MOOG
North American Drives Operations

Panel Mount, Digital Motor Controller

User's Manual

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BRUSHLESS ELECTRIC MOTORS
AND DIGITAL CONTROLS
USER'S MANUAL
MOOG P/N C22468-001

MOOG, INC.
BRUSHLESS TECHNOLOGY PRODUCTS

SERIES T164-901	**DIGITAL PANEL MOUNT CONTROLLER**
SERIES T164-903	**DIGITAL PANEL MOUNT CONTROLLER**
SERIES T164-905	**DIGITAL PANEL MOUNT CONTROLLER**
SERIES T164-907	**DIGITAL PANEL MOUNT CONTROLLER**
SERIES T164-909	**DIGITAL PANEL MOUNT CONTROLLER**
SERIES T150-901	**POWER SUPPLY**
SERIES G4XX	**BRUSHLESS SERVO MOTORS**

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REV	DESCRIPTION	DATE	EFFECTIVITY
A	Initial Release	04/20/98	ALL
B	CORRECT MISCELLANEOUS ERRORS REMOVE RS485 SUPPORT CORRECT H1 TERMINAL COMMANDS	07/24/98	SECTIONS: 1.1.5, 1.1.10, 1.2, 2.7.6, 2.10.3, 3.2, 3.5, 3.5.2, 4.1.2, 4.1.2.3, 4.1.3.2, 4.1.3.2, 4.1.7.1.2, 4.1.7.1.2, 4.1.8.2, 4.1.18, 4.2, 4.2.1, 4.2.1, 4.2.1.1, 4.2.2.4, 4.2.2.5, 4.2.4.1, 4.2.6.1.1, 4.2.9.2.3, 4.3.1, 4.3.1.1, 4.3.1.1.1, 4.3.1.1.3, 4.3.2.4, 4.3.2.5, 4.3.4.1, 4.3.6.1.3, 4.3.9, 5.2, 5.2.2.6, 5.2.3, 5.3, 5.4, 5.5, 5.6, 5.6.2, 5.7, 5.7, 5.9. FIGURES: 1.1, 2.11, 2.13, 2.15, 2.17, 2.19, 2.22, 2.24, 2.27, 2.32, 2.6, 2.7, 2.8, 2.9, 4.2, 4.52 4.6, 4.62, 5.21, 5.22 TABLE: 5-5

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1. GENERAL INFORMATION

This user's manual is intended to provide sufficient information on how to install, wire and tune a MOOG brushless electric motor system which includes all of the equipment outlined in Section 1.1.

Section 1.2 covers SAFETY and SYSTEM SAFEGUARDS. Section 1.3 covers Electromagnetic Compatibility (EMC). This user's manual must be read and understood before applying power and operating the equipment described.

This equipment must be installed only by service personnel technically qualified to a minimum level of British HNC in electrical engineering or equivalent. All information in this manual is directed towards such personnel only.

Throughout this user's manual may be found NOTES, CAUTIONS, and WARNINGS. They are defined as follows:

NOTE
NOTES are general in nature and are intended to emphasize information.

CAUTION
CAUTIONS are to alert personnel to actions that could cause equipment damage resulting in the equipment becoming unsafe

WARNING
WARNINGS serve to make personnel aware of potentially hazardous actions that may result in personal injury.

1.1 SYSTEM COMPONENTS

The following components are required to build a MOOG brushless motor velocity or torque digital control system, (refer to FIGURE 2.2 and FIGURE 2.3). Section 5 provides more thorough descriptions and complete specifications of these components.

NOTE

Throughout this Section, references are made to user-supplied equipment. In instances, third party products are listed. Moog has found these products to perform satisfactorily with the T164 Series equipment and T150-901 Power Supply when used as described herein. Moog assumes no responsibilities, provides no guarantees of performance or product availability, nor provides any warranties associated with third party equipment.

1.1.1 ISOLATION TRANSFORMER - (USER SUPPLIED)

This is a required part of the total system and serves the following functions:

- Matching the mains supply line voltage to the required power supply input voltages.
- Mains isolation.
- Limiting available short circuit fault current to be within the interrupting rating of the a.c. input circuit breaker.

NOTE

The system is designed to allow direct a.c. off line operation from a 220 Vr.m.s 50/60 Hz three phase source capable of delivering not more than 5000 r.m.s. symmetrical amperes. A mains isolation transformer constructed in accordance with European standard EN 60742 is required to meet applicable electrical safety requirements of European safety standard EN 60204-1 and to provide fault current limiting. For CE compliance a 380/220 V, 3 Phase, step down transformer rated 15 kW maximum shall be used.

Transformers should be installed in a clean, dry, enclosed environment. Consult manufacturers data sheets for maximum ambient temperature.

1.1.2 A.C. INPUT CIRCUIT BREAKER - (USER SUPPLIED)

WARNING

The T150-901 Power Supply requires the user to supply an a.c. disconnecting device (circuit breaker) rated at 63 A r.m.s. on all incoming a.c. voltage supply lines for each T150-901 Power Supply used in an application.

A hand-operated supply disconnecting device (circuit breaker) shall be provided for each incoming supply. This supply disconnecting device (circuit breaker) shall meet the requirements of European standard EN 60204-1 as detailed below.

This device shall disconnect the electrical equipment of the machine from the supply when required (e.g. during work on the electrical equipment).

When two or more supply disconnecting devices are provided, protective interlocks shall be used where a hazardous condition or damage to the machine or to the work in progress could occur.

The supply disconnecting device (circuit breaker) shall be one of the following types:

- ❑ a switch disconnect in accordance with European standard EN 60947-3; utilization category AC-23B or DC-23B;

- ❑ a disconnect which has an auxiliary contact which in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnect;

- ❑ a circuit-breaker in accordance with European standard EN 60947-2 suitable for isolation in accordance with European standard EN 60947-3;

The supply disconnection device, disconnect, or circuit breaker shall fulfill all of the following requirements:

- ❑ Isolate the electrical equipment from the supply and have one OFF and one ON position only, clearly marked with “O” and “I” and with the actuating directions in accordance with European standard IEC 447. Circuit breakers which, in addition , have a reset (tripped) position between “O” and “I” are also deemed to satisfy this requirement;

- ❑ Have a visible gap or position indicator which cannot indicate OFF until all contacts are actually open and there is an adequate isolating distance between all the contacts in accordance with European standard EN 60947-3

- ❑ Have an external operating handle. Where the disconnect does not also serve as an emergency stop device, its operating handle shall not be RED. Black or Grey is recommended;

- Be provided with a means permitting it to be locked in the OFF position (e.g. by padlocks)

- Disconnect all live conductors of its power supply circuit.

- Have a breaking capacity sufficient to interrupt the current of the largest motor when stalled, together with the sum of the normal running currents of all other motors and/or loads.

The handle of the supply disconnecting device (circuit breaker) shall be installed in a manner to be easily accessible. It shall be located between 0.6 meters and 1.9 meters above the servicing level; a maximum height of 1.7 meters is recommended.

WARNING

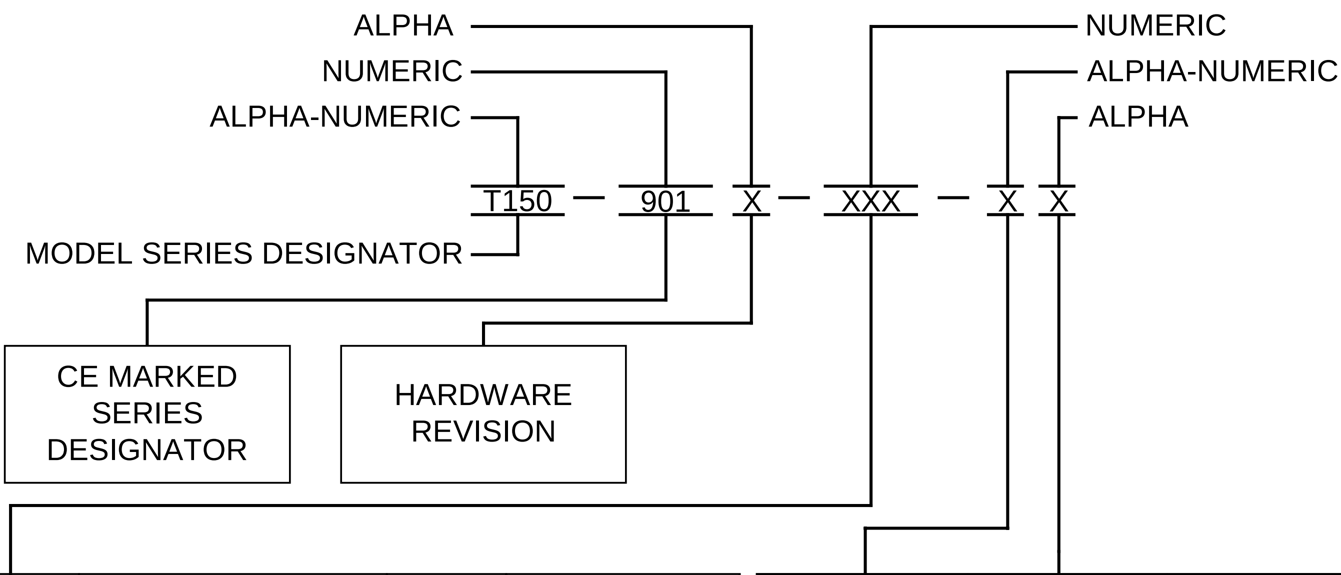
The supply disconnecting device (circuit breaker)must be switched to the OFF position before any service or maintenance activity is commenced.

It is also recommended to install a drive rated three pole contactor between the output of the AC mains isolation transformer and the incoming a.c. voltage supply power lines of the T150-901 Power Supply, (refer to FIGURE 2.2 and FIGURE 2.3). This contactor should be controlled directly by Emergency stop buttons and other series connected safety switches to remove a.c. input power in any situation affecting personnel safety.

1.1.3 POWER SUPPLY - MODEL T150-901

The Power Supply converts the incoming AC voltage to the d.c.. voltage supplied to the T164 Series Drives. The Power Supply provides up to 15 kW continuous output power thus allowing a number of drives to operate from a single power supply unit.

The Power Supply also bleeds energy from the d.c. bus to an internal regeneration (regen) resistor when a motor or motors are in a regeneration mode. Optional external mounted regen resistors are available for applications requiring higher regen capabilities, (refer to Section 2.7).



REGEN IDENTIFIER	REGEN CONFIGURATION DESCRIPTION	REGEN POWER LEVEL	REGEN RESISTOR KIT REQUIRED
000	UNCONFIGURED FOR REGEN	---	NONE
701	REGEN -FULLY CONFIGURED	40W	NONE
702	REGEN- INTERNALLY CONFIGURED ONLY, REQUIERS ADDITIONAL REGEN RESISTOR KIT FOR FINAL CONFIGURATION	240W	C09838-002
706		600W	C09838-006
722*		1000W*	C09838-010*
722		2500W	C09838-022
723		2500W	C09838-023

BRAND NAME	BRAND REVISION	BRAND REVISION
1	A	MOOG LEXAN (BLACK)
2	A	MOOG LEXAN (MAROON) (USED WITH WINDRIVE)

* NOTE: AVAILABLE IN EUROPE ONLY

FIGURE 1.1 T150 Boxcar System

1.1.4 DRIVE - MODEL T164 SERIES

Five drive current ratings are available, rated 5, 10, 20, 40, 60 A r.m.s. continuous per motor phase. All drives are configurable in either velocity or torque control mode. The drive outputs a synthesized variable frequency and variable amplitude three phase sinusoidal current for accurate control of motor speed and torque.

All drives include an internal switchmode power supply (SMPS) which generates drive logic power. This internal SMPS operates from a user supplied external 24 Vd.c. source. The external 24 Vd.c. allows control power to be maintained without high power energized.

The external 24 Vd.c. voltage must be a Safety Extra Low Voltage (SELV - As defined by European standard EN 60950) and must also be supplied from a power supply which is compliant with the European Union (EU)
EMC Directive 89/336/EEC (as amended by EU Directives 92/31/EEC and 93/68/EEC)

BASE MODEL NUMBER	CURRENT RATING CONT./PEAK A r.m.s.
T164-901	5/10
T164-903	10/20
T164-905	20/40
T164-907	40/80
T164-909	60/140

TABLE 1-1 Model T164 Series Definition

Several option cards are available for the T164 Series Drives; an Encoder Simulation Card, an Extended input/output (I/O) card, a Point Card, a CAN Interface Card and Input Brackets. The Encoder Simulation card, using rotor position data from the output of a resolver to digital converter, emulates a rotary incremental encoder. The output signals of the Encoder Simulation card are optically isolated. The Extended I/O card provides additional isolated input and output capability. The Point Card provides point-to-point position control that is sequenced by a User defined program. Discrete analog and serial interfaces are available to allow sense and control of external devices. Point provides a true stand alone single axis control system. CAN is a high speed serial interface used for communication of real time position feedback, command reference and status information. The Input Brackets option allows clockwise (cw) and counter clockwise (ccw) limit inputs, torque/velocity selection and auto/manual mode operation. Consult Moog for additional information concerning the option cards.

The complete model number describing a T164 Series drive utilizes a boxcar number system which is comprised of the base model number (FIGURE 1.2), followed by suffixes which designate the model revision, the option cards installed in option slots 1 and 2, and the drive software version. Contact your Moog Sales Representative for current details on the box car model number system.

The T164 is described in a "boxcar" system (Refer to FIGURE 1.2). Each option, revision, and model is described according to the following structure.

T164-90XX-XX-XX-X-XX

Current Rating:
1 - 5/10 Arms
3 - 10/20 Arms
5 - 20/40 Arms
7 - 40/80Arms
9 - 60/140 Arms

Hardware Revision Level i.e A:

Expansion Cards:
0 - None
1 - ESM B89378-001
2 - CAN isolated C09242-001
4 - CAN non - isolation C09242-003
5 - Point B92214-004
6 - Extended I/O B89666-002
7 - Extra Inputs Bracket (1st slot only) C09743-001
8 - Extended I/O Card Full Version B89666-003

Labeling Kit:
1A - MOOG
2A - Windrive

Communications:
2 - RS232
4 - RS485

Software Revision:

Hx - Windrive
Cx - Moogterm
Gx - CAN Profile Mode

For the Expansion Cards:
The first digit equals first slot, second digit equals second slot, slot 1 should be used prior to using slot 2.

FIGURE 1.2 T164-90X Boxcar System

1.1.5 SERIAL SET-UP TERMINAL (USER SUPPLIED)

A serial communication port is provided for configuration and monitoring of the T164 Series Drive. An RS232 interface should be established for drive communications, using a user supplied IBM compatible personal service set-up computer (PC) or a hand held service terminal (See also Section 4.3 of this Users Manual).

The hand held terminal or personal computer are service engineer tools only and must be installed so that use of the key sequences which allow control of the machine functions is accessible to authorized qualified service personnel only. All such hand held service terminals or service set-up computers must be CE marked as compliant with the EU EMC Directive.

1.1.6 VD.C. POWER SUPPLY (USER SUPPLIED)

To develop control power, the user must supply a 24 Vd.c. power supply. The 24 Vd.c. control power option allows high voltage motor power to be removed from a T164 Series Drive without losing control power. The acceptable voltage range for this supply is 21 to 35 Vd.c. with a minimum current rating of 1.5 A d.c. per T164 Series Drive connected.

This 24 Vd.c. power supply must be compliant with the requirements of the EU EMC Directive. The 24 Vd.c. voltage output from the power supply must be Safety Extra Low Voltage (SELV - as defined by European standard EN 60950).

NOTE

Power supplies which incorporate internal electronic current limiting can cause problems in start-up of the T164 Series Drives' internal SMPS. Such current limiting supplies must be capable of providing 2 amps minimum short circuit current per T164 Series Drive.

1.1.7 BRUSHLESS SERVO MOTORS

The standard G400 series brushless servo motors are offered in five frame sizes. Each frame size includes four different stack lengths. The continuous output power varies from 150 Watt to 7.8 KWatt. Motors are also available with an optional static holding brake.

Normal connection to the motor requires two cables, a power and a resolver cable. The power cable provides three phase stator power, protective earth and brake connections. The resolver cable carries rotor position information and also the thermistor connections. Position information is provided by a 2-pole pancake resolver which is integral to the motor. The thermistor is embedded in the stator winding head and used for thermal protection.

1.1.8 HEAT SINKS - ELECTRONIC COMPONENTS

The need for heat sinks and/or air conditioning will depend on the duty cycle of the system and the surrounding ambient temperature. The maximum ambient temperature to prevent damage to the drives and power supply described herein is 55°C (131°F). T164 Drives and the T150-901 Power Supplies incorporate integral heat sinks which provide for air flow around the power devices. Other than controlling ambient temperature, additional heat sinking should not be required.

1.1.9 MATING CONNECTORS, CABLES AND WIRING

Cables are not provided for the interconnections between the equipment described in Sections 1.1.1 through 1.1.6 Refer to Section 1.2, 1.3 and Section 2 for safety and electromagnetic compatibility requirements for cables and wiring and details/drawings on cabling requirements. The power and resolver cables as well as the mating connector for the motor-drive connections are available and can be purchased from MOOG.
Four different cable lengths 5 m, 10 m, 15 m and 20 meters are standardized.
See Section 2.10 for detailed information.

1.2 SAFETY

> **NOTE**
> *These safety precautions are guidelines only and are not claimed to be comprehensive.*

The Moog Brushless Technology products described herein, in conjunction with the system drive, provide the capability for control of remote devices. Typically, these remote devices move at high speeds and exert considerable force. Like all mechanical systems and most industrial equipment, they must be treated with respect by both the user and the operator.

> **NOTE**
> *This user's manual defines "user" as the responsible person or company and "operator" as a person who starts, stops or monitors workcell operation.*

This user's manual should be read by all personnel who operate or maintain the computer controlled systems, or who work within or near the workcell.

> **NOTE**
> *Individuals responsible for the installation of the equipment described in this user's guide must insure; 1) only technically qualified individuals are employed to work on the installation, 2) these qualified individuals have the accompanying documentation available at all times when working on the installation and are obliged to use this documentation in a consistent manner, and 3) work on, or close to, the installation is prohibited for non-technically qualified individuals..*

This user's manual assumes that the user has a basic working knowledge of brushless technology servo products and the system drive. The user should provide the necessary additional training for ALL personnel working within or around the workcell.

1.2.1 SYSTEM SAFEGUARDS

1.2.1.1 GENERAL SAFETY REQUIREMENTS

Users are required to implement safety measures into all equipment, systems and installations into which the T150-901 Power Supply and T164 Series Drives are installed. In addition, safeguards must be an integral part of workcell design, installation, operator training and operator procedures where this equipment is used.

Users are directed to refer to the European Union (EU) Machine Safety Directive: 89/392/EEC (as amended by EU Directives 91/368/EEC, 93/44/EEC and 93/68/EEC) and EU Low Voltage Directive 73/23/EEC (as amended by EU Directive 93/68/EEC) for essential health and safety requirements to be met. Furthermore the requirements of the EU EMC Directive: 89/336/EEC (as amended by EU Directive 92/31/EEC and 93/68/EEC) must be met by all equipment, systems and installations into which the T150-901 Power Supply and T164 Series Drives are installed.

For further information on the requirements of the European Union Directive on machine safety the user is recommended to refer to the publication: Community Legislation on Machinery (Pierre Massimi and Jean-Pierre Van Gheluwe) 1993 , published by the Office for Official Publications of the European Communities, Luxembourg (ISBN 92-826-5692-6).

For further information on the requirements of the European Union Low Voltage Directive for electrical safety of machinery the user is recommended to refer to European Standard EN 60204-1:1992: Safety of Machinery - Electrical equipment of machines Part 1: General requirements (1992), published CENELEC, the European Committee for Electrotechnical Standardization, Brussels.

Further information on the requirements of the EU EMC Directive are given in Section 1.3 of this General Information part.

1.2.1.2 SPECIFIC SAFETY REQUIREMENTS

The specific safety measures described below are required to be installed by the user into all equipment, systems and installations into which the T150-901 Power Supply and T164 Series Drives are installed.

The user is required to provide safety interlocks to prevent unexpected restart during servicing of the T150-901 Power Supply, the T164 Series Drives and any equipment attached to or driven by these units.

The T150-901 Power Supply and T164 Series Drives themselves must be installed in enclosures or cabinets which provide a degree of ingress protection against liquids and objects of at least IP54. These enclosures or cabinets must be accessible to technically qualified service or maintenance persons only.

The T150-901 Power Supply and T164 Series Drives must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure or cabinet must be permanently connected to Earth. The Earth continuity between the earth terminal and any accessible part of the enclosure or cabinet shall be less than or equal to 0.1 ohms.

All external Regen (Regenerative circuit) resistors used with the T150-901 must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP54 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.

All external d.c.. supply voltages used with the T150-901 Power Supply and T164 Series Drives must be derived from a Safety Extra Low Voltage (SELV) supply as defined by standard EN60950. Such SELV voltages do not exceed a value of 60 Vd.c. or 42.4 V peak under normal conditions and are supplied by circuits which are separated from all hazardous voltage conductors by permitted safety methods such as reinforced insulation.

The user is required to connect the PSU fault signal supplied by the Moog T150-901 power supply and amp fault supplied be the MOOG T164-90X drive to the front end drive system. This must be done to prevent accidental start up following stoppage due to power failure or fault operation.

Interlocking must be installed by the user to delay drive enabling until the power supply fault output signal clears, otherwise damage to the power supply may result.

All electrical supply wires and cables to this equipment must be installed in wireways (cable routings) which are smooth and free from sharp edges.

All external electrical wiring connected to this equipment must be color coded in accordance with European Standard EN 60204-1 requirements. (Refer to Section 2.9.1 of this Users Manual).

All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the T150-901 Power Supply, the T164 Series Drives and the Regen resistor(s) must be protected and anchored in accordance with the requirements of EN 60204-1. (Refer to section 2.9of this Users Manual).

A mains circuit breaker must be installed with this equipment. This circuit must be installed in a manner accessible to the user and must conform with the requirements of EN60204-1 Para. 5.3.2 and 5.3.3. (Refer to section 1.1.2 and Section 2.1of this Users Manual).

A mains isolation transformer must be installed between the mains voltage supply and the power inputs of the T150-901 power supply. This transformer is required to be constructed in accordance with the requirements of European standard EN 60742 to meet the requirements of standard EN 60204-1. For CE compliance this transformer shall be a 380/220VAC, 3 Phase transformer rated 15 kW maximum.

Overload protection must be installed for motors with ratings exceeding 2 kW connected to the T164 Series Drives.

All hand held service terminals and/or service set-up computers connected to the T164 Series Drives which allow control of the machine functions must be installed as service tools only and access to these service tools must be restricted to technically qualified service/maintenance persons only.

The User must restrict to technically qualified service/maintenance persons only instructions on use of key sequences for such service tools which allow the control of the machine functions.

1.2.2 EQUIPMENT SAFETY

All persons must observe sound safety practices during the operation and testing of all electrically powered equipment.

Prior to first use power should not be applied to the T150-901 Power Supply and T164 Series Drives until all instructions in the Configuration Section of this Users Manual have been carried out.

WARNING

Power must always be removed from the T150-901 Power Supply and T164 Series Drives before commencing any servicing, maintenance, repair or upgrading of this equipment.

WARNING

DO NOT remove or replace any assemblies, subassemblies or components with primary power present.

WARNING

Lethal voltages remain present within this equipment when the power mains power is removed. It is recommended to refrain from commencing any servicing, maintenance, repair or upgrading of this equipment until at least five minutes after power shutdown. It is further recommended to measure the voltage level at all high voltage terminals before commencing any such activities, to ensure that no lethal voltages are present.

WARNING

Repair or internal adjustments to the T150-901 Power Supply and T164 Series Drives must not be attempted. All faulty items must be returned to Moog Service Centers for maintenance and repair. (Refer to Section 8 of this Users Manual).

1.3 ELECTROMAGNETIC COMPATIBILITY (EMC)

The T150-901 Power Supply and T164 Series Drives are system components which must be installed in a correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. The requirements of European Union (EU) EMC Directive: 89/336/EEC (as amended by EU Directives 92/31/EEC and 93/68/EEC) must be met by all equipment, systems and installations into which the T150-901 Power Supply and T164 Series Drives are installed.

For further information on the requirements of EU EMC Directive the user is recommended to refer to the publication: Guidelines on the Application of Council Directive 89/336/EEC (Brussels 25 - 26 October, 1993), published by the Office for Official Publications of the European Communities, Luxembourg.

The T150-901 Power Supply and T164 Series Drives have been tested for compliance with the requirements of the EU EMC Directive in so far as they can be regarded as single functional units. The T150-901 Power Supply and T164 Series Drives have been tested in typical configurations and it has been found that these configurations meet the essential requirements of the EU EMC Directive.

Details of these T150-901 Power Supply and T164 Series Drives EMC test configurations are given in Section 1.3.2 of this Users Manual. The EMC standards applied were as follows:

- ❑ EMC Emission standard EN 55011:1991, Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment (Class A limits).
- ❑ EMC Immunity standard EN 50082-2:1995, Electromagnetic compatibility Generic immunity standard Part 2: Industrial environment.

Both these standards are published by CENELEC, the European Committee for Electrotechnical Standardization, Brussels.

1.3.1 SPECIFIC ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

The EMC measures outlined below are required to be installed by the user into all equipment, systems and installations into which the T150-901 Power Supply and T164 Series Drives are installed. Further details are given in the referenced Sections of this Users Manual.

The T150-901 Power Supply and T164 Series Drives must be installed by mounting on a panel in a manner that ensures that EMC earthing requirements are met. (Refer to Section 2.5of this Users Manual).

For safety reasons the T150-901 Power Supply and T164 Series Drives and the panel on which they are mounted must be installed in enclosures or cabinets which provide a degree of ingress protection against liquids and objects of at least IP54. These enclosures or cabinets must be accessible to technically qualified service or maintenance persons only. (Refer to Section 1.2.1 of this Users Manual).

For Electrostatic Discharge (ESD) reasons all service or maintenance persons must ground themselves to the chassis of the equipment when performing service functions inside the IP54 rated enclosure or cabinet in which the T150-901 Power Supply and T164 Series Drives are installed. This may be done by using an ESD wristband with earth strap.

All external d.c.. supply voltages used with the T150-901 Power Supply and T164 Series Drives must be supplied from power supplies which are compliant with the requirements the EU EMC Directive.

All external computers, hand held terminals or similar equipment attached by the user to the T150-901 Power Supply and T164 Series Drives must be CE marked as compliant with the requirements of the EU EMC Directive.

An a.c. power input line filter is required to be installed by the user in the a.c. power input supply lines to the T150-901 Power Supply. Details of a.c. power line filters which have been tested with the typical configurations of T150-901 Power Supply and T164 Series Drives referred to in Section 1.3.2 of this Users Manual and are given in Section 2.3 of this Users Manual. Detailed installation instructions for such a.c. power line filters are given in Section 2.3 of this Users Manual.

Ferrite EMC suppression components are required to be installed by the user on cables connected to certain ports on the T150-901 Power Supply and T164 Series Drives. Details of ferrite EMC suppression components which have been tested with the typical configurations of T150-901 Power Supply and T164 Series Drives are referred to in Section 1.3.2 of this Users Manual and are given in Section 2.5 of this Users Manual. Detailed installation instructions for such ferrite EMC conformity components are given in Section 2.5of this Users Manual.

Shielded cable is required to be installed by the user for many external user cable connections to the T150-901 Power Supply and T164 Series Drives. Details of areas where shielded cable must be installed and details of earthing arrangements which must be implemented for the shields of such cables are given in Section 2.5 and Section 2.9of this Users Manual. Installation requirements for external Regen (Regenerative Circuit) resistors are given in Sections 2.5and 2.7of this Users Manual.

1.3.2 T150-901 POWER SUPPLY AND T164 SERIES DRIVES EMC TEST CONFIGURATIONS

Configuration I:

The configuration consisted of three phase a.c. mains input via a Siemens B84143-A36-R filter and 380/220 V r.m.s, 3 Phase Step Down mains isolation transformer to a T150-901 Power Supply plus T164-901, T164-903, and T164-909 Drives. Three meter terminated shielded communications cables were connected to the J1 output ports of each drive.

The T164-909 drive had an ESM II option card installed with a terminated unshielded 3 meter communications cable connected to the ESM II port (J4). A Fair-Rite Products Type 0443164151 common mode ferrite was installed on this cable at the ESM II port (J4). An Oyster Terminals Type 4 service terminal was permanently connected to the communications port (J3) of this drive. The T164-909 Drive with ESM II option was driving a Moog Type G425-800 motor.

The T164-903 drive had a CAN option card installed with a 30 meter shielded cable connection to a remote Crisp Industrial 386 P.C. A Steward Type 28A2024-0A0 common mode ferrite was installed on this cable at the DMC CAN port (X2) with 1.5 turns of the cable through the ferrite. A Steward Type 28A2024-0A0 common mode ferrite was installed on this cable with 1.5 turns of the cable through the ferrite at the Crisp PC port end of the cable. The T164-903 Drive with CAN (CANBUS) option was driving a Moog Type G415-600 Motor.

A three meter terminated CAN interface shielded cable was permanently connected to the second CAN card daisy chain port (X3). A Steward Type 28A2024-0A0 common mode ferrite was installed on this cable at the DMC CAN Port (X3) with 1.5 turns of the cable through the ferrite. A three meter terminated shielded communications cable was connected to the CAN card X1 output port. An Oyster Terminals Type 4 service terminal peripheral was permanently connected to the communications port (J3) of the drive

The T164-901 drive had a Point option card installed with 3 meter terminated shielded cable permanently connected to the Point output port (X4). A Fair-Rite Products Type 0443164151 common mode ferrite was installed on the cable at the Point port (X4).

An operating routine was downloaded via the Point card communications interface port (X3)connector prior to testing. A B81655 Axis ID Module option card plus 3 meter terminated RS485 interface shielded cable was permanently connected to this Point communications interface port (X3)during testing. An Oyster Terminals Type 4 service terminal peripheral was permanently connected to the communications port (X3) of the drive. The T164-901 Drive with Point option was driving a Moog Type G415-600 Motor.

A 24Vd.c. external power supply was connected to all drives. An external regen resistor was connected via a 5 meter shielded cable to the T150-901 Power Supply. Ten meter long shielded motor power and motor resolver cables were connected between the drives and the motors. The motor power cable and external regen resistor cable shields were grounded to the Chassis Earth using P clips. Shielded cable was used for the mains power input cable and all power cable connections between the a.c. input power Line Filter and the T150-901 Power Supply power input.

Unshielded cable was used for all connections between the T150-901 Power Supply and T164 Drives and for the external 24Vd.c. supply to the T164 Drives. All cables from Drive output ports were grouped together and routed along the frame of the fixture in a manner typical to cable routing on machinery. The motor power and resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor and resolver cables, regen resistor cable and power input cables had segregated routings.

