I.L.16-800-287

M5B THYRISTOR POWER SYSTEM FIELD START-UP PROCEDURE FOR MOTOR ARMATURE SUPPLIES

INDEX	SECTION

I. INTRODUCTION

These instructions provide a step - by - step procedure for the first time start-up of a M5B Thyristor Power System used as an armature supply for a d.c. motor drive.

Non -standard functions such as special sequencing, director logic, interconnection with other drives, etc. which pertain to a specific application will be covered by separate instructions.

The procedures should be followed in the specified sequence, checking each step against the schematic diagram. This will develop familiarity with the system and insure proper operation of the drive system when the sequence is completed. If difficulity is encountered at any step, the source of trouble and/or remedy may be obvious. If not, refer to "Trouble Shooting" section of this instruction leaflet for more detailed test procedures.

It should be possible to place the drive system in operation by following the start-up procedure as described, referring only to the applicable schematic diagram. However, a more efficient and confident approach requires a knowledge of fundamental functions and relations which can be obtained by referring to the Instruction Leaflets (I.L.) listed in the Appendix.

II. BASIC SYSTEM

A. General

This section is devoted to a procedure for first time start-up of the basic M5B thyristor power system. The basic system consists of the following:

1. TPM - Thyristor Power Modulator assembly, either single or double converter.

2. Basic Regulator assembly containing:

GS	-	gate synchronizer
GPG	-	gate pulse generator
TGD	-	thyristor gate driver
VC & RL	-	voltage controller and reversing logic for double converters
VS	-	voltage sensor
CC	-	current controller
SC or VRC	-	speed controller or voltage reference controller
S & P	-	sequence and protection
PS1	-	±24V, +15V regulated power supply
FI	-	fault indicator (optional)
RFG	-	ramp function generator (optional)
CAL	-	reference calibration (optional)

GS, GPG, TGD: gating system

Input and pot boards

Note: The standard basic regulator back plane contains the wiring for the optional boards.

3. a-c and d-c power circuits with standard protection (either Class 1 or Class 3) and sequencing.

B. Start - Up Procedure

1.0 Recommended Test Equipment

1.1 A multimeter with a internal impedance of 20,000 ohm/volt.

1.2 Adjustable battery powered test supply, 0-22V, with reversing and turn-off switch.

1.3 Dual beam oscilloscope such as Tektronix 502, 545 or equivalent.

NOTE: Be sure that the scope is NOT GROUNDED at the line plug or elsewhere. When the drive is energized, the scope case may be at some voltage potential above ground.

1.4 30 Pin extension board (S#1339A38G02)

2.0 Before applying a-c power:

2.1 Make a visual check of the equipment for loose wires and connections, remove blocking from relays and contactors, all function boards are present and plugged in to the basic regulator and all external connections are made.

2.2 Disconnect one side of motor armature from the drive.

2.3 Remove the RG/SC/01 or RG/VRC/01 board if used in the basic regulator.

2.4 Remove the current controller board (RG/CC/01) and replace with a 30 pin extension board (S#1339A38G02)

2.5 Plug the current controller board into the extension board and open up the jumper connection on the extension board to pin 47.

2.6 Jumper out any Zone A and Zone B contacts of Input Board 1 that do not originate in the M5B structure.

2.7 Remove any incoming -V[B]* wire from the terminal blocks of the magnetic panel assembly. Connect a ±15V VDC adjustable test voltage between -V[B]* and PSC. Set a 0 volts.

2.8 Connect a scope across pin 59 (+V[B]) and PSC of the VS board.

2.9 Make sure that the DC LOOP selector switch normally mounted on the M5B cabinet door is in the PERMISSIVE CLOSE position.

3.0 Apply rated 3 phase a-c power with phase sequence R-S-T and observe:

3.1 Transformer primary circuit breaker (if supplied) remains closed on transformer inrush. If the breaker trips out, increase the trip setting # in increments of "2" until the breaker remains closed.

3.2 Red indicating light mounted on the door indicates AC POWER ON.

3.3 Cabinet and TPM ventilating fans (if supplied) are operating and the air flow is from the bottom to the top of the structure.

3.4 Green indicating light mounted on the door indicates POWER SUPPLY READY. (Relay PSR is energized).

3.5 Voltage across CX and CY is 115V ±5V.

3.6 Light emitting diodes (LED'S) on the PS1 board indicate that PSP, PSN, and LP15 are energized.

The regulator power supply voltages should be as follows:

PSP	=	+24V ± 1V
PSN	=	-24V ± 1V
LP15	=	+15V ± 0.5V
RP	=	+24V + 4V, -2V

3.7 ZONE A, ZONE B, and the STOP LED'S on Input Board 1 are energized.

3.8 The PH. SEQ (1 LED) and the OSC (2 LED) LED'S on the RG/GS/01 board are energized.

3.9 The OC (overcurrent) LED, the PL (power loss) LED, and the ON LED on the RG/S&P/01 board are deenergized.

3.10 If the conditions in step 3.9 are not observed, the following voltages or logic signals should be checked at the following pins of the RG/S&P/01 board. (a logic "1" = +12.5V to +16V and a logic "0" = 0V to + 1.5V).

pin	4	=	logic "1"	pin	27	=	logic "1"
pin	6	=	+24V	pin	29	=	+24V
pin	7	=	0V	pin	33	=	logic "1"
pin	8	=	logic "1"	pin	36	=	logic "1"
pin	11	=	logic "1"	pin	38	=	logic "0"
pin	13	=	logic "1"	pin	39	=	logic "1"
pin	14	=	logic "0"	pin	40	=	logic "0"
pin	15	=	logic "1"	pin	41	=	logic "0"
pin	16 & 17	=	PSC	pin	44	=	logic "1"
pin	19	=	logic "1"	pin	55	=	logic "1"
pin	21	=	logic "1"	pin	57	=	0V
pin	25	=	logic "1"				

ON ALL SUBSEQUENT STEPS THROUGHOUT THIS START-UP PROCEDURE IT IS ASSUMED THAT THE SERVICE ENGINEER WILL INVESTIGATE PREVENTATIVE INTERLOCKING CIRCUITS TO ENSURE THAT THE TEST FUNCTIONS CAN BE COMPLETED.

4.0 Inner Voltage Loop Test

4.1 Close the d-c contactor (M) by connecting a jumper between terminals 19 and 20 of the Input Board 1 terminal block assembly or by closing the relay function between the above two terminals.

4.2 Observe that the M and ON LED'S on Input Board 1 are energized and the ON LED on the RG/S&P/01 board are energized. (This indicates that the d-c contactor is closed and that the current controller and the outer loop controller have been released).

4.3 Slowly adjust the test voltage applied to terminal -V[B]* of the magnetic panel from 0 to -10 volts and observe:

4.3.1 TPM output voltage waveshape should be smoothly controllerable with six pulses per cycle. The pulses should be stable and of equal magnitude over the voltage range with no random jitter. Figures 1 and 2 show typical waveform at 50% and at rated voltage. Refer to the trouble shooting section if the correct waveshapes are not obtained.

4.3.2 The TPS output voltmeter varies smoothly from 0 to approximately positive rated volts.

4.3.3 Miniature meter +V[B] varies smoothly from 0 to +9.6 volts.

4.3.4 Miniature meter -V[C1] varies smoothly from +5V $\pm$1V to + 0.4V $\pm$ 0.2V from 0 output to rated output respectively.

4.3.5 On double converters only, the FWD (1 LED) on the RG/VC&RL/01 board is energized.

4.4 For double converters, reverse the polarity of the test voltage applied in step 4.3 and observe:

4.4.1 Performance should duplicate that previously observed in steps 4.3.1 thru 4.3.4 except with all polarities reversed except -V[C1].

4.4.2 The REV [2 LED] on the RG/VC&RL/01 board is energized.

4.5 Remove a-c power.

5.0 Voltage Limit Adjustment

5.1 Disconnect the test voltage from terminal -V[B]* of the magnetic panel, and reconnect the original wiring to this point.

5.2 Close the pin 47 circuit on the extender board in which the current controller is plugged.

5.3 Apply a-c power and close the d-c loop contactor.

5.4 The bus voltage is now to be set at 104% of rated value. For this purpose the board producting -V[B]* (normally the current controller) is driven into saturation by applying the test voltage (+) to +I[D]* on the magnetic panel.

5.5 Trim the BUS VOLTAGE ADJUST pot (1P) on pot board (S#1752A05G01) to obtain 104% of rated bus voltage.

5.6 For double converters reverse the polarity of the test supply and note that the magnitude of the "reverse" output voltage is within ±2% of the "forward" output voltage in step 5.5.

5.7 Remove a-c power.

CAUTION: BEFORE CONDUCTING STALLED CURRENT TESTS ON A DC MOTOR, PLEASE REFER TO I.L.16-800-286.

6.0 Current Loop Test

6.1 Verify that the current feedback polarity is correct per the schematic information.

6.2 Set-up the following temporary conditions:

6.2.1 Remove the motor field excitation.

6.2.2 Reconnect the motor armature circuit.

6.2.3 Turn pot 2P on the pot board (S#1752A05G01) fully CW.

6.2.4 Open the red jumper (2J) with Berg terminals to pin 35 of the current controller [RG/CC/01] so that +I[D]* can only produce rated current.

6.2.5 Check that 1J on the pot board is in the 125% position.

6.2.6 Remove the Reference Calibration board [RG/CAL/01] and the Ramp Function Generator [RG/RFG/01] if used.

6.2.7 Place a scope between pin 7 of the pot board and PSC to monitor -/I[D]/F.

6.2.8 Apply the adjustable test reference to pin 35 (+I[D]*) of the current controller. Set at 0 volts.

6.2.9 Make sure that the current controller gain jumper (3J), red jumper with Berg terminals, is connected between pins 51 and 49 of RG/CC/01.

6.3 Apply a-c power and close the d-c contactor. The current reference ramp and the current controller should be released by logic generated by Input Board 1 and RG/S&P/01. (pin 27 and 29 of the CC should be +15 VDC).
Note that the output voltage remains at zero and the motor remains at stand still.

6.4 Slowly increase the test reference to +10 VDC.

6.5 With pot 2P of the pot board, adjust the armature current for defined rated current. The voltage at pin 17 of the current controller should be -2V ±5% at rated current. Refer to the trouble shooting section if -2V is not obtained.

6.6 Observe that the current feedback signal is similar to the one observed in the Inner Voltage Loop test. (six pulses per cycle of nearly equal amplitude).

6.7 Turn the current controller gain pot 4P on the pot board clockwise and move the CC gain jumper 3J (red jumper between pins 49 and 51 of the RG/CC/01) towards a higher gain position until the current feedback pulses become suddenly radically unequal (every second or third pulse is larger than others which indicates an instability of two or three times basic frequency).

The following tabulation indicates the gain changes achieved by connecting the gain jumper 3J attached to pin 51 to various other pins on the RG/CC/01 board.

JUMPER PINS	GAIN
51 - 49	Minimum gain
No jumper *	Next highest gain
51 - 53	Next highest gain
51 - 55	Highest gain

* Leave one end of the jumper on pin 51 and open the other end.

6.8 Put the gain jumper (3J) to its next lower gain position. The current loop is now dynamically adjusted.

6.9 Return the test reference to zero and remove a-c power.

7.0 Adjustment of Gate Pulse Suppression

CAUTION: BEFORE CONDUCTING STALLED CURRENT TESTS ON A DC MOTOR, PLEASE REFER TO I.L.16-800-286.

7.1 Set the Forward Gate Pulse Suppression jumper 1J on pot board S#1752A05G01 at the next highest increment setting above the desired current limit setting. Gate pulse suppression is normally set between 120% and 125% of the current limit setting. The following is a table showing the standard fixed current limit settings that are available and their corresponding GPS settings. (values based on % of rated current).

C. L. SETTING	JUMPER CONNECTIONS	G.P.S. SETTING
100%	No Jumper	125%
125%	35 - 37	150%
150%	35 - 39	185%
175%	35 - 41	215%
200%	35 - 5	245%
250%	35 - 7	310%
300%	35 - 9	370%
400% (Test only)	35 - 33	

7.2 Place the current limit setting jumper (red jumper 2J) of the current controller edge connector to its "test" position (jumper between pins 35 and 33).

