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**INSTALLATION**

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**RETROFIT CONVERSION  
TO THE  
FRICK<sup>®</sup> QUANTUM<sup>™</sup> HD CONTROL**

**INSTALLATION INSTRUCTIONS**

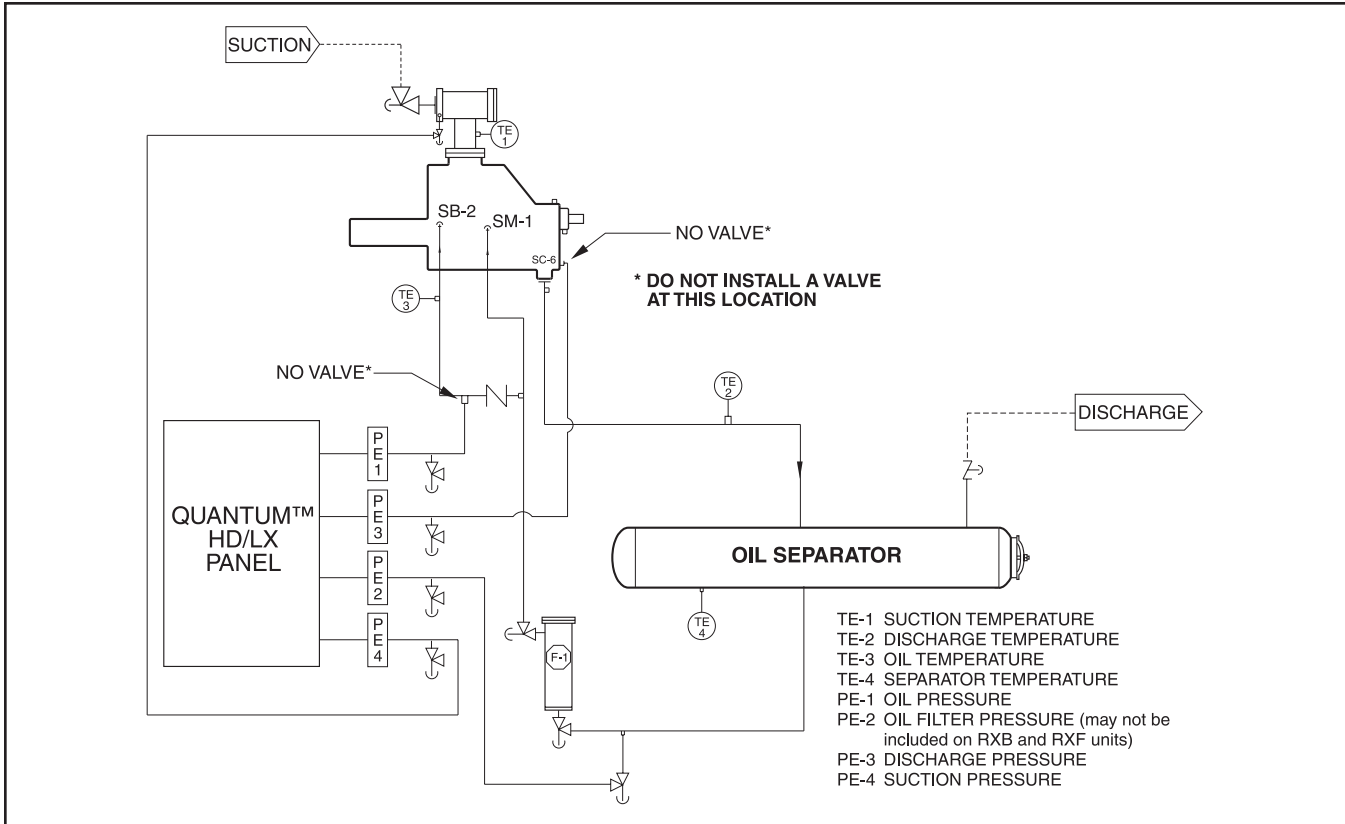


Figure 1 - Transducer Connection Diagram For Converting RWB II, RXB, RXF & RDB To Quantum™HD Control

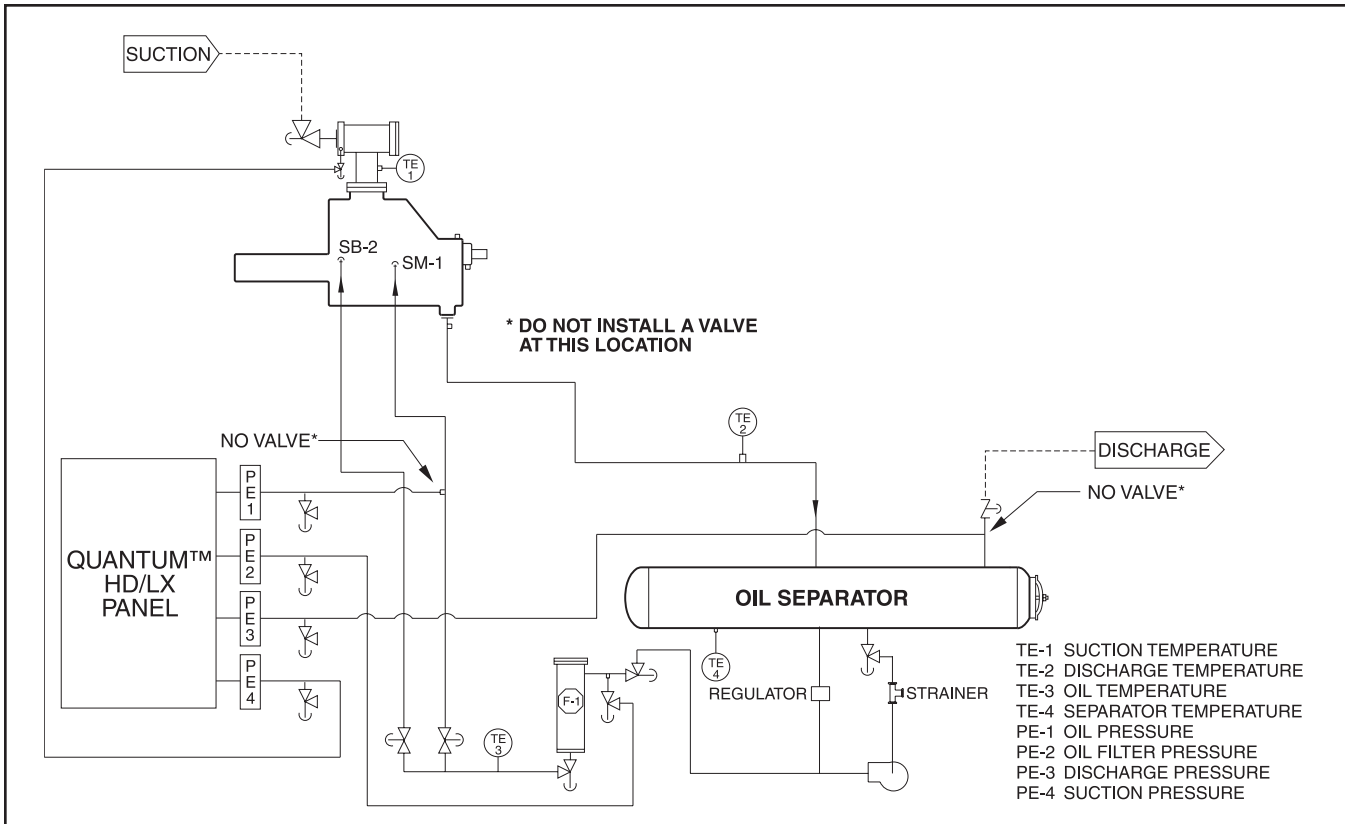


Figure 2 - Transducer Connection Diagram For Converting RWB And Other Manufacturer's Units To Quantum™HD Control