Configuration II:

The configuration consisted of three phase a.c. mains input via a Siemens B84143-A36-R filter and 380/220 V r.m.s., 3 Phase Step Down Isolation transformer to a T150-901 Power Supply plus T164-901, T164-903, and T164-905 Drives. All drives had ESM II option cards installed.

The T164-905 Drive was driving a Moog Type G425-800 Motor.
The T164-903 Drive was driving a Moog Type G415-600 Motor.
The T164-901 Drive was driving a Moog Type G415-600 Motor.

A 24Vd.c. external power supply was connected to all drives. An external regen resistor was connected via a 5 meter shielded cable to the T150-901 Power Supply. Ten meter long shielded motor power and motor resolver cables were connected between the drives and the motors. The motor power cable and external regen resistor cable shields were grounded to the Chassis Earth using P clips. Shielded cable was used for the mains power input cable and all power cable connections between the a.c. input power Line Filter and the T150-901 Power Supply power input.

Unshielded cable was used for all connections between the T150-901 Power Supply and T164 Drives and for the external 24Vd.c. supply to the T164 Drives. All cables from Drive output ports were grouped together and routed along the frame of the fixture in a manner typical to cable routing on machinery. The motor power and resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor and resolver cables, regen resistor cable and power input cables had segregated routings.

Configuration III:

The configuration consisted of three phase a.c. mains input via a Siemens B84143-A36-R filter and 380/220 V r.m.s., 3 Phase Step Down Isolation transformer to a T150-901 Power Supply plus T164-907 and T164-909 Drives. Both drives had ESMII cards installed Terminated unshielded communications cables of length 3 meters each were connected to the J4 ports of both ESM II cards. A Fair-Rite Products Type 0443164151 common mode ferrite clamp was installed on each of the cables at the ESM II J4 port.

An Oyster Terminals Type 4 service terminal peripheral was permanently connected to the J3 communications port of the T164-907 drive. A B81655 Axis ID Module option card plus 3 meter terminated RS485 interface shielded cable was permanently connected to the J3 communications port of the T164-909 drive. Three meter terminated shielded communications cables were connected to the J1 output ports of each drive.

A 24Vd.c. external power supply was connected to both drives. An external regen resistor was connected via a 5 meter shielded cable to the T150-901 Power Supply. Ten meter shielded motor power and motor resolver cables were connected between the drives and the motors. The motor power cable and external regen resistor cable shields were earthed to Chassis Earth using P clips. Shielded cable was used for the mains power input cable and all power cable connections between the a.c. input power Line Filter and the T150-901 Power Supply power input

Unshielded cable was used for all connections between the T150-901 Power Supply and T164 Drives and for the external 24 Vd.c. supply to the T164 Drives. All cables from Drive output ports were grouped together and routed along the frame of the fixture in a manner typical to cable routing on machinery. The motor power and resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor and resolver cables, regen resistor cable and power input cables had segregated routings.

Relevant EMC tests were also conducted using this configuration with the following alternative components installed:

- ❑ Schaffner FN351-36-33 mains filter installed in place of the Siemens B84143-A36-R filter.
- ❑ Schaffner FN258-42-07 mains filter installed in place of the Siemens B84143-A36-R filter.

Users are directed to refer to Section 2 of this Users Manual for installation information on EMC suppression components.

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2. INSTALLATION AND WIRING

This section covers the installation, wiring and cabling of the Moog brushless motor digital control system components.

A pictorial diagram of a typical one-axis system is shown in FIGURE 2.3 .
FIGURE 2.5 provides a typical multiple axis system schematic/installation diagram.
FIGURE 2.3 and FIGURE 2.5 will be referred to throughout this user's manual.

WARNING

This equipment must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure in which the T150-901 Power Supply and T164 Series Drives are installed must be reliably connected to Earth. System earth connections must be provided as shown in FIGURE 2.2 and FIGURE 2.5. Stranded copper wire, not sealtite or another metallic covering must be used to carry the earth.
FAILURE TO PROVIDE AN ADEQUATE EARTH MAY CAUSE SERIOUS PERSONAL INJURY AND EQUIPMENT MALFUNCTION.

2.1 POWER CIRCUIT BREAKER/LINE FILTER/DRIVE CONTACTOR - INSTALLATION

A a.c. power circuit breaker (supply disconnecting device) and a.c. power input Line Filter must be installed in the in the incoming a.c. primary power input lines of the mains isolation transformer (Refer to Section 1.1.1 for a.c. mains isolation transformer requirements). The a.c. power input Line Filter must be installed between the output of the a.c. power circuit breaker and the input of the mains isolation transformer. A drive rated contactor shall be installed between the output of the mains isolation transformer and the primary power input of the T150-901 Power Supply.

The a.c. power circuit breaker (supply disconnecting device), a.c. power input Line Filter, mains isolation transformer and drive rated contactor are all user supplied items.

2.2 POWER CIRCUIT BREAKER (SUPPLY DISCONNECTING DEVICE)

Install a circuit breaker (supply disconnecting device) in the incoming a.c. primary power lines. This circuit breaker (supply disconnecting device) must be installed between the a.c. mains power supply and the input of the a.c. power input line filter. The circuit breaker (supply disconnecting device) should be sized so that it provides adequate r.m.s protection based upon power supply kW rating, (15 kW for the T150-901 Power Supply), and primary voltage.

Surge current tolerance and single phase protection should also be considered when selecting a circuit breaker (supply disconnecting device). (Refer to Section 1.1.2 for additional information regarding the AC input circuit breaker.)

WARNING

The handle of the circuit breaker must be installed in a manner to be easily accessible. It shall be located between 0.6 meters and 1.9 meters above the servicing level. a maximum height of 1.7 meters is recommended.

2.3 POWER LINE FILTERING

An a.c. power input Line Filter is required to be installed by the user in the a.c. power input supply lines to the mains Isolation Transformer. The following power input Line Filter is recommended:

Type: B84143-A36-R, manufactured by Siemens, Germany. (Rated 36 A r.m.s.)

The following Line Filters have also been tested with the configurations of T150-901 Power Supply and T164 Series Drives referenced in Section 1.3 of this Users Manual and it has been found that they do not adversely affect the EMC characteristics of these configurations:

Type: FN351-36-33, manufactured by Schaffner, Switzerland. (Rated 36 A r.m.s.)
Type: FN258-42-07, manufactured by Schaffner, Switzerland. (Rated 42 A r.m.s.)

Care must be taken when installing the a.c. power input Line Filter to ensure that the ability of the filter to function effectively is not degraded.

When installing the Line Filter, care must be taken to implement the following measures:

- ❑ Install the Line Filter on an earthed metal panel. There must be continuous earth continuity with good HF bonding between this panel and the panel on which the T150-901 Power Supply and T164 Series Drives are mounted. This must result in continuous earth continuity with good HF bonding between the enclosure of the Line Filter and the enclosures of the T150-901 Power Supply and T164 Series Drives.

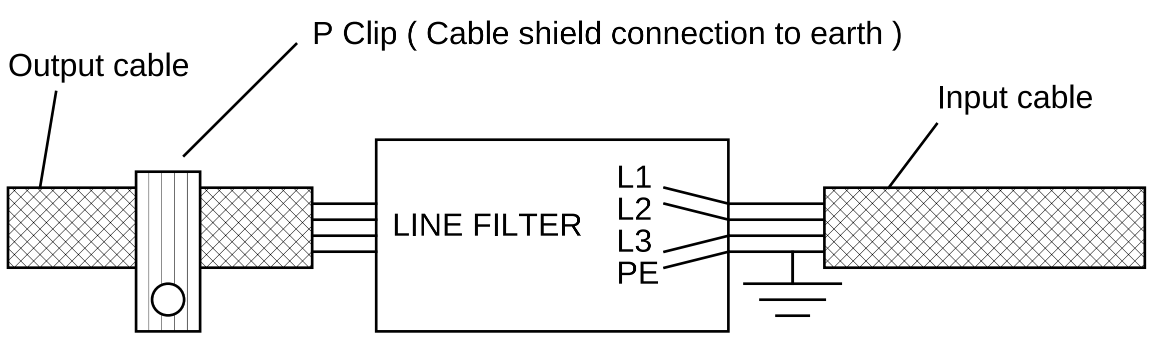
- ❑ Remove paint or other insulating materials and provide conductive corrosion protection at the mounting points for the Line Filter. Secure the filter using conductive bolts and conductive locking washers.

- ❑ Locate the Line filter as close as possible to the T150-901 Power supply. Total cable length from Line Filter to mains Isolation Transformer, Transformer to Contactor and Contactor to T150-901 Power Supply should not exceed 1 meter. Keep all cable lengths as short as possible and route separately from other cables and conductors.

- ❑ Use shielded or armored cable for all connections from Line Filter to mains isolation Transformer, Transformer to Contactor and Contactor to T150-901 Power Supply. The shields of these voltage supply cables should be earthed to Chassis Earth using a 180 degree metal clamp (P clip) connection. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.

- ❑ Ensure that the Line Filter is firmly connected to mains earth and that the Protective Earth (PE) of the Line Filter is correctly connected to the Protective Earth (PE) of the T150-901 Power Supply and T164 Series Drives. Ensure that there is good high-frequency (HF) bonding between enclosure of the Line Filter, T150-901 Power Supply, T164 Series Drives and Protective Earth (PE).

- ❑ Ensure that input and output cables from the Line Filter are segregated as much as possible to prevent noise coupling. (See FIGURES below). It is essential that the input conductors to the Line Filter be completely segregated from both the filter output conductors and all other cables and conductors in the installed product.



Correct Input/Output Cable Routing

FIGURE 2.1 Power Line Filter Routing

2.4 DRIVE CONTACTOR

Install a drive rated contactor between the output of the mains isolation transformer and the power input of each T150-901 Power Supply. This contactor shall be sized based on the continuous power of the system (motor, drive). A rule of thumb of 5 amps/kW continuous power can be used.

2.5 EQUIPMENT MOUNTING

2.5.1 T150-901 POWER SUPPLY AND T164 SERIES DRIVES.

The T150-901 Power Supply and T164 Series Drives must be panel mounted within an enclosure or cabinet which provides a degrees of ingress protection against liquids and objects of at least IP54. Such enclosures or cabinets must be accessible to technically qualified service or maintenance persons only.

It is recommended that the cabinet is ventilated using filtered or conditioned air, free of corrosive or electrically conductive contaminants. The accumulation of dust, dirt etc. on the equipment must be avoided.

The T150-901 Power Supply, T164 Series Drives and all conductive parts in the IP54 rated enclosure or cabinet must be permanently connected to earth. The earth continuity between the earth terminal and any accessible part of the enclosure or cabinet shall be less than or equal to 0.1 ohms.

For Electrostatic Discharge (ESD) reasons all service or maintenance persons must ground themselves to the chassis of the equipment when performing service functions inside the IP54 rated enclosure or cabinet in which the T150-901 Power Supply and T164 Series Drives are installed. This may be done by using an ESD wristband with earth strap.

All external Regen (Regenerative circuit) resistors used with the T150-901 must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP54 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.

The T150-901 Power Supply and T164 Series Drives are system components which must be installed in a correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. (Refer to Section 1.3 of this Users Manual).

The T150-901 Power Supply and T164 Series Drives must be installed by mounting on a panel with a flat solid surface in a manner that ensures that EMC earthing requirements are met. There must be a clean flat conductive surface at all the mounting points. It is important that there is good high-frequency bonding between the panel, the T150-901 Power Supply and T164 Series Drives. Conductive bolts with conductive locking washers shall be used.

The T150-901 Power Supply and T164 Series Drives shall be bolted to the panel in a vertical orientation using M5 metric or # 10 bolts. The panel shall be installed to be free of excessive vibration. The top and bottom of the T150-901 Power Supply and T164 Series Drives must remain unobstructed by at least 75 mm (3 inches) to provide adequate air flow for cooling. Mounting dimensions are shown on the equipment installation drawings; FIGURE 2.6 for the T150-901 Power Supply,
FIGURE 2.7 for the T164-901 through T164-905, 76.2 mm (3 inch) Drives and FIGURE 2.8 for the T164-907 and T164-909, 127 mm (5 inch) Drives.

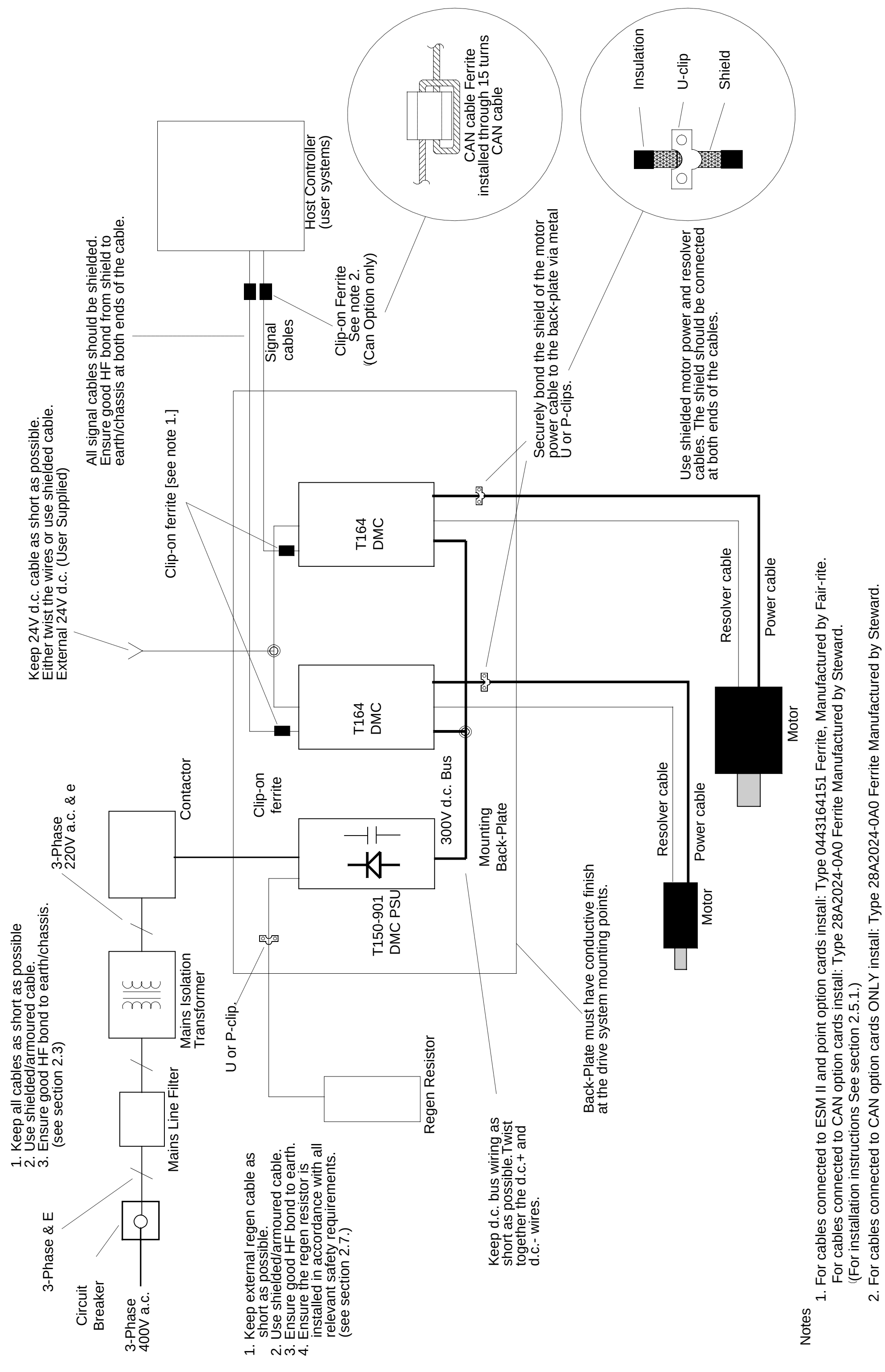


FIGURE 2.2 Typical installation configuration with EMC suppression measures Installed

2.5.2 T150-901 POWER SUPPLY AND T164 SERIES DRIVES AND ASSOCIATED EQUIPMENT

Additional electromagnetic compatibility (EMC) measures must be installed on equipment associated with the T150-901 Power Supply and T164 series Drives.

The following measures must be implemented:

- ❑ Use shielded or armored cable to connect the external regen resistor (if installed) to the T150-901 power supply. The length of this cable should be as short as possible. The shields of these voltage supply cables should be earthed to Chassis Earth using a 180 degree metal clamp (P clip) connection to ensure a good HF earth bond. Secure the clip using conductive bolts and locking washers. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland. (Refer to Section 1.2.1and Section 2.7 for safety and other relevant installation requirements for Regen resistors).

- ❑ Cables supplying external d.c. supply voltages to the T164 Series Drives (For example, the 24 Vd.c. supply) must be as short as possible. The supply wires should be twisted together or alternatively shielded cable should be used.

- ❑ Cables connecting the 300 Vd.c. bus from the T150-901 Power supply to the T164 Series Drives must be as short as possible. The supply wires should be twisted together.

- ❑ Motor power cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the T164 Drive end of the cable the shield should be earthed to Chassis Earth using a 180 degree metal clamp (P clip) connection to ensure a good HF earth bond. Secure the clip using conductive bolts and locking washers.

- ❑ Motor resolver cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.

- ❑ Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.

- ❑ T164 Drives with ESM II option cards installed must additionally have a clip-on ferrite installed on the signal cable to the ESM II port (J4). This shall be a Type 0443T164151 ferrite, manufactured by Fair-rite and shall be installed on the cable approximately 50 mm (2 inches) from the ESM II port J4).

- T164 Drives with Point option cards installed must additionally have a clip-on ferrite installed on the signal cable to the Point port (X4). This shall be a Type 0443T164151 ferrite, manufactured by Fair-rite and shall be installed on the cable approximately 50 mm (2 inches) from the Point port (X4).

- T164 Drives with CAN option cards installed must additionally have clip-on ferrites installed on the signal cables to the CAN ports (X2, X3). A Type 28A2024-0A0 ferrite, manufactured by Steward shall be installed through 1.5 turns (see FIGURE 2.2) on the cables approximately 50 mm (2 inches) from the CAN ports (X2, X3). This clip-on ferrite shall be installed as above on all CAN daisy-chain connection cables as well as at the T164 Drive end of the signal cable form the remote CAN Host Drive (User supplied). This clip-on ferrite shall also be installed as above at the remote CAN Host Drive end of the signal cable.

The above information is summarized in FIGURE 2.2 , which shows a typical installation configuration with EMC conformity measures installed.

Further details for the correct installation of external Regen resistors is given in Section 2.7 of this Users Manual.

Further details for the correct installation, shielding and safety color coding of cables and conductors in given in Section 2.9 and throughout Section 2 of this Users Manual.

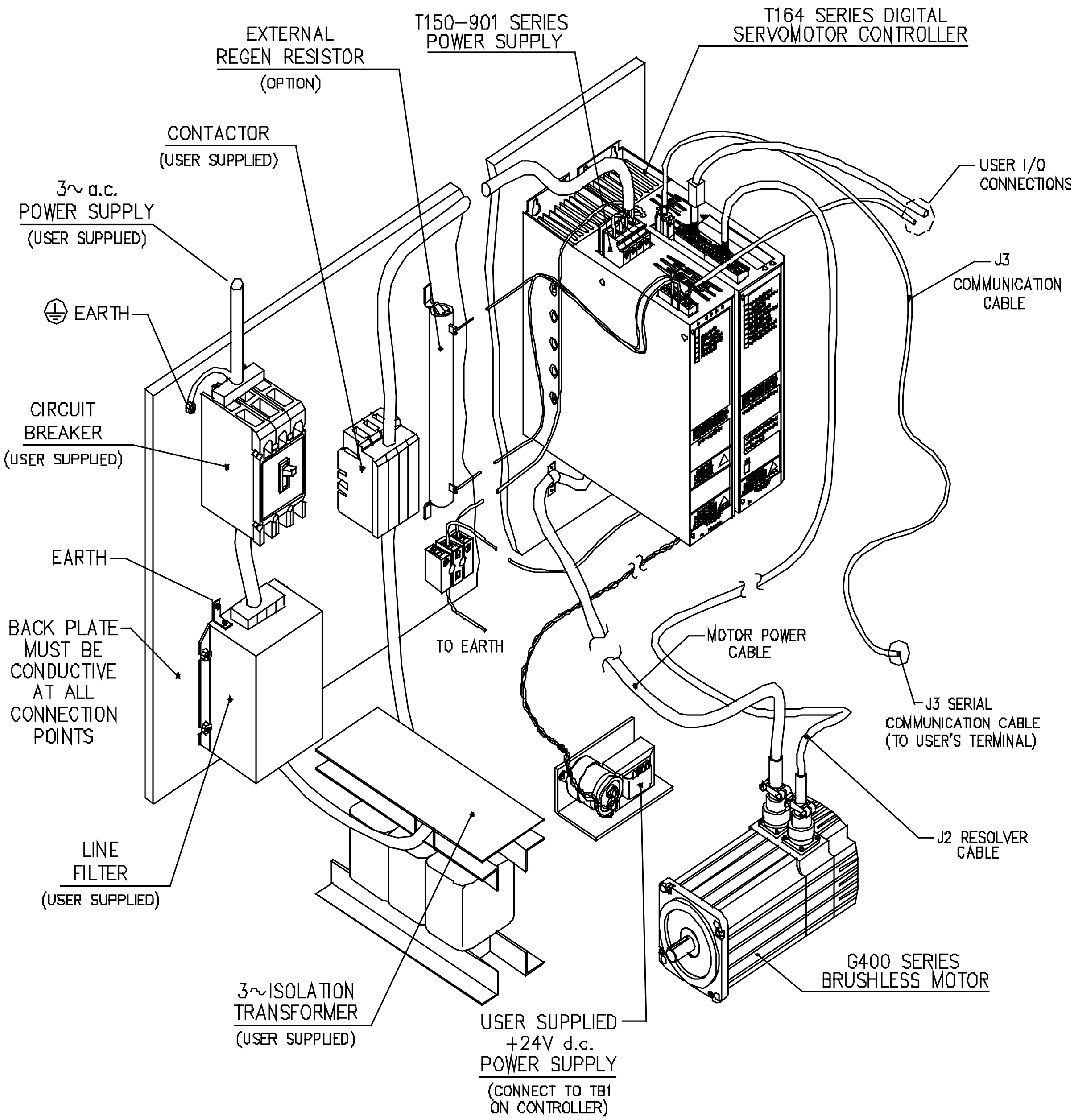


FIGURE 2.3 Typical Single-Axis System Pictorial Diagram

2.6 POWER DISSIPATION

To calculate cabinet cooling requirements, TABLE 2-1 provides approximate equipment power dissipation values. If the application employs regeneration, be sure to include the regen resistor power dissipation, (use the continuous wattage rating of the regen resistor if actual application regen dissipation is unknown).
The following formula can be used to estimate the required enclosure size.
Consult the enclosure manufacturer for recommendations regarding ventilated applications.

$$A = (2.38) \bullet \frac{W}{T_{\max} - T_{\text{amb}}}$$

Where:

A = Exposed surface area of enclosure.
W = Watts dissipated.
$T_{max.}$ = Maximum ambient temperature of equipment (55°C for T164 Series)
T_{amb} = Ambient temperature outside enclosure.

% of Rated Continuous Output Current	Power Dissipation (Watts)					
	T164-901	T164-903	T164-905	T164-907	T164-909	T150-901 3 phase
0	18	20	20	25	25	5
25	44	50	55	65	100	40
50	53	70	95	135	175	80
75	66	95	145	225	260	120
100	78	125	200	325	355	160

TABLE 2-1 Estimated Power Dissipation For The T164 Series And T150-901 Power Supply

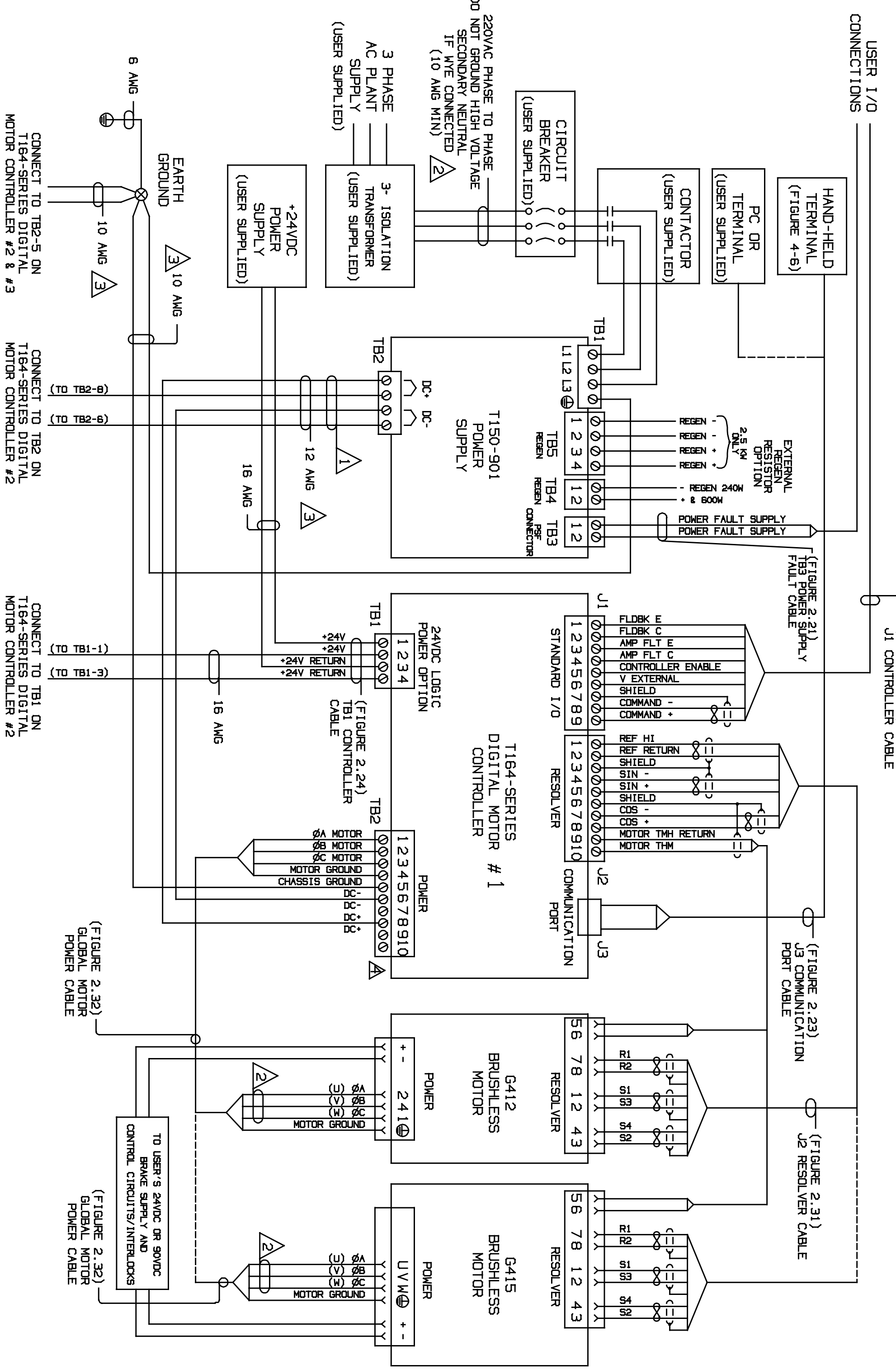


FIGURE 2.4 TYPICAL SYSTEM SCHEMATIC DIAGRAM A

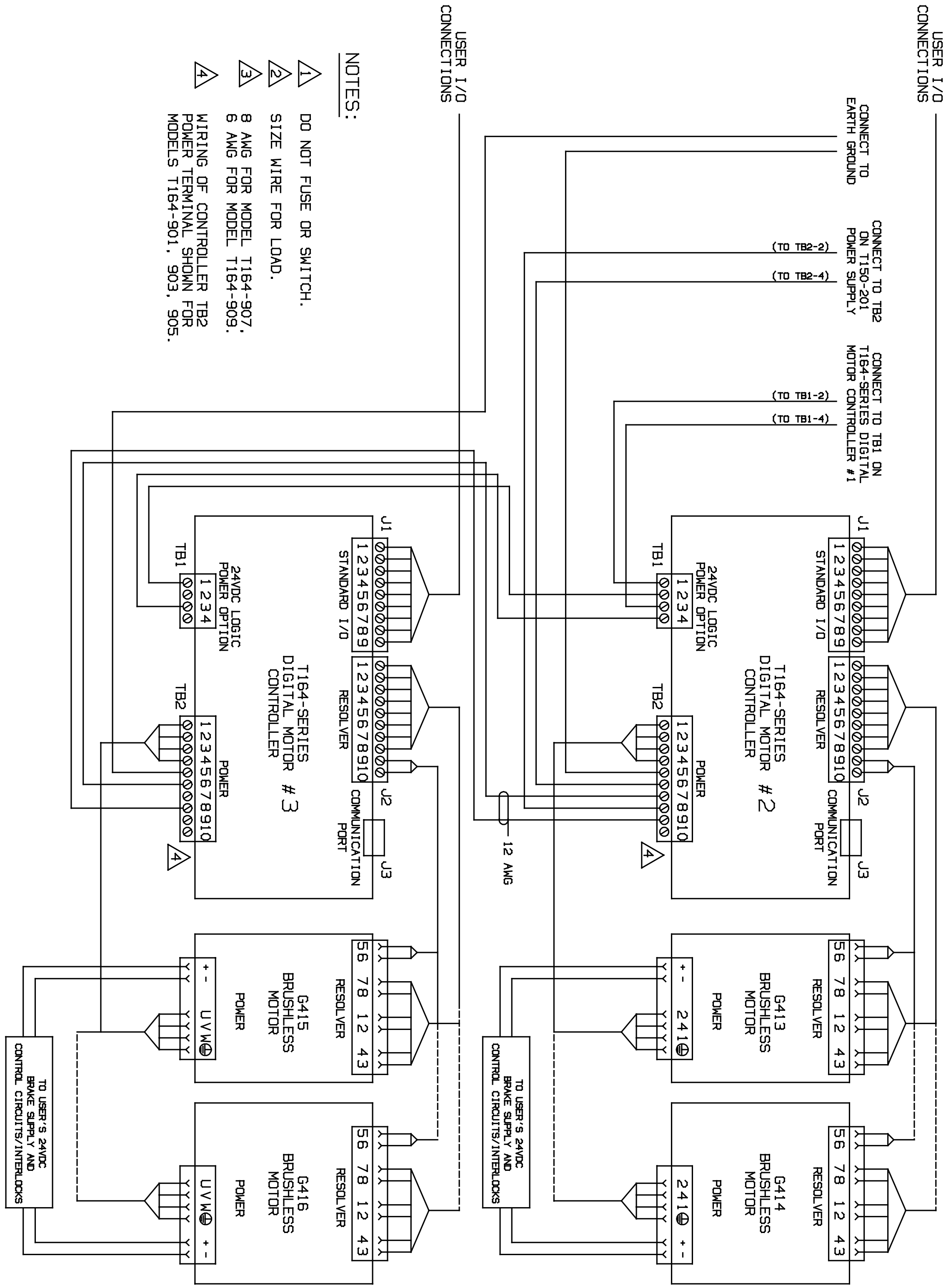
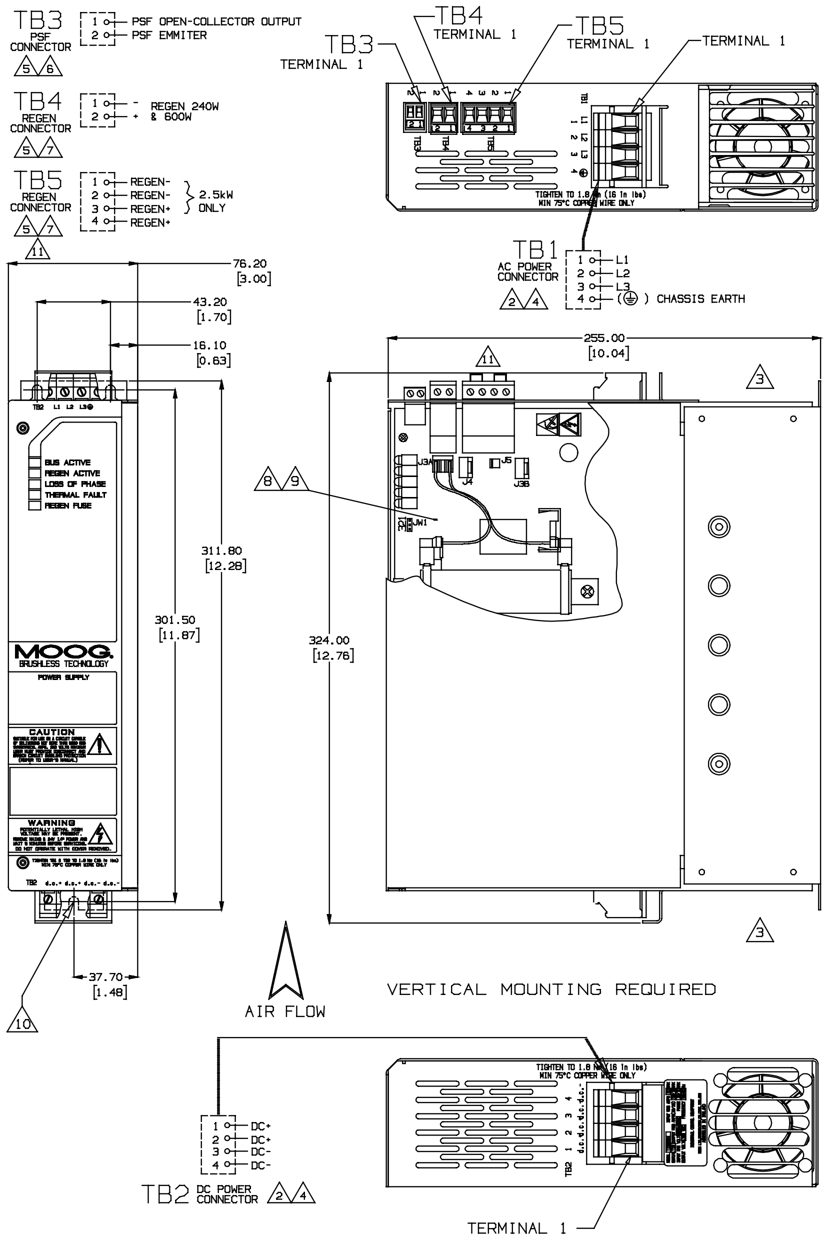


