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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 highest 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.

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.*



**INSTALLATION AND START-UP INSTRUCTIONS FOR
AF-600 FP BYPASS, NON-BYPASS & DISCONNECT DRIVE PANELS.**

The following information is provided for reference use during the installation of your AF-600 FP Bypass, NON Bypass & Disconnect Drive Panels. Please note that all equipment shall be installed in accordance with the 2008 edition of NFPA 70 (National Electric Code) along with applicable local codes. This document provides information pertaining to: inspections, environment, installation, and wiring. The AF-600 FP Drive User's Guide (DET - 609 or DET - 610) and the AF-600 FP Panel Operating Instructions contained in this notebook have additional information and will be referenced through out this document.

INSPECTION #1

After unpacking your control panel inspect it 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.

**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 when wiring your AF-600 FP 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.

ENVIRONMENT

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

WARNING: Failure to comply to 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. 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. All wall-mounted enclosures must be mounted on a non-flammable or heat resistant surface.

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

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

WARNING: The temperature of the inverter 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.

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.

Use 3/8-16 Hardware's for all slim line wall mount enclosures and 1/2-13 Hardware's for all Standard Wall mount and Floor mount enclosures mounting to fulfill Seismic Requirements

For NEMA 12 enclosure types, liquid tight conduit and fittings shall be installed to maintain the enclosure integrity.

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.

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.

Incoming power cables should be terminated at line side of the lugs provided with the Circuit breaker or Disconnect switch.

Locate terminals (T1, T2, and T3) in the panels and use these terminals to connect the motor wires. Depending on actual drive panel configuration, motor cables should be terminated on the load side lugs provided with the core drive (Disconnect drive or non-bypass panel without load reactor), load reactor (Disconnect drive or non-bypass panel with load reactor), contactor (non-bypass panel with load contactor) or overload relay (all Bypass contactor configurations).

For drive panels of certain HP ratings & 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. Refer to Appendix B for details for units with bus bar terminals for motor connections.

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.

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

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 (24 Vdc or less), isolation of the signal wiring 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 Bypass 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 "CTB". Please reference the appropriate wiring diagram. Torque values for connecting to "CTB" are located in the Appendices.

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 Panels require no additional control wiring to operate properly. Additional control interfacing to your Bypass & Non Bypass panels can be accomplished through the panel mounted customer terminal board "CTB". Please reference the appropriate wiring diagram. Torque values for connecting to "CTB" are located in the Appendices.

If your application requires wiring to the AF-600 FP inverter I/O control terminal board, Use 20 to 28 AWG wire.

Connections on the inverter 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.

MISCELLANEOUS INFORMATION

Refer Appendix B (Table A, B and C) for estimated watts loss of the panel.

If your enclosure is equipped with forced ventilation for keeping the inverter and other components within their thermal recommendations, the cooling fan(s) used to ventilate your enclosure also need to be cleaned periodically. Cleaning the cooling fan(s) is recommended to keep the proper amount of air circulating through the enclosure.

GE Drives recommends that all power connections be checked for proper tightness every 6 months due to thermal cycling that may occur during normal operation.

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.

**OPERATING AND TROUBLESHOOTING INSTRUCTIONS FOR
AF 600 FP BYPASS PANELS**

Your AF 600 FP Bypass Panel comes with an AF 600 FP Adjustable Frequency Drive from GE Drives mounted on or 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® Non-Fused Disconnect w/through-the-door lockable handle (or equivalent)
- ABB® 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™ Selector Switches and Pilot Lights
- GE Type IP Encapsulated or Vacuum Impregnated 115 VAC 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 (Drive inbuilt)

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

- DET - 609 *AF 600 FP User's Guide for up to 60HP @ 208V @ & up to 125HP @460/575*
- DET - 610 *AF 600 FP User's Guide for 150HP and above @ 460/575V*

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

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NOTE: *The terms drive and inverter is used interchangeably in this*

1. Operator Devices

Your Bypass panel is equipped with several panel door mounted operator devices which may include the following: one (1) through-the-door, lockable, input device disconnect handle; three (3) operator selector switches; six (6) indicator lights; and one (1) speed potentiometer. The operation of these devices is explained in this section.

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 bypass panel and AF 600 FP 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 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 inverter or drive, it is always advisable to wait at least 20 mins if not specified.

380-480V, 150-300 HP, wait at least 20 minutes

525-600V, 60 – 300 HP, wait at least 20 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 bypass 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.

Test/Isolate/Normal Selector This selector has a padlock-able clear plastic cover to allow servicing of the AF 600 FP drive when the selector is in the “Isolate” position.

WARNING: Although input power is removed from the drive in the “Isolate” position this does not guarantee that dangerous voltage levels are absent. The AF 600 FP drives contain capacitors, which can maintain dangerous voltage levels for an extended period following removal of AC input power. Details of waiting time are given above

In the "Test" position AC input power to the drive will be applied and the inverter will run at the speed dictated by the speed pot with the Hand/Off/Auto (H-O-A) switch in the "Hand" position. If the H-O-A switch is in the "Auto"

position the inverter will run at the speed dictated by the remote customer supplied reference signal (0-10 VDC or 4-20 mA). However, power will not be applied from the inverter to the motor even if the Drive/Off/Bypass selector is in the "Drive" position. The "Test" setting will also be operational when the Drive/Off/Bypass switch is in the "Bypass" position allowing the inverter to be operated without interrupting power to the motor.

In the "Normal" position AC input power to the drive will be applied and the inverter will operate according to the setting of the H-O-A and Drive/Off/Bypass switches. Power can be applied from the inverter to the motor only if the Drive/Off/Bypass selector is in the "Drive" position.

Drive/Off/Bypass Selector

The setting of this selector switch determines whether power to the motor will be from the adjustable frequency drive ("Drive" position) or directly from the AC line ("Bypass" position). This selector can be changed "on-the-fly" without first completely stopping the motor. However, when changing from "Drive" to "Bypass" mode a short delay is required to be inserted by the operator (approximately 10 seconds) to allow time for the motor's rotor flux to decay prior to applying AC line power. If your panel includes the optional "automatic bypass" functionality the operator can switch directly from "Drive" to "Bypass" with pausing in the "Off" position. The required time delay is automatically inserted to allow time for the motor's flux to decay.

CAUTION: Please see the instructions in the "Adjustments" section of this manual regarding the setting of this time delay. An improper setting could result in damage to your motor and/or driven equipment.

When changing from "Bypass" to "Drive" mode the drive will utilize the inherent catch-a-spinning motor feature for a smooth transfer.

If your bypass panel is configured for automatic switchover, then in the event of a drive fault during "Drive" operation the panel's control logic will automatically transfer the motor from drive to bypass (i.e.: across-the-line) operation.