7.3 Apply a-c power and close the d-c loop.

7.4 Slowly increase the test reference +I[D]* until gate pulse suppression occurs. The value should be within ±5% of the selected setting.

7.5 Return test reference to zero and depress the GATE PULSE SUPPRESSION RESET pushbutton. GPS can also be reset by shorting the two lance terminals (LN1 and LN2) provided at the front edge of the RG/S&P/01 board.

7.6 The drive should return to its "ready" state (relay PSR should be energized).

7.7 For double converters reverse the polarity of the test reference +I[D]*.

7.8 Slowly increase the test reference until gate pulse suppression occurs. This value should be within ±2% of step 7.4.

7.9 Repeat step 7.5.

7.10 Remove a-c power.

8.0 Current Limit Adjustment

8.1 Place the current limit setting jumper (red jumper 2J found on the current controller edge connector) to the desired current limit value. Refer to table in step 7.1.

8.2 Plug in the outer loop regulator board producing +I[D]*. This will normally be the RG/SC/01 or RG/VRC/01 board.

8.3 Connect the test reference to pin 17 of the SC or VRC. Set at zero volts.

8.4 Convert the outer loop controller (SC or VRC to a proportional amplifier as follows:

Speed Regulator (RG/SC/01) -

8.41 Short out the 10MFD capacitor by placing a jumper between pin 33 and 35.

8.42 Apply a small test voltage to pin 17 of RG/SC/01 and adjust the PROP. GAIN pot 3P on the meter pot panel so that the speed controller has a gain of approximately 1.

Voltage Regulator (RG/VRC/01

8.43 Connect a jumper between pins 11 and 49.

8.44 Apply a small test voltage to pin 17 of RG/VRC/01 and adjust the VOLT REF. CONT. GAIN pot 6P on pot board S#1752A05G01 so that the voltage reference controller has a gain of approximately 1.

8.5 Reset the test voltage to zero volts. Apply a-c power and close the d-c loop.

8.6 Note that the output limit value of the outer loop controller, +I[D]* (+10V + 0.2V), corresponds to the current limit setting of the drive following the calibration of 2P on the pot board.

8.7 Slowly increase the test voltage until the outer loop controller reaches its output limit value of +10V + 0.2V. The armature current should be the desired current limit value within ±5%.

DOUBLE CONVERTERS

8.8 Reverse the polarity of the test voltage.

DOUBLE CONVERTERS WITH SYMMETRICAL CURRENT LIMIT

8.9 Remove the red jumper (6J) from the back plane between pin 27 of RG/SC/01 or RG/VRC/01 and pin 57 of the pot board.

8.10 Increase the test voltage and check that the reverse current limit is ±5% of that in step 8.7.

DOUBLE CONVERTERS WITH ASYMMETRICAL CURRENT LIMIT

8.11 Turn the REVERSE CURRENT LIMIT pot 5P on the pot board full CCW.

8.12 Apply a test reference of +11V.

8.13 Turn 5P of the pot board CW until the desired "reverse" current limit value is obtained.

9.0 IR Compensation (Voltage Regulator only)

9.1 Motor field is still disconnected.

9.2 Turn IR COMPENSATION pot 2P on the meter pot panel full CCW.

9.3 The test reference is still connected to pin 17 of the RG/VRC/01 board and the controller is still connected as per step 8.43.

9.4 Apply a-c power and close the d-c loop.

9.5 Increase the negative test voltage until 10% rated aramture current (I_{nc}) is obtained.

9.6 Adjust the IR COMPENSATION pot 2P located on the meter - pot panel until the armature current (I_c) is increased as required. Percentage compensation is calculated from the two current values in steps 9.5 and 9.6 as follows:

$$\% \text{ IR COMPENSATION} = \frac{I_c - I_{nc}}{I_c} \times 100$$

NOTE: DO NOT EXCEED 50% IR COMPENSATION.

10.0 Adjustment of Dynamics of Outer Loop Controller

10.1 Speed Regulator (Type 1)

NOTE: ON SPEED REGULATED SYSTEMS (STEPS 10.1 & 10.2 BELOW), MAKE SURE POLARITY OF SPEED FEEDBACK IS CORRECT. IF MOTOR STARTS TO RUN AWAY, REMOVE A-C POWER AT ONCE.

10.11 Reconnect motor field.

10.12 Make sure there is a red jumper (5J) from pin 29 of the RG/SC/01 board to PSC.

10.13 Check to see that the tach attenuator board is connected per the table below.

TACH VOLTS @ MAX SPEED	TG+ CONN. TO TERMINAL	JUMPER REQD. BETWEEN TERMINALS
45 - 65	1	NONE
65 - 85	2	NONE
85 - 110	3	1 and 2
110 - 130	3	NONE
130 - 150	4	2 and 3
150 - 170	4	1 and 2
170 - 190	4	NONE
190 - 210	5	3 and 4
210 - 230	5	2 and 3
230 - 250	5	1 and 2

NOTE: Voltage at terminal 13 of RG/SC/01 should be approximately +46V at maximum rated speed after proper adjustment of the SPEED CALIBRATION pot 4P on the meter-pot panel. This assumes that the speed reference is approximately -10V at maximum rated speed. CAUTION: Measure this voltage with a scope or a high impedance instrument so that the circuit impedance is not changed appreciably.

10.14 Remove any temporary jumpers that were used in steps 8.0 and 9.0.

10.15 Make sure that pin 37 of RG/SC/01 will be +15V when the drive is running.

10.16 Place the speed controller gain jumper (4J) in its minimum gain position and set the SPEED CONTROLLER GAIN pot 6P on the pot board ECCW. Also set the DROOP pot 1P (on the meter-pot panel) ECCW.

10.17 Connect the test supply to pin 21 of the speed controller.

10.18 Apply the a-c power and close the d-c loop.

10.19 Apply a small negative signal into pin 21 until the motor is running at approximatley 25% rated speed. Then apply a small reference step and record speed response.

NOTE: MAKE SURE DRIVE DOES NOT GO INTO CURRENT LIMIT.

10.20 Turn gain pot 6P CW and move the gain jumper toward pin 57 to increase the gain of the speed controller while making small step reference changes. A good speed response should have 5% or less overshoot and no relaxation oscillation; i.e. motor changes speed when operating near zero speed (this usually occurs if gain is too low).

NOTE: With steady state speed, if the current trace becomes erratic, the speed gain is set too high

10.2 Speed Regulator (Type 2)

Set up a speed regulator type 2 in a similar manner as step 10.1 with the following exceptions:

a) Step 10.12 - There is no connection between pin 29 and PSC of the RG/SC/01 board.

b) Step 10.20 - Turn gain pot 6P CW and move the gain jumper toward pin 57 to increase the gain of the speed controller while making small step reference changes. A good speed response will have approximately a 20% overshoot and no relaxation oscillation; i.e. motor changes speed when operating near zero speed (this usually occurrs if gain is too low).

NOTES: 1) With steady state speed, if the current trace becomes erratic the speed gain is set to high.

2) The 20% overshoot obtained with the type 2 speed regulator is an inherent feature of the control system. It does not result from poor damping, but is due to initial conditions. Any adjustments made to reduce the overshoot will result in a very sluggish load response.

3) A motor disconnected from its load may exhibit instability tendencies and therefore it should be connected to its actual load.

10.3 Voltage Regulator (Multi-Loop)

10.31 Reconnect motor field.

10.32 Remove any temporary jumpers that we used in steps 8.0 & 9.0

10.33 Set the VOLTAGE REFERENCE CONTROLLER GAIN pot 6P on the pot board ECCW (minimum gain setting) and set the DROOP pot 1P ECCW.

10.34 Connect the test supply to pin 21 of the voltage reference controller.

10.35 Apply the a-c power and close the d-c loop.

10.36 Apply a small negative signal into pin 21 until 10% armature voltage is reached. Then apply a small reference step and record the response.

10.37 Increase the voltage gain by turning pot 6P CW so that the output voltage has a sharp response as possible to a step reference input.

NOTES: 1) Ensure that the drive does not go into current limit.

2) Dynamic adjustment of the voltage loop is affected by settings of the gain pot 6P, droop pot 1P (on the meter-pot panel), IR compensation pot 2P (on the meter-pot panel), as well as the gain established in the current controller. Usually satisfactory performance can be obtained over a wide range of potentiometer settings as long as a little droop is used.

3) If the voltage gain is set extremely high, it can produce instability in the drive. Erratic current conduction could occur while running at steady state speed.

4) If IR compensation is used, some overshoot will occur. If the overshoot is to large, decrease the gain of the voltage reference controller or decrease the amount of IR compensation.

11.0 DROOP

11.1 De-energize thyristor power supply.

11.2 Remove the outer loop controller (RG/SC/01 or RG/VRC/01) and replace with a 30 pin extension board S#1339A38G02).

11.3 Plug the outer loop controller board into the extension board and open up the following jumper connections to pins 13, 21, 37, 39.

11.4 Remove the current controller board.

11.5 Place the DROOP pot 1P (located on the meter-pot panel) to ECCW.

11.6 Apply ± 24V power.

11.7 Energize static relays 1CR and 2CR of the outer loop controller by applying PSC to pins 37 and 39.

11.8 Apply a negative reference to terminal 21 corresponding to speed droop in % of top speed at stall current limit. (Example: Reference at top speed at pin 21 is -10 volts. Desired droop at current limit is 5%. Apply -0.5 volts (.05 X10V) reference to pin 21.

11.9 The outer loop controller should limit at approximately +10 volts.

11.10 Gradually turn DROOP pot 1P CW until the amplifier starts to come out of staturation, which represents the desired droop setting.

III. TROUBLE SHOOTING

A. General

This discussion is restricted to the standard M5B basic regulator system as used for d-c motor armature. Since the equipment was tested at the factory, it is assumed that any trouble is due to component failure rather than incorrect wiring. In case of trouble in the basic TPS system the start-up procedure described in Section II provides an organized approach to trouble shooting. Those steps involving voltage measurements and sequence checks are considered to be self explanatory. However, if trouble is encountered in checking the basic regulator, the following trouble shooting procedure may be used.

B. Basic Regulator

1.0 Incorrect TPM Output Waveshape

1.1 If the waveshape is not similar to figure 1 or figure 2, a missing pulse is immediately apparent and indicates the corresponding thyristor is not firing. Check for open fuses or an open gate circuit. A typical pulse train is seen in figure 3. This trace is obtained when a scope is connected across the gate of a thyristor at the pulse transformer and RC board (located on the TPM) with "G" (gate) positive with respect to "K" (cathode).

NOTE: The thyristor firing sequence is identified by color code as follows:

1TH = Brown		4TH = Yellow	
2TH = Red		5TH = Green	
3TH = Orange (or White)		6TH = Blue	

IF THE PROBLEM IS NOT THE THYRISTOR OR A BLOWN FUSE, WE THEN WILL ASSUME IT'S IN THE TGD OR GPG'S.

WITH THE ASSUMPTION THAT THE GATE SYNC. BOARD IS OPERATING CORRECTLY, CHECK THE FOLLOWING BOARD OUTPUTS:

1.2 Check the output of the gate pulse generators (S#1671A17G01) as follows:

1.2.1 Remove the PC board producing the +V[C1] signal, i.e. the RG/VC&RL/01 board for a double converter or the RG/CC/01 board for a single converter.

1.2.2 Tie pin 57 of the gate synchronizing board (RG/GS/01) to PSC.

1.2.3 If a double converter, remove the "REV" TGD board.

1.2.4 Keep the d-c loop open..

1.2.5 Make sure when the system is energized that all permissive signals to the "FWD" TGD board are as follows:

pin 41 = logic "1"
pin 11 = logic "1"
pin 15 = PSC

1.2.6 CALIBRATE SCOPE PROBES. Set scope on line sync. and chopped mode.

1.2.7 Put scope probe 1 on X1 (brown lead) of the gate control transformer with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of the a-c wave is 70 volts ± 7V peak to PSC.

