms from a single-phase variable speed drive powering a three-phase motor. As can be seen, the current waveform of the non-linear load is markedly different than the sinusoidal shape of the voltage waveform. The power source is sufficiently stiff so there is no distortion in the voltage waveform. If the load was a larger percentage of the power capability of the power supply, the distortion would be much greater.

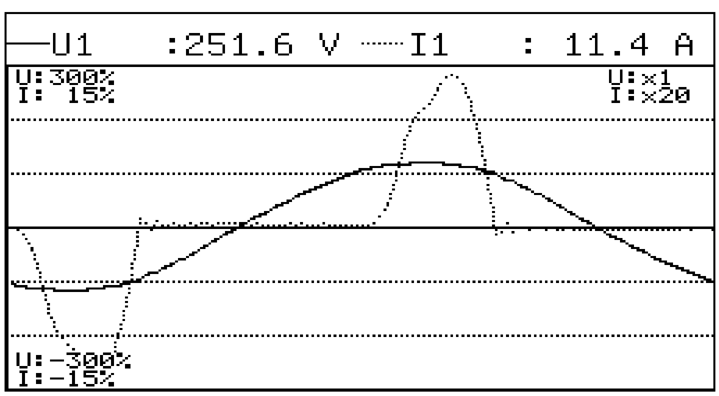



**Figure 2**

## Harmonics

Because the current waveform in these systems is interrupted by the switching action of the variable speed drive, the current contains frequency components that are multiples of the power system frequency or harmonics. Harmonics are the sinusoidal component of a periodic wave having a frequency that is an integer multiple of the fundamental frequency. For a 60Hz base supply, harmonics would integer frequencies above 60Hz such as 120Hz, 180Hz, and so on. Depending upon the magnitude of these harmonics, their presence can lead to a distortion of the voltage waveform yielding noise, heating, and other unwanted effects. Distortion power factor is used to describe how the harmonic distortion of a load current decreases the average power transferred to the load.

## Power Factor

The power factor (PF) of an AC electric power system is defined as the ratio of the real power flowing to the load to the apparent power. Real power (W) is the capacity of the circuit for performing work in a particular time. Apparent power (VA) is the product of the current and voltage of the circuit during this same time. The significance of power factor lies in the fact that utility companies supply customers with volt-amperes, but bill them for watts. Power factors below 1.0 require a utility to generate more than the minimum volt-amperes necessary to supply the real power.

The system's reactive power (VAR) is the portion of power which is momentarily stored in the system's inductive and capacitive elements in the form of magnetic fields. When this stored energy is returned to the source, or due to a non-linear load that distorts the waveform of the source, the apparent power can be greater than the real power. While there is no transfer of reactive power to the actual load, it requires consideration when sizing of conductors to carry the additional current, dissipation of heat, or audible noise.

Figure 3 illustrates the improvements to power factor and reduction in reactive power on the same load with and without the incorporation of a line inductor in the system:

