INSTALLATION - OPERATION - MAINTENANCE

IC DRIVER/ REGULATOR

S-22

GENERAL ELECTRIC

INSTRUCTION

IC DRIVER/REGULATOR

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SECTION I

GENERAL

1.1 SCOPE OF MANUAL

This instruction manual is furnished as a guide to the start-up, check-out, and operation of the drive system. It includes a detailed description of the IC Driver Regulator and general troubleshooting guides. Refer to the other attached manuals and the system diagrams for detailed instructions on special function cards which may be included in the IC Driver Regulator rack. For more information on the power conversion modules and motor field exciters, refer to the appropriate instruction manual.

This manual is structured around a four quadrant (regenerative) drive with the Instrument/Diagnostic modification and a Motor Field Control provided for operation in the constant horsepower region. Those sections peculiar to these modifications are so noted and may be ignored if these modifications were not ordered. Refer to the system drawings to determine the modifications furnished.

SECTION II

DESCRIPTION

A speed regulated drive consists of at least a speed reference, a speed feedback, a driver regulator, a power conversion module, a motor, a motor field exciter or motor field control and relay logic. The driver/regulator receives inputs from the reference, feedback and relay logic, and provides the appropriate signals to the power conversion module to control the power applied to the motor.

2.0 PRINTED CIRCUIT CARDS

The elements on a driver/regulator are described below. For convenience, an alphabetical list of the nomenclature used in this instruction manual is included at the end of this section.

2.1.1 Card Location Table: The IC Driver/Regulator is a panel mounted assembly which contains a set of printed circuit cards mounted in a card rack, a ready-to-run/reset indicator located in the lower left hand corner of the card rack and a power assembly bolted underneath.

For a one quadrant (non-regenerative) drive, from left to right the printed circuit cards are:

Name	Nomenclature	Number	Slot Location
20V Power Supply	PS	193X257AAG01	B
Gate Control	GC	193X262AAG01	C
Phase Control	PC	193X259AAG01	D
Monitor	M	193X261ACG01	E
Driver Coordination	DC	193X260BAG01	F
Standard Regulator	R	193X267BAG01	G
* Diagnostic	D	193X275AAG01	H
* Instrument	I	193X295AAG01	K

For a four quadrant (regenerative) drive, from left to right the printed circuit cards are:

Name	Nomenclature	Number	Slot Location
20V Power Supply	PB	193X257AAG01	B
Gate Control	GC	193X262AAG01	C
Phase Control	PC	193X259ACG01	D
Monitor	M	193X261ACG01	E
Quadrant Control	QC	193X270AAG01	F
Driver Coordination	DC	193X260ABG01	G
Standard Regulator	R	193X267BAG01	H
* Diagnostic	D	193X275AAG01	J
* Instrument	I	193X295AAG01	L

* Optional - supplied only if ordered.

2.1.2 20V Power Supply: The 20V Power Supply card receives unregulated ±30 volt DC from the rectifier card in the Power Assembly and provides regulated ±20 volt DC for the Driver/Regulator, and up to 100 mA of external load. It also provides the unregulated power to activate the solid state switches on the Regulator card. The Power Supply outputs are fused with 1.5A instrument fuses located on the front of the PS card. Both fuses will clear, removing all power from the cards, if an overload or overvoltage condition exists on either the positive or the negative output.

2.1.3 Gate Control: The Gate Control card contains the oscillator for "burst" firing, a circuit to control the length of the burst train, and the steering logic to either inhibit all pulses or direct the firing signals to the Power Module forward or reverse. The firing signals originate from the Phase Control card and the steering inputs come from the Quadrant Control card. The outputs go through the RPL and SPL connectors to the forward and reverse Power Modules. For one quadrant drives only one Power Module is provided, and the firing signals are always steered toward this power module thru the RPL connector. The terms RPL and SPL are only connector designations - they have no special significance.

2.1.4 Phase Control: The Phase Control card has the line comparators synchronizing networks, the ramp generators and the input which convert the reference signal from the Driver Coordination card to six outputs phase shifted in time for use by the Gate Control card. 50 Hz operation is selected by connecting tab 26 to tab 27 on this card.

2.1.5 Monitor: The Monitor card contains the circuits to detect a DC Power fuse failure, incorrect phase sequence or loss of phase, open Power Module thermostat (module overtemperature), or an instantaneous overcurrent trip. When a trip occurs the Monitor fault relay, F, will open, one of the three Monitor indicators will latch on, and a signal, 1STP, is sent to the Driver Coordination card to initiate a drive shutdown. After a trip condition has been cleared, the card is reset by pushing the RTR/Reset button located in the left hand corner of the Driver/Regulator.

2.1.6 Quadrant Control: The Quadrant Control card receives information from the Driver Coordination card and performs the logic to select the proper power module and control the transfer from one power module to the other. The commutation detection logic and input line impedance compensation circuits are on this card.

2.1.7 Driver Coordination: The Driver Coordination card amplifies the isolated armature voltage signal from the Resistance Isolator in the Power Assembly and the current feedback signal from the Power Module(s). It contains the driver current limit and voltage limit adjustment and provides the proper signals to the Phase Control and Quadrant Control cards to maintain the armature voltage proportional to the driver reference from the Standard Regulator card.

2.1.8 Standard Regulator: The Standard Regulator card receives a speed reference and speed feedback from the System and provides the proper reference to the Driver Coordination card to maintain the speed proportional to the reference. It also contains a linear time section, a feedback scaling section, a current limit section, an auxiliary preset reference and static switches to control the preconditioning and reference as determined by the external relay logic. Eight system adjustments are also on this card. See section 3.3, Adjustments.

** Four Quadrant only

2.1.9 Diagnostic Card: If ordered, the Diagnostic Card is used to setup and checkout the drive.

Located on the front of the Diagnostic card is LR, the local test reference slide potentiometer, a six station pushbutton assembly, and a red transfer indicator.

The potentiometer is a zero center pot which will run the drive forward when pushed up from center and reverse when pulled down. The LR may be preset to a selected value by monitoring instrument position 1 with all pushbuttons out.

The top four pushbuttons are used to select any one of four operating modes, three test modes and one normal operation. The switch is mechanically interlocked to prevent more than one mode position from being selected at one time. After a mode has been selected, it is locked in until depressed to release.

The firth button down, MOTR, is used to pickup and dropout the motor loop contactor in the different test modes. Refer to the test mode descriptions for its exact function.

The last button, STEP, is a momentary pushbutton which will apply a small step reference change to the regulator.

The diagnostic card may be completely removed from the drive by connecting GTB21 to GTB22 (located on the Power Assembly).

2.1.10 Instrument Card: If ordered, the Instrument Card is used in conjunction with the Diagnostic card to monitor important signals internal to the IC Driver/Regulator.

2.2 POWER ASSEMBLY, PA

The power assembly consists of a low voltage transformer and rectifier card mounted behind the assembly, a resistance isolator RI mounted in the power assembly, a power terminal board with two connectors and a control terminal board.

2.2.1 Power Terminal Board (from left to right):

H1	115V AC required for low voltage transformer
H2	115V AC for low voltage transformer
NDC	Negative DC buss from the P1 terminal of the rev. power module
NDCF	Negative DC buss from the P2 terminal of the forward power mod
PDC	Positive DC buss from the P2 terminal of the referse module
PDCF	Positive DC buss from the P1 terminal of the forward module
AC3	3-Phase AC line from the T3 terminals of the power module
AC2	3-Phase AC line from the T2 terminals of the power module
AC1	3-Phase AC line from the T1 terminals of the power module

If a four quadrant drive is not provided, only one power module is furnished, and NDC will be connected NDCF and PDC will be connected to PDCF.

2.2.2 Control Terminal Board (from left to right):

Location	Nomen.	
GTB1	COIL	Output from the Diagnostic card to the coil of the pilot relay for the MD contactor
GTB2	-20V	-20V DC up to 100 mA from the power supply for external use
GTB3	+20V	+20V DC up to 100 mA from the power supply for external use
GTB4	SR	System reference input to Regulator card
GTB5	FCR	Test reference output from Diagnostic to Motor Field Control or MFC (if supplied).
GTB6	FB+	Tachometer feedback input to Regulator which is positive when drive is running in forward direction
GTB7	COMP	Current compensation output from Regulator to MFC (if supplied)
GTB8	COM	Driver/Regulator common - connect to external ground in appropriate location
GTB9	FB-	Tachometer feedback input to Regulator which is negative when drive is running in forward direction
GTB10	F	Normally open contact from internal
GTB11	F	Fault relay on Monitor. Held closed in normal operation. Normally connected in drive protective relay logic
GTB12	FCM	Input from MFC to Instrument to monitor field control performance
GTB13	CFB	Output from Quadrant Control of Driver Coordination in one quadrant drives proportional to motor armature current to operate external current load meter (50 μa movement) if ordered
GTB14	SFB	Output from Regulator to MFC proportional to tachometer feedback to drive the overspeed and tach loss section of the motor field control
GTB15	SYS	Input from MFC to Monitor which will shutdown drive in event of field loss, tachometer loss or reversal, or overspeed. May also be used for E-STOP, if supplied
GTB16	FCI	Output from Diagnostic to MFC to prevent operation in constant horsepower range in certain test modes
GTB17	-30V	Unregulated negative voltage return from Power Supply for ORR, OAPR and OSR switch inputs
GTB18	ORR	Input to Regulator which will release driver/regulator preconditioning when connected to -30V through the appropriate relay contact(s).
GTB19	OAPR	Input to Regulator which will activate the adjustable preset reference on the Regulator card when connected to -30V through the appropriate relay contact(s
GTB20	OSR	Input to regulator which will apply the system reference SR to the regulator when connected to -30V through the appropriate relay contact(s).
GTB21	PI	A normally closed contact located on the Diagnostic
GTB22	PO	card normally inserted between the STOP and the START pushbuttons, with PI connected to the STOP and PO connected to the START. If the Diagnostic card is not provided, these two points are jumpered together.

2.2.3 Located on the Power Assembly are two round plugs SPL and RPL. RPL, the right hand plug, is connected through a harness to the forward conversion module and SPL is connected to the reverse module if supplied.