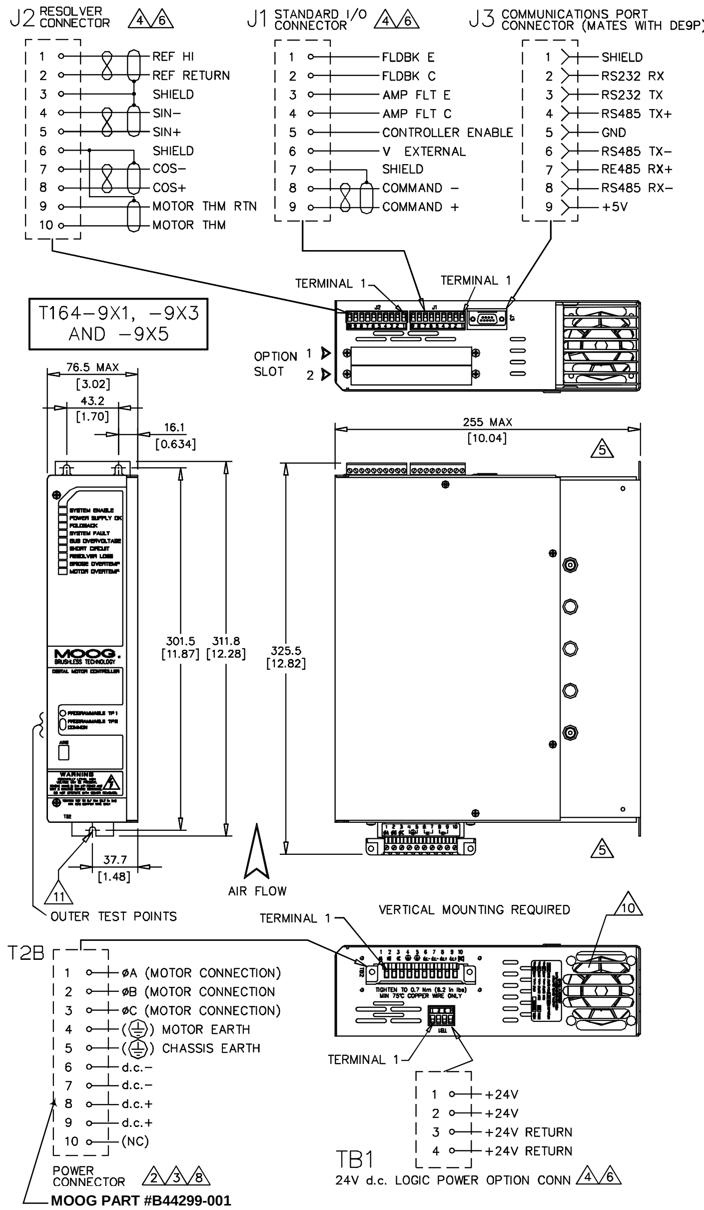
FIGURE 2.5 TYPICAL SYSTEM SCHEMATIC DIAGRAM B



Note :

1. All dimension's are in Millimeters, dimensions in brackets are in Inches.
2. Terminal block will accept CSA 8.4mm^2 (8 AWG) wire maximum. [TB1 and TB2]
3. Top and bottom must remain unobstructed by 75mm (3 inches) to provide adequate air flow for cooling.
4. Recommended terminal screw torque: 1.50 ± 0.05Nm (13.2 ±0.5 in lbs).[TB1 and TB2]
5. Recommended terminal screw torque: 0.55 ± 0.05Nm (5.0 ±0.5 in lbs). [TB3, TB4 and TB5]
6. Wire range : CSA 2.08 mm^2 to 0.081 mm^2 (14 AWG to 28 AWG). [TB3, TB4 and TB5]
7. Wire range : CSA 5.26 mm^2 to 0.081 mm^2 (10 AWG to 28 AWG). [TB3, TB4 and TB5]
8. Units configured for 40 Watts of regen power. See following section for regen power option and configuration.
9. Internal assembly contains electrostatic sensitive components. Proper handling procedures must be used with cover removed.
10. M5 or #10 mounting screws 3 places.

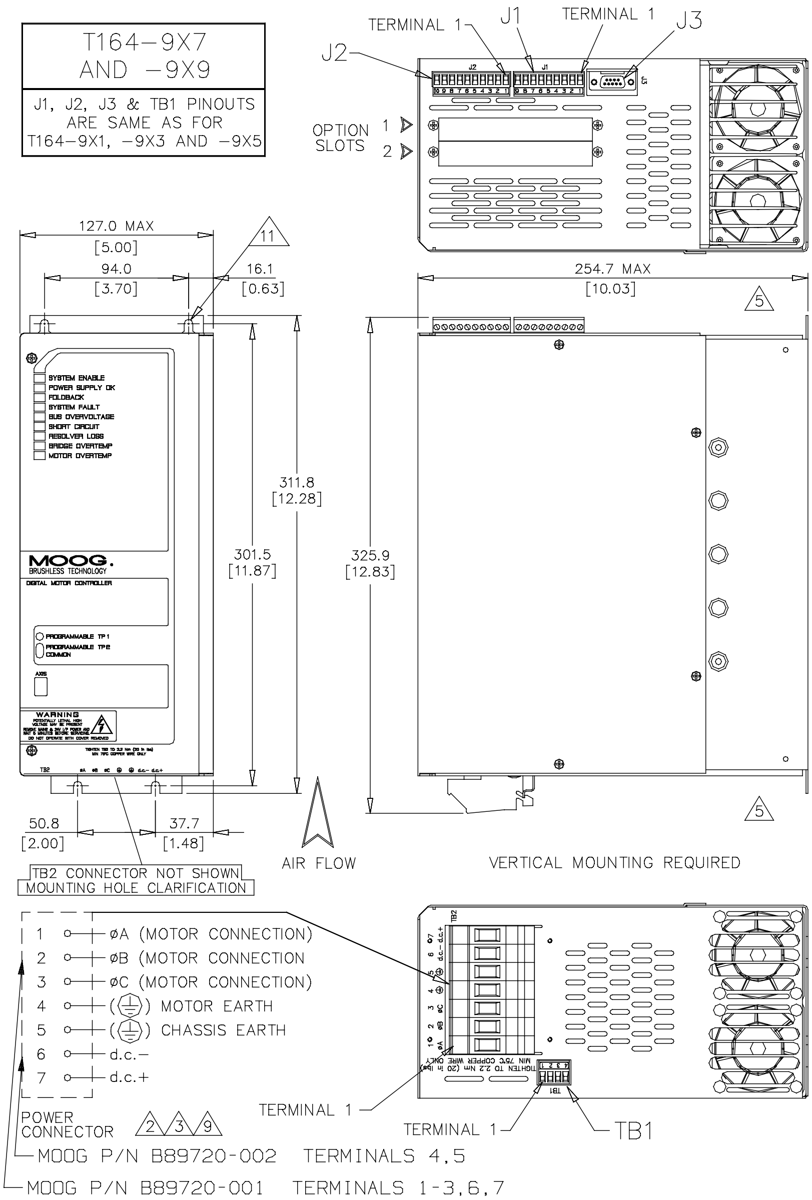
FIGURE 2.6 T150-901 Power Supply Installation



Notes:-

1. All dimensions are in millimeters, dimensions in brackets are in inches.
2. TB2 Maximum wire size:
   CSA 3.25mm^2 (12AWG) on models T164-9X1, -9X3 and -9X5
3. Size wire for load (do not fuse or switch d.c. bus for proper regeneration protection).
4. Recommended terminal screw torque: 0.55 ± 0.05 Nm [5.0 ± 0.5 in lbs]
5. Top and bottom must remain unobstructed by minimum distance of 75mm [3 inches] to provided adequate air flow for cooling.
6. Wire range: CSA 2.08mm^2 to 0.128mm^2 (14AWG to 26AWG).
7. Internal assembly contains electrostatic sensitive components. Proper handling procedures must be used with cover removed. (MIL-STD-1686, Class 1)
8. Recommended terminal screw torque: 0.7 ± 0.06 Nm [6.2±0.5 in lbs]
10. Fan assembly not used on model T164-9X1.
11. M5 or #10 mounting screws 3 places (4 places on T164-9X7 and -9X9)

FIGURE 2.7 T164-901, T164-903 and T164-905 Digital Motor Drive



TB2

Notes:-

1. All dimensions are in millimeters, dimensions in brackets are in inches.
2. TB2 Maximum wire size:
   CSA 8.4mm^2 (8AWG) on models T164-9X7 and -9X9
3. Size wire for load (do not fuse or switch d.c.. bus for proper regeneration protection).
4. Recommended terminal screw torque: 0.55 ± 0.05 Nm [5.0 ± 0.5 in lbs]
5. Top and bottom must remain unobstructed by minimum distance of 75mm [3 inches] to provided adequate air flow for cooling.
6. Wire range: CSA 2.08mm^2 to 0.128mm^2 (14AWG to 26AWG).
7. Internal assembly contains electrostatic sensitive components. Proper handling procedures must be used with cover removed. (MIL-STD-1686, Class 1)
9. Recommended terminal screw torque: 2.2 ± 0.06 Nm [20±0.5 in lbs]
11. M5 or #10 mounting screws 3 places (4 places on T164-9X7 and -9X9)

FIGURE 2.8 T164-907, -909 Digital Motor Drive

2.7 INTERNAL AND EXTERNAL REGENERATION (REGEN) RESISTORS-OPTIONS

All external Regen (regenerative circuit) resistors used with the T150-901 Power Supply must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP54 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.

All external Regen resistors shall be mounted to allow adequate heat dissipation and such that heat from the Regen resistor is not directed to air intakes of other equipment.

For EMC purposes use shielded or armored cable to connect the external Regen resistor to the T150-901 Power Supply. The length of this cable should be as short as possible. The shields of these voltage supply cables should be connected to Chassis Earth using a 180 degree metal clamp (P clip) connection to ensure a good HF earth bond. Secure the clamp using conductive bolts and locking washers. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland. (Refer to sections 2.5, 2.5.1 and 2.5.2 for equipment mounting and installation instructions for EMC suppression measures).

Refer to sections 2.9, 2.9.1 and 2.9.2 for further safety and EMC requirements for cable installation.

NOTE

Regeneration energy in high inertia and/or rapid deceleration applications can exceed the regen circuit maximum rating. The T150-901 Power Supply internally disables regen when the regen rating is exceeded. This action will result in drive over voltage faults. In applications where high or continuous regeneration energy is anticipated, consult your Moog Sales representative, requesting an application review.

Details of all internal and external Regen resistor options which can be installed with the T150-901 Power Supply are given in TABLE 2-2 .

Instructions for installing the different internal and external Regen resistor configurations are given in sections 2.7.1 through 2.7.6 of this Users Manual.

WARNING

External regen resistors are connected to the Drive d.c.. bus voltage which can reach 400 Vd.c. Connections to external regen resistors must be electrically insulated and mechanically shielded for safety. High voltage warning stickers are also recommended.

WARNING

When Performing any changes to the regen resistor configuration a.c. Input Power must be removed from the T150-901 Power Supply. Wait 5 minutes upon removal of all a.c. input power before removing the power supply cover. Do not operate the Power Supply with the cover removed.

CAUTION

Operation of the T150-901 Power Supply with other than the specified fuse type for the particular regen resistor configuration can result in equipment malfunction and/or damage resulting in the equipment becoming unsafe..

Power Supply Continuous Regen Power Options						
POWER SUPPLY MODEL NUMBER	T150-901-701	T150-901-702	T150-901-706	T150-901-722 ①	T150-901-722	T150-901-723
REGEN POWER MOOG KIT P/N:	40 Watts Standard	240 Watts C09838-002	600 Watts C09838-006	1000 Watts C09838-010 2000Watts C09838-010 (2x)	2500 Watts C09838-022	2500 Watts C09838-023
INTERNAL JUMPER J3C POSITION	Pins 2-3	Pins 2-3	Pins 2-3	Pins 1-2	Pins 1-2	Pins 1-2
50 Ω, 55 WATT INTERNAL RESISTOR CONNECTED TO:	J3A	J3A	J3B	J4	J4	J4
EXTERNAL REGEN RESISTOR	None	10 Ω, 225 Watt, Wired to TB4	8 Ω, 750 Watt, Wired to TB4	1 X 10 Ω [2x], 1kW [2kW], Wired to TB5	2 x 8 Ω, 1500 Watt, Wired to TB5	2 x 8 Ω, 1500 Watt, Wired to TB5
FUSE F1 (ON PS CONTROL PWB) MOOG P/N:	3 AMP/500 Volt Non-Time Delay C09762-003-000	10 AMP/500 Volt Non-Time Delay C09762-010-000	15 AMP/500 Volt Non-Time Delay C09762-015-000	3 AMP/500 Volt Non-Time Delay C09762-003-000	3 AMP/500 Volt Non-Time Delay C09762-003-000	3 AMP/500 Volt Non-Time Delay C09762-003-000
EXTERNAL FUSE MOOG P/N	none	none	none	12 AMP/500 Volt C09762-012-000	25 AMP/500 Volt C09762-025-000	25 AMP/500 Volt C09762-025-000
EXTERNAL REGEN CONNECTOR PLUG MOOG P/N (INCLUDED)	not required	TB4 C09727-002	TB4 C09727-002	TB5 C09727-004	TB5 C09727-004	TB5 C09900-001

① Option only for Europe

TABLE 2-2 Power Supply Continuous Regen Power Options

The following notes apply to FIGURE 2.9 through FIGURE 2.19.

1. Regen fuse (see TABLE 2-2)
2. Secure external regen resistor with supplied mounting brackets. Use M5 or #10 hardware to mount brackets to panel mount resistor in a location that will allow adequate heat dissipation and such that heat from the resistor is not directed to air intake of other equipment. Keep combustible material and wires at least 100mm (4 inches) from the 225W resistor. At least 200mm (8 inches) from the 750W resistor, 300mm (12 inches) from 1.5kW resistor.
3. 55 Watt internal regen resistor is in parallel with 225 Watt external regen resistor in this configuration.
4. Internal 50Ω resistor should be connected to J3A for 240W regen operation.
5. Internal 50Ω resistor should be connected to J3B for 600W regen operation.
6. Internal 50Ω resistor should be connected to J4 for 2.5kW regen operation.
7. Jumper J3C should be placed in position 2-3 for 240W/600W regen resistor.
8. Jumper J3C should be placed in position 1-2 for 1kW, 2kW and 2.5kW regen resistor.

2.7.1 T150-901 POWER SUPPLY 40 W REGEN CONFIGURATION.

WARNING
Do NOT operate unit with cover removed

WARNING
Do NOT perform procedures described on this page with the power on. *The T150-901 Power Supply contains lethal a.c. and d.c. voltages in operation.* ***Switch off*** *all incoming a.c. power, ensure all motors are stopped, wait five (5) minutes, ensure all front panel LEDs are off, then remove and tape exposed wire ends from TB1 and TB2 before removing the cover and configuring external Regen resistors or fuses.*

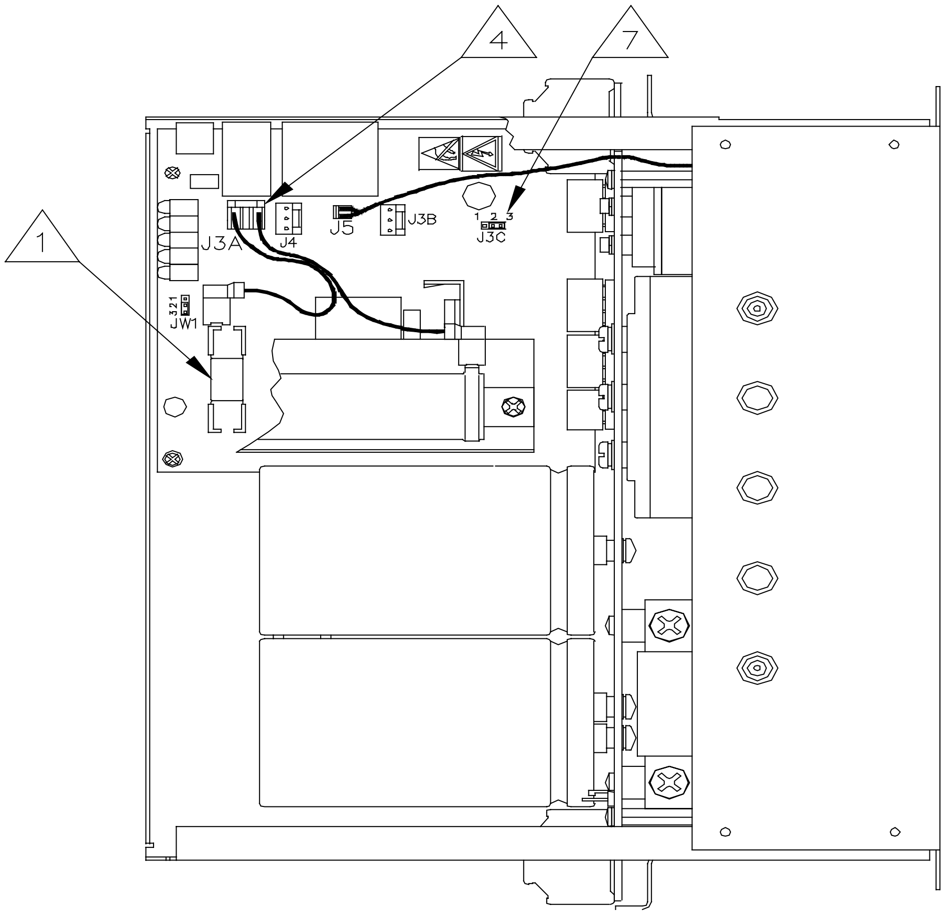


FIGURE 2.9 T150-901 Power Supply 40 Watt Regen Configuration.

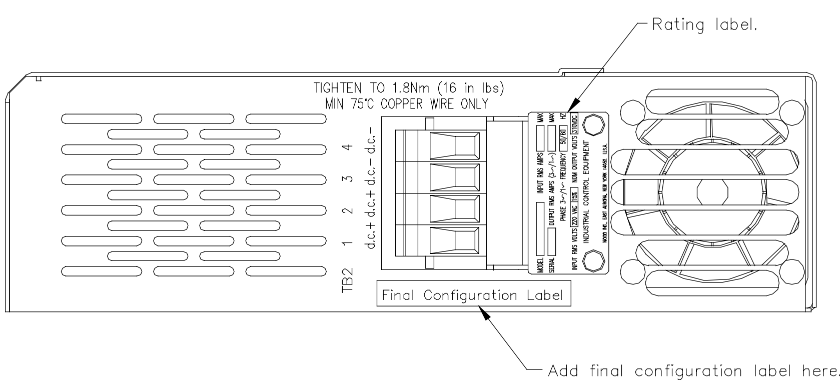


FIGURE 2.10 Final Configuration Label Mounting Location.

2.7.2 T150-901 POWER SUPPLY 240 W REGEN CONFIGURATION

WARNING

Do NOT operate unit with cover removed

WARNING

Do NOT perform procedures described on this page with the power on.

The T150-901 Power Supply contains lethal a.c. and d.c. voltages in operation. ***Switch off*** *all incoming a.c. power, ensure all motors are stopped, wait five (5) minutes, ensure all front panel LEDs are off, then remove and tape exposed wire ends from TB1 and TB2 before removing the cover and configuring external Regen resistors or fuses.*

This kit C09838-002 contains:

1 Label, final configuration.
2 Installation specification, T150-901 240W regen kit.
3 Resistor, 10 ohm, 225 W.
4 Resistor mounting bracket kit.

Instructions:

1. Secure the external regen resistor with the supplied mounting brackets. Observe mounting location requirements of Section 2.5 of this Users Manual. Mounting bracket feet may be turned in to conserve space.

2. Connect the external regen resistor between pins 1 and 2 of TB4.

3. Place the supplied Final Configuration Label along the bottom of the housing beside TB2 as shown in FIGURE 2.12.

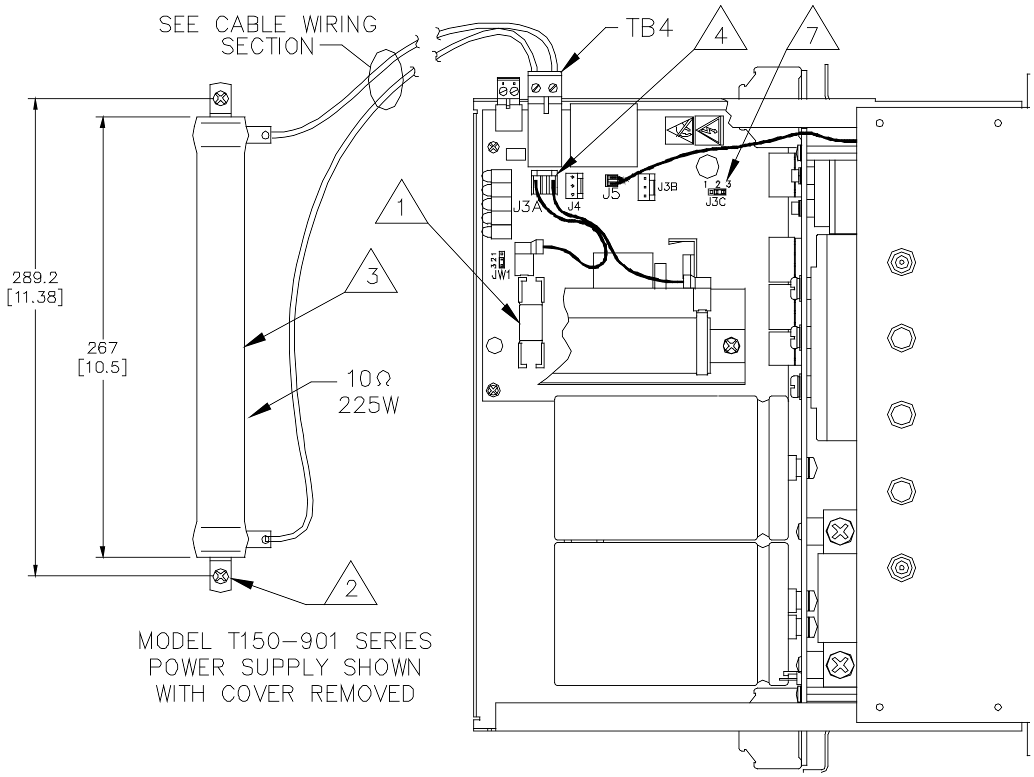


FIGURE 2.11 T150-901 Power Supply 240 Watt Regen Configuration.

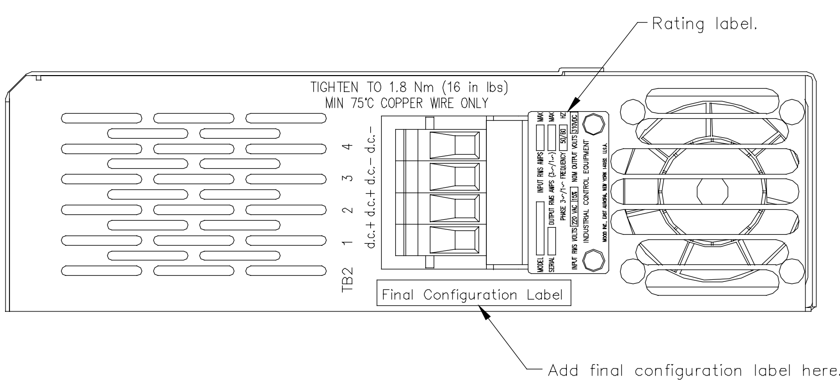


FIGURE 2.12 Final Configuration Label Mounting Location

2.7.3 T150-901 POWER SUPPLY 600 W REGEN CONFIGURATION

WARNING
Do NOT operate unit with cover removed

WARNING
Do NOT perform procedures described on this page with the power on. *The T150-901 Power Supply contains lethal a.c. and d.c. voltages in operation.* ***Switch off*** *all incoming a.c. power, ensure all motors are stopped, wait five (5) minutes, ensure all front panel LEDs are off, then remove and tape exposed wire ends from TB1 and TB2 before removing the cover and configuring external Regen resistors or fuses.*

This kit C09838-006 contains:

1 Label, final configuration.
2 Installation specification, T150-901 PSU 600W regen kit.
3 Resistor, 8 ohm, 750 W.
4 Resistor mounting bracket kit

Instructions:

1. Secure the external regen resistor with the supplied mounting brackets. Observe mounting location requirements of Section 2.5 of this Users Manual. Mounting bracket feet may be turned in to conserve space.

2. Connect the external regen resistor between pins 1 and 2 of TB4.

3. Place the supplied Final Configuration Label along the bottom of the housing beside TB2 as shown in FIGURE 2.14.

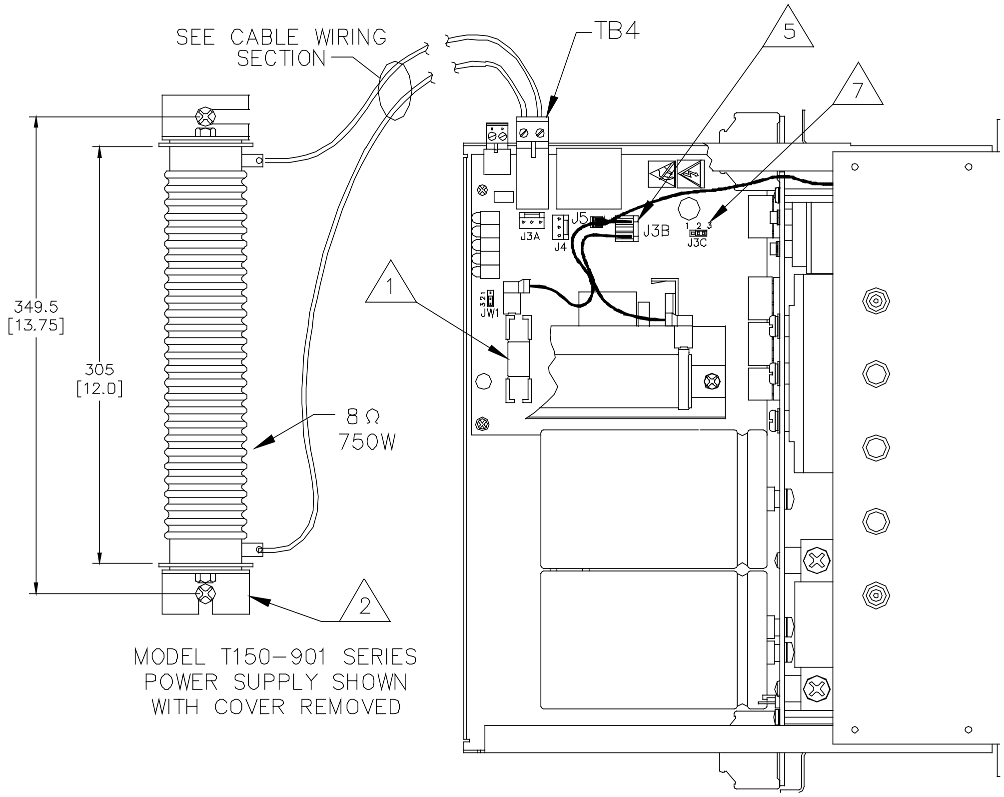


FIGURE 2.13 T150-901 Power Supply 600 Watt Regen Configuration

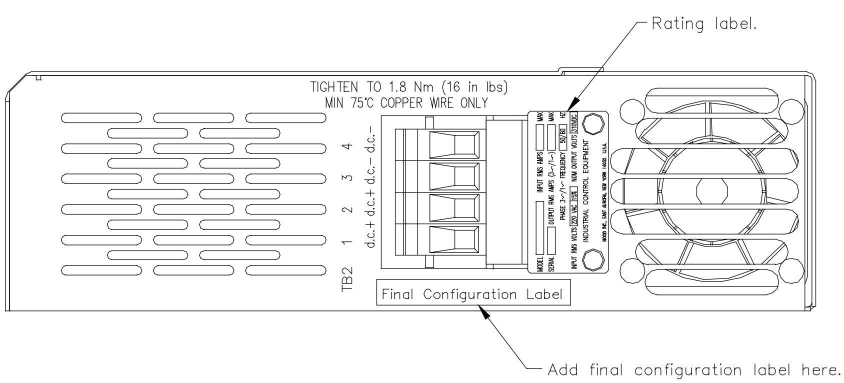


FIGURE 2.14 Final Configuration Label Mounting Location.