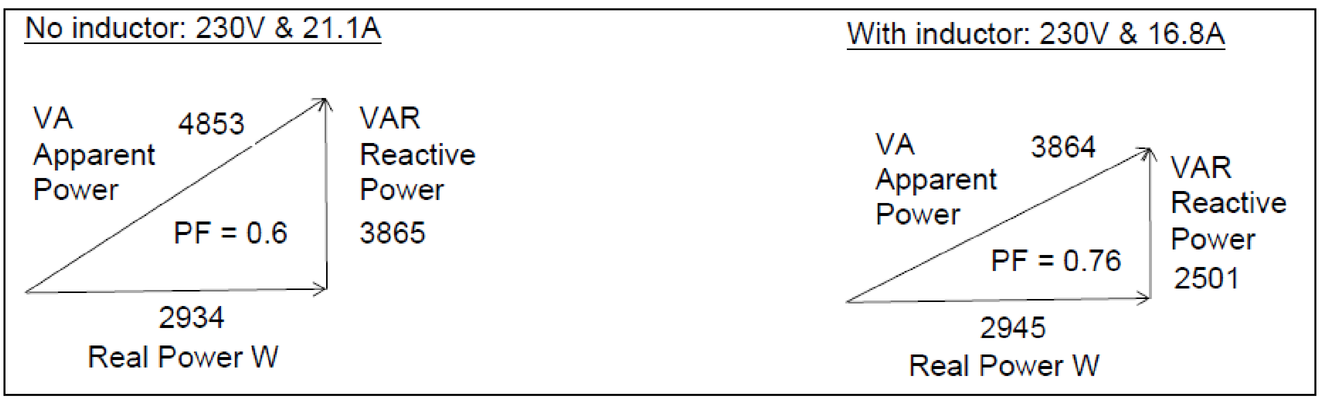



**Figure 3**

## Linear Components

The addition of linear components such as an inductor can reduce the system's harmonic content and improve the overall system's power factor. Current passing through the wire of the inductor creates a magnetic flux proportional to the current itself (Faraday's Law). The inductor reacts against fluctuations in current by dropping voltage in the polarity necessary to oppose the change (Lenz's Law). Figure 4 illustrates the impact to a non-linear system's input waveform with, and without the addition of a line inductor in series with the line supply:

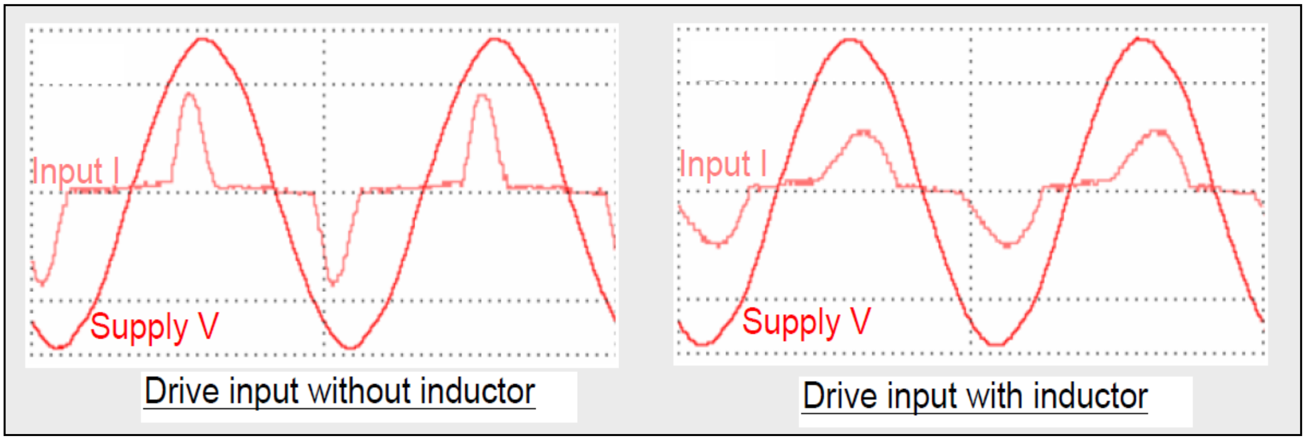
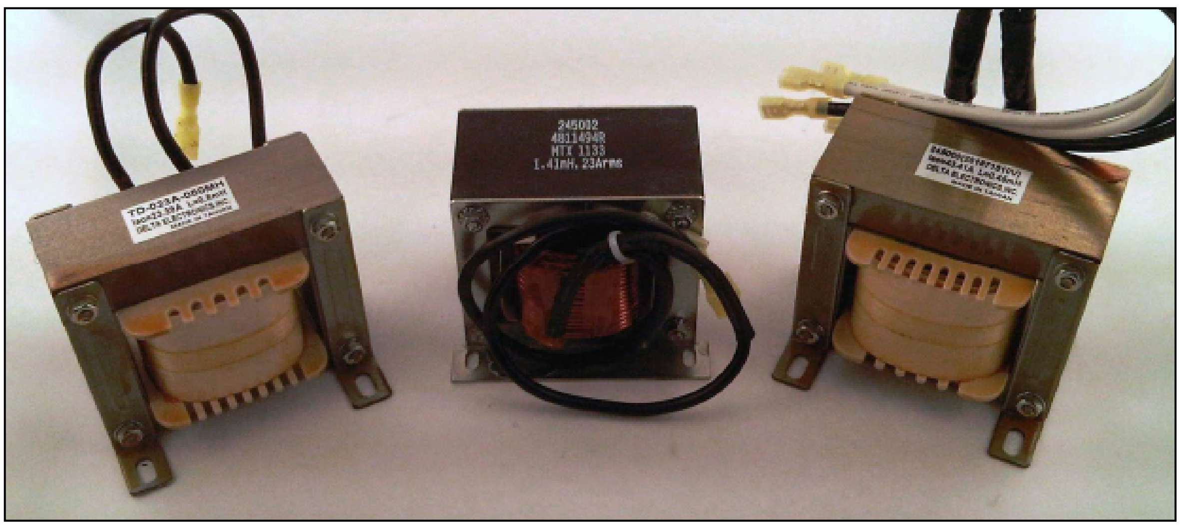