NOTE: *In the event of a drive fault the motor will continue to operate in bypass mode as long as the AF 600 FP drive's fault output stays in the energized state. This means that if the Test/Isolate/Normal switch is moved to the "Isolate" position that the motor will stop since removal of drive power will cause the fault output to de-energize. Therefore, if it is desired to service the drive without interruption of power to the motor, turn the Drive/Off/Bypass selector to the "Bypass" position prior to removing power from the drive.*

Hand/Off/Auto Selector

This selector is also referred to as the H-O-A switch. In the “Off” position power will be removed from the motor in both bypass and drive modes of operation. It should be noted that this will not cause AC input power to be removed from the drive. To remove drive input power the Test/Isolate/Normal switch, If Provided should be placed in the “Isolate” position.

In “Hand” mode, power will be applied to the motor from either the drive or the AC line according to the Drive/Off/Bypass selector. In this mode the inverter’s frequency reference is determined by the position of the speed pot on the panel if ordered.

In “Auto” mode, power will be applied to the motor only when a connection is made between the two remote run contacts on the customer terminal board inside the panel enclosure. In this mode the inverter’s frequency reference is determined by a customer supplied 0-10 VDC or 4-20 mA signal.

Hand - Off - Auto on Drive Keypad

All AF-600 FP Drive Panels include a keypad for programming and operation of the drive and includes Hand, Off, and Auto operation keys / buttons. When shipped from the factory, the Hand, Off and Auto buttons are enabled . Pressing the Off button while the drive is running will cause the drive to decelerate and shut off regardless of the positions of the panel’s selector switches. To resume normal operations (that is control the unit from its selector switches and analog signal) press the Auto Button one time.

For more details on the Hand, Off, and Auto operation keys, refer to manuals DET-620



WARNING: Enabling and using the Hand operation key may cause control inputs to drive to be ignored and may result in unintended operations / starting of the drive unit.

Emergency Stop

This operator is used to shut off the panel output in case of Emergency. To restart the panel, Reset the E-stop by turn to release.

Power On Indicator

This white light on the panel door indicates that the circuit breaker/disconnect switch is closed and that AC power is present at the panel input terminals. Absence of light from this indicator when it should be on may indicate the presence of a blown fuse(s) on the primary or secondary of the control power transformer or a blown bulb.

Normal Indicator

This operator and functionality is only available on the 3 Contactor Bypass Panel.

This green light on the panel door indicates that AC input power is being applied to the drive input terminals. This indicating light will energize when the input contactor is energized and the Test/Isolation/Normal switch is in “Normal.



Enable Indicator

This clear light on the panel door indicates that the customer interlock circuit is closed and the system is ready for the motor to be energized. Note, with the customer safety interlock circuit open the panel will not allow output power to the motor in either "Bypass" or "Drive".

Motor Overload Indicator

This red light on the panel door indicates that the Class 20/30 motor overload (OL) relay has actuated to protect the motor from damage due to excessive current for an extended period of time. Actuation of the OL relay will automatically cause power to be removed from the motor regardless of the positions of the H-O-A and Drive/Off/Bypass selectors. The GE C-2000™ OL relay in your panel can be set for either manual or automatic reset. It is shipped for manual reset, which means that the red button on the front of the OL relay will have to be pressed to turn off the OL indicator and reapply power to the motor. If desired that the motor restart automatically when the OL relay has cooled down sufficiently, following an overload condition, then set the relay for automatic reset. However, please note that the motor could restart at any time without warning if the settings of the front panel selector switches still call for a run condition.

CAUTION: Frequent activation of the motor overload relay may indicate a problem with the ratings of your motor and/or drive panel components relative to the nature of the driven load. Since an improper setting of the overload relay could result in damage to the motor, please see the "Adjustments" section in these instructions for details on the setting of the overload relay dial.

Bypass Run Indicator

This blue light on the panel door indicates that the bypass contactor is energized and therefore that 50 or 60 cycle AC line power is being applied to the motor. In order for this to happen the Drive/Off/Bypass selector must be in the "Bypass" position and the H-O-A switch must be in either the "Hand" or "Auto" positions (if "Auto" then remote run contacts must also be closed). Note that bypass operation can also occur in "Drive" mode if the drive has tripped due to a fault and the panel is configured with the optional automatic bypass functionality. Note, included with the optional automatic bypass functionality there is an intentional time delay inserted following a change from operating from the inverter prior to bypass operation to allow time for the motor's rotor flux to decay.

CAUTION: Please reference the instructions in the "Adjustments" section of this manual regarding the setting of this time delay. An improper setting could result in damage to your motor and/or driven equipment.

Drive Run Indicator

This optional green light on the panel door indicates that the drive output contactor is energized and the drive will output power to the motor. The conditions that will cause this light to become energized are; Drive/Off/Bypass and Test/Isolate/Normal switches are in the "Drive" and "Normal" positions



Without the drive reporting a fault condition. Note that this light only means that the drive output contactor is energized and the panel is operating in “Drive” mode. If the motor’s shaft is not rotating then it may be due to 1) no run command provided to the drive (i.e. H-O-A switch in the “Off” position) 2) No Speed ref.

Drive Fault Indicator

This optional orange light on the panel door indicates that the inverter is reporting a fault condition. If your panel was ordered with the optional automatic bypass functionality the panel will automatically switchover to “Bypass” mode of operation following an inverter fault trip.

2. Customer Terminal Board – “CTB”

Inside the panel enclosure there is terminal board for convenient connection of customer control wiring. The customer interface drawing provides a visual reference of the terminal board positions with the detailed descriptions as follows:

CTB1-1 through CTB1-3

Customer safety interlocks. Put normally closed contacts between CTB-1 and CTB-3. CTB-2 and CTB-3 provide an additional connection point if required. An open circuit between these positions will cause the bypass and drive output contactors to drop out resulting in power being removed from the motor. These positions come jumpered together from the factory and require removal of the factory jumpers prior to connecting customer normally closed contacts.

WARNING: When the circuit breaker/disconnect handle is turned to the “On” position, terminal board positions CTB-1 through CTB-3 can be at 115 VAC with respect to ground. Therefore, prior to making any connections to these points lock the disconnect handle in the “Off” position. In fact, good safety practice dictates that prior to servicing any electrical equipment that all sources of electrical energy be disconnected and “locked out” to avoid reconnection by a third party unaware of the maintenance efforts underway.

NOTE: One apparent exception to the above rule would be the need to service the AF 600 FP drive while running in bypass mode. The padlock-able Test/Isolate/Normal switch satisfies this need. This switch comes with a padlock-able clear plastic cover that maintenance personnel can “lock out” to ensure the switch stays in the “Isolate”

CTB1-4 through CTB1-5

Provides customer with “drive ready to run” status via contact closure. Panel conditions that provide contact closure are; 1) drive output contactor is energized with drive not faulted and 2) drive has been issued a run command. Typical use for this status is “drive enabled” ready for speed reference to output power to the motor. Contacts are rated 5A @ 240V AC, 24 VDC.