2.7.4 T150-901 POWER SUPPLY 1000 W/ 2000 W REGEN CONFIGURATION (EUROPE ONLY)

WARNING
Do NOT operate unit with cover removed

WARNING
Do NOT perform procedures described on this page with the power on. *The T150-901 Power Supply contains lethal a.c. and d.c. voltages in operation. Switch off all incoming a.c. power, ensure all motors are stopped, wait five (5) minutes, ensure all front panel LEDs are off, then remove and tape exposed wire ends from TB1 and TB2 before removing the cover and configuring external Regen resistors or fuses.*

This kit C09838-010 contains:
Note: Two kits are required for 2000W option
1 Fuse, 12A, Quick Blow.
2 Label, final configuration.
3 Installation specification, T150-901 PSU 1000W/2000W regen kit.
4 Resistor, 10 ohm, 1.0 kW.
5 Resistor mounting bracket kit (2)
6 Fuse Block

Instructions:

1. Secure the external regen resistor with the supplied mounting brackets. Observe mounting location requirements of Section 2.5 of this Users Manual. Mounting bracket feet may be turned in to conserve space.
2. Connect one end of each external regen resistor to pins 1 and 2 of TB5, wiring each pin separately.
3. Connect the other end of each regen resistor to the fuse block(s).
4. Connect the other end of the fuse block(s) to pins 3 and 4 of TB5, using a separate wire to each pin of TB5.
5. Install the supplied 12A regen fuse(s) in the fuse block.
6. Place the supplied Final Configuration Label along the bottom of the housing beside TB2 as shown in FIGURE 2.16.

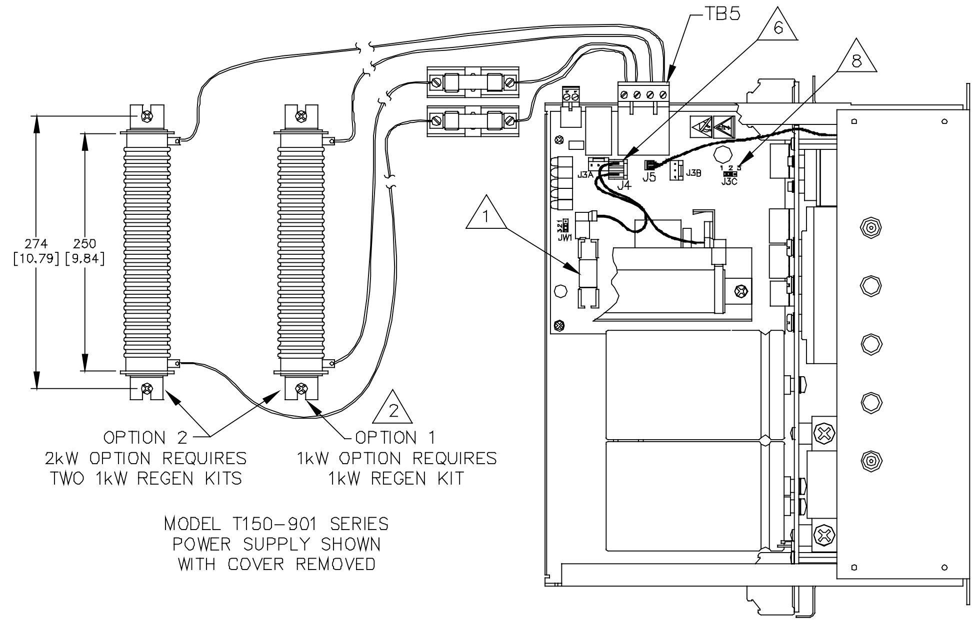


FIGURE 2.15 T150-901 Power Supply 1000/2000 Watt Regen Configuration.

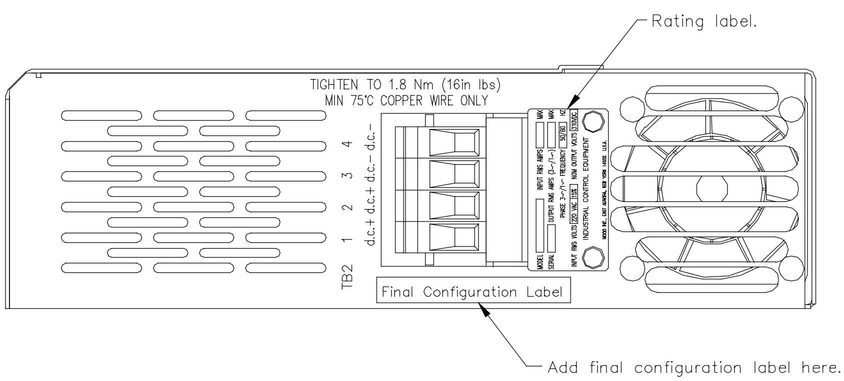


FIGURE 2.16 Final Configuration Label Mounting Location.

2.7.5 T150-901 POWER SUPPLY 2500 W REGEN CONFIGURATION

WARNING
Do NOT operate unit with cover removed

WARNING
Do NOT perform procedures described on this page with the power on.
The T150-901 Power Supply contains lethal a.c. and d.c. voltages in operation. Switch off all incoming a.c. power, ensure all motors are stopped, wait five (5) minutes, ensure all front panel LEDS are off, then remove and tape exposed wire ends from TB1 and TB2 before removing the cover and configuring external Regen resistors or fuses.

This kit C09838-022 contains:

1 Fuse, 25A, Quick Blow.
2 Label, final configuration.
3 Installation specification, T150-901 PSU 2500W regen kit.
4 Resistor, 8 ohm, 1.5 kW(2).
5 Resistor mounting bracket kit (2)
6 Fuse Block

Instructions:

1. Secure the external regen resistors with the supplied mounting brackets. Observe mounting location requirements of section 2.5 of this Users Manual. Mounting bracket feet may be turned in to conserve space.
2. Connect one end of each external regen resistor together, and the connect to pins 1 and 2 of TB5, wiring each pin separately.
3. Connect the other end of each regen resistor together, and the connect to the fuse block.
4. Connect the other end of the fuseblock to pins 3 and 4 of TB5, using a separate wire to each pin of TB5.
5. Install the supplied 25A regen fuse in the fuseblock.
6. Place the supplied Final Configuration Label along the bottom of the housing beside TB2 as shown in FIGURE 2.18.

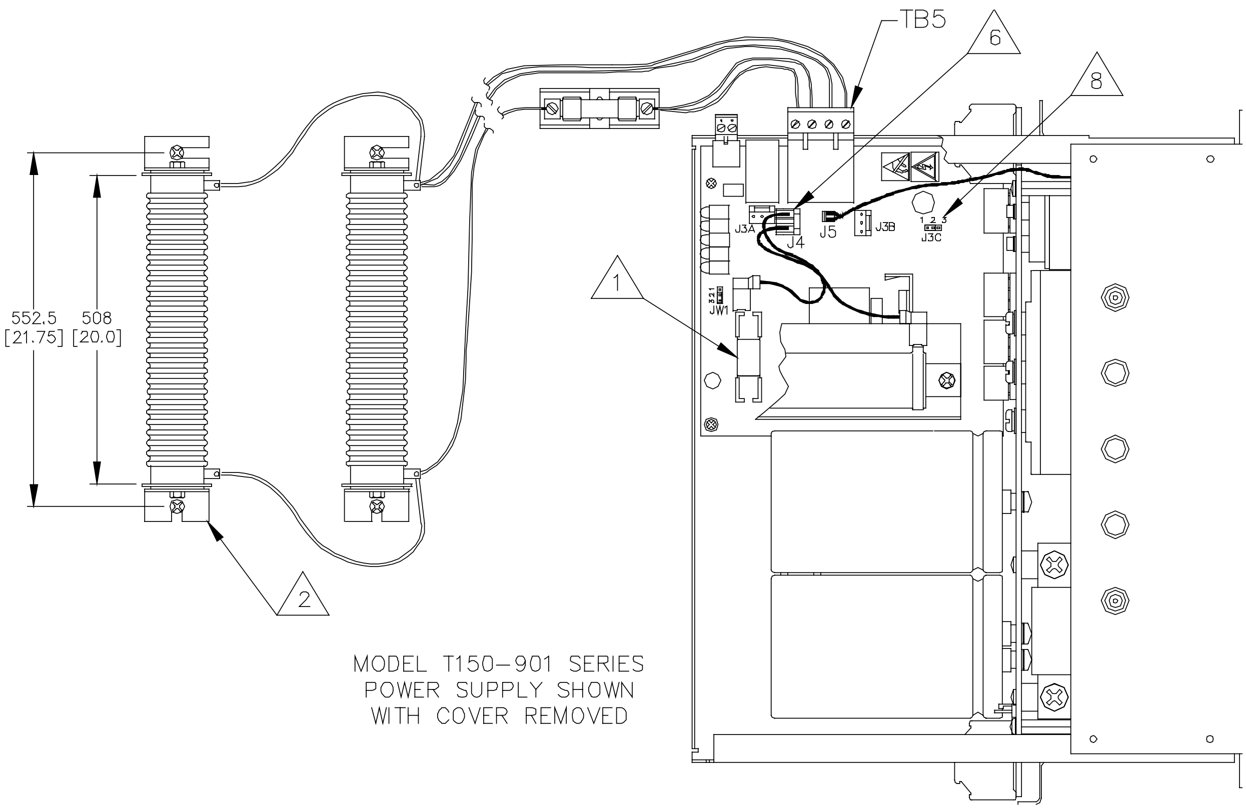


FIGURE 2.17 T150-901 Power Supply 2500 Watt Regen Configuration

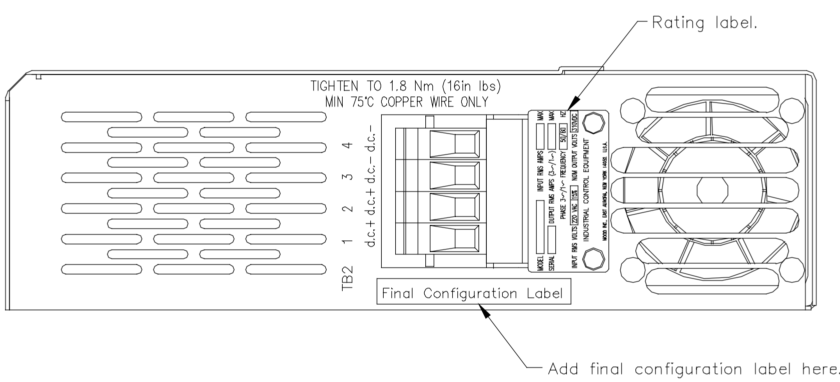


FIGURE 2.18 Final Configuration Label Mounting Location.

2.7.6 T150-901 POWER SUPPLY 2.5 KW 2-POLE REGEN CONFIGURATION

WARNING
Do NOT operate unit with cover removed

WARNING
Do NOT perform procedures described on this page with the power on. *The T150-901 Power Supply contains lethal a.c. and d.c. voltages in operation.* ***Switch off*** *all incoming a.c. power, ensure all motors are stopped, wait five (5) minutes, ensure all front panel LEDs are off, then remove and tape exposed wire ends from TB1 and TB2 before removing the cover and configuring external Regen resistors or fuses.*

This kit CO9838-023 contains:

1 Fuse, 25A, Quick Blow.
2 Label, final configuration.
3 Installation specification, T150-901 2500W regen kit.
4 Resistor, 8 ohm, 1.5 kW(2).
5 Resistor mounting bracket kit (2)
6 Fuse block

Instructions:

1. Secure the external regen resistors with the supplied mounting brackets. Observe mounting location requirements of section 2.5 of this Users Manual. Mounting bracket feet may be turned in to conserve space.
2. Connect one end of the two external regen resistors together, and then connect to pin 1 of TB5.
3. Connect the other ends of the two regen resistors together, and then connect to one end of the fuse block.
4. Connect the other end of the fuse block to pin 4 of TB5. Do not remove the shorting links from the plug in TB5.
5. Install the supplied 25A regen fuse in the fuse block.
6. Place the supplied Final Configuration Label along the top of the housing beside TB2 as shown in FIGURE 2.20.

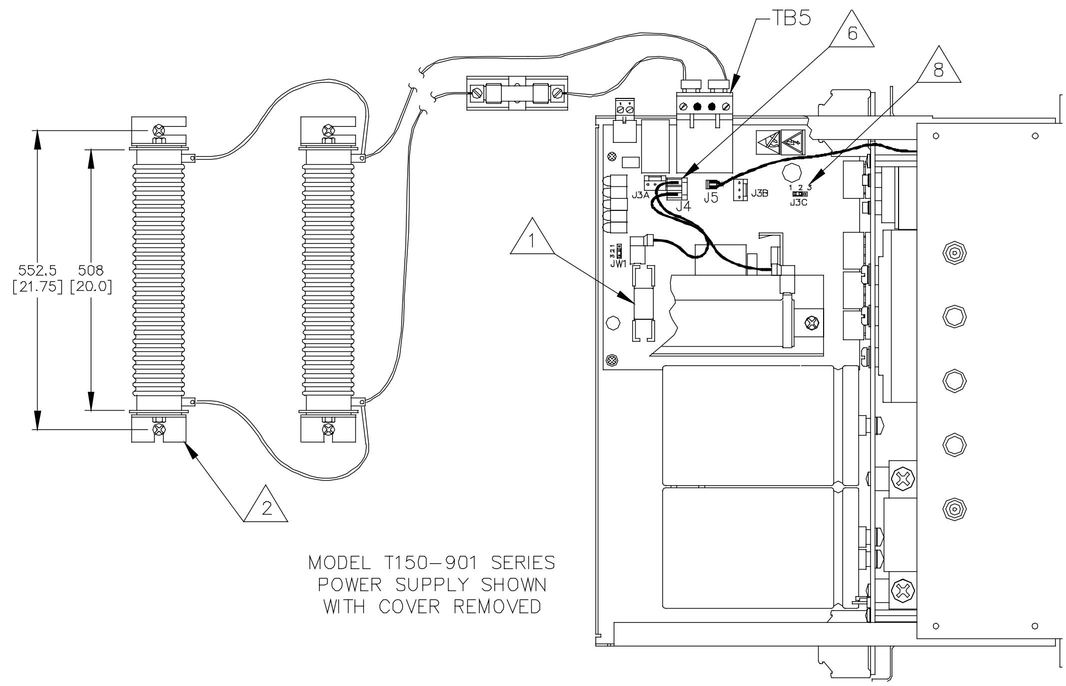


FIGURE 2.19 T150-901 Power Supply 2.5 KW, 2-Pole Regen Configuration

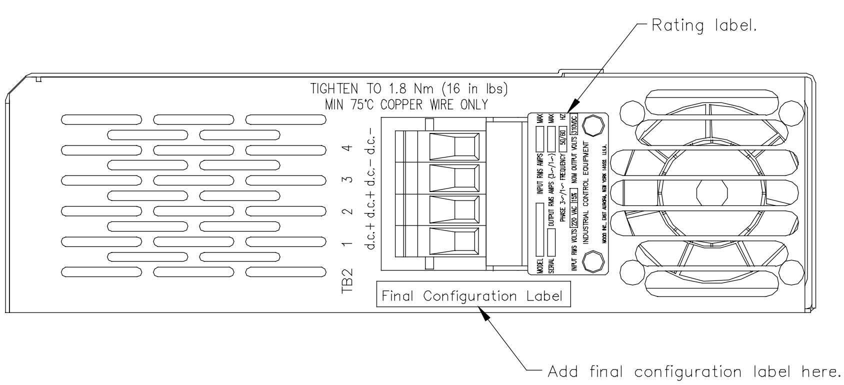


FIGURE 2.20 Final Configuration Label Mounting Location.

2.8 MOTORS - INSTALLATION

Motors should be sized by qualified personnel. Improper sizing will directly affect performance and reliability.

> **NOTE**
> *The components making up the drive system may only be installed and serviced by duly qualified personnel. The accident prevention regulations (UVV VBG 4, VDE 100, VDE 105) and the installation regulations (EN 60204 Part 1, prEN 50178) must be taken into account.*

Unqualified work on the drive components and failure to comply with the warnings contained in this manual or affixed to the components can result in serious physical injury or damage to property.

The work permitted within the scope of this manual may consequently only be undertaken by duly qualified personnel.

This includes the following people:

- **Planning and engineering design personnel** familiar with the safety guidelines for measurement and control instrumentation.
- **Operating personnel** who have been duly instructed with regard to the handling of measurement and control instrumentation and who are familiar with the operating instructions contained in this manual.
- **Commissioning and service personnel** authorized to start up, ground and mark the circuits for components and systems in accordance with safety engineering standards.

2.8.1 SAFETY INSTRUCTIONS

The following safety instruction are related to motors and may only apply when replacing a component.

WARNING

Danger - High voltage!

The servo drives operate with potentially lethal voltages. For this reason:

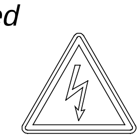
Disconnect the system from the mains supply. Before starting any work on the drive system, it must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.

The servomotors must come to a complete stop. Rotating servomotors can generate potentially lethal voltages by acting as generators.

NOTE

Danger - High voltage

(Sticker on the power supply and servomotor).The symbol indicates that the power supply operates with high voltages which can prove extremely dangerous if touched



WARNING

Beware of mechanical hazards!

Servomotors can accelerate highly dynamically. They also have enormous torque. The following points must therefore be noted when starting the system.

The danger zone of the motor must be cordoned off. The system must feature a guard door preventing personnel from reaching into or entering the danger zone. The drive system must be de-energized automatically as soon as the guard door is opened.

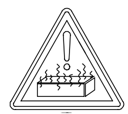
The motor may accelerate inadvertently on account of wiring faults or software errors. Appropriate safety precautions must therefore be taken in the system to ensure that neither personnel nor machine components are endangered in any way.

Servomotors can become very hot in operation. Good heat dissipation must therefore be ensured when installing the motor, i.e. it should be flanged onto a suitably solid metal part of the machine. Adequate convection must also be ensured. Forced cooling (e.g. with fans) will increase the continuous power, while bad convection may decrease the continuous performance.
In individual cases, the motor must furthermore be protected against contact due to the risk of burns.

NOTE

Beware of hot parts

(Sticker on servomotor) In extreme applications, the surface of the servomotor may heat up to more than 100 °C and can cause skin burns if touched. The servomotor must therefore be protected to prevent contact.



2.8.2 INTENDED USE

The drive components have been developed and built for installation and operation in industrial systems.

See additional information regarding installation, mounting, rated radial load and operating conditions in section 5 “G400 Series Motors”.

2.9 CABLES

This Section defines the cable requirements for the T164 Series Drives and related equipment.

> **NOTE**
> *Cabling and component wiring is critical in obtaining successful operation of the system. Pay close attention to specified wiring practice, cabling information, earthing and shielding requirements. Improper wiring can result in EMC and other electrical noise generation and unstable motor performance, resulting in the equipment becoming unsafe.*

Assure chassis earth connections are securely made throughout the equipment. The Earth continuity between the earth terminal and any accessible part of the equipment enclosure or cabinet shall be less than or equal to 0.1 ohms.

Terminate all individual chassis earth connections to a single tie point such as the equipment earth Bus. All earth connections should be as short as possible. Ensure that a good high frequency (HF) earth bond is maintained.

Tighten all terminal screws securely to avoid faulty operation and to avoid the equipment becoming unsafe. Torque screws to the specified values noted on the installation and cable drawings.

Do not solder the ends of the cables to be inserted into screw clamp terminals.

All connections to the T164 Series Drives are through removable plug-in mating connectors. All mating connectors except Communications Port connector J3 are supplied with the drive.

> **CAUTION**
> *All electrical supply wires and cables to this equipment must be installed in wireways (cable routings) which are smooth and free from sharp edges.*

> **CAUTION**
> *All external electrical wiring connected to this equipment must be color coded in accordance with European Standard EN 60204-1 requirements. (Refer to section 2.9.1 of this Users Manual).*

CAUTION

All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the T150-901 Power Supply, the T164 Series Drives and the Regen resistor(s) must be protected and anchored in accordance with the requirements of EN 60204-1. (Refer to section 2.9.1.1 of this Users Manual).

CAUTION

Ferrite EMC suppression components are required to be installed by the user on cables connected to certain ports on the T150-901 Power Supply and T164 Series Drives. Details of ferrite EMC suppression components which have been tested with the typical configurations of T150-901 Power Supply and T164 Series Drives referred to in section 1.3.1 of this Users Manual are given in section 2.5.2 of this Users Manual. Detailed installation instructions for such ferrite EMC suppression components are given in section 2.5.2 of this Users Manual.

CAUTION

Shielded cable is required to be installed by the user for many external user cable connections to the T150-901 Power Supply and T164 Series Drives. Details of areas where shielded cable must be installed and details of earthing arrangements which must be implemented for the shields of such cables are given in sections 2.5.2 and 2.9.2 of this Users Manual. Installation requirements for external Regen (Regenerative Circuit) resistors are given in sections 2.5 and 2.7 of this Users Manual.

CAUTION

Additional electromagnetic compatibility (EMC) measures which must be installed on a.c. power input Line Filter cables are given in section 2.3 of this Users Manual.

CAUTION

Additional electromagnetic compatibility (EMC) measures which must be installed on equipment cables associated with the T150-901 Power Supply and T164 series Drives are given in section 2.5.2 of this Users Manual.

2.9.1 SAFETY REQUIREMENTS FOR CABLES

2.9.1.1 REQUIREMENTS - CONDUCTORS AND CABLES

All cables and conductors used shall be specified as compliant with the requirements of European standard EN 60204-1 for the environment in which they are installed and for the voltage and current carried.

Conductors and cables shall be specified and selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stresses) which can exist.

Wherever possible, insulated conductors and cables which have flame-retardant properties shall be used.

Conductors shall be of copper. Conductors of any other material shall have a nominal cross-sectional area such that, carrying the same current, the maximum conductor temperature shall not exceed the values given in TABLE 2-3. Where aluminum is used, the cross sectional area shall be at least 16 mm^2.

Where insulated conductors and cables can constitute a fire hazard due to the propagation of a fire or the emission of toxic or corrosive fumes (e.g. PVC), guidance from the cable supplier should be sought. In particular it is important to maintain the integrity of circuits having a safety function (e.g. emergency stop) for as long as possible under these conditions.

The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts.

The voltage drop on cables and conductors shall not exceed 5% of the nominal voltage. The current carrying capacity of the conductors and cables is determined by both:

- The maximum allowable conductor temperature under the highest possible steady state current under normal conditions.
- The ultimate allowable short-time conductor temperature under short circuit conditions.

A conductor cross-sectional area shall be such that for the highest steady state current or its equivalent the conductor temperature does not exceed the value given in TABLE 2-3.

Types of insulation	Maximum conductor temperature under normal conditions (deg. C)	Ultimate short-time conductor temperature under short-circuit conditions (see Note) (deg. C)
Polyvinyl chloride (PVC)	70	160
Rubber	60	200
Cross-linked polyethylene (XLPE)	90	250
Silicone Rubber (SiR)	180	350
NOTE: Assuming adiabatic behavior for a period of not more than 5 s.		

TABLE 2-3 Maximum Allowable Conductor Temperatures

2.9.1.2 WIRING PRACTICES - CONNECTIONS AND ROUTING

All connections, especially those of the protective bonding circuit, shall be secured against accidental loosening.

The means of connection shall be suitable for the cross-sectional areas and nature of the conductors being terminated. In the case of aluminum or aluminum alloy conductors, particular consideration shall be given to the problem of electrolytic corrosion.

The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one protective bonding circuit conductor shall be connected to one terminal connecting point.

Soldered connections shall only be permitted where terminals are provided which are suitable for soldering.

Terminals on the terminal blocks shall be plainly identified to correspond with markings on the diagrams.

The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings.

Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals which are not equipped with this facility. Solder shall not be used for this purpose.

Shielded conductors shall be so terminated as to prevent fraying of strands and to permit easy disconnection.

Identification tags shall be legible, permanent, and appropriate for the physical environment.

Terminal blocks shall be so mounted and wired, that the internal and external wiring does not cross over the terminals.

2.9.1.3 WIRING PRACTICES - CONDUCTOR AND CABLE RUNS

Conductors and cables shall be run from terminal to terminal without splices or intervening joints

Where it is necessary to connect and disconnect cables and cable assemblies, sufficient extra length shall be provided for this purpose.

The terminations of multicore cables shall be adequately supported where undue strain can be exerted on the terminations of the conductors.

Wherever possible, the protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop.

2.9.1.4 WIRING PRACTICES - CONDUCTORS OF DIFFERENT CIRCUITS

Subject to the constraints for EMC suppression given in sections 1.3, 2.5 and 2.7 of this Users Manual, conductors of different circuits may be laid side by side, may occupy the same duct (e.g. conduit, cable trunking system), or may be in the same multicore cable, provided that the arrangement does not impair the proper functioning of the respective circuits. Where these circuits operate at different voltages, the conductors shall be either separated by suitable barriers or insulated for the highest voltage to which any conductor within the same duct can be subjected.

Circuits which are not switched off by the supply disconnecting device (circuit breaker) shall be either physically separated from other wiring or distinguished by color (or both) so that they can be identified as being live when the supply disconnecting device is in the OFF or OPEN position.

2.9.1.5 WIRING PRACTICES - IDENTIFICATION OF CONDUCTORS

Conductors shall be identifiable at each termination in accordance with the technical documentation.

Where color-coding is used for identification of conductors, the following colors shall be used:

BLACK	BROWN
RED	ORANGE
YELLOW	GREEN
VIOLET	GREY
WHITE	PINK
TURQUOISE	BLUE (including LIGHT BLUE)

It is recommended that, where color is used for identification, the color be used throughout the length of the conductor either by the color of the insulation or by color markers. An acceptable alternative may consist of additional identification at selected locations.

For safety reasons, the color Green or the color Yellow shall not be used where there is a possibility of confusion with the bicolor combination GREEN-AND-YELLOW.

Color identification using combinations of those colors listed above may be used provided there can be no confusion and that GREEN or YELLOW is not used, except in the bicolor combination GREEN- AND-YELLOW.

2.9.1.6 WIRING PRACTICES - IDENTIFICATION OF THE PROTECTIVE CONDUCTOR

The protective conductor shall be readily distinguishable by shape, location, marking or color. When identification is by color alone, the bicolor combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. this color identification is strictly reserved for the protective conductor.

For insulated conductors, the bicolor combination GREEN-AND-YELLOW shall be such that on any 15 mm length, one of the colors covers at least 30% and not more than 70% of the surface of the conductor, the other color covering the remainder of the surface.

Where the protective conductor can be easily identified by its shape, position or construction (e.g. braided conductor), or where the insulated conductor is not readily accessible, color coding throughout its length is not necessary but the ends or accessible positions shall be clearly identified by the graphical symbol 417-IEC-5019 or by the bicolor combination GREEN-AND-YELLOW.

2.9.1.7 WIRING PRACTICES - IDENTIFICATION OF THE NEUTRAL CONDUCTOR

Where a circuit includes a neutral conductor identified by color, the color shall be LIGHT BLUE. LIGHT BLUE shall not be used for identifying any other conductor where confusion is possible.

In the absence of a neutral conductor, a LIGHT BLUE conductor may be used for other purposes except for use as a protective conductor.

Where identification by color is used, bare conductors used as neutral conductors shall be either colored by a LIGHT BLUE stripe, 15 mm to 100 mm wide, in each compartment or unit or at each accessible position, or colored LIGHT BLUE throughout their length.

2.9.1.8 WIRING PRACTICES - IDENTIFICATION OF OTHER CONDUCTORS

Identification of other conductors shall be by color (either solid or with one or more stripes), number, alphanumeric, or a combination of color and numbers or alphanumeric. When numbers are used, they shall be Arabic; letters shall be Roman (either upper or lower case).

Insulated single-core conductors shall be color-coded as follows:

- ❑ BLACK: a.c. and d.c. power circuits;
- ❑ RED: a.c. control circuits;
- ❑ BLUE: d.c. control circuits; and
- ❑ ORANGE: interlock control circuits supplied from an external power source.

Exceptions to the above are permitted as follows:

- ❑ for internal wiring on individual devices purchased completely wired;
- ❑ where insulation is used that is not available in the colors required; or
- ❑ Where multicore cable is used, but not the bicolor combination GREEN-AND-YELLOW.

2.9.1.9 WIRING PRACTICES - WIRING INSIDE ENCLOSURES

Panel conductors shall be supported where necessary to keep them in place. Non-metallic channels or ducts shall be permitted only when made with a flame-retardant insulating material. where possible earthed shielded metal cable ducting should be used to minimize EMC noise coupling.

It is recommended that electrical equipment mounted inside the enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure. Where this is not possible and control devices are connected from the rear of the enclosure, access doors or swingout panels shall be provided.

Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with European standard EN 60204-1, to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and the movable part independently of the electrical connections.

Conductors and cables which do not run in ducts shall be adequately supported.

Terminal blocks or attachment plug/socket combinations shall be used for control wiring which extends beyond the enclosure.

Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended.

2.9.1.10 WIRING PRACTICES - WIRING OUTSIDE ENCLOSURES

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced.

Conductors and their connections external to the electrical equipment IP54 enclosures shall be installed in suitable ducts (i.e. conduit or cable trunking systems) as described in section 2.9.1.11, except for suitably protested cables which may be installed without enclosing ducts and with or without the use of open cable trays or cable support means.

Fittings used with ducts or multiconductor cable shall be suitable for the physical environment.

Flexible conduit or flexible multiconductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of pendant stations shall be supported by means other than the flexible conduit or the flexible multiconductor cable, except where the conduit or cable is specifically designed for that purpose.

Flexible conduit or flexible multiconductor cable shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to normally stationary motors, to position switches, and to other externally mounted devices.

Connections to frequently moving parts shall be made with conductors suitable for flexing service in accordance with European standard EN 60204-1. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points nor any sharp bending. The loop shall have sufficient length to provide for a bending radius of the cable of at least ten times its outside diameter.

