INSTRUCTIONS

GEK-24999B

AF-400*

AC-Adjustable Speed Drive
10—60 HP, 230V, 10—100 HP, 460V, 3 Phase, 60/50 Hz

Digital/Analog Driver — 2 to 1 Constant HP Range

INSTALLATION

DESCRIPTION

START—UP

TROUBLESHOOTING

MAINTENANCE

These instructions do not purport to cover all details or variations in equipment nor 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 General Electric Company

GENERAL ELECTRIC

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GEK-24999B
Errata Sheet No. 1
June, 1990

GE Drive Systems

INSTRUCTIONS

AF-400
ADJUSTABLE SPEED DRIVES

This Errata Sheet affects GEK-24999B; it should be attached inside the front cover and retained as a portion of that publication. The book's text should be changed with the following information.

SUBSTITUTE ON PAGE 21 -- V/HZ-VOLTS/HERTZ
Operate the drive at a reference of 12 volts at driver TB2(32) to TB2(48) (reading of 12 volts on Meter card position 2). Adjust the V/Hz potentiometer to obtain a DC link voltage between P2 and N2 of 236 volts DC for 230 volt AC drives and 472 volts DC for 460 volt AC drives. This corresponds to 11.7 reading on Meter card position 4.

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GENERAL

INTRODUCTION

This instruction manual is structured around a basic core drive. It is a guide for the installation, checkout and operation of the equipment furnished with general troubleshooting procedures for the basic drive.

It is designed for the installation or maintenance electrical technician or engineer. In order to use the manual effectively, the individual must be familiar with basic electronic terms and concepts and be able to use the required test equipment effectively.

Any special purpose equipment, as requested on the order, will normally be covered in the schematic drawings included with this package. These instructions do not purport to cover all details or variations in the equipment nor to provide for every possible contingency to be met in connection with the installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to General Electric Company.

RECEIVING

The equipment should be placed under adequate cover immediately upon receipt as packing is not suitable for out-of-doors or unprotected storage.

All equipment is factory inspected before shipment and is shipped in good condition. Any damages or shortages evident when the equipment is received must be immediately reported to the commercial carrier who transported the equipment. If required, assistance may be received from General Electric Company, Speed Variator Products Operation, Erie, PA. When seeking assistance, please use the purchase order number, requisition number, and model number to help us in assisting you. ***Telephone 814—455-3219.***

HANDLING

Power units can be transported by lift trucks with the forks completely under the wooden shipping base. Crane lifting eyelets are supplied on the top of the unit for handling by a crane. A spreader bar must be used when lifting from above.

WARNING

IMPROPER LIFTING PRACTICES CAN CAUSE SERIOUS OR FATAL INJURY.

LIFT ONLY WITH ADEQUATE EQUIPMENT AND TRAINED PERSONNEL.

STORAGE

This equipment may be stored at an ambient temperature of -20°C to +40°C for a period of up to one year. Air must be free of chemical and electrically conductive contaminations, and other conditions must be such that no moisture condensation occurs in or on the equipment.

In addition, when a drive that has been in operation is shut down for either a short or extended period of time, it is recommended the environmental conditions be maintained the same as when in operation.

It is recommended that space heaters or equivalent devices be used to maintain the equipment in its normal operating environment (temperature).

The electrolytic filter capacitors require "forming" after a six month or longer storage period without being energized. It is necessary to form the capacitors to prevent excessive leakage which can result in capacitor failure. The procedure for forming the filter capacitor is given in step 13 of the Start-up Instructions.

SAFETY RECOMMENDATIONS

Qualified electrical and electronics personnel should install and maintain this equipment. They should read the complete instructions prior to applying power or troubleshooting the equipment. They should heed all ***WARNING*** and ***CAUTION*** notes or labels listed in this Manual or posted on the equipment. Definitions of label terms and colors are as follows:

WARNING

DENOTES OPERATING PROCEDURES AND PRACTICES THAT MAY RESULT IN PERSONAL INJURY OR LOSS OF LIFE IF NOT CORRECTLY FOLLOWED.

COLOR: BLACK OR WHITE LETTERING ON RED FIELD.

CAUTION

DENOTES OPERATING PROCEDURES AND PRACTICES THAT, IF NOT STRICTLY OBSERVED, MAY RESULT IN DAMAGE TO, OR DESTRUCTION OF, THE EQUIPMENT.

COLOR: BLACK LETTERING ON AMBER FIELD.

INSTALLATION

LOCATION

AF-400 drive power units are suitable for most factory areas where other industrial equipment is installed. They should be installed in well-ventilated areas with ambient temperatures ranging from 10°C (50°F) to 40°C (104°F) and relative humidities up to 90%. It should be recognized, however, that since the life expectancy of any electronic component decreases with increased ambient temperature, reduction of the ambient temperature will bring about extended component life. For example, longer component life should be expected if the ambient temperature is held between 20°C (68°F) and 30°C (87°F).

Proper performance and normal operational life can be expected by maintaining a proper environment for the drive system. Environments which include excessive amounts of one or more of the following characteristics should be considered hostile to drive performance and life:

1. Dirt, dust and foreign matter.
2. Vibration and shock.
3. Moisture and vapors.
4. Temperature excursions.
5. Caustic fumes.
6. Power line fluctuations.
7. Electromagnetic interference (noise).

WARNING

NORMAL OPERATION OF THIS EQUIPMENT PRODUCES ELECTRICAL ARCING. BECAUSE OF POTENTIAL FIRE AND EXPLOSION HAZARD, THIS EQUIPMENT SHOULD NOT BE INSTALLED WHERE INFLAMMABLE OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT.

MOUNTING

POWER UNIT

The basic core power unit is a 50″ high, 24″ wide, 18″ deep panel that may be mounted in a NEMA I enclosure 60″, 76″ or 90″ high, 20″ deep along with optional components and sub-assemblies as may be required (See Figure 1).

Cases may be bolted down using 3/8″ diameter mounting bolts or studs. If studs are cast in floor, they should extend 3 1/2″ minimum above floor. Conduit entry openings through the base are fitted with removable sheet steel covers. Other conduit entry area is available through the top of the case.

CAUTION

IF CONDUIT ENTRY OPENINGS ARE TO BE CUT IN THE TOP OF THE CASE, ADEQUATE PRECAUTIONS SHOULD BE TAKEN TO PREVENT METAL PARTICLES FROM ENTERING DEVICES AND COMPONENTS.

OPERATOR'S STATION

The Operator's Station must be disassembled for mounting and wiring. First, remove the screws securing the cover to the Operator's Station enclosure and then remove the cover (with control devices mounted on the cover) from the enclosure.

When using either rigid or thin wall conduits, it is generally easier to attach the unit to the end of the conduit before locating and installing the mounting screws.

Mount the Operator's Station on any firm, reasonably flat, vertical surface by means of mounting holes in both top, back and bottom back of enclosure. The Operator's Station is suitable for either wood screws or No. 10 machine screws.

NOTE: Signal wires and power leads should be run in separate conduits. All signal wires, speed reference, instrument leads, etc., should be twisted or twisted/shielded wires with the shields connected to ground at the power unit end only.

AC MOTOR(S)

A separate instruction book is provided giving information on location and mounting of the motor(s). The motor(s) should be mounted on the driven machine (or as appropriate for the installation) before proceeding with wiring, set up and adjustment.

ELECTRICAL WIRING & INTERCONNECTIONS

All wiring shall be in accordance with the National Electrical Code and be consistent with all local codes. All internal electrical connections between components in the power units are made at the factory. When installing AF-400 drives, all connections should be checked for tightness. Connections may become loose in shipping or storage. A diagram showing the connections between the power unit and the related components is furnished with the equipment. All terminals to which the external connections are to be made are numbered on the diagram. The equipment should be wired as per the elementary diagram and verified by continuity tests. It is recommended that as each connection or wire is connected to the equipment, it may be checked off on the elementary diagram.

WARNING

IN ORDER TO REDUCE THE DANGER OF ELECTRICAL SHOCK, ALL MOTOR BASES AND EQUIPMENT ENCLOSURES SHOULD BE CONNECTED TO THE FACTORY OR FACILITY EARTH GROUNDING SYSTEM.

MOTOR CONNECTIONS

The motor leads should be connected for the drive nameplate voltage rating according to the connection diagram plate on the motor. Connecting wire sizes and motor protection should be selected in accordance with NEC Standards based on the motor(s) nameplate data. Be sure to connect motor thermal switch (if supplied) back into the drive stop circuit. Tape all motor connections.

POWER UNIT CONNECTIONS

Electrical codes generally require the use of a fused disconnect switch or circuit breaker in the AC power line ahead of the power unit and transformer (if used). The disconnect switch and fuse (or circuit breaker) should be selected in accordance with the National Electrical Code and/or local code requirements based on the power input data on the power unit nameplate. If any additional relays, solenoids, brakes, etc., are added to the system, R.C. suppression networks must be added across the coils, (.5uf in series with 220 ohms at 115/230V).

OPERATOR'S STATION CONNECTION

Using the elementary diagram, make all the required wiring connections between devices in the Operator's Station and the connections to the power unit. Reassemble the Operator's Station. Carefully dress the interconnecting wire into the back of the station so that the device assembly may be installed. Keep the wires away from sharp edges and do not force the device assembly into place. Replace the station cover and secure with cover retaining screws.

DESCRIPTION

The AF-400 drive is an adjustable frequency AC motor drive designed for industrial applications. Either single motor or multi-motor operation from a single power unit can be accomplished. Adjustment of motor speed is achieved by changing both motor frequency and voltage. This is accomplished in separate sections of the drive, since the AF-400 drive includes a variable voltage DC link type of inverter.

The various modules and components to be described are physically located in the AF-400 drive power unit as shown in Figure 1. These modules and components are also shown in the system block diagram of Figure 2. Following, is a description and operating explanation of each system block, starting with the power blocks and finishing with the control blocks.

CONVERTER MODULE

The converter module is a three-phase, full-wave controlled rectifier which converts the incoming three-phase AC power to variable voltage DC power. The six SCR converter is shown in more detail in the power circuit of Figure 3. The SCR snubber circuits (not shown) act to protect the converter SCR's against voltage transients. The converter module also contains the commutating power supply (card) and the commutating feedback circuitry described below. The converter DC output voltage can be adjusted from zero to maximum output by adjusting the firing point of each SCR relative to its AC supply phase voltage. The resultant DC output voltage, therefore, contains a six times AC supply frequency ripple component of voltage. This ripple voltage must be filtered to improve the wave-form before being applied to the inverter section.

DC LINK FILTER

An iron core reactor L1 and a bank of electrolytic capacitors C1 act as an LC filter in the DC link, as shown in Figure 3. In addition to filtering the output of the converter, it also prevents inverter commutation transients from being applied back to the converter. The C1 capacitor also acts to supply motor reactive power.

INVERTER MODULES

The three-phase inverter consists of three identical single-phase inverter modules, as shown in Figures 2 and 3. Each module consists of two inverter SCRs, two commutating SCRs, two bypass diodes and an LC commutating circuit. Output phase A (T1) of Figure 3 will be described, since all three phases operate in an identical manner, except for being displaced by 120 degrees in phase relationship. For simplicity, only phase A commutating circuit is shown.

The AC motor lead T1 is alternately connected to the positive P3 DC bus or the negative N2 DC bus, by inverter SCRs ISP or ISN respectively. The frequency at which terminal T1 is alternately connected to the two DC potentials is the fundamental frequency applied to the AC motor, which determines its speed.

Although an SCR can readily be turned on by applying a firing signal to its gate, it must be commutated off by supplying an alternate path for the current which was flowing through the SCR, and by applying a small reverse voltage to the SCR for a short period of time. This is accomplished by means of the commutating SCR's, CSP and CSN, and by the commutating reactor LC and commutating capacitor CC.

At the time when inverter SCR ISP is to be commutated off, capacitor CC is charged such that the T1 side is positive. When commutating SCR CSP is fired, the motor current flowing through ISP is diverted to the alternate path of CSP, CLP, LC, and CC due to the voltage charge on CC. When the commutating current in this alternate path exceeds the motor current, no more current exists in ISP. As capacitor CC discharges further, the excess commutating current (above the motor current level) flows through the LP and diode DP back reverse voltage across ISP to cause it to return to its blocking or off state. Therefore, for successful commutation, the commutation current must exceed the motor current for the amount of turn-off time required for the SCR. In order to minimize this time and the commutating energy required, special inverter grade SCR's are used which have a short turn-off time.

The commutating current pulse takes the form of a half-cycle sine wave because of the interaction of capacitor CC with reactor LC. After the commutating current peaks and starts diminishing, the charge on capacitor CC reverses, and the energy stored in reactor LC charges CC up in the opposite direction. At the point in time when the commutating current falls below the level of the motor current, the current in diode DP goes to zero and the potential of the T1 motor lead changes from the inverter positive bus P3 to the negative bus N2 so that diode DN can furnish the motor current. The above action occurs if the oncoming inverter SCR ISN is not fired earlier, the transition of T1 from positive to negative bus will occur earlier in the commuation interval. In any case, capacitor CC becomes charged up in the opposite direction (T1 side negative) at the end of the ISP commutation interval. It is now charged correctly to commutate off inverter SCR ISN when commutating SCR CSN is fired. This commutating action is the same as the one just described. At the end of each commutating interval, the commutating SCR is commutated off by the charge on capacitor CC producing a reverse voltage to the commutating SCR which had just been conducting.

The four-leg reactors, CLP, CLN, LP and LN act in conjunction with the SCR snubber circuits (not shown in Figure 3) to limit dv/dt and protect the SCRs against voltage transients. The leg reactors also serve to limit current if an inverter fault should occur.

The commutation losses, although small in relation to the total commutation energy, must be replaced in order to keep the commutation capacitor charged up to the proper voltage. These losses are replaced from the variable voltage DC link (P2 to N2) when it is near its maximum value. The amount of energy replaced, and thus the level of the commutation capacitor voltage, is determined by the firing point of the oncoming inverter SCR in the commutation interval. As the DC link voltage is reduced down to zero voltage, however, the commutation losses are replaced from another source, the commutation power supply.

COMMUTATION POWER SUPPLY

This card contains three diodes and two resistors (R3 and R4). It is located in the converter module (lower left hand rear). These devices are all relatively small since the commutating losses this card furnishes are a very small percentage of the drive rating.

The diodes, in Figure 3, form a three-phase, half-wave bridge which operates in conjunction with the negative SCR portion of the converter (1SN, 2SN and 3SN) to provide a constant voltage bus relative to DC link bus. This DC supply is filtered by resistor R3 and capacitor C2 and the amount of energy furnished by the commutation power supply to each inverter phase commutation circuit depends on the level of the DC link voltage and on the point in the commutation interval when the appropriate oncoming inverter SCR is fired. Since the energy loss per commutation is small, the losses are replaced only every other commutation in each phase. The driver regulates the commutating current and voltage over the whole DC link voltage operating range, irrespective of how much of the commutating losses are supplied from the commutating power supply or from the DC link.

PROTECTION AND COOLING

Drive short circuit protection is provided by current limiting fuses in the AC supply. An incoming circuit breaker can be supplied (if ordered) to provide both AC disconnection and short circuit protection.

Power unit cooling is provided by a fan which is mounted at the bottom of the power unit case, as shown in Figure 1. A thermoswitch, which opens on an overtemperature condition, is placed in the cooling air stream to detect fan failure. This switch may be connected either to shut down the drive or sound an alarm.

SYSTEM CONTROL

The system control and associated operator's devices will vary considerably depending on the application of the drive. Refer to the system elementary diagrams and instructions for description of your particular drive system.

DRIVER MODULE

The driver takes the operator and system control commands and translates them into SCR firing signals to the various power modules to obtain the commanded drive operation. It makes use of several voltage and current feedbacks to monitor the commanded operation, and to protect the drive from misoperation and fault conditons. It contains adjusting means to provide the desired operating performance. It also contains indicating lights to provide visual indication of operating or fault conditions. Finally, it provides a number of signal readouts to alert the system control of various operating and fault conditions.

The driver rack shown in Figure 1 contains five control cards plus a power supply card. The control power transformer (TX1) is located on the commutating capacitor panel directly below the ventilating fan. In addition, the optional meter card can be provided (if ordered) for drive set-up and diagnostics. All cards are plug-in type for ease of replacement. Inter-connections between driver and all power modules is by wire harnesses which plug into receptacles at both ends. Inputs and outputs are on terminal boards located on the bottom front of the commutating capacitor panel. See connection diagram for the inverter, 36D870024AA sheet 1, for inputs and outputs and for card layout and interconnections.

A functional block diagram of the driver is shown in Figure 4. A more detailed description of the driver functions on each card, plus signal flow, is given under the following card headings. Also refer to the "Driver Notes" on the driver elementary diagram for detailed information on inputs, feedbacks, adjustments, read-outs, etc.

SYSTEM CARD

The system card consists mainly of logic elements, and acts as the logic interface between the system control and the driver.

The Start-Stop logic insures that starting occurs at minimum frequency and voltage, and that acceleration to the reference input is through the timed acceleration circuit (located on the Regulator card). Stopping is accomplished by first decelerating at the set timed rate until a low voltage level is reached, at which time the inverter is stopped.

A DMF input provides a special decelerate to minimum frequency operation, from the set reference level, without stopping the inverter, the deceleration occurring at a faster than set timed rate. The AC motor can be connected to the inverter at this minimum frequency operating level without disturbance, and will then be accelerated to the reference level at the set timed rate when the DMF signal is removed.

The minimum voltage and frequency detection logic contained on this card provides an MVFR signal readout to alert the system control when this drive condition is reached. An RUNR readout provides a signal dependent on whether the inverter is operating or in a stopped condition. An IF indicating light on this card gives a visual idea of inverter operating frequency by its blinking frequency.

If a fault shutdown of the drive occurs due to any cause, the FTR readout provides a signal for the system control. Reset of the fault logic and fault indicating lights will normally occur if a normal stop operation is accomplished. However, if a separate fault reset operation is desired in addition to the STOP operation, the XFR input can be used for this purpose.

An inverse time overcurrent trip function, plus trip indicating light ITOC, is provided to shut down the drive. This operates immediately for overcurrents above 175 to 200% of rated current. For overcurrents where the current limit function on Regulator card is limiting, the shutdown will occur in 15 seconds to 1 minute after current limiting begins, depending on the overcurrent level.

If synchronization of the inverter frequency to another frequency is desired, an SYNC signal input will cause the inverter frequency to follow the external frequency signal. A digital discriminator compares the oscillator frequency with the external frequency, and provides logic signals to the Regulator card to cause the oscillator frequency to be synchronized to the external frequency in the correct phase relationship. When phase and frequency lock-in is achieved, a SYNC indicating light on the card lights and an SR inverter synchronized readout signal is provided.

A logic output, ***LG***, will change the gain of the regulator filter section to a low level when taken low. This occurs when a protecive function overrides and unlocks the Phase Locked Loop (PLL). Current limit, linear time override, slowdown control override due to high ***link*** voltage, inverter not synchronized or not started are conditions making ***LG*** low for low gain operation.

REGULATOR CARD

The Regulator card contains mainly analog regulating circuitry plus adjustment potentiometers in the driver. A midpoint control voltage level (+10 volts) is generated on this card to provide midpoint around which the internal regulating control can swing both positive and negative. However, all input and readout control signals are relative to the control power common potential.

This card accepts the analog reference input and except when this signal is clamped at zero or some other level by the start-stop or other logic on the System card, applies it to the linear timing circuit. This function provides separately adjustable timed acceleration and deceleration to or from the set reference change in either direction.

An adjustable link current limit function is provided to override the analog reference if motor current exceeds the current limit setting. This setting can be adjusted from 60% to 150% of rated drive output current. A current limit stability potentiometer CLST is adjusted depending on the motor and load inertia to obtain stable current limit operation.

The resultant RFV output signal is fed to both the voltage regulator and the frequency generator in two separate paths.

The reference to the voltage regulator is affected by the adjustment of four potentiometers. The V/Hz potentiometer provides a gain adjustment that will result in rated output voltage for a reference range of 50% to 105%. The voltage boost potentiometer, VB, adds a fixed amount of voltage irrespective of the frequency adjustable over a range from zero to 7% of rated output.

The IR compensation potentiometer, IRC, adds a variable amount of voltage proportional to the link current feedback signal, LCS. The adjustment range is zero to 10% of rated voltage with rated link current (LCS =1 volt).

The voltage limit, VLIM, limits the voltage reference to prevent the converter from phasing full on and saturating. This function is only required in the constant horsepower range where a reference increase from base to maximum frequency would otherwise increase the voltage reference past the saturation point and unbalance the stability circuit.

The voltage regulator compares this modified reference with a feedback signal proportional to converter DC output voltage which is obtained from the Converter card. The output of the voltage regulator is then fed to the Converter card as the reference signal to the phase control.

The other path of the RFV reference signal to the frequency generator is affected by the adjustment of two potentiometers and a jumper selection. The ***MINF*** potentiometer adjusts the inverter minimum frequency from 3% to 12% of set base frequency. The ***BF*** potentiometer adjusts the inverter base frequency over a minimum 2 to 1 range within either of the three base frequency ranges, 37.5 to 75 Hz, 75 to 150 Hz, or 150 to 300 Hz, selected by the jumper on the regulator card.

The frequency generator takes the analog frequency voltage signal and converts it into a pulse train whose frequency is 6 times the desired fundamental motor frequency. This frequency signal is fed to the Inverter card. The analog frequency voltage signal input to the frequency generator is also used to provide the FVR frequency voltage readout, which is a voltage signal proportional to actual inverter frequency.

The stability-slowdown control provides the following functions:

1. Provides stabilizing for motors at their underdamped operating points.
2. Overrides the frequency reference, when it calls for substantially faster than motor coast slowdown, to keep the volts/Hz applied to the motor within normal limits.
3. Provides system stabilizing during slowdown and current limit operation.
4. Provides the input to the high link voltage deflection circuit.

