GE Energy

AF-600 FP / AF-650 GP MultiPulse Drive Panel Operation and Maintenance Manual

imagination at work

TABLE OF CONTENTS

1 Notes

GE Drives wishes to thank you for choosing our adjustable frequency controller product. We are committed to being the world's leading supplier of AC adjustable speed drives by providing the st quality products as well as the best documentation and product support available in the industry.

Compiled in this manual is a comprehensive set of documentation for your purchase. The manual is designed to provide you installation, commissioning, preventative maintenance, trouble-shooting and proper operating instructions for your GE Drives adjustable speed drive product. We suggest complete review of the manual by your personnel prior to installation and subsequent operation of the product.

Before proceeding to the instructions note that throughout this manual are several warnings, cautions and notes which are highlighted in shadowed boxes as shown below. Please take time to read these special instructions because they contain important information regarding protection and safety of personnel and equipment.

Owners should contact **1-888-GE-RESOLVE** for any warranty questions about the panel
Contact **1-800-GE-1STOP** for all operation and troubleshooting issues or customer service

WARNING: Denotes operating procedures and practices that may result in personal injury or loss of life if not correctly followed

CAUTION: Denotes operating procedures and practices that, if not strictly observed, may result in damage to, or destruction of equipment.

NOTE: *Notes call attention to information that is especially significant in understanding and operating the equipment.*

2 Installation and Start-up

The following information is provided for reference use during the installation of your AF-600 FP and AF-650 GP MultiPulse Drive Panels. Please note that all equipment shall be installed in accordance with the 2011 edition of NFPA 70 (National Electric Code) along with applicable local codes. This document provides information pertaining to: inspections, environment, installation, and wiring. AF 650 GP Design and Installation Guide (DET–767), AF-650 GP Programming Guide (DET-618) and the AF-600 FP Design and Installation Guide (DET–768), AF-600 FP Programming Guide (DET-620) and the AF-600 FP and AF-650 GP MultiPulse Drive Panel Operating Instructions contained in this notebook have additional information and will be referenced throughout this document.

GE MultiPulse Drive Panels, which include 18 pulse drives and variations like 12 or 24 units, incorporate an AF-600 FP or AF-650 GP core drive with additional rectifiers, a phase shifting transformer and control components to provide solutions with a lower level of incoming line harmonics and easier compliance with IEEE 519-1992 distortion levels.

2.1 Inspection # 1

After unpacking your control panel inspect it for damage that may have occurred during shipment.

If any damage is found please report it to the distributor from which the panel was purchased.

CAUTION: Care should be taken when unpacking the panel, improper use of tools could damage equipment.

2.2 Preparing for Installation

Remove and discard desiccant packs, if included.

Before you begin to install the drive panel, make sure the proper equipment for lifting is available. Refer to the appropriate *Outline* drawing for the dimensions, estimated weight, and required clearances for installation.

WARNING: Improper lifting of enclosure could result in a fatal or serious injury.

Refer to *Layout* and *Elementary* diagrams shipped with the panel when wiring your AF-600 FP and AF-650 GP MultiPulse Drive Panel.

CAUTION: On Wall-Mounted enclosures the panel doors can swing through 180+ degrees and there are no stops to inhibit the door from hitting equipment located next to the panel. This could result in damage to the door mounted switches and indicator lights on the panel door.

2.3 Environment

AF-600 FP and AF-650 GP MultiPulse Drive Panels are available in different NEMA types of enclosures. These types of enclosures consist of NEMA 1, 12, 3R, 4 & 4X. The environment must also be totally free from flammable or combustible vapors and/or dust.

WARNING: Failure to comply with this instruction could result in a fire and/or explosion, thus resulting in a fatal or serious injury.

The environments for NEMA Type 1 enclosures shall be indoor where the following condition may exist; falling dirt.

The environments for NEMA type 12 enclosures shall be located indoors where the following conditions may exist; dust, falling dirt, and/or non-corrosive dripping liquids. The environments for NEMA Type 3R enclosures shall be indoor or outdoor where the following conditions may exist; falling dirt, rain, sleet and snow and undamaged by the external formation of ice on the enclosures.

The environments for NEMA Type 4 enclosures shall be indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water; and that will be undamaged by the external formation of ice on the enclosure.

The environments for NEMA Type 4X enclosures shall be indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water, and corrosion, and that will be undamaged by the external formation of ice on the enclosure.

It is recommended that outdoor enclosures should not be mounted in direct sun light to avoid tripping over temperature & possible damage to equipment.

For all enclosure types the ambient temperature must remain in the range from -10° C (14° F) to 40° C (104° F). Never store or operate panel below or above ambient range.

CAUTION: Damage to equipment will result if panel is operated or stored below or above stated ambient temperature range.

All wall-mounted enclosures must be mounted on a non-flammable or heat resistant surface.

WARNING: The temperature of the Drive heat sink fins may reach 90° C (194° F). Thus if not mounted on a heat resistant or a non-flammable surface a fire may occur resulting in a fatal or serious injury, as well as damage to equipment.

Some enclosure configurations of AF-600 FP and AF-650 GP MultiPulse Panels require ventilation to keep the components and Drive within their thermal recommendations. The enclosure door and sides may contain grilles at the bottom and/or top to allow for air to circulate through the enclosure. Ventilation is accomplished by the cooling fan(s) mounted at the bottom/top grille(s) pulling air into the enclosure and forcing it out the top/bottom grille(s).

The air used for ventilating the enclosure must be free from condensation, moisture, dirt, dust, and flammable or combustible vapors and/or dust.

The recirculation of air leaving the enclosure should be avoided. Air forced out of the enclosure should not be allowed to circulate back into the enclosure. All enclosures shall be installed where the doors are able to completely open. Do not mount enclosure where the air flow into or out of it may be restricted.

2.4 Installation

Panels must be installed per NEC 110.26 and local codes and have minimum clearance to operate door safely and allow for proper maintenance as needed, (e.g., access and change filters).

Determine conduit entry and exit locations on the enclosure before mounting. See the appropriate *Outline* drawing for recommended conduit locations.
Allow for power in and power out wiring to be located in separate conduit.
No conduit holes are provided in the enclosure; therefore the customer must install all conduit holes. Place a protective covering over the components of the panel while installing the conduit holes.

CAUTION: Failure to cover components from metal shavings may result in damage to equipment.

For NEMA 12/3R4/4X enclosure types, liquid tight conduit and fittings shall be installed to maintain the enclosure integrity.

2.5 Grounding

All field wiring shall be copper and have a minimum insulation rating of 75°C (167° F).

Size grounding conductors according to local and national codes.

Each panel contains a grounding bus with provisions for connecting a field-grounding conductor.