Where cables subject to movement are close to moving parts, precautions shall be taken so that a space of at least 25 mm shall be maintained between the moving parts and the cables. Where this distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

The cable sheath shall be resistant to the normal wear which can be expected from movement, and to the effects of atmospheric contaminants (e.g. oil, water, coolants, dust).

Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit or cable under all conditions of operation.

Flexible metal conduit shall not be used for rapid or frequent movements, except when specifically designed for that purpose.

Prewired devices (e.g. position switches, proximity switches) provided with an identified cable may be provided without provisions for termination of the conduit.

2.9.1.11 WIRING PRACTICES - DUCTS, CONNECTION AND JUNCTION BOXES

All sharp edges, flash, burrs, rough surfaces, or threads, with which the insulation of the conductors may come in contact, shall be removed from ducts and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from the moving parts and in such a manner so as to minimize the possibility of damage or wear.

Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine or equipment into which they are installed.

2.9.2 EMC REQUIREMENTS FOR CABLES

- Avoid close parallel routing of signal cables and power cables. Always use the minimum length of cable necessary and install all cables in a fixed routing.

- Data signal cables, motor and resolver cables, regen resistor cables and power input cables shall have segregated routings. Where cable routings must intersect it is recommended that they intersect at an angle of 90 degrees, to minimize EMC noise coupling.

Where signal and power cables must run in parallel it is recommended that these cables are separated by at least 20 cm. Where possible cables should be routed in earthed shielded cable ducting, to minimize electromagnetic noise coupling.

Use shielded or armored cable to connect the external regen resistor (if installed) to the T150-901 power supply. The length of this cable should be as short as possible. The shields of these voltage supply cables should be earthed to Chassis Earth using a 180 degree metal clamp (P clip) connection to ensure a good HF earth bond. Secure the clip using conductive bolts and locking washers. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland. (Refer to Section 1.2.1 and Section 2.7 for safety and other relevant installation requirements for Regen resistors).

Cables supplying external d.c. supply voltages to the T164 Series Drives (For example, the 24 Vd.c. supply) must be as short as possible. The supply wires should be twisted together or alternatively shielded cable should be used.

Cables connecting the 300 Vd.c. bus from the T150-901 Power supply to the T164 Series Drives must be as short as possible. The supply wires should be twisted together.

Motor power cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the T164 Drive end of the cable the shield should be earthed to Chassis Earth using a 180 degree metal clamp (P clip) connection to ensure a good HF earth bond. Secure the clip using conductive bolts and locking washers.

For CE compliance motor resolver cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.

Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.

Additional electromagnetic compatibility (EMC) measures which must be installed on a.c. power input Line Filter cables are given in section 2.3 of this Users Manual.

Additional electromagnetic compatibility (EMC) measures which must be installed on equipment cables associated with the T150-901 Power Supply and T164 series Drives are given in section 2.5.2 of this Users Manual.

Further information about electromagnetic compatibility (EMC) requirements which must be met when the T150-901 Power Supply and T164 series Drives are given in sections 1.3, 2.5 and 2.7 of this Users Manual.

2.10 SPECIFIC CABLES

2.10.1 POWER SUPPLY TB3 CABLE (PSU FAULT OUTPUT CONNECTION)

For TB4/TB5 connections see section 2.7.
Wire this cable per FIGURE 2.21.

Use a two conductor shielded cable to wire the Power Supply Fault Output to user supplied sequencing logic which disables all drives when a power supply fault occurs. The Power Supply Fault Output requires a user supplied external 4.5 to 35 Vd.c. power source. This may be the same source as used for the Drive I/O, (refer to section 2.5.1).

CAUTION

The T164 Series Drives should not be enabled during AC power up until the Power Supply Fault Output clears. The user must supply the logic to accomplish this interlock. Failure to delay enabling of the Drives, or having any other external load on the T150 Series Power Supply, on AC power up will defeat the proper operation of the soft start circuitry in the T164-901 Power Supply and can result in tripping of the AC input circuit breaker and/or damage to the T164-901 Power Supply resulting in the equipment becoming unsafe.

2.10.2 DRIVE J1 CABLE (STANDARD I/O CABLE)

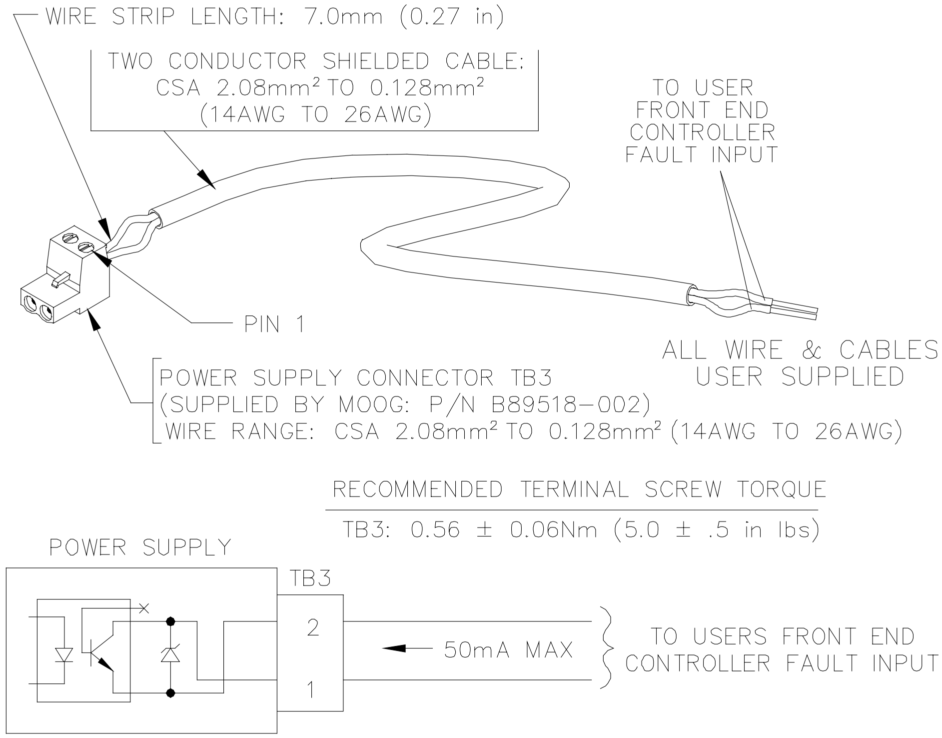
Use a multi-conductor shielded cable and wire per FIGURE 2.22.

Velocity/torque command wires must be a shielded twisted pair, with shield terminated at the T164 Series Drive as shown in FIGURE 2.22.

NOTE

An external 4.5 to 35 Vd.c. power source (user supplied) is required for the I/O functions. The amperage rating of this power source will depend on the number of I/O functions utilized.
Refer to sections 5 and also to sections 1.2.1, 1.3, 2.5.1 and 2.5.2 for safety and EMC requirements.

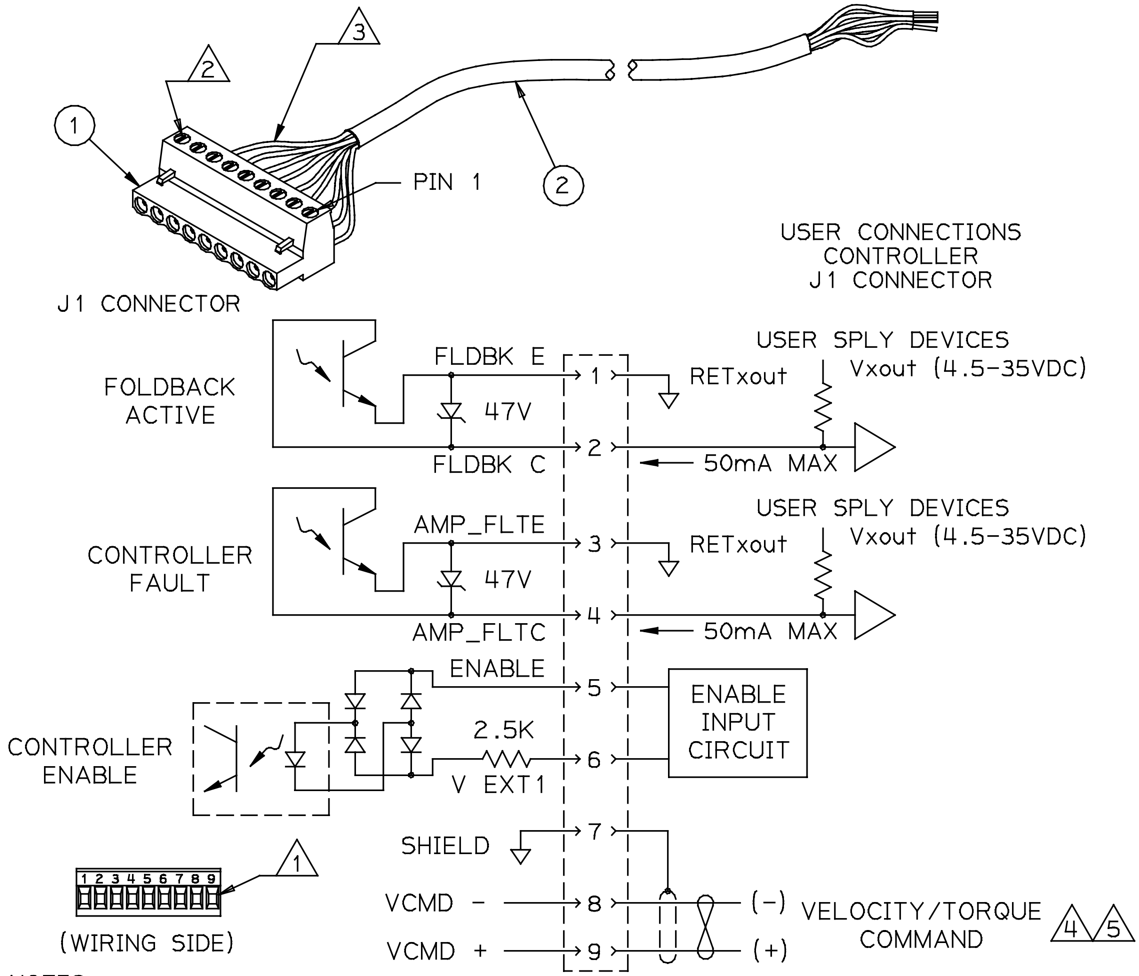
The user should monitor each drive fault and foldback active optoisolator output. It is the users' responsibility to provide external circuitry to shut down all axes of a machine if a drive fault occurs.



Notes pertaining to cable wiring to TB3:

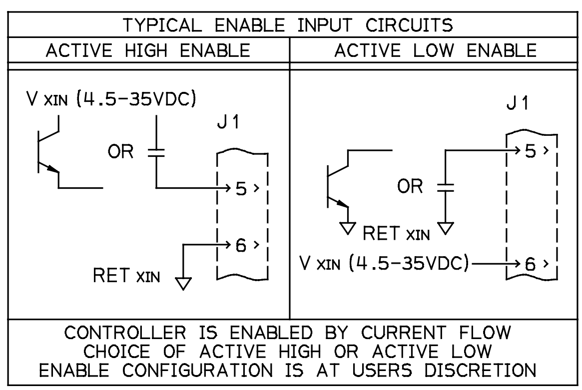
1. The Power Supply fault output must be connected to the user-supplied sequencing logic which disables all drives when a power supply fault occurs. A user-supply external power source of 4.5 to 35Vd.c. is required for this circuit, and may be the same source as used for the drive I/O.
   (See safety precautions for further requirements)

FIGURE 2.21 TB3 Power Supply Fault (PSF) Output Cable



NOTES:

1. WIRE RANGE:
   14 AWG TO 26 AWG.
2. RECOMMENDED TERMINAL SCREW TORQUE:
   5.0 ±.5 IN LBS.
   [.56 ±.06 NM]
3. WIRE STRIP LENGTH:
   .27 IN. [7.0 mm]
4. COMMAND SIGNAL MUST BE TWISTED SHIELDED PAIR CABLE.
5. VCMD+ POSITIVE WITH RESPECT TO VCMD- CAUSES CLOCKWISE (CW) MOTOR ROTATION.



= TWISTED PAIR

FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	B89518-009	CONNECTOR 9 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE 1	USER SPLY AR

FIGURE 2.22 DRIVE J1 CABLE (STANDARD I/O)

2.10.3 DRIVE J3 CABLE (COMMUNICATIONS CABLE)

For RS232 communications, use a 3 wire conductor configured per FIGURE 2.23.
If the communication device is a "dumb terminal" or "DTE" the pin out is shown in the top illustration. If the communication device is a PC or "DCE", then the pin out is shown in the middle illustration. For PCs, the cable is in a "Null Modem" configuration. If a commercial cable is used, ensure a "Null Modem" adapter is included.

The 5Vd.c. from pin 9 is a supply used by the Hand Held Terminal and is not required by a user for any other device.

2.10.4 VDC LOGIC POWER CABLE

Wire the fused output of a user supplied 24 Vd.c. external power supply per FIGURE 2.24. Twisted pair is recommended to minimize radiation of high frequency switchmode noise generated by the SMPS in the T164 Series Drive. If more than one drive is used, the 24 Vd.c. external power can be daisy chained to additional drives, as shown in FIGURE 2.24. Note that continuity of the 24 Vd.c. power occurs in the drive and not the plug. Hence, if a 24 Vd.c. Logic Power connector in a daisy chain is unplugged from its drive, 24 Vd.c. power to all downstream drives is lost.

2.10.5 ENCODER SIMULATION J4 CABLE (OPTION

Use individually shielded four pair CSA 0.556 sq. mm (20 AWG) cable and wire per FIGURE 2.25**.**

2.10.6 EXTENDED I/O J5 CABLE (OPTION) USED WITH EXTENDED I/O BOARD ASSEMBLY (B89666-003/B89666-002)

Use multi-conductor shielded cables for the input and output connectors and wire per FIGURE 2.26.

2.10.6.1 EXTENDED I/O J6 CABLE (OPTION) USED WITH EXTENDED I/O BOARD ASSEMBLY (B89666-003)

Use multi-conductor shielded cables for the input and output connectors and wire per FIGURE 2.27.

2.10.7 EXTENDED INPUT BRACKET CABLE (OPTION)

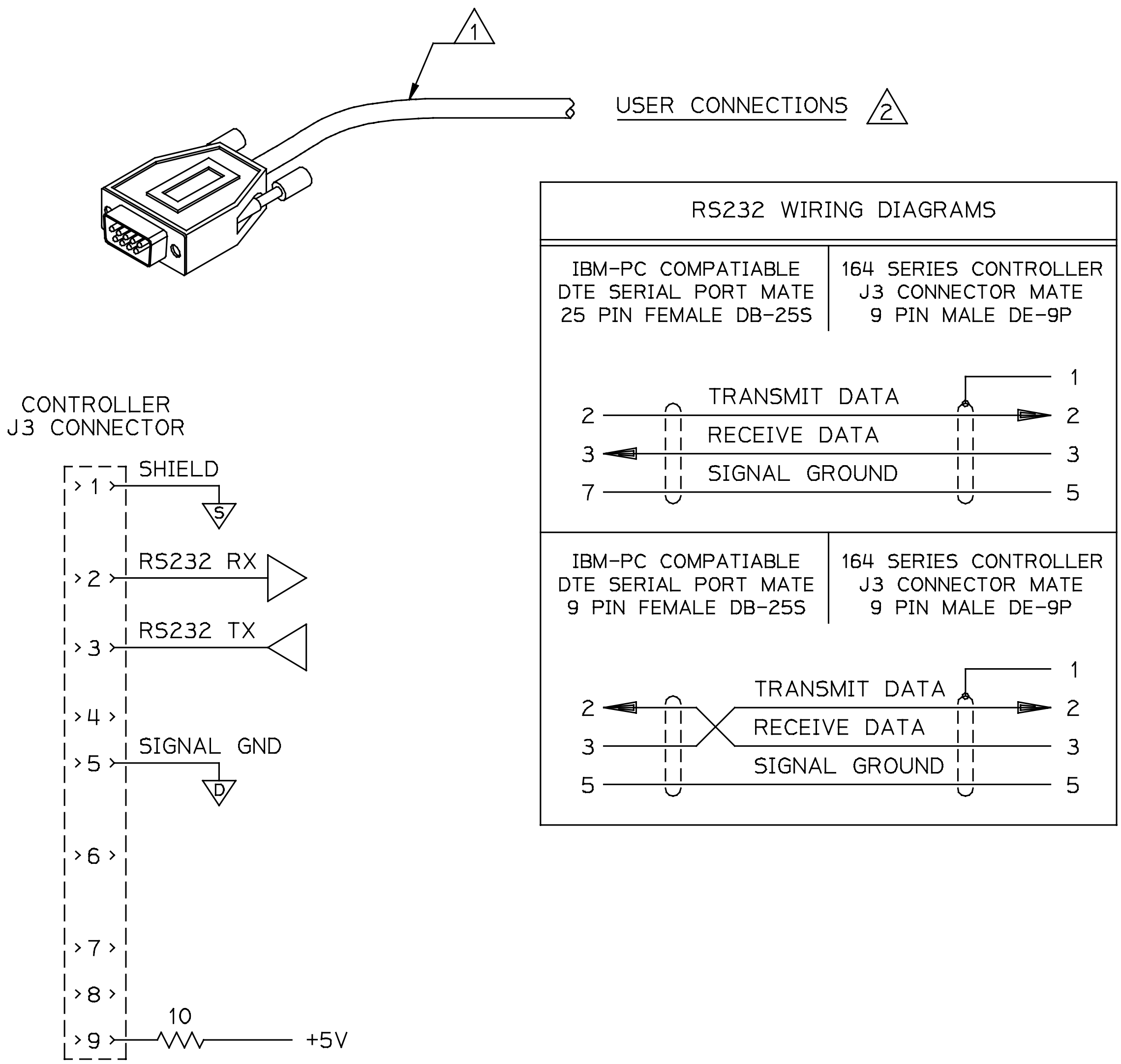
Use multi-conductor shielded cables for the input connector and wire per FIGURE 2.28.

2.10.8 CAN INTERFACE I/O OPTION CARD CABLE (OPTION)

Use multi-conductor shielded cables for the input and output connectors see FIGURE 2.29.

2.10.8.1 CAN INTERFACE X2/X3 SERIAL CABLE (OPTION)

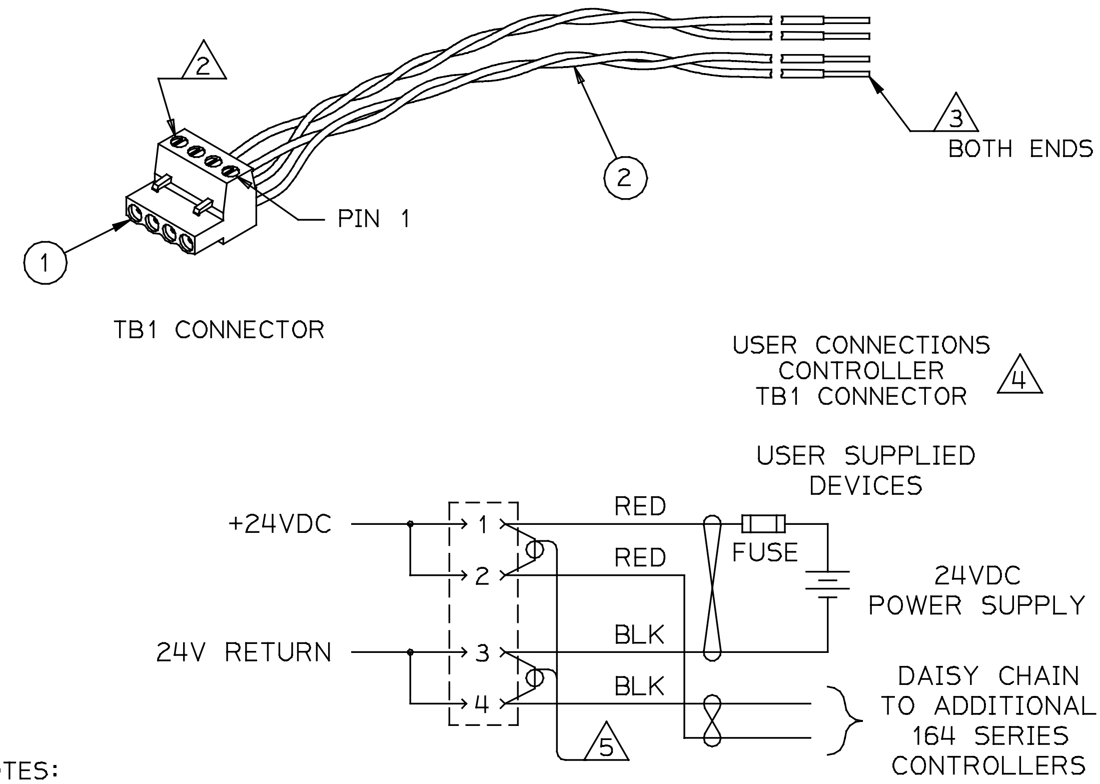
Use multi-conductor shielded communication cable and wire per FIGURE 2.30.



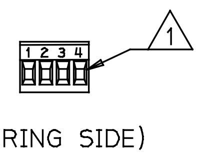
NOTES:

1. CABLE LENGTH NOT TO EXCEED 50 FEET [15 METERS] FOR RS232 OPERATION.
2. CONNECTOR TYPE AND PIN OUT VARIES PER APPLICATION. (REFER TO TABLE ABOVE)

FIGURE 2.23 Drive J3 Cable (Serial Communication)



NOTES:

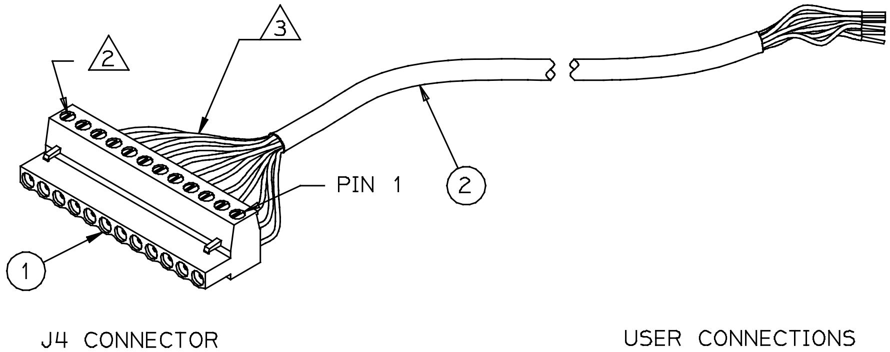


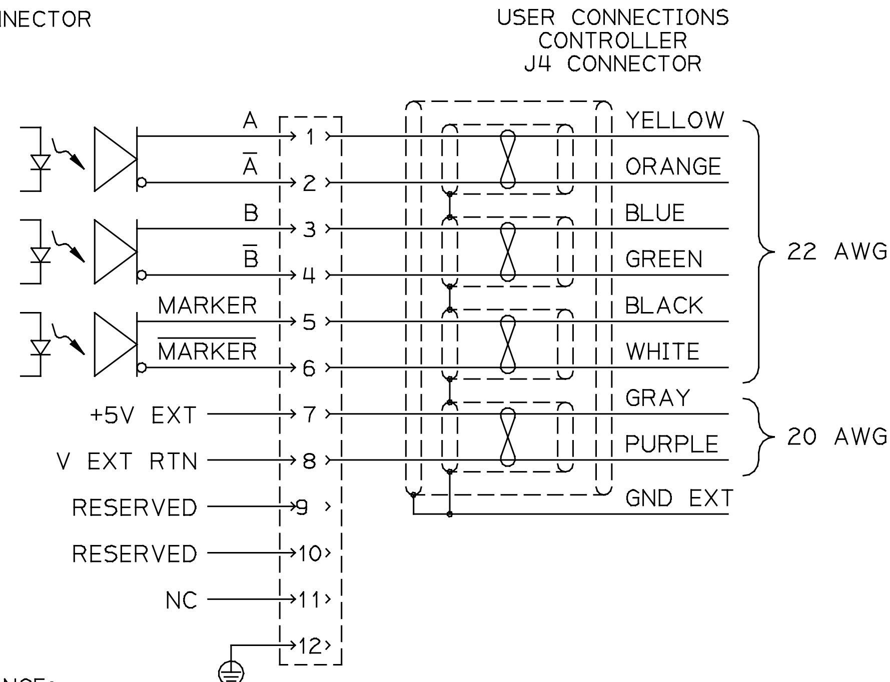
1. WIRE RANGE:
   14 AWG TO 26 AWG.
2. RECOMMENDED TERMINAL
   SCREW TORQUE:
   5.0 ±.5 IN LBS.
   [.56 ±.06 NM]
3. WIRE STRIP LENGTH:
   .27 IN. [7.0 mm]
4. WIRE COLORS ARE OPTIONAL.
5. JUMPER PIN 1 TO PIN 2 AND
   PIN 3 TO PIN 4 TO PROVIDE
   CONTINUITY OF 24VDC CONTROL
   POWER WHEN CONNECTOR IS
   UNPLUGGED FOR MULTIPLE AXIS
   APPLICATIONS.

= TWISTED PAIR

FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	B89518-004	CONNECTOR 4 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE 1	USER SPLY AR

FIGURE 2.24 Drive TB1 Cable (24Vd.c. Logic Power)

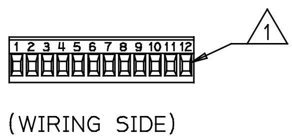




NOTES:

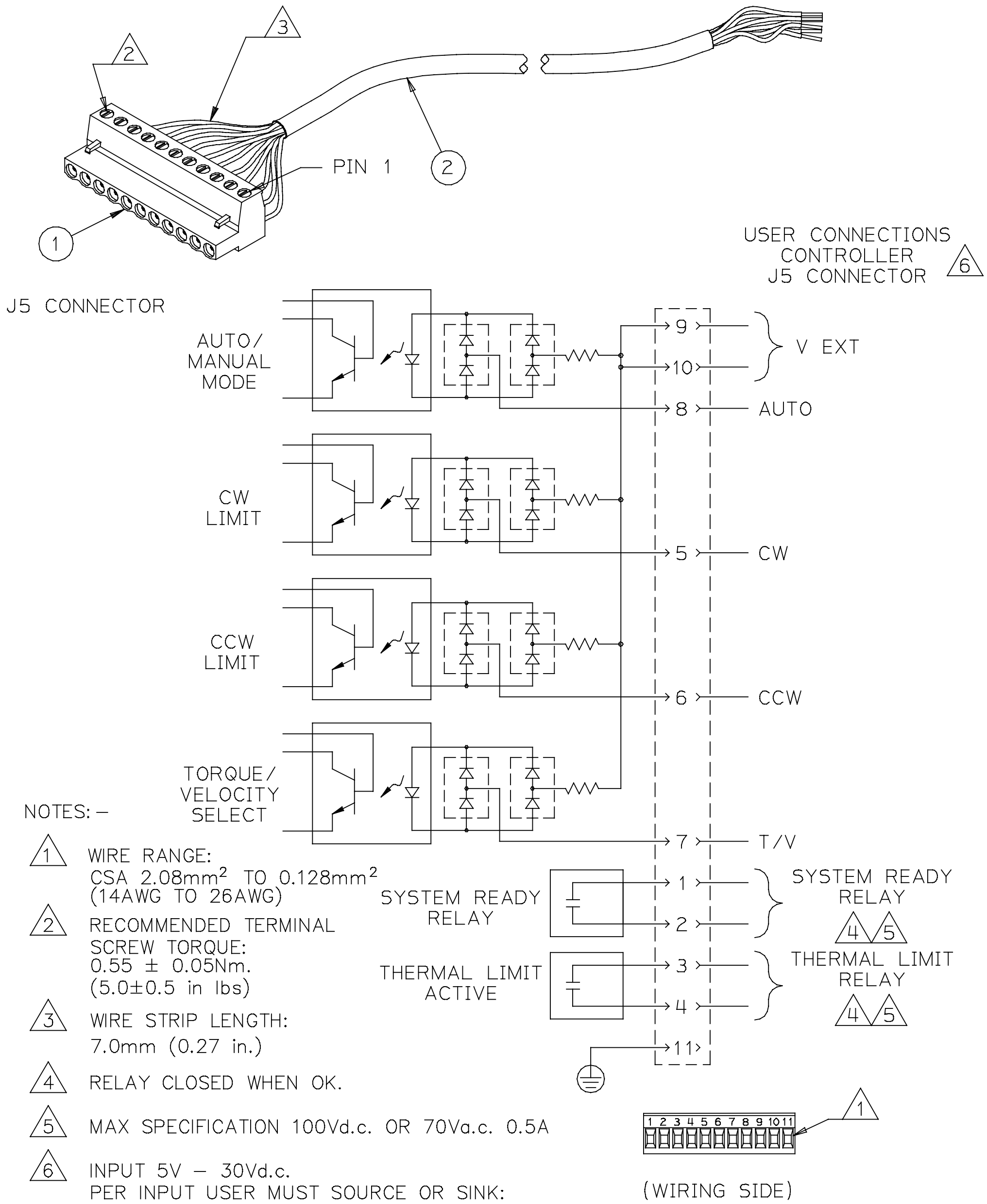
1. WIRE RANGE: 14 AWG TO 26 AWG.
2. RECOMMENDED TERMINAL SCREW TORQUE: 5.0 ±.5 IN LBS. [.56 ±.06 NM]
3. WIRE STRIP LENGTH: .27 IN. [7.0 mm]

∞ = TWISTED PAIR



FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	B69687-012	CONNECTOR 12 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE, INDIVIDUALLY SHIELDED TWISTED, 4 PAIR (BELDEN PN: 9891) 1	USER SPLY AR