## FRICK® QUANTUM™ HD RETROFIT PANELS

The QUANTUM™HD control panels sold under this program are designed to handle standard screw compressor package piping and instrument design. Compressors are to be electric motor driven only. Other drive lines can be accommodated through Frick® Engineering. Lubrication is accomplished by electric motor or shaft driven oil pumps, or differential pressure lube systems. If the compressor package does not meet these basic requirements, contact Frick® for Engineering assistance. Frick® can make the proper changes for most applications. Additional engineering and drawing charges will be quoted. Examples of standard piping and instrument designs for both Frick and other manufacturer's designs are shown in Figures 1 and 2.

In some cases, even though the screw compressor package meets the basic requirements, package modifications and/or control panel modifications may be required: non-standard sensors, modified piping, additional solenoids and check valves, and additional relays into the control circuits, etc. This is the case with most vertical separators, screw chiller packages, and other specific-duty screw compressor packages. Normally, an experienced installer can handle these items in the field. Contact Frick® Engineering for assistance if a problem is encountered.

The QUANTUM™HD control panel will be offered in a "kit" form which will include the panel, drawings, and the current installation, operation, and maintenance manuals. Standard pressure and temperature sensor kit includes four pressure and four temperature sensors. Pressure sensor connections are 1/4" MPT. Temperature sensors are available in either 3/4" or 1/2" MPT. Additional pressure transducers, temperature probes, and slide valve indicator potentiometers and assemblies are optional items and must be ordered separately, if required. See page 3 of the Order Entry Data Sheet (Publication 090.100A-P) to select these and other options.

### INTRODUCTION

#### CONVERSION OF SCREW COMPRESSOR UNITS TO THE FRICK® QUANTUM™HD CONTROL PANEL.

These instructions are based on the installer having a fundamental knowledge of refrigeration design and installation. Instructions are for conversion to the standard design unit. Special package and/or control modifications furnished on the existing unit will require deviation from these instructions. Contact Frick® if you have any questions, concerns or problems. Frick® does not take responsibility for the suitability of these instructions, for any nonstandard installation or for consequential damages resulting from the conversion.

### SAFETY PRECAUTION DEFINITIONS



Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation or practice which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation or practice which, if not avoided, will result in damage to equipment and/or minor injury.



Indicates an operating procedure, practice, etc., or portion thereof which is essential to highlight.

## NOTICE

**Do not initiate retrofit conversion until you have completely reviewed all instructions and checked material received for suitability and completeness.**

Instructions are provided for retrofit conversion from either RWB Electromechanical or RWB II Microprocessor control to QUANTUM™HD control. Other screw compressors not manufactured by Frick® can also be converted to the QUANTUM™HD control. Frick® screw compressor packages, where the compressor itself was not manufactured by Frick®, are considered to be in this "other manufacturers" category.

Material supplied with this retrofit kit by Frick® are the Frick® Operation, Maintenance, and Retrofit Conversion manuals:

- A. Complete QUANTUM™HD control panel.
- B. Optional pressure transducers with pressure block plus temperature probes with wells:

WHEN CONVERTING FROM:	TO:	OPTION REQUIRED
RWB Electromechanical	QUANTUM HD	YES
Other Manufacturers	QUANTUM HD	YES
RWB II Micro	QUANTUM HD	NO
RXB Plus Micro	QUANTUM HD	NO
RXF Plus Micro	QUANTUM HD	NO
RXF Micro	QUANTUM HD	NO
RDB Plus Micro	QUANTUM HD	NO
RDB Electromechanical	QUANTUM HD	YES

- C. Optional 1000 OHM rotary slide valve indicator potentiometer:

WHEN CONVERTING FROM:	TO:	OPTION REQUIRED
RWB Electromechanical (with Dunham Bush version E and later compressors; For DB models A-D, see Note D)	QUANTUM HD	YES
Other Manufacturers (Without 1000 OHM potentiometer)	QUANTUM HD	YES
RWB II Micro	QUANTUM HD	NO
Other Manufacturers (With 1000 OHM potentiometer)	QUANTUM HD	NO
RXB Plus Micro	QUANTUM HD	NO
RXF Plus Micro	QUANTUM HD	NO
RXF Micro	QUANTUM HD	NO
RDB Plus Micro	QUANTUM HD	NO
RDB Electromechanical	QUANTUM HD	YES

- D. Optional slide valve indicator assembly (chain driven):

WHEN CONVERTING FROM:	TO:	OPTION REQUIRED
RWB Electromechanical (with Dunham Bush models A through D compressors)	QUANTUM HD	YES

E. Optional 2000 OHM linear slide valve indicator potentiometer:

WHEN CONVERTING FROM:	TO:	OPTION REQUIRED
RXB Electromechanical	QUANTUM HD	YES

**MATERIAL TO BE SUPPLIED BY INSTALLER AS REQUIRED**

- Pressure tubing and fittings (1/4 inch stainless steel)
- Pipe, fittings, and adaptors
- Electrical conduit, fittings, and solenoids
- Wire
- Current transformer in the compressor motor starter, control transformer, and any motor starter components or modifications.
- Labor and tools required to complete installation and start-up.

**INSTRUCTIONS**

**NOTICE**

Before proceeding, read the instructions in the "Proper Installation of Electronic Equipment in an Industrial Environment" section at the end of this manual.

1. Push [STOP] key to shut down the compressor package. Open the disconnect (power source) switch for the compressor motor starter and (if applicable) oil pump motor starter. Lock-out and tag-out all sources of power to the compressor package and controller.
2. Close the discharge, and (if applicable) liquid injection feed valve.
- 2a. Identify and close any additional lines or pipes that are feeding the package with refrigerant or oil that will be exposed to atmosphere as a result of retrofitting the controller.
3. If not already open, open the suction check bypass valve to SLOWLY equalize the separator to system suction pressure. Once equalized, close the main suction valve and the suction check bypass valve.
4. Evacuate the remaining refrigerant from the package relative to the refrigerant type and local, state and federal regulations.
5. In many cases the temperature and pressure sensors are changed as part of the retrofit process. To avoid any unexpected refrigerant or oil release, be certain to investigate the source of pressure/temperature of each sensor to be changed, ensuring each sensor is isolated and evacuated prior to removal.
6. If an oil separator temperature probe well is to be installed, drain the oil from the oil separator.

**CAUTION**

To avoid any unexpected refrigerant or oil release, be certain to investigate the source of pressure/temperature of each sensor to be changed, ensuring each sensor is isolated and evacuated prior to removal.

**NOTICE**

Recover or transfer all refrigerant vapor in accordance with local, state and federal ordinances before opening to atmosphere. The package MUST be equalized to atmospheric pressure.

