Product Data

Bulletin 1391
AC PWM Servo Controller

Introduction

This publication provides detailed information about the Bulletin 1391 AC Servo Controller. The topics covered in this publication are listed below in order of presentation.

Controller Description

The Bulletin 1391 is a Pulse Width Modulated, single axis AC servo controller which is UL listed, CSA approved and designed to meet IEC standards 146.

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 Isolation Transformer, Bulletin 1326 AC Servomotor and Bulletin 1326 Cables (if needed) complete the servo system.

Publication 1391-2.0 – August, 1990
Supersedes August, 1986

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.
- External analog input that varies the current limit from 10 to 200% of the continuous current rating of the motor.
- UL listed per UL 508, meets IEC standards 146 and CSA approved.

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.

- External Shunt Regulator Resistor
  On the 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 more regenerative energy to dissipate. For these applications, an external shunt regulator resistor rated at 386 watts continuous can be supplied for user mounting on the 22.5A unit. 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.

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.

Accessories

The accessories available for the Bulletin 1391 Servo Controller include:

- Isolation Transformers (1.5, 3.5, 5.0, 10.0, 12.5 and 15.0 kVA)
- Bulletin 1326 AC Servomotors.
- Bulletin 1388-XA, Anti-Backlash Module. This module operates and controls two Bulletin 1391 controllers and their connected servomotors. The use of this system on a machine allows the backlash in a rack and pinion system to be minimized by having the motors apply a load against each other continuously. For further information, contact Allen-Bradley.
- Bulletin 1388-XB, Linear Accel/Decel Board. Converts step changes in the speed reference voltage to a ramp output, providing smooth accel/decel response. The Linear Accel/Decel Board is used when the Bulletin 1391 will be operated manually without a position controller.
- Bulletin 1388-XC Velocity Reference Board. Provides a regulated velocity reference voltage of ±10V DC. The Velocity Reference Board is used when the Bulletin 1391 will be operated manually without a position controller.

Catalog Number Explanations

An explanation of the Bulletin 1391 catalog numbering system is provided on the following pages.

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
T	Transformer Open Core & Coil

No.	kVA
015	1.5
035	3.5
050	5.0
100	10.0
125	12.5
150	15.0

Code	Input
D	240/480V AC, 3-ph., 60Hz
E	240/380/415/480V AC, 3-ph., 50/60 Hz
N	208/230/460/575V AC, 3-ph., 60Hz

Code	Description
T	230V AC, 3-ph. & four 35.5V AC 1-ph., CT windings

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 – A00

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 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

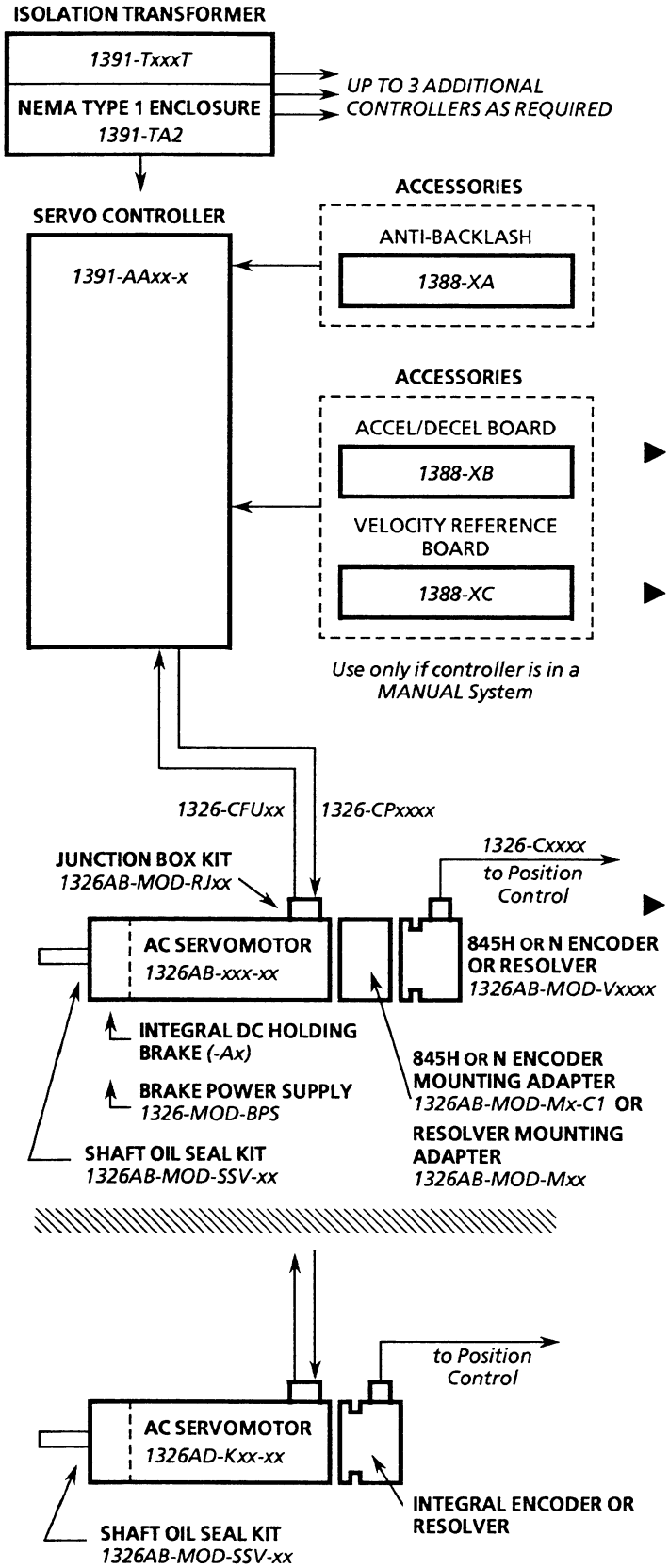
First Position — Bulletin Number

Second Position — Accessory Module

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

BULLETIN 1391 CONFIGURATION GUIDE



ISOLATION TRANSFORMER

(UP TO 4 CONTROLLERS /TRANSFORMER)

# of Axis	TRANSFORMER KVA = Machine Tool Duty	Rapid Accel/Decel Duty
1	kW (Largest Motor) x 0.43 + 0.2	kW (Largest Motor) x 0.60 + 0.2
2	kW (Largest Motor) x 0.61 + 0.4	kW (Largest Motor) x 0.85 + 0.4
3	kW (Largest Motor) x 0.86 + 0.6	kW (Largest Motor) x 1.20 + 0.6
4	kW (Largest Motor) x 1.28 + 0.8	kW (Largest Motor) x 1.80 + 0.8

