Rotor-AID™

HD300 SERIES
Heavy Duty Rotor Controller

Model HD341 (1-tube)
and
Model HD343 (3-tube)

Owner's Manual
(p/n 69216 Rev. T)

June 2008

--SERVING THE MEDICAL X-RAY FIELD SINCE 1969 –

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1.0 INTRODUCTION

Rotor-AID HD300 Series Heavy Duty Rotor Controllers provide the necessary control signals, interlocks and power outputs to drive the anode rotors of x-ray tubes to near 3600 or 10,800 rpm or to other rotational speeds using the PROM programmed frequency memory and then to dynamically Brake them. Both Boost and Brake are achieved in the shortest possible time periods which are digitally preset for each individual tube.

Solid state logic is provided (some optional) to accommodate all common procedures such as Fluoroscopic, Cine and Spot Film as well as straight Radiographic, CT and Digital.

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.

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.

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

Rotor Start Input	60971 TB1, pins 1 & 2
High Speed Select	60971 TB1, pins 3 & 4
Auxiliary In (AUXIN)	60971 TB1, pins 5 & 6
Coast	60971 TB1, pins 7 & 8
Fluoro Select*	60971 TB2, pins 1 & 2
Spot Film Select*	60971 TB2, pins 3 & 4
Cine Select*	60971 TB2, pins 5 & 6
Tube Select*	60971 TB3, pins 1-6

* Available on HD343 only.

2.3 Control Interface Output (60979 TB4)

(All contacts rated 120VAC, 2 Ampere resistive, except as noted)

Functions	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 Change Interlock	Closed during Boost, Run, Brake operation	1 set N.O.

2.4 Power Requirements

SECTION 2.0 SPECIFICATIONS

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

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 for each tube.

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

4.5 second Boost, main inverter 600VAC, phase inverter 1080VAC.

9 second Run, main inverter 115VAC, phase inverter 190VAC.

7 second Brake, 125VDC.

19.5 second rest.

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 standard 60977 Interlock board:
High Speed near 10,800 rpm (181.8Hz).
Low Speed near 3600 rpm (62.5Hz).

When the 60977 Interlock board is custom programmed for specific drive frequencies the anode rotation speed is near the programmed drive frequencies.

2.8 Timer Adjustment Ranges

SECTION 2.0 SPECIFICATIONS

Individual identical timer boards are provided for each x-ray tube to set Boost and Brake times; and one additional board is provided to set continuance (holdover time) and to set time for an auxiliary function such as Fluoro Hold. Time intervals are set by small DIP switches on the board as follows:

Control	Usable Range	Resolution
Boost, High Speed	0.8 to 12.7 seconds	0.1 second
Boost, Low Speed	0.8 to 12.7 seconds	0.1 second
Brake, High Speed	0.0 to 12.7 seconds	0.1 second
Brake, Low Speed	0.0 to 12.7 seconds	0.1 second
Continuance	0 to 21 minutes 10 seconds	10 seconds
AUXOUT	0 to 21 minutes 10 seconds	10 seconds
Spot (Cassette Delay)	0 to 1.5 seconds set by potentiometer 60978 R66	continuous

2.9 Controls and Indicators

External Controls - None

External Indicators - None

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

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 150C 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 and during tube switch-over.

- 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 change interlock is available for users who do stator switching in their generator systems. It 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 one exhaust fan in top.

Nominal Dimensions (refer to Figures 3.1 and 3.2):

inches:	32 high x 21-1/4 wide x 10-1/2 deep
mm:	813 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 +65C

Ambient Temperature, operating: +10 to +40C

Humidity: 10% to 95%, non-condensing

2.15 Three Tube Radiographic and Fluoroscopic Model

Three Tube Switching - Utilizing tube select signals from the generator, the rotor controller provides stator switching and tube changeover logic. Different Boost and Brake time adjustments are provided for each tube. Boost, Run and Brake voltages are independently adjustable for each tube.

2.16 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 with the ETL monogram.

SECTION 2.0 SPECIFICATIONS

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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 45 inches high (584mm x 965mm x 1143mm). 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 40C.

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.

SECTION 3.0 INSTALLATION AND SUPPORT REQUIREMENTS

Figure 3.1

CABINET INSTALLATION

Figure 3.2

HD341 1-TUBE OVERALL COMPONENT LAYOUT

Figure 3.3

HD343 3-TUBE OVERALL COMPONENT LAYOUT

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 Figures 3.2 and 3.3 for component locations. Use the cable clamps provided to route any interface wiring inside the rotor controller.

a) Inputs to the Rotor Controller

All input signals to the rotor controller may be either 100VAC to 125VAC, 20VDC to 30VDC or 10VDC to 15VDC. Unless otherwise requested, the rotor controller is shipped configured for 100VAC to 125VAC input signals and may be field programmed for other input voltages. Loading is approximately 10mA in all cases. Refer to schematic 60971, HD300 series (1-tube or 3-tube) overall schematics and input voltage programming detail for programming information.