1.2.8 Put scope probe 2 on pin 5 (GP1) of the RG/GPG/01 board (pulse 1,3,5) with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of pulse is +15V ±2V (PULSE #1).

1.2.9 Apply a-c power.

1.2.10 Superimpose the two wave forms and compare to figure 5. Note that the delay angle is approximately 145° and the pulse train is approximately 85° long.

1.2.11 The remaining pulse trains can be checked in a similar manner.

PULSE #2 (GP2) - Move probe 1 to X2 (red lead) of the gate control transformer. Move probe 2 to pin 5 of the pulse 2,4,6, GPG.
The trace should be the same as figure 5.

PULSE #3 thru #6- Move probe 1 per color code sequence with respect to GP3 thru GP6 for the two GPG boards. Compare to figure 5.

1.2.12 If all GPG outputs check out OK, proceed to step 1.3.

1.3 Check the output of the thyristor gate driver (S#1668A25G01) as follows:

1.3.1 Set-up conditions the same as steps 1.2.1 thru 1.2.6.

1.3.2 Probe 1 of scope is to be used the same as in step 1.2.7.

1.3.3 Put scope probe 2 on pin 29 (brown) of the FWD TGD with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of pulse is +22V ±3V (PULSE #1)

1.3.4 Apply a-c power.

1.3.5 Superimpose the two wave forms and compare to figure 4. Note that the delay angle is approximately 145° and the pulse train is approximately 85° long (start of first pulse to the end of the last pulse of the pulse train and does not include the exponential decay).

1.3.6 The remaining pulse trains can be checked in a similar manner.

PULSE #2 - Move probe 1 to X2 (red lead) of the gate control transformer.
Move probe 2 to pin 27 (red) of the FWD TGD.
The trace should be the same as figure 4.

PULSE #3 thru 6 - Move probes per color code firing sequence as specified in step 1.1.
Compare to figure 4.

1.3.7 For double converter remove the "FWD" TGD and replace the "REV" TGD in its prober edge connector
Repeat steps 1.3.1 thru 1.3.6 making sure that the permissive signals to the "REV" TGD are the same as in step 1.2.5.

1.4 If all the waveforms have checked out up to this point and the source of trouble has not been located, please refer to I.L.16-800-289 for further information.

2.0 Incorrect Current Feedback Signal

2.1 If the current sensor output is not -2V at rated armature current several things could be wrong:

2.1.1 Primary turns (used only for small HP drives) may be incorrect.

2.1.2 PC board could have a cold solder joint.

2.1.3 CT ratio could be incorrect.

$$\text{C.S. Output (volts)} = \frac{I_{DC} \times 0.76 \times 5X \text{ PRI. TURNS}}{CT}$$

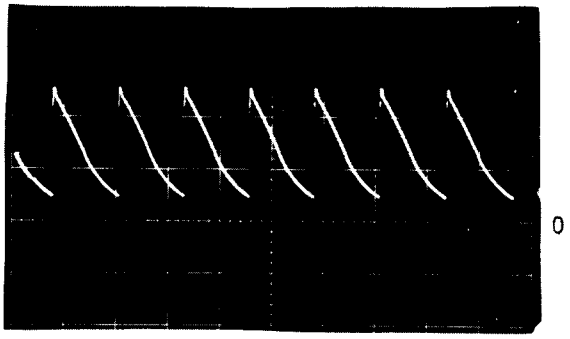
where:

I_{DC} = d-c armature current

PRI TURNS = # of cable loops thru CT +1
(this will normally be = 1 except for small HP drives)

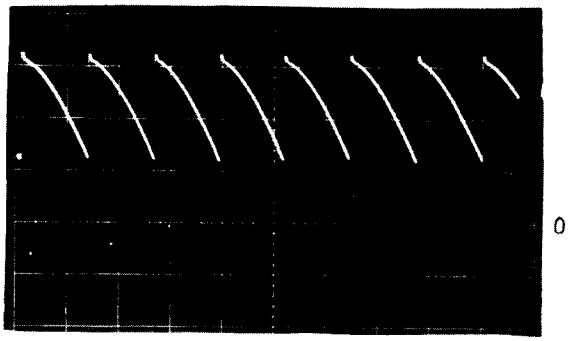
CT = current transformer primary ampere rating (200, 400, or 600) as marked on the CT.

IV APPENDIX



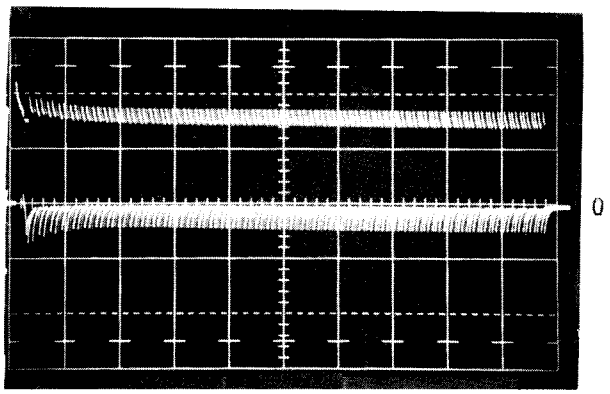
50% VOLTAGE 2ms/cm

FIG. 1



RATED VOLTAGE 2ms/cm

FIG. 2



1V/cm
0.2 ms/cm (uncalibrated)

FIG. 3

THYRISTOR GATE PULSE TRAIN

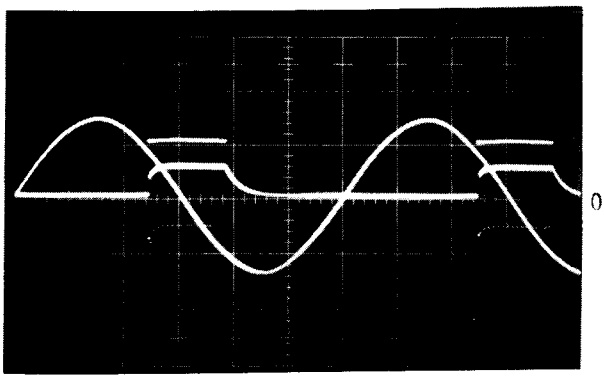


FIG. 4

THYRISTOR GATE DRIVER OUTPUT PULSE TRAIN

50V/cm - GCT Output
20V/cm - TGD Output
1ms/cm - (uncalibrated)

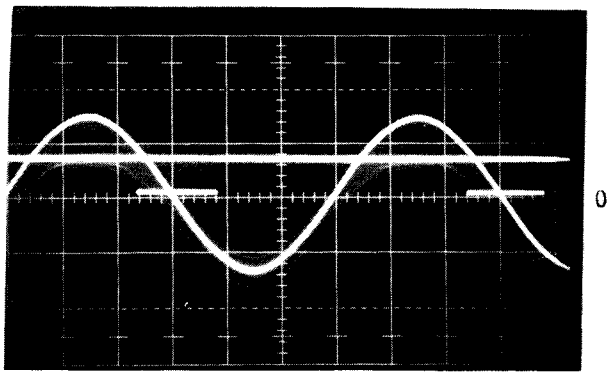


FIG. 5

GATE PULSE GENERATOR OUTPUT PULSE TRAIN

50V/cm - GCT Output
20V/cm - GPG Output
1ms/cm - (uncalibrated)

INSTRUCTION LEAFLETS (REFERENCE)

The following instruction leaflets (I.L.) describe the M5B system and its standard components.

SYSTEMS AND BASIC REGULATOR

I.L. 16-800-288	M5B	Thyristor Power System
16-800-289	M5B	Gating System

V SERVICE

Personnel familiar with electrical equipment utilizing semiconductors can isolate most problems using an oscilloscope, multimeter, and information contained in the instruction leaflet.

Semiautomatic equipment is available at the factory to test static and dynamic performance of all edge-connected printed circuit boards. Generally, repair of boards is facilitated by returning them to:

Westinghouse Electric Corporation
Industrial Systems Division
P.O. Box 225
Buffalo, New York 14240

Printed in USA

Westinghouse Electric Corporation
Industrial Systems Division; Buffalo, New York

M5B THYRISTOR POWER SYSTEM FIELD START-UP PROCEDURE FOR MOTOR ARMATURE SUPPLIES

INDEX	SECTION

I. INTRODUCTION

These instructions provide a step - by - step procedure for the first time start-up of a M5B Thyristor Power System used as an armature supply for a d.c. motor drive.

Non -standard functions such as special sequencing, director logic, interconnection with other drives, etc. which pertain to a specific application will be covered by separate instructions.

The procedures should be followed in the specified sequence, checking each step against the schematic diagram. This will develop familiarity with the system and insure proper operation of the drive system when the sequence is completed. If difficulty is encountered at any step, the source of trouble and/or remedy may be obvious. If not, refer to "Trouble Shooting" section of this instruction leaflet for more detailed test procedures.

It should be possible to place the drive system in operation by following the start-up procedure as described, referring only to the applicable schematic diagram. However, a more efficient and confident approach requires a knowledge of fundamental functions and relations which can be obtained by referring to the Instruction Leaflets (I.L.) listed in the Appendix.

II. BASIC SYSTEM

A. General

This section is devoted to a procedure for first time start-up of the basic M5B thyristor power system. The basic system consists of the following:

1. TPM - Thyristor Power Modulator assembly, either single or double converter.

SUPERSEDES I.L. 16-800-287
EFFECTIVE MAY 1979

2. Basic Regulator assembly containing:

GS	-	gate synchronizer
GPG	-	gate pulse generator
TGD	-	thyristor gate driver
		gating system
VC & RL	-	voltage controller and reversing logic for double converters
VS	-	voltage sensor
CC	-	current controller
SC or VRC	-	speed controller or voltage reference controller
S & P	-	sequence and protection
PS1	-	±24V, +15V regulated power supply
FI	-	fault indicator (optional)
RFG	-	ramp function generator (optional)
CAL	-	reference calibration (optional)

Input and pot boards

Note: The standard basic regulator back plane contains the wiring for the optional boards.

3. a-c and d-c power circuits with standard protection (either Class 1 or Class 3) and sequencing.

B. Start - Up Procedure

1.0 Recommended Test Equipment

1.1 A multimeter with a internal impedance of 20,000 ohm/volt.

1.2 Adjustable battery powered test supply, 0-22V, with reversing and turn-off switch.

1.3 Dual beam oscilloscope such as Tektronix 502, 545 or equivalent.

NOTE: Be sure that the scope is NOT GROUNDED at the line plug or elsewhere. When the drive is energized, the scope case may be at some voltage potential above ground.

1.4 30 Pin extension board (S#1339A38G02)

2.0 Before applying a-c power:

2.1 Make a visual check of the equipment for loose wires and connections, remove blocking from relays and contactors, all function boards are present and plugged in to the basic regulator and all external connections are made.

2.2 Disconnect one side of motor armature from the drive.

2.3 Remove the RG/SC/01 or RG/VRC/01 board if used in the basic regulator.

2.4 Remove the current controller board (RG/CC/01) and replace with a 30 pin extension board (S#1339A38G02)

2.5 Plug the current controller board into the extension board and open up the jumper connection on the extension board to pin 47.

2.6 Jumper out any Zone A and Zone B contacts of Input Board 1 that do not originate in the M5B structure.

2.7 Remove any incoming -V[B]* wire from the terminal blocks of the magnetic panel assembly. Connect a ±15V VDC adjustable test voltage between -V[B]* and PSC. Set a 0 volts.

2.8 Connect a scope across pin 59 (+V[B]) and PSC of the VS board.

2.9 Make sure that the DC LOOP selector switch normally mounted on the M5B cabinet door is in the PERMISSIVE CLOSE position.

3.0 Apply rated 3 phase a-c power with phase sequence R-S-T and observe:

3.1 Transformer primary circuit breaker (if supplied) remains closed on transformer inrush. If the breaker trips out, increase the trip setting # in increments of "2" until the breaker remains closed.

3.2 Red indicating light mounted on the door indicates AC POWER ON.

3.3 Cabinet and TPM ventilating fans (if supplied) are operating and the air flow is from the bottom to the top of the structure.