Continuous Duty

KVA = Σ ALL MOTORS KW x 1.2

▶ TRANSFORMER 1391-T _ _ _ _T

NEMA 1 ENCLOSURE KIT 1391-TA2

SERVO CONTROLLER

▶ 1391-AA _ _ _- _____
(OPTIONS)

ACCESSORIES

1388-XA ANTI-BACKLASH MODULE

1388-XB ACCEL/DECEL BOARD

1388-XC VELOCITY REFERENCE BOARD

AC SERVOMOTOR

▶ 1326A _ - _____

MOTOR OPTIONS

90V DC INTEGRAL BRAKE (AB ONLY)	- A _ *(ADD TO ABOVE)*
SHAFT OIL SEAL KIT	1326AB-MOD-SSV - _1
BRAKE POWER SUPPLY (AB ONLY)	1326-MOD-BPS
JUNCTION BOX KIT (AB ONLY)	1326AB-MOD-RJ _ _

FEEDBACK OPTIONS *(BULLETIN 1326AB MOTORS ONLY)*

ENCODER/RESOLVER MOUNTING KIT

1326AB-MOD- M _- _ _

RESOLVER FEEDBACK PACKAGE

1326AB-MOD-V _ _ _ _

CABLES

POWER	1326-CP _ _ _ _
COMMUTATION	1326-CFU _ _
ENCODER/RESOLVER	1326-C _ _ _ _

▶ *DENOTES MINIMUM REQUIRED TO CONFIGURE A BASIC SYSTEM*

Controller Specifications

The general specifications of the Bulletin 1391 are provided in the listing below. Please note that specifications are for reference only and are subject to change without notice.

	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, THREE-PHASE, 50/60 HZ (±3 HZ) CONTROL: 35.5V AC C.T., 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

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

Controller Power Dissipation *(Watts)*

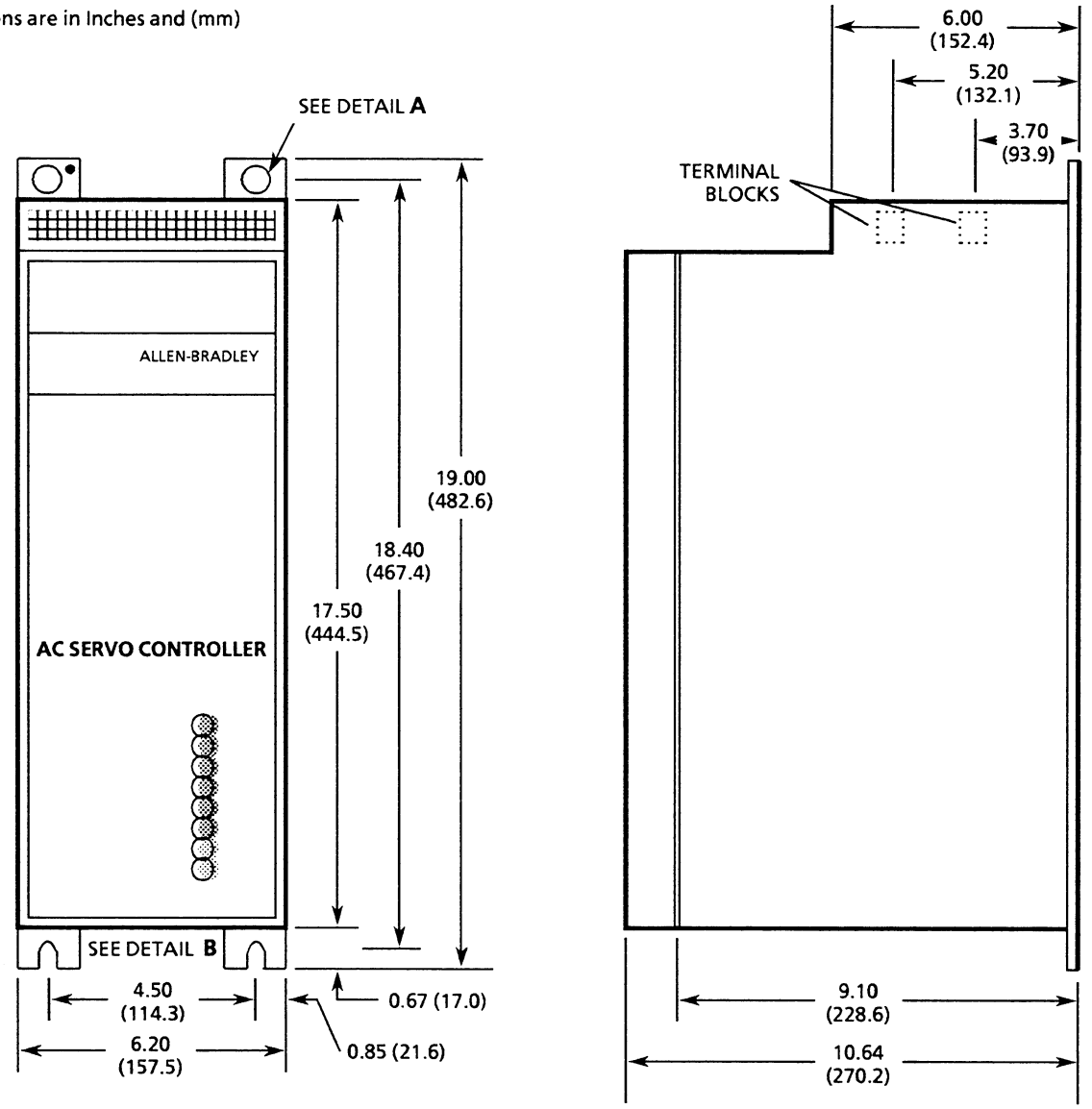
Rated Power Output *(%)*	1391-AA15	1391-AA22	1391-AA45
20	38	55	104
40	76	110	208
60	114	165	312
80	152	220	416
100	190	275	520

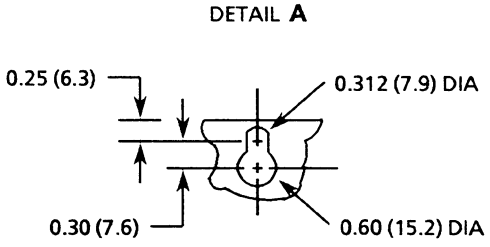
Bulletin 1391 Isolation Transformer Power Dissipation *(Watts)*