**Figure 4**

For these reasons, Bristol recommends that all VS drive applications use a line inductor to reduce the peak line current, provide protection from voltage surges, help mitigate harmonics, and improve the overall system power factor.




**Important**: The 5-ton inductor (far right) has two (2) conductors each for Line In and Line Out. Both conductors must be used due to the current limitations of the .250 inch (.6cm) quick connect terminals (i.e., maximum 25A per terminal).

- **Sample Inductors For Development Evaluation:**
  Inductor samples with thermocouples will be provided by Bristol for running thermal and agency tests upon request. The inductors are rated Class F with a max coil temperature rating of 311°F (155°C). The lead wire and connections are rated with a maximum temperature rating of 221°F (105°C). Care should be taken to monitor and observe these temperature limits during worst case testing scenarios.  If there is a need for customers to install thermocouple inductors, please contact Bristol for instructions.

- **Inductor Mounting Requirements:**
  The inductor is to be mounted on a metal surface within the outdoor cabinet of the air conditioner or heat pump. The selected mounting location should allow for adequate airflow to cool the inductor while preventing direct contact with water or condensing moisture.  Sufficient airflow must be available to keep the inductor within the temperature limits and to meet agency requirements for approval.  The mounting location and method of securement are critical elements in assuring the inductor does not vibrate or create noise. There is concentrated magnetic energy around the entire inductor; especially at the air gap. Metal enclosures very near the air gap should be avoided as the magnetic energy produced could cause vibration or audible noise if not properly mounted. The inductor should not be mounted near microcomputer controls, or where it could or induce magnetic energy into signal circuits.

- **Inductor specifications:**
  Insulation Class F 311°F (155°C), meets UL508
  Operating temperature range:  -22°F—158°F (-30°C—+70°C)
  Storage temperature range:  -40°F—212°F (-40°C—+100°C)
  Operating humidity range:  0—99% Rh non-condensing
  Storage humidity range (no corrosion):  0—99% Rh non-condensing
  Hi-Pot Test:  3KVAC, 10mA, 1 Sec
  Maximum System Voltage:  600VAC
  Fundamental Frequency:  50/60 Hz

