INSTRUCTIONS

GEK-24982B

AF-400*

AC ADJUSTABLE SPEED DRIVE

INSTALLATION

DESCRIPTION

START-UP

TROUBLESHOOTING

MAINTENANCE

GENERAL ELECTRIC

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GENERAL

INTRODUCTION

This instruction manual is structured around a basic drive. It is a guide for the installation, checkout and operation of the equipment furnished with general troubleshooting procedures for the basic drive. 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 ambient temperature of $-20^{\circ}C$ to $+40^{\circ}C$ for a period of up to one year. Air must be free of chemical and electrically conductive contaminants, and other conditions must be such that no moisture condensation occurs in or on the equipment.

In addition, when a control 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

Only 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

EQUIPMENT SHOULD NEVER BE INSTALLED WHERE HAZARDOUS, INFLAMABLE OR COMBUSTIBLE VAPORS OR DUSTS ARE PRESENT. SUFFICIENT CLEARANCE IN FRONT OF THE UNITS SHOULD BE ALLOWED FOR ACCESS FOR MAINTENANCE OR REPAIR.

MOUNTING

POWER UNIT

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 re–removable sheet steel covers. Other conduit entry area is available through the top of the case.

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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.

AC MOTOR(S)

A separate instruction book is provided giving information on location, conduit 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 be checked off on the elementary diagram.

WARNING

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 nameplate data. Be sure to connect motor thermal switch (if supplied) back to the power unit. Tape all motor connections.

POWER UNIT CONNECTIONS

Electrical codes generally require the use of a fused disconnecting switch or circuit breaker in the a–c power line ahead of the power unit and transformer (if used). The disconnecting 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, 220 ohms @ 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 is an adjustable frequency a.c. 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 is a variable voltage d.c. link type of inverter.

The various modules and components to be described are physically located in the AF-400 power unit as shown in Figures 1 and 2, for two different KVA ratings. These modules and components are also shown in the system block diagram of Figure 3. 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 a.c. power to variable voltage d.c. power. The six SCR converter is shown in more detail in the power circuit of Figure 4. The three saturable chokes 1L, 2L, and 3L in the incoming phases plus the SCR snubber circuits (not shown) act to protect the converter SCR's against voltage transients. The converter d.c. output voltage can be adjusted from zero to maximum output by adjusting the firing point of each SCR relative to its a.c. supply phase voltage. The resultant d.c. output voltage, therefore, contains a six times a.c. supply frequency ripple component of voltage. This ripple voltage must be filtered to improve the waveform 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 d.c. link, as shown in Figure 4. 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 3 and 4. Each module consists of two inverter SCRs, two commutating SCRs, two bypass diodes and an LC commutating circuit. Output phase A (T1) of Figure 4 will be described, since all three phases operate in an identical manner, except for being displaced by 120 degrees in phase relationship.

The a.c. motor lead T1 is alternately connected to the positive P11 d.c. bus or the negative P2 d.c. bus, by inverter SCRs ISPA or ISNA respectively. The frequency that terminal T1 is alternately connected to the two d.c. potentials is the fundamental frequency applied to the a.c. 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 SCRs CSPA and CSNA, and by the commutating reactor LCA and commutating capacitor CCA.

At the time when inverter SCR ISPA is to be commutated off, capacitor CCA is charged such that the T1 side is positive. When commutating SCR CSPA is fired, the motor current flowing through ISPA is diverted to the alternate path of CSPA, CLPA, LCA and CCA due to the voltage charge on CCA. When the commutating current in this alternate path exceeds the motor current, no more current exists in ISPA. As capacitor CCA discharges further, the excess commutating current (above the motor current level) flows through the ILPA and diode DPA back to CSPA. The voltage drop across DPA produces a small reverse voltage across ISPA 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 requried for the SCR. In order to minimize this time and the commutating energy requried, special inverter grade SCRs 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 CCA with reactor LCA. After the commutating current peaks and starts diminishing, the charge on capacitor CCA reverses, and the energy stored in reactor LCA charges CCA 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 DPA goes to zero and the potential of the T1 motor lead changes from the inverter positive bus P11 to the negative bus P2 so that diode DNA can furnish the

INVERTER MODULES (continued)

motor current. The above action occurs if the on–coming inverter SCR ISNA is not fired before this point in time. If ISNA is fired earlier, the transition of T1 from positive to negative bus will occur earlier in the commutation interval. In any case, capacitor CCA becomes charged up in the opposite direction (T1 side negative) at the end of the ISPA commutation interval. It is now charged correctly to commutate off inverter SCR ISNA when commutating SCR CSNA is fired. This commutating action is the same as the one just described. At the end of each commutating inter–val, the commutating SCR is commutated off by the charge on capacitor CCA producing a reverse voltage to the commutating SCR which had just been con–ducting.

The four leg reactors, CLPA, CLNA, ILPA and ILNA act in conjunction with the SCR snubber circuits (not shown in Figure 4) 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 d.c. link (P11 to P2) when it is near its maximum value. The amount of energy re–placed, and thus the level of the commutation capaci–tor voltage, is determined by the firing point of the oncoming inverter SCR in the commutation interval. As the d.c. link voltage is reduced down to zero voltage however, the commutation losses are replaced from the commutation power supply.

COMMUTATION POWER SUPPLY

This module contains six SCRs and six diodes (only three of each on 230V AC drives where seriesing is not required), plus three reactors, an RC filter and protec–tive fuses. These devices are all relatively small since the commutating losses this module furnishes are a very small percentage of the drive rating.

The diodes, AD1, AD2 and AD3 in Figure 4, form a three phase half wave bridge which operates in con–junction with the negative SCR portion of the con–verter to provide a constant voltage bus relative to d.c. link bus P2. This d.c. supply is filtered by resistor RA and capacitor CFA and applied to SCRs ASA, ASB and ASC, one for each phase of the inverter. The reactors LXA, LXB and LXC limit the maximum current through the SCRs to only about one–eighth of the commutating current level of the inverter.

The amount of energy furnished by the commutation power supply to each inverter phase commutation circuit depends on the level of the d.c. link voltage and on the point in the commutation interval when the appropriate commutation power supply SCR is fired. Since the energy loss per commutation is small, the losses are replaced only every other commutation in each phase; that is, only during each positive inverter SCR commutation in each phase. SCR ASA is fired at the same time as inverter SCR ISNA is first fired, ASB at the same time as ISNB, and ASC at the same time as ISNC. In this manner the driver regulates the commu–tating current and voltage over the whole d.c. link volt–age operating range, irrespective of how much of the commutating losses are supplied from the commuta–ing power supply or from the d.c. link.

PROTECTION AND COOLING

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

Power unit cooling is provided by a fan for small power ratings and by multiple blowers for larger power ratings. These are mounted together with an air dis–tribution chamber at the bottom of the power unit case, as shown in Fig. 1 and 2. All fan or blower motors are three phase and are protected with fuses. Correct fan or blower rotation depends on the a.c. supply phase sequence. The same wrong phase se–quence fault circuit that prevents drive operation also will prevent incorrect fan or blower rotation. A thermoswitch, which opens on an overtemperature condition, is placed in the cooling air stream to detect fan or blower failure. This switch may be connected either to shut down the drive or sound an alarm.

SYSTEM CONTROL

The system control and associated operators 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 conditions. 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 Figures 1 and 2 is the same for all non–paralleled drive ratings. It contains five control cards plus a power supply card and associated control power transformer. 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. All inputs, selections and readouts are connected to the driver terminal boards. Refer to the driver elementary and connection diagrams for driver inputs and outputs, and for card layout and interconnections.

A functional block diagram of the driver is shown in Figure 5. 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, readouts, 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. 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

An ODMF input provides a special decelerate to minimum frequency operation, from the set reference level, without stopping the inverter, the deceleration occuring at a faster than set timed rate. The a.c. 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 ODMF signal is removed.

The minimum voltage and frequency detection logic contained on this card provides an OMVFRO signal readout to alert the system control when this drive condition is reached. An ORRO run 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 IFTRO 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 OSTOP operation, the 1XFR 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 the 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 OSYNC signal input will cause the inverter frequency to change from the reference level to the external frequency level, and to lock into that frequency. A digital discriminator compares the inverter frequency with the external frequency, and provides logic signals to the Regulator card to cause the inverter 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 OSRO inverter synchronized readout signal is provided.

REGULATOR CARD

The regulator card contains mainly analog regulating circuitry plus all of the adjustment potentiometers in the driver.

REGULATOR CARD (continued)

A midpoint control voltage level (+10 volts) is generated on this card to provide a 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 level, or to a new reference level. The timing is adjustable from 2.5 to 25 seconds for a maximum reference change in either direction. A substantially faster acceleration or deceleration time than the setting can be initiated by an OFR logic signal from the System card.

An adjustable motor 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 analog reference, linear timing and current limit functions are all bypassed when the inverter frequency is synchronized to an external frequency by means of logic on the System card. However, the output level of the linear timing circuit then is determined by the synchronized frequency, such that when synchronized operation is ended, the drive will return to the analog reference level at the set linear time rate.

The resultant RFV reference 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 three potentiometers. The V/Hz potentiometer provides a vernier adjustment of the volts per hertz of the inverter within +15%, –5% of nominal. The voltage boost potentiometer VB adjusts the fixed amount of voltage which is added to the inverter, irrespective of frequency, to overcome the motor IR drop. It is adjustable from zero to 7% of rated voltage. The third adjustment, the voltage limit potentiometer VLIM, is an initial set–up adjustment which prevents the converter from turning completely on and saturating. This adjustment limits the maximum inverter a.c. output voltage to be slightly less than the a.c. supply voltage. This function keeps the stability–slowdown control (described later) in its regulating range, and is also important in limiting the inverter voltage when motor transfer from inverter to a.c. supply is done.

The voltage regulator compares this modified reference with a feedback signal proportional to converter d.c. 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 ***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. For ***RFV*** reference levels below the set minimun frequency level, only inverter voltage is decreased. The ***BF*** potentiometer adjusts the inverter base frequency over a base frequency range of 37.5 to 75 Hz or 75 to 150 Hz, selected by the ***BFR*** jumper on the driver terminal board. An external base frequency adjustment potentiometer may be connected to modify the card setting by as much as plus or minus 50%, within the 150 Hz maximum frequency rating.

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 then fed to the Inverter card. The analog frequency voltage signal input to the frequency generator is also used to provide the FVRO frequency voltage readout, which is a voltage signal proportional to actual inverter frequency.

The stability–slowdown control provides the following three functions:

1. Provides stabilizing for motors at their under–damped operating points.

2. Overrides the frequency reference, when it calls for substantially faster than motor coast slow–down, to keep the volts/Hz applied to the motor within normal limits.

3. Provides system stabilizing during slowdown and current limit operation.

REGULATOR CARD *(continued)*

The stability–slowdown control is only effective during analog reference operation, being locked out when the inverter frequency is synchronized to an external frequency.

CONVERTER CARD

The Converter Card controls the firing of the converter SCR's to obtain the correct d.c. link voltage to be applied to the inverter.

The three a.c. 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 a.c. supply phase to neutral voltages. These signals are used in the phase control to determine the correct firing points of the six converter SCR's. 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 a.c. 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 cards 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 d.c. 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 d.c. 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 commutations 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 commutation power supply and oncoming inverter SCRs at a point sometime after the midpoint of the commutation interval, dependent on the commutation current regulator.

The "460V Jumper" on this card produces the correct commutation timing for 460 volt inverters. This jumper must be removed for 230 volt inverters where the commutation timing is different.

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 feed back from the Current Feedback cards in the inverter phase modules. The current peaks are compared to a desired level and the regulator then initiates earlier or later firing of the commutation power supply and 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

INVERTER CARD (continued)

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. The resultant firing signals can then be applied to pulse transformers in the power modules to obtain isolation of the control from the power.

The delayed firing supply on this card is used to provide firing signal power 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 d.c. link filter capacitor. This is detected by current transformer CTF and fed back to the Inverter card. When this current exceeds a set level indicating an inverter fault has occured, an immediate drive shutdown is produced and the Inverter Fault Light IFT will light. The immediate drive shutdown produced by either an inverter fault, a control undervoltage, a commutation overcurrent, or a d.c. 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 IFT to light when any of the other three faults described above occur.

The overfrequency trip function provides a drive shutdown and an 10F light indicating if the inverter frequency exceeds a set limit due to any reason. This overfrequency limit is selectable by means of a driver terminal board jumper to be either 75 Hz or 110 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, inverter, and commutating power supply 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.

Both the normal starting and stopping of inverter operation must be accomplished at a certain point in the commutation sequence in each inverter phase for proper operation. The start–stop logic performs this function on an individual phase basis. On starting, the commutating power supply SCR is fired to charge up the commutating capacitor before inverter firing begins in that phase. On stopping, the last inverter firing operation in each phase causes the commutating capacitor to be charged in the correct starting polarity in case immediate restarting is required.