ROTOR START - For all radiographic work connect to TB1 pins 1 and 2. For DC input signals pin 1 is positive and pin 2 is common. This signal will cause the rotor controller to begin the sequence of Boost and Run. Removal of the Rotor Start signal 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 - Connect to TB1 pins 3 and 4. For DC input signals pin 3 is positive and pin 4 is common. 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 60978 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 60972 Timer board plugged into the 60978 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 HEAT EXCHANGER in Section 3.4 b)].

COAST INPUT - Connect to TB1 pins 7 and 8. For DC input signals pin 7 is positive and pin 8 is common. 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.

FLUORO INPUT - 3-tube units only. Connect to TB2 pins 1 and 2. For DC input signals pin 1 is positive and pin 2 is common. The Fluoro command may be used to initiate a low speed Boost-Run sequence and, if programmed, activate a fluoro continuance timer. Fluoro work may also occur at the speed indicated by the high speed select input, if desired, by a change in programming.

SPOT INPUT - 3-tube units only. Connect to TB2 pins 3 and 4. For DC input signals pin 3 is positive and pin 4 is common. The Spot command may be used to supply a Rotor Start and high speed select signal to the rotor controller. It may also be used to trigger a high speed continuance timer. A cassette delay used to inhibit interlock for a period of 0 to 1.5 seconds is also triggered from this signal.

CINE INPUT - 3-tube units only. Connect to TB2 pins 5 and 6. For DC input signals pin 5 is positive and pin 6 is common. The Cine command may be used to supply a Rotor Start and high speed select signal to the rotor controller.

TUBE SELECTS - 3-tube units only. Tube selection is accomplished by supplying a signal to TB3 pins 1 and 2 (tube 1), TB3 pins 3 and 4 (tube 2) or TB3 pins 5 and 6 (tube 3). For DC input signals pins 1, 3 and 5 are positive and pins 2, 4 and 6 are common. If a Boost, Run, Brake sequence is in progress when a tube selection change is made the rotor controller will switch its output to the tube selected after the Boost, Run, Brake sequence has been completed. The tube select signal is also used to select the Boost/Brake timer card and the appropriate set of Boost, Run and Brake voltages for that tube.

b) Outputs from the Rotor Controller

ROTOR INTERLOCK - A set of normally open contacts for rotor interlock is available at 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 TB4 pins 7 and 8 by positioning jumper 60979 W3 (b/c) so that 60979 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 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 (Rotor Start may also be supplied by the Spot, Cine or Fluoro signal, if so configured) indicates an interlock malfunction.

HIGH SPEED VERIFIED - A set of normally open contacts is available at 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 60979 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 TB4 pins 9 and 10 indicate when the rotor controller is currently driving or braking an x-ray tube rotor. Jumper 60979 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 60978 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 - (Available on 1-tube units only). An external DC signal may be routed through the thermal switches of the input transformer, TR1, the DC supply choke, L1, and the main and phase inverter chokes, L2 and L3, 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 - (Available on 1-tube units only). 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

1-Tube Radiographic Units.
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

3-Tube Radiographic and Fluoroscopic Units.
Make stator connections as indicated in table below:

Stator Wire Color	Connection	Description
White	61068 TB6 pin 1	Tube 3, H9, Stator Common
Black	61068 TB6 pin 3	Tube 3, H7, Main Stator
Green (Red)	61068 TB6 pin 5	Tube 3, H8, Phase Stator
White	61068 TB6 pin 8	Tube 2, H9, Stator Common
Black	61068 TB6 pin 10	Tube 2, H7, Main Stator
Green (Red)	61068 TB6 pin 12	Tube 2, H8, Phase Stator
White	61068 TB7 pin 1	Tube 1, H9, Stator Common
Black	61068 TB7 pin 3	Tube 1, H7, Main Stator
Green (Red)	61068 TB7 pin 5	Tube 1, 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

Refer to 60971 schematic and component layout in Section 7.0 for control signal input voltage programming detail. The rotor controller is normally programmed for 100VAC to 125VAC input signals. If 20VDC to 30VDC or 10VDC to 15VDC signals are used, then:

1. Locate the 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 60978 schematic, component layout and Section 4.10 for jumper selection detail. Note that some options are available on 3 tube rotor controllers supplied for radiographic and fluoroscopic systems only.

AUXILIARY TIMER - Auxiliary Timer Jumpers 60978 W1, 60978 W10 and 60978 W14 are used to determine the function performed by the auxiliary timer. 60978 W10 selects the timer trigger source and 60978 W1 directs its output. When 60978 W1 is in the 2-3 (b/c) position and 60978 W14 is also in the 2-3 (b/c) position, the auxiliary timer is used as a fluoroscopic continuance timer, if continuance times other than normal radiographic continuance time are required. 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 60977 Rotor Interlock board. The various PROMs and their drive frequencies are listed in Table 4.1

