Installing, Operating, and Maintaining the Three-Phase Input HR2000™ High Performance Controller and Motors

208/230 VAC, 60 HZ INPUT
1 THROUGH 4 HP

(All information may not pertain to all motors. Read motor nameplate for compliance.)

VS® DRIVES

Instruction Manual D5-3018-9

April, 1995

IMPORTANT, READ ALL INSTRUCTIONS BEFORE INSTALLING THIS MOTOR. "SAVE THESE INSTRUCTIONS"

RELIANCE ELECTRIC

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1: Receive and Accept the Drive

The products described in this instruction manual are manufactured by Reliance Electric Industrial Company.

Identify the Drive

Each HR2000 controller and HR2000 motor can be positively identified by its model number (standard) or sales order number (modified product). This number appears on the shipping label and is stamped on the respective nameplate. The nameplate is located on the lower left side of the controller and on the frame of the motor. Refer to this number whenever discussing the equipment with Reliance Electric personnel.

The sales order number uniquely describes the controller manufactured to customer specifications. The model number describes the controller as follows:

3RA 2 0 01

HR2000 High Performance Controller

Input Voltage (208/230 VAC)

Software
- 0 = 2000 RPM

Controller Horsepower
- 01 = 1 HP
- 02 = 2 HP
- 03 = 3 HP
- 04 = 4 HP

The model number describes the motor as follows:

B 14H XXXX

Motor
- B = HR2000 High Performance Motor
- S = Low Inertia Servo Motor

Mounting Flange
- 14H = 140 C-Face
- 18H = 180 C-Face
- 90H = FF200 IEC Flange
- 14J = 140 C-Face Explosion Proof
- 18J = 180 C-Face Explosion Proof

As Designated by Factory

Receive and Accept the Shipment

Reliance Electric's terms of sales, in all instances, are F.O.B. point of origin. The Consignee (user) is responsible for thoroughly inspecting this equipment before accepting shipment from the Carrier (transportation company).

If any item called for on the bill of lading or on the express receipt is not included or if any items are obviously damaged, do not accept the shipment until the freight or express agent makes all appropriate notations on the freight bill or express receipt.

If any concealed loss or damage is discovered later, notify your freight or express agent within 15 days of receipt and request that he/she make an inspection of the shipment. Keep the entire shipment intact in its original shipping container.

The Consignee is responsible for making claim against the Carrier for any shortage or damage occurring in transit. Claims for loss or damage in shipment must not be deducted from the Reliance Electric invoice, nor should payment of the Reliance® invoice be withheld while awaiting adjustment of such claims since the Carrier guarantees safe delivery.

If considerable damage has been incurred and the situation is urgent, contact the nearest Reliance Electric Sales Office for assistance.

CAUTION: Motor HP and Controller HP must match. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

NOTE: *3000 RPM data does not apply to HAZARDOUS location motor.*

File a Return Request

1. To return equipment, send a written request to Reliance Electric within ten days of receipt.
2. Do not return equipment without a numbered authorization form (ERA form) from Reliance Electric.
3. Reliance Electric reserves the right to inspect the equipment on site.

Store the Drive until Installation

After receipt inspection, repack the equipment in its shipping container until installation.

To ensure satisfactory drive operation at startup and to maintain warranty coverage, store the equipment as follows if storage will be less than 5 months:

- indoors
- in its original container with its internal packing in a clean, dry, safe place.
- within an ambient temperature range of -25°C to 60°C (-13°F to 140°F).
- within a relative humidity range of 5 to 95% without condensation.
- away from a corrosive atmosphere. In harsh or dusty environments, cover the shipping/storage container.
- away from construction areas.

If storage will be longer than 5 months, contact Reliance for long-term storage instructions.

2: Know the Drive

Terminology Used in This Manual

Definitions and Abbreviations

CCW: The abbreviation for counter-clockwise.

Controller: The term used throughout this manual for "HR2000 Controller" to make this manual easier to read and understand.

CW: The abbreviation for clockwise.

Drive: The reference to the controller and the motor combined as one system.

Factor: The term used for an integer scaling constant that is used to calibrate input pulse frequency. The integer is set by using the Operator's Terminal. The default value is 4; the integer range is 1 to 10.

IET: The abbreviation for instantaneous electronic trip.

Motor: The term used throughout this manual for "HR2000 Motor" to make this manual easier to read and understand.

NEC: The abbreviation for the National Electrical Code.

P→|→|: The symbol used for twisted wire having at least two twists per inch.

PG: The abbreviation for pulse generator or encoder.

Pot: The shortened reference for potentiometer.

PPR: The abbreviation for pulses per revolution.

Scope: The shortened reference for oscilloscope.

Dangers, Warnings, and Cautions

Dangers, warnings, and cautions point out potential trouble areas. All three of these forms are enclosed in a box to call attention to them.

- A **danger** alerts a person that high voltage is present, which could result in severe bodily injury or loss of life if procedures are not followed.
- A **warning** alerts a person of potential bodily injury if procedures are not followed.
- A **caution** alerts a person that, if procedures are not followed, damage to, or destruction of, equipment could result.

Drive Components

The drive consists of an HR2000 Controller and an HR2000 Motor. Because the HR2000 Motor is specifically designed to provide high performance operation when powered by the HR2000 Controller, neither of these components can be purchased separately.

Operator control devices must be connected to the controller. These devices can be locally or remotely mounted and may be supplied by the user or may be purchased from Reliance. Enclosed controllers can have the devices mounted in the enclosure door.

For motion control applications, a RamPak module may be used to control the HR2000 Drive.

Controller LEDs

Red LEDs

POWER Three phase input power is present; D-C bus voltage is greater than 50 VDC.

B.BK Output transistors base driver disabled.

COM Serial communication error.

CPU Central Processing Unit malfunction.

SFB Overspeed or encoder failure.

OL Inverse time overload trip.

UV D-C bus undervoltage.

ZS Speed/Torque mode: illuminates when motor speed is less than desired minimum speed; the PG pot adjustment determines when this LED illuminates.

Position Mode: Positioning complete.

POS Position regulator: Error register overflow.

OH Overtemperature.

OV D-C bus overvoltage.

OC Output overcurrent.

PL Phase loss or ground fault condition exists.

Green LEDs

RUN Controller is operating.

RDY Controller is ready to run.

Controller Regulator Pots

OL Inverse time overload

CL Maximum instantaneous current output

SG Speed loop gain

SZ Speed offset; sets motor speed with minimum reference for Speed and Torque modes

DEC Deceleration rate

FRQ Notch filter frequency

OS Overspeed IET setting

SR Input reference gain

PG In Speed or Torque mode, adjusts minimum speed detection circuit and illuminates ZS LED; in Position mode, position loop gain

TST Reference input in Test mode

ACC Acceleration rate

QF Notch filter Q factor

Controller Regulator Switches

TST Test mode

SI Speed loop integral

OP Accel/Decel rate

DIR Direction in Position mode

DV Pulse divider

MDE Regulator mode

PG Motor/Encoder

OL Maximum overload

AP P or PI speed loop

B.BK Base drive disable

INS Inspection/Test mode

Controller Regulator Jumpers

The following user jumpers are located on the regulator board:

1J Notch filter enable

2J Accel/Decel rate enable

3J Factory setup: Do not remove.

5J Low-pass filter enable

6J Low-pass filter enable

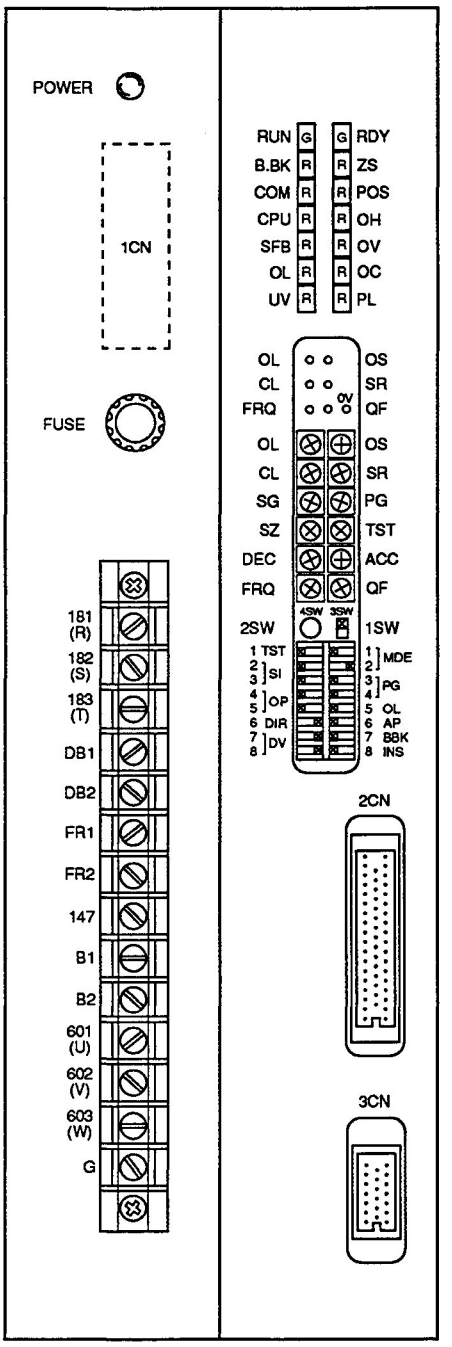


Figure 2-1. Typical Controller Faceplate Components.

Customer Interlocks, Inputs, and Output Signals

Dry FAULT Contact (FR1 and FR2)

- D-C rating: A maximum voltage of 30 VDC or a maximum current of 1.0 amp resistive only.
- A-C rating: 250 VA maximum with a maximum voltage of 250 VAC or a maximum current of 1 amp resistive only.

Connector 2CN

- 12 to 24 VDC power supply (customer supplied) must be able to source 60 mA on pins 10, 26-32 (0VI).
- Speed pot (customer supplied): 12 VDC, 5 mA maximum loading; recommend a 5K ohm, 2 watt speed pot.
- Differential reference input, 16.7K ohms input impedance on pins 3 and 4.
- Single ended reference input 10K ohms input impedance on pins 5, 19-25 (0V) and 39, 19-25 (0V).
- Logic inputs, opto-isolated 7 mA maximum loading per input.
- Logic output, opto-isolated open emitter, 25 mA maximum loading per output.
- Speed: Analog output proportional to motor speed on pins 8, 19-25 (0V); 1 mA maximum loading.
  0 to 4.3 VDC when using 2000 RPM motors with 2500 PPR encoders.
  0 to 4.1 VDC when using 3000 RPM motors with 2500 PPR encoders.
- Load: 0 to 8 VDC analog output proportional to output current on pins 9, 19-25 (0V); 1 mA maximum loading.

Controller Features

Standard Features

- UL Listed to UL508 standards
- Near unity power factor throughout the speed range
- Operation on a distribution system up to 5,000 amperes fault current without an isolation transformer
- Insensitive to incoming power phase sequence
- Line-to-line and line-to-ground output short circuit protection
- Line transient protection to minimize effects of power line transients
- Single board, microprocessor-based regulator for increased reliability
- Electronic reversing from any speed
- Restart from any speed or direction
- Motoring current limit
- Fault Reset pushbutton
- Automatic shutdown with fault indication under any of the following conditions:
  Communication Error
  CPU Malfunction
  Overspeed
  Inverse Time Overload
  Undervoltage
  Overtemperature
  Overvoltage
  Overcurrent
  Input power dip or Ground Fault
  Position Regulation Error
- Standard adjustments:
  Inverse Time Overload
  Current Limit
  Speed Loop Gain
  Speed Offset
  Accel/Decel Rate
  Overspeed
  Reference Gain
  Position Loop Gain
  Notch Filter
  Filter Q Factor
- Sequencing and encoder mating connectors

Optional Features

- Input Disconnect Kit
- Dynamic Braking resistor and output contactor
- Encoder Isolation/Buffer Kit
- Encoder Tester
- Exercise Module
- RS232 Connector for use with Operator's Terminal
- Operator's Terminal
- D-C Snubber resistors
- Speed and load meters
- Cables for motor mounted encoders and controller connectors to terminal boards

Motor Features

Standard Features

- UL Listing (UL 674)
- Thermally isolated optical encoder
- C-Face (with feet) or IEC Flange mounting
- Motor thermostats
- Class F insulation, Class B rise
- MS encoder mating connector
- Conduit box with 380 aluminum cover
- Bearing type 6205 on 140 C-Face and 6206 on 180 C-Face; type 6205 on opposite drive end
- Rare earth magnets

Drive Specifications

Ratings

Input Power Supply
3 phase
50/60 hz
208/230 VAC
Maximum A-C Line Symmetrical Fault Current
5000 amps RMS
Continuous Input Amps (RMS)
2000 RPM BASE SPEED

	MOTOR*	CONTROLLER
1 HP	3.6	4.3
2 HP	6.8	8.4
3 HP	9.8	12.4
4 HP	13.8	17.0

Nominal D-C Bus Voltage
310 VDC
Continuous Output Amps (RMS)
2000 RPM BASE SPEED

	MOTOR*	CONTROLLER
1 HP	3.3	4.0
2 HP	6.5	8.0
3 HP	9.5	12.0
4 HP	13.0	16.0

Peak Output Amps (RMS) (200%)
2000 RPM BASE SPEED

	MOTOR*	CONTROLLER
1 HP	6.6	8.0
2 HP	13.0	16.0
3 HP	19.0	24.0
4 HP	26.0	32.0

* Column's marked "MOTOR" indicate Rated Current when using Reliance motor.

Fuse Data

Control Fuse 4FU (1)
Reliance part number 64676-23N; Bussmann Type MDQ, 0.5 A, 250 V; or equivalent

Torque and Inertia Data

See Figure 2-2.

Service Conditions

Elevation
to 3300 feet (1000 meters)
Ambient temperature
Chassis
0°C to 55°C (32°F to 131°F)
Enclosed
0°C to 40°C (32°F to 104°F)
Storage temperature
-40°C to 65°C (-40°F to 149°F)
Atmosphere
5 to 95% relative humidity non-condensing
A-C line voltage variation
±10% of selected voltage
A-C line frequency
50/60 hz ±2 hz

Application Data

Current Control Method
Sinusoidal
Service Factor
1.0
Displacement Power Factor
0.96
Maximum Load
150% for 20 seconds
200% for 10 seconds
Speed Range
2000:1
Speed Regulation
0 to 100% load change: 0.03%
±10% input voltage change: ±0.03%
0 to 55°C temperature change: ±0.5%
D-C Snubber Braking Power
Frequency (times) of brakes from the rated speed allowed in a state that the motor vs load inertia ratio is "1:4":

1 ~ 2HP	80 watts (RMS), 6 times/min
3 ~ 4HP	220 watts (RMS), 8 times/min

FCC Part 15, Subpart J
Meets requirements

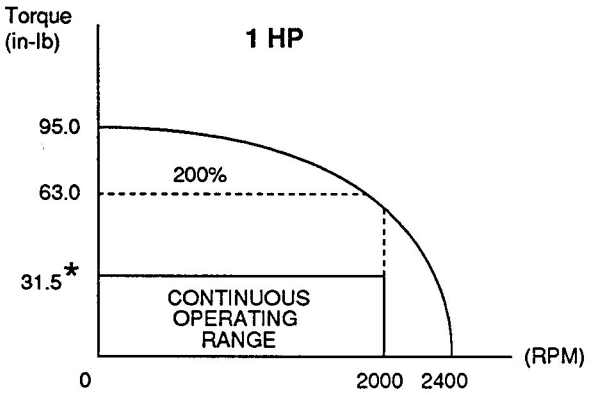
Adjustments

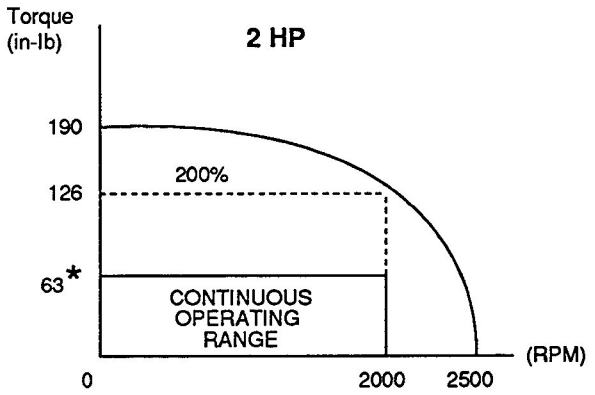
Inverse Time Overload
33 to 100% Controller Rated Current
Current Limit
0 to 200%
Speed Loop Gain
10 to 30 dB
Speed Offset
2000 RPM BASE SPEED
0 to ± 650 RPM
3000 RPM BASE SPEED
0 to ±950 RPM
Accel/Decel Rate
0.1 to 1.8 seconds (1 to 18 seconds available with switch)
Overspeed
2000 RPM BASE SPEED
1500 to 3000 RPM
3000 RPM BASE SPEED
2300 to 3400 RPM
Reference Gain
0.3 to 2.7 differential input (0.5 to 4.0 for single-ended input)
Position Loop Gain
0.3 to 4.8 mV/pulse
Test Mode Reference
0 to ±10 V
Notch Filter
30 to 1400 hz
Filter Q Factor
0.5 to 2.5

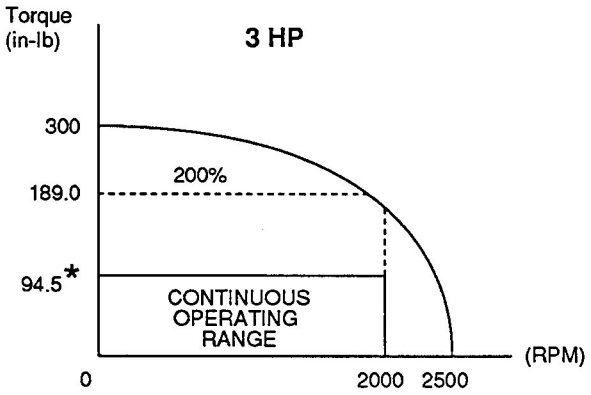
Product Publications

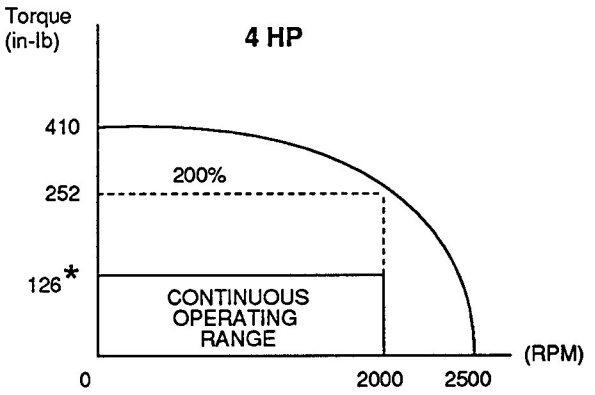
Controller Data Sheet
D-2814
Controller Wiring Diagram

1 HP	W/R-B4001
2 HP	W/R-B4002
3 HP	W/R-B4003
4 HP	W/R-B4004









HP	Flange Mounting	Torque (in lbs)	Base Speed (RPM)	Inertia (lb in S^2)
1	140TC with feet	31.5	2000	0.012
	FF200 IEC flange			
2	140TC with feet	63	2000	0.021
	FF200 IEC flange			
3	180TC with feet	94.5	2000	0.031
	FF200 IEC flange			
4	180TC with feet	126	2000	0.041
	FF200 IEC flange			

APPLICATION NOTE:

ALL SPEED TORQUE CURVES SHOWN IN THIS MANUAL ARE FOR MOTORS OPERATING FROM POWER MATCHED HR2000 CONTROLLERS WITH 230 V INPUT POWER.

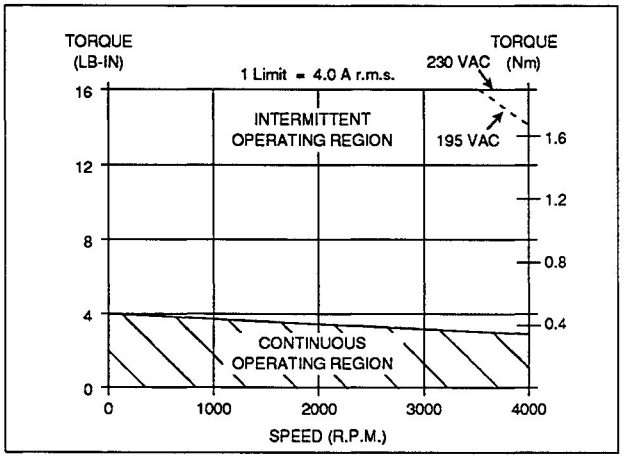
* Acceptable use of HAZARDOUS duty motor is at or below these torque values on a continuous duty basis.

Figure 2-2. Torque and Inertia Data.

Servo engineering data

Motor Frame		S-2005	S-4030	S-4050	S-4075
HR2000 Model		3RA2001	3RA2002	3RA2003	3RA2004
Stall Torque(1)	(lb-in)	4.0	29	54	76
	(Nm)	0.45	3.28	6.1	8.59
Speed (rpm)(2)		4000	3000	3000	2500
Jm (lb-in-sec $\times 10^{-3}$)		0.13	2.2	4.1	6.0
Jm (kg-m$^2 \times 10^{-3}$)		0.015	0.25	0.46	0.68
Kt(3)	(lb-in/A)	3.1	4.4	4.4	6.6
	(Nm/A)	0.35	0.50	0.50	0.74
Ke (M/kpm)(4)		42	60	60	90
R (ohms)(5)		24	2.0	0.8	0.9
L (mH)(5)		25	9.0	3.3	5.4
Friction	(lb-in)	0.25	0.30	0.60	1.2
	(Nm)	0.028	0.034	0.068	0.14
Damping	(lb-in/kpm)	0.12	0.30	0.40	0.60
	(Nm/kpm)	0.014	0.034	0.045	0.068
Thermal Resistance (°C/Watt)(1)		1.45	0.79	0.57	0.48
Motor Weight	(lbs)	5	15.5	22	29
	(kg)	2.3	7.0	10	13.2

(1) Motor is Mounted on a 12" x 12" x 1/2" Aluminum Plate And Ambient Is 40°C
(2) Maximum Continuous Operating Speed
(3) Peak Amps of Per Phase Sine Wave
(4) Peak Volts of Per Phase Sine Wave
(5) Phase to Phase



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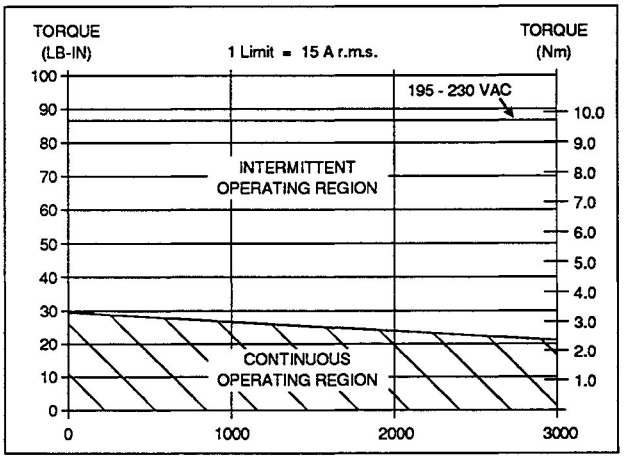

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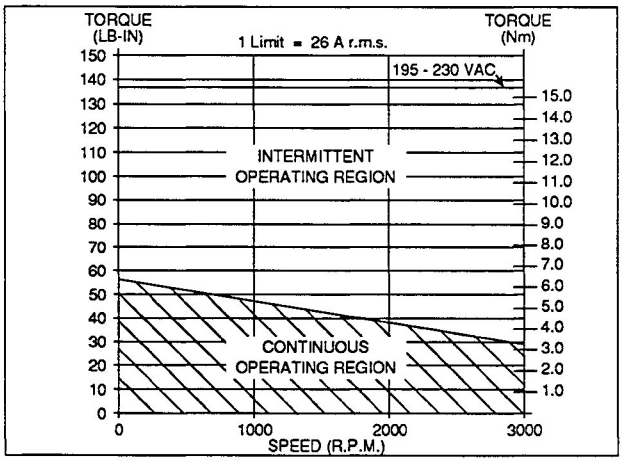

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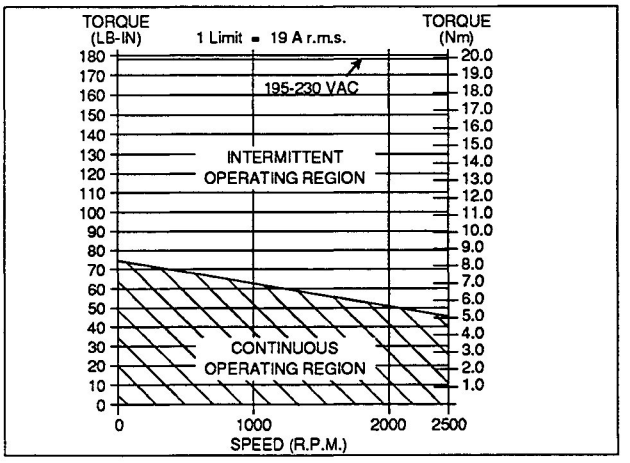


3RA2004/S-4075

Figure 2-3. Torque and Engineering Data - S Series Motors.

3: Install the Drive

DANGER

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE, AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

DANGER

THE USER IS RESPONSIBLE FOR CONFORMING TO THE NEC AND ALL OTHER APPLICABLE LOCAL CODES WIRING PRACTICES, GROUNDING, DISCONNECTS, AND OVERCURRENT PROTECTION ARE OF PARTICULAR IMPORTANCE. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

WARNING

THE USER IS RESPONSIBLE FOR ENSURING THAT DRIVEN MACHINERY, ALL DRIVE-TRAIN MECHANISMS, AND PROCESS LINE MATERIAL ARE CAPABLE OF SAFE OPERATION A SPEED 1.5 TIMES AS HIGH AS THE APPLIED MOTOR SPEED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

CAUTION: Do not install the amplifier "Drive" in a hazardous location. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

NOTE: *This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with this instruction manual, may cause interference to radio communications.*

Plan and Perform the Installation

Read and understand this chapter in its entirety before beginning the actual installation. Follow these guidelines and procedures to minimize both installation and operation problems.

The controller is shipped standard as a chassis and is fully assembled for mounting in an enclosure. An enclosed controller is available as a sales order and is shipped fully assembled in its own enclosure.

Select the Controller Location

1. Verify that the controller can be kept clean, cool and dry.
2. Make sure the selected location is away from oil, coolant, corrosive gas, metal powder, other air-borne contaminants, direct sunlight and hazardous atmospheres.
3. Check that the controller will not be exposed to excessive vibration and noise nor be near instruments that are very sensitive to electrical noise.
4. Check that temperatures in the controller vicinity are between 0°C to 55°C (32°F to 131°F) for chassis controllers and 0°C to 40°C (32°F to 104°F) for enclosed controllers.
5. Check that relative humidity is between 5% and 95% (non-condensing).
6. Do not install above 3300 feet (1000 meters) without derating. For every 1000 feet above 3300 feet, derate the current rating 4%. Contact your Reliance Electric Sales Office for installations above 5000 feet.