3.4 Green indicating light mounted on the door indicates POWER SUPPLY READY. (Relay PSR is energized).

3.5 Voltage across CX and CY is 115V ±5V.

3.6 Light emitting diodes (LED'S) on the PS1 board indicate that PSP, PSN, and LP15 are energized.

The regulator power supply voltages should be as follows:

PSP	=	+24V ± 1V
PSN	=	-24V ± 1V
LP15	=	+15V ± 0.5V
RP	=	+24V + 4V, -2V

3.7 ZONE A, ZONE B, and the STOP LED'S on Input Board 1 are energized.

3.8 The PH. SEQ (1 LED) and the OSC (2 LED) LED'S on the RG/GS/01 board are energized.

3.9 The OC (overcurrent) LED, the PL (power loss) LED, and the ON LED on the RG/S&P/01 board are deenergized.

3.10 If the conditions in step 3.9 are not observed, the following voltages or logic signals should be checked at the following pins of the RG/S&P/01 board. (a logic "1" = +12.5V to +16V and a logic "0" = 0V to + 1.5V).

pin	4	=	logic "1"	pin	27	=	logic "1"
pin	6	=	+24V	pin	29	=	+24V
pin	7	=	0V	pin	33	=	logic "1"
pin	8	=	logic "1"	pin	36	=	logic "1"
pin	11	=	logic "1"	pin	38	=	logic "0"
pin	13	=	logic "1"	pin	39	=	logic "1"
pin	14	=	logic "0"	pin	40	=	logic "0"
pin	15	=	logic "1"	pin	41	=	logic "0"
pin	16 & 17	=	PSC	pin	44	=	logic "1"
pin	19	=	logic "1"	pin	55	=	logic "1"
pin	21	=	logic "1"	pin	57	=	0V
pin	25	=	logic "1"				

ON ALL SUBSEQUENT STEPS THROUGHOUT THIS START-UP PROCEDURE IT IS ASSUMED THAT THE SERVICE ENGINEER WILL INVESTIGATE PREVENTATIVE INTERLOCKING CIRCUITS TO ENSURE THAT THE TEST FUNCTIONS CAN BE COMPLETED.

4.0 Inner Voltage Loop Test

4.1 Close the d-c contactor (M) by connecting a jumper between terminals 19 and 20 of the Input Board 1 terminal block assembly or by closing the relay function between the above two terminals.

4.2 Observe that the M and ON LED'S on Input Board 1 are energized and the ON LED on the RG/S&P/01 board are energized. (This indicates that the d-c contactor is closed and that the current controller and the outer loop controller have been released).

4.3 Slowly adjust the test voltage applied to terminal -V[B]* of the magnetic panel from 0 to -10 volts and observe:

4.3.1 TPM output voltage waveshape should be smoothly controllerable with six pulses per cycle. The pulses should be stable and of equal magnitude over the voltage range with no random jitter. Figures 1 and 2 show typical waveform at 50% and at rated voltage. Refer to the trouble shooting section if the correct waveshapes are not obtained.

4.3.2 The TPS output voltmeter varies smoothly from 0 to approximately positive rated volts.

4.3.3 Miniature meter +V[B] varies smoothly from 0 to +9.6 volts.

4.3.4 Miniature meter -V[C1] varies smoothly from +5V $\pm$1V to + 0.4V $\pm$ 0.2V from 0 output to rated output respectively.

4.3.5 On double converters only, the FWD (1 LED) on the RG/VC&RL/01 board is energized.

4.4 For double converters, reverse the polarity of the test voltage applied in step 4.3 and observe:

4.4.1 Performance should duplicate that previously observed in steps 4.3.1 thru 4.3.4 except with all polarities reversed except -V[C1].

4.4.2 The REV [2 LED] on the RG/VC&RL/01 board is energized.

4.5 Remove a-c power.

5.0 Voltage Limit Adjustment

5.1 Disconnect the test voltage from terminal -V[B]* of the magnetic panel, and reconnect the original wiring to this point.

5.2 Close the pin 47 circuit on the extender board in which the current controller is plugged.

5.3 Apply a-c power and close the d-c loop contactor.

5.4 The bus voltage is now to be set at 104% of rated value. For this purpose the board producting -V[B]* (normally the current controller) is driven into saturation by applying the test voltage (+) to +I[D]* on the magnetic panel.

5.5 Trim the BUS VOLTAGE ADJUST pot (1P) on pot board (S#1752A05G01) to obtain 104% of rated bus voltage.

5.6 For double converters reverse the polarity of the test supply and note that the magnitude of the "reverse" output voltage is within ±2% of the "forward" output voltage in sten 5.5.

5.7 Remove a-c power.

CAUTION: BEFORE CONDUCTING STALLED CURRENT TESTS ON A DC MOTOR, PLEASE REFER TO I.L.16-800-286.

6.0 Current Loop Test

6.1 Verify that the current feedback polarity is correct per the schematic information.

6.2 Set-up the following temporary conditions:

6.2.1 Remove the motor field excitation.

6.2.2 Reconnect the motor armature circuit.

6.2.3 Turn pot 2P on the pot board (S#1752A05G01) fully CW.

6.2.4 Open the red jumper (2J) with Berg terminals to pin 35 of the current controller [RG/CC/01] so that +I[D]* can only produce rated current.

6.2.5 Check that 1J on the pot board is in the 125% position.

6.2.6 Remove the Reference Calibration board [RG/CAL/01] and the Ramp Function Generator [RG/RFG/01] if used.

6.2.7 Place a scope between pin 7 of the pot board and PSC to monitor -/I[D]/F.

6.2.8 Apply the adjustable test reference to pin 35 (+I[D]*) of the current controller. Set at 0 volts.

6.2.9 Make sure that the current controller gain jumper (3J), red jumper with Berg terminals, is connected between pins 51 and 49 of RG/CC/01.

6.3 Apply a-c power and close the d-c contactor. The current reference ramp and the current controller should be released by logic generated by Input Board 1 and RG/S&P/01. (pin 27 and 29 of the CC should be +15 VDC).
Note that the output voltage remains at zero and the motor remains at stand still.

6.4 Slowly increase the test reference to +10 VDC.

6.5 With pot 2P of the pot board, adjust the armature current for defined rated current. The voltage at pin 17 of the current controller should be -2V ±5% at rated current. Refer to the trouble shooting section if -2V is not obtained.

6.6 Observe that the current feedback signal is similar to the one observed in the Inner Voltage Loop test. (six pulses per cycle of nearly equal amplitude).

6.7 Turn the current controller gain pot 4P on the pot board clockwise and move the CC gain jumper 3J (red jumper between pins 49 and 51 of the RG/CC/01) towards a higher gain position until the current feedback pulses become suddenly radically unequal (every second or third pulse is larger than others which indicates an instability of two or three times basic frequency).

The following tabulation indicates the gain changes achieved by connecting the gain jumper 3J attached to pin 51 to various other pins on the RG/CC/01 board.

JUMPER PINS	GAIN
51 - 49	Minimum gain
No jumper *	Next highest gain
51 - 53	Next highest gain
51 - 55	Highest gain

* Leave one end of the jumper on pin 51 and open the other end.

6.8 Put the gain jumper (3J) to its next lower gain position. The current loop is now dynamically adjusted.

6.9 Return the test reference to zero and remove a-c power.

7.0 Adjustment of Gate Pulse Suppression

CAUTION: BEFORE CONDUCTING STALLED CURRENT TESTS ON A DC MOTOR, PLEASE REFER TO I.L.16-800-286.

7.1 Set the Forward Gate Pulse Suppression jumper 1J on pot board S#1752A05G01 at the next highest increment setting above the desired current limit setting. Gate pulse suppression is normally set between 120% and 125% of the current limit setting. The following is a table showing the standard fixed current limit settings that are available and their corresponding GPS settings. (values based on % of rated current).

C. L. SETTING	JUMPER CONNECTIONS	G.P.S. SETTING
100%	No Jumper	125%
125%	35 - 37	150%
150%	35 - 39	185%
175%	35 - 41	215%
200%	35 - 5	245%
250%	35 - 7	310%
300%	35 - 9	370%
400% (Test only)	35 - 33	

7.2 Place the current limit setting jumper (red jumper 2J) of the current controller edge connector to its "test" position (jumper between pins 35 and 33).

7.3 Apply a-c power and close the d-c loop.

7.4 Slowly increase the test reference +I[D]* until gate pulse suppression occurs. The value should be within ±5% of the selected setting.

7.5 Return test reference to zero and depress the GATE PULSE SUPPRESSION RESET pushbutton. GPS can also be reset by shorting the two lance terminals (LN1 and LN2) provided at the front edge of the RG/S&P/01 board.

7.6 The drive should return to its "ready" state (relay PSR should be energized).

7.7 For double converters reverse the polarity of the test reference +I[D]*.

7.8 Slowly increase the test reference until gate pulse suppression occurs. This value should be within ±2% of step 7.4.

7.9 Repeat step 7.5.

7.10 Remove a-c power.

8.0 Current Limit Adjustment

8.1 Place the current limit setting jumper (red jumper 2J found on the current controller edge connector) to the desired current limit value. Refer to table in step 7.1.

8.2 Plug in the outer loop regulator board producing +I[D]*. This will normally be the RG/SC/01 or RG/VRC/01 board.

8.3 Connect the test reference to pin 17 of the SC or VRC. Set at zero volts.

8.4 Convert the outer loop controller (SC or VRC to a proportional amplifier as follows:

Speed Regulator (RG/SC/01) -

8.41 Short out the 10MFD capacitor by placing a jumper between pin 33 and 35.

8.42 Apply a small test voltage to pin 17 of RG/SC/01 and adjust the PROP. GAIN pot 3P on the meter pot panel so that the speed controller has a gain of approximately 1.

Voltage Regulator (RG/VRC/01

8.43 Connect a jumper between pins 11 and 49.

8.44 Apply a small test voltage to pin 17 of RG/VRC/01 and adjust the VOLT REF. CONT. GAIN pot 6P on pot board S#1752A05G01 so that the voltage reference controller has a gain of approximately 1.

8.5 Reset the test voltage to zero volts. Apply a-c power and close the d-c loop.

8.6 Note that the output limit value of the outer loop controller, +I[D]* (+10V + 0.2V), corresponds to the current limit setting of the drive following the calibration of 2P on the pot board.

8.7 Slowly increase the test voltage until the outer loop controller reaches its output limit value of +10V + 0.2V. The armature current should be the desired current limit value within ±5%.

DOUBLE CONVERTERS

8.8 Reverse the polarity of the test voltage.

DOUBLE CONVERTERS WITH SYMMETRICAL CURRENT LIMIT

8.9 Remove the red jumper (61) from the back plane between pin 27 of RG/SC/01 or RG/VRC/01 and pin 57 of the pot board.

8.10 Increase the test voltage and check that the reverse current limit is ±5% of that in step 8.7.

DOUBLE CONVERTERS WITH ASYMMETRICAL CURRENT LIMIT

8.11 Turn the REVERSE CURRENT LIMIT pot 5P on the pot board full CCW.

8.12 Apply a test reference of +11V.

8.13 Turn 5P of the pot board CW until the desired "reverse" current limit value is obtained.

9.0 IR Compensation (Voltage Regulator only)

9.1 Motor field is still disconnected.

9.2 Turn IR COMPENSATION pot 2P on the meter pot panel full CCW.

9.3 The test reference is still connected to pin 17 of the RG/VRC/01 board and the controller is still connected as per step 8.43.

9.4 Apply a-c power and close the d-c loop.

9.5 Increase the negative test voltage until 10% rated aramture current (I_{nc}) is obtained.

9.6 Adjust the IR COMPENSATION pot 2P located on the meter - pot panel until the armature current (I_c) is increased as required. Percentage compensation is calculated from the two current values in steps 9.5 and 9.6 as follows:

$$\% \text{ IR COMPENSATION} = \frac{I_c - Inc}{I_c} \times 100$$

NOTE: DO NOT EXCEED 50% IR COMPENSATION.