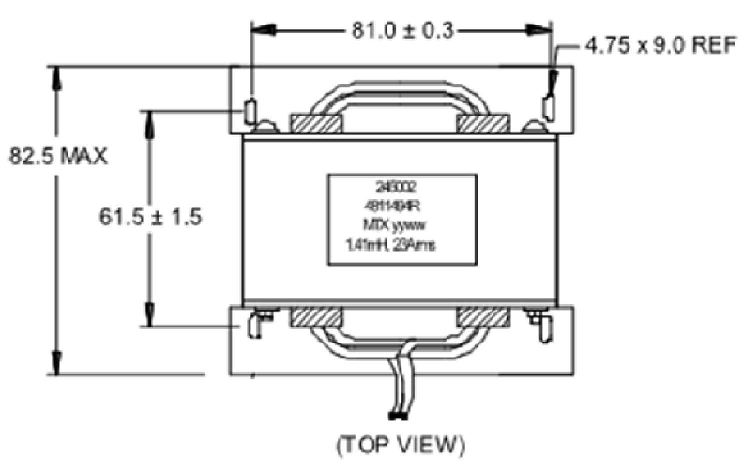
## Inductor Selection Chart

| Compressor | Variable Speed Drive (VSD) | Inductor |
|---|---|---|
| **Model<br>Size** | **Size<br>Voltage/Phase/Freq** | **Part Number<br>Mfg / mH** |
| V80J183MB2A<br>2 Ton | 2 or 3 Ton<br>208-230/1/60 | 245002<br>MTX / 1.4 |
| V80J183MB2A / V80J303MB2A | 3 or 5 Ton<br>208-230/3/60 | 245003<br>MTX / 0.5 (1.0 ph-ph) |
| V80J303MB2A<br>3 Ton | 3 or 5 Ton<br>460/3/60 | 245004<br>MTX / 1.0 (2.0 ph-ph) |
| V80J403MB2A<br>4 Ton | 4 or 5 Ton<br>208-230/1/60 | 245005<br>MTX / 0.45 |
| V80J403MB2A / V80J503MB2A | 5 Ton<br>208-230/3/60 | 245003<br>MTX / 0.5 (1.0 ph-ph) |
| V80J503MB2A<br>5 Ton | 5 Ton<br>460/3/60 | 245004<br>MTX / 1.0 (2.0 ph-ph) |

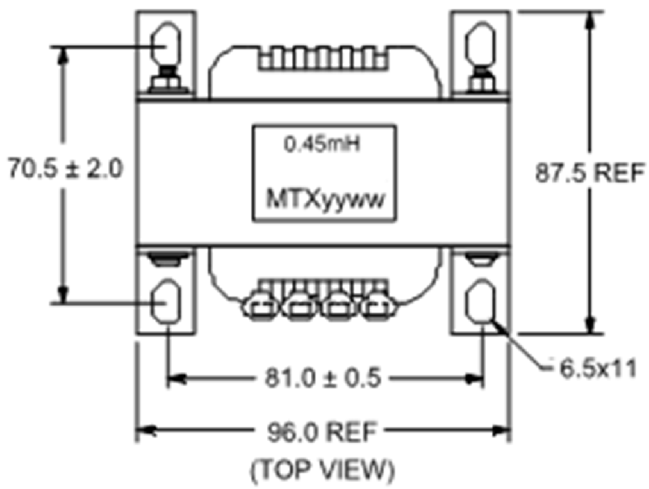
## Inductor Pictorial vs. Part Number

(Please consult Bristol Compressors as values or part numbers may change without notice)