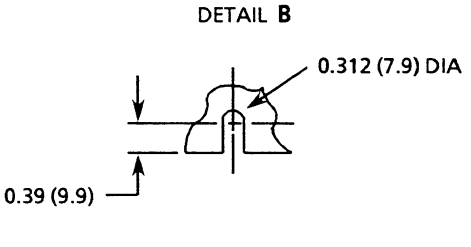
Rated Power Output *(%)*	1.5kVA	3.5kVA	5.0kVA	10.0kVA	12.5kVA	15.0kVA
20	13	35	50	100	125	150
40	25	70	100	200	250	300
60	38	105	150	300	375	450
80	50	140	200	400	500	600
100	60	175	250	500	625	750

CONTROLLER DIMENSIONS

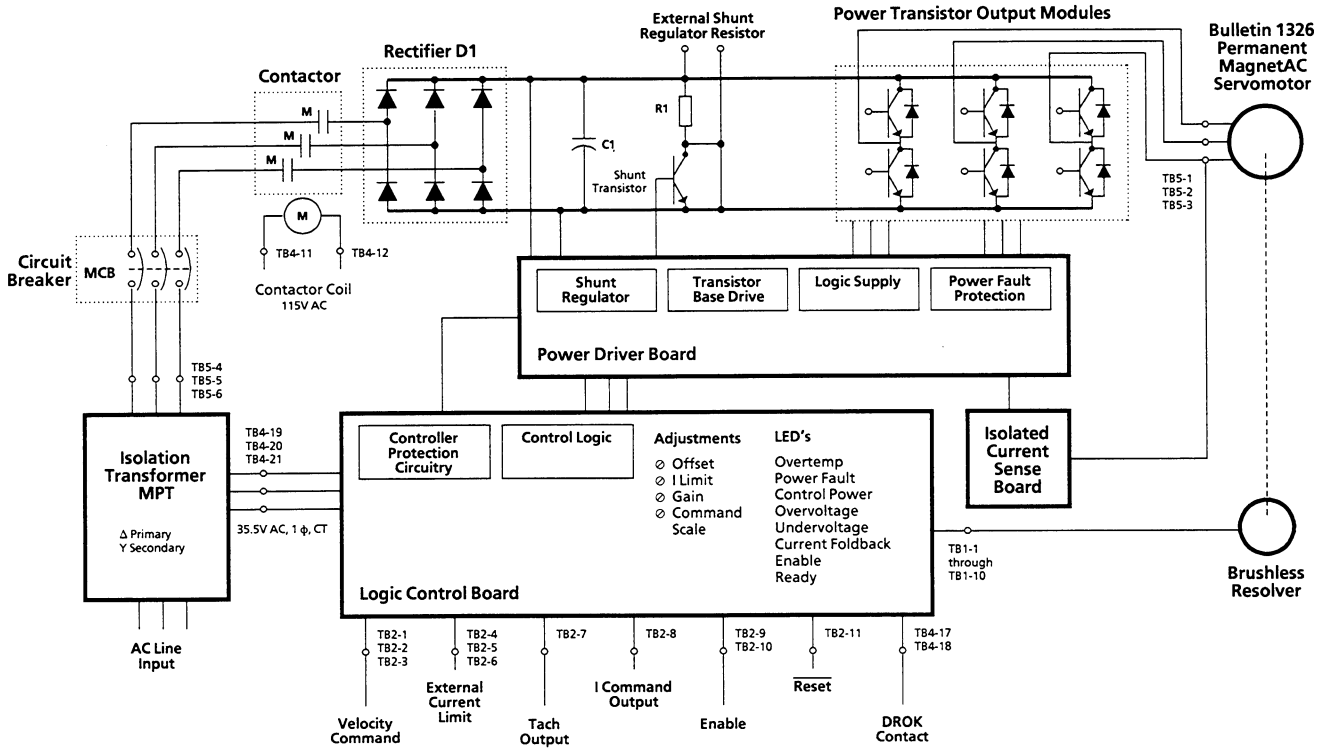
Dimensions are in Inches and (mm)







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.



Bulletin 1391 Block Diagram

Controller Overview

CIRCUIT DESCRIPTION

General

The Bulletin 1391 PWM Servo Controller consists 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/DB contactor.

The intended use of the Bulletin 1391 is to control the speed and torque of an 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.*

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).

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.

Shunt Regulator Operation *(Continued)*
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 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.

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.

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 of the 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.

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.

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.

Line/DB Contactor
The three-phase incoming AC line is opened by the contactor whenever the input 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.

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

Controller Overview
(Continued)

FAULT MONITORING 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 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
A thermal switch on the controller heat sink indirectly senses transistor module temperature.

Power Fault
Monitors the power bridge section of the controller.

Control Power
If the control voltage varies more than ±10% of the nominal 12V DC a fault occurs.

Overvoltage
The DC power bus voltage is continuously monitored. If it exceeds a preset level of 405V DC a fault occurs.

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 response of the DROK relay to an undervoltage condition.

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 and a fault signal will be present at TB4.

Controller Overview
(Continued)

STARTING AND STOPPING

Starting and Stopping must be accomplished by hardwired user supplied elements as shown in the *Bulletin 1391 Interconnect Drawing*. 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 Volts	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.

Regenerative Braking - Normal run commands to the controller are performed through the Enable input and any additional customer supplied control circuitry. 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.

INTERFACE SIGNALS

Interface signals to and from the Bulletin 1391 are connected at terminal blocks. The terminal blocks are designated TB1 through TB5 and are conveniently located on the front of the controller. Refer to the figure on page 14 for terminal block locations.

The following ***inputs*** are available for customer use:

Velocity Command Input

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. The shield must be terminated at source end only. The input impedance of the velocity command input is 20k ohms.

Controller Overview
(Continued)

External Current Limit
The application of 0 to +5V DC at terminals 5 and 6 of TB2 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.

Enable Input
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) or mechanical contact closure at this input will cause the controller to run. When this input is de-energized, the controller will cause a regenerative braking action in the motor.

Drive OK (DROK) Contacts
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 energizes. The contacts remain closed until a controller fault occurs or power is removed from the transformer. Contact rating: 115V AC, 1A or 24V DC, 0.3A.

Reset
Removing the Enable signal and momentarily connecting terminal 11 of TB2 to signal common will reset the controller after a controller fault occurs.

Resolver Signals
Terminals are provided for resolver connections.