10.0 Adjustment of Dynamics of Outer Loop Controller

10.1 Speed Regulator (Type 1)

NOTE: ON SPEED REGULATED SYSTEMS (STEPS 10.1 & 10.2 BELOW), MAKE SURE POLARITY OF SPEED FEEDBACK IS CORRECT. IF MOTOR STARTS TO RUN AWAY, REMOVE A-C POWER AT ONCE.

10.11 Reconnect motor field.

10.12 Make sure there is a red jumper (5J) from pin 29 of the RG/SC/01 board to PSC.

10.13 Check to see that the tach attenuator board is connected per the table below.

TACH VOLTS @ MAX SPEED	TG+ CONN. TO TERMINAL	JUMPER READ. BETWEEN TERMINALS
45 - 65	1	NONE
65 - 85	2	NONE
85 - 110	3	1 and 2
110 - 130	3	NONE
130 - 150	4	2 and 3
150 - 170	4	1 and 2
170 - 190	4	NONE
190 - 210	5	3 and 4
210 - 230	5	2 and 3
230 - 250	5	1 and 2

NOTE: Voltage at terminal 13 of RG/SC/01 should be approximately +46V at maximum rated speed after proper adjustment of the SPEED CALIBRATION pot 4P on the meter-pot panel. This assumes that the speed reference is approximately -10V at maximum rated speed. CAUTION: Measure this voltage with a scope or a high impedance instrument so that the circuit impedance is not changed appreciably.

10.14 Remove any temporary jumpers that were used in steps 8.0 and 9.0.

10.15 Make sure that pin 37 of RG/SC/01 will be +15V when the drive is running.

10.16 Place the speed controller gain jumper (4J) in its minimum gain position and set the SPEED CONTROLLER GAIN pot 6P on the pot board ECCW. Also set the DROOP pot 1P (on the meter-pot panel) ECCW.

10.17 Connect the test supply to pin 21 of the speed controller.

10.18 Apply the a-c power and close the d-c loop.

10.19 Apply a small negative signal into pin 21 until the motor is running at approximately 25% rated speed. Then apply a small reference step and record speed response.

NOTE: MAKE SURE DRIVE DOES NOT GO INTO CURRENT LIMIT.

10.20 Turn gain pot 6P CW and move the gain jumper toward pin 57 to increase the gain of the speed controller while making small step reference changes. A good speed response should have 5% or less overshoot and no relaxation oscillation; i.e. motor changes speed when operating near zero speed (this usually occurs if gain is too low).

NOTE: With steady state speed, if the current trace becomes erratic, the speed gain is set too high

10.2 Speed Regulator (Type 2)

Set up a speed regulator type 2 in a similar manner as step 10.1 with the following exceptions:

a) Step 10.12 - There is no connection between pin 29 and PSC of the RG/SC/01 board.

b) Step 10.20 - Turn gain pot 6P CW and move the gain jumper toward pin 57 to increase the gain of the speed controller while making small step reference changes. A good speed response will have approximately a 20% overshoot and no relaxation oscillation; i.e. motor changes speed when operating near zero speed (this usually occurrs if gain is too low).

NOTES: 1) With steady state speed, if the current trace becomes erratic the speed gain is set to high.

2) The 20% overshoot obtained with the type 2 speed regulator is an inherent feature of the control system. It does not result from poor damping, but is due to initial conditions. Any adjustments made to reduce the overshoot will result in a very sluggish load response.

3) A motor disconnected from its load may exhibit instability tendencies and therefore it should be connected to its actual load.

10.3 Voltage Regulator (Multi-Loop)

10.31 Reconnect motor field.

10.32 Remove any temporary jumpers that we used in steps 8.0 & 9.0

10.33 Set the VOLTAGE REFERENCE CONTROLLER GAIN pot 6P on the pot board FCCW (minimum gain setting) and set the DROOP pot 1P FCCW.

10.34 Connect the test supply to pin 21 of the voltage reference controller.

10.35 Apply the a-c power and close the d-c loop.

10.36 Apply a small negative signal into pin 21 until 10% armature voltage is reached. Then apply a small reference step and record the response.

10.37 Increase the voltage gain by turning pot 6P CW so that the output voltage has a sharp response as possible to a step reference input.

NOTES: 1) Ensure that the drive does not go into current limit.

2) Dynamic adjustment of the voltage loop is affected by settings of the gain pot 6P, droop pot 1P (on the meter-pot panel), IR compensation pot 2P (on the meter-pot panel), as well as the gain established in the current controller. Usually satisfactory performance can be obtained over a wide range of potentiometer settings as long as a little droop is used.

3) If the voltage gain is set extremely high, it can produce instability in the drive. Erratic current conduction could occur while running at steady state speed.

4) If IR compensation is used, some overshoot will occur. If the overshoot is to large, decrease the gain of the voltage reference controller or decrease the amount of IP compensation.

11.0 DROOP

11.1 De-energize thyristor power supply.

11.2 Remove the outer loop controller (RG/SC/01 or RG/VRC/01) and replace with a 30 pin extension board S#1339A38G02).

11.3 Plug the outer loop controller board into the extension board and open up the following jumper connections to pins 13, 21, 37, 39.

11.4 Remove the current controller board.

11.5 Place the DROOP pot 1P (located on the meter-pot panel) to ECCM.

11.6 Apply ± 24V power.

11.7 Energize static relays 1CR and 2CR of the outer loop controller by applying PSC to pins 37 and 39.

11.8 Apply a negative reference to terminal 21 corresponding to speed droop in % of top speed at stall current limit. (Example: Reference at top speed at pin 21 is -10 volts. Desired droop at current limit is 5%. Apply -0.5 volts (.05 X10V) reference to pin 21.

11.9 The outer loop controller should limit at approximately +10 volts.

11.10 Gradually turn DROOP pot 1P CW until the amplifier starts to come out of staturation, which represents the desired droop setting.

III..TROUBLE SHOOTING

A. General

This discussion is restricted to the standard M5B basic regulator system as used for d-c motor armature. Since the equipment was tested at the factory, it is assumed that any trouble is due to component failure rather than incorrect wiring. In case of trouble in the basic TPS system the start-up procedure described in Section II provides an organized approach to trouble shooting. Those steps involving voltage measurements and sequence checks are considered to be self explanatory. However, if trouble is encountered in checking the basic regulator, the following trouble shooting procedure may be used.

B. Basic Regulator

1.0 Incorrect TPM Output Waveshape

1.1 If the waveshape is not similar to figure 1 or figure 2, a missing pulse is immediately apparent and indicates the corresponding thyristor is not firing. Check for open fuses or an open gate circuit. A typical pulse train is seen in figure 3. This trace is obtained when a scope is connected across the gate of a thyristor at the pulse transformer and RC board (located on the TPM) with "G" (gate) positive with respect to "K" (cathode).

NOTE: The thyristor firing sequence is identified by color code as follows:

1TH = Brown		4TH = Yellow	
2TH = Red		5TH = Green	
3TH = Orange (or White)		6TH = Blue	

IF THE PROBLEM IS NOT THE THYRISTOR OR A BLOWN FUSE, WE THEN WILL ASSUME IT'S IN THE TGD OR GPG'S.

WITH THE ASSUMPTION THAT THE GATE SYNC. BOARD IS OPERATING CORRECTLY, CHECK THE FOLLOWING BOARD OUTPUTS:

1.2 Check the output of the gate pulse generators (S#1671A17G01) as follows:

1.2.1 Remove the PC board producing the +V[C1] signal, i.e. the RG/VC&RL/01 board for a double converter or the RG/CC/01 board for a single converter.

1.2.2 Tie pin 57 of the gate synchronizing board (RG/GS/01) to PSC.

1.2.3 If a double converter, remove the "REV" TGD board.

1.2.4 Keep the d-c loop open..

1.2.5 Make sure when the system is energized that all permissive signals to the "FWD" TGD board are as follows:

pin 41 = logic "1"
pin 11 = logic "1"
pin 15 = PSC

1.2.6 CALIBRATE SCOPE PROBES. Set scope on line sync. and chopped mode.

1.2.7 Put scope probe 1 on X1 (brown lead) of the gate control transformer with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of the a-c wave is 70 volts ± 7V peak to PSC.

1.2.8 Put scope probe 2 on pin 5 (GP1) of the RG/GPG/01 board (pulse 1,3,5) with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of pulse is +15V ±2V (PULSE #1).

1.2.9 Apply a-c power.

1.2.10 Superimpose the two wave forms and compare to figure 5. Note that the delay angle is approximately 145° and the pulse train is approximately 85° long.

1.2.11 The remaining pulse trains can be checked in a similar manner.

PULSE #2 (GP2) - Move probe 1 to X2 (red lead) of the gate control transformer. Move probe 2 to pin 5 of the pulse 2,4,6, GPG.
The trace should be the same as figure 5.

PULSE #3 thru #6- Move probe 1 per color code sequence with respect to GP3 thru GP6 for the two GPG boards. Compare to figure 5.

1.2.12 If all GPG outputs check out OK, proceed to step 1.3.

1.3 Check the output of the thyristor gate driver (S#1658A25G01) as follows:

1.3.1 Set-up conditions the same as steps 1.2.1 thru 1.2.6.

1.3.2 Probe 1 of scope is to be used the same as in step 1.2.7.

1.3.3 Put scope probe 2 on pin 29 (brown) of the FWD TGD with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of pulse is +22V ±3V (PULSE #1)

1.3.4 Apply a-c power.

1.3.5 Superimpose the two wave forms and compare to figure 4. Note that the delay angle is approximately 145° and the pulse train is approximately 85° long (start of first pulse to the end of the last pulse of the pulse train and does not include the exponential decay).

1.3.6 The remaining pulse trains can be checked in a similar manner.

PULSE #2 - Move probe 1 to X2 (red lead) of the gate control transformer.
Move probe 2 to pin 27 (red) of the FWD TGD.
The trace should be the same as figure 4.

PULSE #3 thru 6 - Move probes per color code firing sequence as specified in step 1.1.
Compare to figure 4.

1.3.7 For double converter remove the "FWD" TGD and replace the "REV" TGD in its prober edge connector
Repeat steps 1.3.1 thru 1.3.6 making sure that the permissive signals to the "REV" TGD are the same as in step 1.2.5.

1.4 If all the waveforms have checked out up to this point and the source of trouble has not been located, please refer to I.L.16-800-289 for further information.

2.0 Incorrect Current Feedback Signal

2.1 If the current sensor output is not -2V at rated armature current several things could be wrong:

2.1.1 Primary turns (used only for small HP drives) may be incorrect.

2.1.2 PC board could have a cold solder joint.

2.1.3 CT ratio could be incorrect.

$$\text{C.S. Output } (-/I[D]/) \text{ (volts)} = \frac{I_{DC} \times 0.76 \times 5X \text{ PRI. TURNS}}{CT}$$

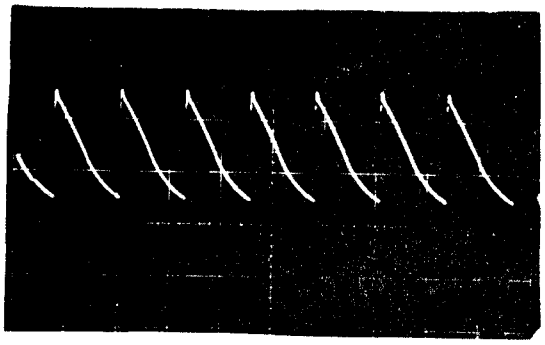
where:

I_{DC} = d-c armature current

PRI TURNS = # of cable loops thru CT +1
(this will normally be = 1 except for small HP drives)

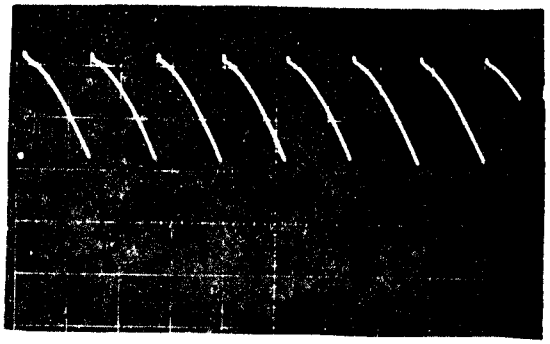
CT = current transformer primary ampere rating (200, 400, or 600) as marked on the CT.