CTB1-6 through CTB1-7

Put normally open remote run contacts between CTB-6 and CTB-7. Closure between these positions is required for the motor to run in either inverter or bypass modes when the H-O-A switch is in the “Auto” position. The positions come jumpered together from the factory.

CTB1-35 through CTB1-36

Put normally open remote bypass contacts between CTB1-35 and CTB1-36. Closure between these positions allow for remote bypassing the drive in the event of a drive fault. After the drive reports a fault condition a minimal time delay of 10 seconds is necessary by the operator prior to closing the remote bypass contacts and bypassing the drive. DO NOT jumper CTB-8 and CTB-9 together.

CAUTION: Jumpering CTB1-35 and CTB1-36 together will not allow for motor flux to decay prior to applying AC line power to the motor in the event of a drive fault. The absence of the 10-second time delay can result in a devastating torque pulse which can damage your motor, driven load and/or installation. The AF 600 FP & Bypass panel does not have a line synchronizing function to permit a smooth switchover to AC line power, therefore a time delay is the only way to ensure a safe transition.

- CTB1-10 through CTB1-12** Provides customer with a drive fault status via contact closure. Contacts are rated 5A @ 240V AC, 24V DC.
- CTB1-13 through CTB1-15** Provides customer with a drive running status via contact closure. Contacts are rated 120/208 VAC or 30 VDC, 5 A.
- CTB1-25 through CTB1-26** Place normally open contacts between CTB1-25 and CTB1-26. Closure between these contacts cause the motor to run at a preset speed (speed programmed by function code C20) or from the AC input power. The preset speed command is issued if the Drive/Off/Bypass and Test/Isolate/Normal selector switches are in "Drive" and "Normal" mode of operation, regardless of the H-O-A switch position. If the Drive/Off/Bypass selector switch is the "Off" position the motor will not run. A typical use for this input is a smoke purge command.
- CTB1-8 through CTB1-9** These positions come with a jumper from the factory to allow testing of the drive with the Test/Isolate/Normal selector switch. When the Test/Isolate/Normal switch is placed in the "Test" position, AC input power will be applied to the drive and it will run at a speed determined by the speed pot or the "Auto" speed reference, depending on the position of the H-O-A switch. However, some inverter function codes can not be changed with a run command issued to the drive. Therefore removal of this jumper and the Test/Isolate/Normal switch in the "Test" mode allows all function codes to be accessible.
- CTB1-20 through CTB1-22** Connect customer supplied 0-10 VDC or 4-20 mA "Auto" speed reference signal. This signal functions as the drive's speed reference when the H-O-A switch is in the "Auto" position. If utilizing a 0-10 VDC signal, CTB1-20 and CTB1-22 are to be used. If utilizing a 4-20 mA signal, CTB1-20 and CTB1-21 are to be used. CTB1-20 is the common terminal for either input signal. See the customer interface diagram for details.
- CTB1-31 through CTB1-32** These positions come with a jumper from the factory. Put normally open enable contacts between CTB1-31 and CTB1-32. Closure between the contacts is required for the motor to run in either drive or Bypass mode.
- CTB1-33 through CTB1-34** Smoke Purge circuit
- CTB1-27 through CTB1-28** Analog output 0/4 – 20mA.

NOTE: 4-20 mA output signal will be available from the drive at terminal 39 and 42, which is wired for customer to terminal board



With Smoke purge option, After C20 Procedure follow below instruction

Main menu

Parameter data set...with down arrow

Ok

E - ## Digital In/Out

Ok

E-0 # Digital Inputs

OK

Down arrow – 5 times

Ok

SET TO [14] Jog

Ok

3. AF 600 FP Drive Terminal Board I/O

Any of the AF 600 FP 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 AF 600 FP User's Guide (DET609 – For up to 60HP@208V and up to 125HP@460/575V or DET610 – For 150HP and above @ 460/575V) which is supplied with your panel documentation package. However there are several I/O points, which will find frequent use in bypass panel applications that they are described below for convenience.

Relay 1 – 01,02,03	Normally open inverter fault contacts. These contacts are utilized to energize an interposing relay for bypass panel control logic and to provide customers with a drive fault status via higher rated normally open contacts than those inherent to the drive. The drive fault status is available on the customer terminal board "CTB1".
Relay 2 – 04,05,06	Normally open programmable contacts. These contacts have been configured to provide a drive running status for customer use. This status is then used to energize an interposing relay to provide customers with drive running status via higher rated normally open contacts than those inherent to the drive. The drive running status is available on the customer terminal board "CTB1".
20, 21, 22, 50,53, 55	Used for drive speed reference inputs. When the H-O-A switch is in the "Hand" position the speed pot is utilized. The speed pot is connected to points 50, 53, and 55. When the H-O-A switch is in the "Auto" position the customer supplied 0-10 VDC or 4-20 mA signal is 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

4. Adjustments

The AF 600 FP & Bypass 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 AF 600 FP & Bypass panel. The user may wish to have a copy of NFPA 70-2008 (commonly known as the National Electric Code or simply NEC) available for reference when setting these adjustments.

Input Fuses

Main input fuses are provided standard with your AF 600 FP & Bypass 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 inverter 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 inverter 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 inverter'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.

Circuit Breaker Trip Level

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 AF 600 FP & Bypass 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.

Motor Overload Trip Level

The overload relay in your AF 600 FP & Bypass 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 $30 \times 0.90 = 27.0$ A*

CAUTION: For all AF 600 FP Bypass 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 (indicated by the red "Motor Overload" light coming on), 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 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 time of the OLs 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.

Inverter-to-Bypass Delay

The AF 600 FP bypass panels come standard with manual bypass functionality only. 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 go down.

CAUTION: Failure to insert enough time delay between operation of the motor from the inverter 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 drive 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 bypass 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. For panels rated 30Hp and below at 208 VAC plus 75Hp and below at 460 VAC & 575 VAC a C-2000™ electronic timer mounted on top of the bypass contactor (M3). This timer is factory set for a 5-second delay and can be easily adjusted via a small flat blade screwdriver. For panels greater than 30Hp at 208 VAC and greater than 75Hp at 460 VAC & 575 VAC a separately mounted time delay relay is provided to insert the required delay. This timer is factory set for a 10-second delay and can be easily adjusted via manually turning the dial on the face of the relay. If it is desired to change the delay setting when transitioning from drive to bypass mode then consult with the manufacturer of your motor and adjust the time delay accordingly.



