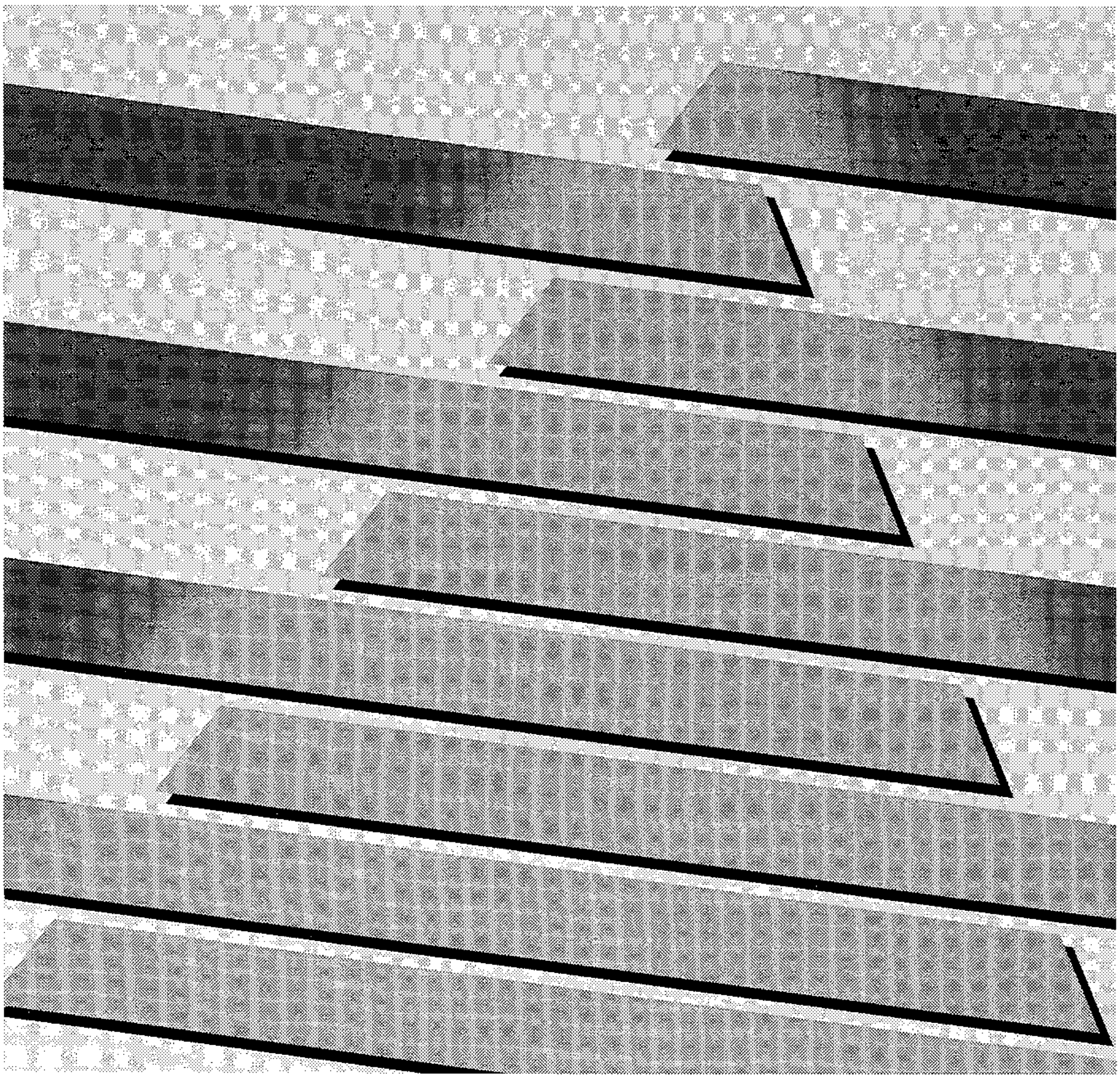
ALLEN-BRADLEY

Bulletin 1391
AC Servo Controller
(Series A and B)

Instruction Manual



Important User Information

Because of the variety of uses for this equipment and because of the differences between this solid-state equipment and electromechanical equipment, the user of and those responsible for applying this equipment must satisfy themselves as to the acceptability of each application and use of the equipment. In no event will Allen-Bradley Company be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The illustrations shown in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, the Allen-Bradley Company cannot assume responsibility or liability for actual use based upon the illustrative uses and applications.

No patent liability is assumed by Allen-Bradley Company with respect to use of information, circuits or equipment described in this text.

The information in this manual is organized in numbered chapters. Read each chapter in sequence and perform procedures when you are instructed to do so. Do not proceed to the next chapter until you have completed all procedures.

WARNING: tells readers about hazards and where prople may be injured if procedures are not followed properly.

CAUTION: tells readers where machinery may be damaged or economic loss can occur if procedures are not followed properly.

These reader-alerts help you identify:

- The probability and severity of hazards.
- The probability and severity of damage.
- The consequences of improper use.
- How to avoid these consequences.

Hazard alert labels are on the product.

Table of Contents

Chapter

1

Introduction

1.0 Manual Objectives

This manual is meant to guide the interface, installation, setup and troubleshooting of a Bulletin 1391 AC Servo Controller. The contents are arranged in order from a general description of the controller to troubleshooting and maintenance. To ensure successful installation and operation, the material presented must be thoroughly read and understood before proceeding. Particular attention must be directed to the Caution, Warning and Important statements contained within.

IMPORTANT: This manual is for standard Bulletin 1391 Controllers Only. It is not intended for use with the Bulletin 1391B-ES Controller. Refer to the *Bulletin 1391B-ES Instruction Manual* for further information on the Bulletin 1391B-ES Controller.

Important Information about this Manual
This manual has been prepared primarily to support this product in a single controller application. It is a standard document that is intended to help the user understand the individual operating characteristics and limitations of this equipment including hazards associated with installation, setup and maintenance procedures. Note the following points:

- This equipment has been designed to meet the requirements of a component controller in an integrated controller system.
- While the potential hazards associated with the controller remain the same when used in a system environment, it must be noted that special considerations are to be given to characteristics of other peripheral solid-state control equipment and the cumulative impact on safety.
- Manufacturers and engineering groups responsible for specification or design of electrical control equipment must refer to applicable industry standards and codes for specific safety guidelines and interface requirements.
- In the actual factory environment, the user is responsible to ensure compliance with applicable machine and operator safety codes or regulations which are beyond the scope and purpose of this document.

1.1 General Precautions

In addition to the precautions listed throughout this manual, the following statements which are general to the controller must be read and understood.

WARNING: Only personnel familiar with the Bulletin 1391 Servo Controller and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the controller. Failure to comply may result in personal injury and/or equipment damage.

CAUTION: An incorrectly applied or installed controller can result in component damage or a reduction in product life. Wiring or application errors, such as, undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures may result in malfunction of the controller.

1.1 General Precautions *(Continued)*

CAUTION: This controller may contain ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference Allen-Bradley publication 8000-4.5.2, *Guarding Against Electrostatic Damage* or any other applicable ESD Protection Handbook.

IMPORTANT: In order to maintain UL listing on Allen-Bradley 1391 Servo Controllers, the user must provide power from a 1391 Isolation Transformer. Use of any other transformer voids the UL listing.

The user is responsible for providing motor overload protection in accordance with the National Electrical Code (NEC), and any other local codes that may apply.

1.2 Controller Description

The Bulletin 1391 Pulse Width Modulated Servo Controller is a dedicated, single axis, AC servo controller. It has been packaged to require a minimum amount of panel space while containing, as standard, a number of features required by the machine tool and automated equipment industries.

The Bulletin 1391 is generally used with a computer aided, closed loop positioning system to control the position and linear or rotary motion of various machine members on an automated machine.

All components are mounted in an open framed package with a slide-on front cover. The controller is intended to be panel mounted in an enclosure and ventilated with filtered and/or cooled air. An internal fan is included to circulate air over the power heat sink.

The Bulletin 1391 converts a three-phase, 50/60 Hz input, to a variable AC voltage with controlled phase, amplitude and frequency. The output which is proportional to a user supplied analog command, regulates the speed and/or current (torque) of a Bulletin 1326 permanent magnet AC servomotor. The controller is available in ratings of 15, 22.5 and 45A RMS with all package sizes being identical. A Bulletin 1391 Transformer, Bulletin 1326 AC Servomotor and Bulletin 1326 Cables complete the servo system.

1.3
Series A, B and D Controllers

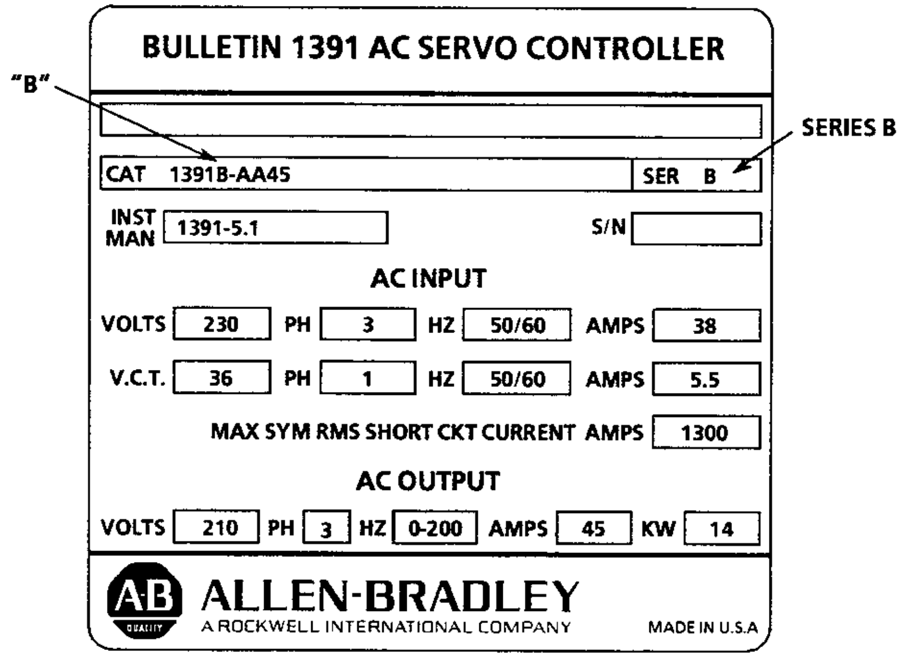


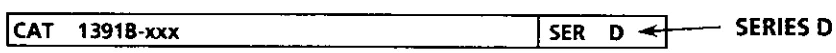
Figure 1.1 – Bulletin 1391 Nameplate

The Bulletin 1391 AC Servo Controller exists in two versions; Series A and Series B. In most installations, the Series A and Series B controllers are functionally equivalent. Mounting and physical dimensions are identical, as are the user interconnects and terminations. The Series B Bulletin 1391 has integrated some of the former options into the standard unit. In addition, some internal design changes have been made, providing improved methods of manufacture.

A Series B controller can be identified by the addition of a letter "B" in the catalog number or by referencing the "Series" field on the shipping carton or product nameplate (see Figure 1.1). Differences between the Series A and Series B controller will be identified throughout the manual as necessary.

IMPORTANT: The Series B Logic Board can be used in a Series A controller, however, it is recommended that a Series A Logic Board not be used in a Series B controller. Use of a Series A Logic Board in a Series B controller may result in a loss of some additional features provided by the Series B Logic Board, including undervoltage sensing.

Series D - Allen-Bradley's commitment to continuing product improvement has led to the introduction of the 1391 Series D Servo Controller. The catalog number string for the Series D will be unchanged, however, the controller nameplate will appear as follows:



This new series incorporates a re-designed Power Driver Board that increases manufacturing quality and provides a platform for new versions of the 1391 that are now in development.

This enhancement is totally transparent to the user of this product. The Control Board(s) and all other components of the controller remain the same. The adjustment, connection, diagnostic and troubleshooting information presented in this manual remains correct.

1.4 Standard Features

The Bulletin 1391 contains a number of standard features required in a typical automated machine servo system.

- Input protected against transient voltage.
- A power line/DB contactor which opens the AC line to the controller and inserts a shunt regulator resistor across the DC bus whenever the contactor is de-energized.
- An integral circuit breaker which will open all three AC line leads in the event of a short circuit condition in the power circuitry.
- A standard 300V DC power bus supply that includes an integral shunt regulator.
- A shunt regulator resistor to dissipate the energy generated by the motor during regenerative braking.
- Velocity loop components to compensate for a system inertia range between 0.03 to 1.0 in.-lbs.-sec^2.
- Logic Board that can be quickly removed and easily interchanged for troubleshooting and diagnostics.
- Three controller ratings that are in the same physical package and have identical mounting dimensions.
- UL listed per UL 508 (file #E59272 - volume 1, section 10, Drives and Transformers), CSA general file LR32334-23,C22.2 and IEC 146.

1.5 Options/Modifications

The Bulletin 1391 contains most functions needed in a servo system. The following are selectable at the user's option:

- Contactor Auxiliary Switch
  Two N.O. contacts are mounted on the main power contactor and wired to the power terminal block. These contacts can be used in a motor brake control circuit or as an indicator that the contactor has closed.

- Current or Torque Amplifier Operation
  When the velocity loop is being closed as part of the position control system, the controller can be configured to operate as a current or torque amplifier by use of the plug jumpers.

- External Shunt Regulator Resistor
  On 15 and 22.5A controllers an internal power resistor that is part of the DC bus voltage shunt regulator can dissipate 125 watts continuous power. Some applications such as an overhauling load have excessive regenerative energy to dissipate. For these applications, an external shunt regulator resistor rated at 386 watts continuous can be supplied for user mounting on 22.5A controllers. This is selectable by removing the jumper on TB5 and using an external resistor. The shunt has integral fusing accessible from the outside of 15 and 22.5A controllers. The 45A controller has an externally mounted resistor and fuse.

  IMPORTANT: An external shunt regulator resistor is included as standard equipment on 45A units. An additional unit is not required.

1.5
Options/Modifications
(Continued)

- Tach Output
  A voltage equal to 2.5V DC/1000 RPM is available at TB2.
  1.5V DC/1000 RPM on units set for 5000 RPM operation.

- Torque or Current Monitor
  A voltage equal to 3.0V DC = 100% scaled current is available at TB2.

- Anti-Backlash
  Provisions to use the Bulletin 1388 Anti-Backlash module are provided.

In addition to the selectable options listed above, the Bulletin 1391 also has a limited number of custom options/modifications available. The type of option can be identified by noting if the controller catalog number is followed by a three character alphanumeric code (i.e. 1391-AA22-A03). This code is sequentially assigned at the factory as options are provided per customer specifications.

IMPORTANT: The Series A, "**A10**" option/modification is now standard on all Series B Bulletin 1391 controllers. The "A10" designation will not appear in the catalog number.

Example: **1391-AA45N-A10** *is now* **1391B-AA45N**

The "A10" modification provides the controller with the ability to sense undervoltage as a fault, without latching, depending on the setting of jumper P8. It also provides an extended bridge enable during bus undervoltage conditions, resulting in an extended regeneration time.

1.6
Controller Layout

Figure 1.2 provides an exterior view of the Bulletin 1391 AC Servo Controller, showing accessibility of various components.

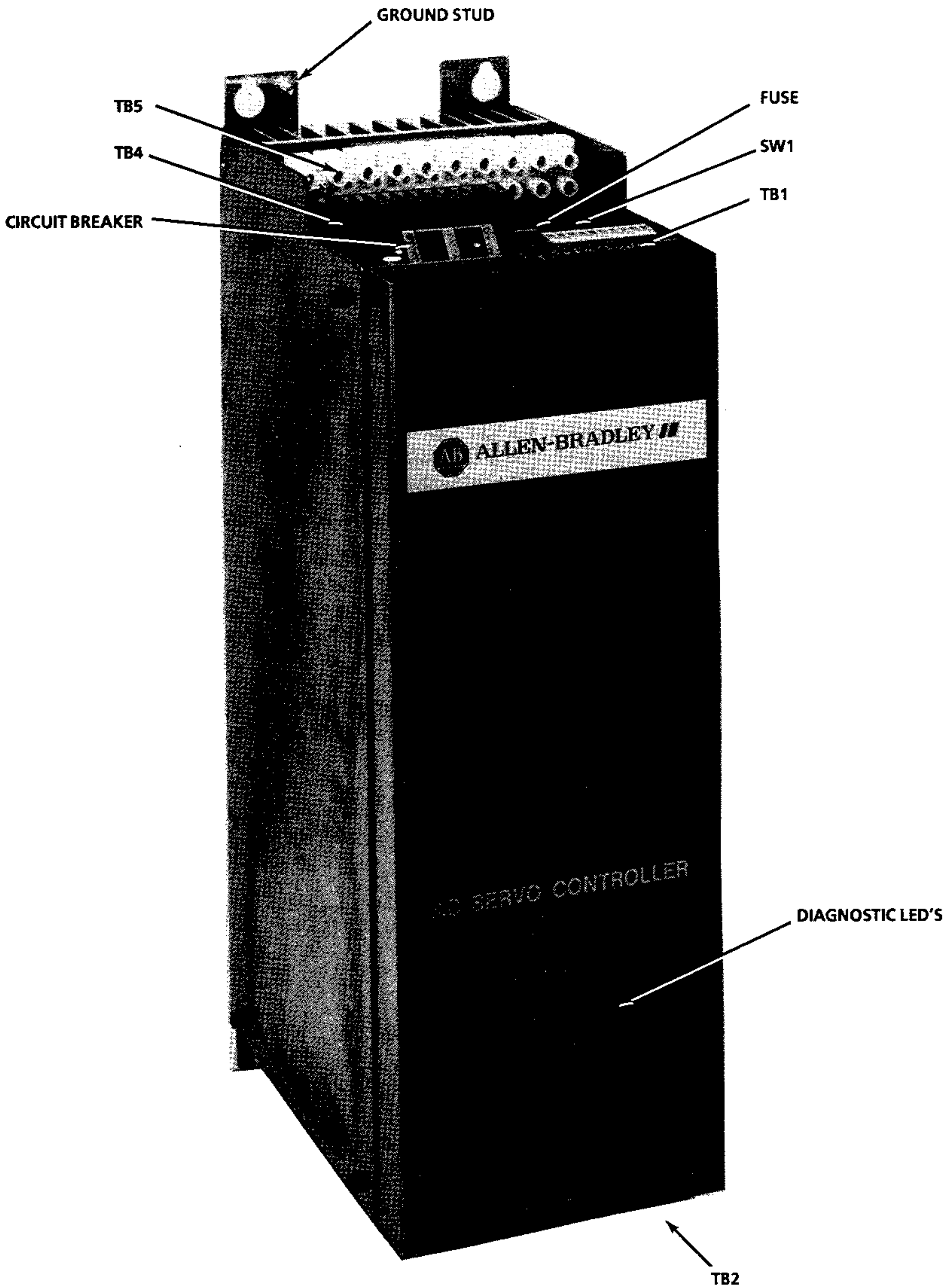


Figure 1.1 – Bulletin 1391 AC Servo Controller

Chapter

2

Specifications

2.0
Chapter Objectives

Chapter two contains the electrical and environmental specifications for the Bulletin 1391. Dimensions are provided in Appendix A.

2.1
Controller Specifications

The general specifications of the Bulletin 1391 are provided in the listing below. The specifications are divided when necessary for the various controller ratings.

	1391-AA15	1391-AA22	1391-AA45
NOMINAL BUS OUTPUT VOLTAGE	300V DC	300V DC	300V DC
CONTINUOUS CURRENT (RMS)	15A	22.5A	45A
PEAK CURRENT (RMS)	30A	45.0A	90A
CONTINUOUS POWER OUTPUT	5.0 KW	7.5 KW	15.0 KW
PEAK POWER OUTPUT	10 KW	15 KW	30.0 KW
INPUT CIRCUIT BREAKER RATING	17 A RMS	26A RMS	38 A RMS
CIRCUIT BREAKER INTERRUPT RATING (SYMMETRICAL AMPERES)	1300A	1300A	1300A
STATIC GAIN (A/RPM)	1.5 X RATED MOTOR I /RPM	1.5 X RATED MOTOR I /RPM	1.5 X RATED MOTOR I /RPM
UNIT WEIGHT IN LBS. & (KG)	22 (9.97)	28 (12.69)	34 (15.40)

	ALL CONTROLLER RATINGS
FORM FACTOR	1.03 OR LESS
PEAK CURRENT LIMIT ADJUST	20 TO 200% OF RATED MOTOR CURRENT (TO 90A MAXIMUM)
CONTROLLER EFFICIENCY (MINIMUM @ RATED LOAD)	85%
MODULATION FREQUENCY	2500 HZ (±10%)
DRIFT (REFERRED TO TACH)	0.07 RPM/°C MAXIMUM
AMBIENT TEMPERATURE	0° TO 60° C (32° TO 140° F)
STORAGE TEMPERATURE	0° TO 65° C (32° TO 149° F)
INPUT VOLTAGE (FROM TRANSFORMER)	POWER: 230V AC (+10%, −15%), THREE-PHASE, 50/60 HZ (±3 HZ) CONTROL: 35.5V AC C.T. (+10%, −15%), SINGLE-PHASE
RELATIVE HUMIDITY	5 TO 95% NON-CONDENSING
DEADBAND	ZERO
ALTITUDE	1000 METERS (3300 FEET)
INTEGRAL FAN OUTPUT	50 CFM (UNLOADED)
MAX. RMS SHORT CIRCUIT CURRENT (SYMMETRICAL AMPERES)	1300 A
TRANSFORMER INPUT TOLERANCE	+10%, −15%

Specifications are for reference only and are subject to change without notice.

2.2 Environmental Specifications

The Bulletin 1391 must be mounted in an enclosure that is clean, dry and ventilated by filtered or cooled air. Enclosures vented with ambient air must have appropriate filtering to protect against contamination caused by oils, coolants, dust, condensation etc. The ambient air temperature must be kept between 0 to 60°C (32° to 140°F) and the humidity between 5 and 95%, non-condensing.

The Bulletin 1391 is equipped with an integral cooling fan. The general flow of air through the unit must be maintained by following the recommended spacing guidelines found in Chapter 6. The Bulletin 1391 can operate at elevations to 3300 feet (1000 meters) without derating, however, the current rating must be derated by 3% for each additional 1000 feet (305 meters) up to 10,000 feet (3050 meters). Consult with your local Allen-Bradley Sales Representative prior to operation over 10,000 feet (3050 meters).

2.3 Controller Power Dissipation

The Bulletin 1391 dissipation characteristics are approximated in Table 2.A.

Table 2.A
Controller Power Dissipation *(Watts)*

Rated Power Output *(%)*	1391-AA15	1391-AA22	1391-AA45
20	38	55	104
40	76	110	208
60	114	165	312
80	152	220	416
100	190	275	520

IMPORTANT: Power Dissipation figures shown are for use in calculating cumulative system heat dissipation to ensure ambient temperature inside enclosure does not exceed 60°C (140°F).

2.4 Transformer Power Dissipation

The power dissipation characteristics of the Bulletin 1391 Isolation Transformer are shown in Table 2.B.

Table 2.B
Bulletin 1391 Isolation Transformer Power Dissipation *(Watts)*

Rated Power Output *(%)*	1.5kVA	3.5kVA	5.0kVA	10.0kVA	12.5kVA	15.0kVA
20	13	35	50	100	125	150
40	25	70	100	200	250	300
60	38	105	150	300	375	450
80	50	140	200	400	500	600
100	60	175	250	500	625	750

Chapter

3

Receiving, Unpacking and Inspection

3.0 Chapter Objectives

Chapter 3 provides the information needed to unpack, properly inspect and if necessary, store the Bulletin 1391 and related equipment. The section entitled *Inspection* provides a complete explanation of the Bulletin 1391 catalog numbering system.

3.1 Receiving

It is the responsibility of the user to thoroughly inspect the equipment before accepting the shipment from the freight company. Check the item(s) received against the purchase order. If any items are obviously damaged, it is the responsibility of the user not to accept delivery until the freight agent has noted the damage on the freight bill. Should any concealed damage be found during unpacking, it is again the responsibility of the user to notify the freight agent. The shipping container must be left intact and the freight agent should be requested to make a visual inspection of the equipment.

3.2 Unpacking

Remove all packing material, wedges, or braces from within and around the controller. Remove all packing material from the cooling fans, heat sink etc.

IMPORTANT: Before the installation and start-up of the controller, a general inspection of mechanical integrity (i.e. loose parts, wires, connections, packing materials, etc.) must be made.

3.3 Inspection

After unpacking, check the item(s) nameplate catalog number against the purchase order. An explanation of the catalog numbering system is included on the following pages as an aid for nameplate interpretation.

3.4 Storing

The controller should remain in its shipping container prior to installation. If the equipment is not to be used for a period of time, it must be stored according to the following instructions:

- Store in a clean, dry location.
- Store within an ambient temperature range of 0 to 65° C (32 to 149°F).
- Store within a relative humidity range of 5% to 95%, non-condensing.
- Do not store equipment where it could be exposed to a corrosive atmosphere.
- Do not store equipment in a construction area.

