Rotor-AID

HD300 SERIES

Heavy Duty Rotor Controller

Model HD341-70
Tube Development System

Owner's Manual
(p/n 69239 Rev. A)

October 1999

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This manual covers the full configuration of the HD341-70 Tube Development Rotor Controller.

Refer to the overall wiring diagram in Section 7.0 and component location drawing in Section 3.0 for an overview.

There are also four standard options:

1) Deletion of the wall-mounting cabinet for installation as an integral part of an x-ray generator.

2) Addition of a 240VAC line filter on the mains input.

3) Addition of a heat exchanger controller.

4) Replacement of the standard (190, 200, 210, 220, 230, 240 and 277VAC input) isolation transformer with an optional (240 and 480VAC input) isolation transformer. This option is not available when using the 240VAC line filter option.

1.0 INTRODUCTION

Rotor-AID Series HD300 Heavy Duty Rotor Controllers provide the necessary control signals, interlocks and power outputs to drive the anode rotors of x-ray tubes to rotational speeds that are set by the drive frequency selected on the remote control panel (adjustable frequency) or to other rotational speeds using the PROM programmed frequency memory (fixed frequency) and then to dynamically brake them. Both boost and brake are achieved in the shortest possible time periods which are digitally preset.

Solid state logic is provided to accommodate all common procedures.

These Rotor Controllers are designed to provide the maximum boost power that almost any tube can accept for rapid acceleration. CARE MUST BE TAKEN NOT TO SELECT OPERATING FACTORS AND DUTY CYCLES THAT ARE BEYOND THE CAPACITY OF THE PARTICULAR X-RAY TUBE TO BE DRIVEN.

Two separate inverters are used to drive pre-selected high power into the two stator windings of an x-ray tube at a phase angle of exactly 90 degrees; no phase shift capacitors are required. Pre-selected DC power is used to brake rapidly.

Current sensing is provided to monitor main, phase and common stator currents during boost and run periods and to provide relay interlock contacts to prevent x-ray exposures if these currents are not within preset limits.

Large and heavy anode tubes with heat storage capacities of one to five million heat units can be rapidly accelerated to full speed.

With even wider application, normal radiographic tubes that have been getting progressively larger and that have been taking longer boost times can now be brought back into the one second boost time range.

SECTION 2.0 SPECIFICATIONS

2.0 SPECIFICATIONS

2.1 Control Interface Input Voltages

Factory/field selectable jumpers for each input circuit permit nominal input levels of 12VDC, 24VDC, or 120VAC for each input circuit. Loading is nominally 10mA for any input voltage selected. NOTE: When using input signals from a source other than the HD341-70 remote control panel, be certain to disconnect the remote control panel wire connections at the terminal block, 60971C TB1.

2.2 Control Input Functions - All inputs must be held on for the duration of the function.

Function	Input
Rotor Start Input	60971C TB1, pins 1 & 2
High Speed Select	60971C TB1, pins 3 & 4
Auxiliary In (AUXIN)	60971C TB1, pins 5 & 6
Coast	60971C TB1, pins 7 & 8

2.3 Control Interface Output (60979U TB4) - All contacts rated 120VAC, 2 Ampere resistive, except as noted.

Function	Characteristics	Contacts
Rotor Interlock	See timing diagrams	1 set N.O. 1 set N.C.
High Speed Verified	High Speed selected	1 set N.O.
Tube Active	Closed during boost, run and brake operation	1 set N.O.

2.4 Power Requirements

Line voltages: Single phase 190VAC to 277VAC ± 10%, 50/60 Hz.

Isolation transformer, TR1
Input voltage taps: 190, 200, 210, 220, 230, 240, 277 VAC.
Input voltage taps (optional): 240, 480 VAC.

Nominal 60 Ampere service required, preferably wired from the same source as the generator power rather than from the generator. Wiring should conform to local and national safety codes using #6AWG wire for runs up to 115 feet (35m) in order to minimize voltage drops during boost.

Internal circuit breakers:
Time delay rated 60 Amperes, 240VAC.

2.5 Power Output

Function	Voltage Range
High Speed Boost	70VAC to about 600VAC (tap 5) 70VAC to about 1000VAC (tap 6)
High Speed Run	70VAC to 150VAC
High Speed (DC) Brake	50VDC to 130VDC at up to 10 Amperes per winding
Low Speed (normal) Boost or Low Speed (high frequency) Boost	50VAC to 280VAC 70VAC to about 600VAC (tap 5) 70VAC to about 1000VAC (tap 6)
Low Speed Run	50VAC to 100VAC
Low Speed (DC) Brake	50VDC to 160VDC at up to 10 Amperes per winding

Each of these six voltages is separately adjustable at the remote control panel (See Figure 2.1). Stator voltages may be monitored at the test point jacks marked “MAIN”, “PHASE” and “COMMON” on the front of the remote control panel.

Boost - Maximum available power output for high frequency - Nominally 5kW per inverter (2 inverters) into most 3 wire split stator windings rated for intermittent power levels of up to about 1000VAC and up to 15 Amperes per winding.

Boost - Maximum available power output for low frequency -
Nominally 3kW per inverter (2 inverters) into most 3 wire split stator windings rated for intermittent power levels of up to 250VAC and up to 15 Amperes per winding.

2.6 Duty Cycle

In the high speed (nominal 180Hz) mode the following duty cycle can be run on a continuous basis using a tube with an "R" type stator:

a) Boost/run/brake/rest cycle

- Boost:
  4.5 seconds,
  main inverter 600VAC,
  phase inverter 1080VAC.

- Run:
  9 seconds,
  main inverter 115VAC,
  phase inverter 190VAC.

- Brake:
  7 seconds,
  125VDC.

- Rest:
  19.5 seconds.

b) Repeat a) for eleven (11) more cycles.

c) Rest 13 minutes.

The maximum power output of this Rotor Controller exceeds the limits that most tubes can safely accept. Check with the tube manufacturer for the maximum power and duty cycle permitted to avoid damaging the x-ray tube.

2.7 Anode Rotation Maintained During Run

For the remote control panel set to “FIXED FREQUENCY”:

High Speed run is near 10,800 rpm (181.8Hz).
Low Speed run is near 3,600 rpm (62.5Hz).

When the remote control panel is set to “ADJUSTABLE FREQUENCY” the anode rotation speed is near that determined by the selected drive frequency as measured between the “GROUND” and “FREQUENCY” test point jacks on the front of the remote control panel. Rotational speed (RPM) is approximately equal to 60 times the drive frequency (Hz).

2.8 Timer Adjustment Ranges

Boost and brake times are set by means of toggle switches on the remote control panel (See Figure 2.1). The continuance (holdover time) and auxiliary timers are set by DIP switches on the 60972D Timer board. All timer switch selections are additive.

Control	Usable Range	Resolution
Boost, High Speed	0 to 15 seconds	0.2 second
Boost, Low Speed	0 to 15 seconds	0.2 second
Brake, High Speed	0 to 15 seconds	0.2 second
Brake, Low Speed	0 to 15 seconds	0.2 second
Continuance	0 to 21 minutes 10 seconds	10 seconds
AUXOUT	0 to 21 minutes 10 seconds	10 seconds

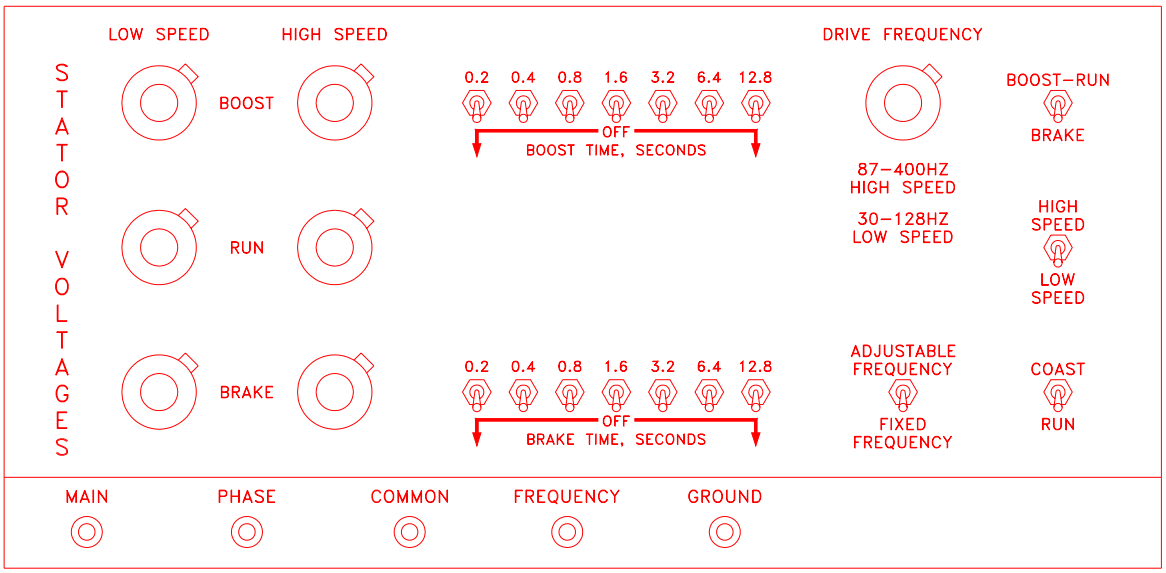
2.9 Controls and Indicators

External Controls and Test Points - See Figure 2.1

External Indicators - None

Internal Indicators - Power On Lamp, 2 Rotor Interlock LEDs, High Speed Verify LED, Tube Active LED and Fault Indicator LED.

Figure 2.1
Remote Control Panel



2.10 Two Phase Drive

Tube drive is accomplished in this unit by means of two separate inverters, each driving one winding of the tube's split stator. The Phase Inverter is always electrically 90 degrees out of phase with the Main Inverter. This system is in contrast to older conventional designs which have only one inverter and which use suitable phase shift capacitors with different x-ray tubes in order to drive the second or phase winding of the tube stators approximately 90 degrees out of phase.

2.11 Isolation Transformer

The transformer TR1 provides seven input power taps from 190VAC to 277VAC.