2.3 SYSTEM ADJUSTMENTS:

	Nomen.	Card Location	
	APR	R	If connected, an Auxiliary Preset Reference which may be connected to provide either a timed or untimed signal (JOG, THREAD) into the regulator when OAPR is connected to -30V.
	TIM-	R	An adjustment to control the time required to linearly decelerate from top speed in the forward direction
	TIM+	R	An adjustment to control the time required to linearly accelerate to top speed in the forward direction
	SMAX	R	An adjustment to set the maximum speed of a drive by adjusting the strength of the feedback
	RESP	R	An adjustment to control the responsiveness of the drive
	ILIM	R	If connected, an adjustment to set the maximum steady-state current to be delivered to the motor. Normally set at 150% of rated motor current
	DAMP	R	An adjustment, which in conjunction with the RESP pot, controls the overshoot or damping factor of the drive system
	COMP	R	An adjustment to improve the load regulation of a voltage regulated drive by compensating for the IR drop of the motor. When a Motor Field Control is furnished, this adjustment is used to compensate the field control for the IR drop of the motor.
	VLIM	DC	A factory-set adjustment to limit the max. voltage applied to the motor. Level should not normally exceed 1.15 times the RMS value of the applied 3-phase line
	LR	D	An adjustable local test reference used in place of the system reference in some diagnostic modes.
**	LINE	QC	An adjustment to compensate for the per unit AC line impedance. This adjustment is factory set.

** Four Quadrant only

2.4 INDICATORS

Nomen.	Location	
T1 T2 T3	PM PM PM	Each power conversion module contains these three indicators. When three phase power is applied to the power module(s) these indicators are on.
RTR	CARD RACK	The Ready-to-Run indicator is combined with the fault reset pushbutton, and is located in the bottom left hand corner of the printed circuit card rack. When the fault relay F located on the Monitor card is picked up, the Ready-to-Run light will be illuminated.
SYS	M	The system monitor indicator SYS will illuminate when any of the following occurs: 1. Incorrect phase sequency/phase loss is applied to the drive 2. One fuse is open in the DC buss or AC line 3. An external signal applied to SYS (GTB15) exceeding +10 volts. * 4. Both the NORM and the MOTR buttons on the Diagnostic card are depressed. * 5. The MOTR button is depressed and the TREF button on the Diagnostic card is either depressed or released. If a Motor Field Control (MFC) is supplied, SYS will also illuminate when: 6. Motor field loss is detected. 7. Incorrect tachometer polarity or tach loss exists. 8. Motor RPM exceeded maximum allowable speed. 9. MFC input fuse open.
IOC	M	The instantaneous overcurrent trip indicator IOC will illuminate whenever the motor current transiently exceeds approximately 400% of the motor nameplate rating.
TEMP	M	The power module overtemperature indicator TEMP will illuminate whenever the protective thermostat in the power module(s) open.
RESET	CARD RACK	The fault reset pushbutton is combined with the RTR (Ready-to-Run) light in the lower left-hand corner of the card rack. Depressing the Reset button will drop out the F relay and reset the SYS, IOC, and TEMP indicators on the Monitor card. If the indicators do not remain off when Reset is released, the fault condition has not been corrected.
TRANSFER	D	The Transfer indicator on the Diagnostic card illuminates whenever a different test mode is selected on the Diagnostic card. Refer to section 3.7.8 for details.

2.5 TEST POSTS

Each test post is isolated from the signal is it monitoring by a 15K ohm resistor. This allows adjacent posts to be accidentally connected together without causing a drive malfunction. This series resistance will, however, cause the voltage measured at the test post to reach slightly lower than the actual voltage due to the internal resistance.

CAUTION

VOLTAGE MEASUREMENTS SHOULD NOT BE MADE DIRECTLY ON THE CARD RECEPTACLE PINS. A MISCONNECTION COULD EASILY DAMAGE THE EQUIPMENT.

Nomen.	Location	
+20V	PS	Connected to the 20V Power Supply outputs.
-20V	PS	They will normally read ±20V DC whenever 115V AC is
COM	PS	applied at H1 and H2.
1F1	GC	Connected to the outputs from the Gate Control to the
1R1	GC	SCR's in the forward and reverse power modules.
1F4	GC	1F1 is the output to the #1 SCR in the forward
1R4	GC	module, 1R3 is the output to the #3 SCR
1F2	GC	in the reverse module. The 1 prefix indicates
1R2	GC	that firing occurs when the signal is high.
1F5	GC	When measured with an oscilloscope,
1R5	GC	the outputs will be as
1F3	GC	shown in Section 4.4
1R3	GC	
1F6	GC	
1R6	GC	
OIP	M	Connected to the initial pulse output of the Phase Control. Each time a firing signal is generated by the Phase Control, this output dips low. When measured with an oscilloscope, the output will be as shown in Figure 1.
DERR	M	Connected to the output of the driver voltage error amplifier, on the Driver Coordination card.
+5V	M	Connected to +5V DC internal power buss. It will normally read between 4 and 6 volts whenever ±20V DC is available.
SR	M	Connected to system reference input (GTB4).
TR	M	Connected to the timed reference output of the linear time section on the Standard Regulator.
SFB	M	Connected to the system feedback output of the feedback scaling amplifier on the Regulator.
DR	M	Connected to the driver reference, the output from the Regulator into the Driver Coordination, which determines the amount of DC voltage applied to the motor.
CFB	M	Connected to the current feedback output from the Quadrant Control card, which is proportional to armature current.
1CST	M	Connected to the drive shutdown input on the Monitor card. When this point is positive, all outputs to the Power Conversion module(s) are removed.

Nomen.	Location	
VFB	M	Connected to the isolated armature voltage output on the Driver Coordination which is proportional to the DC voltage out of the conversion module(s).
PCR	M	Connected to the phase control reference, the output of the Driver Coodination into the Phase Control which determines the phase angle where the SCR's in the conversion module will be fired.
SEL	M	The select test post is connected to a moveable jumper to allow voltage measurements to be safety made at any card receptable pin. A 15K ohm resistor is in series with the test post SEL and the jump er. The jumper is normally connected to tab 13 of the Standard Regulator card.
SYNC	M	Connected to a line synchronized output of the Phase Control card to provide line synchronization for portable oscilloscopes.
COM	M	Driver/Regulator common.
** OFE	QC	Connected to the driver error polarity detector on the Quadrant Control card. If this point is high, SCR firing signals are applied to the reverse module; if low, they are applied to the forward module.
** VR	QC	Connected to the output of the voltage ripple detector. The drive will not transfer from motoring to regenerating or back until the voltage ripple is zero.

2.6 INSTRUMENT CARD SWITCH POSITIONS (if ordered)

Pos.	Nomen.	
1	LRO	The local test reference output on the Diagnostic card which is applied to the driver regulator in certain diagnostic test modes.
2	SR	The input from the system speed reference to the linear time section of the Regulator.
3	TR	The timed system reference on the Regulator card which determines motor speed.
4	DR	The driver reference applied to the Driver Coordination card which determines motor voltage.
5	PCR	The phase control reference applied to the Phase Control card which determines the phase angle where the SCR's are to be turned on.
6	SFB	The speed feedback signal on the Regulator card which is proportional to actual motor speed.
7	CFB	The current feedback signal on the Quadrant Control card which is proportional to actual motor current.
8	VFB	The voltage feedback signal on the Driver Coordination card which is proportional to actual motor voltage.
9	RERR	The amplified difference between TR, the desired motor speed, and SFB, the actual motor speed. This difference, or regulator error, forces DR, the driver voltage reference to move in a direction to decrease the error.

** Four Quadrant only

2.6 (Continued)

Pos.	Nomen.	
10	DERR	The amplified difference between DR, the desired motor voltage, and VFB, the actual motor voltage. This difference, or driver error, forces the phase control reference, PCR, to move in a direction to reduce the error.
11	ORR	The input which releases the driver/regulator preconditioning. If ORR is positive, the drive is unable to run.
12	OSR	The input which applies the system reference, SR to the linear time section of the regulator. If OSR is positive, SR is not connected to the regulator.
13	OAPR	The input which applies the auxiliary preset reference, APR, to the regulator. If OAPR is positive, APR is not applied.
14	1STP	The output from the Monitor card to the driver coordination which will stop the drive and remove the firing signals from the SCR's.
15	SYS	The system trip input from either the MFC or other input at GTB15 which trips the SYS indicator on the Monitor card and shuts down the drive.
16	PCM	The input from the MFC at GTB12 to monitor motor field control performance.
17 18	+20V -20V	The $\pm$20V DC power supply outputs.
19	SEL	Connected to the moveable jumper in the Driver/Regulator back plane.

2.7 TEST MODES

A drive system consists of four basic sections; the regulator and power conversion section, the motor and loop contactor section, the reference and relay logic section, and the system feedback and stability section. The diagnostic card programs the IC Driver/Regulator to allow each section to be set up and checked out independently.

2.7.1 The first test mode is TREG, (test regulator) with MOTR out. With TREG depressed and MOTR out, the LR pot is connected to the linear time section of the Regulator card, the system reference and APR switches are off, the system feedback is off, and unity gain feedback is connected around all integrators. The SCR pulses are locked in maximum phase-back condition, and a dummy current feedback signal proportional to the LR setting is injected into the drive. In this mode the system adjustments TIM+, TIM- and ILIM may be adjusted. If an MFC is provided, a dummy voltage signal proportional to LR is used to adjust the SMAX (max. field), SMIN (min. field), FLOSS (field loss), and CROSS (crossover) in the motor field control. The field loss and IOC shutdown circuits may also be verified.

2.7.2 The second test mode is TREF (test reference) with MOTR out. With TREF depressed and MOTR out, the SCR pulses are locked off, and local unity gain feedbacks are inserted around each integrator. LR has no effect. In this mode, the system reference(s) and relay logic may be checked out, including the motor loop contactor and limit switches without the motor shaft turning. The APR adjustment in the IC Driver/Regulator is set.

2.7.3 The third test mode is TREG with MOTR in. In this mode, the LR is substituted for the system reference(s) and a local gain loop is substituted for the system feedback in the regulator. The motor loop contactor has been picked up, and the Motor Field Control, if used, is locked in full field operation. The SCAL (speed calibrate) and the direction of motor rotation is verified.