CONVERTER CARD

The Converter Card controls the firing of the converter SCRs to obtain the correct DC link voltage to be applied to the inverter.

The three AC supply phase voltages are fed to this card through high impedance isolating resistors contained in the wire harness. The Converter card isolating circuits produce three voltage signals equivalent in phase relationship and magnitude to the AC supply phase control to determine the correct firing points of the six converter SCRs. They are also used to detect incorrect phase sequence or loss of one or more phases, which produces a PS/LOP light indication and prevents drive operation under these conditions.

The phase control takes the Regulator card voltage regulator output and uses it in conjunction with the three AC line signals to generate the six converter SCR firing signals. These six firing signals are modulated by the firing oscillator signal from the Inverter card to produce pulse train signals, which are amplified and fed to the Pulse Transformer card in the converter power module. The actual amplified firing signals are fed from a delayed firing supply from the Inverter card which delays firing signal transmission until the control has settled down after driver energization.

The converter output voltage is fed back to this card through high impedance isolating resistors in the wire harness. The isolating circuit produces a converter voltage feedback signal which is fed to the voltage regulator on the Regulator card.

The DC link voltage applied to the inverter is also fed back through high impedance isolating resistors in the wire harness. Its isolating circuit produces a link voltage feedback signal which is fed to the stability-slowdown circuit on the Regulator card and to the minimum voltage detection logic on the System card. It is also used to detect DC link overvoltage, which produces a LOV light indication and an immediate drive shutdown.

Converter firing shutdown, after a fault is detected, occurs in two steps. The first step is an immediate phase back of firing signals to the maximum retard condition to quickly reduce converter output current to zero. The second step occurs about 0.1 seconds later when all firing signals are locked out to stop converter operation.

INVERTER CARD

The Inverter card controls the inverter commutation process and provides fault detection and inverter shutdown logic.

The six times fundamental frequency pulse train generated on the Regulator card is used to initiate each commutation interval, since there are six inverter commutation per cycle. The commutation control generates the logic signals which are fed to the Phase Logic card to accomplish the following inverter firing sequence during each commutation interval:

1. Stops firing the inverter SCR to be commutated off.

2. Fires the proper commutation SCR to begin the commutation process.

3. Initiates firing of the proper oncoming inverter SCRs at a point sometime after the midpoint of the commutation interval, dependent on the commutation current regulator.

A jumper on this card sets the correct commutation timing. This jumper must be placed in the B, 230V AC or A, 460V AC position depending on the equipment rating. For 75 and 100 KVA this jumper must be in the B position. The commutation current regulator affects the commutation interval firing in order to maintain the commutation capacitor voltage within the desired limits over the whole inverter operating range for proper SCR commutation. This is accomplished by monitoring the commutation current feedback from the Current Feedback circuit in the converter module. The current peaks are compared to a desired level and the regulator then initiates earlier or later firing of the oncoming inverter SCRs in the commutation interval to control the amount of energy added to the inverter commutation circuit. If the commutation current and voltage become too high because of excessive motor current or circuit misoperation, a commutation overcurrent detection circuit produces a COC light indication and an immediate drive shutdown.

The pulse train oscillator on this card produces a pulse frequency which is used to modulate the continuous firing signals generated on the Converter and Phase Logic cards. This supply is not energized until approximately 1 second after driver control power is applied so that the control logic can become operative before any SCR firing is possible. If the delayed firing supply voltage goes below a set level, an immediate drive shutdown is produced and the control undervoltage light CUV will light. If the main +20 volt control voltage goes below approximately 18 volts, it also produces an immediate drive shutdown and CUV light indication. In addition, the delayed firing supply is locked out for control voltages under the shutdown level so that inadvertent SCR firing cannot occur.

A short circuit fault in any phase module of the inverter will produce a large discharge current from the DC link filter capacitor. This is detected by current transformer CTC and fed back to the Inverter card. When this current exceeds a set level indicating an inverter fault has occurred, an immediate drive shutdown is produced and the inverter fault light, IOC, will light. The immediate drive shutdown produced by either an inverter fault, a control undervoltage, a commutation overcurrent, or a DC link overvoltage causes all normal inverter firing to be locked out and produces a firing of six inverter SCRs by means of signals supplied to the Phase Logic card. This action causes the inverter to be commutated off. This immediate shutdown action, however, always causes the inverter fault light IOC to light when any of the other three faults described above occur.

The overfrequency trip function provides a drive shutdown and an IOF light indication if the inverter frequency exceeds a set limit due to any reason. This overfrequency limit is selectable by means of an Inverter card jumper to be either 75 Hz, 110 Hz, 165 Hz, 275 Hz or 400 Hz.

PHASE LOGIC CARD

The Phase Logic card translates the Inverter card logic signals into three-phase logic to control the firing of all commutation and inverter SCRs.

The six times fundamental frequency logic from the Inverter card is translated into three-phase, full-wave logic in a positive ABC phase sequence by the Phase Logic card. This three-phase logic is used to sequentially steer the six times per cycle commutation logic from the Inverter card to the proper phase SCR firing logic dependent on the three-phase sequence.

The SCR firing pulse generators take power from the delayed firing supply on the Inverter card to produce firing pulses for six inverter SCRs and six commutation SCRs in the three inverter phase modules. The firing signals for the six inverter SCRs are half cycle long signals which are modulated by the firing oscillator pulse train from the Inverter card, whereas, the other nine firing signals are single short time pulses.

The fault shutdown logic produces an immediate inverter shutdown in response to fault logic signals from the Inverter card. This logic locks out all normal inverter firing signals and produces a firing of the six inverter SCRs to produce a shoot-through commutation of the whole inverter.

POWER SUPPLY CARD

The 26 volt winding on the control power transformer provides single-phase AC power to the Power Supply card. A full-wave rectifier and filter capacitor on this card provides unregulated DC power to the series pass power transistors which produce the regulated +20 volt control power output. Short circuit protection is provided by an overvoltage detection and crowbar circuit.

The power transistors are controlled by a regulator circuit which provides accurate +20 volt regulation from a reference zener. This zener also provides the reference for the control undervoltage trip function on the Inverter card.

This card has the provision for DC input supply power for AC power outage ride-through.

METER CARD

The optional Meter card fits into a prewired driver receptacle and is a valuable tool for drive set-up and diagnostic checkout.

This card contains a 19 position signal selector switch for connecting to the meter and test posts any preselected and prewired signals or a back plane probe and its associated buffer circuitry to enable reading almost all card terminal signals without affecting driver operation. This card also contains a 3 position scale selector switch plus the necessary circuitry to enable the meter to read either AC rms, DC average or the peak reading of any signal. These functions provide this card with the capability of reading inverter link currents, peak commutating current, and peak levels of short time logic pulses, as well as the normal analog signals.

CURRENT ISOLATOR CARD

This card is located in back of the driver module and connected with spade terminals to terminal board TB3. This card contains an oscillator for modulation/demodulation of the incoming DC link current signal, using a transformer to provide isolation between the high voltage side and the control side. The current feedback potentiometer CFA on the isolator card is normally set to make the current output (LCS) equal to 1 volt DC with rated output current.

PULSE TRANSFORMER CARDS

These cards are mounted on the converter and inverter phase modules. Their major function is to provide voltage isolation between the driver control and the SCR power circuit.

Each card consists of identical pulse transformer circuits which amplifies the SCR firing signals from the driver. They also contain input noise suppression and self protection from abnormal loading.

1. Pulse Transformer card with current feedback (193X389AAG01). This card is mounted on the front insulation cover of the converter power module. For 75/100 KVA a G02 card is used.

The pulse transformer card has six channels for firing six isolated SCRs with each channel providing voltage isolation between the driver control and the SCR power circuits.

The inverter commutation current transformer is connected to a rectifier bridge and specified loading resistor to provide a unidirectional voltage signal. This signal peak is 12.5 volts for the desired commutation current level of each inverter rating. An additional negative commutation current loading resistor is included so that the commutation current regulator will mainly regulate the positive commutation current in each phase.

2. Pulse Transformer Card (193X390AAG01). This card is mounted on the front insulation cover of each of the Inverter Phase modules (Qty. 3). This card has four channels for firing four isolated SCRs, and is also fitted with the commutation current feedback circuit.

START-UP AND CHECK-OUT

Every AF-400 Inverter drive has been factory tested and is ready to operate, provided that the external power and control connections have been properly made and no shipping and installation damage had been sustained. It is recommended that the following step-by-step setup procedure be followed to ensure proper operation of the equipment.

WARNING

DOOR INTERLOCKS ARE SOMETIMES FURNISHED TO DISCOURAGE UNAUTHORIZED ACCESS WHICH COULD RESULT IN PERSONAL INJURY OR LOSS OF LIFE DUE TO ELECTRICAL SHOCK HAZARD. IF DOOR INTERLOCKS (IF SUPPLIED) ARE DEACTIVATED OR BYPASSED, EXTREME CAUTION MUST BE USED. BE SURE TO REMEMBER TO RETURN INTERLOCKS TO OPERATING CONDITION AFTER START-UP OR TROUBLESHOOTING.

TEST EQUIPMENT REQUIRED

The following listed equipment should be available during start-up and check-out. The first two items listed are recommended for normal operation and maintenance.

Meter Card — 193X481AAG01
Volt-Ohmmeter — Digital preferred, 20K per volt min. input impedance
Clamp-on Ammeter — Adjustable range up to 300 amp.

If available, an oscilloscope (preferably dual trace) is preferable.

TESTING SAFETY PRECAUTIONS

Certain precautions need to be observed in testing this equipment.

All of the control in the driver, with the exception of the 115 volt AC supply to the option card (when furnished), is at a low voltage level with respect to ground. The control common is connected to the driver case which is connected to the power unit enclosure, which should be connected to an earth grounding system. Any control circuitry on the driver side of the pulse transformer cards, is also at the low voltage level.

All power modules, power components, power wiring, and control wiring and components connected to the power must be assumed to be at a high voltage to ground. The following safety precautions must be strictly observed when testing in the power area:

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS THROUGHOUT THE DRIVE. CHARGED CAPACITORS REQUIRE AT LEAST ONE MINUTE DISCHARGE TIME TO 50 VOLTS OR LESS.

When testing in the power area, it is recommended from a safety standpoint, that the equipment be turned off, the test equipment connections be made, and the power applied for the measurement, and the equipment then be turned off again, prior to disconnecting the test equipment.

WARNING

GREAT CAUTION SHOULD BE OBSERVED WHEN INSTRUMENTS SUCH AS OSCILLOSCOPES ARE USED TO TEST LIVE (ENERGIZED) POWER CIRCUITS. THE INSTRUMENT COMMON LEAD SHOULD NOT BE CONNECTED TO ANY UNGROUNDED POINT IN THE SYSTEM UNLESS THE INSTRUMENT IS ISOLATED FROM GROUND AND ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE PERMITS GROUNDING OF THE INSTRUMENT CASE, EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN TWO LIVE POINTS IN THE CIRCUIT.

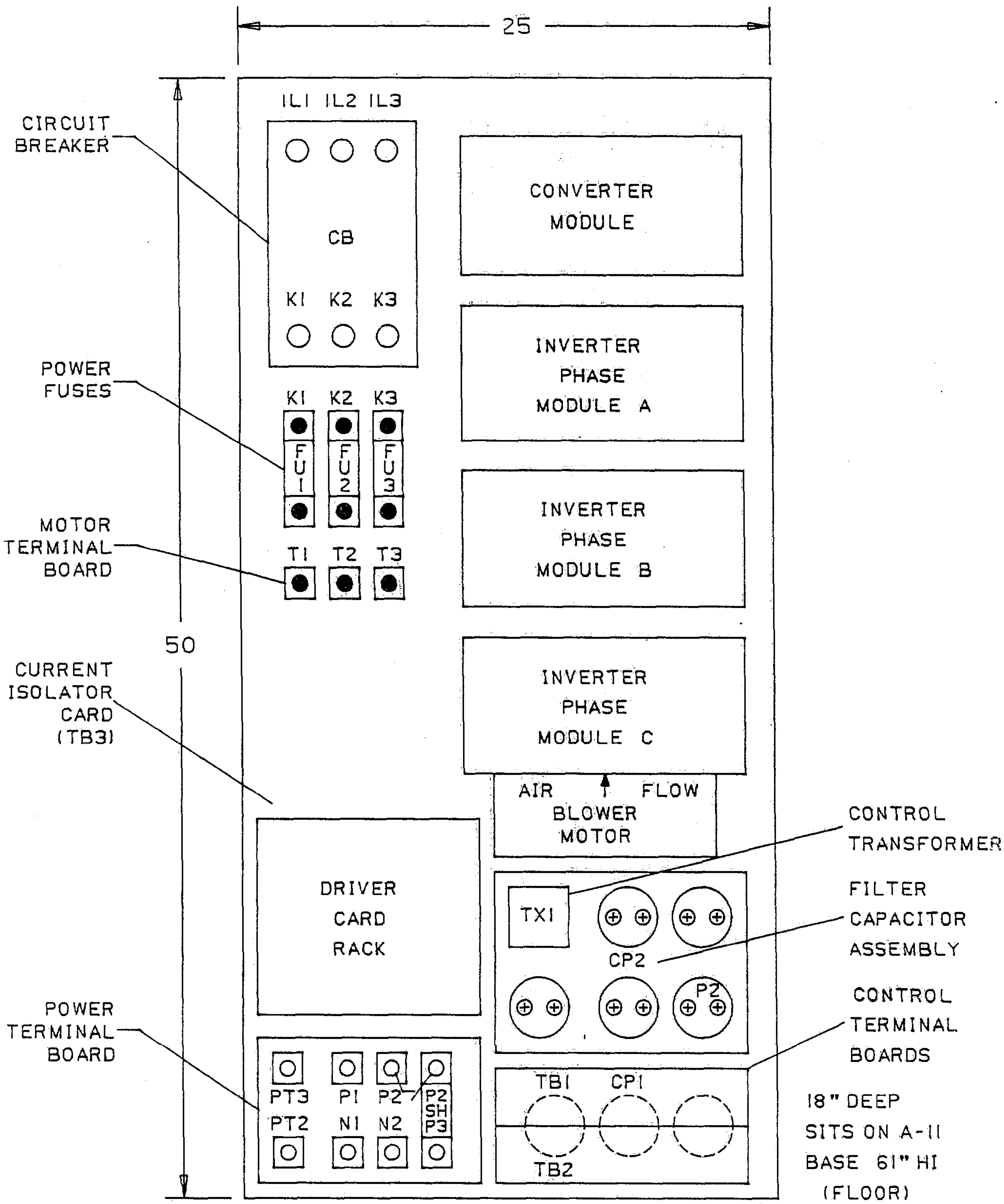


FIG 1. AF-400 DRIVE POWER UNIT, PANEL MOUNTED.