The following ***outputs*** are available:

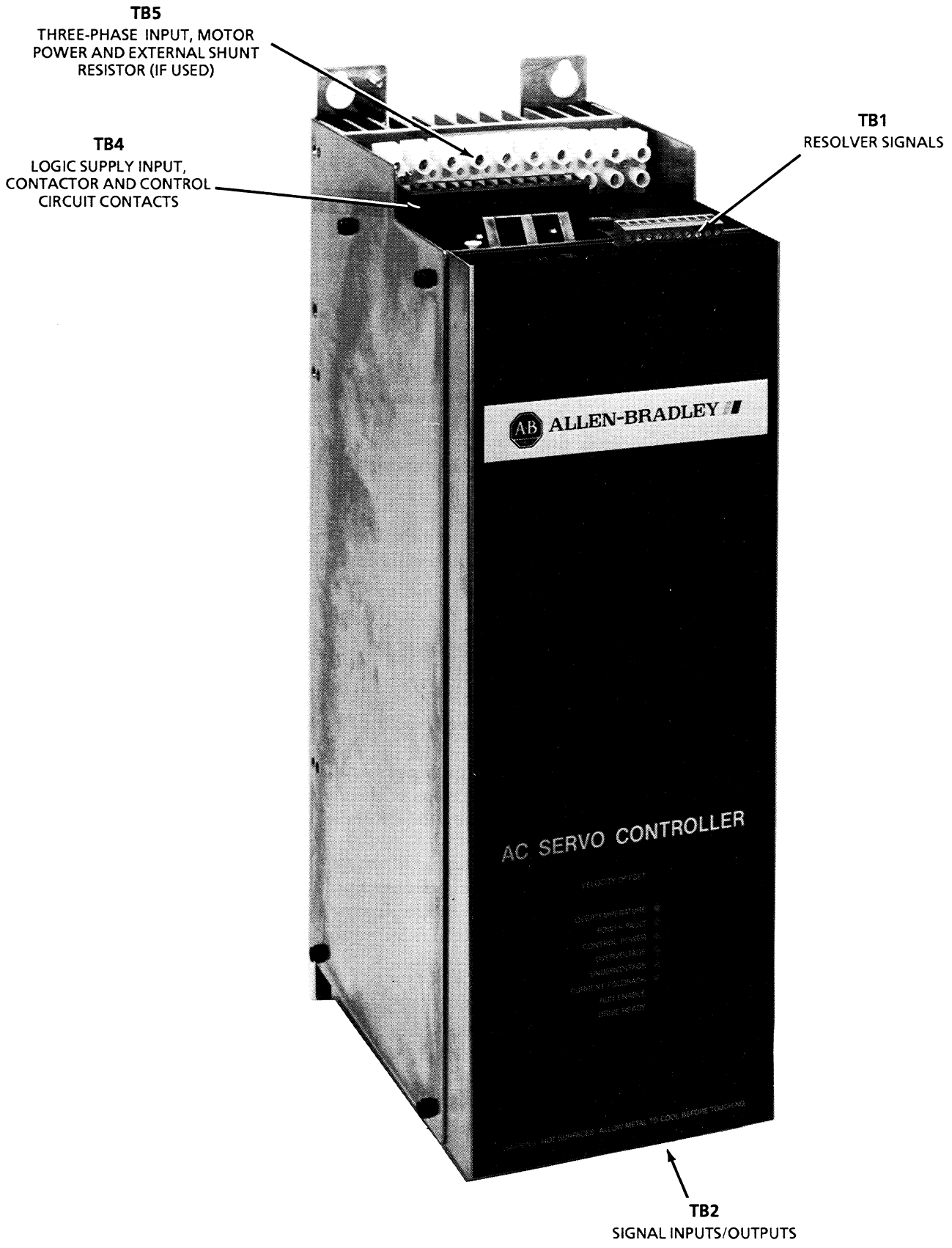
Tachometer Output
A voltage corresponding to the motor velocity and direction of rotation will be present between terminal 7 of TB2 and signal common.

I Command Output
The voltage present between terminal 8 of TB2 and signal common is proportional to the motor current. A voltage of ±3.0V DC (1mA out maximum) equals the rated motor current as set by switch S1.

Low Bus
Terminal 13 of TB2 provides an open collector output of 12V DC at 5mA to indicate a low bus voltage condition.

Current Foldback
Terminal 14 of TB2 provides an open collector output of 12V DC at 5mA to indicate that current foldback is in operation.

BULLETIN 1391 POWER & SIGNAL INPUTS/OUTPUTS



Controller Overview
(Continued)

ADJUSTMENT FEATURES

The following features are adjustable:

Current Limit
Allows adjustment of the maximum current available to the servomotor. The maximum setting is 200% of the continuous and can be calibrated (fine tuned).

Velocity Gain
Fine tunes the response characteristics of the system. Clockwise rotation increases the dynamic gain of the servo amplifier, while counterclockwise rotation decreases gain.

Offset
Provides adjustment of the system offset voltages.

Velocity Command Scale
Allows scaling of the command signal with the velocity feedback signal.

SWITCH AND JUMPER SETTINGS

The Current Scaling switch (S1) allows a controller to be used with Bulletin 1326 AC servomotors having lower current ratings.

The plug jumpers allow selection of the various controller parameters listed below:

Tachometer Output Voltage Select - Configures the Bulletin 1391 tachometer synthesis circuitry to a range appropriate for the applied motors.

I_D Cut In - Sets the speed at which the I_D current is added to the output of the controller. I_D current extends the operational speed of the controller. The point at which I_D current is added changes with different motors.

Electronic Counterbalance - Configures the controller to produce an offset torque in one direction of rotation for use on uncounterbalanced axes.

Velocity Error Disable - Disables the velocity error amplifier to configure the controller for torque block operation.

Velocity Loop Compensation - This jumper is used to compensate the velocity loop for applications with higher load inertia.

Velocity Compensation Defeat - Defeats the integral portion of the velocity loop compensation for torque block operation.

Undervoltage Fault Sense - This jumper is used to determine controller response to bus undervoltage and 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.

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.

Controller Overview (Continued)

I Limit - Configures the controller for special current limit options and is only active on special option controllers. Consult your Allen-Bradley Sales Representative for further information.

