Instruction Book

INSTALLATION, OPERATION & MAINTENANCE

OF

ELECTRICAL CONTROL

FOR A SINGLE PHASE

1 THRU 4 HP THYRISTOR DRIVE

INSTRUCTION BOOK

NUMBER IB-5623-1A

Westinghouse Electric Corporation

TABLE OF CONTENTS

SECTION I

DESCRIPTION OF APPARATUS

SINGLE PHASE DRIVES

Device designations are same as those on the schematic diagram.

Disc. SW - Main line circuit breaker or disconnect located in the incoming line, normally supplied by customer.

1T - Single phase transformer to convert line voltage into proper value for the thyristor-diode power converter.

2T - Single phase tranformer to convert line voltage into 115 volt control voltage.

Silicon Diode Rectifiers:

1REC - Full wave bridge to convert 230 volts AC into DC for motor shunt field excitation.

3D, 4D - Connected in the Thyristor-Diode assembly to convert the applied AC voltage to full wave DC for application to the DC motor armature. Also provides a "free wheeling" or discharge path for the stored energy in the motor inductive circuit during periods when thyristors 1TN, & 2TN, are not conducting.

Thyristors:

1TN, & 2TN - Silicon controlled rectifiers which function similar to switches and are used to determine the conductive period of the full wave bridge rectifier.

Contactors and Relays:

MR - Main armature contactor for applying and removing DC power from the DC power converter to the motor armature.

MS1 - Control relay operated by the start-stop pushbuttons to energize and de-energize the main armature contactor. Also completes the running speed reference voltage circuit.

JR - Jog Relay (when used) to energize the main armature contactor and also to set the proper speed reference voltage for jogging.

Resistors:

FBR - Armature current signal resistors.

MFR - Motor shunt field resistor set to provide proper base speed motor shunt field current.

DBR - Dynamic braking resistor (when used).

4R - Discharge resistor for capacitors, 5C.

5R - Maximum jog speed reference voltage resistor (when used).

P2 - Minimum operating speed reference voltage adjusting rheostat.

Filters:

3C & 3R - AC voltage filter for filtering spikes and hash to protect the thyristors and diodes.

4C & 4R - Commutation filter.

1C & 1R - To protect 1REC from spikes and hash.

Fuses:

1FU - Incoming line fuses to protect against short circuits or overloads in main AC circuitry.

2FU - AC control voltage fuses to protect against short circuits in the magnetic control.

1FU & 2FU in Thyristor Amp - Amptrap fuses which are exceptionally fast acting to protect the thyristors and diodes.

Overload:

1OL - Thermal overload relay for motor armature circuitry.

Capacitors:

4C - Current limit stabilizing capacitor.

5C - Accelerating capacitor to provide timed acceleration.

Reactor:

1L - Adds inductance in the armature circuit for smoothing out the ripple from the thyristor-diode power amplifier.

DESCRIPTION OF APPARATUS

A-305 - S#456A435G01

1X - Thyristor gating amplifier to fire 1TN, & 2TN Thyristors.

1P - Maximum armature voltage/speed adjustment.

2P - Minimum speed adjustment.

3P - I. R. Compensation adjustment.

4P - Current limit signal adjustment.

5P - Thyristor gating amplifier bias adjustment.

4Z - Zener reference diode.

18R - Current limit signal linearizing resistor.

19R - Current limit signal delay resistor (with 4C).

26R1 & 26R2 - Voltage regulating system gain resistors.

27R - Armature feedback voltage divider resistor (with 1P).

6C - Filter capacitor for armature feedback voltage signal.

28R - Load resistor for Zener diode, 4Z.

8C - Zener diode, 4Z, filter capacitor.

23D & 27D - Current limit bias diodes.

25D & 26D - Delay circuit bypass diodes (eliminate current limit delay for large current surges).

24D - Clipper diodes, clamps down large changes in output of gating amplifier due to large changes in error signal.

29D - Error limit diode. Allows only predetermined current to flow through error winding.

9C - Error limit filter capciter.