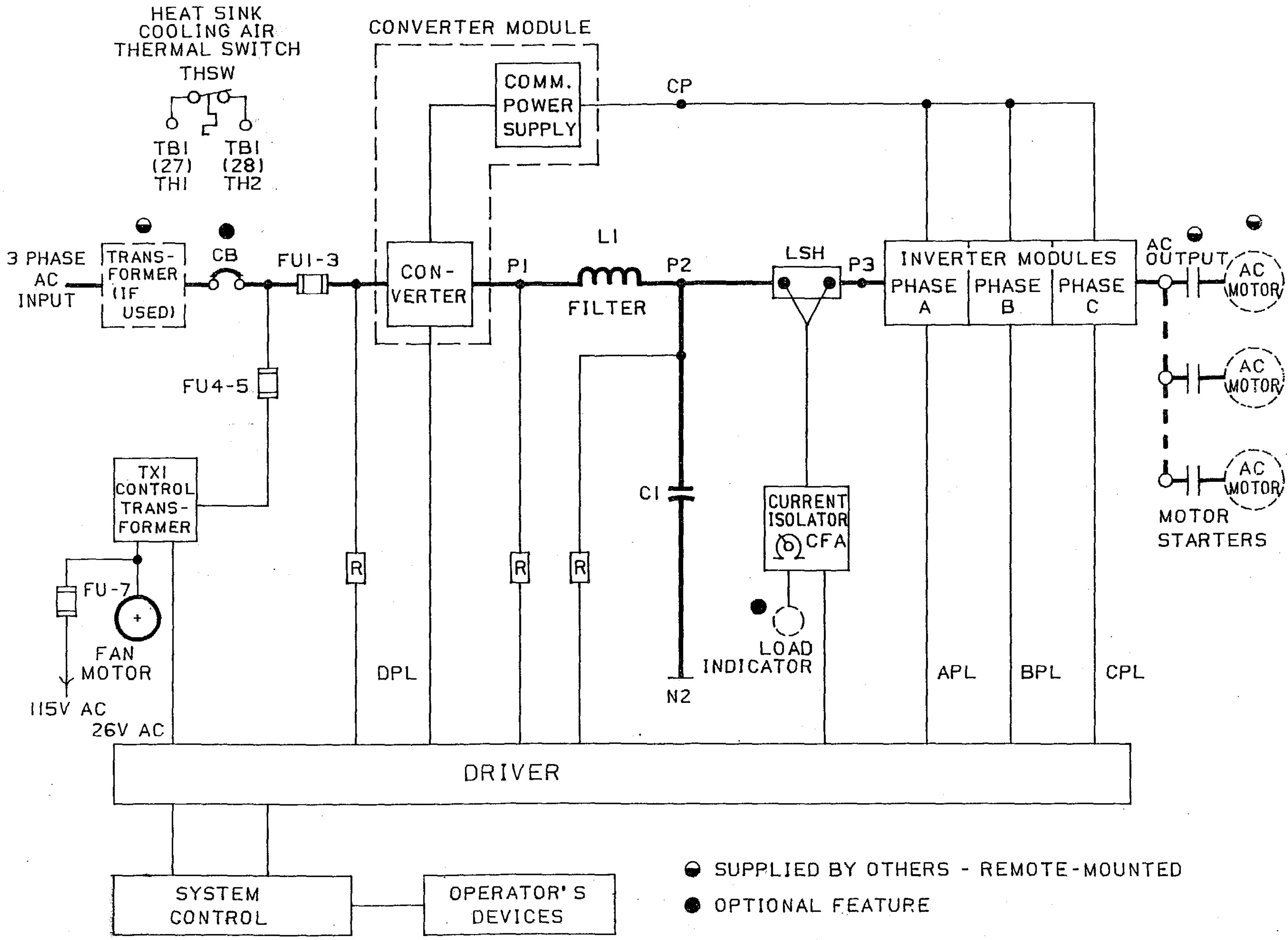


FIG. 2 AF-400 DRIVE SYSTEM BLOCK DIAGRAM

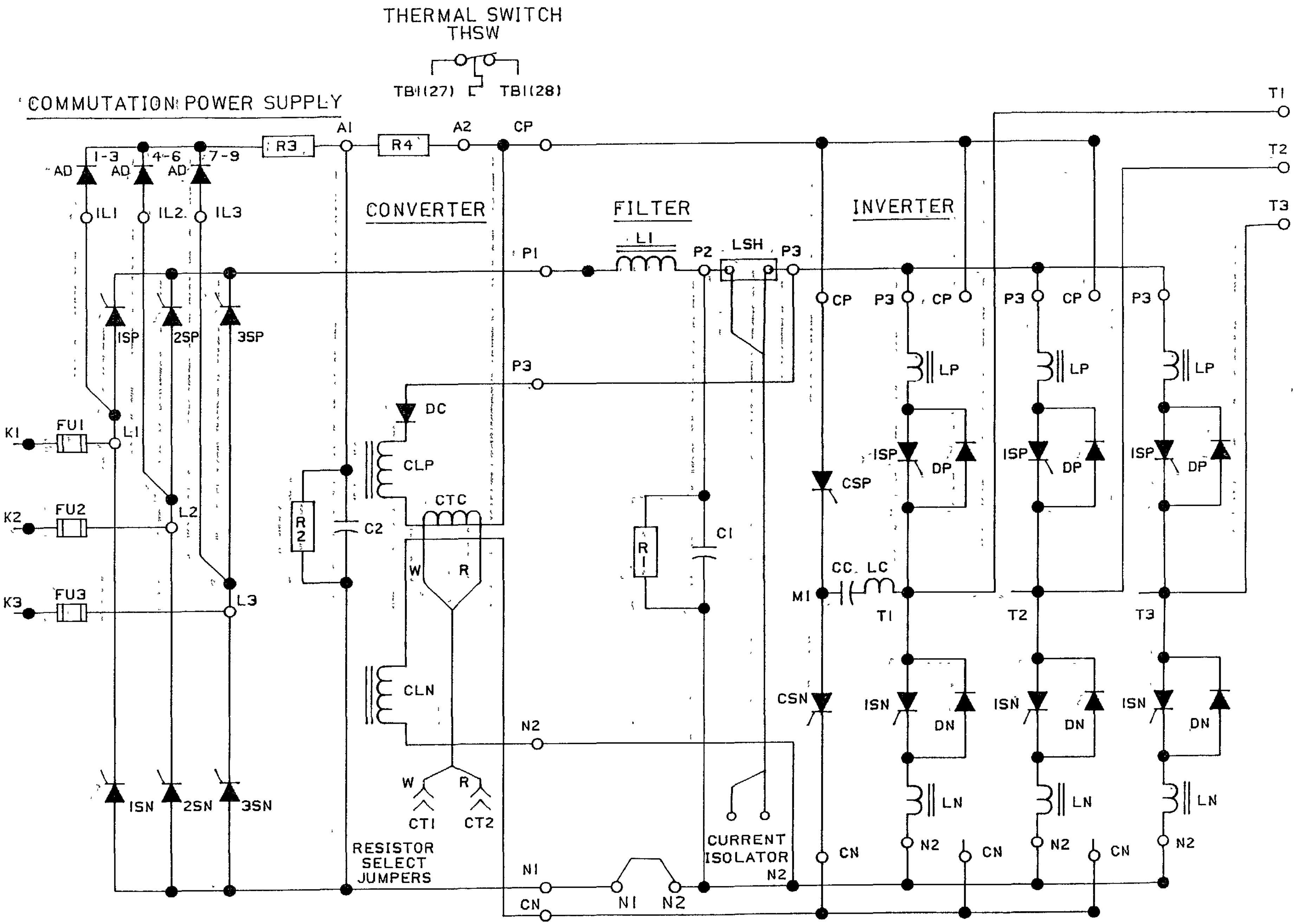


FIG.3 AF400 DRIVE POWER CIRCUIT

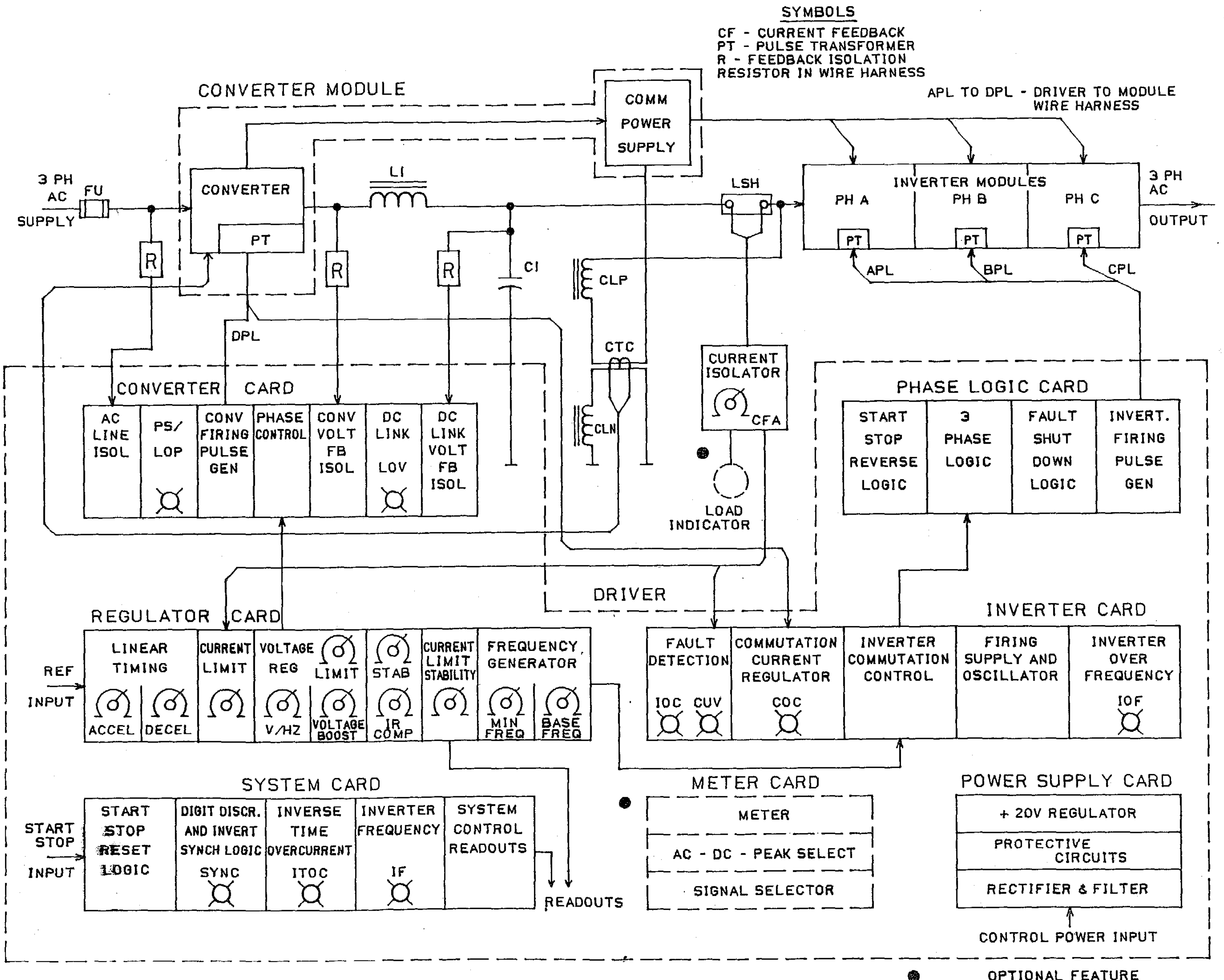


FIG. 4 AF-400 DRIVE FUNCTIONAL BLOCK DIAGRAM

CAUTION

WHEN TESTING IN THE CONTROL AREA, REMEMBER THAT THESE ARE LOW VOLTAGE CIRCUITS (20 VOLTS) AND CAN BE DAMAGED BY IMPROPER TEST PROCEDURES.

CAUTION

DO NOT CONNECT POWER AND CONTROL CIRCUITRY TOGETHER IN ANY TEST HOOKUP. THIS DEFEATS THE PURPOSE OF THE CONTROL ISOLATION FUNCTION AND CAN DAMAGE THE EQUIPMENT.

CAUTION

DO NOT REMOVE OR INSERT PRINTED CIRCUIT CARDS IN THE EQUIPMENT WHILE POWER IS APPLIED. THIS CAN DAMAGE THE EQUIPMENT.

POWER — OFF CONTINUITY TEST

WARNING

VERIFY THAT THE MAIN THREE—PHASE AC POWER INPUT TO THE SYSTEM EQUIPMENT IS DISCONNECTED OR SWITCHED OFF. PERSONAL INJURY OR LOSS OF LIFE DUE TO ELECTRICAL SHOCK HAZARD CAN THUS BE AVOIDED.

Perform a point-to-point continuity test for all newly installed wiring and interconnection. Continuity is defined as 1/2 ohm or less.

DRIVER SELECTIONS

These are four card selections which should be checked before starting up the drive.

NOTE

IF EITHER THE INVERTER CARD (193X476AAG01) OR THE CONVERTER CARD (193X477AAG01) IS REPLACED, THE NEW CARD SHOULD HAVE THE SAME POSITION OF ITS JUMPER AS THE CARD BEING REPLACED.

230/460V JUMPER ON INVERTER CARD (193X476AAG01 or equivalent)

This jumper should be positioned for 230V (B) or 460 (A) to agree with the drive rating **EXCEPT** for 100 KVA 460V drives which use position (B).

OVERFREQUENCY TRIP JUMPER — ON INVERTER CARD

This jumper selects the upper inverter frequency at which the drive will trip and shut down to prevent motor overspeed. The fequency trip levels are selected by placing the jumper in the appropriately marked socket position.

75 Hz frequency — 75 Hz socket position
110 Hz frequency — 110 Hz socket position
165 Hz frequency — 165 Hz socket position
275 Hz frequency — 275 Hz socket position
400 Hz frequency — 400 Hz socket position

Consult your specific drive elementary diagram for proper jumper placement.

CAUTION

INCORRECT JUMPER CONNECTION OR DISCONNECTION MAY RESULT IN MALFUNCTION AND POSSIBLE DAMAGE TO THE INVERTER.

60 Hz JUMPER — ON CONVERTER CARD 193X477AAG01 (or equivalent)

This jumper should be present on all drives supplied from 60 Hz AC power, and should be removed on all drives supplied from 50 Hz AC power.

REGULATOR BASE FREQUENCY RANGE JUMPER — 75, 150, and 300 Hz on Regulator card.

This jumper selects the inverter base frequency range. It should be placed in the appropriately marked socket position.

Base Freq. Range of 37.5 to 75 Hz — 75 Hz socket position.
Base Freq. Range of 75 to 150 Hz — 150 Hz socket position.
Base Freq. Range of 150 to 300 Hz — 300 Hz socket position.

Base Frequency is the frequency at which the inverter reaches full voltage and is adjusted by the BF potentiometer (on the Regulator card) within each of the above ranges. Consult your specific drive elementary diagram for proper jumper selection.

Commutation Current Feedback Jumper on the Converter Module Pulse Transformer card 193X389AAG01: This jumper should be positioned to agree with the drive rating **(not motor rating)**. The positions are labeled with a letter followed by a two digit number. The letter stands for the voltage rating (L for 230, H for 460) and the number corresponds to drive KVA (15, 30, 60 or 100).

CAUTION

IMPROPER JUMPER CONNECTION OR DISCONNECTION MAY RESULT IN DRIVE MALFUNCTION.

WARNING

IMPROPER JUMPER PLACEMENT MAY PRESENT AN EQUIPMENT OR PERSONNEL HAZARD RESULTING IN PERSONAL INJURY OR LOSS OF LIFE OR EQUIPMENT DAMAGE OR DESTRUCTION DUE TO MOTOR OVERSPEED.

CURRENT FEEDBACK CALIBRATION

A potentiometer adjustment (***CFA***) on the current isolator card provides the means to calibrate the link-current feedback signal. This card is located in back of the "pull out" driver card rack. The ***CFA*** potentiometer is normally adjusted, such that the LCS signal reads 1.0 volts RMS with rated load at base frequency. This would normally occur with 100 millivolts across the shunt LSH.

START-UP PROCEDURE

Perform the following step-by-step procedure in the sequence given below. If during this procedure a problem is encountered, refer to the Troubleshooting Section of this manual.

1. Before applying AC supply power to the drive, verify that it is the proper voltage, phase and frequency as denoted on the equipment data nameplate. Also check all jumpers for proper placement.

2. Disconnect the three-phase output cables from the drive terminals T1, T2 and T3, or inactivate the output contactor if one is provided.

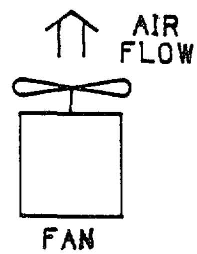
3. Disconnect control wire harness APL, BPL, CPL and DPL from their plug receptacles at the converter and phase modules.

4. Using a volt-ohmmeter selected to the X1 ohms scale, check that no short exists between DC link busses P2 and N2. Also check the three AC supply power fuses and all control power fuses to confirm that they are not blown.

5. Supply AC power to the drive.

6. Check the driver card indicating lights. Only the IF inverter frequency light should be indicating and it should be blinking at a low frequency. If the PS/LOP phase sequence/loss of phase light is indicating, check that the correct voltage is present on all three AC supply power terminals L1, L2 and L3. If these are correct, the phase sequence is wrong. Disconnect the AC power, interchange any two cables and repeat steps 5 and 6.

7. Check that the fan is operating properly and producing air flow through the power modules. Refer to the sketch below and to labels on the air distribution chamber for correct operation.



If no rotation occurs, check if 115V AC is present between TB1 (AC3) and TB1 (AC2).

8. Set the driver reference input at zero. Check for zero reference voltage by selecting Meter card switch position 2, or measure the voltage between driver terminal board points TB2 (32) to TB2 (48).

9. Interrupt AC power to the drive, connect the DPL wire harness plug to the converter module and reapply AC power.

10. Check the driver lights again. Only the IF light should be on, blinking at a low frequency. Run through the Meter card selector switch positions 1 through 17 and compare these readings with the readings shown on the driver label mounted on the inside of the power unit enclosure door. This label is also included in the Instruction Book.The readouts taken should compare with those given for the "Off Condition".

    If a Meter card is not available, use a volt-ohmmeter to check REF from TB2 (32) to TB2 (48), FVR TB2 (44) to TB2 (48), and the converter output voltage between P2 and N2. The P2 to N2 voltage should not exceed 30 volts DC for 230 volt AC drives or 60 volts DC for 460 volt AC drives, before the inverter is started.

11. Press the drive "Start" pushbutton. Check driver lights and Meter card position 4, or P2 to N2 voltage. They should be the same as for step 10.

12. Increase reference input to the driver slowly until the P1 to N2 voltage reaches half of rated DC link voltage (150 volts DC for 230 volt AC drives and 300 volts DC for 460 volt AC drives). The Meter card positions 2 and 4 should both read 7.5 (7.5 volts between TB2 (32) and TB2 (48).

CAUTION

WHEN THE DRIVE HAS *NOT* BEEN OPERATED FOR 6 MONTHS OR MORE, THE ELECTROLYTIC CAPACITORS IN THE FILTER CAPACITOR ASSEMBLY MUST BE REFORMED. FOLLOW THE PROCEDURE IN STEP 13 IF FORMING IS REQUIRED, OR SKIP STEP 13 IF NOT REQUIRED.

13. If capacitor forming is required, increase the P1 to N2 DC link voltage in the following steps, pausing for 5 minutes at each step in the forming process.

Operating Voltage Level		Operating Time
230VAC Drive	460VAC Drive	
200 Volts DC	400 Volts DC	5 Min.
250 Volts DC	500 Volts DC	5 Min.
300 Volts DC	600 Volts DC	5 Min.
(or at maximum reference)		

During each step of the forming process, check the voltage at the Q or midpoint of the seriesed capacitor asm (460 volt AC drives only). The difference between the P1 to Q and Q to N2 voltage readings should not exceed 5% of the P1 to N2 voltage. For example, at a P1 to N2 voltage of 600 volts, the difference between the P1 to Q and Q to N2 voltages should not exceed 30 volts. If the Q midpoint varies more than 5%, refer to the Troubleshooting Section of this manual. In no case should more than 400 volts DC be applied across a single capacitor.

14. Press the drive "Stop" pushbutton and decrease the driver reference to zero. The DC link voltage between P2 and N2 (Meter position 4) should discharge down to less than 10% of maximum in about 30 seconds.

15. Interrupt AC supply power to the drive, connect the APL, BPL and CPL wire harness plugs to the phase modules and reapply AC power.

16. With reference input to the driver at zero, press the driver "Start" pushbutton and check the driver card lights. Run through the Meter card positions 1 through 17 and compare these readings with those given on the driver label for "0 Ref., 0 Load."

If a Meter card is not available, use an oscilloscope to check the inverter commutation current feedback signals, at the CF connector point of DPL on the converter pulse transformer card. The peak voltage level of the higher commutation pulse in each phase should agree with the values given on the driver label, and the waveshapes should appear as shown in Figure 5. The positive commutation current pulse is normally the higher since the negative pulse is attenuated.

17. Slowly increase the driver reference input up to maximum while checking the inverter commutation current peak level of each phase, by means of select position 9 on the Meter card, or by means of an oscilloscope as described in step 16. The commutation current peaks should increase as shown on the driver label, but should remain in the ranges shown.

Also check that the base frequency is correct for your motor drive system and readjust if necessary. See Base Frequency in the Adjustments section for checking and adjustment instructions.

18. Press the drive "Stop" pushbutton and reduce the driver reference to zero. The inverter should decelerate down to about one-fourth of rated frequency and voltage, and then stop.

19. Interrupt the AC power to the drive. Reconnect the three-phase output cables to drive terminals T1, T2 and T3, or reactivate the output contactor, to connect the motor(s) to the inverter.

20. Reapply AC power to the drive. With reference input to the driver at zero, press the drive "Start" pushbutton and slowly bring the reference up to half rated. Run through the Meter card positions 2 through 17 and compare these readings with those given on the driver label for "1/2 Ref., 1/2 Load." If the motor loading is different than one-half of rated, the positions 7 and 9 readings will be different from those given.

If any Meter reading discrepancies exceeding 5% full scale (1.0V) from those values given in the drive table are found, proceed to the Adjustments section.

Use a clamp-on ammeter to read the inverter AC output current in each phase to check that they are balanced. Also check the AC supply input currents to the converter to check that they are balanced.

21. Slowly increase the driver reference up to the maximum of 15 volts. Run through the Meter card positions 2 through 17 and compare these readings with those given on the drive label for "1 Ref., 1 Load." Again, positions 7 and 9 readings will depend on the actual motor load.

ADJUSTMENTS

Although the drive has been adjusted in factory test, it is recommended that these adjustments be checked to determine if they are correct for your application and power system. The following sequence should be followed in checking and modifying the driver adjustments, all of which are located on the Regulator card. (The VLIM and STAB potentiometers are located at the card top edge rather than the front edge, and is adjusted through the top opening in the driver rack). Before starting, record the factory adjustment positions of each potentiometer. The driver label may be used for this purpose, and for indicating any changes in adjustment that may be made.

NOTE

IF THE DRIVER REGULATOR CARD IS REPLACED, SET ALL POTENTIOMETER ARROWS ON THE NEW CARD THE SAME AS ON THE CARD BEING REPLACED. THE FOLLOWING ADJUSTMENT PROCEDURE SHOULD THEN BE FOLLOWED TO CHECK THE ADJUSTMENT OF THE NEW CARD.

VB — VOLTAGE BOOST

This adjustment is dependent on the amount of motor torque required at speeds below about one-fourth of rated, or the amount of breakaway torque required. If motor torque requirements below one-fourth rated speed are less than 25% of rated torque, no voltage boost is required and ***VB*** should be set fully counter-clockwise. For higher motor loading at low speeds, a certain amount of voltage boost is required to prevent the motor from "pulling out" and stalling. The amount of adjustment of the VB potentiometer from the CCW end depends on the amount of motor load torque at low speeds and type of motor (larger motors require less voltage boost than smaller motors). Adjust ***VB*** only enough so that the motor(s) accelerates smoothly from rest.

IRC — IR COMPENSATION

Turning the ***IRC*** potentiometer clockwise will increase the output voltage proportional to the link current feedback, LCS. With IRC pot fully clockwise the voltage increase will be 10% of rated LCS = 1.0 volts corresponding to rated current.

IR compensation will normally only be required if the starting and low speed running torque exceeds 100% of rated. Again, the amount of ***IRC*** setting depends on both the amount of torque required and the type of motor.

Too much voltage boost or IR compensation will produce excessive motor peak currents which will cause torque pulsations or "cogging." If this occurs at low speeds the ***VB*** and/or ***IRC*** setting should be reduced.

V/HZ — VOLTS/HERTZ

Operate the drive at a reference of 12 volts at driver TB2 (32) to TB2 (48) (reading of 12 volts on Meter card position 2). Adjust the V/Hz potentiometer to obtain a DC link voltage between P2 and N2 of 250 volts DC for 230 volt AC drives and 500 volts DC for 460 volt AC drives. This corresponds to 12.5 reading on Meter card position 4.

The above volts/hertz setting should include the effects of the ***VB*** voltage boost setting. If the ***VB*** setting is changed, the volts/hertz should be readjusted to maintain proper motor excitation.

VLIM — VOLTAGE LIMIT/CONSTANT HP OPERATION (located at top edge card)

The voltage limit function is not required and may be turned fully CW unless constant horsepower operation is used. In this case the V/Hz, BF and VLIM adjustments can be made as follows:

1. With BF set CCW, V/Hz set CCW and VLIM set CW apply maximum reference of 15 volts at REF, TB2(32). Adjust BF for maximum frequency.

2. Reduce the reference until the inverter operates at base frequency. Adjust V/Hz for a DC link voltage of 300 or 600 volts for 230 or 460 volts drive respectively. Turn ***VLIM*** fully CCW.

3. With ***VLIM*** set CCW increase the reference back to maximum. Adjust ***VLIM*** for a DC link voltage of 300-310 volts for 230V drives or 600-620 volts for 460V drives.

BF — BASE FREQUENCY

With the driver reference at the rated 15 volts TB2 (32) to TB2 (42) or Meter card position 2, adjust the ***BF*** potentiometer to obtain the desired motor base frequency. This frequency can be read by means of a frequency counter connected between driver TB2 (52) (IPAD) and TB2 (48) (COM). It can also be read to within ±2% accuracy by connecting a digital volt-ohmmeter between

TB2 (44) (FVR) and TB2 (48) (COM). The frequency is obtained by multiplying the voltage reading by 5 for the 75 Hz base frequency range; by 10 for the 150 Hz range and by 20 for the 300 Hz range.

A third method of reading frequency, to within ±5 accuracy, is by taking the Meter card position 3 reading and applying the 5, 10 or 20 times multiplier just described.

MINF — MINIMUM FREQUENCY

Normally the ***MINF*** potentiometer is set at or near the counter-clockwise end for best starting of motors, especially if any breakaway torque is required. If a transformer is used between the power unit and the motor, the minimum frequency will have to be set higher to prevent transformer saturation. A higher minimum frequency can be obtained by turning ***MINF*** in a clockwise direction.

ATIM & DTIM — ACCELERATION AND DECELERATION TIME

With the driver reference at the rated 15 volts, start the drive from rest and check the acceleration time and the Meter card position 10 reading. If the meter reading goes below 10 during acceleration, the drive is going into current limit, and it is desirable to increase the acceleration time by adjusting the ***ATIM*** potentiometer in the clockwise direction. If a Meter card is not available, the motor current can be read with a clamp-on ammeter to measure the acceleration load.

With the drive operating at rated speed, quickly adjust the driver refrence to zero and check the deceleration time and the Meter card position 6 reading. If the meter reading goes above 10 before deceleration is completed, the drive is going to slowdown limit, and it is probably desirable to increase the deceleration time by adjusting the ***DTIM*** potentiometer in the clockwise direction.

If shorter acceleration or deceleration times are desired, the ***ATIM*** or ***DTIM*** potentiometers should be adjusted in the counter-clockwise direction, and the operation checked as described above. The minimum times obtainable, within the 5 to 50 second adjustment range are limited by the current limit and slowdown limit control.

CLIM — CURRENT LIMIT

The percentage of rated drive output current at which current limit will occur can be approximated by the setting position of the ***CLIM*** potentiometer, per the following table:

CLIM Setting	CCW End	1/4 from CCW End	Mid-point	1/4 from CW End	CW End
% Rated Current	50 to 60%	75 to 90%	105 to 120%	130 to 145%	155 to 175%

CLST — CURRENT LIMIT STABILITY

This stability adjustment for current limit operation is dependent on the motor and load inertia, motor HP rating, and on the current limit setting. The correct setting of the ***CLST*** potentiometer can be determined by using the following table:

	CLST Setting for Motor HP	
Load Inertia	10 to 100 HP	100 to 400 HP
Negligible load inertia	CW end to 1/3 from CW end	1/3 from CW end to midpoint
Load inertia equals motor inertia	Midpoint to 1/3 from CCW end	1/3 from CCW end to 1/4 from CCW end
Load inertia equals 2 x motor inertia	1/4 from CCW end to 1/6 from CCW end	1/6 from CCW end to 1/8 from CCW end
Load inertia equals 5 x motor inertia or greater	1/8 from CCW end to CCW end	CCW end

The setting ranges given in the table cover the current limit ***CLIM*** setting range, such that the ***CLST*** setting varies toward the clockwise end of its setting range as the ***CLIM*** setting is adjusted towards its clockwise end, and vice-versa.