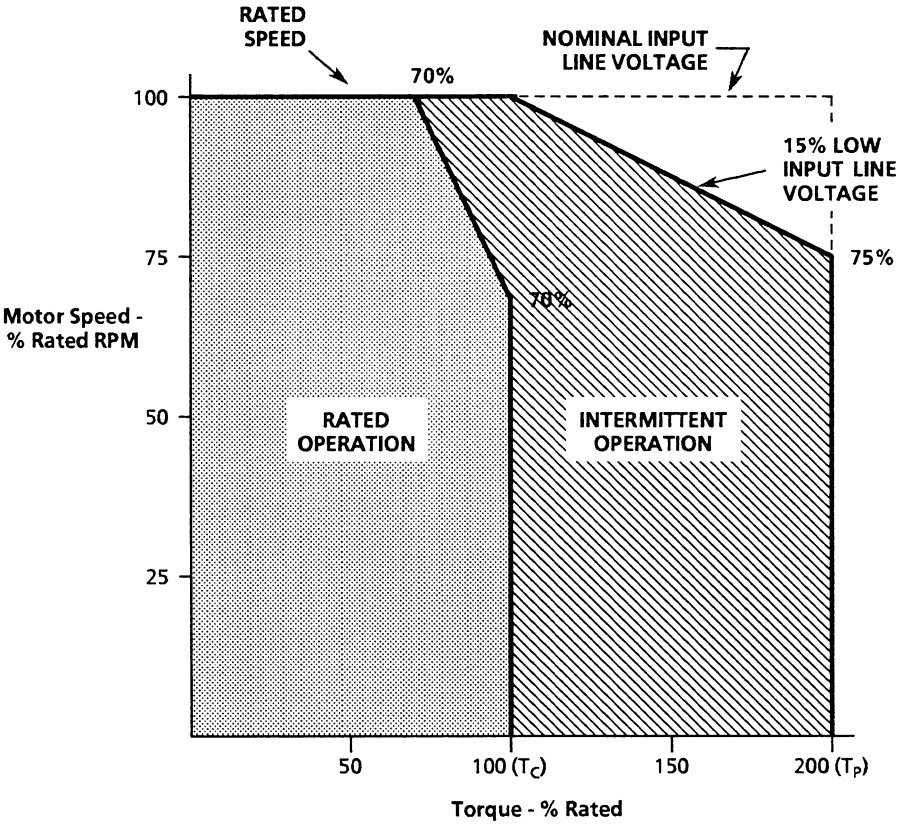
Velocity Command Range - This jumper is used to configure the velocity command range of the controller.

Anti-backlash - Configure the controller for use with the Bulletin 1388-XA Anti-backlash Module. Refer to the *Anti-backlash Module Instruction Manual* for further information.

Operation with the Bulletin 1326 AC Servomotor

This section describes the operation of a Bulletin 1326 AC Servomotor with the Bulletin 1391 AC Servo Controller. Refer to publication *1326A-2.3* or *1326A-2.5* for further information on Allen-Bradley AC Servomotors.

In general, the Bulletin 1326 motor will follow the speed-torque curve shown above.



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.

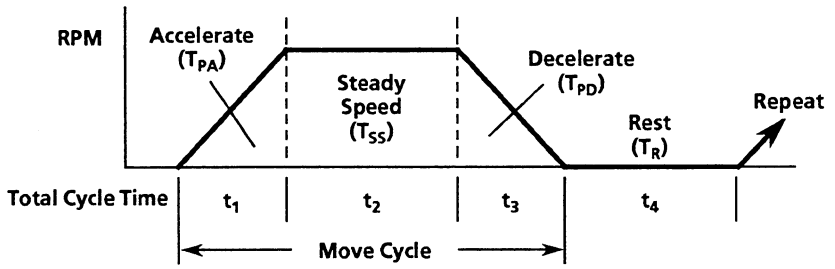
T_P – the Peak Torque that can be produced by the motor and controller combination with both at rated temperature with the motor in a 40°C ambient and the controller in a 60°C ambient. Since 200% current torque peaks are common in many applications for optimal controller usage, the following curves show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

Operation with the Bulletin 1326 AC Servomotor (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



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

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

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.

Bulletin 1391 Isolation 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. A standard line of open core transformers have the necessary secondaries and terminal connections to operate multiple controllers and include a normally closed (N.C.) thermal switch and secondary neutral grounding point.

Transformer Selection

Guidelines for selecting the proper transformer kVA ratings are shown below:

Number of Axis	TRANSFORMER kVA = Machine Tool Duty	Rapid Accel/Decel Duty
1	$kW_{(Largest\ Motor)} \times 0.43 + 0.2$	$kW_{(Largest\ Motor)} \times 0.60 + 0.2$
2	$kW_{(Largest\ Motor)} \times 0.61 + 0.4$	$kW_{(Largest\ Motor)} \times 0.85 + 0.4$
3	$kW_{(Largest\ Motor)} \times 0.86 + 0.6$	$kW_{(Largest\ Motor)} \times 1.20 + 0.6$
4	$kW_{(Largest\ Motor)} \times 1.28 + 0.8$	$kW_{(Largest\ Motor)} \times 1.80 + 0.8$

A general calculation to be used when the duty cycle cannot be defined or 100% duty cycle is required is shown below:

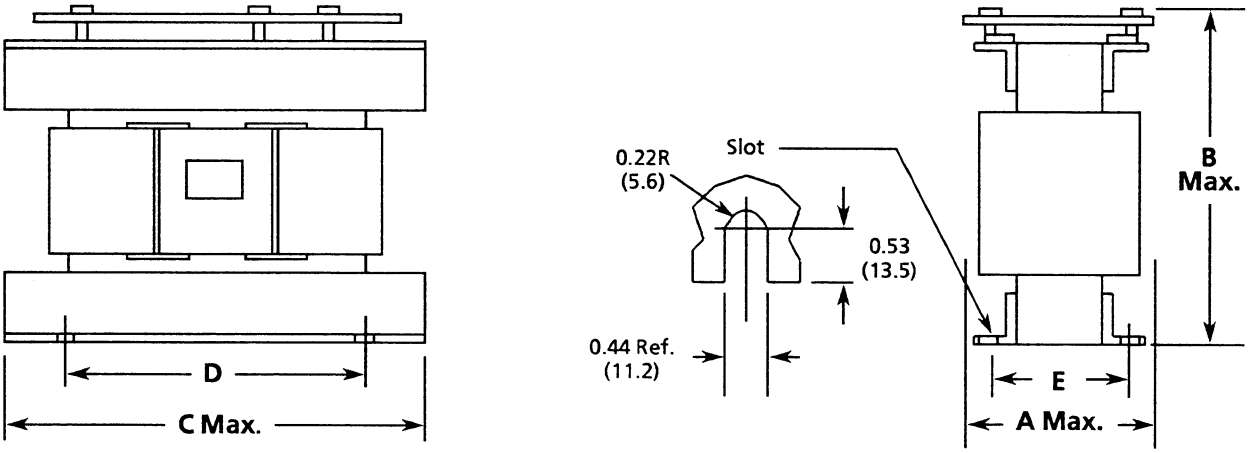
$$kVA = \Sigma \text{ ALL MOTORS } kW \times 1.2 \text{ (minimum of 1 kVA)}$$

Select the transformer kVA rating that is equal to or larger than the calculated value (maximum 15kVA). Refer to the transformer dimension drawing for available ratings and corresponding Allen-Bradley catalog numbers. If all motors must simultaneously supply continuous rated output at speeds exceeding one third of rated speed, contact your Allen-Bradley Sales Representative for assistance.