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 commutating SCRs in the three inverter phase modules, and for three SCRs (series pairs for 460 volt drives) in the commutating power supply. 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

A 115 volt to 25 volt transformer in the driver provides single phase a.c. power to the Power Supply card. A full wave rectifier and filter capacitor on this card provides unregulated d.c. power to the series pass power transistors which produce the regulated +20 volt control power output. Short circuit protection is provided by a fuse while output overvoltage

POWER SUPPLY CARD (continued)

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 d.c. input supply power for a.c. 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 selector switch for connecting to the meter and test posts any one of 18 preselected and prewired signals or a red wire back plane selector probe. The objective of the back plane probe and its associated buffer circuitry is 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 output current, peak commutating current, and peak levels of short time logic pulses, as well as the normal analog signals.

POWER MODULE CONTROL CARDS

The following two cards are mounted in the power modules and act as an interface between the driver and the power module.

CURRENT FEEDBACK CARD

One of these cards is mounted in each inverter phase module to provide a calibrated feedback of inverter commutation current and inverter output current to the motor. There are five groups of this card, with jumper selections for three different current transformer loading resistors for each group, to cover all of the inverter current ratings. This standardizes the inverter output current feedback signal at 1.0 volt rms for rated current of each inverter rating. The inverter commutation current transformer is connected to a rectifier bridge and specified loading resistor for each card group, 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.

PULSE TRANSFORMER CARD

These cards are mounted on the converter and inverter phase modules and commutation power supply, one card being required for each pair of SCRs. Their major function is to provide voltage isolation between the driver control and the SCR power circuit.

Each card consists of two identical pulse transformer circuits. These provide current amplification of the actual SCR firing signals over the signals received from the driver. They also contain input noise suppression and self protection from abnormal loading.

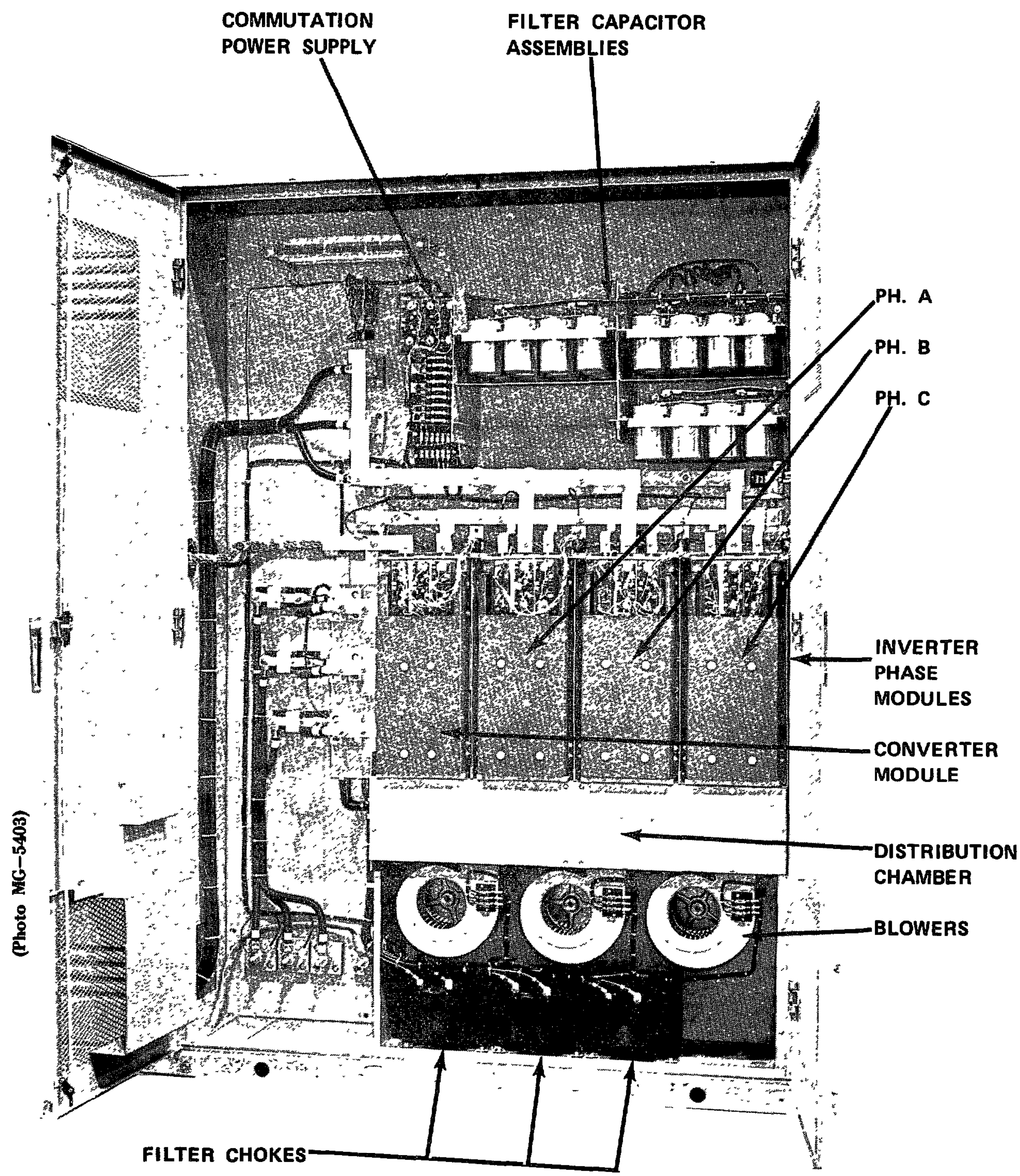
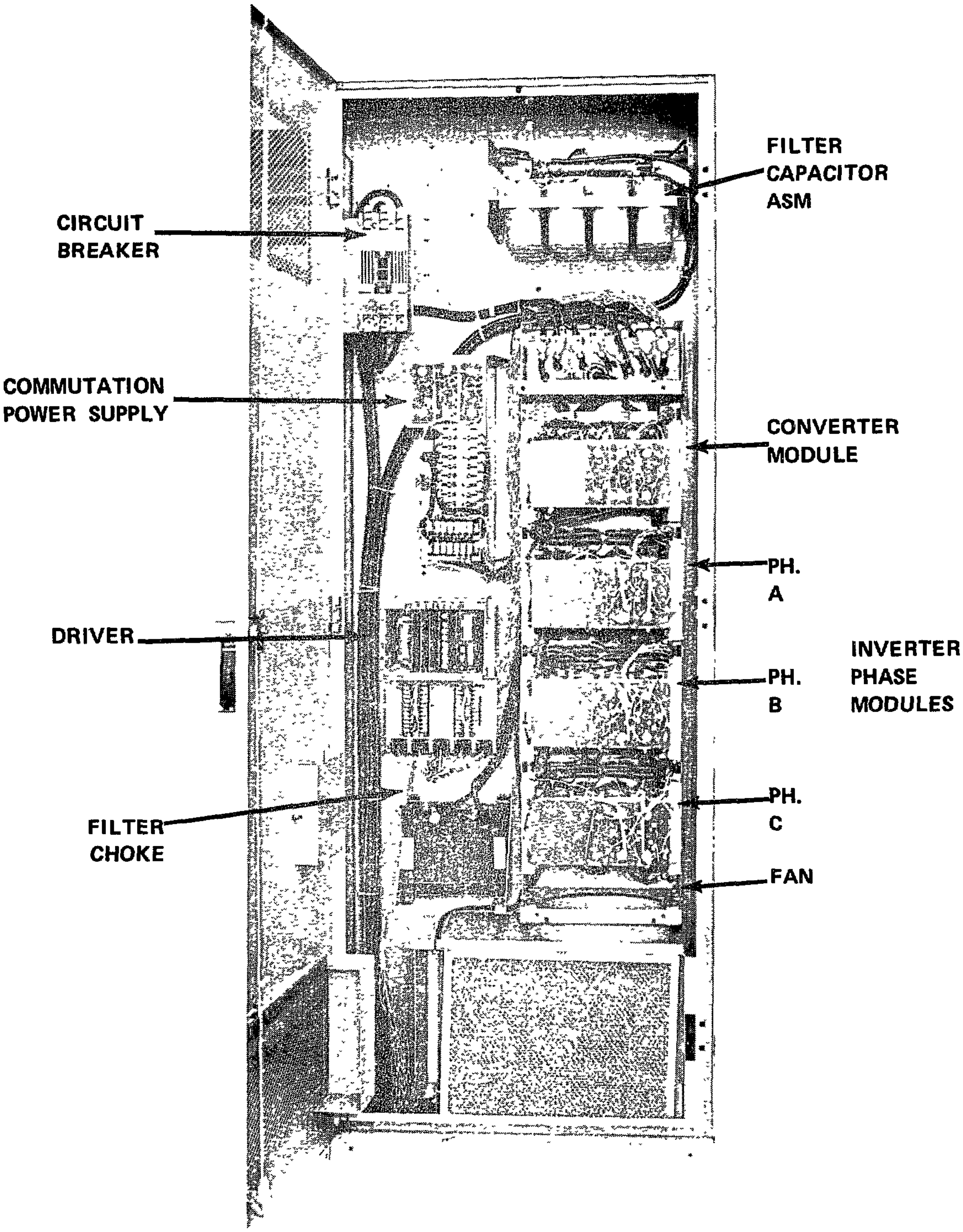


FIGURE 1. AF–400 POWER UNIT INTERIOR – 300 KVA

(DRIVER LOCATED IN SEPARATE CONTROL CASE)

(PHOTO MG-5400-4)



AF-400 POWER UNIT INTERIOR - 100 KVA
(WITH POWER MODULE COVER REMOVED)