If instability occurs during current limit operation, the ***CLST*** potentiometer should be adjusted toward its counterclockwise end.

STAB - STABILITY

To prevent an oscillatory interchange of energy between the DC link capacitor and AC motor rotational inertia an error signal obtained by comparing the DC converter reference with DC link capacitor voltage is used to modulate the inverter frequency.

DIGITAL FOLLOWER OPERATION

Digital Follower Operation is typically set up as the AUTO mode of a MAN/AUTO mode selection. In MAN the driver operates from an analog (potentiometer) reference signal. The set up procedure is made in this mode as described above. In the AUTO mode, the drive follows a digital frequency reference (pulse train) applied at DPF, TB1(23). To enable the frequency/phase comparator, SYNC, TB2(42) must be connected to common (the extra contact on the MAN/AUTO switch may be used).

In the digital mode the BF potentiometer should be adjusted for RFVX, TB2(47) voltage of 16.0 volts at maximum frequency.

The regulator timing circuit will override the frequency reference signal. If it is desirable for the drive to follow the digital reference during acceleration and deceleration, the regulator accel time must be set faster and decel time must be set slower than the accel and decel times of the digital reference.

TROUBLESHOOTING

A systematic approach to troubleshooting will reduce the time required to find the problem. This approach consists of trying to localize the problem or cause, in the following step-by-step fashion.

1. Is the problem inside the AF-400 drive power unit or caused by external conditions or equipment?
2. Which model in the power unit is causing the problem?
3. Which component within the model is at fault or has failed?

The means to accomplish this are the recommended test equipment to use, and the troubleshooting procedures outlined in this section. The efficiency with which they are used will be dependent on the skill and experience of the test personnel, and how well they understand the drive operation, as explained in the Description section of this manual.

TEST EQUIPMENT REQUIRED

The following test equipment should be available for troubleshooting, and is listed in the order of recommended preference. The first two items are recommended for normal operation and maintenance.

Meter Card	193X481AAG01
Volt Ohmmeter	Digital preferred — 20K per volt min. input impedance.
Oscilloscope	Dual trace preferred
Clamp-on Ammeter	Adjustable range up to 300 amps

TESTING SAFETY PRECAUTIONS

Certain precautions need to be observed in testing this equipment.

All of the control in the Driver, with the exception of the 115 volt AC supply to the Option card (when supplied) is at a low voltage level with respect to ground. The control common is connected to the driver case which is connected to the power unit enclosure, which should be connected to an earth grounding system. Any control circuitry on the Driver side of the pulse transformers on Pulse Transformer cards is also at the low voltage level.

All power modules, power components, power wiring and control wiring and components connected to the power must be assumed to be at a high voltage to ground. The following safety precautions must be strictly observed when testing in the power area:

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS THROUGHOUT THE DRIVE. CHARGED CAPACITORS REQUIRE AT LEAST ONE MINUTE DISCHARGE TIME, TO 50 VOLTS OR LESS.

When testing in the power area, it is recommended from a safety standpoint that the equipment be turned off, the test equipment connections be made, and the power applied for the measurement, and the equipment then be turned off again, prior to disconnecting the test equipment.

WARNING

GREAT CAUTION SHOULD BE OBSERVED WHEN INSTRUMENTS SUCH AS OSCILLOSCOPES ARE USED TO TEST LIVE (ENERGIZED) POWER CIRCUITS. THE INSTRUMENT COMMON LEAD SHOULD NOT BE CONNECTED TO AN UNGROUNDED POINT IN THE SYSTEM UNLESS THE INSTRUMENT IS ISOLATED FROM GROUND AN ITS METAL PARTS TREATED AS LIVE EQUIPMENT. USE OF AN INSTRUMENT HAVING BOTH LEADS ISOLATED FROM THE CASE. PERMITS GROUNDING OF THE INSTRUMENT CASE, EVEN WHEN MEASUREMENTS MUST BE MADE BETWEEN TWO LIVE POINTS IN THE CIRCUIT.

CAUTION

WHEN TESTING IN THE CONTROL AREA, REMEMBER THAT THESE ARE LOW VOLTAGE CIRCUITS (20 VOLTS) AND CAN BE DAMAGED BY IMPROPER TEST PROCEDURES.

CAUTION

DO NOT CONNECT POWER AND CONTROL CIRCUITRY TOGETHER IN ANY TEST HOOKUP. THIS DEFEATS THE PURPOSE OF THE CONTROL ISOLATION FUNCTION AND CAN DAMAGE THE EQUIPMENT.

CAUTION

DO NOT REMOVE OR INSERT PRINTED CIRCUIT CARDS IN THE EQUIPMENT WHILE POWER IS APPLIED. THIS CAN DAMAGE THE EQUIPMENT.

FAULT INDICATION

The two basic indications of a drive problem are:

A. Drive Operates Improperly

1. Driver is at fault — refer to Driver Troubleshooting in this section
2. System Control is at fault — refer to the system elementary diagrams for system logic and control circuits and operation notes.

B. Drive Shuts Down, or Will Not Start

1. Driver card fault lights are indicating — refer to Fault Indicating Lights in this section.
2. Driver is at fault — refer to Driver Troubleshooting in this section.
3. System control is at fault — refer to the system elementary diagram for system logic and control circuits and operating notes.
4. AC supply fuses or circuit breakers have interrupted, or control power fuses have blown — Disconnect AC power from drive and check AC supply fuses. If fuses blown, or if AC breaker tripped, check the converter and inverter modules for faulty SCRs. Refer to Converter Troubleshooting and Inverter Module Troubleshooting in this section. Also check control fuses. If these check out all right, check for defective filter capacitors (See DC Link Filter Troubleshooting in this Section) or for power cable or bus bar shorts in the AC supply, DC link and AC output. Also check for grounds in power cables and in motor windings.

FAULT INDICATING LIGHTS (on Driver cards)

The IF inverter frequency light and the SYNC inverter synchronized light are ***not*** fault lights but indicate operating conditions. The IF light should be indicating at all times that the driver is energized, even after a fault. Its blinking frequency indicates the driver operating frequency.

IOF only — this indicates an inverter overfrequency shutdown. Refer to Driver Troubleshooting in this section.

COC and IOC — This indicates a commutation overcurrent trip which produces an inverter fault shutdown. Check for drive overloading at or near full speed operation. Also refer to Driver Troubleshooting and Commutation Power Supply Troubleshooting in this section.

COC, IOC and ITOC — This indicates a combination commutation overcurrent, motor overcurrent shutdown. Check for drive overloading at or near full speed operation. Also refer to Driver Troubleshooting and Commutation Power Supply Troubleshooting in this section.

CUV only — This indicates a control undervoltage condition. Refer to Driver Troubleshooting in this section.

CUV and IOC — This indicates a control undervoltage trip which produces an inverter fault shutdown. Check the AC supply for outage problems.

LOV and IOC — This indicates a DC link overvoltage trip which produces an inverter fault shutdown. Refer to Driver Troubleshooting in this section.

LOV, IOC, COC and/or ITOC — This indicates a combination shutdown which would normally occur due to the effects of the DC link overvoltage. Refer to Driver Troubleshooting in this section.

PS/LOP only — This indicates the presence of, or a shutdown caused by, wrong AC supply phase sequence or a loss of one or more AC supply phases. Disconnect the AC power and check the AC supply fuses or circuit breaker, especially if the driver is supplied from another power source. Check that the drive is connected to the AC supply in the correct phase sequence.

ITOC only — This indicates an inverter output overcurrent shutdown, either due to an instantaneous trip for current levels over 175% of rated drive current, or an inverse time trip of from 15 seconds to 1 minute for lower overcurrent levels, depending on the current limit setting. Check for motor overloading, excessive volts/hz adjustment, locked rotor, or for motor single phasing. Check that the ***CFA*** potentiometer is adjusted for LCS = 1.0 volt at rated load. Also check for motor being switched on to the inverter at other than synchronized operation or minimum voltage and frequency. Finally check for motor cable shorts or grounds. Also refer to Driver Troubleshooting in this section.

ITOC and IOC — This indicates an inverter output overcurrent which is excessive enough to also cause an inverter fault. Check for motor jam-ups, excessive volts/hz adjustment, locked rotor, or for motor single phasing. Also check for motor being switched on to the inverter at other than synchronized operation or minimum voltage and frequency. Finally, check for shorts or grounds in output cable and motor windings.

DRIVER TROUBLESHOOTING

The driver consists of six or more cards, each of which contains quite a few circuits. To help in understanding and troubleshooting the driver, the functions contained on each card are shown in the Functional Block Diagram of Figure A. These functions are described in the Description section of this manual.

The optional Meter card is a great help in troubleshooting the driver. If a Meter card is available, an oscilloscope is not required except in only the most difficult cases. Normally, the use of the Meter card will allow pinpointing a specific card, which can then be replaced, or to a certain power module.

The driver label, mounted on the inside of the enclosure door, gives the normal readings for the Meter card selector switch positions for five operating conditions. This label also is in the Drive Instruction Book. These normal readings are given for the 17 selected signals, plus the inverter and converter firing signals selected by the position 19 back plane selector probe.

The Meter card can be used in several ways. It is useful in checking through the 17 key driver signals when operating at the conditions specified, to determine if any readings are abnormal. When position 19 is selected, the red wire back plane probe can be used to check card (receptacle) terminal signals. The troubleshooting notes will specify correct and incorrect readings for special test conditions to determine if various faults exist.

If a Meter card is not available, these same readings can be made using a digital volt-ohmmeter or an oscilloscope.

When using the back plane selector probes, there are few sensitive card terminals which should be avoided when the drive is operating with a motor, since connection of an instrument may cause changes in the drive output. These sensitive terminals are:

Receptacle F Converter Card	Receptacle G Regulator Card	Receptacle H System Card
term. 16—LVP	term. 7—SSDI	term. 28—RFC
term. 17—LVN	term. 11—BFI	term 24—R1
term. 19—CVN	term. 12—BFD	
term. 20—CVP	term. 23—SSDO	Receptacle E Inverter Card
term. 22—L2S	term. 32—RFC	
term. 23—L1S		term. 4—FCC
term. 24—L3S		

Care should be also be used in connecting an instrument to the driver reference REF receptacle H term. 30, receptacle K, term. 18 since this may produce a small motor speed.

Other diagnostic points are provided for oscilloscope usage. These are:

LPA — Meter Pos. 17
— A square wave logic signal which is in phase with the AC supply line phase A (or phase 1) to neutral voltage.

IPAD — TB2(52)
— A square wave logic signal which is in phase with the inverter output phase A to neutral voltage. May be used for a frequency counter reference.

These signals are especially useful for oscilloscope triggering when reading other signals.

CAUTION

IF DURING TROUBLESHOOTING, ONE OF THE FOLLOWING CARDS IS REPLACED, THE NEW CARD SHOULD HAVE THE SAME POTENTIOMETER SETTINGS, JUMPER CONNECTIONS AS THE OLD CARD.

REGULATOR CARD — TEN POTENTIOMETERS (INCL. VLIM AND BASE FREQUENCY JUMPER 75 HZ, 150 HZ & 300 HZ)

CONVERTER CARD — 60 HZ JUMPER

INVERTER CARD 230/460V JUMPER AND OVERFREQUENCY JUMPER (75 HZ, 110 HZ, 165 HZ, 275 HZ & 410 HZ)

A. Drive Operates Improperly

1. Cannot obtain maximum rated frequency and speed.

a. Check the driver reference REF volts (Meter card pos. 2 or driver receptacle K, terminal 18 to terminal 2 (COM). If less than 15 volts check the reference potentiometer (should be 5000 ohms) or check the system control (see system elementary diagrams).

b. Check the converter voltage reference CVR (Meter card pos. 6 or driver receptacle K, term. 14 voltage to common). This voltage should decrease at an even rate to approximately 3.5 volts as the driver reference is increased to 15 volts. If this is the case, continue on to part (c). However, if the CVR voltage suddenly decreased to about 1.5 volts, it indicates the converter is saturating. Check the DC link voltage. It should read approximately 15 at Meter card pos. 4 or should read either approximately 300 volts DC or 600 volts DC between power circuit terminals P2 and N2, for a 230 volts AC 460 volt AC drive respectively. If this voltage is significantly less, check the AC supply voltage level and check the converter. See Converter Troubleshooting in this section. If the DC link voltage is approximately 1.35 times the AC supply voltage the voltage limit ***VLIM*** potentiometer on the Regulator card is not adjusted properly. Refer to Adjustments section.

c. Check the inverter frequency voltage FVR (Meter card pos. 3 or driver receptacle K, terminal 17 to terminal 2 (COM). The drive output frequency should be 5 times this voltage reading when the 75 Hz base frequency jumper is selected or 10 times when the 150 Hz base frequency jumper is used and 20 times for the 300 Hz base frequency jumper. If the FVR reading agrees with the output frequency and all jumpers are correct, then the ***BF*** potentiometer on the Regulator card should be adjusted (Refer to Adjustments section). If the output frequency does not agree with the FVR reading, or if the ***BF*** adjustment appears faulty, replace the Regulator card and check the operation.

2. Motor will not accelerate from stall or low speed.

a. Check the driver REF volts (Meter card pos. 2 or driver receptacle, terminal 18 to terminal 2. If it less than 2 volts, check the reference potentiometer or system control (see system elementary diagrams).

b. Check if the inverter is operating. Meter card pos. 11 (R1), or driver receptacle K, term. 9 voltage to common, should be near 20. If zero, refer to Drive Shuts Down, or Will Not Start.

c. Check the DMF input at driver TB2, terminal 35. It should be high (near 20 volts to common). If it is near zero volts to common, check the system control connected to this input.

d. Check if the drive is in current limit. (The drive should shut down with an ITOC fault light after about 45 seconds). Meter card, pos. 10 (CL), or driver receptacle K, term. 10 voltage to common, should be near 20. If less than 10, check the settings of the current limit ***CLIM*** and voltage boost ***VB*** potentiometers on the Regulator card. Refer to Adjustments section.

e. If the problem cannot be found, replace the Regulator card and check operation.

3. Motor operation is rough or unstable.

a. Check voltage boost potentiometer adjustment. Excessive voltage boost at low speed and light load operation will cause motor "cogging" or a grinding noise. Refer to Adjustments section.

b. Check IR compensation, ***IRC*** potentiometer adjustment. Too high a setting may result in rough or unstable operation. Refer to Adjustments section.

c. If unstable motor operation occurs below one-half rated speed, check that the stability-slowdown circuit is connected. On driver receptacle H, terminal 23 should be connected to terminal 7.

d. If low frequency instability occurs it may be necessary to turn the stability potentiometer ***STAB*** clockwise. for constant HP and digital follower operation the ***STAB*** potentiometer may have to be turned CCW to reduce the stability circuit gain.

e. If unstable operation occurs when in current limit, stability ***CLST*** potentiometer is not adjusted properly. Refer to Adjustments section.

f. Check for low AC supply voltage to the driver TB1, terminals 3 and 4. This should not be less than 105 volts AC.

g. Check for uneven motor loading or motor single phasing.

h. If the problem cannot be found, replace the Regulator card and check operation.

4. Cannot control motor speed.

a. Check the driver reference REF (Meter card pos. 2 or TB2 (32) voltage) to see if the problem is in the driver or in the system control. If the problem appears to be in the system control, refer to the system elementary diagrams.

b. Check the SYNC input at driver TB2. It should be about 20 volts to common, except when operating in the digital follower mode.

c. Check the FU4, FU5 and control fuses. Refer to Commutation Power Supply Troubleshooting in this section.

d. If the problem cannot be found, replace the Regulator card and check operation.

5. Cannot stop motor.

NOTE

IF MOTOR CANNOT BE STOPPED BY THE NORMAL MEANS, INTERRUPT AC POWER TO THE DRIVE.

a. Check the STOP input at driver TB2 (34). It should be low (near zero volts to common) to stop the drive. If it is higher than 3 volts to common, check the system control connected to this input (see system elementary diagrams).

b. Check the FU4, FU5 and control fuses. Refer to Commutation Power Supply Troubleshooting in this section.

c. Check for low DC link voltage. If the Meter card pos. 4 reads less than 3, or if the DC voltage between power circuit terminals P3 and N2 is less than 70 volts (230 volt AC drive) or 140 volts (460 volt AC drive), and the STOP driver input is low, then the System card is probably defective and should be replaced.

d. Check for high DC link voltage. If the Meter card pos. 4 reads higher than 4, or if the DC voltage between power circuit terminals P3 and N2 is greater than 75 volts (230 volt drive) or 150 volts (460 volt AC drive), and the STOP driver input is low, the converter is not turning off. Check the converter reference voltage CVR (Meter card pos. 6 or driver receptacle K, term. 14). If this voltage to common is about 10 volts, the problem is either in the Converter card or in the converter power module. Refer to Converter Troubleshooting in this section. If the CVR voltage to common is less than 8, then the problem is either in the Regulator card or the System card. Try replacing each card separately and checking the operation.

6. Cannot obtain rated motor horsepower.

a. Check the motor nameplate for the rated voltage and frequency for rated horsepower. Check the inverter output voltage and frequency at rated reference. See the driver label for Meter card pos. 2, 3, 4, and 7 readings for the 1 REF, 1 LOAD condition. If these readings and/or the inverter output voltage is too low, refer to Adjustments section for proper base frequency, volts per Hz, and voltage limit settings. Rated power output cannot be obtained at a driver reference voltage, that is much less than 15 volts since this voltage is closely related to the DC link voltage and thus the inverter AC output voltage.

b. Check the AC power supply voltage. It should not be less than 5% below rated nameplate AC input voltage to the drive.

7. Cannot synchronize inverter with external frequency.

a. Check that SYNC input at driver TB2 (42) is low (near common). If it is not, check the system control (refer to the system elementary diagrams).

b. If SYNC is low, check IS at Meter card, pos. 12 or receptacle K, term. 8. If IS is high (near +20 volts), use an oscilloscope to determine if the proper frequency signals appear at receptacle G terminals 9 and 10. The oscillator frequency should be applied to terminal 9 and the, OP, external frequency reference, should be applied to terminal 10. Also check that RFC is not clamped to common.

c. If the IS signal is low, check the SYNC light and the SR readout at driver TB2 (36). If the light does not indicate and SR remains high, try replacing the System card and the Regulator card separately and check operation after each replacement to determine if either card is defective.

B. Drive Shuts Down, or Will Not Start

1. IOF Fault light on.

a. Check the frequency trip selection on the inverter card. Refer to the driver label, or Start-up and Check-out section of this manual, for proper jumper placement.

b. Check for an overhauling load pumping back into the inverter DC link to increase the voltage and frequency.

c. If the problem keeps occurring, replace the Inverter card and check operation.

2. COC and I0C (and ITOC) fault lights on.

a. Check the peak voltage of the three commutation current feedback signals over the whole operating range of the drive. This can be read on Meter card position 9 or with an oscilloscope by probing receptacle K, terminal 11. Refer to the driver label for the normal peak voltage reading. See Figure 5 for wave shape of a normal commutation current pulse. A COC trip should not occur until one of these peaks reaches about 18 volts

b If one of the commuation current peaks is significantly higher than the others, the commutation reactor LC or capacitor CC in one of the phase modules could be defective or have the wrong value. Replace the defective component or the phase module if LC or CC appears to be defective and check drive operation.

c. If all current feedback signals are the same, but go too high near rated output, check for motor overloading or for high AC supply voltage.

d. If excessive commutation currents persist, replace the Inverter card and check operation

3. CUV (and IOC) fault lights on.

a. Check the +10 volt (Meter card, pos. 1) and +20 volt TB2 (40) control power. A CUV trip will occur at about 18 volts. If the +20 volt measures low, check the 115 volt AC supply to the driver TB1 (1) and (2). It should be no lower than 105 volts AC. If the AC supply is all right, check for excessive loading of the Power Supply card especially from external loads connected to driver TB2 (40). If the low +20 volt problem cannot be found, replace the Power Supply card and check operation.

b. If the +20 volt is all right, check the DFS voltage (Meter card, pos. 13, or receptacle K, term. 7 voltage to common). If it is below 16 volts, interrupt AC power to the drive and disconnect driver wire harnesses at APL, BPL, CPL and DPL. Check if DFS is being pulled down by either the Converter card or the Phase Logic card by energizing the driver with either one of these cards pulled out. If either of these cards loads DFS down, it should be replaced and the test repeated. If DFS is pulled down with both cards pulled, the Inverter card should be replaced and the operation checked.

c. If the DFS voltage is above 18 volts. but the CUV light stays on when the fault is reset, disconnect the DPL wire harness at the converter, module, If the CUV light can then be reset, the problem is in the Pulse Transformer card on the converter module. Refer to Converter Troubleshooting in this section.

d. If the DFS voltage is above 18 volts, and the CUV light does not indicate until the inverter is started (to start the motor), disconnect wire harness APL, BPL or CPL. If the CUV light does not come on, stop the drive and connect only one of the (APL, BPL and CPL) wire harnesses to the driver and check for the CUV light when a drive start is initiated, with the driver reference at zero.

CAUTION

NEVER TRY TO START THE INVERTER WITH TWO OF THE THREE (APL, BPL OR CPL) WIRE HARNESSES CONNECTED WHEN THE MOTOR IS CONNECTED TO THE DRIVE. ALSO, THE DRIVER REFERENCE SHOULD NEVER BE INCREASED FROM ZERO WITH ANY OF THE WIRE HARNESSES DISCONNECTED, UNLESS THE DC LINK IS OPENED (SEE INVERTER MODULE TROUBLESHOOTING.