ISOLATION TRANSFORMER

1391 – T 015 D T

First Position	Second Position		Third Position		Fourth Position		Fifth Position	
Bulletin Number	**Type**		**kVA Rating**		**Primary Voltage & Frequency**		**Secondary Voltage**	
	Code	Description	No.	kVA	Code	Input	Code	Description
	T	Transformer Open Core & Coil	015	1.5	D	240/480V AC, 3-ph., 60Hz	T	230V AC, 3-ph. & four 35.5V AC 1-ph., CT windings
			035	3.5				
			050	5.0	E	240/380/415/480V AC, 3-ph., 50/60 Hz		
			100	10.0				
			125	12.5	N	208/230/460/575V AC, 3-ph., 60Hz		
			150	15.0				

NEMA TYPE 1 TRANSFORMER ENCLOSURE KIT

1391 – TA2

First Position	Second Position	
Bulletin Number	**Accessory Module**	
	Letter	Description
	TA2	Fits all kVA Ratings on Bulletin 1388, 1389 and 1391 Isolation Transformers

BULLETIN 1391 CONTROLLER

1391B – A A 45 – XXX

First Position	*Second Position*	*Third Position*	*Fourth Position*	*Fifth Position*
Bulletin Number	**Type and Construction**	**Nominal Output Voltage**	**Current Rating**	**Options** *(if required)*

First Position – Bulletin Number

Description
1391 = Series A
1391B = Series B

Second Position – Type and Construction

Letter	Description
A	Open Frame Internal Heat Sink

Third Position – Nominal Output Voltage

Letter	Description
A	230V AC, Three-Phase

Fourth Position – Current Rating

Code	Description
15	15A RMS Cont./ 30A Peak
22	22.5A RMS Cont./ 45A Peak
45	45A RMS Cont./ 90A Peak

Fifth Position – Options (if required)

Description

A three character alphanumeric field assigned to special modifications. Contact your local Allen-Bradley Sales Representative for further information.

Code	Description
A07	24V DC Contactor Coil
A08	240V AC Contactor Coil

ACCESSORIES - MODULES

1388 – X A

First Position	*Second Position*	*Third Position*
Bulletin Number	**Accessory Module**	**Accessory**

Third Position – Accessory

Letter	Description
A	Anti-Backlash Module w/Mounting Assem.
B	Accel/Decel Board w/Mounting Rack
C	Velocity Reference Board w/Mounting Rack

AC SERVOMOTOR

1326 A B – A 3 E – 11 – A4

First Position	*Second Position*	*Third Position*	*Fourth Position*	*Fifth Position*	*Sixth Position*	*Seventh Position*	*Eighth Position*
Bulletin No.	**Type**	**Design**	**Series**	**Motor Length**	**Maximum Operating Speed**	**Mounting & Shaft Description**	**Standard Options**
	Code / Type A — AC Servo-motor PM Type	See Below	Sequentially lettered to designate frame diameters. Code / Dia. A — 4.25" (108mm) B — 5.88" (149mm) C — 7.63" (194mm)	Sequentially numbered to indicate stack length within a given frame size.	Code / RPM B — 1600 C — 2000 E — 3000 G — 5000	Code / Description 11 — Inch Combination Face/flange with Keyway 21 — NEMA/IEC Metric Flange with Keyway	See Table Below

Third Position (Design):

Code	Description
B	General Purpose Ceramic Magnet
D	High Performance Low Inertia

Eighth Position (Standard Options):

Code	Description	
A4	72 in.-lb. (8.1 N-m), 90V DC Brake	1326AB-A Series
A5	120 in.-lb. (13.6 N-m), 90V DC Brake	1326AB-B Series
A7	360 in.-lb. (40.7 N-m), 90V DC Brake	1326AB-C Series
K4	72 in.-lb. (8.1 N-m), 24V DC Brake	1326AB-A Series
K5	120 in.-lb. (13.6 N-m), 24V DC Brake	1326AB-B Series
K7	360 in.-lb. (40.7 N-m), 24V DC Brake	1326AB-C Series

SHAFT OIL SEAL KIT

1326AB – MOD – SS V – A 1

First Position	*Second Position*	*Third Position*	*Fourth Position*	*Fifth Position*	*Sixth Position*
Bulletin No.	**Type**	**Shaft Seal**	**Material**	**Motor Series**	**Motor Mounting**
	Code / Description MOD — Modification Kit		Letter / Type V — Viton	Letter / *For* 1326AB A — -A Series B — -B Series C — -C Series	Number / Description 1 — Std. Inch 2 — Metric

BLOWER MOD KIT

1326AB – MOD – G3

Bulletin No.	Type		Description	
	Code	Description	Code	Motor Series
	MOD	Modification Kit	G3	Rear Mount Blower for C Series Motors
			G4	Side Mount Blower for "C" Series Motors

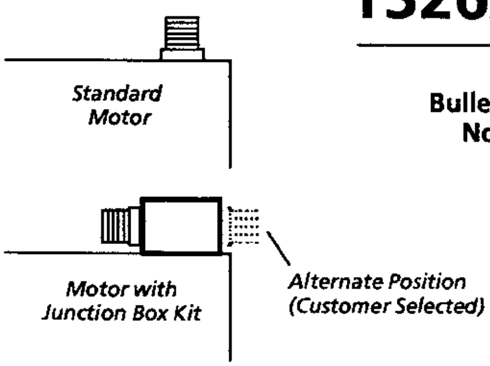
BRAKE POWER SUPPLY RECTIFIER

1326 – MOD – BPS

Bulletin Number	Type		Description	
	Code	Description	Code	Description
	MOD	Modification Kit	BPS	Single-Phase, Full-Wave, Panel Mounted Rectifier. 115V AC Input, 90V DC Output Supplies power for up to four 90V DC brakes on Bulletin 1326AB or AD motors.

MOTOR JUNCTION BOX KIT*

1326AB - MOD – RJAB



Bulletin No.	Type		Description	
	Code	Description	Code	Description
	MOD	Modification Kit *	RJAB	For All AB-A and AB-B Series Motors
			RJBC	For AB-B4 and AB-Cx Series Motors

IMPORTANT: The motor comes standard with IP65 plug style connectors mounted radially to the motor. This kit allows the connectors to be brought out axially to the motor without further wiring.

* Kit includes Motor Junction Box and Mounting Hardware

EXTERNAL SHUNT REGULATOR RESISTOR

1326 – MOD – SR22A

Bulletin Number

Type

Code	Description
MOD	Modification Kit

Description

Code	Description
SR22A	Shunt Regulator Resistor for 22.5A Controller
SR45A	Shunt Regulator Resistor for 45A Controller

FEEDBACK MOUNTING ADAPTER KIT

1326AB – MOD – M4 – C1

First Position — **Bulletin No.**

Second Position — **Type**

Code	Description
MOD	Modification Kit

Third Position — **Mounting Adapter Kit *For..***

Fourth Position — **Coupling Size *For..***

Code	Motor Series
C1	A, B, C
Blank	For M22, M23, M25, M26

Code	Description
M4	A-B 845H Encoder for AB-A Series Motor
M5	A-B 845H Encoder for AB-B Series Motor
M6	A-B 845H Encoder for AB-C Series Motor
M22	Type VC/VD 4.25" (108mm) Resolver for AB-B Series Motor
M23	Type VC/VD 4.25" (108mm) Resolver for AB-C Series Motor
M24	0.375" (9.5mm) Diameter Heavy Duty Shaft Extension for Type VC/VD 4.25" (108mm) Resolver
M25	0.625" (15.9mm) Diameter Heavy Duty Shaft Extension for Type VC/VD 4.25" (108mm) Resolver
M26	Foot Mounting Kit for M25

IMPORTANT: All kits contain a feedback device mounting adapter and mounting hardware. M4, M5 and M6 include a motor to encoder coupling. M22 and M23 do not include a coupling since it is included with the resolver feedback device.

FEEDBACK COUPLING

(Included in all Feedback Mounting Adapter Kits)

1326 – MOD – C1

First Position	*Second Position*	*Third Position*
Bulletin No.	**Type**	**Coupling Size**

Type

Code	Description
MOD	Modification Kit

Coupling Size

Code	Motor Shaft
C1	3/8" to 3/8" (9.5mm to 9.5mm)
C2	3/8" to 1/4" (9.5mm to 6.3mm)

RESOLVER FEEDBACK PACKAGE

1326AB – MOD – VC 1:1

First Position	*Second Position*	*Third Position*	*Fourth Position*
Bulletin No.	**Type**	**Resolver Feedback Package**	**Gear Ratio Input:Resolver**

Type

Code	Description
MOD	Modification Kit*

Resolver Feedback Package

Code	Description
VC	4.25" (108mm) feedback package w/cast housing and single or vernier (dual) format with receiver (Harowe 11BRW-300-F-58A or equivalent) type resolver(s) for use with 8200, IMC 120, IMC 123.
VD	4.25" (108mm) feedback package w/cast housing and single or vernier (dual) format with transmitter (Harowe 11BRCX-300-C10/6 or equivalent) type resolver(s) for use with A-B series 8600, SAM and MAX REC-4096 Board.

Gear Ratio Input:Resolver

Code	Description
1:1	Single device format - 1 turn of the motor shaft to 1 turn of the resolver.
1:2	Single device format - 1 turn of the motor shaft to 2 turns of the resolver.
1:2.5	Single device format - 1 turn of the motor shaft to 2.5 turns of the resolver.
1:5	Single device format - 1 turn of the motor shaft to 5 turns of the resolver.
255	Absolute master/vernier format - 1:1 input/master 255:256 master/vernier for IMC 120, 123 only.
256	Absolute master/vernier format - 1:1 input/master, 256:255 master/vernier for 8600 series controls and Creonics only.
424	Absolute master/vernier format - 1:1 input/master, 424:425 master/vernier for IMC 120, 123 only.
425	Absolute master/vernier format - 1:1 input/master, 425:424 master/vernier for 8600 series controls and Creonics only.
800	Absolute master/vernier format - 1:1 input/master, 800;801 master/vernier for IMC 120, 123 only.
801	Absolute master/vernier format - 1:1 input/master, 801:800 master/vernier for 8600 series controls and Creonics only.

* Kit includes Resolver Feedback Package, Mounting Hardware and 3/8" to 3/8" (9.5mm to 9.5mm) Resolver to Motor Mounting Coupling.

POWER AND FEEDBACK CABLES

1326 – C P AB 15

First Position	*Second Position*	*Third Position*	*Fourth Position*	*Fifth Position*
Bulletin No.	**Type**	**Function**	**Motor Size Used On**	**Cable Length**

Second Position — Type

Code	Description
C	Connector & Cable Assembly

Third Position — Function

Letter	Type
P	Power Connection
F	Commutation & Feedback Connection
E	845H Encoder
V	All 4.25" (108mm) Resolver Packages

Fourth Position — Motor Size Used On

Code	Type
AB	Series A & B (except 1326AB-B4)
C	Series C & 1326AB-B4
U	All Series

Fifth Position — Cable Length

Code	Description
K	Connector Kit (No Cable)
15	15' (4.6m)
30	30' (9.1m)
50	50' (15.2m)
100	100' (30.4m)

Chapter

4

Description of Operation

4.0 Chapter Objectives

Chapter 4 is intended to familiarize the reader with the circuitry of the Bulletin 1391 in terms of function and operation.

4.1 General

The Bulletin 1391 PWM Servo Controller is made up of the following: 300V DC power supply, power transistor output modules, shunt regulator circuit, logic power supply, Logic Control Board, isolated current sensing, circuit breaker and line contactor.

The intended use of the Bulletin 1391 is to control the speed and torque of a Bulletin 1326 AC servomotor in a closed loop position system. A complete servo system can be configured with a Bulletin 1391 Servo Controller, Bulletin 1326 AC Servomotor and Bulletin 1391 Isolation Transformer. Refer to the *Bulletin 1391 Block Diagram* presented in Figure 4.3.

4.2 300V DC Power Bus Supply

The controller contains an integral, unregulated, 300V DC nominal, full load power supply. It consists of the power transformer input (230V AC, three-phase, 50 or 60 Hz), a three-phase input bridge rectifier and one power supply filter capacitor (C1).

4.3 PWM Operation

The Bulletin 1391 incorporates a fixed timing wave (V_T) of 2500 Hz. The controller also generates a three-phase sine wave whose frequency corresponds to the velocity command. An output voltage signal (V_O) is generated by the intersection of these two curves as shown in Figure 4.1.

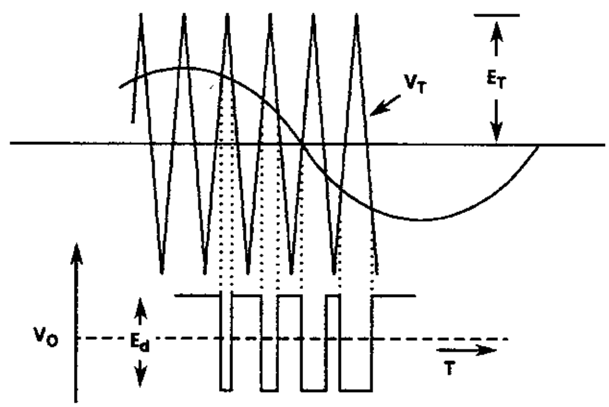


Figure 4.1 – PWM Waveform

The three-phase relationship between the reference signal and the timing wave provide a PWM wave to the power transistor base drive. This base drive switches the power transistors across the 300V DC bus, providing current to the motor windings, thus causing the motor to turn. A resolver attached to the motor provides a signal corresponding to the actual rotor position of the motor. This signal is decoded to a signal representing rotor position and is fed to the commutation logic along with the torque command. In this way, the controller combines the desired position signal and current reference with the decoded resolver signal to produce a reference signal commanding the controller to speed up or slow down. See Figure 4.2.

4.3 PWM Operation (Continued)

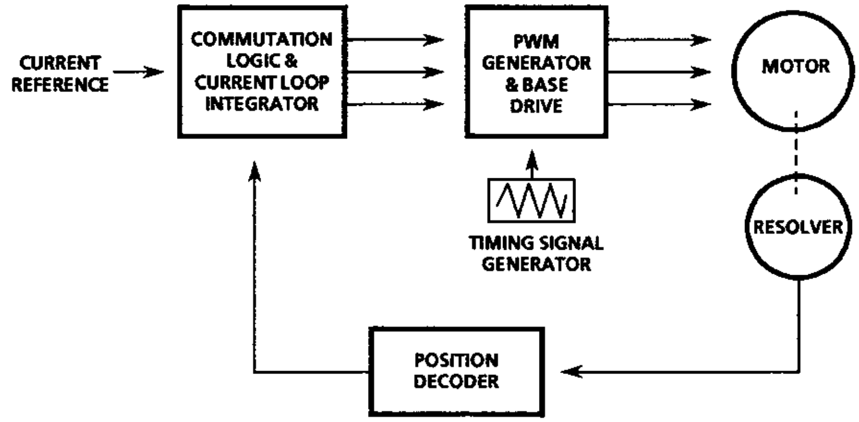


Figure 4.2 – Operation

4.4 Shunt Regulator Operation

The Bulletin 1391 shunt regulator provides power dissipation for regenerative conditions when the energy returned to the controller by the motor exceeds that which can be stored in the bus capacitors. The shunt regulator monitors the bus voltage and at a predetermined "ON" point activates the shunt regulator transistor, allowing current to flow through the shunt resistor and dissipating power in the form of heat. A fuse is placed in series with the resistor to protect it against short circuit conditions. When the shunt transistor is activated and power is being dissipated at the resistor, the bus voltage will quickly decrease, turning the transistor off when the voltage reaches the "OFF" point. This cycle repeats, provided the bus voltage continues to increase to the "ON" point. If too much regenerative energy is present, the bus voltage will continue to increase even with the shunt regulator on. At a predetermined bus voltage level, the Bulletin 1391 will determine that an overvoltage condition exists, and trip out on an Overvoltage Fault.

The shunt regulator behavior is further modified by an adjustable duty cycle timer. The timer is used to model the shunt resistor temperature. SW1, a selector switch located on the top of the controller (see Figure 1.1) determines the temperature level and therefore the average power level at which the controller will trip out. When this level is reached, the controller will be forced to trip out on an Overvoltage Fault. This action would be equivalent to turning the shunt regulator off. Refer to Chapter 9 for further shunt regulator information.

4.5 Logic Power Supply

The Bulletin 1391 control logic voltage is ±12V DC and +5V DC. The voltages are generated on the Power Driver and Logic Control Boards, which receive a 35.5V AC center-tapped input from a tertiary winding on the isolation transformer.

4.6 Logic Control Board

The Logic Control Board is the printed circuit board that is readily accessible behind the front cover of the controller. This board contains all circuits necessary to control the Bulletin 1391. These circuits include: the velocity and current loop, fault detection and annunciation circuits, power-up/power-down logic, PWM generation and forward/reverse controlling circuits.

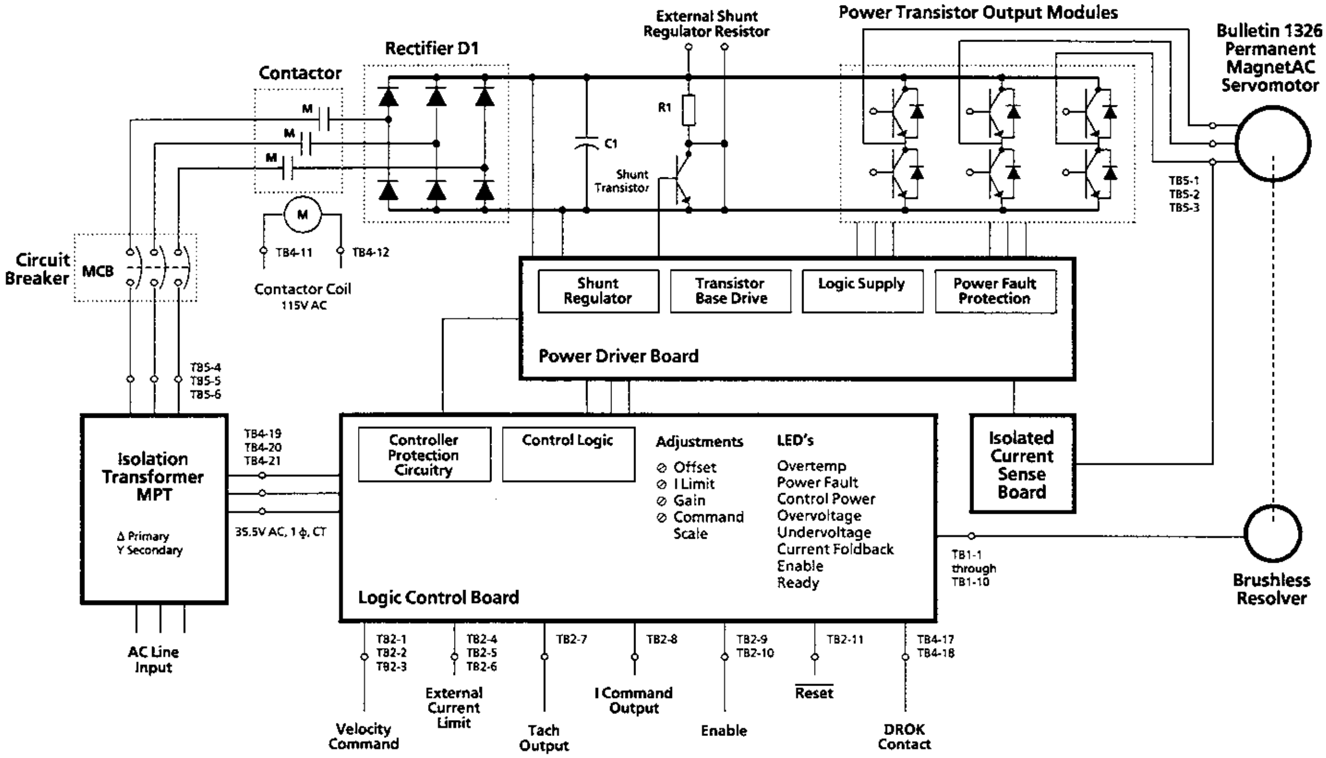


Figure 4.3 – Bulletin 1391 Block Diagram

4.7 *Controller/System Fault Monitor and Detection*

A number of Fault Monitor and Detection functions exist on the Bulletin 1391 that guard the controller and help to minimize motor and system faults. The occurrence of a fault will cause the controller to trip out. In this condition, the Drive OK (DROK) contact will open and remain open until the fault is cleared. If the DROK contact is wired into the user's stop circuit, the line/DB contactor (M) will also de-energize. This will place the shunt resistor across the bus causing the motor to dynamic brake to a stop.

These fault conditions are annunciated through the front panel LED indicators. The conditions displayed include:

OVERTEMPERATURE – The controller contains a thermal switch on the heat sink which indirectly senses transistor module temperature. If the temperature rating of the switch is exceeded, the LED illuminates, the DROK contact opens and the controller is disabled.

POWER FAULT – A fault related to the power bridge section of the controller will cause the controller to be disabled, illuminate the LED and open the DROK contact.

CONTROL POWER – If the control voltage varies more than ±10% of the nominal 12V DC, the LED illuminates, the DROK contact opens and the controller is disabled.

OVERVOLTAGE – The DC power bus voltage is continuously monitored. If it exceeds a preset level of 405V DC, the LED illuminates, the DROK contact opens and the controller is disabled.

4.7 Controller/System Fault Monitor and Detection *(Continued)*

UNDERVOLTAGE – If the DC power bus voltage drops below 50% of its nominal operating value, the LED illuminates and a signal will be present at TB2-13. A jumper setting selects the reaction of the DROK contacts to an undervoltage detection. Refer to section 5.3 for further information.

IMPORTANT: Regardless of interaction with the DROK contacts, the transistor bridge is disabled upon an undervoltage condition. This is done to protect the output transistors against voltage transients.

CURRENT FOLDBACK – The controller contains a fixed time versus current overload circuit which monitors the current through each leg of the output bridge. If a fixed-time versus current-product is exceeded, the LED is illuminated and a signal will be present at TB2-14. This condition will reduce the current limit or torque available to the motor.

RUN/ ENABLE – The application of an enable signal by the machine position controller will cause the RUN ENABLE LED to illuminate.

DRIVE READY – The status of the power supplies and fault conditions are monitored continuously. If a fault is present, the DRIVE READY LED will not be illuminated, a fault signal will be present at TB4 and the DROK contact will be open.

4.8 Isolated Current Sensing

The Logic Control Board receives current feedback from the Isolated Current Sense Board. This circuitry also provides the data used for inverter thermal protection and power fault sensing.

4.9 Integral Circuit Breaker

The control logic and power circuitry are protected against overcurrents by an integral circuit breaker. The DC bus supply and input rectifier utilizes a three pole magnetic circuit breaker.

4.10 Line/DB Contactor

The three-phase incoming AC line is opened by the contactor whenever the input connected to terminals 11 and 12 of TB4 is removed. This operation in conjunction with the shunt regulator reduces the bus voltage when the contactor is disabled. The Logic Control Board remains energized except when voltage is removed from the incoming isolation transformer.

IMPORTANT: The Bulletin 1391 contains a definite purpose contactor that is not to be energized/de-energized more than twice an hour on a continuous basis. The life of the contactor may be reduced considerably if this cycle is exceeded. Contact your local Allen-Bradley Sales Representative for additional information.

4.11 Power Driver Board

The Power Driver Board contains the circuitry needed to switch the power transistor modules.

4.12 Starting and Stopping

WARNING: The Enable control circuitry in the Bulletin 1391 includes solid-state components. If hazards due to accidental contact with moving machinery or unintentional flow of liquid, gas or solids exist, an additional hardwired contingency stop circuit may be required. Refer to the codes and standards applicable to your particular system for specific requirements and additional information. A device that removes AC input power when a contingency stop is initiated is an integral part of this controller. Refer to the individual stop mode explanations below.

WARNING: The user has the ultimate responsibility to determine which stopping method is best suited to the application and will meet applicable standards for operator safety.

Starting and Stopping must be accomplished by hardwired user supplied elements as shown in Appendix B. Stopping modes for the Bulletin 1391 are outlined below. Refer to the paragraphs that follow for detailed information. The effects described below assume that the 35.5V AC control voltage has not been de-energized.

CAUSE	EFFECT ON MOTOR
De-energize Line/DB Contactor (M) Coil	Dynamic Brake
Speed Command brought to Zero	Regenerative Brake
Open Enable Input	Regenerative Brake
DROK Opens (Fault)	Coast to Stop

Dynamic Braking - When the line/DB contactor (M) is de-energized by the control circuitry, an inherent dynamic braking effect will occur during the DC bus decay, provided the 35.5V AC logic voltage is not de-energized. The dynamic braking effect depends on the value of the shunt regulator resistor and total load inertia.

IMPORTANT: Frequent cycling of the line/DB contactor to start/stop the motor will reduce the life of the contactor. Refer to the paragraph that follows.

Regenerative Braking - Normal run commands to the controller are performed through the Enable input and any additional customer supplied control circuitry. Refer to Appendix B. With input power applied, a mechanical contact closure between TB2-9 & 10 or solid-state contact closure (open collector, +15 to +30V DC) between TB2-10 & 12 will cause the controller to run, provided the line/DB contactor (M) has been energized by the control circuitry. When the Enable input is de-energized, the maximum available reverse torque is applied to the motor in a regenerative stopping mode, which will occur for approximately 450ms.

Coast - An internal controller fault opens the DROK contact. Coasting will only occur if the DROK contact ***is not*** wired to the line/DB contactor coil (M) or the Enable input circuits.

4.13 Power-Up/Down Sequence

Figure 4.4 describes the various steps involved in the power-up/down sequence of the Bulletin 1391 controller.