2.7.4 The fourth test mode is TREF with MOTR in. In this mode, the LR is disconnected and the system reference(s) are applied. A local feedback is substituted for the system feedback and the MFC is locked in full field. The motor will operate as a voltage regulator under the commands from the system reference and relay logic.

2.7.5 The fifth test mode is TFBK (test feedback) with MOTR in. In this mode, the LR is substituted for the system reference(s) but the IC Driver/Regulator and the MFC are operating in normal mode. The SMAX, DAMP, COMP, and RESP adjustments in the IC Driver/Regulator and the SLIM (max. speed trip) adjustments in the MFC are set.

2.7.6 The last test mode is TFBK with MOTR out. In this mode LR is substituted for the system reference(s) and local feedbacks are substituted for the system feedback. SCR pulses are not inhibited. This test mode is normally used only for trouble shooting the IC Driver/Regulator.

2.7.7 For normal operation depress NORM (normal) and leave MOTR out.

2.7.8 TRANSFER:

When transferring from mode to mode, internal circuitry will prevent the drive from operating in the new mode until the motor voltage is down to a safe level. The transfer circuit is initiated whenever a mode is released or the MOTR button is selected or released. Transfer will not be complete until a new mode has been selected and the motor voltage is at a safe level. During transfer, the red indicator will be on. When the indicator goes out, the drive is operating under the control of the new mode.

If an attempt is made to transfer into or out of test mode TREG with MOTR in, a system trip will be generated, opening the F relay on the monitor card and illuminating the SYS indicator. The trip may be reset by depressing the RTR/Reset indicator.

If an attempt is made to operate in the normal mode with MOTR depressed, a system trip will be initiated as above. To clear the trip, release the MOTR button and depress the RTR/Reset indicator.

2.8 STANDARD PARAMETER SELECTIONS

Several design parameters may be modified in the IC Driver/Regulator by selectively adding wire jumpers between pins in the backplane. A list of these standard selections is shown below. In addition to these standards, additional parameter modifications may have been furnished to meet a particular drive requirement. Refer to the system elementary to determine exactly what has been furnished on a particular drive. These selections have been made at the factory and will not normally need to be changed.

Standard Selections for:		Connect on:
		Phase Control Card
1a.	60 Hz	None
1b.	50 Hz	26 - 27
		Driver Coordination Card
2a.	Driver Curr. Limit, less than 75HP	None
2b.	Driver Curr. Limit, more than 75HP	20 - 32
2c.	No Driver Current Limit	20 - 31
		Regulator Card
3a.	20V System Reference	15 - 26X
3b.	10V System Reference	None
3c.	3V System Reference	25X - 26X
4a.	No Auxiliary Reference	None
4b.	Timed Auxiliary Reference forward	23X - 29X, 30X - 31
4c.	Timed Auxiliary Reference reverse	23X - 29X, 2 - 30X
4d.	Untimed Aux. Reference forward	24X - 29X, 2 - 30X
4e.	Untimed Aux. Reference reverse	24X - 29X, 30X - 31
5a.	No Linear Time	None
5b.	.5 - 3 Sec. Linear Time	20X - 27X
5c.	3 - 30 Sec. Linear Time	20X - 28X
	Tachometer Feedback between	
6a.	43 - 62V DC	13X - 14X, 17 - 18
6b.	60 - 115V DC	13X-14X, 17-18, 14-15, 18X-19X
6c.	100 - 200V DC	14X - 15X, 15X - 18
6d.	190 - 380V DC	14X-15X, 15X-18, 14-15, 18X-19X
6e.	26 - 48V AC	11-19, 13X-14X, 17-18
6f.	47 - 85V AC	11-19, 13X-14X, 17-18,14-15,15X-19X
6g.	82 - 152V AC	11-19, 14X-15X, 15X-18
6h.	151-275V AC	11-19, 14X-15X, 15X-18, 14-15, 15X-19
6i.	Voltage Regulator	3 - 14, 15 - 18X
7a.	No Load Regulator Compensation	None
7b.	Load Regulation Compensation	5X - 12
8a.	Low Response Range	None
8b.	Normal Response Range	6 - 16
9a.	No Regulator Current Limit	None
9b.	Regulator Current Limit	9X - 16

2.8 (Continued)

	Top Speed/Base Speed, Ratio between	
10a.	.9 - 1	10 - 11X, 8 - 15
10b.	1 - 1.10	10 - 11X
10c.	1.1 - 1.15	10 - 11X, 8 - 11X
10d.	1.15 - 1.3	10 - 11X, 8 - 9
10e.	1.3 - 1.45	10X - 11X, 8 - 15
10f.	1.45 - 1.6	10X - 11X
10g.	1.6 - 1.75	10X - 11X, 8 - 11X
10h.	1.75 - 2	10X - 11X, 8 - 9
10i.	2 - 2.25	8 - 15
10j.	2.25 - 2.55	None
10k.	2.55 - 2.7	8 - 11X
10l.	2.7 - 3.0	8 - 9
10m.	3.0 - 3.25	10X - 15, 8 - 9
10n.	3.25 - 3.75	10 - 10X, 8 - 15

2.9 TABLE OF ABBREVIATIONS

The following is an alphabetical list of all abbreviations used in this instruction with a cross reference to where it may be located (terminal board, test post, instrument switch position or card assembly) and its normal voltage or condition. For these signals which vary as a function of the operating conditions the typical top speed condition is indicated with an asterisk. Polarities are as shown when drive is operating as forward rotating motor at rated load.

			Normal	Location			
Abbrev.	Name	Type	State	TB	TP	I	Card/Asm.
AC1	3Ø AC	Input	230/460	AC1			
AC2	3Ø AC	Input	230/460	AC2			
AC3	3Ø AC	Input	230/460	AC3			
APR	Aux. Preset Reference	Adjust.		-	-	-	R
CRB	Current Feedback	Output	+2.5*	13	M	7	
COIL	Coil MD Pilot Relay	Output		1	M,PS, MFC	-	
COM	Common		0	8			
COMP	IR Compensation	Adjust.		7			R
CROSS	Voltage Crossover	Adjust.					MFC
D	Diagnostic	Card					
DAMP	Motor Damping	Adjust.					R
DC	Driver Coordination	Card					
DERR	Driver Error		-6*		M	10	
DR	Driver Reference		+10*		M	4	
F	Fault Relay Contact		Closed	10,11			
FB+	Positive Tach Feedback	Input	+( )*	6			
FB-	Negative Tach Feedback	Input	-( )*	9			
FCI	Field Control Inhibit	Output	Open	16			
FCM	Field Control Monitor	Input	+8*	12		16	
FCR	Field Control Test Ref.	Output	0	5			

2.9 (Continued)

Abbrev.	Name	Type	Normal State	Location: TB	TP	I	Card/Asm.
FLOSS	Field Loss	Adjust.					MFC
FMAX	Maximum Field	Adjust.					MFC
FMIN	Minimum Field	Adjust.					MFC
GC	Gate Control	Card					
GTB	Control Term. Board						
H1	115V AC	Input	115	H1			
H2	115V AC	Input	115	H2			
I	Instrument	Card					
IC	Integrated Circuit						
ILIM	Reg. Curr Limit	Adjust.					R
IOC	Instant. Curr. Trip	Indicator	OFF				M
LINE	AC Impedance Comp.	Adjust.					QC
LR	Local Test Reference	Adjust.				1	D
M	Monitor	Card					
MD	Motor Loop Contactor		CLOSED				
MFC	Motor Field Control						
MOTR	Motor Loop Test	Pushbut.	OUT				D
NDC	Negative DC Power	Input		NDC			
NDCF	Neg. DC Power Fused	Input		NDCF			
NORM	Normal Mode Operation	Pushbut.	IN				D
P1	Positive Module	Output					
P2	Negative Module	Output					
PA	Power Assembly						
PC	Phase Control	Card					
PCR	Phase Control Ref.		+6*		M	5	
PCD	Positive DC Power	Input		PDC			
PDCF	Positive DC Pow.Fused	Input		PDCF			
PI	{Diagnostic Switch	Input		21			
PO	{Interlock for MD	Output	↑CLOSED	22			
PS	Power Supply	Card					
QC	Quadrant Control	Card					
R	Regulator	Card					
RERR	Regulator error		0			9	
RESET	Fault Reset	Pushbut.					
RESP	Response	Adjust.					R
RPL	Forward Mod. Connector	Output					PA
RTR	Ready-to-Run	Indic.	ON				PA
SCAL	Sp.Feedback Calibrate	Adjust.					MFC
SCR	Silicon Controlled Rect.						
SEL	Selectable Test				M	19	

2.9 (Continued)

Abbrev.	Name	Type	Normal State	Location TB	TP	I	Card/Asm.
SFB	Scaled Tach Feedback		+8*	1H	M	6	
SLIM	Overspeed Limit	Adjust.					MFC
SMAX	Maximum speed	Adjust.					R
SPL	Reverse Mod.Connector	Output					PA
SR	System Reference	Input	+( )*	4	M	2	
STEP	Step Ref. for Test	Pushbut.	OUT				D
SYNC	Line Synchronization	Output	0, 5		M		
SYS	System Fault	Ind./Input	OFF	15	M	15	M
T1,T2,T3	Power Mod. Input	Indica.	ON				
TDS	Test Data Sheet						
TEMP	Module Overtemp.	Indica.	OFF				M
TBFK	Test Feedback Mode	Pushbut.	OUT				D
TIM+	Linear Time Accel.	Adjust.					R
TIM-	Linear Time Decel.	Adjust.					R
TR	Timed Reference		-10*		M	3	
TRANSFER	Mode Transfer	Indica.	OFF				D
TREF	Test Reference Mode	Pushbut.	OUT				D
TREG	Test Regulator Mode	Pushbut.	OUT				D
VFB	Voltage Feedback		-5*		M	8	
ULIM	Voltage Limit	Adjust.					DC
VR	Voltage Ripple				QC		
+5V	+5V DC Power Supply		+4 to +6		M		DC
+15V	+15V Power Supply		+14 to +16				DC
+20V	+20V DC Power Supply		+19.9 to 20.1	3	PS	17	
+30V	+30V DC Power		+20 to +40				
-15V	-15V DC Power Supply		-14 to -16				
-20V	-20V DC Power Supply		-19.9 to 20.1	2	PS	18	
-30V	-30V DC Power Supply		-20 to -40	17			
OAPR	APR Switch	Input	-30V=ON	19		13	
OFE	Forward Error		{ 0=Fwd.		QC		
OIP	Initial Pulse		{ +5=Rev.		M		
ORR	Reg. Run Switch	Input	-30V=ON	18		11	
OSR	System Ref.Switch	Input	-30V=ON	20		12	
1CST	Zero Current Shutdown		{ 0=Norm. +2=for shutdown		M		
1F1-1F6	Forward Firing Signal	Output	-20V		GC		RPL
1R1-1R6	Reverse Firing Signal	Output	-20V		GC		RPL
1STP	Controlled Stop		{ 0=Norm +6 for Stop			14	

SECTION III

START and CHECKOUT

3.0 GENERAL

This section is written in a step-by-step approach to start-up and checkout the basic drive system. If during the start-up and checkout, a step cannot be performed or completed, refer to Section TROUBLESHOOTING. The troubleshooting table is written to follow each startup step in sequence. Start-up and checkout steps are cross-referenced in the troubleshooting table by paragraph number and indication. This section does not include instructions on special regulators or auxiliary functions or controls and indicators which may be included in individual special systems. These will be covered in the system elementary diagram notes.