5. AF 600 FP Drive Function Code Changes

The AF 600 FP Adjustable Frequency Drive has programmable function. A complete description of these function codes can be found in DET – 609 or DET – 610. The purpose of this section is to identify those function codes which changed from the factory defaults for bypass panel installation.

Live Zero Time Out Time	(AN00)	Set to "10" seconds
Live Zero Time Out Function	(AN01)	Set to "3" Jogging
Terminal 53 Live Zero	(AN17)	Set to "0" Disabled
Terminal 54 Live Zero	(AN27)	Set to "1" Enabled
Jog Speed	(C20)	Set to "50" Hz
Frequency Command 2	(C30)	Set to "2" Analog Input 54
Terminal 27 Digital Input	(E03)	Set to "2" Coast inverse
Terminal 32 Digital Input	(E05)	Set to "14" Jog
Terminal 33 Digital Input	(E06)	Set to "6" Stop Inverse
Relay 1	(E24)	Set to "9" Alarm
Relay 2	(E24)	Set to "5" Running
Electronic Overload	(F10)	Set to "4" Elec OL Trip 1
Motor Thermistor Input	(F12)	Set to "0" None
Auto-Reset (Times)	(H04)	Set to "13" Infinite Auto Reset

Drive Programming

Loss of reference control – Run at preset speed

Main Menu

Parameter data set

Down arrow

AN - ##

OK



AN - 0 #

OK

AN - 00 TIME [Loss of ref time]

10 Sec - Default

AN - 01 - TIME OUT FUNCTION

[3] Jogging

Jog frequency setup

Main Menu

Parameter data set

Down arrow

C - ##

OK

C - 0 #

Down arrow

C - 2 #

OK

C - 20 Jog speed in Hz

50Hz - Default

For Smoke purge option, follow below procedure to program the drive

After C20 Procedure

Main Menu

Parameter data set.... With down arrow

Ok

E-## Digital In/out

Ok



E-0 # Digital Inputs

Ok

5 Times downward arrow

Ok

SET TO [14] JOG

Ok

Auto-Tune

In the event that it is desired to “auto-tune” the drive to the connected motor, reference the following instructions along with the AF 600 FP User’s Guide (DET – 609 or DET - 610):

With power applied to the panel –

- 1) Place the Test/Isolate/Normal, Hand/Off/Auto, and Drive/Off/Bypass selector switches in the “Normal”, “Off”, and “Drive” positions respectively.
- 2) For Full Auto tuning follow the instruction below

Quick Menu

Ok

Quick start

Ok

Once Up arrow

Ok

P-04 Auto Tuning

Ok

[1] Full Auto tune

Ok

Follow the Keypad direction

Note: If the panel has a load reactor, select “Reduced Auto tune”.

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.

**OPERATING AND TROUBLESHOOTING INSTRUCTIONS FOR
AF-600 FP NON BYPASS & DISCONNECT DRIVE PANELS**

Your AF-600 FP NON Bypass & Disconnect Drive Panels comes with an AF-600 FP Adjustable Frequency Drive from GE Drives mounted on or in an enclosure, which contains the following equipment to control motor operation from the drive.

- ABB® Non-Fused Disconnect w/through-the-door lockable handle (or equivalent)
- ABB® Fused Disconnect w/through-the-door lockable handle (optional) (or equivalent)
- 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 (optional)
- GE *C-2000™* Class 20/30 Fixed Heater Motor Overload Relays (optional)
- GE *C-2000™* Selector Switches and Pilot Lights
- GE Type IP Encapsulated or Vacuum Impregnated 115 VAC Control Power Transformer w/fuses
- Busman/ Ferraz Shawmut *Amp-trap®* Time-Delay Class J Fuses (or equivalent)
- GE Line Reactors (optional)
- GE Load Reactors (optional)
- GE DC Link Reactors (Drive inbuilt)
- MTE Line or Load reactor

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

DET - 609 *AF 600 FP User's Guide for up to 60HP @ 208V @ & up to 125HP @460/575*
DET - 610 *AF 600 FP User's Guide for 150HP and above @ 460/575V*

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

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NOTE: *The terms drive and inverter is used interchangeably in this*

1. Operator Devices

Operator Devices for Disconnect Drive – The following section does not apply to the Disconnect Drive Panels. All door mounted operator functions and annunciations are provided through the drive’s keypad.

Your panel is equipped with several panel door mounted operator devices which may include the following: one (1) through-the-door, lockable, input device disconnect handle; two (2) operator selector switches; five (5) indicator lights; and one (1) speed potentiometer. The operation of these devices is explained in this section.

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 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 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 inverter or drive, it is always advisable to wait at least 20 mins if not specified.

380-480V, 150-300 HP, wait at least 20 minutes

525-600V, 60 – 300 HP, wait at least 20 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.

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.

Hand/Off/Auto Selector

This selector is also referred to as the H-O-A switch. In the “Off” position the drive will stop outputting power the motor.

In “Hand” mode, power will be applied to the motor through the drive and in this mode the inverter’s frequency reference are determined by the setting of the drive’s keypad or by the position of the speed pot on the panel if ordered.

In “Auto” mode, power will be applied to the motor only when a connection is made between the two remote run contacts on the customer terminal board inside the panel enclosure. In this mode the inverter’s frequency reference is determined by a customer supplied 0-10 VDC or 4-20 mA signals.

Hand - Off - Auto on Drive Keypad

All AF-600 FP Drive Panels include a keypad for programming and operation of the drive and includes Hand, Off, and Auto operation keys / buttons. When shipped from the factory, the Hand, Off and Auto buttons are enabled. Pressing the Off button while the drive is running will cause the drive to decelerate and shut off regardless of the positions of the panel's selector switches. To resume normal operations (that is control the unit from its selector switches and analog signal) press the Auto Button one time.

For more details on the Hand, Off, and Auto operation keys, refer to manuals DET-620



WARNING: Enabling and using the Hand operation key may cause control inputs to drive to be ignored and may result in unintended operations / starting of the drive unit.

Emergency Stop

This operator is used to shut off the panel output in case of Emergency. To restart the panel, Reset the E-stop by turn to release.

Power On Indicator

This white light on the panel door indicates that the circuit breaker/disconnect switch is closed and that AC power is present at the panel input terminals. Absence of light from this indicator when it should be on may indicate the presence of a blown fuse(s) on the primary or secondary of the control power transformer or a blown bulb.

Enable Indicator

This clear light on the panel door indicates that the customer interlock circuit is closed and the system is ready for the motor to be energized. Note, with the customer safety interlock circuit open the panel will not allow output power to the motor in either "Bypass" or "Drive".

Drive Run Indicator

This optional green light on the panel door indicates that the drive is running and outputting power to the motor.