Install the Controller

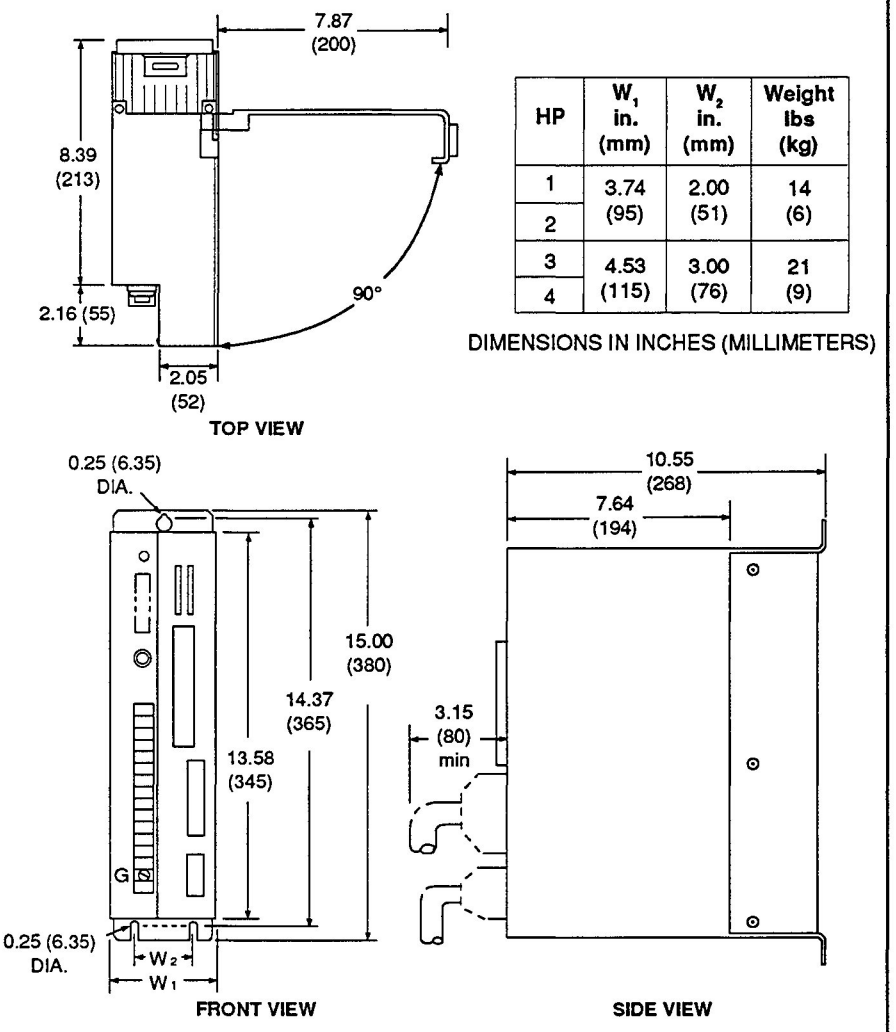
CAUTION: Complete all drilling, cutting, welding, etc., before mounting the controller. During installation protect the controller from metal chips, weld splatters and other debris. Failure to observe these precautions could result in damage to, or destruction of, the equipment.

Install the Chassis Controller

1. In the location selected, mount the enclosure in which the controller will be mounted.
2. See Figure 3-1 for controller mounting dimensions. Note that the regulator panel swings 90 degrees to the right.
3. Make sure the controller will have adequate air ventilation:
   - At least 4 inches clearance from the top and bottom of the controller to adjacent non-heat producing equipment. When designing a ventilating system or sizing a non-ventilated enclosure, consider the energy dissipation of all components within the enclosure. The heat dissipation for the controller is as follows:

Controller Horsepower	Power Loss (watts)
1	60
2	100
3	140
4	180

   - At least 2 inches clearance from the side of the controller to the enclosure side wall.
   - At least 1 inch between multiple controllers. Note, however, that the hinged panel must be open during startup procedures and troubleshooting for monitoring various signals from points on the regulator board.
4. Make sure that the enclosure door or other components will not hinder service access.
5. Mount the controller directly to the enclosure mounting panel. Vertical mounting is recommended for ease in reading labels. Standoff hardware is not necessary.



HP	W_1 in. (mm)	W_2 in. (mm)	Weight lbs (kg)
1	3.74 (95)	2.00 (51)	14 (6)
2			
3	4.53 (115)	3.00 (76)	21 (9)
4			

DIMENSIONS IN INCHES (MILLIMETERS)

Figure 3-1. Chassis Controller Dimensions and Weights.

Install the Enclosed Controller

1. Refer to documentation supplied inside the enclosure for mounting dimensions.
2. Make sure the controller enclosure will have at least 4 inches clearance from the top and bottom of the enclosure to adjacent non-heat producing equipment for air ventilation.
3. Make sure the door or other components do not hinder service access.
4. In the location selected, mount the enclosed controller.

Install the Motor

NOTE: *If the motor has been in storage or subjected to adverse moisture conditions, dry it thoroughly before installation.*

1. Verify the motor is the appropriate size to use with the controller.
2. Turn the motor shaft by hand to insure free rotation. A slight resistance may be felt due to a rotor magnetic force.
3. Make sure the motor's foundation is sufficiently rigid to prevent vibration.
4. Mount the motor to the machine. See Figure 3-2 through 3-4 for typical mounting dimensions.
5. Make sure the motor is properly aligned with the driven machine to minimize unnecessary motor loading from shaft misalignment. After careful alignment, bolt the motor securely in place.
6. If the motor will be accessible while it is running, install a protective guard around all exposed rotating parts.

CAUTION: Motor shaft being turned may cause sparking on unconnected leads. Do not rotate shaft without motor and controller covers tightly closed. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

Install a Transformer (If needed)

Recommended transformer size for HR 2000 1-4 HP Controllers is three-phase with a 230 VAC nominal secondary.

Input transformers step up or step down input voltage and can be either auto-transformers or isolation transformers. Isolation transformers help eliminate:

- Damaging A-C line voltage transients from reaching the controller.
- Damaging currents, which could develop if a point inside the controller becomes grounded.

CAUTION: Controller can withstand 5000 amperes short circuit RMS symmetrical current. If the power source can generate more, provide an isolation transformer, a line reactor, or other means of similar impedance. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

Install an Input Disconnect

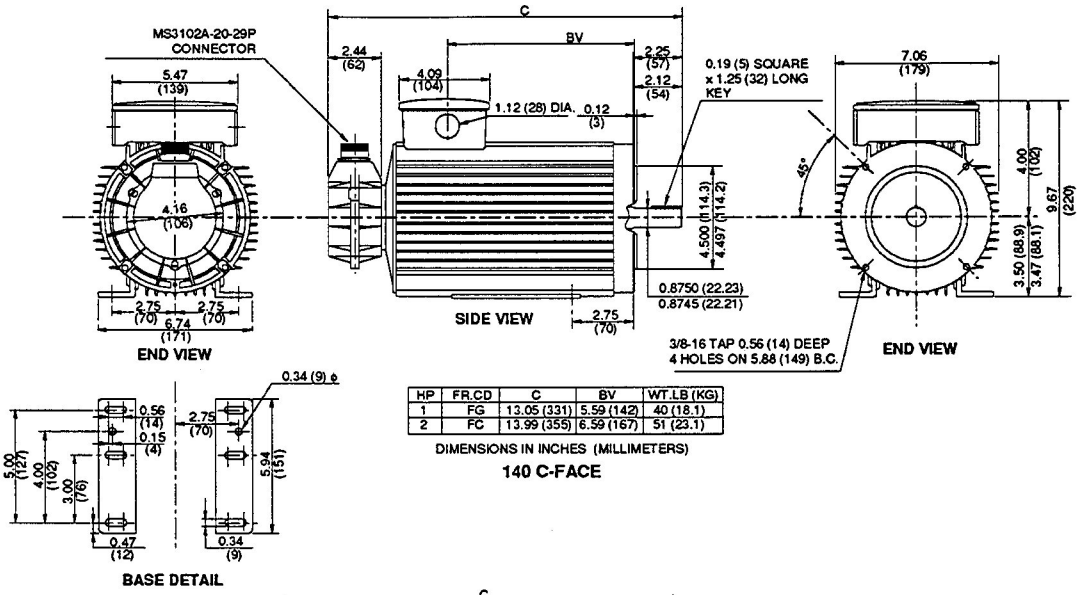
DANGER

THE NEC REQUIRES THAT AN INPUT DISCONNECT BE PROVIDED IN THE INCOMING POWER LINE AND EITHER BE LOCATED WITHIN SIGHT OF THE EQUIPMENT OR BE LOCKABLE. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Install an input disconnect in the incoming power line according to the NEC. It must either be located within sight of the controller or be lockable.
2. Size the disconnect to handle the primary circuit inrush current of the input transformer, if used, as well as any loads the disconnect may supply.
3. Install the disconnect in the primary circuit of the input transformer, if used.

Suppress Electrical Noise

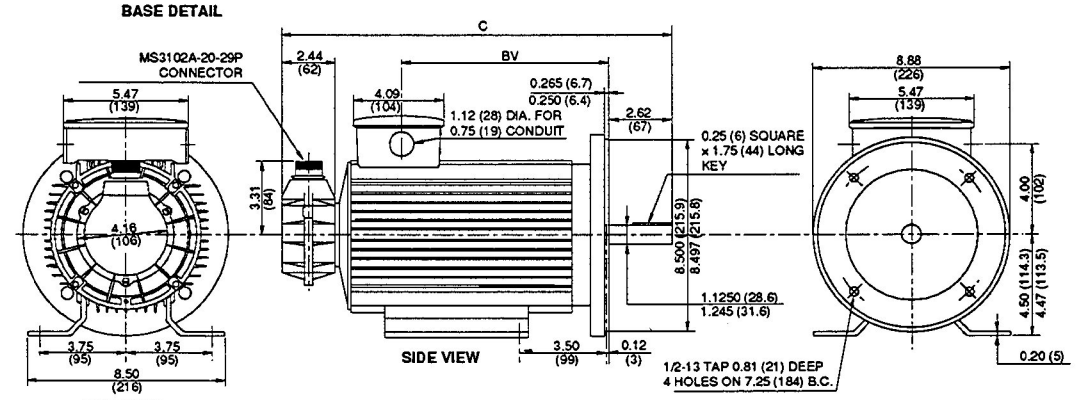
1. Suppress each switched inductive device or its wiring (solenoids, relay coils, starter coils, etc.) near the controller with an RC suppression device, such as Reliance part 600686-33A, to avoid transient voltages that could disturb electronic circuits. A 220-ohm, 1/2 watt resistor in series with a 1/2 microfarad, 600-volt capacitor can be used as the suppressor.
2. Physically separate the wiring of the switching devices noted in Step1 above from low level signal circuits.



HP	FR.CD	C	BV	WT.LB (KG)
1	FG	13.05 (331)	5.59 (142)	40 (18.1)
2	FC	13.99 (355)	6.59 (167)	51 (23.1)

DIMENSIONS IN INCHES (MILLIMETERS)

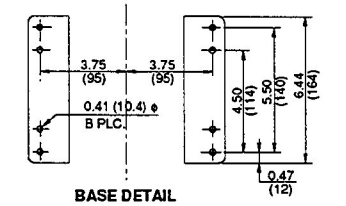
140 C-FACE

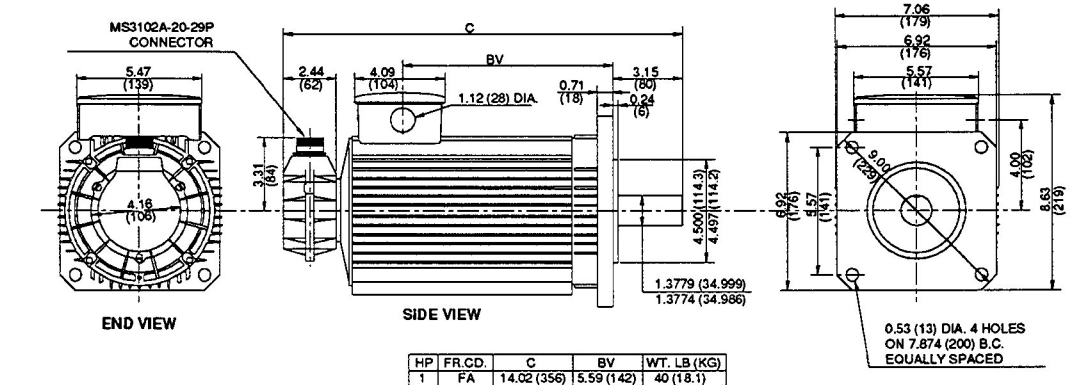


HP	FR.CD.	C	BV	WT. LB (KG)
3	FZ	16.74 (425)	8.83 (224)	62 (28.1)
4	FF	18.36 (473)	10.45 (265)	74 (33.6)

DIMENSIONS IN INCHES (MILLIMETERS)

180 C-FACE



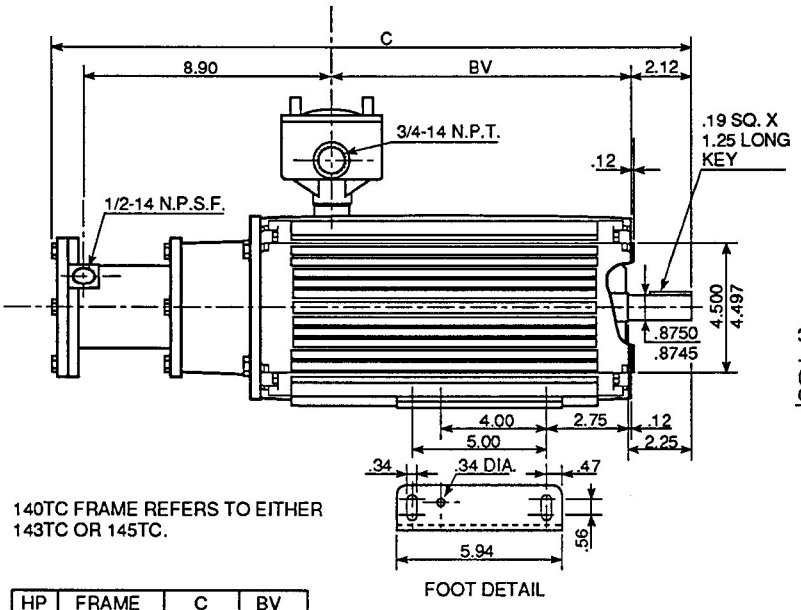


HP	FR.CD.	C	BV	WT. LB (KG)
1	FA	14.02 (356)	5.59 (142)	40 (18.1)
2	FG	15.08 (383)	6.65 (169)	51 (23.1)
3	FD	17.08 (434)	8.65 (220)	62 (28.1)
4	FE	18.08 (459)	9.65 (245)	74 (33.6)

DIMENSIONS IN INCHES (MILLIMETERS)

FF200 IEC-FLANGE

Figure 3-2. Ordinary Motor Mounting Dimensions.

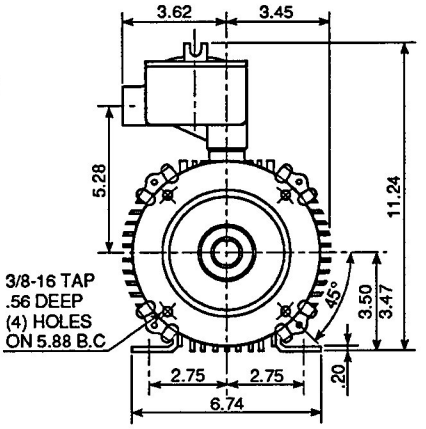


FOOT DETAIL

140TC FRAME REFERS TO EITHER
143TC OR 145TC.

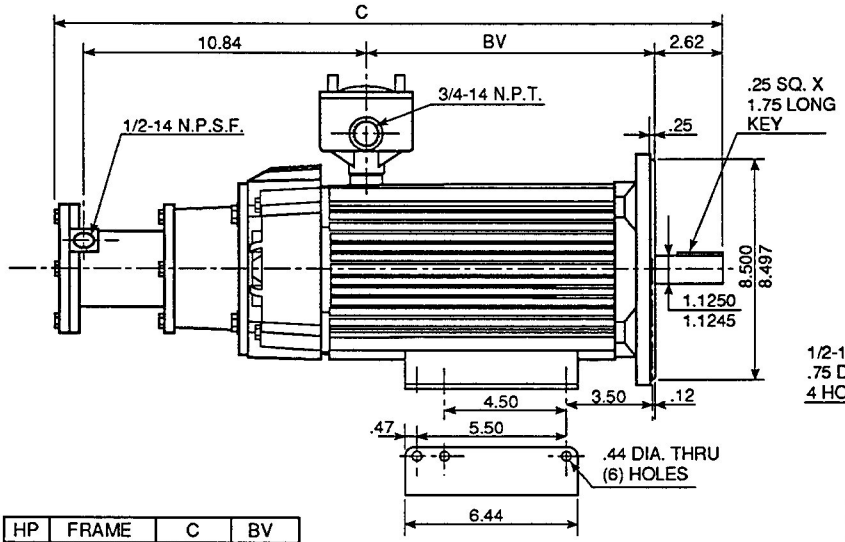
HP	FRAME	C	BV
1	XD140TC	20.93	8.69
2	XE140TC	21.93	9.69

FACE RUNOUT AND ECCENTRICITY .004 T.I.R.
SHAFT RUNOUT .002 T.I.R.



ENCLOSURE: EXPLOSION PROOF
MOUNTING: FOOT AND
140 NEMA "C" FACE
COOLING: NON-VENTILATED
TYPE: PPS

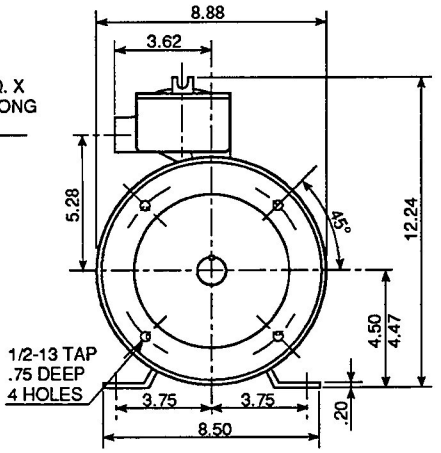
FRAME 140TC



FOOT DETAIL

HP	FRAME	C	BV
3	XE180TC	24.85	10.18
4	XF180TC	25.85	11.18

FACE RUNOUT AND ECCENTRICITY .004 T.I.R.
SHAFT RUNOUT .002 T.I.R.



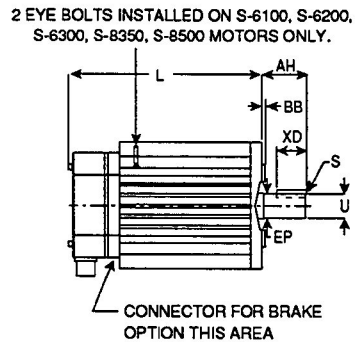
ENCLOSURE: EXPLOSION PROOF
MOUNTING: FOOT AND
180 NEMA "C" FACE
COOLING: FAN COOLED
TYPE: PPS

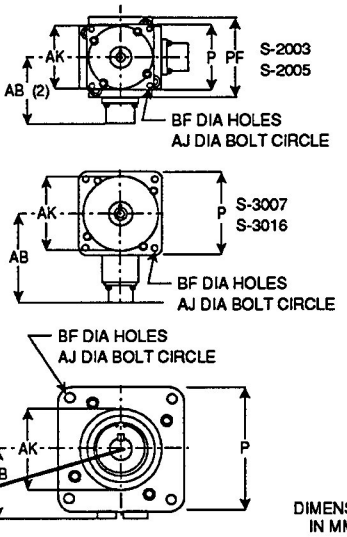
FRAME XF180TC

DIMENSIONS ARE IN INCHES.

Figure 3-3. Explosion Proof Motor Mounting Dimensions.

S SERIES
MOTOR DIMENSIONS





Motor Series	Thread	Thread/Depth
S-2000	M3 x 0.5 mm	10 mm/.39 in
S-3000	M4 x 0.7 mm	10 mm/.39 in
S-4000	M6 x 1.0 mm	15 mm/.59 in

DIMENSIONS ARE IN MM/INCHES

Model	AB	AJ	AK	P	PF	U	EP	AH	BB	BF	XD	S	L	With Brake
S-2005	62/2.44	75/2.95	60/2.36	63.5/25	76.2/3.0	11/.43	12/.47	23/.91	2.4/.09	5.8/.23	18/.71	4 x 4/.16 x .16	228/8.96	-
S-4030	76/3.00	145/5.71	110/4.33	121/4.76	-	19/.75	20/.79	50/1.97	3/.12	10/.39	40/1.57	6 x 6/.24 x .24	222/8.73	276/10.85
S-4050	76/3.00	145/5.71	110/4.33	121/4.76	-	19/.75	20/.79	50/1.97	3/.12	10/.39	40/1.57	6 x 6/.24 x .24	273/10.73	327/12.85
S-4075	76/3.00	145/5.71	110/4.33	121/4.76	-	19/.75	20/.79	50/1.97	3/.12	10/.39	40/1.57	6 x 6/.24 x .24	324/12.73	378/14.85

Motors are manufactured to millimeter dimensions shown. Inch dimensions shown are approximate conversions from millimeters.
For further motor detail, engineering specification drawings are available upon request.

S-4000 SERIES WITH C-FACE

	WITHOUT BRAKE	WITH BRAKE
S-4030 NEMA SEC	8.73	10.85
S-4050 NEMA SEC	10.73	12.85
S-4075 NEMA SEC	12.73	14.85

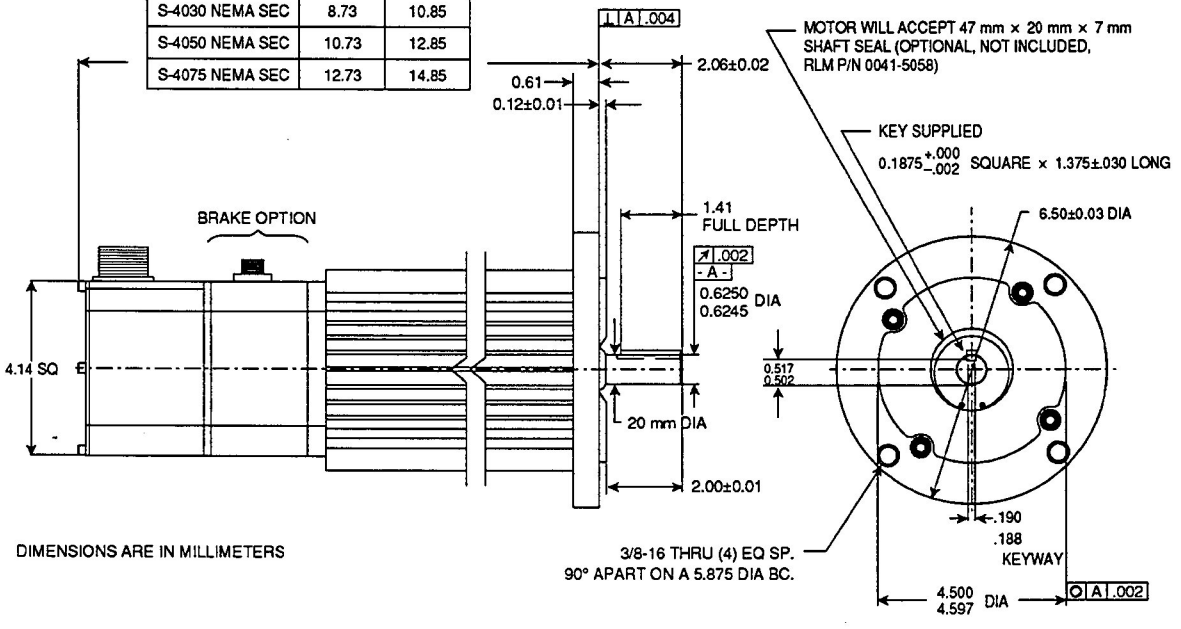


Figure 3-4. S Series Motor Mounting Dimensions.

Review the 2CN Connector Pin Functions before Wiring

The controller interfaces with external operator devices, motion control modules, PLC, and other logic devices through the 2CN connector. This connector accepts input analog signals and logic signals. The connector also contains outputs for remote monitoring.

12-Volt Control Power Supply

The controller is designed to isolate the reference and sequencing circuits by using two power supplies. The controller includes a 12 VDC power supply to operate the reference circuit. This power is available on pins 2CN-1 (+12 VDC), 2CN-2 (-12 VDC), and 2CN-19 through 2CN-25 (0V).

The sequencing circuit contains all optically isolated inputs and outputs. Power for these functions is not included with the controller. The power supply can be 12 to 24 VDC and must be wired to 2CN-10 (+VI) and 2CN-26 through 2CN-32 (0VI). This power supply must source 60 mA maximum at 24 VDC.

Analog Input Signals

Speed/Torque Reference

The controller accepts analog reference signals when operating as a speed or torque regulator. The SR pot allows maximum differential input voltage between 3 and 12 volts. Maximum single-ended inputs can be between 2 and 16 volts. The reference can be either differential or single-ended signals. See Figure 3-5. Differential signals wire to pins 3 and 4. Two inputs exist for single-ended signals. The positive pins are 5 and 39 while the common pins are 19 through 25. The input impedance is 10K ohms for these inputs.

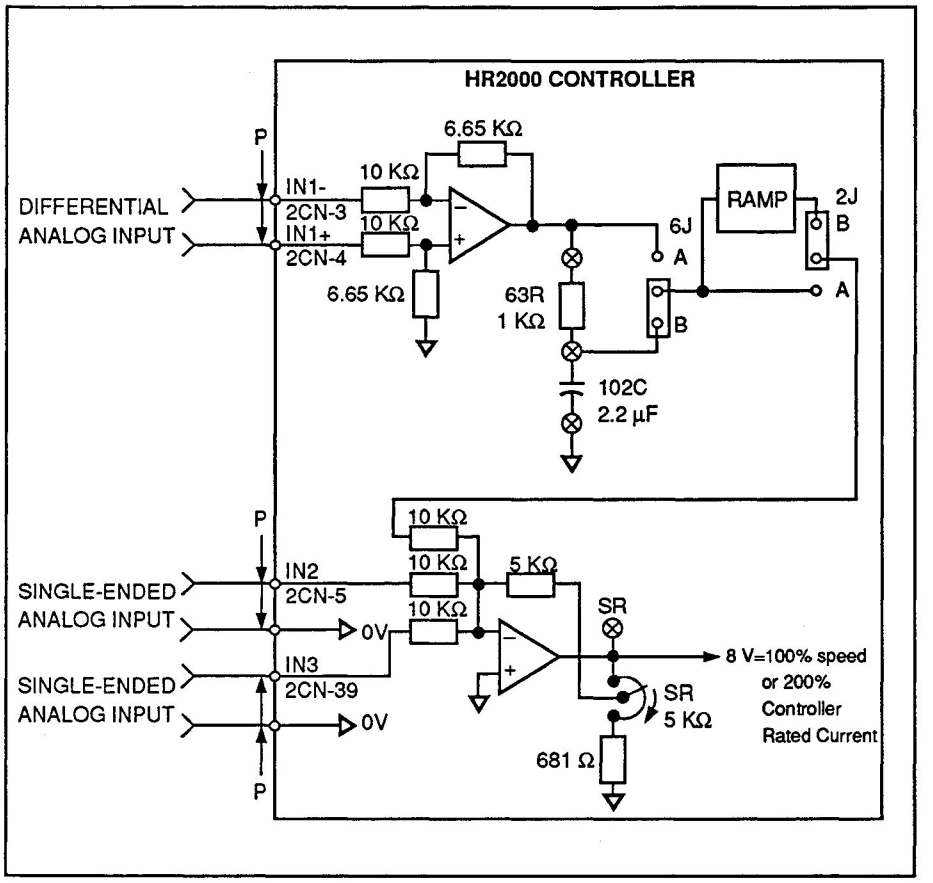


Figure 3-5. Speed/Torque Reference Circuitry.