Any additional limit switches or protective circuits added during installation should be checked out and operational. The basic drive has been factory tested and adjusted and a Test Data Sheet is provided to indicate factory test settings and measurements. Recommended methods of re-setting the system adjustments are given in the following procedure but normally changes will not be required.

3.1 TEST EQUIPMENT REQUIRED

This drive has been designed so that a volt-ohm meter (VOM) is all that is required for the normal startup and checkout. In addition to the VOM, other test equipment that may be required for auxiliary functions and devices or detailed troubleshooting is listed:

a) Volt-Ohm Meter (VOM) three ranges minimum X1, X10 and X100; 20,000 Ohm per volt DC sensitivity, 0 to 600V range
   or
   Instrument card
b) Oscilloscope (Scope) DC, Triggered Sweep, 1MHZ
c) PRM Measuring Device (0 to 4,000 RPM Tach)

3.2 POWER-OFF CONTINUITY TEST

WARNING

VERIFY THAT THE MAIN THREE-PHASE AC POWER INPUT TO THE SYSTEM EQUIPMENT IS DISCONNECTED OR SWITCHED OFF.

Perform a point-to-point continuity test for all newly installed wiring and interconnection. Continuity is defined as 1/2 ohm or less.

Manually operate all contactors, breakers (if provided) and relays.

Check that all plug-in devices (printed circuit cards and relays) are fully seated.

Verify all terminal board connections are tight and remove all tools and wire scraps from the case.

Insure that the motor shaft is properly coupled to the load and that the load is free to be driven.

Verify that the AC input line voltage is the proper value and frequency as per the drive unit data nameplate.

NOTE

Due to the variations of equipment supplied the test data sheet entries under the factory column should be used for comparison measurements, whenever any difference between instruction book measurements and equipment measurements occur.

WARNING

ELECTRIC SHOCK CAN CAUSE PERSONAL INJURY OR LOSS OF LIFE. WHETHER THE AC SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS THROUGHOUT THE DRIVE.

NOTE

During checkout, record measurements and settings on the test data sheet supplied, under the user data column. TDS beside a step indicates an entry on the test data sheet.

CAUTION

ALWAYS RETURN SPEED REFERENCE INPUT TO ZERO AND LET MOTOR COME TO A REST PRIOR TO REMOVING AC POWER.

3.3 POWER APPLIED TEST

Release all buttons on the Diagnostic card (if supplied) and apply three-phase power. The orange phase indicator (T1, T2, T3) on the power module will be lit, and RTR/Reset indicator will be on, and the transfer indicator on the Diagnostic card will be on. If RTR is off and the STS indicator on the Monitor card is onk the input phase sequence is probably incorrect. If the phase sequence is not ABC as measured on T1, T2, T3 or the power module(s), remove power and reverse any two of the incoming power leads.

3.4 START-UP with DIAGNOSTIC & INSTRUMENT

In the following test modes, the Instrument card switch position to measure a particular voltage is indicated in parentheses.

3.4.1 TREG (Test Regulator)
With all buttons out, adjust LR (local reference potentiometer) until LR(1) just reaches zero. Depress TREG.

3.4.1.1 Slide LR to full top. The IOC indicator will come on. Reset LR(1) to zero.

3.4.1.2 (MFC only) Verify that FMAX TDS is correct by comparing FCM(16) to the TDS.

Max. Field Adjustment FMAX (MFC only)
The test data sheet indicates the factory setting of FMAX with the corresponding value of FCM, the scaled field current. To change the max. field current, compute a new value for FC max. from the following formula:

$$\text{FCM max. new} = \text{factory FCM max.} \times \frac{\text{New max. field (from motor nameplate)}}{\text{Factory max. field}}$$

Set LR(1) to zero and monitor FCM(16). If FCM is less than desired rotate FMAX CW. If FCM is more than desired, rotate FMAX CCW. Note: If the FMAX potentiometer has insufficient range, the current scaling tabs of the field control card must be changed as noted in the MFC instruction manual. If the tabs are changed, a DC ammeter must be inserted in the motor field circuit to measure actual amps and FMAX, FMIN and FLOSS must be recalibrated.

3.4.1.3 (MFC only) Verify that FMIN is correct by comparing FCM(16) to the TDS.

Min. Field Adjustment FMIN (MFC only)
The test data sheet indicates the factory setting of FMIN and the corresponding value of FCM. To change the min. field adjustment, first compute a new FCM min. by:

$$\text{FCM min. new} = \text{FCM min. factory} \times \frac{\text{New min. field (from motor nameplate)}}{\text{Factory min. field}}$$

Depress TREG and slide LR to full top. (The IOC indicator will light indicating that the instantaneous overcurrent trip circuit is functioning.) If FCM is too low, rotate FMIN CW, if FCM is too high, rotate FMIN CCW. Note: As SMIN is rotated, the SYS trip light on the monitor may light. This will happen whenever the min. field is adjusted lower than the field loss adjustment FLOSS. If this happens, set min. field, then reset the field loss adjustment, FLOSS.

3.4.1.4 (MFC only) Verify the FLOSS adjustment by sliding LR down until the STS indicator lights. Compare FCM(16) to the TDS.

Field Loss Adjustment, FLOSS (MFC only)
Compute the desired value for FCM loss as before. Monitor FCM(16), and with TREG depressed, slide LR down below center until FCM reads the desired value. Monitor the system trip input SYS at positive 15. If SYS is zero, rotate FLOSS CW until SYS just goes positive. If SYS is positive, rotate FLOSS CCW until it just goes to zero. Monitor FCM(16) and slide LR to the top. FCM(16) will be at the min. field setting. Push the RTR/Reset button and the SYS light will go out.

3.4.1.5 (MFC only) Verify the CROSS adjustment by sliding LR upwards until FCM(16) just begins to decrease. Compare LR(1) to the TDS.

Field Crossover Adjustment, CROSS (MFC only)
Refer to the test data sheet for the factory setting of crossover and the corresponding value of LR. Compute new value for LR as before. With LREG depressed, monitor LR(1) and adjust LR upward for the desired value. Monitor FCM(16). If FCM is at the minimum field value, slowly rotate CROSS CW until FCM just begins to move. If FCM is at the max. field value, slowly rotate CROSS CCW until FCM just begins to decrease.

3.4.1.6 Return LR(1) to zero. Verify the TIM+ adjustment by sliding LR to full top and measuring the time it takes for TR(3) to move from zero to -10 volts. Verify the TIM- adjustment by sliding LR to full bottom and measuring the time it takes for TR(3) to move from -10 volts to zero.

Timed Ramp Adjustments TIM+, TIM-
Rotate TIM+ and TIM- clockwise to increase the time, CCW to decrease the time.

3.4.1.7 Return RL(1) to zero. Verify the ILIM adjustment by moving LR upward until DR(4) just begins to decrease. Compare CFB(7) to the TDS.

Current Limit Adjustment, ILIM
The test record sheet indicates the factory setting of current limit. To change the current limit level, first compute a new CFB limit value from the following formula:

$$\text{New CFB limit} = \text{old CFB limit} \times \frac{\text{New Amp Limit}}{\text{Old Amp Limit}}$$

CAUTION

DO NOT INCREASE THE CURRENT LIMIT SETTING WITHOUT VERIFYING THAT AN EQUIPMENT OVERLOAD WILL NOT RESULT.

Monitor CFB(7). Depress TREG and move LR up until CFB is at the new CFB limit value.

Monitor DR(4). If DR is positive, rotate ILIM CCW until DR just begins to go negative. If DR is negative, rotate ILIM CW until DR just begins to go positive.

3.4.2 Return LR(1) to zero and depress the Reset button.

TREF (Test System Reference and Relay Logic)
Depress TREF. In this test mode the firing signals to the power module(s) are inhibited. The voltage at DR(4) corresponds to what motor RPM will be when the drive is running in Normal mode.

3.4.2.1 Monitor DR(4) and operate the relay logic. Verify that DR(4) behaves as the motor RPM is expected to behave.

3.4.2.2 Verify the APR adjustment by comparing PR(4) to the TDS.

Auxiliary Preset Reference Adjustment, APR
Rotate APR clockwise to increase the APR signal.

3.4.3 TFBK (Test voltage feedback and power module)
Release all buttons, set LR(1) to zero and depress TFBK.
Verify the power loop is functional. As LR is moved upward VFB(8) will swing negative to about 5 volts. VFB(8) will "track" the movement of LR.

3.4.4 TREG and MOTR (Test Motor and Power Loop)
Release all buttons, set LR(1) to zero, and depress TREG and MOTR. The drive is now programmed as a voltage regulator.

3.4.4.1 Verify that the direction of motor rotation by pushing LR upward until the motor shaft just begins to turn. If the motor is not rotating forward, remove AC power and interchange the motor field leads.