FIGURE 2

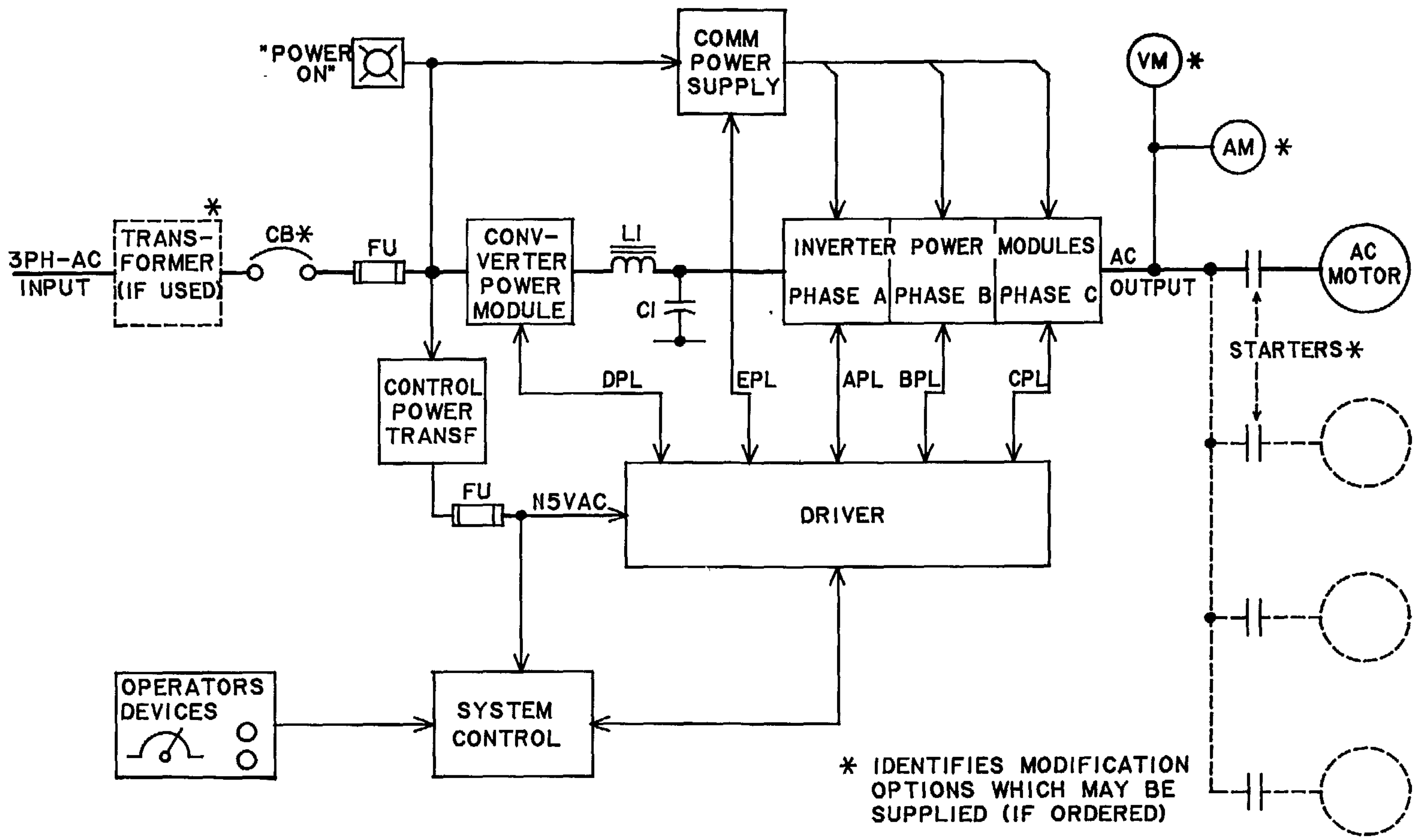


FIGURE 3. AF-400 SYSTEM BLOCK DIAGRAM ©

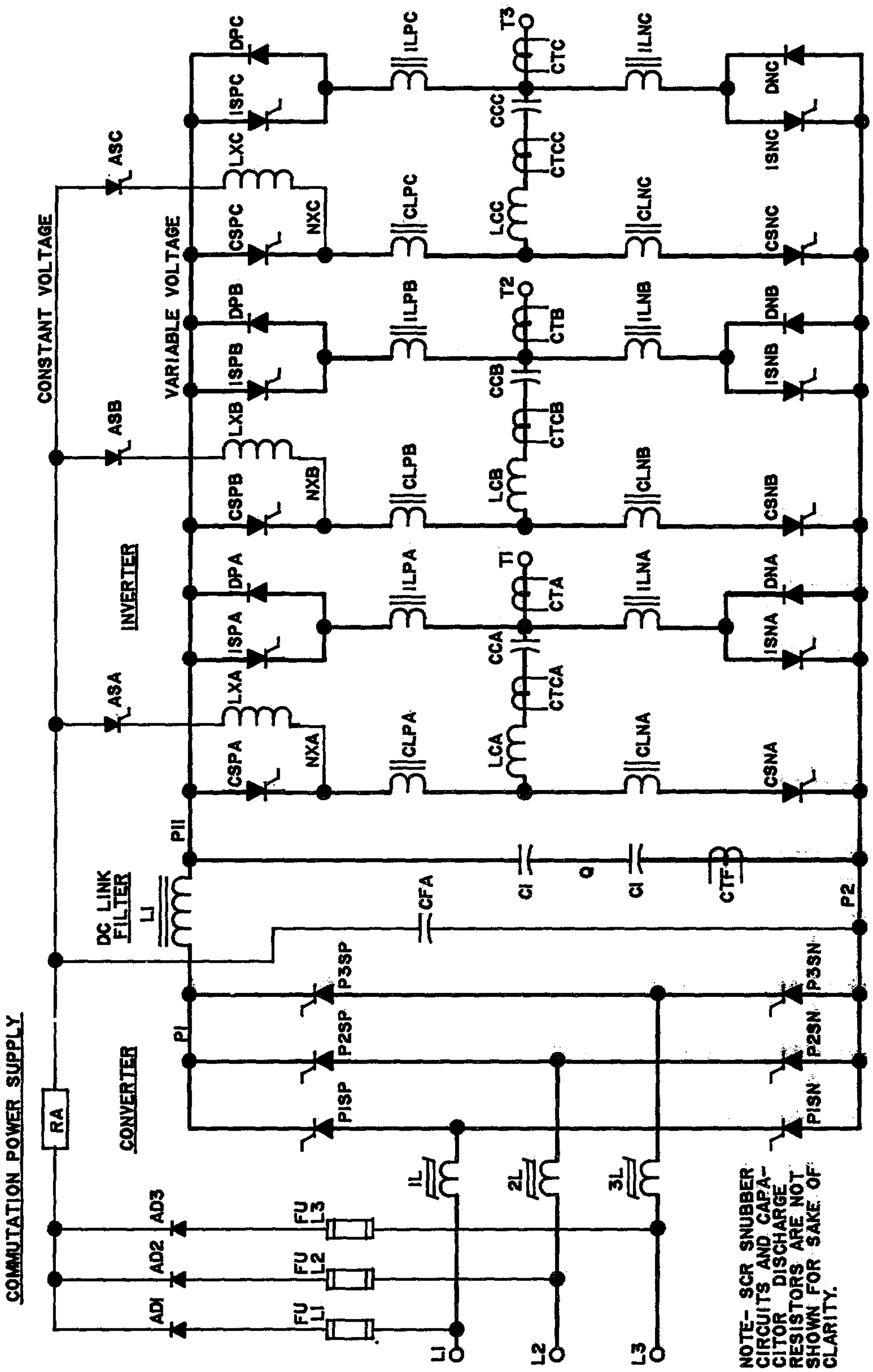


FIGURE 4. AF-400 POWER CIRCUIT ©

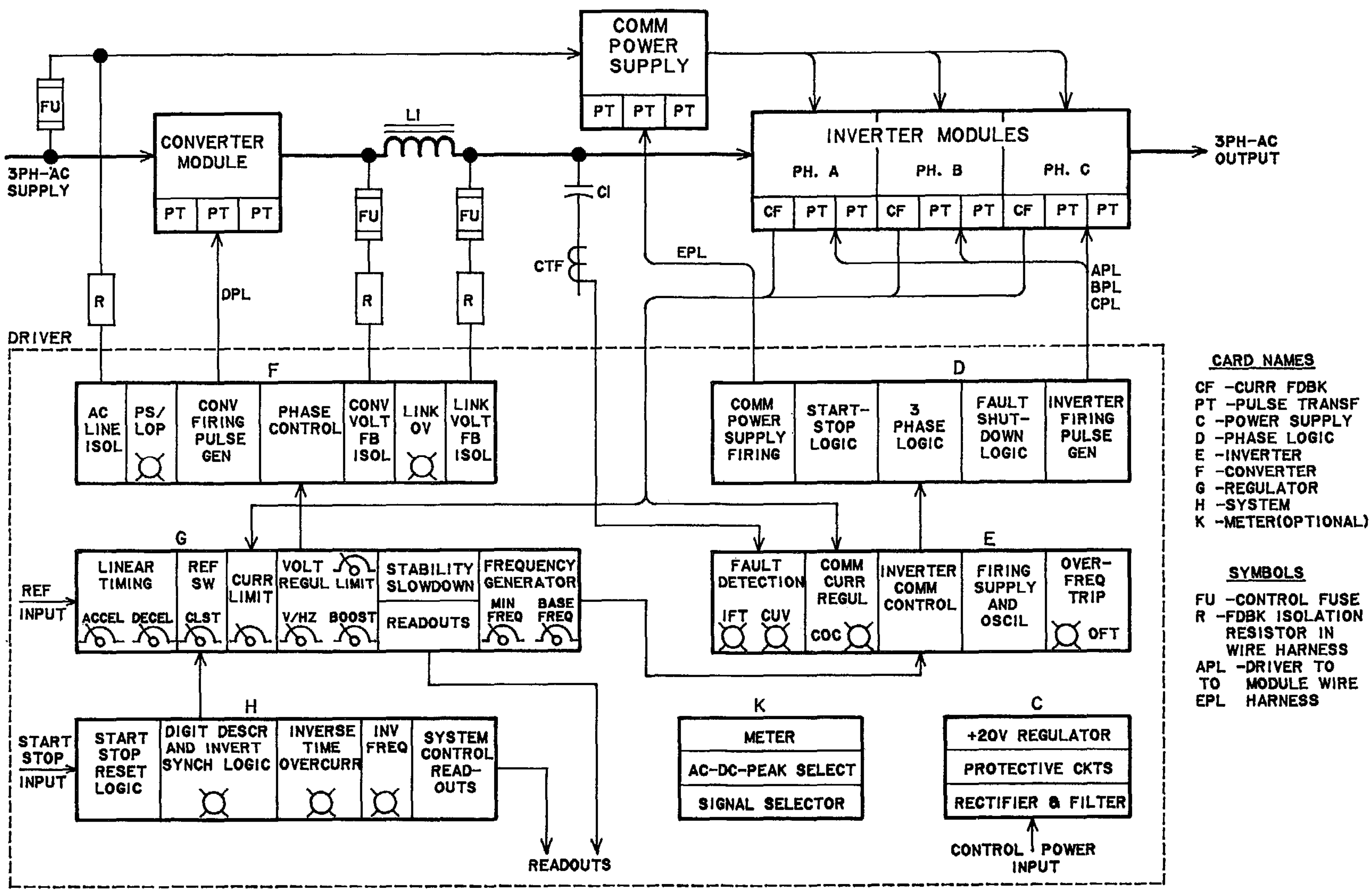


FIGURE 5. AF-400 FUNCTIONAL BLOCK DIAGRAM

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 has been sustained. It is recommended that the following step by step start–up procedure be followed to ensure proper operation of the equipment.

WARNING

IF DOOR INTERLOCKS ARE DEACTIVATED, BE SURE 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 – 193X381_ _G01
Volt–Ohmmeter – Digital preferred, 20K per volt min. input impedance
Clamp–on Ammeter – Adjustable range up to 600 amp.

If the Meter card is not available, an oscilloscope (preferably dual trace) will be required.

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 a.c. supply to the control transformer, 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 power module mounted Current Feedback cards and 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 A–C 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.

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 (ENERIZED) 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.

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 AND THAT CAPACITORS ARE DISCHARGED.

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

There are two card selections and two driver terminal board selections which should be checked before starting up the drive.

NOTE

IF EITHER THE INVERTER CARD (193X376AAG01) OR THE CONVERTER CARD (193X377AAG01) IS REPLACED, THE NEW CARD SHOULD HAVE THE SAME JUMPERS AS THE CARD BEING REPLACED.

460V JUMPER ON INVERTER CARD, 193X376_ _G0_ (or equivalent)

This jumper should be present on all drives whose inverter section operates at 460 volts a.c. maximum output voltage. This jumper should be removed on all drives whose inverter section operates at 230 volts a.c. maximum output voltage.

CAUTION

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

60 HZ JUMPER – ON CONVERTER CARD, 193X377_ _G0_ (or equivalent)

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

BASE FREQUENCY RANGE (BFR) JUMPER – Driver TB35 to TB34

This jumper selects the inverter base frequency range as follows:

Base Freq. Range of 37.5 to 75 Hz – Jumper TB35 to TB34

Base Freq. Range of 75 to 150 Hz – no Jumper on TB35

Base Frequency is the frequency at which the inverter reaches full voltage and is adjusted by the BF potentiometer (on the Regulator card) within either of the above two ranges. Although the standardized driver label shows this jumper present, consult your specific drive elementary diagram for proper jumper selection.

CAUTION

IMPROPER JUMPER CONNECTION OR DISCONNECTION MAY RESULT IN DRIVE MALFUNCTION AND DAMAGE.

OVERFREQUENCY TRIP JUMPER –

This jumper selects the upper inverter frequency at which the drive will trip and shut down to prevent motor overspeed. The frequency trip levels are selected as follows:

75 Hz frequency trip – No jumper required
110 Hz frequency trip – Jumper TB30 to TB31

Consult your specific drive elementary diagram for proper jumper placement

WARNING

IMPROPER JUMPER PLACEMENT MAY PRESENT AN EQUIPMENT OR PERSONNEL HAZARD DUE TO MOTOR OVERSPEED.

INVERTER PHASE MODULE SELECTION

A jumper selection on the Current Feedback card (193X382_ _), which is mounted on the front of each inverter phase module, provides the means to calibrate the inverter current feedback signal to the drive current rating. The card group number and jumper selection must be the same on all three inverter phase modules. The jumper selection should be made using the table on the phase module elementary diagram or Table 2 of the Current Feedback card printed circuit

INVERTER PHASE MODULE (CONTINUED)

diagram. Use the nominal inverter rms amps given in the table that is closest to the drive nameplate output current rating to check for the correct Current Feedback card group number and jumper selection. Incorrect jumper selection will effect the current limit and overcurrent shutdown levels.

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 a.c. supply power to the drive, verify that it is the proper voltage, phase and frequency as denoted on the equipment data nameplate.

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 bottom of the driver. Do not disconnect the EPL plug.

4. Using a volt–ohmeter selected to the X1 ohms scale, check that no short exists between d.c. link busses P1 and P2. Also check the three a.c. supply power fuses, all fuses on the commutation power supply module, and all control power fuses to confirm that they are not blown.

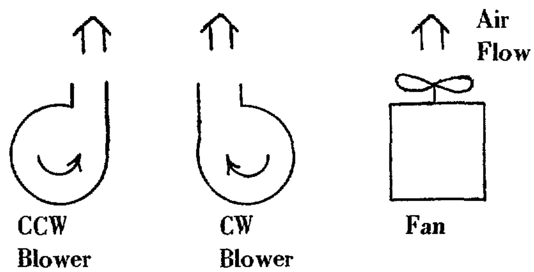
5. Apply a.c. power to the drive and check that the "Power On" light indicates.

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 driver wire harness EPL containing the a.c. supply input is plugged into the driver, and that the correct voltage is present on all three a.c. supply power terminals L1, L2 and L3. If these are correct, the phase sequence is wrong. Disconnect the a.c. power, interchange any two cables, and repeat steps 5 and 6.

7. Check that blower or fan rotation is correct and that they are operating properly and producing air flow through the power modules. Refer to the

7. (Continued)

sketches below and to labels on the air distribution chamber for correct operation.



If blower or fan rotation is incorrect, interchange any two a.c. supply leads to the blower motor. If no rotation occurs, check blower or fan fuses on the commutation power supply module.

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 TB16 to TB8.