Current Limit

Although a current limit pot is standard on the controller faceplate, provisions for remote current limit are provided. Two remote current limit pots, one for each direction, can be wired according to Figure 3-6.

Analog Output Signals

Two analog outputs are available for remote monitoring of speed and load. These outputs are used when optional meters are supplied. See Figure 3-7. The maximum source for each output is 1 mA.

SPEED: The signal on pin 8 (+) and 19 through 25 (0V) calibration is based on the motor/encoder selection on 1SW-3 and 1SW-4. When using 2000 RPM motors with 2500 PPR encoders, the signal will be 4.3 VDC at rated speed. The polarity of the signal is either positive or negative based on direction.

TORQUE: The signal on pin 9(+) and 19 through 25 (0V) is proportional to output torque when power-matched control and motor are operating. The signal is 4 VDC at 100% of the controller's rated current. The polarity of the signal is either positive or negative based on direction.

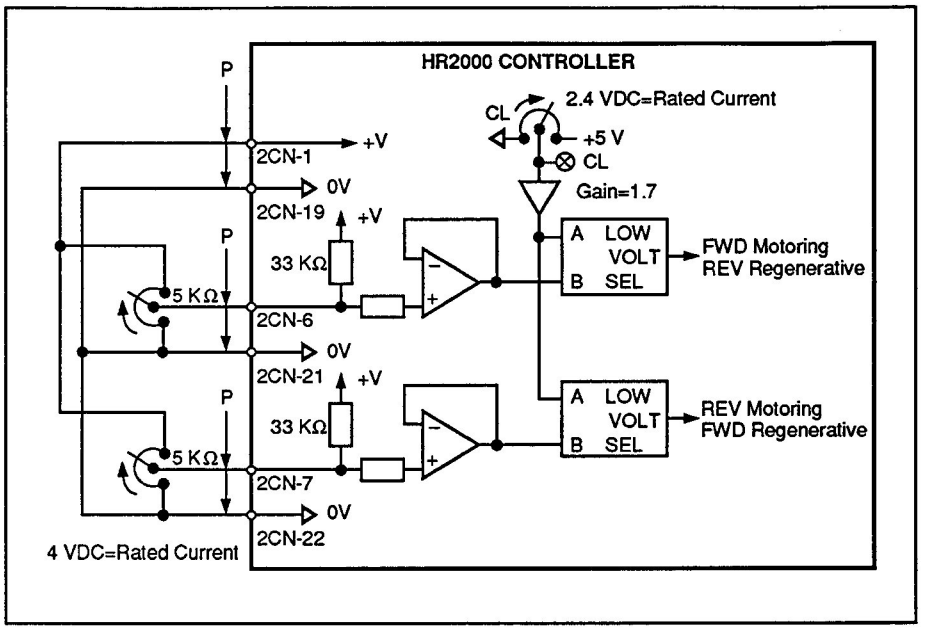


Figure 3-6. External Current Limit Pot Circuitry.

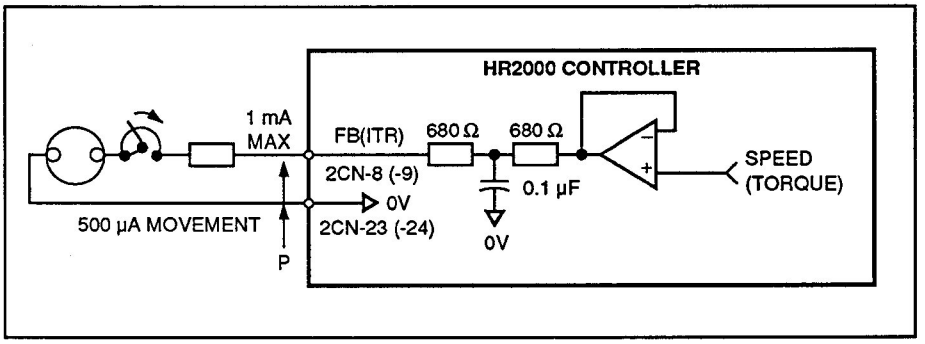


Figure 3-7. Typical Circuitry for Monitoring Speed/Torque.

Logic Input Signals

Seven optically isolated inputs are available through the 2CN connector. Each input requires 7 mA in the ON state when a 24 VDC supply is used. A typical input is shown in Figure 3-8. The common (0V) for all inputs are pins 26 through 32. A brief description of the seven functions follows; the pin numbers are shown in parentheses.

RUN (11): This input (RUN) starts the controller when closed. Maintained-Start/Stop operator devices must be used for this function.

RESET (12): This input (RST) resets the controller after a fault has occurred. A momentary operator device must be used for this function.

PROPORTIONAL SPEED LOOP (13): This function (P) selects the speed loop regulator in proportional control.

NOTE: *1SW-6 has no effect with this Function enabled.*

SHAFT CLAMP (14) and INHIBIT REFERENCE (18): Signals (SLK and ZHC) cause the regulator to hold zero speed and present shaft position when the controller operates in position or speed mode. They also prevent the controller from responding to speed/torque references when the parameter dip switches are selected for speed/torque regulation.

WARNING
THIS DRIVE IS INTENDED TO OPERATE AT A PREDETERMINED MINIMUM SPEED UNLESS DISCONNECTED FROM THE POWER SOURCE. IF THE APPLICATION REQUIRES ZERO SPEED OPERATION WITHOUT SUCH DISCONNECTION, THE USER IS RESPONSIBLE FOR ASSURING SAFE CONDITIONS FOR OPERATING PERSONNEL BY PROVIDING SUITABLE GUARDS, AUDIBLE OR VISUAL ALARMS, OR OTHER DEVICES. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

INHIBIT(+) REFERENCE (16): This input (FHC) prevents the controller from responding to a positive speed/torque reference.

INHIBIT (–) REFERENCE (17): This input (RHC) prevents the controller from responding to a negative speed/torque reference.

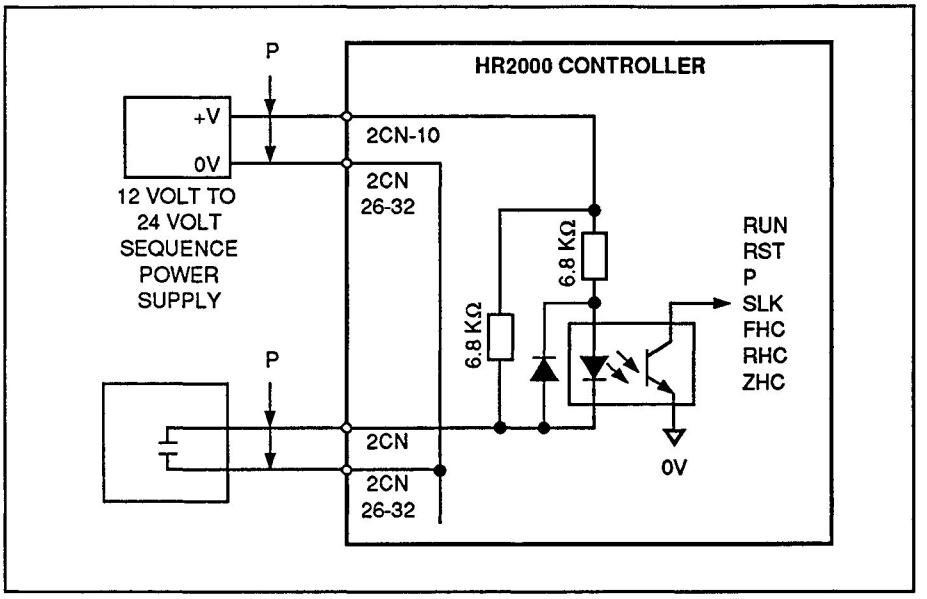


Figure 3-8. Typical Optically Isolated Input.

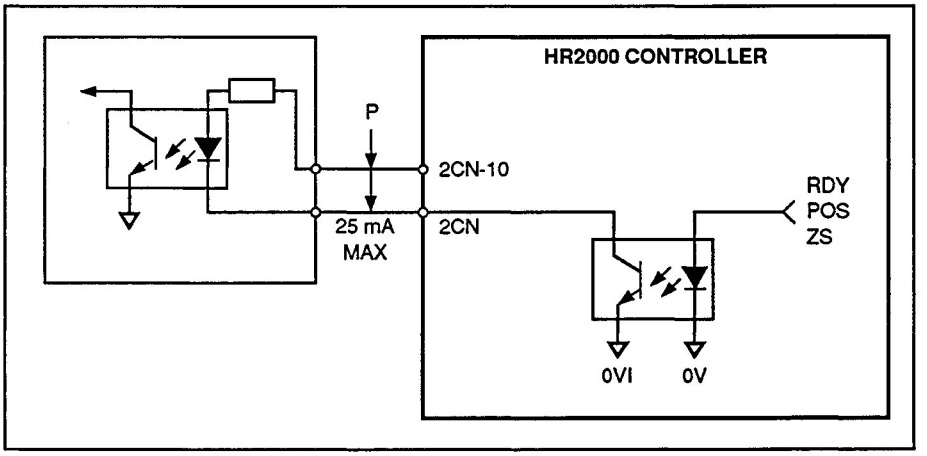


Figure 3-9. Typical Optically Isolated Output.

Logic Output Signals

Three optically isolated outputs are available on the 2CN connector. Each output will source a maximum of 25 mA. The common (0VI) of these outputs are pins 26 through 32. A brief description of the outputs follows; the pin numbers are shown in parentheses. Figure 3-9 shows the typical circuitry of an output.

READY (42): This output (RDY) indicates proper power is applied and no faults are present.

POSITION ERROR (43): This output (POS) indicates that an error has occurred when the controller is operating in the Position mode.

ZS (44): The indication of this output depends on the mode selected:

SPEED/TORQUE: Indicates that the drive is operating at a speed less than the value determined by the PG pot.

POSITION: Indicates that positioning is completed.

Signal Inputs

When placed in Position mode, the controller accepts a serial pulse train reference on pins 49 and 50. This reference can be either a single or dual channel signal. When using either single or dual channel signal, the pulse magnitude should be 3.5 to 8 volts and the maximum input frequency should not exceed 750 KHz. If 750 KHz is exceeded, the controller will IET. The pulse characteristics are shown in Figure 3-10.

Dual Channel Signal Input

The dual channel signal should be 90 degrees in quadrature so that the HR2000 controller will reverse with the source signal. Connect one channel of the dual channel signal to pins 47 and 48, and the other channel to pins 49 and 50 as shown in Figure 3-10. Setting of 2SW-5 is ON.

Single Channel Signal Input

If a single channel signal is used, connect the reference frequency to pins 49 and 50. Connect the direction signal to pins 47 and 48. Refer to Figure 3-10 for single channel input signals. Setting of 2SW-5 is OFF.

The speed is based on the input frequency using the following formula:

$$\text{Max Pulse Freq (Hz)} = \text{Encoder (PPR)} \times \frac{\text{Motor Speed (RPM)}}{60}$$

The direction of rotation in this mode is determined by the voltage level on pins 47 and 48. Both inputs are optically isolated.

It is also possible to connect A phase of 90° signal between 47 and 48, or B phase of 90° signal between 49 and 50.

Note: In position control, while the motor is rotating, a position error exists depending on its speed and position loop gain. In the event where the rotation is 2000 RPM, number of PG pulses is 2500 PPR, and the position loop gain is the minimum, the position error will be about 2.7 revolution.

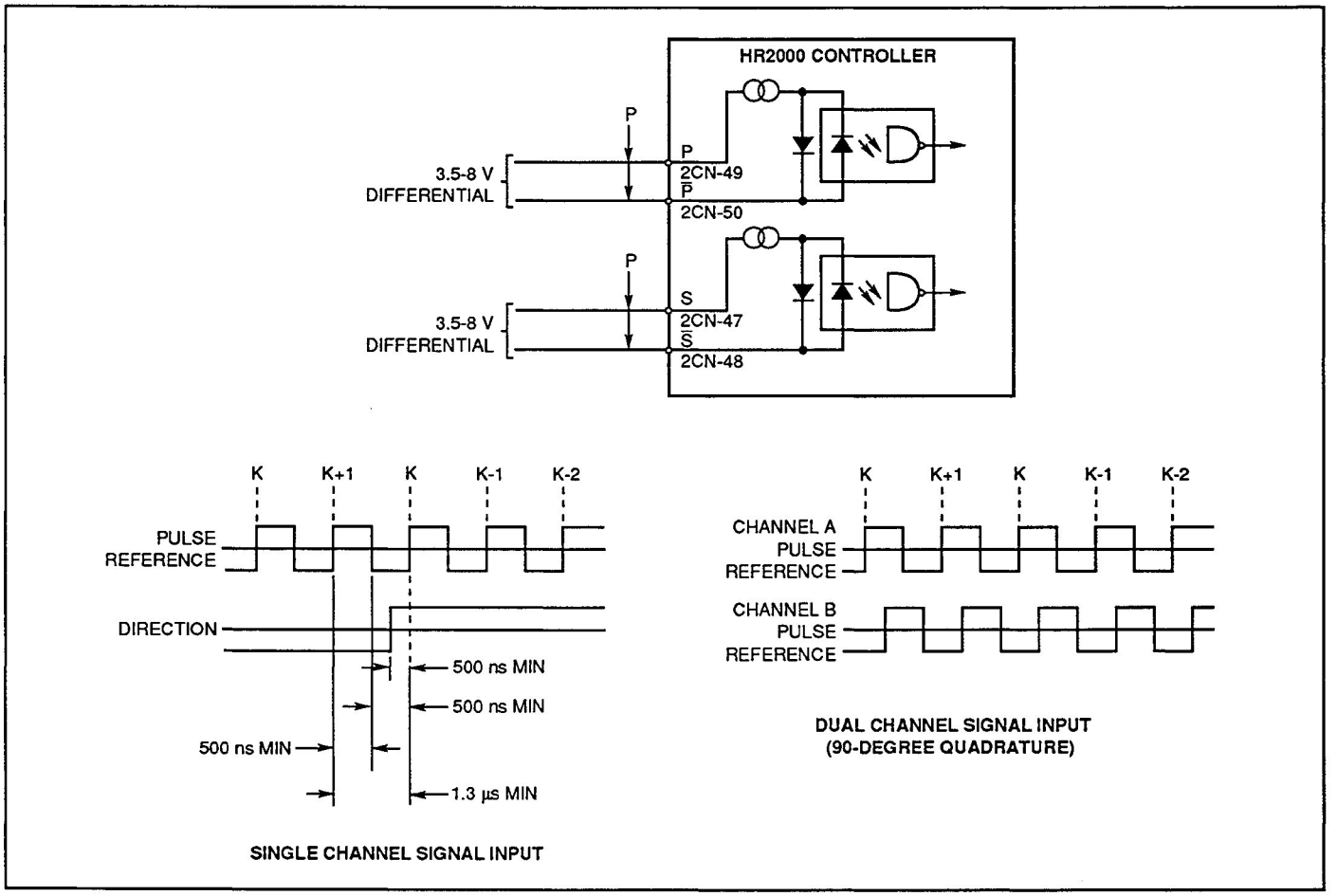


Figure 3-10. Typical Position Reference Circuit and Serial Pulse Train.

Signal Outputs

The motor mounted encoder feedback signals are repeated and available on the 2CN connector. The signals available are Channel A, B, Z, and their complements. The output signal is a TTL compatible differential line driver. The high level output range is 3.2 volts (Typ.) with a minimum of 2.5 volts at 20 mA load. The low level output range is 0.32 volts (Typ.) to 0.50 volts (Max.) at 20 mA load. Channels A and B can be divided by 1, 2, or 4 by using 2SW-7 and 2SW-8 switches. See Figure 3-11 for a typical wiring configuration.

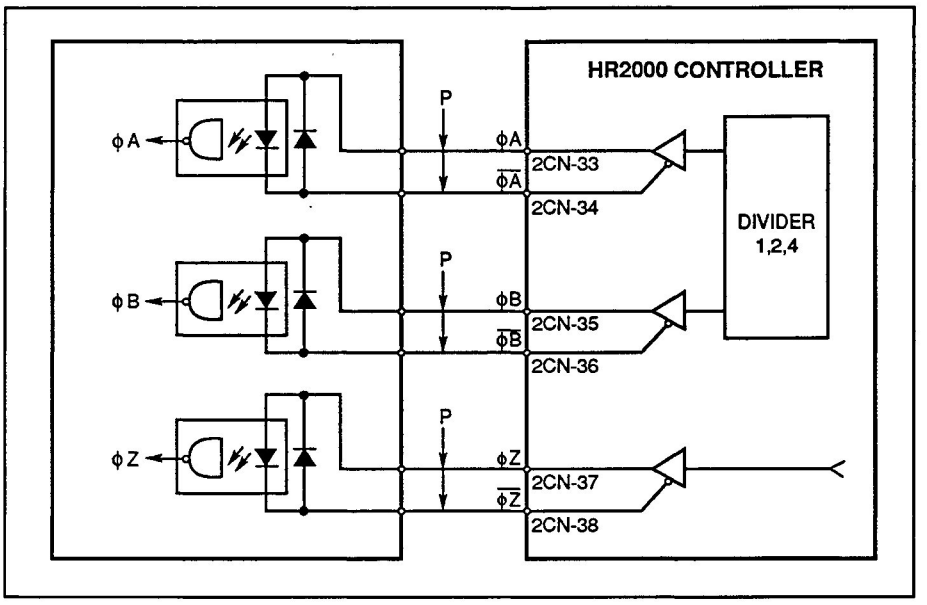


Figure 3-11. Typical Signal Output Circuitry.

Wire the Drive

Check Input Power Requirements

1. Verify that the input power to the controller corresponds to the controller nameplate voltage and frequency and that the plant supply is of sufficient ampacity to support the input current requirements of the controller.
2. The controller is shipped to accept 230 volts A-C. If input voltage is 208 volts, reconnect the power supply terminals located inside the controller as follows (Figure 3-12):
   - Open the hinged controller panel by removing the two screws, pulling the panel up on the hinge, and swinging the panel to the right.
   - Locate the internal three-position power terminal block in the non-hinged part of the controller and reconnect the RED wire:

   —230 VAC (factory set): RED wire on top spade connector across from BROWN wire.

   —200/208 VAC: RED wire on center spade connector across from BLACK wire.

CAUTION: If the power supply connections do not correspond to the input line voltage, incorrect voltage is applied which could cause an IET. Failure to observe this precaution could result in damage to, or destruction of, the controller.

   - Close and secure the hinged controller panel.
3. Provide a transformer between the plant power supply and the controller if the correct input line voltage is not available. Refer to "Install a Transformer (if needed)" in this chapter.
4. Throughout the wiring procedures, refer to Figure 3-13 for wiring locations.

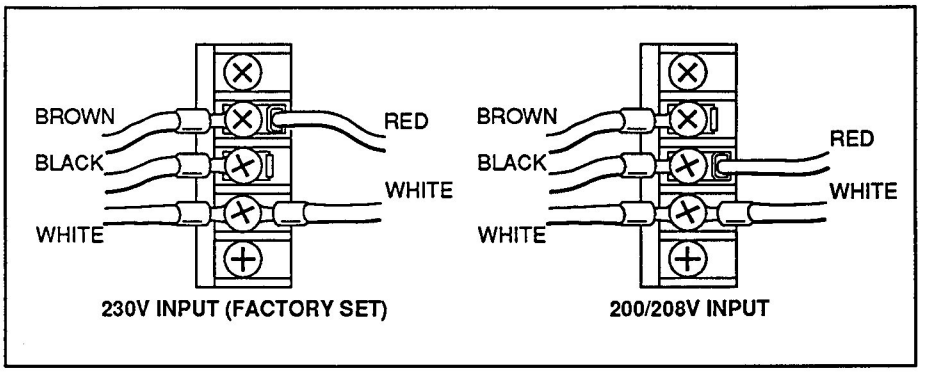


Figure 3-12. Internal Input Power Supply Connections.

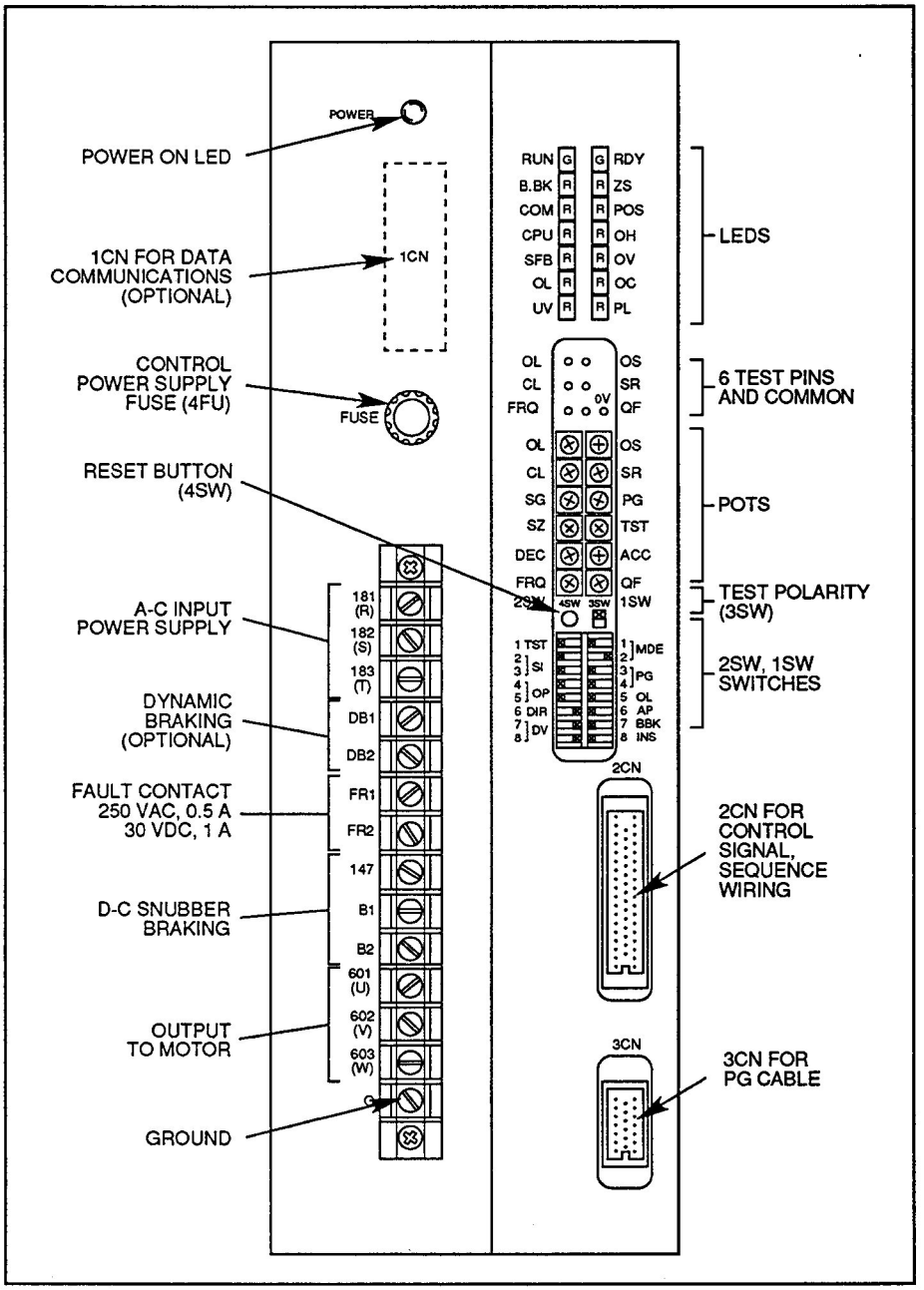


Figure 3-13. Location of Typical Control Wiring and Startup Components.

Provide Appropriate Grounding

DANGER

THE USER IS RESPONSIBLE TO MEET ALL CODE REQUIREMENTS WITH RESPECT TO GROUNDING ALL EQUIPMENT. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Run a suitable equipment grounding conductor or bonding jumper **unbroken** from the chassis ground (G) terminal on the controller faceplate (Figure 3-13) to the grounding electrode conductor (earth ground). Note that, with an enclosed controller, the chassis ground (G) terminal is connected to the ground terminal near the top of the enclosure; therefore, connect the enclosure ground to earth ground.
2. Connect a suitable equipment grounding conductor or bonding jumper to the motor frame, the remote operator's control station (if used), the input power transformer (if used), and the controller enclosure. Run this conductor or jumper **unbroken** to the grounding electrode conductor (earth ground).

Make Power Wiring Connections

CAUTION: Motor leads U, V, and W must be connected to terminals 601 (U), 602 (V), and 603 (W) respectively. Failure to observe this precaution could result in damage to, or destruction of, this equipment.

1. Size and select input and output power wire according to all applicable codes so that it is adequate for the voltages and currents to which it will be subjected.
2. Connect motor leads U, V, and W to terminals 601 (U), 602 (V), and 603 (W), respectively, on the faceplate of the controller as shown in Figure 3-14.

   Note: The motor could operate erratically if leads are not connected to the respectively labeled terminals.
3. Connect the normally closed motor thermostat to pins 40 and 41 of connector 2CN as shown in Figure 3-14.

CAUTION: If the motor thermostat is not properly wired, the controller will not stop when the contact is opened. Failure to observe this precaution could result in damage to, or destruction of, this equipment.

4. Connect the load side of the drive short circuit protective device to terminals 181 (R), 182 (S) and 183 (T) on the faceplate of the controller or through the optional Disconnect Kit if used. See Figure 3-14.

DANGER

THE OPTIONAL DISCONNECT KIT IS A CONVENIENCE DISCONNECT ONLY AND DOES NOT PROVIDE THE REQUIRED DRIVE SHORT CIRCUIT PROTECTION. IT IS THE USER'S RESPONSIBILITY TO PROVIDE THE REQUIRED DRIVE SHORT CIRCUIT PROTECTION. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

NOTE: *Drive short circuit protection must be provided by the customer with a UL listed or CSA certified fuse or circuit breaker in a circuit with maximum available symmetrical short circuit current equal to or less than 5000 Amps.*

If the optional Disconnect Kit is not being used, select a drive short circuit protective device from columns 1, 2, 3 or 4 of Table 3-1. If the Disconnect Kit is used and available symmetrical short circuit current is greater than 1000 Amps but less than 5000 Amps, select a drive short circuit protective device from columns 1 or 2 only.

Depending on the application, the drive short circuit protection may be the same device as that required by the NEC.

Table 3-1. Drive Short Circuit Protection Requirements.