Table 4.1
PRE-PROGRAMMED PROM DRIVE FREQUENCIES

PROM Part Number		Low Speed Frequency	Alternate Low Speed Frequency	High Speed Frequency	VRS Frequency
32229*	Sect. 1	62.5Hz	56.3Hz	163.3Hz	222.2Hz
	Sect. 2	62.5Hz	56.3Hz	181.8Hz	222.2Hz
32230.00	Sect. 1	50.0Hz	56.3Hz	163.3Hz	222.2Hz
	Sect. 2	62.5Hz	56.3Hz	181.8Hz	222.2Hz
32231.00	Sect. 1	62.5Hz	50.0Hz	163.3Hz	222.2Hz
	Sect. 2	62.5Hz	50.0Hz	153.8Hz	222.2Hz
32236.00	Sect. 1	62.5Hz	56.3Hz	163.3Hz	222.2Hz
	Sect. 2	50.0Hz	56.3Hz	105.3Hz	222.2Hz
32238	Sect. 1	62.5Hz	56.3Hz	163.3Hz	222.2Hz
	Sect. 2	50.0Hz	56.3Hz	121.2Hz	222.2Hz
32240.00	Sect. 1	50.0Hz	56.3Hz	121.2Hz	222.2Hz
	Sect. 2	60.6Hz	62.5Hz	181.8Hz	222.2Hz

SECTION 4.0 TESTS AND ADJUSTMENTS

* The Rotor-AID is normally shipped with the 32229 PROM, programmed for 62.5 Hz inverter frequency for low speed operation and 181.8 Hz inverter frequency for high speed operation. All other PROM configurations are optional.

PROM 32229 replaces PROMs 32196A and 32221A.
PROM 32230 replaces PROMs 32196A and 32223.
PROM 32231 replaces PROMs 32199A and 32224.

Custom PROMs can be programmed for specific frequencies, e.g.: Low frequencies (Hz) 55.6, 56.3, 57.1, 58.0, 58.8, 59.7, 60.6, 61.5, 62.5, etc. High frequencies (Hz) 160.0, 166.7, 173.9, 181.8, 190.5, 200.0, 210.5, 222.2, etc.

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

60977 W1 should be in the a/b position to select SECTION 1 of PROMs 32229, 32230, 32231, 32236, 32238 and 32240.

60977 W1 should be in the b/c position to select PROMs 32195A, 32196A, 32199A, 32221A, 32223, 32224 and SECTION 2 of PROMs 32229, 32230, 32231, 32236, 32238 and 32240.

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

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

60977 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 60974 W1 b/c and remove capacitor 60974 C8.
- Select 60977 W3 a/b.
- Select 60979 W2 b/c
- Adjust low speed Boost voltage, 60980 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 60978 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, 60980 R4, can be adjusted 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 60980 R4 to provide the correct speed at the end of Boost. For this adjustment a tachometer is required to measure tube speed.

ROTOR START OPTIONS - radiographic and fluoroscopic units only. The Spot, Fluoro, and/or Cine inputs can be used to initiate a Rotor Start. Jumpers 60978 W4, W8 and W11 will affect this condition for Spot, Cine and Fluoro respectively when correctly positioned.

Systems used for Fluoro/Spot or Fluoro/Cine, where one function is Run at low speed and the other at high speed, must not be configured for high frequency low speed Boost.

HIGH SPEED SELECT OPTIONS - radiographic and fluoroscopic units only. The Spot and/or Cine inputs may be used to force a high speed condition by selecting 60978 W5 1-2 (a/b) and/or 60978 W9 2-3 (b/c) respectively. The auxiliary timer may be used to force a high speed condition (e.g. when used for continuance) by selecting 60978 W19 2-3 (b/c).

CONTINUANCE TIMER OPERATION - In the normal mode of operation the continuance timer is used for high and low speed continuance; however, selection of 60978 W3 2-3 (b/c) will select continuance on high speed only. Continuance may be initiated by normal Rotor, Fluoro, Spot or High Speed by selecting jumpers 60978 W14 1-2 (a/b), W12 2-3 (b/c), W13 2-3 (b/c) or W15 1-2 (a/b) respectively. When using Fluoro or Spot to trigger continuance, jumper 60978 W14 must be left in the 2-3 (b/c) position.

SEPARATE CONTINUANCE TIMES FOR FLUORO AND SPOT - Radiographic and fluoroscopic units only. The normal continuance timer is used for Spot as described above in CONTINUANCE TIMER OPERATION. The auxiliary timer is used for Fluoro continuance by selecting 60978 W10 2-3 (b/c) and 60978 W1 2-3 (b/c).

FLUORO FORCES LOW SPEED - Radiographic and fluoroscopic units only. The high speed select input may be deactivated during Fluoro by selecting 60978 W6 1-2 (a/b).

INHIBIT CONTINUANCE AND AUXILIARY TIMERS FOR SPECIFIC TUBES - Radiographic and fluoroscopic units only. The continuance and auxiliary timer functions may be inhibited for Tube 1, Tube 2 or Tube 3 by selecting the 1-2 position of jumpers 60978 W20, W21 or W22 respectively. The storage position (2-3) of these jumpers allows normal timer operation.

4.5 Boost/Brake Timer Adjustments

Boost Time Setting:

Refer to the timer switch selection detail on the 60972 Component Location diagram in Section 3.0. The timer switch selections are additive. To set the Boost time for tube 1, locate the tube 1 60972 timer board using the overall component location drawing in Section 7.0. Next, locate the Boost time switches using the timer switch selection detail. 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.

If you have a 3-tube rotor controller, then repeat this process for tube 2 and tube 3, if used.

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 and the auxiliary timer is normally programmed for Fluoro continuance time.