FIGURE 2.25 Encoder Simulation Option Card Cable

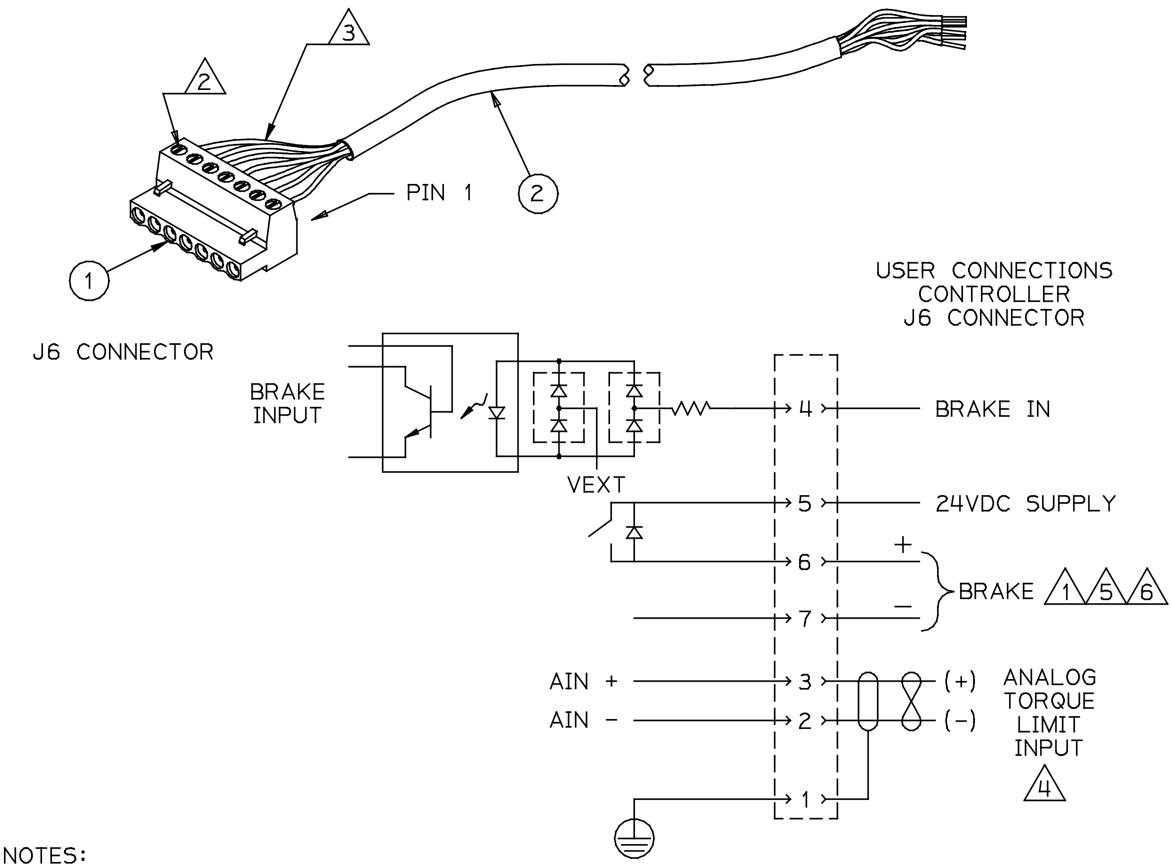


NOTES: –

1. WIRE RANGE:
   CSA $2.08mm^2$ TO $0.128mm^2$
   (14AWG TO 26AWG)
2. RECOMMENDED TERMINAL
   SCREW TORQUE:
   0.55 ± 0.05Nm.
   (5.0±0.5 in lbs)
3. WIRE STRIP LENGTH:
   7.0mm (0.27 in.)
4. RELAY CLOSED WHEN OK.
5. MAX SPECIFICATION 100Vd.c. OR 70Va.c. 0.5A
6. INPUT 5V – 30Vd.c.
   PER INPUT USER MUST SOURCE OR SINK:
   1.15mA AT 5V
   12.1MA AT 30V

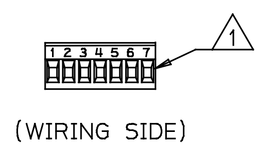
FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	B69687-011	CONNECTOR 11 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE 1	USER SPLY AR

FIGURE 2.26 J5 Extended I/O Option Card Cable



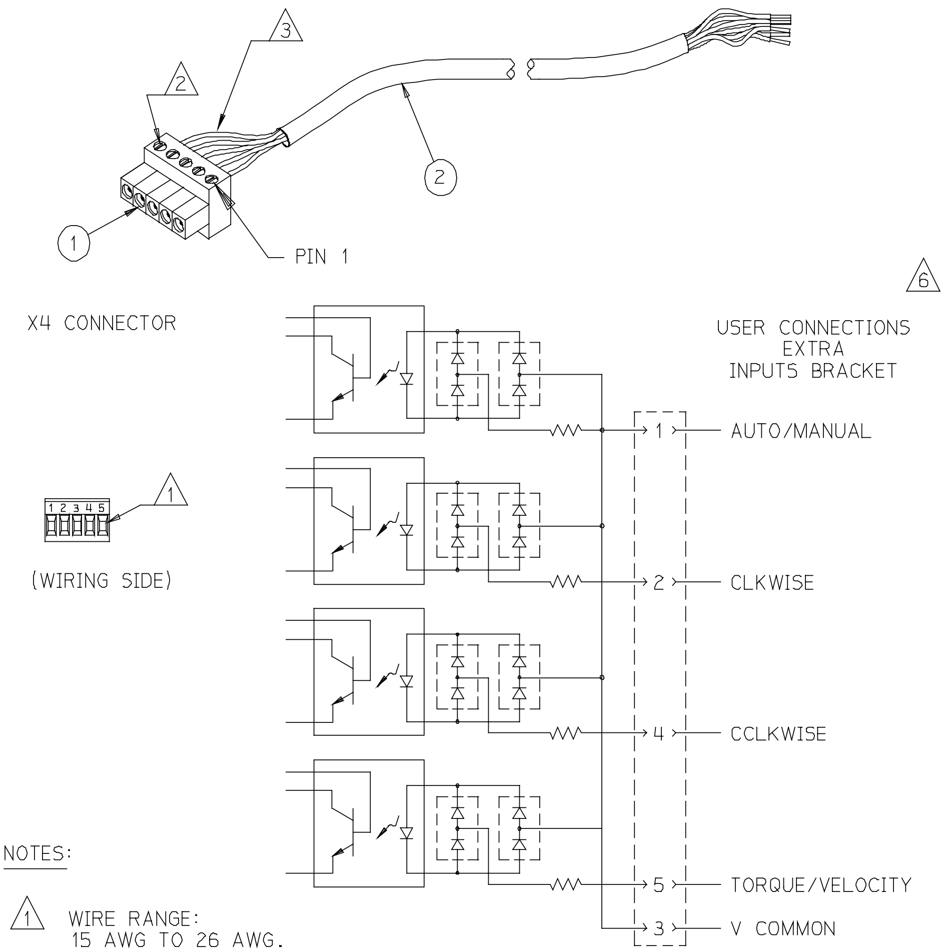
NOTES:

1. WIRE RANGE:
   14 AWG TO 17 AWG.
2. RECOMMENDED TERMINAL
   SCREW TORQUE:
   5.0 ±.5 IN LBS.
   [.56 ±.06 NM]
3. WIRE STRIP LENGTH:
   .27 IN. [7.0 mm]
4. SIGNAL MUST BE TWISTED SHIELDED PAIR 8 = TWISTED PAIR
5. SUPPLY SHOULD BE MAX. 1.5A AT 24VDC. SEE TABLE 5-5 FOR BRAKE DATA
6. 24VDC SUPPLY RETURN SHOULD
   BE WIRED TO PIN 7 ALSO.



FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	C09464-007	CONNECTOR 7 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE 1	USER SPLY AR

FIGURE 2.27 J6 Extended I/O Option Card Cable

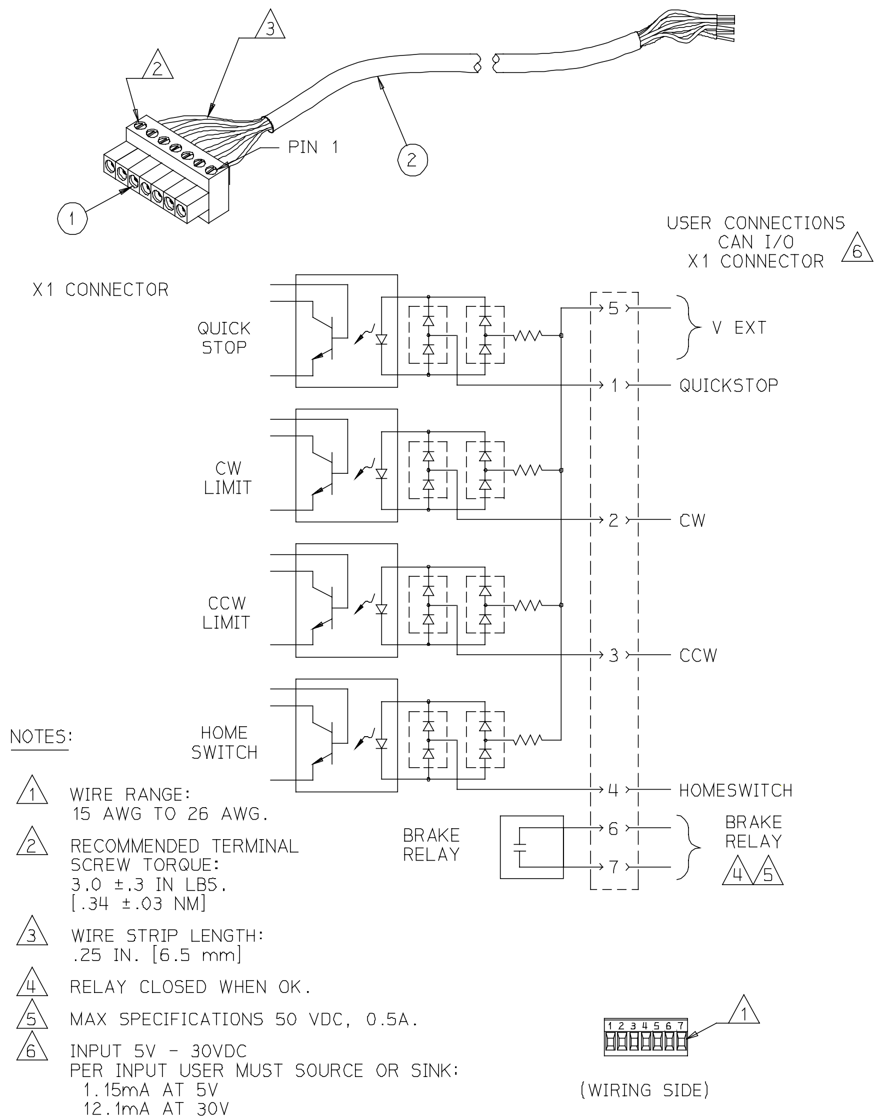


NOTES:

1. WIRE RANGE:
15 AWG TO 26 AWG.
2. RECOMMENDED TERMINAL
SCREW TORQUE:
3.0 ±.3 IN LBS.
[.34 ±.03 NM]
3. WIRE STRIP LENGTH:
.25 IN. [6.5 mm]
4. INPUT TO V INPUT EXT (5V - 35VDC)
PER INPUT USER MUST SOURCE OR SINK:
1.15mA AT 5V
12.1mA AT 30V

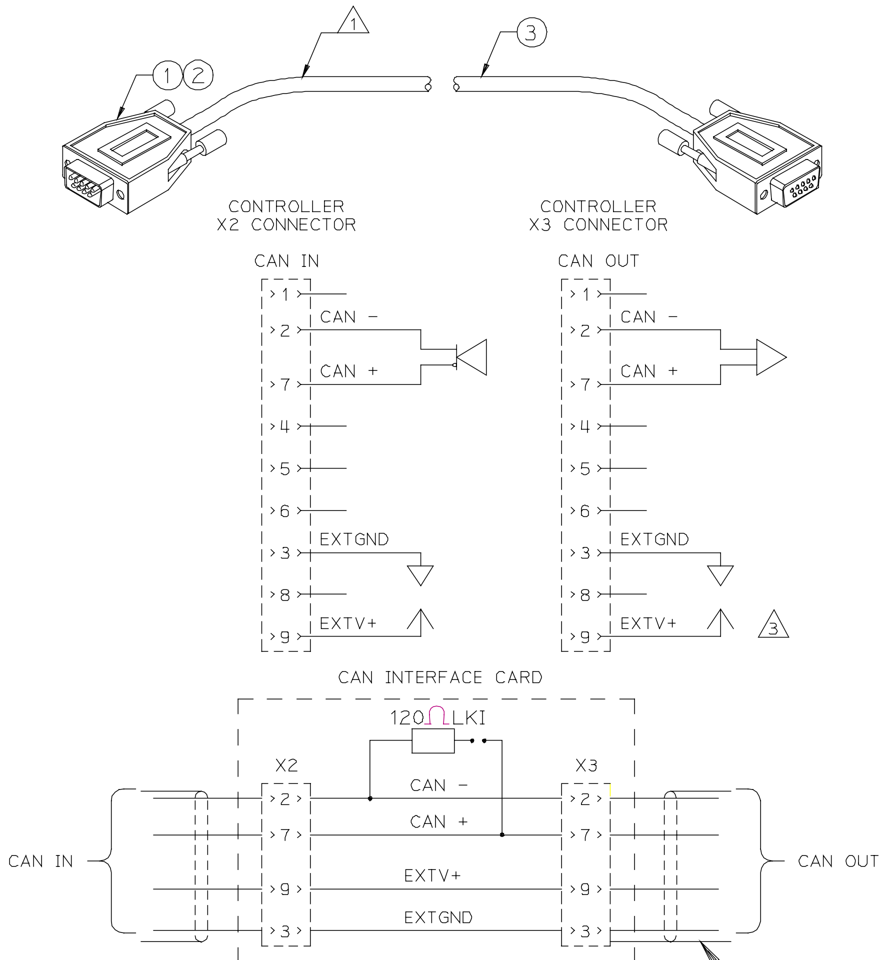
FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	C09906-005	CONNECTOR 5 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE 1	USER SPLY AR

FIGURE 2.28 Extended Inputs Bracket Cable



FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	B53998-007	CONNECTOR 7 P (SUPPLIED BY MOOG)	1
2	MAKE ITEM	CABLE 1	USER SPLY AR

FIGURE 2.29 Can Interface I/O Option Card Cable



NOTES:

1. CABLE LENGTH NOT TO EXCEED 40 METERS FOR 1MBAUD OPERATION. CABLE SHOULD NOT EXCEED 100 METERS FOR 500KBAUD OPERATION.
2. SHOULD BE CONNECTED AT ONE END ONLY.
3. VOLTAGE RANGE 7-13V DC.

FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	MAKE ITEM	CONNECTOR 9 WAY D TYPE MALE	USER SPLY
2	MAKE ITEM	CONNECTOR 9 WAY D TYPE FEMALE	USER SPLY
3	MAKE ITEM	CABLE BELDEN 9842	USER SPLY

FIGURE 2.30 X2/X3 Can Interface Option Card Serial Cable

2.10.9 MOTOR RESOLVER AND POWER CABLE

Use of the made-up cable sets is recommended for connecting the MOOG brushless servomotors. These cable sets are available in standardized lengths refer to TABLE 2-4 and TABLE 2-5 .
If MOOG cables are not used, the values specified below with regard to the cable make-up must be maintained **in all cases**. See TABLE 2-7 for assembly tooling, which might be required for the mating connector attachment.

Depending on location, there are two global sources for cables specified.

Europe and Asia
MOOG GmbH
Hanns-Klemm-Strasse 28
71034 Boeblingen
GERMANY
phone: +0049 - 7031 - 622 -0
fax: +0049 - 7031 - 622 - 100

America
MOOG.INC / NADO
Jamison Road
East Aurora, NY 14052
USA
phone: +001 - 716 - 652 - 2000
fax: +001 - 716 - 687 - 4870

2.10.9.1 MOTOR POWER CABLE

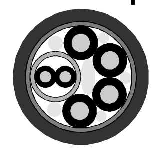
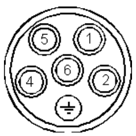
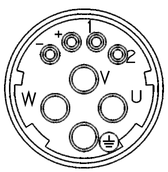
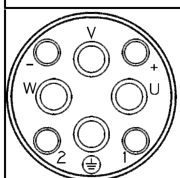
Wire the motor power connector in accordance with FIGURE 2.32.
Use wire sizes based on the motor's continuous stall current (r m s) and wire length requirements.
Wiring must be in accordance with standard EN 60204-1 (See section 2.9 and 2.9.1 of this Users Manual.
For proper drive commutation of G400 series motors, it is required that the motor phase conductors, Phase U (A), Phase V (B), and Phase W(C) be wired exactly as shown in TABLE 2-6

2.10.9.2 DRIVE J2 CABLE (RESOLVER CABLE)

NOTE
Avoid running this cable near other high power wiring.

Wire the motor resolver connector in accordance with FIGURE 2.31.

Pin assignment for Motor Power Cable and Mating Connectors

Pin Layout ④	Pin Connection	Motor Size	Part Number Power Cables Assembled	Part Number Mating Power Connector loose	Part Number Bare Power Cable	Cable Description 	Cable Specification
	1 Phase W 2 Phase U 4 Phase V 5 24V Brake + 6 24V Brake - ⏚ PE	G4x2 G4x3 G4x4	B47914-001-xxx ① C22294-001-xxx ②	A63472-001	B47890-001 ③	$4x1.5mm^2$ (AWG 16) Power Lead Wires $2 \times 1.0mm^2$ (AWG 17); Brake Wires twisted shielded pair; with overall shield	OD 12 mm (.472 in) Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 C to 90 C continuous operation
	U Phase U V Phase V W Phase W + 24V Brake + - 24V Brake - ⏚ PE	G4x5	B47915-001-xxx ① C22295-001-xxx ②	B47736-001	B47903-001 ③	$4x2.5mm^2$ (AWG 14) Power Lead Wires; $2x1.0mm^2$ (AWG 17) Brake Wires twisted shielded pair; with overall shield	OD 13 mm (.512 in) Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 C to 90 C continuous operation
	U Phase U V Phase V W Phase W + 24V Brake + - 24V Brake - ⏚ PE	G4x6	B47916-001-xxx ① C22296-001-xxx ②	B47711-001	B47904-001 ③	$4x\ 10mm^2$ (AWG 8) Power Lead Wires; $2x1.0mm^2$ (AWG 17) Brake Wires twisted shielded pair; with overall shield	OD 20.5 mm (.807 in) Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 C to 90 C continuous operation

① Partnumber for Europe and Asia Market
-xxx stands for cable length in meter
standard lengths are -010 (10 meters) and -020 (20 meters)

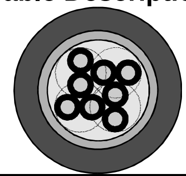
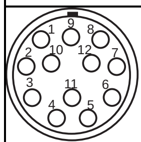
② Partnumber for US Market
-xxx stands for cable length in meter
standard length are -005; -010; -015; -020 (in meters)

③ Bare cable not available in US

④ Layout shows top view of Mating Connector

TABLE 2-4 Motor Power Cable

Pin assignment for Motor Signal (Resolver) Cable and Mating Connector

Pin Layout ④	Pin Connection	Motor Size	Part Number Power Cables Assembled	Part Number Mating Power Connector loose	Part Number Bare Power Cable	Cable Description 	Cable Specification
	1 S1 2 S3 3 S2 4 S4 5 NTC 6 NTC 7 R1 8 R2 9 - 12 n.c.	G4x2 G4x3 G4x4 G4x5 G4x6	B47886-002 xxx ① C22297-001-xxx ②	A63021-001	B47885-001 ③	4x2x0.25mm^2 (AWG24) 4 twisted pairs twisted with overall shield	OD 7 mm (.276 in) Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 C to 90 C continuous operation

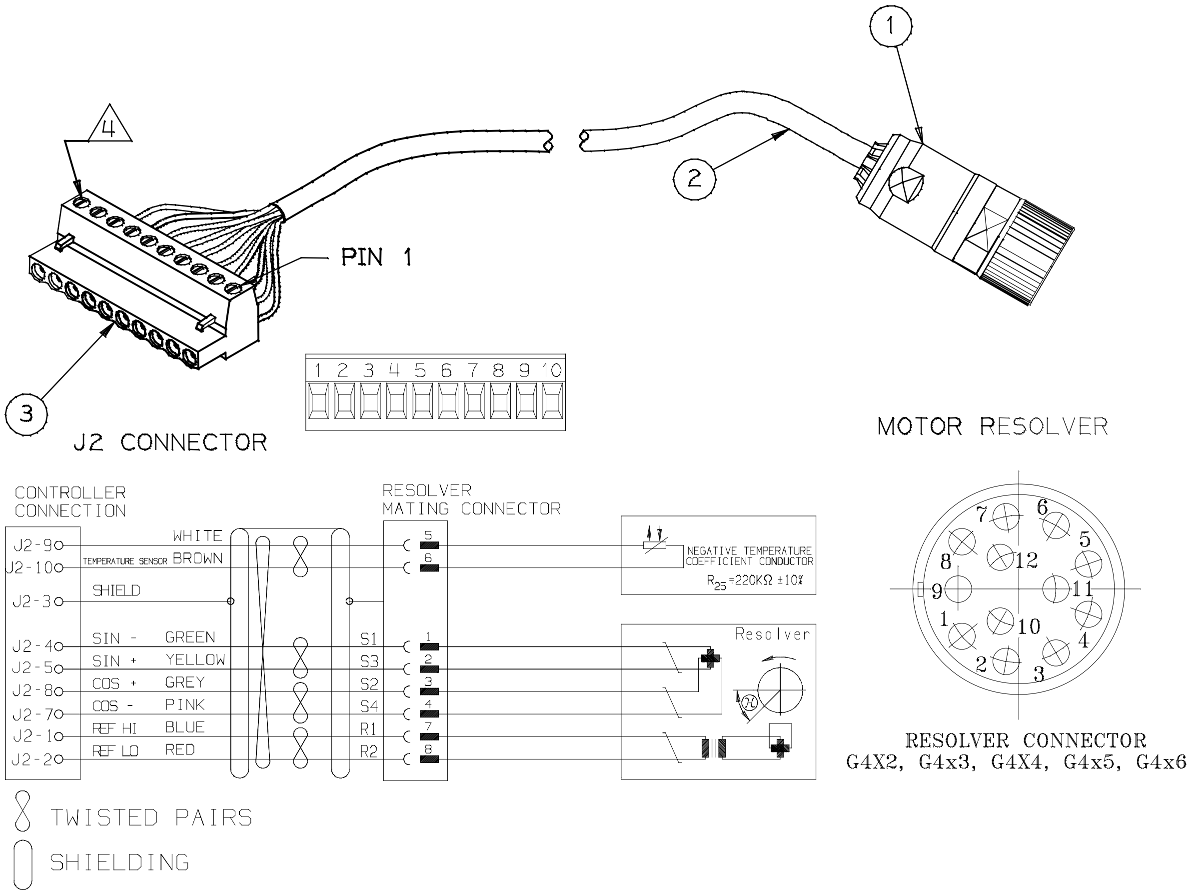
① Partnumber for Europe and Asia Market
-xxx stands for cable length in meter
standard lengths are -010 (10 meters) and -020 (20 meters)

② Partnumber for US Market
-xxx stands for cable length in meter
standard length are -005; -010; -015; -020 (in meters)

③ Bare cable not available in US

④ Layout shows top view of Mating Connector

TABLE 2-5 Motor Resolver Cable

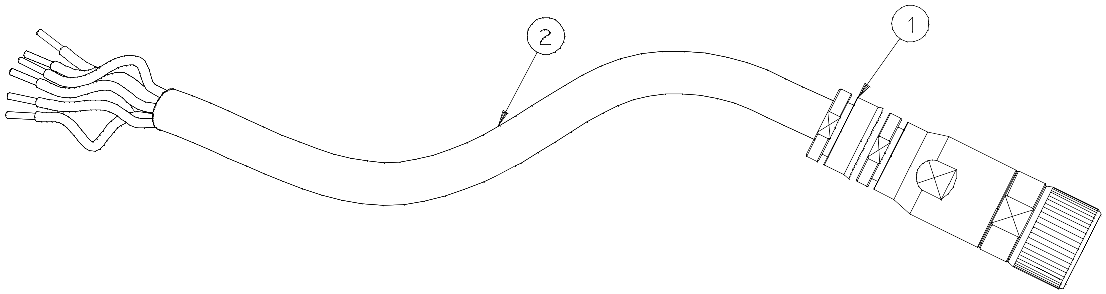


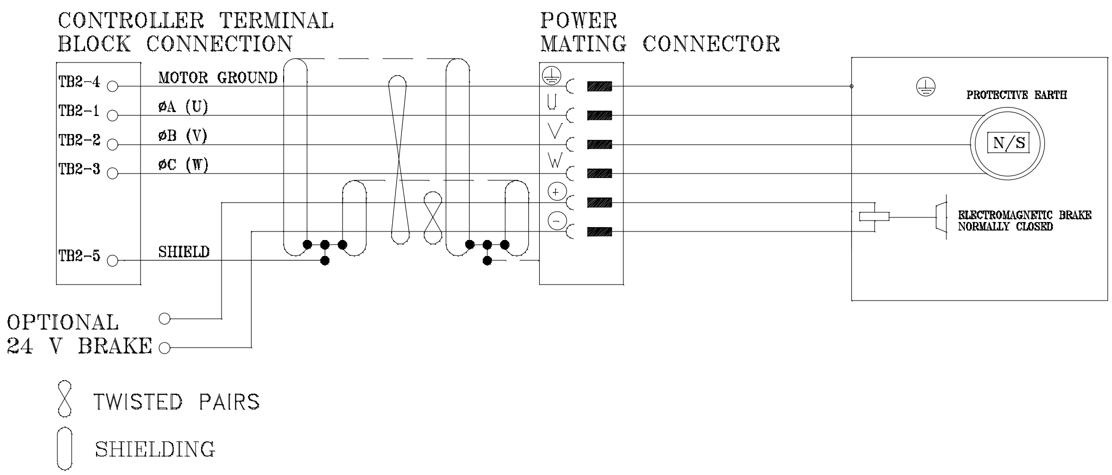
Find No.	MOOG Part No.	Description	Quantity
	B47886-002-xxx C22297-001-xxx ①	Complete Cable Assembly	1
1	A63021-001	Signal Mating Connector OD Cable 5,5 mm to 12 mm (.217 in to .472 in) Wire Gages 0,08 mm^2 to 0.82 mm^2 (AWG 28 to AWG 18)	1
2	B47885-001 ①	Bare Cable	1
3	B89518-010	Connector 10P (supplied by MOOG)	1

① Refer to TABLE 2-5 for detailed information

Notes:
1. Cable Length not to exceed 90 meter (300 ft.)
2. Recommended Terminal Screw torque 0.56 ± 0.06Nm (5.0 ± .5 in-lb)
3. For CE-Compliance Shield has to be attached on both sides.

FIGURE 2.31 Drive J2 (Resolver) Cable





POWER MATING CONNECTOR

	G4X2, G4X3, G4X4	G4X5	G4X6
⏚	⏚	⏚	⏚
U	2	U	U
V	4	V	V
W	1	W	W
⊕	5	+	+
⊖	6	–	–

FIGURE 2.32 Motor Power Cable

Find No.	MOOG Part No.			Description	Quantity
	G4x2/3/4	G4x5	G4x6		
	B47914-001-xxx C22294-001-xxx ①	B47915-001-xxx C22295-001-xxx ①	B47916-001-xxx C22296-001-xxx ①	Complete Power Cable Assembly	1
1	A63472-001 OD Cable 9-14.5 mm (.354 - .570 in) Power Wire Gage 0,14 mm^2 - 1.5 mm^2 (AWG 26 - AWG 16) Brake Wire Gage 0,14 mm^2 - 1.5 mm^2 (AWG 26 - AWG 16)	B47736-001 OD Cable 12-18,5 mm (.472 - .728 in) Power Wire Gage 1 mm^2 - 6 mm^2 (AWG 17 - AWG 10) Brake Wire Gage 0,3 mm^2 - 2 mm^2 (AWG 22 - AWG 14)	B47711-001 OD Cable 9-24 mm (.354 - .945 in) Power Wire Gage 1,5 mm^2 - 16 mm^2 (AWG 16 - AWG 6) Brake Wire Gage 1 mm^2 - 2.5 mm^2 (AWG 17 - AWG 14)	Power Mating Connector	1
2	B47890-001 ①	B47903-001 ①	B47904-001 ①	Bare Cable	1

① Refer TABLE 2-4 for detailed information

Notes:
1. Cable Length not to exceed 90 meter (300 ft.)
2. For CE-Compliance Shield has to be attached on both sides.

TABLE 2-6 Motor Power Cable Specifications

2.10.9.3 CRIMPING TOOLS FOR MOTOR CABLES

Even when Pins are soldered extracting tools might be necessary.

Mating Connector	crimping tool	positioner	inserting tool	extracting tool	additional information
G4X2/G4X3/G4X4					
Power Connection	B47918-001	B47918-005	no need	no need	Pins can
Resolver Connection	B47918-001	B47918-004	B47918-010	B47918-013	also be soldered
G4X5					
Power Connection					Pins can
Power Pins	B47918-002	B47918-008	no need	no need	also be
Brake Pins	B47918-001	B47918-004	B47918-010	B47918-013	soldered
Resolver Connection	B47918-001	B47918-004	B47918-010	B47918-013	
G4X6					
Power Connection					Pins can
Power Pins	B47918-002	B47918-006	no need	no need	also be
Brake Pins	B47918-002	B47918-003	no need	no need	soldered
Resolver Connection	B47918-001	B47918-004	B47918-010	B47918-013	

TABLE 2-7 Cable Assembly Tools

2.11 COMPONENT WIRING

The following sequence for wiring is a recommendation. Individual wiring steps are denoted by a box (❑), which can be used as an installation check off list.

The terminal block layout on all power supplies and drives has been designed to isolate low voltage from high voltage circuits. Cabinet wire ways should be arranged to maintain this physical separation. See sections 2.9, 2.9.1 and 2.9.2 of this Users Manual for safety and EMC requirements for cables.

CAUTION

Do not cable AC mains, +300 Vd.c. bus, or motor power wires with 24Vd.c.wires or other control wires. Maintain segregated cable routings.

The wiring steps discussed in this Section are shown schematically in FIGURE 2.2, FIGURE 2.3, FIGURE 2.4 and FIGURE 2.5, which include wire size information.

NOTE

Prior to installing pre-wired cables, each cable should be checked (rung through) using a volt ohm meter to insure proper wiring, continuity and no shorting.

2.11.1 TRANSFORMER WIRING

❑ Wire phases from the a.c. power input Line Filter to the mains isolation transformer primary.

2.11.2 MODEL T150-901 POWER SUPPLY WIRING

❑ Wire 380/400 V a.c., 3 Phase, mains to a user supplied power supply circuit breaker (supply disconnecting device). Make a secure and reliable connection between the chassis of the equipment and Earth.

❑ Wire 380/400 V a.c., 3 Phase, mains from the circuit breaker (supply disconnecting device) to a user supplied a.c. power Line Filter (Refer to section 2.3 of this Users Manual)

❑ Wire 380/400 V a.c., 3 Phase, mains from the a.c. power Line Filter to a user supplied mains isolation transformer (Refer to section 1.1.1 of this Users Manual)

❑ Wire 220 V a.c., 3 phase from transformer secondary to the input poles of a user supplied drive contactor. (Refer to section 2.4 of this Users Manual)

❑ Wire 220 V a.c., 3 phase from the drive contactor output poles to power supply terminals TB1-1, TB1-2, and TB1-3 (TB1-1 and TB1-2).

❑ Wire power supply terminal TB1-4 to chassis Earth tie point.

NOTE
All chassis earth wires from the power supply(s) and drive(s) must be individual wires terminated to a single earth tie point.