APPROXIMATE DIMENSIONS AND WEIGHT – ISOLATION TRANSFORMER

IN INCHES (MILLIMETERS) AND POUNDS (KILOGRAMS)

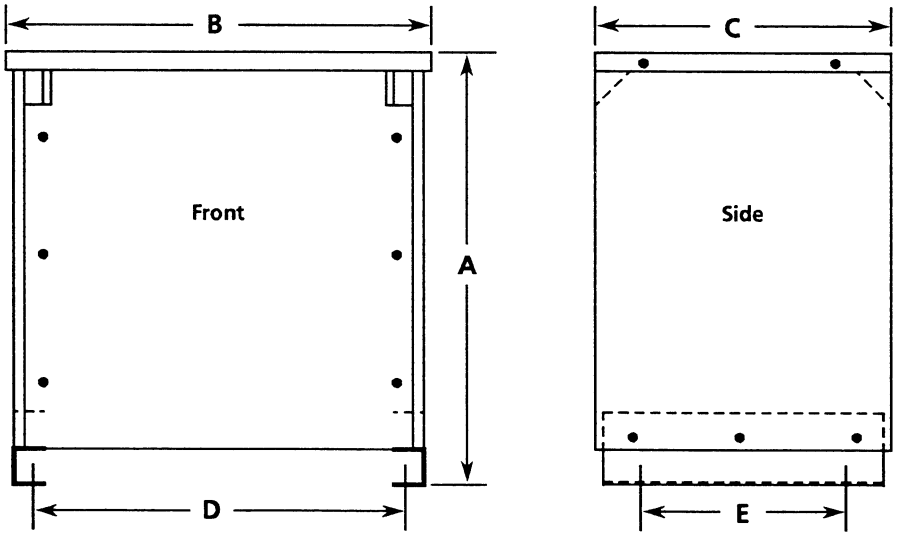
Catalog Number	kVA	A	B	C	D	E	Weight
1391-T015DT	1.5	9.00 (228)	10.00 (254)	13.00 (330)	5.00 (127)	3.10 (79)	27 (12.2)
1391-T015ET/NT		9.00 (228)	10.00 (254)	13.00 (330)	5.00 (127)	3.50 (89)	40 (18.2)
1391-T025DT	2.5	11.00 (279)	11.00 (279)	14.00 (356)	6.00 (152)	3.30 (84)	42 (19.0)
1391-T025ET		11.00 (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)



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)

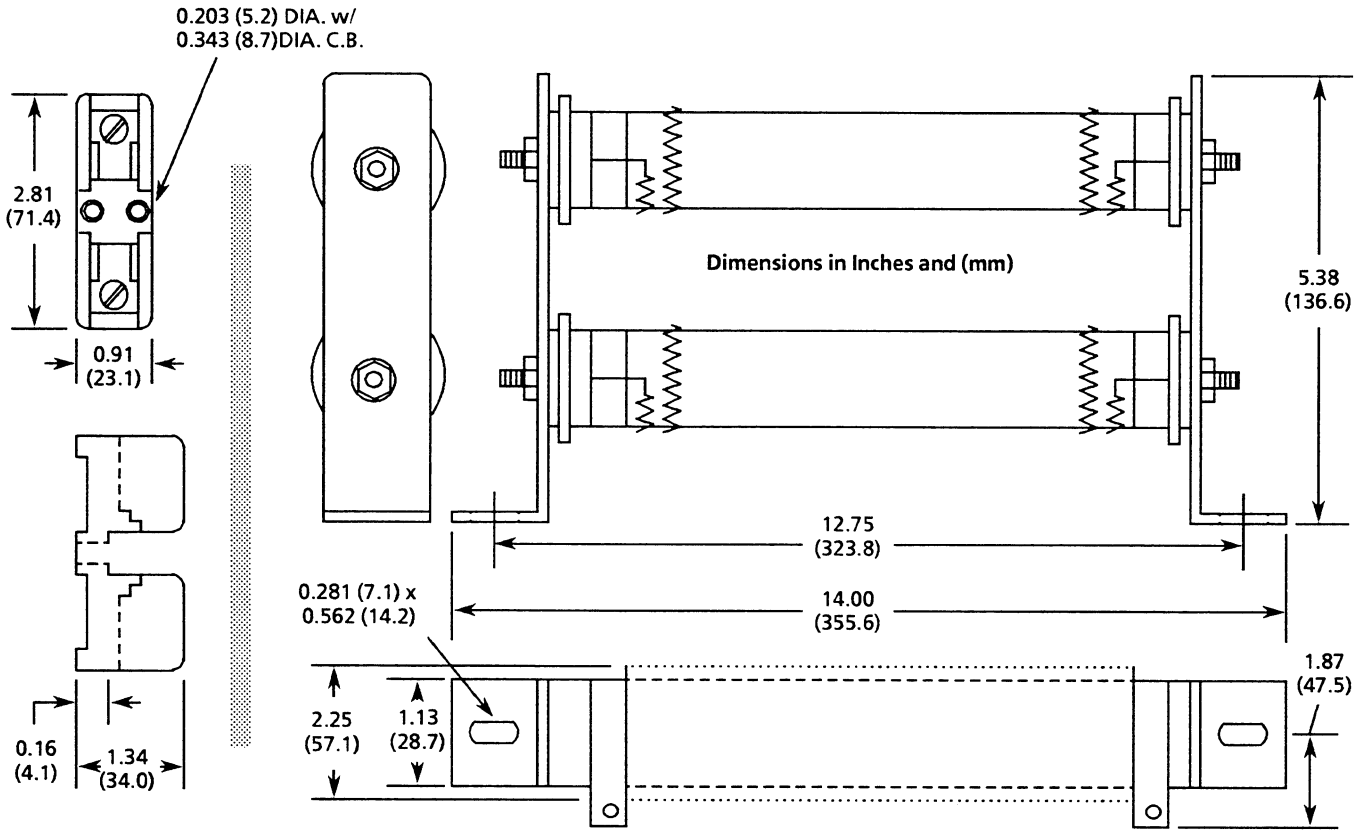


External Shunt Resistors

The Bulletin 1391 is designed to allow the use of an external shunt resistor on the 22.5 and 45A units. This is available for applications that require the dissipation of more regenerative energy to the DC Bus. The shunt regulator resistor supplied with the Bulletin 1391-AA45 must be externally mounted and connected to TB5.

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.