Brake Time Setting:

Boost the x-ray tube anode to high speed Run and remove the Rotor Start command. The Brake time should be long enough to bring anode speed to less than 500 rpm. Excessive Brake time should be avoided.

The Brake timer is adjusted by means of dip switches on the 60972 timer board corresponding to the tube selected. Adjust the Brake time if necessary.

4.6 Output Voltage Adjustments

There is a set of six potentiometers located on the 60980 board for each of x-ray tube connected to the Rotor-AID Rotor Controller. The tube select signal actuates the appropriate set of potentiometers for the selected tube.

Table 4.2 describes the function of the six potentiometers and lists the typical factory settings for each. Voltages may be set differently at the factory at the customer's request:

60980 Adjustment	Function	Main Stator Output Voltage
R1	Low Speed Brake	100 VDC
R2	High Speed Brake	125 VDC
R3	Low Speed Run	60 VAC
R4	Low Speed Boost	250 VAC*
R5	High Speed Run	100 VAC
R6	High Speed Boost	600 VAC

* About 600 VAC if the high frequency mode of Boosting to low speed has been selected (Section 4.4).

The AC voltages are based on factory adjustments for typical unbalanced stator windings where the output voltage from the main inverter has been taken between taps 4 and 5. In this case the output voltage from the phase inverter would be taken between taps 4 and 6 and would be approximately 64 percent higher.

Any of the above voltages, specifically those that are not in the x-ray tube manufacturer's recommended range, may be adjusted as required.

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 frequency 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 for any time between 0.8 and 12.7 seconds, as required, by setting dip switches on the 60972 timer board corresponding to the selected tube. See Section 4.5 for Boost/Brake Timer Adjustments.

Fig. 4.1

Envelope of high frequency 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, 60978 C33 and R68.

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

(4) End of Run or continuance, total delay time = 220ms, 60974 C4 and R6.

At the end of the 130ms delay the Brake relay is pulled in by turning on 60978 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, 60978 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 60979 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 60979 TP1 with an oscilloscope or DVM. Boost and Run the x-ray tube rotor at high speed. Adjust 60979 R3 for a minimum voltage of 2VDC at 60979 TP1 during high speed Run. Check for approximately the same voltage during low speed Run.

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

4.9 Cassette Delay Adjustment

A cassette delay timer is provided to prevent exposure if the programmed Boost time is less than the cassette positioning time. The cassette delay prevents interlock for up to 1.5 seconds following the receipt of a Spot Film command to allow time for the film cassette to come into position. The cassette delay may be adjusted by monitoring the output of 60978 IC-N pin 10 (U10 pin 6 on 60978 assembly revisions AB and later) with an oscilloscope during operation. The signal is low during the cassette delay.

SECTION 4.0 TESTS AND ADJUSTMENTS

4.10 Programmable Jumper Selections

The following is a list of all programmable jumpers in the HD341 and HD343 Rotor-AID Rotor Controllers. 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
60971	12V	12VDC input signals.
	24V	24VDC input signals.
	120V	120VAC input signals.
		[See Section 3.4 a) INPUTS TO THE ROTOR CONTROLLER and Section 4.2].
60974 W1	a/b	60Hz low speed boost.
	b/c	180Hz low speed boost.
		(See Section 4.4 DRIVE FREQUENCIES and Section 5.4 INVERTER MODULES).
60976 W1 or (61110 W1)	a/b (1-2)	Start count at 0.
	b/c (2-3)	Start count at 10.
		(See Section 5.4 CONVERTER MODULE).
60976 W2 or (61110 W2)	a/b (1-2)	Start count at 0.
	b/c (2-3)	Start count at 20.
		(See Section 5.4 CONVERTER MODULE).
60976 W3 or (61110 W3)	a/b (1-2)	Low fault reference voltage.
	b/c (2-3)	High fault reference voltage.
		(See Section 5.4 FAULT DETECTOR CIRCUIT).
60977 W1	a/b	IC "R" = 2732 SECTION 1.
	b/c	IC "R" = 2716 and 2732 SECTION 2.
		(See Section 4.4 DRIVE FREQUENCIES).
60977 W2	a/b	Normal low speed run frequency.
	b/c	Alternate low speed run frequency.

		(See Section 4.4 DRIVE FREQUENCIES).
60977 W3	a/b	Alternate low speed boost frequency.
	b/c	Normal low speed boost frequency.
		(See Section 4.4 DRIVE FREQUENCIES).
60978 W1	1-2 (a/b)	AUX Timer drives AUX OUT at 60978 J2-19.
		[See Section 3.4 b) HEAT EXCHANGER and Section 4.4 AUXILIARY TIMER].
	2-3 (b/c)	AUX Timer used as alternate CONTINUANCE
		Timer (used in conjunction with W14 2-3).
		(See Section 4.4 SEPARATE CONTINUANCE TIMES FOR FLUORO AND SPOT).
60978 W2	1-2 (a/b)	VRS frequency selected.
	2-3 (b/c)	VRS frequency not selected.
		(See Section 4.4 DRIVE FREQUENCIES).
60978 W3	1-2 (a/b)	CONTINUANCE in high and low speed.
	2-3 (b/c)	CONTINUANCE in high speed only.
		(See Section 4.4 CONTINUANCE TIMER OPERATION).
60978 W4	1-2 (a/b)	SPOT command used as ROTOR START command.
	2-3 (b/c)	Storage position.
		(See Section 4.4 ROTOR START OPTIONS).
60978 W5	1-2 (a/b)	SPOT forces high speed.
	2-3 (b/c)	High or low speed SPOT.
		(See Section 4.4 HIGH SPEED SELECT OPTIONS).
6098 W6	1-2 (a/b)	FLUORO forces low speed.
	2-3 (b/c)	High or low speed FLUORO.
		(See Section 4.4 FLUORO FORCES LOW SPEED).
60978 W7	1-2 (a/b)	Not used on model HD341 or HD343.