Drive Fault Indicator

This optional orange light on the panel door indicates that the inverter is reporting a fault condition.

2. Customer Terminal Board – “CTB”

The following section does not apply to the Disconnect Drive Panels. All customer terminations for control wiring are made on the drive’s connections. Refer to product user guide for details.

Inside the panel enclosure there is a terminal board for convenient connection of customer control wiring. The customer interface drawing provides a visual reference of the terminal board positions with the detailed descriptions as follows:

CTB1-1 through CBT1-3 Customer safety interlocks. Put normally closed contacts between CTB1-1 and CTB1-3. CTB1-2 and CTB1-3 provide an additional connection point if required. An open circuit between these positions will cause the drive output to stop and/or drive output contactor to drop out resulting in power being removed from the motor. These positions come jumpered together from the factory and require removal of the factory jumpers prior to connecting customer normally closed contacts.

WARNING: When the circuit breaker/disconnect handle is turned to the “On” position, terminal board positions CTB1-1 through CTB1-3 can be at 115 VAC with respect to ground. Therefore, prior to making any connections to these points lock the disconnect handle in the “Off” position. In fact, good safety practice dictates that prior to servicing any electrical equipment that all sources of electrical energy be disconnected and “locked out” to avoid reconnection by a third party unaware of the maintenance efforts underway.

CTB1-4 through CTB1-5 Provides customer with “drive ready to run” status via contact closure. Panel conditions that provide contact closure are; 1) drive output contactor is energized with drive not faulted and 2) drive has been issued a run command. Typical use for this status is “drive enabled” ready for speed reference to output power to the motor. Contacts are rated 5A @ 240V AC, 24 VDC.

CTB1-6 through CTB1-7 Put normally open remote run contacts between CTB-6 and CTB-7. Closure between these positions is required for the motor to run when the Hand/Off/Auto switch is in the “Auto” position. The positions come jumpered together from the factory.

CTB1-10 through CTB1-12 Provides customer with a drive fault status via contact closure. Contacts are rated 5A @ 240V AC, 24 VDC.

CTB1-13 through CTB1-15 Provides customer with a drive running status via contact closure. Contacts are rated 5A @ 240V AC, 24 VDC

CTB1-14 through CTB1-15 Place normally open contacts between CTB-14 and CTB-15. Closure between these contacts cause the motor to run at a preset speed (speed programmed by function code C20) from the drive. A typical use for this input is a smoke purge command.



CTB1-27 through CTB1-28 Analog Output 0/4-20 mA.

NOTE: 4-20 mA output signal will be available from the drive at terminal 39 and 42, which is wired for customer to terminal board CTB1-27 and CTB1-28.

CTB1-20 through CTB1-22 Connect customer supplied 0-10 VDC or 4-20 mA "Auto" speed reference signal. This signal functions as the drive's speed reference when the H-O-A switch is in the "Auto" position. If utilizing a 0-10 VDC signal, CTB1-20 and CTB1-22 are to be used. If utilizing a 4-20 mA signal, CTB1-20 and CTB1-21 are to be used. CTB1-20 is the common terminal for either input signal. See the customer interface diagram for details

CTB1-31 through CTB1-32 These positions come with a jumper from the factory. Put normally open enable contacts between CTB1-31 and CTB1-32. Closure between the contacts is required for the motor to run in either drive or Bypass mode.

CTB1-33 through CTB1-34 Smoke Purge circuit.

With Smoke purge option, After C20 Procedure follow below instruction

Smoke purge option is not available in Disconnect Drive Panels

Main menu

Parameter data set...with down arrow

Ok

E - ## Digital In/Out

Ok

E-0 # Digital Inputs

OK

Down arrow - 5 times

Ok

SET TO [14] Jog

Ok



3. AF-600 FP Drive Terminal Board I/O

CTB-Customer Terminal Boards are not available in Disconnect Drive panels

Any of the AF 600 FP terminal board I/O points which are not already in use for proper operation of the Non bypass panel are available for customer use. The meanings and connection diagrams for these I/O points are well described and illustrated in the AF 600 FP User's Guide (DET609 – For up to 60HP@208V and up to 125HP@460/575V or DET610 – For 150HP and above @ 460/575V) which is supplied with your panel documentation package. However there are several I/O points, which will find frequent use in Non bypass panel applications that they are described below for convenience.

Relay 1 – 01,02,03	Normally open inverter fault contacts. These contacts are utilized to energize an interposing relay for bypass panel control logic and to provide customers with a drive fault status via higher rated normally open contacts than those inherent to the drive. The drive fault status is available on the customer terminal board "CTB1".
Relay 2 – 04,05,06	Normally open programmable contacts. These contacts have been configured to provide a drive running status for customer use. This status is then used to energize an interposing relay to provide customers with drive running status via higher rated normally open contacts than those inherent to the drive. The drive running status is available on the customer terminal board "CTB1".
20, 21, 22, 50,53, 55	Used for drive speed reference inputs. When the H-O-A switch is in the "Hand" position the speed pot is utilized. The speed pot is connected to points 50, 53, and 55. When the H-O-A switch is in the "Auto" position the customer supplied 0-10 VDC or 4-20 mA signal is 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	Modbus RTU / RS485 port
39,42	Analog output

4. Adjustments

The AF-600 FP 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 panel, wiring, and motor are adequately protected. The following list comprises all of the user adjustable devices/components inside the AF-600 FP, Bypass & Disconnect Drive Panels. The user may wish to have a copy of NFPA 70-2008 (commonly known as the National Electric Code or simply NEC) available for reference when setting these adjustments.

Input Fuses

Main input fuses are provided standard with your AF-600 FP, Bypass & Disconnect Drive Panels. 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 panel has been closely coordinated to provide short circuit protection for the inverter.

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 the input fuse amp rating is less than or equal to the actual motor FLA * 1.75. 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 panel may be the fuse holder. The appendices provide a table for the maximum fuses size permitted in the existing fuse holder. If these fuses shall ever need to be replaced, refer for rating label located on the back of panel cover.

Circuit Breaker Trip Level

The optional circuit breaker in the AF-600 FP HVAC 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.

In panels not requiring bypass the AF-600 FP drive essentially “soft-starts” the motor by increasing the output voltage and frequency. Therefore high motor inrush currents will not occur and should not be an issue. However, the rating plugs for the circuit breakers in the AF-600 FP 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 panel rated current and the circuit breaker still trips it is probably due to the fact that the drive has a large DC capacitor bank which requires charging upon applying AC power. The drive inherently contains a charge limiting circuit but in a very small number of circumstances, the inrush may cause the circuit breaker to trip even at a setting of 13 times the panel rating. If this is the case, 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 breakers are unfavorable.
- 4) Add an AC Line Reactor to the input of the drive, which increases input impedance and decreases the input current.