All panels/enclosures must be grounded. Grounding methods must comply to local and national codes.

2.6 Power Wire (Greater than 120 VAC)

All field wiring shall be copper and have a minimum insulation rating of 75° C (167° F).

Size all wire based on panel nameplate current ratings in accordance with local and national codes. Do not use the cable sizes listed in DET - 609 & DET - 610.

All power wiring must be routed away from other wiring. Avoid running power wiring parallel to other wiring without a minimum separation distance of four (4) inches. Power wiring should only cross perpendicular to other wiring.

Input and output power shall be connected as per the wiring diagram.

CAUTION: Do not connect power supply voltage greater than panel rated voltage, or damage will occur to equipment.

WARNING: Never connect or disconnect output wiring with voltage applied, a serious or fatal injury may result.

For drive panels of certain HP ratings and panel configuration, no lugs are provided with core drive, load reactor, contactor or overload relay. Use appropriate size UL listed ring or fork or suitable ferrule to terminate the cables on busbars terminals of core drive, load reactor, contactor or overload relay.

WARNING: Never connect or disconnect input wiring with voltage applied, a serious or fatal injury may result.

2.7 Control Wiring (120 VAC)

All field wiring shall have a minimum insulation rating of 75° C (167° F).

Size wire according to local and national codes.

All control wiring must be routed away from power wiring. If control wiring is routed parallel to signal wiring (24vdc or less), signal wiring isolation must be maintained. A minimum of four (4) inches is needed to adequately separate signal and control wiring. If signal wire is UL recognized shielded cable, separation can be minimized to a one (1) inch separation.

AF-600 FP and AF-650 GP MultiPulse Panels require no additional control wiring to operate properly. Additional control interfacing to your control panel can be accomplished through the panel mounted customer terminal board. Please reference the appropriate wiring diagram.

2.8 Signal Wiring (24 VDC or less)

All field wiring shall have a minimum insulation rating of 75° C (167° F).

Size wire according to local and national codes.

All field signal wiring must be twisted and shielded. All shields must be grounded at one point ONLY. It is recommended to terminate the shield drains at the signal source. Avoid routing signal wiring with power wiring. If signal wiring is routed with control wiring a minimum separation of one (1) inch is required.

AF-600 FP and AF-650 GP MultiPulse Panels require no additional signal wiring to operate properly. Additional signal interfacing to your control panel can be accomplished through the panel mounted customer terminal board Please reference the appropriate customer interface diagram for signal interfacing to your control panel

If your application requires wiring to the AF-600 FP / AF-650 GP Drive I/O control terminal board, Use 16 to 24 AWG wire.

Connections on the Drive I/O terminal board should be tight enough such that a slight tug on the wire will not result in the wire coming partially or completely out of the terminal board.

CAUTION: Do not over-tighten terminal board connectors, damage to the equipment may occur.

CAUTION: Input pressure must be dry air or inert gases only. Any other pressure media will damage the transducer.

2.9 Miscellaneous Information

Refer to the appropriate *Outline* drawing for estimated watts loss of the panel.

If your enclosure is equipped with forced ventilation for keeping the Drive and other components within their thermal recommendations, the cooling fan(s) used to ventilate your enclosure also need to be cleaned periodically.

2.10 Inspection # 2

Prior to start-up of your drive panel inspect the following:

- The mechanical installation for any safety and local or national code violation.
- The electrical installation for proper connections and any violation of local or national code.
- Proper grounding of equipment.

- All field wiring for tight and proper connections (no split wire ends that may come in contact with adjacent connection points).
- No loose hardware, metal shavings, or wiring chips.
- All factory wiring for proper tightness that may have become loose due to shipping vibration.

WARNING: Do NOT start up and run the Drive without proper programming. Always check all the Drive parameters before connecting and powering up the load.

2.11 Maintenance Notes

DANGER
HAZARDOUS VOLTAGE
Turn off all power before working on the equipment!
Electrical shock will cause severe injury or death!

WARNING: Remove power to the panel before attempting to open the enclosure cover.

Risk of electric shock, do not attempt to open the enclosure cover, refer servicing to qualified personnel

To reduce risk of fire, replacement protectors (fuses/breakers) should be of the same type and rating

The panel needs maintenance for trouble free operation over its lifetime, periodically check for any insulation break down, enclosure damage or any other signs of damage and replace it with same type and rating

Dirt and debris may collect on enclosure surface, it is recommended to clean the surface with cleaning agents as needed

Periodically replace/clean the fan filters to keep the proper amount of air circulation through the enclosure.
It is recommended that all power connections to be checked for proper tightness every 6 months due to thermal cycling that may occur during normal operation.

3 Operating and Troubleshooting Instructions

Your AF-600 FP or AF-650 GP MultiPulse Panel comes with an AF-600 FP or AF-650 GP Adjustable Frequency Drives respectively from GE Drives mounted in an enclosure which contains the following equipment to manually or automatically allow motor operation across-the-line in addition to motor operation from the drive.

ABB® / Ferraz Shawmut Non-Fused Disconnect w/through-the-door lockable handle (or equivalent)

ABB® / Ferraz Shawmut Fused Disconnect w/through-the-door lockable handle (optional) (or equivalent)

GE *Spectra RMS™ Mag-Break* Solid State Circuit Breaker w/through-the-door lockable handle

GE *C-2000™* 3-Pole Non-Reversing Contactors

GE *C-2000™* Class 20/30 Fixed Heater Motor Overload Relays

GE *C-2000™* / 104P Selector Switches and Pilot Lights

GE Type IP Encapsulated or Vacuum Impregnated Control Power Transformer w/fuses

Bussman/ Ferraz Shawmut *Amp-trap®* Time-Delay Class J Fuses (or equivalent)

GE Line Reactors (optional)

GE Load Reactors (optional)

GE DC Link Reactors internal to Drive

Trenco make Phase shifting transformer

Vishay make Bridge rectifiers

These instructions are intended as a supplement to the User's Guide for the AF-600 FP and AF-650 GP drives. For programming, operating and troubleshooting instructions for the adjustable frequency drives please refer to this instruction manual, which is included with your panel documentation package.

DET - 767 *AF- 650 GP Design and Installation Guide*

DET - 618 *AF- 650 GP Programming Guide*

DET - 768 *AF-600 FP Design and Installation Guide*

DET - 620 *AF-600 FP Programming Guide*

Also included with your panel documentation package are installation instructions, electrical and mechanical drawings of your panel, and a parts list that includes recommended spares.