28D - DC reference circuit rectifier.

30D - Error signal unidirectional diode.

SECTION II

DESCRIPTION OF OPERATION

Single Phase THYRISTOR Drives

This drive is designed to operate over a speed range of 10:1 by armature voltage control.

1. AC line power is applied to a single phase bridge rectifier circuit comprised of two THYRISTORS and two silicon diode rectifiers.

2. The Magamp type gating amplifier supplies the THYRISTORS with the necessary firing pulses.

3. The angular relationship between the AC supply voltage and the firing pulse from the gating amplifier determines the THYRISTOR conduction period, hence, the DC power applied to the motor.

4. Commutating or free wheeling diodes, 3D & 4D, provide a path for the inductive discharge of the motor armature which cannot flow through the THYRISTORS when their conduction period is small. This means that at low speeds the full armature current of the motor would try to flow through resistors 1R & 2R, increasing the THYRISTOR voltage causing:

    a) The THYRISTORS to be switched on well into the next half cycle of the AC applied voltage (negative half voltage).

    b) Smaller voltage range and therefore a smaller speed range.

5. The gating amplifier output is controlled by the net or total ampere turns (AT) of the control windings. Positive AT (odd numbered control winding terminal has a positive polarity with respect to the even numbered terminal) produce an output pulse which will increase the THYRISTOR conduction time. Negative AT produce the exact opposite effect.

6. Voltage regulation is obtained through the "error" control winding which is associated with a voltage matching circuit comprised of an adjustable DC reference voltage and the DC armature feedback voltage. The net difference between these two voltages is the error voltage which causes a current to flow through the error winding thus controlling the angular relationship between the firing pulse from the gating amplifier and the applied AC voltage to the THYRISTORS.

7. a) Assume that a 24 volt reference produces an armature voltage of 180V DC, (speed pot at maximum).

    b) Assume that it required 0.8 AT (current X turns) to produce 180V DC from the single phase bridge rectifier.

7. c) Assume that the armature feedback voltage is 223V DC when the armature voltage is 180V DC.

   d) Assume that the 24 volt reference produces 1.2 AT when the armature feedback voltage is zero, due to the error limit circuit.

   e) Initially, current flows from the positive side of the reference voltage source, thru 3P and 1P, 26R1, 26R2 from 9 to 10 on the "error" winding (+AT), thru 30D thru SPD Rheo and to the negative side of the reference supply.

   f) This increases the armature voltage and the armature feedback voltage begins to appear across 1P (max. arm. volts).

   g) The armature feedback voltage across 1P (MAV) opposes the reference voltage, hence the current flowing thru 1P (MAV) and the "error" winding decreases.

   h) When the armature voltage reaches 180 volts the feedback voltage is 22.3 volts. The error voltage (reference volts (-) feedback volts) is 1.7 volts which will permit sufficient current to pass thru the "error" winding to produce the 0.8 AT required to maintain 180 volts across the armature.

Regulating Action

Should the armature voltage decrease below 180 volts, the error voltage would increase. More current would flow thru the "error" winding and the output pulses from the gating amplifiers would direct the THYRISTORS to fire earlier thus increasing the voltage applied to the motor armature.

Should the armature voltage increase above 180 volts, the error voltage would decrease, less current would flow thru the "error" winding and the THYRISTORS would fire later or conduct less to reduce the armature voltage.

I. R. Compensation - Speed regulation by CEMF Control

Speed of a DC motor is proportional to CEMF. Assuming the drive is not provided with the IR compensation feature, when the loading on the motor increases, the motor current increases and speed decreases due to IR drop (V=CEMF+IR) in order to obtain a more constant motor speed for varying load conditions, CEMF and not armature voltage should be fed into the regulator. The only way to measure CEMF is by subtracting the IR drop from the armature voltage. A resistor in series with the motor armature (FBR) senses the motor current and provides the regulator with a voltage signal proportional to the motor current.