**CAUTION**

Oil-entrained refrigerant may vaporize, causing an increase in separator pressure. Repeat venting or refrigerant recovery/evacuation may be necessary.

7. Take digital photographs of all internal connections of the existing controller to use as a reference when making the connections on the replacement controller. Remove the existing panel from the compressor package. **DO NOT CUT WIRES OR TUBING LINES.** They will be used to connect to the new panel.

8. If converting from an RWB or RWB II to a QUANTUM™HD, remove the front panel assembly. Remove wires on the I/O board which run from the micro enclosure to the junction box. Remove the analog wires from the FRK-1 board. Remove ground, +5 VDC, ±12 VDC and +24 VDC from the FRK-1, SBC and I/O boards. Be sure all of the above wires are labeled because all except ±12 VDC and +24 VDC will be connected to the QUANTUM™HD.

9. Remove existing thermometers, temperature switches and pressure switches (if applicable) from the compressor package.

10. Mount the QUANTUM™HD panel on the compressor package by bolting the panel to the existing panel mounting structure. It may be necessary to weld new panel mounting brackets to the screw compressor package to accommodate the proper panel height. If so, **DO NOT WELD TO THE PRESSURE VESSEL.** Weld only to existing mounts or other structural material. **DO NOT WELD WITH THE CONTROL PANEL IN PLACE.** Welding currents can cause damage to the electronic components. Refer to the PANEL MOUNTING HEIGHT diagram in Figure .

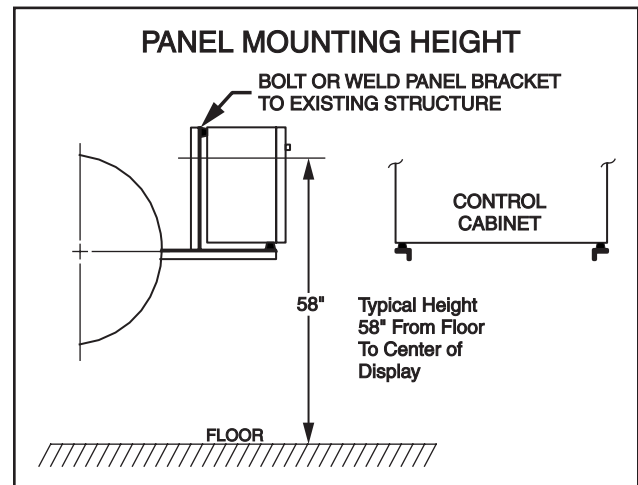


Figure 3 - Panel Mounting Height

11. Replacement temperature probes are available in either 3/4" or 1/2" MPT with thermowells or in 1/4" MPT less the well. The 1/4" MPT less well is typically used with Vilter VSS retrofits. The kit provides 4 temperature and 4, 24' 2-wire shielded cables. Specify well or sensor size when ordering. If replacing the temperature probes, remove the old probe assembly including the wells. Replace with the new integrated temperature probe, well and DIN connector assembly. This connector can accept either a 1/2" conduit connection or a single shielded cable using the provided strain relief.

## NOTICE

When ordering pressure and temperature sensors, the following sensors and cables\* are provided.

\*Cables ARE NOT provided for added sensors as the distance between those sensors and the panel is unknown.

### Pressure Sensors

- 1 - 0-200 psia 1/4" MPT (suction)
- 3 - 0-500 psia 1/4" MPT (discharge, oil & pre-filter)
- 4 - 24' 3-wire Shielded Cables with DIN Connector

### Temperature Sensors

- 4 - ICTD style temperature sensors
- 4 - 24' 2-wire Shielded Cables w/DIN Connector

### Available Temperature Sensors

(specify size when ordering)

- ICTD with 3/4" Thermowell (See Figure 4a)
- ICTD with 1/2" Thermowell (See Figure 4b)
- ICTD 1/4" MPT less thermowell  
(Typical for Vilter VSS retrofits. Sensor threads into existing 1/4" x 1/2" thermowell - See Fig. 4c)

Fig. 4a. ICTD with 3/4" thermowell

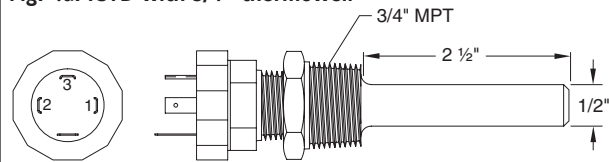


Fig. 4b. ICTD with 1/2" thermowell

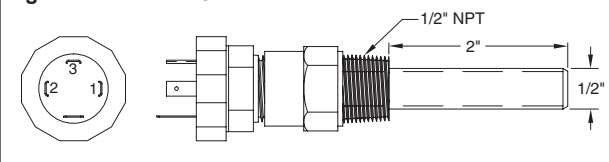


Fig. 4c. ICTD with 1/4" connection\* (less thermowell)

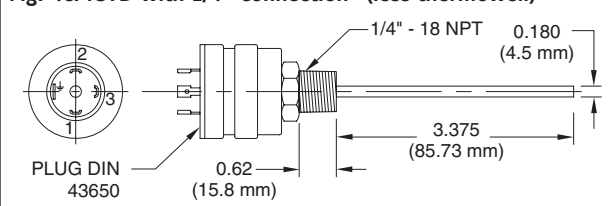


Figure 4 - ICTD Sensor Options

\*NOTE: Fig. 4c is an ICTD sensor only. Typically used with Vilter packages, the sensor threads into an existing thermowell.

12. Before making the final wiring connection for the sensors, refer to the multipage drawing that is provided in the new controller or the panel wiring diagrams in the 090.070-M manual. Temperature probe cabling is grounded at the ground block in the panel. Cut off the shield and drain wire at the probe end and use heat shrink or electrical tape to cover the bare wire, preventing contact with ground.

13. Connect the white and black wires to the analog I/O board as shown on the on the panel wiring diagrams in the 090.070-M manual.



14. New pressure transducers are provided with a 1/4" MPT connection. If replacing the pressure transducers, remove the old transducers and replace with the appropriate range transducers. The standard kit provides 1, 0-20 psia and 3, 0-500 psia transducers with 1/4" MPT connection. The kits also provides 4, 24' 3-wire shielded cable w/DIN connectors. Tubing used to route a pressure from the package to a transducer mounting block needs to be properly braced to prevent breakage due to vibration. Do not install an isolation valve that can be used to isolate the discharge pressure transducer from the source of compressor discharge pressure.

15. Refer to the panel wiring diagrams in the Maintenance manual and connect the red, black, and white wires of the pressure transducers to the QUANTUM™ HD analog board. The shield of the transducer cable is grounded inside the transducer and should not be grounded inside the cabinet.

16. Determine if there is a slide valve potentiometer on the slide valve indicator assembly. Potentiometers provided by Frick are either a single turn, 1000 ohm potentiometer or for Dunham Bush models A - D only, a special chain-driven potentiometer assembly.

17. Run separate electrical conduit between the control panel and the slide valve indicator assembly. **DO NOT RUN SLIDE VALVE WIRING WITH AC CONTROL WIRING.**

18. The wiring between the control panel and the slide valve indicator must be shielded twisted-three wire. Belden part number 8770 or equivalent is recommended.