5. AF 600 FP Drive Function Code Changes

The following section does not apply to the Disconnect Drive Panels. All programmable functions are at the drive's factory defaults.

The AF 600 FP Adjustable Frequency Drive has programmable function. A complete description of these function codes can be found in DET – 609 or DET - 610. The purpose of this section is to identify those function codes which changed from the factory drive defaults for panel installation.

Live Zero Time Out Time	(AN00)	Set to "10" seconds
Live Zero Time Out Function	(AN01)	Set to "3" Jogging
Terminal 53 Live Zero	(AN17)	Set to "0" Disabled
Terminal 54 Live Zero	(AN27)	Set to "1" Enabled
Jog Speed	(C20)	Set to "50" Hz
Frequency Command 2	(C30)	Set to "2" Analog Input 54
Terminal 27 Digital Input	(E03)	Set to "2" Coast inverse
Terminal 32 Digital Input	(E05)	Set to "14" Jog
Terminal 33 Digital Input	(E06)	Set to "6" Stop Inverse
Relay 1	(E24)	Set to "9" Alarm
Relay 2	(E24)	Set to "5" Running
Electronic Overload	(F10)	Set to "4" Elec OL Trip 1
Motor Thermistor Input	(F12)	Set to "0" None
Auto-Reset (Times)	(H04)	Set to "13" Infinite Auto Reset

Drive Programming

Loss of reference control – Run at preset speed

Loss of reference control option is not available in Disconnect Drive Panels

Main Menu

Parameter data set

Down arrow

AN - ##

OK



AN - 0 #

OK

AN - 00 TIME [Loss of ref time]

10 Sec - Default

AN - 01 - TIME OUT FUNCTION

[3] Jogging

Jog frequency setup

Main Menu

Parameter data set

Down arrow

C - ##

OK

C - 0 #

Down arrow

C - 2 #

OK

C - 20 Jog speed in Hz

50Hz - Default

For Smoke purge option, follow below procedure to program the drive

Smoke purge option is not available in Disconnect Drive Panels

After C20 Procedure

Main Menu

Parameter data set.... With down arrow

Ok

E-## Digital In/out

Ok



E-0 # Digital Inputs

Ok

5 Times downward arrow

Ok

SET TO [14] JOG

Ok



6. Troubleshooting

In the event that it is desired to “auto-tune” the drive to the connected motor, reference the following instructions along with the AF-600 FP User’s Guide (DET – 609 or DET - 610):

With power applied to the panel –

- 1) Place the Hand/Off/Auto selector switches in the “Off” positions respectively. (Need to make sure the drive is energized but not in a run state)
- 2) For Full Auto tuning follow the instruction below

Quick Menu

Ok

Quick start

Ok

Once up arrow

Ok

P-04 Auto Tuning

Ok

[1] Full Auto tune

Ok

Follow the Keypad direction

Note: If the panel has a load reactor, select “Reduced Auto tune”.



AF-600 FP User's Guide

DET -609 AF 600 FP User's Guide for up to 60HP @ 208V & up to 125HP @460/575

or

DET - 610 AF 600 FP User's Guide for 150HP and above @ 460/575V

to be inserted here along with any other GEI for any options which may be included.

Appendix A – Current Ratings and Fuse Sizes

Table A	208 VAC Panel Current Ratings and Maximum Allowable Fuse Sizes
Table B	460 VAC Panel Current Ratings and Maximum Allowable Fuse Sizes
Table C	575 VAC Panel Current Ratings and Maximum Allowable Fuse Sizes
	In-Warranty Information Form

Table A

AF 600 FP Panels – 208 VAC
 Current Ratings and Maximum Fuse Sizes

VAC Panel Hp Rating	VAC Panel Current Rating	Max Allowable Fuse Size
1	4.6	10.33
2	7.5	13.13
3	10.6	18.55
5	16.7	29.23
7.5	24.2	42.35
10	30.8	53.90
15	46.2	80.85
20	59.4	103.95
25	74.8	130.90
30	88	154.00
40	115	199.50
50	143	250.25
60	170	295.75

Table B

AF 600 FP Panels – 460 VAC
 Current Ratings and Maximum Fuse Sizes

VAC Panel Hp Rating	VAC Panel Current Rating	Max Allowable Fuse Size
1	2.1	3.68
2	3.4	5.95
3	4.8	8.40
5	8.2	13.30
7.5	11	19.25
10	14.5	24.50
15	21	36.75
20	27	47.25
25	34	59.50
30	40	70.00
40	52	91.00
50	65	113.75
60	80	134.75
75	105	168.00
100	130	217.00
125	160	273.00
150	190	320.25
200	240	420.00
250	302	528.50
300	361	631.75
350	443	747.25
450	540	929.25
500	590	1032.50
550	678	1167.25
600	730	1256.50

Table C

AF 600 FP Panels - 575 VAC
 Current Ratings and Maximum Fuse Sizes

VAC Panel Hp Rating	VAC Panel Current Rating	Max Allowable Fuse Size
1	1.8	4.20
2	2.7	4.73
3	3.9	7.18
5	6.1	10.68
7.5	9	15.75
10	11	19.25
15	18	30.10
20	22	38.50
25	27	47.25
30	34	57.23
40	41	71.75
50	52	91.00
60	62	108.50
75	83	138.08
100	100	173.25
125	131	218.75
150	155	264.25
200	192	336.00
250	242	423.50
300	290	505.75
350	344	593.25
400	400	682.50
450	450	759.50
500	500	843.50
600	570	994.00
650	630	1076.25



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 Bypass OR NON Bypass OR Disconnect 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 _____ Inverter 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: **1-800-533-5885** (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.