	1	2	3	4	
Drive Horse Power	**Rated Input Fuse UL Class RK5 250 VAC**	**Maximum Input Fuse UL Class RK5 250 VAC**	**Thermal Magnetic C/B**	**Magnetic Only C/B**	**Trip Position**
				Westinghouse Reference Number is shown in ( )	
1	7 Amp	15 Amp	15 Amp	15 Amp (HMCP015E0)	A
2	15 Amp	20 Amp	20 Amp	30 Amp (HMCP030H1)	A
3	20 Amp	30 Amp	30 Amp	30 Amp (HMCP030H1)	A
4	25 Amp	30 Amp	30 Amp	30 Amp (HMCP030H1)	A

Make Control and Signal Wiring Connections

NOTE: *Signal wiring must be soldered to the mates that connect to the multiple pin Honda® connectors located on the face of the controller hinged panel. The mating connectors and sleeve tubing are supplied with the controller. Refer to Table 7-5 for sequencing and encoder cables with a Honda connector on one end and terminal boards on the opposite end for control cabinet mounting that are available from Reliance. Encoder signals terminate at the motor through an MS connector. The mating MS connector is supplied with the motor. Refer to Table 7-5 for available Reliance encoder cable kits that have a pre-soldered MS connector on one end and either a Honda connector or wire lugs on the opposite end.*

1. Use a minimum of #22 AWG twisted wire (Reliance part number 417900-76EAD or equivalent) having two to three twists per inch.
2. Follow the below procedures for routing wiring:
   - Be sure all control and signal wiring is physically isolated from power wiring. Current in power circuits can induce voltages in signal wiring.
   - Run signal wiring in a separate steel conduit (steel or flexible armored steel). Dedicated conduit is preferred.
   - Do not route signal wiring through junction or terminal boxes that contain power or control wiring.
   - Have control wiring and PG wiring intersect power wiring at a 90-degree angle.
   - Do not route signal wiring near devices producing external magnetic fields.
3. If the motor is mounted more than 100 feet from the controller, install the optional Encoder Isolation/Buffer Kit (M/N 3EB1) between the controller and the motor encoder.
4. Wire control and signal wiring to the appropriate Honda connector on the face of the controller hinged panel according to connection diagram Figure 3-14. Refer to Figures 3-15 and 3-16 to identify connector pin locations and Tables 3-2 and 3-3 for connector pin functions.
5. If the motor model being used is explosion proof (Models B14J1050, B14J160, B14J1070, or B14J1080), then go to step 7.
6. For 3CN and Encoder (Motor MS) Connector Pin Configurations (Figure 3-16), wire the connection pins S and E per Figure 3-16. Note that the sensing terminal for the encoder (P/S) needs 5 volts D-C for proper operation.
7. The following applies for explosion proof motors only.

   Remove the keyed MS connector from the cable by cutting it off. Remove the encoder-end plate from the motor to expose the motor encoder terminal board as shown in Figure 3-17. Perform the wiring directions as follows.

   a. Remove 3 inches of the cable's outer jacket. Strip 1/8 inch of insulation on each wire.

   b. Feed this stripped end of the cable through the opening marked "1/2-14 N.P.S.F." on the explosion-proof motor mounting dimension sheet in the D5-3018 manual.

   c. Connect each wire to the motor encoder terminal board. Refer to Figure 3-17 for connection details and Table 3-4 for a cross reference of functions and twisted pair color coding.

CAUTION: Termination to encoder T/B 15 (shield) will require caution. If soldering or crimping a lead wire to cable shield, be particularly careful not to damage twisted wire pairs. Insulate shielded wire strands and lead wire to prevent contact with other T/B points. SFB/CPU faults and other erratic motor operation may occur. Failure to observe these precautions could result in damage to, or destruction of, the equipment.

   d. Check that each wire is connected. Follow the accompanying notes to Table 3-4 for those wires which are connected together.

   e. Re-attach the motors encoder end plate.

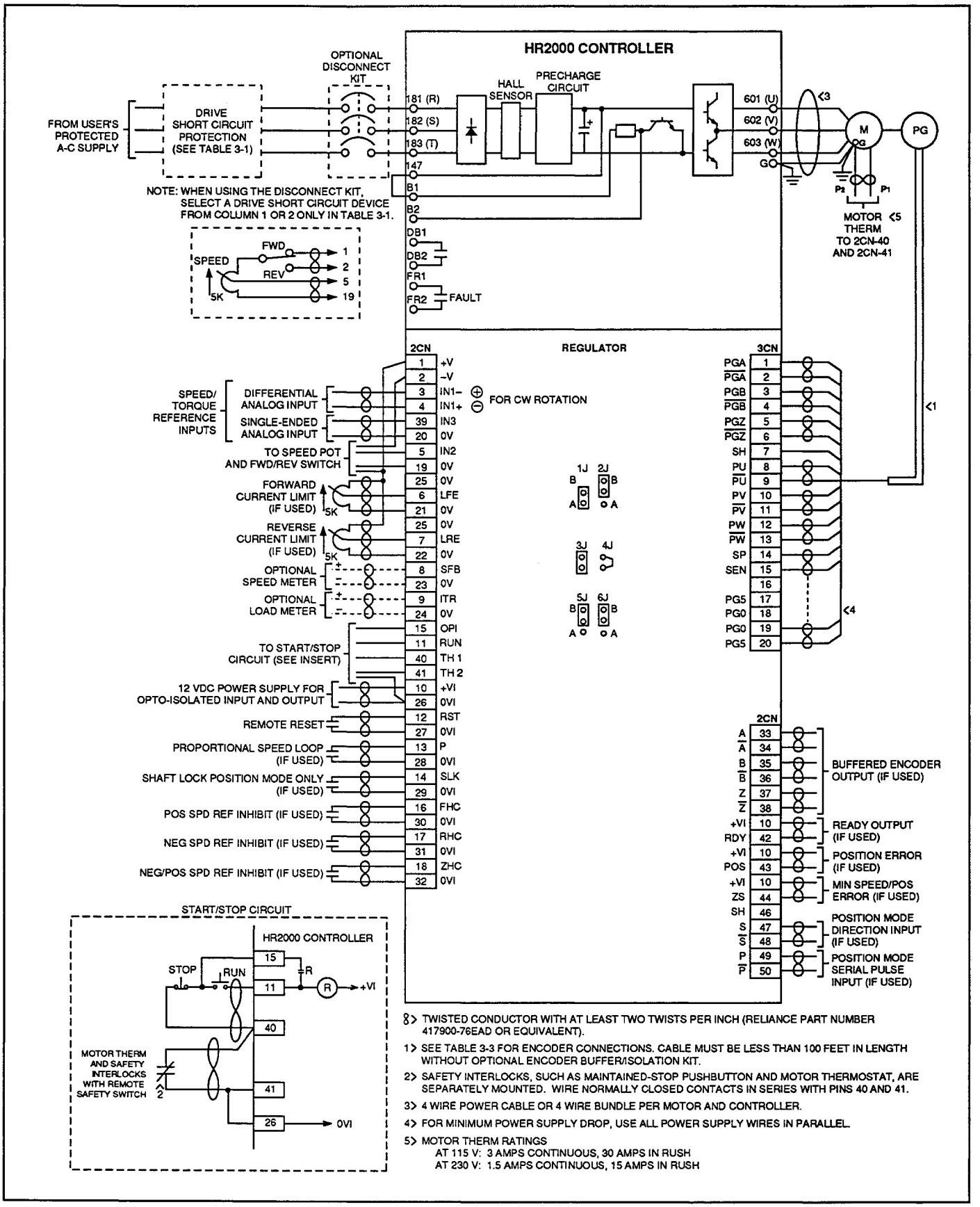


Figure 3-14. Typical Connection Diagram.

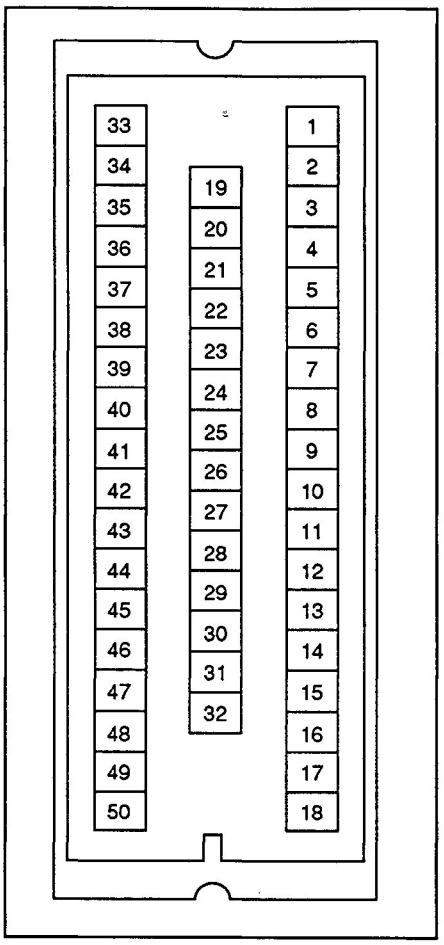


Figure 3-15. 2CN Connector Pin Configuration.

Table 3-2. 2CN Connector Pin Details.

PIN	SYMBOL	FUNCTION
1	+V	+12V internal power supply – 20 mA draw max
2	-V	-12V internal power supply – 20 mA draw max
3	IN1-	Positive differential Speed/Torque reference input
4	IN1+	Negative differential Speed/Torque rerference input
5	IN2	Single-ended Speed/Torque reference input
6	LFE	Remote current limit input for FWD motoring, REV regenerative 4VDC=Rated Current
7	LRE	Remote current limit input for REV motoring, FWD regenerative 4VDC=Rated Current
8	SFB	Analog output proportional to speed ±4 to 4.4 VDC = rated speed
9	ITR	Analog output proportional to torque ±8.0 VDC = 200% controller rated current
10	+VI	Isolated 12 to 24 Volt power for sequencing circuit
11	RUN	Start/Stop – maintained contact required
12	RST	Reset – momentary contact required
13	P	Proportional speed loop
14	SLK	Inhibits torque reference in torque mode Locks motor shaft in position/speed mode
15	OPI	Seal contact for "RUN". See Figure 3-14 (Start/Stop Circuit).
16	FHC	Inhibits positive speed/torque reference
17	RHC	Inhibits negative speed/torque reference
18	ZHC	Inhibits torque reference in torque mode Locks motor shaft in position/speed mode
19-25	0V	Commmon for ±12V supply on pins 1 and 2
26-32	0VI	Common for isolated 12 to 24 Volt supply on pin 10
33	A	Channel A of buffered encoder output
34	$\overline{A}$	Channel $\overline{A}$ of buffered encoder output
35	B	Channel B of buffered encoder output
36	$\overline{B}$	Channel $\overline{B}$ of buffered encoder output
37	Z	Channel Z of buffered encoder output
38	$\overline{Z}$	Channel $\overline{Z}$ of buffered encoder output
39	IN3	Single-ended Speed/Torque reference input
40	TH1	Connection points for remote safety devices (thermostats, etc.)
41	TH2	
42	RDY	Ready to run
43	POS	Position mode error
44	ZS	Speed/Torque: low speed; Position: positioning complete
45	OPO	Motor rotation direction: ON=FWD (CCW viewed from the shaft-end).
46	SH	Shield wire connection
47	S	Rotation direction or A phase of 90° signal in position mode (Forward direction rotation when 47 is Low and 48 is High.)
48	$\overline{S}$	
49	P	Serial pulse input or B phase of 90° signal in position mode (Positive edge be effective.)
50	$\overline{P}$	

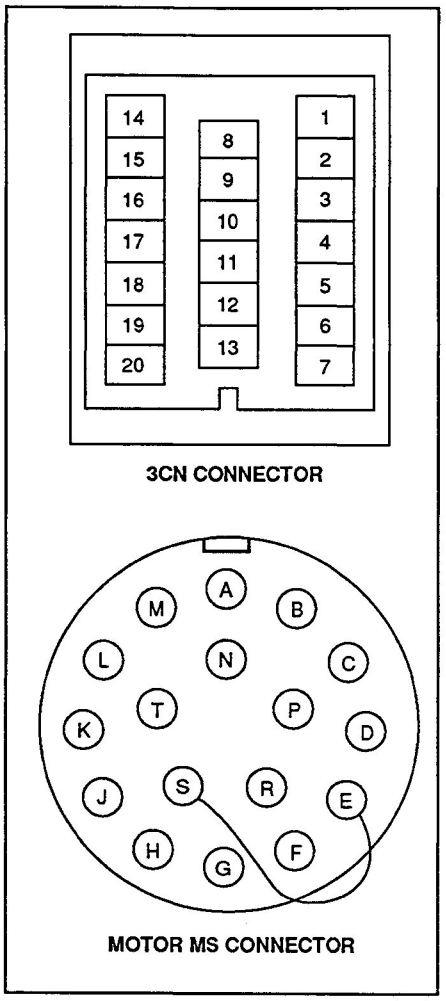
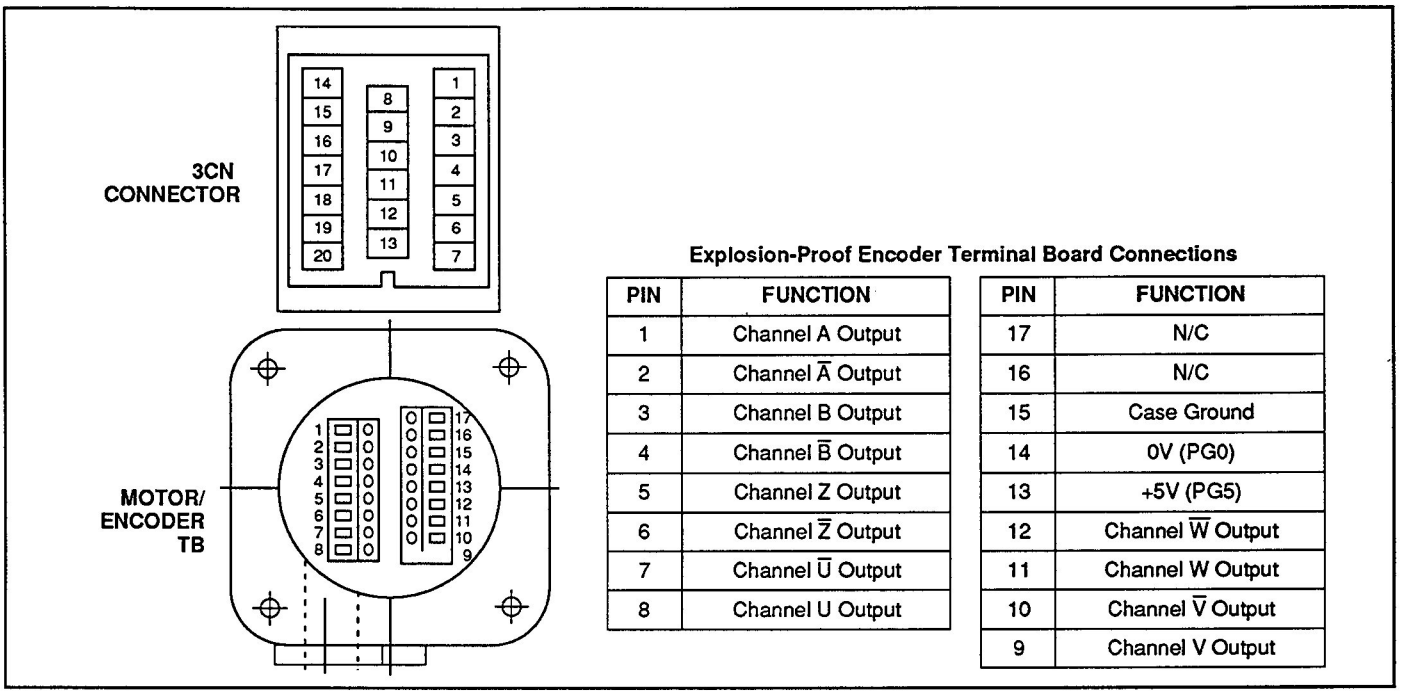


Figure 3-16. 3CN and Encoder (Motor MS) Connector Pin Configurations.

Table 3-3. 3CN Connector Pin Details (Grouped by Reg'd Twisted Pair).

3CN Pin	Motor MS Pin	Function	Symbol [1]
1	A	Channel A output	PGA
2	B	Channel $\overline{A}$ output	$\overline{PGA}$
3	C	Channel B output	PGB
4	D	Channel $\overline{B}$ output	$\overline{PGB}$
5	F	Channel Z output	PGZ
6	G	Channel $\overline{Z}$ output	$\overline{PGZ}$
7	N	Shield	SH
8	H	Channel U output	PU
9	J	Channel $\overline{U}$ output	$\overline{PU}$
10	K	Channel V output	PV
11	L	Channel $\overline{V}$ output	$\overline{PV}$
12	M	Channel W output	PW
13	T	Channel $\overline{W}$ output	$\overline{PW}$
14	P		SP
15	E	Sensing terminal for encoder P/S	SEN
16	—	Not used	
17	S	+5V power supply	PG5
18	R	0V power supply	PG0
19	R	0V power supply	PG0
20	S	+5V power supply	PG5
19	R	0V power supply	PG0
20	E	+5V power supply	PG5

[1] Refer to Instruction Manual D5-3024 for the motor encoder cable color chart.



Explosion-Proof Encoder Terminal Board Connections

PIN	FUNCTION
1	Channel A Output
2	Channel $\overline{A}$ Output
3	Channel B Output
4	Channel $\overline{B}$ Output
5	Channel Z Output
6	Channel $\overline{Z}$ Output
7	Channel $\overline{U}$ Output
8	Channel U Output

PIN	FUNCTION
17	N/C
16	N/C
15	Case Ground
14	0V (PG0)
13	+5V (PG5)
12	Channel $\overline{W}$ Output
11	Channel W Output
10	Channel $\overline{V}$ Output
9	Channel V Output

Figure 3-17. 3CN and Explosion-Proof Board Configuration.

Table 3-4. 3CN Connector Pin Details - Explosion-Proof Motor Connections.

3CN Pin	Expl.-Proof Encoder T/B	Function	Symbol [1]	Wire Color	
				MB-B4013	613905
1	1	Channel A output	PGA	Green	Green
2	2	Channel $\overline{A}$ output	$\overline{PGA}$	White	White/Green
3	3	Channel B output	PGB	Red	Red
4	4	Channel $\overline{B}$ output	$\overline{PGB}$	White	White/Red
5	5	Channel Z output	PGZ	Purple	Purple
6	6	Channel $\overline{Z}$ output	$\overline{PGZ}$	White	White/Purple
7	15	Shield (earth/case) ground	SH	–	–
8	7	Channel U output	PU	Blue	Blue
9	8	Channel $\overline{U}$ output	$\overline{PU}$	Brown	White/Blue
10	9	Channel V output	PV	Yellow	Yellow
11	10	Channel $\overline{V}$ output	$\overline{PV}$	Brown	White/Yellow
12	11	Channel W output	PW	Green	Orange
13	12	Channel $\overline{W}$ output	$\overline{PW}$	Brown	White/Orange
14	17[3]	Spare wire	SP	Brown	Brown
15	13	Sensing terminal for encoder buffer	SEN[1]	Red	White/Brown
16	—	Not used		–	–
17	13	+5V power supply	PG5[1]	Purple	Gray
18	14	0V power supply	PG0[2]	Brown	White/Gray
19	14	0V power supply	PG0[2]	White	Tan
20	13	+5V power supply	PG5[1]	Blue	White/Tan
19	14	0V power supply	PG0[2]	White	Pink
20	13	+5V power supply	PG5[1]	Yellow	White/Pink

[1] These four (4) wires must be connected together (PG5, SEN) at Encoder T/B pin 13.
[2] These three (3) wires must be connected together (PG0) at Encoder T/B pin 14.
[3] T/B pin 17 is a no-connection tie point.

Set Regulator Dip Switches

Dip switches are provided to set parameters for the regulator. Each switch can be ON (to the right) or OFF (to the left).

1. Locate these switches through the window on the face of the controller hinged panel.
2. Set dip switches 1SW and 2SW for the regulator parameters desired. Refer to Table 3-5 for details about the dip switches.
3. The following functions are not enabled while the controller is running: PG, OL, INS, and DIR. These functions must be initialized to be operative. To initialize, stop the controller, remove all input power, make the desired regulator switch setting(s), and reapply power.

Table 3-5. Dip Switch Descriptions.

<table>
<tr><th>Switch</th><th>Paramter</th><th>Description</th></tr>
<tr><td colspan="3">Switch 1SW Functions</td></tr>
<tr><td>1SW-1
1SW-2</td><td>Control Mode (1)</td><td>Selects 1 of 4 operating modes: speed regulator, torque regulator, position regulator, or encoder test mode. The encoder test mode disables the feedback and will run the motor at a high rate of speed. Use this mode only for diagnosing encoder faults.
<table>
<tr><th rowspan="2">Switch</th><th colspan="3">Regulation</th><th rowspan="2">Encoder Test</th></tr>
<tr><th>Speed</th><th>Torque</th><th>Position</th></tr>
<tr><td>1SW-1</td><td>OFF</td><td>OFF</td><td>ON</td><td>ON</td></tr>
<tr><td>1SW-2</td><td>ON</td><td>OFF</td><td>OFF</td><td>ON</td></tr>
</table></td></tr>
<tr><td>1SW-3
1SW-4</td><td>PG (1)</td><td>Defines the encoder PPR and motor type applied to the controller.
1SW-3 ON = 3000 PPR OFF = 2500 PPR
1SW-4 ON = 4 Pole 3000 RPM Motor OFF = 4 Pole 2000 RPM Motor
NOTE: 1SW-3 and 1SW-4 can be redefined in EEPROM. See Operator's Terminal I/M D5-3025 for details. CPU LED will light for unsupported motor/controller combinations.</td></tr>
<tr><td>1SW-5</td><td>OL (1)</td><td>Selects the overload protection characteristics.
(OFF = 50 to 100 % controller rated current; ON = 33 to 66% controller rated current).</td></tr>
<tr><td>1SW-6</td><td>AP (2)</td><td>Enables P/PI automatic switching of Speed Control Amp
(ON = P/PI automatic switching, OFF = PI)</td></tr>
<tr><td>1SW-7</td><td>BBK</td><td>Disables the base driver and prevents the output transistors from firing; use only during troubleshooting. Enabling this switch will cause the BBK LED to illuminate (ON = DISABLE; OFF = ENABLE).</td></tr>
<tr><td>1SW-8</td><td>INS (1)</td><td>Inspection mode; used only by Reliance personnel during test and setup procedures prior to shipping
(OFF = Normal run mode; ON = Inspection mode).</td></tr>
<tr><td colspan="3">Switch 2SW Functions</td></tr>
<tr><td>2SW-1</td><td>TST</td><td>Enable the test signal, a reference generated by the TST pot (ON = test signal enable; OFF = test signal disable). The 3SW switch above 1SW selects polarity of the test signal.</td></tr>
<tr><td>2SW-2
2SW-3</td><td>SI</td><td>Speed loop integral switches; adds more capacitance to the speed loop regulator.
<table>
<tr><th>Switch</th><th>×1</th><th>×3</th><th>×6</th><th>×8</th></tr>
<tr><td>2SW-2</td><td>OFF</td><td>ON</td><td>OFF</td><td>ON</td></tr>
<tr><td>2SW-3</td><td>OFF</td><td>OFF</td><td>ON</td><td>ON</td></tr>
</table>
(Increases integral time; decreases integral gain.)</td></tr>
<tr><td>2SW-4</td><td>OP1</td><td>Selects the acceleration and deceleration rates (OFF = 1 to 18 seconds; ON = 0.1 to 1.8 seconds)</td></tr>
<tr><td>2SW-5</td><td>OP2</td><td>Selects the position reference signal input (ON = Dual channel signal input; OFF = Single channel signal input).</td></tr>
<tr><td>2SW-6</td><td>DIR (1)</td><td>Determines the direction of shaft rotation for a positive reference (ON = FWD, CCW when looking at the motor shaft; OFF = REV, CW when looking at the motor shaft).</td></tr>
<tr><td>2SW-7
2SW-8</td><td>DIV</td><td>Divides the isolated/buffered encoder pulses repeated on connector 2CN.
<table>
<tr><th rowspan="2">Switch</th><th colspan="4">Division</th></tr>
<tr><th>4</th><th>2</th><th>1</th><th>Do Not Use</th></tr>
<tr><td>2SW-7</td><td>OFF</td><td>ON</td><td>ON</td><td>OFF</td></tr>
<tr><td>2SW-8</td><td>ON</td><td>OFF</td><td>ON</td><td>OFF</td></tr>
</table></td></tr>
</table>

(1) The following functions are not enabled while the controller is running: PG, OL, INS, and DIR. These functions must be initialized to be operative. To initialize, stop the controller, remove all input power, make the desired regulator switch setting(s), and reapply power.

(2) Automatic switching enables integral control above 3 RPM and disables integral control below 3 RPM. Also, 2CN pin 13 will override this switch if asserted resulting in proportional only control at all times.

4: Start and Adjust the Controller

DANGER

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE, AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Gather Necessary Test Equipment

CAUTION: Do not use a megger to perform continuity checks in the drive equipment. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

The following equipment or their equivalent are recommended:

- A two-channel oscilloscope with 10 to 1 probes.
- A digital volt-ohmmeter with a 10 megohm input impedance on all ranges, such as a Fluke 8022B.
- Either an optional Exercise Module (M/N 3RE4) or a function generator with ±0.5 V peak, 1 to 3 hz square wave output or manually operated switch with ungrounded ±0.5 V supply.

Check the Installation

WARNING

THE USER IS RESPONSIBLE FOR ENSURING THAT DRIVEN MACHINERY, ALL DRIVE-TRAIN MECHANISMS, AND PROCESS LINE MATERIAL ARE CAPABLE OF SAFE OPERATION AT A SPEED 1.5 TIMES AS HIGH AS THE APPLIED MOTOR SPEED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

1. Make sure the input disconnect is in the OFF position (power OFF).
2. Verify that motor nameplate data corresponds to the controller output ratings.
3. Make sure that any motor thermal switch or overload device, if required, is sized for the rated motor current and is wired according to Figure 3-12.
4. Rotate the motor shaft by hand to check that the motor is free from any binding or mechanical load problem and that no loose items, such as shaft keys, couplings, etc., are present.
5. Visually check the controller for mechanical damage and remaining installation debris, wire strands, etc.
6. Make sure that all coils, such as relays and magnetic valves, that are connected to the controller or located in the controller vicinity are suppressed: A-C coils with RC filters and D-C coils with diodes in a non-conducting direction.

Check the Wiring

1. Verify that the controller is wired according to connection diagram Figure 3-12.
2. Check that all connections are tight.
3. Check that no solder bridges are present on the connectors.
4. Check that signal leads are separated from electromagnetic fields.
5. Verify that A-C line voltage is three phase, 230 VAC (208 VAC if the internal input power voltage RED wire was changed as shown in Figure 3-10).
6. Verify that A-C line frequency is 60 hz.
7. Verify that the A-C line feeding the controller has less than 5,000 amps fault short circuit rating.