9. Interrupt a.c. power to the drive, connect the DPL wire harness plug to the driver (which controls the converter module), and reapply a.c. 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 18 and compare these readings with the readings shown on the driver label mounted on the inside of the power unit enclosure door. This label also is sheet 4 of the driver connection diagram. The readings taken should compare with those given for the "Off Condition" (except for positions 7,8,9,16,17 and 18 which are meaningless since wire harness APL, BPL and CPL are not connected).

    If a Meter card is not available, use a volt–ohmmeter to check REF (TB16 to TB8), FVRO (TB22 to TB8), and the converter output voltage between P1 and P2. The P1 to P2 voltage should not exceed 30 volts d.c. for 230 volt a.c. drives or 60 volts d.c. for 460 volt a.c. drives, before the inverter is started.

11. Press the drive "Start" pushbutton. Check driver lights and Meter card position 4, or P1 to P2 voltage. They should be the same as for step 10.

12. Increase reference input to the driver slowly until the P11 to P2 voltage reaches half of rated d.c. link voltage (150 volts d.c. for 230 volt a.c. drives and 300 volts d.c. for 460 volt a.c. drives). The Meter card positions 2 and 4 should both read 7.5 (7.5 volts between TB16 and TB8).

CAUTION

THE FILTER CAPACITORS MUST BE REFORMED ON START–UP. THIS IS TO BE DONE REGARDLESS OF SHIPMENT DATE OR FACTORY LAST ENERGIZED DATE. FOLLOW PROCEDURE OUTLINED IN STEP 13.

13. If capacitor forming is required, increase P11 to P2 DC link voltage in the following steps, pausing for 5 minutes at each step in the forming process.

OPERATING VOLTAGE LEVEL		OPERATING
230VAC DRIVE	460VAC DRIVE	TIME
200 VOLTS D.C.	400 VOLTS D.C.	5 Min.
250 VOLTS D.C.	500 VOLTS D.C.	5 Min.
300 VOLTS D.C.	600 VOLTS D.C.	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. (s) (460 volt a.c. drives only). The difference between the P11 to Q and Q to P2 voltage readings should not exceed 5% of the P11 to P2 voltage. For example, at a P11 to P2 voltage of 600 volts, the difference between the P11 to Q and Q to P2 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 d.c. be applied across a single capacitor.

14. Press the drive "Stop" pushbutton and decrease the driver reference to zero. The d.c. link voltage between P1 and P2 (Meter position 4) should discharge down to less than 10% of maximum in about 30 seconds.

15. Interrupt a.c. supply power to the drive, connect the APL, BPL and CPL wire harness plugs to the driver (which controls the inverter phase modules), and reapply a.c. 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 18 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, using the driver SEL1 and SEL2 back plane diagnostic probes which are color coded black and violet respectively. Connect these probes to driver receptacle K, terminals 32, 31 and 30. Connect the oscilloscope leads to driver terminal board points TB39 (SEL1) or TB40 (SEL2) and TB34 (COM). 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 Fig. 6. The positive commutation current pulse is normally the higher since the negative pulse is attenuated on the Current Feedback card.

17. Slowly increase the driver reference input up to maximum while checking the inverter commutation current peak level of each phase, by means of selector positons 16, 17 and 18 on the Meter card, or by means of SEL1 and SEL2 and an oscilloscope as described in step 16. The commutation current peaks should increase somewhat, 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 a.c. 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 a.c. power to the drive. With reference input to the driver at zero, press the drive "Start" pushbutton and slowly bring the ref–

20. (Continued)

ërence up to half rated. Run through the Meter card positions 2 through 18 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 position 7, 8 and 9 readings will be different from those given, but they should all be the same value.

If any Meter reading discrepancies exceeding 5% full scale (1.0) from those values given in the drive table are found, proceed to the Adjust– ments Section.

If a Meter card is not available, use a clamp–on ammeter to read the inverter a.c. output current in each phase to check that they are balanced. Also check the a.c. 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 position 2 through 18 and compare these readings with those given on the driver label for "1 Ref., 1 Load". Again position 7, 8 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 nine driver adjustments, all of which are located on the Regulator card. (The Voltage Limit VLIM potentiometer is 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 any changes in adjustment that may be made.

NOTE

IF THE DRIVER REGULATOR CARD IS REPLACED, SET ALL NINE 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. Too much voltage boost will produce excessive motor peak currents which will cause torque pulsations or "cogging". If motor "cogging" or a grinding noise occurs at low motor speeds, the voltage boost should be reduced (VB turned toward CCW end).

V/HZ – VOLTS/HERTZ

Operate the drive at a reference of 12 volts at driver TB16 to TB8 (reading of 12 on Meter card position 2). Adjust the V/Hz potentiometer to obtain a d.c. link voltage between P11 and P2 of 250 volts d.c. for 230 volt a.c. drives and 500 volts d.c. for 460 volt a.c. 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 (located at top edge card)

This is normally a factory adjustment and should not have to be readjusted. To check this adjustment, operate the drive at rated base speed (normally at a driver reference of 15 volts). Using the volt–ohmmeter, or any reliable rectifier type a.c. volt–meter (but not an iron vane type), read the inverter output voltage between terminals T1 and T2 and compare it with the a.c. supply voltage read with the same meter. The inverter output voltage should be 10 volts less than the supply voltage for nominal 230 volt a.c. drives and 20 volts less than the supply voltage for nominal 460 volt a.c. drives. If the voltage difference is less, turn the VLIM potentiometer counter–clockwise until the 10 or 20 volt difference is obtained. If the voltage difference is greater, and the a.c. supply voltage is less than 240 or 480 volts a.c., turn the VLIM potentiometer clockwise until the 10 or 20 volt difference is obtained.

If the a.c. supply voltage is above 240 or 480 volts a.c. the drive will not be in voltage limit (with rated reference and proper volts/hertz adjustment) so the voltage difference between a.c. supply and inverter output voltage will be greater than the 10 or 20 volts. The voltage limit function, therefore, only can be checked if a higher than rated reference is applied to the driver, when the a.c. supply voltage exceeds 5% above the rated voltage.

BF – BASE FREQUENCY

With the driver reference at the rated 15 volts (TB16 to TB8) – 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 TB37 (IPAD) and TB34 (COM). It can also be read to within $\pm 2\%$ accuracy by connecting a digital volt–meter between TB22 (FVRO) and TB8 (COM). The frequency is obtained by multiplying the voltage reading by 5 when TB35 is connected to TB34, and multiplying

BF – BASE FREQUENCY (continued)

by 10 when TB35 is left open. A third method of reading frequency, to within ±5% accuracy, is by taking the Meter card position 3 reading and applying the 5 or 10 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 probably 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 reference 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 into 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 2.5 to 25 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:

Load Inertia	CLST Setting for Motor HP	
	10 to 100HP	100 to 400HP
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 counter–clockwise end.

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 power unit or caused by external conditions or equipment?
2. Which module in the power unit is causing the problem?
3. Which component within the module 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	193X381AAG01
Volt Ohmmeter	Digital preferred – 20K per volt min. input impedance.
Oscilloscope	Dual trace preferred
Clamp–on Ammeter	Adjustable range up to 600 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 a.c. supply to the control transformer, 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 power module mounted Current Feedback cards and 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 A.C. 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.

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 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 CIRCUITS.

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 Trouble–shooting in this section.

2. System Control is at fault – refer to the system elementary diagrams for system logic and control circuits and operating 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 Trouble–shooting 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. A.C. supply fuses or circuit breakers have interrupted, or control power fuses have blown — Disconnect a.c. power from drive and check a.c. supply fuses. If fuses are blown, or a.c. 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 by referring to Commutation Power Supply Troubleshooting in this section. 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 a.c. supply, d.c. link and a.c. 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.

IFT *only*– If this is the only fault light that is indicating, an inverter fault has occurred. Refer to Inverter Module Troubleshooting in this section.

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

COC and IFT – This indicates a commutation over–current trip which produces an inverter fault shut–down. Check for drive overloading at or near full speed operation. Also refer to Driver Troubleshooting and Commutation Power Supply Troubleshooting in this section.

COC, IFT and ITOC – This indicates a combination commutation overcurrent, motor overcurrent shutdown. Check for drive overloading at or near full speed opera–tion. Also refer to Driver Troubleshooting and com–mutation Power Supply Troubleshooting in this section.

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

CUV and IFT – This indicates a control undervoltage trip which produces an inverter fault shutdown. Refer to Driver Troubleshooting in this section.

CUV, IFT and PS/LOP – This indicates a combination control and power undervoltage shutdown. Check the a.c. supply for outage problems.

LOV and IFT – This indicates a d.c. link overvoltage trip which produces an inverter fault shutdown. Refer to Driver Troubleshooting in this section.

LOV, IFT, COC and/or ITOC – This indicates a com–bination shutdown which would normally occur due to the effects of the d.c. link overvoltage. Refer to Driver Troubleshooting in this section.

FAULT INDICATING LIGHTS (on driver cards) (cont)

PS/LOP only – this indicates the presence of, or a shut–down caused by, wrong a.c. supply phase sequence or a loss of one or more a.c. supply phases. Disconnect the a.c. power and check the a.c. supply fuses or circuit breaker, especially if the driver is supplied from another power source. Also check the FUL1, FUL2 and FUL3 control fuses on the commutating power supply. Refer to Commutating Power Supply Troubleshooting if any of these fuses are blown. Check that the drive is connected to the a.c. supply in the correct phase sequence.

ITOC only – This indicates an inverter output over–current 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. 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 IFT – 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 cables 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 func–tions contained on each card are shown in the Func–tional Block Diagram of Figure 5. These functions are described in the Description Section of this manual.

The optional Meter Card is a great help in trouble–shooting 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 of the problem to 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 selec–tor switch positions for five operating conditions. This label also is sheet 4 of the driver connection diagram. These normal readings are given for the 18 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 18 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 selector probe can be used to check card (receptacle) terminal signals. The trouble–shooting notes will specify correct and incorrect read–ings 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 oscillo–scope. One input to the instrument is connected to either driver TB39 (SEL1) or TB40 (SEL2) and the other input is connected to TB34 (COM). The two back plane selector probes (SEL1 is the black wire probe and SEL2 is the violet wire probe) can then be connected to the appropriate driver receptacle terminal as denoted in the troubleshooting notes.

When using the back plane selector probes, there are a few sensitive card terminals which should be avoided when the drive is operating with a motor, since connection of an instrument will cause changes in the drive output. These sensitive termianls 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. 19–CVN	term. 12–BFD	
term. 20–CVP	term. 23–SSDO	
term. 22–L2S	term. 32–RFC	
term. 23–L1S		
term. 24–L3S		

Care should also be used in connecting an instrument to the driver reference REF (TB16, receptacle G, term. 30, receptacle K, term. 18) since this may produce a small motor speed change.

DRIVER TROUBLESHOOTING (continued)

Three other diagnostic terminal board points are pro–vided for oscilloscope usage. These are –

TB36 (LPAD) –A square wave logic signal which is in phase with the a.c. supply line phase A (or phase 1) to neutral voltage.

TB37 (IPAD) –A square wave logic signal which is in phase with the inverter output phase A to neutral voltage.

TB38 (OCPD) –A normally high logic signal having a short low going pulse at the start of every inverter commutation (six times the inverter frequency).

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 POTENTIO–METER SETTINGS, OR JUMPER PRESENCE OR ABSENCE, AS THE OLD CARD.

REGULATOR CARD –NINE POTENTIOMETERS (INCL. VLIM)
CONVERTER CARD –60 HZ JUMPER
INVERTER CARD –460V JUMPER

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 TB16 to TB8 voltage). If less than 15 volts check the reference potentiometer (should be 5000 ohms) and the RMAX volts TB17 to TB8, or check the system control (see system elementary diagrams).

b) Check the converter voltage reference CVR (Meter card pos. 6 or driver re–ceptacle 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 decreases to about 1.5 volts, it indicates the converter is saturating. Check the d.c. link voltage. It should read approximately 15 at Meter card pos. 4 or should read either approxi–mately 300 volts d.c. or 600 volts d.c. between power circuit terminals P11 and P2, for a 230 volt a.c. or 460 volt a.c. drive respectively. If this voltage is significantly less, check the a.c. supply voltage level and check the converter. See Converter Troubleshooting in this section. If the d.c. link voltage is approximately 1.35 times the a.c. supply voltage, the voltage limit VLIM poten–tiometer on the Regulator card is not adjusted properly. Refer to Adjustments section.

c) Check the inverter frequency voltage FVRO (Meter card pos. 3 or driver TB22 to TB8 voltage). The drive output frequency should be 5 times this voltage reading when driver TB35 is connected to TB34 or 10 times when TB35 is left open. If the FVRO reading agrees with the output frequency, if the presence or absence of the base frequency range BFR jumper at TB35 is correct, and if BFD TB43 is jumpered to TB44 or properly connected to an external base frequency potentiometer which is set correctly, then the BF potentiometer on the Regulator card should be adjusted. (Refer to Adjustments section.) If the output frequency does not agree with the FVRO reading, or if the BF adjust–ment appears faulty, replace the Regula–tor 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 TB16 to TB8 voltage). If it is less than 2 volts, check the ref–erence potentiometer or system control (see system elementary diagrams).