Current Limit

A current limit circuit is provided to:

1. Prevent excessive armature current from flowing during acceleration and deceleration of the motor.

2. Limit the maximum value of armature current for any given operating condition.

The current signal is used to decrease the armature voltage when the load current exceeds a preset value. When the preset value is exceeded, silicon diodes 23D, 25D, 26D, 27D conduct and current flows in a plus to minus direction thru winding 7-8 of the gating amplifier such that terminal 8 is positive with respect to terminal 7. Negative AT are produced and the output pulses from the gating amplifier decreases the conduction time of the THYRISTORS to reduce the armature voltage.

NOTE: Diodes 23D, 25D, 26D, 27D do not conduct until the voltage applied to them from 4P is sufficient to overcome the combined forward voltage drop of the diodes.

The armature voltage decrease caused by current limit action will be approximately great enough to limit the motor current to a maximum of 170% full load current with the motor stalled.

Capacitor 4C provides a time delay for the current limit signal under normal operating conditions. However, when the current signal increases above a predetermined level, diodes 25D and 26D conduct readily to eliminate the time delay.

Dynamic Braking

Drives which incorporate the dynamic braking feature, slow the motor rapidly when the "Stop" button is pressed, by connecting a low resistance across the motor armature. The motor then acts as a generator and dissipates its rotational energy in the dynamic braking resistor in the form of heat.

INSTALLATION AND START-UP INSTRUCTIONS

At the time of installation, care must be taken in checking out the equipment not only electrically but also mechanically.

Before coupling or mechanically connecting the motor to the load, a physical check of the motor must be made. Manually rotate the motor armature, the armature should rotate freely and smoothly. Check the seating of all brushes. Look for any visible damage that may have occured during shipping or installation.

Check all relays and contactors for freedom of operation. Remove any packing from the devices that may have been added for protection during shipment.

Using the external connection diagrams as reference, be sure that all electrical connections to the controllers are made correctly and properly in accordance with good wiring practices and all applicable national and local electrical codes.

Check and tighten the connections to all terminal blocks.

Check out the required rotation of motor before making the final physical coupling of the motor to the load. Normal motor rotation is counterclockwise when viewed from the commutator end when A1 is positive and F1 is positive. If other than CCW motor rotation is required, it is recommended that the armature connection be changed rather than the field connections, usually the wiring is less involved in the armature circuit than in the field circuits.

After checking out the installation both mechanically and electrically, power can be applied to the drive.

Electrical Installation and Start-Up

1. Check out the operation of any auxiliary motors, be sure rotation is correct.

2. Check all transformer voltages per the schematic diagram.

3. Sequence check per the schematic diagram.

4. Check the DC voltage at 1REC which should be 208V DC ± 10 volts.

5. Check and adjust (RES. MFR) for rated DC motor shunt field current when the field is hot. See the motor nameplate for rated current when hot.

6. Trim the drive for desired operating speeds.

SECTION III

ALIGNMENT PROCEDURE FOR AVT SINGLE PHASE DRIVES USING THE A-305 MODULE

1. Equipment required:

   1 - 20,000 ohms/volt DC voltmeter
   1 - DC ammeter
   1 - 5000 ohms/volt AC voltmeter
   1 - hand type tachometer
   1 - 1 TEKTRONIX 502 scope or equivalent

2. Make the following initial potentiometer settings on A-305.

   a) Bias pot 5P at 0% or cutoff.
   b) Maximum armature volts pot 1P at 30%.
   c) Minimum speed pot 2P at 0%.
   d) IR compensation pot 3P at 0%.
   e) Current limit pot 4P at 70%.
   f) All the other resistors and potentiometers per the schematic.

3. Voltage check and preliminaries:

   Be sure that the phasing between the A-305 and the thyristor power amplifier is connected as shown on the schematic.

   a) AC line voltage, terminals 11 to 13 on A-305 should be 230V ± 4%.
   b) AC control voltage should be between 110 and 120V AC.
   c) Place the DC voltmeter across the motor armature connections.
   d) Connect the DC ammeter in the main armature loop.
   e) Connect the scope across N to P on the thyristor power amplifier, P is common.