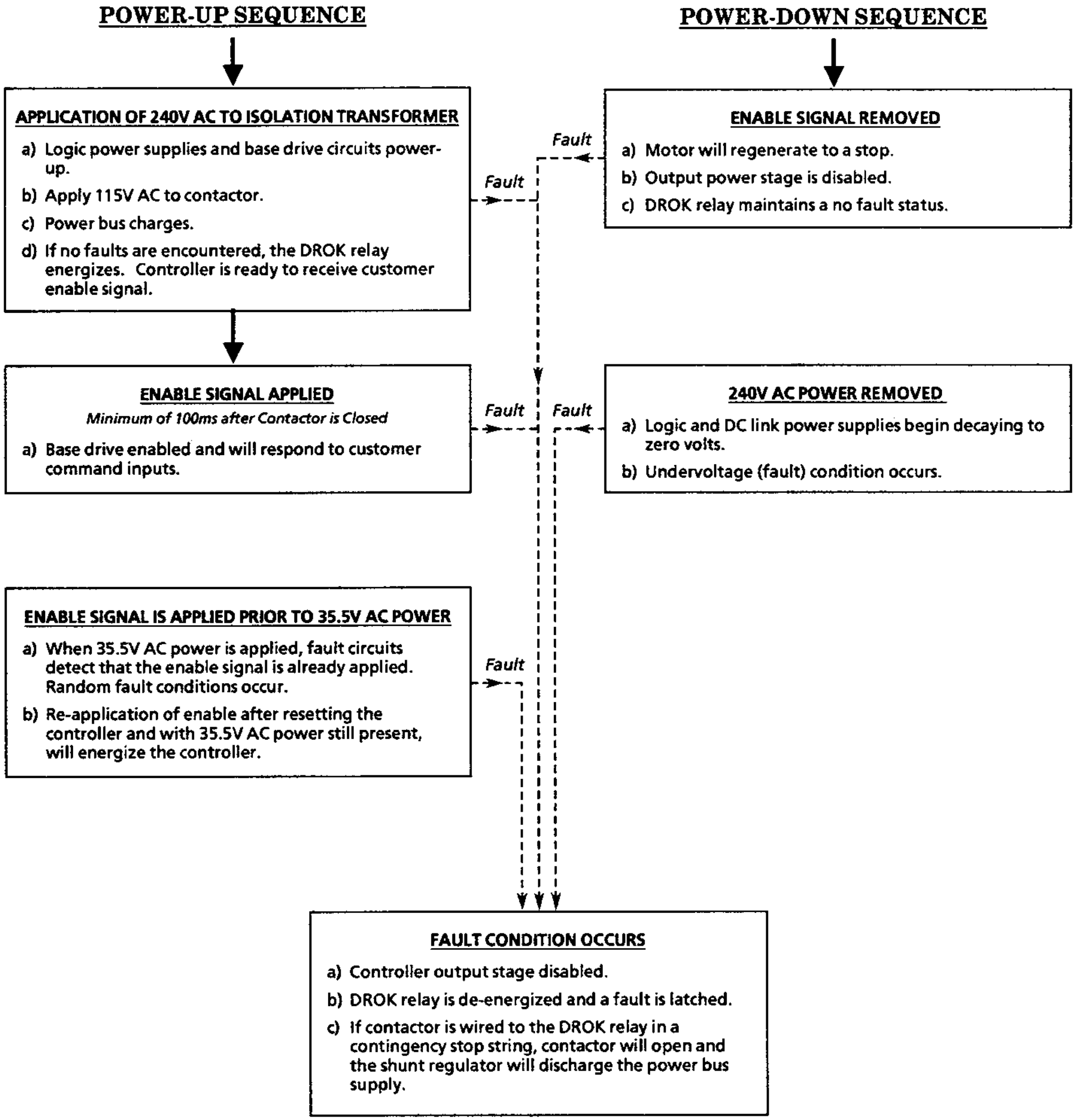


Figure 4.4 – Power-Up/Down Sequence

Chapter

5

Inputs, Outputs and Adjustments

5.0 Chapter Objectives

Chapter 5 contains descriptions of the various inputs and outputs available on the Bulletin 1391 Servo Controller. Additionally, a comprehensive listing and description of the potentiometer, switch and jumper settings is provided. In some cases adjustment methods are provided for use during start-up. This information is provided to help you understand some of the important aspects about the controller prior to the actual installation and start-up. For information on shunt regulator adjustments, refer to Chapter 9.

5.1 Inputs/Outputs

The following paragraphs provide detailed descriptions of the various inputs and outputs available for the Bulletin 1391. See Figure 5.1 for terminal block locations.

TERMINAL BLOCK - TB1

Resolver Signals *(TB1, Terminals 1-10)*
These terminals are used for connection to the resolver. Refer to Appendix B for connection details.

TERMINAL BLOCK - TB2

Velocity Command Input *(TB2, Terminals 1, 2, 3)*
The controller will accept up to a ±10V DC velocity command signal to achieve maximum motor speed. The plus (+) and minus (−) reference are at terminals 2 and 1, respectively. Shield must be terminated at source end only. The input impedance of the velocity command input is 40k ohms (20k ohms for single ended inputs).

External Current Limit Inputs *(TB2, Terminals 4, 5, 6)*
The application of 0 to +5V DC at terminals 5 and 6 will vary the peak current available to the motor from 20 to 200% of the scaled rating. Leaving the terminals open sets the current limit at 200% of scaled motor current or the rated motor current value set with the Current Limit pot (R148). Jumpering the terminals will reduce the peak current to 20% of rated motor current or less.

Tachometer Output *(TB2, Terminal 7)*
A voltage corresponding to the motor velocity and direction of rotation will be present between this terminal and Signal Common. With jumper P1 set to "OUT," a voltage of ±2.5V DC/1000 RPM will be present (for 2000 and 3000 RPM motors). With P1 "IN," a voltage of ±1.5V DC/1000 RPM will be present (for 5000 RPM Bulletin 1326AB-AxG motors). Output current is 1mA maximum. Refer to section 5.3 for further information.

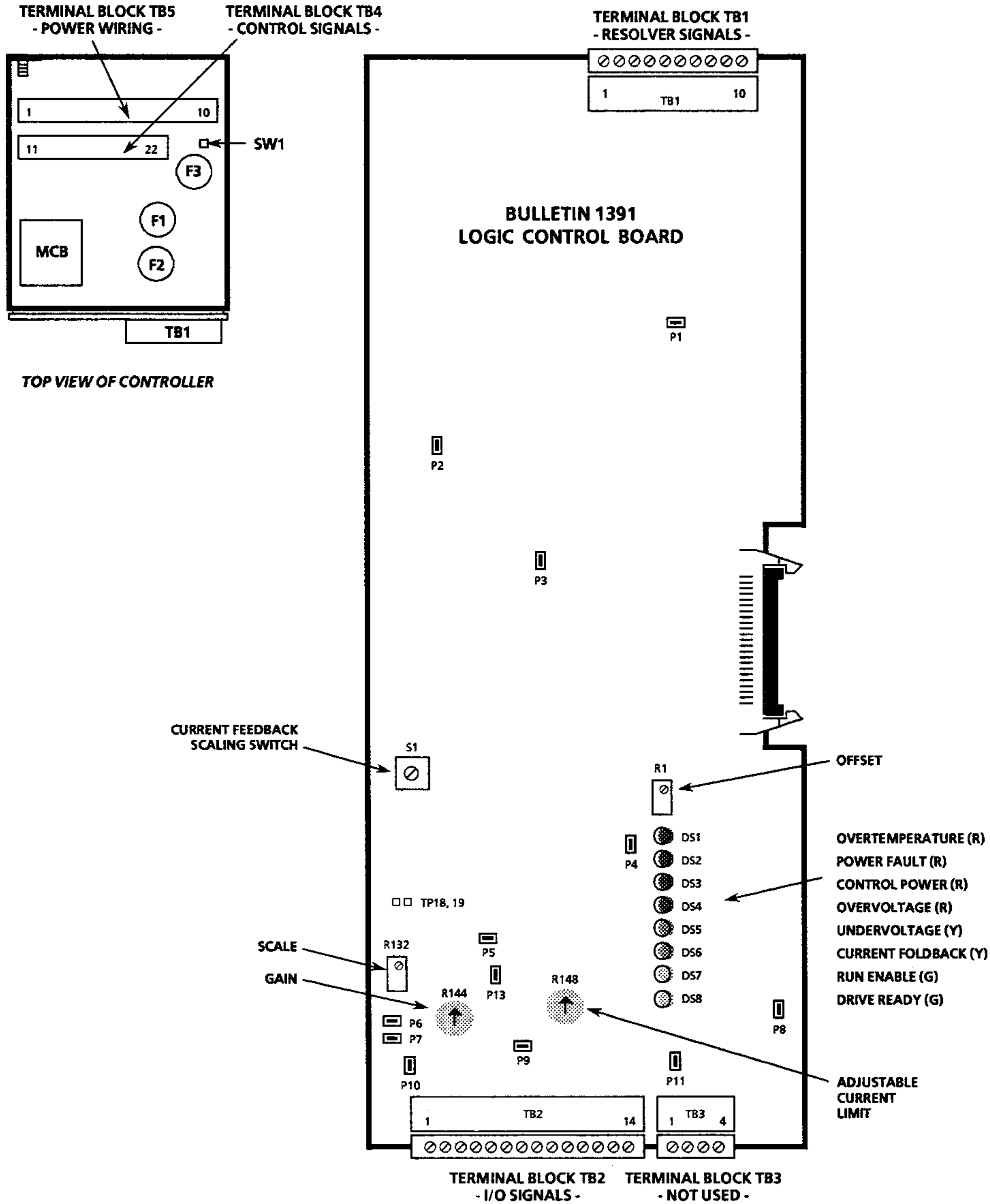


Figure 5.1 – Terminal Block, Potentiometer and Switch Locations

5.1
Inputs/Outputs
(Continued)

I Command Output *(TB2, Terminal 8)*
The voltage present between this terminal and Signal Common corresponds to the motor current. A voltage of ±3.0V DC (1mA out maximum) equals the rated motor current as set by switch S1.

Enable Input *(TB2, Terminals 9, 10)*
Normal Run commands to the controller are performed through the Enable input and any additional user supplied run control circuitry. With input power applied and the line contactor energized, a solid-state contact closure (rated +15 to +30V DC, 30mA) between TB2-10 & 12 or a mechanical contact closure between TB2-9 & 10 will cause the controller to run. When this input is de-energized, the control will cause a regenerative braking action in the motor.

Reset *(TB2, Terminal 11)*
Removing the Enable signal and momentarily connecting this terminal to Signal Common (TB2-12) will reset the controller after a controller fault occurs.

IMPORTANT: A Reset must ***not*** be initiated until the cause is determined and corrected.

Signal Common *(TB2, Terminal 12)*
Signal input reference point.

Low Bus *(TB2, Terminal 13)*
This terminal provides an open collector output rated at 12V DC, 5mA to indicate a low bus voltage condition. Reference to Signal Common.

Current Foldback *(TB2, Terminal 14)*
This terminal provides an open collector output rated at 12V DC, 5mA to indicate that current foldback is in operation. Reference to Signal Common.

TERMINAL BLOCK - TB3

Spares *(TB3, Terminals 1-4)*
Reserved for future use and are not to be used.

TERMINAL BLOCK - TB4

Drive OK (DROK) Contacts *(TB4, Terminals 17, 18)*
Application of power to the transformer energizes the logic supply of the controller. When 90% of rated DC Bus voltage is achieved and no controller faults are detected, this relay contact is closed. The contact remains closed until a controller fault occurs or power is removed from the transformer. Contact rating: 115V AC, 1A or 24V DC, 0.3A. Refer to *Jumper P8* on page 5-10 for further information.

35.5V AC Logic Supply Voltage *(TB4, Terminals 19, 20, 21)*
The isolation transformer contains four separate windings. Each winding supplies 35.5V AC with a center tap. The 35.5V AC leads are brought out to terminals 19 and 21 of TB4. The center tap must be connected to terminal 20 of TB4. See Chapter 9 for transformer details.

5.1
Inputs/Outputs
(Continued)

TERMINAL BLOCK - TB5

Motor Power Terminals *(TB5, Terminals 1, 2, 3)*
Motor power is provided at these terminals. Refer to Chapter 6 and Appendix B for connection details.

Input Power Terminals *(TB5, Terminals 4, 5, 6)*
The controller requires a 230V AC, three-phase, 50 or 60 Hz input supplied by the transformer secondary. Refer to Chapters 6, 9 and Appendix B for wiring and transformer information.

External Shunt Regulator Resistor *(TB5, Terminals 8, 9, 10)*
The 22.5A controllers have provisions to accept an external shunt resistor to supplement the integral unit. This is available for applications that require the dissipation of more regenerative energy to the DC Bus. To use an external shunt resistor, first remove the jumper at terminals 8 and 10 of TB5. Consult the Allen-Bradley sales office for application assistance.

The shunt regulator resistor supplied with the Bulletin 1391-AA45 must be externally mounted and connected to terminals 8 and 9 of TB5 prior to operation. Refer to Chapter 9 and Appendix B for details.

5.2
Potentiometer Adjustments

Preliminary adjustment of the Logic Control Board potentiometers is required as explained below. Descriptions of the potentiometers follow.

Initially the potentiometers shall be set as shown in Table 5.A. See Figure 5.1 for potentiometer locations.

Table 5.A
Initial Potentiometer Settings

Potentiometer	Setting
Current Limit (R148)	Fully counterclockwise
Velocity Gain (R144)	Fully counterclockwise, then clockwise 25%
Offset (R1) and Scale (R132)	Leave at the present setting until adjustment becomes necessary in the Start-Up procedure.

Current Limit *(R148)*
This single turn potentiometer adjusts the maximum current available to the servomotor. The maximum setting is 200% of the continuous motor rating and can be calibrated (fine tuned) using TP21 and the proportion: 3V DC = 100% continuous motor current.

Velocity Gain *(R144)*
This potentiometer is used to fine tune the response characteristics of the system. Clockwise rotation increases the dynamic gain of the servo amplifier, while counterclockwise rotation decreases gain. When used in conjunction with the velocity loop plug jumper (P6), the system response can be adjusted over a wide range.

Offset *(R1)*
Adjustment for system offset voltages is provided by this multi-turn pot.

Velocity Command Scale *(R132)*
This adjustment is a multi-turn pot that scales the command signal with the velocity feedback signal.

5.3 *Switch and Jumper Settings*

This section provides information on setting the Duty Cycle Selector switch (SW1), the Current Scaling switch (S1) and plug jumpers located on the Logic Control Board. Note that settings for Bulletin 1326**AP** motors are the same as Bulletin 1326**AB** motors.

DUTY CYCLE SELECTOR SWITCH - SW1

The Duty Cycle Selector Switch (SW1) which is located on top of the controller, modifies the behavior of the shunt regulator. The switch determines the temperature level and therefore the average power level at which the controller will fault. Refer to section 9.2 for detailed switch setting information.

CURRENT FEEDBACK SCALING SWITCH - S1

The Bulletin 1391 employs a current feedback scaling circuit which allows a controller to be used with Bulletin 1326 AC Servomotors having lower current ratings.

Tables 5.B and C provide the information necessary to correctly set the current feedback scaling using switch S1 (See Figure 5.1). Table 5.B provides general information on switch settings for typical motor/controller combinations. Table 5.C provides examples of switch settings for specific Bulletin 1326 AC Servomotors. Refer to the motor nameplate for actual rated current (I_C is continuous current rating in amperes).

IMPORTANT: The motor and controller rated current (as listed on their respective nameplates) should be noted and the correct adjustment of switch S1 made prior to applying power to the system.

Set S1 to a position equal or nearest to the rated motor current. One setting higher must be used if the motor current is between current ratings. Once the current feedback scaling is set, the current limit and peak current capabilities will be a function of the motor current rating and not the controller current rating.

Table 5.B
Typical Current Feedback Scaling

Motor Rated Current				
1391-AA15	1391-AA22	1391-AA45	1391B-AA45-A06①	S1 Switch Setting
15.0	22.5	45.0	–	F
14.1	21.1	42.2	–	E
13.1	19.7	39.4	–	D
12.2	18.3	36.6	–	C
11.3	16.9	33.8	–	B
10.3	15.5	30.9	–	A
9.4	14.0	28.1	33.8 - 45.0	9
8.4	12.6	25.3	30.4	8
7.5	11.3	22.5	27.1	7
6.6	9.8	19.7	23.7	6
5.6	8.5	16.9	20.3	5
4.7	7.0	14.1	16.9	4
3.8	5.7	11.3	13.5	3
2.8	4.2	8.4	10.1	2
1.9	2.8	5.6	6.8	1
0.9	1.4	2.8	3.4	0

① Due to the increased peak current rating of the Bulletin 1391B-AA45-A06 controller, a 10 position Current Feedback Scaling switch is used instead of the usual 16 position switch.

5.3
Switch and Jumper Settings
(Continued)

Table 5.C
Typical Scaling for Bulletin 1326 AC Servomotors

Bulletin 1326 AC Servomotor ③	I_C (A)	S1 Switch Setting ② 1391-AA15	1391-AA22	1391-AA45
1326AB-A1E	2.6	2	1	
1326AB-A2E	5.2	5	3	
1326AB-A3E	7.8	8	5	
1326AB-B1C	5.7	6	4	
1326AB-B1E	8.2	8	5	
1326AB-B2C	11.4	C	8	
1326AB-B2E	16.4		B	5
1326AB-B3C	17.0		C	6
1326AB-B3E	24.6			8
1326AB-B4E	35.7			C
1326AB-C1C	11.7	C	8	
1326AB-C1E	16.6		B	5
1326AB-C2C	23.3			8
1326AB-C2E	33.2			B
1326AB-C3C	34.4			C
1326AB-C3E	49.1			F
1326AB-C4B	38.2			D
1326AB-C4C	46.6			F
1326AD-K2G	4.8	5	3	
1326AD-K3G	4.9	5	3	
1326AD-K4F	4.9	5	3	
1326AD-K5E	4.8	5	3	

② For reference only. Refer to motor nameplate for rated current value.

③ Settings for Bulletin 1326**AP** and Bulletin 1326**AB** AC Servomotors are identical. If using blower, increase I_C by 35% and set S1 accordingly.

PLUG JUMPER SETTINGS

Prior to start-up, the Logic Board jumpers must be checked against the listing in Table 5.D to assure proper setting. Refer to Figure 5.1 for jumper locations and the paragraphs following Table 5.D for descriptions.

WARNING: Only personnel familiar with the Bulletin 1391 controller and its associated machinery should plan or implement the adjustment, calibration, start-up and subsequent maintenance of the controller. Failure to comply may result in personal injury and/or equipment damage.

CAUTION: An incorrectly applied or calibrated controller can result in component damage or a reduction in product life. Wiring or application errors, such as, undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures may result in malfunction of the controller.

IMPORTANT: Jumper P8 (Undervoltage Fault Latch) is different for Series A and B units. Series A units utilized a two position jumper to serve the A10 and A11 modifications as well as standard operation. Series B units have a three position jumper incorporating all of the P8 functions.

5.3 *Switch and Jumper Settings* *(Continued)*

IMPORTANT: The Bulletin 1391 Series B is suitable for use with 5000 RPM Bulletin 1326 AC Servomotors. However, restrictions still apply to Series A controllers. Consult your Allen-Bradley Sales representative for further information.

Table 5.D
Plug Jumper Descriptions

Jumper	Description	Setting	
P1	Tach Output Voltage Select	IN OUT	1.5V/kRPM - 1326AP/AB-Axx, 1326AD 2.5/kRPM - all 1326AP/AB-Bxx, Cxx *
P2	I_D Cut In	IN OUT	High speed motor (see description)* Low speed motor (see description)
P3	Electronic Counterbalance	IN OUT	Counterbalance enabled Counterbalance not used*
P4	Reserved for Future Use - See Description	IN OUT	N/A Normal operation*
P5	Velocity Error Disable	IN OUT	Torque block operation Velocity loop operation*
P6	Velocity Loop Compensation	IN OUT	High system inertia (>3 x motor) Normal system operation*
P7	Velocity Compensation Defeat	IN OUT	Torque block operation Velocity loop Operation*
P8	Undervoltage Fault Sense	A B OUT	Sensed but not latched Latched fault (IN on Series A) Not sensed* (OUT on Series A)
P9	I Limit	IN OUT	Option 200% standard*
P10	Velocity Command Range	If jumper **P1** is "**IN**," then set P10 as follows: IN OUT If jumper **P1** is "**OUT**," set P10 as follows: IN OUT	 2.5-5V per 1000 RPM 1.5-2.5V per 1000 RPM* 4-7V per 1000 RPM 2.5-4V per 1000 RPM*
P11	Preload (Anti-backlash)	IN OUT	Anti-backlash Velocity loop operation*
P13	Motor Compensation (Series B Only)	IN OUT	Compensation All 1326AP and 1326AB motors*
TP18 to TP19		IN OUT	Torque block operation Velocity loop operation*

* Denotes jumper status at time of shipment.

Tachometer Output Voltage Select *(P1)*

Jumper **P1** is used to configure the Bulletin 1391 tachometer synthesis circuitry to a range appropriate for the applied motors. Select the "**IN**" position for all Bulletin 1326AP/AB-Axx and 1326AD motors. "**OUT**" is used for Bulletin 1326AP/AB-Bxx and Cxx motors.

I_D Cut In *(P2)*

This jumper sets the I_D cut in speed. I_D is a phase specific current added to the torque producing current at higher speeds to extend the performance range of the controller. The I_D point differs with the motor used. Refer to Table 5.E for jumper settings. For motors not listed, consult your Allen-Bradley Sales Representative.

5.3
Switch and Jumper Settings
(Continued)

Table 5.E
P2 Jumper Settings

Catalog Number④	P2 Jumper Setting	Catalog Number④	P2 Jumper Setting
1326AB-A1E	IN	1326AB-C1C	OUT
1326AB-A1G	IN	1326AB-C1E	IN
1326AB-A2E	IN	1326AB-C2C	OUT
1326AB-A2G	IN	1326AB-C2E	IN
1326AB-A3E	IN	1326AB-C3C	OUT
1326AB-A3G	IN	1326AB-C3E	IN
1326AB-B1C	OUT	1326AB-C4C	OUT
1326AB-B1E	IN	1326AB-C4B	OUT
1326AB-B2C	OUT	1326AD-K2G	OUT
1326AB-B2E	IN	1326AD-K3G	OUT
1326AB-B3C	OUT	1326AD-K4F	OUT
1326AB-B3E	IN	1326AD-K5E	OUT

④ Settings for Bulletin 1326AP and Bulletin 1326AB AC Servomotors are identical.

Electronic Counterbalance *(P3)*
P3 configures the controller to produce an offset torque for use on uncounterbalanced axes. When the jumper is placed to the "IN" position, the controller can be adjusted to produce a constant current (torque) offset of user calibrated magnitude. The "OUT" position provides operation without the electronic counterbalance/torque offset feature (horizontal and counterbalanced axes will use the "OUT" jumper position). Refer to the following *Calibration and Adjustment Procedure.*

1. Ensure that all power to the controller has been removed.
2. Connect a wire between terminals 1 and 2 of TB2.
3. Assure that the Current Feedback Scaling switch is set properly for the motor being used.
4. Connect a DC voltmeter (analog or digital) between TP22 and TP12 on the Logic Control Board.
5. Apply power, enable controller and release brake (or other mechanical holding mechanism) on the uncounterbalanced axis. Adjust R1 (Offset) on the vertical LED Board to minimize any drift on the axis.
6. Observe and record the voltage at TP22 for use in the following calculations.
7. Reset the brake and disable the controller by removing power.
8. Insert a jumper at position P3 on the Logic Control Board.
9. Apply power, enable controller and release the brake (or other mechanical holding mechanism) on the uncounterbalanced axis. Adjust R60 on the Logic Control Board until a reading of approximately 0V DC is obtained. Readjust R1 (vertical LED Board) if necessary, to eliminate any drift caused by the R60 adjustment.
10. Disable controller by removing power. Remove the wire between terminals 1 & 2 of TB2, leaving jumper P3 in place. This completes the procedure.

5.3
Switch and Jumper Settings
(Continued)

IMPORTANT: Electronic counterbalance introduces a torque offset which is seen as a constant current command by the controller. The sum of this command and the current limit setting must not exceed the peak current rating of the controller. Refer to the following as a check.

Icbal = (TP22 reading / 3) x S1 Setting in Amperes
Ipeak = Controller Continuous Rating x 2
% I Limit < = (Ipeak – Icbal) / S1 Switch Setting (amperes) or 200% (whichever is less)
Voltage at TP21 = % I Limit x 3 (6V DC maximum)

EXAMPLE
Assume a 45A controller and a 1326AB-C3E motor. The S1 setting for this motor is "F" which scales the current feedback for 45.0A. Following the above procedure a voltage of 1.5V DC was observed.

Icbal = (1.5 / 3) x 45.0 = 22.5A
Ipeak = 45 x 2 = 90A
% I Limit < = (90 – 22.5) / 45.0 = 1.5
Voltage at TP21 = 1.5 x 3 = 4.5V DC

Therefore R148 should be adjusted to obtain a reading of 4.5V DC at TP21 on the Logic Board.

The duty cycle must also be considered when using electronic counter-balance to ensure that the continuous RMS rating of the motor is not exceeded.