DRIVER TROUBLESHOOTING (continued)

2. (continued)

b) Check if the inverter is operating. Meter card pos. 11 (1R1), 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 ODMF input at driver TB10. 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 (OCL), 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 VB 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) If violently unstable motor operation occurs below one–half rated speed, check that the stability–slowdown circuit is connected. On driver receptacle G, terminal 23 should be connected to terminal 7.

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

d) Check for low a.c. supply voltage to the driver TB1 to TB2. This should not be less than 105 volts a.c.

e) Check for uneven motor loading or motor single phasing.

f) 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 driver TB16 to TB8 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 OSYNC input at driver TB11. 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.

c) Check the FUP1, FUP11 and FUP2 control fuses on the commutating power supply. 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 a.c. power to the drive.

a) Check the OSTOP input at driver TB12. 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 FUP1, FUP11 and FUP2 control fuses on the commutation power supply. Refer to Commutation Power Supply Troubleshooting in this section.

DRIVER TROUBLESHOOTING (continued)

c) Check for low d.c. link voltage. If the Meter card pos. 4 reads less than 3, or if the d.c. voltage between power circuit terminals P11 and P2 is less than 70 volts (230 volt a.c. drive) or 140 volts (460 volt a.c. drive), and the OSTOP driver input is low, then the System card is probably defective and should be replaced.

d) Check for high d.c. link voltage. If the Meter card pos. 4 reads higher than 4, or if the d.c. voltage between power circuit terminals P11 and P2 is greater than 75 volts (230 volt a.c. drive) or 150 volts (460 volt a.c. drive), and the OSTOP 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, 7, 8 and 9 readings for the 1REF, 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 d.c. link voltage and thus the inverter a.c. output voltage.

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

7. Cannot synchronize inverter with a.c. line or other external frequency.

a) Check that OSYNC input at driver TB11 is low (near common). If it is not, check the system control (refer to the system elementary diagrams).

b) If OSYNC is low, check OIS at Meter card, pos. 12 or receptacle K, term 8. If OIS is high (near +20 volts), use an oscilloscope connected to SEL1 and SEL2 to determine if the proper frequency signals appear at receptacle H terminals 9 and 10. The inverter frequency should be applied to terminal 9 and the a.c. line, or external frequency, should be applied to terminal 10. Also check that the RFC clamp is being applied to override the reference by checking that the driver reference will not affect motor speed.

c) If the OIS signal is low, check the SYNC light and the OSRO readout at driver TB18. If the light does not indicate and OSRO 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 at driver TB30 through TB31. 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 d.c. link to increase the voltage and frequency.

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

DRIVER TROUBLESHOOTING (continued)

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

a) Check the peak voltages of the three commutation current feedback signals over the whole operating range of the drive. These can be read on Meter card positions 16, 17 and 18, or with an oscilloscope by probing receptacle K, terminals 32, 31 and 30, for phases A, B and C respectively. Refer to the driver label for the normal peak voltage readings. See Figure 6 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 commutation current peaks is significantly higher than the others, shut down the drive and check the Current Feedback card on the inverter phase module of the phase in question. Check the resistance between the K1 to K2 terminals of the Current Feedback card, and compare with the resistance value (for the correct card group no.) given in Table 3 of the Current Feedback card printed circuit diagram. Replace this card if it 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 a.c. supply voltage.

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

3. CUV (and IFT) fault lights on.

a) Check the +10 volt (Meter card, pos. 1) and +20 volt (TB7 to TB8 voltage) control power. A CUV trip will occur at about 18 volts. If the +20 volt measures low, check the 115 volt a.c. supply to the driver TB1 and TB2. It should be no lower than 105 volts a.c. If the a.c. supply is all right, check for excessive loading of the Power supply card, especially from external loads connected to driver TB7. 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 a.c. power to the drive and disconnect driver wire harnesses 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 with the Stop pushbutton (or external fault reset), disconnect the DPL wire harness from driver. If the CUV light can then be reset, the problem is in one of the Pulse Transformer cards on the converter module, or in the DPL wire harness. 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 driver wire harnesses APL, BPL and CPL. If the CUV light still comes on when a drive start is initiated, the problem is in one of the Pulse Transformer cards on the commutation power supply, or in the EPL wire harness. Refer to the Commutation Power Supply Troubleshooting in this section. If the CUV light does not come on, stop the drive and connect only one of the (APL, BPL or CPL) wire harnesses to the driver and check for the CUV light when a drive start is initiated, with the driver reference set at zero.

DRIVER TROUBLESHOOTING (continued)

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 D.C. LINK IS OPENED. (SEE INVERTER MODULE TROUBLESHOOTING).

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

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

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

b) Check for overhauling load or for excessive a.c. 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 or the problem is in the EPL wire harness or its connections to the power circuit. Check the FUP1, FUP11 and FUP2 voltage feedback fuses on the commutation power supply. Replace the Converter card and check the operation.

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

a) Check the inverter a.c. output current feedback signals for all three phases, over the whole operating range of the drive. These can be read on Meter card positions 7, 8 and 9 using the AC (X10) scale, or with an oscilloscope by probing receptacle K, terminals 13, 12 and 11, for phases A, B and C respectively. The normal feedback signal voltage is 1 volt rms for rated load, or a reading of 10 on the Meter card. See Figure 7 for the wave shape of a normal motor current feedback signal. An instantaneous ITOC trip should not occur until the Meter card reads over 17 volts, or until the peak of the current feedback reaches about 3 volts as seen on the oscilloscope.

b) If one of the current feedback signals is significantly larger than the others, shut down the drive and check the Current Feedback card on the inverter phase module of the phase in question. Check that the jumper is connected to the proper XA, XB or XC post (for the correct card group number) as given in Table 2 of the Current Feedback card printed circuit diagram, based on the drive nameplate output rms amp rating. Check that jumper placement is the same on all three inverter phase modules. Temporarily remove the wires to the J3 and K3 card posts and measure the resistance between K3 and K4, comparing it with the correct value given in Table 2. 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) Check the FUP1, FUP11 and FUP2 voltage feedback fuses on the commutation power supply. Refer to Commutation Power Supply Troubleshooting in this section.

e) 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

DRIVER TROUBLESHOOTING (continued)

can be started and stopped satisfactorily.

6. Cannot reset fault lights.

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

b) Check that the OSTOP input at driver TB12 is low (near common) and that 1XFR input at driver TB14 is high (near +20 volt). If they are not, check the system control (refer to the system *elementary diagrams*).

c) Check that the ORRO readout at driver TB20 is high and the OMVFRO readout at driver TB21 is low. If they are not, check the d.c. link voltage. Meter card, pos. 4 should read 1.5 or less, and the P11 to P2 voltage should read no higher than 30 volts d.c. (230 volt a.c. drives) or 60 volts d.c. (460 volt a.c. drives). If inconsistent or higher voltages are read, refer to part 7 c).

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

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

a) Check that the OSTOP input at driver TB12 is high (near +20 volt) and the OSTART input at TB13 is low (near common). If they are not, check the system control (refer to the system elementary diagrams).

b) Check that the ORRO readout at driver TB20 and the OMVFRO readout at TB21 are both low. If they are not, check that the 1FTRO fault readout at driver TB19 is low. Also check the d.c. link voltage. Meter card pos. 4 should read 1.5 or less, and the P11 to P2 voltage should read no higher than 30 volts d.c. (230 volt a.c. drives) or 60 volts d.c. (460 volt a.c. drives).

c) If inconsistent or higher d.c. link voltages are present when the drive is at standby, check the voltage feedback fuses FUP1, FUP11 and FUP2 on the commutating power supply. If these are all right, 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 not indicating, or on continuously at standby.

a) Check the +10 volt (Meter card, pos. 1) and +20 volt (TB7 to TB8) control voltage. If they are zero, but 115 volt a.c. appears between driver TB1 and TB2, check the fuse FU1 on the Power Supply card. If no voltage is present between TB1 and TB2, 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 TB37 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 OCPD signal TB38. If there is no pulse frequency signal at OCPD (consisting of 35 usec, wide, low going pulses), replace the Regulator card and check operation. If frequency pulses appear at OCPD, check ICFF signal at Meter card, pos. 15 or receptacle K, term. 5. If high going frequency pulses appear at ICFF, replace the Phase Logic card and check operation. If no frequency pulses appear at ICFF, 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 1FTRO fault readout at driver TB19 is low. If a fault has occurred, it will lock out all firing signals.

DRIVER TROUBLESHOOTING (continued)

9. (continued)

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 thru 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 use the black or violet wire back plane selector probes with an oscilloscope connected to driver TB39 (SEL1) or TB40 (SEL2) and common, and compare with the wave shapes of Figure 8.

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 TB20 (ORRO) 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 use the black or violet back plane selector probes with an oscilloscope connected to driver TB39 (SEL1) or TB40 (SEL2) and common, and compare with the wave shapes of Figure 9.

e) If any firing signals are present at the driver but missing at the inverter modules or commutation power supply, check the plug connections at both ends of the appropriate wire harness APL, BPL, CPL or EPL (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 contains the fan or blower fuses, and d.c. link and a.c. supply feedback fuses, in addition to the commutation power circuits. To help in troubleshooting this module, refer to the Commutation Power Supply elementary diagram and to the simplified overall power circuit of Figure 4. Since practically all of the circuitry on this module is at a.c. supply potential, troubleshooting should be done with the a.c. power off. Wait 1 minute after dis– connecting power before doing any checking, to allow capacitors to discharge.

1. Fan or blower fuses

   If the fan or blowers are not operating, check the lower three fuses FUB1, FUB2 and FUB3. If one or more are blown, check for motor or blower binding and for motor winding shorts. Replace blown fuses and check operation.

2. A.C. Supply fuses

   If the PS/LOP light in the driver is indicating check the middle three fuses, FUL1, FUL2, and FUL3. If one or more are blown, check the commutation power supply diodes, SCR's and filter capacitor for failed devices (see 4., 5. and 6.) Replace blown fuses and check operation.

3. Voltage feedback fuses

   If the driver voltage, feedback signals do not agree with the measured d.c. link voltages, check the upper three fuses FUP1, FUP11 and FUP2. If FUP2 is blown, check the commutation power supply filter capacitor and resistor (see 6. and 7.). Replace blown fuses and check operation.

4. Diodes AD1, AD2 and AD3

   The commutation power supply diodes may be checked with a volt–ohmmeter selected to read ohms on the X 1K scale. First lift one end of fuses FUL1, FUL2 and FUL3 to isolate the diodes from the a.c. line, and check for blown fuses. Connect one lead of the volt–ohmmeter to any one of the top row of SCR heat sink plates, and the other lead to the L1F, L2F or L3F fuses. Good diodes will provide an almost infinite resistance in the reverse direction and a low reading in the forward direction. Failed diodes will read almost zero resistance in both directions (shorted) or infinite resistance in both directions (open).

   If any diodes appear to be failed, refer to the Maintenance and Repair section for disassembly and replacement information. The SCRs, filter capacitor and resistor, and wiring should also be checked for damage before repairing the assembly, reinstalling, and checking operation.

5. SCRs ASA, ASB and ASC (and snubbers)

   The commutation power supply SCRs may be checked with a volt–ohmmeter selected to read ohms on the X 1K scale. On 460 volt a.c. drives, connect one lead to any one of the top row of SCR heat sink plates and connect the other lead to each of the bottom row heat sinks. Good SCRs will provide an almost infinite resistance in both the forward and reverse directions, while failed SCRs will read zero in one or both direc– tions. Check the other three SCRs by connect– ing the meter between the bottom row ASA, ASB, or ASC heat sinks and the NXA, NXB or NXC terminals respectively. This also pertains to 230 volt a.c. drives where there are only three SCRs.

   If any SCRs appear to be failed, refer to the Maintenance and Repair section for disassembly and replacement information. The SCRs should be rechecked after their leads have been dis– connected from the other circuitry. See the Checking SCRs portion of this section. The RC snubbers around the SCRs, diodes, filter capaci– tors and resistor, SCR chokes, and wiring should also be checked for damage before repairing the assembly, reinstalling, and checking operation.

6. Filter capacitor CFA, Resistor RA and Chokes LXA, LXB and LXC.

   The filter capacitor may be checked with a volt– ohmmeter to determine if it charges up or is shorted. Also refer to DC Link Filter Trouble– shooting in this section for further information on electrolytic capacitor inspection.

   The filter resistor and SCR chokes may be check– ed with a volt–ohmmeter to determine if they are open or shorted. Refer to the Maintenance and Repair section for disassembly and replacement information.

COMMUTATION POWER SUPPLY TROUBLESHOOTING (continued)

7. Checking Pulse Transformer Cards

The Pulse Transformer cards on the front of the assembly 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 1COM or 2COM 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 10. Change the oscilloscope probe lead to the top tab of the other red power transistor to check the other half of this dual channel card. If normal pulses are observed when the inverter is operating, the card is probably good. If no pulses are observed, connect the oscilloscope probe to the FS1 or FS2 input terminals to check for driver firing signals. See Figure 9 for normal firing signals. Also check for +20 volt firing power at +20A or +20B 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.