A 150°C thermal-overload switch is located inside the transformer to prevent damage in case of excessive temperature buildup.

2.12 Interlocks

Exposure interlocks are provided to prevent exposures under the following operating conditions:

- During boost, cassette delay, and brake portions of the timing cycles.
- When stator winding currents are less than preset amounts, to prevent exposures for defective or unconnected windings or inadequate drive from the controller.

A high speed verified interlock is provided to indicate that a high speed select signal has been received and the rotor controller is delivering high frequency power to the stator.

A tube active interlock indicates when the rotor controller is currently driving or braking a rotor.

2.13 Physical Appearance and Dimensions

Painted steel cabinet with hinged door and key lock. Air intake filter assembly in bottom and two exhaust fans in top.

Nominal Dimensions (refer to Figure 3.1):

inches - 40 high x 21-1/4 wide x 10-1/2 deep
mm - 1016 high x 540 wide x 265 deep

Weight:

195 pounds (88.5kg)
225 pounds (102kg), shipping

2.14 Environmental Characteristics

Ambient Temperature, storage: -20 to +65°C

Ambient Temperature, operating: +10 to +40°C

Humidity: 10% to 95%, non-condensing

2.15 Regulatory Compliance

ETL Testing Laboratories, Inc.

This product complies with the requirements of the Standard for X-ray Equipment (ANSI/UL 187, 5TH Ed.) when labeled:

3.0 INSTALLATION AND SUPPORT REQUIREMENTS

Electrical Service - 190VAC to 277VAC, Nominal 60 Ampere service required, preferably wired from the same source as the generator power rather than from the generator. Wiring should conform to local and national safety codes using #6AWG wire for runs up to 115 feet (35m) in order to minimize voltage drops during boost.

Mounting Access - Requires mounting access as shown in Figure 3.1. Mounting wall access is at least 23 inches wide x 38 inches deep x 52 inches high (584mm x 965mm x 1321mm). Requires wall or mounting surface rated to 250 pounds (115kg). Requires free air circulation above and below cabinet up to at least 6 inches (150mm). Intake air temperature and mounting surface not to exceed 40°C.

External Wiring - Control signals - #18AWG, 300VAC, 100 feet (30.5m) maximum length. If control signals are 120VAC, each line must be fused for 5 Amperes or less.

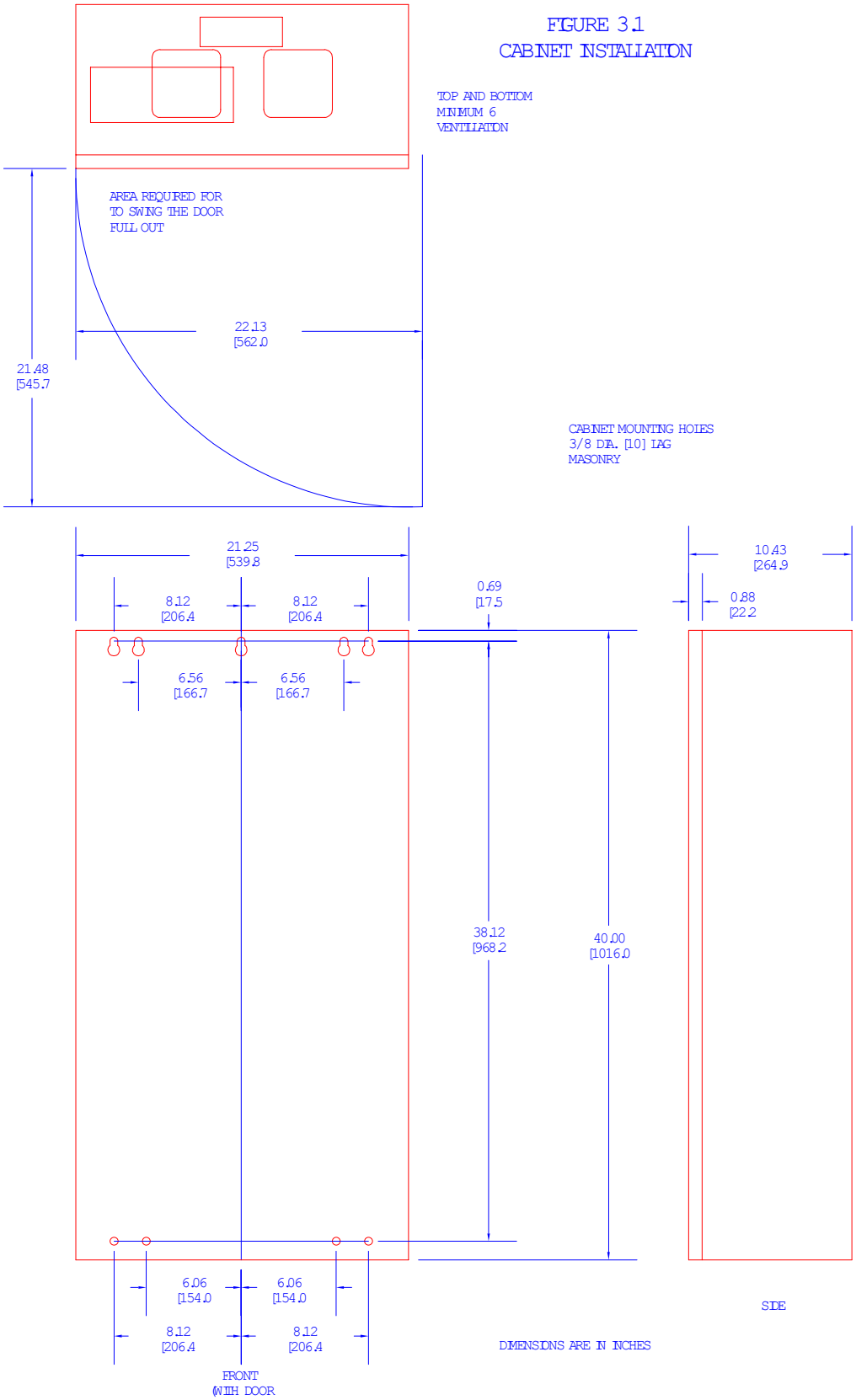
3.1 Tools and Materials Required

- Standard field service tool kit.
- A digital voltmeter AC/DC.
- Oscilloscope with 10X and 100X probes.
- Four bolts or studs suitable for hanging the cabinet on the wall.

3.2 Cabinet Installation

The complete unit weighs approximately 200 pounds (90 kg). For details on wall mounting see Figure 3.1. Be sure that the wall and cabinet attachment anchors are strong enough to support the rotor controller weight.

FIGURE 3.1
CABINET INSTALLATION



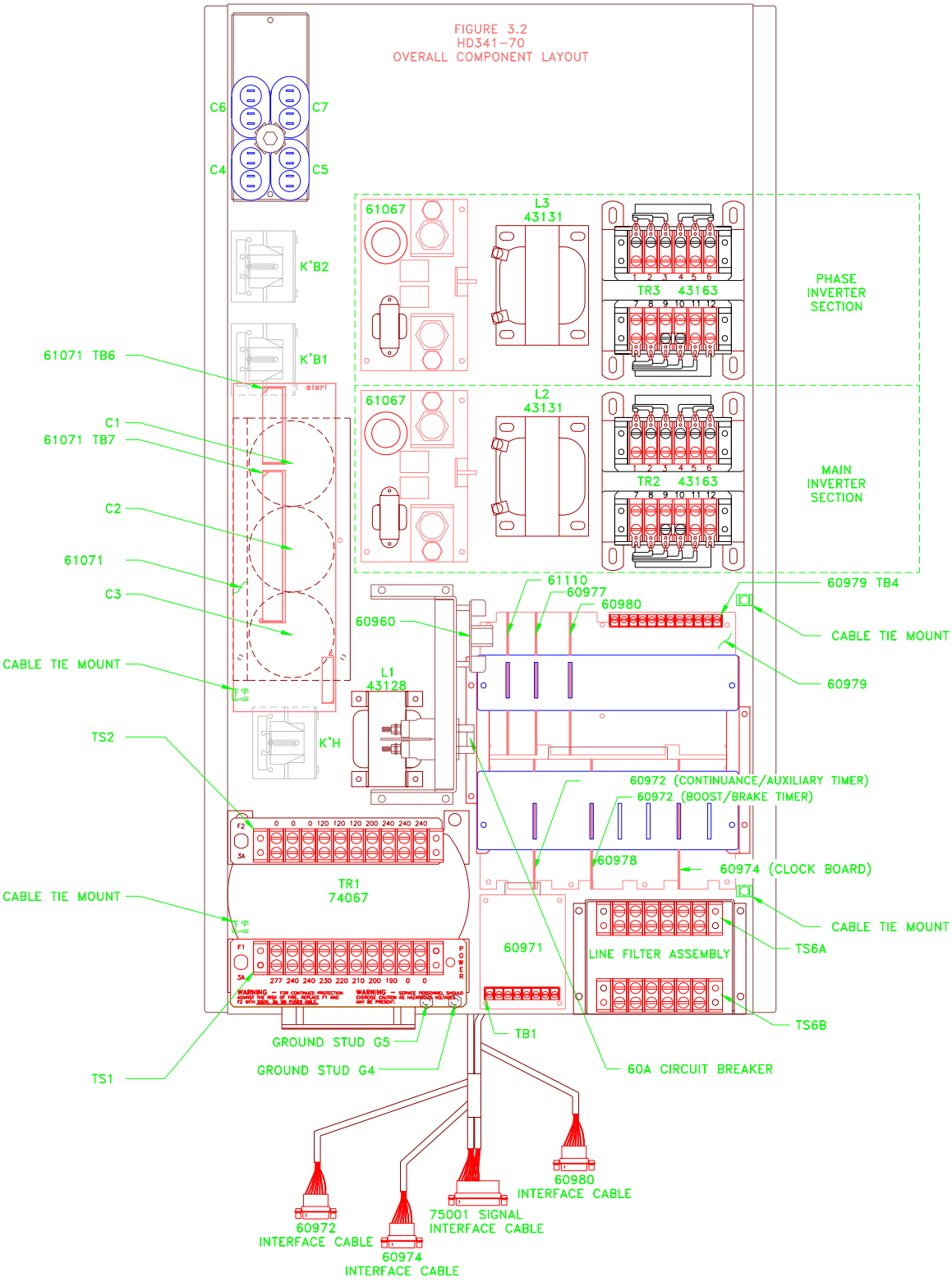


FIGURE 3.2
HD341-70
OVERALL COMPONENT LAYOUT
C6
C7
C4
C5
61067
L3
43131
TR3 43163
PHASE
INVERTER
SECTION
K'B2
K'B1
61071 TB6
61067
L2
43131
TR2 43163
MAIN
INVERTER
SECTION
C1
61071 TB7
C2
61071
C3
61110
60977
60980
60960
60979 TB4
CABLE TIE MOUNT
60979
CABLE TIE MOUNT
L1
43128
K'H
TS2
60972 (CONTINUANCE/AUXILIARY TIMER)
60972 (BOOST/BRAKE TIMER)
60978
60974 (CLOCK BOARD)
TR1
74067
CABLE TIE MOUNT
CABLE TIE MOUNT
60971
LINE FILTER ASSEMBLY
TS6A
TS6B
TB1
GROUND STUD G5
GROUND STUD G4
TS1
60A CIRCUIT BREAKER
60980
INTERFACE CABLE
75001 SIGNAL
INTERFACE CABLE
60972
INTERFACE CABLE
60974
INTERFACE CABLE