If the CUV light comes on when any one wire harness is connected, the problem is in the Pulse Transformer card on the inverter module related to that wire harness. Refer to Inverter Module Troubleshooting in this section.

4. LOV and IOC (and COC, ITOC) fault lights on.

a. Check that the slowdown control is connected. On driver receptacle H, terminal 23 should be connected to terminal 7.

b. Check for overhauling load or for excessive AC supply voltage.

c. Check that the link voltage feedback and the converter voltage feedback at driver receptacle F, terminals 15 & 21 are at the same voltage to common. If their voltage levels are different, either the Converter card is defective of the resistance isolated feedback signals through RF4-7 are incorrect. Check the FU4 and FU control fuses. Replace the Converter card and check the operation.

5. (ITOC and IOC) fault lights are on.

a. Check the converter DC link (LCS) feedback signals, over the whole operating range of the drive. This can be read on Meter card position 7, or with an oscilloscope by probing TB3. The normal feedback signal voltage should be adjusted for 1 volt rms with rated load. See Figure 6 for the wave shape of normal motor current. An instantaneous ITOC trip should not occur until the peak of the current feedback reaches about 5 volts as seen on the oscilloscope.

b. If the current feedback signal is significantly more than 1.0 volt, RMS, adjust the ***CFA*** potentiometer on the Current Isolator card until the DC link (LCS) output current feedback signal equals 1.0 volt for 100% reference and 100% load. Replace this card if it appears to be defective and check drive operation.

c. Check the current limit ***CLIM*** potentiometer setting on the Regulator card to see if it is too low for the motor loading. If shutdown occurs because the motor cannot get started, check the voltage boost ***VB*** setting. Refer to Adjustments section.

d. If a transformer is used between the power unit and the motor, check the settings of the ***MINF*** and ***VB*** potentiometers. Increase the minimum frequency by turning ***MINF*** clockwise and decrease the voltage boost by turning ***VB*** counter-clockwise, until the drive can be started and stopped

6. Cannot reset fault lights.

a. Check that fault is not a maintained fault that has not been cleared.

b. Check that the STOP input at driver TB2 (33) is low (near common) and that XFR input at driver TB2 (43) is high (near +20 volt). If they are not, check the system control (refer to the system elementary diagrams).

c. Check that the RUNR readout at driver TB2 (31) is high and the MVFR readout at driver TB2 (38) is low. If they are not, check the DC link voltage. Meter card, pos. 4 should read 1.5 or less, and the P3 to N2 voltage should read no higher than 30 volts DC (230 volt AC drives) or 60 volts DC (460 volt AC drives). If inconsistent or higher voltages are read, refer to part 7c.

d. If the above four logic signals are correct, try replacing the System card and checking operation.

7. Drive shuts down (no fault lights on), or drive will not start (no fault lights on).

a. Check that the STOP input at driver TB2 (34) is high (near +20 volt) and the START input at TB2 (33) is low (near common). If they are not, check the system control (refer to the system elementary diagrams).

b. Check that the RUNR readout at driver TB2 (31) and the MVFR readout at driver TB2 (38) are both low. If they are not, check that the FTR fault readout at driver TB2 (37) is low. Also check the DC link voltage. Meter card pos. 4 should read 1.5 or less, and the P3 to N2 voltage should read no higher than 30 volts DC (230 volt AC drives) or 60 volts DC (460 volt AC drives).

c. If inconsistent or higher link voltages are present when the drive is in standby, check the converter reference voltage CVR (Meter card, pos. 6 or driver receptacle K, term. 14). If this voltage to common is about 10 volts, the problem is either in the Converter card or in the converter power module. Refer to Converter Troubleshooting in this section. If the CVR voltage to common is less than 8, then the problem is either in the Regulator card or in the System card. Try replacing each card separately and checking the operation.

8. If light is not indicating, or is on continuously at standby.

a. Check the +10 volt (Meter card, pos. 1) and +20 volt TB1 (3) to TB1 (4) control voltage. If they are zero, but 115 volt AC appears between driver terminal 1 and terminal 2, check the fuse FU7 above TB1. If no voltage is present between terminal 1 and terminal 2, check the control power transformer and its fuse (see system elementary diagram).

b. If +20 volt control power is all right, check the IPAD signal at driver TB2 (52) with an oscilloscope. If a square wave frequency is present, replace the System card and check the operation. If no frequency appears at IPAD, check the OP signal at driver connector K, terminal 19. If there is no pulse frequency signal at OP (consists of 35 usec. wide, low going pulses), replace the Regulator card and check operation. If frequency pulses appear at OP replace the Phase Logic card and check operation. If no frequency pulses appear at IBL, replace the Inverter card and check operation.

9. SCR firing signals not reaching power modules.

a. Check that there are no fault lights indicating and that the FTR fault readout at driver TB2 (37) is low. If a fault has occurred, it will lock out all firing signals. Clear the fault and reset the fault circuits to enable the firing signals.

b. Converter firing signals should be present at drive standby. Check for firing signals at driver receptacle F, terminals 26 through 31. Use either the red wire back plane selector probe with the Meter card, pos. 19 and compare with readings on the driver label, or an oscilloscope and compare with the wave shapes of Figure 7.

c. If any firing signals are present at the driver but missing at the converter modules, check the plug connections at both ends of wire harness DPL for loose pins or bad connections and check the wire harness for broken wires. If any firing signals are missing or faulty at the driver, replace the Converter card and check the operation.

d. Inverter firing signals will not be generated until the drive is started. Check that Meter card, pos. 11 reads high or that driver TB2 (31) RUNR reads low. Check for firing signals at driver receptacle D terminals 5 through 19. Use either the red wire back plane selector probe with the Meter card, pos. 19 and compare with the readings on the driver label, or an oscilloscope and compare with the wave shapes of Figure 8.

e. If any firing signals are present at the driver but missing at the inverter modules, check the plug connections at both ends of the appropriate wire harness APL, BPL, or CPL (refer to driver elementary diagram). Check the plugs for loose pins or bad connections, and check the wire harness for broken wires. If any firing signals are missing or faulty at the driver, replace the Phase Logic card and check the operation.

COMMUTATION POWER SUPPLY TROUBLESHOOTING

The commutation power supply components are contained in the converter module and consist of the Commutation Power Supply card, CPS, the filter capacitor, C2, the commutation leg reactors, CLP and CLN, the DC Link decoupling rectifier, DC, and the commutation current transformer CTC.

To help in troubleshooting, refer to the elementary diagram. Wait 3 minutes after disconnecting power and verify that capacitors are discharged by checking the voltage between terminal CP and N1 before removing the converter module from its rack.

1. CPS Card

Remove and inspect the card for damaged components and etching runs or loose connections. Verify proper resistor values per elementary diagram, Table 1. The power supply diodes may be checked with a VOM on the X 1K resistance scale. Good diodes will have a low forward resistance and almost infinite reverse resistance. If any components appear to be defective, replace the card.

2. Filter Capacitor, C2

The capacitor may be checked with a VOM on the highest resistance scale to determine if it charges up. Also, verify that the discharge resistor, R2, mounted on the capacitor terminals is undamaged and has the correct value.

3. Reactors CLP and CLN

The reactors should indicate a very low resistance when checked with a VOM. During operation, the reactors will run hot and will typically show some discoloration. However, there should not be any charring or cracking of the insulation tape wrapped around the coils.

4. Rectifier, DC

This rectifier is mounted on a heatsink in back of the module. With a VOM on the X 1K resistance scale, the rectifier should have a low forward resistance and essentially infinite reverse resistance.

5. Current Transformer — CTC

Disconnect the CT1 or CT2 connection at the pulse transformer card and with a VOM check that the winding resistance measures between 15 and 25 ohms. Check that arrow marked on the outside of the transformer points from the CLP reactor towards the CP terminal.

Inspect the transformer for any mechanical damage and make sure it is not in direct contact with the reactors or any terminals.

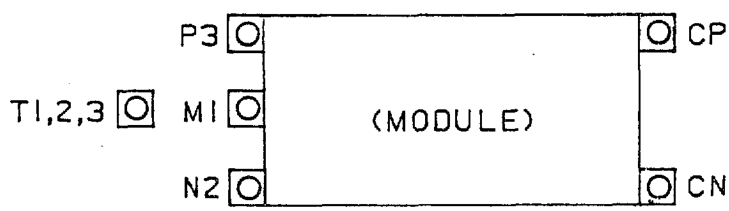
INVERTER MODULE TROUBLESHOOTING

Each of the three identical inverter modules contains the power circuitry for one-phase of the three-phase inverter. To help in troubleshooting these modules, refer to the inverter phase module elementary diagram and to the simplified overall power circuit of Figure 3. Since practically all of the circuitry on these modules is at AC supply potential, troubleshooting should be done with the AC power off where possible. Wait 3 minutes after disconnecting power before doing any checking, to allow capacitors to discharge.

1. Checking SCRs, Diodes and Snubbers

The inverter phase module SCRs and diodes can be checked, with the power off, without disconnecting anything. The measurement points for the phase modules are as follows:

10 TO 100 KVA



P3 to M1 — Checks positive inverter SCR and diodes.
N2 to M1 — Checks negative inverter SCR and diodes.
CP to MC — Checks positive commutation SCR.
CN to MC — Checks negative commutation SCR.

Using a volt-ohmmeter selected to read ohms on the X1 ohm or X10 ohm scale, the normal readings indicating good devices are as follows, with the positive meter lead connected to the first point.

P3 to M1 — High resistance
M1 to P3 — Low resistance
M1 to N2 — High resistance
N2 to M1— Low resistance
CN to MC1, MC to CN — High resistance
CP to MC1, MC to CP — High resistance

If any of the above readings are zero, the phase module should be disconnected from the rest of the power circuitry at terminal points P3, N2, CP, T(1, 2, 3) and M1. (The phase module may have to be pulled partly out to accomplish this). Recheck the above readings at the disconnected phase module terminals. If the readings still indicate a bad device, refer to the Maintenance and Repair section for removal, disassembly and replacement information. The individual SCRs and diodes should be rechecked when they are disconnected from each other to ensure that a short in one device does not produce a faulty reading across another device. See the Checking SCRs portion of this section.

Whenever a phase module has been removed for replacement of SCRs or diodes, the RC snubber circuits around the SCRs, commutating capacitor and choke, leg chokes and wiring should be inspected and checked for damage.

2. Checking Commutating Capacitors CCA, CCB, and CCC.

These capacitors may be checked by connecting the volt-ohmmeter selected to the X 1K scale, between M1 and MC for each phase module. A good capacitor will read above 100K resistance (after a brief charging period) whereas a bad capacitor will give a low or zero reading. The capacitors should be checked again after the phase module has been removed and the capacitors have been disconnected from the other power circuitry. Refer to the Maintenance and Repair section.

3. Inverter Phase Module Operational Test

If checking all phase module SCRs, diodes and commutation capacitors according to the preceding instructions does not indicate any failed devices, but inverter fault shutdowns still occur, the following procedure should be used to locate the problem.

Interrupt the DC link between N1 and N2 to prevent power flow from the converter into any inverter fault condition. This is easiest accomplished by disconnecting the N1 to N2 jumper wire at N1.

With the DC link disconnected the drive can be started and the inverter operated up to full reference. With the motor disconnected from the inverter, the P3 to N2 DC link voltage will build up somewhat as the reference is increased. With the motor connected to the inverter, the DC link will stay close to zero. The maximum inverter frequency that can be obtained at full reference will be limited to less than half of rated by the below normal DC link voltage. Except for these differences from normal, the inverter can be operated to check out the inverter SCR firing and commutation operation without danger of further damaging the equipment if a fault problem is present. In addition, by disconnecting the plugs of two of the three wire harnesses APL, BPL or CPL, just one phase module can be operated at a time to simplify checking and to help in pin-pointing the problem.

The inverter phase commutations can be checked in the driver by checking the commutation current feedback signal, CFA. The peak value of commutation current can be read on the Meter card (See the driver label on the inside of the power unit door for normal readings). The commutation current can also be read with an oscilloscope connected driver TB39 (SEL1) and TB34 (COM), and using the black wire, back plane selector probe to receptacle K terminals. See Figure 5 for normal commutation current wave shapes.

4. Checking Pulse Transformer Cards

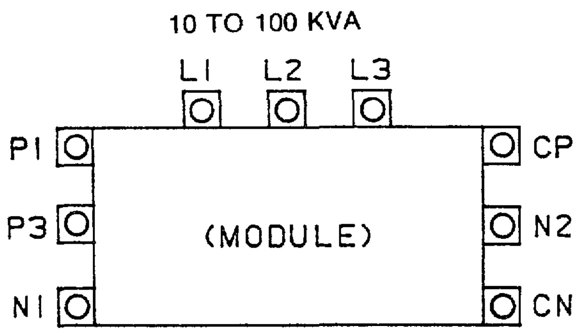
The Pulse Transformer card on the front of the phase module may be checked with an oscilloscope to see if SCR firing signals from the driver are being applied to the pulse transformers. Connect the ground lead of the oscilloscope to the card COM terminal, and connect the probe lead to the top (cooling) tab of one of the red power transistors. A normal pulse wave shape is shown in Figure 9. Change the oscilloscope probe lead to the top tab of the other red power transistors to check this four channel card. If normal pulses are observed when that inverter phase is operating, the card is probably good. If no pulses are observed, connect the oscilloscope probe to the 1P, 2P, 1N and 2N input terminals to check for driver firing signals. See Figure 8 for normal firing signals. Also check for +20 volt firing power at the 20V input terminal. If input firing power and firing pulses are present, then the card is probably defective. Replace the card and check operation. If no input power or firing pulses are present, refer to part 9 of Drive Shuts Down, or Will Not Start in the Driver Troubleshooting portion of this section.

CONVERTER MODULE TROUBLESHOOTING

To help in troubleshooting this module, refer to the converter module elementary diagram and to the simplified overall power circuit of Figure 3. Since practically all of the circuitry on this module is at AC supply potential, troubleshooting should be done with the AC power off where possible. Wait 1 minute after disconnecting power before doing any checking to allow capacitors to discharge.

1. Checking SCRs and Snubbers

The converter SCRs can be checked with the power off, without disconnecting anything. The measurement points for the module are as follows:



L1 to P1 — Checks positive phase 1 SCR, (1SP)
L1 to N1 — Checks negative phase 1 SCR, (1SN)
L2 to P1 — Checks positive phase 2 SCR, (2SP)
L2 to N1 — Checks negative phase 2 SCR, (2SN)
L3 to P1 — Checks positive phase 3 SCR, (3SP)
L3 to N1 - Checks negative phase 3 SCR, (3SN)

Using a volt-ohmmeter selected to read ohms on the X 1K scale, check across all six SCRs in both directions. Good SCRs should read over 100K in both the forward and reverse directions, while failed SCRs will read zero ohms in one or both directions.

If any SCRs appear to be failed, the converter module should be disconnected from the rest of the power circuitry at terminal points L1, L2, L3, P1, P3, N1, N2, CP and CN. Recheck the above readings at the disconnected converter module terminals. If the readings still indicate a bad device, refer to the Maintenance and Repair section for removal, disassembly and replacement information. The individual SCRs should be rechecked when they are disconnected from the converter circuit to ensure that a short in one device does not produce a faulty reading across another device. See the Checking SCR's portion of this section.

2. Converter Module Operational Test

If converter misoperation is suspected, but all converter SCRs appear to be good, the following procedure should be used to perform an operational test.

Interrupt the DC link to prevent any power flow from the converter from reaching the filter capacitor or inverter. This is easiest to accomplish by disconnecting the power cable connected at P3, the lower terminal at the shunt

With the DC link disconnected, the drive can be started and the converter operated up to full voltage. The inverter will operate also, but at a low voltage and reduced frequency, with or without the motor connected.

The converter operation may be checked by means of the Driver Meter card selected to position 5. The reading should change from 10 at zero reference to 5.5 at full reference. The converter output voltage may also be checked by connecting a volt-ohmmeter across the P1 to N1 terminals. The DC output voltage should be controllable from near zero to approximately 300 volts DC (230 volts AC input drives) or 600 volts DC (460 AC input drives).

If full output voltage cannot be obtained, it is possible that one or more converter SCRs are not firing, or that the driver is not putting out the proper signals. Refer to part 1, of Drive Operates Improperly and part 9 of Drive Shuts Down, or Will Not Start under Driver Troubleshooting. If the driver is putting out the proper firing signals, check the converter Pulse Transformer cards. If these check out good, an open SCR should be suspected. Refer to Checking SCRs to test for this problem.

3. Checking Pulse Transformer Cards

The Pulse Transformer card on the front of the converter module may be checked with an oscilloscope to see if SCR firing signals from the driver are being applied to the pulse transformers. Connect the ground lead of the oscilloscope to the card COM terminal, and connect the probe lead to the top (cooling) tab of one of the red power transistors. A normal pulse wave shape is shown in Figure 9.

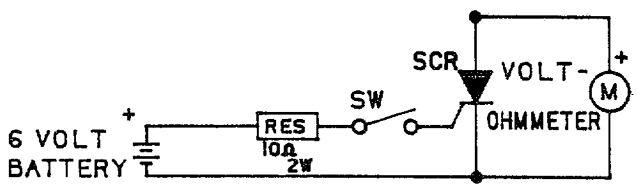
Change the oscilloscope probe lead to the top tab of the other red power transistor to check the other circuits of this card. If no pulses are observed, connect the oscilloscope probe to the 1P, 2P, 1N, 2N input terminals to check for driver firing signal. See Fig. 7 for normal firing signals. Also check for +20 volt firing power at the 20V input terminals. If input firing power and firing pulses are present, then the card is probably defective. Replace the card and check operation. If no input power or firing pulses are present, refer to part 9 of Drive Shuts Down, or Will Not Start in the Driver Troubleshooting portion of this section.

CHECKING SCRs

Disconnect the suspected SCR as much as possible from the remainder of the power circuitry. Using a volt-ohmmeter selected to read ohms on the times 1K scale, check the forward and reverse resistance of each individual SCR cell (See the Module Elementary diagram). Good or faulty SCRs will give the following typical readings:

SCR Description	Forward Reading	Reverse Reading
Good SCR	100K to Infinity	100K to Infinity
Shorted SCR	Zero	Zero
Inoperative SCR	1 to 2K	100K to Infinity
Open SCR	100K to Infinity	100K to Infinity

Since an open SCR will give about the same resistance reading as a good SCR, another method must be used to find this type of fault. It should be pointed out, however, that practically all cells fail by shorting and very few by opening. If an open SCR is suspected, or if it is desired to check the switching operation of an SCR, the following circuit should be used:



The volt-ohmmeter is selected to read ohms on the 1K scale, and is connected to read the forward resistance of the SCR. When switch SW is closed, the forward resistance of a good SCR will change from a high value (100K to infinity) to a low value (1 to 10K). When the switch is opened, a good SCR will revert to its high forward resistance or blocking state if the holding current source (volt-ohmmeter battery) is momentarily removed. A faulty SCR will not switch, remaining in either an open or a conducting state.

If any SCRs are suspected of being faulty from the above resistance checks, the SCR conversion module should be removed from the case. After the SCR (cathode) and gate leads have been disconnected, recheck the forward and reverse resistance before replacing the SCR.

This should be done before the SCR is definitely classified as damaged or faulty, since a fault in another SCR or another part of the circuitry can produce a faulty reading from a good SCR before it is disconnected from the circuit. After a Press-Pak SCR is removed from the heatsink it may read open due to lack of pressure against the internal cell structure. Apply pressure to obtain a true reading.

DC LINK FILTER TROUBLESHOOTING

The DC link filter consists of the L1 filter choke and the C1 filter capacitor assembly.

1. C1 Filter Capacitor Assembly(s)

This consists of one assembly of paralleled (230 volt AC drives) or series-paralleled (460 volt AC drives) electrolytic capacitors. When the drive has not been operated for 6 months or more, these capacitors start to degrade and their leakage current increases. A procedure called "forming" is required to return the electrolytic capacitors to their rated operating capability. Refer to step 13 of the Start-up Procedure in the Start-up and Check-out section for the proper forming procedure.

Electrolytic capacitors can fail by shorting, can exhibit excessive leakage current, or can dry up and lose their capacitance. The latter usually results from a ruptured vent plug due to "gassing" from excessive current and/or temperature.

The filter capacitor assembly can be checked for shorted capacitors using a volt-ohmmeter after the power has been off for more than 1 minute and the P2 to N1 voltage is less than 10 volts. On 460 volt AC drives with seriesed capacitors, the assembly can be checked for excessive leakage capacitors by checking the midpoint, or Q point, voltage when the drive is operating. Using a volt-ohmmeter, check the difference between the P2 to Q and the Q to N2 voltages at maximum DC link voltage. This difference should not exceed 5% of the P2 to N2 voltage. If the above tests indicate either a shorted or leaking capacitor, the filter assembly should be removed and disassembled to the point where the resistance of each capacitor can be individually checked. Refer to the Maintenance and Repair section for instructions. Any shorted or leaky capacitors should be replaced. The remaining capacitors should be inspected for ruptured vent plugs according to the following instructions:

The best way of evaluating the condition of the electrolytic capacitors is to visually inspect their vent plugs. These are 3/16" diameter red plugs in the top cover of the capacitor case. Internal gas pressure can cause a bubble to form in this plug and the red color will lighten until it is almost white. Eventually, the plug will rupture. However, this does not cause an immediate capacitor failure, but will result in a gradual loss of capacitance. Any electrolytic capacitors which are found to have ruptured plugs should be replaced as soon as conveniently possible. If any capacitor vent plug contains a bubble larger than 1/16" in diameter, the capacitor assembly should be inspected at the next scheduled shutdown planned maintenance for ruptured vent plugs.