Initialize the Regulator

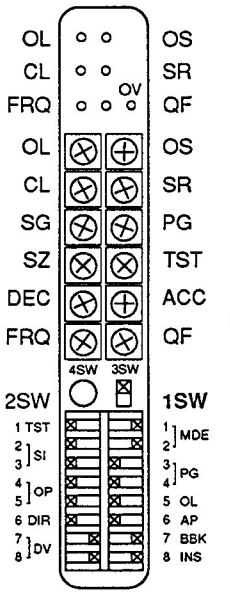
NOTE: *Perform this procedure with the motor uncoupled from the load.*

CAUTION: To prevent ignition of hazardous atmospheres, all of motor and encoder covers are to be tightly closed and all screws in place when unit in operation. Failure to observe this precaution could result in damage to, or destruction of the equipment.

The HR2000 controller contains non-volatile read-write memory (EEPROM). This memory provides the ability to operate a variety of motor and encoder designs by storing the default value of the drive parameters listed in Table 4-1. The HR2000 1 through 4 HP controllers are initialized at the factory to INIT0. If the controller is being installed for the first time from the factory and the motor you are using has the pole/RPM and encoder characteristics for INIT0 per Table 4-1, initializing the regulator is not necessary (NOTE: *If the motor has a speed of 1750 RPM, INIT selections are still valid*). The preferred INIT selections for 4 and 6 pole motors are listed in Table 4-1. If you are unsure of the motor's design either obtain the data from the nameplate or refer to Table 4-2.

To initialize the regulator, do the following:

1. Determine which initialization (INIT0 or INIT3) and procedure to use based on the motor's pole/RPM and encoder characteristics. Refer to Table 4-1.
2. **(INIT0)** - Use this step for 4 pole motors only.
   - 2.1 Turn power OFF.
   - 2.2 Set 1SW Dip switches for INIT0 as follows:



☒ = SWITCH POSITION
RIGHT POSITION = ON

1SW Settings:
1: ON
2: ON
3: OFF
4: OFF
5: OFF
6: OFF
7: ON
8: ON

   - 2.3 Turn power ON for 10 seconds.
   - 2.4 Turn power OFF.
   - 2.5 Turn 1SW-7 and 1SW-8 OFF. INIT0 procedure is now complete.
   - 2.6 Determine the motor base speed and encoder PPR. Refer to Table 4-2 to cross reference motor model numbers with poles, base speed and encoder PPR. Set 1SW-3 and 1SW-4 switches per your determined motor base speed and encoder PPR with reference to the followings:

     1SW-3: OFF 2500 PPR
     ON 3000 PPR

     1SW-4: OFF 2000 RPM
     ON 3000 RPM

   - 2.7 Refer to Table 3-4 to set other 1SW switches per your application requirements.
   - 2.8 Continue with the startup and adjustment instructions for "Review the Controller Regulator Jumpers" in this section.

Table 4-1. Default Values of EEPROM Version J.

INIT	Procedure	Poles	Speed	Encoder PPR	Other Defaults Common to All INITS
INIT0 (Factory Setting)	Use Step 2 of this procedure.	4	2000/3000	2500/3000	**ZS Offset:** Not Supported **ZS Delay:** 353.6 msec. **POSC:** • Scope: 16 • Delay: 353.6 msec • Signal: CONTINUOUS • Gear Ratio: 4
INIT3	Use Step 3 of this procedure.	6	2000/3000	2500/3000	

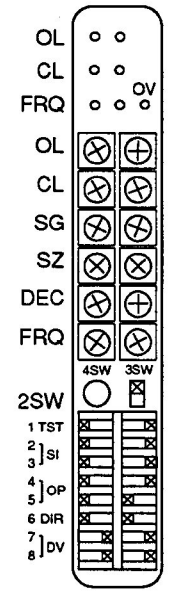
Table 4-2. Motor/Encoder Characteristics for Initialization.

Motor Poles	Base Speed	Encoder PPR	Motor Model Number
4	2000	2500	B14Hxxxx series B18Hxxxx series B90Hxxxx series
4	3000	2500	S-2005
6	3000	2500	S-40xx series

3. **(INIT3)** - Use this step for 6 pole motors only.

   3.1 Turn power OFF.

   3.2 Set 1SW Dip switches for INIT3 as follows:



1SW Settings:

1: ON
2: ON
3: ON
4: ON
5: OFF
6: OFF
7: ON
8: ON

☒ = SWITCH POSITION
RIGHT POSITION = ON

   3.3 Turn power ON for 10 seconds.

   3.4 Turn power OFF.

   3.5 Turn 1SW-7 and 1SW-8 OFF. INIT3 procedure is now complete.

   3.6 Determine speed and encoder PPR. Refer to Table 4-2 to cross reference motor model numbers with poles, base speed and encoder PPR. Set 1SW-3 and 1SW-4 switches per your determined motor base speed and encoder PPR with reference to the followings:

   1SW-3: OFF 3000 PPR
   ON 2500 PPR

   1SW-4: OFF 3000 RPM
   ON 2000 RPM

   3.7 Refer to Table 3-4 to set other 1SW switches per your application requirements.

   3.8 Continue with the startup and adjustment instructions for "Review the Controller Regulator Jumpers" in this section.

Review the Controller Regulator Jumpers

The regulator has several jumpers to enable functions or to change the range of adjustments. Jumpers available for customer selection are 1J, 2J, 5J, and 6J. See Figure 7-11 for their location on the regulator board.

Notch Filter 1J

This jumper has 3 pins: position A, common, and position B.

Position A disables the filter, causing the FRQ and QF pots to have no effect. Position B allows the notch filter to effect the reference circuit to prevent torsional vibrations on applications in which reflected load inertia is substantially larger than motor inertia.

Accel/Decel Ramp 2J

This jumper has 3 pins: position A, common, and position B.

Position A bypasses the ramp circuit such that the input reference is fed directly into the regulator's internal circuitry without conditioning, causing the ACC and DEC pots to be inoperative.

Position B places the ramp circuit in series with the differential input reference; the acceleration and deceleration rates can be adjusted using the ACC and DEC pots.

Factory Setup 3J

Disables current minor loop operation.

This jumper is used for regulator adjustment and monitoring at the factory. Do not remove.

Low-pass Filter 5J

This jumper has 3 pins: position A, common, and position B.

Position A disables the filter. Position B allows the low-pass filter to eliminate the noise from speed feedback signal. This selection is effective to prevent torsional vibrations on applications. This jumper may be used with 6J. See Figure 4-1 for the circuitry.

Low-pass Filter 6J

This jumper has 3 pins: position A, common, and position B.

Position A disables the filter. Position B allows the low-pass filter to eliminate the noise from speed feedback signal. This selection is effective to prevent torsional vibrations on applications. This jumper may be used with 5J.

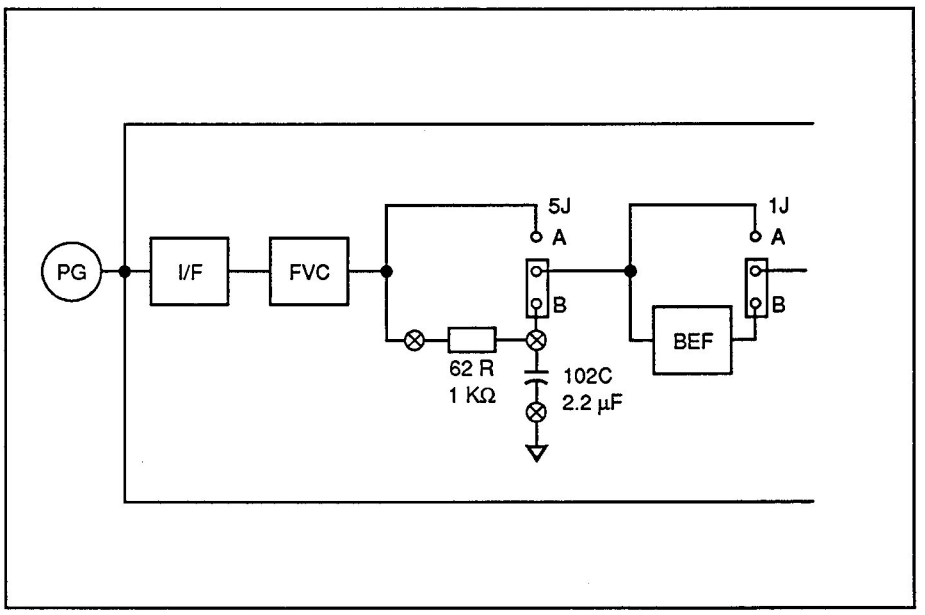


Figure 4-1. Low-pass Filter Circuitry for Speed Feedback.

Review the Regulator Pots

The controller has twelve pots for use during startup. To access the pots, remove the tinted plastic cover that covers the pots. On the inside of the cover is a plastic screwdriver with which to adjust the pots.

Symbol: **OL**
Function: Inverse time overload
Range: See Figure 4-2A.
Factory Setting:
2000 RPM BASE SPEED
2.6 V, 100% of motor rating

CAUTION: The Electronic Overload Function of this controller uses the motor current reference signal and may not meet the Application Requirements for "Motor Overload Protection". Failure to observe these precautions could result in damage to, or destruction of, the equipment.

Symbol: **CL**
Function: Maximum instantaneous current output
Range: See Figure 4-2B.
Factory Setting:
2000 RPM BASE SPEED
3.8 V, 200% of motor rating

Symbol: **SG**
Function: Speed loop gain
Range: 10 to 30 dB
Factory Setting: 20 dB

Symbol: **SZ**
Function: Speed feedback offset
Range:
2000 RPM BASE SPEED
0 to ±650 RPM
3000 RPM BASE SPEED
0 to ±950 RPM
Factory Setting: Mid range, approximately 0 RPM

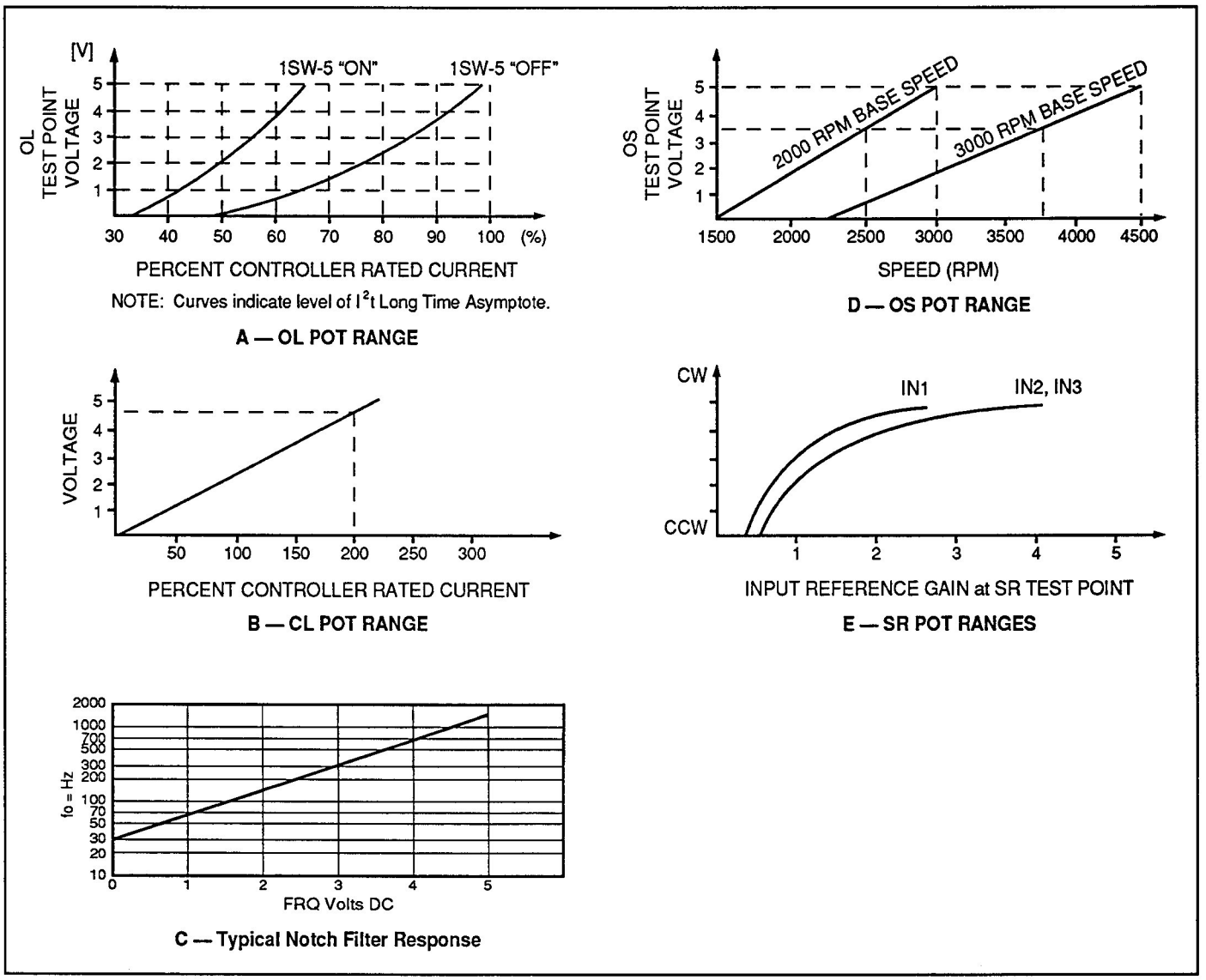


Figure 4-2. Curves Showing Ranges of Regulator Pots.

Symbol: **DEC**
Function: Deceleration rate
Range:
- With 2SW-4 ON, 0.1 to 1.8 seconds
- With 2SW-4 OFF, 1.0 to 18 seconds

Inoperative if jumper 2J is in position A.
Factory Setting: 1 second

Symbol: **FRQ**
Function: Notch filter frequency
Range: 30 to 1400 hz
Inoperative if jumper 1J is in position A.
Factory Setting:
1HP: 660 Hz (3.95 VDC)
2HP: 600 Hz (3.85 VDC)
3HP: 590 Hz (3.80 VDC)
4HP: 550 Hz (3.75 VDC)
See Figure 4-2C.

Symbol: **QF**
Function: Notch filter Q factor
Range: 0.5 to 2.5
Inoperative if jumper 1J is in position A.
Factory Setting: Full CCW = 0.5

Symbol: **OS**
Function: Overspeed IET setting
Range: See Figure 4-2D.
Frequency Setting:
2000 RPM BASE SPEED
3.5 V 2600 RPM
3000 RPM BASE SPEED
3.5 V 3800 RPM

Symbol: **SR**
Function: Input reference gain at SR Test Point.
Range:
- 0.3 to 2.7 for differential inputs
- 0.5 to 4.0 for single-ended inputs

See Figure 4-2E.
Factory Setting: 4 V input equals 50% reference

Symbol: **PG**
Function: Has two functions dependent on regulator mode:
- Speed/Torque mode: Adjusts minimum speed detection circuit, used to illuminate ZS LED and change logic level of ZS output
- Position mode: Position loop gain

Range:
Speed/Torque mode:
2000 RPM BASE SPEED
0.5 to 90 RPM
3000 RPM BASE SPEED
0.5 to 130 RPM
Position mode: 0.4 mV to 4.8 mV per pulse
Factory Setting: Full CCW

Symbol: **TST**
Function: Reference input in test mode
Test mode is turned ON by 2SW-1. Test signal polarity is selected by 3SW.
Range: 0 to 10 volts
Factory Setting: Full CCW

Symbol: **ACC**
Function: Acceleration rate
Range:
- With 2SW-4 ON, 0.1 to 1.8 seconds
- With 2SW-4 OFF, 1.0 to 18 seconds

Inoperative if jumper 2J is in position A.
Factory Setting: 1 second

Start the Controller

Startup is a two-part procedure that is performed in the following sequence:

1. Running the drive in the Speed Regulation mode with the motor uncoupled from the machine or load.
2. Running the drive in the Speed Regulation mode with the motor coupled to the machine or load.

NOTE: *Should the controller IET, press the Reset pushbutton (4SW) on the front of the hinged panel of the controller to reset all faults.*

Perform Startup Procedure 1 with Motor Uncoupled

CAUTION: Do not perform Procedure 2 before Procedure 1. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

WARNING

THIS DRIVE CAN OPERATE AT ZERO SPEED. IF THE APPLICATION REQUIRES ZERO SPEED OPERATION WITHOUT DISCONNECTION FROM THE POWER SOURCE, THE USER IS RESPONSIBLE FOR ASSURING SAFE CONDITIONS FOR OPERATING PERSONNEL BY PROVIDING SUITABLE GUARDS, AUDIBLE OR VISUAL ALARMS, OR OTHER DEVICES. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

1. Follow all of the "Check the Installation" procedures if not already performed.
2. Make sure all power is OFF. The POWER LED should not be illuminated.

DANGER

THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. WHENEVER POWER IS REMOVED, VERIFY WITH A VOLTMETER AT FACEPLATE TERMINAL 147(+) AND REGULATOR BOARD TERMINAL B1(–) THAT THE D-C BUS CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY INTERNAL PARTS OF THE CONTROLLER. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

3. Connect a voltmeter to faceplate terminal 147(+) and regulator board terminal B1(–) (See Figure 7-11). Read this voltage every time you turn power OFF to verify the D-C bus is fully discharged. Also make sure the POWER LED is not illuminated.
4. Uncouple the motor from the machine or load.
5. Set regulator switches 1SW and 2SW as shown in Figure 4-3.

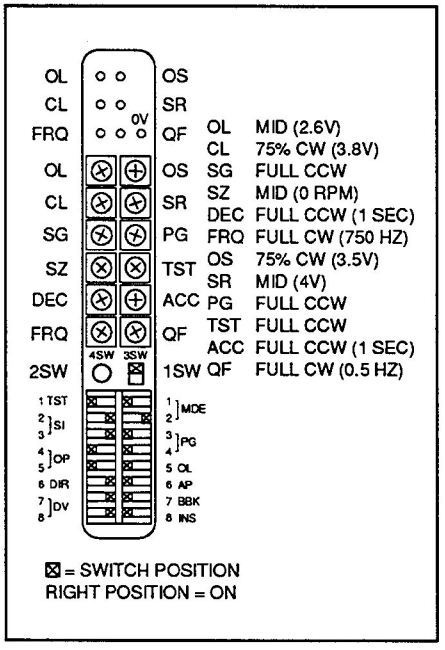


Figure 4-3. Controller Switch and Pot Settings for Procedure 1 and Speed Mode.

6. Verify that the pots are set according to "Review the Regulator Pots." See Figure 4-3.
7. Wire the controller for Speed reference using Figure 3-12.

WARNING

VERIFY THE START CONTACTS ARE OPEN AND A START SIGNAL IS NOT PRESENT BEFORE APPLYING POWER. ELECTRICAL NOISE, IMPROPER WIRING, OR MALFUNCTIONING COMPONENTS COULD CAUSE THE MOTOR TO ROTATE WHILE THE CONTROLLER IS SET AT ZERO SPEED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

8. Verify that the Start contacts are open, a Start signal is not present, and the Speed reference input is 0 volts.

DANGER

THE REMAINING STEPS ARE MADE WITH POWER ON. EXERCISE EXTREME CARE BECAUSE HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

9. Turn power ON.

   NOTE: *The POWER ON, the RDY, and the ZS LEDs should illuminate.*

10. Give the controller a Start command. The RUN LED should illuminate.
11. Make sure the drive shutdown interlocks, such as safety switches installed around the driven machine, are operational. When activated, they must shut down the drive.

CAUTION: Make sure electrical commons are not intermixed when monitoring voltage and current points in the controller. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

12. Check motor shaft rotation. If the motor is not rotating, slowly increase the Speed reference until the motor rotates. If shaft rotation is correct, proceed to Step 13. If shaft rotation is incorrect:
    - Give the controller a Stop command. Wait until the motor has completely stopped.
    - Turn power OFF.
    - After verifying the D-C bus voltage is zero and the POWER LED is not illuminated, change the position of switch 2SW-6 on the hinged panel.
    - Turn power ON.
    - Give the controller a Start command.
13. Place a digital voltmeter (20 VDC scale) on 2CN connector pins 8(+) and 23(COM).

    NOTE: *This analog D-C signal (SFB) is proportional to speed.*

14. Increase the Speed reference input until the voltmeter reads 4.3 VDC. This corresponds to a motor speed of 2000 RPM when using a 2500 PPR encoder. Use a tachometer to verify the speed.

    NOTE: *The polarity of the signal is either positive or negative based on direction.*

15. If the meter does not read 4.3 VDC or a different maximum speed is required, adjust the SR pot until the proper speed is reached. The SR test point will read 8.0 VDC at base speed.

    If a **faster maximum speed** is required:
    - Turn the SR pot CW until the proper maximum speed is reached. If the controller IETs and the OS LED illuminates, the overspeed trip point has been exceeded.
    - Turn the OS pot 1/8 turn CW.
    - Push the Reset pushbutton (4SW).
    - The POWER ON, the RDY, and the ZS LEDs should illuminate.
    - Repeat this Step until the desired speed is reached.

If a **slower maximum speed** is required:

- Turn the SR pot CCW until the proper maximum speed is reached.
- Turn the OS pot CCW until the controller IETs and the OS LED illuminates.
- Turn the OS pot 1/8 turn CW.
- Push the Reset pushbutton (4SW).

16. Decrease the Speed reference to zero volts.
17. Give the controller a Stop command.
18. Turn power OFF.
19. Proceed to "Perform Startup Procedure 2 with Motor Coupled."

Perform Startup Procedure 2 with Motor Coupled

CAUTION: Do not perform Procedure 2 before Procedure 1. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

1. Determine the regulator mode necessary for your application: speed regulator, torque regulator, or position regulator.
2. Proceed to the section corresponding to the selected regulation mode:
   - "Perform Startup in Speed Regulator Mode,"
   - "Perform Startup in Torque Regulator Mode," or
   - "Perform Startup in Position Regulator Mode."

Perform Startup in Speed Regulator Mode

WARNING

THIS DRIVE CAN OPERATE AT ZERO SPEED. IF THE APPLICATION REQUIRES ZERO SPEED OPERATION WITHOUT DISCONNECTION FROM THE POWER SOURCE, THE USER IS RESPONSIBLE FOR ASSURING SAFE CONDITIONS FOR OPERATING PERSONNEL BY PROVIDING SUITABLE GUARDS, AUDIBLE OR VISUAL ALARMS, OR OTHER DEVICES. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

1. Make sure all power is OFF. The POWER LED should not be illuminated.
2. Couple the motor to the machine or load.
3. Remove the Speed reference circuit from Procedure 1 and wire any necessary inputs or outputs to the controller for proper machine operation in the Speed Regulator mode.
4. With power OFF, verify the regulator switches are set as shown in Figure 4-3.
5. Verify Notch Filter 1J is enabled (position B). Refer to Figure 7-11 for location of jumper 1J.

DANGER

THE REMAINING STEPS ARE MADE WITH POWER ON. EXERCISE EXTREME CARE BECAUSE HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

6. With the Speed reference at minimum, turn power ON.

   NOTE: *The POWER ON, and the RDY LEDs should illuminate.*

7. Place a digital voltmeter (20 VDC scale) on 2CN connector pins 8(+) and 23 (COM).

   NOTE: *This analog D-C signal (SFB) is proportional to speed.*

8. Adjust the SZ pot until the voltmeter reads zero. The ZS LED should be illuminated.

CAUTION: The continuous operation of the motor in torsional resonance (high frequency range ~ 400 Hz to 1400 Hz) or other system related resonances/vibrations (lower frequency range of less than 150 Hz) will result in damage to, or destruction of, the motor, encoder, and/or the coupled equipment.

9. Give the controller a Start command. The RUN LED should illuminate.
10. NOTE: *Torsional and system related resonances may occur at the same time. Torsional resonances will typically occur when connected to load inertias of greater than three times the motor rotor inertias and moderate speed loop gain (SG). Torsional resonance will be more apparent at minimum speed loop gain if inertias of loads are greater than five to eight times motor inertia. System related resonances are usually the result of too high of speed loop gain (SG) or Integral gain or system backlash.*

    If an audible high frequency motor noise or motor vibration is present, that was not when the motor was not coupled to the load, perform the following:

    - Turn the SG pot fully CCW.
    - Adjust the FRQ pot until the oscillation is minimized.
    - Readjust SZ per Step 8.

11. Increase the Speed reference to maximum. The motor will accelerate to the maximum speed setting.
12. Connect a digital voltmeter to 2CN connector pins 8(+) and 24(COM) to monitor speed output.
    Verify that digital voltmeter reads 4.3 VDC. This corresponds to a motor speed of 2000 RPM when using a 2500 PPR encoder.

    NOTE: *The polarity of the signal is either positive or negative based on direction.*

13. If the meter does not read 4.3 VDC or a different maximum speed is required, adjust the SR pot until the proper speed is reached. The SR test point will read 8.0 VDC at base speed. See Figure 4-3.

    If a **faster maximum speed** is required:

    - Turn the SR pot CW until the proper maximum speed is reached. If the controller IETs and the OS LED illuminates, the overspeed trip point has been exceeded.
    - Turn the OS pot 1/8 turn CW.
    - Push the Reset pushbutton (4SW).
    - The POWER ON, the RDY, and the ZS LEDs should illuminate.
    - Repeat this Step until the desired speed is reached.

    If a **slower maximum speed** is required:

    - Turn the SR pot CCW until the proper maximum speed is reached.
    - Turn the OS pot CCW until the controller IETs and the OS LED illuminates.
    - Turn the OS pot 1/8 turn CW.
    - Remove the Speed reference input.
    - Push the Reset pushbutton (4SW).

CAUTION: The continuous operation of the motor in torsional resonance (high frequency range ~ 400 Hz to 1400 Hz) or other system related resonances/vibrations (lower frequency range of less than 150 Hz) will result in damage to, or destruction of, the motor, encoder, and/or the coupled equipment.

14. Run the controller at approximately 50% speed.
15. NOTE: *Torsional and system related resonances may occur at the same time. Torsional resonances will typically occur when connected to load inertias of greater than three times the motor rotor inertias and moderate speed loop gain (SG). Torsional resonance will be more apparent at minimum speed loop gain if inertias of loads are greater than five to eight times motor inertia. System related resonances are usually the result of too high of speed loop gain (SG) or Integral gain or system backlash.*

    If an audible high frequency motor noise or motor vibration is present, that was not when the motor was not coupled to the load, perform the following:

    - Turn the SG pot fully CCW.
    - Adjust the FRQ pot until the oscillation is minimized.
    - Readjust SZ per Step 8.

16. If the Ramp Generator (See Figure 3-3) is used:

    a) NOTE: *Ramp Generator works with differential inputs only. With the Speed reference at minimum, quickly increase to maximum speed. If acceleration time is too long, turn the ACC pot a quarter turn CW and accelerate the motor again. Repeat the motor acceleration process until the desired acceleration time is achieved. If a long time is required, turn switch 2SW-4 OFF and repeat this Step.*

    b) NOTE: *The shortest acceleration time is limited by the current limit circuit. When the ACC pot no longer has any effect, the acceleration rate is at its maximum for the application. If accel and decel ramps are not required for the application, put jumper 2J in position A. See Figure 7-11.*

    Increase the Speed reference to maximum and wait until the motor reaches top speed. Quickly reduce the Speed reference to minimum speed. If the deceleration time is too long, turn the DEC pot 10% CW and decelerate the motor again. Repeat the motor deceleration process until the desired deceleration time is achieved.

    c) NOTE: *The shortest deceleration time is limited by the D-C snubber resistor power, load inertia, and machine friction. When the DEC pot no longer has any effect or the controller trips, the deceleration rate is at its maximum for the application.*

17. Give the controller a Stop command.
18. Turn power OFF.
19. For high response applications, proceed to High Performance Tuning W/Load procedure; otherwise proceed to Step 20 if your application is working properly.
20. After verifying the D-C bus voltage is zero and the POWER LED is not illuminated, remove the voltmeters and any other instrumentation connected during startup.
21. Close and secure the controller enclosure door if applicable.