- Bristol part number 245002 1.4mH 1Ø, 23Arms, Max DC resistance 0.05Ω

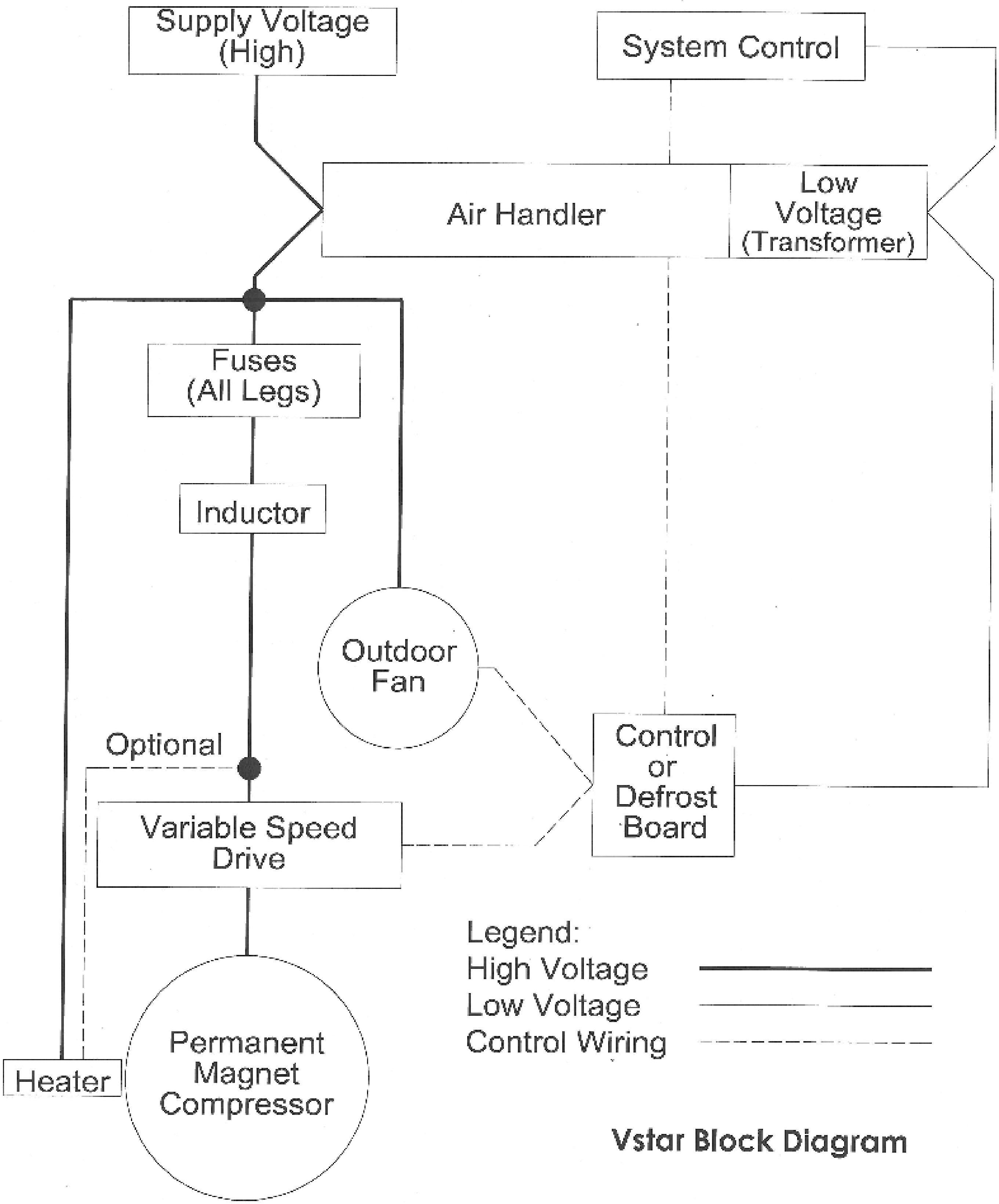


- Bristol part number 245003 TBD, 3Ø
- Bristol part number 245004 TBD, 3Ø
- Bristol part number 245005 0.45mH, 1Ø, 43Arms, Max DC resistance 0.04Ω