	2-3 (b/c)	Storage Position.
60978 W8	1-2 (a/b)	Storage position.
	2-3 (b/c)	CINE command used as ROTOR START.
		(See Section 4.4 ROTOR START OPTIONS).
60978 W9	1-2 (a/b)	High or low speed CINE.
	2-3 (b/c)	CINE forces high speed.
		(See Section 4.4 HIGH SPEED SELECT OPTIONS).
60978 W10	1-2 (a/b)	AUX INPUT triggers AUX Timer.
		[See Section 3.4 a) AUXILIARY INPUT and Section 4.4 AUXILIARY TIMER].
	2-3 (b/c)	FLUORO triggers AUX Timer.
		(See Section 4.4 SEPARATE CONTINUANCE TIMES FOR FLUORO AND SPOT).
60978 W11	1-2 (a/b)	FLUORO command used as ROTOR START.
	2-3 (b/c)	Storage position.
		(See Section 4.4 ROTOR START OPTIONS).
60978 W12	1-2 (a/b)	FLUORO CONTINUANCE disabled.
	2-3 (b/c)	FLUORO triggers CONTINUANCE Timer.
		(See Section 4.4 CONTINUANCE TIMER OPERATION).
60978 W13	1-2 (a/b)	SPOT CONTINUANCE disabled.
	2-3 (b/c)	SPOT triggers CONTINUANCE Timer.
		(See Section 4.4 CONTINUANCE TIMER OPERATION).
60978 W14	1-2 (a/b)	ROTOR START triggers CONTINUANCE.
		(See Section 4.4 CONTINUANCE TIMER OPERATION).
	2-3 (b/c)	AUX Timer used as alternate CONTINUANCE
		Timer (used in conjunction with W1 2-3).
		(See Section 4.4 AUXILIARY TIMER).

60978 W15	1-2 (a/b)	HIGH SPEED command triggers CONTINUANCE Timer
	2-3 (b/c)	Storage position.
		(See Section 4.4 CONTINUANCE TIMER OPERATION).
60978 W16	---	Not used on model HD341 or HD343.
60978 W17	---	Not used on model HD341 or HD343.
60978 W19	1-2 (a/b)	Storage position.
	2-3 (b/c)	CONTINUANCE triggers high speed.
		(See Section 4.4 HIGH SPEED SELECT OPTIONS).
60978 W20	1-2	CONTINUANCE and AUXILIARY timers inhibited for Tube 1.
	2-3	Storage position. Normal operation of CONTINUANCE and AUXILIARY timers for Tube 1.
		(See Section 4.4 INHIBIT CONTINUANCE AND AUXILIARY TIMERS FOR SPECIFIC TUBES).
60978 W21	1-2	CONTINUANCE and AUXILIARY timers inhibited for Tube 2.
	2-3	Storage position. Normal operation of CONTINUANCE and AUXILIARY timers for Tube 2.
		(See Section 4.4 INHIBIT CONTINUANCE AND AUXILIARY TIMERS FOR SPECIFIC TUBES).
60978 W22	1-2	CONTINUANCE and AUXILIARY timers inhibited for Tube 3.
	2-3	Storage position. Normal operation of CONTINUANCE and AUXILIARY timers for Tube 3.
		(See Section 4.4 INHIBIT CONTINUANCE AND AUXILIARY TIMERS FOR SPECIFIC TUBES).
60979 W1	a/b	N.O. contacts used for TUBE CHANGE INTERLOCK.
	b/c	N.C. contacts used for TUBE CHANGE INTERLOCK.
		[See Section 3.4 b) TUBE ACTIVE].
60979 W2	a/b	Normal or alternate frequency used for low speed boost.
	b/c	High speed frequency used for low speed boost.
		(See Section 4.4 DRIVE FREQUENCIES).

60979 W3	a/b	RY2 is used for HIGH SPEED VERIFICATION.
		[See Section 3.4 b) HIGH SPEED VERIFIED].
	b/c	RY2 is used for ROTOR INTERLOCK.
		[See Section 3.4 b) ROTOR INTERLOCK].
60980 W1	a/b	3-Tube units (HD343).
	b/c	1-Tube units (HD341).
61110 W1	1-2	Start count at 0.
	2-3	Start count at 10.
		(See Section 5.4 CONVERTER MODULE).
61110 W2	1-2	Start count at 0.
	2-3	Start count at 20.
		(See Section 5.4 CONVERTER MODULE).
61110 W3	1-2	Low fault reference voltage.
	2-3	High fault reference voltage.
		(See Section 5.4 FAULT DETECTOR CIRCUIT).
61110 W4	1-2	Lower fault reference voltage during run.
	2-3	Fault reference voltage is same during boost and run.
		(See Section 5.4 SOFT FAULT CIRCUIT).