3.3 Power Connections

Connect single phase power (190VAC to 277VAC) directly to the appropriate input tap on TR1. Note that a 60 Ampere service is required by the rotor controller. Connect one line to the terminal marked 0V and the second line to the terminal corresponding to the appropriate line to line voltage. If the line filter option is selected, make the power connections directly to the line filter or terminal strip positions for the line filter (dependent on specific model). The output of the line filter must be connected to the proper input tap of the transformer. Make a ground connection to the large ground stud on the cabinet, marked G1. If the cabinet is deleted, make a ground connection to the large ground stud on the base plate, marked with a ground symbol.

3.4 Interconnections to X-Ray Control

Refer to Figure 3.2 for component locations. Use the cable clamps provided to route any interface wiring inside the rotor controller.

a) Inputs to the Rotor Controller (Refer to Figure 2.1).

All input signals to the rotor controller may be either 100VAC to 125VAC, 20VDC to 30VDC or 10VDC to 15VDC. When using the remote control panel for input signals, the rotor controller is configured 24VDC input signals and may be field programmed for other input voltages. Loading is approximately 10mA in all cases. Refer to schematic 60971C, HD341-70 overall schematic and input voltage programming detail for programming information.

NOTE: When using input signals from a source other than the HD341-70 remote control panel, be certain to disconnect the remote control panel wire connections at the terminal block, 60971C TB1.

ROTOR START - The “BOOST-RUN/BRAKE” toggle switch on the remote control panel is connected to 60971C TB1 pins 1 and 2. Setting this switch for “BOOST-RUN will cause the rotor controller to begin the sequence of boost and run. Setting this switch to “BRAKE” removes the rotor start signal and will initiate brake unless a continuance time is programmed. If a continuance time is programmed then the rotor will continue to run for the duration of the continuance time and will initiate brake at the end of the continuance time.

HIGH SPEED SELECT - The “HIGH SPEED/LOW SPEED” toggle switch on the remote control panel is connected to 60971C TB1 pins 3 and 4. This signal determines the speed at which the rotor will run. Absence of the high speed select signal will cause low speed operation and the presence of it causes high speed operation.

AUXILIARY INPUT - TB1 pins 5 and 6. For DC input signals pin 5 is positive and pin 6 is common. When jumper 60978AI W10 is set in the 1-2 (a/b) position, a signal connected to TB1 pins 5 and 6 will activate the auxiliary timer (timer 2 of the 60972D Timer board plugged into the 60978AI J1 connector). The DIP switches of the auxiliary timer may be set to remain on for a time period up to 21 minutes and 10 seconds (in 10 second increments) after the auxiliary input is removed. The auxiliary timer may be used to control an external device [see Section 3.4 b) HEAT EXCHANGER].

COAST INPUT - The “COAST/RUN” toggle switch on the remote control panel is connected to 60971C TB1 pins 7 and 8. A Coast input will cause the rotor controller to stop driving the rotor for a period of up to 15 seconds. No braking will occur. Power will be completely removed from the stator during the Coast time. During Coast, rotor interlock and high speed verify drop out.

b) Outputs from the Rotor Controller

ROTOR INTERLOCK - A set of normally open contacts for rotor interlock is available at 60979U TB4 pins 3 and 4. These contacts are rated at 120VAC, 2 Amperes and are used to inhibit an exposure when open. A second set of normally open contacts is available at 60979U TB4 pins 7 and 8 by positioning jumper 60979U W3 (b/c) so that 60979U RY2 is also used as a rotor interlock relay (instead of as a high speed verified relay).

INTERLOCK CHECK - A set of normally closed contacts for rotor interlock check is available at 60979U TB4 pins 5 and 6. These contacts are rated at 120VAC, 2 Amperes and should be used to check the interlock condition prior to Rotor Start. An open condition prior to a Rotor Start indicates an interlock malfunction.

HIGH SPEED VERIFIED - A set of normally open contacts is available at 60979U TB4 pins 7 and 8 as an interlock to verify that the rotor controller is operating in the high speed mode. This set of contacts will close when the rotor controller has responded to a high speed select signal and is driving the tube at high speed. These contacts are rated at 120VAC, 2 Amperes. Jumper 60979U W3 must be in the a/b position. This connection does not eliminate the need for the rotor interlock function. (See ROTOR INTERLOCK above).

TUBE ACTIVE - A set of contacts connected to 60979U TB4 pins 9 and 10 indicate when the rotor controller is currently driving or braking an x-ray tube rotor. Jumper 60979U W1 selects either a normally closed (W1; a/b) or normally

open (W1; b/c) configuration for these contacts. These contacts are provided for use only in installations where the generator system provides stator switching but does not include an internal interlock to prevent stator switching while the rotor controller is driving or braking an x-ray tube. Contacts are rated 120VAC, 2 Amperes.

HEAT EXCHANGER - (Optional) A set of normally open contacts on the optional 60968 Heat Exchanger Controller board may be used to power auxiliary equipment. These contacts switch 240VAC, fused at 3 Amperes, from the primary side of the input transformer, TR1, to pins 2 and 5 of the terminal block on 60968. When jumper 60978AI W1 is set in the 1-2 (a/b) position, these contacts are controlled by the auxiliary timer [See AUXILIARY INPUT in Section 3.4 a) and W60968A in Section 7.0].

THERMAL CUT-OUT - An external DC signal may be routed through the thermal switch of the input transformer, TR1, to drive a relay with a set of normally open contacts. These contacts, in turn, may be used to remove the input power supply to the rotor controller in the event of thermal overload. (See Section 7.0 W61071A). Note: This feature may not be used with the brake Interlock.

BRAKE INTERLOCK - A set of normally closed or normally open contacts can be provided at TB6 pins 3, 4 and 5 to indicate when a brake is in progress. These contacts will open or close during braking. (See Section 7.0 W61071B). Note: This feature may not be used with the Thermal Cut-Out.

3.5 Tube Stator Connections

Make stator connections as indicated in table below:

Stator Wire Color	Connection	Description
White	61071 TB7 pin 1	H9, Stator Common
Black	61071 TB7 pin 3	H7, Main Stator
Green (Red)	61071 TB7 pin 5	H8, Phase Stator

Proceed to Section 4, Tests and Adjustments.

4.0 TESTS AND ADJUSTMENTS

4.1 Adjustment Notes

Stator voltages are factory set. Different voltages may be set during installation, if desired.

If an oscilloscope is used for troubleshooting or to make adjustments, it must have a differential mode of operation or equivalent, dual trace capability with algebraic addition features, and 100X probes.

4.2 Control Signal Input Voltage Programming

All input signals to the rotor controller may be either 100VAC to 125VAC, 20VDC to 30VDC or 10VDC to 15VDC. When using the remote control panel for input signals, the rotor controller is configured 24VDC input signals and may be field programmed for other input voltages. Loading is approximately 10mA in all cases. Refer to schematic 60971C, HD341-70 overall schematic and input voltage programming detail for programming information.

NOTE: When using input signals from a source other than the HD341-70 remote control panel, be certain to disconnect the remote control panel wire connections at the terminal block, 60971C TB1.

If 100VAC to 125VAC or 10VDC to 15VDC signals are used, then:

1. Locate the 60971C jumper corresponding to the input command being changed.

2. Move the jumper to the set of pins corresponding to the input voltage being used for that signal. Note that the 120VAC selection is valid for voltages between 100VAC and 125VAC, the 24VDC selection is valid for voltages between 20VDC and 30VDC, and the 12VDC selection is valid for voltages between 10VDC and 15VDC.

4.3 Inverter Transformer Tap Selection

Unless otherwise requested, rotor controllers are programmed to be used with "R" stators, which have different impedance stator windings. The Main Inverter, TR2, is connected for the lower output voltage (tap 5 selected on the inverter transformer output) and the Phase Inverter, TR3, is connected for the higher output voltage (tap 6 selected on the inverter transformer output). Tap 5 voltage is approximately 61% of the tap 6 voltage.

When using balanced impedance ("E") stators, both inverter outputs should be the same (both tap 5) and the voltages adjusted as required for the particular tube type.

When using balanced low impedance stators, both inverter outputs should be the same, taps 5-6 (tap 6 common), and the voltages adjusted as required for the particular tube type.

For "Q" stators the output wires from the main inverter transformer are moved from taps 4 and 5 to taps 5 and 6 respectively; the two white wires from the phase inverter transformer are moved from 6 to 5. After changing taps, set boost and run voltages per tube specifications.

4.4 Functional Programming Information

Refer to the 60978AI schematic, component layout and Section 4.10 for jumper selection detail.

AUXILIARY TIMER - Auxiliary Timer Jumpers 60978AI W1, 60978AI W10 and 60978AI W14 are used to determine the function performed by the auxiliary timer. 60978AI W10 selects the timer trigger source and 60978AI W1 directs its output. The auxiliary timer may also be used to control an external device [see HEAT EXCHANGER in Section 3.4 b)].