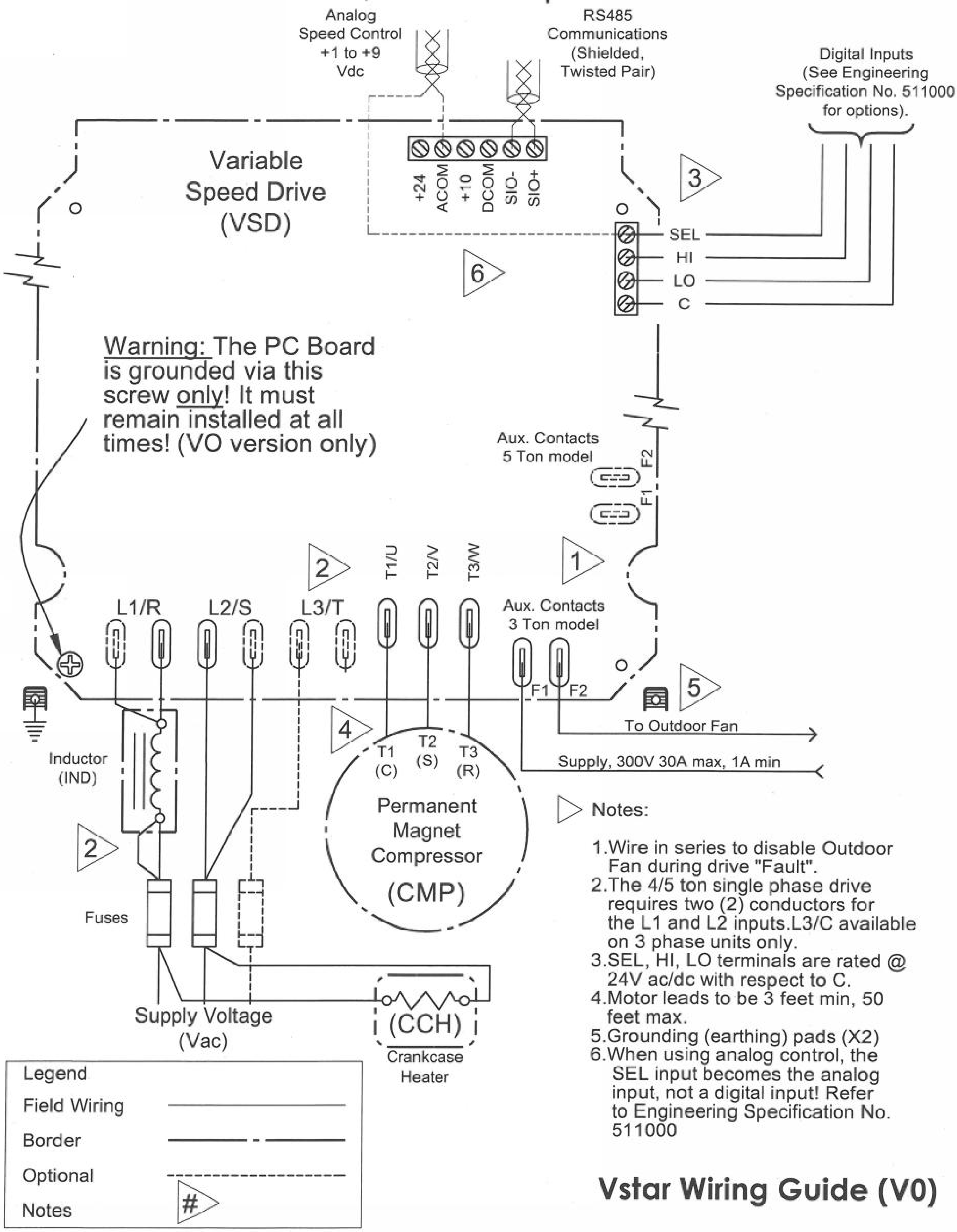
# Block Diagrams, Schematics, Wiring

Bristol Compressors
VStar, System Block Diagram




**Vstar Block Diagram**

# Bristol Compressors
# VStar, Variable Speed Drive

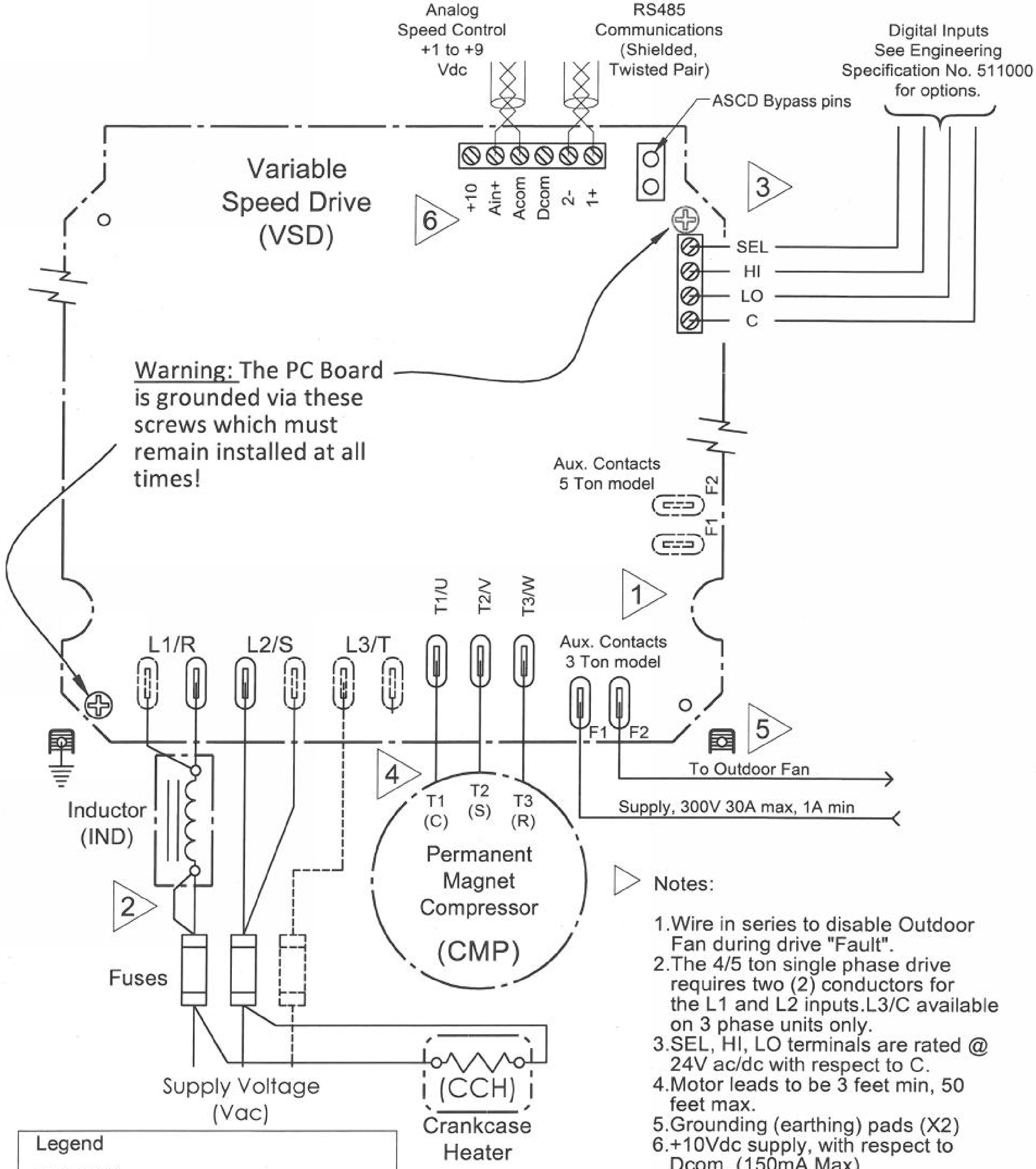



Notes:

1. Wire in series to disable Outdoor Fan during drive "Fault".
2. The 4/5 ton single phase drive requires two (2) conductors for the L1 and L2 inputs.L3/C available on 3 phase units only.
3. SEL, HI, LO terminals are rated @ 24V ac/dc with respect to C.
4. Motor leads to be 3 feet min, 50 feet max.
5. Grounding (earthing) pads (X2)
6. When using analog control, the SEL input becomes the analog input, not a digital input! Refer to Engineering Specification No. 511000

## Vstar Wiring Guide (V0)

# Bristol Compressors
# VStar, Variable Speed Drive




Notes:

1. Wire in series to disable Outdoor Fan during drive "Fault".
2. The 4/5 ton single phase drive requires two (2) conductors for the L1 and L2 inputs.L3/C available on 3 phase units only.