   NOTE: Do not ground the frame of the scope. The scope plug must not be grounded. Scope may be above 230V AC line when the ground lead of the scope is connected to terminal P.

4. Bias pot adjustment.

   a) Assuming that the preceding steps have been satisfactorily completed, place the speed pot at minimum, close the main line AC circuit breaker and press the drive start button.

   b) Adjust the bias pot 5P on the A305 such that the voltage between P and N just reaches zero.

5. Setting of maximum and minimum speed pots:

   a) Set the speed pot at '0'.
   b) Slowly adjust the speed pot to the maximum position. Trim the maximum armature volts pot 1P on the A-305 module to obtain rated DC voltage across the unloaded motor armature.
   c) Reset the speed pot to the minimum position and adjust the minimum speed pot 2P on the A-305 for the minimum speed desired.

6. Setting of current limit pot 4P on A-305.

   a) Set the speed pot in the maximum position.
   b) With the motor stalled, adjust the C.L. pot, 4P for 170% maximum armature current. This operation should last a few seconds to prevent the overload relay to warm up. It may be repeated allowing time between consecutive operations.

7. Setting of the I.R. compensation pot 3P.

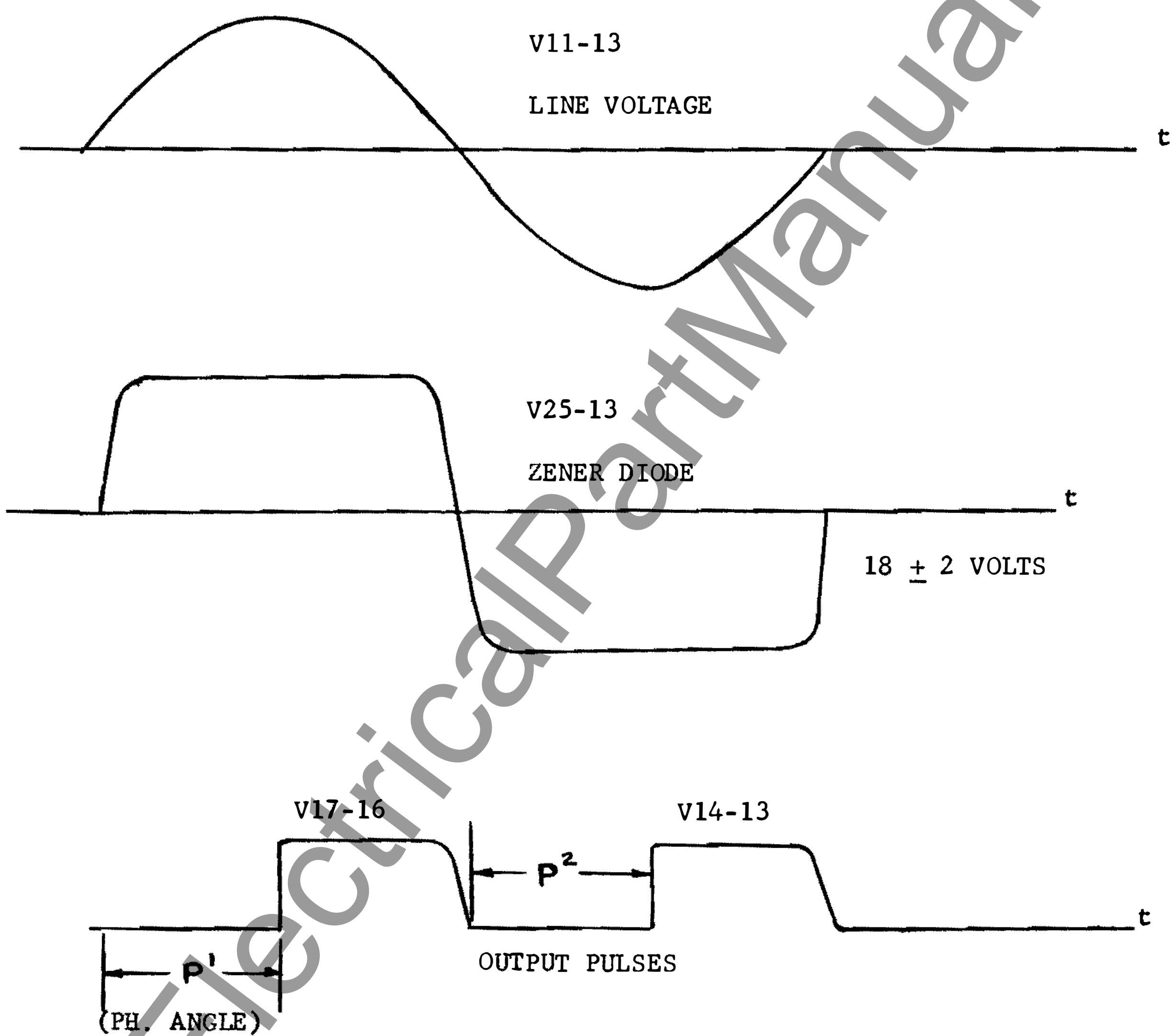
   The I.R. compensation adjust potentiometer (3P) on the A-305, is normally set at 400 RPM (for a 1750 base speed motor) the motor speed will neither increase or decrease when the motor loading varies from 10% to 100% load. However, a flat speed regulating characteristic can be set for other speeds if desired.