3.1 Operator Devices

Your panel may be equipped with one or several panel door mounted operator devices which may include the following: through-the-door, lockable, input device disconnect handle; operator selector switches; indicator lights; speed potentiometer,

3.1.1 Input Disconnect

The purpose of the panel mounted input disconnect with through-the-door handle is to provide a local, lockable method of removing all AC input power from the panel and AF-600 FP and AF-650 GP drive.

WARNING: Although input power is removed from the drive in the "Off" position this does not guarantee that dangerous voltage levels are absent. The AF-600 FP and AF-650 GP drives contain capacitors which can maintain dangerous voltage levels for an extended period following removal of AC input power.

Before touching any potentially live parts of the frequency Drive, it is always advisable to wait at least 20 minutes if not specified.

380-500V AF-650 GP drives
15 to 100HP wait at least 15 minutes
125 to 300HP wait at least 20 minutes
350HP and above, wait at least 40 minutes

525-690V AF-650 GP drives
50 to 400HP wait at least 20 minutes
500 and above, wait at least 30 minutes

Shorter time is allowed only if indicated on the nameplate for the specific unit.

If your panel includes a circuit breaker, in addition to providing a manual method of applying and removing AC input power from the panel, the circuit breaker also provides short circuit protection for the panel components and the motor.

WARNING: Since an improper setting of the circuit breaker trip level can result in code violations or inadequate short circuit protection possibly resulting in a fire or safety hazard, refer to the "Adjustments" section of this manual for further instructions on setting the trip level.

4 Drive Terminal Board I/O

Any of the AF-600 FP and AF-650 GP terminal board I/O points which are not already in use for proper operation of the bypass panel are available for customer use. The meanings and connection diagrams for these I/O points are well described and illustrated in the

DET - 767 *AF- 650 GP Design and Installation Guide*

DET - 618 *AF- 650 GP Programming Guide*

DET - 768 *AF-600 FP Design and Installation Guide*

DET - 620 *AF-600 FP Programming Guide*

Which are supplied with your panel documentation package. However there are several I/O points, which will find frequent use in panel applications that they are described below for convenience.

Relay 1 – 01, 02, 03
Programmable contacts

Relay 2 – 04, 05, 06
Programmable contacts.

20, 21, 22, 50, 53, 55
Used for drive speed reference inputs. The speed pot can be connected to points 50, 53, and 55. The customer supplied 0-10 VDC or 4-20 mA signal can also be utilized. Customer supplied 0-10 VDC signal is connected to points 20 and 22. Customer supplied 4-20 mA signal is connected to points 20 and 21.

29 and **12**
Used for issuing preset speed command to drive. The speed at which the motor will run can be set via drive function code C20.

1, 2, 3, 4, 5	DEVICE NET
62, 63, 66, 67, CS	PROFIBUS/BACNET
79, 80	LONWORKS
68, 69, 61	RS485 Port
39, 42	Analog output
27 (Drive Ready)	Digital output

5 Adjustments

The panel has several user settable adjustments, which allow it to be tailored specifically for your 3-phase induction motor. Setting these adjustments appropriately is an important factor in ensuring that applicable safety codes are met and that your bypass panel, wiring, and motor are adequately protected. The following list comprises all of the user adjustable devices/components inside the panel. The user may wish to have a copy of NFPA 70-2011 (commonly known as the National Electric Code or simply NEC) available for reference when setting these adjustments.

5.1 Input Fuses

Main input fuses are provided standard with your panel. In general there are two configurations that utilize input fuses; 1) input disconnect with load side separately mounted fuses and 2) input Fused Disconnect where the fuses are an integral part of the disconnect. If your panel was ordered with the circuit breaker option, the disconnect device and fuses are replaced by the circuit breaker. The main input fuses provided with your bypass panel has been closely coordinated to provide short circuit protection for the Drive along with short circuit and over current protection for the motor. In "Drive" mode of operation, the fuses only provide short circuit protection due to the fact that the Drive has inherent over current protection. In "Bypass" mode of operation, the fuses provide both short circuit and over current protection for the motor.

UL listed Class J time-delay fuses are provided with your panel. These fuses have been sized in accordance to NEC section 450-52 and Table 450-152. NEC states fuses of this type are to be sized at 175% of motor full-load amps (FLA). Due to the fact that actual motor FLA along with starting current requirements vary between manufacturer and motor types the fuses provided are based on standard NEC motor data. Verify that actual motor FLA * 1.75 is equal to or greater than the input fuse amp rating. In the case where the actual motor FLA * 1.75 is less than the provided fuses amp rating then smaller fuses may need to be installed to be in compliance with NEC section 430-52 and Table 430-152. Please note exception 1 to NEC 430-52, which states that where the calculated fuse amp rating does not correspond to a standard fuse size the next higher standard fuse size may be used. In cases where the fuses provided is not sufficient for the starting current requirements of the motor, please note exception 2-b to NEC 430-52. Exception 2-b states the rating of a time-delay fuse may be increased but shall not exceed 225% of the motor FLA in any case. In the case where a larger or smaller fuse is required, a limiting factor in the bypass panel may be the fuse holder. The appendices provide a table for the maximum fuse size permitted in the existing fuse holder.

Coordinating the fuses for the bypass starter is the over current protection coordination between the Class 20/30 overload relay and the fuse's over current protection. This coordination is to avoid nuisance blowing of fuses. Coordination between the Drive's short circuit rating and the fuse's RMS let through currents during a short circuit condition has also been closely evaluated. Changing the main input fuses may impact one or both of the above coordination issues. Therefore if it is necessary to change the input fuses please consult your preferred fuse supplier and/or your local GE starter distributor for Type 2 and overload relay coordination.

5.2 Circuit Breaker

The optional circuit breaker in the AF 600 FP & Bypass panel is a solid state *Spectra RMS™* molded case circuit breaker from GE. The purpose of the circuit breaker is to provide short circuit protection and over current for the panel components, field wiring and the motor. The breaker uses a solid state sensing element which calculates the true RMS™ value of the current every cycle, resulting in a tripping action which is very fast. For this reason the NEC allows the trip level to be set at 700% of the motor FLA to allow for the high locked rotor current which the motor draws during across-the-line starts (see NEC section 430-52 and Table 430-152 of the NEC). Because instantaneous trip circuit breakers are so fast acting, the NEC actually allows trip level settings up to 1300% of motor FLA if it can be shown to be required by engineering evaluation. When a motor is started across the AC line it can draw a very large peak current for the first half-cycle which can cause nuisance tripping in instantaneous trip breakers set at 700%. GE Motors & Industrial Systems has conducted analyses, which show that certain models can require this 1300% trip level to avoid nuisance tripping on across-the-line starts. Generally the trip level will need to be higher for premium efficiency motors than for standard efficiency ones.