Appendix B – Wire Sizes, Torque and Estimated Watt loss Details

Table 1	Wire Sizes and Torque Requirements for 208 VAC Panels
Table 2	Wire Sizes and Torque Requirements for 460 VAC Panels
Table 3	Wire Sizes and Torque Requirements for 575 VAC Panels
Table A	6KFP Series Bypass Configuration - Electrical Channel
Table B	6KFP Series Non-Bypass Configuration - Electrical Channel
Table C	6KFP*L Series Non-Bypass Configuration - Electrical Channel
	In-Warranty Information Form

Table - 1 (208V)

Device	AF - 600 HP Rating(s)	Minimum Wire Size	Maximum Wire Size	Required Torque
NON FUSED DISCONNECTOR AND FUSE BLOCK	2-5Hp	# 14 AWG	# 4 AWG	Note 1
	7.5-10HP	# 14 AWG	# 4 AWG	Note 1
	15-20	# 8 AWG	1/0	Note 1
	25-30	# 8 AWG	1/0	Note 1
	40-60	# 4 AWG	300 MCM	Note 1
FUSED DISCONNECTOR	1 through 15	# 10 AWG	# 3 AWG	Note 1
	20	# 14 AWG	# 2/0 AWG	Note 1
	25 through 50	# 6 AWG	# 3/0 AWG	Note 1
	60	# 2 AWG	600MCM	Note 1
Circuit Breaker	1 through 30	# 12 AWG	# 3/0 AWG	Note 1
	40 through 60	# 8 AWG	350 MCM	Note 1
Overload Relay	1 through 10	# 14 AWG	# 8 AWG	20 lb. in.
	15 through 30	# 10 AWG	# 3 AWG	50 lb. in.
	40 through 50	# 6 AWG	250 MCM	275 lb. in., Note 2
	60	# 6 AWG	350 MCM	200 lb. in., Note 2
Drive output power Terminal Board	1 through 5	# 4 AWG	# 10 AWG	16 lb.in.
	7.5 through 15	# 10 AWG	# 7 AWG	16 lb.in.
	20	# 35 AWG	# 2 AWG	40 lb.in.
	25 through 40	# 50 AWG	1/0	89 lb.in.
	50	# 95 AWG	4/0	212 lb.in.
	60	# 120 MCM	250MCM	212 lb.in.
Load Reactor (6KFP Series)	1 through 2	# 22 AWG	# 10 AWG	4.5 lb.in
	3 through 10	# 14 AWG	# 6 AWG	16 lb.in
	15 through 30	# 6 AWG	1/0	45 lb.in (6 - 4AWG), 50 lb.in (2-1/0 AWG)
	40	# 2 AWG	4/0	150 lb.in
	50 through 60	Note 2	Note 2	Note 1
Load Reactor (6KFP*L Series) - 3% Z	1 through 3	# 22 AWG	# 10 AWG	4.5 lb.in
	5	# 14 AWG	# 6 AWG	16 lb.in
	7.5	# 22 AWG	# 14 AWG	16 lb.in
	10	# 14 AWG	# 6 AWG	16 lb.in
	15 through 25	# 6 AWG	1/0	45 lb.in (6 - 4AWG), 50 lb.in (2-1/0 AWG)
	30 through 60	Note 2	Note 2	Note 1
Control Terminal Board	1 through 60	# 26 AWG	# 10 AWG	Note 1

Note (1): For unmentioned torques, Refer UL508A tables in tab "UL508A" in the same excel file

Note (2): The input and output terminals have Busbars provision for motor connections.

Table - 2 (460V)

Device	AF - 600 HP Rating(s)	Minimum Wire Size	Maximum Wire Size	Required Torque
NON FUSED DISCONNECTOR AND FUSE BLOCK	1 through 10Hp	# 14 AWG	# 4 AWG	Note 1
	15 through 30Hp	# 14 AWG	# 4 AWG	Note 1
	40 through 50Hp	# 8 AWG	1/0	Note 1
	60 through 75Hp	# 8 AWG	1/0	Note 1
	100 through 125Hp	# 4 AWG	300 MCM	Note 1
	150 through 300Hp	# 2 AWG	600 MCM	Note 1
FUUSED DISCONNECTOR	1 through 30	# 10 AWG	# 3 AWG	Note 1
	40 through 50	# 14 AWG	# 2/0 AWG	Note 1
	60 through 100	# 6 AWG	# 3/0 AWG	Note 1
	125 through 250	# 2 AWG	# 600MCM	Note 1
	300 through 500	2 X # 2 AWG	2 X 600MCM	Note 1
	550 through 600	4 X # 2 AWG	4 X 600MCM	Note 1
Circuit Breaker	1 through 75	# 12 AWG	# 3/0 AWG	Note 1
	100 through 150	# 8 AWG	350 MCM	Note 1
	200 through 350	2 X 2/0	2 X 500 MCM	Note 1
	200 through 350	#8 AWG	600 MCM	Note 1
	450 through 500	3X #3/0 AWG	3X 500 MCM	Note 1
	550 through 600	4X #250 AWG	4X 500 MCM	Note 1
Overload Relay	2 through 25	# 14 AWG	# 8 AWG	20 lb. in.
	30 through 75	# 10 AWG	# 3 AWG	50 lb. in.
	100 through 125	# 6 AWG	250 MCM	275 lb. in., Note 2
	150 through 250	# 6 AWG	350 MCM	200 lb. in., Note 2
	300	# 8 AWG	500 MCM	375 lb. in., Note 2
Drive output power Terminal Board	1 through 10	# 4 AWG	# 10 AWG	16 lb.in
	15 through 25	# 10 AWG	# 7 AWG	16 lb.in
	30 through 40	# 35 AWG	# 2 AWG	40 lb.in
	50 through 75	# 50 AWG	1/0	89 lb.in
	100	# 95 AWG	4/0	212 lb.in
	125	# 120 MCM	250MCM	212 lb.in
	150 through 200	2X2/0	2X2/0	Note 1, 2
	250 through 350	2X350 MCM	2X350 MCM	Note 1, 2
	450 through 600	4X500 MCM	4X500 MCM	Note 1, 2

Continued...

Table - 2 (460V)

Device	AF - 600 HP Rating(s)	Minimum Wire Size	Maximum Wire Size	Required Torque
Load Reactor (6KFP Series)	1 through 5	# 22 AWG	# 10 AWG	4.5 lb. in.
	7.5 through 15	# 14 AWG	# 6 AWG	16 lb. in.
	20 through 30	# 18 AWG	# 4 AWG	16 lb. in.
	40 through 75	# 6 AWG	# 1/0	45 (6 - 4AWG), 50 (2-1/0 AWG)
	100	# 2 AWG	# 4/0	150 lb. in.
	125 through 300	Note 2	Note 2	Note 1
Load Reactor (6KFP*L Series) - 3% Z	1 through 7.5	# 22 AWG	# 10 AWG	4.5 lb. in.
	10 through 25	# 14 AWG	# 6 AWG	16 lb. in.
	30 through 75	# 6 AWG	# 1/0	45 (6 - 4AWG), 50 (2-1/0 AWG)
	100 through 600	Note 2	Note 2	Note 1
Load Reactor (6KFP*L Series) - 1% Z	1 through 7.5	# 22 AWG	# 10 AWG	4.5 lb. in.
	10 through 15	# 14 AWG	# 6 AWG	16 lb. in.
	20	# 22 AWG	# 14 AWG	16 lb. in.
	25	# 14 AWG	# 6 AWG	16 lb. in.
	30 through 60	# 6 AWG	# 1/0	45 (6 - 4AWG), 50 (2-1/0 AWG)
	75 through 600	Note 2	Note 2	Note 1
Control Terminal Board	2 through 300	# 26 AWG	# 10 AWG	Note 1

Note (1): For unmentioned torques, Refer UL508A tables in tab "UL508A" in the same excel file

Note (2): The input and output terminals have Busbars provision for motor connections.