   a) Set the speed pot to obtain 400 RPM on the motor, or any other desired minimum load speed of the motor.

   b) Increase the load to running load and adjust 3P on the A-305 so that the speed remains constant.

FIGURE 1

OSCILLOSCOPE IMAGES
A-305 GATING AMPLIFIER



FIRING PULSES SHOWN FOR $P^1 = P^2 = 90^o$

MAINTENANCE & TROUBLE SHOOTING

Maintenance of static components and of controls, using static devices, is primarily a combination of good common sense and good housekeeping. Static devices such as silicon diodes and thyristors will give long trouble-free service if properly cared for. Silicon devices are heat sensitive and if dust, dirt, or some type of corrosive film is permitted to develop and build up on the devices or upton its heat sink, damage to the device usually will result due to excessive heat build up within the device. If replacement of any of the static devices should be required, read IL 16-800-15B for basic instruction.

Maintenance of the rotating equipment should be done in line with existing practices. The contactors and relays should be checked regularly and the contacts cleaned as required to maintain satisfactory operation.

A well-planned and executed preventive maintenance schedule will be invaluable in maintaining satisfactory operation of electrical and mechanical equipment.

Trouble Shooting Procedure

The best tools for trouble shooting are plain, old-fashioned common sense and a logical orderly procedure for locating the trouble. A trouble shooting guide, presented in this I.B., provides the logical, orderly procedure to be followed when trying to locate a specific trouble.

The first step in trouble shooting is to check the AC and DC supply and control voltages and to be sure that the relays and contactors are making or breaking per the schematic diagram circuitry. If all voltages check out properly, utilize the following trouble shooting charts to help isolate the trouble.

SYMPTOM	CAUSE/REMEDY
1. Cannot obtain the desires speed.	Check: (1) Check the setting of Pot 1P on the A-305 module.
	(2) Check the operation of the speed pot and the voltage from the speed pot.
	(3) Check the thyristor gating module in the A-305.
	(4) Check for a blown fuse in the thyristor power amplifier.
	(5) Check for correct motor shunt field excitation.

SYMPTOM		CAUSE/REMEDY
2. Poor control of motor speeds at low speeds.	Check:	(1) Check for loose connections. (2) Check for defective speed or minimum speed pot. (3) Check for high resistance on relay contacts.
3. Fuse blown in the thyristor power module.		A fuse blown in the power amplifier usually indicates that there is a malfunction. (1) Disconnect and remove the thyristor power amplifier module. Disconnect the diode and thyristor leads and check with an ohmmeter set on the X10K scale. Replace when required. Replace module. (2) Check for loose connections or shorts.