Reserved for Future Use *(P4)*
This jumper is not functional on all Bulletin 1391 controllers as of this publication date. Previously published literature refers to this jumper as "Anti-backlash Option" anticipating future use. However, this jumper is not required in anti-backlash applications and is now reserved for future controller enhancements. Refer to the *Bulletin 1388-XA Anti-backlash Module Instruction Manual,* for information on using the Bulletin 1391 in anti-backlash applications.

Velocity Error Disable *(P5)*
Jumper P5 is used to disable the velocity error amplifier and is used with jumpers P7, TP18 and TP19 to configure the controller for torque block operation. In torque block mode the controller acts as a current amplifier producing current (torque) proportional to the command present at terminals 1 and 2 of TB2. Note that the Command Scale and Velocity Loop Gain potentiometers (R132 & R144) have no effect in the torque block mode. Scaling for torque block is 3V Command = 100% of the S1 Current Setting (i.e. motor rated current). Place jumper P5 to the "IN" position for torque block operation and "OUT" for velocity loop operation.

Velocity Loop Compensation *(P6)*
This jumper is used to compensate the velocity loop for applications with higher load inertia. Position the jumper to "IN" for high inertia compensation. High inertia compensation will generally improve performance on systems with load inertias greater than three times motor rotor inertia, although the user may wish to evaluate the impact of this compensation at slightly lower inertias.

5.3
Switch and Jumper Settings
(Continued)

Velocity Compensation Defeat *(P7)*
P7 is used to defeat the integral portion of the velocity loop compensation for torque block operation. This jumper is used in conjunction with jumpers P5, TP18 and TP19. Refer to the Velocity Error Disable jumper (P5) for further information. Position the jumper to "IN" for torque block operation and "OUT" for velocity loop operation.

Undervoltage Fault Sense *(P8)*
The Series B version of the Bulletin 1391 utilizes a three position jumper; A, B and OUT. This jumper is used to determine controller response to bus undervoltage. The jumper position will depend on user preference.

Bus undervoltage is defined as the point at which the DC bus voltage is less than 50% of its nominal operating value of 300 volts. Low bus voltage can affect the controllers ability to produce torque.

When P8 is "OUT," a bus undervoltage will not cause the DROK ("Drive OK") contacts to open. This is the same as the "OUT" position on all series A controllers.

The "B" position will cause the DROK contacts to open and remain open for a bus undervoltage until a reset is performed after the bus voltage is acceptable. Note that in this position, bus undervoltage is ignored on initial power up and therefore the bus must first reach a voltage level of 150V DC before a subsequent fall below this will be flagged. This jumper position is equivalent to the "IN" position on Series A controllers <u>without</u> the A10 or A11 options.

The "A" position will cause the DROK contacts to open for a bus undervoltage, but they will only remain open while the undervoltage condition exists. Barring other faults or user actions, the DROK contacts will close without any user intervention when the bus voltage is restored. This jumper position is equivalent to the "IN" position on Series A controllers <u>with</u> the A10 or A11 options.

IMPORTANT: In all cases regardless of interaction with the DROK contacts, the transistor bridge is disabled upon an undervoltage. This is done to protect the output transistors from voltage transients.

I Limit *(P9)*
Jumper P9 configures the controller for special current limit options. It is only active on special option controllers. Consult your Allen-Bradley Sales Representative for further information. This jumper must be set to the "OUT" position.

5.3
Switch and Jumper Settings
(Continued)

Velocity Command Range *(P10)*
Jumper P10 is used to configure the velocity command range. The setting of this jumper is dependent on the position of the P1 jumper.

When P1 is "IN," the P10 "IN" position will configure the controller for input commands of 2.5 to 5V DC per 1000 RPM. When P1 is "IN" and P10 is "OUT" the controller will be configured for 1.5 to 2.5V DC per 1000 RPM.

When P1 is "OUT," the P10 "IN" position will configure the controller for input commands of 4 to 7V DC per 1000 RPM. When P1 and P10 are "OUT" the controller will be configured for 2.5 to 4V DC per 1000 RPM.

The controller can be adjusted in the above ranges by using the Scale potentiometer (R132). The controller should always be set to use the widest practical command range for best resolution.

IMPORTANT: The maximum command voltage must not exceed ±10.0V DC.

Max. Command Volts = Scale (V/kRPM) x Max. Motor Speed (kRPM)

Anti-backlash *(P11)*
This jumper is used to configure the controller for use with the Bulletin 1388-XA Anti-backlash Module. Refer to the *Anti-backlash Module Instruction Manual* for further information. For applications not using anti-backlash, the jumper must be positioned to "OUT."

Special Motor Compensation *(P13)*
This jumper is used only for special option motors and must be set to "OUT" for all Bulletin 1326AB, AD and AP motors. Consult your local Allen-Bradley Sales Representative for further information.

TP18 to TP19
This is used for configuring the controller for torque block operation in conjunction with jumpers P5 and P7. Place the jumper to the "IN" position for torque block operation. This connects the command amplifier direct to the current command input. Place the jumper to the "OUT" position for all velocity loop applications. Refer to Jumper P5 for further information.

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Chapter

6

Installation

6.0 Chapter Objectives

Chapter 6 provides the information needed to mount and wire the Bulletin 1391 Servo Controller for operation. Since most start-up difficulties are the result of incorrect wiring, every precaution must be taken to assure that the wiring is done as instructed. **All items must be read and thoroughly understood before the actual installation begins.**

WARNING: The following information is merely a guide for proper installation. The National Electrical Code and any other governing regional or local code will overrule this information. The Allen-Bradley Company **cannot** assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this controller or associated equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

6.1 Mounting

Mounting dimensions for the Bulletin 1391 Servo Controller can be found in Appendix A. Chapter 2 provides information on power dissipation and environmental specifications. The controller must be located on a flat, rigid, vertical surface and must **not** be subjected to shock, vibration, moisture, oil mist, dust, corrosive vapors, etc. or temperatures that exceed 60° C (140°F) ambient.

Controllers can be mounted adjacent to each other with a minimum clearance of 0.312" (7.9mm) between units and/or surrounding cabinetry and non-current carrying surfaces. However, it is recommended that a space of approximately 1.0" (25.4mm) be left between adjacent units to allow easy access and removal of the front cover. To allow for proper airflow, a minimum clearance of 3.0" (76.2mm) is required along the top and bottom of the unit and any adjacent components.

The transformer that supplies 230V AC, three-phase and 35.5V AC to each servo controller must have 3" (76.2mm) of clearance around it and any adjacent components. This will allow for proper airflow and wiring access. The transformer can be mounted in either a horizontal or vertical position.

CAUTION: The installation of the controller must be planned such that all cutting, drilling, tapping and welding can be accomplished with the controller removed from the enclosure. The controller is of the open type construction and any metal debris must be kept from falling into it. Metal debris or other foreign matter may become lodged in the circuitry resulting in component damage.

6.2 *Wiring Recommendations*

General Information
The information supplied in this manual on wire sizes, practices, layouts, system configurations and grounding/shielding techniques for the Bulletin 1391 Servo Controller are presented as guidelines. Due to the diversity of applications and systems, no single method of wiring is completely applicable.

IMPORTANT: This information represents common PWM servo system wiring configurations, size and practices that have proven satisfactory in a majority of applications. The National Electrical Code, local electrical codes, special operating temperatures, duty cycles or system configurations will take precedence over the values and methods listed.

Wire Sizes
Unless noted, the wire sizes in this manual are recommended minimums and assume type MTW wire (machine tool wire, 75° C, minimum) per NFPA 79. Since ambient conditions vary widely, on certain applications, a derating factor has to be taken into account. Consult the National Electrical Code for factors on ambient conditions, length etc. or the Allen-Bradley Sales Representative in your area for further information.

Shielding
Reasonable care must be taken when connecting and routing power and signal wiring on a machine or system. Radiated noise from nearby relays (relay coils should have surge suppressors), transformers, other electronic drives, etc. may be induced into the velocity command signal lines causing undesired movement of the servomotor.

To help alleviate the problem, machine power and signal lines must be routed separately. The Bulletin 1391 power and signal lines must be shielded, twisted and routed in separate conduit or harnesses spaced at least 12" (304.8mm) apart. Power leads are defined here as the transformer primary and secondary leads, motor leads and any 115V AC or above control wiring for relays, fans, thermal protectors etc. Signal wiring is defined as velocity command, resolver feedback, enable lines and low level logic signal lines.

Feedback, command signal and other shields must be insulated from each other and connected at a common machine or system earth ground in a "star" fashion (i.e. all shields connected to a single earth ground point). This helps to minimize radiated and induced noise problems and ground loops. Refer to the paragraph entitled "Grounding" and Appendix B.

Open ended shields (resolver feedback cable at the resolver and velocity command cable at the servo controller) must be insulated so that they do not accidentally cause ground loops.

6.2
Wiring Recommendations
(Continued)

EMI Shielding
The Bulletin 1391 has an inverter carrier frequency of 2500 Hz. Therefore, the system may induce noise into sensitive equipment lines adjacent to it.

WARNING: This controller can produce electromagnetic radiation that may cause industrial or radio controlled equipment to operate erratically and cause possible injury to personnel.

The Bulletin 1391 system is designed to be interconnected with Allen-Bradley EMI shielded motor cables only. ***Do Not*** substitute cables. The EMI shield of the motor cable only, must be grounded at ***both*** ends to function properly.

IMPORTANT: The thermal switch and brake wires are routed near motor power and can pickup PWM radiation. Isolation from control devices may be required.

Grounding
All equipment and components of a machine or process system shall have their chassis connected to a common earth ground point. This ground system provides a low impedance path that helps minimize shock hazards to personnel and damage to equipment caused by short circuits, transient overvoltages and accidental connection of energized conductors to the equipment chassis.

Grounding requirements, conventions and definitions are contained in the National Electrical Code. Local codes will usually dictate what particular rules and regulations are to be followed concerning system safety grounds. See Appendix B.

6.3
Wiring

WARNING: The National Electrical Code (NEC) and local codes outline provisions for safely installing electrical equipment. Installation must comply with specifications regarding wire types, conductor sizes, branch circuit protection, motor overload protection and disconnect devices. Failure to do so may result in personal injury and/or equipment damage.

The Interconnect Drawing presented in Appendix B provides typical interconnection wiring for the Bulletin 1391 AC Servo Controller. Typical control logic circuitry (starting and stopping), motor interconnections and grounding techniques are shown.

6.3
Wiring
(Continued)

Motor Wiring - The motor wiring size is determined by the continuous and overload current requirements (RMS Duty Cycle), NEC and local codes. In general, motors operated from the following controllers would not require wire sizes larger than those accepted by TB5, but codes must be followed. In addition, the motor leads must be twisted throughout their entire length to minimize radiated electrical noise. The use of Allen-Bradley Bulletin 1326 cables are recommended where applicable. The maximum motor wire sizes that the Bulletin 1391 controller will accept are shown in Table 6.A.

Table 6.A
Maximum Motor Wire Sizes (TB5)

Controller Catalog Number	Maximum Wire Size Accepted
1391-AA15	#8 AWG - MTW
1391-AA22	#8 AWG - MTW
1391-AA45	#8 AWG - MTW

WARNING: To guard against hazard of personal injury or damage to equipment, the interconnections to the motor and resolver must be made exactly as shown in Appendix B. Failure to do so could cause loss of motor control and/or severe oscillation of the motor shaft.

Transformer Wiring - The transformer secondary (230V AC, three-phase) connection to the controller is phase insensitive and is shown in Appendix B. The maximum wire size TB5 will accept is 8 AWG. Refer to Chapter 9 for the transformer wiring diagrams.

The *minimum* recommended wire sizes for the transformer secondary are listed below.

Table 6.B
Minimum Transformer Wire Sizes

	kVA					
Input V AC	1.5	3.5	5.0	10.0	12.5	15.0
208	#12	#12	#12	#8	#8	#6
240	#12	#12	#12	#8	#8	#8
380	#12	#12	#12	#10	#10	#8
415	#12	#12	#12	#12	#10	#10
480	#12	#12	#12	#12	#10	#10
575	#12	#12	#12	#12	#12	#10

IMPORTANT: All wire sizes are AWG. The transformer primary requires protection by means of a customer supplied branch circuit disconnect device. Refer to Appendix B.

6.3
Wiring
(Continued)

Fusing (Transformer Primary) - Time delay fusing similar to Bussman Fusetron FRS Series or equivalent must be used if the primary circuit is fused. Circuit breakers must provide equivalent operation.

Fuse ratings shown in Table 6.C are the highest ratings allowed in a 25° C (77° F) ambient temperature. Higher electrical enclosure ambient temperatures will require fuses with higher current ratings. Consult fuse manufacturer's derating data. Fuses larger than those listed below may result in transformer damage.

Table 6.C
Fuse Current Rating (A)

Primary Voltage	kVA					
	1.5	3.5	5.0	10.0	12.5	15.0
208V AC	8	17.5	20	40	50	60
240V AC	7	15	20	35	45	50
380V AC	4.5	9	12	25	30	35
415V AC	4	8	12	20	25	30
480V AC	3.5	7	10	17.5	25	30
575V AC	3	6	8	15	20	25

External Shunt Regulator Resistor - The external Shunt Regulator Resistor and fuse for the 45A Bulletin 1391 must be connected to TB5-8 and TB5-9 as described in Chapter 9.

22.5A controllers must be converted for use with an external shunt resistor and fuse. Refer to Chapter 9 for detailed instructions.

Interface Connections - Refer to Chapter 5 and Appendix B for connection information.

Motor Option Wiring - Wiring information is provided in Chapter 8 for the Blower Mod and Brake Power Supply kits.

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Chapter

7

Start-Up

7.0
Chapter Objectives

Chapter 7 provides the steps needed to properly start-up the Bulletin 1391 AC Servo Controller. Included in the procedure are typical adjustments and voltage checks to assure proper operation.

7.1
Start-Up Procedure

The following procedure provides the required steps to start-up the Bulletin 1391 AC Servo Controller in velocity and position mode.

⚠ **WARNING:** Power must be applied to the controller to perform many of the adjustments specified in the following paragraphs. Voltages behind the front panel are at incoming line potential. To avoid injury to personnel and/or damage to equipment, only qualified service personnel should perform the following start-up procedures. Thoroughly read and understand the following procedure before beginning the Start-Up Procedure. If an event does not occur while performing this start-up, **Do Not Proceed. Remove Power** by opening the branch circuit disconnect device and correct the malfunction before continuing.

⚠ **WARNING:** This product contains stored energy devices. To avoid hazard of electrical shock, verify that all voltage on the capacitors has been discharged before attempting to service, repair or remove this unit.

Voltage at terminals 9 (+) and 7 (–) of TB5 *must* be "0.00" as measured with a standard digital voltmeter or multimeter.

Only qualified personnel familiar with solid-state control equipment and safety procedures in publication NFPA 70E should attempt this procedure.

☐ 1. Most start-up difficulties are the result of wiring errors. Therefore, prior to applying power to the primary of the transformer or system, check all of the system interconnection wiring.

☐ 2. Check terminal block connections as described in Chapter 5 and Appendix B.

☐ 3. Assure that preliminary adjustment of the following items has been performed:

- Potentiometer adjustments as described in section 5.2.
- Switch and jumper settings as described in sections 5.3 and 9.2.

IMPORTANT: The above adjustments must be performed before proceeding.

☐ 4. Turn the controller circuit breaker (MCB) OFF.

7.1 Start-Up Procedure
(Continued)

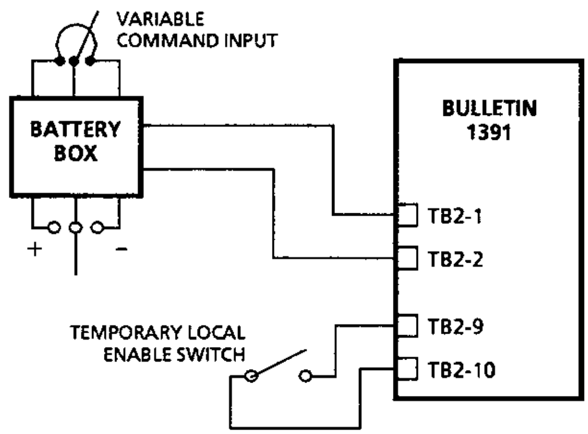

Figure 7.1 – Local Control Connections

☐ 5. Apply power to the transformer, but **DO NOT** enable the controller or energize the line/DB contactor (M).

☐ 6. Using a voltmeter, verify that the voltages listed below are present at the locations shown. The tolerance for all voltages is ±10%. Clear faults before replacing any blown fuses.

Location	Voltage
TB5-4 to TB5-5	230V AC
TB5-4 to TB5-6	230V AC
TB5-5 to TB5-6	230V AC
TB4-19 to TB4-20	18V AC
TB4-21 to TB4-20	18V AC
TB4-21 to TB4-19	35.5V AC
TP13 to TP12	+12V DC
TP14 to TP12	−12V DC

☐ 7. Remove all power to the transformer.

☐ 8. The wires connected to terminals 9 and 10 of TB2 must be marked and removed to allow for local operation of the Enable circuit. Connect a suitable temporary switch between these terminals and insulate the switch connections. See Figure 7.1.

☐ 9. The wires connected to terminals 1 & 2 of TB2 (Velocity Command Input) must be marked and removed. A ±10V DC local control (battery box) is to be connected to these terminals. See Figure 7.1.

The polarity of the Command signal from the battery box should be the same as the actual control source to assure correct motor rotation when the controller is placed into operation as part of the system.

7.1
Start-Up Procedure
(Continued)

CAUTION: Even though the Command SCALE potentiometer is set to zero, the servomotor may begin to rotate and cause incorrect machine movement when the controller is enabled. Be prepared to remove controller power by opening (MCB) or the branch circuit disconnect device if this occurs. This movement may be due to a wiring error or system component malfunction and **must be corrected** before proceeding with this procedure. Damage to machine system components can occur due to uncontrolled machine movements.

It is recommended that the motor be mechanically disconnected from the load if:

A) Improper direction of rotation could cause damage to equipment.
B) Uncontrolled motor rotation due to improper phasing will cause damage to the equipment.

☐ 10. Once control connections are made:

a) Set Command input to zero at the battery box.
b) Open Enable switch.
c) Apply power to the transformer primary.
Place the circuit breaker (MCB) to the ON position. The green DRIVE READY LED should illuminate.

IMPORTANT: If power is applied while the controller is enabled, one or more Fault LED's will illuminate and disable the controller. The controller may be reset by removing the Enable signal and momentarily grounding the $\overline{\text{Reset}}$ terminal (TB2-11). An alternate method would be to remove and reapply the branch circuit or controller power (MCB) with the Enable input removed.

WARNING: In the following step, reverse rotation or uncontrolled rotation at high speed can occur. To guard against injury, read through the procedure *before* attempting to start the motor.

☐ 11. With a 10% Command input signal applied to terminals 1 and 2 of TB2, *momentarily* close the local Enable switch and observe motor speed and direction of rotation. The motor should rotate slowly under control (following the Command signal). If the motor is under control but rotating in the wrong direction, reverse the command input signal polarity and note the change on the machine interconnection drawing.

If the motor is uncontrollable, check the feedback wiring at the controller and check for correct phasing of the motor leads. If this does not correct the problem, the position feedback device may be incorrectly phased. Check that the current feedback scaling is set properly and slowly adjust the Current Limit potentiometer (R148) to the maximum clockwise position.

7.1
Start-Up Procedure
(Continued)

- ☐ 12. Open the Enable switch and branch circuit disconnect.

- ☐ 13. Remove battery box and connect a jumper between terminals 1 and 2 of TB2. Apply power and close the Enable switch. Adjust the Velocity Loop OFFSET potentiometer (R1) to obtain zero rotation of the motor shaft.

- ☐ 14. Open the branch circuit disconnect. Remove jumper and reconnect the wires removed in step 9. Reapply power.

- ☐ 15. On position controlled systems, the position loop gain (system following error) should be set by adjusting the Velocity Command SCALE potentiometer (R132) while commanding various moves from the position controller to achieve desired following error.

  On velocity controlled systems (no position loop), the Velocity Command SCALE pot (R132) should be adjusted to give the desired motor speed at the maximum command (reference) voltage.

- ☐ 16. If the proper position loop gain (following error adjustment) or speed cannot be set at maximum motor speed, plug jumpers P6 and P10 may be improperly set (see section 5.3).

- ☐ 17. **IMPORTANT:** Before performing this step, ensure that the GAIN pot is set to "3" or below. A setting higher than "3" could cause the motor to vibrate violently.

  Adjust the Velocity GAIN potentiometer (R144) and insert/remove plug jumper P6 as needed. The GAIN adjust pot is used to fine tune the servo system response, jumper P6 will provide varying degrees of response. Setting GAIN at position #4 and removing P6 will give satisfactory response for most applications. If further optimization of the system response is required, the *System Compensation Procedure* should be followed. If optimization is not required, proceed to step 20.

System Compensation Procedure

- ☐ 18. Monitor the velocity feedback signal at terminals 6 (common) and 7 of TB2 with an oscilloscope or chart recorder.

WARNING: If an oscilloscope (or chart recorder) is used during Start-Up or Troubleshooting, it **must** be properly grounded. The oscilloscope chassis may be at a potentially fatal voltage if not properly grounded. Always connect the oscilloscope chassis to earth ground.

When using an oscilloscope (or chart recorder) it is recommended that the test probe ground be connected to TP12.

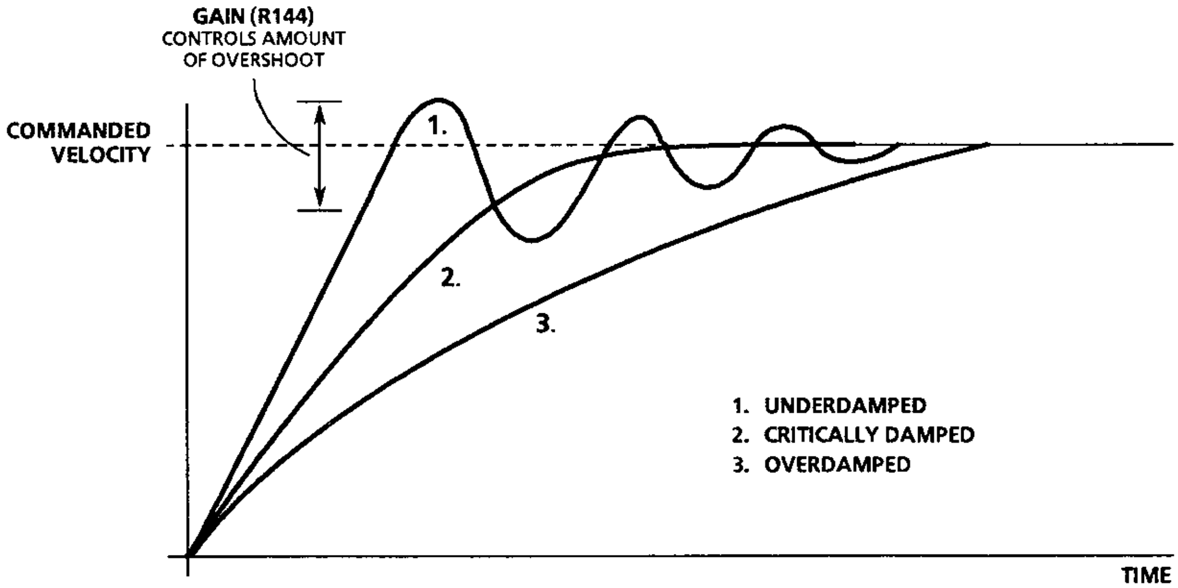

Figure 7.2 – Velocity Response Profiles

***7.1 Start-Up Procedure** (Continued)*

- ☐ 19. Adjust the Velocity GAIN potentiometer (R144) and observe the velocity response (at TB2-7) profile at various levels of step input speed commands. Response curve #1 in Figure 7.2 with a single velocity overshoot of 20-30% on accel and decel is optimal on a point to point positioning or velocity controlled system. Response curve #2 is desirable on a contouring or metal removing system.

  The GAIN pot should be adjusted so that the motor achieves the commanded speed or final position as quickly as possible with no overshoot. In addition to the dynamic response, the motor shaft should not oscillate or exhibit any erratic motion at zero speed.

- ☐ 20. Remove power with the branch circuit disconnect.

- ☐ 21. Remove the local Enable switch and reconnect external wiring.

- ☐ 22. Apply power and check system operation.

- ☐ 23. Remove power with the branch circuit disconnect and if necessary, reconnect motor to load.

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Chapter

8

Operation with the Bulletin 1326 AC Servomotor

8.0 Chapter Objectives

Chapter 8 describes the operation of a standard Bulletin 1326 AC Servomotor with the Bulletin 1391 AC Servo Controller. General information on the blower motor, integral holding brake and shaft oil seal kit is also provided. For further information on Allen-Bradley AC Servomotors, refer to publication 1326A-2.3.

8.1 Introduction

In general, the Bulletin 1326 motor will follow the speed-torque curve shown in Figure 8.1.