3.4.4.2 Verify that the tachometer polarity is correct. With LR pushed slightly upward, the motor will be rotating forward and SFB(6) will be positive. If SFB is not positive, remove AC power and interchange the tachometer input leads.

3.4.4.3 (MFC only) Verify that SCAL is properly adjusted. Connect test post CM to test post TA in the MFC. Monitor FCM(16) and increase LR. FCM should not exceed ±2 volts as LR is moved to full top.

Speed calibration adjustment SCAL (MFC only)
Temporarily connect test post CM to TA in the MFC. Monitor FCM(16) and slowly increase LR. Adjust SCAL to bring FCM to zero. If FCM cannot be adjusted to zero, remove power, reverse the tachometer leads and repeat. When SCAL is properly adjusted FCM(16) will not vary by more than two volts as LR is moved from full forward (up) to full reverse. Disconnect the jumper between the CM and TA test posts.

3.4.4.4 The motor will operate between zero and base speed as LR is moved from center to top. Four quadrant drives will operate between base speed reverse to base speed forward as LR is moved from bottom to top.

3.4.4.5 Verify that VLIM is correct by comparing VFB(8) to the TDS with LR at full top.

Voltage Limit Adjustment (VLIM)

CAUTION

IF VOLTAGE LIMIT IS SET TOO HIGH IN FOUR QUADRANT DRIVES, CERTAIN OPERATING CONDITIONS MAY CAUSE THE DRIVE TO MISOPERATE AND BLOW FUSES.

To reset the voltage limit, set LR at either end of its travel, measure the armature voltage and adjust VLIM until the armature voltage reaches the desired level.

3.4.5 TREF and MOTR (Voltage Regulator)
Release all buttons then depress TREF. Depress MOTR. The drive is nos programmed to operate from the system reference and relay logic as a base speed voltage regulator.

This test mode is not normally used in start-up.

3.4.6 TFBK and MOTR (Test Feedback and Stability)
Release all buttons, set LR(1) to zero, and depress TFBK and MOTR.

3.4.6.1 Verify that SMAX is correct by monitoring the motor RPM and pushing LR upward. When LR is at top, the motor RPM should be at top speed.

3.4.6.1 (Continued)

Maximum Speed Adjustment SMAX
Monitor TR(3) and set to 10 volts with LR. Measure the motor RPM and adjust SMAX to set desired top speed.

3.4.6.2 Speed Limit Trip Adjustment SLIM (MFC only)
Slowly slide LR to full top. Measure motor RPM and adjust SMAX until the desired trip RPM is reached. Slowly turn SLIM CCW until the SYS indicator on the Monitor card comes on and the drive trips off. If the drive trips prematurely, turn SLIM slightly CW, slide LR halfway down, push the RTR/Reset pushbutton and repeat.
Note: The drive will not reset until the motor has come down in RPM.
Re-adjust SMAX.

3.4.6.3 Verify the drive is stable by operating the drive over the speed range. If a system instability exists, the condition may normally be corrected by first turning RESP 1/8 CCW, then turning DAMP 1/8 turn CW. If the instability is worse when the drive is operating in the constant horsepower range, turn COMP 1/8 turn CW.

Stability Adjustments RESP, DAMP
Monitor VFB(8) and set for approximately 4 volts by adjusting LR. Monitor the regulator error signal RERR(9) and depress the STEP button. RERR will jump high then return to zero. As RERR comes back to zero, it will undershoot slightly. Adjust RESP and DAMP for the quickest return to zero with the minimum amount of undershoot. Increasing the RESP will speed up the return to zero but slightly increase the undershoot, and increasing DAMP will decrease the undershoot but slightly slow down the return to zero.

Current Compensation Adjustment COMP

a) Tachometer feedback not provided. Monitor VFB(8) and set to approx. 4 volts. Measure the motor RPM under no load. Apply full load to motor and adjust COMP CW until the full load RPM is equal to the measured no load RPM.

b) Tachometer feedback provided, no Motor Field Control. COMP is not normally connected into the circuit. Refer to system elementary for special instructions, if any.

c) Motor Field Control and Tachometer Feedback provided. Monitor FCM(16) and increase LR until FCM just begins to decrease. Monitor RERR(9) and push the STEP button. Adjust COMP to minimize the undershoot of RERR as noted in the DAMP and RESP adjustment section. Continue to increase LR and adjusting COMP until the drive is running at top speed. It may be required to slightly adjust RESP and DAMP to obtain optimum performance at top speed.

3.4.6.4 Set LR(1) to zero, release all buttons and depress NORM. Review the system drawings and set up and special function adjustments provided.

This completes the drive start-up.

3.5 START-UP WITHOUT INSTRUMENT and DIAGNOSTIC

3.5.1 (MFC only) Reapply power and verify that SMAX is properly adjusted by measuring FCM (GTB12) and comparing it to the TDS.

Maximum Field Adjustment (MFC only)
The test data sheet indicates the factory setting of FMAX with the corresponding value of FCM, the scaled field current. To change the max. field current, compute a new value for FC max. from the following formula:

$$\text{FCM max. new} = \text{factory FCM max.} \times \frac{\text{New max. field (from motor nameplate)}}{\text{Factory max. field}}$$

Monitor FCM, at GTB12. If FCM is less than desired rotate FMAX CW. If FCM is more than desired, rotate FMAX CCW.

Note: If the FMAX potentiometer has insufficient range, the current scaling tabs on the field control card must be changed as noted in the MFC instruction manual. If the tabs are changed, a DC ammeter must be inserted in the motor field circuit to measure actual amps and FMAX, FMIN and FLOSS must be recalibrated.

3.5.2 (MFC only) Connect a 10K ohm potentiometer between -20V (GTB2) and +20V (GTB3). Connect the wiper to FCR (GTB5) and set for -10 volts. Verify the SMIN adjustment by comparing FCM (GTB12) to the TDS.

Minimum Field Adjustment FMIN (MFC only)
The test data sheet indicates the factory setting of FMIN and the corresponding value of FCM. To change the minimum field adjustment, first compute a new FCM min. by:

$$\text{FCM min. new} = \text{FCM min. factory} \times \frac{\text{New min. field (from motor nameplate)}}{\text{Factory min. field}}$$

Monitor FCM (GTB12). If FCM is too low, rotate FMIN CW, if FCM is too high, rotate FMIN CCW.

Note: As SMIN is rotated, the SYS trip light on the monitor may light. This will happen whenever the min. field is adjusted lower than the field loss adjustment. If this happens, set min. field, then reset the field loss adjustment, FLOSS.

3.5.3 (MFC only) Apply a positive voltage to FCR (GTB5) until the STS indicator trips. Verify the FLOSS adjustment by comparing FCM (GTB12) to the TDS.

Field Loss Adjustment, FLOSS (MFC only)
Compute the desired value for FCM loss as before. Monitor FCM (GTB12) and adjust the pot until FCM reads the desired value. Monitor the system trip input SYS (GTB12). If SYS is zero, rotate FLOSS CW until SYS just goes positive. If SYS is positive, rotate FLOSS CCW until it just goes to zero. Push the RTR/Reset button and the STS light will go out.

3.5.4 Remove power. Open the card rack and connect the selectable jumper to pin 23 on the Regulator card. Close the card rack. Connect the SEL test post on the Monitor card to +20 volts (GTB3). Connect FCI (GTB16) to common (GTB8). Disconnect the 10K potentiometer and reapply power. The drive will now run as a base speed voltage regulator.

3.5.5 Set the system reference to zero. While watching the motor shaft, start the drive. If motor direction is incorrect, remove power and interchange the leads to the motor field.

3.5.6 Run the motor in the forward direction and monitor test post SFB. If the tachometer is properly connected, SFB will be negative and will be proportional to the reference. If SFB is positive, remove power and reverse the tachometer input leads.

3.5.7 (MFC only) Monitor the voltage at test post TA in the MFC and start the drive. TA will be less than ± 2 volts as the reference is turned to maximum.

Speed Calibration Adjustment SCAL (MFC only)
Measure the voltage between test post TA and COM in the MFC, and slowly increase the reference. Adjust SCAL for zero volts at TA.

3.5.8 With the drive reference at maximum verify that VLIM is correct by comparing the voltage on test post VFB to the TDS.

Voltage Limit Adjustment (VLIM)

CAUTION

IF VOLTAGE LIMIT IS SET TOO HIGH IN FOUR QUADRANT DRIVES, CERTAIN OPERATING CONDITIONS MAY CAUSE THE DRIVE TO MISOPERATE AND BLOW FUSES.

To reset the voltage limit, run the drive at maximum reference, measure the armature volts and adjust VLIM. The armature voltage limit is normally set at 1.15 times the applied AC line voltage.

Current Limit Adjustment ILIM
Remove power. If a Motor Field Control is provided, remove the +20V input to the MFC. If a fixed field exciter is furnished, remove the AC input to the exciter and temporarily jumper the field loss relay contacts. Install an ammeter in the motor armature circuit. Mechanically block the motor shaft to prevent rotation.

WARNING

THE SHAFT SHOULD BE RIGIDLY BLOCKED DURING THIS ADJUSTMENT, AS A SIGNIFICANT PERCENTAGE OF THE RATED TORQUE MAY BE DEVELOPED DUE TO THE RESIDUAL MAGNETISM OF THE FIELD. IF THE SHAFT BEGINS TO ROTATE, MOTOR OVERSPEED MAY RESULT IN EQUIPMENT DAMAGE OR DESTRUCTION.

CAUTION

WHEN MAKING THIS ADJUSTMENT, POWER SHOULD NOT BE APPLIED TO THE MOTOR FOR MORE THAN THREE SECONDS TO PREVENT MOTOR DAMAGE FROM OVERHEATING. THIS CONDITION MAY NOT BE REPEATED MORE THAN ONCE A MINUTE FOR A MAX. OF THREE TIMES.

CAUTION

DO NOT INCREASE THE CURRENT LIMIT SETTING WITHOUT VERIFYING THAT AN EQUIPMENT OVERLOAD WILL NOT RESULT.