SECTION IV

DC Motors - 1 to 4 HP

Types M010, M110 & M210 Contactors	IL 15-800-M010/110/210-1
Types M011, M111 & M211 Contactors	IL 15-800-M011/111/211-1
Type MW11 Overload Relay	IL 12476
Replacement of Semiconductor Devices	IL 16-800-15B
A305 Thyristor & Regulator Gating Amplifier	IL 5623-7

A-305 THYRISTOR REGULATOR & GATING AMPLIFIER

I. GENERAL DESCRIPTION

The A-305 gatimg module produces phase controlled pulses for firing thyristors on a full-wave bridge rectifier.

The module contains a printed circuit board on which is mounted a magnetic amplifier, an output transformer and associated circuitry.

All external connections and adjustments are made at the face plate.

II. SCOPE OF APPLICATION

The A-305 will control thyristors up to and including size 5 (70 ampere) units in single phase circuits at a supply frequency of 60 cps. Ambient temperature 0 to 55°C.

III. ELECTRICAL SPECIFICATIONS

1. Line voltage V11-13 - 115V ± 10% - 60 cps.

2. Output Pulse: 13-14, 17-16

Load	Pulse Amplitude	Pulse Length
100 ohm	4.3 volts	2.2 ms
47 ohm	3.1 volts	2.8 ms
22 ohm	2.0 volts	3.5 ms

Refer to figure #1 for phase relation and pulse shapes (IL 5623-5, page 3).

3. Phasing:

Output terminals 14 and 16 are pulsed positive during the half cycle terminal 11 is positive.

4. Control Windings:

Terminal	Turns	Max. Current Ma	Resistance-ohms
5-6	500	50	48.0
7-8	500	150	48.0
9-10	200	200	4.8
11-12	200	200	4.8

Current flow into an even-numbered control winding terminal increases the phase angle of the gating module while current flow into an odd-numbered winding terminal decreases the phase angle.

III. Electrical Specifications (cont.)

5. Gain (Linear Range) - 260°/AT.

IV. DESCRIPTION OF OPERATION

This gating module produces pulses which can be shifted relative to the line voltage by a DC signal in order to advance or retard the firing angle of the thyristors.

Figure 1 shows the schematic diagram for the A-305 gating module.

The module operates as follows:

Line AC voltage single phase is applied to terminals 11 and 24 and approximate square wave voltages are obtained from the zener controlled bridge rectifier to supply the MAGAMP reactor 1X. The MAGAMP reactor 1X is series connected to the primary of output transformer 2X and its phase angle is adjustable by a DC control current in any of the four control windings.

Output pulses are available across the secondary windings of 2X to fire the thyristors. Figure 1 shows in phase relation the more important waveshapes of the A-305 (IL5623-5, Page 3).

Phasing of the single phase line into the A-305 is required. When connected properly, the two pulses from the output transformer secondary will control the output of the full wave bridge rectifier. When terminal 11 goes positive, the firing pulse will be from winding 3-4. The calibration portion of the module includes circuitry for a voltage regulator, IR drop compensation, and current limit protection for the single phase thyristor drive.

V. ADJUSTMENTS

The A-305 has the following adjustable potentiometers mounted on the face plate of the module:

a) Bias pot 5P.
b) Maximum armature voltage pot 1P.
c) Minimum speed pot 2P.
d) I.R. Compensation pot 3P.
e) Current limit pot 4P.

Refer to IL 5623-5, Alignment Procedure for AVT single phase drives using the A-305 module, for the setting of all potentiometers.

VI. TROUBLE SHOOTING

The normal procedures for isolating a defective part, once a module is proven defective, apply to this assembly. It is assumed that the personnel servicing this unit possess those basic skills.

VI. Trouble Shooting (cont.)

The following steps serve to instruct the service man on the procedure for determining if a module is defective or not:

1. Remove the module in question from the control.

2. Check the gating amplifier in the following way:

   a. Turn 5P to 0% or cutoff.
   b. With no external control signal, apply 115 volts, AC to terminals 11 and 13.
   c. Place 100 ohm resistors across terminals 13-14 and 16-17.
   d. Connect an oscilloscope to terminals 13-14. A pulse should appear. The width and magnitude of the pulse should conform to the value shown in section III (Electrical Specifications, output pulse figure #2). As 5P is rotated clockwise, the pulse will retard in phase angle. As the rotation of 5P is continued, the pulse will disappear.
   e. If the pulse does not conform to these specifications or react as described, the module is defective.
   f. Repeat steps (a) through (c) for output 16-17.