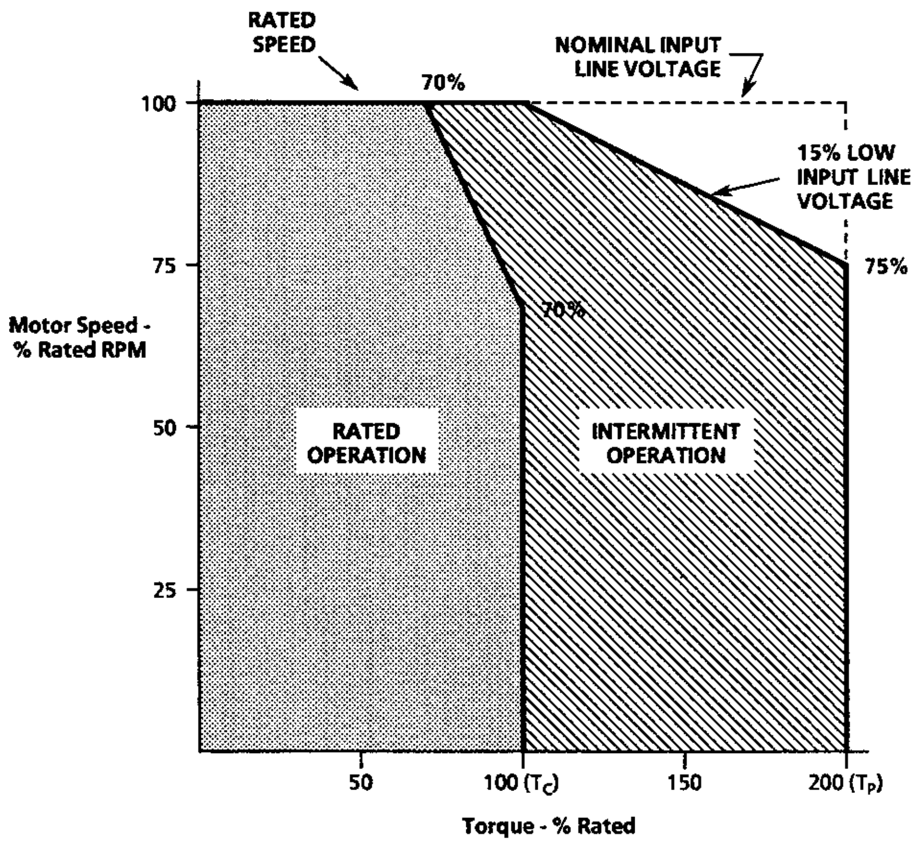


Figure 8.1 – Typical Bulletin 1326 Speed-Torque Curve

T_C – Rated Torque of motor with windings at rated temperature and an ambient of 40°C. The controller is operating in a rated ambient of 60°C.

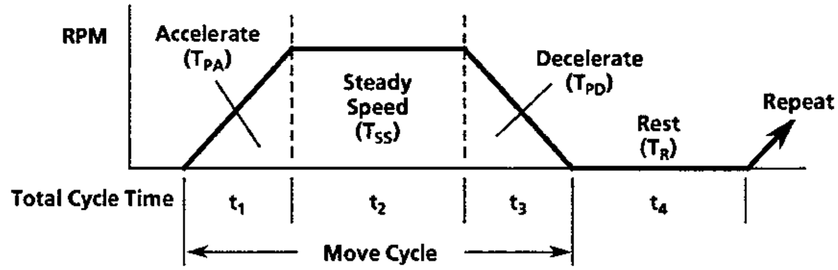
T_P – the Peak Torque that can be produced by the motor and controller combination with both at rated temperature and the motor in a 40°C ambient and the controller in a 60°C ambient. Since 200% current torque peaks are common in many applications for optimal controller usage, the following curves show typical system performance. Higher peak torques are permissible where RMS torque is less than or equal to the rated torque (T_C).

8.1
Introduction
(Continued)

Rated Speed – the operating speed of the controller and motor combination at which a minimum of 70% of continuous rated torque (T_C) can be developed. This point is defined with the motor at 25°C and controller operating in a 60°C ambient.

Rated Operation Area – boundary of speed-torque curve where the motor and controller combination may operate on a servo basis without exceeding the RMS rating of either.

Duty Cycle Profile



$$Torque = \sqrt{\frac{T_{PA}^2 \times t_1 + T_{SS}^2 \times t_2 + T_{PD}^2 \times t_3 + T_R^2 \times t_4}{t_1 + t_2 + t_3 + t_4}}$$

where:

T_{RMS}	The motors RMS or average torque over the duty cycle. (Expressed in Lb.-In. or Lb.-Ft. The same units must be used throughout the formula.)
T_{PA}	Motor peak torque to accelerate to maximum speed. (Expressed in Lb.-In. or Lb.-Ft. The same units must be used throughout the formula.)
T_{SS}	Motor torque present at the motor shaft during constant speed segment. (Expressed in Lb.-In. or Lb.-Ft. The same units must be used throughout the formula.)
T_{PD}	Motor peak torque to decelerate to zero speed. (Expressed in Lb.-In. or Lb.-Ft. The same units must be used throughout the formula.)
T_R	Torque when motor is at zero speed.
t_1, t_2, t_3, t_4	Time for each portion of the duty cycle in seconds.

Note:

To convert Newton-Meters to Lb.-Ft., multiply by 0.7376

To convert Newton-Meters to Lb.-In., multiply by 8.8512

Intermittent Operation Area – boundary of speed-torque curve where the motor and controller combination may operate in acceleration-deceleration mode without exceeding peak rating of either, provided that the duty cycle RMS continuous torque limit is not exceeded.

8.1 Introduction (Continued)

Table 8.A contains the Bulletin 1326AB performance data. Included is a selection list detailing the performance parameters of selected amplifier/motor combinations.

Table 8.A
Bulletin 1391B/1326AB Performance Data

Continuous Stall Torque (T_C) *Lb.-In./N-m*	Peak Stall Torque (T_P) *Lb.-In./N-m*	Rated Speed *RPM*	Motor Catalog Number	Servo Controller Catalog No.	Amperes at Continuous Torque (I_C)	Rotor Inertia (J_M) *Lb.-In.-Sec²/Kg-m²*	Rated Output *kW*
48/5.4	96/10.84	3000	1326AB-A3E	1391B-AA15	7.8	0.010/0.001	1.2
93.3/10.53	186.6/21.0	3000	1326AB-B2E	1391B-AA15	16.4	0.05/0.006	2.28
102/11.5	204/23.0	3000	1326AB-B2E	1391B-AA22	16.4	0.05/0.006	2.5
140/15.8	280/31.6	3000	1326AB-B3E	1391B-AA22	24.6	0.08/0.009	3.5
153/17.3	306/34.6	3000	1326AB-B3E	1391B-AA45	24.6	0.08/0.009	3.8
210/23.7	420/47.5	3000	1326AB-C2E	1391B-AA45	33.2	0.14/0.015	5.2
310/35.0	568/64.1	3000	1326AB-C3E	1391B-AA45	49.1	0.22/0.024	7.5
420/47.4	811/91.7	2000	1326AB-C4C	1391B-AA45	45.6	0.29/0.032	7.0
420/47.4	840/94.8	1600	1326AB-C4B	1391B-AA45	38.2	0.29/0.032	5.6

① All ratings are for 40°C motor ambient, 110°C case and 60°C amplifier ambient. For extended ratings at lower ambients, consult Allen-Bradley.

8.2 Bulletin 1326AB Motor Options

General information on the Blower mod kit, Integral Holding Brake and Shaft Oil Seal kit are presented on the following pages. Refer to Appendix B for motor interconnection information.

Blower Mod Kit (1326AB-MOD-G3)
The kit consists of an impedance protected fan (UL recognized, CSA Approved), housing, grille guard and necessary hardware. Refer to the specifications below and Figure 8.2 for connection and dimension information.

SPECIFICATIONS

INPUT VOLTAGE	220/230V AC, 50/60 HZ, 1-PH.
LINE AMPERES	0.15/0.14
AIR INLET CLEARANCE	6" (152.4)

IMPORTANT: THE BULLETIN 1326AB-MOD-G3 OPTION KIT MUST NOT BE USED IN ENVIRONMENTS REQUIRING IP 65 PROTECTION.

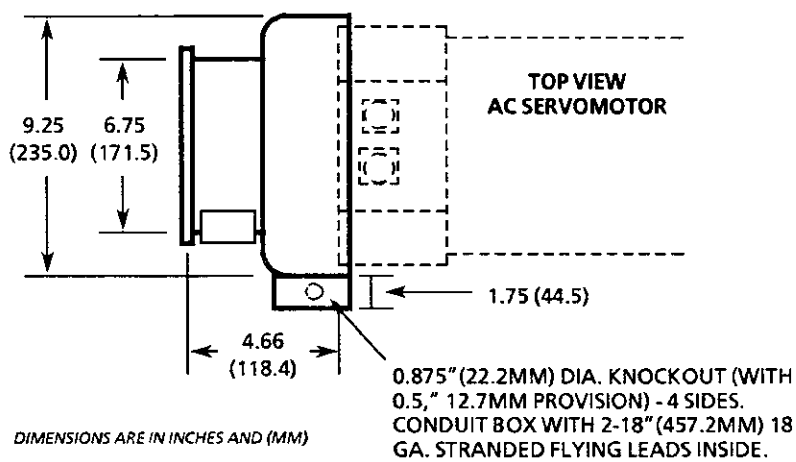


Figure 8.2 – Blower Cooling Option

8.2
Bulletin 1326AB Motor Options
(Continued)

Integral Holding Brake & 90V DC Power Supply (1326-MOD-BPS)
The Bulletin 1326AB servomotor contains an integral holding brake when the motor catalog number contains a suffix of -Ax (90V DC input) or -Kx (24V DC input). The brake is a disc type that is spring-set upon removal of power. The brake is designed to hold a load at rest and provide limited braking torque for emergency stopping. However, it is ***not*** intended to be continuously cycled to assist in stopping a load.

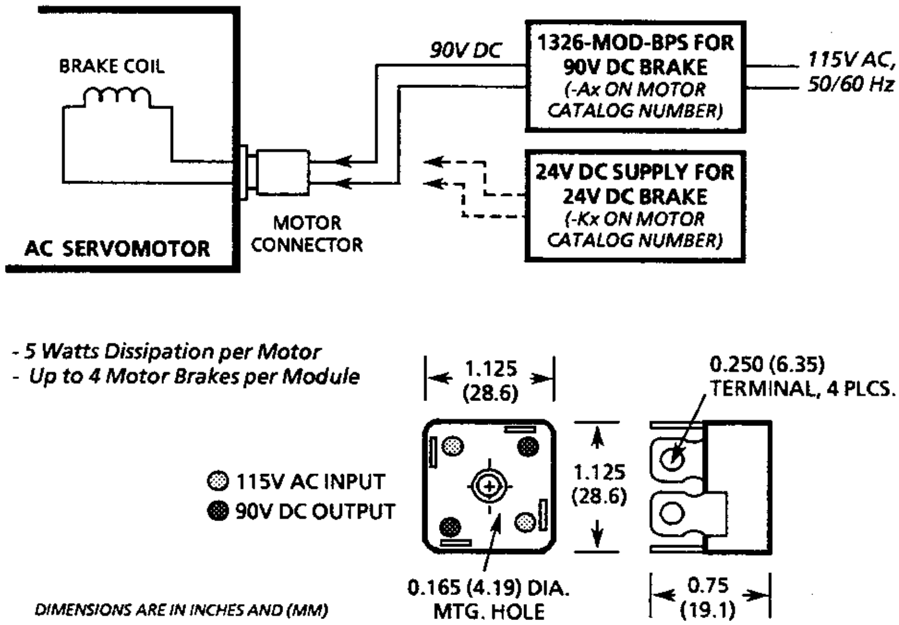


Figure 8.3 – Brake Power Supply Connections

Shaft Oil Seal (1326AB-MOD-SSV)
The Shaft Oil Seal Kit consists of a Viton seal which is intended for use in applications where the motor shaft may be subjected to occasional oil splashes (motor mounted to a gearbox, etc.).

IMPORTANT: This kit is not intended to be used in applications where the motor shaft is partially or fully submerged in oil.

The following items will be required for installation:
- Small Hammer (8oz/0.23kg)
- Bearing Grease

☐ 1. Apply a light coating of grease to the inside diameter of the seal to minimize the possibility of seal damage during installation.

IMPORTANT: Use care when placing the seal over the shaft, to guard against cutting or scraping the surface in contact with the motor shaft. Any damage will reduce the effectiveness of the seal.

☐ 2. Place the seal over the shaft (see Figure 8.4). The seal must be installed with the solid shield side facing the motor bearing.

☐ 3. Slide the seal along the shaft into position over the end bell bore. Using the small hammer, gently tap around the circumference of the seal. The seal must be installed flush with the outside of the casting.

8.2
Bulletin 1326AB Motor Options
(Continued)

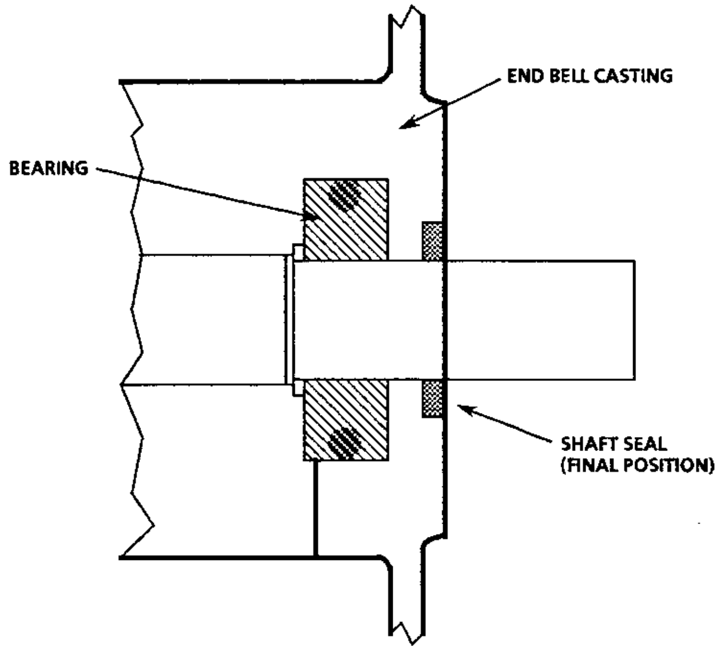


Figure 8.4 – Shaft Oil Seal Installation

8.3
Motor Maintenance

Bulletin 1326AB brushless AC servomotors require little or no maintenance. The connectors should be mounted down, if possible, to guard against coolants or other materials from coming into contact with the connector seals.

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Chapter

9

Transformers and Shunt Regulators

9.0 *Chapter Objectives*

Chapter 9 provides connection, dimension and enclosure information for the Bulletin 1391 Isolation Transformer. In addition, shunt regulator information including operation and external resistor dimensions are provided.

9.1 *Bulletin 1391 Transformers*

The Bulletin 1391 must operate from an isolation transformer having a three-phase, 230V AC output and a single-phase, 35.5V AC output.

Transformers supplied with the Bulletin 1391 can provide power for up to **four** controllers. Standard three-phase input voltages for the 60 Hz units are available. The kVA values specified are the continuous outputs of the units in a 60°C ambient.

IMPORTANT: The maximum rating that can be connected to the Bulletin 1391 is 15 kVA.

IMPORTANT: The Bulletin 1391 controller uses a phase sensitive 35.5V AC transformer tap to provide power to the Logic Control Board. It is recommended that a Bulletin 1391 Isolation Transformer be used. Contact your local Allen-Bradley Sales Representative if a transformer of a different type must be used. Refer to Figure 9.1 and Appendix B for connection information.

⚠ **CAUTION:** Damage to the controller will result if the center tap wire (Y2, Y5, Y8, Y11) shown in Figure 9.1 is not connected to TB4-20 as shown in Appendix B.

60 HZ Transformers
Two 60 Hz transformers are available and have input ratings of:

1. 240/480V AC , three-phase
2. 208/230/460/575V AC, three-phase

If other input voltages or special enclosures are required, consult your local Allen-Bradley Sales Representative. Refer to Figure 9.1 for connection information and Figure 9.2 for dimensions.

50/60 HZ Transformers
The 50/60 Hz transformer that is available has an input rating of 240/380/415/480V AC, three-phase.

Connections to the 50/60 Hz transformer are shown in Figure 9.1 with dimensions provided in Figure 9.2.

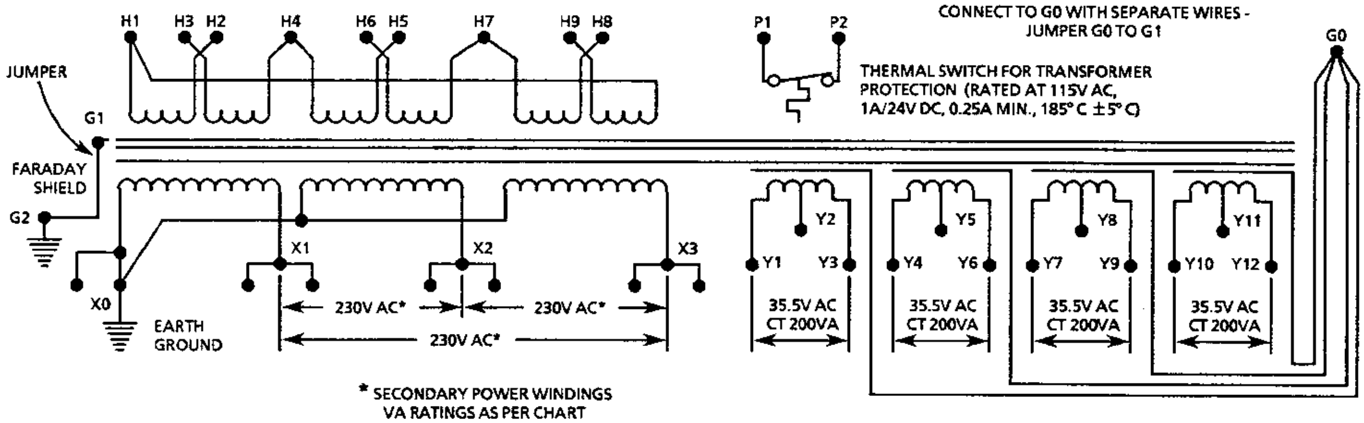
NEMA TYPE 1 ENCLOSURE

Dimensions for the NEMA Type 1 enclosures are shown in Figure 9.3.

IMPORTANT: The NEMA Type 1 enclosure is shipped as a kit for customer assembly.

BULLETIN 1391-TxxxDT

PRIMARY VOLTAGE	CONNECT	LINES ON
240V AC	H1 TO H3 TO H8 H2 TO H4 TO H6 H5 TO H7 TO H9	HI H4 H7
480V AC	H2 TO H3 H5 TO H6 H8 TO H9	HI H4 H7



BULLETIN 1391-TxxxET

PRIMARY VOLTAGE	CONNECT	LINES ON
240V AC	H2 TO H6 H7 TO H11 H12 TO H1	HI H6 H11
380V AC	H3 TO H6 H8 TO H11 H13 TO H1	
415V AC	H4 TO H6 H9 TO H11 H14 TO H1	
480V AC	H5 TO H6 H10 TO H11 H15 TO H1	

BULLETIN 1391-TxxxNT

PRIMARY VOLTAGE	CONNECT	LINES ON
208V AC	H2 TO H6 H7 TO H11 H12 TO H1	HI H6 H11
240V AC	H3 TO H6 H8 TO H11 H13 TO H1	
480V AC	H4 TO H6 H9 TO H11 H14 TO H1	
575V AC	H5 TO H6 H10 TO H11 H15 TO H1	

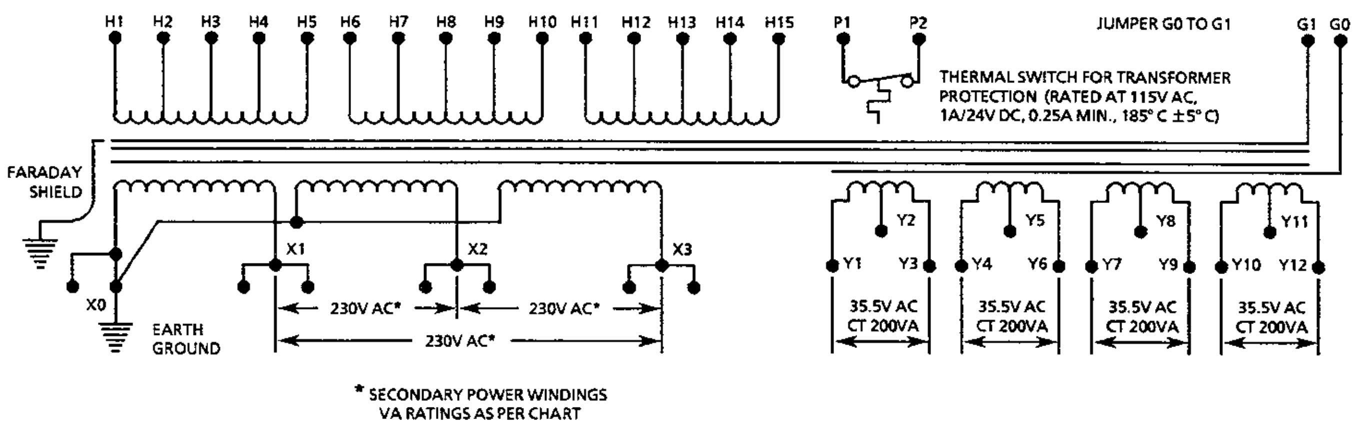


Figure 9.1 – Bulletin 1391 Transformer Wiring Diagrams

APPROXIMATE DIMENSIONS AND WEIGHT – ISOLATION TRANSFORMER

IN INCHES (MILLIMETERS) AND POUNDS (KILOGRAMS)

Catalog Number	kVA	A	B	C	D	E	Weight
1391-T015DT	1.5	9.00 (228)	10.00 (254)	13.00 (330)	5.00 (127)	3.10 (79)	27 (12.2)
1391-T015ET/NT		9.00 (228)	10.00 (254)	13.00 (330)	5.00 (127)	3.50 (89)	40 (18.2)
1391-T025DT	2.5	11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	3.30 (84)	42 (19.0)
1391-T025ET		11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	4.00 (102)	60 (27.2)
1391-T035DT	3.5	11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	4.50 (114)	60 (27.2)
1391-T035NT		11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	4.50 (114)	85 (38.6)
1391-T050DT	5.0	11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	5.25 (133)	75 (34.0)
1391-T050ET/NT		11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	6.00 (152)	100 (45.4)
1391-T100DT	10.0	12.00 (305)	12.50 (317)	16.00 (406)	8.00 (203)	5.85 (149)	112 (50.8)
1391-T100ET/NT		12.00 (305)	12.50 (317)	16.00 (406)	8.00 (203)	5.85 (149)	140 (63.6)
1391-T125DT	12.5	12.00 (305)	12.50 (317)	16.00 (406)	8.00 (203)	5.63 (143)	126 (57.1)
1391-T125ET/NT		12.00 (305)	12.50 (317)	16.00 (406)	8.00 (203)	5.63 (143)	160 (72.7)
1391-T150DT	15.0	13.00 (330)	14.00 (356)	17.50 (444)	9.50 (241)	6.00 (152)	150 (68.0)
1391-T150ET/NT		13.00 (330)	14.00 (356)	17.50 (444)	9.50 (241)	6.00 (152)	200 (90.9)

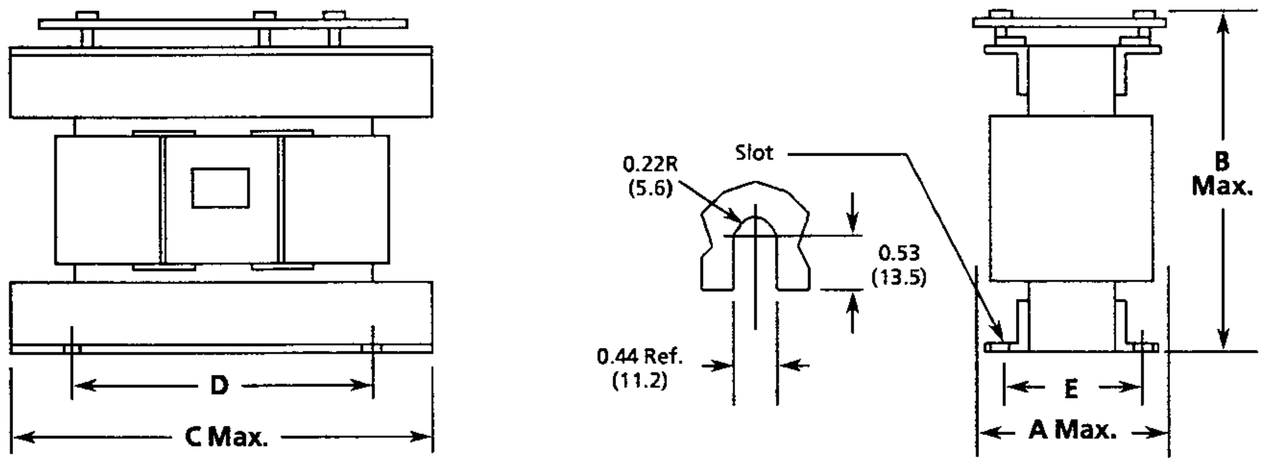


Figure 9.2 – Isolation Transformer Dimensions

APPROXIMATE DIMENSIONS AND WEIGHT – NEMA TYPE 1 ENCLOSURE

IN INCHES (MILLIMETERS) AND POUNDS (KILOGRAMS)

Catalog Number	kVA	A	B	C	D	E	Weight
1391-TA2	All	17.00 (432)	19.00 (483)	14.50 (368)	16.50 (419)	12.00 (305)	35.5 (16.1)

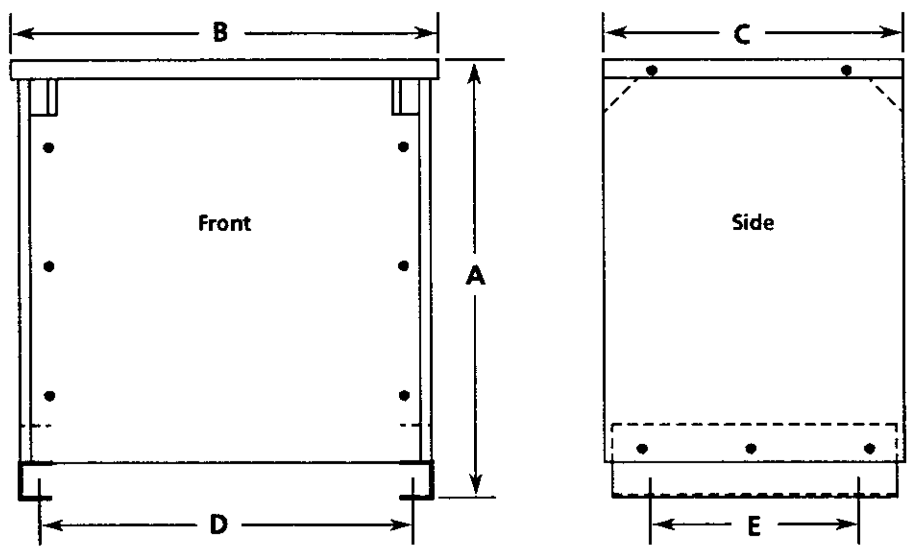


Figure 9.3 – NEMA Type 1 Enclosure Dimensions

9.2 *Shunt Regulator Operation*

Refer to section 4.4 for an explanation of the shunt regulator circuitry. The nominal data for the shunt regulator is provided below.