If more than 25% of the capacitors have broken vent plugs, and the drive has been operated over 20,000 hours, consideration should be given to replacing all of the capacitors in the filter assembly. Refer to the Maintenance and Repair section for instructions.

2. L1 Filter Choke

This choke should be visually checked for signs of overheating, damaged insulation or loose connections.

MISCELLANEOUS TROUBLESHOOTING CHECKS

The following check list of miscellaneous items is included to provide additional directions of investigation in troubleshooting this drive.

A. Cooling and Temperature Problems

1. Check for sufficient air flow through power unit.
2. Check if fan rotation is correct.
3. Check if air filters are clean (if provided).
4. Check if intake air is below 40°C.
5. Check for adjacent heat sources.
6. Check for recirculation of discharge air.
7. Check if room ventilation is adequate to remove the heat being produced.

B. Input Power

1. Check for correct voltage (within +10%, -5% of nameplate rating) and frequency.
2. Check for balanced phase voltages.
3. Check for transient over or under voltages.
4. Have transient voltages occurred due to lightening or ground faults?
5. Check for excessive line regulation due to a high impedance (soft) AC supply.
6. Is AC supply grounded or ungrounded?
7. Is the available short circuit current too high?
8. Are there power factor correction capacitors causing harmonics, or is their switching causing voltage transients.

C. System Grounds

1. Check that the power unit case is properly grounded.
2. Check for grounds in motor windings or in power cables to the motor.
3. Check for grounds in control wiring.

D. Loose or Shorted Connections

1. Check incoming power connections.
2. Check connection to power modules, filter capacitor and choke, circuit breaker or fuses, etc.
3. Check outgoing power connections to starters, motors, etc.
4. Check incoming control wiring connections.
5. Check connections to Pulse Transformer cards.
6. Check for bent terminals shorting to one another on driver back plane.
7. Check that the flat cable connectors are properly inserted on the driver back plane.

E. Electrical Noise

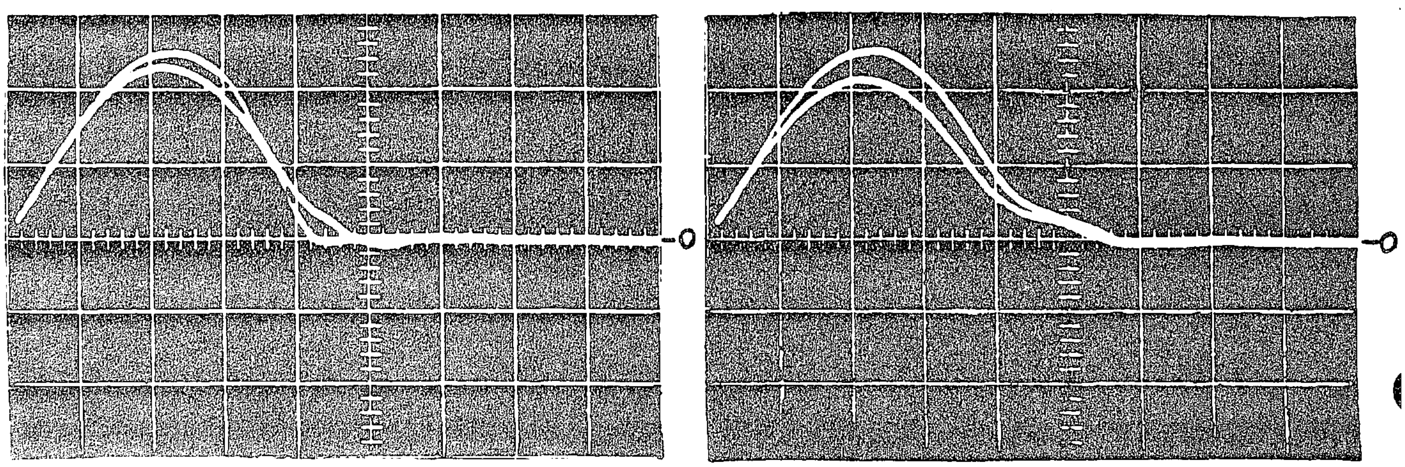
1. Check that all power unit relays have RC suppression on their coils.
2. External relays, solenoids, brakes, etc., interfacing with the power unit should also be suppressed.
3. Check for other external sources of electrical noise.

F. Output Load

1. Check starting torque requirements.
2. Check for transformer saturation at low frequencies if output transformer is used.
3. Check for motor overloads or jam-ups.
4. Check operation of motor transfer switching.

INVERTER COMMUTATION CURRENT WAVE SHAPE

At 1/2 rated voltage & frequency — At rated voltage & frequency



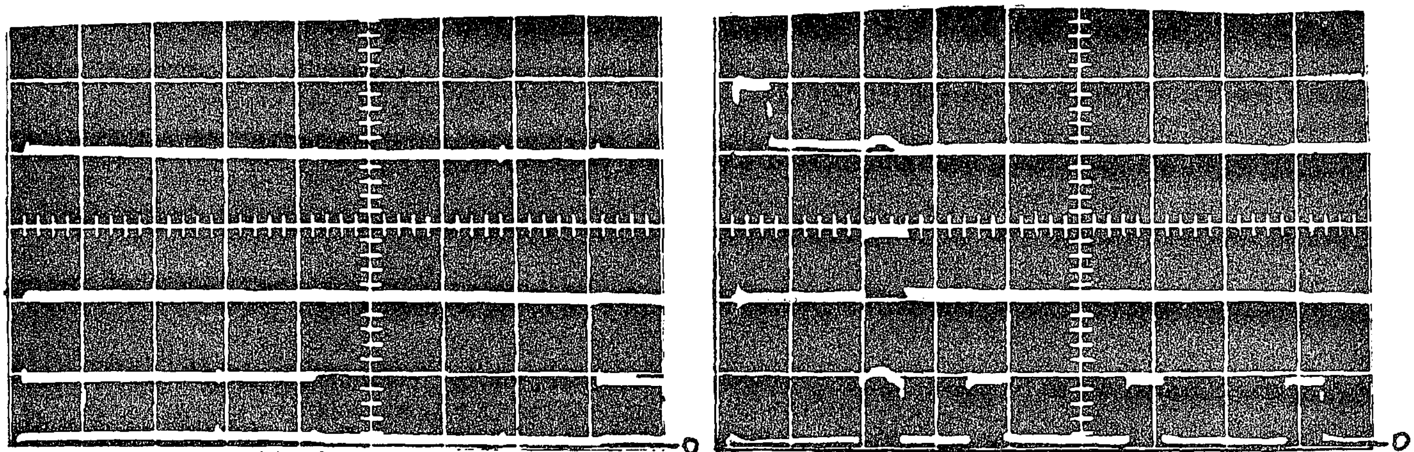
10 sec/div. (230V AC Drives)
20 sec/div. (460V AC Drives)

5 Volts Division

FIGURE 5

INVERTER FIRING SIGNALS

Top trace - A, B, CCP - Positive commutation SCR firing signal
Middle trace - A, B, CA - Commutation power supply SCR firing signal

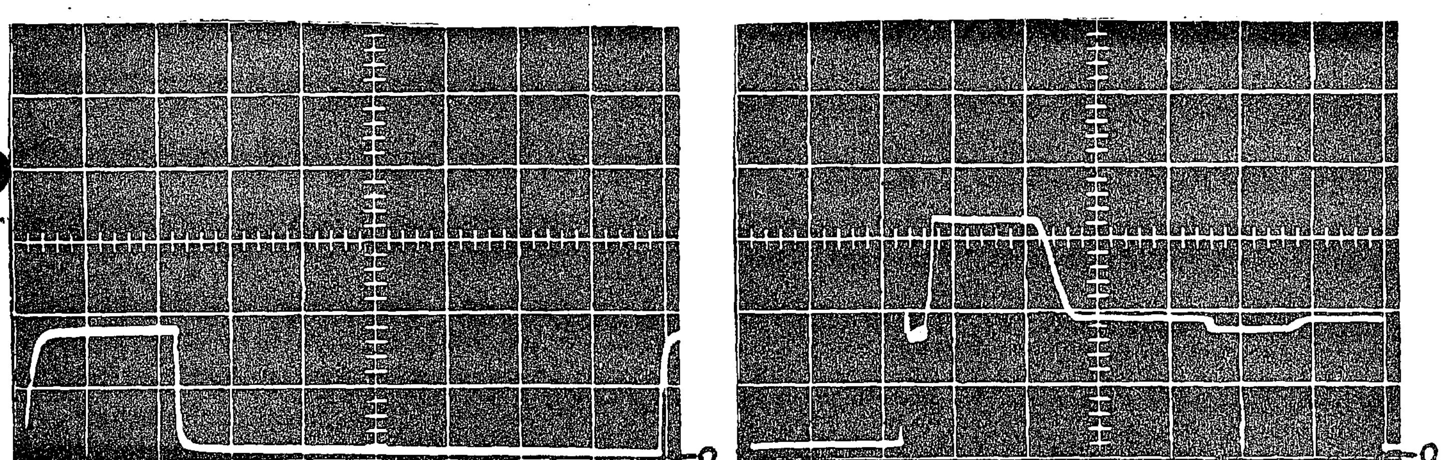


2 msec./division
20 volts/division

20 sec./division
20 volts/division

FIGURE 8

PULSE TRANSFORMER CARD PULSE WAVE SHAPE



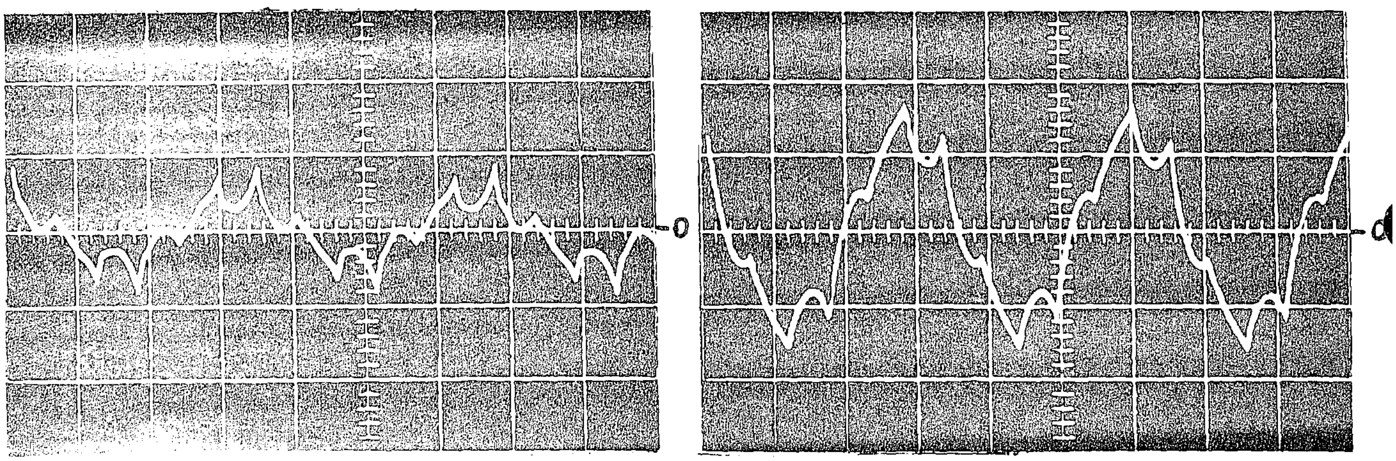
5 sec./division
10 volts/division

5 sec./division
10 volts/division

FIGURE 9

MOTOR CURRENT WAVE SHAPE

At half speed and low load | At full speed and full load

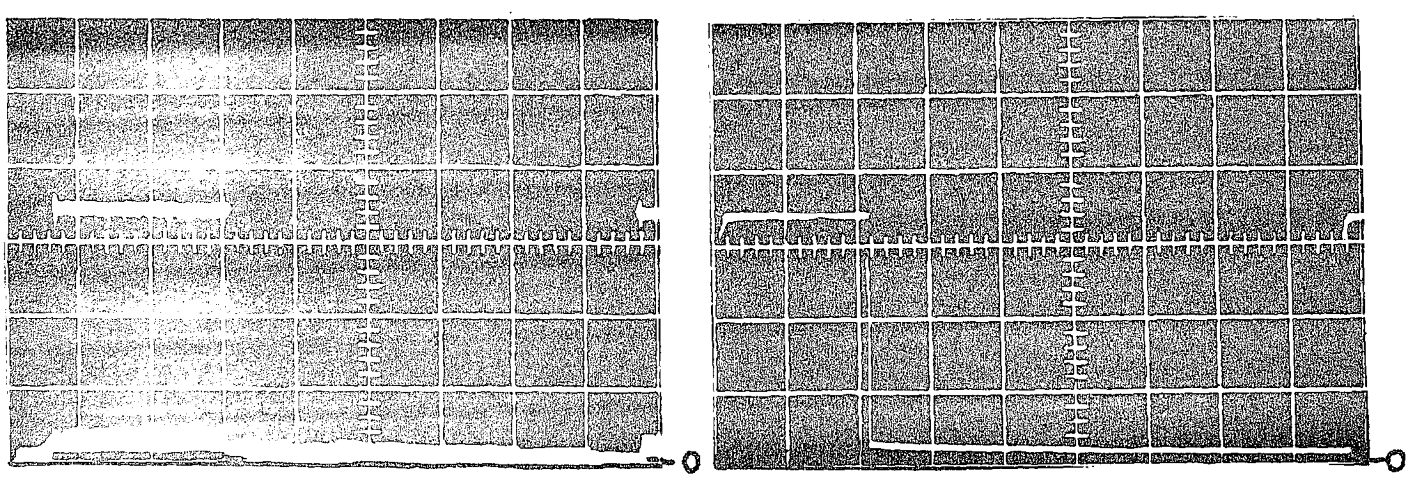


10 msec./div.
1 volt/div.

5 msec./div.

FIGURE 6

CONVERTER FIRING SIGNALS



2 msec./division
5 volts/division

5 sec./division
5 volts/division

FIGURE 7

REMOVAL/REPAIR AND REPLACEMENT

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHEN POWER OFF MAINTENANCE IS BEING PERFORMED VERIFY ALL POWER TO THE DRIVE IS SWITCHED OFF OR DISCONNECTED. RECOMMEND POWER SWITCHES BE RED-TAGGED DURING POWER OFF MAINTENANCE.

MECHANICAL INSPECTION

The mechanical maintenance required for the drive system is divided into two basic units; the power unit and motor. The power units only mechanical maintenance is checking that the unit is free of dirt and dust.

Motor maintenance is covered by the motor instruction book supplied with the motor and should be followed in all cases.

ELECTRICAL INSPECTION

Power off (every six months): Check all electrical connections for tightness. Look for signs of poor connections or overheating (arcing or discoloration). Manually check cooling fan for easy rotation.

POWER MODULE REPAIR

The removal, repair and/or replacement instructions vary depending on the type of power module and its KVA rating.

Refer to the instructions which follow under the specific heading and rating which applies to your drive.

If minimized down time is a critical factor, it is recommended that a complete converter module and a complete inverter phase module be stocked as spares.

CONVERTER MODULE REPLACEMENT

The converter module is best removed as follows:

1. Tools required:

   Ratchet — 3/8″
   Socket — 7/16″ for 3/8″ ratchet
   Nut Driver — 7/16″ with 6″ shaft

2. Disconnect the three-phase AC input power.

3. Check voltage across capacitor C1 (P2 to N2) with a DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work proceeds.

4. Disconnect the ribbon cable connector DPL.

5. Remove the nine (9) nuts and washers from the power connectors:
   L1, L2 and L3 across the top of the module. P1, P3 and N1 to the left of the module.
   CP, N2 and CN to the right of the module.

6. Carefully pull module out of the rack using the red plastic insulation cover in front of the module (See Fig. 10).

7. See Press-Pak SCR Replacement converter module or stud mounted SCR Replacement Converter Module.

8. To install the repaired or spare converter module, lift the module onto the top rack. Slide the assembly into the rack using the red plastic insulation cover on front of the module.

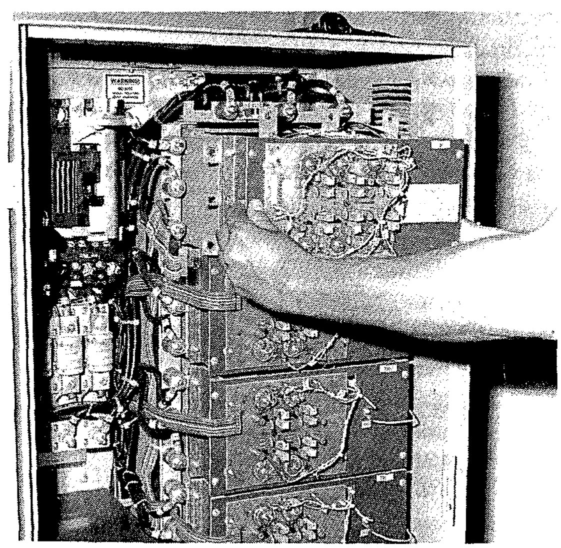


FIGURE 10
AF-400 Converter Module being removed.

9. Reconnect the power terminals L1, L2, L3, P1, P3, N1, CP, N2 and CN. Reconnect the ribbon cable connector DPL.

10. Check to see that all electrical connectors are tight before re-applying power.

INVERTER PHASE MODULE REPLACEMENT

The Inverter phase module is best removed as follows:

1. Tools required:
   Ratchet — 3/8″
   Socket — 7/16″ for 3/8″ ratchet
   Nut Driver — 7/16″ with 6″ shaft

2. Disconnect the three-phase input power.

3. Check voltage across capacitor C1 (P2 to N2) with a DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work proceeds.

4. Disconnect firing ribbon cable connector APL, BPL or CPL.

5. Remove the five (5) nuts and washers from the power connectors.
   P3, M1 and N2 to the left of the module.
   CP and CN to the right of the module.

6. Carefully pull the module(s) out of the rack using the red plastic insulation cover in front of the module (See Figure 11).

7. See (1) Press-Pak SCR Replacement — Phase Module or (2) stud mounted SCR Replacement — Phase Module or (3) Press-Pak SCR and stud mounted SCR Replacement — Phase Module.

8. To install the repaired module or a spare module, lift the phase module(s) onto the Inverter rack. Slide the assembly into the rack using the red insulation cover on the front of the module.

9. Reconnect the power terminals P3, M1, N2, CP and CN. Reconnect the firing ribbon cable connector APL, BPL or CPL.

10. Check to see that all electrical connections are tight before reapplying power.

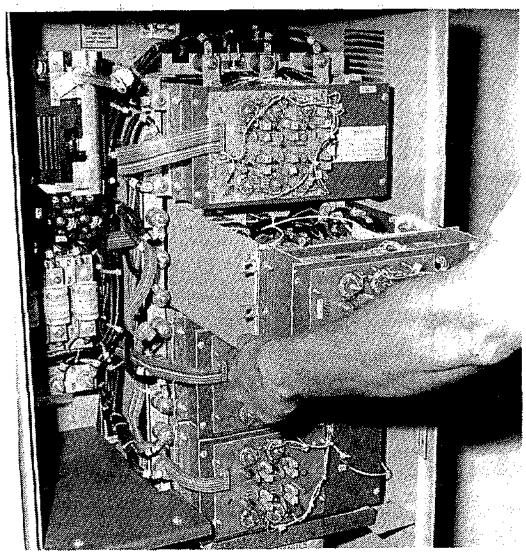


FIGURE 11
AF-400 Drive Inverter Phase Module being removed

PRESS-PAK SCR REPLACEMENT CONVERTER MODULE 40 TO 60 KVA, 230V AC AND 40 TO 100 KVA, 460V AC

1. Tools required:

   Table — 30″ high
   Ratchet — 3/8″
   Deep Socket — 7/16″ for 3/8″ ratchet
   Wrench — 7/16″ box
   Wrench — 3/8″ box
   Screwdriver — 8″ long with 5/16″

2. Stand the Converter Module on its backside on table. The pulse transformer, printed circuit card should be on top (normally on the front of the module). See Figure 12.

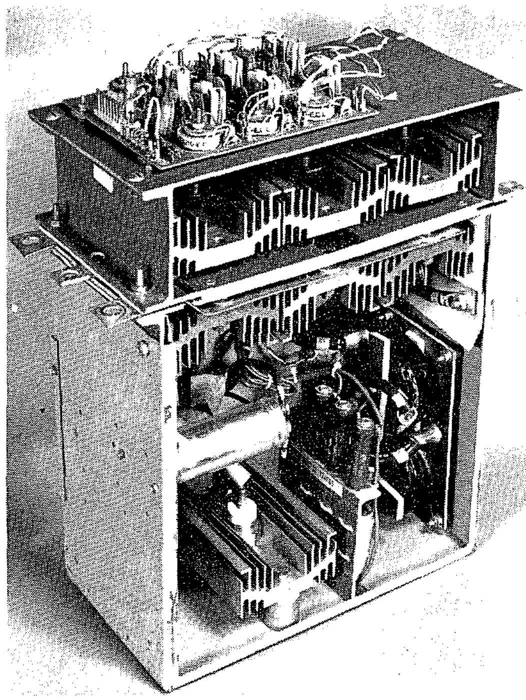


FIGURE 12
AF-400 Converter Module
standing on a table
Press-Pak SCRs
40-60 KVA, 230V AC
40-100 KVA, 460V AC

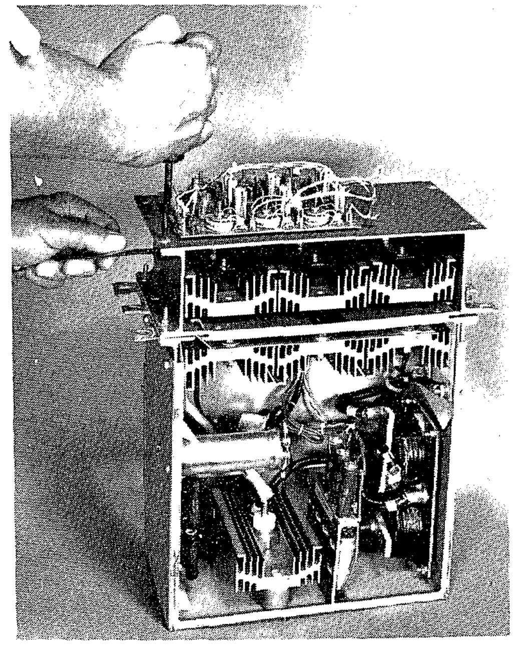


FIGURE 13
AF-400 Drive Converter Module
showing removal of machine
screws that secure the front cover,
Press-Pak SCRs
40-60 KVA, 230V AC
40-100 KVA, 460V AC

3. After locating the defective Press-Pak SCR cell (1SP, 2SP, 3SP, 1SN, 2SN or 3SN), trace the appropriate red (cathode) and white (gate) firing circuit loads to the pulse transformer printed circuit card. Remove the plastic tie wraps from the appropriate firing circuit. Disconnect these circuits from the pulse transformer card, fasten connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective cell.