DRIVE FREQUENCIES - The boost and run drive frequencies for the Rotor-AID HD300 Series Rotor Controller are determined by the programmed PROM used with the 60977S Rotor Interlock board. The HD341-70 is normally shipped with the 32229 PROM. When the remote control panel DRIVE FREQUENCY switch is set for “FIXED FREQUENCY” the rotor controller will operate 62.5 Hz inverter frequency for low speed operation and 181.8 Hz inverter frequency for high speed operation. Setting this switch to "ADJUSTABLE FREQUENCY” enables the remote control panel “DRIVE FREQUENCY” locking potentiometer to select high speed operation between 87 and 400 Hz and low speed operation between 30 and 128 Hz. The drive frequency may be monitored at the test point jack marked “FREQUENCY” on the remote control panel.

The programmable jumpers on the 60977S board should be set as follows:

60977S W1 should be in the a/b position to select PROM SECTION 1.

60977S W1 should be in the b/c position to select PROM SECTION 2.

60977S W2 should be in the a/b position for normal low speed frequency.

60977S W2 should be in the b/c position for alternate low speed frequency.

60977S W3 should be in the b/c position for low frequency low speed boost.

When using the standard 32229 PROM, the 181.8 Hz boost frequency can be used for low speed operation and will result in maximum power for rotor acceleration and cut boost times by approximately a factor of three (3) compared to 62.5 Hz boost frequency. In this mode caution must be used in setting boost times for 181.8 Hz boost frequency so that a low speed x-ray tube does not exceed its rated speed. Refer to the x-ray tube manufacturer's specifications and set the boost time for 181.8 Hz boost frequency to approximately one-third of the recommended 60 Hz boost time for the x-ray tube. In 181.8 Hz or 222.2 Hz boost frequency operation, the low speed boost time is one third of the high speed boost time. See section 4.5 for setting the boost times.

To change from 62.5 Hz to 181.8 Hz boost frequency for low speed operation the following changes must be made:

- Select 60974E W1 b/c and remove capacitor 60974E C8.
- Select 60977S W3 a/b.
- Select 60979U W2 b/c
- Adjust low speed boost voltage, 60980M R4, to about 600VAC.

In some applications faster boost times can be accomplished by using the 222.2 Hz boost frequency instead of 181.8 Hz boost frequency. To change from 181.8Hz to 222.2 Hz boost frequency select 60978AI W2 1-2 (a/b). Note that the 222.2 Hz boost frequency can also be used for low speed operation with the caution that the boost time in such a mode should be set to approximately one-fourth of the recommended 60 Hz boost time for the x-ray tube.

Since low and high speed boost times are not independently adjustable (low speed boost time equals one-third of high speed boost time), the low speed boost voltage can be adjusted on the remote control panel to provide the proper

speed at the end of boost. To do this, set the high speed boost time as required. Then in the low speed mode adjust low speed boost locking potentiometer to provide the correct speed at the end of boost. For this adjustment a tachometer is required to measure tube speed.

CONTINUANCE TIMER OPERATION - In the normal mode of operation the continuance timer is used for high and low speed continuance; however, selection of 60978AI W3 2-3 (b/c) will select continuance on high speed only. Continuance may be initiated by normal rotor or high speed by selecting jumpers 60978AI W14 1-2 (a/b) or W15 1-2 (a/b) respectively.

4.5 Boost/Brake Timer Adjustments

Refer to Figure 2.1 for boost and brake timer switch locations. The timer switch selections are additive.

Boost Time Setting:

To set the boost time turn on the switches that cumulatively add up to the high speed boost time desired. If the required boost time is unknown, start at a low setting, then progressively increase the boost time until high speed is reached within the boost time. Typically, 1 million heat unit tubes require less than 6.3 seconds to reach 9600 rpm. Tubes with 4" anodes will generally require boost times in the range of 0.8 to 1.5 seconds. Repeat this process to set the high speed brake time switches for the same tube.

Set continuance and auxiliary timer switch settings, as needed, referring to the timer switch selection drawing. Note that the continuance timer is normally programmed for low and high speed continuance.

Brake Time Setting:

Boost the x-ray tube anode to high speed run by first setting the remote control panel “HIGH SPEED/LOW SPEED” switch to “HIGH SPEED” and then set the “BOOST-RUN/BRAKE” switch to “Boost-Run”. Remove the rotor start command by switching to “BRAKE”. The brake time should be long enough to bring anode speed to less than 500 rpm. Excessive brake time should be avoided. Adjust the brake time if necessary.

4.6 Output Voltage Adjustments

There is a set of six locking potentiometers located on the HD341-70 remote control panel (refer to Figure 2.1). These potentiometers are used to set the stator output voltages for both low speed and high speed boost, run and brake. The ranges of these potentiometers are listed in section 2.5. These setting should be made according to the x-ray tube manufacturer's specifications. Stator voltages may be monitored at the test point jacks marked "MAIN", "PHASE" and "COMMON" on the front of the remote control panel.

4.7 Functional Test

Oscilloscope setting:

Horizontal 0.2 seconds/cm.
Vertical 10V/cm (using 100X probe).
Monitor: Between stator leads H7 (main) and H9 (common) for the tube selected.

Boost the x-ray tube anode to high speed. The envelope of the high speed main to common stator voltage will appear as in Figure 4.1. Use a reed tachometer or the tube manufacturer's recommended speed measurement equipment to make sure the tube is up to speed. The tube must reach the manufacturer's recommended speed before making exposures; however, excessive boost time should be avoided as it puts unnecessary heat into the x-ray tube stator and reduces the duty cycle capability of the system. The boost time may be adjusted, as required, by setting the boost timer switches on the remote control panel. See Section 4.5 for Boost/Brake Timer Adjustments.

Fig. 4.1

Envelope of high speed main to common stator voltage as seen on oscilloscope.

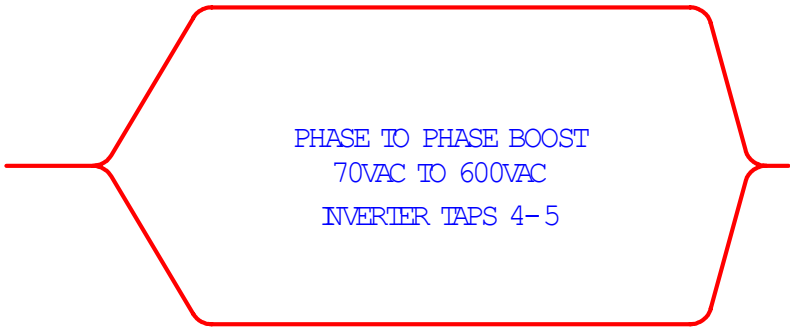
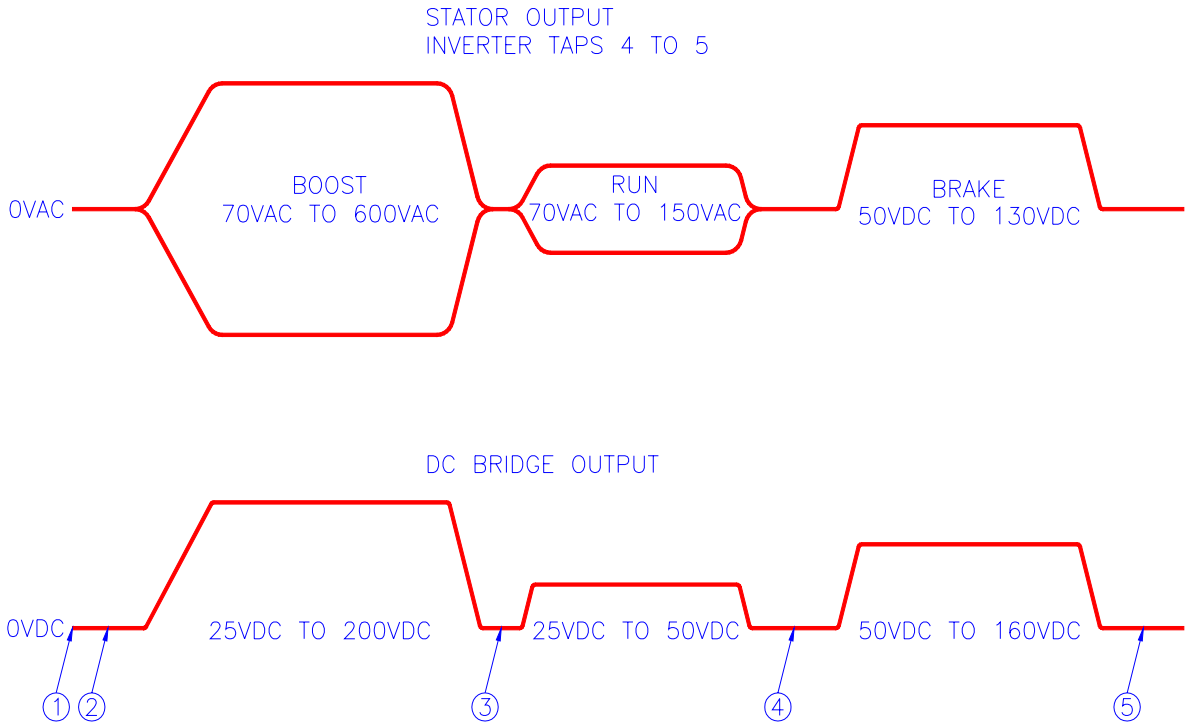


Fig. 4.2

High Speed Sequence of Events



Inhibit Timing (Numbers in parentheses refer to numbers in circles in Figure 4.2).

(1) Rotor Start signal (prep).

(2) 47ms inhibit, 60978AI C33 and R68.

(3) End of boost, 100ms, 60978AI C32 and R57.

(4) End of run or continuance, total delay time = 220ms, 60974E C4 and R6. Simultaneously, there is a 130ms delay, 60978AI C3, R29 and R67.

At the end of the 130ms delay the brake relay is pulled in by turning on 60978AI Q2. After 220ms of inhibit, brake power is applied to the stator for the time selected on the 60972 timer board.