Overvoltage Trip Point	= 405V DC ± 2.5%
DC Bus Shunt "ON" Point	= 386.4V DC
DC Bus Shunt "OFF" Point	= 366.9V DC
Nominal DC Bus Voltage	= 300V DC
DC Bus Undervoltage Detect	= 145V DC ± 20%

The shunt regulator behavior is modified by an adjustable duty cycle timer. The timer is used to model the shunt resistor temperature. A selector switch (SW1) determines the temperature level and therefore the average power level at which the controller will fault. When this level is reached, the controller will be forced to fault on an overvoltage. This action would be equivalent to turning the shunt regulator off.

The Duty Cycle Selector Switch is located on top of the controller near terminal Block, TB5 (see Figure 10.2). The switch has 16 positions designated "0 to F," with "0" being the lowest value and "F" the highest. The higher the setting, the higher the average power seen by the shunt resistor. The Duty Cycle Selector Switch settings for the various controller/shunt combinations are shown in Tables 9.A and B.

IMPORTANT: Accurate operation of the Duty Cycle Timer is dependent on the shunt resistor value. Do Not substitute alternate values.

Table 9.A provides the required Duty Cycle Selector Switch settings and resistor power trip points for factory supplied configurations. An external resistor assembly (catalog number 1391-MOD-SR22A) is available for the 22.5A Bulletin 1391.

Table 9.A
Maximum Switch Settings and Trip Points for Factory Supplied Configurations

Configuration	SW1 Switch Setting	Nominal Trip Point *(in watts, ± 10%)*
1391-AA15 with standard 16 ohm internal resistor	B*	164
1391-AA22 with standard 12 ohm internal resistor	B*	162
1391-AA22 with 9 ohm external shunt resistor (Catalog # 1391-MOD-SR22A)	F	386
1391-AA45 with standard 5 ohm external resistor	D*	715

* Denotes SW1 setting at time of shipment. User must reconfigure controller for use with 1391-MOD-SR22A.

CAUTION: The designated settings for the factory supplied configurations must be used or damage to the controller may result.

Table 9.B shows the nominal resistor power trip levels in watts for the various switch settings. When shunt requirements exceed the selector setting, the excess power will cause the bus voltage to rise, resulting in an Overvoltage Fault condition.

9.2
Shunt Regulator Operation
(Continued)

Table 9.B
Nominal Power Trip Level Reference Data
(Continuous Watts, ± 10%)

SW1 Switch Setting	15A *with Internal 16 Ohm Resistor*	22.5A *with Internal 12 Ohm Resistor*	22.5A *with External 9 Ohm Resistor*	45A *with External 5 Ohm Resistor*
0	67	73	98	215
1	71	77	103	227
2	75	82	109	241
3	80	86	115	256
4	85	92	122	274
5	91	98	130	294
6	99	105	139	317
7	107	113	150	344
8	118	122	163	378
9	130	133	177	417
A	145	146	195	466
B	164*	162*	216	527
C	–	–	243	607
D	–	–	277	715*
E	–	–	323	872
F	–	–	386*	1115

* Denotes the maximum allowable settings for factory supplied configurations.

WARNING: To guard against personal injury and/or equipment damage from an overheated resistor, the designated duty cycle settings for factory supplied shunt resistor configurations must not be exceeded. Check the Duty Cycle Selector Switch (SW1) to ensure that it is set properly before operation.

WARNING: When using a customer supplied external shunt resistor assembly, the Duty Cycle Selector Switch (SW1) must be set to an appropriate level for that resistor assembly. Consult the resistor manufacturer for the appropriate derating guidelines. Failure to comply could result in personal injury and/or equipment damage from an overheated resistor.

Frequent overvoltage trips on high inertia systems (load is 2 or 3 times the motor inertia) during regenerative states (deceleration) may be an indication that an external shunt resistor having increased power dissipation capacity is required. Based on the data supplied, Allen-Bradley will specify a shunt resistor with the proper resistance value for the controller being used.

9.3
Shunt Regulator Installation

EXTERNAL SHUNT RESISTORS

The Bulletin 1391 is designed to allow the use of an external shunt resistor on the 22.5 and 45A units. To use an external shunt resistor with the 22.5A units, the user must reconfigure the controller at terminal block TB5.

The following steps provide the information needed to properly convert 22.5A controllers for use with an external shunt resistor and fuse. Refer to the resistor and fuse mounting dimensions provided in Figure 9.4 and the Interconnect Diagram in Appendix B, as required.

WARNING: To guard against an electrical shock hazard, ensure that all power to the controller has been removed prior to performing the following procedure and the bus voltage at terminal 9 (+) and 7(−) of TB5 measures 0.00 volts.

1. Remove and discard the jumper present between terminals 8 and 10 of TB5. This disconnects the internal shunt resistor and fuse from the shunt regulator circuit.

WARNING: When using an external shunt resistor assembly with the 22.5A Bulletin 1391, ensure that the internal resistor assembly has been disconnected per the above instructions. Personal injury and/or equipment damage could result from an overheated resistor if the internal resistor is not disconnected.

2. Connect one end of the new external shunt fuse to terminal 9 of TB5. Connect the other end of the fuse to one end of the shunt resistor.

   IMPORTANT: The external shunt resistor must have a fuse in series with the shunt resistor. Refer to the paragraph entitled "*Shunt Fusing*" for more information.

3. Connect the remaining end of the shunt resistor to terminal 8 of TB5.

4. Using Table 9.B, set the Duty Cycle Selector Switch to the appropriate setting for the resistor being used.

WARNING: Proper derating must be applied to the manufacturers nominal resistor power ratings when using these in external shunt configurations. Consult the resistor manufacturer for recommended derating. Failure to comply could result in personal injury and/or equipment damage from an overheated resistor.

5. Install the appropriate shunt fuse in its holder.

9.3
Shunt Regulator Installation
(Continued)

SHUNT FUSING

Shunt regulator fusing is provided with all of the Bulletin 1391 controllers. The fuse is in series with the resistor and used to protect the resistor against short circuits. The shunt fuse is located on top of the controller near the circuit breaker for 15 and 22.5A controllers. External resistors for 22.5A and 45A controllers are supplied with a fuse which must be mounted external to the controller (see Figure 9.4 for mounting dimensions). Refer to Table 9.C for further shunt fuse information.

Table 9.C
Shunt Fuse Information

Controller	Fuse Location	Fuse Type
15A	Top Panel	Buss KLM-10 or equivalent
22.5A	Top Panel	Buss FNM-6.25 or equivalent
22.5A	External	Buss KTK-15 or equivalent
45A	External	Buss KLM-20 or equivalent

IMPORTANT: Repeated overvoltage tripping can be an indication that the shunt fuse has malfunctioned.

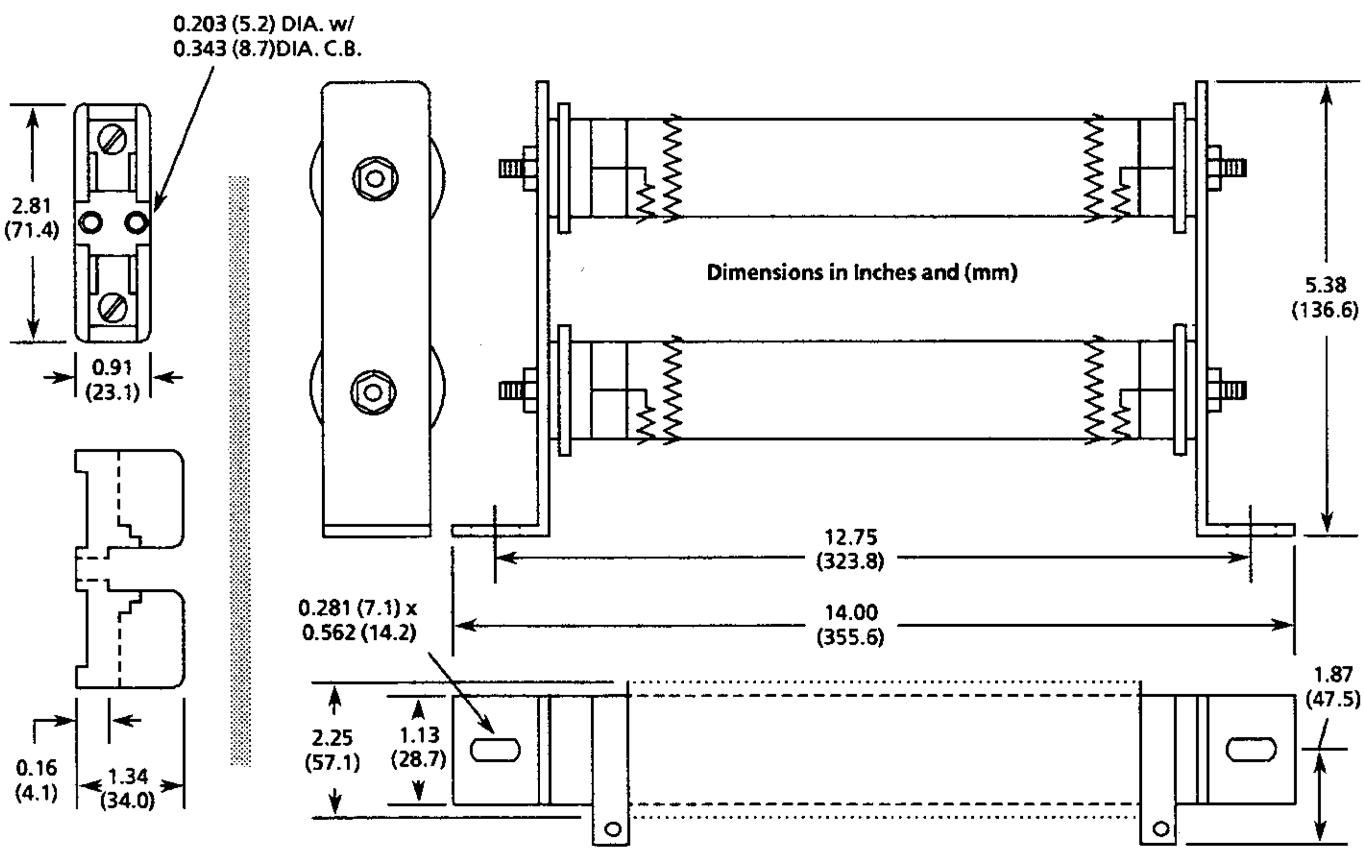


Figure 9.4 – Approximate Dimensions, External Shunt Resistor and Fuse

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Chapter

10

Troubleshooting

10.0 Chapter Objectives

Chapter 10 provides information to guide the user in troubleshooting the Bulletin 1391. Included in the chapter are LED descriptions and fault diagnosis, general system troubleshooting and test point descriptions.

10.1 System Troubleshooting

Most controller faults are annunciated by the LED diagnostic indicators on the front of the controller. Many system malfunctions manifest themselves through a controller fault. The use of LED indications may aid in identifying servo controller and motor malfunctions.

Table 10.A provides a listing and description of the LED indicators. In addition, potential causes are listed.

Tables 10.B and 10.C provide a number of common system and servomotor malfunctions and their possible causes.

Table 10.D provides a listing and description of the Bulletin 1391 test points.

⚠ **WARNING:** This product contains stored energy devices. To avoid hazard of electrical shock, verify that all voltage on the capacitors has been discharged before attempting to service, repair or remove this unit.

Voltage at terminals 9 (+) and 7 (–) of TB5 *must* be "0.00" as measured with a standard digital voltmeter or multimeter.

Only qualified personnel familiar with solid-state control equipment and safety procedures in publication NFPA 70E should attempt this procedure.

Table 10.A
LED Descriptions and Fault Diagnosis

LED	LED Description	Condition / Potential Cause
OVER-TEMPERATURE *(RED)*	The controller contains a thermal switch on the heat sink which senses the power transistor temperature. If the temperature is exceeded the LED will illuminate.	**OVERTEMPERATURE LED is Illuminated** The logic supply (±12V DC, +5V DC) circuits have malfunctioned (fuse blown etc.) or the AC input at TB4-19, 20, 21 is incorrectly wired. The heat sink thermal overload has tripped. One or more of the following may have occurred: 1. The cabinet ambient temperature is too high. 2. The machine duty cycle requires an RMS current exceeding the continuous rating of the controller. 3. The integral fan is not functioning. 4. The airflow access to the controller is limited or blocked.
POWER FAULT *(RED)*	The current through the power output transistors is monitored. If the current exceeds a fixed level (greater than 300% of controller rating) the LED will illuminate.	**POWER FAULT LED is Illuminated** 1. The current through any one of the power transistors has exceeded 300% of the controller's current rating. 2. Malfunctioning power transistor. 3. Shorted load. 4. Excessive winding to case motor capacitance.

Table 10.A *(Continued)*
LED Descriptions and Fault Diagnosis

LED	LED Description	Condition / Potential Cause
CONTROL POWER *(RED)*	If the logic supply rises or drops 10% from its nominal value, a fault occurs and the LED is illuminated.	**CONTROL POWER LED is illuminated** 1. The input line voltage is low. 2. The transformer auxiliary logic supply winding is open. 3. The logic supply (± 12V DC, + 5V DC) circuits have malfunctioned (fuse blown etc.) or the AC input at TB4-19, 20, 21 is incorrectly wired.
OVERVOLTAGE *(RED)*	The DC Power Bus is continuously monitored. If it exceeds a preset level a fault is sensed, the power supply is disabled and the LED is illuminated.	**OVERVOLTAGE LED is illuminated** The logic supply (± 12V DC, + 5V DC) circuits have malfunctioned (fuse blown etc.) or the AC input at TB4-19, 20, 21 is incorrectly wired. The power bus voltage has exceeded 405V DC 1. The Logic Board is malfunctioning and incorrectly sensing the bus voltage. 2. A vertical axis with insufficient counterbalancing is overdriving the servomotor and causing excessive energy to be returned to the power supply bus. 3. The system inertia is too high causing excessive energy to be returned to the power supply bus. 4. The input line voltage exceeds the maximum controller input voltage rating. 5. The position controller acceleration / deceleration rate is incorrectly set. 6. The shunt regulator or transistor has malfunctioned. 7. Shunt regulator fuse has blown. 8. Shunt regulator resistor not connected to controller.
UNDERVOLTAGE *(YELLOW)*	If the DC Power Bus drops below a preset level, a fault occurs and the LED is illuminated.	**UNDERVOLTAGE LED is illuminated** The power bus voltage has dropped below a preset DC value 1. The power contactor (M) has not energized or has dropped out. 2. The input line voltage is low. 3. The shunt regulator circuit has malfunctioned and is placing the shunt resistor across the power bus. 4. The power bus capacitor has malfunctioned. 5. The circuit breaker (MCB) has tripped. 6. The three-phase input line is open. 7. The transformer is providing the incorrect line voltage or has malfunctioned. The logic supplies have dropped 10% below their nominal value 1. The input line voltage is low. 2. The transformer auxiliary logic supply winding is open. 3. The logic supply (± 12V DC, + 5V DC) circuits have malfunctioned (fuse blown etc.) or the AC input at TB4-19, 20, 21 is incorrectly wired.
CURRENT FOLDBACK *(YELLOW)*	The CURRENT FOLDBACK LED illuminates when the Current Foldback circuitry is operating.	**CURRENT FOLDBACK LED is illuminated** The logic supply (± 12V DC) circuits have malfunctioned (fuse blown etc.) or the AC input at TB4-19, 20, 21 is incorrectly wired. The output current is exceeding its time-current rating 1. The acceleration/deceleration command from the position controller is requiring peak current for an excessive amount of time. 2. The Gain pot is set too high causing excessive peak currents. 3. The machine friction, inertial load and/or viscous loading is excessive. 4. The servomotor has been improperly sized. 5. A short circuit exists across the controller output terminals.
RUN ENABLE *(GREEN)*	The application of an Enable signal by the machine position controller will cause the RUN ENABLE LED to illuminate.	**ENABLE LED is NOT Illuminated** 1. The position controller has not enabled the controller. 2. The Enable wiring to the controller is open. 3. The position controller Enable relay/switch has malfunctioned. 4. The position controller has detected a machine system malfunction that will not allow the controllers to be Enabled. 5. Power has not been applied to input transformer. 6. The logic supply (± 12V DC) circuits have malfunctioned (fuse blown etc.) or the AC input at TB4-19, 20, 21 is incorrectly wired.

Table 10.A *(Continued)*
LED Descriptions and Fault Diagnosis

LED	LED Description	Condition / Potential Cause
RUN ENABLE *(Continued)*		**ENABLE LED is Illuminated, but Controller does not Enable** 1. A controller malfunction has occurred but is not annunciated by the LED indicators. Check the status of the Drive OK output (DROK) relay. 2. A component malfunction exists in the Enable circuit. 3. The circuit breaker (MCB) is tripped. 4. The power contactor has not been energized or has malfunctioned. The controller logic supplies are not operational 1. The logic supply fuses are blown 2. Logic supply AC voltage is missing 3. A controller malfunction has occurred but is not annunciated by the LED indicators (check the status of the Drive OK contacts).
DRIVE READY *(GREEN)*	This LED is continuously illuminated until a system fault occurs.	**DRIVE READY LED is NOT illuminated** 1. System fault has occurred.

Table 10.B
General System Troubleshooting

Condition	Possible Cause
Axis or System runs uncontrollably	1. The velocity feedback, position feedback device or velocity command signal wiring is incorrect or open. 2. An internal controller malfunction exists.
Axis or System is unstable	1. Velocity Loop Compensation or Gain potentiometer is incorrectly set. 2. Position Loop Gain or Position Controller accel/decel rate is improperly set. 3. Improper grounding or shielding techniques are causing noise to be transmitted into the position feedback or velocity command lines, causing erratic axis movement.
Desired motor acceleration / deceleration cannot be obtained	1. The Current Limit pot is incorrectly set. 2. The Current Feedback Scaling is incorrect. 3. The system inertia is excessive. 4. The system friction torque is excessive. 5. Available controller current is insufficient to supply the correct accel/decel rate.
Motor does not respond to a Velocity Command	1. The controller has a malfunction. 2. The controller is not enabled. 3. The power contactor is not energized. 4. Power transformer is supplying the incorrect voltage or none at all. 5. The motor wiring is open. 6. The motor or transformer thermal overload has tripped. 7. The motor has malfunctioned. 8. The motor coupling has malfunctioned. 9. The feedback circuit (motor to controller) is open.
Presence of noise on Command or Tach signal wires	1. 60 Hz line frequency may be present. 2. 120 Hz from a single phase logic supply may be present. 3. 180 or 360 Hz from other adjustable speed drives may be present. 4. Variable frequency (varies with motor speed) may be velocity feedback ripple or a disturbance caused by gear teeth or ballscrew balls etc. The frequency may be a multiple of the motor power transmission components or ballscrew speeds. 5. Recommended grounding per Appendix B has not been followed.

Table 10.C
General Servomotor Troubleshooting

Condition	Possible Cause
No Rotation	1. The motor connections are loose or open. 2. Foreign matter is lodged in the motor. 3. The motor load is excessive. 4. The bearings are worn. 5. The brake is set (when equipped).
Overheating	1. The rotor is partially demagnetized causing excessive motor current. 2. Motor voltage is exceeding the maximum value. 3. The duty cycle is excessive.
Abnormal Noise	1. Loose parts are present in the motor. 2. Through bolts are loose. 3. The bearings are worn. 4. GAIN setting is too high.
Erratic Operation - Motor locks into position, runs without control or with reduced torque	1. Phases A & B, A & C or B & C reversed 2. Sine, Cosine or Rotor leads reversed 3. Sine, Cosine, Rotor lead sets reversed 4. Combinations of 1, 2, 3

10.2 Test Point Descriptions

Table 10.D describes the various test points found in the Bulletin 1391 controller. Refer to Figure 10.1 for test point locations.