For 61071 jumper positions refer to Section 7.0 W61071A and W61071B.

SECTION 5.0 PRINCIPLES OF OPERATION

5.0 PRINCIPLES OF OPERATION

5.1 Functional Description

The Rotor-AID HD300 Series Heavy Duty Rotor 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 60978 Mother board. The 60977 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 rotor controller may optionally:

1. Automatically apply DC 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

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.

FLUOROSCOPIC MODE - In the Fluoroscopic mode, the basic timing logic cycle as described below is used except that only Low Speed is required.

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.

3. Exposure are allowed during the coast command only when the rotor interlock is unused or disabled.

SPOT FILM MODE - Radiographic and Fluoroscopic Units Only

As illustrated in Figure 5.4, the Spot Film mode provides an additional system time delay (Td) capability to allow a film cassette to be positioned prior to an exposure. The Spot Film mode is usually preceded by the system being in the Fluoro mode, and the Boost cycle is then taken from low speed to high speed. Exposures are inhibited during the cassette positioning delay time (Td).

Figure 5.4 is representative of one of many possible application variations that can be accommodated by factory or field installed wiring.

Figure 5.4

SPOT FILM TIMING LOGIC WITH CASSETTE DELAY

Note: If continuance is selected, the rotor will remain in high speed between spot film exposures avoiding the delays required to accelerate between low and high speeds. Boost times are approximately 2/3 the time required to Boost from zero speed. Separate continuance times can be set for Fluoro and Spot functions.

CINE MODE - Radiographic and Fluoroscopic Units Only

As illustrated in Figure 5.5, Cine is similar to the Spot Film mode in that the tube anode is required to change speed. The Cine Mode is usually preceded by the system being in the Fluoro mode, and the Boost cycle is then taken from low speed to high speed. Note that the acceleration and deceleration times are approximately 2/3 the times normally required from and to zero speed.

Figure 5.5

CINE TIMING LOGIC

Note: When going from the Spot or Cine mode (high speed) back to the Fluoro mode (low speed), the low speed Boost is used to Brake the tube to the low speed.

SECTION 5.0 PRINCIPLES OF OPERATION

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 60978 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. In a three tube unit the outputs of the Boost/Brake timers are gated by signals from the 60975 Tube Change Logic board so that only the board corresponding to the tube selected is used.

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 60974 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 waveform. The SCR firing points are controlled in the following manner:

The DC voltages set on the 60980 Phase Shift II board, by adjusting the set(s) of R1-R6 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 60980 board include:

- A short, active low, sync pulse that appears at 60980 TP3 for each zero crossing of input line voltage. This signal is used to reset and load the counters 60976 IC-F and 60976 IC-P (61110 U5 and 61110 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 60980 TP1 and is 10kHz for a 50Hz line and 12kHz for a 60Hz line.

The 60976 (61110) board utilizes signals generated by the 60980 board to adjust the firing point of SCRs in the DC supply bridge. Counters 60976 IC-N and 60976 IC-E (61110 U4 and 61110 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 N and E is adjusted up or down every half cycle depending upon the logic state of the error direction line.

The count contained in N and E is loaded into P and F once every half cycle near the zero crossing. P and F 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 P and F 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.

SECTION 5.0 PRINCIPLES OF OPERATION

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 N and E must have a decimal output significantly greater than 0. Note that counter E is the most significant digit.

- The output of counter F 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 60977 Interlock board and the 61067 Inverter boards in Section 7.0. The 60977 Interlock board supplies SCR gate pulses of approximately 200us via pulse transformers on the 61067 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 60974 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 60977 board utilizes a pre-programmed PROM to provide the proper drive signals for the inverter SCRs. When ordering a 60977 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 60976 (61110), 60979 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, 60976 R10 (61110 R19). The voltage developed across the resistor is connected through a filter to the inverting input of the fault comparator 60976 A (61110 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 60976 W3 (61110 W3). Setting the jumper 60976 W3 a/b (61110 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 60976 W3 b/c (61110 W3 2-3) selects a higher fault reference (approximately 5.0VDC). For units using a 74016 (AMVECO) torodial input transformer, setting the jumper 60976 W3 a/b (61110 W3 1-2) selects the lower fault reference.

Digital Soft Fault Circuit:

Units using the 61110 phase shift and fault detect board in place of 60976 are equipped with the digital soft fault circuit. This circuit allows the rotor controller to continue operation in spite of temporary internal or external disturbances such as tube arcs, line voltage transients or inverter miscommutation which may cause an inverter fault.