The rating plugs for the circuit breakers in the panels have been chosen to allow trip level settings up to 13 times the current ratings of the panel. If the trip level is set at 13 times the motor FLA and the circuit breaker still trips it is probably due to the fact that your motor has very high efficiency and therefore exhibits the highest inrush currents. Possible corrective actions are:

1. Make sure there is not an actual short causing the trip.
2. Try starting several times. The inrush level is a function of the point on the AC line when the breaker is applied. Try enough times and you'll probably apply power at a favorable point.
3. Try another rating plug. Perhaps the tolerances on the one included with your breaker are unfavorable.
4. Start the motor with the adjustable frequency drive and then switch over to bypass mode once the motor is up to speed. This will not trip the breaker because the drive "soft-starts" the motor by applying a very low voltage and gradually ramping up.
5. For NEMA E motors (super premium efficiency) the NEC 1996 version will allow a trip setting of 1700% of motor FLA.

5.3 Motor Overload

The overload relay in your panel is the *C-2000™* Class 20 or Class 30 fixed heater type from GE which is panel mounted. Class 30 overload relays are utilized for panels rated 60Hp and above at 208 VAC plus 150Hp and above at 460 VAC. The overload relay carries all motor current whether it is running from the drive or across the AC line (bypass mode). Whereas the panel circuit breaker or input fuses is intended to provide short circuit protection for the panel components, field wiring and the motor, the overload relay's function is to provide continuous long term overload protection against loads which draw current in excess of the motor's rating.

According to GE ED&C publication DET-034B entitled *C-2000™ Contactors & Starters Technical Information*; the trip level dial on the contactors should be set as follows.

- *Motors with Service Factor of 1.15 or Greater* - adjust OL relay dial to the motor nameplate FLA.
- *Motors with Service Factor Less than 1.15* - adjust OL relay dial according to the formula FLA times Service Factor times 0.90.

Example: 30 A motor with 1.00 service factor
Set OL dial at 30 x 0.90 = 27.0 A

CAUTION: For all panels the overload relay dial should never be set higher than the panel rated current even if allowed by the above formula because the overload relay protects panel components such as the contactors and line reactor in addition to the motor.

If the overload relay dial is set correctly but trips in normal running situations, then your motor is probably undersized for your load. Possible corrective actions are:

1. Make sure there is not an unintended additional loading on the motor resulting in the excessive current.
2. Try another OL relay. Perhaps the tolerances on the one included with your panel are unfavorable.
3. Reduce the load on the motor. For variable torque loads when running on the drive, this can be accomplished simply by slowly reducing speed until the tripping stops. For bypass operation this would require a change to the driven load.

If the overload relay dial is set correctly but tripping occurs on across-the-line starts this is probably due to a large load inertia which results in high starting current being applied for a longer time to accelerate the motor from a stopped to full speed condition. Traditionally the problem of starting motors with high inertia loads across the line has been solved by a number of methods falling into the category of soft-starters. The AF-600 FP and AF-650 GP adjustable frequency drive is, by its very nature, a "soft-starter" since it applies a very low voltage to the motor when it is stopped and gradually increases to full voltage at full speed. Recognizing that this problem can only occur during full voltage across-the-line starts (in other words, starting in bypass mode), then possible corrective actions are:

1. Allow the OL to cool sufficiently between restarts. There is typically a 4 to 1 difference between the operation times of the OL in their cold state versus their warm state.
2. Try another OL relay of the same rating. Tolerances on the OLs are loose, trip times can vary significantly from unit to unit of the same rating (range of 2 to 1 or more is not uncommon).
3. Reduce the load on the motor during acceleration. Total motor load during this period is the sum of the accelerating torque plus load torque. Once motor is up to speed the load can be reapplied.

WARNING: The overload relay should not be turned to a higher setting than allowed by the rules above to allow starting the motor across the line without tripping. Doing so will compromise the overload protection which could lead to component damage or fire which could threaten personnel safety. Refer to NEC for further information.

5.4 Drive-to-Bypass Delay

If the AF-600 FP or AF-650 GP panels are equipped with manual bypass functionality, then this requires an operator to manually transition power from the drive to the AC line via the Drive/Off/Bypass selector switch in the event of a drive fault. When transitioning power to the motor from "Drive" to "Bypass" the operator must place the switch in the "Off" position for a minimal of 10 seconds. This delay is to allow for the motor's rotor flux to decay prior to applying direct AC line power, which would be out of sync and phase with the flux, resulting in a potentially damaging current and torque pulsation. Typically a delay of three motor AC time constants will be adequate to ensure that the flux has decayed to a low enough level to apply AC line power. An induction motor's open circuit AC time constant is dependent on a number of factors including horsepower rating and number of poles. Generally speaking the time constant increases as HP goes up and as the number of poles goes down.

CAUTION: Failure to insert enough time delay between operation of the motor from the Drive and operation across-the-line can result in a devastating torque pulse which can damage your motor, driven load and/or installation. The AF-600 FP and AF-650 GP drives does not have a line synchronizing function to permit a smooth switchover to AC line power, therefore the time delay is the only way to ensure a safe transition.

If your panel was ordered with the optional automatic bypass functionality, the time delay required when transitioning between drive and bypass has been designed into the panels control logic.

5.5 Phase loss relay

Set the Phase loss relay to desired system voltage to avoid any malfunction.

6 Troubleshooting

If careful attention to phase rotation is not made during connection of the panel to the three-phase power supply and motor, then there is only a one chance in four that the motor will rotate correctly in both drive and bypass modes.

The other three possibilities and the corresponding corrective actions are as follows:

* **Problem:** Motor turns correctly in Bypass mode and incorrectly in Drive mode
  Solution: Swap two of three power supply leads AND two of three motor leads

* **Problem:** Motor turns correctly in Drive mode and incorrectly in Bypass mode
  Solution: Swap two of three power supply leads

* **Problem:** Motor turns incorrectly in both modes
  Solution: Swap two of three motor leads
  Note that if the rotation in bypass mode is opposite to the rotation in drive mode, it is possible that the panel's motor overload will trip if a full-speed transition between modes is attempted. This is due to the large amount of current required to decelerate the motor to a stop prior to accelerating it in the correct direction.

***Problem:** Trouble with VFD and External Rectifier section.

Solution: It is always good to see the overall circuit as shown in the figure 6.1. If the supply breaker keeps tripping, chances are that one or more diodes are shorted.
Begin by isolation the circuit:

1) Lockout the supply breaker and wait until the DC bus is below 50VDC.
2) Pull CR4 to keep C1 and C2 off.
3) Remove the +DC Bus and –DC Bus cables from the VFD (mark them "+" and "-").
4) (1, 4, 7) is a phase shifting transformer and needs to be disconnected from the VFD. See figures 6.1, 6.2 and 6.3.
5) Test the 6 VFD diodes using a diode meter. Measure from L1, L2, L3 to +DC and –DC. Use the Service Manual **DET-712** for details on testing and replacing devices.
6) Whether the VFD rectifiers check good or bad, the external diodes still need to be tested. With the breaker still OFF, open the hood to the external rectifier section. See figure 6.3.