High Performance Tuning W/Load

1. Connect a function generator or manual switch to ±0.5 V supply to 2CN connector pin 3 and return to pin 4. An Exercise Module (M/N 3RE4) rather than a function generator may be used. Refer to Instruction Manual D5-3022 for operating procedures.

WARNING

THE FOLLOWING PROCEDURE REQUIRES THE MOTOR TO ROTATE IN BOTH THE FORWARD AND REVERSE DIRECTIONS. MAKE SURE MECHANICAL EQUIPMENT IS CAPABLE OF SUCH OPERATION. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

2. Connect the scope Channel A to 2CN connector pin 9 (ITR), Channel B to 2CN connector pin 8 (SFB), and scope common to 2CN connector pin 23.

3. Set the scope to trigger on the rising edge of Channel A.
4. Adjust the function generator output for approximately 1 hz and an amplitude that does not cause the current signal to reach current limit. (i.e. ITR signal current pulses do not have flattened peaks during reversal. See Figure 4-4.)
5. Observe the speed feedback signal with the scope. Compare the scope waveform with Figure 4-5. These forms represent response types usually encountered. To compensate the velocity loop:
   - Give the controller a Stop command and remove power.
   - Increase the speed loop integral time on switches 2SW-2 and 2SW-3.
   - Reapply power and give the controller a Start command.
   - Continue to increase integral time and adjust SG (Speed Gain) pot until a waveform similar to "C" is observed.
6. If ringing in the transition regions and/or motor noise occur, perform the following:
   - Turn the SG pot CCW until the oscillation stops.
   - Adjust the FRQ pot until the oscillation is minimized.
   - Adjust QF pot as far CW as possible while still being able to eliminate the oscillation with the FRQ pot.

   NOTE: *Adjustment of FRQ and QF pots is effective on shaft torsional resonant frequency when coupled to high inertia loads.*
   - Place a digital voltmeter (20 VDC scale) on 2CN connector pins 8(+) and 23 (COM).

     NOTE: *This analog D-C signal (SFB) is proportional to speed.*
   - Adjust the SZ pot until the voltmeter reads zero. The ZS LED should illuminate.
7. Give the controller a Stop command.
8. Turn power OFF.
9. Perform custom tuning if desired. If custom tuning is desired, pins (100C and 18R) are provided on the Regulator Board (see Figure 7-11) for tuning the Speed Regulator outside of the gains that can be obtained by using the SG potentiometer, 2SW-2 and 2SW-3.
   a. Adding Capacitor 100C reduces both the lead frequency and the low frequency gain (decreases integral gain).
   b. Reducing 18R (33.2 K ohm) increases lead frequency and reduces high frequency gain.
10. Remove the function generator input. Reconnect the Speed reference.
11. After verifying the D-C bus voltage is zero and the POWER LED is not illuminated, remove the voltmeters and any other instrumentation connected during startup.
12. Close and secure the controller enclosure door, if applicable.

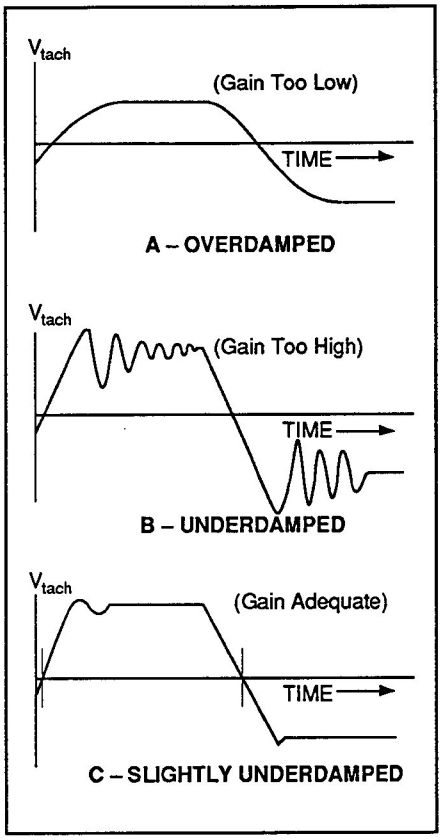


Figure 4-5. Speed Feedback Signals with Small Step Response.

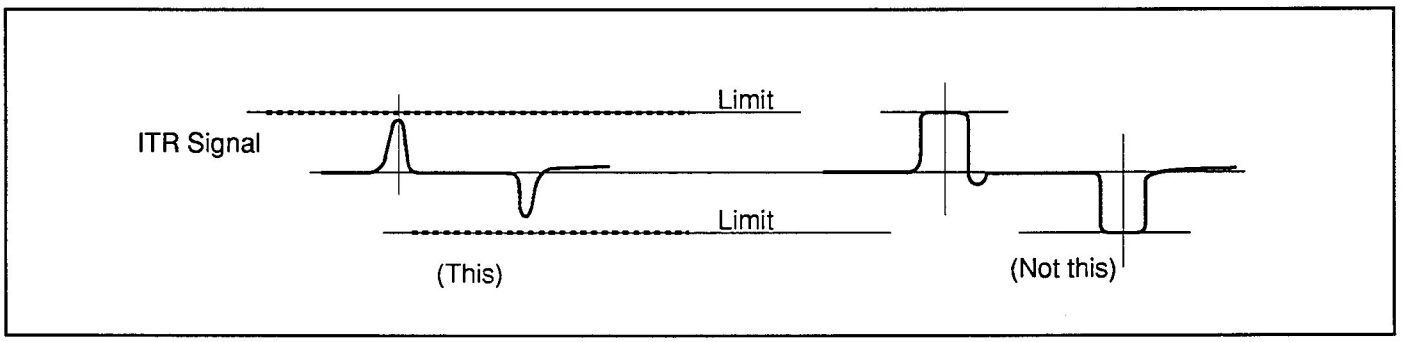


Figure 4-4. ITR Signal.

Perform Startup in Torque Regulator Mode

WARNING
THIS DRIVE CAN OPERATE AT ZERO SPEED. IF THE APPLICATION REQUIRES ZERO SPEED OPERATION WITHOUT DISCONNECTION FROM THE POWER SOURCE, THE USER IS RESPONSIBLE FOR ASSURING SAFE CONDITIONS FOR OPERATING PERSONNEL BY PROVIDING SUITABLE GUARDS, AUDIBLE OR VISUAL ALARMS, OR OTHER DEVICES. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

WARNING
IMPROPER CONNECTION OR CALIBRATION OF CONTROLLER MAY CAUSE THE DRIVE TO OVERSPEED. AT THE INITIAL STARTUP, BE PREPARED TO STOP THE DRIVE IMMEDIATELY IF UNCONTROLLED ACCELERATION SHOULD OCCUR. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

1. Make sure all power is OFF. The POWER LED should not be illuminated.
2. Couple the motor to the machine or load.
3. Remove the Speed reference circuit and wire any necessary inputs or outputs to the controller for proper machine operation in the Torque Regulator mode.
4. With power OFF, set the regulator switches as shown in Figure 4-6.
5. Connect the positive lead of a scope or voltmeter (20 VDC scale) to the SR test pin and connect the common lead to the 0 V pin.
6. Turn power ON and set the torque reference at maximum voltage. The controller's current limit function is not functional in torque mode. Torque reference must be limited externally. DO NOT START THE CONTROLLER.
7. Adjust the SR pot for the maximum current (torque) required at the SR test pin. (8 volts = 200% controller's rated current).
8. Connect the positive lead of a Digital Voltmeter to the OS test pin and the common lead to the 0 V pin.
9. Turn the OS pot slowly CW until the trip point is slightly greater than the maximum Application Motor Speed. Use Figure 4-2D to determine the equivalent voltage reading of the overspeed trip point.
10. With Torque reference at minimum, turn power ON.
11. Give the controller a Start command.
12. Slowly increase Torque reference until the motor starts to rotate.
13. If motor shaft rotation is incorrect:
    - Give the controller a Stop command. Wait until the motor has completely stopped.
    - Turn power OFF.
    - After verifying D-C bus voltage is zero and the POWER LED is not illuminated, change the position of switch 2SW-6 on the hinged panel.
    - Turn power ON.
    - Give the controller a Start command.
14. Give the controller a Stop command.
15. Turn power OFF.
16. After verifying the D-C bus voltage is zero and the POWER LED is not illuminated, remove the voltmeters and any other instrumentation connected during startup.
17. Close and secure the controller enclosure door, if applicable.

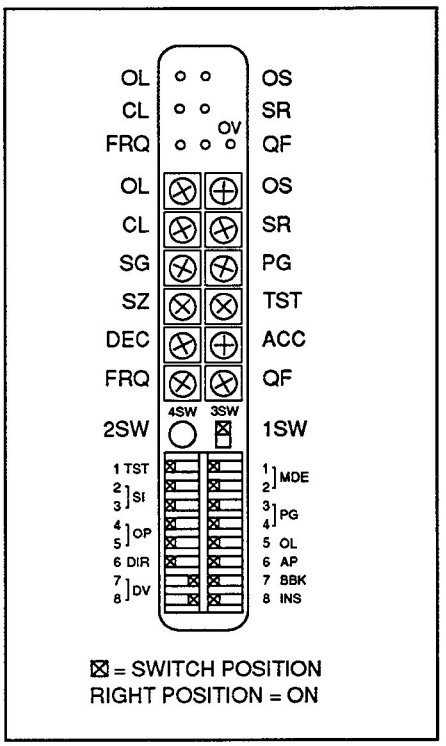


Figure 4-6. Controller Switch Settings for Torque Mode.

Perform Startup in Position Regulator Mode

WARNING
THIS DRIVE CAN OPERATE AT ZERO SPEED. IF THE APPLICATION REQUIRES ZERO SPEED OPERATION WITHOUT DISCONNECTION FROM THE POWER SOURCE, THE USER IS RESPONSIBLE FOR ASSURING SAFE CONDITIONS FOR OPERATING PERSONNEL BY PROVIDING SUITABLE GUARDS, AUDIBLE OR VISUAL ALARMS, OR OTHER DEVICES. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

1. Make sure all power is OFF. The POWER LED should not be illuminated.
2. Perform "Start-Up in Speed Regulator Mode" steps #4 thru 26, and tune for high response application.
3. Remove the Speed reference circuit and wire any necessary inputs or outputs to the controller for proper machine operation in the Position Regulator mode.
4. With power OFF, set 1SW-1 ON and 1SW-2 OFF. Select 2SW-5 for your application.

   ON: Dual channel signal input
   OFF: Single channel signal input
5. Wire the reference, a serial pulse, to 2CN connector pins 49 and 50 according to Table 3-2.
6. If remote forward and reverse is desired, wire 2CN connector pins 47 and 48 according to Table 3-2.
7. Turn power ON.
8. Connect the positive lead of a digital voltmeter to the OS test pin and the common lead to the 0V pin.
9. Turn the OS pot slowly CW until the trip point is slightly greater than the maximum application motor speed. Use Figure 4-2D to determine the equivalent voltage reading of the overspeed trip point.
10. Start the controller.
11. With no input pulse reference, verify that the motor is not rotating and that no IETs exist.
12. Add a pulse reference at a low frequency. Note the motor's rotation. If motor shaft rotation is incorrect:
    - Give the controller a Stop command.
    - Turn power OFF.
    - After verifying D-C bus voltage is zero and the POWER LED is not illuminated, change the position of switch 2SW-6 on the hinged panel.
    - Turn power ON.
    - Give the controller a Start command.
13. Give the controller a Stop command.
14. Determine the Maximum Pulse Frequency required for the application, using the following formula:

$$\text{Max Pulse Freq (Hz)} = \text{Encoder (PPR)} \times \frac{\text{Max Motor Speed (RPM)}}{60}$$

Example: If a 2000 RPM base speed motor with a 2500 PPR encoder is to operate at base speed,

$$\text{Max Pulse Freq (Hz)} = 2500 \text{ (PPR)} \times \frac{2000 \text{ (RPM)}}{60}$$

$$= 83.3\text{K hz}$$

83.3K hz input corresponds to 2000 RPM on this motor/encoder combination.

15. Give the controller a Start command.
16. With the reference pulse frequency at 0 hz, increase the reference to maximum. The motor will accelerate to the maximum speed. Note that, if the reference frequency is changed too quickly, the controller will IET and the POS LED will illuminate. If the acceleration time is too long, turn the PG pot 1/8 turn CW and accelerate the motor again. Repeat the motor acceleration process until the desired time is achieved.

    NOTE: *The shortest acceleration time is limited by current limit. When the PG pot no longer has any effect, the acceleration rate is at its maximum for the application.*
17. Give the controller a Stop command.
18. Turn power OFF.
19. After verifying the D-C bus voltage is zero and the POWER LED is not illuminated, remove the voltmeters and any other instrumentation connected during startup.
20. Close and secure the controller enclosure door, if applicable.

    NOTE: *In position control, while the motor is rotating, a position error exists depending on its speed and position loop gain. In the event where the rotation is 2000 RPM, number of PG pulses is 2500 PPR, and the position loop gain is the minimum, the position error will be about 2.7 revolution.*

5: Understand How the Controller Operates

Fundamentals of the HR2000 Controller and the Motor

The drive system consists of an electronic controller and a permanent magnet A-C motor. The controller consists of two major sections: a power section and a regulator section. The motor consists of a three-phase wound stator, a permanent magnet rotor, and a shaft-mounted optical encoder. Refer to the functional block diagram in Figure 7-10.

Input power is applied to terminals 181(R), 182(S), and 183(T) on the controller faceplate. From these terminals, power branches to a control transformer that supplies the low voltage power required for the regulator and a cooling fan, when used. Input power also feeds the diode bridge. Input diodes convert three-phase A-C power to nominal 310-volt D-C power. A Hall transductor monitors this D-C power for high D-C bus output currents. The regulator in the IET circuit monitors the Hall transductor, which, when large output currents are sensed, will remove power from the motor by removing base voltage to the output transistors.

After bus filter capacitor voltage reaches a predetermined level, the precharge relay bypasses or shunts the precharge resistor ensuring a soft start on power up. The D-C bus then feeds a bridge of six output transistors that power the motor by their sine wave PWM output. The Hall transductor, having outputs monitored by the regulator for sine wave current control and for current limit of the controller output, also monitors two of the three output phases.

The run, reset, proportional/proportional plus integral loop, and shaft clamp inputs are all optically isolated. These inputs are fed into the microprocessor for monitoring of their functions.

The notch filter frequency bandwidth, inverse time overload, overspeed trip, and the position gain pots are fed into the microprocessor for setting and monitoring. Analog reference inputs are directed into the regulator speed and torque loops. The controller also has three optically isolated outputs that indicate ready to run, position error, and minimum speed.

The controller has three (3) user reference inputs: a differential input that feeds an RAMP, and two (2) single ended inputs. The RAMP circuit may be disabled/enabled by using jumper 2J. The output of the RAMP circuit feeds a summing amplifier, which is also fed by a Test mode reference. The tester pot is enabled when a dip switch, accessed through the hinged panel faceplate, is switched ON.

The output of this operational amplifier is fed into an electronic switch. The switch is fed by three optically isolated inputs to restrict torque produced in either forward, reverse, or both forward and reverse motor rotation directions. The output of this switch feeds the speed loop amplifier. The speed loop sums these signals along with the speed feedback signal. A notch filter is provided in the feedback loop to eliminate torsional resonances due to large loads and motor inertia mismatches. The notch filter circuit may be disabled/enabled by using jumper 1J.

The speed loop contains two capacitors that may be switched into the circuit through two dip switches on the controller faceplate. The output of the speed loop feeds the current regulator. The torque regulator switch simply bypasses the speed loop such that the output of the summing junction for reference signals feeds directly into the current regulator.

The microprocessor uses the motor encoder to determine rotor position. This information is used to convert the quadrature current/torque reference (ITR) to two motor line current references. Two motor line current feedbacks are then subtracted from the two motor line current references to produce two line current errors. The third line current error is the sum of the first two. The motor line current errors are then fed to three independent motor line current regulators. The outputs of the motor line current regulators are then fed into the base drivers that control the output transistors.

If Position mode regulation is selected (See Figure 5-1), the input reference must be a pulse signal. This pulse signal feeds directly into the microprocessor. This control method allows the microprocessor to act as an up/down counter. The reference pulses are up-counts, and the encoder feedback pulses subtract from the up-counts so that the encoder moves only as many pulses that have been given as a reference.

If a continuous pulse input is received by the controller, a constant speed will be maintained on the motor. Pulse count error is multiplied by the position regulator gain and converted to an analog speed reference. The analog speed reference (test point DA) is then fed to the speed loop amplifier. The speed loop used in the speed mode becomes a speed minor loop in the position mode. Refer to D5-3025 for the setup and operation of the Operator's Terminal.

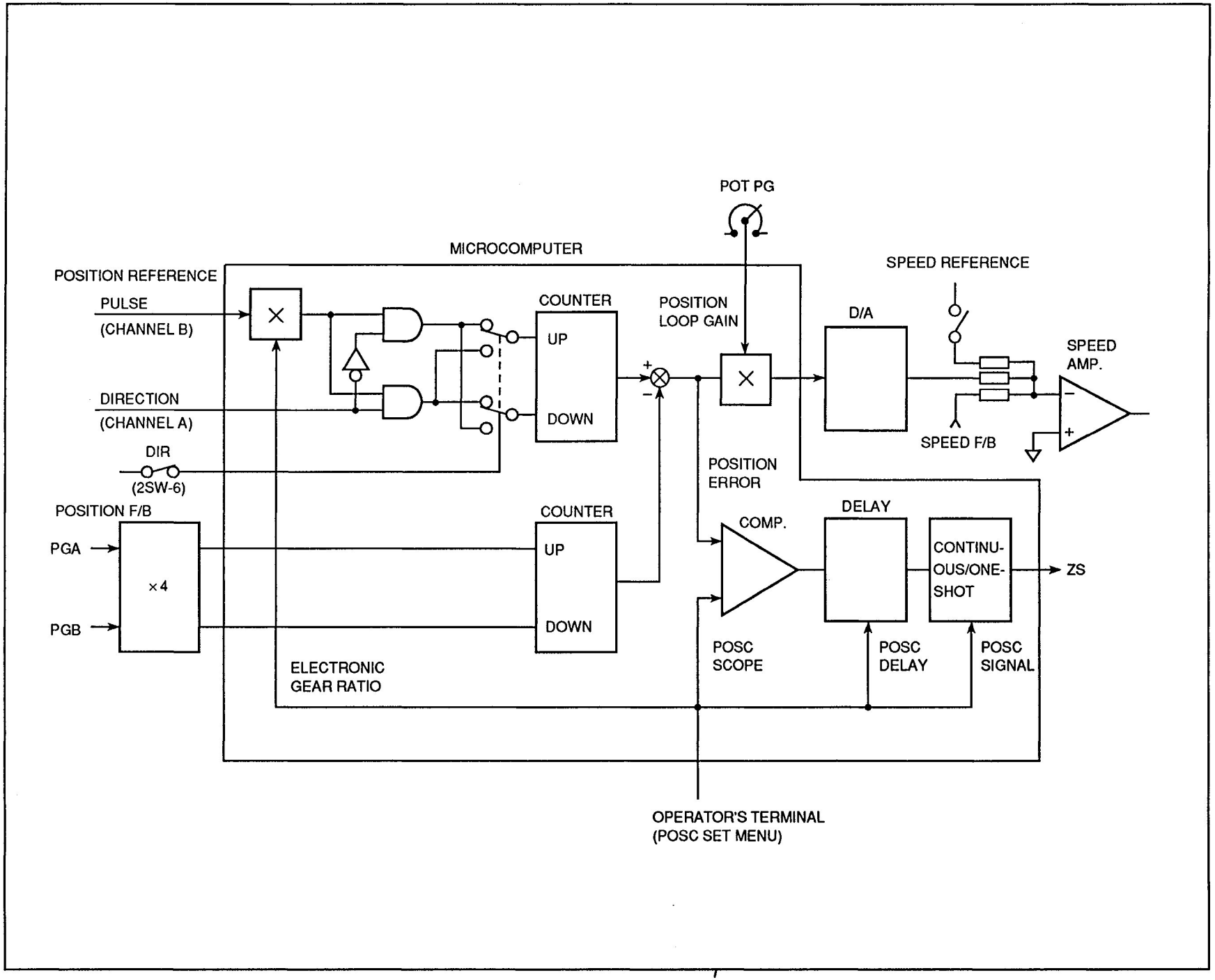


Figure 5-1. Position Mode Block Diagram.

Timing Flow of Input/Output Signal

In the amplifier, sequence signals are handled according to the following timing.

1. When power source is supplied to the converter, D-C Bus voltage to the amplifier is established in approximately 1.2 seconds.
2. If the amplifier is normal, the contact signal FAULT (FR1, FR2) will close.
3. Approximately 50 msec after the RUN signal becomes ON, motor-control is started.
4. When protection circuit is activated, motor control is stopped immediately, and the contact signal FAULT (FR1, FR2) will open.
5. The condition of Item 4 is maintained until the RESET signal is turned ON or power is re-applied. The RESET signal is effective only when it becomes first ON and then OFF.

   If the condition is normal, the contact signal FAULT (FR1, FR2) will be closed immediately after RESET is cycled and the motor control will be restarted after approximately 50 msec.
6. When converter power supply is cut off during motor control, the RUN command and the FAULT contact will change state causing the motor to stop and D-C power will be discharged.

Fundamentals of Controller's Operator Controls

Start/Stop Control

With power ON, closing a contact or maintained pushbutton places the controller in the Run mode. Opening the contact or pushbutton causes the motor to decelerate to a stop. Since a seal-in circuit is not present, maintained switches or contacts must be used.

Speed Setting Control

The speed of the motor can be controlled by either a pot or a serial pulse signal. A pot is used when the regulator is set for Speed mode. A pulse signal is used when the regulator is set for Position mode.

If a differential input signal is given, a ramp circuit may effect the reference. Single-ended reference signals are not effected by the ramp circuit.

Forward/Reverse Control

The direction of motor rotation is determined by the reference polarity when the regulator is set for Speed or Torque modes.

When the controller is in Position mode, motor rotation is determined by the logic level state of an optically isolated input.

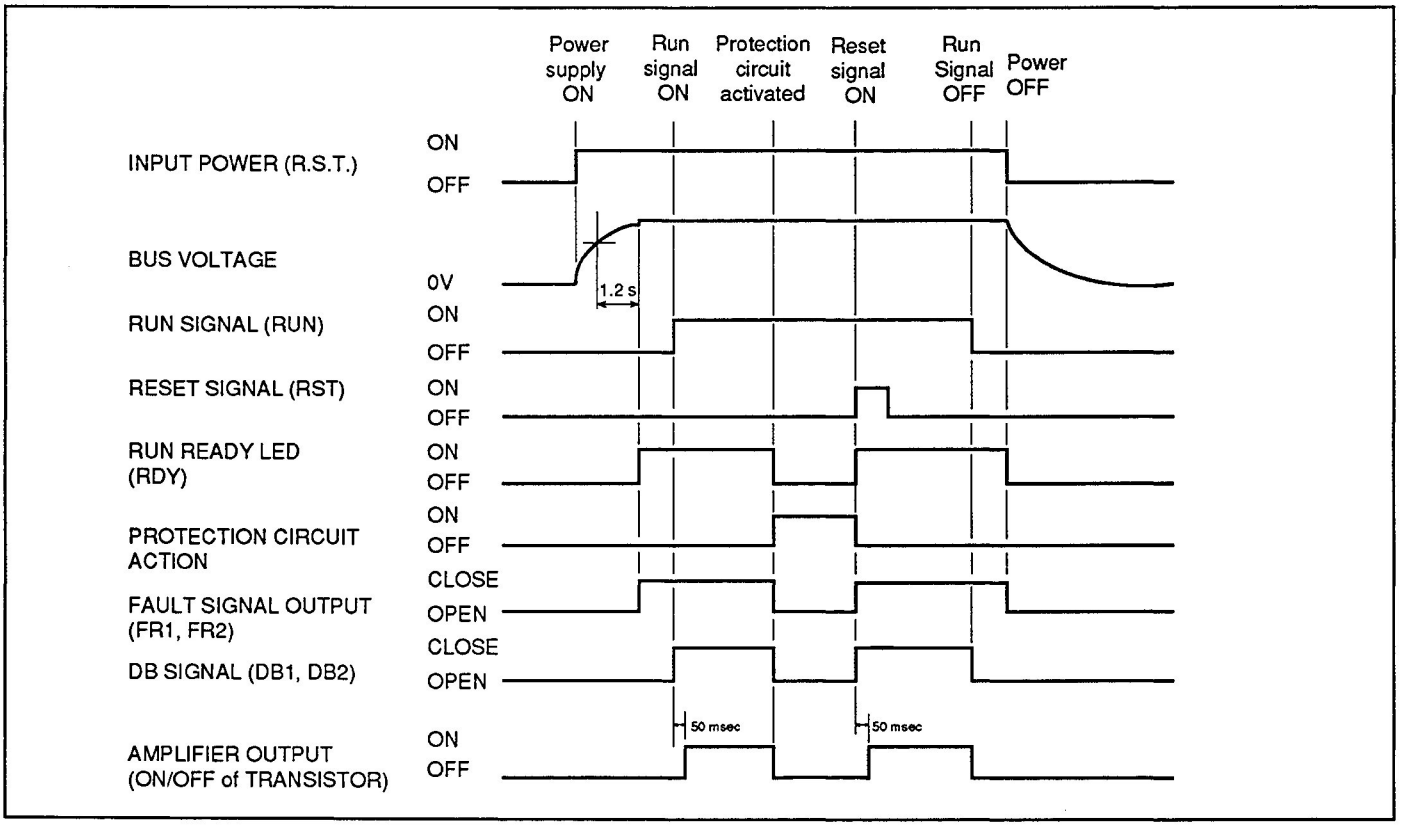


Figure 5-2. Input/Output Signal Timing.

6: Service the Motor

DANGER

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE, AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

DANGER

EXERCISE EXTREME CARE BECAUSE HAZARDOUS VOLTAGE EXISTS. DISCONNECT AND LOCKOUT OR TAG POWER BEFORE TOUCHING ANY INTERNAL PART. FAILURE TO OBSERVE THIS PRECAUTION COULD CAUSE SEVERE BODILY INJURY OR LOSS OF LIFE.

Establish Regular Motor Maintenance Program

A fundamental principle of electrical maintenance is keeping the apparatus clean and dry. This requires periodic inspection of the motor, the frequency depending on the type of motor and the service.