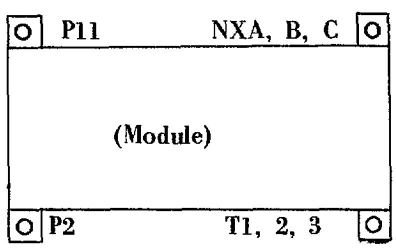
INVERTER MODULE TROUBLESHOOTING

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 4. Since practically all of the circuitry on these modules is at a.c. supply potential, troubleshooting should be done with the a.c. power off where possible. Wait 1 minute after disconnecting power before doing any checking, to allow capacitors to discharge.

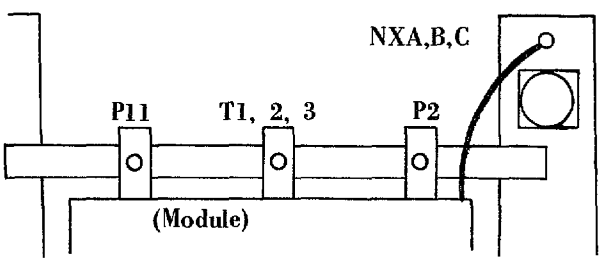
1. Checking SCRs, Diodes and Snubbers

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

30 TO 100 KVA



125 TO 400 KVA



T(1,2,3)	to P11	checks positive inverter SCR and diodes
T(1,2,3)	to P2	checks negative inverter SCR and diodes
NX(A,B,C)	to P11	checks positive commutation SCR
NX(A,B,C)	to P2	checks negative commutation SCR

Using a volt–ohmmeter selected to read ohms on the X1 ohm or X 10 ohm scale, the normal readings indicating good devices are as follows, with the positive meter lead connected to the first point.

P11 to T(1,2,3)	High resistance
T(1,2,3) to P11	Low resistance
P2 to T(1,2,3)	Low resistance
T(1,2,3) to P2	High resistance
P11 to NX(A,B,C)	High resistance
NX(A,B,C) to P11	High resistance
P2 to NX(A,B,C)	High resistance
NX(A,B,C) to P2	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 P11, P2, T(1,2,3) and NX(A,B,C). (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 capacitors 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 NXA and T1, NXB and T2, or NXC and T3. 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.

INVERTER MODULE TROUBLESHOOTING (cont.)

3. (continued)

Interrupt the d.c. link between P1 and P11 to prevent power flow from the converter into any inverter fault condition. This is easiest to accomplish on 30 through 100 KVA drives by disconnecting both the cable and control wire from one side of the L1 reactor, connecting the cable and wire together, and taping the connection. On 125 through 200 KVA drives, this is accomplished by disconnecting and taping the P1 cable from the left, top power terminal of the converter module, keeping the P1 control wire (going to the commutation power supply) connected to the converter P1 terminal On 250 through 400 KVA drives, this is accomplished by loosening the converter module P1 terminal, disconnecting the P1 bus bar at the right angle joint and rotating and securing (or taping) the bus bar to interrupt the P1 circuit, making sure that the P1 control wire (going to the commutation power supply) is connected to the converter module side of the break point.

With the DC link disconnected between P1 and P11, the drive can be started and the inverter operated up to ***half reference only***. With the *motor disconnected from the inverter, the P11 to* P2 DC link voltage will build 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 half 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 signals. The peak value of commutation current can be read on the Meter card selected to positions 16, 17 and 18 for phases A, B and C respectively. (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 between driver TB39 (SEL1) and TB34 (COM), and using the black wire, back plane selector probe to connect to receptacle K terminals 32, 31 and 30 for phases A, B and C respectively. See Figure 6 for normal commutation current wave shapes.

4. Checking Pulse Transformer Cards

The Pulse Transformer cards on the front of the phase module may be checked with an oscilliscope 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 1COM or 2COM 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 10. Change the oscilloscope probe lead to the top tab of the other red power transistor to check the other half of this dual 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 FS1 or FS2 input terminals to check for driver firing signals. See Figure 9 for normal firing signals. Also check for +20 volt firing power at +20A or +20B 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.

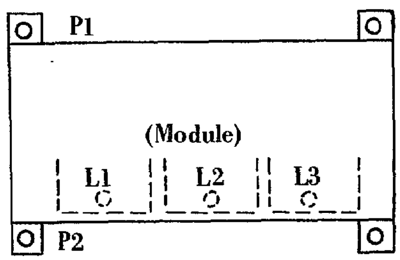
CONVERTER MODULE TROUBLESHOOTING

To help in troubleshooting this module, refer to the Converter Module elementary diagram and to the simplified overall power circuit of Figure 4. Since practically all of the circuitry on this module is at a.c. supply potential, troubleshooting should be done with the a.c. power off where possible. Wait 1 minute after disconnecting power before doing any checking to allow capacitors to discharge.

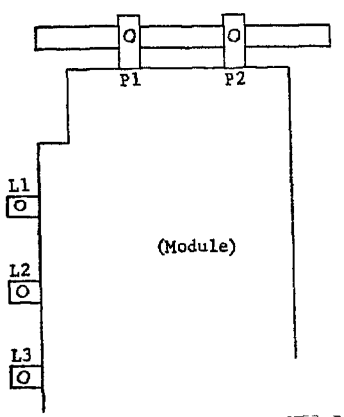
1. Checking SCRs and Snubbers

   The converter SCRs can be checked with the power off, without disconnecting anything. The measurement points for the two types of phase modules are as follows:

30 TO 100 KVA



125 TO 400 KVA



L1 to P1	Checks positive phase 1 SCR
L1 to P2	Checks negative phase 1 SCR
L2 to P1	Checks positive phase 2 SCR
L2 to P2	Checks negative phase 2 SCR
L3 to P1	Checks positive phase 3 SCR
L3 to P2	Checks negative phase 3 SCR

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 and P2. (The module may have to be pulled partly out to accomplish this.) 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 re–placement 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 SCRs portion of this section.

Whenever the converter module has been removed for replacement of SCRs, the RC snubber circuit around the SCRs a.c. line chokes and wiring should be inspected and checked for damage.

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 opera–tional test.

   Interrupt the d.c. link between P1 and P11 to prevent any power flow from the converter from reaching the filter capacitor or inverter. This is easiest to accomplish on 30 through 100 KVA drives by disconnecting both the cable and control wire from one side of the L1 reactor, connecting the cable and wire together, and taping the connection. On 125 through 200 KVA drives, this is accomplished by disconnecting and taping the P1 cable from the left, top power terminal on the converter module, keeping the P1 control wire (going to the commutation power supply) connected to the converter P1 terminal. On 250 through 400 KVA drives, this is accomplished by loosening the converter module P1 terminal. disconnecting the P1 bus bar at the right angle joint and rotating and securing (or taping) the bus bar to interrupt the P1 circuit, making sure that the P1 control wire (going to the

CONVERTER MODULE TROUBLESHOOTING (cont.)

2. (Continued)

commutation power supply) is connected to the converter module side of the break point.

With the d.c. link disconnected between P1 and P11, the drive can be started and the converter operated up to full voltage. This will occur at full reference if the P1 control wire (for converter voltage feedback) has been connected to the converter module P1 terminal. 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 P2 terminals. The d.c. output voltage should be controllable from near zero to approximately 300 volts d.c. (230 volts a.c. input drives) or 600 volts d.c. (460 volt a.c 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 or open gate SCR should be suspected. Refer to Checking SCRs to test for this problem.

3. Checking Pulse Transformer Cards

The Pulse Transformer cards 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 1COM or 2COM 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 10.

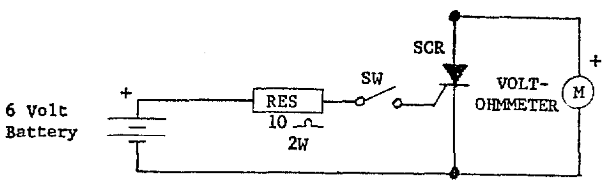
Change the oscilloscope probe lead to the top tab of the other red power transistor to check the other half of this dual channel card. If normal pulses are observed when the converter is operating, the card is probably good. If no pulses are observed, connect the oscilloscope probe to the FS1 or FS2 input terminals to check for driver firing signals. See Fig. 8 for normal firing signals. Also check for +20 volt firing power at +20A or +20B 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 SCR'S

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 SCR's 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 re–sistance 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 SCR's 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 resistances 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 dis–connected 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 d.c. link filter consists of the L1 filter choke and the C1 filter capacitor assembly.

1. C1 Filter Capacitor Assembly(s)

   This consists of one or more assemblies of paralleled (230 volt a.c. drives) or series–paralleled (460 volt a.c. 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 P11 to P2 voltage is less than 10 volts. On 460 volt a.c. drives with seriesed capacitors, the assembly can be checked for excessive leakage capacitors by checking the mid–point, or Q point, voltage when the drive is operating. Using a volt–ohmmeter, check the difference between the P11 to Q and the Q to P2 voltages at maximum d.c. link voltage. This difference should not exceed 5% of the P11 to P2 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 or 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 blower or 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 lightning or ground faults?
5. Check for excessive line regulation due to a high impedance (soft) a.c. supply.
6. Is a.c. supply grounded or ungrounded?
7. Is the available short circuit current too high?
8. Are there power factor correction capacitors causing harmonics, or 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 connections 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

D. (continued)

5. Check connections to Pulse Transformer cards and Current Feedback cards on power modules.
6. Check for bent terminals shorting to one another on driver back plane.

E. Electrical Noise

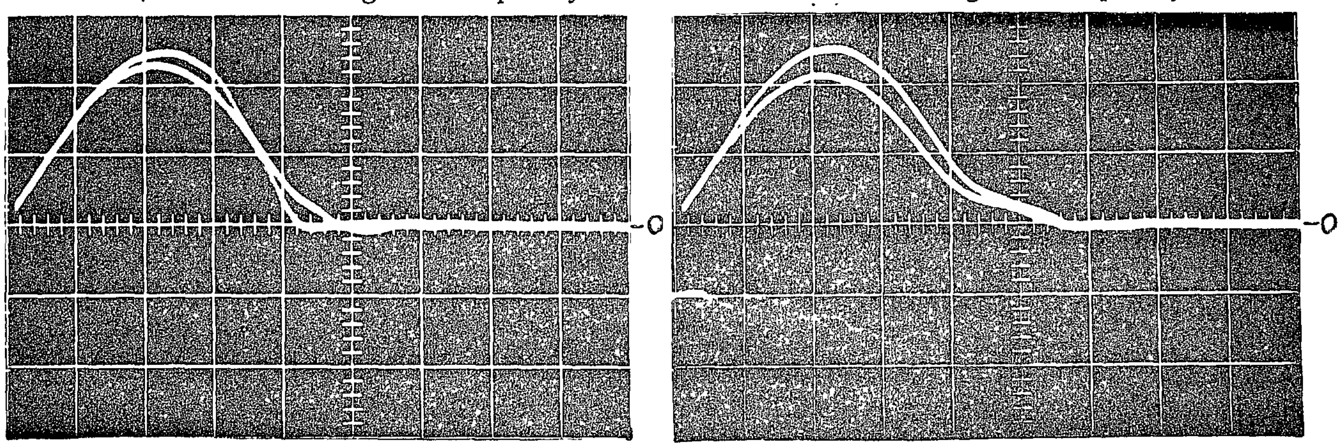
1. Check that all power unit relays have RC suppression on their coils.
2. External relays, solenoids, brakes, etc. interfacing with the power unit should also be suppressed.
3. Check for other external sources of electrical noise.