(5) At the end of brake the brake relay is held on for an additional 330ms, 60978AI C3 and R29, to discharge the power supply before switching the brake relay.

4.8 Rotor Interlock Adjustment

The rotor interlock is adjusted for general purpose tubes. For maximum protection these adjustments may be changed at installation for optimum performance. Make sure boost and run voltages have been set to their desired levels prior to making interlock adjustments.

TP1 and TP2 on the 60979U board are test points to monitor the main winding and phase shift winding current.

Note: Adjustments should be made after the x-ray tube housing has been warmed up.

1. Monitor 60979U TP1 with an oscilloscope or DVM. Boost and run the x-ray tube rotor at high speed. Adjust 60979U R3 for a minimum voltage of 2VDC at 60979U TP1 during high speed run. Check for approximately the same voltage during low speed run.

2. Monitor 60979U TP2 with an oscilloscope or DVM. Boost and run the x-ray tube rotor at high speed. Adjust 60979U R4 to a minimum voltage of 2VDC at 60979U TP2 during high speed run. Check for approximately the same voltage during low speed run.

4.9 Programmable Jumper Selections

The following is a list of all programmable jumpers in the Rotor-AID Rotor Controller. These jumpers are set at the factory to customer specifications. Under normal conditions these jumpers need not be adjusted in the field.

Jumper	Position	Function	Reference
60971C	12V	12VDC input signals.	Section 3.4 a) INPUTS TO THE ROTOR CONTROLLER and Section 4.2.
"	24V	24VDC input signals.	"
"	120V	120VAC input signals.	"
60974E W1	a/b	60Hz low speed boost.	Section 4.4 DRIVE FREQUENCIES and Section 5.4 INVERTER MODULES.
"	b/c	180Hz low speed boost.	"
61110A W1	a/b (1-2)	Start count at 0.	Section 5.4 CONVERTER MODULE
"	b/c (2-3)	Start count at 10.	"
61110A W2	a/b (1-2)	Start count at 0.	"
"	b/c (2-3)	Start count at 20.	"
61110A W3	a/b (1-2)	Low fault reference voltage.	Section 5.4 FAULT DETECTOR CIRCUIT

Jumper	Position	Function	Reference
“	b/c (2-3)	High fault reference voltage.	“
60977S W1	a/b	IC “R” = 2732 SECTION 1.	Section 4.4 DRIVE FREQUENCIES
“	b/c	IC "R" = 2716 and 2732 SECTION 2.	“
60977S W2	a/b	Normal low speed run frequency.	“
	b/c	Alternate low speed run frequency.	“
		(See Section 4.4 DRIVE FREQUENCIES).	“
60977S W3	a/b	Alternate low speed boost frequency.	“
	b/c	Normal low speed boost frequency.	“
60978AI W1	1-2 (a/b)	AUX Timer drives AUX OUT at 60978AI J2-19.	Section 3.4 b) HEAT EXCHANGER and Section 4.4 AUXILIARY TIMER
“	2-3 (b/c)	AUX Timer used as alternate CONTINUANCE	
60978AI W2	1-2 (a/b)	VRS frequency selected.	Section 4.4 DRIVE FREQUENCIES
“	2-3 (b/c)	VRS frequency not selected.	“
60978AI W3	1-2 (a/b)	CONTINUANCE in high and low speed.	Section 4.4 CONTINUANCE TIMER OPERATION
“	2-3 (b/c)	CONTINUANCE in high speed only.	“
60978AI W4	1-2 (a/b)	Not applicable.	NONE
“	2-3 (b/c)	Storage position.	“
60978AI W5	1-2 (a/b)	Not applicable.	“
“	2-3 (b/c)	Not applicable.	“
60978AI W6	1-2 (a/b)	Not applicable.	“
“	2-3 (b/c)	Not applicable.	“
60978AI W7	1-2 (a/b)	Not applicable.	“
“	2-3 (b/c)	Storage Position.	“
60978AI W8	1-2 (a/b)	Storage position.	“
“	2-3 (b/c)	Not applicable.	“
60978AI W9	1-2 (a/b)	Not applicable.	“
“	2-3 (b/c)	Not applicable.	“
60978AI W10	1-2 (a/b)	AUX INPUT triggers AUX Timer.	Section 3.4 a) AUXILIARY INPUT and Section 4.4 AUXILIARY TIMER
“	2-3 (b/c)	Not applicable.	NONE
60978AI W11	1-2 (a/b)	Not applicable.	“
“	2-3 (b/c)	Storage position.	“

Jumper	Position	Function	Reference
60978AI W12	1-2 (a/b)	Storage position.	“
“	2-3 (b/c)	Not applicable.	“
60978AI W13	1-2 (a/b)	Storage position.	NONE
	2-3 (b/c)	Not applicable.	“
60978AI W14	1-2 (a/b)	ROTOR START triggers CONTINUANCE.	Section 4.4 CONTINUANCE TIMER OPERATION
“	2-3 (b/c)	AUX Timer used as alternate CONTINUANCE. Timer (used in conjunction with W1 2-3).	Section 4.4 AUXILIARY TIMER
60978AI W15	1-2 (a/b)	HIGH SPEED command triggers CONTINUANCE Timer	Section 4.4 CONTINUANCE TIMER OPERATION
“	2-3 (b/c)	Storage position.	NONE
60978AI W16	---	Not applicable.	“
60978AI W17	---	Not applicable.	“
60978AI W19	1-2 (a/b)	Storage position.	“
“	2-3 (b/c)	CONTINUANCE triggers high speed.	Section 4.4 HIGH SPEED SELECT OPTIONS
60978AI W20	1-2	Not applicable.	NONE
“	2-3	Storage position. Normal operation of CONTINUANCE and AUXILIARY timers.	“
60978AI W21	1-2	Not applicable.	“
“	2-3	Storage position. Normal operation of CONTINUANCE and AUXILIARY timers for Tube 2.	“
60978AI W22	1-2	Not applicable.	“
“	2-3	Storage position. Normal operation of CONTINUANCE and AUXILIARY timers for Tube 3.	“
60979U W1	a/b	N.O. contacts used for TUBE ACTIVE INTERLOCK.	Section 3.4 b) TUBE ACTIVE
“	b/c	N.C. contacts used for TUBE ACTIVE INTERLOCK.	“
60979U W2	a/b	Normal or alternate frequency used for low speed boost.	Section 4.4 DRIVE FREQUENCIES
“	b/c	High speed frequency used for low speed boost.	“
60979U W3	a/b	RY2 is used for HIGH SPEED VERIFICATION.	Section 3.4 b) HIGH SPEED VERIFIED
“	b/c	RY2 is used for ROTOR INTERLOCK.	Section 3.4 b) ROTOR INTERLOCK

Jumper	Position	Function	Reference
60980M W1	a/b	Not applicable.	NONE
“	b/c	1-Tube units (HD341).	“

5.0 PRINCIPLES OF OPERATION

5.1 Functional Description

The Rotor-AID Series HD300 Heavy Duty Controllers use two high efficiency inverters to supply the necessary power to accelerate an x-ray tube's anode rotor rapidly to its operational speed.

High speed boost may be programmed for either of two frequencies by jumper selection on the 60978AI Mother board. The 60977S Interlock board with PROM programmed drive frequencies allows for alternative selections of boost and run frequencies. In addition, taps on the inverter output transformers are provided for stator matching.

5.2 Basic Timing/Logic Cycle:

As diagrammed in Figures 5.1, 5.2 and 5.3, an externally derived Rotor Start signal initiates a boost time period during which maximum power is delivered to the tube stator/rotor. The setting of the boost time period is determined by the physical characteristics of the tube as a motor. At the conclusion of the boost time, the anode rotor continues to run with minimum power applied until the external Rotor Start signal is removed. During this interim run time, exposures may be taken.

At the conclusion of run the controller may optionally:

1. Automatically brake for a period of time preset to bring the rotor to near zero rpm.

2. Continue to provide run power (continuance) for a preset period of time which maintains rotation at the correct speed thus allowing exposures to be made immediately without the need for subsequent boost periods. At the conclusion of the continuance time, the controller will automatically brake to stop rotation as described above.

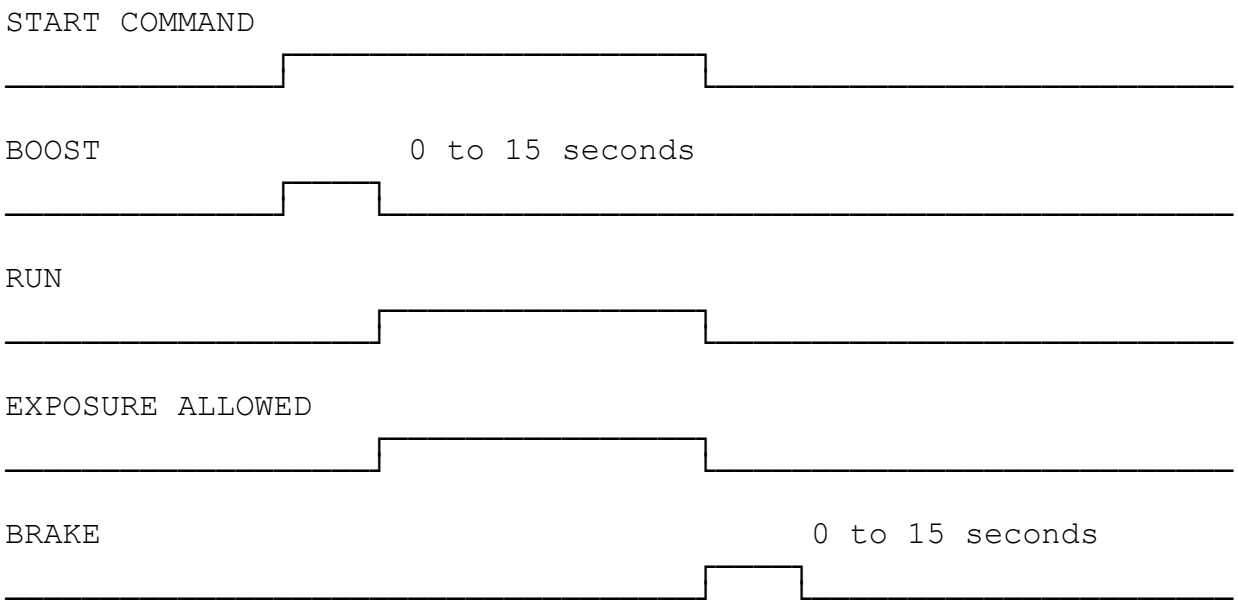
5.3 Applications

In addition to the basic timing cycle, several special application modes are provided:

RADIOGRAPHIC MODE - In the Radiographic mode, the basic boost-run (continuance)- brake cycle is used with either high or low speed selected. Figures 5.1 and 5.2 illustrate the basic timing cycle without and with, respectively, the use of continuance timing. Figure 5.3 shows the effect of a coast input signal on rotor controller output.