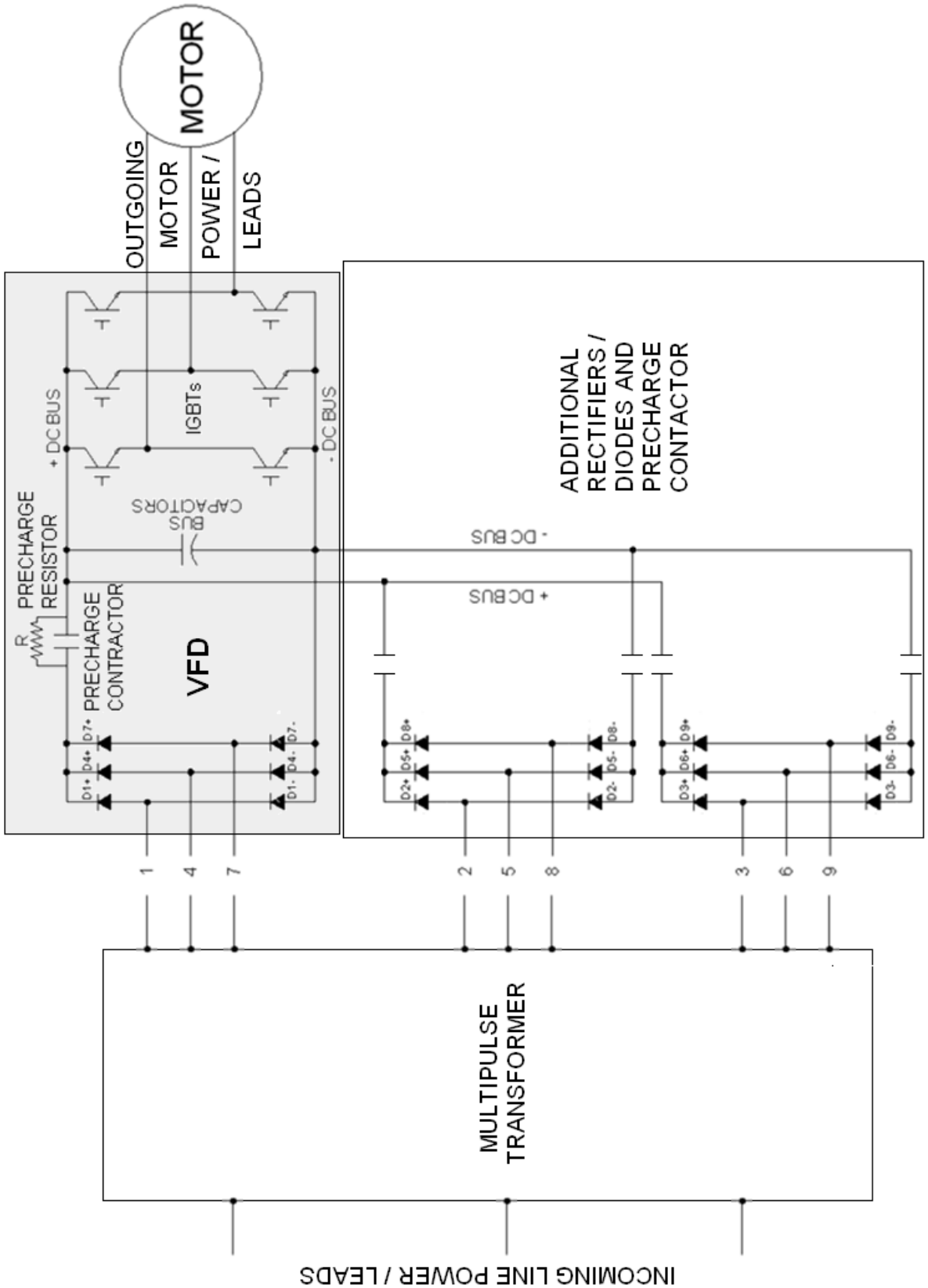

Figure 6.1 – Block diagram of MultiPulse Drive panel

Figure 6.2 –MultiPulse Transformer

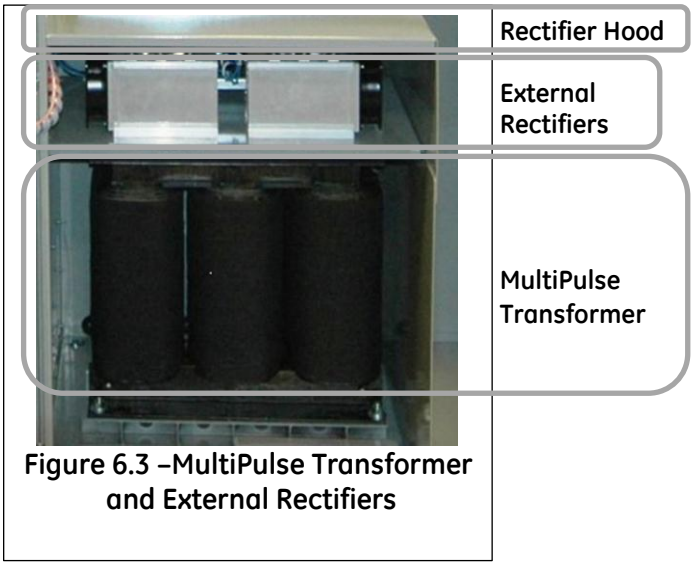

Figure 6.3 –MultiPulse Transformer and External Rectifiers

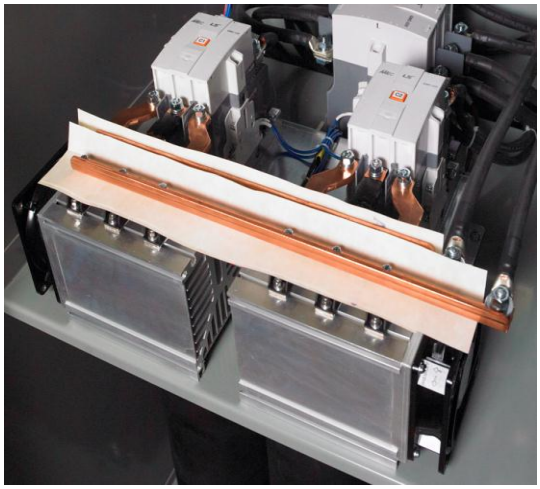

Figure 6.4 - External Rectifiers and PreCharge Assembly

Figure 6.5 - External Rectifiers and PreCharge Assembly

7) Take a picture of the DC bus so you can see how to put it back together when done. See figure 6.4 and 6.5.
8) Notice how the insulation paper is arranged so you can re-assemble when done. See figure 6.4.
9) Completely remove the DC BUS from the diodes.