Perform the following two steps for 3 inch (76.2 mm) drives, Models T164-901 through T164-905 only.

❑ Wire d.c.+ from power supply terminal TB2-1 or TB2-2 to drive terminal TB2-8. (Note: for multiple 76.2 mm (3 inch) drives, Models T164-901 through T164-905 d.c.+ may be daisy chained from one 76.2 mm (3 inch) drive terminal TB2-9 to another 76.2 mm (3 inch) drive terminal TB2-8).

❑ Wire d.c.- from power supply terminal TB2-3 or TB2-4 to drive terminal TB2-6. (Note: for multiple 76.2 mm (3 inch) drives, Models T164-901 through T164-905 d.c. - may be daisy chained from one 76.2 mm (3 inch) drive terminal TB2-7 to another 76.2 mm (3 inch) drive terminal TB2-6).

Perform the following two steps for127 mm (5 inch)) drives, Models T164-9077 and T164-909 only.

- ❑ Wire d.c.+ from power supply terminal TB2-1 or TB2-2 to drive terminal TB2-7.
- ❑ Wire d.c. - from power supply terminal TB2-3 or TB2-4 to drive terminal TB2-6.

NOTE
Daisy chained d.c.+ and d.c.- wiring from a power supply to drives should be avoided if possible. When necessary, locate and wire highest current drives closest to the power supply.

- ❑ Attach the appropriate power supply Regen cable, (pre-wired per section 2.10.1).

2.11.3 DRIVE WIRING

Repeat steps in this Section for each drive in system.

- ❑ Plug in drive connector J1 Standard I/O cable, (pre-wired per section 2.10.2), and connect to user I/O equipment.
- ❑ Plug in drive connector J2 Resolver cable, (pre-wired per section 2.10.9.2).
- ❑ Plug in drive connector TB1 24 Vd.c. Logic Power cable, (pre-wired per section 2.10.4), and connect to user supplied 24 Vd.c. power supply.

Perform the following step only if using Encoder Simulation Option card.

- ❑ Plug in drive encoder simulation option card connector J4, Encoder Simulation cable, (pre-wired per section 2.10.5), and connect to user encoder input.

Perform the following step only if using Extended I/O Option card.

- ❑ Plug in drive extended I/O option card connector J5, Extended I/O Input cable, (pre-wired per section 2.10.6), and connect to user extended input/output circuitry.
- ❑ Connect motor power cable, (pre-wired per FIGURE 2.32 as appropriate, based on motor model series), motor phase A (U) to drive TB2-1, motor phase B (V) to drive TB2-2, motor phase C (W) to drive TB2-3, motor earth to drive TB2-4 and motor power cable shield to drive TB2-5.

❑ Connect a chassis earth wire from drive TB2-5 to chassis earth tie point

NOTE
All chassis earth wires from the power supply(s) and drive(s) must be individual wires terminated to a single earth tie point.

2.11.4 MOTOR WIRING

Repeat steps in this Section for each motor in the system.

❑ Plug and screw tight resolver cable to motor resolver connector.

❑ Plug and screw tight motor power cable to motor power connector.

Perform the following step only for motors with a static holding brake option.

❑ Connect brake leads to an external 24Vd.c. power source.
(Refer to FIGURE 2.32) .

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3. QUICK SETUP

WARNING

This equipment must be installed only by service persons technically qualified. All information in this manual is directed towards such persons only.

NOTE

This section is to be used as a general guideline only. It is Moog's understanding that only technically qualified personnel who have read and understood the previous sections of this manual are to use the following section.

3.1 WIRING

- ❑ Refer to Section 2 for safety and EMC installation requirements for cables and wiring.
- ❑ Wire the 24 Vd.c to the terminal TB1 as indicated in FIGURE 2.24.
- ❑ Wire resolver cable to J2 connector as indicated in FIGURE 2.31.
- ❑ Wire motor power cable as indicated in FIGURE 2.32
- ❑ Wire the T150-901 Power Supply as stated in section 2.5.2.
- ❑ If necessary wire the appropriate external regen resistor to the T150-901Power Supply, reference Section 2.7.
- ❑ Wire drive I/O to J1 connector as indicated in FIGURE 2.22.
- ❑ Apply power to the 24 Vd.c. logic (TB1) input.

NOTE

The "System Fault" LED will flash at a rate of 1 per second. This indicates the drive is waiting for initialization.

3.2 WINDRIVE STARTUP

This section assumes the following:

- ❑ WinDrive has been installed correctly. For instructions for this please consult Section 4.1 of the manual.
- ❑ The drive has been wired correctly and the 24Vd.c. logic supply has been applied.
- ❑ The SYSTEM FAULT LED should be flashing on and off at the rate of approximately one per second.
- ❑ The RS232 cable has been connected correctly.
- ❑ The RS232 mode jumper (W2) is set for the correct communications mode.

After completion of the following section consult Section 4 for details on tuning the drive and the use of the data logger for viewing signals.

NOTE

The procedures in sections 3.2 through 3.7.7 are written for use with:
WinDrive software version 1.4.4 dated 11/10/97
DMC firmware version H1 dated 12/20/96.
The user must consult Moog for updates to the procedure for drives with any other software or firmware version/date.

WARNING

A hardware enable/disable switch wired so that the motor can be stopped quickly in an emergency must be provided at all times. Software enable/disable commands do not meet safety requirements and should never be used instead of a hardware circuit.

NOTE

The installation and wiring described in Section 2 should be completed and verified before proceeding with drive initialization.

CAUTION

The T164 Series drive should not be enabled during a.c.. power up until the Power Supply Fault Output clears. The user must supply the logic to accomplish this interlock. Failure to delay enabling of the drives, or having any other external load on the T150-901 Power Supply, on a.c.. power up will defeat the proper operation of the soft start circuitry in the T150-901 Power Supply and can result in tripping of the a.c. input circuit breaker and/or damage to the T150-901 Power Supply.

3.3 OPENING THE PROGRAM

- ❑ From the Program Manager (WINDOWS 3.1) / Task Bar (WINDOWS 95) double click on theWinDrive icon.

FIGURE 3.1 WinDrive Icon

3.4 CONFIGURING THE COMMUNICATION PORT

- ❑ From the *Communication Port* dialog box select the PC communication port linked to the drive then click the **OK** button.

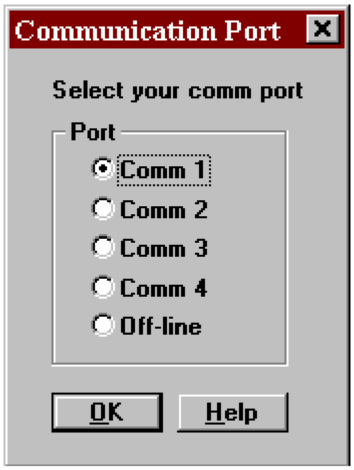

FIGURE 3.2 Communication Port Dialog Box

3.5 SELECTING COMMUNICATION PROTOCOL

- ❑ The drive must be configured to communicate with a PC using RS232 mode. The mode can be identified by the 3rd last digit of the model number of the drive. This digit will be a ***2*** if the drive is configured for RS232. Please consult the factory if it is necessary to change the configuration.

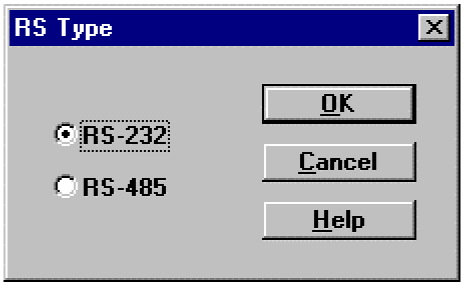

FIGURE 3.3 Communication Protocol Dialog Box

3.5.1 RS232 SETUP

- ❑ Check that the wiring of the RS232 cable as per specified in Section 2. Plug the cable into the correct Com port on the PC and into connector J3. Click on the RS232 button and then **OK**.

3.6 ENTERING THE PASSWORD

- ❑ Enter zero (0) for the password and click on OK to accept. The default value when the drive has been unconfigured is **0**. This can be changed after configuration, see Section 4 for details.

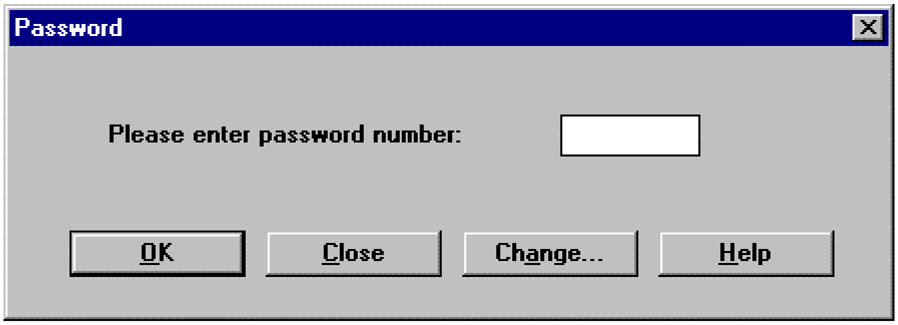

FIGURE 3.4 Password Dialog Box

- ❑ Click **OK** in the *Windows User Access Level dialog box*.

FIGURE 3.5 User Access Level Notification Dialog Box

3.7 CONFIGURING THE DRIVE

Select the **Basic Drive Setup** option from the **Drive** menu. The option will present the user with a series of dialog boxes which step through the basic configuration parameters needed to allow motion at the motor shaft.

NOTE
Prior to initial setup (sections 3.7.1 through 3.7.4) the drive should be disabled using one of the following: f4 key, disable button on the floating tool bar, or select disable from the drive menu.

3.7.1 MOTOR SELECTION

Within the *Select Motor* dialog box select the servo-motor as follows:

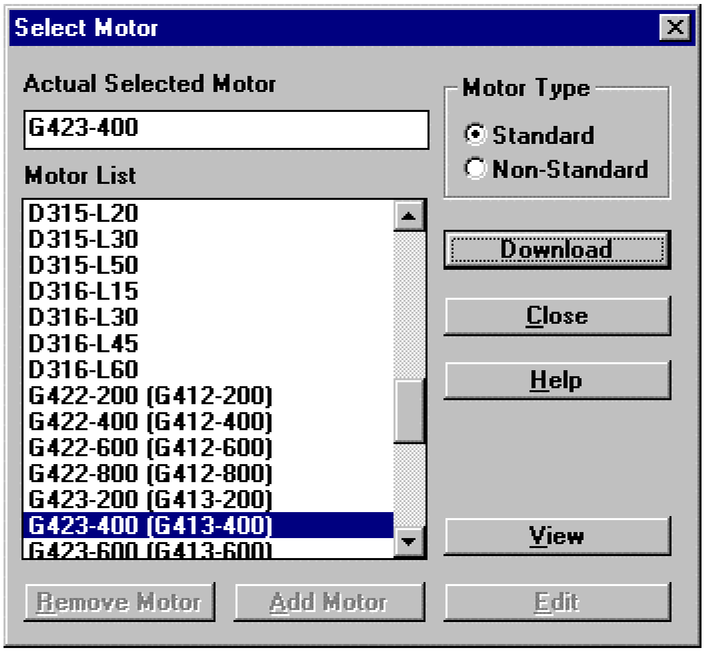

FIGURE 3.6 Select Motor Dialog Box

3.7.1.1 STANDARD MOTOR SELECTION

- ❑ Select Standard in the **Motor Type** section
- ❑ From the **Motor List** window select the Moog motor model number
- ❑ To view selected motor parameters select the **View** button.
- ❑ When the correct motor is chosen select the **Download** button.

3.7.2 REFERENCE SOURCE

Select one (1) reference source in the *Reference Source* dialog box from the following options:

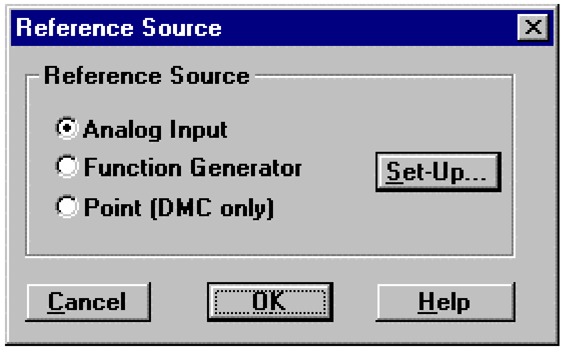

FIGURE 3.7 Reference Source Dialog Box

- ❑ **Analog Input**: This input is selected when the user is supplying a ±10 Vd.c reference. After **Analog Input** is selected press the Set-Up button to configure the analog input parameters in the *Analog Input* dialog box as follows:

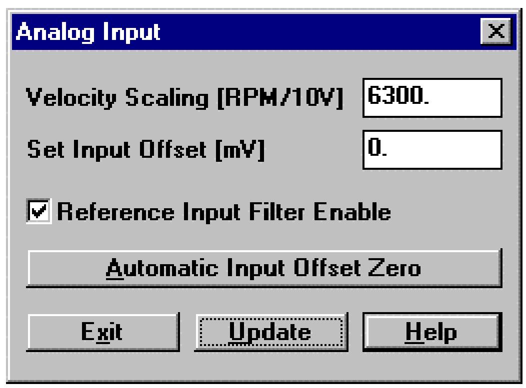

FIGURE 3.8 Analog Input Dialog Box

⇒ **Velocity Scaling**: Enter the maximum motor velocity (RPM) that will correspond to a 10V input signal.

⇒ **Set Input Offset** (mV): Enter the zero speed offset voltage if any. The Factory default is 0 mV.

⇒ **Reference Input Filter Enable**: Check this box to enable a software based filter that attenuates high frequency noise components in the reference signal.

⇒ **Automatic Input Offset Zero**: Select this button to automatically null the analog input when internal and external offsets are present in the system with the reference set to zero (0).

⇒ **Update**: Select the update button to store the settings in memory.

⇒ **Exit**: Select the **Exit** button to return to the *Reference Source* dialog box.

❑ **Function Generator**: Select this reference source to use the software based function generator for drive tuning. After Function Generator is selected press the **Set-Up** button to configure the input parameters in the *Function Generator* dialog box as follows:

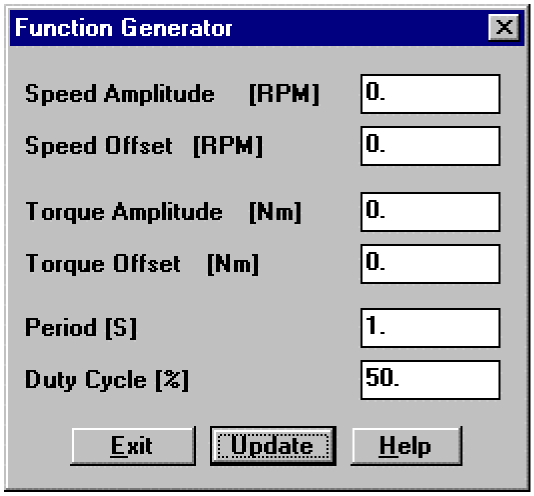

FIGURE 3.9 Function Generator Dialog Box

⇒ **Speed Amplitude** (RPM): Set the motor velocity in RPM. For tuning a value equal to 10% of the rated motor RPM should be used.

⇒ **Speed Offset** (RPM): This value, in RPM, is added to the Speed Amplitude for one direction of rotation and subtracted from the other. A factory default value of 0 results in equal movement of the motor shaft in both directions.

⇒ **Torque Amplitude**: Set the required motor torque.

NOTE
DO NOT EXCEED THE RATED MOTOR TORQUE.

⇒ **Torque Offset:** This value sets the torque bias in Nm for the motor in both directions of rotation.

⇒ **Period:** Enter the time, in seconds, for one cycle of motor operation.

⇒ **Duty Cycle:** This value determines what percentage of the Period the Velocity or Torque Amplitude is positive. The remaining portion of the period the amplitude is negative. For tuning a duty cycle of 50% should be entered to produce equal clockwise and counter-clockwise shaft rotation.

❑ **Point:** If the DMC drive contains a Point card the user may select this as the reference source. To program the Point control see the ***Point Users Manual***, Part # C05100.

3.7.3 SETTING TORQUE AND VELOCITY LIMITS

Setup the system torque and velocity limits as follows:

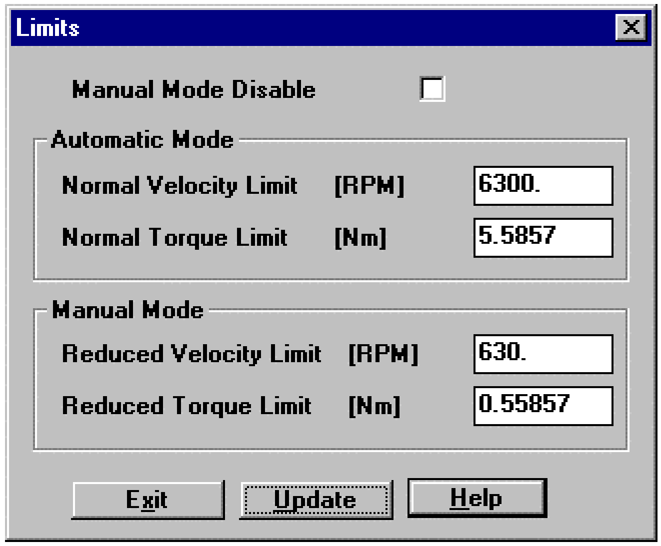

FIGURE 3.10 Limits Dialog Box

- **Manual Mode Disable**: Check this box to disable **Manual Mode** limits. The drive will then run using the values in the **Automatic Mode** section.

- **Automatic Mode**: Normal operating mode limit values.

  ⇒ **Normal Velocity Limit**: Enter maximum allowed motor speed (RPM) in normal operation. The default value is the same as the **Nominal Speed** value in the *Standard/Non-Standard Motor Parameters* dialog box (see section 3.7.1)

  ⇒ **Normal Torque Limit**: Enter maximum allowed motor torque (NM) in normal operation. The default value is approximately ten (10) times the **Torque Constant** value in the *Standard/Non-Standard Motor Parameters* dialog box (see section 3.7.1)

- **Manual Mode**: Reduced operating limits. These limits are **not functional** on a DMC drive unless an extended I/O card or a extra inputs bracket is installed.

  ⇒ **Reduced Velocity Limit**: Enter a reduced motor speed limit to ensure proper tuning and safe system operation.

  ⇒ **Reduced Torque Limit**: Enter a reduced motor torque limit to ensure proper tuning and safe system operation.

3.7.4 LIMIT SWITCHES

If the drive system has limits switches connected configure them as follows:

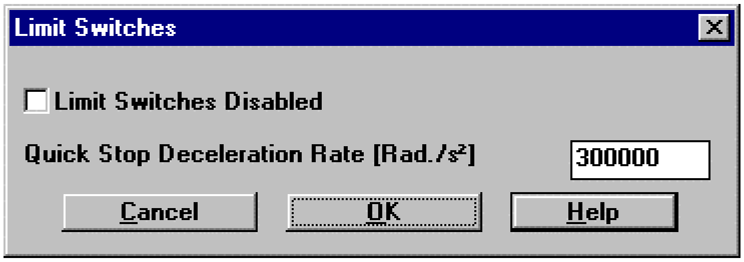

FIGURE 3.11 Limit Switches Dialog Box

- **Limit Switches Disabled**: Check box to disable limit switch inputs.
- **Quick Stop Deceleration Rate**: If limit switch inputs are enabled this variable determines the rate at which the drive decelerates the motor after a limit switch is tripped.

3.7.5 TUNING

In the Tuning dialog box select **Torque** or **Velocity Mode** based on the systems operating mode. Based on your selection go to the corresponding tuning mode section below.

3.7.5.1 BASIC VELOCITY TUNING MODE

This section provides a recommended velocity mode standard tuning procedure for use with WinDrive. The procedure should be followed in the sequence listed below:

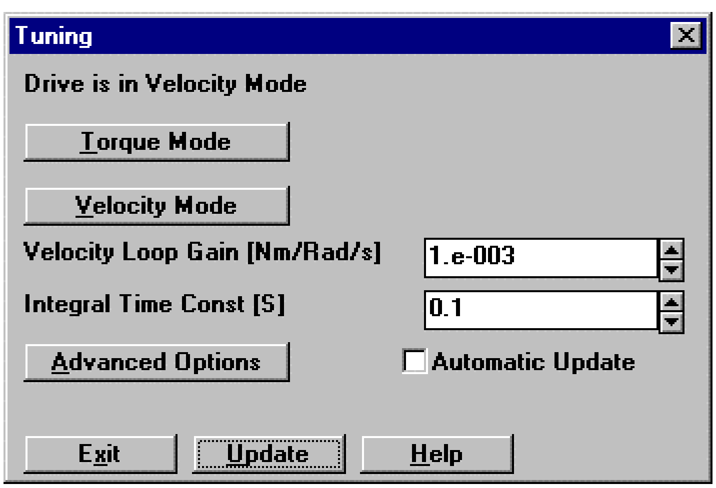

FIGURE 3.12 Tuning Dialog Box

WARNING

The motor should be uncoupled if incorrect movements during the drive tuning procedure can damage the machine. If this is not possible, the safety limit switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.

- ❑ Disable the drive, using the hardware enable switch.
- ❑ Confirm that the message "Drive is in Velocity Mode" is displayed at the top of the *Tuning* dialog box (FIGURE 3.12). If it is not select the **Velocity Mode** button and reconfirm message.
- ❑ Confirm that the drive velocity and torque limits ARE SET TO 10% OF NORMAL SYSTEM LIMITS (see section 3.7.3).

WARNING

During tuning set the drive to 10% of rated torque and speed via manual mode or by altering automatic mode parameters. Failure to do so might result in machine damage and/or personal injury.

- ❑ Apply a low frequency squarewave reference source. This source can be supplied from an external source or by the internal software Function Generator (see section 3.7.2). Set the command reference source to 10% of the rated motor rpm, 0 rpm offset, 1 second period, and 50% duty cycle.

WARNING

Insure that the application allows using this speed amplitude and length of travel, (period, duty cycle), without damage to the machine before proceeding with the tuning procedure.

- ❑ Configure WinDrive so that the torque demand variable, IDC.CurrentMonitor, is monitored in one of the two Data Logger Channels (see section 4.1.9.1) or at one of the Front Panel Test points (see section 4.1.9.5) via an oscilloscope. This signal must not saturate during motor acceleration/deceleration (i.e. must be less then 1 Vd.c.). If the signal saturates then the Function Generator setup (see section 3.7.2) must be altered or the Drive Torque Limit increased (see section 3.7.3) until saturation does not occur.

- ❑ Configure WinDrive so that the actual velocity variable, ACTUAL.VELOCITY, is monitored in the second Data Logger Channel (see section 4.1.9.1) or at the second Front Panel Test Point (see section 4.1.9.5).

- ❑ Set the **Integral Time Constant** (I) in the *Tuning* dialog box to 3 seconds.

- ❑ Enable the drive: Hardware enable first using the External Enable input, then software enable using the F3 Key, Enable button on floating tool bar, or **Enable Controller** option in the **Drive** menu.

- ❑ Check the **Automatic Update** box in the *Tuning* dialog box to force changes made to P or I to be immediately sent to the drive.

- ❑ Place the cursor in the **Velocity Loop Gain** field (P) and use either the up arrow at the right end of the field or the up arrow keyboard key to increase the P gain until the motor shaft begins turning.

- ❑ Continue increasing the Velocity Loop Gain (P) while monitoring the Actual Velocity on the Data logger Plot or via an oscilloscope. Increase P until a slight overshoot occurs in the velocity response, as seen in FIGURE 3.13A.

- ❑ Decrease the Velocity Loop Gain (P) by using the down arrow at the right end of the field or the down arrow keyboard key. Decrease P until the overshoot just disappears (see FIGURE 3.13C).

- ❑ Place the cursor in the **Integral Time Const** field (I) while still monitoring the Actual Velocity. Decrease I using the down arrow or the down key until a slight overshoot occurs in the velocity response again.

- ❑ Place the cursor back in the Velocity Loop Gain (P) field and increase the value until the slope of the step response is similar to that in FIGURE 3.13D.

- ❑ For **Advanced Velocity Mode** tuning options see section 4.1.13.6.

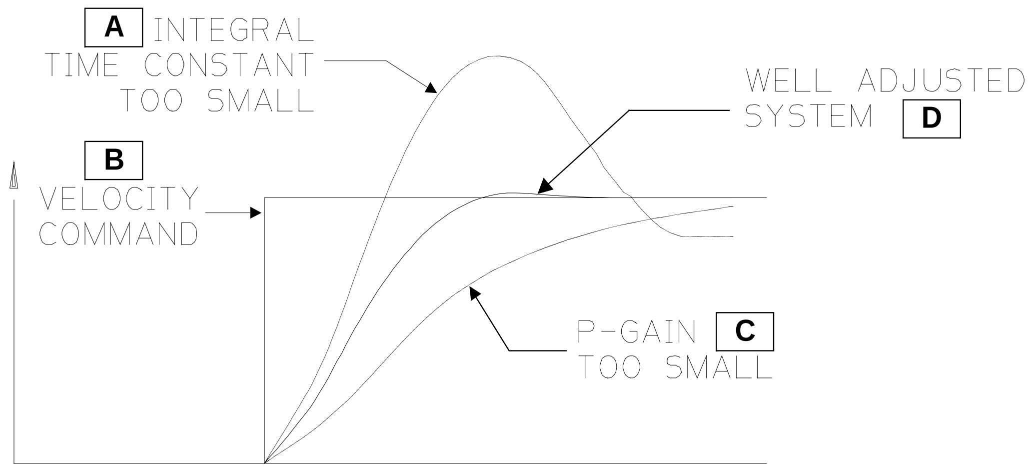

FIGURE 3.13 Velocity Mode Tuning Waveforms

> **Note**
> *If the Function Generator along with the Data Logger are used for tuning the user may choose to utilize the* Combined Tuning *dialog box via the* ***Setup*** *option in the* ***Drive*** *menu. This box contains both the Data Logger Control Panel and the Function Generator to simplify the user interface.*

3.7.6 ENCODER SIMULATION

An optional Encoder Simulation Card may be set up using the *Encoder Simulation Card 2* dialog box. Open this dialog box via the **Encoder** button in the Main Window Button Console (FIGURE 4.11) or by selecting **Encoder** under the **Setup** option of the **Drive** menu.

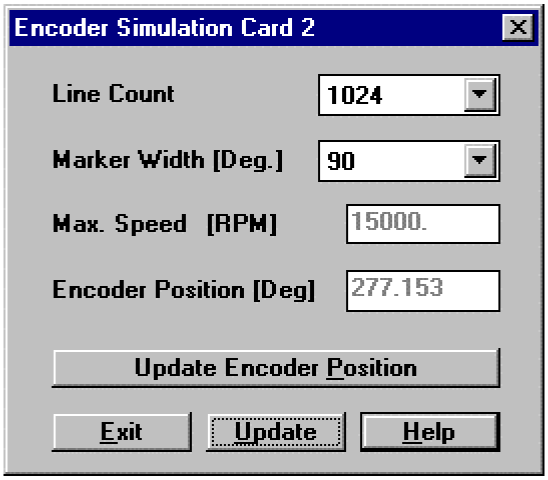

FIGURE 3.14 Encoder Simulation Card 2 Dialog Box

Configure the Encoder Simulation card (ESM) using the dialog box as follows:

- ❑ Choose the incremental **Line Count** from the pull down list via the arrow at the end of the **Line Count** window. (Discrete range: 128 - 16384)
- ❑ Select a **Marker Width** from the pull down list at the field end. The width choices are 90°, 180°, 360°. Factory default is 90°. See FIGURE 5.21.
- ❑ The **Max Speed** is determined in software and displayed. This field is not accessible by the user.
- ❑ The **Encoder Position** is determined from the system and can be updated using the **Update Encoder Position** button. This field is not accessible by the user.
- ❑ After configuration of the ESM card is complete select the **Update** button to save the configuration.
- ❑ Select **Exit** to close the dialog box.

3.7.7 SAVE TO EEPROM

Use this function to write the fully configured drive parameters to the drives' non-volatile EEPROM memory.

Follow these steps to **Save To EEPROM**:

- ❑ Select **Save To EEPROM** from the **File** menu.
- ❑ Select **Save** in the *Save To EEPROM* dialog box.

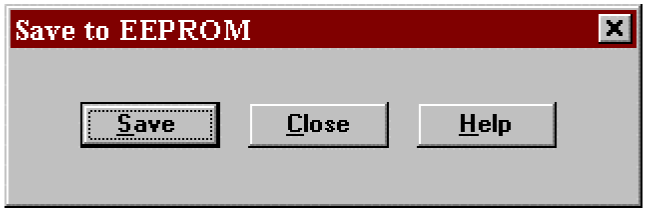

FIGURE 3.15 Save to EEPROM Dialog Box

❑ Wait for the Successfully saved to EEPROM! notice in the *Moog WinDrive for Windows* dialog box (FIGURE 3.16). Select **OK.**

FIGURE 3.16 Successfully Saved To EEPROM Notice

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4. CONFIGURATION AND TUNING

Within this section there are three (3) main subsections. The first two (2) subsections are for use with H1 firmware, the final subsection (4.3) contains instructions for C4 firmware.
To determine the firmware version in your drive review the nameplate model number as shown below:

T164-9XX X - XX - XX - X - XX

Two (2) character firmware version.
ie: H1.

4.1 WINDRIVE COMMUNICATIONS WITH H1 FIRMWARE

This section is intended to give the user a full understanding of programming a T164 DMC containing H1 firmware while using the WinDrive program.

4.1.1 SOFTWARE SETUP

4.1.1.1 MINIMUM SYSTEM REQUIREMENTS

- ❑ IBM compatible PC with:
  - ⇒ 386 or higher processor running MS Windows 3.1(1) with 4MB RAM, and 3MB of free hard disk space.
  - ⇒ 486 or higher processor running MS Windows 95 with 16MB RAM, and 3MB of free hard disk space.
- ❑ VGA display with a resolution of at least 640 x 480 pixels.
- ❑ A Moog WinDrive System Disk

An RS232 Communication Interface Cable.

4.1.1.2 INSTALLATION

To install the WinDrive software, place the WinDrive disk in drive A:

Windows 3.1(1): From the program manager File menu select Run. In the Run program dialog box type A:\Setup
Press Return.

Windows 95: From the Start menu select Run. In the Run dialog box type
A:\Setup
Press Return

When the installation is complete, a WinDrive Group should be created in the Program Manager(W3.11)/Task Bar (W95). Within the group, a WinDrive Program Icon and a WinDrive Help Icon and a Textfile Icon (readme.txt) should be visible. The Help system can be started from the Program Manager by double clicking on the Help Icon or from within WinDrive, using the **F1** key, **Help Menu** or **Help** buttons. If the setup procedure fails (an error message will be given), the icons are not created, or the software fails to run, the disks may be damaged. In this case a Moog Field Service Representative should be contacted.
The text file "Readme.txt" describes the operation of the setup file.