Figure 5.1

BASIC TIMING LOGIC WITHOUT CONTINUANCE

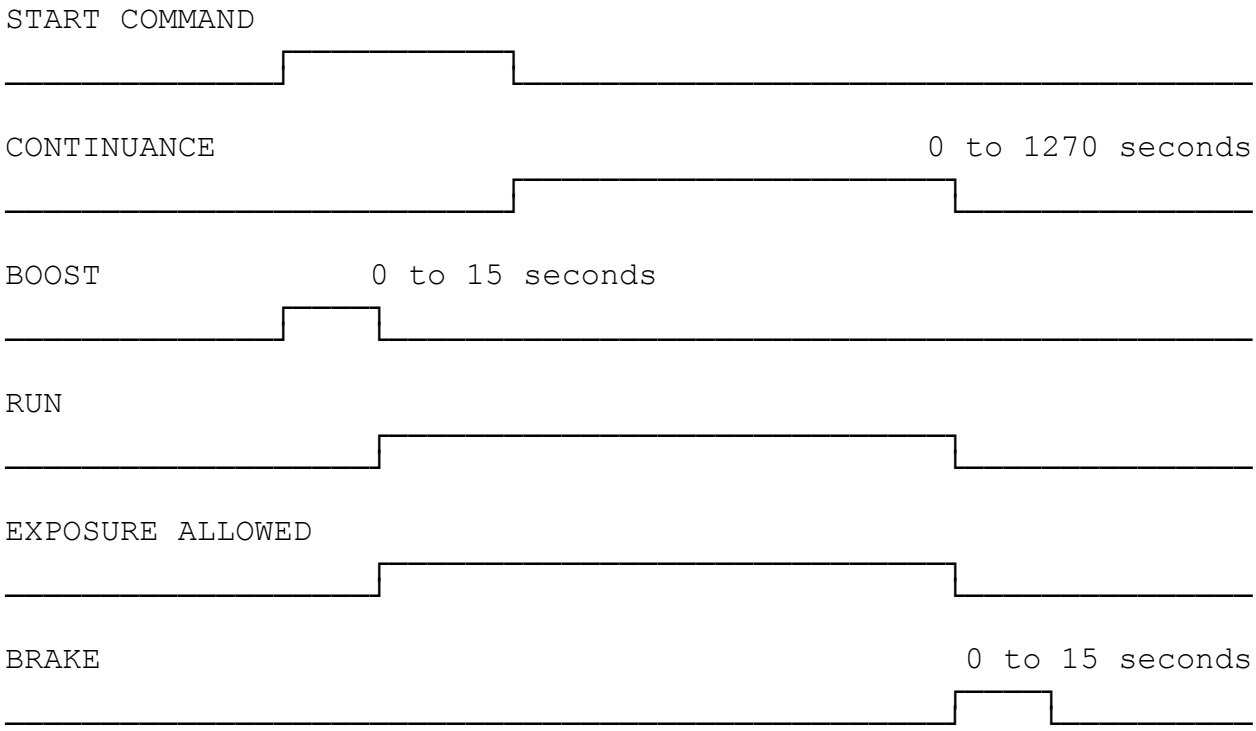


Notes: 1. Above times (in seconds) indicate programming ranges accommodated by the Rotor-AID Rotor Controller.

2. Start and run times depend upon exposure duration and the operator's "rotor prep" control.

Figure 5.2

BASIC TIMING LOGIC WITH CONTINUANCE



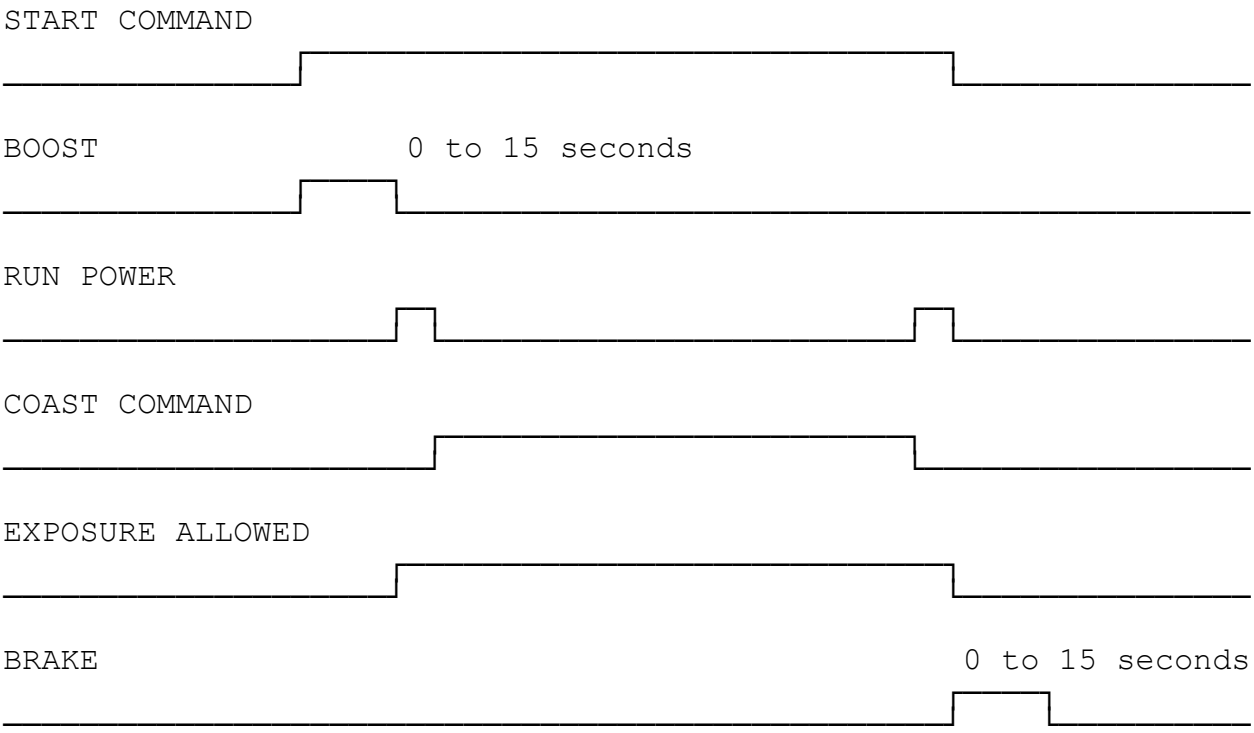
Notes: 1. Above times (in seconds) indicate programming ranges accommodated by the Rotor-AID Rotor Controller.

2. Start and run times depend upon exposure duration and the operator's "rotor prep" control.

COAST MODE - To assure proper interlock operation the coast command should be applied only after boost is completed and rotor interlock closure has occurred. Rotor interlock and high speed verify drop out during the coast period. If the Rotor-AID rotor interlock normally open or normally closed contacts are used by the generator to inhibit exposures, then these inhibits must be over-ridden during Coast to allow exposures. Coast time is limited internally by the rotor controller to a maximum of about 15 seconds.

Figure 5.3

BASIC TIMING LOGIC WITH COAST



Notes: 1. Above times (in seconds) indicate programming ranges accommodated by the Rotor-AID Rotor Controller.

2. Start and run times depend upon exposure duration and the operator's "rotor prep" control.

5.4 Circuit Logic

Boost/Brake/Continuance Timing:

All of the dual timer boards in the HD300 are physically identical. The only difference occurs when they are used in a particular slot in the 60978AI board. The inputs for the boost/brake timers consist of a 0.001 second clock and a pair of start inputs, one for the boost timer and one for the brake timer. The outputs consist of a boost duration signal and a brake duration signal.

Upon power-on-reset the outputs of all timers are low. When either timer receives a low start pulse it will begin timing by resetting its 4040 counter and 14518B divider. The timer's output will remain high until all switch selected outputs of the 4040 go high causing the output of the 8 input NAND gate to go low. This stops the timing cycle by cutting off clock pulses to the 4040 and resetting the timer's output latch.

Shortening of the boost time for a transition from low speed to high speed and shortening of the brake time for a low speed brake are accomplished, on the 60974E Clock board, by modifying the clock signal to the timer board.

The continuance/auxiliary timer works in the same manner except that the clock rate into that board is 0.1 second and the start signals are developed from different conditions.

Converter Module:

An SCR controlled full-wave bridge and filter are used to provide a variable voltage supply for the output inverters. By turning each SCR on sooner during its half cycle of conduction the DC supply capacitors are allowed to charge up more closely to the peak of the input voltage wave-form. The SCR firing points are controlled in the following manner:

> The DC voltages set on the remote control panel, by adjusting the six potentiometers, serve as references to regulate the DC supply to the inverters during boost, run and brake. During any mode of operation the DC reference voltage for the current operation appears at IC-L, pin 2. This voltage is compared with the scaled down voltage sensed at the DC supply filter capacitors which also appears at IC-L, pin 3. If the DC supply voltage is too low, the error direction line will be high indicating that SCR firing needs to occur closer to the zero crossing.

Other signals supplied by the 60980M board include:

- A short, active low, sync pulse that appears at 60980M TP3 for each zero crossing of input line voltage. This signal is used to reset and load the counters 61110A U5 and 61110A U11 Phase Shift and Fault Detect board once every half cycle.