19. Refer to the panel wiring diagrams in the Maintenance manual and connect the red, black, and white wires of the twisted-three wire to the slide valve potentiometer. Cut off the shield wire at the slide valve indicator end and place tape or heat shrink tubing around the exposed shield so that it will not come in contact with the compressor or slide valve cover.

20. Connect the shield wire of the twisted-three wire cable to the ground block in the control panel.

21. Connect the red, black, and white twisted-three wires to the microprocessor board, as shown on the panel wiring diagrams in the 090.070-M manual.

22. If the compressor is an RWB II model, locate the slide stop potentiometer. Verify that the existing wiring between the slide stop potentiometer and control panel is wired with Belden 8770 or equivalent.

23. Refer to the panel wiring diagrams in the 090.070-M manual and verify that the red, black, and white wires of the twisted-three wire to the slide stop potentiometer are wired properly. Verify that the shield wire at the slide stop end is cut off and taped to prevent contact with the compressor. Leave slide stop cover off until the calibration procedure is complete.

24. Connect the red, black, and white twisted-three wires to the microprocessor board, as shown on the panel wiring diagrams in the 090.070-M manual.

25. Connect the shield wire of the twisted-three wire cable to the ground block in the control panel.



## ⚠ CAUTION

Frick requires a shunt-trip mechanism on all starters sold with new equipment. This is to avoid the rare circumstance where a compressor starter stays engaged after the run signal is removed. Since this type of event is more likely to occur on older starters due to worn contactors or for other reasons related to age, Frick strongly recommends the installation of a shunt-trip device on the main circuit breaker in older starters as part of the retrofit/upgrade process, if one does not exist.

How the "Shunt Trip" works:

If the Quantum HD senses the starter is running (by reading motor amps or the Compressor Auxiliary digital input) when the run signal is not present, it energizes the "Shunt Trip" digital output. This energizes the shunt-trip device on the starter's main circuit breaker, stopping the compressor.

26. Before starting the AC control wiring, the following items should be checked in the compressor starter. Refer to the compressor motor starter diagrams.

- A. The compressor requires a minimum of 2 KVA transformer for 120 VAC control and heater power.
- B. The compressor starter must have a ground wire pulled from the three-phase source. The ground must be connected to the starter backplate and the neutral terminal (2) on the secondary side of the control transformer.
- C. Verify that the current transformer (CT) is placed as shown on the motor starter diagram in the IOM and is sized according to the current transformer (CT) selection calculation.
- D. Verify that auxiliary contacts are provided on the compressor and oil pump contactor (if oil pump is required).
- E. Verify that the compressor motor overloads are sized properly.
- F. If the compressor and oil pump starters do not have interposing relays already provided, the relays must be mounted and wired as shown on the drawings.
- G. If converting from an RWB or RWB II to a *QUANTUM™HD*, connect the motor amp signal from the current transformer in the motor starter (wires 3 & 4) directly to the analog board in the *QUANTUM™HD* panel, bypassing any conditioning transformers/devices that may be in the existing circuit.

**The most common electronic control panel problems are due to undersized AC power wiring, poor grounds, and control power supplied from lighting panels that have other devices tied to them that generate large amounts of AC line noise. Please follow these directions carefully. (For additional information see section "Installation of Electronic Equipment in an Industrial Environment")**

Metal oxide varistors (MOV or surge suppressor) are recommended for the load/unload solenoid coils, compressor starter coil, oil pump starter coil (if applicable) and liquid injection solenoid coil (if applicable). The MOVs should be placed directly at the coils of these devices. Placement of the MOVs at the control panel terminal strip negates the surge suppression effect.

27. Using 10 AWG wire, connect the control transformer in the compressor starter panel to the proper terminals in the *QUANTUM™HD* control panel, as shown in the IOM on the compressor motor starter diagrams and the panel wiring diagrams. These wires are: black or red (1), white (2), and green (GND). (Copper ground only. Conduit ground is not acceptable.)

The main power wiring to the *QUANTUM™HD* panel (line and neutral) must be 10 AWG. A separate ground wire is also required for each *QUANTUM™HD* panel and must also be at least a number 10 insulated copper wire.

28. Connect the remaining control wires between the starter and the control panel, as shown in the IOM on the compressor motor starter diagrams and the panel wiring diagrams. These control wires are typically:

- A. Compressor start (18)
- B. Compressor auxiliary (20)
- C. Current transformer (3 and 4)
- D. Oil pump start (if required) (8)
- E. Oil pump auxiliary (if required) (19)
- F. Circuit breaker shunt trip (26)

29. Connect the remaining package control wires, including options, to the control panel, as shown on the panel wiring diagrams in the manuals 090.070-M or 090.070-O.

30. Before applying power to the *QUANTUM™HD* control panel, make the following checks:

- A. Check each terminal for loose connections or damage to the circuit boards or cables.
- B. Check for wire clippings or metal drill filings on the circuit board or in the panel. Clean *QUANTUM™HD* control panel thoroughly before applying the control power.

31. Make sure that the circuit breakers (1CB and 2CB) in the *QUANTUM™HD* control panel are in the "OFF" position. Engage the electrical disconnect at the compressor starter.

32. Using a DIGITAL VOLTMETER, verify the AC line voltage in the *QUANTUM™HD* control panel. The AC line voltage should be between 100 VAC and 125 VAC or 185 VAC to 254 VAC.

33. Check for AC volts (in millivolts) between AC neutral (2) and AC ground (GND). If the millivolt reading is greater than 500 millivolts, pull the electrical disconnect at the motor starter and reverify ground and neutral circuits.

34. Turn circuit breakers 1CB and 2CB to the "ON" position.

### 35. POWER SUPPLY CALIBRATION

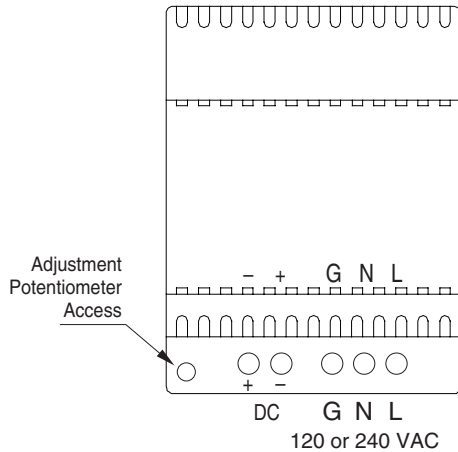
**QUANTUM™ - There are three separate power supplies in the *QUANTUM™HD*, and are designated from left to right as +5 VDC, +12 VDC and +24 VDC.**

Each power supply (5, 12, & 24 VDC) is labeled with the part # and acceptable voltage output range.

The voltages for the 5, 12, & 24 VDC supplies are as follows:

- 5 VDC range = 5.10 - 5.20 VDC
- 12 VDC range = 12.10 - 12.20 VDC
- 24 VDC range = 24.2 - 24.5 VDC

The power supplies accept both 120 or 220 VAC (input range = 100 - 240 VAC)



**Figure 5 - Power Supply, 5, 12, or 24 VDC**

36. At this point, the operating display on the controller should be seen.

Log in to the controller. Both controllers have default login codes for the various access levels.

**QUANTUM HD**

- Basic = 1
- Operation = 2
- Service = 3

These login codes can be changed as part of the configuration process.