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



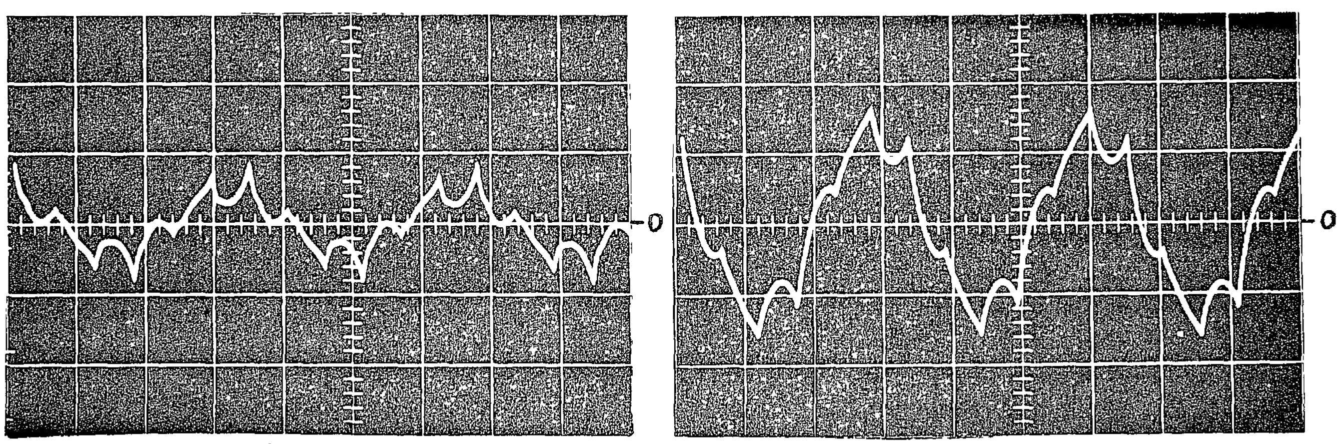
10 µsec./div. (230V AC Drives)
20 µsec./div. (460V AC Drives)

5 Volts division

FIGURE 6

MOTOR CURRENT WAVE SHAPE

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

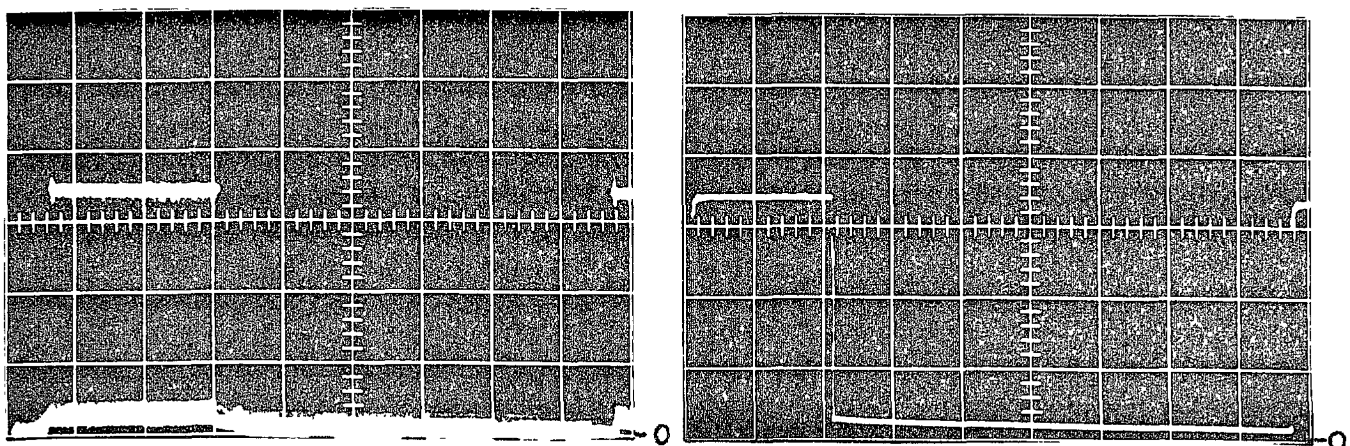


10 msec./div.
1 volt/div.

5 msec./div.
1 volt/div.

FIGURE 7

CONVERTER FIRING SIGNALS



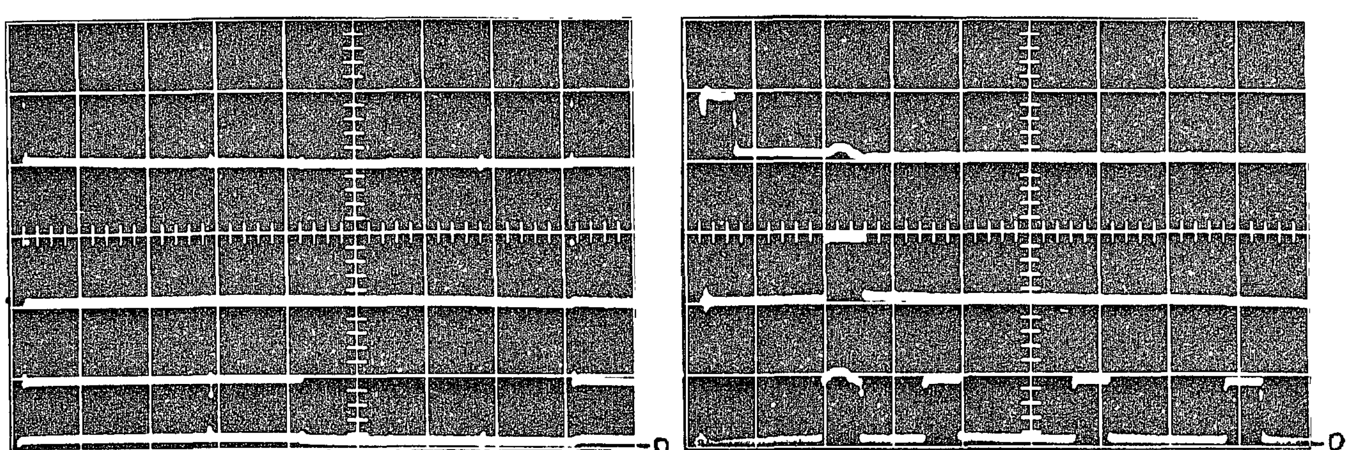
2 msec./division
5 volts/division

5 μsec./division
5 volts/division

FIGURE 8

INVERTER FIRING SIGNALS

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



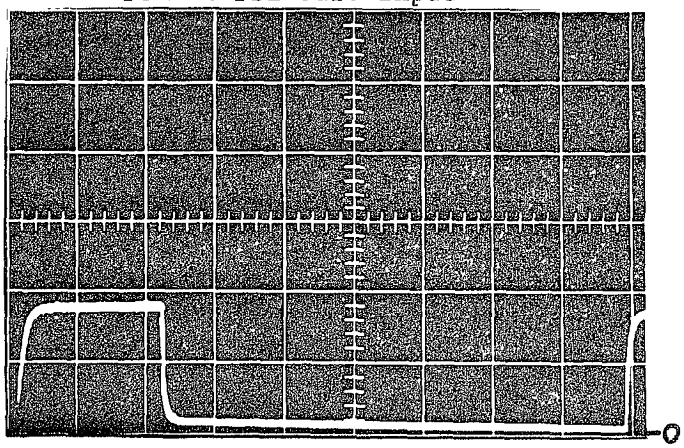
2 msec./division
20 volts/division

20 μsec./division
20 volts/division

FIGURE 9

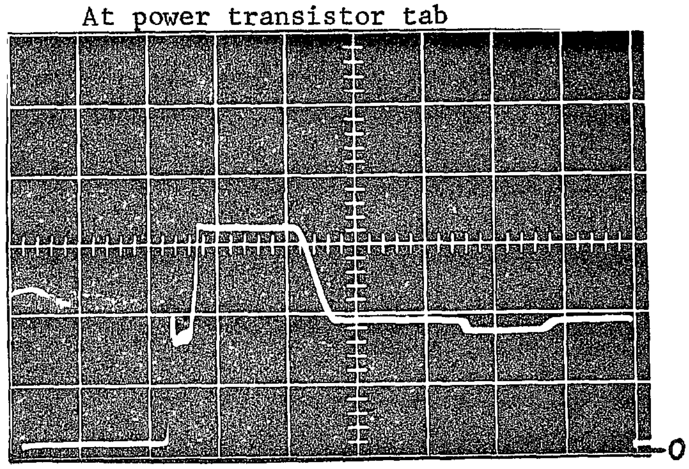
PULSE TRANSFORMER CARD PULSE WAVE SHAPE

At FS1 or FS2 card input



5 μsec./division
10 volts/division

At power transistor tab



5 μsec./division
10 volts/division

FIGURE 10

MAINTENANCE AND REPAIR

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. VERIFY THAT THE CAPACITORS ARE DISCHARGED.

MECHANICAL INSPECTION

The mechanical maintenance required for the drive system is divided into two basic units; power unit and motor. The power unit's only mechanical maintenance is checking and changing any air filters before they become clogged.

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, discoloration). Manually check cooling fan/blower for easy rotation.

POWER MODULE REPAIR

The removal, repair and replacement instructions vary depending on the type of power module and its KVA rating. Refer to the instructions which follow under the specific heading which applies to your drive.

If minimized down time is a critical factor, it is recommended that a complete inverter phase module of your drive rating be stocked as spares.

INVERTER PHASE MODULE REPLACEMENT – 125 to 400 KVA

1. Tools required:

   Table – 30" high
   Screw Driver – 8" long blade, 5/16" shank
   Deep Socket – 1/2" for 3/8" ratchet
   Ratchet – 3/8"
   Nut driver – 5/16" with 6" blade
   Nut driver – 3/8" with 6" blade

2. Open all electrical circuits to the case in which the phase module is located.

3. Check voltage across capacitor tray (P11 to P2) with a d.c. voltmeter. The capacitor discharge resistor should have reduced this voltage to 10 volts or below before work starts in the case.

4. Disconnect firing lead plug A, B, CPL.

5. Disconnect NXA, B, C lead from the terminal post.

6. Remove three captive nut–washer assemblies from Power Busses P11, P2 and T1, 2, 3 above the module.

7. Remove the retaining angle below the module.

   NOTE: This angle is used to help secure the module during shipment or when high case vibration is encountered. Normally this angle can be discarded after drive installation.

8. Place a 30" high table in front of the case beneath the module.

9. Pull the module out of the rack onto the table using the red insulation cover in front of the module. (See Figure 11)

10. The module can be repaired on the table. (See Press–Pak* Cell Replacement – Phase Module)

11. To install the repaired module or a spare module, first set the module upright on a 30" high table in front of the inverter case.

12. Lift the back end of the phase module onto the inverter rack. Lift the front end of the phase module and slide the assembly into the rack using the red insulation cover in front of the module.

13. Reconnect the power busses P11, P2 and T1, 2, 3, the NXA, B, C control lead and the firing lead plug A, B, CPL.

14. Check to see that all electrical connections are tight before re–applying power.

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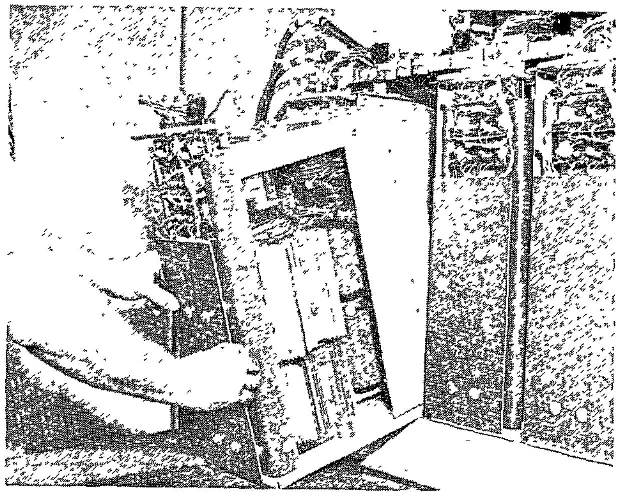
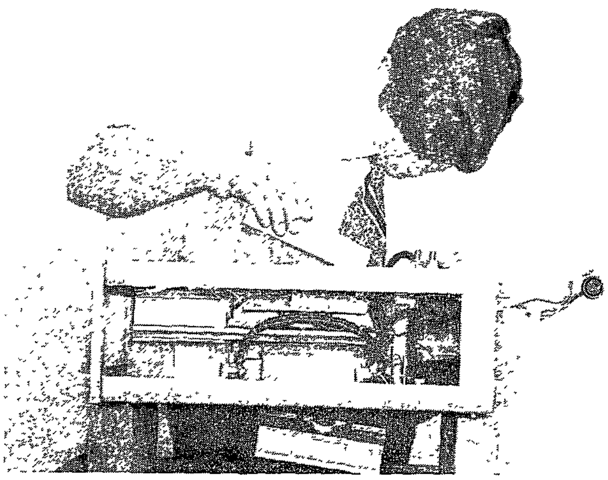


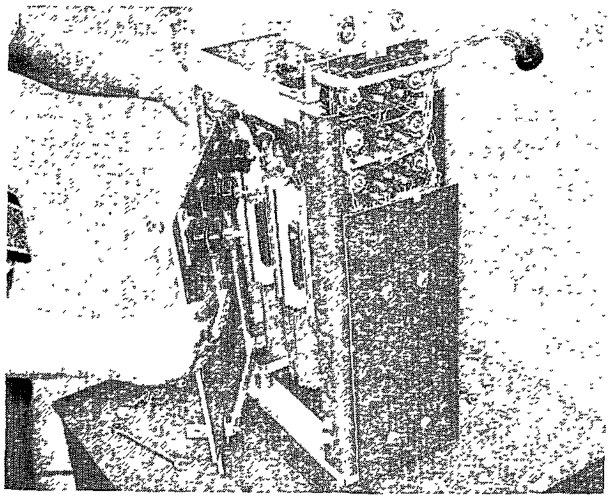
(Photo MG–5400–3)

FIGURE 11 – REMOVING AN INVERTER PHASE MODULE
(Also Applies to Converter Module)



(Photo MG–5400–2)

FIGURE 12 – REPAIRING AN INVERTER PHASE MODULE
(Also Applied to Converter Module)



(Photo MG–5400–1)

FIGURE 13 – REPAIRING A CONVERTER MODULE

PRESS–PAK CELL REPLACEMENT – PHASE MODULE

1. Tools required:

   2 wooden blocks – 4" x 4" x 12"
   Ratchet – 3/8"
   Ratchet extension – 3/8", 6" long
   Deep socket – 1/2" for 3/8" ratchet
   Deep socket – 9/16" for 3/8" ratchet
   Screw driver – 8" long blade, 5/16" shank

2. Disconnect the electrical connections to both heatsinks associated with the clamp containing the faulty cell (SCR or diode).