3. SEL, HI, LO terminals are rated @ 24V ac/dc with respect to C.
4. Motor leads to be 3 feet min, 50 feet max.
5. Grounding (earthing) pads (X2)
6. +10Vdc supply, with respect to Dcom. (150mA Max)

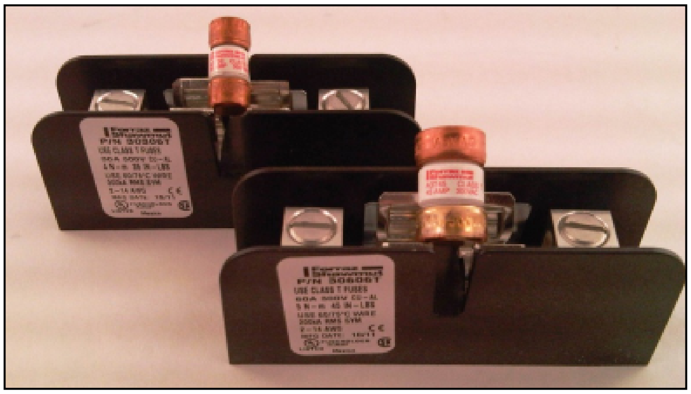
| | |
|---|---|
| Legend | |
| Field Wiring | ———————— |
| Border | ———— - ———— |
| Optional | ------------------------ |
| Notes | # |

## Vstar Wiring Guide (V1)

# System Line Fuse Requirements/Info

# Supplement G
# Fuse and Fuse Holder

The VStar Variable Speed Drives have been UL 508C recognized providing integral solid state motor protection. Branch circuit protection must be provided in accordance with the National Electric Code and any additional local codes.



- **Sample Fuses and Holders For Development Evaluation:**
  Fuse and fuse holders will be provided by Bristol Compressors upon request for development testing. The fuses are rated Class T providing a high degree of current limitation in a very small profile. A fuse and holder will be required for each leg of power to the drive.