The fault current sense from P9-25 is half wave rectified, filtered, and voltage limited before it arrives at U12 pin 3. U12 (LM311) is a voltage comparator that detects any over current condition in the primary circuitry of the rotor controller. If the fault sense voltage from P9-25 exceeds the reference voltage at U12 pin 2 then U12 pin 7 puts out a low going pulse. The low going pulse from U12 pin 7 triggers two non-resettable monostable multivibrators (one shots) made up of U13-D and U13-C, and U13-A and U13-B. The one shot which includes U13-D and U13-C has a time constant of 100mS. This one shot increments the fault counter U14 (4017) and inhibits the gate pulses to the DC power supply by turning off gate U8-B (74C20). The one shot which includes U13-A and U13-B has a time constant of 5 seconds which removes the reset command from the fault counter U14 for 5 seconds. The fault counter will remain active for 5 seconds. If, during this time, a repetitive or permanent fault reoccurs 5 times, then the fault counter U14 pin 1 will set flip flop U9-C and U9-D and inhibit gate pulses to the DC power supply until the run command is removed and then restored. If the fault condition does not happen 5 times within 5 seconds the one shot times out and resets the fault counter to 0.

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 61110 W4 in the 1-2 position.

Note: For the digital soft fault circuit on 61110 to operate properly, the unit must be equipped with the 60977S rotor interlock board as well as either the 61071N stator output board for single tube units (HD341) or the 61068L stator output board for three tube units (HD343). The 60977S, 61071N and 61068L assemblies increase the rotor interlock delays allowing the digital soft fault circuit to integrate the fault sense and distinguish between a soft (temporary) fault and a hard (permanent) fault.

Rotor Interlock Circuit:

The current to the x-ray tube stator is monitored by the rotor interlock circuits on the 60977 Interlock Board and the Stator Output board, 61068 or 61071. 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 Figures 3.2 and 3.3 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 4.10).

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.

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 60979 LED1 light during a Rotor Start signal?

If yes, then:

- Check to see if the Circuit Breaker is on.
- Check to see that the Boost Time, 60972 board, is set properly.
- Replace 60972 board.
- Replace 60976 or 61110 board.
- Replace 60980 board. Check the six Boost, Run and Brake
- Replace 60974 board. Make sure that the shunt (jumper) is

If no, then:

- Check the interface wiring.
- Check for the presence of the Rotor Start signal.
- Replace 60971 board. Make sure that the shunts (jumpers) are
- Check thermal switch. If switch is bad, replace input power
- Check wiring to the Stator Output board. Replace board if
- Check the 60979 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 60979 board. Replace any open fuses. If replaced fuses open when power is applied, then remove all plug- in PC boards from the 60978 and 60979 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 60979 and then adjust 60979 R3 and R4 as described in Section 4.8.

SYMPTOM: NO RUN

Check to see that the 60972 Continuance Time is set correctly.

Replace the 60972 Continuance/Aux. Timer board.

Replace 60980 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 Brake Time is set correctly.

Replace the appropriate 60972 board if necessary.

Replace 60980 board. Check the six Boost, Run and Brake voltages and adjust the appropriate potentiometers if necessary.

Replace 60978 board. Make sure that all the shunts (jumpers) are programmed properly.

Replace 60974 board. Make sure that the shunt (jumper) is programmed properly.

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 60978 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 (60977 board, pins 23, 22, 21 and 20). If necessary, replace 60977 board. Make sure that the shunts (jumpers) are programmed properly.

Check wiring to the 61067 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 61067 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 61067 Inverter Drive and SCR board in the Phase Inverter Section. Reconnect the wire to TR3 terminal 2.

Replace the 60960 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 60976 or 61110 board.

Replace 60977 board. Verify the shunt (jumpers) programming.

Replace 60980 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, 60979 LED3 and 61071 LED 1 (1-tube) or 61068 LED1 (3-tube) 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, 60979 RY3 and 61071 RY1 (1-tube) or 61068 RY1 (3-tube), and correct any problems.

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

Replace 60977 board. Make sure that the shunts (jumpers) are programmed properly.

Adjust 60979 R3 and R4 as described in Section 4.8.

Replace 60979 board. Make sure shunts (jumpers) are in the correct position. If necessary, adjust 60979 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 60980 board.

Replace the 61068 (3-Tube) or 61071 (1-Tube) 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 60980.

Replace 60980 board. Check the six Boost, Run and Brake voltages and adjust the appropriate potentiometers if necessary.

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

Replace 60976 or 61110 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 potentiometer on the 60980 board.

Replace the 60980 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 potentiometer on the 60980 board.

Replace 60980 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 60960 board.

Replace the 61067 boards, one at a time, for both the main and phase inverter sections. Note that the 61067 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.

SYMPTOM: 60971 BOARD FAILS 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 60971 board and program the voltage selector shunts (jumpers) for the input voltages that are being applied.