3. Lay phase module on its side with the heatsink clamp nuts up. The module top frame should rest on one wooden block, and the bottom frame on the other block; the blocks being positioned to permit hand access to the bottom heatsink associated with the faulty cells clamp. (See Figure 12)

4. Supporting the bottom heatsink and clamp with one hand underneath the module, loosen and remove the two clamp nuts.

5. NOTE CAREFULLY THE ARRANGEMENT OF THE CLAMP PARTS AND THE CELL ORIEN–TATION.
6. Remove the bottom heatsink and cell by dropping the assembly so the clamp rods are free.

7. The faulty SCR should have its gate and cathode leads with faston terminals disconnected from the Pulse Transformer card and the SCR (or diode) should be removed from the assembly. The gate and cathode leads of the replacement SCR should be connected to the Pulse Transformer card per the phase module elementary diagram.

8. The other cell associated with the clamp assem–bly should be carefully lifted from the module mounting surfaces.

9. Inspect the surfaces that both cells mount be–tween. These surfaces should be wiped clean with a lint–free cloth. Inspect the surfaces and make sure they are smooth; if not smooth, re–place the heatsink assembly.
10. Lubricate both mounting surfaces for each cell with a drop of silicone oil, SF1153* silicone fluid (or equivalent thermal compound).

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11. 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 cell fits over a roll pin in the heatsink and the top cell fits over a roll pin in the plate.

12. The clamp parts and heatsinks 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.

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

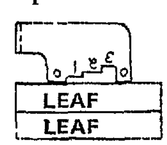
14. With the nuts finger tight use a wrench to tighten each nut alternately in 1/6 turn steps until the clamp tightness is as specified in the following table:

Cell Nomen.	Clamp Tightness Number Turns over Finger Tight		
	400 KVA	300 KVA	200 KVA
ISP, ISN	*	*	2–3/6
DP, DN	2–3/6	2–2/6	2–2/6
CSP, CSN	2–2/6	2–2/6	2–2/6

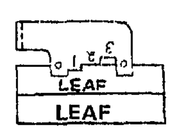
NOTES:

* This clamp has a clamp tightness gauge. Tighten nut until the indicator notch marked "2" lines up with the bottom of the spring.

Unloaded the "O" land of gauge indicator should line up with bottom spring leaf



Loaded the "2" land of guage indicator should line up with bottom spring leaf



15. Reconnect all electrical connections to both heat–sinks, and the SCR gate leads to the Pulse Transformer cards.

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

CONVERTER MODULE REPLACEMENT – 125 to 400 KVA

1. Tools required:

   Table – 30" high
   Ratchet – 3/8"
   Nut Driver – 5/16"
   Deep Socket – 1/2" for 3/8" ratchet
   Deep Socket – 9/16" for 3/8" ratchet

2. Open all electrical circuits to the case in which the Converter Module is located.

3. Check voltage across capacitor tray (P11 to P2) with a d.c. voltmeter. The capacitor discharge resistor should have reduced this voltage to 10 volts or below before work starts in the case.

4. Disconnect firing lead plug DPL.

5. Remove five captive nut–washer assemblies from P1 and P2 busses above the module, and L1, L2 and L3 to the left of the module.

6. Remove the retaining angle below the module.

   NOTE: This angle is used to help secure the module during shipment or when high case vibration is encountered. Normally this angle can be discarded after drive installation.

7. Place a 30" high table in front of the case beneath the Converter Module.

8. Pull the module out of the rack onto the table using the red insulation cover in front of the module. See Figure 11.

9. The module can be repaired on the table. (See Press–Pak SCR Replacement – Converter Module)

10. To install the repaired or a spare Converter Module, first set the module upright on a 30" high table located in front of the Inverter case.

11. Lift the back end of the Converter Module onto the Inverter rack. Lift the front end of the module and slide the assembly into the rack using the red insulation cover in front of the module.

12. Reconnect the power terminals P1, P2, L1, L2 & L3 and the firing lead plug DPL.

13. Check to see that all electrical connections are tight before re–applying power.

PRESS–PAK SCR REPLACEMENT – CONVERTER MODULE

1. Tools required:

   Two blocks – wooden, 4" x 4" x 12" long
   Ratchet – 3/8"
   Deep Socket – 7/16" for 3/8" ratchet
   Deep Socket – 1/2" for 3/8" ratchet
   Wrench – 7/16" box
   Wrench – 3/4" box
   Screw Driver – 5/16" shank – 8" long blade
   Nut Driver – 1/4" with 6" blade

2. Disconnect the flexible power leads from the three ferrite core assemblies in the a.c. lines.

3. Remove the five 1/4" screw–nut assemblies which secure the insulation board containing the a.c. bus and ferrite core assemblies.

4. Remove the insulation board containing the a.c. bus and ferrite core assemblies from the Converter Module (see Figure 13).

5. Lay the Converter Module on its side with the heatsink clamp nuts up. The module top frame should rest on one wooden block, and the bottom frame on the other block; the blocks being positioned to permit hand access to the bottom heatsink associated with the faulty SCR's clamp (see Figure 12).

6. Remove the two clamp nuts securing the faulty SCR while supporting the bottom heatsink and clamp with one hand underneath the module.

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

8. Remove the bottom heatsink and SCR by dropping the assembly to free the clamp rods.

9. The faulty SCR should have its gate and cathode leads with faston terminals disconnected from the Pulse Transformer card and the SCR should be removed from the assembly. The gate and cathode leads of the replacement SCR should be connected to the Pulse Transformer card per the converter module elementary diagram.

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

11. Inspect the surfaces that both SCRs 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

12. Lubricate both mounting surfaces for each SCR using a drop of silicone oil, SF1153* silicone fluid (or equivalent thermal compound).

13. 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.
    NOTE: The bottom SCR fits over a roll pin in the heatsink and the top SCR fits over a roll pin in the plate.

14. The clamp parts and heatsinks 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.

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

16. With the nuts finger tight use a wrench to tighten each nut alternately in 1/6 turn steps until the clamp tightness is as specified in the following table:

Inverter KVA	Clamp Tightness No. Turns over Finger Tight
400	2–3/6
300	2–3/6
200	2–2/6

17. Reconnect all electrical connections to both heatsinks and the SCR gate leads to the Pulse Transformer cards.

18. Re–install the insulation board containing the AC bus and ferrite core assemblies and bolt it in place.

19. Reconnect flexible power leads to the three ferrite core assemblies in the a.c. lines.

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

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CONVERTER AND INVERTER MODULE REPAIR 30 to 100 KVA

1. Tools required:

   Ratchet – 3/8"
   Ratchet Extension – 3/8", 6" long
   Deep Socket – 7/16" for 3/8" ratchet
   Deep Socket – 1/2" for 3/8'. ratchet
   Deep Socket – 9/16" for 3/8" ratchet
   Screw Driver – 1/8" shank, 2" long blade
   Screw Driver – 3/8" shank, 4" long blade

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

3. Check voltage across capacitor tray (P11 to P2) with d.c. voltmeter. The capacitor discharge resistor should have reduced this voltage to 10 volts or below before work starts in the case.

4. Remove the front cover from the module.

5. Remove faulty module from the case.

6. Remove printed circuit card cover from the heatsink assembly.

7. Remove heatsink assembly from its mounting bracket.

8. Remove the two nuts from the heatsink clamp containing the failed cell.

9. Remove failed cell (SCR or diode).

10. With a soft lint–free cloth, clean the aluminum plate and both heatsinks where both the failed cell and the other cell mount. Inspect all cell mounting surfaces to make sure they are smooth; if not smooth, replace the heatsink assembly.

11. Apply a small dab of G322L Versilube* (or equivalent thermal compound) to each side of the two cells being installed so that under pressure the compound will cover only the raised center cell surfaces.

12. Place the two cells in the same orientation as the original assembly.

13. The clamp parts should be assembled in the original manner and the two nuts tightened finger tight so that the number of threads show–ing are the same on both clamp rods.

14. Check to see the cell holes are still over the heatsink roll pins.

15. With the nuts finger tight use a wrench to tighten each nut alternately in 1/6 turn steps, until the nuts have completed 2–1/3 turns each.

16. Reassemble the module and reinstall it in the case.

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COMMUTATION POWER SUPPLY REPAIR

1. Tools required:

   Ratchet – 3/8"
   Ratchet Extension – 12" long for 3/8" ratchet
   Deep Socket – 3/8"
   Nut Driver – 1/4" with 6" blade
   Nut Driver – 11/32" with 6" blade
   Screw Driver – 5/16" shank, 8" long blade
   Torque wrench – 30 lb.–in or slightly higher
   Socket – 7/16" (for torque wrench)
   Solder iron and Resin Core solder (non–acid)

2. Open all electrical circuits to the case in which the Commutation Power Supply is located.

3. Check the voltage across the capacitor tray (P11 to P2) with a d.c. voltmeter. The capacitor discharge resistor should have reduced this voltage to 10 volts or below before works starts in the case.

4. Disconnect all electrical connections to the Com–mutation Power Supply:

   Three wires to Fuse blocks FUP1, FUP11 FUP2
   Six wires to fuse blocks FUB1, FUB2, FUB3
   Seven wires to terminal board 1TB
   Three wires to terminal board 2TB
   Disconnect plug EPL

5. Remove flanged plug section from Commutation Power Supply frame.

6. Remove Commutation Power Supply Assembly from case by removing four mounting screws.

7. To replace an SCR in the Commutation Power Supply:

   Remove heatsink asm. containing two SCRs one of which is the faulty SCR.
   Unbolt the faulty SCR from the heatsink.
   Unsolder the cathode and gate leads to the faulty SCR.
   With a soft lint–free cloth, wipe clean the heatsink where the SCR mounts.
   Apply G322L Versilube* (or equivalent) thermal compound) to the heatsink SCR mounting surface.

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7. (continued)

   Assemble SCR to heatsink as was done originally and tighten the SCR stud nut. The nut for 1/4" stud mounted SCR's should be torqued to 30 lb–in. Solder the cathode and gate leads to the new SCR.

8. Remount the Commutation Power Supply in the case.

9. Reconnect all wires checking for proper connec–tion points.

10. Remount plug housing EPL to the Commutation Power Supply.

11. Reconnect the plug EPL.

FILTER CAPACITOR REPLACEMENT

1. Tools required:

   Ratchet – 3/8"
   Deep Socket – 7/16" for 3/8" ratchet
   Wrench – 7/16" box
   Screw Driver – 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 capacitor tray (P11 to P2) with d.c. voltmeter. The capacitor discharge resistor should have reduced this voltage to 10 volts or below before work starts in the case.

4. Remove two screws which secure the capacitor tray to the rack.

5. Disconnect the P11 and P2 power leads to the capacitor tray.

6. Slide the capacitor tray from the rack.

7. 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.

8. Slide the repaired tray into the rack.

9. Reconnect all power leads.

10. Replace the two screws to secure the capacitor tray to the rack.

11. 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 Check–out section for the proper forming procedure.

BLOWER REPLACEMENT – 125 to 400 KVA

1. Tools required:

   Ratchet – 3/8"
   Deep Socket – 7/16" for 3/8" ratchet
   Nut Driver – 5/16" with 6" blade
   Screw Driver – 5/16" shank, 8" long blade

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

3. Check the voltage across the capacitor tray (P11 to P2) with a d.c. voltmeter. The capacitor discharge resistor should have reduced this volt–age to 10 volts or below before work starts in the case.

4. Remove the cover from the air distribution chamber.

5. Remove from the blower assembly, which is being removed, the four mounting screws located in–side the air distribution chamber.

6. Disconnect three power leads to the blower terminal board.

7. Slide the blower forward and lift it from the rack.

8. Slide the replacement blower into the rack.

9. Replace the blower mounting bolts.

10. Reconnect the three power leads.

11. Re–install the air distribution chamber cover.

12. Check all electrical connections to see that they are tight.

13. Apply power to the blower and note the rotation of the replacement blower blades. The rotation should be as shown on the rotation nameplate. (The rotation should be counter–clockwise look–ing into the blower intake and the blower blade should have its concave side as the leading side.)

    Should the rotation be clockwise, interchange any two power leads to the blower terminal board. When power is re–applied, the rotation will have reversed.

FAN REPLACEMENT – 30 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" blade
   Screw Driver – 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 (P11 to P2) with a d.c. voltmeter. The capacitor dis–charge resistor should have reduced this voltage to 10 volts or below before work starts in the case.

4. If an air filter is supplied, it should be removed.

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

6. Remove the mounting bolts from the motor mounting bracket supporting the fan motor to prevent it from falling.

7. Remove the motor and fan assembly.

8. The repaired or replacement motor and fan assembly should be bolted in place positioning the fan blade so that its top edge is 0.9" into the entrance duct.

9. Reconnect the motor leads to the terminal board.

10. Check all electrical connections for tightness.

11. Apply power to the fan motor. Looking into the motor from the fan side, the rotation should be counter–clockwise, and the air flow will be toward the top of the case.

12. Open the electrical circuit to the fan motor. If the motor rotation was incorrect any two motor leads may be interchanged at the terminal board to correct this.

13. Re–install the air filter

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