IV APPENDIX



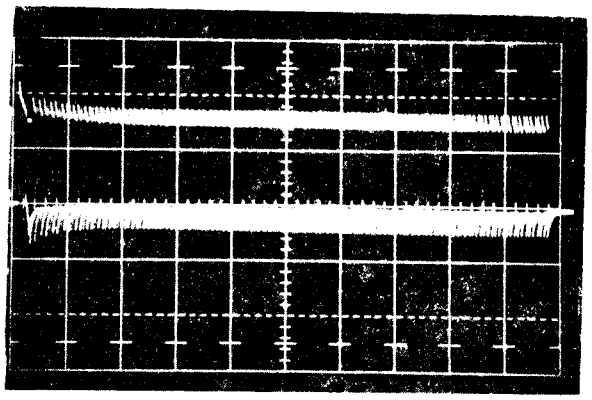
50% VOLTAGE 2ms/cm

FIG. 1



RATED VOLTAGE 2ms/cm

FIG. 2



1V/cm
0.2 ms/cm (uncalibrated)

FIG. 3

THYRISTOR GATE PULSE TRAIN

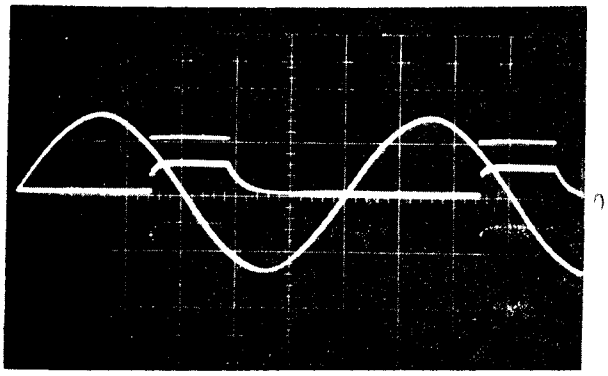


FIG. 4

THYRISTOR GATE DRIVER OUTPUT PULSE TRAIN

50V/cm - GCT Output
20V/cm - TGD Output
1ms/cm - (uncalibrated)

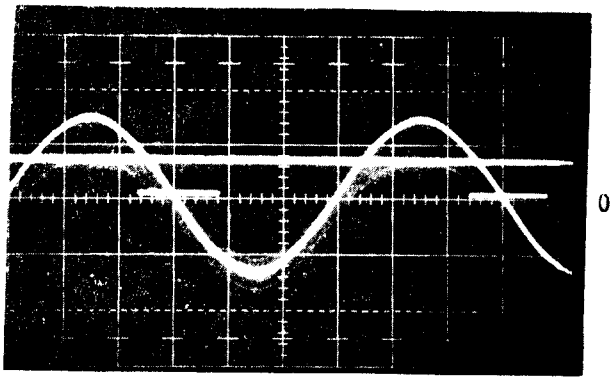


FIG. 5

GATE PULSE GENERATOR OUTPUT PULSE TRAIN

50V/cm - GCT Output
20V/cm - GPG Output
1ms/cm - (uncalibrated)

INSTRUCTION LEAFLETS (REFERENCE)

The following instruction leaflets (I.L.) describe the M5B system and its standard components.

SYSTEMS AND BASIC REGULATOR

I.L. 16-800-288	M5B Variable Regulator
16-800-289	M5B Gating System
16-800-296	M5B Thyristor Power System
16-800-298	Replacement of Thyristors in M5B TPM Assemblies

V SERVICE

Personnel familiar with electrical equipment utilizing semiconductors can isolate most problems using an oscilloscope, multimeter, and information contained in the instruction leaflet.

Semiautomatic equipment is available at the factory to test static and dynamic performance of all edge-connected printed circuit boards. Generally, repair of boards is facilitated by returning them to:

Westinghouse Electric Corporation
Industrial Systems Division
P.O. Box 225
Buffalo, New York 14240

M5B THYRISTOR POWER SYSTEM FIELD START-UP PROCEDURE FOR MOTOR ARMATURE SUPPLIES

INDEX	SECTION

I. INTRODUCTION

These instructions provide a step - by - step procedure for the first time start-up of a M5B Thyristor Power System used as an armature supply for a d.c. motor drive.

Non -standard functions such as special sequencing, director logic, interconnection with other drives, etc. which pertain to a specific application will be covered by separate instructions.

The procedures should be followed in the specified sequence, checking each step against the schematic diagram. This will develop familiarity with the system and insure proper operation of the drive system when the sequence is completed. If difficulty is encountered at any step, the source of trouble and/or remedy may be obvious. If not, refer to "Trouble Shooting" section of this instruction leaflet for more detailed test procedures.

It should be possible to place the drive system in operation by following the start-up procedure as described, referring only to the applicable schematic diagram. However, a more efficient and confident approach requires a knowledge of fundamental functions and relations which can be obtained by referring to the Instruction Leaflets (I.L.) listed in the Appendix.

II. BASIC SYSTEM

A. General

This section is devoted to a procedure for first time start-up of the basic M5B thyristor power system. The basic system consists of the following:

1. TPM - Thyristor Power Modulator assembly, either single or double converter.

2. Basic Regulator assembly containing:

GS	-	gate synchronizer }
GPG	-	gate pulse generator } gating system
TGD	-	thyristor gate driver }
VC & RL	-	voltage controller and reversing logic for double converters
VS	-	voltage sensor
CC	-	current controller
SC or VRC	-	speed controller or voltage reference controller
S & P	-	sequence and protection
PS1	-	±24V, +15V regulated power supply
FI	-	fault indicator (optional)
RFG	-	ramp function generator (optional)
CAL	-	reference calibration (optional)

Input and pot boards

Note: The standard basic regulator back plane contains the wiring for the optional boards.

3. a-c and d-c power circuits with standard protection (either Class 1 or Class 3) and sequencing.

B. Start - Up Procedure

1.0 Recommended Test Equipment

1.1 A multimeter with a internal impedance of 20,000 ohm/volt.

1.2 Adjustable battery powered test supply, 0-22V, with reversing and turn-off switch.

1.3 Dual beam oscilloscope such as Tektronix 502, 545 or equivalent.

NOTE: Be sure that the scope is NOT GROUNDED at the line plug or elsewhere. When the drive is energized, the scope case may be at some voltage potential above ground.

1.4 30 Pin extension board (S#1339A38G02)

2.0 Before applying a-c power:

2.1 Make a visual check of the equipment for loose wires and connections, remove blocking from relays and contactors, all function boards are present and plugged in to the basic regulator and all external connections are made.

2.2 Disconnect one side of motor armature from the drive.

2.3 Remove the RG/SC/01 or RG/VRC/01 board if used in the basic regulator.

2.4 Remove the current controller board (RG/CC/01) and replace with a 30 pin extension board (S#1339A38G02)

2.5 Plug the current controller board into the extension board and open up the jumper connection on the extension board to pin 47.

2.6 Jumper out any Zone A and Zone B contacts of Input Board 1 that do not originate in the M5B structure.

2.7 Remove any incoming -V[B]* wire from the terminal blocks of the magnetic panel assembly. Connect a ±15V VDC adjustable test voltage between -V[B]* and PSC. Set a 0 volts.

2.8 Connect a scope across pin 59 (+V[B]) and PSC of the VS board.

2.9 Make sure that the DC LOOP selector switch normally mounted on the M5B cabinet door is in the PERMISSIVE CLOSE position.

3.0 Apply rated 3 phase a-c power with phase sequence R-S-T and observe:

3.1 Transformer primary circuit breaker (if supplied) remains closed on transformer inrush. If the breaker trips out, increase the trip setting # in increments of "2" until the breaker remains closed.

3.2 Red indicating light mounted on the door indicates AC POWER ON.

3.3 Cabinet and TPM ventilating fans (if supplied) are operating and the air flow is from the bottom to the top of the structure.

3.4 Green indicating light mounted on the door indicates POWER SUPPLY READY. (Relay PSR is energized).

3.5 Voltage across CX and CY is 115V ±5V.

3.6 Light emitting diodes (LED'S) on the PS1 board indicate that PSP, PSN, and LP15 are energized.

The regulator power supply voltages should be as follows:

PSP	=	+24V ± 1V
PSN	=	-24V ± 1V
LP15	=	+15V ± 0.5V
RP	=	+24V + 4V, -2V

3.7 ZONE A, ZONE B, and the STOP LED'S on Input Board 1 are energized.

3.8 The PH. SEQ (1 LED) and the OSC (2 LED) LED'S on the RG/GS/01 board are energized.

3.9 The OC (overcurrent) LED, the PL (power loss) LED, and the ON LED on the RG/S&P/01 board are deenergized.

3.10 If the conditions in step 3.9 are not observed, the following voltages or logic signals should be checked at the following pins of the RG/S&P/01 board. (a logic "1" = +12.5V to +16V and a logic "0" = 0V to + 1.5V).

pin	4	=	logic "1"	pin	27	=	logic "1"
pin	6	=	+24V	pin	29	=	+24V
pin	7	=	0V	pin	33	=	logic "1"
pin	8	=	logic "1"	pin	36	=	logic "1"
pin	11	=	logic "1"	pin	38	=	logic "0"
pin	13	=	logic "1"	pin	39	=	logic "1"
pin	14	=	logic "0"	pin	40	=	logic "0"
pin	15	=	logic "1"	pin	41	=	logic "0"
pin	16 & 17	=	PSC	pin	44	=	logic "1"
pin	19	=	logic "1"	pin	55	=	logic "1"
pin	21	=	logic "1"	pin	57	=	0V
pin	25	=	logic "1"				

ON ALL SUBSEQUENT STEPS THROUGHOUT THIS START-UP PROCEDURE IT IS ASSUMED THAT THE SERVICE ENGINEER WILL INVESTIGATE PREVENTATIVE INTERLOCKING CIRCUITS TO ENSURE THAT THE TEST FUNCTIONS CAN BE COMPLETED.

4.0 Inner Voltage Loop Test

4.1 Close the d-c contactor (M) by connecting a jumper between terminals 19 and 20 of the Input Board 1 terminal block assembly or by closing the relay function between the above two terminals.

4.2 Observe that the M and ON LED'S on Input Board 1 are energized and the ON LED on the RG/S&P/01 board are energized. (This indicates that the d-c contactor is closed and that the current controller and the outer loop controller have been released).

4.3 Slowly adjust the test voltage applied to terminal -V[B]* of the magnetic panel from 0 to -10 volts and observe:

4.3.1 TPM output voltage waveshape should be smoothly controllerable with six pulses per cycle. The pulses should be stable and of equal magnitude over the voltage range with no random jitter. Figures 1 and 2 show typical waveform at 50% and at rated voltage. Refer to the trouble shooting section if the correct waveshapes are not obtained.

4.3.2 The TPS output voltmeter varies smoothly from 0 to approximately positive rated volts.

4.3.3 Miniature meter +V[B] varies smoothly from 0 to +9.6 volts.

4.3.4 Miniature meter -V[C1] varies smoothly from +5V $\pm$1V to + 0.4V $\pm$ 0.2V from 0 output to rated output respectively.

4.3.5 On double converters only, the FWD (1 LED) on the RG/VC&RL/01 board is energized.

4.4 For double converters, reverse the polarity of the test voltage applied in step 4.3 and observe:

4.4.1 Performance should duplicate that previously observed in steps 4.3.1 thru 4.3.4 except with all polarities reversed except -V[C1].

4.4.2 The REV [2 LED] on the RG/VC&RL/01 board is energized.

4.5 Remove a-c power.

5.0 Voltage Limit Adjustment

5.1 Disconnect the test voltage from terminal -V[B]* of the magnetic panel, and reconnect the original wiring to this point.

5.2 Close the pin 47 circuit on the extender board in which the current controller is plugged.

5.3 Apply a-c power and close the d-c loop contactor.

5.4 The bus voltage is now to be set at 104% of rated value. For this purpose the board producting -V[B]* (normally the current controller) is driven into saturation by applying the test voltage (+) to +I[D]* on the magnetic panel.