- **Fuse and Holder Mounting Requirements:**
  The fuse and holder are to be properly mounted within the outdoor cabinet of the air conditioner or heat pump.  The selected mounting location should prevent direct contact with water or condensing moisture.  The mounting location and method of securement are critical elements in assuring the fuse and holder do not vibrate or create noise.

## Fuse and Fuse Holder Selection

**Alternate suppliers and configurations of fuses and holders are available for use by the end customer. The information provided is solely for reference.**

VStar 2-3T 208-230/1/60 Hz:

- Ferraz Shamut Fuse Part Number: A3T30 Class T, Fast Acting Fuse, Rated 300V, 30A
- Ferraz Shamut Fuse Holder Part Number: 30306T 1Pole, 30307T Dual Pole

VStar 4-5T 208-230V/1/60 Hz:

- Ferraz Shamut Fuse Part Number: A3T45 Class T, Fast Acting Fuse Rated 300V, 45A
- Ferraz Shamut Fuse Holder Part Number: 30606T 1Pole, 30607T Dual Pole

VStar 2-5T 208-230V/3/60Hz: TBD

VStar 2-5T 460V/3/60Hz: TBD

# VS Compressor Model Nomenclature

| Example: | V | 8 | 0 | J | 303 | M | B | 2 | A |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |

(1) Temperature/Application

V = Variable Speed (High Temp)

(2) Type of Refrigerant

8 = Refrigerant (R410A)

(3) Mechanical Variation

0 = First Generation – Basic Standard Model

(4) Family Series

J = Benchmark

(5) Nominal Compressor Output in BTU/Hr @ 120 Hz (3600 RPM)

303 = 30 by $10^3$ = 30,000 BTU/Hr
503 = 50 by $10^3$ = 50,000 BTU/Hr

(6) The eighth character designates the Motor Type

M = 3 Phase ALS Variable Speed Permanent Magnet Motor

(7) Internal Thermal Protection

B = Internal line break

(8) May be followed by one suffix number indicating nominal compressor motor input from the variable speed drive. This value does not designate the input power supply to the Variable speed drive.

2 = 180V - 3 - 120Hz (3600 RPM)

(9) Mounting Foot Configuration (various)

# DRIVE MODEL NUMBER NOMENCLATURE

**A A X 2 0 1 3 0 N P M V**

| | |
|---|---|
| **A** | Heat Sink Cut Out |
| **A** | Heat Sink Application |
| **X** | Drive Cover configuration |
| **2** | Drive Electrical Input Supply |
| **0 0** | Drive Hardware Id (2 characters) |
| **3 0** | Capacity (X.X) Tons |
| **N** | Drive Fan relay type |
| **P** | Drive Power Factor Correction |
| **M** | Compressor Motor type |
| **V** | Drive Mfg |

| | |
|---|---|
| **Drive Manufacturer** | **V = Vacon** |
| **Motor Type** | **N = Induction**<br>**M = Permanent Magnet** |
| **Power Factor Correction** | **A = Active**<br>**P = Passive** |
| **Fan Relay Type** | **N = Induction**<br>**E = ECM** |
| **Capacity (X.X) Tons** | **20 = 2.0 Tons**<br>**30 = 3.0 Tons**<br>**40 = 4.0 Tons**<br>**50 = 5.0 Tons** |
| **Hardware Id** | **00 = Version 0 Drive**<br>**01 = Version 1 Drive** |
| **Electrical Input Supply** | **2 = 208-230V / 1Ø / 50-60Hz (includes 220V / 1Ø / 50Hz)**<br>**4 = 265V / 1Ø / 60Hz & 200-240V / 1Ø / 50Hz**<br>**5 = 208-230V / 3Ø / 50-60Hz (includes 220V / 3Ø / 50Hz)**<br>**7 = 380-460V / 3Ø / 50-60Hz** |
| **Cover Configuration** | **S = Standard**<br>**X = None** |
| **Heat Sink Application** | **A = Air Cooled** **R = Refrigerant cooled**<br>**P = Liquid cooled Plate** |
| **Heat Sink Cut Out** | **A = 4.75" x 4.75" (12cm x 12cm)**<br>**B = 9.25" x 5.50" (23.5cm x 14cm)** |