   Notice that there are six external rectifier modules consisting of
   (D2+ & D2-)
   (D5+ & D5-)
   (D8+ & D8-)
   (D3+ & D3-)
   (D6+ & D6-)
   (D9+ & D9-)

   Each module has three terminals:
   (AC) (–) (+)

Figure 6.6 - External Rectifier sample

10) Once the DC bus is removed and while C1 and C2 are still open each diode can be tested individually

    Check each diode with diode meter and record on the chart found on the next page.
    Keep in mind you should see continuity with your BLK lead on the + output of each rectifier to AC input.

    And NO CONTINUITY with the RED lead on the (+) output of each rectifier to the AC input.

    Then one should see continuity with RED lead on the (–) output of each rectifier to the AC input.

    And NO CONTINUITY with the BLK lead on the (–) output of each rectifier to the AC input.

11) Replace each defective rectifier module being sure to spread a thin layer of heat sink compound on the back before screwing in place), do not connect (1, 4, 7) to VFD until step 17.
12) Re-assemble the DC bus onto the rectifiers
13) Use Dupont make NOMEX 410 new electrical insulation paper as needed. Try to Keep at least ½" distance for any path of arc.
14) Leave the DC bus leads OFF from the VFD (Tape them so they don' t short out).
15) While measuring VDC on the DC Bus, Use a cord to supply 120VAC through a series light bulb into (2,5) then (5, 8) then (3, 6) then (6, 9). one should see about 108VDC each time.
16) While measuring VDC on the VFD (+DC,-DC), Feed 120VAC through the light bulb into VFD (L1, L2) then (L2, L3), one should see the VFD capacitors charge to 170VDC each time.
17) If diodes pass test of step 15 & 16, reconnect DC bus to VFD and reconnect (1, 4, 7)
18) Put CR4 back in. Close doors to protect you from arc flash. Turn on 480V
19) If VFD comes on successfully, turn 480V back off, and connect harmonic meter
20) Turn 480VAC back on and run at full speed
21) If each phase current is below 8% TDH current, your job is a great success.
22) Turn off the supply breaker, wait for DC bus to get below 50V
23) Re-assemble hood over the rectifier section
24) Complete!

TEST CHART for VFD with diodes connected to BUS CAPACITORS

Diode Meter RED	Diode Meter BLK	Expected	Actual
L1	+DC Bus	0.2-0.6VDC	
L2	+DC Bus	0.2-0.6VDC	
L3	+DC Bus	0.2-0.6VDC	
+DC Bus	L1	Charging	
+DC Bus	L2	Charging	
+DC Bus	L3	Charging	
L1	-DC Bus	Charging	
L2	-DC Bus	Charging	
L3	-DC Bus	Charging	
-DC Bus	L1	0.2-0.6VDC	
-DC Bus	L2	0.2-0.6VDC	
-DC Bus	L3	0.2-0.6VDC	

TEST CHART for (R2, S2, T2) or (2,5,8) with Bus removed

Diode Meter RED	Diode Meter BLK	Expected	Actual
R2	+DC Bus Cathode	0.2-0.6VDC	
S2	+DC Bus Cathode	0.2-0.6VDC	
T2	+DC Bus Cathode	0.2-0.6VDC	
+DC Bus Cathode	R2	Open	
+DC Bus Cathode	S2	Open	
+DC Bus Cathode	T2	Open	
R2	-DC Bus Anode	Open	
S2	-DC Bus Anode	Open	
T2	-DC Bus Anode	Open	
-DC Bus Anode	R2	0.2-0.6VDC	
-DC Bus Anode	S2	0.2-0.6VDC	
-DC Bus Anode	T2	0.2-0.6VDC	

TEST CHART (R3, S3, T3) or (3,6,9) with Bus removed

Diode Meter RED	Diode Meter BLK	Expected	Actual
R3	+DC Bus Cathode	0.2-0.6VDC	
S3	+DC Bus Cathode	0.2-0.6VDC	
T3	+DC Bus Cathode	0.2-0.6VDC	
+DC Bus Cathode	R3	Open	
+DC Bus Cathode	S3	Open	
+DC Bus Cathode	T3	Open	
R3	-DC Bus Anode	Open	
S3	-DC Bus Anode	Open	
T3	-DC Bus Anode	Open	
-DC Bus Anode	R3	0.2-0.6VDC	
-DC Bus Anode	S3	0.2-0.6VDC	
-DC Bus Anode	T3	0.2-0.6VDC	

7 Appendix A – Current Ratings and Fuse Sizes

Table 7.1
208 VAC Panel Current Ratings and
Maximum Allowable Fuse Sizes

Panel HP Rating	Panel Current Rating (Amps)	Maximum Allowable Fuse Size (Amps)
1	4.6	10.3
2	7.5	13.1
3	10.6	18.6
5	16.7	29.2
7.5	24.2	42.4
10	30.8	53.9
15	46.2	80.9
20	59.4	104.0
25	74.8	130.9
30	88	154.0
40	115	199.5
50	143	250.3
60	170	295.8

Table 7.2
460 VAC Panel Current Ratings and
Maximum Allowable Fuse Sizes

Panel HP Rating	Panel Current Rating (Amps)	Maximum Allowable Fuse Size (Amps)
1	2.1	3.7
2	3.4	6.0
3	4.8	8.4
5	8.2	13.3
7.5	11	19.3
10	14.5	24.5
15	21	36.8
20	27	47.3
25	34	59.5
30	40	70.0
40	52	91.0
50	65	113.8
60	80	134.8
75	105	168.0
100	130	217.0
125	160	273.0
150	190	320.3
200	240	420.0
250	302	528.5
300	361	631.8
350	443	763.0
450	540	929.3
500	590	1032.5
550	678	1167.3
600	730	1256.5
650	780	1352.8
750	890	1541.8
900	1050	1828.8
1000	1160	2009.0
1200	1380	2409.8
1350	1530	2649.5

Table 7.3
575 VAC Panel Current Ratings and
Maximum Allowable Fuse Sizes

Panel HP Rating	Panel Current Rating (Amps)	Maximum Allowable Fuse Size (Amps)
1	1.8	4.2
2	2.7	4.7
3	3.9	7.2
5	6.1	10.7
7.5	9	15.8
10	11	19.3
15	18	30.1
20	22	38.5
25	27	47.3
30	34	57.2
40	41	71.8
50	52	91.0
60	62	108.5
75	83	138.1
100	100	173.3
125	131	218.8
150	155	264.3
200	192	336.0
250	242	423.5
300	290	505.8
350	344	593.3
400	410	691.3
450	450	759.5
500	500	843.5
600	570	994.0
650	630	1076.3
750	730	1267.0
950	850	1477.0
1050	945	1650.3
1150	1060	1849.8
1350	1260	2198.0

8 In-Warranty Information Form

The purpose of this form is to provide specific information to GE Drives to aid in expediting part replacement and/or troubleshooting assistance for AF-600 FP OR AF-650 GP MultiPulse Drive Panels. The following information is required prior to any assistance being provided.