Table 10.D
Test Point Descriptions

Test Point	Description
TP1	Buffered Resolver Rotor Signal
TP3	Tachometer Output (2.5V/kRPM)
TP4	Demodulated Sine Wave
TP5	Demodulated Cosine Wave
TP6	I_D
TP7	PWM Triangle (2.5 kHz, 11Vp-p)
TP8	PWM B
TP9	PWM A
TP10	PWM C
TP11	PWM Multiplier Triangle (22.5 kHz, 15V p-p)
TP12	Signal Common
TP13	+12V DC
TP14	−12V DC
TP15	I_B Reference
TP16	I_A Reference
TP17	|I| Absolute Value
TP18	Velocity Gain Calibration
TP19	Buffered Velocity Command
TP20	Velocity Error
TP21	Current Limit Calibration (adjust with R148, 3V= Rated Motor Current)
TP22	Current Command
TP23-TP24	Velocity Loop Response Calibration
TP26-TP27	Velocity Loop Response Calibration
TP28	Signal Common
TP29	Current Feedback (Phase B, 2.5V p-p=Rated Motor Current)
TP30	Current Feedback (Phase A, 2.5V p-p=Rated Motor Current)
TP31	Signal Common

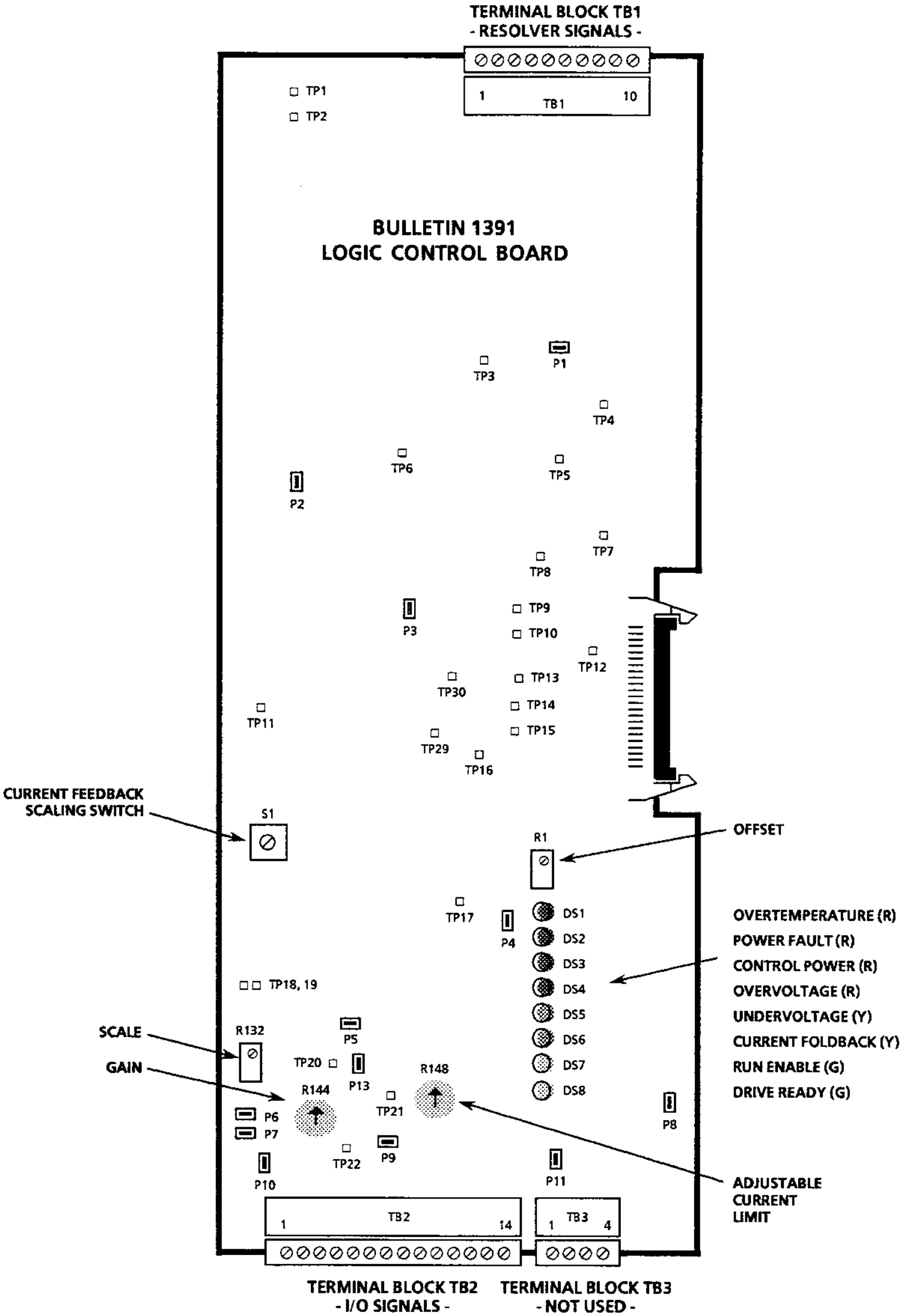
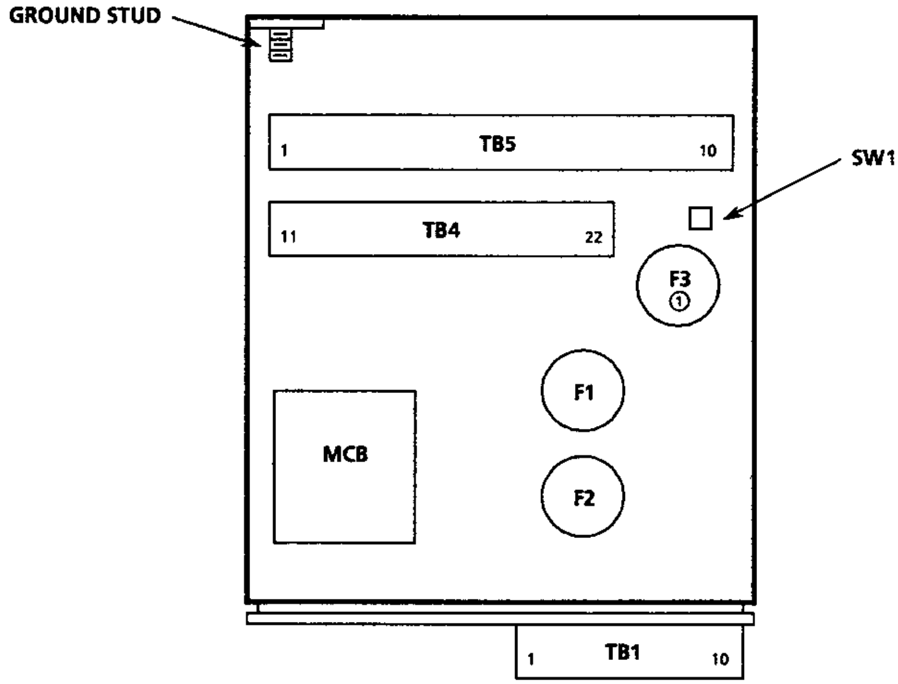


Figure 10.1 – Logic Control Board Test Point Locations

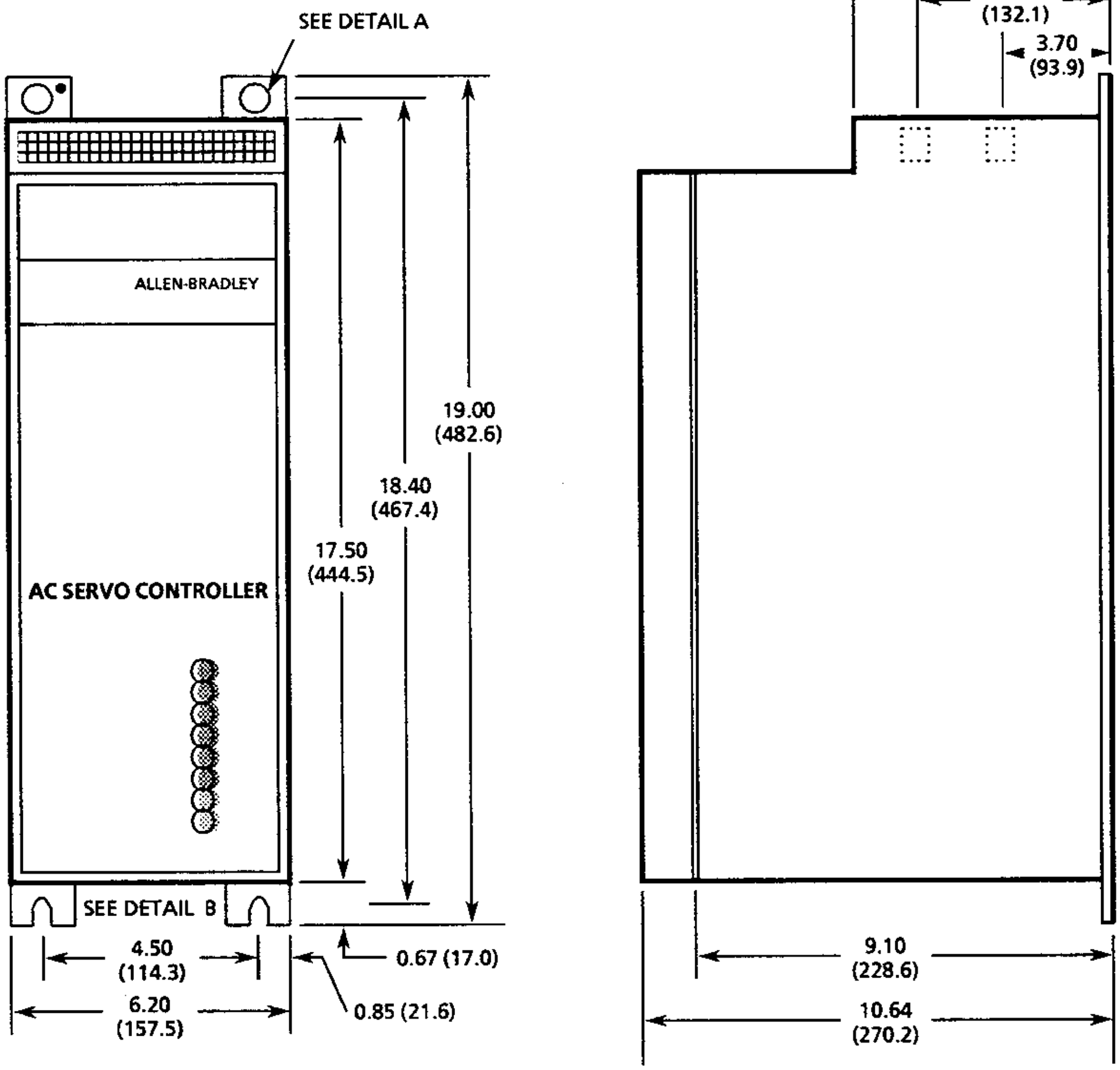


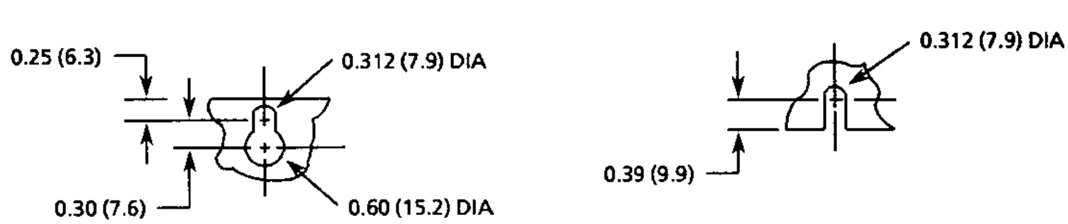
① F3 PROVIDED ON 15 AND 22.5A UNITS ONLY.
15A KLM-10
22.5A FNQ 6 1/4 SERIES B ONLY

Figure 10.2 – Bulletin 1391 Top Panel

Controller Dimensions

Dimensions are in Inches and (mm)





NOTES: 1. MOUNTING SLOTS AND KEYHOLE WILL ACCEPT 1/4-20 (7MM) HARDWARE.
2. A MINIMUM SPACING OF 0.312" (7.9MM) IS REQUIRED BETWEEN ADJACENT CONTROLLERS. 1" (25.4MM) IS RECOMMENDED.

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Appendix

B

Interconnect Drawings

Interconnect Drawings

Appendix B provides typical interconnection diagrams that illustrate the wiring between the Bulletin 1391 and various other Allen-Bradley position control products. Due to the numerous electrical circuit designs possible, these diagrams are provided for reference only.

The diagrams provided include:

- Bulletin 1391 interconnect drawing showing the inputs, outputs and recommended control circuitry.
- Bulletin 1391 / IMC 120 Interconnect Drawing
- Bulletin 1391 / IMC 123 Interconnect Drawing
- Bulletin 1391 / 8400 Series CNC Interconnect Drawing
- Bulletin 1391 / 8600 Series CNC Interconnect Drawing
- Bulletin 1391 / Creonics MAX4 and MAX/CONTROL Interconnect Drawing

Bulletin 1391 Interconnect Drawing

The Bulletin 1391 Interconnect Drawing is presented on pages B-2 and B-3. Refer to the "Notes" listed below when using this drawing.

NOTES:

1) POWER WIRING UNLESS NOTED:
   15A 12 AWG MIN. 75C MIN.
   22.5A 10 AWG MIN. 75C MIN.
   45A 8 AWG MIN. 75C MIN.

2) SIGNAL WIRING: 18 AWG MIN.

3) ALLEN-BRADLEY SUPPLIED CABLE:
   8 AWG MOTOR 1326-CPCxx
   12 AWG MOTOR 1326-CPABxx
   RESOLVER 1326-CFUxx

4) RESOLVER CABLE: 1326-CFUxx

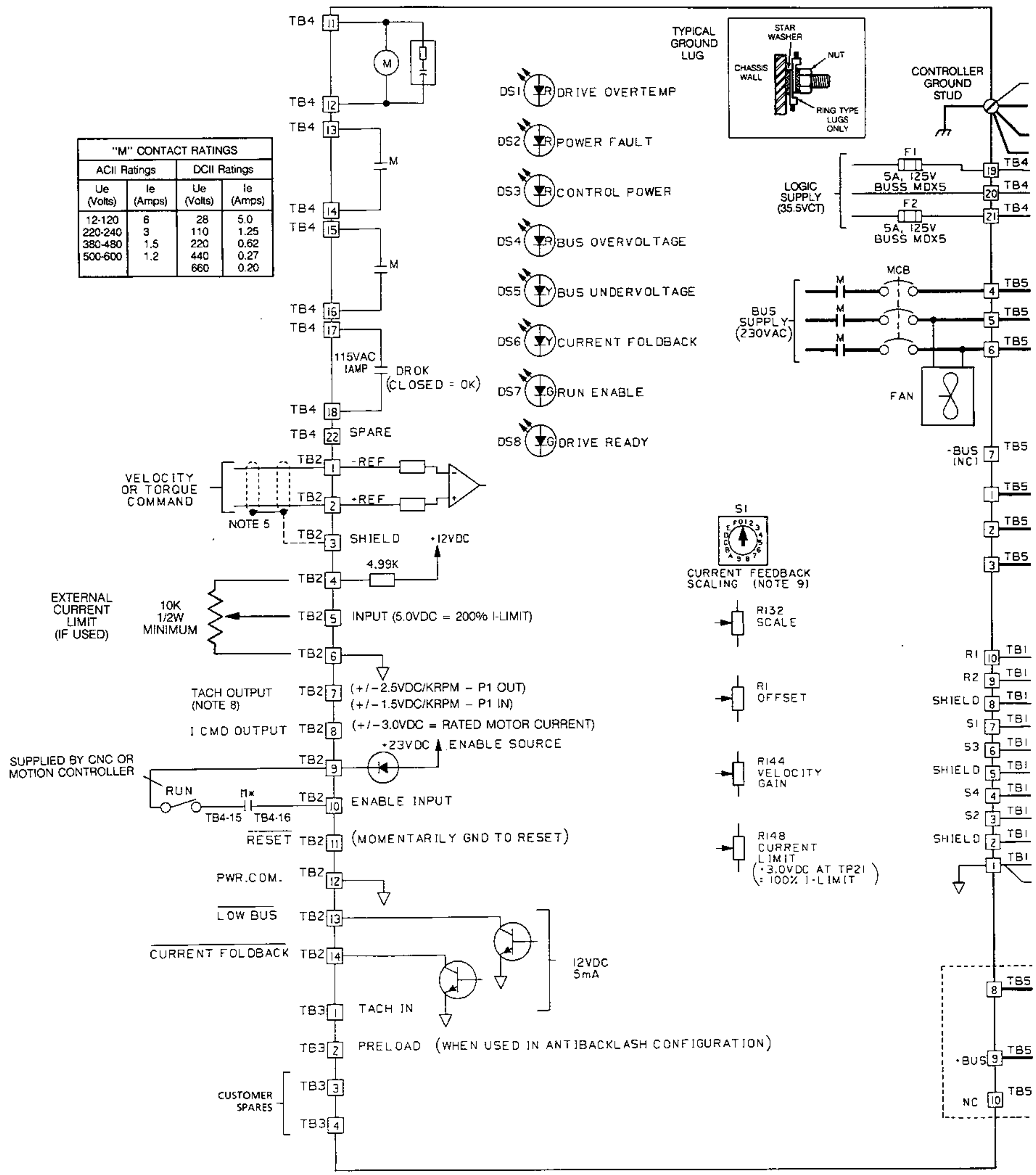
5) TERMINATE SHIELD ON SOURCE END ONLY.

6) DO NOT MAKE CONNECTIONS TO UNUSED PINS ON THE RESOLVER CONNECTOR.

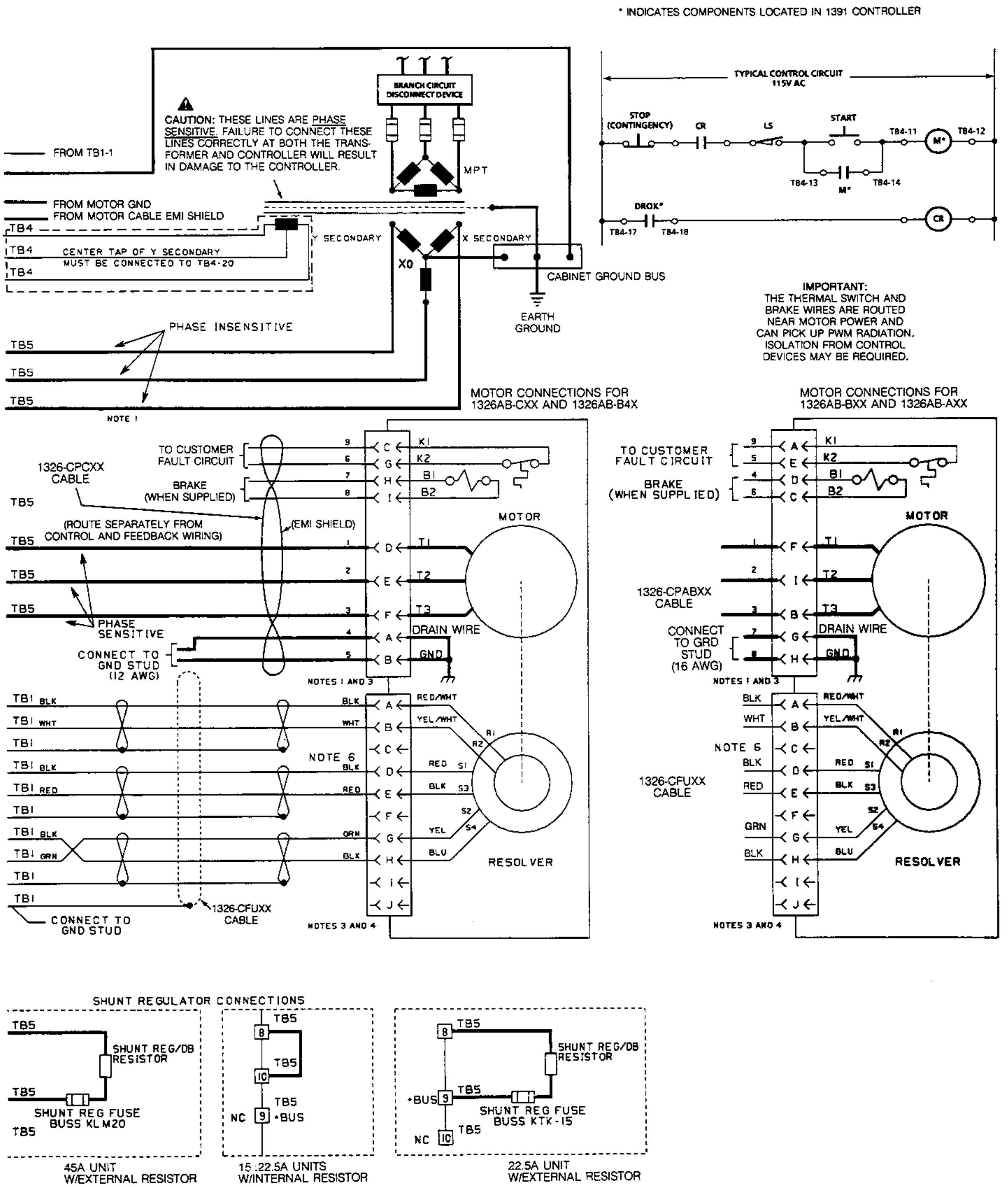
7) F3 PROVIDED ON 15 & 22.5A UNITS ONLY. 15A=KLM-10, 22.5A=FNQ 6 ¼ SERIES B ONLY.

8) P1 INSERTED FOR 1.5V/KRPM, P1 REMOVED FOR 2.5V/KRPM.

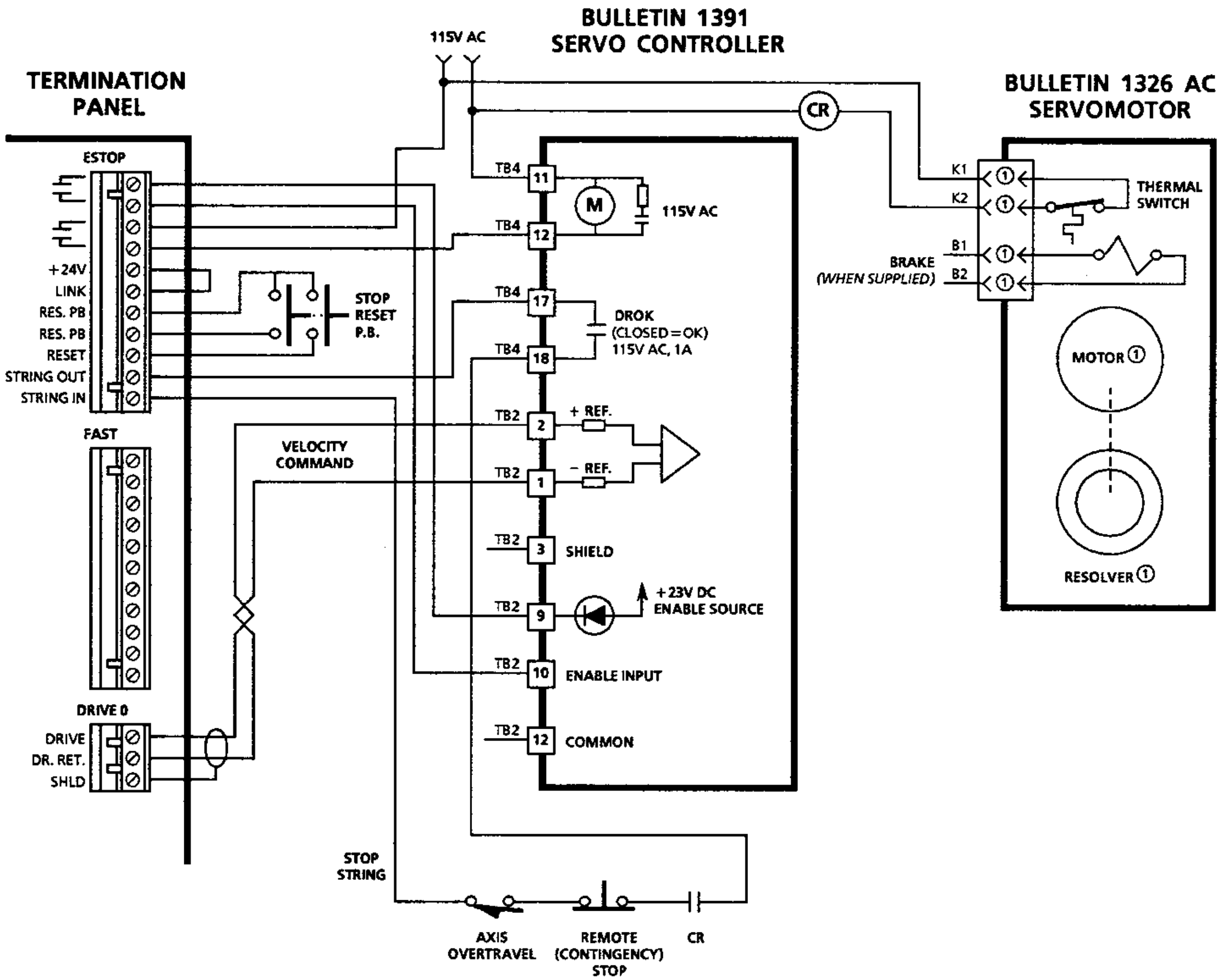
9) CURRENT FEEDBACK SCALING: SEE SECTION 5.3.