Approximate Dimensions, External Shunt Resistor and Fuse

Bulletin 1391 Interconnect Drawing

The Bulletin 1391 Interconnect Drawing is presented on the following pages. 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

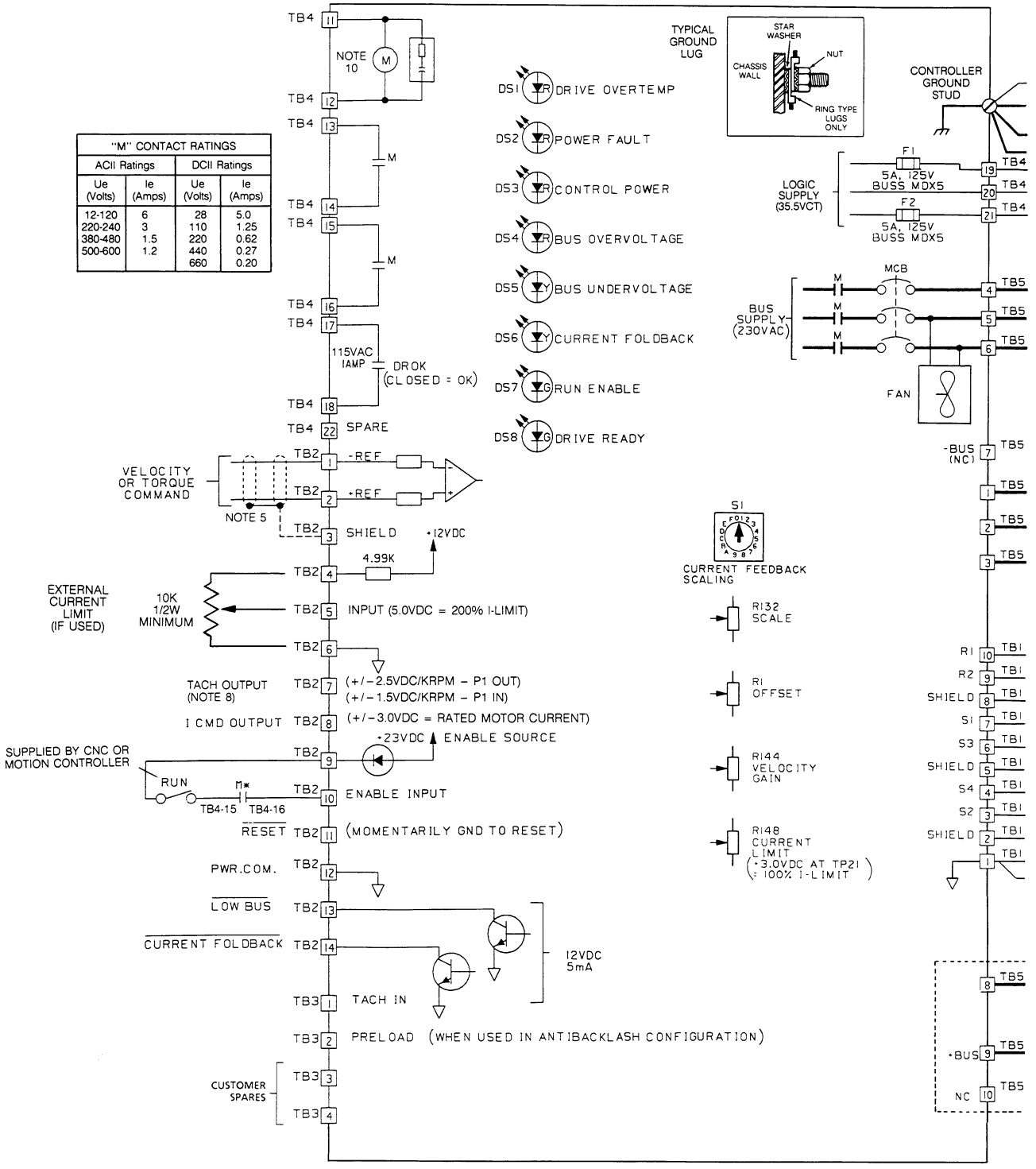
4) RESOLVER CABLE: 1326-CFUxx

5) TERMINATE SHIELD ON SOURCE END ONLY.

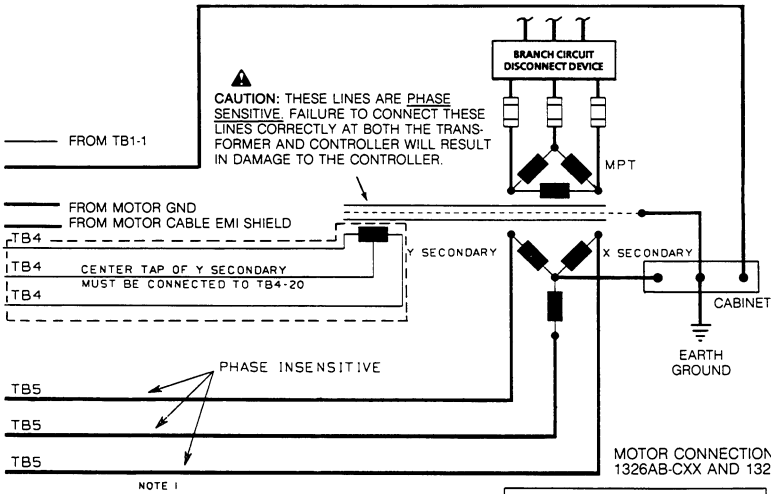
6) DO NOT MAKE CONNECTIONS TO UNUSED PINS ON THE RESOLVER CONNECTOR.

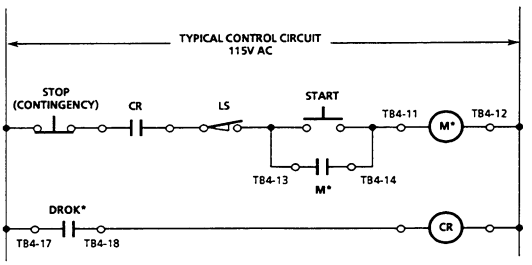
7) F3 PROVIDED ON 15 & 22.5A UNITS ONLY. 15A=KLM-10, 22.5A=FNQ 6¼ SERIES B ONLY.