37. Referring to the Operation manual (090.040-O or 090.070-O), ensure that all setpoints have been properly entered.

38. Before calibrating the analog devices (sensors), check the configuration of all utilized analog devices to ensure that they are configured correctly with regard to sensor output and sensor range. If using older Frick sensors or existing sensors on another manufacturer’s compressor, some if not all of the default configuration may need to be adjusted. The analog board in the Quantum HD provides 12-14 VDC excitation for the sensors. If a higher level of excitation is needed, the 24 VDC supply can be used for that purpose.

Sensor default configuration is as follows for the following sensors. Any additional sensors will also need checked for proper configuration.

**Pressure Transducers**

Location	Sensor Output	Sensor Range
Suction	1-5 VDC	0 to 200 PSIA
Oil, Oil Filter & Discharge	1-5 VDC	0 to 500 PSIA

**Temperature Probes**

Location	Sensor Output	Sensor Range
Suction, Oil, Separator & Discharge	ICTD (integrated circuit temperature device)	-459.3 to 463.1°F (not adjustable)

**Capacity Slide, Volume Slide & Motor Amps**

Location	Sensor Output	Sensor Range
Capacity Slide	4-20 mA	0 to 100%
Volume Slide	4-20 mA	2.2 to 5.0 Vi
Motor Amps	CT (0-5 amp secondary)	0 to 100 mps

39. Locate the associated temperature probe on the compressor package and pull the temperature probe from the well. Place the temperature probe in a container of water along with a quality test thermometer.

40. Wait for approximately two minutes and compare the thermometer reading with the temperature probe reading. Enter in the correction for temperature, if required.

41. Step to the next temperature to be calibrated and locate the associated temperature probe on the compressor package. Repeat the calibration procedure for each temperature probe.

42. After the temperature probe calibration is complete, reinsert the temperature probes into the wells.

43. Open the suction and discharge stop valves. If applicable, open the side load stop valve, the economizer stop valve, and the liquid injection stop valve.

**44. CHECK FOR LEAKS!**

45. To calibrate the pressure transducers, a quality test gauge is required. Go to the Pressure Calibration display and step to the suction pressure setting.

46. Attach the test gauge to the suction pressure service valve behind the control panel. Read the pressure on the test gauge and compare this reading to the displayed value. Adjust the displayed value, if necessary.

47. Step to the discharge pressure setting on the Pressure Calibration display.

48. Repeat the calibration procedure using the value from the gauge.

49. Step to the oil pressure setting on the Pressure Calibration display.

50. Repeat the calibration procedure using the value from the gauge.

51. Step to the oil filter pressure setting on the Pressure Calibration display.

52. Remove the gauge from the suction service valve and attach the test gauge to the oil filter service valve. Compare the reading on the gauge with the displayed oil filter pressure reading. Adjust the displayed value, if necessary.

53. To calibrate the slide valve, slide stop, and the motor current, refer to the Operation manual (090.040-O or 090.070-O).

54. For additional sensors not provided with the retrofit kit, refer to the OEM instructions regarding the sensor power requirement, signal type, signal range, and calibration process.

55. This completes the *QUANTUM™HD* retrofit instructions.

## PROPER INSTALLATION OF ELECTRONIC EQUIPMENT IN AN INDUSTRIAL ENVIRONMENT

In today's refrigeration plants, electronic controls have found their way into almost every aspect of refrigeration control. Electronic controls have brought to the industry more precise control, improved energy savings, and operator conveniences. Electronic control devices have revolutionized the way refrigeration plants operate today.

The earlier relay systems were virtually immune to radio frequency interference (RFI), electromagnetic interference (EMI), and ground loop currents. Therefore installation and wiring were of little consequence and the wiring job consisted of hooking up the point-to-point wiring and sizing the wire properly. In an electronic system, improper installation will cause problems that may outweigh the benefits of electronic control. Electronic equipment is susceptible to RFI, EMI, and ground loop currents which can cause equipment shutdowns, processor memory and program loss, as well as erratic behavior and false readings. Manufacturers of industrial electronic equipment take into consideration the effects of RFI, EMI, and ground loop currents and incorporate protection of the electronics in their designs. However, these design considerations do not make the equipment immune, so manufacturers require that certain installation precautions be taken to protect the electronics from these effects. All electronic equipment must be viewed as sensitive instrumentation and therefore requires careful attention to installation procedures. These procedures are well known to instrumentation, networking, and other professions but may not be followed by general electricians.

There are a few basic practices that if followed, will minimize the potential for problems resulting from RFI, EMI and/or ground loop currents. The National Electric Code (NEC) is a guideline for safe wiring practices, but it does not necessarily deal with procedures used for electronic control installation. Use the following procedures for electronic equipment installation. These procedures do not override any rules by the NEC, but are to be used in conjunction with the NEC code and any other applicable codes.

With exclusion of the three phase wire sizing, Frick drawing 649D4743 should be used as a reference for properly sizing control wires and other wiring specifications.

Throughout this document the term Electronic Control Panel is used to refer to the microprocessor mounted on the compressor package or a Central Control System panel.

### NOTICE

**It is very important to read the installation instructions thoroughly before beginning the project. Make sure you have drawings and instructions with your equipment. If not, call the manufacturer and request the proper instructions and drawings. Every manufacturer of electronic equipment should have a knowledgeable staff, willing to answer your questions or provide additional information. Following correct wiring procedures will ensure proper installation and consequently, proper operation of your electronic equipment.**

### WIRE SIZING

Control power supply wires should be sized one size larger than required for amperage draw to reduce instantaneous voltage dips caused by large loads such as heaters, contactors, and solenoids. These sudden dips in voltage can cause the electronic control panel, whether it is a microprocessor,

a computer, or a PLC, to malfunction momentarily or cause a complete reset of the control system. If the wire is loaded to its maximum capacity, the voltage dips are much larger, and the potential of a malfunction is very high. If the wire is sized one size larger than required, the voltage dips are smaller than in a fully loaded supply wire and the potential for malfunction is much lower. The NEC code book calls for specific wire sizes to be used based on current draw. An example of this would be to use #14 gauge wire for circuits up to 15 amps or #12 gauge wire for circuits of up to 20 amps. Therefore, when connecting the power feed circuit to an electronic control panel, use #12 gauge wire for a maximum current draw of 15 amp and #10 wire for a maximum current draw of 20 amp. Use this rule of thumb to minimize voltage dips at the electronic control panel.

### VOLTAGE SOURCE

Selecting the voltage source is extremely important for proper operation of electronic equipment in an industrial environment. Standard procedure for electronic instrumentation is to provide a clean, isolated, separate-source voltage in order to prevent EMI (from other equipment in the plant) from interfering with the operation of the electronic equipment. Connecting electronic equipment to a breaker panel (also known as lighting panels or utility panels) subjects the electronic equipment to noise generated by other devices connected to the breaker panel. This noise is known as electromagnetic interference (EMI). EMI flows on the wires that are common to a circuit. EMI cannot travel easily through transformers and therefore can be isolated from selected circuits. Use a control power transformer of the proper VA rating, usually provided in the compressor drive motor starter, to isolate the electronic control panel from other equipment in the plant that generate EMI. See Figure 6.