Check the following at regular intervals:

1. Make sure the exterior is kept dry and free of dust, grease, oil, and dirt. Because HR2000 motors are enclosed, they require little attention.
2. Make sure terminal connections, assembly screws, bolts, and nuts are tight.
3. Make sure the motor is securely bolted to minimize vibration.
4. With all motor wiring disconnected from the controller, periodically check insulation resistance of motors in service at approximately the same temperature and humidity conditions to determine possible deterioration of the insulation. When these measurements indicate a wide variation, determine the cause.

CAUTION: Disconnect all conductors between the motor and controller. Insulation resistance measurements will subject the controller to destructive voltages. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

5. Recondition the motor if it has been subjected to excessive moisture; rewind or reinsulate as necessary.

Ball Bearing Lubrication

The ball bearings are deep grooved, double-shielded bearings with sufficient lubricant packed into the bearings by the manufacturer for "life lubrication." No grease fittings are provided because the initial lubrication is adequate for operation under normal conditions.

Troubleshoot the Motor

Perform Initial Motor Checks

Make the following checks if trouble develops when operating the motor:

1. Check that the bearings are in normal condition.
2. Make sure there is no mechanical misadjustment or binding to prevent free rotation of moving motor parts.
3. Make sure all bolts and nuts are properly tightened.
4. Make sure that motor installation instructions have been carefully carried out.
5. Make sure the motor is properly wired to the controller (Figure 3-12).
6. Check that low voltage devices in control equipment or other protective devices are in proper working order.
7. Check that no excessive overload exists on the motor.

CAUTION: Motor must be serviced at UL approved service shop. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

Disassemble the Motor

NOTE: *Reliance Electric cannot be held responsible for expense incurred in any repairs performed by other than Reliance Engineers or Authorized Service Stations unless authorization has been granted by Reliance Field Representatives or the factory at Cleveland, Ohio.*

NOTE: *Reassembly of the motor requires re-alignment of the encoder in its housing. Encoder alignment is critical for successful drive operation. Re-alignment can only be done with the use of the Encoder Tester Kit (M/N 3RE5) available from Reliance. See Table 7-5.*

DANGER

INTERNAL PARTS OF THIS MOTOR MAY BE AT LINE VOLTAGE EVEN WHEN THE MOTOR IS NOT ROTATING. BEFORE CONTACTING ANY INTERNAL PART, DISCONNECT ALL A-C LINE INPUT CONNECTIONS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. **Make sure the disassembly location is free of metallic particles.**
   The motor contains permanent magnets. Metallic particles will accumulate in the air gap between the rotor and stator preventing successful operation of the motor.

WARNING

THE MOTOR CONTAINS VERY STRONG PERMANENT MAGNETS. EXERCISE CARE WHEN REMOVING THE ROTATING ASSEMBLY. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

2. Exercise care to not damage the stator windings during disassembly. Insulation can be damaged by improper or rough handling.
3. Exercise care to keep bearings clean.
4. Disconnect the motor from the controller. Tag the leads to insure proper reconnection.
5. Remove the motor from its mounting base.

Remove End Shields

6. Remove the outer encoder housing and loosen the set screws on the stub shaft.
7. Remove the inner encoder housing and the encoder from the motor bracket.
8. Mark each end shield relative to its position on the frame so it can be easily replaced.
9. Remove any bearing clamp screws.
10. Remove the end shield through-bolts.
11. Pull the end shields.

Remove and Replace Ball Bearings

12. Thoroughly clean and repack the bearing bore and cavity with approximately 1/2 teaspoon (1.5 ml) of recommended grease (Chevron SRI #2 or equivalent).
13. Remove the drive end bearing with bearing pullers using a center insert in the end of the shaft to protect the shaft center. Remove the front end bearing by slipping a sleeve over the stub shaft (There is no center drill.) and pressing the bearing off the shaft.

Reassemble the Motor

1. Re-install bearings by preheating and pressing the bearings on the shaft with a bench press applying pressure to the inner race. Use a square-faced sleeve or piece of pipe that fits over the shaft to avoid damaging the bearing.
2. Re-align the encoder in its housing. The Encoder Tester Kit (M/N 3RE5) is required. Follow the alignment procedures in the kit D5-3023 Instruction Manual.

CAUTION: Encoder signals PU, PV, and PW must be aligned according to the Encoder Tester Kit D5-3023 Instruction Manual for successful drive operation. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

3. Reverse the procedure given in "Disassemble the Motor."

7: Service the Controller

DANGER

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE, AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

Know Function of Service Aids

Understand Controller LED Indicators

The LED indicators can be viewed through the window on the face of the controller hinged panel.

Red Fault LEDs

The controller has 12 red LEDs that indicate drive status or a fault condition. Ten of these LEDs will illuminate when its respective fault condition occurs, initiating an appropriate and orderly drive shutdown. The other two red LEDs (B.BK and ZS) indicate a status condition. The controller will not operate when the B.BK LED is illuminated though will operate with the ZS LED illuminated.

The normal status of these 12 LEDs is OFF. After a fault occurs, the controller cannot be restarted until the fault is cleared and the controller is reset. The controller can be reset by pushing the Reset button (4SW) on the hinged panel faceplate or a remote Reset pushbutton available through connector 2CN. Refer to Table 7-1 for a summary of these faults.

Green LEDs

RDY Indicates that proper rated power is present on the input terminals and that the D-C precharge is complete. The controller is ready to accept a Start command.

RUN Indicates the controller is operating without any faults present.

Table 7-1. Red LED Functions and Possible Causes for Fault.

Symbol	Indicated	Possible Causes
B.BK	Base Driver Blocked (DISABLED)	• Dip switch 1SW-7 turned ON, preventing output transistors from turning ON. Use only when troubleshooting controller.
COM	Communication Error	• Noise present when using optional RS232 connector.
CPU	Microprocessor Fault	• Regulator component failure. • Sequencing or encoder miswired, or switching of 1SW-1, 2 (MDE), or 2SW-6 (DIR) during operation. • Low voltage on regulator power supply. • Encoder miswired if SFB LED also illuminated. • Incorrect switch setting on 1SW-3 and 1SW-4 if COM LED also illuminated. • Loose encoder cable.
SFB	Speed Feedback	• Encoder in resonance. • Motor rotational speed exceeded value selected by OS pot. • Motor-mounted encoder failure. • Encoder miswired if CPU LED also illuminated.
OL	Inverse Time Overload	• Output motor current exceeded allowable overload as adjusted by OL pot. • Motor's RMS load greater than continuous motor rating.
UV	Undervoltage	• D-C snubber transistor shorted. • Input voltage less than 207 V when 230 V input selected. • Input voltage less than 188 V when 208 V input selected.
PL	Phase Loss	• Input power dip. • Motor lead or motor ground present.
ZS	Speed/Torque Mode	• Driving at a speed less than the value determined by the PG pot.
	Position Mode	• Positioning complete.
POS	Error Register Overflow in Position Mode	• Accel/Decel rate too short for load.
OH	Overtemperature	• Ambient temperature of controller exceeds 55°C. • Cooling fan failure (2-4 HP only). • Regenerative power required for application greater than internal D-C snubber resistor capability. • Frequency (times) of brakes from the rated speed allowed in a state that the motor vs load inertia ratio is "1:4": 1 ~ 2 HP 6 times/min 3 ~ 4 HP 8 times/min
OV	Overvoltage	• Input voltage greater than 255 VAC. • External D-C snubber resistance is too large.
OC	Overcurrent	• Short in power devices (motor, output transistor, or D-C bus components). • Line transient.

Understand Controller Status Indicators

Fault Contact

This contact indicates that a fault has occurred as described in Table 7-1. A dry fault contact is connected at terminals FR1 and FR2 on the terminal board on the faceplate of the controller. This contact is open when no input power is present or when a fault condition is present; it is closed under normal running conditions. This contact has the following ratings:

- D-C: A maximum voltage of 30 VDC or a maximum current of 1 amp resistive.
- A-C: 250 VA maximum with a maximum voltage of 250 VAC or a maximum current of 1 amp resistive.

Solid State Outputs

Three optically isolated solid state outputs are located on connector 2CN. Each output is rated at 24 VDC with 20 mA maximum sourcing capability. Use twisted pair wire to monitor these outputs.

- Ready (RDY): Indicates the controller has proper power applied to the input terminals and no fault conditions exist. This output is available between connector 2CN pin 42 (RDY) and any unused pin from 26-32 (0VI).
- Position Counter Overflow (POS): Indicates that the pulse buffer, used to accept reference in the Position mode, has overflowed. This output is available between connector 2CN pin 43 (POS) and any unused pin from 26-32 (0VI).
- Zero Speed (ZS): This output is available between connector 2CN pin 44 (ZS) and any unused pin from 26-32 (0VI). The indication of this output depends on the mode selected:

  SPEED/TORQUE: Indicates that the drive is operating at a speed less than the value determined by the PG pot.

  POSITION: Indicates Positioning complete.

Understand Controller Test Points

1. The controller has 6 test points and a common on the regulator that are accessible through the hinged panel faceplate.
2. A scope or digital voltmeter connected to a test point will monitor the signal that can be adjusted by the respective controller pot.
3. Fine tune the signal by slowly turning the pot until the waveform is as desired.
4. Refer to "Review the Regulator Pots" in Chapter 4 for a summary of these pots along with the waveform typical for the factory setting of the pot.

Gather Necessary Test Equipment

CAUTION: Do not use a megger to perform continuity checks in the drive equipment. Failure to observe this precaution could result in damage to, or destruction of, the equipment.

The following equipment or their equivalent are recommended:

- A two-channel oscilloscope with 10 to 1 probes.
- A digital volt-ohmmeter with a 10 megohm input impedance on all ranges, such as a Fluke 8022B.
- Either an optional Exercise Module (M/N 3RE4) or a function generator with ±9 V peak, 1 to 3 hz square wave output or manually operated switch with ungrounded ±9 V supply.

Perform General Troubleshooting Procedure

1. Before removing power to the controller, check to see if any red LED is illuminated, indicating that an IET has occurred. (Removing power to the controller will lose the status of the LED.) If any LED is illuminated, refer to Table 7-1 for possible causes of the IET.

DANGER

THE REMAINING STEPS ARE MADE WITH POWER ON. EXERCISE EXTREME CARE BECAUSE HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

   - Clear the fault.
   - Reset the controller by pressing the Reset button located above the 2SW switches on the face of the controller hinged panel.
   - Give the controller a Start command.
   - If the controller does not restart, proceed with this procedure.

2. Turn power OFF.

DANGER

THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. WHENEVER POWER IS REMOVED, VERIFY WITH A VOLTMETER AT FACEPLATE TERMINAL 147(+) AND REGULATOR BOARD TERMINAL B1(-) THAT THE D-C BUS CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY INTERNAL PARTS OF THE CONTROLLER. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

3. With power OFF, make a complete physical inspection of all control and motor wiring for correct and tight connections. Be sure that connectors on the controller are correctly positioned and tight.
4. Unscrew control fuse 4FU on the faceplate of the controller. If the fuse is blown, replace with Reliance part number 64676-23K; Bussmann Type MDQ, 3/10 A, 250 V; or equivalent.
5. Verify that the input power voltage corresponds with the voltage selected within the controller (factory set for 230 VAC) and is in the ± tolerance range. If not, reconnect the RED lead connection and/or add a transformer between the plant power supply and the controller.
6. Make sure the controller ground terminals on the faceplate and the motor frame are connected to earth ground.
7. Check for and correct poor wiring conditions:
   - Input and output leads routed through the same conduit.
   - Input or output leads running parallel or in the same conduit with control signal wiring.
   - Control signal wire that is not twisted or shielded.
8. Make sure that all nearby relays, solenoids, or brake coils are suppressed.
9. Check that the ambient temperature does not exceed 0°C to 55°C (32°F to 131°F) for chassis controllers or 0°C to 40°C (32°F to 104°F) for enclosed controllers.
10. Check that all pots, dip switches, and jumpers are in the correct position for the application.
11. Check that external sequencing logic is wired properly to the controller through connector 2CN.
12. If satisfactory operation still cannot be obtained, proceed to the "Identify Fault Symptom and Correct Using Flow Charts."

Identify Fault Symptom and Correct Using Flow Charts

1. Determine the operating condition under which the fault occurred.
2. Identify the fault symptom from the following list:

   Figure 7-1. Motor will not run, which includes the following symptoms:
   - Controller will not start.
   - Control fuse 4FU is blown.
   - IET trip occurs when the controller is started.

   Figure 7-2. Motor runs at uncontrolled speed, which includes the following symptoms:
   - Controller starts but motor stays at low speed.
   - Controller IET occurs during acceleration.

   Figure 7-3. Motor rotation is unstable.

   Figure 7-4. Acceleration/Deceleration is not smooth.

   Figure 7-5. Heavy vibration results when motor stops.
3. Turn to the flow chart figure number listed in front of the selected symptom.
4. Proceed through the selected flow chart.
5. Proceed through the "Check the Power Unit" in this chapter.
6. Refer to the wiring diagram (Figure 7-9) as necessary.
7. Output speed and load can be monitored on the 2CN connector (See Figure 3-5.) as indicated below:

   SPEED: 0 to +4.3 V output with 4.3 V output when the 2000 RPM, 2500 PPR motor is operating at base speed.

   LOAD: 0 to +8.0 V output where 8 V is 200% of the controller rating.
8. Refer to Table 7-4 for replacement parts data.
9. If satisfactory operation cannot be obtained, contact your Reliance Electric Sales Office for service coordination.

"SAVE THESE INSTRUCTIONS"

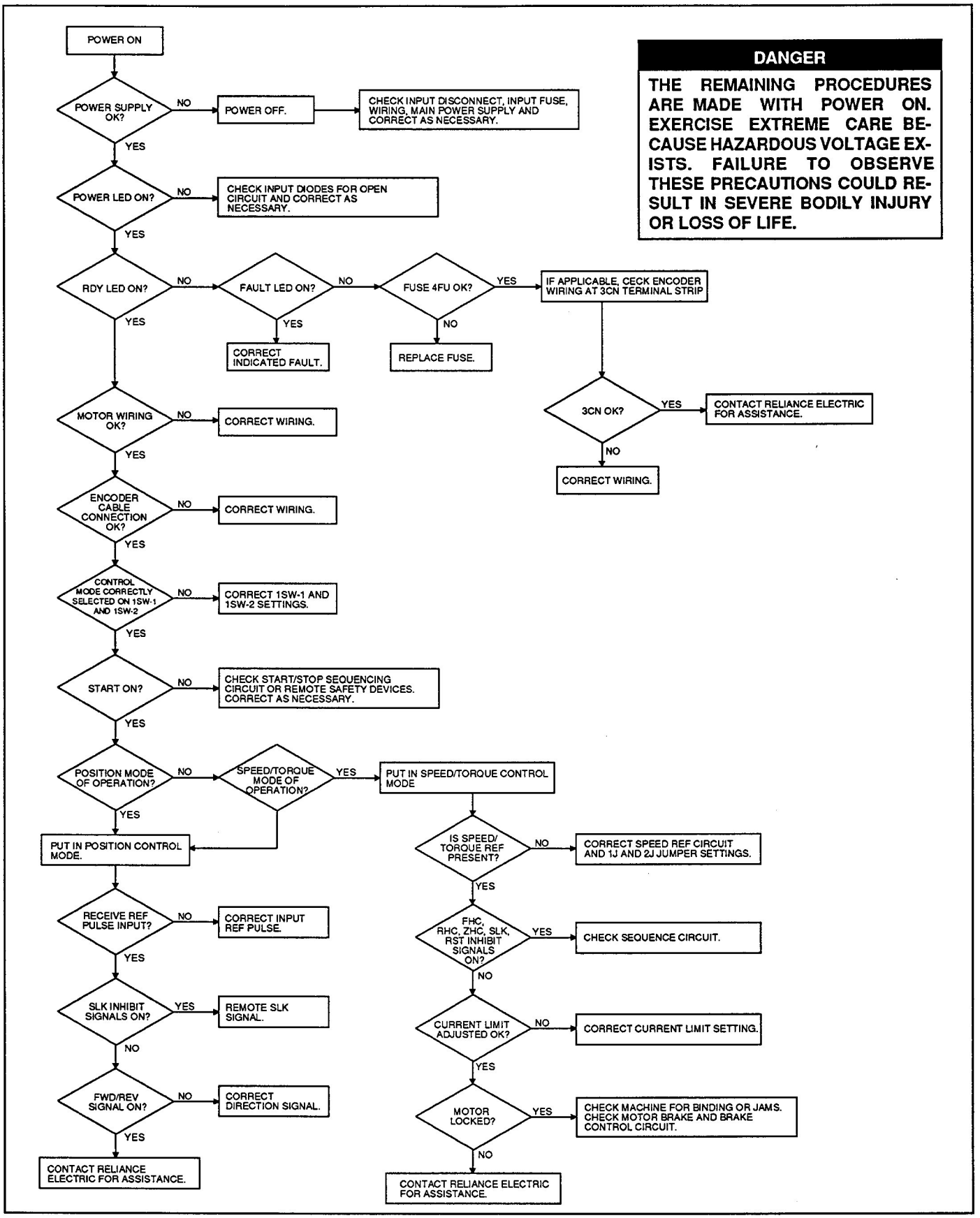


Figure 7-1. Motor Will Not Run.

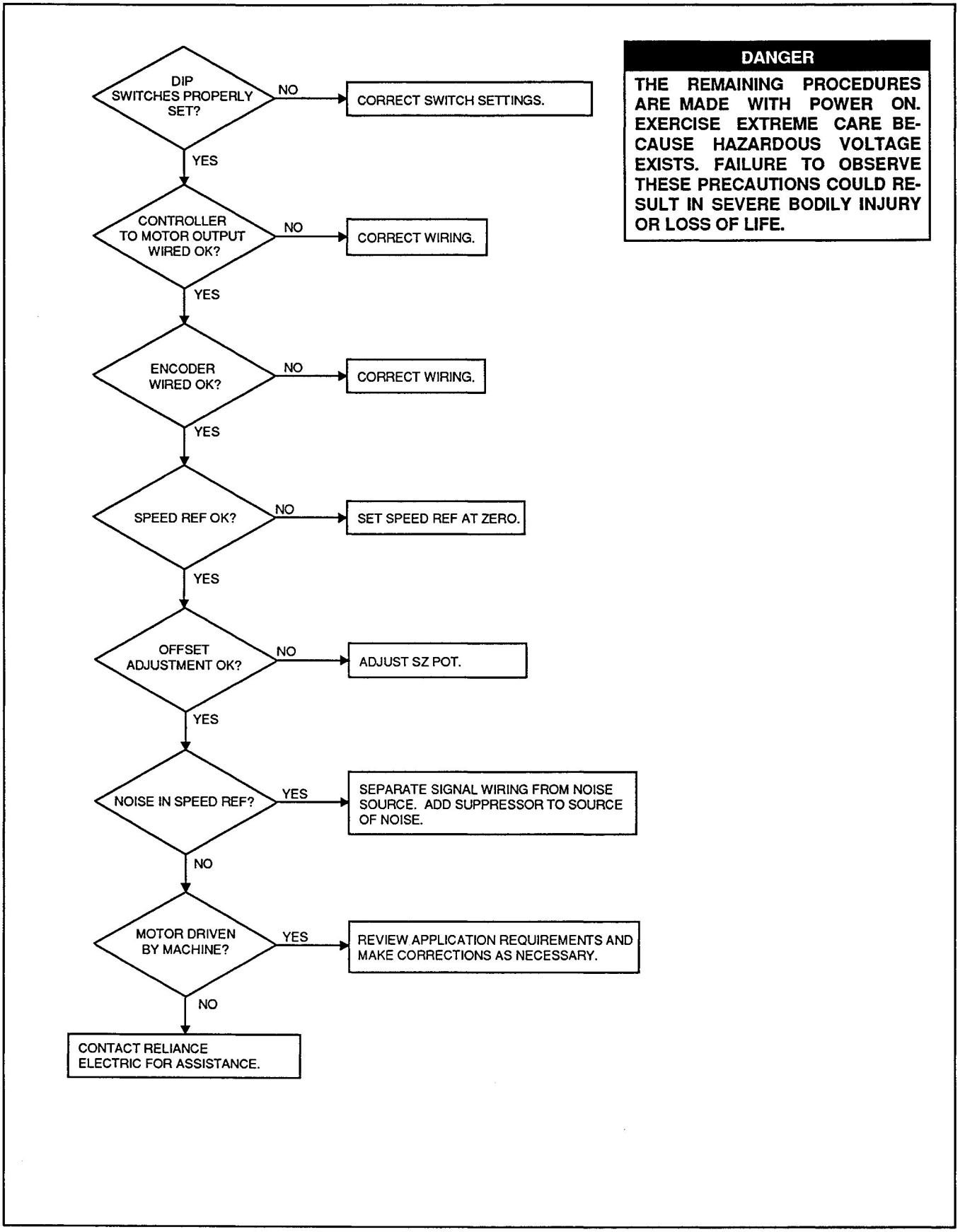


Figure 7-2. Motor Runs at Uncontrolled Speed.

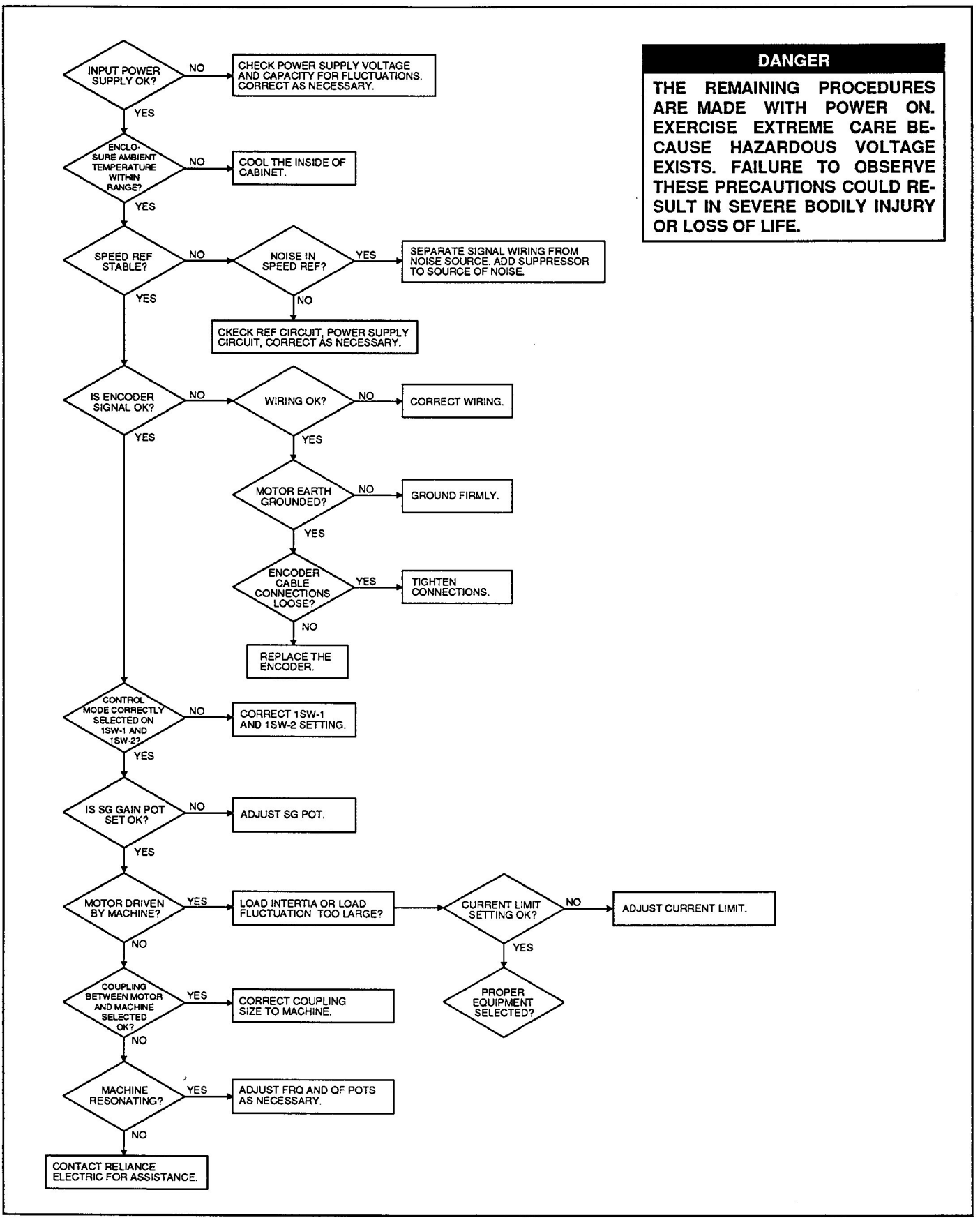


Figure 7-3. Motor Rotation Is Unstable.

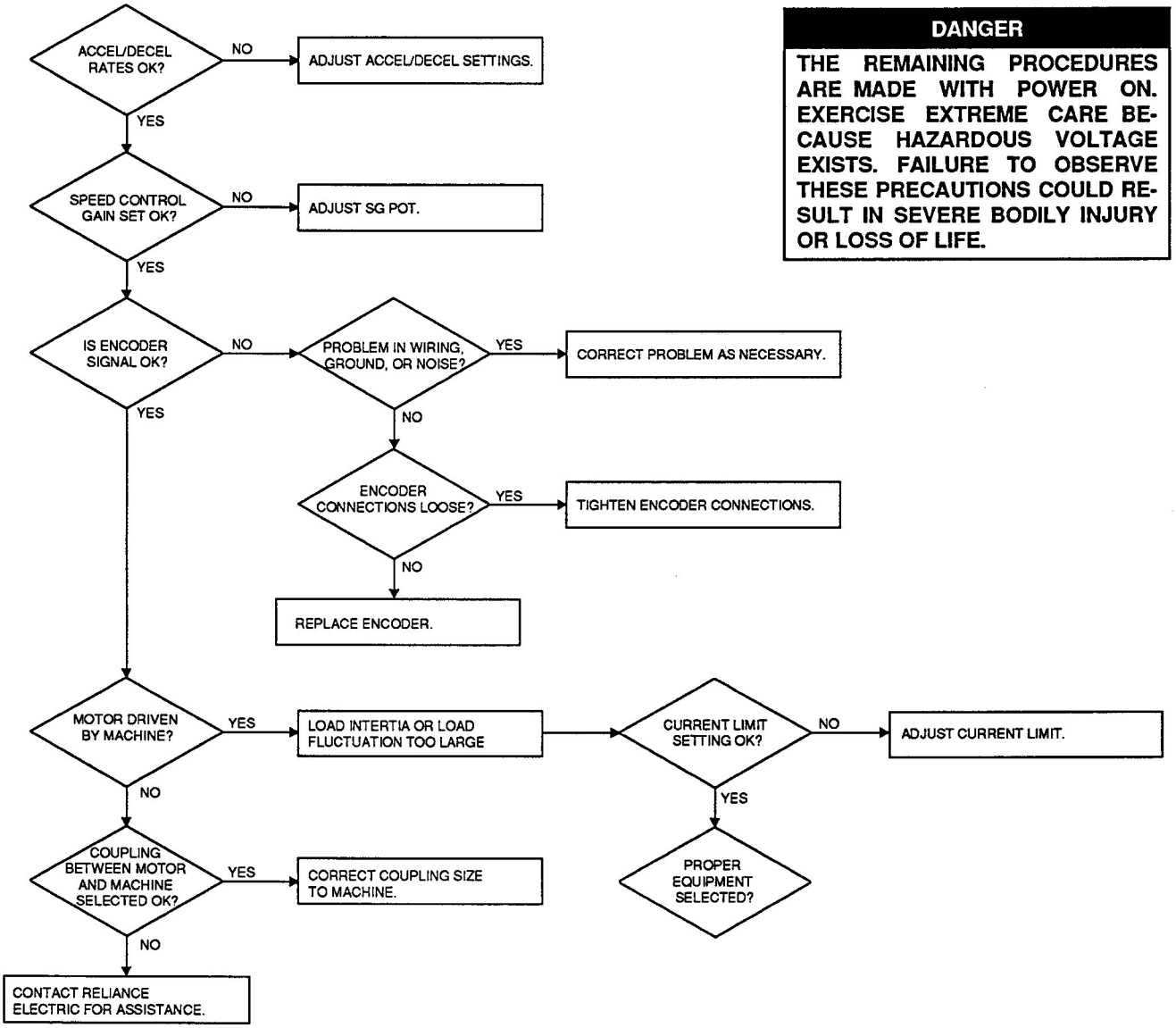


Figure 7-4. Acceleration/Deceleration Is Not Smooth.