5.5 Trim the BUS VOLTAGE ADJUST pot (1P) on pot board (S#1752A05G01) to obtain 104% of rated bus voltage.

5.6 For double converters reverse the polarity of the test supply and note that the magnitude of the "reverse" output voltage is within ±2% of the "forward" output voltage in step 5.5.

5.7 Remove a-c power.

CAUTION: BEFORE CONDUCTING STALLED CURRENT TESTS ON A DC MOTOR, PLEASE REFER TO I.L.16-800-286.

6.0 Current Loop Test

6.1 Verify that the current feedback polarity is correct per the schematic information.

6.2 Set-up the following temporary conditions:

6.2.1 Remove the motor field excitation.

6.2.2 Reconnect the motor armature circuit.

6.2.3 Turn pot 2P on the pot board (S#1752A05G01) fully CW.

6.2.4 Open the red jumper (2J) with Berg terminals to pin 35 of the current controller [RG/CC/01] so that +I[D]* can only produce rated current.

6.2.5 Check that 1J on the pot board is in the 125% position.

6.2.6 Remove the Reference Calibration board [RG/CAL/01] and the Ramp Function Generator [RG/RFG/01] if used.

6.2.7 Place a scope between pin 7 of the pot board and PSC to monitor -/I[D]/F.

6.2.8 Apply the adjustable test reference to pin 35 (+I[D]*) of the current controller. Set at 0 volts.

6.2.9 Make sure that the current controller gain jumper (3J), red jumper with Berg terminals, is connected between pins 51 and 49 of RG/CC/01.

6.3 Apply a-c power and close the d-c contactor. The current reference ramp and the current controller should be released by logic generated by Input Board 1 and RG/S&P/01. (pin 27 and 29 of the CC should be +15 VDC).
Note that the output voltage remains at zero and the motor remains at stand still.

6.4 Slowly increase the test reference to +10 VDC.

6.5 With pot 2P of the pot board, adjust the armature current for defined rated current. The voltage at pin 17 of the current controller should be -2V ±5% at rated current. Refer to the trouble shooting section if -2V is not obtained.

6.6 Observe that the current feedback signal is similar to the one observed in the Inner Voltage Loop test. (six pulses per cycle of nearly equal amplitude).

6.7 Turn the current controller gain pot 4P on the pot board clockwise and move the CC gain jumper 3J (red jumper between pins 49 and 51 of the RG/CC/01) towards a higher gain position until the current feedback pulses become suddenly radically unequal (every second or third pulse is larger than others which indicates an instability of two or three times basic frequency).

The following tabulation indicates the gain changes achieved by connecting the gain jumper 3J attached to pin 51 to various other pins on the RG/CC/01 board.

JUMPER PINS	GAIN
51 - 49	Minimum gain
No jumper *	Next highest gain
51 - 53	Next highest gain
51 - 55	Highest gain

* Leave one end of the jumper on pin 51 and open the other end.

6.8 Put the gain jumper (3J) to its next lower gain position. The current loop is now dynamically adjusted.

6.9 Return the test reference to zero and remove a-c power.

7.0 Adjustment of Gate Pulse Suppression

CAUTION: BEFORE CONDUCTING STALLED CURRENT TESTS ON A DC MOTOR, PLEASE REFER TO I.L.16-800-286.

7.1 Set the Forward Gate Pulse Suppression jumper 1J on pot board S#1752A05G01 at the next highest increment setting above the desired current limit setting. Gate pulse suppression is normally set between 120% and 125% of the current limit setting. The following is a table showing the standard fixed current limit settings that are available and their corresponding GPS settings. (values based on % of rated current).

C. L. SETTING	JUMPER CONNECTIONS	G.P.S. SETTING
100%	No Jumper	125%
125%	35 - 37	150%
150%	35 - 39	185%
175%	35 - 41	215%
200%	35 - 5	245%
250%	35 - 7	310%
300%	35 - 9	370%
400% (Test only)	35 - 33	

7.2 Place the current limit setting jumper (red jumper 2J) of the current controller edge connector to its "test" position (jumper between pins 35 and 33).

7.3 Apply a-c power and close the d-c loop.

7.4 Slowly increase the test reference +I[D]* until gate pulse suppression occurs. The value should be within ±5% of the selected setting.

7.5 Return test reference to zero and depress the GATE PULSE SUPPRESSION RESET pushbutton. GPS can also be reset by shorting the two lance terminals (LN1 and LN2) provided at the front edge of the RG/S&P/01 board.

7.6 The drive should return to its "ready" state (relay PSR should be energized).

7.7 For double converters reverse the polarity of the test reference +I[D]*.

7.8 Slowly increase the test reference until gate pulse suppression occurs. This value should be within ±2% of step 7.4.

7.9 Repeat step 7.5.

7.10 Remove a-c power.

8.0 Current Limit Adjustment

8.1 Place the current limit setting jumper (red jumper 2J found on the current controller edge connector) to the desired current limit value. Refer to table in step 7.1.

8.2 Plug in the outer loop regulator board producing +I[D]*. This will normally be the RG/SC/01 or RG/VRC/01 board.

8.3 Connect the test reference to pin 17 of the SC or VRC. Set at zero volts.

8.4 Convert the outer loop controller (SC or VRC to a proportional amplifier as follows:

Speed Regulator (RG/SC/01) -

8.41 Short out the 10MFD capacitor by placing a jumper between pin 33 and 35.

8.42 Apply a small test voltage to pin 17 of RG/SC/01 and adjust the PROP. GAIN pot 3P on the meter pot panel so that the speed controller has a gain of approximately 1.

Voltage Regulator (RG/VRC/01

8.43 Connect a jumper between pins 11 and 49.

8.44 Apply a small test voltage to pin 17 of RG/VRC/01 and adjust the VOLT REF. CONT. GAIN pot 6P on pot board S#1752A05G01 so that the voltage reference controller has a gain of approximately 1.

8.5 Reset the test voltage to zero volts. Apply a-c power and close the d-c loop.

8.6 Note that the output limit value of the outer loop controller, +I[D]* (+10V + 0.2V), corresponds to the current limit setting of the drive following the calibration of 2P on the pot board.

8.7 Slowly increase the test voltage until the outer loop controller reaches its output limit value of +10V + 0.2V. The armature current should be the desired current limit value within ±5%.

DOUBLE CONVERTERS

8.8 Reverse the polarity of the test voltage.

DOUBLE CONVERTERS WITH SYMMETRICAL CURRENT LIMIT

8.9 Remove the red jumper (61) from the back plane between pin 27 of RG/SC/01 or RG/VRC/01 and pin 57 of the pot board.

8.10 Increase the test voltage and check that the reverse current limit is ±5% of that in step 8.7.

DOUBLE CONVERTERS WITH ASYMMETRICAL CURRENT LIMIT

8.11 Turn the REVERSE CURRENT LIMIT pot 5P on the pot board full CCW.

8.12 Apply a test reference of +11V.

8.13 Turn 5P of the pot board CW until the desired "reverse" current limit value is obtained.

9.0 IR Compensation (Voltage Regulator only)

9.1 Motor field is still disconnected.

9.2 Turn IR COMPENSATION pot 2P on the meter pot panel full CCW.

9.3 The test reference is still connected to pin 17 of the RG/VRC/01 board and the controller is still connected as per step 8.43.

9.4 Apply a-c power and close the d-c loop.

9.5 Increase the negative test voltage until 10% rated aramture current (I_{nc}) is obtained.

9.6 Adjust the IR COMPENSATION pot 2P located on the meter - pot panel until the armature current (I_c) is increased as required. Percentage compensation is calculated from the two current values in steps 9.5 and 9.6 as follows:

$$\% \text{ IR COMPENSATION} = \frac{I_c - I_{nc}}{I_c} \times 100$$

NOTE: DO NOT EXCEED 50% IR COMPENSATION.

10.0 Adjustment of Dynamics of Outer Loop Controller

10.1 Speed Regulator (Type 1)

NOTE: ON SPEED REGULATED SYSTEMS (STEPS 10.1 & 10.2 BELOW), MAKE SURE POLARITY OF SPEED FEEDBACK IS CORRECT. IF MOTOR STARTS TO RUN AWAY, REMOVE A-C POWER AT ONCE.

10.11 Reconnect motor field.

10.12 Make sure there is a red jumper (5J) from pin 29 of the RG/SC/01 board to PSC.

10.13 Check to see that the tach attenuator board is connected per the table below.

TACH VOLTS @ MAX SPEED	TG+ CONN. TO TERMINAL	JUMPER REQD. BETWEEN TERMINALS
45 - 65	1	NONE
65 - 85	2	NONE
85 - 110	3	1 and 2
110 - 130	3	NONE
130 - 150	4	2 and 3
150 - 170	4	1 and 2
170 - 190	4	NONE
190 - 210	5	3 and 4
210 - 230	5	2 and 3
230 - 250	5	1 and 2

NOTE: Voltage at terminal 13 of RG/SC/01 should be approximately +46V at maximum rated speed after proper adjustment of the SPEED CALIBRATION pot 4P on the meter-pot panel. This assumes that the speed reference is approximately -10V at maximum rated speed. CAUTION: Measure this voltage with a scope or a high impedance instrument so that the circuit impedance is not changed appreciably.

10.14 Remove any temporary jumpers that were used in steps 8.0 and 9.0.

10.15 Make sure that pin 37 of RG/SC/01 will be +15V when the drive is running.

10.16 Place the speed controller gain jumper (4J) in its minimum gain position and set the SPEED CONTROLLER GAIN pot 6P on the pot board ECCW. Also set the DROOP pot 1P (on the meter-pot panel) ECCW.

10.17 Connect the test supply to pin 21 of the speed controller.

10.18 Apply the a-c power and close the d-c loop.

10.19 Apply a small negative signal into pin 21 until the motor is running at approximatley 25% rated speed. Then apply a small reference step and record speed response.

NOTE: MAKE SURE DRIVE DOES NOT GO INTO CURRENT LIMIT.

10.20 Turn gain pot 6P CW and move the gain jumper toward pin 57 to increase the gain of the speed controller while making small step reference changes. A good speed response should have 5% or less overshoot and no relaxation oscillation; i.e. motor changes speed when operating near zero speed (this usually occurs if gain is too low).

NOTE: With steady state speed, if the current trace becomes erratic, the speed gain is set too high

10.2 Speed Regulator (Type 2)

Set up a speed regulator type 2 in a similar manner as step 10.1 with the following exceptions:

a) Step 10.12 - There is no connection between pin 29 and PSC of the RG/SC/01 board.

b) Step 10.20 - Turn gain pot 6P CW and move the gain jumper toward pin 57 to increase the gain of the speed controller while making small step reference changes. A good speed response will have approximately a 20% overshoot and no relaxation oscillation; i.e. motor changes speed when operating near zero speed (this usually occurrs if gain is too low).

NOTES: 1) With steady state speed, if the current trace becomes erratic the speed gain is set to high.

2) The 20% overshoot obtained with the type 2 speed regulator is an inherent feature of the control system. It does not result from poor damping, but is due to initial conditions. Any adjustments made to reduce the overshoot will result in a very sluggish load response.

3) A motor disconnected from its load may exhibit instability tendencies and therefore it should be connected to its actual load.

10.3 Voltage Regulator (Multi-Loop)

10.31 Reconnect motor field.

10.32 Remove any temporary jumpers that we used in steps 8.0 & 9.0

10.33 Set the VOLTAGE REFERENCE CONTROLLER GAIN pot 6P on the pot board FCCW (minimum gain setting) and set the DROOP pot 1P FCCW.

10.34 Connect the test supply to pin 21 of the voltage reference controller.

10.35 Apply the a-c power and close the d-c loop.

10.36 Apply a small negative signal into pin 21 until 10% armature voltage is reached. Then apply a small reference step and record the response.

10.37 Increase the voltage gain by turning pot 6P CW so that the output voltage has a sharp response as possible to a step reference input.

NOTES: 1) Ensure that the drive does not go into current limit.