Turn the reference up and start the drive. Quickly measure the motor current and stop the drive. If the motor current is too high turn ILIM slightly CCW and repeat. When the current limit is properly adjusted, remove power, remove the jumper from the field loss relay, replace the fuses in the exciter or the +20V input to the MFC and attempt to start the drive. The motor loop contactor should not pick up. Remove the mechanical block from the motor shaft.

3.5.9 Remove power. Remove the jumper from test post SEL and +20V. Remove the jumper from FCI (GTB16) and common.

3.5.10 Verify the drive is stable by operating the drive over the speed range. If a system instability exists, the condition may normally be corrected by first turning RESP 1/8 CCW, then turning DAMP 1/8 turn CW. If the instability is worse when the drive is operating in the constant horsepower range, turn COMP 1/8 turn CW.

Stability Adjustments RESP, DAMP

Remove power, open the card rack and connect the moveable backplane jumper to pin 12 on the Regulator card. Close the card rack. Connect a 100K ohm resistor from -20V (GTB2) thru a pushbutton to the SEL test post on the Monitor card. Reapply power and set the motor voltage to approximately 80% of rated. Monitor the motor RPM and depress the pushbutton. Adjust RESP and DAMP for good response, with a minimum amount of speed overshoot. In general, rotating the RESP adjustment CW will increase the drive response, and rotating the DAMP adjustment CW will decrease the overshoot.

Current Compensation Adjustment COMP

a) Tachometer feedback not provided. Adjust the reference for approximately 80% of top speed and measure the motor RPM. Apply load to the motor, and adjust COMP until the loaded RPM equals the unloaded RPM.

b) Tachometer feedback provided, no motor field control. COMP is not normally connected into the circuits. Refer to system elementary for special instructions, if any.

c) Motor field control and tachometer feedback provided. Increase the reference until the motor voltage reaches crossover. Using the pushbutton arrangement detailed in the RESP and DAMP section, adjust COMP for desired performance. Slowly increase the reference and continue to adjust COMP until satisfactory performance is achieved at top speed. It may be necessary to trip the RESP and DAMP adjustments to obtain optimum performance.

3.5.11 (MFC only) Verify that CROSS is properly adjusted by running the drive up in speed until the test post VFB reaches a maximum. Compare this value to the TDS.

Field Crossover Adjustment CROSS (MFC only)

Measure the motor voltage and increase the reference to just past where the voltage ceases to rise. Adjust CROSS to set the desired level.

3.5.12 Verify that SMAX is properly adjusted by measuring the motor RPM when the reference is at maximum.

<u>Maximum Speed Adjustment SMAX</u>
With the reference at maximum, measure the motor RPM and adjust SMAX until the desired top speed is reached.

3.5.13 (MFC only) Verify that SLIM is properly adjusted by running the drive at maximum reference and depressing the pushbutton described in the RESP adjustment section. The SYS indicator should light when the button is pushed.

<u>Speed Limit Trip Adjustment SLIM (MFC only)</u>
Monitor motor RPM and increase the reference to maximum. Rotate SMAX CW until motor RPM reaches desired trip level. Slowly rotate SLIM CCW until the SYS indicator on the Monitor card lights and the drive trips off. If a trip occurs prematurely, turn SLIM slightly CW, depress the RTR/Reset indicator and repeat.
Note: The drive will not reset until the motor has come down in RPM.

3.5.14 Verify that the TIM+, TIM- and APR adjustments are correct.

<u>Timing Ramp Adjustment TIM+</u>
Preset the reference to maximum forward and start the drive. If the acceleration time is too short, turn TIM+ CW and repeat.

<u>Timing Ramp Adjustment TIM-</u>
Preset the reference to maximum reverse and start the drive. If the acceleration time is too short, turn TIM- CW and repeat.

Note: If the acceleration times are too long, first tri rotating TIM+ (or TIM-) CCW. If this does not reduce the acceleration times, the drive may be accelerating in current limit, or if an MFC is provided, on the slow rate of the motor field.

<u>Auxiliary Preset Reference Adjustment APR</u>
Actuate the appropriate relay logic that connects OAPR (GTB19) to -30 volts. Adjust APR for desired motor RPM.

3.5.15 Review the system drawings and set up any special function adjustments provided.

3.5.16 This completes the start-up of the drive.

SECTION IV

TROUBLESHOOTING

4.0 If trouble is encountered, first refer to the troubleshooting tables 4.1 and 4.2. Table 4.1 lists the probable trouble areas when the drive will not operate, and Table 4.2 lists the probable trouble areas when the drive operates but not correctly. To correctly use the tables check the drive for each symptom listed, beginning at the top of the table, until a problem area is located. It is important that troubleshooting begin at the first symptom encountered on the table.

Section 4.3 pertains to troubleshooting the IC Driver/Regulator assembly after tables 4.1 and 4.2 have indicated the problem is in the IC Driver/Regulator.

Section 4.4 shows the typical voltage waveforms of various test points in the drive.

4.1 DRIVE SYSTEM NOT OPERATING

Symptom	Probable Problem Area
T1, T2, T3 OFF	1. Check 3-phase input against drive nameplate. 2. Check the AC line fuses. If any of the fuses are open they were probably blown by one of the following: a) Removing or inserting the printed circuit cards with power applied. b) A short across the AC input or DC output. c) A defective SCR
TEMP indicator ON	1. The harnesses between the power module(s) and the driver regulator are loose. The connectors should be tightened until they "click". 2. The module has been overloaded. Check drive rating and actual load conditions. 3. The cooling air has been restricted. Check filters (if provided), fan rotation (if provided) and air paths for blockage. 4. Module ambient temperature is too high. 5. If TEMP will not reset after power is removed, and the voltage on pin 17 of the Monitor card is zero, replace the Monitor card.
IOC indicator ON	1. If the driver current limit has been inhibited, a transient acceleration current probably tripped the drive. Turn the RESP adjustment 1/8 turn CCW to slow down the drive. 2. A "glitch" occurred in the driver regulator - normally caused by an unsuppressed relay operating in the vicinity of the driver regulator.

IOC indicator ON	3.	In four quadrant drives, a failure to regenerate may cause the current to exceed the trip level. A commutation failure normally occurs whenever the applied AC voltage dips lower than the CEMF of the motor. The CEMF of the motor may be limited to a lower value by lowering the voltage limit with the VLIM adjustment. A secondary cause of commutation failure is a high impedance input line. The quadrant control card has an adjustment LINE to help the drive commutate. LINE should be adjusted as follows: Compute the per unit line impedance based on the drive ratings. Set the LINE adjustment to match the per unit impedance. With tab 14 on the Quadrant Control card open LINE has a linear range from 2 to 5% as LINE is rotated CW. With tab 14 connected to tab 19, LINE has a range of 4 to 10%. The factory setting is nominally 3%. In general, commutation problems must be analyzed on a system basis, as they are normally caused by line disturbances, not by a failure in the control.
	4.	Defective Monitor or Driver Coordination card.
SYS indicator ON	1.	Incorrect phase sequence or loss or phase.
	2.	If Diagnostic Card ordered, an attempt to run with both NORM and MOTR depressed will institute a trip. A transfer into or out of TREF with MOTR in will institute a trip.
	3.	A DC link fuse (if furnished) is open or the jumpers between PDC-PDCF and NDC-NDCF are missing if DC fuses were not furnished. The primary reason for blowing DC link fuses is either a commutation failure or a motor flashover.
	4.	If an MFC is provided, a loss of motor field will cause a trip. If a permanent loss of field has occurred, FCM will be at close to zero volts. If a transient field loss signal caused the trip, FCM will be at the maximum field value on the TDS and the SYS input will be zero. A transient field loss signal normally indicates that the field loss adjust FLOSS is set too close to the minimum field adjustment FMIN. A typical setting for FLOSS might be at 90% of FMIN.

5. If an MFC is provided, a loss of tachometer signal, incorrect tachometer polarity, or an overspeed condition existed. If the tachometer feedback is correct (see section 4.4.4.2) the drive either has excessive overshoot when accelerating to top speed which can be corrected with the RESP, DAMP, and COMP adjustments, or the SCAL, SMAX and SLIM adjustments are incorrect. Typical setting for SLIM might be 10% above SMAX.

6. Check system elementary for any additional signals connected to the SYS input which may have initiated a trip.

7. Defective Monitor card.

RTR indicator OFF	1. Loss of 115V AC control power at H1 and H2.
	2. A short across the $\pm$20V outputs caused the Power Supply card fuses to open or a defective 20V Power Supply card.
	3. Defective indicator or F relay. If the loop contactor can be picked up, the F relay is all right.
Loop Contactor will not pick-up	1. Check that Diagnostic card is inserted, or if not, that GTB21 is connected to GTB22.
	2. Check that the NORM button on the Diagnostic card is depressed.
	3. Check relay magnetics.
All Indicators and relay magnetics correct, but still won't run	1. If the drive will run from the local reference in the diagnostic mode TREG-MOTR, check the inputs SR, OSR, OAPR, ORR.
	2. If the drive will not run in TREG-MOTR, check the current limit setting ILIM. If ILIM is correct, the trouble is in the Driver/Regulator. See section 4.3.

4.2 DRIVE SYSTEM OPERATES, BUT NOT PROPERLY

Symptom	Probable Problem Area
Runs at top speed - no control	1. If the drive will run from the Local Reference LR in the diagnostic mode TREG-MOTR, check the SR input and tachometer polarity (section 4.4.4.2).
	2. If the drive cannot be controlled in TREG-MOTR, the trouble is in the Driver/Regulator. (See section 4.3).