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

DWG No.	Description
WHD341	HD341 Overall Schematic
S75001	Optional Signal Interface 25 Pin Sub D
W60968 B	Heat Exchanger Option
W61071 A	Thermal Cut-Out Option
W61071 B	Brake Interlock Option
WTS6	Supplemental Terminal Strip Option
WHD343	HD343 Overall Schematic
S75002	Optional Signal Interface 37 Pin Sub D
S75017A	UD150 BIO/L Signal Interface 37 Pin Sub D
S75017B	HD150 G-60 Signal Interface 37 Pin Sub D
S60960	Driver, SCR gate
S60971	Input board
S60972	Dual timer board
S60974	Clock board
S60975	Tube change logic board
S60976	Phase shift and fault detect board
S60977	Interlock board, PROM programmed
S60978	Mother board
S60979	Power supply board
S60980	Phase shift 2 board
S61067	Inverter drive and SCR board
S61068	3-Tube stator output board
S61071	1-Tube stator output board

S61110	Phase shift and fault detect board with digital soft fault
W74072	240/480 VAC Optional Input

7.3 Component location diagrams

PC board	Description
60960	Driver, SCR gate board
60971	Input board
60972	Dual timer board
60974	Clock board
60975	Tube change logic board
60976	Phase shift and fault detect board
60977	Interlock board, PROM programmed
60978	Mother board
60979	Power supply board
60980	Phase shift 2 board
61067	Inverter drive and SCR board
61068	3-Tube stator output board
61071	1-Tube stator output board
61110.00	Phase shift and fault detect board with digital 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.

	P/N	DESCRIPTION	QTY.
PC boards	60960	Driver, SCR gate board	1.00
	60971	Input board	1.00
	60972	Dual timer board	1.00
	60974	Clock board	1.00
	60975*	Tube change logic board	1.00
	60976	Phase shift and fault detect board	1.00
	60977	Interlock board, PROM programmed	1.00
	60978	Mother board	1.00
	60979	Power supply board	1.00
	60980	Phase shift 2 board	1.00
	61067	Inverter drive and SCR board	1.00
	61068*	3-Tube stator output board	1.00
	61071**	1-Tube stator output board	1.00
	61110***	Phase shift and fault detect board with digital soft fault	1.00
	70544.00	Extender board kit	1.00
Fuses	45045.00	3A SB 3AG fuse	1.00
	45075.00	0.125A SB 5x20 mm fuse	1.00
	45077.00	0.05A SB 5x20 mm fuse	1.00
Miscellaneous Repair Parts	24042.00	8uf 660VAC	2.00
	31018.00	Diode S3280	2.00
	31086.00	STD-057/08 SCR/Diode power module	1.00
	41006.00	K'H, Brake (K'B1, K'B2)	2.00
	49009.00	Fan	1.00
	54392.00	Air Filter	1.00

* Used on HD343 ONLY. ** Used on HD341 ONLY. *** To use 61110 the unit must be equipped with 60977S and either 61068L or 61071N (See Section 5.4 SOFT FAULT).

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

TYPE	P/N	DESCRIPTION	QTY.
Transistors	30004.00	TIP111 NPN DARLINGTON TO-220AB	2.00
	30006.00	2N5308 NPN DARLINGTON TO-92	1.00
	30007.00	2N4125 PNP GENERAL PURPOSE T0-92	1.00
	30008.00	2N4123 NPN GENERAL PURPOSE T0-92	1.00
	30027.00	2N6718 NPN MEDIUM POWER TO-237	1.00
ICs	32001.00		1.00
	32002.00		1.00
	32042.00		1.00
	32046.00		1.00
	32048.00		1.00
	32054.00		1.00
	32060.00		1.00
	32065.00		1.00
	32072.00		1.00
	32074.00		1.00
	32105.00	3A SB 3AG fuse	1.00
	32124.00	0.08A SB 5x20 mm fuse	1.00
	32132.00	0.05A SB 5x20 mm fuse	1.00
	32138.00	8uf 660VAC	2.00
	32140.00	Diode S3280	2.00
	32144.00	STD-057/08 SCR/Diode power module	1.00
	32156*	K'H, Brake (K'B1, K'B2)	2.00
	32161.00	Fan	1.00
	32193.00	Air Filter	1.00
Relays	41002**	Optional Functions Relay	1.00
	41040.00	Function Relay	2.00
	41071.00	Signal Input	1.00
	41067*	Tube Select	1.00

* HD343 ONLY. ** HD341 ONLY

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.

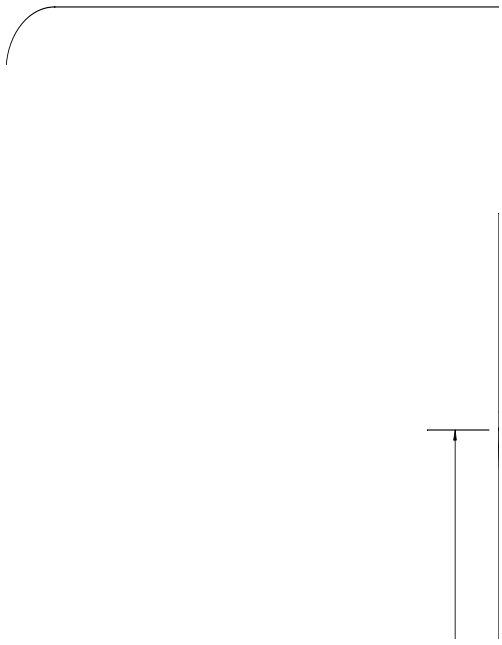
Check the fan fuse , F2 (3A SB 3AG, AID P/N 45045), at the input transformer (74016).

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. Refer to Section 3.5 and to the 61068 or 61071 Stator Output board schematics in Section 7.0 to determine where to measure these voltages. 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.


START COMMA
BOOST
(Low Speed)

START COMMAND

BOOST
(Low Speed)