4. Remove 4 machine screws and nuts that secure the front red plastic insulation cover to the converter module. See Figure 13.

5. Fold back the cover, thereby, exposing the Press-Pak SCR heatsink clamps. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective Press-Pak SCR cell. See Figure 14.

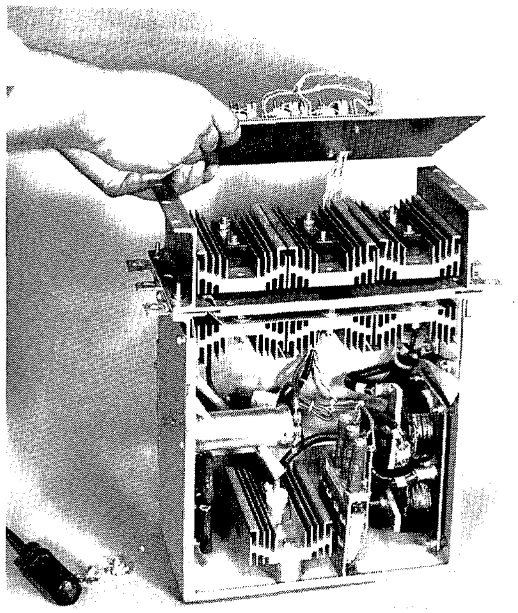


FIGURE 14
AF-400 Drive Converter Module
with front insulation
cover folded back
40-60 KVA, 230V AC
40-100 KVA, 460V AC

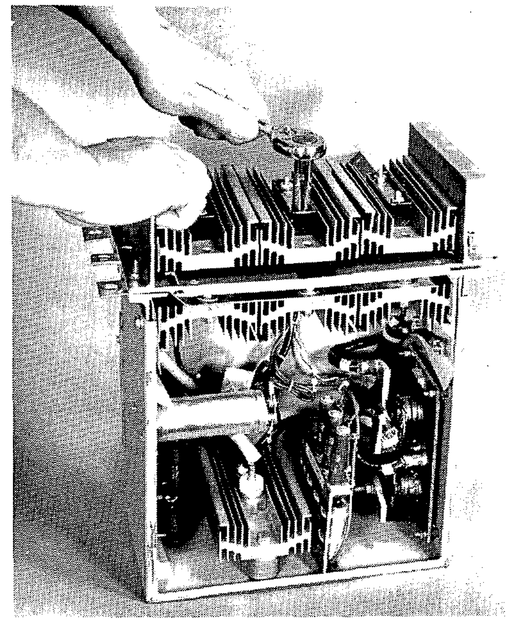


FIGURE 15
AF-400 Drive Converter Module, showing
removal of the nut and washers
tht secure the heatsink clamp. Press-
Pak SCRs, 40-60 KVA, 230V AC
40-100 KVA, 460V AC

6. Remove the bolt, two flat washers and nut that holds the heatsink associated with the defective SCR cell to the DC bus (P1 or N1). See Figure 15.

7. Remove the two clamp nuts that secure the defective SCR, while supporting the bottom heatsink and clamp with one hand underneath the heatsink assembly. See Figure 16.

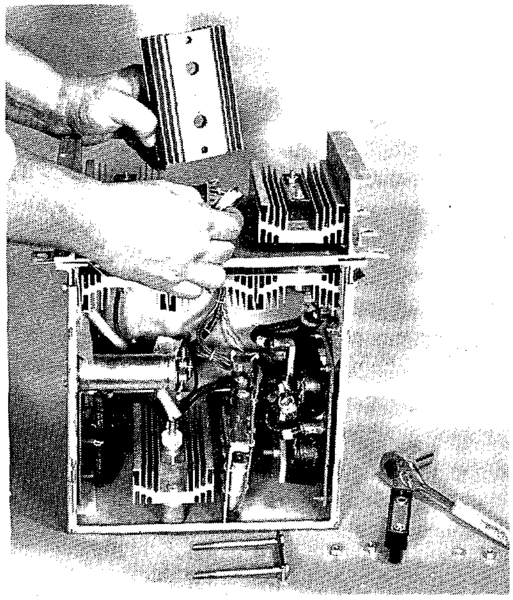


FIGURE 16
AF-400 Drive Converter Module showing removal of heatsink, Press-Pak SCRs, 40-60 KVA, 230V AC 40-100 KVA, 460V AC

8. Note that 1SP, 2SP and 3SP SCRs are connected to the top heatsinks, whereas, 1SN, 2SN and 3SN SCRs are connected (back to back) on the bottom heatsink assembly.

9. NOTE CAREFULLY THE ARRANGEMENT OF THE CLAMP PARTS AND SCR ORIENTATION.

10. Remove the clamp rods, thereby, separating the two heatsinks and permitting the defective SCR to be removed along with its red and white firing circuit leads which were previously removed from the pulse transformer printed circuit card.

11. The gate and cathode leads of the replacement SCR should be connected to the pulse transformer card per the converter module elementary diagram. See Figure 17.

12. SCR associated with the clamp assembly should be carefully lifted from the heatsink mounting surfaces.

13. Inspect the surfaces that both SCR mount between. These surfaces should be wiped clean with a lint-free cloth. Inspect the surfaces and make sure they are smooth; if not smooth, replace the heatsink assembly.

14. Lubricate both mounting surfaces for each SCR using a thin coat of thermal grease, General Electric, G322L, Versilube® Plus (or equivalent).

15. Place both SCRs in the same orientation, as in the original assembly and place the SCR center holes over the roll pin in the mounting surface.

16. The clamp parts and heatsink should be assembled in the original manner and the two nuts tightened finger tight so that the threads showing are the same on both clamp rods.

17. Check to see that the SCR center holes are still over the roll pins.

18. With the nuts finger tight use a wrench to tighten each nut, alternately in one quarter (1/4) turn steps *until the clamp tightness (over finger tightness)* equals one and one quarter (1 1/4) turns.

NOTE

WHEN TIGHTENING THE CLAMP, USE A SOCKET WRENCH TO HOLD THE BOTTOM HEADS OF THE CLAMPS RODS WHEN COUNTING TURNS.

19. Reconnect all electrical connections to both heatsinks and the SCR firing circuit leads to the pulse transformer card.

20. Re-install the front insulation board which includes the pulse transformer card and bolt in place with the four (4) machine screws and nuts.

21. Re-tie the SCR firing circuit leads with plastic clamps.

22. Check to see that all electrical connections are tight.

COMMUTATING DIODE (DC) REPLACEMENT
CONVERTER MODULE
40 to 60 KVA, 230V AC
40 to 100 KVA, 460V AC

1. Tools required:
   Table — 30″ high
   Ratchet — 3/8″
   Deep Socket — 9/16″for 3/8″ ratchet
   Deep Socket — 7/16″ for 3/8″ ratchet
   Wrench — 7/16″ box

2. Stand the converter module on its back side on a 30″ high table. See Figure 12.

3. Remove the P3 connection (anode) to the commutating diode (DC).

4. Remove the two bolts that secure the (DC) diode heatsink to the converter module.

5. Remove the top protective metal plate (2-1/4/20 machine screws).

6. Remove the stud mounted diode from its heatsink. It is secured with a nut and lock washer. See Figure 17.

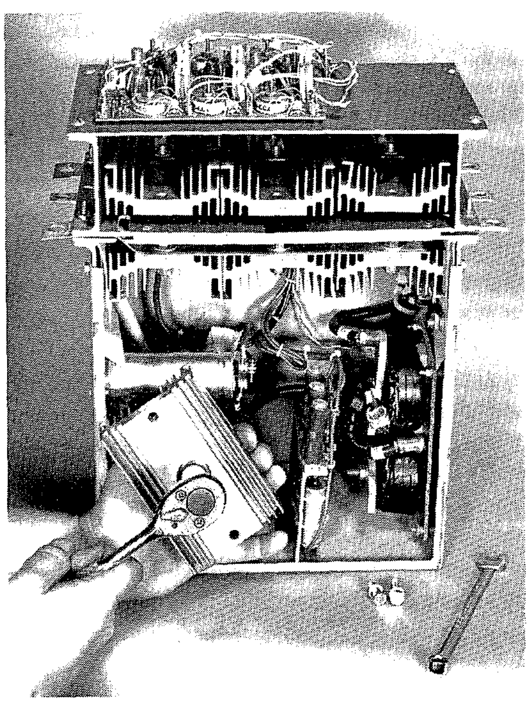


FIGURE 17
AF-400 Drive Converter Module
showing removal of the commutating
diode (DC) heatsink
40-60 KVA, 230V AC
40-100 KVA, 460V AC

7. Before replacing the commutating diode inspect the mounting surface on the heatsink as well as the stud mounted diode mounting surface. These surfaces should be wiped clean with a lint-free cloth. Inspect the surfaces and make sure they are smooth.

8. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric G322L, Versilube® Plus (or equivalent).

9. Insert the diode into the heatsink and tighten down the stud nut to a pressure equivalent to 100 inch pounds using a torque wrench.

10. Replace the two bolts that secure the heatsink to the converter module.

11. Replace the anode connection P3.

12. Replace the top protective metal plate.

COMMUTATION POWER SUPPLY REPLACEMENT
CONVERTER MODULE
40 to 60 KVA, 230V AC
40 to 100 KVA, 460 VAC

1. Tools required:
   Table — 30″ high
   Screwdriver — 8″ long with 5/16″ tip
   Nut Driver — 1/4″ with 6″ shaft

2. Remove the top protective metal plate (2-1/4/20 machine screws).

3. The commutating power supply is contained on a printed circuit board located on the left side of the converter module. It is connected through five (5) slotted terminals on terminal board TB1.

4. Loosen the five (5) terminal board screws on terminal board TB1 and slip the card away from the terminal board.

5. To replace the card, reverse the above procedure.

6. Make sure the five (5) terminal board screws are tight. These are electrical connections that also serve to support the card.

STUD MOUNTED SCR REPLACEMENT — CONVERTER MODULE

10 to 30 KVA, 230V AC or 460V AC

1. Tools required:
   Table — 30″ high
   Ratchet — 3/8″
   Deep Socket — 7/16″ for 3/8″ ratchet
   Wrench — 7/16″ box
   Screwdriver — 8″ long with 5/16″ tip

2. Stand the converter module on its back side on a table. The pulse transformer printed circuit card should be on top. (Normally on the front of the module).

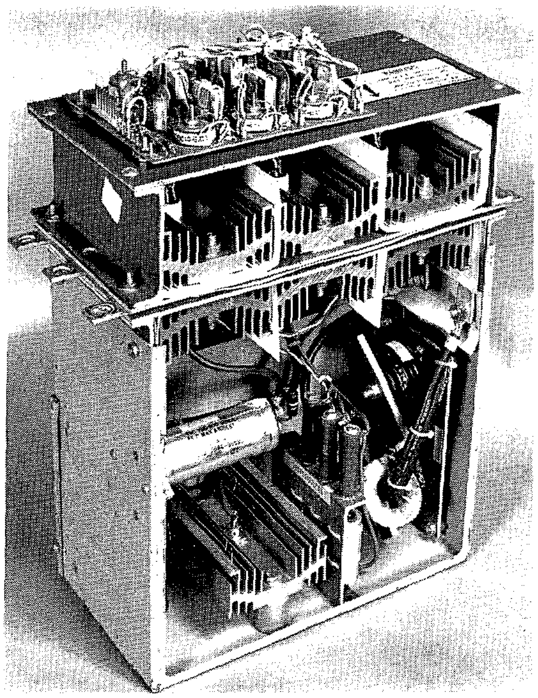


FIGURE 18
AF-400 Drive Converter Module with stud mounted SCRs standing on a table
10-30 KVA, 230 or 460V AC

3. After locating the defective stud mounted SCR cell (1SP, 2SP, 3SP, 1SN, 2SN or 3SN) trace the appropriate red (cathode) and white (gate) firing circuit leads to the pulse transformer printed circuit card. Remove the plastic tie wraps from the appropriate firing circuits. Disconnect these circuits from the pulse transformer card faston connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective cell.

4. Remove four (4) machine screws and nuts that secure the front, red, plastic insulation cover to the converter module.

5. Lift back the cover, thereby, exposing the stud mounted SCR heatsinks. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective stud mounted SCR cell.

6. Remove the two (2) nuts that secure the defective SCR heatsink to the DC bus (P1 or N1).

7. Disconnect the SCR power circuits.

8. Remove the stud mounted SCR from its heatsink. It is secured with a nut and lock washer. See Figure 19.

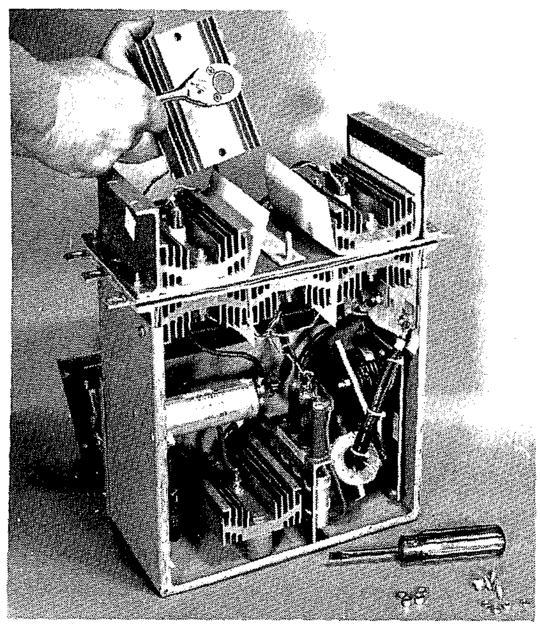


FIGURE 19
AF-400 Drive Converter Module with stud mounted SCRs showing removal of stud mounted SCR cell
10-30 KVA, 230 or 460V AC

9. Before replacing the stud mounted SCR inspect the mounting surface on both the heatsink as well as the stud mounted SCR cell. These surfaces should be wiped clean with a lint-free cloth. Inspect the surfaces and make sure they are smooth.

10. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric, G322L, Versilube® (or equivalent).

11. Insert the stud mounted SCR into the heatsink and tighten down the stud nut to a pressure equivalent to 30 inch pounds, using a torque wrench.

12. Replace the heatsink and the two (2) nuts that secure it to the DC bus, (P1 or N1).

13. Reconnect all electrical connections to their respective buses and the SCR firing leads to the pulse transformer card.

14. Re-install the insulation board which includes the pulse transformer card and bolt it in place with the four (4) machine screws and nuts.

15. Carefully fold into the harnesses the power wiring and SCR firing circuit leads. Re-tie all leads with plastic clamps.

16. Check to see that all electrical connections are tight.

PRESS-PAK SCR REPLACEMENT — INVERTER PHASE MODULE

40-60 KVA 230V AC

1. Tools required:
   Table — 30″ high
   Ratchet — 3/8″
   Deep Socket — 7/16″ for 3/8″ ratchet
   Wrench — 3/8″ box
   Screwdriver — 8″ long with 5/16″ tip

2. Stand the Inverter phase module on its back side on a 30″ high table. The pulse transformer printed circuit card should be on top. (Normally on the front of the module). See Figure 20.

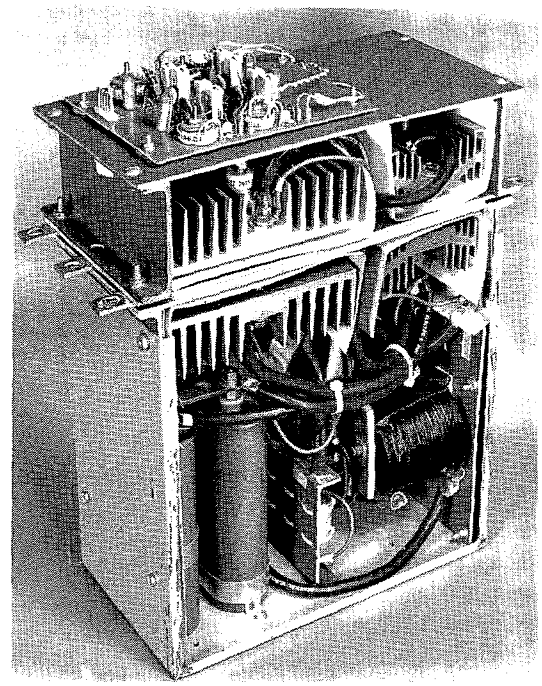


FIGURE 20
AF-400 Drive Inverter Phase Module standing on a table Press-Pak SCRs 40-60 KVA, 230V AC

3. After locating the defective Press-Pak SCR cell (1SP and 1SN — Main SCRs or CSP and CSN — Commutating SCRs) trace the appropriate red (cathode) and white (gate) firing circuit leads to the pulse transformer printed circuit card. Remove the plastic tie wraps from the appropriate firing circuits. Disconnect these circuits from the pulse transformer card, faston connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective cell.

4. Remove four (4) machine screws and nuts that secure the front, red plastic insulation cover to the Inverter phase module.

5. Lift back the cover, thereby, exposing the Press-Pak SCR heatsink clamps. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective Press-Pak SCR cell.

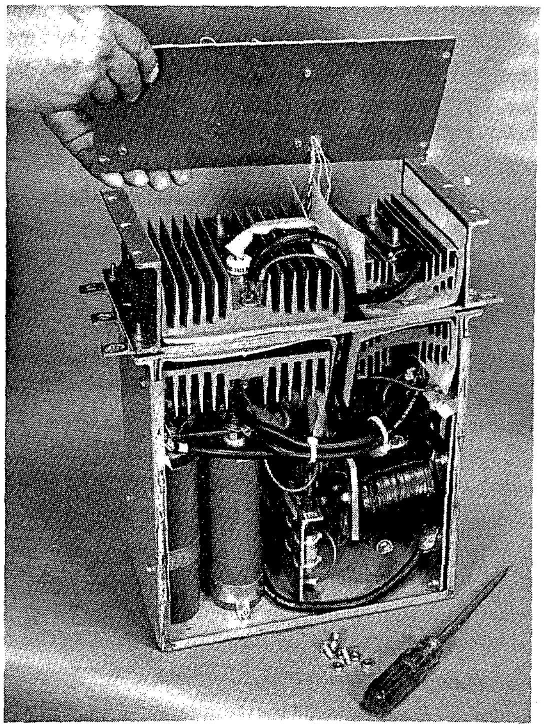


FIGURE 21
AF-400 Drive Inverter Phase Module
with the front cover folded back Press-Pak SCRs
40-60 KVA, 230V AC

6. Remove the two (2) clamp nuts that secure the defective SCR cell while supporting the bottom heatsink and clamp with one hand underneath the heatsink assembly.

7. Note that 1SP and CSP SCR cells are connected to the top heatsinks whereas 1SN and CSN SCR cells are connected to the bottom heatsink assembly.

8. NOTE CAREFULLY THE ARRANGEMENTS OF THE CLAMP PARTS AND SCR ORIENTATION.

9. Remove the bottom heatsink and SCR cell by dropping the assembly so the clamp rods are free. Carefully remove the defective SCR cell along with its red and white firing circuit leads which were previously removed from the pulse transformer printed circuit card.

10. The gate and cathode leads of the replacment SCR should be connected to the pulse transformer card per the inverter phase module elementary diagram.

11. The other SCR cell associated with the clamp assembly should be carefully lifted from the heatsink mounting surfaces.

12. Inspect the surfaces that both SCR cells mount between. These surfaces should be wiped clean with a lint-free cloth. Inspect the surface and make sure they are smooth; if not, replace the heatsink assembly.

13. Lubricate both mounting surfaces for each SCR cell using a thin coat of thermal grease, General Electric, G322L, Versilube® Plus (or equivalent).

14. Place both cells in the same orientation as in the original assembly and place the cell center holes over the roll pin in the mounting surface.

NOTE

THE BOTTOM SCR CELL FITS OVER A ROLL PIN IN THE HEATSINK AND THE TOP SCR FITS OVER A ROLL PIN IN THE PLATE.

15. The clamp parts and heatsink should be assembled in the orignal manner and the two nuts tightened finger tight so that the threads showing are the same on both clamp rods.

16. Check to see that the SCR cell center holes are still over the roll pins.

17. With the nuts finger tight use a wrench to tighten each alternately in 1/4 turn steps until the clamp tightens (over finger tightness) equals one and one quarter (1 1/4) turns.

NOTE

WHEN TIGHTENING THE CLAMP USE A SOCKET WRENCH TO HOLD THE BOTTOM HEADS OF THE CLAMP RODS WHEN COUNTING TURNS.

18. Re-connect all electrical connections to both heatsinks and the SCR firing circuit leads to the pulse transformer card.

19. Re-install the red plastic insulation board which includes the pulse transformer card and bolt it in place with the four (4) machine screws and nuts.