Drive runs too slow	1. If RERR is zero: a) Too much feedback. Check the SMAX adjustment, the tachometer voltage and the voltage range selected in section 3.8, item 6. SFB should be between 6 and 12 volts at top speed. b) Not enough reference. Check the input SR, the input voltage range selected in section 3.8, item 3. Adjust the SR input so that TR just reaches 10 volts when the system reference is at maximum. Reset SMAX to obtain the correct top speed. 2. If RERR is not zero: a) For drives furnished with a fixed voltage field exciter, the field current may be too high. Adjust the external field resistance until current corresponds to nameplate data. b) VLIM set too low or too much DAMP compensation used. c) If an MFC is provided, CROSS may be set too close to VLIM, or FMIN may be set too high. In normal operation, the value of VFB will not exceed the CROSS adjustment. If NFB starts to increase as the drive approaches top speed, FMIN is set too high and should be reduced. If FMIN is changed, FLOSS should be checked to insure that a small undershoot in field current does not trip the drive.
Drive runs too fast	1. Not enough feedback. Check the SMAX adjustment, the tachometer voltage and the voltage range selected in section 3.8, item 6. SFB should be between 6 and 12 volts at top speed. 2. Too much reference. Check the SR input and the input voltage range selected in section 3.8, item 3. Adjust the SR input so that TR just reaches 10 volts when the system reference is at maximum. Reset SMAX to obtain the correct top speed.
Output has cyclic variations. Frequency does not vary with load or output speed.	1. This is a system instability and normally caused by a drive misadjustment. Check the RESP and DAMP adjustments, and the top speed/base speed range selected in section 3.8, item 10. If changing the RESP and DAMP adjustment does not solve the problem, select the next lower top speed/base speed ratio.
(MFC only) Output has cyclic variations only when operating in the constant horsepower region	1. This is primarily caused by a misoperation of COMP. RESP and DAMP may need to be slightly returned if the COMP adjustment is changed significantly. 2. Check the top speed/base speed range selected in section 3.8, item 10.

Output has cyclic variations whose frequency changes with RPM or load	1.	This is a mechanical problem. Check the mechanical assembly to determine if there is any binding, misalignment, or backlash present. The problem may be localized by analyzing the mechanical parts which are rotating at the same angular frequency as the oscillation.
Erratic Operation	1.	Check the voltage and current feedback signals VFB and CFB with an oscilloscope to determine if all SCR's are working properly. See section 4.4.
	2.	Check for excessive line notching on the AC input lines.
	3.	Check for noise signals appearing on the inputs.

4.3 IC DRIVER/REGULATOR TROUBLESHOOTING

If trouble is suspected in the IC Driver/Regulator, select Diagnostic Mode TREG-MOTR. If the motor runs smoothly from zero to base speed under the control of LR, it is highly unlikely that the driver regulator is defective. For further help go to section 4.1 or 4.2. This procedure assumes that sections 4.1 and 4.2 have been completed. The following procedure will help determine which card or assembly in the Driver/Regulator is defective.

NOTE

When special function cards are provided, analyze the system diagrams in conjunction with this procedure to insure that these other cards are not causing the outputs to appear to be defective.

NOTE

The fastest and most convenient method for troubleshooting is by card substitution. But prior to substituting any cards, verify that the ±20 volt, ±15 volt, and +5 volt power supply voltages are within tolerance. Failure to do this may cause the new card to fail from excessive voltage if the power supplies are defective. ±20 and +5 are on test posts. Use the selectable jumper to check the ±15 volt supplies.

CAUTION

ALWAYS REMOVE POWER PRIOR TO OPENING THE CARD RACK OR REMOVING OR INSERTING PRINTED CIRCUIT CARDS. CLOSE THE CARD RACK PRIOR TO REAPPLYING POWER.

CAUTION

ALWAYS USE THE SELECTABLE JUMPER TO MONITOR THE SIGNALS ON THE CARD PINS.

Check that the jumpers installed in the backplane correspond to the jumpers called for on the system diagrams. Particularly check the jumpers installed on pins 7, 10, 10X, 14, 14X, 18 and 18X of the Regulator card.

For the following procedure, instrument switch positions are indicated by [a] where a is the switch position number. Card pin numbers are designated by the card abbreviation and the pin number in parenthesis, i.e., (DC4) is the fourth pin on the Driver Coordination card.

4.3.1 <u>Drive System not Operating</u>

4.3.1.1 <u>Diagnostic Test</u>
Remove the Diagnostic card and jumper from GTB21 to GTB22. If the drive now functions normally, replace the Diagnostic card.

4.3.1.2 <u>Power Supply Test</u>
With power applied, +20V [17] should be between +19.5 and +20.5 volts and -20V [18] should be between -19.5 and -20.5 volts. If not, check the following:

If (PS20) is not more than +20 volts or (PS10) is not more negative than -20 volts, either 115V AC is not applied to H1 and H2 or the Transformer/Power Supply Rectifier located in the Power Assembly is defective.

Check 1.5a fuses in Power Supply card. If blown, check for output overloads prior to replacing the fuses.

Replace the Power Supply card.

4.3.1.3 <u>Monitor Card Test</u>
Select test mode TREF and push the reset button. SYS, IOC and TEMP will not be lit and RTR will be on. 1STP 14 will be zero volts and the relay contact between GTB10 and GTB11 will be closed. If not, check the following:

If TEMP is on but (M17) is zero volts, replace the Monitor card. If IOC is on but (M16) is zero volts, replace the Monitor card. If SYS is on but (M7) is zero volts, (M3), (M5), (M29) are zero volts and (M13) equals (M14), replace the Monitor card. If 1STP is not zero, replace the Monitor card.

If RTR is off, either the indicator is bad or the F relay on the Monitor card is defective.

4.3.1.4 <u>Regulator Card Test</u>
Select test mode TREF and depress the START button. TR 3 should change from 0 to -10 volts as the system reference is moved from zero to top speed forward. If not, check the following:

SR 2 should change from 0 to +(3,10,20) as the system reference is moved.

OSR 12 should be more negative than -18 volts
ORR 11 should be more negative than -18 volts
(R28) should be more negative than -18 volts
(R22) should be more negative than -18 volts
(R29) should be more negative than -18 volts

If the voltages above are correct but TR 3 will not follow the reference, the card is defective.

Transfer to test mode TFBK. As LR is moved from its midpoint to full top, DR 4 should change from 0 to +10 volts. If not, check the following:

Check that RERR 9 is positive.
Check any inputs to the Regulator from other cards on (R8X), (R9X), (R11), (R12) and (R24X) which might be causing misoperation.
Check that (R9) is positive.
Temporarily remove the Driver Coordination card.
If DR [4] is now correct, the Driver Coordination is defective.

4.3.1.5 <u>Driver Coordination Card Test</u>
Select test mode TFBK. DERR [10] should change from 0 to at least -3 volts as LR is moved from midpoint to top. PCR [5] should change from zero to at least +3 volts as LR is moved from midpoint to top. VFB [8] will be zero volts when the power module output voltage is zero.

Select test mode TREG. (DC11) will change from 0 to at least +10 volts as LR is moved. The IOC indicator will not light until LR 1 exceeds 9 volts, and will have illuminated by the time LR [1] is 12 volts.
(DC25) will be between +14 and +16 volts.
(DC8) will be between -14 and -16 volts.
(DC4) will be between +4 and +6 volts.

DC Monitor (DC26). When 115V AC is applied to H1 and H2 DC26 will be negative for about 1/2 second, then will switch to at least +18 volts.

If trouble is encountered in the above, check the following:
Check that (DC5) is zero.
If DERR 10 is misoperating, check the input signals applied to (DC19) to determine if they are causing misoperation.
If PCR 5 is misoperating, check the inputs on (DC9), (DC10), and (DC7).
Check that OIP is not zero.

4.3.1.6 Quadrant Control Card Test (if provided)
Select test mode TFBK. When LR [1] is positive, DERR 10 will be negative, PCR 5 will be positive, OFE will be zero and (QC29) will be +5 volts. When LR [1] is negative, DERR [10] will be positive, PCR [5] will be positive, OFE will be +5 volts and (QC29) will be zero. (QC25) will be +5 volts. If trouble is encountered in the above, check the following:

(QC27) should be +5 volts.
(QC26) should be 0 volts.
(QC30) should be +5 volts when (QC29) should be zero.

4.3.1.7 Phase Control Card Test
Select test mode TFBK. Monitor OIP with an oscilloscope. With the oscilloscope synchronized to the AC line, (or from the SYNC test post on the Monitor card) the "pips" shown in Figure 1 will move to the left as PCR [5] increases from zero volts. If not, check the following:

A shorted input on the Gate Control card may be causing the problem.
Remove power, remove the Gate Control card and repeat the above test.

4.3.1.8 Gate Control Test
Select Test mode TFBK. Monitor the outputs 1F1-1F6 and 1R1-1R6 with an oscilloscope. With the oscilloscope synchronized to the AC line, the outputs will extend to the left as PCR [5] increases as shown in Figure 2. The 1F1-1F6 outputs will move when OFE is zero, and the 1R1-1R6 outputs will move when OFE is +5 volts. At no time should both the forward and reverse outputs exist together. If trouble is encountered, check the following:

(GC30) should be more than +18 volts.
(GC26) should be more negative than -13 volts.
When calling for forward outputs,
(GC6X) and (GC10) should be +5 volts.
When calling for reverse outputs,
(GC9X) and (GC12) should be +5 volts.

If the Gate Control outputs are proper, check the pulse amplifier card(s) in the Power Conversion Module, the harness between the Driver and the Conversion Module, and the SCR's.