"M" CONTACT RATINGS			
ACII Ratings		DCII Ratings	
Ue (Volts)	Ie (Amps)	Ue (Volts)	Ie (Amps)
12-120	6	28	5.0
220-240	3	110	1.25
380-480	1.5	220	0.62
500-600	1.2	440	0.27
		660	0.20


* INDICATES COMPONENTS LOCATED IN 1391 CONTROLLER
BRANCH CIRCUIT DISCONNECT DEVICE
CAUTION: THESE LINES ARE PHASE SENSITIVE. FAILURE TO CONNECT THESE LINES CORRECTLY AT BOTH THE TRANSFORMER AND CONTROLLER WILL RESULT IN DAMAGE TO THE CONTROLLER.
FROM TB1-1
MPT
FROM MOTOR GND
FROM MOTOR CABLE EMI SHIELD
TB4
TB4
CENTER TAP OF Y SECONDARY MUST BE CONNECTED TO TB4-20
TB4
Y SECONDARY
X SECONDARY
X0
CABINET GROUND BUS
EARTH GROUND
PHASE INSENSITIVE
TB5
TB5
TB5
NOTE 1
TYPICAL CONTROL CIRCUIT 115V AC
STOP (CONTINGENCY)
CR
LS
START
TB4-11
M*
TB4-12
TB4-13
M*
TB4-14
DROK*
CR
TB4-17
TB4-18
IMPORTANT: THE THERMAL SWITCH AND BRAKE WIRES ARE ROUTED NEAR MOTOR POWER AND CAN PICK UP PWM RADIATION. ISOLATION FROM CONTROL DEVICES MAY BE REQUIRED.
MOTOR CONNECTIONS FOR 1326AB-CXX AND 1326AB-B4X
TO CUSTOMER FAULT CIRCUIT
1326-CPCXX CABLE
BRAKE (WHEN SUPPLIED)
TB5
(ROUTE SEPARATELY FROM CONTROL AND FEEDBACK WIRING)
(EMI SHIELD)
TB5
TB5
TB5
PHASE SENSITIVE
CONNECT TO GND STUD (12 AWG)
K1
K2
B1
B2
MOTOR
T1
T2
T3
DRAIN WIRE
GND
NOTES 1 AND 3
TB1 BLK
TB1 WHT
TB1
TB1 BLK
TB1 RED
TB1
TB1 BLK
TB1 GRN
TB1
TB1
NOTE 6
RED/WHT
YEL/WHT
R1
R2
RED S1
BLK S3
S2
YEL S4
BLU
RESOLVER
CONNECT TO GND STUD
1326-CFUXX CABLE
NOTES 3 AND 4
MOTOR CONNECTIONS FOR 1326AB-BXX AND 1326AB-AXX
TO CUSTOMER FAULT CIRCUIT
BRAKE (WHEN SUPPLIED)
1326-CPABXX CABLE
CONNECT TO GRD STUD (16 AWG)
NOTES 1 AND 3
1326-CFUXX CABLE
NOTES 3 AND 4
SHUNT REGULATOR CONNECTIONS
TB5
SHUNT REG/DB RESISTOR
TB5
SHUNT REG FUSE BUSS KLM20
TB5
45A UNIT W/EXTERNAL RESISTOR
TB5
8
TB5
10
TB5
NC 9 +BUS
15 :22.5A UNITS W/INTERNAL RESISTOR
TB5
8
SHUNT REG/DB RESISTOR
+BUS 9
TB5
SHUNT REG FUSE BUSS KTK-15
NC 10
TB5
22.5A UNIT W/EXTERNAL RESISTOR

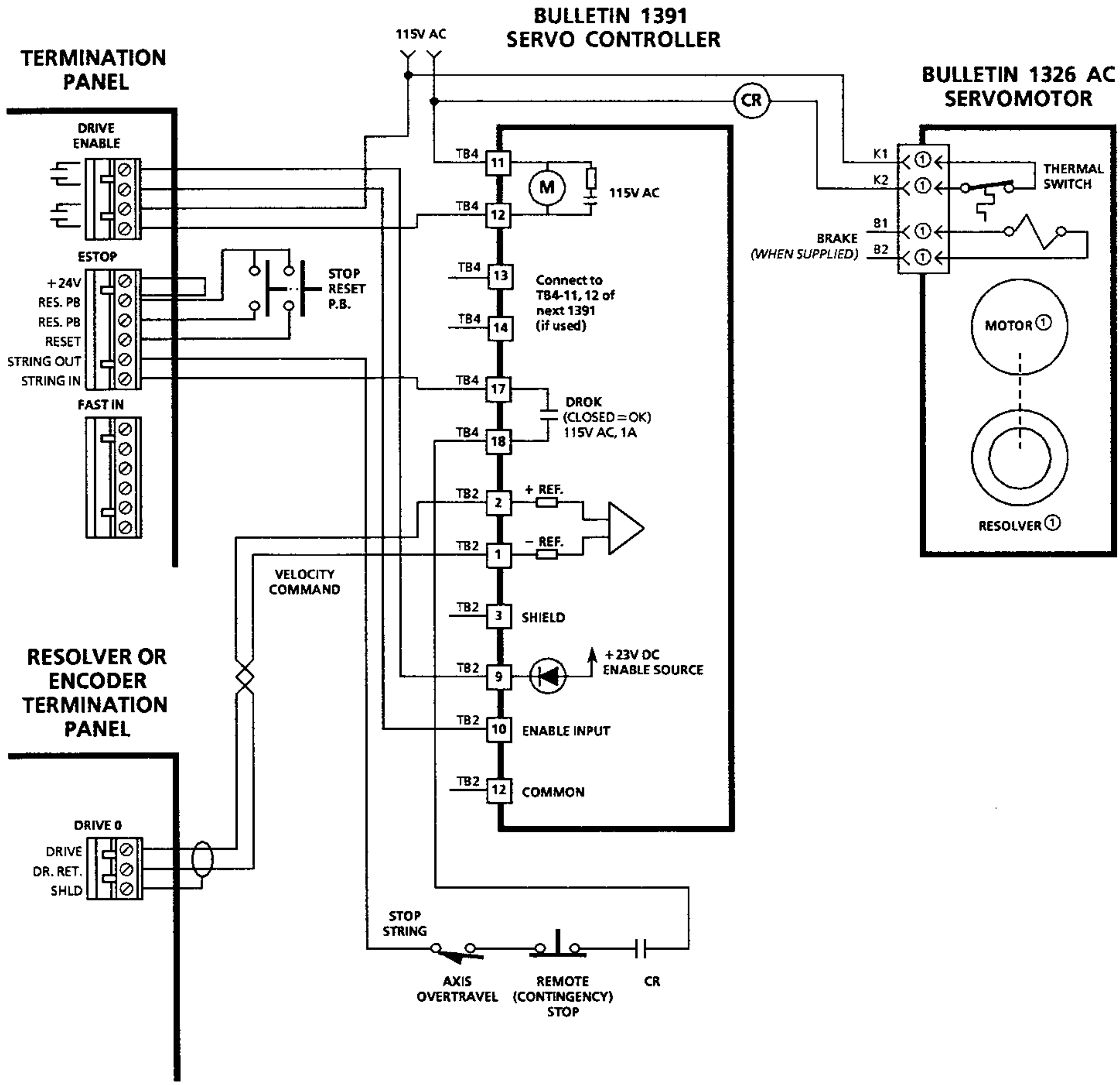
TYPICAL IMC 120 INTERCONNECT DIAGRAM



① REFER TO THE *BULLETIN 1391 INTERCONNECT DRAWING* FOR DETAILS ON THE FOLLOWING:

- MOTOR/RESOLVER CONNECTIONS
- CONNECTOR DESIGNATIONS
- CABLES
- SHIELDS AND GROUNDING

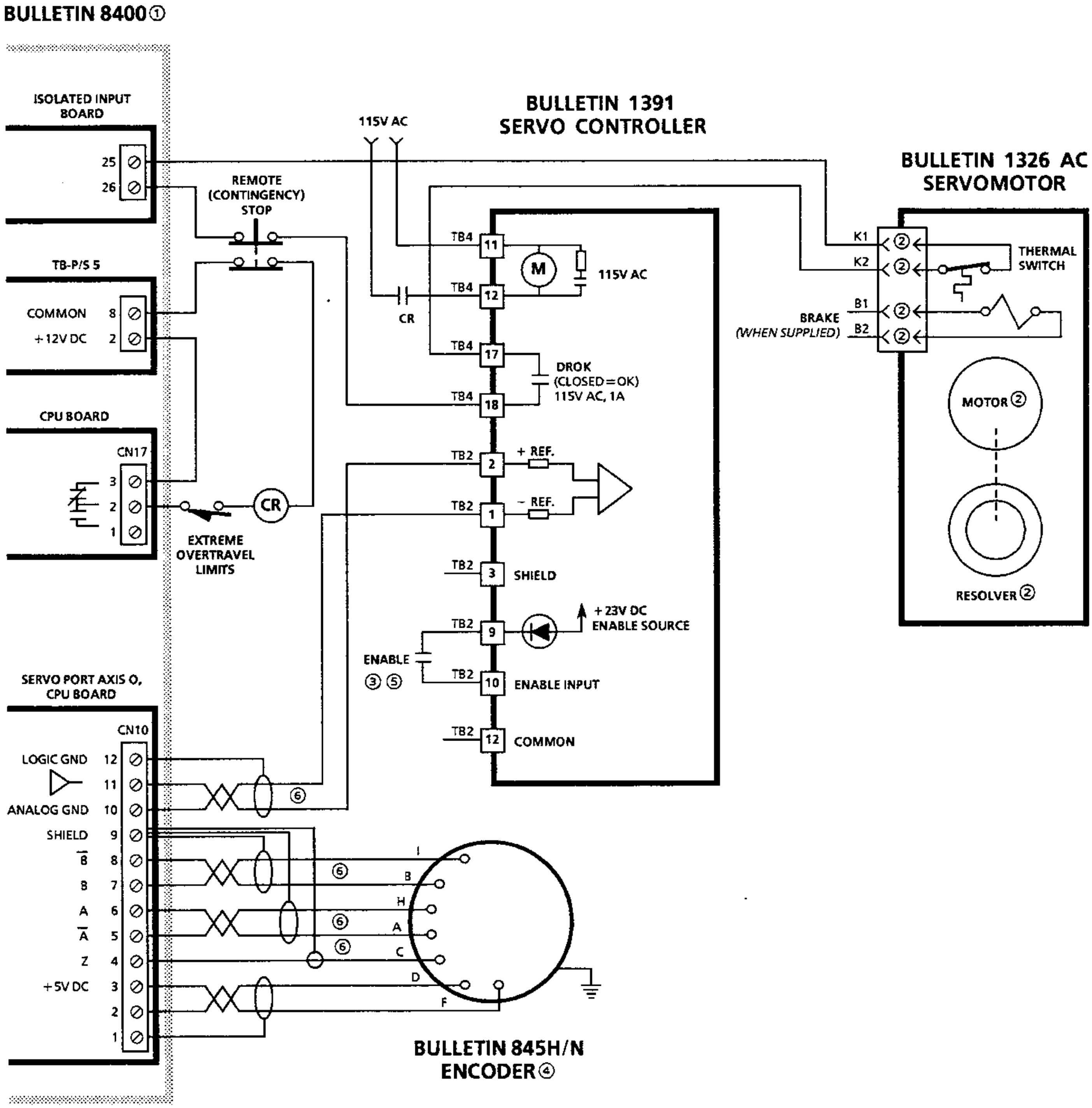
TYPICAL IMC 123 INTERCONNECT DIAGRAM



① REFER TO THE *BULLETIN 1391 INTERCONNECT DRAWING* FOR DETAILS ON THE FOLLOWING:

- MOTOR/RESOLVER CONNECTIONS
- CONNECTOR DESIGNATIONS
- CABLES
- SHIELDS AND GROUNDING

TYPICAL 8400 SERIES CNC INTERCONNECT DIAGRAM



① REFER TO A-B PUBLICATION 8400-4.1, *SERIES 8400 CNC INTERFACE DESIGN MANUAL* FOR DETAILS.

② REFER TO THE BULLETIN 1391 INTERCONNECT DRAWING FOR DETAILS ON THE FOLLOWING:
- MOTOR/RESOLVER CONNECTIONS
- CONNECTOR DESIGNATIONS
- CABLES
- SHIELDS AND GROUNDING

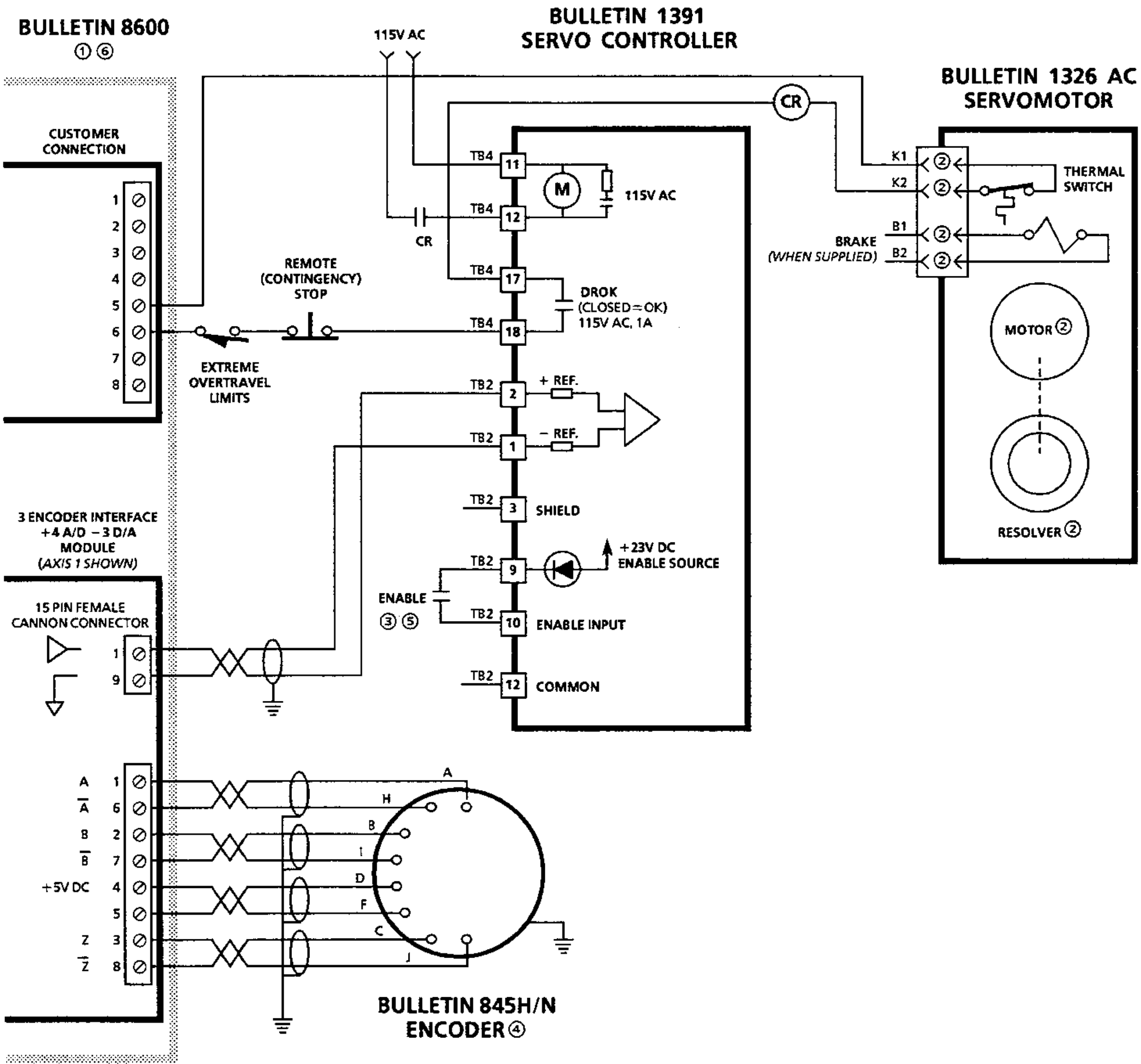
③ ENABLE RELAY IS SHOWN AS TYPICAL ONLY. BULLETIN 1391 CAN BE ENABLED WITHOUT AN EXTERNAL RELAY. REFER TO CHAPTERS 5 AND 6 FOR FURTHER INFORMATION.

④ TYPICALLY DIFFERENTIAL LINE DRIVER OUTPUT.

⑤ A-B CATALOG NUMBER 700-HC14Z12 (RELAY) AND 700-HN103 (MOUNTED BASE).

⑥ BELDEN 9730 OR EQUIVALENT, 50 FEET (15.2 METERS) MAXIMUM, SHIELDS GROUNDED AT CONTROL ONLY.

TYPICAL 8600 SERIES CNC INTERCONNECT DIAGRAM



① REFER TO A-B PUBLICATION 8600-4.1, *SERIES 8600 CNC INTERFACE DESIGN MANUAL* FOR DETAILS.

② REFER TO THE *BULLETIN 1391 INTERCONNECT DRAWING* FOR DETAILS ON THE FOLLOWING:
- MOTOR/RESOLVER CONNECTIONS
- CONNECTOR DESIGNATIONS
- CABLES
- SHIELDS AND GROUNDING

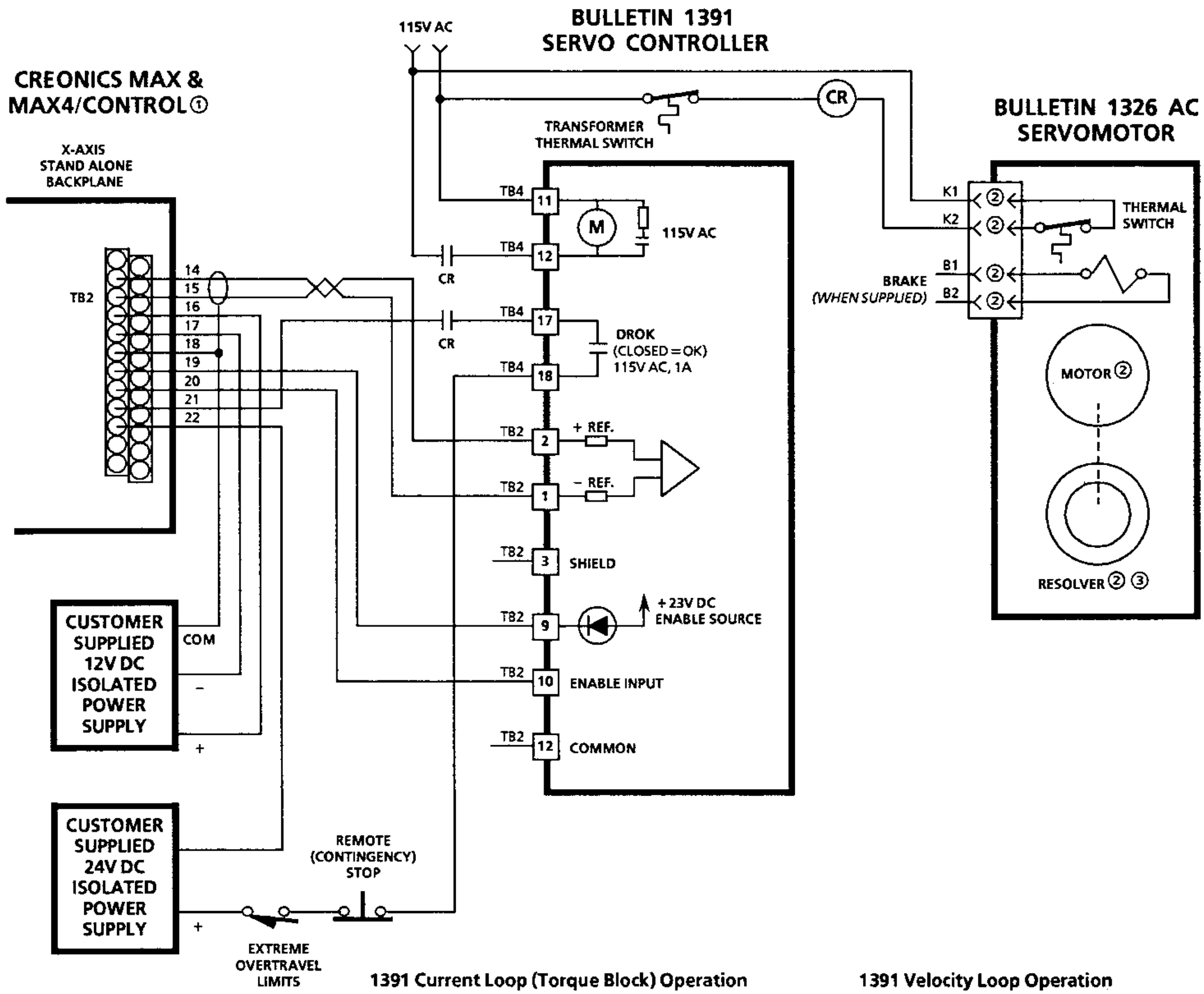
③ ENABLE RELAY IS SHOWN AS TYPICAL ONLY. BULLETIN 1391 CAN BE ENABLED WITHOUT AN EXTERNAL RELAY. REFER TO CHAPTERS 5 AND 6 FOR FURTHER INFORMATION.

④ TYPICALLY DIFFERENTIAL LINE DRIVER OUTPUT.

⑤ A-B CATALOG NUMBER 700-HC14Z12 (RELAY) AND 700-HN103 (MOUNTED BASE).

⑥ TYPICAL 3 AXIS SYSTEM SHOWN FOR 8605, 8610 AND 8650 CNC.

CREONICS MAX & MAX4/CONTROL INTERCONNECT DIAGRAM



1391 Current Loop (Torque Block) Operation

Jumper/Parameter	Setting
1391 Jumper P5	IN
1391 Jumper P7	IN
1391 TP18 to TP19	IN
MAX4/CONTROL "Servo Amplifier Type" Parameter	PWM/Current

1391 Velocity Loop Operation

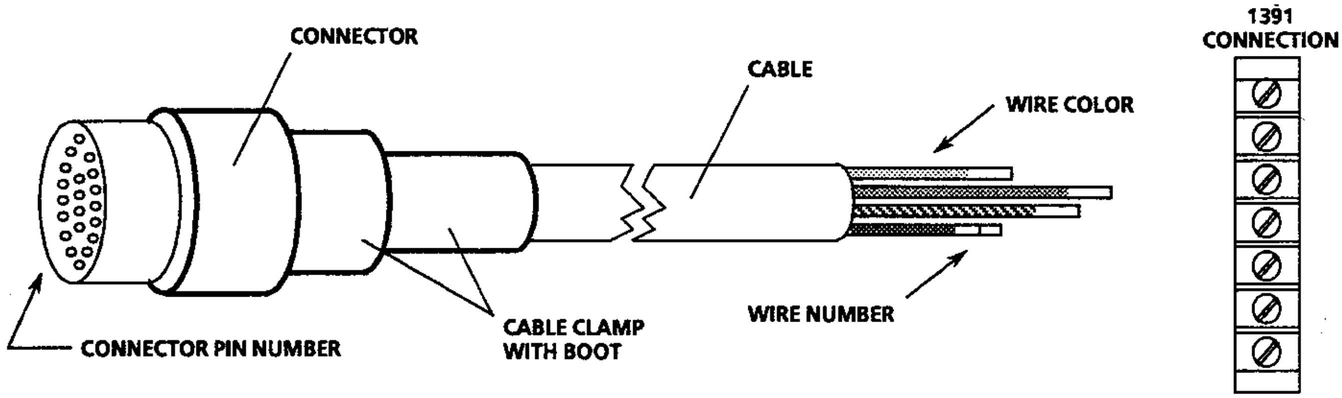
Jumper/Parameter	Setting
1391 Jumper P5	OUT
1391 Jumper P7	OUT
1391 TP18 to TP19	OUT
MAX4/CONTROL "Servo Amplifier Type" Parameter	Velocity

① REFER TO THE *MAX OR MAX4/CONTROL INSTALLATION AND SETUP MANUAL* FOR DETAILS.

② REFER TO THE *BULLETIN 1391 INTERCONNECT DRAWING* FOR DETAILS ON THE FOLLOWING:
• MOTOR/RESOLVER CONNECTIONS • CONNECTOR DESIGNATIONS • CABLES • SHIELDS AND GROUNDING

③ ENCODER IS REQUIRED FOR CONNECTION TO THE MAX AND MAX4. REFER TO THE MAX OR MAX4 MANUAL FOR CONNECTION DETAILS.

Cable Information



1326-CFUxx COMMUTATION (RESOLVER) CABLE

(for Series A, B & C Motors)

Wire Color	Wire Gauge	Connector Pin Number	1391 Terminal #
Black	#20	A	TB1-10
White	#20	B	TB1-9
Shield - Drain	#20	N/C	TB1-8
Black	#20	D	TB1-7
Red	#20	E	TB1-6
Shield - Drain	#20	N/C	TB1-5
Black	#20	H	TB1-4
Green	#20	G	TB1-3
Shield - Drain	#20	N/C	TB1-2
Braided Shield	#36	N/C	TB1-1 to Ground Stud

1326-CPABxx POWER CABLE

Wire Number	Wire Color	Wire Gauge	Connector Pin Number	1391 Terminal #
1	Black	#12	F	TB5-1
2	Black	#12	I	TB5-2
3	Black	#12	B	TB5-3
4	Black	#16	D	Brake Power
5	Black	#16	E	Thermal Switch
6	Black	#16	C	Brake Power
7	Drain Wire	#16	G	Power Ground
8	Black	#16	H	Power Ground
9	Black	#16	A	Thermal Switch
Mylar Shield	Mylar Shield	#16	N/C	Ground Stud

N/C = Not Connected

1326-CPCxx POWER CABLE

Wire Number	Wire Color	Connector Pin Number	Wire Gauge	1391 Terminal Number
1	Black	D	#8	TB5-1
2	Black	E	#8	TB5-2
3	Black	F	#8	TB5-3
4	Drain Wire	A	#12	Power Ground
5	Black	B	#12	Power Ground
6	Black	G	#16	Thermal Switch
7	Black	H	#16	Brake Power
8	Black	I	#16	Brake Power
9	Black	C	#16	Thermal Switch
Mylar Shield	Mylar Shield	N/C	#16	Ground Stud

N/C = Not Connected

1326-CVUxx MASTER/VERNIER (RESOLVER) CABLE

	Pair	Wire Color	Function	Connector Pin Number	Wire Gauge
Master	1	White	Rotor 1	A	#22
		Black	Rotor 2	B	#22
	2	Red	Stator 1	D	#22
		Black	Stator 3	F	#22
	3	Orange	Stator 2	E	#22
		Black	Stator 4	G	#22
Vernier	4	Blue	Rotor 1	J	#22
		Black	Rotor 2	K	#22
	5	Green	Stator 2	N	#22
		Black	Stator 4	R	#22
	6	Violet	Stator 1	M	#22
		Black	Stator 3	P	#22

1326-CEUxx 845H & 845N ENCODER FEEDBACK CABLE

Pair	Wire Color	Connector Pin Number	Wire Gauge
1	Black	H	#22
	White	A	#22
2	Black	F	#22
	Red	D	#22
3	Black	J	#22
	Orange	C	#22
4	Black	I	#22
	Blue	B	#22
5	Black	F	#22
	Green	E	#22

Notes

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- ❏ SUGGEST / RESPONSIBLE FOR THE PURCHASE OF EQUIPMENT
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- ❏ DESIGN / IMPLEMENT ELECTRICAL SYSTEMS
- ❏ TRAIN / EDUCATE MACHINE USERS
- ❏ SUPERVISE FLOOR OPERATIONS

✔ **WHAT LEVEL OF EXPERIENCE DO YOU HAVE WITH EACH OF THE FOLLOWING PRODUCTS?**

	NONE	LITTLE	MODERATE	EXTENSIVE
PROGRAMMABLE CONTROL	❏	❏	❏	❏
AC / DC DRIVES	❏	❏	❏	❏
PERSONAL COMPUTERS	❏	❏	❏	❏
NC / CNC CONTROLS	❏	❏	❏	❏
DATA COMMUNICATIONS / LAN	❏	❏	❏	❏

✔ **RATE THE OVERALL QUALITY OF THIS MANUAL BY CIRCLING YOUR RESPONSE BELOW. (1) = POOR (5) = EXCELLENT**

HELPFULNESS OF INDEX / TABLE OF CONTENTS	1	2	3	4	5
CLARITY	1	2	3	4	5
EASE OF USE	1	2	3	4	5
ACCURACY AND COMPLETENESS	1	2	3	4	5
QUALITY COMPARED TO OTHER COMPANIES' MANUALS	1	2	3	4	5
QUALITY COMPARED TO OTHER ALLEN-BRADLEY MANUALS	1	2	3	4	5

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