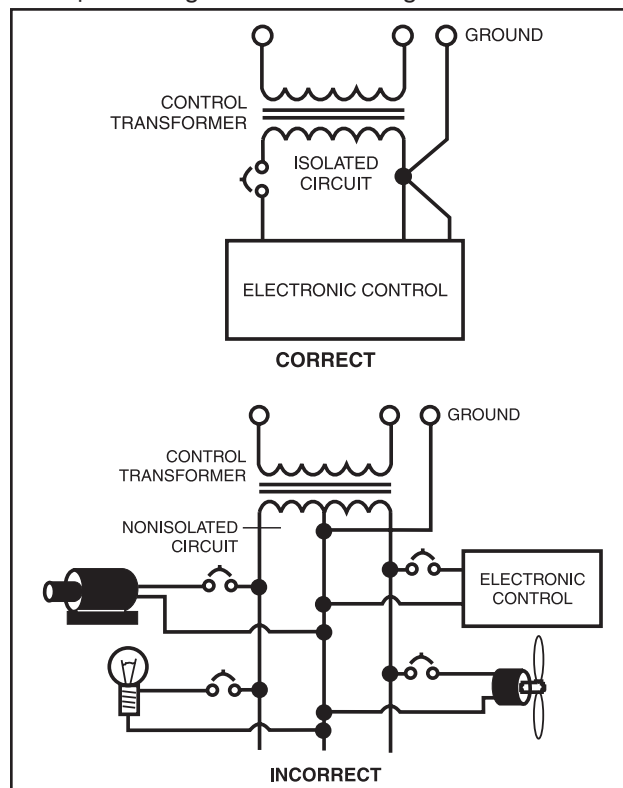


Figure 6 - Voltage Source Circuit To Prevent EMI



## GROUNDING

Grounding is the most important factor for successful operation and is typically the most overlooked. The NEC states that control equipment may be grounded by using the rigid conduit as a conductor. This worked for the earlier relay systems, but it is in no way acceptable for electronic control equipment. Conduit is made of steel and is a poor conductor relative to an insulated stranded copper wire. Electronic equipment reacts to very small currents and must have a proper ground in order to operate properly; therefore, stranded copper grounds are required for proper operation.

For proper operation, the control power ground circuit must be a single continuous circuit of the proper sized insulated stranded conductor, from the electronic control panel to the plant supply transformer (See Figure 7). Driving a ground stake at the electronic control may also cause additional problems since other equipment in the plant on the same circuits may ground themselves to the ground stake causing large ground flow at the electronic control panel. Also, running multiple ground conductors into the electronic control panel from various locations can create multiple potentials resulting in ground loop currents. A single ground wire (10 AWG or 8 AWG) from the electronic control panel, that is bonded to the control power neutral at the secondary side of the control power transformer in the starter and then to the 3-phase ground point, will yield the best results.

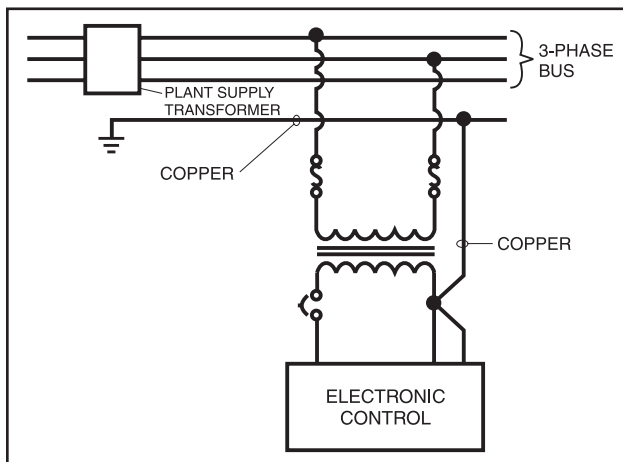


Figure 7 - Control Power Ground Circuit

## NOTICE

**Structural grounding can also result in multiple ground potentials and is also a relatively poor conductor. Therefore, this is not an acceptable method for proper operation of electronic equipment.**

There must be a ground for the three-phase power wiring. This must be sized in accordance to the NEC and any local codes relative to the highest rated circuit overload protection provided in the circuit. The manufacturer may require a larger ground conductor than what is required by the NEC for proper steering of EMI from sensitive circuits. This conductor must also be insulated to avoid inadvertent contact at multiple points to ground, which could create Ground Loops. In many installations that are having electronic control problems, this essential wire is usually missing, is not insulated, or improperly sized.

NEC size ratings are for safety purposes and not necessarily for adequate relaying of noise (EMI) to earth ground to avoid possible interference with sensitive equipment. Therefore sizing this conductor 1 – 2 sizes larger than required by code will provide better transfer of this noise.

Johnson Controls-Frick® requires that the ground conductor meet the following:

- Stranded Copper
- Insulated
- One size larger than NEC requirements for conventional starters
- Two sizes larger than NEC requirements for VFD starters
- Conduit must be grounded at each end
- The ground circuit must be continuous from the motor to the starter/drive and then from the motor/drive to the plant supply transformer (power source).

For Direct Coupled, Package Mounted Starters, the ground between the motor and the starter may need to be made externally (See Figure 8). The connection on the starter end must be on the starter side of the vibration isolators. Be certain the connection is metal to metal. Paint may need to be removed to ensure a proper conductive circuit. The use of counter-sunk star washers at the point of connection at each end will maximize metal to metal contact.

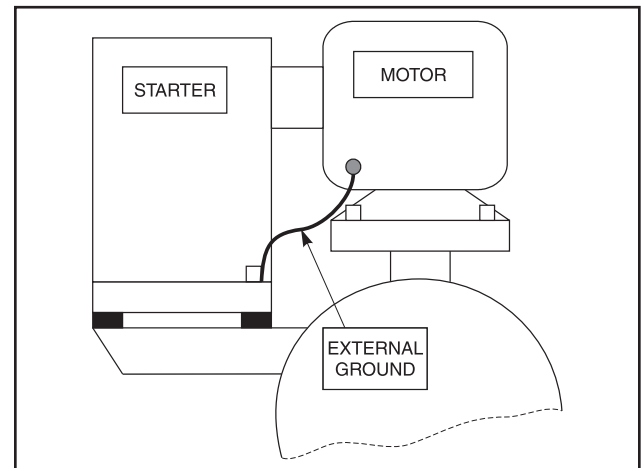


Figure 8 - Motor And Starter Grounding

## VFD APPLICATIONS

The primary ground conductor that accompanies the three-phase supply must be stranded copper, insulated and two sizes larger than the minimum required by the NEC or any other applicable codes. This is necessary due to the increased generation of EMI which is a characteristic of a VFD output to the motor when compared to a conventional starter.

For VFD applications, isolation of the control power, analog devices, and communications ground from the 3-phase ground within the starter and the electronic control panel may be necessary. This is due to the higher noise (RFI/EMI) levels generated between the VFD output and the motor, relative to a conventional starter. If these grounds are left coupled by a common back-plate in the starter/drive, this noise can be direct coupled to the control power, analog device, and communications grounding and may cause unexplained behavior and possible damage to components.

To install correctly, run a separate, properly sized (10 or 8 AWG typically) insulated ground along with and taken to ground with, the 3-phase ground at the 3-phase supply transformer (plant). This will require that the 3-phase ground and the control power ground be electrically isolated except for the connection at the plant supply transformer.