- A square wave generated using a sign detector to direct which SCR is firing for a given half cycle.

- A 10kHz or 12kHz clock that is used to break up each half cycle into 100 possible firing points regardless of line frequency. This signal appears at 60980M TP1 and is 10kHz for a 50Hz line and 12kHz for a 60Hz line.

The 61110A board utilizes signals generated by the 60980M board to adjust the firing point of SCRs in the DC supply bridge. Counters 61110A U4 and 61110A U1 are starting point memories which may be set to numbers from 16 to 99. Initially at the start of any boost, run or brake, the counters are reset to 16. A Count of 16 is the minimum firing point and will produce an output voltage of approximately 50Vrms at taps 4 and 5 of the inverter transformers. A count of 99 produces the maximum voltage on the DC supply, approximately 200VDC (approximately 600Vrms at taps 4 and 5 of the inverter transformers). The count contained in U4 and U1 is adjusted up or down every half cycle depending upon the logic state of the error direction line.

The count contained in U4 and U1 is loaded into U11 and U5 once every half cycle near the zero crossing. U11 and U5 are then allowed to count up to 100 utilizing the 10kHz or 12kHz clock. When the counters overflow a latch consisting of 2 gates is set and one of the 2 SCRs in the DC bridge is fired. Counters U11 and U5 will overflow (reach 100) almost instantly if loaded with a count of 99. This would cause the SCR to be turned on for almost a complete half cycle assuring maximum charging of the DC supply capacitors.

In order to have DC supply voltage the following conditions must be satisfied:

- The POR (power-on-reset) line must be high (9-12VDC).
- The fault line must be high. A low fault line would indicate a condition of excessive current draw by the inverters.
- The coast line must be low. Coast causes an interruption of DC supply voltage.
- The inhibit line must be high. Inhibit will be low prior to boost and after brake. It will pulse low during transitions from boost to high speed run (100ms), from boost to low speed run (100ms), and from run to brake (220ms).
- Counters U4 and U1 must have a decimal output significantly greater than 0. Note that counter U1 is the most significant digit.
- The output of counter U5 must be pulsing at a point other than a zero crossing of the line voltage.

Inverter Modules:

Refer to the overall HD300 Series wiring diagram and the schematics for the 60977S Interlock board and the 61067C Inverter boards in Section 7.0. The 60977S Interlock board supplies SCR gate pulses of approximately 200μs via pulse transformers on the 61067C Inverter Drive boards to the main and phase inverters at the proper frequency for the particular operation being executed.

The high frequency boost may be used to boost to low or high speed. Only one third the time is required to boost a tube to low speed using the high frequency boost. It is only necessary to set the proper minimum high speed boost time and the one third time interval will occur automatically when low speed is selected.

There may be some instances where it is possible and desirable to shorten boost time by using the Very Rapid Start (VRS) mode. If so, this mode can be operated the same as the high frequency mode described above for both high speed and low speed operation.

It is also possible to boost to low speed operation with low frequency outputs from the inverters. This should be done if there is any concern about high frequency over-boosting a tube into a resonance frequency range by not having the correct minimum boost time set for high frequency, and consequently having an incorrect one third period for low speed. When low frequency boost is used, the low speed boost time should be selected to be the same period as for high speed boost, thus requiring more boost time than when using high frequency boost for low speed operation. This selection is made by setting jumper 60974E W1 in the a/b position.

High speed run is always at high frequency and low speed run is always low frequency. The outputs of the main and phase inverters always operate at the same frequencies. They have a fixed phase relationship of 90 degrees to provide proper drive to the 2 phase induction motor in the x-ray tube (no phase shift capacitors are utilized.)

The 60977S board utilizes a pre-programmed PROM to provide the proper drive signals for the inverter SCRs. When ordering a 60977S board you must specify which PROM you require. The PROMs that are available at this time are listed in Section 4.4 Table 4.1.

The SCR inverters are class C inverters. One SCR is gated off by the other turning on. Should an SCR fail to commutate off for any reason the fault detector will shut off the DC supply.

Fault Detector Circuit:

Refer to drawings 61110A, 60979U and the HD300 series overall drawings. The fault detector is designed to monitor the current in the AC to DC bridge. A current transformer with a 1/2 turn primary is connected between the input transformer and the DC bridge. The secondary of the current sense transformer is connected to a 10 ohm resistor, 61110A R19. The voltage developed across the resistor is connected through a filter to the inverting input of the fault comparator 61110A U12. During normal operation the voltage generated by the current sense transformer does not exceed the reference voltage of the comparator. If a fault should occur during either boost or run, the voltage increases and exceeds the reference voltage and causes the fault line to go low, which gates off the SCR firing pulses.

The fault comparator reference level may be set using jumper 61110A W3. Setting the jumper 61110A W3 1-2 selects a lower fault reference (approximately 4.3VDC) which is typically used on older units equipped with the 43188 solid core input transformer. Units which use the 74016 (IMAG) toroidal input transformer, setting the jumper 61110A 2-3 selects a higher fault reference (approximately 5.0VDC). For units using a 74016 (Amveco) toroidal input transformer, setting the jumper 61110A 1-2 selects the lower fault reference.

Soft Fault Circuit:

The 61110A phase shift and fault detect board is equipped with the soft fault circuit. This circuit allows the rotor controller to continue operation in spite of temporary external disturbances such as tube arcs and line voltage transients which may cause an inverter fault. To help distinguish between higher boost currents and lower run currents, the fault comparator reference level may be set to an even lower level (approximately 2.0VDC) during run by setting jumper 61110A W4 in the 1-2 position.

The 60977S and 61071N assemblies increase the rotor interlock delays allowing the soft fault circuit to integrate the fault sense and distinguish between a soft (temporary) fault and a hard (recurring) fault.

Rotor Interlock Circuit:

The current to the x-ray tube stator is monitored by the rotor interlock circuits on the 60977S Interlock Board and the Stator Output board 61071N. Before an exposure can be made, sufficient boost and run current must flow in the main, phase, and common leads to the x-ray tube stator.

The Rotor Interlock circuit is factory adjusted for general purpose tubes. For maximum protection, these adjustments may be changed on location for optimum performance of the circuit. Refer to Section 4.8 for detailed adjustments to this circuit.

6.0 TROUBLE SHOOTING GUIDE

The following is a list of possible problems and their likely corrections. The list is not all-inclusive, but covers field serviceable problems. Additional questions should be referred to the factory or service center.

Refer to Section 7.0 for schematics and component location diagrams. Refer to Section 3.0 Figure 3.2 for overall component locations.

6.1 Preliminary Checks

Check all external connections to the rotor controller for proper wiring and secure connections.

Check to see that all selectable jumpers are in place and programmed correctly (See Section 4.9).

Check input power voltage and make sure that the input power is wired to the correct voltage input tap.

Check to see that the Power On indicator on the input transformer, TR1, assembly is lighted. If it is not lighted, check input power lines to the rotor controller and correct any problems.

Check to see that the circuit breaker is on and that no fuses are open.

Check the boost, continuance and brake time settings.

If the optional input line filter is used, check the voltage at the output of the input line filter. If the proper input line voltage is being applied to the input line filter, but the wrong output voltage is being observed, replace the input line filter (49063).

Note: Whenever replacing parts, boards or assemblies make note of their EXACT wiring before removing them. DO NOT install or remove PC boards when the power is on.

SECTION 6.0 TROUBLE SHOOTING GUIDE

6.2 Trouble-shooting procedures

SYMPTOM: NO BOOST If the unit faults, see trouble shooting section on faults.

Check the stator leads to make sure they are not shorted and are properly connected. Correct any problems.

Check the K'H relay (41006) for good connections and proper mechanical operation. Replace if necessary.

Does 60979U LED1 light during a Rotor Start signal?

If yes, then:

- Check to see if the Circuit Breaker is on.
- Check to see that the remote control panel boost time is set properly.
- Replace 60972E board.
- Replace 61110A board.
- Replace 60980M board. Check the six boost, run and brake voltages and adjust the appropriate potentiometers if necessary.
- Replace 60974E board. Position the program jumpers per Section 4.9.

If no, then:

- Check the interface wiring.
- Check for the presence of the Rotor Start signal.
- Replace 60971C board. Position the program jumpers per Section 4.9.
- Check thermal switch. If switch is bad, replace input power transformer 74016.
- Check wiring to the Stator Output board. Replace board if necessary.
- Check the 60979U board for the -12VDC, +12VDC and +25VDC supply voltages.

  If all voltages are missing, check the in-line 3A SB fuse, F1, at the input transformer, 74016.

  If any voltage is missing, check fuses F1 and F2 on the 60979U board. Replace any open fuses. If replaced fuses open when power is applied, then remove all plug- in PC boards from the 60978AI and 60979U boards. Replace open fuses and reinstall plug-in PC boards one at a time until the fuses open again. Replace any plug-in PC boards that cause the fuses to open. NOTE: Do not install or remove any PC boards with the power on.

  If any voltage is still missing or incorrect in value, replace 60979U and then adjust 60979U R3 and R4 as described in Section 4.8.

SYMPTOM: NO RUN

Check to see that the 60972D continuance time is set correctly.

Replace the 60972D Continuance/Aux. Timer board.

Replace 60980M board. Check the six boost, run and brake voltages and adjust the appropriate potentiometers if necessary.

Check K'H relay (41006) for good connections and proper mechanical operation (in 240VAC position only for high speed boost). Replace if necessary.

If the unit faults, see trouble shooting section on faults.

SYMPTOM: NO BRAKE

Check to see that the remote control panel brake time is set correctly.

Replace the 60972E board if necessary.

Replace 60980M board. Check the six boost, run and brake voltages and adjust the appropriate potentiometers if necessary.

Replace 60978AI board. Position the program jumpers per Section 4.9.

Replace 60974E board. Position the program jumpers per Section 4.9.

Check K'B2 relay (41006) for good connections and proper mechanical operation. Replace K'B2 if necessary.

SECTION 6.0 TROUBLE SHOOTING GUIDE

SYMPTOM: FAULT OCCURS DURING BOOST OR RUN

NOTE: During a fault 60978AI LED1 will be lit.