3. Check the calibration of the module using an ohmmeter on the resistance times one (1) scale.

VII. SPARE PARTS

It is recommended that a spare A-305 module be stocked. The A-305 module ordering identification is stamped on the nameplate located on the front of the assembly. In addition to this, it may be desirable to stock the printed circuit board assembly for repairing defective modules. The board assembly identification is etched on the component side of the board. The identification number will be a series similar to this example (999A999G01).

Your Westinghouse sales or service man can assist you with the procurement of spares.

VIII. SERVICE

Your nearest Westinghouse sales or service office will be pleased to advise you on any service problems.

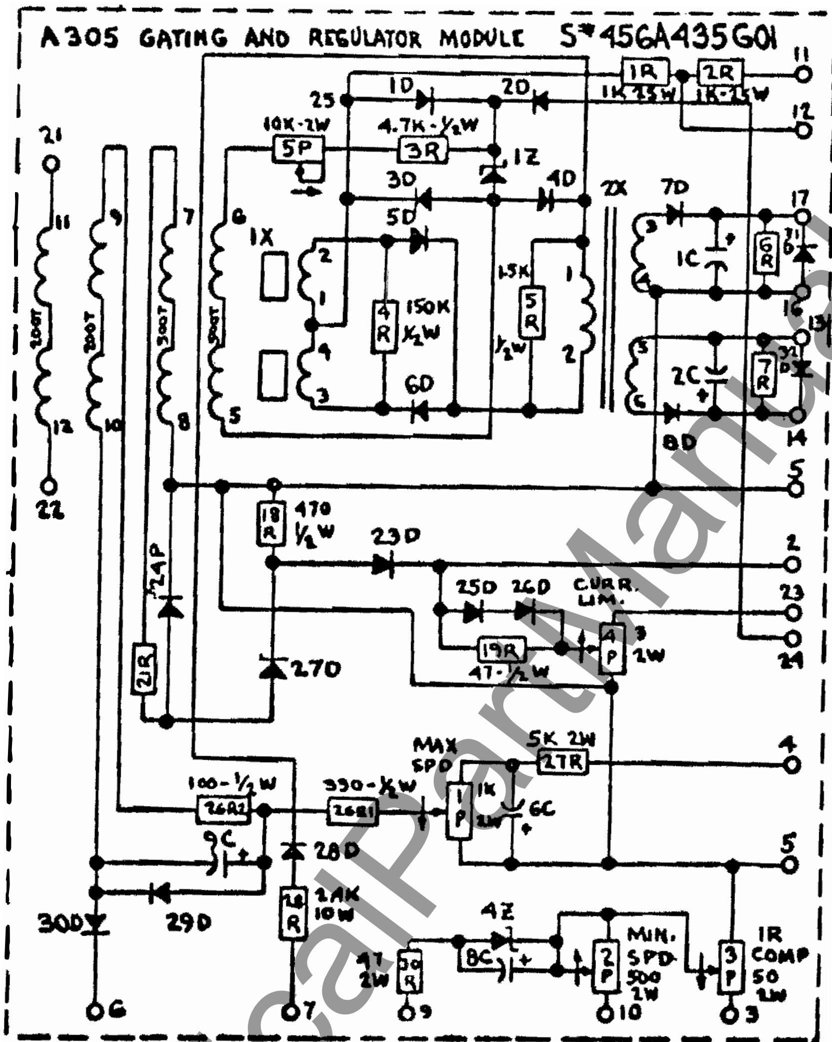

A305 GATING AND REGULATOR MODULE S# 456A435G01
MAX SPD
CURR. LIM.
MIN. SPD
IR COMP

FIGURE I