This style of grounding should steer the noise (EMI/RFI) to earth ground, reducing the potential for it to affect the sensitive equipment, which could occur if the grounds were left coupled.

## NOTICE

IF ALL OTHER RECOMMENDATIONS FOR GROUNDING ARE FOLLOWED, THIS PROCESS SHOULD NOT BE NECESSARY.

### CONDUIT

All national and local codes must be followed for conduit with regard to materials, spacing and grounding. In addition, **JOHNSON CONTROLS-FRICK REQUIREMENTS MUST BE FOLLOWED WHERE THEY EXCEED OR MATCH NATIONAL OR LOCAL CODES. CONVERSELY, THERE IS NO ALLOWANCE FOR ANY PRACTICES THAT ARE SUBSTANDARD TO WHAT IS REQUIRED BY NATIONAL OR LOCAL CODES.**

Johnson Controls-Frick conduit requirements:

- For *variable frequency drives* (VFDs) of any type, threaded metallic or threaded PVC-coated metallic is required for both the power feed (line side) from the source and between the VFD output and the motor (load side).
- PVC conduit is acceptable **ONLY** when *VFD rated cable* of the proper conductor size and ground is used. This applies to both the line side and load side of the drive. When VFD rated cable is not used, threaded metallic or threaded PVC-coated metallic must be used.
- When threaded metallic or threaded PVC-coated metallic is used, it must be grounded at both ends.
- When not required to be in metal or other material by national or local codes, conduits for the power feed (3-phase) of constant speed starters may be PVC.
- When not required to be in metal or other material by national or local codes, conduits between a constant speed starter and the motor (3-phase) may be PVC.
- Any unshielded control voltage, signal, analog, or communication wiring that does not maintain 12 inches of separation from any 3-phase conductors for every 33 feet (10 meters) of parallel run must be in metal conduit which will be grounded.

Separation: (0-33 feet, 0-10 meters – 12 inches, .3 meters), (33-66 feet, 10-20 meters – 24 inches, .6 meters)

- Since PVC conduit does absolutely nothing to protect lower voltage lines from the magnetic field effects of higher voltage conductors, running either the lower or the higher voltage lines in PVC, does not reduce these requirements on separation. Only running in metal conduit can relieve these requirements.
- Due to the level of EMI that can be induced onto lower voltage lines when running multiple feeders in a trench,

control power, communications, analog, or signal wiring cannot be run in trenches that house multiple conduits/ electrical ducts carrying 3-phase power to starters/vfd or motors.

- Control power, communications, analog, or signal wiring should be run overhead (preferred) or in a separate trench. If these lines are not in threaded metallic or threaded PVC-coated metallic, abiding by the separation requirements noted above is necessary.
- Though not recommended, if cable trays are used, *metallic* dividers must be used for separation of conductors of unlike voltages and types (AC or DC).

## NOTICE

When in doubt contact the factory or use threaded metallic or threaded PVC coated metallic conduit.

### WIRING PRACTICES

Do not mix wires of different voltages in the same conduit. An example of this would be the installation of a screw compressor package where the motor voltage is 480 volts and the electronic control panel power is 120 volts. The 480 volt circuit must be run from the motor starter to the motor in its own conduit. The 120 volt circuit must be run from the motor starter control transformer to the electronic control panel in its own separate conduit. If the two circuits are run in the same conduit, transients on the 480 volt circuit will be induced onto the 120 volt circuit causing functional problems with the electronic control panel. Metallic dividers must be used in wire way systems (conduit trays) to separate unlike voltages. The same rule applies for 120 volt wires and 220 volt wires. Also, never run low voltage wires for DC analog devices or serial communications in the same conduit with any AC wiring including 120 volt wires. See Figure 9.

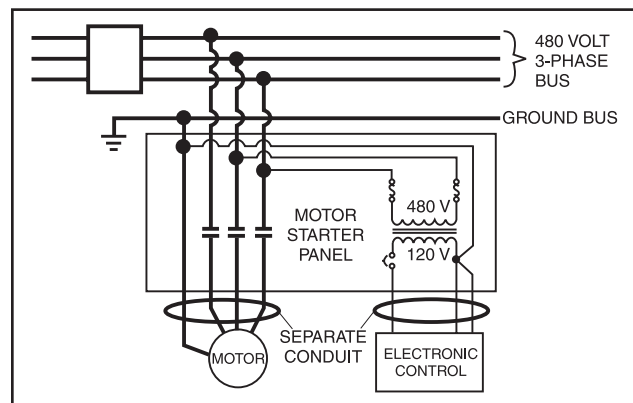


Figure 9 - Separation Of Different Voltage Circuits

**NEVER RUN ANY WIRES THROUGH AN ELECTRONIC CONTROL PANEL THAT DO NOT RELATE TO THE FUNCTION OF THE PANEL.** Electronic control panels should never be used as a junction box. These wires may be carrying large transients that will interfere with the operation of the control panel. **AN EXTREME EXAMPLE OF THIS WOULD BE TO RUN 480 VOLTS FROM THE STARTER THROUGH THE ELECTRONIC CONTROL PANEL TO AN OIL PUMP MOTOR.**

When running conduit to the electronic control panel, use the access holes (knockouts) provided by the manufacturer. These holes are strategically placed so that the field wiring

does not interfere with the electronics in the panel. Never allow field wiring to come in close proximity with the controller boards since this will almost always cause problems.

Do not drill into an electronic control panel to locate conduit connections. You are probably not entering the panel where the manufacturer would like you to since most manufacturers recommend or provide prepunched conduit connections. You may also be negating the NEMA rating of the enclosure. Drilling can cause metal filings to land on the electronics and create a short circuit when powered is applied. If you must drill the panel, take the following precautions:

- First, call the panel manufacturer before drilling into the panel to be sure you are entering the panel at the right place.
- Take measures to avoid ESD (electrostatic discharge) to the electronics as you prep the inside of the Electronic control panel. This can be done by employing an antistatic wrist band and mat connected to ground.
- Cover the electronics with plastic and secure it with masking or electrical tape.
- Place masking tape or duct tape on the inside of the panel where you are going to drill. The tape will catch most of the filings.
- Clean all of the remaining filings from the panel before removing the protective plastic.

When routing conduit to the top of an electronic control panel, condensation must be taken into consideration. Water can condense in the conduit and run into the panel causing catastrophic failure. Route the conduit to the sides or bottom of the panel and use a conduit drain. If the conduit must be routed to the top of the panel, use a sealable conduit fitting which is poured with a sealer after the wires have been pulled, terminated, and the control functions have been checked. A conduit entering the top of the enclosure must have a NEMA-4 hub type fitting between the conduit and the enclosure so that if water gets on top of the enclosure it cannot run in between the conduit and the enclosure. This is extremely important in outdoor applications.

NOTICE

**It is simply NEVER a good practice to enter through the top of an electronic control panel or starter panel that does not already have knockouts provided. If knockouts are not provided for this purpose it is obvious this is not recommended and could VOID WARRANTY.**

**NEVER ADD RELAYS, STARTERS, TIMERS, TRANSFORMERS, ETC. INSIDE AN ELECTRONIC CONTROL PANEL WITHOUT FIRST CONTACTING THE MANUFACTURER.** Contact arcing and EMI emitted from these devices can interfere with the electronics. Relays and timers are routinely added to electronic control panels by the manufacturer, but the manufacturer knows the acceptable device types and proper placement in the panel that will keep interference to a minimum. If you need to add these devices, contact the manufacturer for the proper device types and placement.