Panel Model Number : _____

Panel Serial Number : _____

Start-Up Date : _____

Failure Date : _____

I. Application Information:

Input Transformer: _____ kVA Wiring distance between motor & drive _____ ft.

Power Factor Correction Capacitors: _____ Yes (_____ Microfarad) _____ No

Other Equipment on Same Power: _____ Yes _____ No

If Yes, what? _____

II. Function Code Different From Factory Settings:

FC	Setting

FC	Setting

III. Failure Message:

Latest Fault ☐ Previous Fault ☐

IV. Status When Failure Occurred (check one):

_____ Power Up _____ Running _____ Drive Mode _____ Bypass Mode

V. Description Of Failure:

_____

_____

Once all the required information above is acquired, contact the following number for assistance:

GE Industrial Systems
phone: **1-888-GE-RESOLVE** *(24hrs.)*

VI. *To aid in part replacement please fill complete the following:*

To: _____ From: _____

Fax: _____ Fax: _____

Phone: _____ Phone: _____

The following is the ship to address for all warranty replacement items:

Company Name
_____

_____

Street Address

_____

_____

City ***State*** ***Zip Code***

_____

Attention

_____

Rm, Dept., Suite, Division, etc.

_____

9 Appendix B – Wire Sizes and Torque Details

Table 9-1

GE IEC 2000 Power Contactors	Wire Range	Wire Tightening Torque (In.lb)
CL00	14-10	15
CL01	14-10	15
CL02	14-10	15
CL25	14-8	20
CL04	14-8	16
CL45	14-8	16
CL06	14-1/0	50
CL07	14-1/0	50
CL08	14-1/0	50
CL09	10-1/0	60
CL10	10-1/0	60
CK75	#6-250 MCM	275
CK08	#6-250 MCM	275
CK09	#6-350 MCM	200
CK95	#6-350 MCM	200
CK10	#8-500 MCM, 2/0-600MCM	375
CK11	#8-500 MCM, 2/0-600MCM	375
CK12	#8-500 MCM, 2/0-600MCM	375

Table 9-2

Ferraz Shawmut Non Fusible Disconnect	Wire Range AWG	Wire Tightening Torque (lb. In.)
SCV30U	# 10 - # 14 (1)	27
SCV60U	# 3 - # 10 (1)	58
SCV100U	# 3 - # 10 (1)	58
SCV200U	3 / 0 - # 6 (1)	200
SCV400U	600 kcmil - #2 (1)	500
SC600	600 kcmil - #2 (2)	500
SC800	600 kcmil - #2 (3)	500

Table 9-3

Ferraz Shawmut - Fusible Disconnect	Wire Range AWG	Wire Tightening Torque (lb. In.)
FBJ30U	# 3 - # 10 (1)	58
FBJ60U	# 3 - # 10 (1)	58
FBJ100U	2 / 0 - # 14 (1)	120
FBJ200U	3 / 0 - # 6 (1)	200
FBJ400U	600 kcmil - #2 (1)	500
FBJ600U	600 kcmil - #2 (2)	500
FBL800U	600 kcmil - #2 (2)	500

Table 9-4

GE Spectra Circuit Breaker	Wire Range	Wire Tightening Torque (lb. in.)
SELA36AI0150	# 12 - # 3/0 Cu. # 12 - # 3/0 Al.	# 12 - # 10 --------- 35 # 8 - # 3 ---------- 100 # 2 - # 3/0 ---------- 150
SFLA36AI0250	# 8 - 350 kcmil Cu. # 8 - 350 kcmil Al.	# 8 - # 4 ---------- 150 # 3 - # 1 ---------- 200 1/0 - 350 kcmil ----- 275
SGLA36AI0400	**Wire Top** # 8 - 500 kcmil Cu. # 8 - 500 kcmil Al. **Wire Bottom** 2/0 - 600 kcmil Cu. 2/0 - 600 kcmil Al.	# 8 - # 3 ---------- 275
SGLA36AI0600		# 2 - 600 kcmil --- 375
SKLA36AI0800	3/0 - 500 kcmil Cu. 3/0 - 500 kcmil Al.	375
SKLA36AI1200	250 - 500 kcmil Cu. 250 - 500 kcmil Al.	375

Table 9-5

GE IEC 2000 series Overload Relay	Wire Range	Wire Tightening Torque (lb. in.)
RT1	# 14 - # 8	14 - 20
RT2A - J	# 10 - # 3	50
RT2K - M	# 10 - # 1	50
RT3	# 6 - 250 kcmil	275
RT4	# 6 - 350 kcmil	200
RT5	# 8 - 500 kcmil # 2/0 - 600 kcmil	375
RT4L	# 6 - 350 kcmil	200
RT5L	# 8 - 500 kcmil # 2/0 - 600 kcmil	375

Table 9-6

Voltage Rating in (VAC)	HP Rating	AF-600 FP (Drive Terminal Cable Size)	AF-650 GP (Drive Terminal Cable Size)	AF-600 FP Unit size	AF-650 GP Unit Size
208	1	10	10	12	12
208	2	10	10	12	12
208	3	10	10	12	12
208	5	10	10	13	13
208	7.5	6	6	23	23
208	10	6	6	23	23
208	15	6	6	23	24
208	20	2	2	24	24
208	25	1/0	1/0	33	33
208	30	1/0	1/0	33	33
208	40	1/0	1/0	33	34
208	50	4/0	4/0	34	34
208	60	250 MCM	--	34	-
460	1	10	10	12	12
460	2	10	10	12	12
460	3	10	10	12	12
460	5	10	10	12	12
460	7.5	10	10	13	13
460	10	10	10	13	13
460	15	6	6	23	23
460	20	6	6	23	23
460	25	6	2	23	24
460	30	2	2	24	24