20. Re-tie the SCR firing circuit leads with plastic clamps.

21. Check to see that all electrical connections are tight.

BY-PASS DIODE (DP AND DN) REPLACEMENT INVERTER PHASE MODULE
40-60 KVA 230V AC

1. Remove the anode connection to the by-pass diode (DP or DN).

2. After separating the two main Press-Pak heatsinks (See Press-PAK SCR Replacement Inverter Phase Module 40-60 KVA, 230V AC) remove the stud mounted by-pass diode from the appropriate heatsink. It is secured with a nut and lock washer.

3. Before replacing the by-pass diode(s), inspect the mounting surface on the heatsink as well as the stud mounted diode mounting surface. These surfaces should be wiped clean with a lint-free cloth. Inspect the surfaces and make sure they are smooth.

4. Lubricate both mounting surfaces using thin coat of thermal grease, General Electric G322L,Versilube® Plus (or equivalent).

5. Insert the diode into the heatsink and tighten down the stud nut to a pressure equivalent to 30 inch pounds, using a torque wrench.

6. Replace the heatsinks according to instructions under Press-Pak SCR Replacement — Inverter Phase Module 40-60 KVA, 230V AC.

7. Replace the anode connection (DP or DN).

STUD MOUNTED SCR REPLACEMENT — INVERTER PHASE MODULE
10-30 KVA 230V AC or 460V AC

1. Tools Required:
   Table — 30″ high
   Ratchet — 3/8″
   Deep Socket — 7/16″ for 3/8″ ratchet
   Wrench — 3/8″ box
   Screwdriver — 8″ long with 5/16″ tip

2. Stand the phase module on its back side on a 30″ high table. The pulse transformer printed circuit card should be on top. (Normally on the front of the module). See Figure 22.

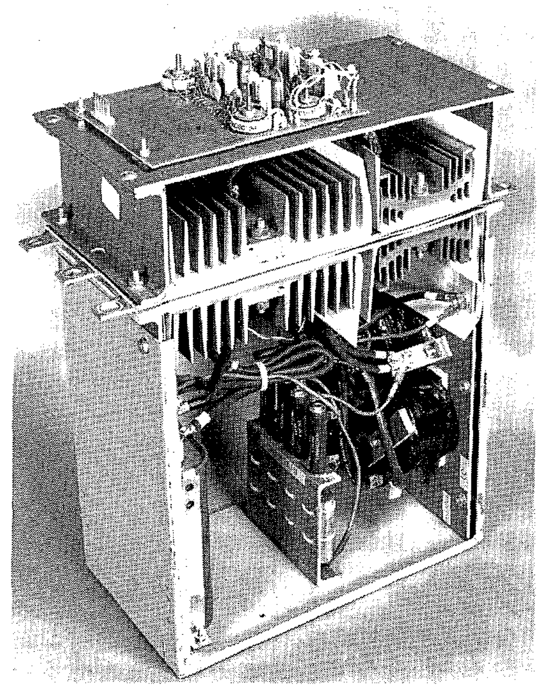


FIGURE 22
AF-400 Drive Inverter Phase Module standing on a table stud mounted SCR 10-30 KVA 230 or 460V AC.

3. After locating the defective stud mounted SCR cell (1SP and 1SN — Main SCRs or LCSP and CSN — commutating SCRs) trace the appropriate red (cathode) and while (gate) firing circuit leads to the pulse transformer printed circuit card. Remove the plastic tie wraps from the appropriate firing circuits. Disconnect these circuits from the pulse transformer card, faston connectors. Free these wires from the harnesses and check to see that they are, in fact, connected to the defective SCR cell.

4. Remove four (4) machine screws and nuts that secure the front red plastic insulation cover to the inverter phase module.

5. Fold back the cover, thereby, exposing the stud mounted SCR heatsinks. The remaining wire harnesses should support the front insulation cover while removing and replacing the defective stud mounted SCR cell. See Figure 23.

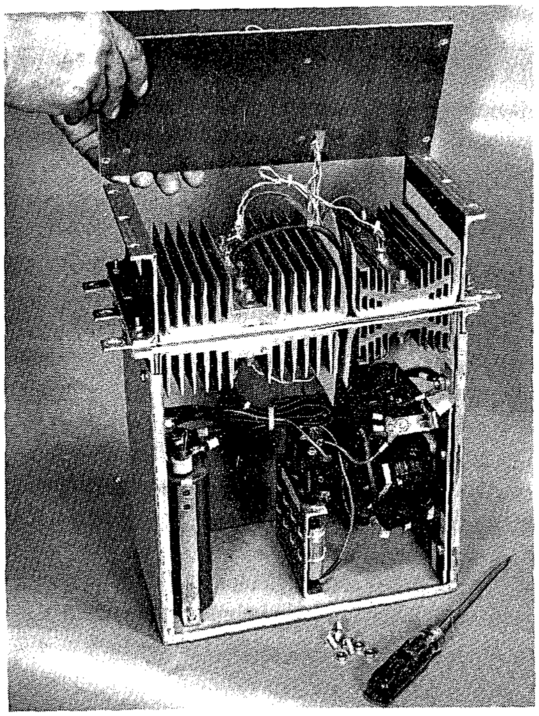


FIGURE 23
AF-400 Drive Inverter Phase Module
with front insulation cover
folded back stud mounted SCRs
10-30 KVA 230 or 460V AC

6. Disconnect the power loads from the appropriate reactors. Replacement stud mounted SCR cells are furnished by General Electric Co. with the power leads and firing circuit leads soldered to the stud mounted SCR cells.

7. Remove the two (2) nuts that secure the heatsink with the defective stud mounted SCR cell to the phase module.

8. Remove the stud mounted SCR cell from its heatsink. It is secured with a nut and lockwasher.

9. Before replacing the stud mounted SCR cell inspect the mounting surfaces on both the heatsink as well as the stud mounted SCR cell. These surfaces should be wiped clean with a lint-free cloth. Inspect the surfaces and make sure they are smooth.

10. Lubricate both mounting surfaces using a thin coat of thermal grease, General Electric, G322L, Versilube® Plus (or equivalent).

11. Insert the stud mounted SCR cell into the heatsink and tighten down the stud nut to a pressure equivalent to 30 inch pounds, using a torque wrench.

12. Replace the heatsink and the two (2) nuts that secure it to the phase module.

13. Re-connect all electrical connections to their respective reactors and the SCR firing leads to the pulse transformer printed circuit card.

14. Re-install the insulation board which includes the pulse transformer card and bolt it in place with the four (4) machine screws and nuts.

15. Carefully fold into the harnesses the power wiring and SCR firing circuit leads. Re-tie all leads with plastic clamps.

16. Check to see that all electrical connections are tight.

INVERTER PHASE MODULE 40-100 KVA, 460V AC PRESS-PAK SCR CELL REPLACEMENT MAIN SCR CELLS STUD MOUNTED SCR CELL REPLACEMENT COMMUTATING SCR CELLS

1. Tool required
   Table — 30″ high
   Ratchet — 3/8″
   Deep Socket — 7/16″ for 3/8″ ratchet
   Deep Socket — 9/16″ for 3/8″ ratchet
   Wrench — 3/8″ box
   Screwdriver — 8″ long with 5/16″ tip

2. Stand the phase module on its back side on a 30″ high table. The pulse transformer printed circuit card should be on top. (Normally on the front of the inverter phase module). See Figure 24.

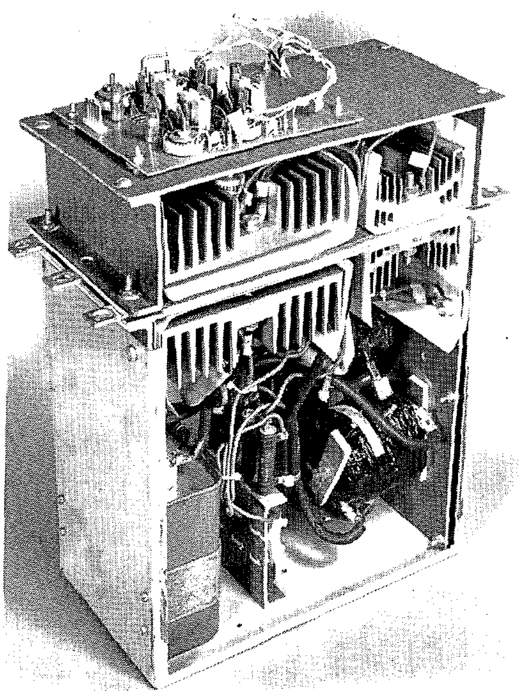


FIGURE 24
AF-400 Drive Inverter Phase Module
40-100 KVA, 460V standing on a table
Press-Pak main SCR cells stud
mounted commuating SCR cells

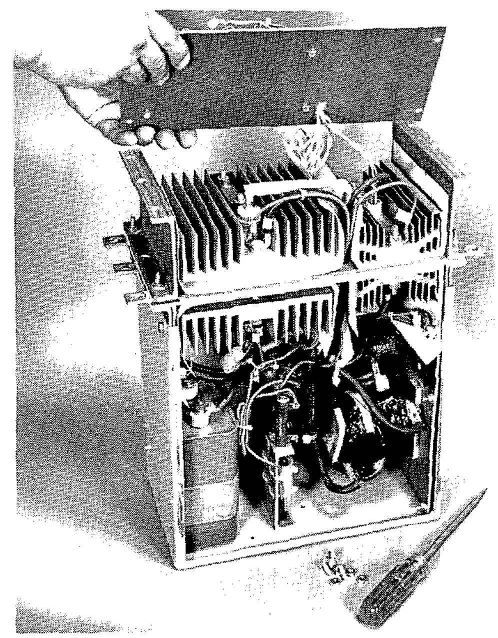


FIGURE 25
AF-400 Drive Inverter Phase Module
40-100 KVA, 460V with front
cover folded back Press Pak main
SCR cells stud mounted commutating cells

3. After locating the defective Press-Pak Main SCR cell (1SP and 1SN) follow the instructions for Press-Pak Main SCR cells, 40—60 KVA; 230V AC units. See Figure 25.

4. After locating the defective stud mounted commutating SCR cell (CSP and CSN) follow the instructions for stud mounted commutating SCR cells, 10—30 KVA;, 230V AC or 460V AC units. See Figure 25.

5. Check to see that all electrical connections are tight.

FILTER CAPACITOR REPLACEMENT

1. Tools required:
   Ratchet — 3/8″
   Deep Socket — 7/16″ for 3/8″ ratchet
   Wrench — 7/16″ box
   Screwdriver — 5/16″ shank, 8″ long blade

2. Open all electrical circuits to the case in which the Filter Capacitors are located.

3. Check voltage across capacitors (N2 to P2) with DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work proceeds.

4. Disconnect the power leads to the capacitor.

5. Loosen the capacitor clamp and remove the capacitor.

6. When the faulty capacitor is replaced, make certain that the new capacitor is connected to the electrical circuit with the same polarity orientation as was the faulty capacitor.

7. Re-connect all power leads.

8. If the replacement electrolytic capacitors have been on the shelf (non-operating) for longer than 6 months, they should be formed. Refer to step 13 of the Start-up Procedure in the Start-up and Checkout section for the proper forming procedure.

FAN REPLACEMENT — 10 to 100 KVA

1. Tools required
   Ratchet — 3/8″
   Ratchet Extension — 3/8″, 6″ long
   Deep Socket — 1/2″ for 3/8″ ratchet
   Nut Driver — 5/16″ with 6″ shaft
   Screwdriver — 5/16″ shank, 8″ long blade

2. Open all electrical circuits to the case in which the faulty fan assembly is located.

3. Check the voltage across the capacitor tray (N2 to P2) with a DC voltmeter. The capacitor discharge resistor (R1) should have reduced this voltage to 10 volts or below before work starts in the case.

4. Disconnect the fan motor leads from the terminal board.

5. Remove the mounting screws from the fan housing that holds the fan motor to the module rack.

6. Remove the fan assembly.

7. The repaired or replacement motor and fan assembly should be bolted in place with the airflow arrow pointing upwards.

8. Reconnect all motor leads to the terminal board.

9. Check all electrical connections for tightness.

10. Apply power to the fan motor. The air flow will be toward the top of the case.

SPARE AND RENEWAL PARTS (HP related)

AF-400 Drive — 10 to 100 HP, 230 or 460 Volts AC, Three-Phase, 50 or 60 Hz

PRINTED CIRCUIT CARDS

Catalog Number	Description
193X385ABG01,G02,G03,G04	Commutation Power Supply Card
193X387ABG01	Current Isolator Card
193X389AAG01,G02	Pulse Transformer w/C.F.B.
193X390AAG01	Pulse Transformer Card
193X391AEG01	Process Follower/Relay Card
193X391AAG02	Auxiliary Relay Card
193X475AAG01	Phase Logic Card
193X476ACG01	Inverter Card
193X477AAG01	Converter Card
193X488ACG01	Regulator Card
193X489AAG01	System Card
193X480AAG01	Power Supply Card
193X481ABG01	Meter Card

SUB ASSEMBLIES AND COMPONENTS (NOT HP RELATED)

Catalog Number	Description
36A353243BAG01,GO2	Control transformer assembly 460V, 230V Transformer with connected wire harness
104X156CA10	Control transformer only
104X215BA012	Ventilating Fan

SPARE AND RENEWAL PARTS (HP RELATED)

AF-400 Drive 10—60 HP, 230 or 10—100HP, 460 Volts AC, Three-Phase, 50 or 60 Hz

Part Name	Drive HP Rating				230 Volts AC				Drive HP Rating					460 Volts AC			
Catalog Number	10	15	20	25	30	40	50	60	10	15	20	25	30	40	50	60	100
AC Power Fuses Qty. 3 104X109AG 50 Amp 60 Amp 100 Amp 175 Amp 300 Amp	007	007	009	009	009	021	021	021	005	005	007	007	007	015	015	015	021
AC Control Circuit Fuses Qty 2 104X109BC 3 Amp	018	018	018	018	018	018	018	018	018	018	018	018	018	018	018	018	018
AC Control Power Fuse Qty. 1 104X109AD 1 Amp	075	075	075	075	075	075	075	075	075	075	075	075	075	075	075	075	075
Inverter Main SCR Qty. 6 942B279 Assembly 104X125DA Unit	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CEG02 136	CEG02 136	CEG02 136	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CEG03 060	CEG03 060	CEG03 060	CEG05 139
Inverter Main Diode Qty. 6 942B279CD Assembly 957A614BA Assembly 104X125AA Unit	G06 131	G06 131	G04 132	G04 132	G04 132	G04 G02 132 134	G04 G02 132 134	G04 G02 132 134	G07 124	G07 124	G07 124	G07 124	G07 124	G03 G01 133 135	G03 G01 0133 135	G03 G01 133 135	G03 G01 133 135
Commutating SCR Qty. 6 942B279 Assembly 104X125DA Unit	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CDG02 127	CEG02 136	CEG02 136	CEG02 136	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131	CDG05 131
Commutating Diode Qty. 6 942B279CD Assembly 957A614BA Assembly 104X125AA Unit	G06 131	G06 131	G04 132	G04 132	G04 132	G04 132	G04 132	G04 132	G07 124	G07 124	G07 124	G07 124	G07 124	G03 133	G03 133	G03 133	G03 133
Converter SCR Qty. 6 942B279 Assembly 104X125DA Unit	CDG03 083	CDG03 083	CDG03 083	CDG03 083	CDG03 083	CEG01 058	CEG01 058	CEG01 058	CDG04 090	CDG04 090	CDG04 090	CDG04 090	CDG04 090	CEG04 057	CEG04 057	CEG04 057	CEG04 057
Phase Module Qty. 3 331X415BA 331X414BA	G03	G03	G02	G02	G02	G01	G01	G01	G03	G03	G02	G02	G02	G01	G01	G01	G04
Converter Module Qty. 1 331X425BA 331X424BA	G03	G03	G02	G02	G02	G01	G01	G01	G03	G03	G02	G02	G02	G01	G01	G01	G04
Filter Reactor — L1 Qty. 1 104X220AB	014	014	013	013	013	012	012	012	014	014	013	013	013	012	012	012	012

SPARE AND RENEWAL PARTS (HP RELATED)
(continued)

Part Name	Drive HP Rating 230 Volts AC								Drive HP Rating 460 Volts AC								
Catalog Number	10	15	20	25	30	40	50	60	10	15	20	25	30	40	50	60	100
Filter Capacitor — C1 104X122AA145 Qty.	2	2	4	4	4	8	8	8	2	2	4	4	4	4	8	8	8
Power Circuit Breaker Kit Qty. 1 104X202BA 30 Amp 104X202RA 50 Amp 104X202RA 100 Amp 104X203EA 200 Amp	G05	G05	G07	G07	G07	G01	G01	G01	G04	G04	G05	G05	G05	G07	G07	G07	G01

SPARE AND RENEWAL PARTS

AF-400 Drive — 10 to 60 HP, 230 or 460 Volts AC, Three Phase, 50 or 60 Hz
10 to 100 HP, 460 Volts AC

MODIFICATION KITS

Catalog Number	Description
6VP10A1	Process Follower Kit
6VREV10A1	Reversing Relay Kit
104X166AA059	Reversing Relay
6VFLT10A1	Fault Relay Kit
104X166AA060	Fault Relay
6VRUN10A1	Run Relay Kit
104X166AA061	Run Relay
6VRAM10A1	Auto/Manual Relay Kit
104X166AA059	Auto/Manual Relay

REMOTE OPERATORS STATION

Catalog Number	Description
6VOC72	Speed Adjust — Start Stop
6VOC82	Speed Adjust — Forward/Reverse Selector — Start Stop
6VOV52	Speed Adjust — Manual/Auto Selector — Start Stop
104X169AA008	Start Pushbutton
104X152AC027	Forward/Reverse Selector Switch
104X152AC027	Manual/Auto Selector Switch
36B605269AAG05	Speed Adjust Pot Assembly

SPEED AND LOAD INDICATORS

Catalog Number	Description
6VSS112A1	Speed Indicator Kit
104X117CC003	DO-91X O—100% Speed Meter
6VL112A1	Load Indicator Kit
104X117CC005	DO-91 O—150% Load Meter
6V1E11	Enclosure for 1 Instrument
6V1E21	Enclosure for 2 Instruments

HOT LINE TELEPHONE NUMBER

The Contract Warranty for AF-400 drives is stated in the General Electric Apparatus Handbook, Section 105, Page 71.

The purpose of the following is to provide specific instructions to the AF-400 drive user regarding warranty and administration and how to obtain assistance on out-of-warranty failures.

AF-400 DRIVE POWER UNITS (10 to 60 HP)

The warranty covers all major parts of the power unit, such as printed circuit boards, SCR modules, etc. but does not provide for replacement of fuses or the power unit.

1. In the event of failure or misapplication during "in warranty" refer to the instruction book to identify the defective part or sub-assembly.

2. When the defective part has been identified (or for assistance in identification) call:

GENERAL ELECTRIC COMPANY
ERIE, PENNSYLVANIA
(814) 455-3219
(24—HOUR PHONE SEVICE)

Before calling, list Catalog numbers of the power unit, operator's station or modification kits.

AF-400 DRIVE MOTORS

AC motor repairs are generally handled by General Electric Apparatus Service Shops. For specific instructions on your motor, call the number listed above and furnish complete nameplate data.

GLOSSARY OF TERMS

APL — Inverter Control Plug - Phase A
ATIM — Acceleration Time Adjust - Regulator Card

BPL — Inverter Control Plug - Phase B
BF — Base Frequency Adjust - Regulator Card

C1 — Converter Filter Capacitor
CB — AC Power Circuit Breaker
CFA — Current Feedback Adjust - Current Isolator
CLIM — Current Limit Adjust - Regulator Card
CLP — Commutating Reactor - Positive
CLN — Commutating Reactor - Negative
CLST — Current Limit Stabililty Adjust - Regulator Card
CN — Commutation Power Supply - Negative
COC — Commutation Overcurrent Trip - Inverter
COM — Common Point - Control
CP — Commutation Power Supply - Negative
CPL — Inverter Control Plug - Phase C
CSN — Commutating SCR - Negative
CSP — Commutating SCR - Positive
CTC — Current Transformer - Commutating
CUV — Control Undervoltage Trip - Inverter
CVR — Converter Voltage Reference

DFS — Delayed Firing Signal
DPL — Converter Control Plug
DMF — Decrease to Minimum Frequency Signal
DTIM — Decel Time Adjust - Regulator Card
FR — Fast Acceleration/Deceleration Rate
FTR — Fault Trip - Readout Signal
FU1-3 — Main Power AC Line Fuses
FU4-6 — Control Circuit Fuses
FU7 — 115V AC Control Power Fuse
FVR — Frequency Voltage Readout Signal

IF — Inverter Frequency Light - System Card
IOC — Instantaneus Overcurrent Trip Light
IOF — Inverter Overfrequency Trip Light
IRC — IR Compensation Adjust - Regulator Card
IS — Inverter Start Relay - Option Card
ISN — Inverter SCR - Negative
ISP — Inverter SCR - Positive
ITOC — Inverter Time Overcurrent Trip - Inverter

GLOSSARY OF TERMS
(continued)

LCS — DC Link Current Signal
L1 — Converter Filter Reactor
LSH — DC Link Shunt
LOV — DC Link Overvoltage Trip
1L1-3 — Commutation Power Supply Input

MINF — Minimum Frequency Adjust - Regulator Card
MVFR — Minimum Voltage Frequency Readout
N1 — Negative Converter Output
N2 — Negative Inverter Input

P1 — Converter Output - Positive
P2 — Converter Filtered Output - Positive
PS/LOP— Phase Sequence/Loss of Phase Trip

R1 — Capacitor Discharge Resistor
REF — Reference Input Signal
REV — Reference Input Signal
RFV — Reference Frequence Voltage
RF1-7 — Isolation Feedback Resistors
RR — Run Readout

SR — Inverter Synchronized Readout Signal
SYNC — Inverter Line Synchronized Light

TX1 — Control Transformer

VB — Voltage Boost Adjust - Regulator Card
V/Hz — Volts per Hertz Adjust - Regulator Card
VLIM — Voltage Limit Adjust - Regulator Card

XFR — External Fault Reset - Input Signal

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