**NEVER RUN REFRIGERANT TUBING INSIDE AN ELECTRONIC CONTROL PANEL.** If the refrigerant is ammonia, a leak will totally destroy the electronics.

**IF THE ELECTRONIC CONTROL PANEL HAS A STARTER BUILT INTO THE SAME PANEL, BE SURE TO RUN THE HIGHER VOLTAGE WIRES WHERE INDICATED BY THE MANUFACTURER.** EMI from the wires can interfere with the electronics if run too close to the circuitry.

**NEVER DAISY-CHAIN OR PARALLEL-CONNECT POWER OR GROUND WIRES TO ELECTRONIC CONTROL PANELS.** Each electronic control panel must have its own control power supply and ground wires back to the power source (Plant Transformer). Multiple electronic control panels on the same power wires create current surges in the supply wires, which may cause controller malfunctions. Daisy-chaining ground wires, taking them to ground at each device, allows ground loop currents to flow between electronic control panels which also causes malfunctions. See Figure 10.

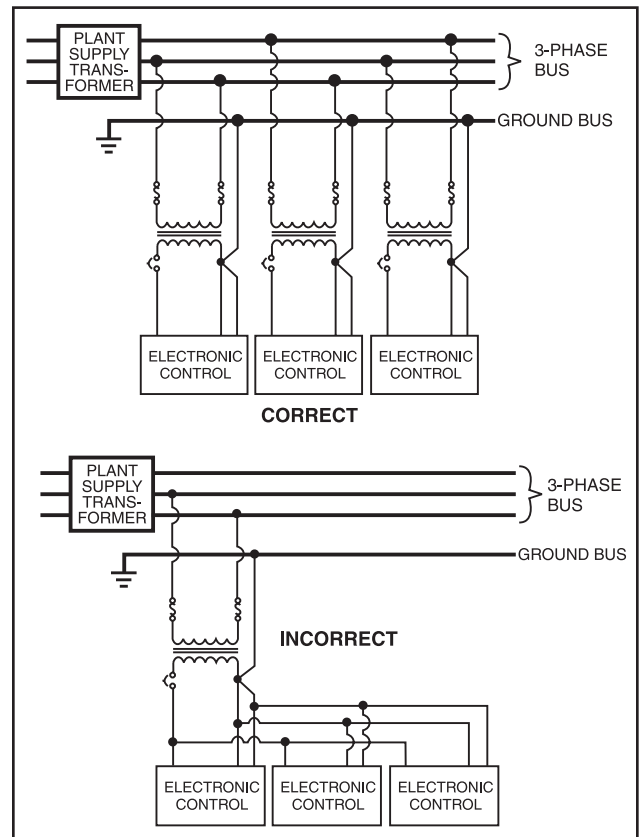


Figure 10 - Electronic Control Panel Power Supplies

## COMMUNICATIONS

The use of communications such as serial and ethernet in industrial environments are commonplace. The proper installation of these networks is as important to the proper operation of the communications as all of the preceding practices are to the equipment.

Serial communications cable needs to be of the proper gauge based on the total cable distance of the run. Daisy-chaining is the only acceptable style of running the communications cable. While Star Networks may use less cable, they more often than not cause problems and interruptions in communications, due to varying impedances over the varying lengths of cable. Ground or drain wires of the communications cable are to be tied together at each daisy-chain connection and only taken to ground in the central control system panel.

It is important to carefully consider the type of cable to be used. Just because a cable has the proper number of conductors and is shielded does not mean it is an acceptable cable. Johnson Controls-Frick recommends the use of Belden #9829 for RS-422 communications and Belden # 9841 for RS-485 up to 2000 feet (600 Meters) total cable length. Refer to Frick drawing 649D4743 for more detail

**COMM PORT PROTECTION:** Surge suppression for the comm ports may not be the best method, since suppression is required to divert excess voltage/current to ground. Therefore, the success of these devices is dependent on a good ground (covered earlier in this section). This excess energy can be quite high and without a proper ground, it will access the port and damage it.

Isolation or Optical Isolation is the preferred comm port protection method. With optical isolation, there is no continuity between the communications cable and the comm port. There is no dependence on the quality of the ground. Be sure to know what the voltage isolation value of the optical isolator is before selecting it. These may range from 500 to 4000 Volts.

Frick® Optical Isolation Kits are offered under part number 639C0133G01. One kit is required per comm port.

## UPS POWER AND QUANTUM™HD PANELS

Johnson Controls does not advise nor support the use of uninterrupted power supply systems for use with the Quantum™HD panel. With a UPS system providing shutdown protection for a Frick Quantum panel, the panel may not see the loss of the 3-phase voltage on the motor because the UPS may prevent the motor starter contactor from dropping out. With the starter contactor still energized, the compressor auxiliary will continue to feed an "okay" signal to the Quantum™HD panel. This may allow the motor to be subjected to the fault condition on the 3-phase bus.

A couple of fault scenarios are: 1. The 3-phase bus has power "on" and "off" in a continuous cycle manner which may cause the motor to overheat due to repeated excessive in-rush current experiences. 2. The motor cycling may damage the coupling or cause other mechanical damage due to the repeated high torque from rapid sequential motor "bumps." 3. Prolonged low voltage may cause the motor to stall and possibly overheat before the motor contactor is manually turned off.

Under normal conditions, the loss of 3-phase power will shut down the Quantum™HD panel and it will reboot upon proper power return. If the panel was in "Auto," it will come back and return to running as programmed. If the unit was in "Remote," the external controller will re-initialize the panel and proceed to run as required. If the panel was in "Manual" mode, the compressor will have to be restarted manually after the 3-phase bus fault/interruption has been cleared / restored.

If the local power distribution system is unstable or prone to problems there are other recommendations to satisfy these problems. If power spikes or low or high line voltages are the problem, then a constant voltage (CV) transformer with a noise suppression feature is recommended. Johnson Controls can provide these types of transformers for this purpose. Contact Johnson Controls for proper sizing (VA Rating) based on the requirement of the job. If a phase loss occurs, then you will typically get a high motor amp shut-down. If the problem continues, an analysis of the facility's power supply quality may be necessary.

## NOTICE

**It is very important to read the installation instructions thoroughly before beginning the project. Make sure you have drawings and instructions for the equipment being installed. If not, call the manufacturer to receive the proper instructions and drawings. Every manufacturer of electronic equipment should have a knowledgeable staff, willing to answer your questions or provide additional information. Following correct wiring procedures will ensure proper installation and consequently, proper operation of your electronic equipment.**

090.400-SB (2014-05)

### January 2018 Form Revisions

- p.6 - Added main circuit breaker shunt-trip caution
- Added shunt-trip control wire item to #28
- p.9 - Revised "continuous" ground circuit wording in the bullet point

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JOHNSON CONTROLS  
100 Cumberland Valley Avenue  
Waynesboro, PA 17268-1206 USA  
Phone: 717-762-2121 • FAX: 717-762-8624  
[www.johnsoncontrols.com/frick](http://www.johnsoncontrols.com/frick)