Table - 3 (575V)

Device	AF - 600 HP Rating(s)	Minimum Wire Size	Maximum Wire Size	Required Torque
NON FUSED DISCONNECTOR AND FUSE BLOCK	1 through 10Hp	# 14 AWG	# 4 AWG	Note 1
	15 through 40Hp	# 14 AWG	# 4 AWG	Note 1
	50 through 60Hp	# 8 AWG	1/0	Note 1
	75 through 100Hp	# 8 AWG	1/0	Note 1
	125 through 150Hp	# 4 AWG	300 MCM	Note 1
	200 through 300Hp	# 2 AWG	600 MCM	Note 1
FUSED DISCONNECTOR	1 through 40	# 10 AWG	# 3 AWG	Note 1
	50 through 60	# 14 AWG	# 2/0 AWG	Note 1
	75 through 125	# 6 AWG	# 3/0 AWG	Note 1
	150 through 300	# 2 AWG	600MCM	Note 1
	350 through 650	2 X # 2 AWG	2 X 600MCM	Note 1
Circuit Breaker	1 through 75	# 12 AWG	# 3/0 AWG	Note 1
	100 through 200	# 8 AWG	350 MCM	Note 1
	250 through 450	2 X 2/0	2 X 500 MCM	Note 1
	250 through 450	#8 AWG	600 MCM	Note 1
	500 through 650	3X #3/0 AWG	3X 500 MCM	Note 1
Overload Relay	2 through 25	# 14 AWG	# 8 AWG	20 lb. in.
	30 through 75	# 10 AWG	# 3 AWG	50 lb. in.
	100 through 150	# 6 AWG	250 MCM	275 lb. in. Note 2
Drive output power Terminal Board	1 through 10	# 4 AWG	# 10 AWG	16 lb.in
	15 through 25	# 16 AWG	# 6 AWG	16 lb.in
	30 through 50	# 35 AWG	#2 AWG	40 lb.in
	60 through 75	# 50 AWG	1/0	89 lb.in
	100	# 95 AWG	4/0	212 lb.in
	125	150MCM	250MCM	212 lb.in
	150 through 200	2x2/0	2x2/0	Note 1, 2
	250 through 400	2x350MCM	2x350MCM	Note 1, 2
450 through 650	4x500MCM	4x500MCM	Note 1, 2	

Continued...

Table - 3 (575V)

Device	AF - 600 HP Rating(s)	Minimum Wire Size	Maximum Wire Size	Required Torque
Load Reactor (6KFP Series)	1 through 5	# 22 AWG	# 10 AWG	4.5 lb. in.
	7.5 through 20	# 14 AWG	# 6 AWG	16 lb. in.
	25 through 40	# 18 AWG	# 4 AWG	16 lb. in.
	50 through 100	# 6 AWG	1/0	45 (6 - 4AWG), 50 (2-1/0 AWG)
	125	# 2 AWG	4/0	150 lb. in.
	150	Note 2	Note 2	Note 1
Load Reactor (6KFP*L Series) - 3% Z	1 through 10	# 22 AWG	# 10 AWG	4.5 lb. in.
	15 through 20	# 14 AWG	# 6 AWG	16 lb. in.
	25	# 18 AWG	# 4 AWG	16 lb. in.
	30 through 75	# 6 AWG	# 1/0	45 (6 - 4AWG), 50 (2-1/0 AWG)
	100 through 650	Note 2	Note 2	Note 1
Load Reactor (6KFP*L Series) - 1% Z	1 through 10	# 22 AWG	# 10 AWG	4.5 lb. in.
	15 through 20	# 14 AWG	# 6 AWG	16 lb. in.
	25	# 22 AWG	# 14 AWG	16 lb. in.
	30	# 14 AWG	# 6 AWG	16 lb. in.
	40 through 75	# 6 AWG	# 1/0	45 (6 - 4AWG), 50 (2-1/0 AWG)
	100 through 650	Note 2	Note 2	Note 1
Control Terminal Board	2 through 300	# 26 AWG	# 10 AWG	Note 1

Note (1): For unmentioned torques, Refer UL508A tables in tab "UL508A" in the same excel file
Note (2): The input and output terminals have Busbars provision for motor connections.

UL508

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 wrench	
	Slot width - 0.047 inch or less and slot length 1/4 inch or less	Slot width - 0.047 inch or slot length - over 1/4 inch	Split bolt connectors	other connectors
18-10	20	35	80	75
8	25	40	80	75
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 screw ^a	Tightening torque, lb.in	
	Slot width of screw ^b smaller than 0.047 in	Slot width of screw ^b 0.047 in and larger
<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

Table A

6KFP Series Bypass Configuration -Electrical Channel			
HP Ratings	Estimated Watt Loss (Watts) at		
	208V	460V	575V
2	58	58	64
3	58	58	64
5	58	58	64
7.5	58	58	64
10	58	58	64
15	70	58	67
20	70	70	81
25	70	70	82
30	70	70	86
40	121	121	59
50	122	121	143
60	122	121	153
75	-	198	236
100	-	201	249
125	-	201	249
150	-	223	289
200	-	223	-
250	-	223	-
300	-	223	-

Table B

6KFP Series Non-Bypass Configuration -Electrical Channel			
HP Ratings	Estimated Watt Loss (Watts) at		
	208V	460V	575V
2	225	181	187
3	266	192	216
5	373	232	290
7.5	488	366	374
10	540	450	448
15	739	517	499
20	966	642	666
25	1133	764	734
30	1261	821	797
40	1863	1090	987
50	2034	1208	1147
60	2422	1336	1331
75	-	1719	1696
100	-	2101	2074
125	-	2256	2228
150	-	4283	4083
200	-	4977	-
250	-	5902	-
300	-	6770	-

Table C

6KFP*L Series Non-Bypass Configuration - Electrical Channel			
HP Ratings	Estimated Watt Loss (Watts) at		
	208V	460V	575V
2	71	68	71
3	101	86	86
5	79	86	91
7.5	111	93	93
10	130	107	93
15	147	130	107
20	172	139	130
25	147	139	101
30	201	142	140
40	380	208	187
50	380	248	198
60	443	248	193
75	-	299	257
100	-	369	373
125	-	369	368
150	-	4014	3902
200	-	4644	4430
250	-	5372	5332
300	-	6369	6247
350	-	7182	7141
400	-	-	7682
450	-	9623	8106
500	-	9701	9140
550	-	10997	-
600	-	11601	10852
650	-	-	10852