2) Dynamic adjustment of the voltage loop is affected by settings of the gain pot 6P, droop pot 1P (on the meter-pot panel), IR compensation pot 2P (on the meter-pot panel), as well as the gain established in the current controller. Usually satisfactory performance can be obtained over a wide range of potentiometer settings as long as a little droop is used.

3) If the voltage gain is set extremely high, it can produce instability in the drive. Erratic current conduction could occur while running at steady state speed.

4) If IR compensation is used, some overshoot will occur. If the overshoot is to large, decrease the gain of the voltage reference controller or decrease the amount of IR compensation.

11.0 DROOP

11.1 De-energize thyristor power supply.

11.2 Remove the outer loop controller (RG/SC/01 or RG/VRC/01) and replace with a 30 pin extension board S#1339A38G02).

11.3 Plug the outer loop controller board into the extension board and open up the following jumper connections to pins 13, 21, 37, 39.

11.4 Remove the current controller board.

11.5 Place the DROOP pot 1P (located on the meter-pot panel) to ECCW.

11.6 Apply ± 24V power.

11.7 Energize static relays 1CR and 2CR of the outer loop controller by applying PSC to pins 37 and 39.

11.8 Apply a negative reference to terminal 21 corresponding to speed droop in % of top speed at stall current limit. (Example: Reference at top speed at pin 21 is -10 volts. Desired droop at current limit is 5%. Apply -0.5 volts (.05 X10V) reference to pin 21.

11.9 The outer loop controller should limit at approximately +10 volts.

11.10 Gradually turn DROOP pot 1P CW until the amplifier starts to come out of staturation, which represents the desired droop setting.

III..TROUBLE SHOOTING

A. General

This discussion is restricted to the standard M5B basic regulator system as used for d-c motor armature. Since the equipment was tested at the factory, it is assumed that any trouble is due to component failure rather than incorrect wiring. In case of trouble in the basic TPS system the start-up procedure described in Section II provides an organized approach to trouble shooting. Those steps involving voltage measurements and sequence checks are considered to be self explanatory. However, if trouble is encountered in checking the basic regulator, the following trouble shooting procedure may be used.

B. Basic Regulator

1.0 Incorrect TPM Output Waveshape

1.1 If the waveshape is not similar to figure 1 or figure 2, a missing pulse is immediately apparent and indicates the corresponding thyristor is not firing. Check for open fuses or an open gate circuit. A typical pulse train is seen in figure 3. This trace is obtained when a scope is connected across the gate of a thyristor at the pulse transformer and RC board (located on the TPM) with "G" (gate) positive with respect to "K" (cathode).

NOTE: The thyristor firing sequence is identified by color code as follows:

1TH = Brown		4TH = Yellow	
2TH = Red		5TH = Green	
3TH = Orange (or White)		6TH = Blue	

IF THE PROBLEM IS NOT THE THYRISTOR OR A BLOWN FUSE, WE THEN WILL ASSUME IT'S IN THE TGD OR GPG'S.

WITH THE ASSUMPTION THAT THE GATE SYNC. BOARD IS OPERATING CORRECTLY, CHECK THE FOLLOWING BOARD OUTPUTS:

1.2 Check the output of the gate pulse generators (S#1671A17G01) as follows:

1.2.1 Remove the PC board producing the +V[C1] signal, i.e. the RG/VC&RL/01 board for a double converter or the RG/CC/01 board for a single converter.

1.2.2 Tie pin 57 of the gate synchronizing board (RG/GS/01) to PSC.

1.2.3 If a double converter, remove the "REV" TGD board.

1.2.4 Keep the d-c loop open..

1.2.5 Make sure when the system is energized that all permissive signals to the "FWD" TGD board are as follows:

pin 41 = logic "1"
pin 11 = logic "1"
pin 15 = PSC

1.2.6 CALIBRATE SCOPE PROBES. Set scope on line sync. and chopped mode.

1.2.7 Put scope probe 1 on X1 (brown lead) of the gate control transformer with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of the a-c wave is 70 volts ± 7V peak to PSC.

1.2.8 Put scope probe 2 on pin 5 (GP1) of the RG/GPG/01 board (pulse 1,3,5) with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of pulse is +15V ±2V (PULSE #1).

1.2.9 Apply a-c power.

1.2.10 Superimpose the two wave forms and compare to figure 5. Note that the delay angle is approximately 145° and the pulse train is approximately 85° long.

1.2.11 The remaining pulse trains can be checked in a similar manner.

PULSE #2 (GP2) - Move probe 1 to X2 (red lead) of the gate control transformer. Move probe 2 to pin 5 of the pulse 2,4,6, GPG.
The trace should be the same as figure 5.

PULSE #3 thru #6- Move probe 1 per color code sequence with respect to GP3 thru GP6 for the two GPG boards. Compare to figure 5.

1.2.12 If all GPG outputs check out OK, proceed to step 1.3.

1.3 Check the output of the thyristor gate driver (S#1668A25G01) as follows:

1.3.1 Set-up conditions the same as steps 1.2.1 thru 1.2.6.

1.3.2 Probe 1 of scope is to be used the same as in step 1.2.7.

1.3.3 Put scope probe 2 on pin 29 (brown) of the FWD TGD with respect to PSC. Uncalibrate scope so that 6 cm=1 cycle (360°). Magnitude of pulse is +22V ±3V (PULSE #1)

1.3.4 Apply a-c power.

1.3.5 Superimpose the two wave forms and compare to figure 4. Note that the delay angle is approximately 145° and the pulse train is approximately 85° long (start of first pulse to the end of the last pulse of the pulse train and does not include the exponential decay).

1.3.6 The remaining pulse trains can be checked in a similar manner.

PULSE #2 - Move probe 1 to X2 (red lead) of the gate control transformer.
Move probe 2 to pin 27 (red) of the FWD TGD.
The trace should be the same as figure 4.

PULSE #3 thru 6 - Move probes per color code firing sequence as specified in step 1.1.
Compare to figure 4.

1.3.7 For double converter remove the "FWD" TGD and replace the "REV" TGD in its prober edge connector
Repeat steps 1.3.1 thru 1.3.6 making sure that the permissive signals to the "REV" TGD are the same as in step 1.2.5.

1.4 If all the waveforms have checked out up to this point and the source of trouble has not been located, please refer to I.L.16-800-289 for further information.

2.0 Incorrect Current Feedback Signal

2.1 If the current sensor output is not -2V at rated armature current several things could be wrong:

2.1.1 Primary turns (used only for small HP drives) may be incorrect.

2.1.2 PC board could have a cold solder joint.

2.1.3 CT ratio could be incorrect.

$$\text{C.S. Output (-/I[D]/) (volts)} = \frac{I_{DC} \times 0.76 \times 5X \text{ PRI. TURNS}}{CT}$$

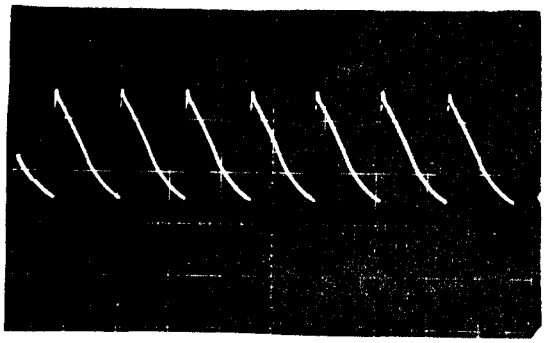
where:

I_{DC} = d-c armature current

PRI TURNS = # of cable loops thru CT +1
(this will normally be = 1 except for small HP drives)

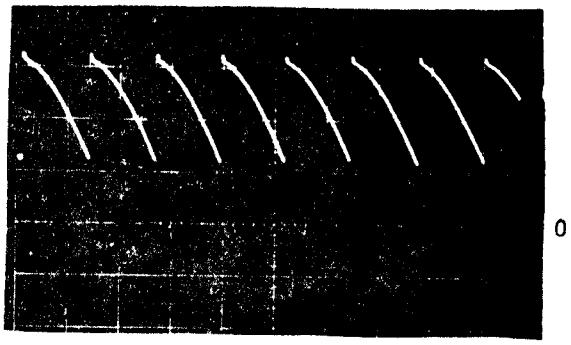
CT = current transformer primary ampere rating (200, 400, or 600) as marked on the CT.

IV APPENDIX



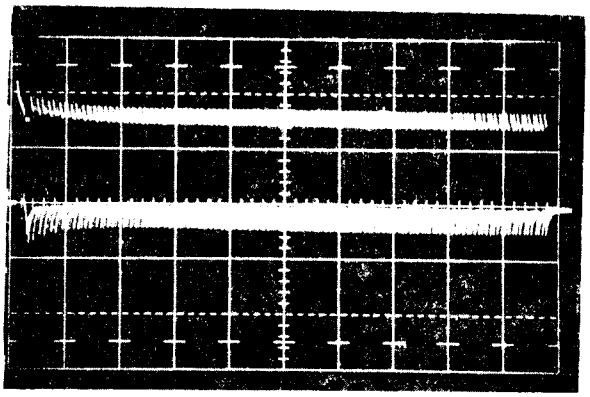
50% VOLTAGE 2ms/cm

FIG. 1



RATED VOLTAGE 2ms/cm

FIG. 2



1V/cm
0.2 ms/cm (uncalibrated)

FIG. 3

THYRISTOR GATE PULSE TRAIN

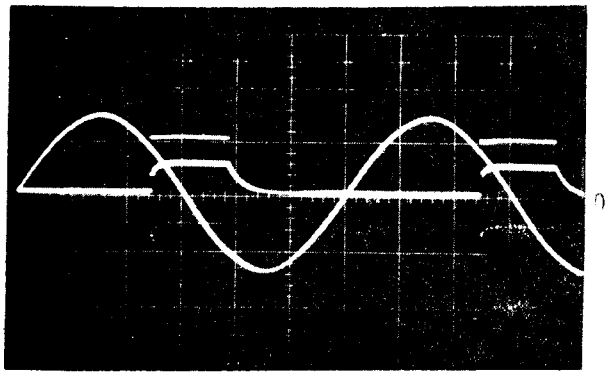


FIG. 4

THYRISTOR GATE DRIVER OUTPUT PULSE TRAIN

50V/cm - GCT Output
20V/cm - TGD Output
1ms/cm - (uncalibrated)

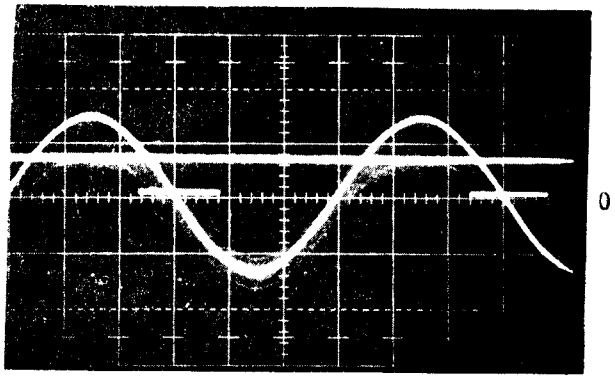


FIG. 5

GATE PULSE GENERATOR OUTPUT PULSE TRAIN

50V/cm - GCT Output
20V/cm - GPG Output
1ms/cm - (uncalibrated)

INSTRUCTION LEAFLETS (REFERENCE)

The following instruction leaflets (I.L.) describe the M5B system and its standard components.

SYSTEMS AND BASIC REGULATOR

I.L. 16-800-288	M5B Variable Regulator
16-800-289	M5B Gating System
16-800-296	M5B Thyristor Power System
16-800-298	Replacement of Thyristors in M5B TPM Assemblies

V SERVICE

Personnel familiar with electrical equipment utilizing semiconductors can isolate most problems using an oscilloscope, multimeter, and information contained in the instruction leaflet.

Semiautomatic equipment is available at the factory to test static and dynamic performance of all edge-connected printed circuit boards. Generally, repair of boards is facilitated by returning them to:

Westinghouse Electric Corporation
Industrial Systems Division
P.O. Box 225
Buffalo, New York 14240