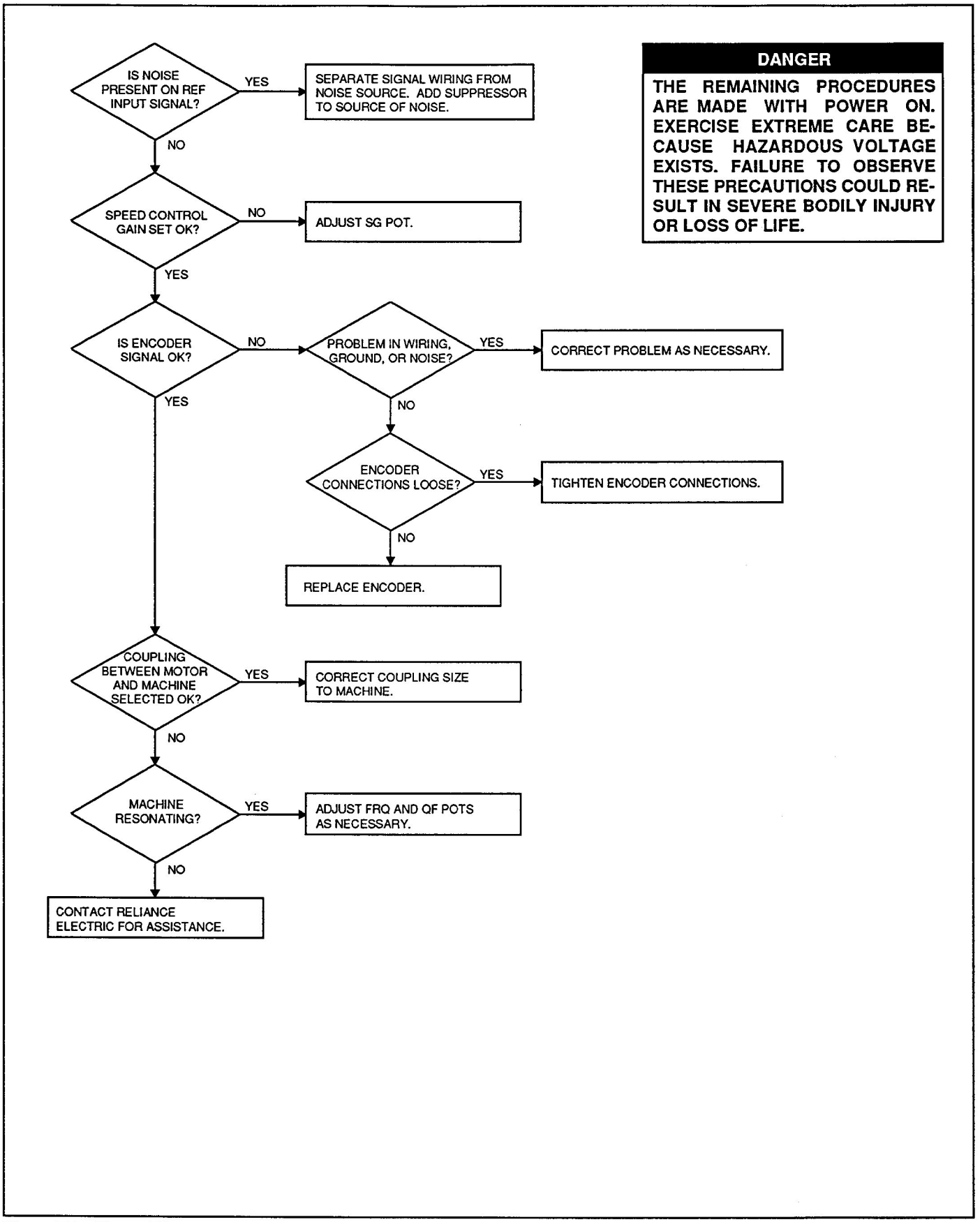


Figure 7-5. Heavy Vibration Results When Motor Stops.

Power Unit Checks

DANGER

THIS EQUIPMENT IS AT LINE VOLTAGE WHEN A-C POWER IS CONNECTED TO THE CONTROLLER. WHENEVER POWER IS REMOVED, VERIFY WITH A VOLTMETER AT FACEPLATE TERMINAL 147 (+) AND REGULATOR BOARD TERMINAL B1(-) THAT THE D-C BUS CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY INTERNAL PARTS OF THE CONTROLLER. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

1. Turn input power OFF. After verifying the D-C bus voltage is zero VDC and the POWER LED is not illuminated, disconnect the motor from the controller.
2. With a volt-ohmmeter on a known diode, determine the meter polarity as shown in Figure 7-6. The meter reading should be a low ohm reading.
3. Set a volt-ohmmeter on the ×1 ohmmeter scale and measure from the transistor collector (+) to the emitter (-) using the terminals defined in Table 7-2.
4. Connect the positive lead determined in Step 2 to the (+) terminal indicated in Table 7-2. Connect the negative lead to the (-) terminal indicated in Table 7-2. Refer to Figure 7-7 for transistor terminal details. The transistors should all read very high resistance. Replace any that read low resistance.
5. With input power removed and the motor disconnected from the controller, remove all transistor connections. When removing the transistor connections, mark the connectors for quick reconnection after the test.

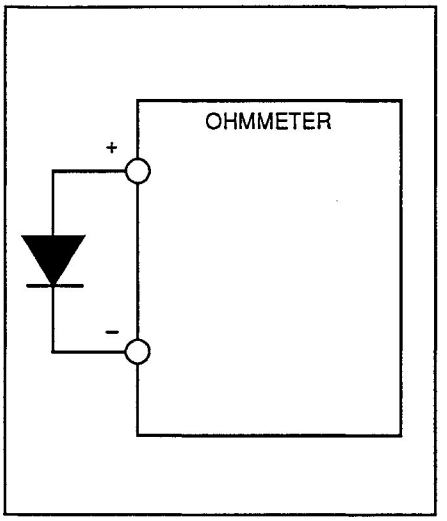


Figure 7-6. Polarity Check at Diode.

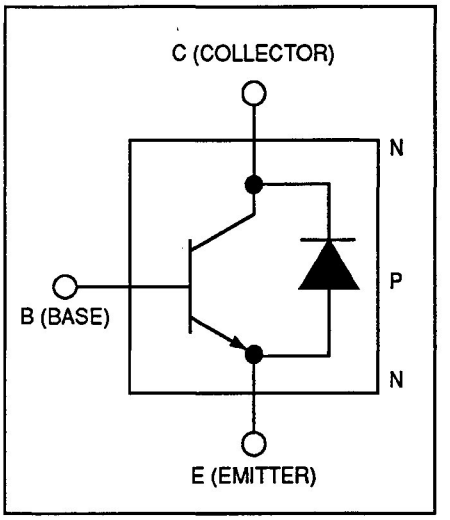


Figure 7-7. Transistor Terminals.

Table 7-2. Transistor Terminals from Which to Take Readings.

Transistor Number	(+) Terminals		(-) Terminals	
	Location	Terminal	Location	Terminal
1	Plus D-C Bus on Faceplate Terminal Block	147	Faceplate Terminal Block	601 (U)
3		147		602 (V)
5		147		603 (W)
2	Faceplate Terminal Block	601 (U)	Minus D-C Bus on Regulator	B1
4		602 (V)		B1
6		603 (W)		B1

6. Set a volt-ohmmeter on the ×1 ohmmeter scale and measure the resistance by referring to the labels B, E, and C on the transistor block. Volt-ohmmeter current must be less than 150 mA. See Figures 7-7 and 7-8 and refer to Table 7-3.
7. If any transistor is defective, replace the transistor.

DANGER

THE FOLLOWING CHECKS ARE MADE WITH INPUT VOLTAGE APPLIED TO THE CONTROLLER. EXERCISE EXTREME CARE BECAUSE HAZARDOUS VOLTAGE EXISTS. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

8. Turn input power ON. With a voltmeter set on the 500 VDC scale, measure the voltage at regulator board terminal B1(-) and faceplate terminal 147(+). The voltage should be greater than 290 VDC.
9. Turn off the base drive circuit by turning 1SW-7 switch ON. The red LED labeled "B.BK" should illuminate.
10. Measure the voltage between the base-emitter (terminals B and E with the yellow and orange twisted cables on the transistor block) at each transistor. There are two transistors per block. If the voltage does not read more than -1 volt, replace the transistor.

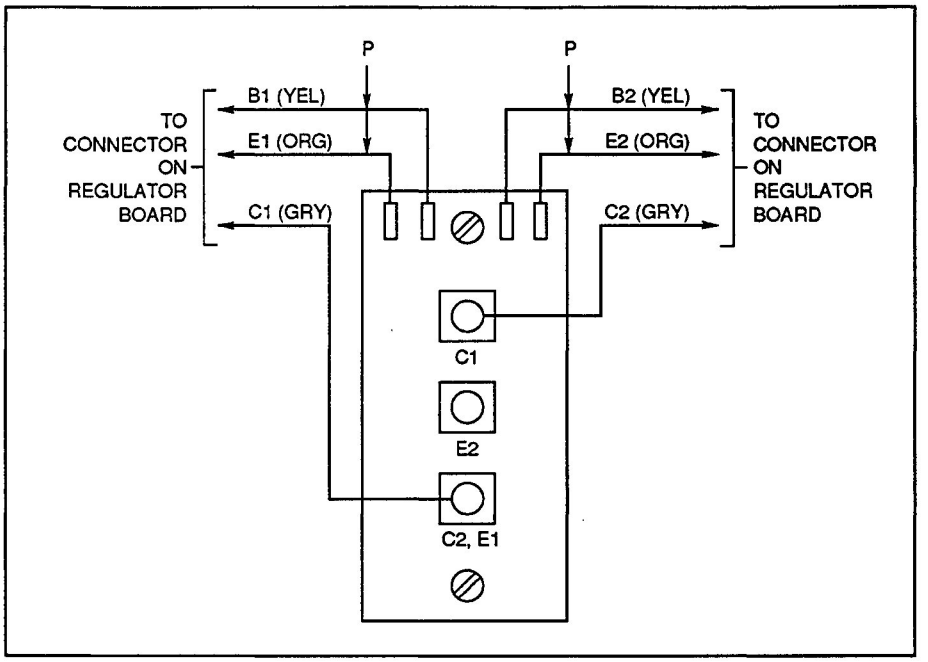


Figure 7-8. Typical Transistor Wiring.

Table 7-3. Transistor Resistance Readings.

(+)	(-)	Transistor Okay	Transistor Defective
Base	Emitter	Low Resistance	Open
Base	Collector	Low Resistance	Open
Emitter	Base	Open	Open
Collector	Base	Open	Low Resistance
Collector	Emitter	Open	Low Resistance
Emitter	Collector	Low Resistance	Open

Table 7-4. Replacement Parts List.

Description	Qty. Per Drive	Reliance U.S. Part Number
Input Power Diode Cube		
1 HP	1	402410-102AG
2 HP	1	402410-103AG
3 HP	1	402410-104AG
4 HP	1	402410-105AG
Output Transistor		
1 HP	1	402410-204AB
2 HP	1	402410-205AB
3 HP	3	402410-206AB
4 HP	3	402410-207AB
Control Transformer		
1-4 HP	1	612180-602R
MOV		
1-4 HP	3	612180-501R
D-C Bus Capacitor		
1 HP	1	402410-406RW
2 HP	1	402410-407SA
3 HP	1	402410-408SE
4 HP	1	402410-409SG
D-C Bus Transistor		
1-3 HP	1	402410-208AB
4 HP	1	402410-209AB
Control Transformer Fuse 4FU		
1-4 HP	1	64676-23N
Precharge Relay		
1-2 HP	1	402410-608A
3-4 HP	1	402410-609A
Precharge Resistor (1R)		
1-2 HP	1	402410-700A
3-4 HP	1	402410-701A
D-C Bus Resistor (2R)		
1-2 HP	1	402410-702A
3-4 HP	1	402410-703A
Cooling Fan		
2 HP	1	402410-900A
3-4 HP	1	402410-901A
Heatsink Thermostat		
1-4 HP	1	402410-905A
Regulator Board		
1 HP	1	0-48680-105
2 HP	1	0-48680-106
3 HP	1	0-48680-107
4 HP	1	0-48680-108
D-C Snubber Resistor (3R)		
1-2 HP	1	402410-704A
3 HP	1	402410-705A
4 HP	1	402410-706A
4 Pole Encoder (M/N B14Hxxxx, B18Hxxxx series Motors)	1	602453-62A
4 Pole Encoder (M/N S-2005 series Motor)	1	0018-7012
6 Pole Encoder (M/N S-4xxx series Motor)	1	0018-7013
Connectors		
2CN (50 pin)	1	69752-91F
3CN (20 pin)	1	69752-91C

Table 7-5. Modification Kits.

Description	HP	Model Number	Instruction Manual
Cables			
Controller to TB Sequencing (2CN)			
3 ft	1-4	4RC034	D5-3026
5 ft	1-4	4RC054	D5-3026
10 ft	1-4	4RC104	D5-3026
Encoder (3CN)			
3 ft	1-4	4RC033	D5-3026
5 ft	1-4	4RC053	D5-3026
10 ft	1-4	4RC103	D5-3026
Motor Encoder MS/Lug Connector			
15 ft	1-4	4RC151	D5-3024
25 ft	1-4	4RC251	D5-3024
50 ft	1-4	4RC501	D5-3024
100 ft	1-4	4RC001	D5-3024
MS/Honda Connector			
15 ft	1-4	4RC152	D5-3024
25 ft	1-4	4RC252	D5-3024
50 ft	1-4	4RC502	D5-3024
100 ft	1-4	4RC002	D5-3024
Circuit Breaker			
7 amp	1	3CB2007	D5-3019
15 amp	2	3CB2015	D5-3019
20 amp	3	3CB2020	D5-3019
30 amp	4	3CB2030	D5-3019
Dynamic Braking			
120 V Coil	1-4	3DB1004	D5-3020
200 V Coil	1-4	3DB2004	D5-3020
230 V Coil	1-4	3DB3004	D5-3020
Encoder Isolation/Buffer	1-4	3EB1	D5-3021
Encoder Tester	1-4	3RE5	D5-3023
Exercise Module	1-4	3RE4	D5-3022
Meters			
Load	1-4	3LM2000	D5-3029
Speed	1-4	3SM2000	D5-3029
Operator's Terminal	1-4	3RE10	D5-3025
RS232 Connector	1-4	3RS232	D5-3027
Snubber Resistor			
43 Ω	1-4	3RR2001	D5-3028
30 Ω	1-4	3RR2002	D5-3028
22 Ω	1-4	3RR2003	D5-3028

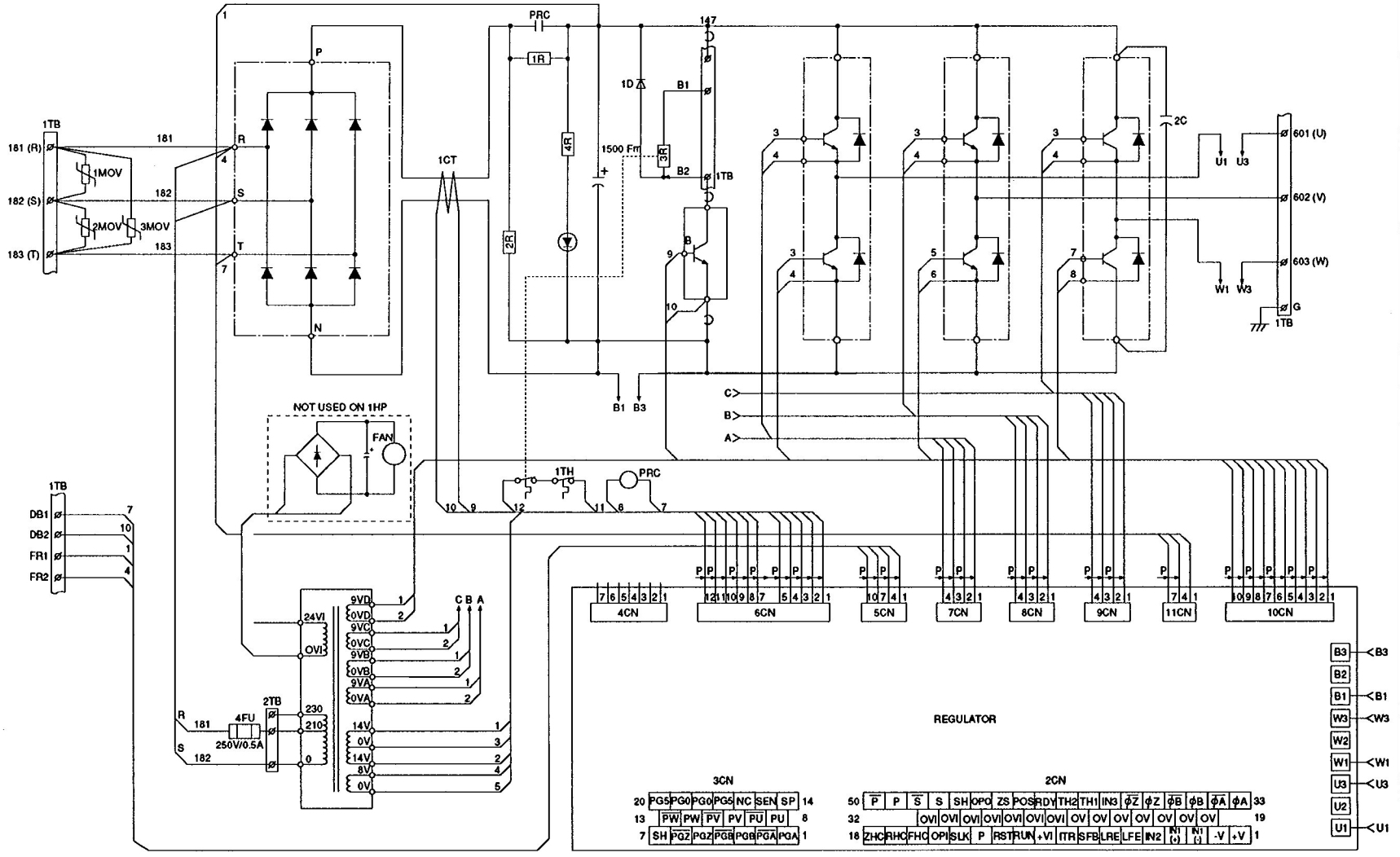


Figure 7-9. Typical Wiring Diagram.

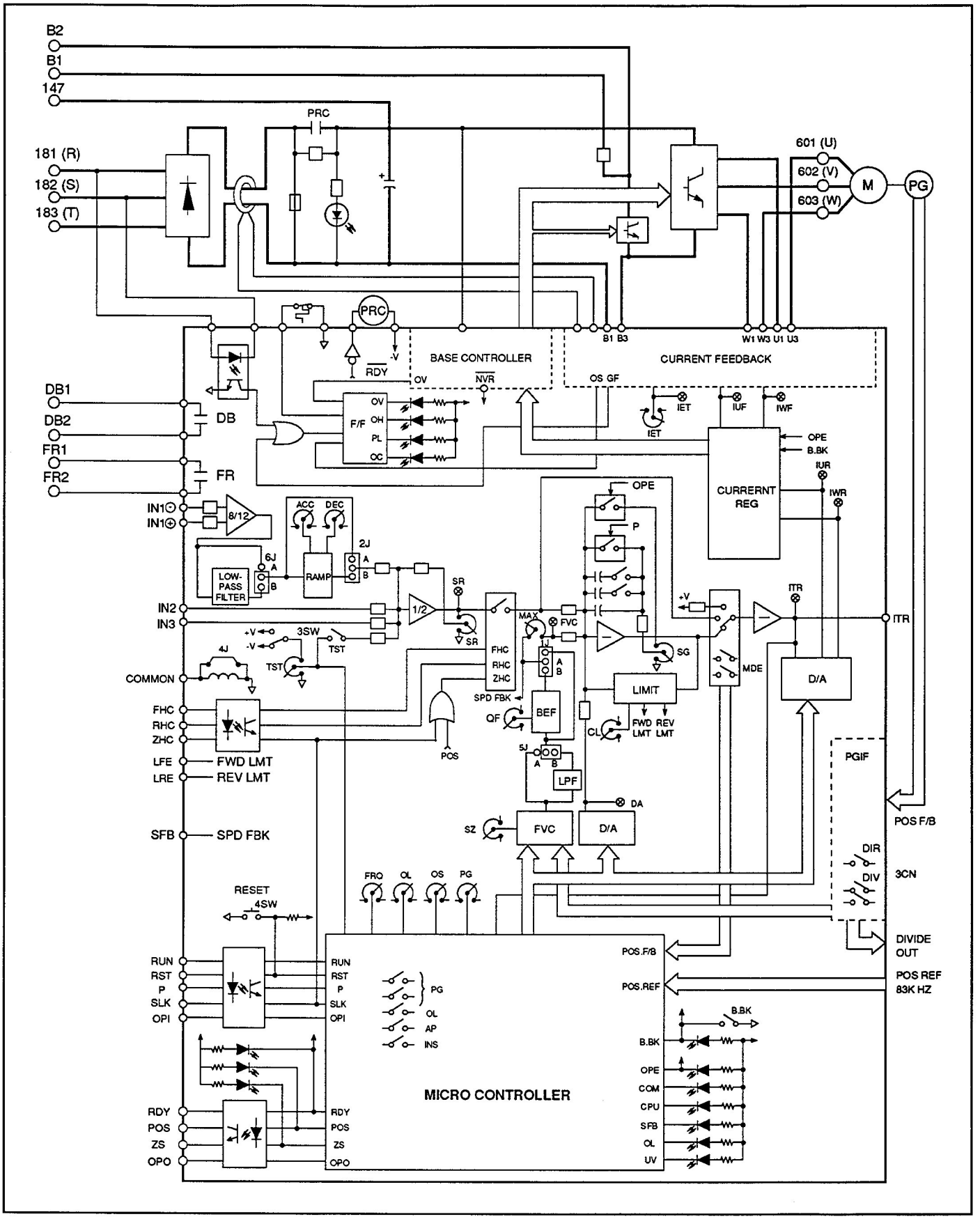


Figure 7-10. Typical Functional Block Diagram.

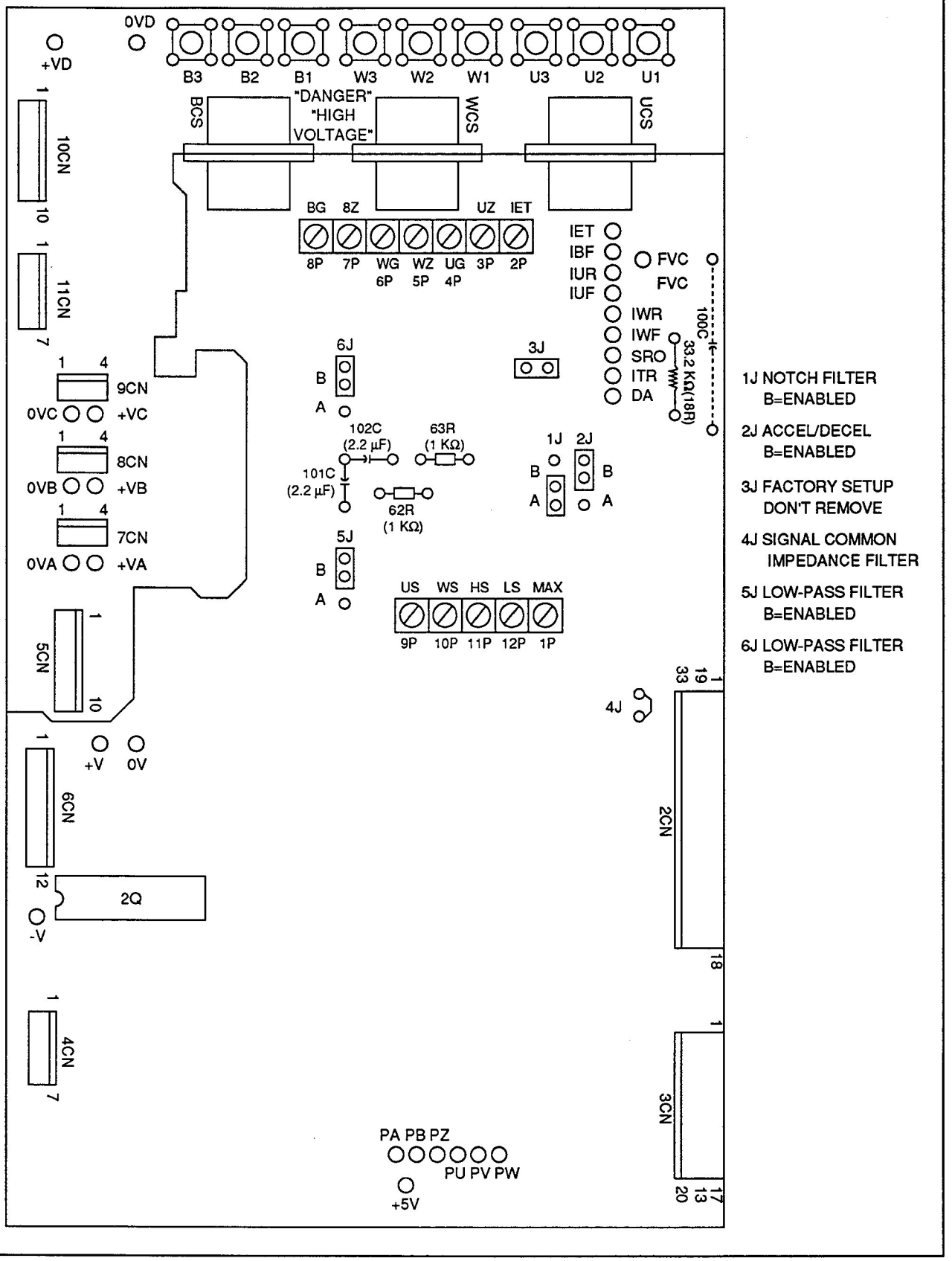


Figure 7-11. Typical Regulator Board Component Layout.

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