Check the line voltage to make sure that the proper input tap is being used.

Check the stator resistance and stator wiring.

Using an oscilloscope, check all inverter gate pulses (60977S board, pins 23, 22, 21 and 20). If necessary, replace 60977S board. Position the program jumpers per Section 4.9.

Check wiring to the 61067C J5 connector in both the Main and Phase Inverter Sections. Note that the wiring differs for the two inverters. If either board has been previously replaced in the field it is possible that the connectors were not rewired in the proper order. Correct misconnections.

Disconnect the wire from TR2 terminal 2 (Main Inverter Section). Operate the rotor controller.

IF NO FAULT OCCURS then replace the 61067C Inverter Drive and SCR board in the Main Inverter Section and reconnect the wire to TR2 terminal 2.
IF A FAULT STILL OCCURS then reconnect the wire to TR2 terminal 2 and disconnect the wire from TR3 terminal 2 (Phase Inverter Section). Operate the rotor controller. If no fault occurs then replace the 61067C Inverter Drive and SCR board in the Phase Inverter Section. Reconnect the wire to TR3 terminal 2.

Replace the 60960A board.

Check the K'H relay (41006) for good connections and proper mechanical operation (in 240VAC position only for high speed boost). Replace if necessary.

Check the SCRs/Diode (DC bridge) for good connections and proper electrical operation. If necessary, replace blocks with part number 31086.

Check the 8MFD capacitors (24042). Replace any that are shorted or open.

Replace 61110A board. Position the program jumpers per Section 4.9.

Replace 60977S board. Position the program jumpers per Section 4.9.

Replace 60980M board. Check the six boost, run and brake voltages and adjust the potentiometers if necessary.

SECTION 6.0 TROUBLE SHOOTING GUIDE

SYMPTOM: MISSING ROTOR INTERLOCK

Check the status of the Rotor Interlock indicators, 60979U LED3 and 61071N LED 1 during rotor controller operation. If the Rotor Interlock indicators light during run, then check the interface wiring to TB4. Correct any problems.

If the Rotor Interlock indicators fail to light during run, then check the Rotor Interlock relays, 60979U RY3 and 61071N RY1, and correct any problems.

Check stator connections to the Stator Output board as listed in Section 3.5. Correct any problems.

Replace 60977S board. Position the program jumpers per Section 4.9.

Adjust 60979U R3 and R4 as described in Section 4.8.

Replace 60979U board Position the program jumpers per Section 4.9. If necessary, adjust 60979U R3 and R4 as described in Section 4.8.

Check the boost and run voltages. If necessary, adjust the boost and run potentiometers on the 60980M board.

Replace the 61071N Stator Output board.

SYMPTOM: BOOST AND OR RUN VOLTAGES EXCESSIVELY HIGH

Check the boost, run and brake voltages and adjust the appropriate potentiometers on the 60980M.

Replace 60980M board. Check the six boost, run and brake voltages and adjust the appropriate potentiometers if necessary.

Replace 60979U board and adjust 60979U R3 and R4 as described in Section 4.8.

Replace 61110A board.

Check for good connections to the DC supply at TB4 pin 11 (ground) and TB4 pin 12 (+DC supply), and at the buss bars on the three 3000MFD capacitors (C1, C2, and C3).

SECTION 6.0 TROUBLE SHOOTING GUIDE

SYMPTOM: INCORRECT BOOST, RUN OR BRAKE VOLTAGE(S)

Adjust the appropriate remote control panel potentiometer.

Replace the 60980M board. Check the six boost, run and brake voltages and adjust the appropriate potentiometers if necessary.

Check the K'H relay (41006) for good connections and proper mechanical operation (in 240VAC position only for high speed boost). Replace if necessary.

SYMPTOM: HIGH SPEED BOOST TOO LOW, CANNOT ADJUST

Check K'H relay (41006) for good connections and proper mechanical operation (in 240VAC position only for high speed boost). Replace if necessary.

Adjust the appropriate remote control panel potentiometer.

Replace 60980M board. Check the six boost, run and brake voltages and adjust the appropriate potentiometers if necessary.

Check wiring on inverter output transformer taps 4, 5 and 6.

SYMPTOM: CIRCUIT BREAKER TRIPS DURING BOOST

Replace the circuit breaker (45072).

Replace the 60960A board.

Replace the 61067C boards, one at a time, for both the main and phase inverter sections. Note that the 61067C J5 connector is wired differently in these two sections.

Check SCRs/Diode in the DC bridge for good connections and proper electrical operation. If necessary, replace.

SECTION 6.0 TROUBLE SHOOTING GUIDE

SYMPTOM: 60971C BOARD DOES NOT RESPOND DURING AN INPUT COMMAND

This means that either the wrong input voltage was applied to the board or that the voltage selector shunts (jumpers) were in the wrong positions for the voltages being applied. Replace the 60971C board and program the voltage selector shunts (jumpers) for the input voltages that are being applied.

NOTE: When using input signals from a source other than the HD341-70 remote control panel, be certain to disconnect the remote control panel wire connections at the terminal block, 60971C TB1.

SYMPTOM: FAN DOES NOT WORK

Check to make sure that the fan blade turns freely. Clear any mechanical obstruction.

Check the connections (plug) at the non-working fan.

Check the voltage at the fan. Make sure that the proper voltage is being applied to the fan(s).

Check the fan fuse, F2 (3A SB), at the input transformer (74016).

If the proper voltage is at the fan and the fan still does not work, replace the fan (49009).

7.0 DOCUMENTATION

7.1 Applicable Patents - US Patent #3,641,408.

7.2 Schematics

WHD341	HD341 Overall Schematic
WTS6B	Supplemental Terminal Strip Option
W74066	Control Console
S60960A	Driver, SCR gate
S60971C	Input board
S60972D	Dual timer board
S60972E	Dual timer board - Remote
S60974E	Clock board - Remote
S60977S	Interlock board, PROM programmed
S60978AI	Mother board
S60979U	Power supply board
S60980M	Phase shift 2 board - Remote
S61067C	Inverter drive and SCR board
S61071N	1-Tube stator output board
S61110A	Phase shift and fault detect board with soft fault

7.3 Component location diagrams

60960A	Driver, SCR gate board
60971C	Input board
60972D	Dual timer board
60977S	Interlock board, PROM programmed
60978AI	Mother board
60979U	Power supply
61067C	Inverter drive and SCR board
61071N	1-Tube stator output board
61110A	Phase shift fault detect board with soft fault

7.4 Spare parts lists

The following spare parts list is recommended for all field service personnel. The quantities listed are suggested on-hand stock levels for each field service person.

Printed Circuit Boards

P/N	DESCRIPTION	QTY	
60960A	Driver, SCR Gate		1
60971C	Input		1
60972D	Timer		1
60972E	Timer - Remote		1
60974E	Clock - Remote		1
60977S	Interlock		1
60978AI	Mother		1
60979U	Power Supply		1
60980M	Phase Shift 2 - Remote		1
61067C	Inverter Drive and SCR		1
61071N	1-tube Stator Output		1
61110A	Phase Shift/Fault Detect with soft fault	1	
70544	Extender board kit		1

Fuses

45045	3A SB 3AG fuse	1	
45062	0.08A SB 5x20 mm fuse	1	
45077	0.05A SB 5x20 mm fuse	1	

Miscellaneous Repair Parts

24042	8uf 660VAC		2
31018	Diode S3280		2
31086	STD-057/08 SCR/Diode power module	1	
41006	K'H, Brake (K'B1, K'B2)		2
49009	Fan	1	
54392	Air filter	1	

SECTION 7.0 DOCUMENTATION

The following is a list of additional parts recommended for companies whose service people trouble-shoot down to the defective component.

Transistors

P/N	DESCRIPTION	QTY
30004	TIP111 NPN DARLINGTON TO-220AB	2
30006	2N5308 NPN DARLINGTON TO-92	1
30007	2N4125 PNP GENERAL PURPOSE T0-92	1
30008	2N4123 NPN GENERAL PURPOSE T0-92	1
30027	2N6718 NPN MEDIUM POWER TO-237	1

IC's

32001	74C00N	1
32002	74C192N	1
32042	74C10N	2
32046	74C20N	2
32048	74C02N	1
32054	4040B	2
32060	LM340T-12 (OR 7812)	2
32065	4093B	4
32072	74C14N	4
32074	74C30N	2
32105	LM311	1
32124	LM3302N	1
32132	CD4089	1
32138	LM1458N	2
32140	CD4028A	1
32144	CD4020A	1
32161	LM320T-12 (OR 7912)	2
32193	74C914N	1

Relays

41002	Optional Functions	1
41040	Function	2
41051	Signal Input	1

8.0 MAINTENANCE

8.1 Air Filter Assembly

A removable air filter is located on the bottom of the rotor controller cabinet. There are four screws holding it in place. If the two screws on the front side are removed and the two screws on the back side loosened, the air filter can be removed easily.

If necessary, the air filter can be washed out in warm soapy water; otherwise shaking it out will suffice. Re-install it and tighten the screws. Depending on the environment, check the air filter at least once a year.

8.2 Fan Assemblies

All HD300 series rotor controllers with cabinets have two fans. One of them is attached to the top, inside of the rotor controller cabinet and one is located on the input transformer assembly.

Look at each fan and determine if it is running properly. It might be necessary to use a flashlight to accomplish the inspection. Determine if both are running at the same speed by comparing one to another. Dirt or worn bearings can cause them to run at less than their normal speed.

Check the fan fuse , F2 (3A SB), at the input transformer (74016).

Proper operation of the rotor controller depends upon both fans running properly, especially for high duty cycles.
Check the fans at least once a year or at any occasion of service.

8.3 Stator Voltages

Stator voltages, boost (AC), run (AC), and brake (DC), should be checked at least once a year or on any occasion of service. This can be accomplished very easily with the use of a digital voltmeter at the test point jacks marked “MAIN”, “PHASE” AND “COMMON” on the remote control panel. When rotor controllers are shipped, the stator voltages are set to customer specifications. If these are not logged on site, call your office for the information, or call Advanced Instrument Development, Inc.