(Table 9-6 continued)					
Voltage Rating in (VAC)	**HP Rating**	**AF-600 FP (Drive Terminal Cable Size)**	**AF-650 GP (Drive Terminal Cable Size)**	**AF-600 FP Unit size**	**AF-650 GP Unit Size**
460	40	2	2	24	24
460	50	1/0	1/0	24	33
460	60	1/0	1/0	33	33
460	75	1/0	1/0	33	34
460	100	4/0	4/0	34	34
460	125	250 MCM	2x2/0	34	43
460	150	2x2/0	2x2/0	43	43
460	200	2x2/0	2x2/0	43	44
460	250	2x350 MCM	2x350 MCM	44	44
460	300	2x350 MCM	2x350 MCM	44	44
460	350	2x350 MCM	2x350 MCM	44	52
460	450	4x500 MCM	4x500 MCM	52	52
460	500	4x500 MCM	4x500 MCM	52	52
460	550	4x500 MCM	4x500 MCM	52	52
460	600	4x500 MCM	8x300 MCM	52	61
460	650	8x300 MCM	8x300 MCM	61	61
460	750	8x300 MCM	8x300 MCM	61	61
460	900	8x300 MCM	8x300 MCM	61	61
460	1000	8x300 MCM	12x300 MCM	61	62
460	1200	12x300 MCM	12x300 MCM	62	62
460	1350	12x300 MCM	-	62	-
575	1	10	10	13	13
575	2	10	10	13	13
575	3	10	10	13	13
575	5	10	10	13	13
575	7.5	10	10	13	13
575	10	10	10	13	13
575	15	6	6	23	23
575	20	6	6	23	23
575	25	6	6	23	24
575	30	2	2	24	24
575	40	2	2	24	24
575	50	2	2	24	33
575	60	1/0	1/0	33	33
575	75	1/0	1/0	33	34
575	100	4/0	4/0	34	34

(Table 9-6 continued)					
Voltage Rating in (VAC)	**HP Rating**	**AF-600 FP (Drive Terminal Cable Size)**	**AF-650 GP (Drive Terminal Cable Size)**	**AF-600 FP Unit size**	**AF-650 GP Unit Size**
575	125	250 MCM	2x2/0	34	43
575	150	2x2/0	2x2/0	43	43
575	200	2x2/0	2x350 MCM	43	44
575	250	2x350 MCM	2x350 MCM	44	44
575	300	2x350 MCM	2x350 MCM	44	44
575	350	2x350 MCM	2x350 MCM	44	44
575	400	2x350 MCM	4x500 MCM	44	52
575	450	4x500 MCM	-	52	-
575	500	4x500 MCM	4x500 MCM	52	52
575	600	4x500 MCM	4x500 MCM	52	52
575	650	4x500 MCM	8x300 MCM	52	61
575	750	8x300 MCM	8x300 MCM	61	61
575	950	8x300 MCM	8x300 MCM	61	61
575	1050	8x300 MCM	12x300 MCM	61	62
575	1150	12x300 MCM	12x300 MCM	62	62
575	1350	12x300 MCM	-	62	-

Table 9-7

GE Drive Unit size	Drive Terminal	Torque (lb. in.)	Torque (Nm)	Bolt Size
12, 13, 23	Line In	16	1.8	NA
	Motor	16	1.8	NA
	DC Connection	16	1.8	NA
	Brake	16	1.8	NA
	Earth	27	3	NA
	Relay	5	0.6	NA
24	Line In	40	4.5	NA
	Motor	40	4.5	NA
	DC Connection	40	4.5	NA
	Brake	40	4.5	NA
	Earth	27	3	NA
	Relay	5	0.6	NA
33	Line In	89	10	NA
	Motor	89	10	NA
	DC Connection	89	10	NA
	Brake	89	10	NA
	Earth	27	3	NA
	Relay	5	0.6	NA
34	Line In	124 (< AWG 4/0) / 212 (> AWG 4/0)	14 (<95 sq.mm.) / 24(> 95 sq. mm.)	NA
	Motor	124 (< AWG 4/0) / 212 (> AWG 4/0)	14 (<95 sq.mm.) / 24(> 95 sq. mm.)	NA
	DC Connection	124	14	NA
	Brake	124	14	NA
	Earth	27	3	NA
	Relay	5	0.6	NA
41, 42 ,43, 44	Mains	168	19	M10
	Motor			
	Load Sharing	84	9.5	M8
	Brake			
51, 52	Mains	168	19	M10
	Motor			
	Load Sharing			
	Brake	84	9.5	M8
61, 62, 63, 64	Mains	168	19	M10
	Motor			
	Load Sharing	168	19	M10
	Brake	84	9.5	M8
	Regen	168	19	M10

Note: For unmentioned torques, Refer UL508A tables 54.1, 54.2 and 54.3

Table 54.1 , Tightening torque for screws

Test wire size installed in connector (AWG)	Tightening torque (lb in.)			
	Slotted head no 10 and large		Hexagonal head - external drive socket	
	Slot width - 0.047 inch or less and slot	Slot width - 0.047 inch or slot length -	Split bolt connectors	other connectors
18-10	20	35	80	75
8	25	40	80	7
6-4	35	45	165	110
3	35	50	275	150
2	40	50	275	150
1	-	50	275	150
1/0 - 2/0	-	50	385	180
3/0-4/0	-	50	500	250
250-350	-	50	650	325
400	-	50	825	375
500	-	50	825	375
600-750	-	50	1000	375
800-1000	-	50	1100	500
1250-2000	-	-	1100	600
Note : For values of slot width or length not corresponding to those specified, the largest torque value associated with the conductor size shall be marked. Slot width is the normal design value. Slot length shall be measured at the bottom of the slot				

Table 54.2 , Tightening torque for slotted head screws smaller than No. 10 intended for use with 8 AWG or smaller conductors

Slot length of screws[a]	Tightening torque, lb.in	
	Slot width of screw[b] smaller	Slot width of screw[b] 0.047 in
<5/32	7	9
5/32	7	12
3/16	7	12
7/32	7	12
1/4	9	12
9/32	-	15
Above 9/32	-	20
[a] For slot length of intermediate values, torques pertaining to next shorter length shall be utilized. For screws with multiple tightening means, the largest torques value associated with the conductor size shall be marked. Slot length shall be measured at the bottom of the slot		
[b] Slot width is the nominal design value		

Table 54.3 , Tightening torque for socket head screws

Socket size across flat in inches	Tightening torque in lb.in
1/8	45
5/32	100
3/16	120
7/32	150
1/4	200
5/16	275
3/8	375
1/2	500
9/16	600

10 Wiring diagrams and Outline drawings

NOTES:

The instructions do not purport to cover all details or variations in equipment or to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the GE Company.

GE Consumer & Industrial
41 Woodford Avenue
Plainville, CT 06062

www.geelectrical.com/drives

DEH41601B (05/13)
AN 12-1027

imagination at work