4.3.2 Drive System operating, but not correctly
Select test mode TFBK-MOTR. If the drive operates correctly from the LR potentiometer, the trouble is in the reference inputs to the Driver/Regulator from the system or other special function cards provided.
Select test mode TREG-MOTR. As LR is moved from midpoint to top:

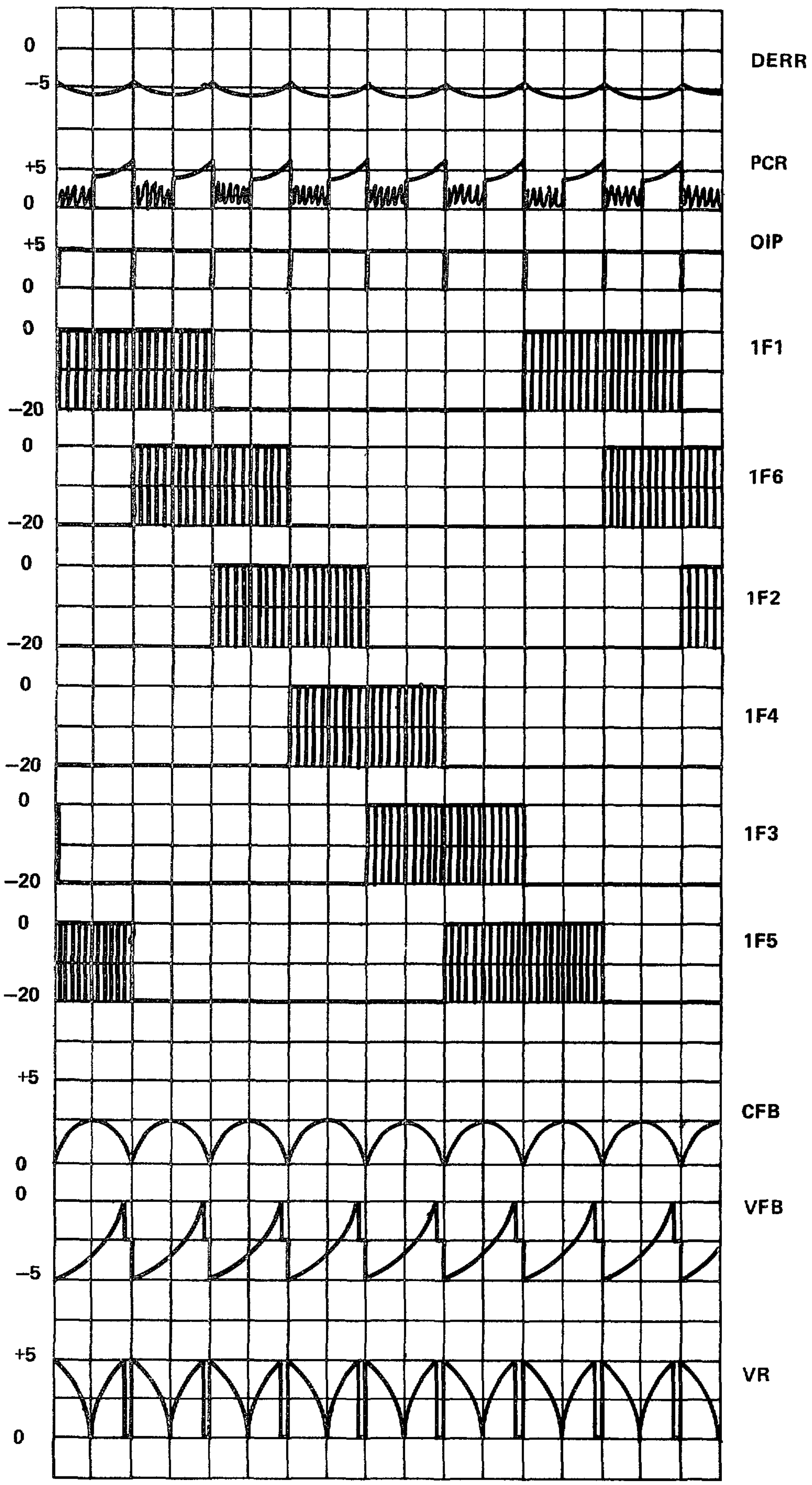
DR [4] will go from 0 to +10 volts. If not, check the Regulator card current limit adjustment ILIM. Go to section

CFB [7] will go from 0 to +2.5 volts as the motor load increases from 0 to rated load. If CFB is too high or too low at rated load, check the jumper connections on the Current Feedback card in the Power Conversion Module. The CFB waveform is shown in

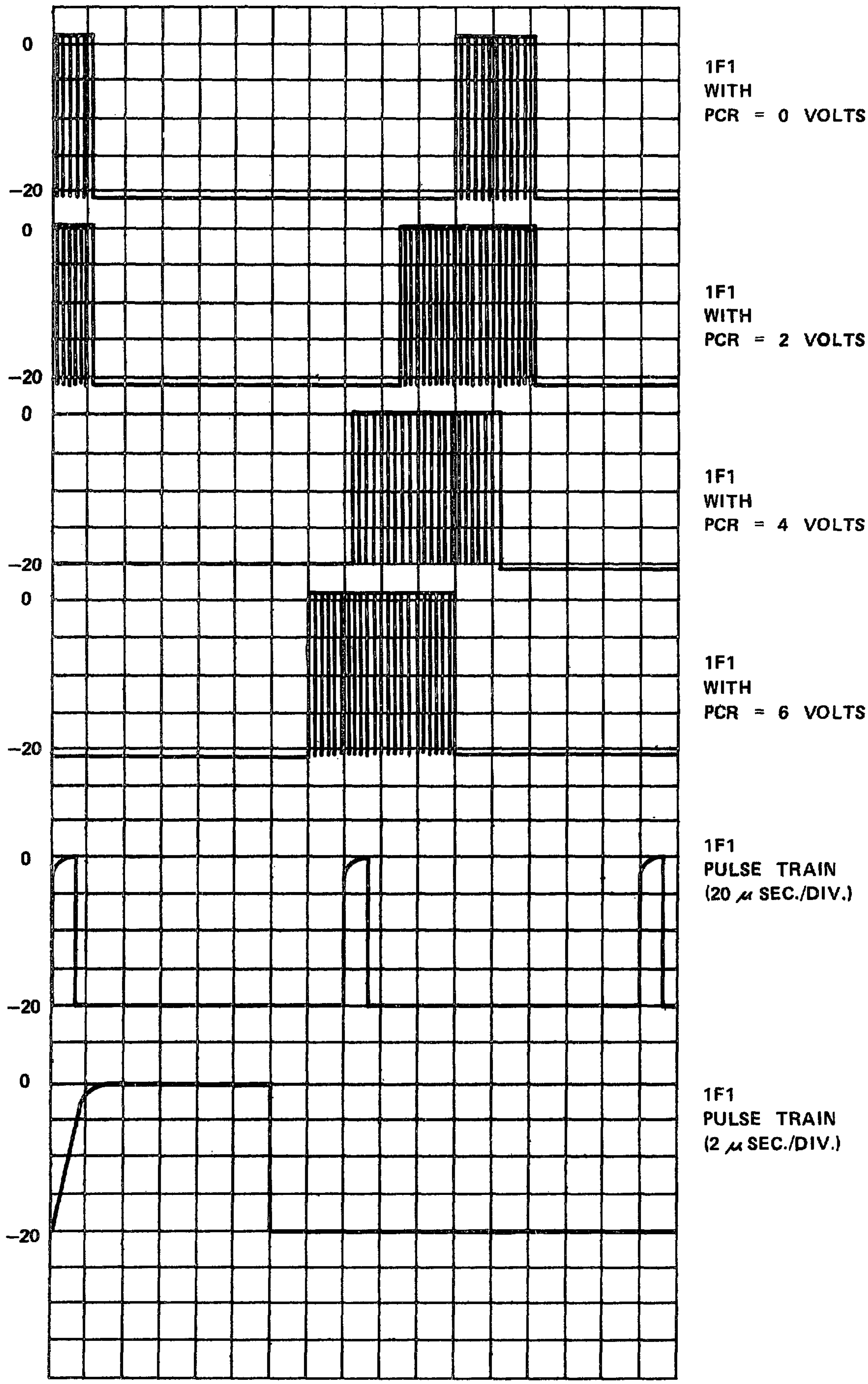
VFB [8] will go from 0 to -5 volts as DR 4 goes from 0 to +10 volts. The VFB waveform is shown in Figure

If CFB, VFB, and DR are proper, the problem is in the Regulator card and its inputs.

If CFB or VFB is not proper, the figures in 4.4 show typical voltage waveforms when the drive is operating normally. Compare the actual waveforms as measured with an oscilloscope synchrnoized to the AC line to the figures to determine the problem.



4.4 TYPICAL WAVEFORMS AT 1/2 VOLTAGE AND ALMOST CONTINUOUS CURRENT


0
−20
1F1
WITH
PCR = 0 VOLTS
0
−20
1F1
WITH
PCR = 2 VOLTS
0
−20
1F1
WITH
PCR = 4 VOLTS
0
−20
1F1
WITH
PCR = 6 VOLTS
0
−20
1F1
PULSE TRAIN
(20 μ SEC./DIV.)
0
−20
1F1
PULSE TRAIN
(2 μ SEC./DIV.)

SECTION V

RECOMMENDED SPARE PARTS

5.0 A realistic "on hand" spares stock coupled with the Speed Variator low cost card exchange plan will lead to faster resolution of down time of the equipment in case of malfunction. By having on hand spare parts, there is no extended down time after the problem has been located awaiting parts that must be ordered and shipped from the factory. The concept of easily removeable (plug in) printed circuit boards is a fallacy if it only takes a few minutes to discover the defective assembly but hours to order and procure a replacement. Therefore, from the standpoint of keeping the equipment/machine operating with a minimum of down time, readily available on hand spares are a must. The advantages coupled with the "Card Exchange Plan" are three fold:

1. Minimum down time due to not awaiting part arrival.
2. The lower cost of the "Card Exchange Plan".
3. No cost for time and special test equipment to troubleshoot, repair and testing of failed cards. The repair and testing of printed circuit cards takes special handling techniques and test equipment that most facilities do not have.

The proper evaluation of profits lost per hour of down time of the machine/system versus the cost of on hand spare parts and the time saved is a readily available figure. A high volume machine output would therefore require a larger spare parts stock to insure minimum down time. For further information on the Speed Variator Section Card Exchange Plan, contact the General Electric Company Service Engineering Component in Erie, Pa.

The Diagnostic and Instrument cards are particularly valuable in troubleshooting a defective drive. Even if these cards were not furnished with the original equipment they may be ordered and installed at any time by simply inserting both cards in the drive and removing the jumper between GTB21 and GTB22.

<u>NOTE</u>

WHEN ORDERING SPARE PARTS BE SURE TO GIVE COMPLETE PART NUMBER, AND ASSEMBLY NAME TO INSURE FAST AND EFFICIENT SERVICE.

The following is a list of recommended spare parts:

Printed Circuit Cards

		Qty.
20Volt Power Supply	193X257AAG01	1
Gate Control	193X262AAG01	1
Phase Control	193X259AAG01	1
Monitor	193X261ABG01	1
Quadrant Control	193X270AAG01	1
Driver Coordination	193X260BAG01	1
Standard Regulator	193X267BAG01	1
Other special function cards		1 of each type

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