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


"M" CONTACT RATINGS
ACII Ratings
DCII Ratings
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
TB4 11
NOTE 10
TB4 12
TB4 13
M
TB4 14
TB4 15
M
TB4 16
TB4 17
115VAC 1AMP
DROK (CLOSED = OK)
TB4 18
TB4 22 SPARE
DS1 DRIVE OVERTEMP
DS2 POWER FAULT
DS3 CONTROL POWER
DS4 BUS OVERVOLTAGE
DS5 BUS UNDERVOLTAGE
DS6 CURRENT FOLDBACK
DS7 RUN ENABLE
DS8 DRIVE READY
TYPICAL GROUND LUG
STAR WASHER
NUT
CHASSIS WALL
RING TYPE LUGS ONLY
CONTROLLER GROUND STUD
F1
5A, 125V BUSS MDX5
F2
5A, 125V BUSS MDX5
LOGIC SUPPLY (35.5VCT)
TB4 19
TB4 20
TB4 21
MCB
BUS SUPPLY (230VAC)
TB5 4
TB5 5
TB5 6
FAN
-BUS (NC) TB5 7
TB5 1
TB5 2
TB5 3
VELOCITY OR TORQUE COMMAND
TB2 1 -REF
TB2 2 +REF
NOTE 5
TB2 3 SHIELD
+12VDC
4.99K
TB2 4
EXTERNAL CURRENT LIMIT (IF USED)
10K 1/2W MINIMUM
TB2 5 INPUT (5.0VDC = 200% I-LIMIT)
TB2 6
S1
CURRENT FEEDBACK SCALING
RI32 SCALE
RI OFFSET
RI44 VELOCITY GAIN
RI48 CURRENT LIMIT (+3.0VDC AT TP21 = 100% I-LIMIT)
TACH OUTPUT (NOTE 8)
TB2 7 (+/-2.5VDC/KRPM - P1 OUT)
(+/-1.5VDC/KRPM - P1 IN)
I CMD OUTPUT TB2 8 (+/-3.0VDC = RATED MOTOR CURRENT)
SUPPLIED BY CNC OR MOTION CONTROLLER
+23VDC ENABLE SOURCE
TB2 9
RUN
M*
TB4-15 TB4-16
TB2 10 ENABLE INPUT
RESET TB2 11 (MOMENTARILY GND TO RESET)
PWR.COM. TB2 12
LOW BUS TB2 13
CURRENT FOLDBACK TB2 14
12VDC 5mA
TB3 1 TACH IN
TB3 2 PRELOAD (WHEN USED IN ANTIBACKLASH CONFIGURATION)
CUSTOMER SPARES
TB3 3
TB3 4
RI TB1 10
R2 TB1 9
SHIELD TB1 8
S1 TB1 7
S3 TB1 6
SHIELD TB1 5
S4 TB1 4
S2 TB1 3
SHIELD TB1 2
TB1 1
TB5 8
-BUS TB5 9
NC TB5 10

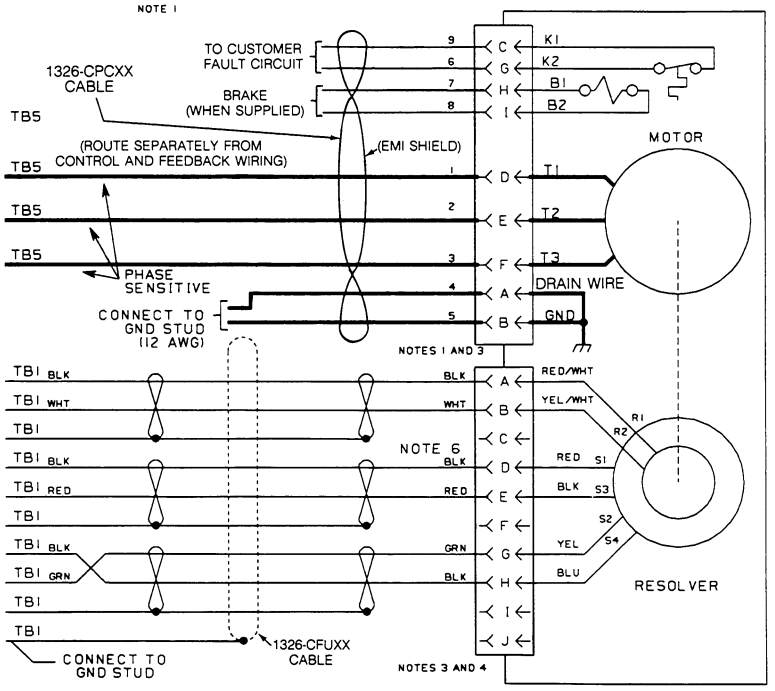
* INDICATES COMPONENTS LOCATED IN 1391 CONTROLLER



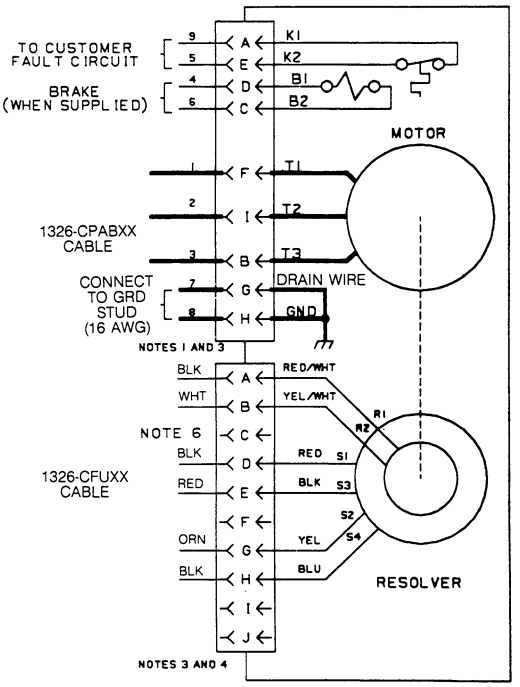


IMPORTANT:
THE THERMAL SWITCH AND BRAKE WIRES ARE ROUTED NEAR MOTOR POWER AND CAN PICK UP PWM RADIATION. ISOLATION FROM CONTROL DEVICES MAY BE REQUIRED.

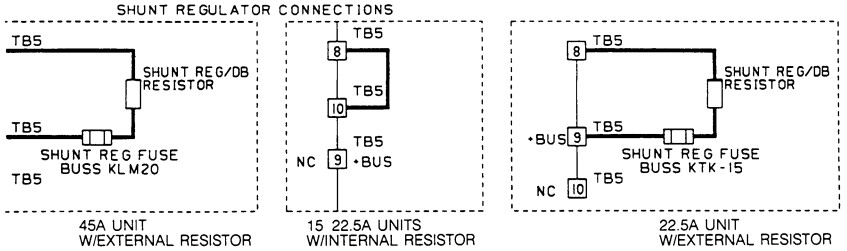
MOTOR CONNECTIONS FOR 1326AB-CXX AND 1326AB-B4X



MOTOR CONNECTIONS FOR 1326AB-BXX AND 1326AB-AXX



SHUNT REGULATOR CONNECTIONS



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