4.1.2 COMMUNICATION HARDWARE SETUP

Use an RS232 serial cable. Before a drive can be configured the hardware should be setup as outlined below:

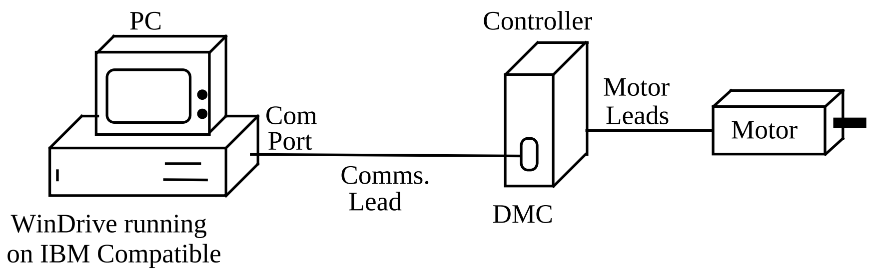


FIGURE 4.1 System Hardware Setup

4.1.2.1 RS232 COMMUNICATION MODE JUMPER SETUP

Set the drives RS communication mode position jumper W2 for RS232:
See Figure 5.4 for jumper location. (The **Factory Default** is RS232, jumper pins 1-2)

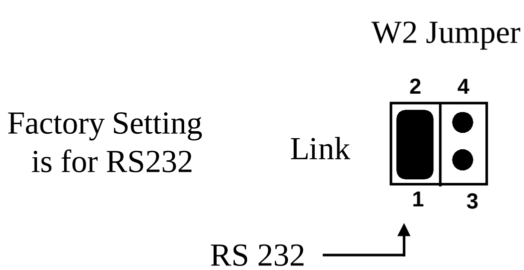


FIGURE 4.2 Position of Links for RS232 Communication

4.1.2.2 RS232 SETUP

In order for the PC to communicate with the drive in RS232 mode proceed as follows:

- ❑ Connect an RS232 cable wired as shown in FIGURE 2.23. The cable is connected from one of the communications ports of the PC to the serial port of the drive.

- [ ] Configure the W2 jumper for RS232 communications as shown in section 4.1.2.1.

4.1.3 WINDRIVE STARTUP

NOTE

The procedures in sections 4.1 through 4.1.18 are written for use with:

- *WinDrive software version 1.4.4 dated 11/10/97*
- *DMC firmware version H1 dated 12/20/96*

The user must consult Moog for updates to the procedure for drives with any other software or firmware version/date.

WARNING

A hardware enable/disable switch wired so that the motor can be stopped quickly in a emergency must be provided at all times. Software enable/disable commands do not meet safety requirements and should never be used in lieu of a hardware circuit.

NOTE

The installation and wiring described in Section 2 should be completed and verified before proceeding with drive initialization.

CAUTION

The T164 Series drive should not be enabled during a.c. power up until the Power Supply Fault Output clears. The user must supply the logic to accomplish this interlock. Failure to delay enabling of the drives, or having any other external load on the T150-901 Power Supply, on a.c. power up will defeat the proper operation of the soft start circuitry in the T150-901 Power Supply and can result in tripping of the a.c. input circuit breaker and/or damage to the T150-901 Power Supply.

When the system is set up correctly as outlined in the previous section, WinDrive is run by double clicking the WinDrive icon. The first window to appear will be the *Communication Port* dialog Box which allows a user to select a PC communication port.

4.1.3.1 OPENING THE PROGRAM

From the Program Manager (WINDOWS 3.1) / Task Bar (WINDOWS 95) double click on the WinDrive icon.

FIGURE 4.3 WinDrive Icon

4.1.3.2 ON-LINE MODE

On-line Mode is when the PC communications port is connected via RS232 to a powered drive.
In order to run in ON-LINE mode proceed as follows:

- ❑ From the *Communication Port* dialog box select the PC communication port linked to the drive then click the **OK** button.

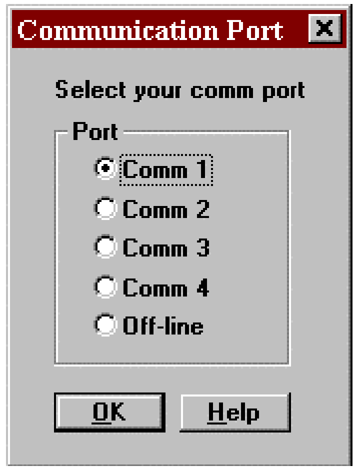


FIGURE 4.4 Communication Port Dialog Box

- ❑ From the *RS Type* dialog box select RS232 serial communications mode then click the OK button.

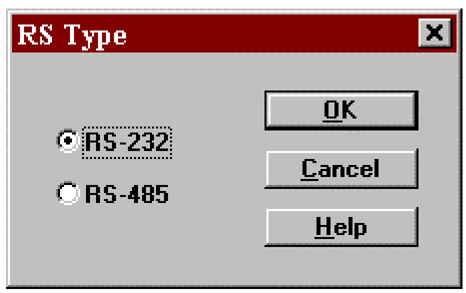


FIGURE 4.5 RS Type Dialog Box

NOTE
RS485 communications is not supported for the T164 drive.

❑ Enter the drive password number (Range: 1-9999). The factory default is 0. Click the **OK** button.

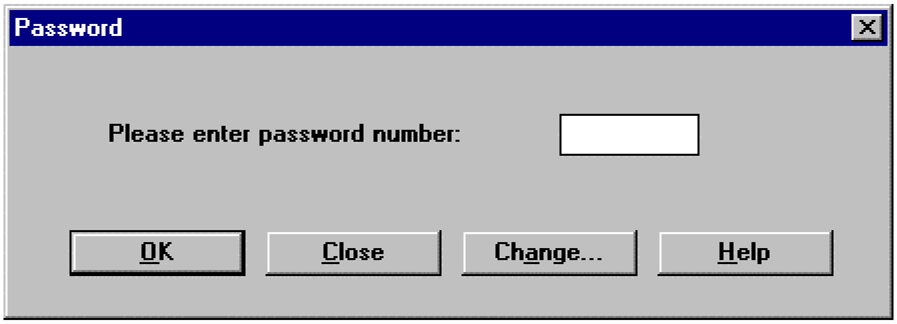


FIGURE 4.6 Password Dialog Box

❑ Click **OK** in the *Windows User Access Level dialog box*.

FIGURE 4.7 User Access Level Notification Dialog Box

4.1.3.3 OFF-LINE MODE

Off-line Mode is activated when the PC communications port is not connected to a drive, the drive is not powered on, or the user has selected **Off-line** in the *Communications Port* dialog box (FIGURE 4.4).
In order to run in OFF-LINE mode proceed as follows:

❑ Select OFF-LINE mode from the *Communication Port* dialog box (FIGURE 4.4). Then click the **OK** button.

❑ Select control type (RMC,DMC) from the *Drive Type (offline)* dialog box. Then click the **OK** button.

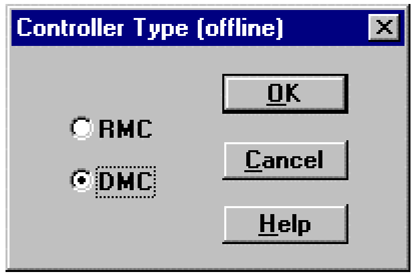


FIGURE 4.8 Drive Type (offline) Dialog Box

NOTE
Items in the various menu bars within WinDrive become "ghosted" when not applicable to the selected drive.

4.1.4 DIALOG BOX BUTTON FUNCTIONS

The select buttons within the WinDrive dialog boxes function as follows:

- **Update**: Immediately sends the input information to the drives RAM. Active dialog box remains open.
- **OK**: Immediately sends the input information to the drives RAM and closes the active dialog box.
- **Download**: Immediately sends the input information to the drives RAM. Active dialog box remains open.
- **Exit**: Closes the active dialog box without saving data.
- **Close**: Exits the active dialog box without saving data.
- **Cancel**: Closes the active dialog box without saving data.
- **Save**: Stores the configuration data to the drives EEPROM.

4.1.5 ON-LINE HELP

Help screens are available for all of the WinDrive functions.

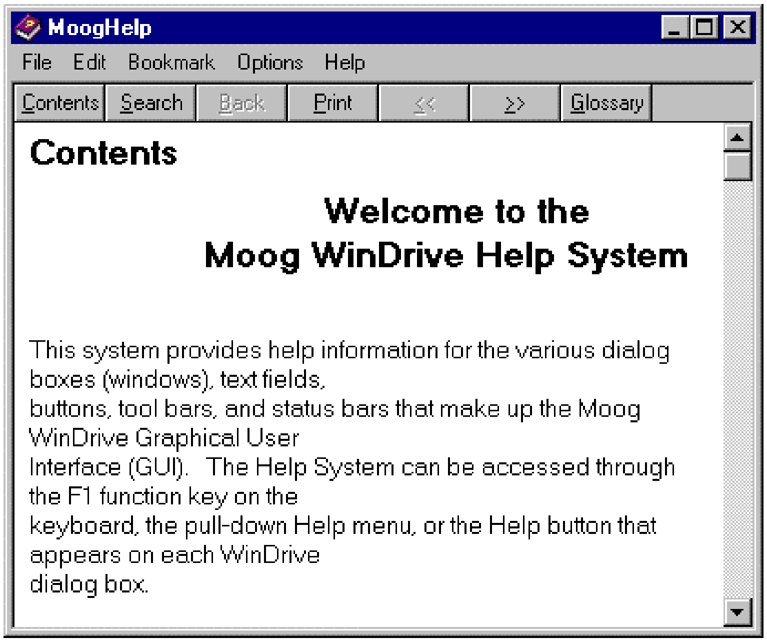


FIGURE 4.9 MoogHelp Dialog Box

4.1.5.1 ACCESSING ON-LINE HELP

On-Line Help may be accessed by using any of the following:

- ❑ Choose the **Contents** option from the **Help** menu.
- ❑ Press the F1 key while in the WinDrive program.
- ❑ Press the HELP button while any dialog box.

4.1.5.2 SEARCHING FOR A HELP TOPIC

- ❑ In the *MoogHelp* dialog box select the **SEARCH** button. From the *Help Topics: Moog Help* dialog box (FIGURE 4.10) enter or select (By double clicking on one of the subjects in the lower portion of the screen) the topic you are searching for.

- ❑ From within MoogHelp click on any highlighted/underlined word to be transferred to the corresponding help topic (NOTE: The mouse pointer becomes a hand when at a Help Link).

FIGURE 4.10 Help Topics: MoogHelp Dialog Box

4.1.6 MAIN WINDOW - FEATURES

The WinDrive Main Window provides a Graphical User Interface (GUI) to setup and monitor the system drive/s.

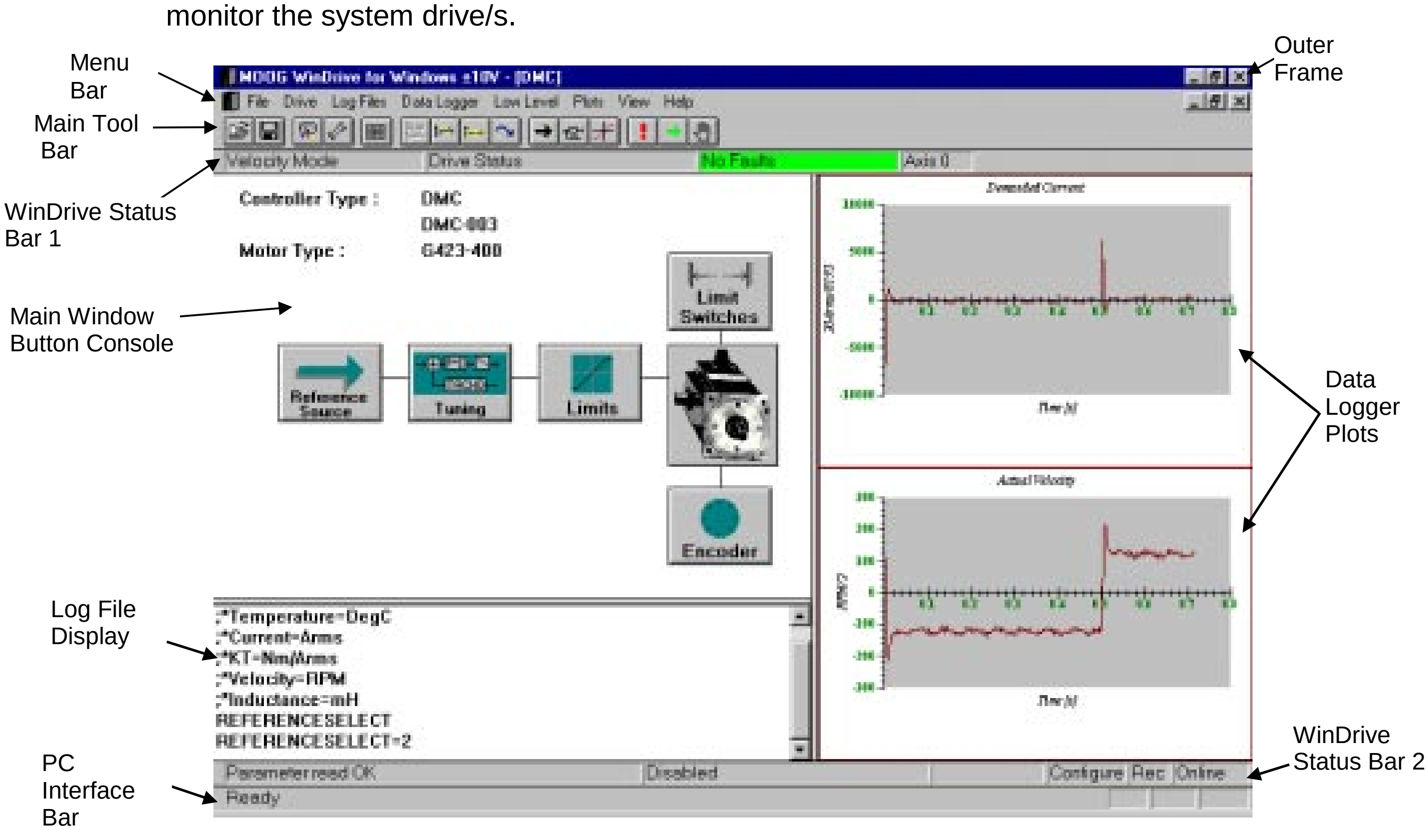


FIGURE 4.11 WinDrive Main Screen

4.1.6.1 WINDOW LAYOUT

- ❑ Outer Frame - Standard Microsoft Windows Frame with minimize/maximize and exit Icons.
- ❑ Menu Bar - Pull-down menus to access all WinDrive features.
- ❑ Main Tool Bar - Icon buttons for various functions and commands.
- ❑ WinDrive Status Bar 1 - Compensator Mode/Drive Status/Fault Status/Axis ID #.
- ❑ Main Window Button Console - Six buttons to access the primary Configure/Tune Dialog Boxes.
- ❑ Data Logger Plots - Contains the output of one/two data logging channels for drive parameters.
- ❑ Log File Display - Displays Log File contents of a recording or previously recorded Log.
- ❑ WinDrive Status Bar 2 -Displays status of : Read -Write parameter/Drive State/Limit Switches/GUI Mode/Logging/ Communications.
- ❑ PC Interface Bar - Tool Bar Help/Caps Lock/Num. Lock/Scroll Lock
- ❑ Floating Toolbar - Quick Stop/Enable Drive/Disable Drive buttons.

NOTE

The Main Window Button Console, Log File Display, and Data Logger Plots are broken into a three way split-window. The mouse cursor converts to a vertical or horizontal resize cursor while over top of a divider line. To resize one of the windows hold down the left mouse button while over top of the windows divider line and move the mouse .

4.1.7 ACCESSING FUNCTIONS

4.1.7.1 MENU BAR

4.1.7.1.1 FILE MENU OPTIONS

- ❑ **Open** - Opens a previously saved log (file extension *.log) or data logger (file extension *.mdl) file.
- ❑ **Save** - Saves the current data logger or log file data to disk for future use.
- ❑ **Print Plots** - Three (3) options are available from the Print Plots option:
  - ⇒ **Print Graph** - Prints the selected plot
  - ⇒ **Print Page** - Prints plots for both datalogger channels

⇒ **Print Options** - Parameters for plot printing may be changed here.

- ❑ **Print Logfile** - Prints the current logfile.
- ❑ **Print Setup** - Printer and printing options are configured using Printer Setup.
- ❑ **Save to EEPROM** - Saves the current drive configuration to the non-volatile EEPROM.
- ❑ **Configuration Upload** - Transfers the drive parameters listed in the *.cfg file from the drive to a specified log file.
- ❑ **Configuration Download** - Transfers parameters stored in a *.log file to the drive.
- ❑ **Passwords** - Allows the setup and changing of drive access passwords.
- ❑ **Exit** - Exits the WinDrive system.

4.1.7.1.2 DRIVE MENU OPTIONS

- ❑ **Setup** – Ten (10) choices are available from the **Setup** option:

⇒ **Reference Source** - Sets the reference source for the drive.

⇒ **Tuning** - Adjusts the drive tuning parameters .

⇒ **Limits** - Set and adjust torque and velocity limits.

⇒ **Motor** - Motor parameters are entered using this option. For standard Moog motors, parameters are selected automatically from a motor parameter database. For non-standard motors, all parameters must be entered by the user.

⇒ **Limit Switches** - Limit Switches may be enabled or disabled using this option and the quick stop deceleration entered or adjusted.

⇒ **Encoder** - Encoder Input parameters are set by the user with this option.

⇒ **Front Panel Test Points** - Two user configurable test points are available on the front lexan of the drive. The Front Panel Test Points option determines the output signal type at each test point.

⇒ **Advanced Options** - Allows 1st Order or 2nd Order low pass filter on Velocity Loop Gain term. Also allows the user to tune the velocity observer.

⇒ **IT Thermal Limits** - Sets and adjusts the IT (current/time) thermal limits. If thermal foldback is being used, this option will be ghosted i.e. if the motor configured is a G41X or D31X series motor.

⇒ **Combined Tuning** - This option provides the user with the tuning, reference and data logger dialog boxes sized correctly to fit on the main window with the plots.

- ❑ **Basic Drive Setup** - A basic drive set up is the fastest means of manually tuning and configuring a drive. All parameters essential for the basic setup are set by the user.

- ❑ **Quick Stop** - Performing the same function as the **F2** key or the **Stop** button of the Floating Toolbar, this function performs a servo-stop on the connected motor.

- ❑ **Enable Drive** - This function enables the drive to switch power to the connected motor. Also available by pressing **F3**, pressing the **Enable** button on the Floating Toolbar and from the **Drive Menu**.

- ❑ **Disable Drive** - The disable function removes power from the motor. Also available from the Floating Toolbar or by pressing **F4**.

- ❑ **Broadcast (RS485 only)** - NOT SUPPORTED FOR T164 DRIVE.

- ❑ **Select Axis (RS485 only)** - NOT SUPPORTED FOR T164 DRIVE.

- ❑ **Drive Status** - Drive Status provides a table of current drive and motor information.

- ❑ **Extended Function Cards** - Extended Function Cards displays which option cards have been detected by the WinDrive software.

- ❑ **Apply Brake** - Applies the optional motor brake.

- ❑ **Release Brake** - Releases the optional motor brake.

- ❑ **Units** - The units in which WinDrive displays temperature, torque, current, torque constant, velocity and inductance may be changed with this option.

4.1.7.1.3 LOG FILES MENU OPTIONS

- ❑ **Start Record** - In order to begin writing a logfile, the Start Record option is selected. The log file window is automatically updated as new parameters and commands are entered. Current units are written to the window as soon as **Record** is selected.

- ❑ **Stop Record** - On completion of log file recording, Stop Record is selected.

- ❑ **Clear Record** - Clear record is used to erase the Log File Display Window. A **Save** option is displayed before the current log file is cleared.

- ❑ **Logfile Player** - The log file player sends log files to the drive memory. Log files may be played as a continuous stream of commands or in a string, stepped through line by line.

4.1.7.1.4 DATA LOGGER MENU OPTIONS

- ❑ **Control Panel** - The Data Logger Control Panel shows the current status of both data logging channels and provides access to the **Go** command which begins the logging of data.
- ❑ **Set Up** - Data logger parameters are entered in this dialog box.
- ❑ **Data Trigger** - Opens dialog box in which the user chooses a system variable to be the data logger trigger.

4.1.7.1.5 LOW LEVEL MENU OPTIONS

- ❑ **EUI Input** - The EUI, or Engineering User Interface, provides access to individual drive parameters, which, depending on user access level, may be read from or written to the drive.
- ❑ **Block Data** - Information on the motor type and the drive model, firmware version number and firmware version release date.
- ❑ **Manual Block Save to File**- This dialog box allows the transfer of block data from a file to the drive and alternatively from the drive to a file.
- ❑ **Set Offline** - If working with a connected, powered drive and the user wishes to operate off line, this option should be selected.
- ❑ **Reset Comm.** - Reset Comm. is used if switching communications ports or switching from off-line to on-line mode.

4.1.7.1.6 PLOT MENU OPTIONS

- ❑ **Display** - Five (5) choices are available from the **Display** option:
  - ⇒ **Superimposed** - Superimposes the two data logger plots to allow for ease of comparison.
    - ⇒ **Individual** - Displays the data logger plots individually.
  - ⇒ **Blow Up Graph** - Expands the selected data logger plot to fill the data logger display window.
  - ⇒ **Restore Graph** - Restores undeleted graphs to the data logger plot display window.
    - ⇒ **Keep Previous** - Stores the previous data logger plots in memory.

- ❑ **Grid Lines** - Two (2) choices are available from the **Grid Lines** option:
  - ⇒ **Horizontal Grid** - Adds a horizontal grid to the current data logger plot.
  - ⇒ **Vertical Grid** - Adds a vertical grid to the current data logger plot.
- ❑ **Save Plots** - Saves the current data logger plots to disk for future use.
- ❑ **Load Plots** - Allows the user to load previously saved plots to the data logger plot display window.

4.1.7.1.7 VIEW MENU OPTIONS

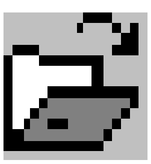
- ❑ **Toolbar** - The icons for general WinDrive use, the toolbar, may be concealed or revealed using the view option.
- ❑ **Status Bar** - Showing drive and software information, the status bar may be concealed, increasing the size of the data logger plot window.
- ❑ **Floating Toolbar** - When not required, the Floating Toolbar may be concealed using the **View** option, also available with the **Ctrl** and **F** key combination.

4.1.7.1.8 HELP MENU OPTIONS

- ❑ **Contents** - Displays the contents of the WinDrive Help system.
- ❑ **Using Help** - Provides a full guide to using the WinDrive On-line Help system.
- ❑ **About Moog WinDrive** - Gives information on the version of WinDrive software being used.

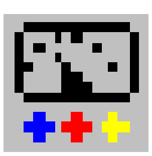
4.1.7.2 TOOLBAR ICONS

The Tool Bar contains fifteen (15) icons which from left to right, perform the following functions:

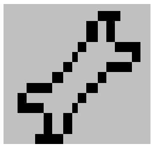


File Open Icon - Opens previously saved datalogger plots and log files. This function is also available from the main application menu under **File/Open**.

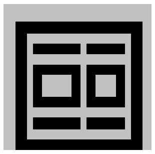
File Save Icon - Saves Current data logger plots or log files to disk for future use. This function is also available from the main application menu under **File/Save**.



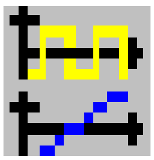
Data Logger Control Panel Icon - Opens the *Data Logger Control Panel* dialog Box. This dialog box may also be opened from the main application menu under **Data Logger/Control Panel**.



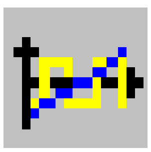
Data Logger Set-up Icon - The Data Logger operating parameters are set up from this dialog box. This function may also be opened from the main application menu under **Data Logger/Setup**.



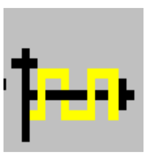
Engineering User Interface - System parameters can be viewed and changed within the *E.U.I* dialog box. This function may also be opened from the main application menu under **Low Level/E.U.I. Input**.



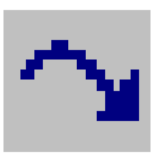
Separate Plots Icon - Separates data logger plots into separate windows. This function is also available from the main application menu under **Plots/Display/Individual**.



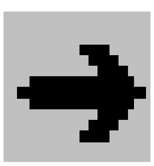
Combine Plots Icon - Superimposes the two current data logger plots into one window. Also available from the main application menu under **Plots/Display/Superimposed**.



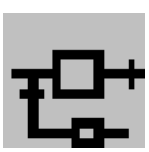
Blowup Plots Icon - Shows only one selected data logger plot in the data plot window. This function is also available for the main application menu under **Plots/Display/Blowup Graph**.



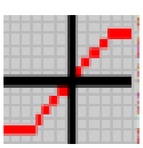
Restore Plots Icon - The Restore Plots Icon restores previous data logger plots held in memory. Also available from the main application menu under **Plots/Display/Restore Graph**.



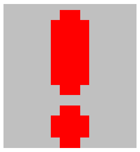
Reference Source Select Icon - Opens the *Reference Source* Dialog Box so that the user can select the drives' control source. This function is also available from the main application menu under **Drive/Setup/Reference Source.**



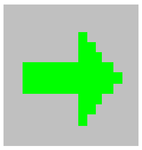
Tuning Icon - Opens the *Tuning* Dialog Box to enable scaling of the P and I velocity loop values. This function is also available from the main application menu under **Drive/Setup/Tuning.**



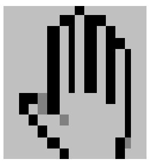
Limits Icon - Opens the Limits Dialog Box to enable setting the automatic and manual motor limits. This function is also available from the main application menu under **Drive/Setup/Limits.**



Drive Stop Icon - This function brings the motor to a servo stop. Also available by pressing **F2**, selecting **Quick Stop** from the **Drive Menu** or clicking on the **Stop** button of the Floating Toolbar.



Drive Enable Icon - This function enables power to the motor. Also available by pressing **F3**, or selecting **Enable Controller** from the **Drive Menu** or clicking on the **Enable** button of the Floating Toolbar.



Drive Disable Icon - This function removes power from the motor. Also available by pressing **F4**, or selecting **Disable Controller** from the **Drive Menu**, or clicking on the **Disable** button of the Floating Toolbar.

4.1.7.3 FUNCTION KEYS

- ❑ **F1** HELP KEY
  - ⇒ Displays MoogHelp contents page if no dialog box/s are open
  - ⇒ Displays function specific help for dialog box if open.

- ❑ **F2** STOP KEY
  - ⇒ Used to Quick Stop (servo stop) a turning motor. The drive is still enabled after **F2** is pressed. The drive must first be disabled before it can be re-enabled to start the motor again.

- ❑ **F3** ENABLE KEY
  - ⇒ Used to Enable the drive (apply power to the motor). If an analog reference source has been set-up with a voltage greater than 0Vdc, the motor should begin turning when the drive is enabled.

- ❑ **F4** DISABLE KEY
  - ⇒ Used to Disable the drive (remove the motor power). If a motor is turning when **F4** is pressed, the motor will stop.

4.1.7.4 SHORT CUT KEYS

- ❑ **ALT** KEY FUNCTION
  - ⇒ Used to access the main menu groups by holding down the **ALT** key and pressing the corresponding underlined letter in the menu name. (i.e.: Pressing **F** while holding down the **ALT** key opens the File menu).

- ❑ **CTRL** KEY FUNCTION
  - ⇒ Used to access the individual menu choices by holding down the **CTRL** key and pressing the corresponding underlined letter in the choice name (i.e.: While in the **File** menu, pressing **S** while holding down the **CTRL** key will Save the current file.)

4.1.7.5 FLOATING TOOL BAR

The *Floating Toolbar* controls power to the motor and can be moved as required about the screen**. Stop (F2)**, **Drive Enable (F3)**, and **Drive Disable (F4)** commands are accessible (see section 4.1.7.3 for command definition) from the *Floating Toolbar*. The buttons can be selected with the mouse or the appropriate function key. The Floating Toolbar operates exclusively in the foreground, and may still be used if WinDrive is being run as a background task.

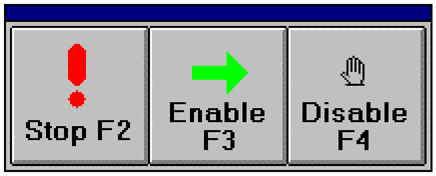


FIGURE 4.12 Floating Toolbar

4.1.8 COMMUNICATION MODE CONFIGURATION AND USAGE

4.1.8.1 CHANGING COMMUNICATION MODE OR PORT

To change the PC communication port while in WinDrive select **Reset Comm** from the **Low Level** menu. The *Communication Port* (FIGURE 4.4) dialog box will appear, from it select a new communications port or select Off-line to work Off-line.

4.1.9 WINDRIVE MONITORING

4.1.9.1 DATA LOGGER

WinDrive's Data Logger function is used for monitoring and recording system parameters. This information is read by WinDrive and plotted in the Data Logger Output Window.

4.1.9.1.1 DATA LOGGER SETUP

Open the *Data Logger Setup* dialog box using the Data Logger Set Up Icon, or from the **Setup** option in the **Data Logger** menu.

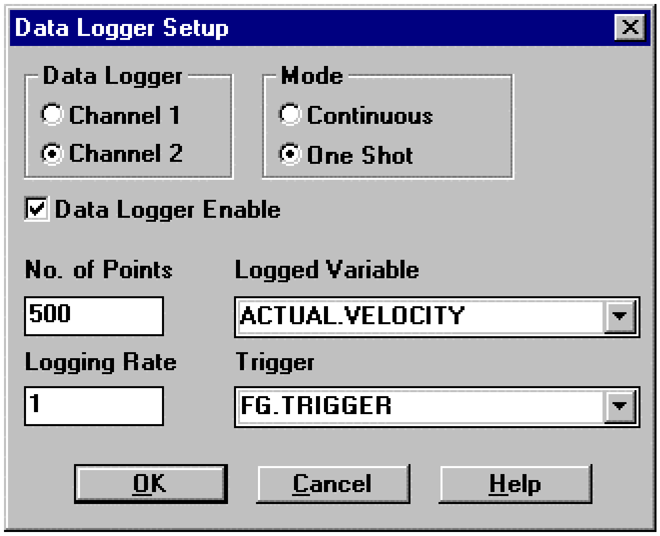


FIGURE 4.13 Data Logger Setup Dialog Box

The data logger function has two (2) channels for data recording, each one (1) should be configured in turn. The following parameters must be set:

- ❑ **Data Logger Enable:** Check box to enable data logging.

- ❑ **Mode:** Two modes of data logging are available, select one (1).

  ⇒ ***Continuous Mode****:* Data is continuously logged until the trigger variable, input by the user, returns to a false value.

  ⇒ ***One Shot Mode****:* Data is logged for a sample size equal to the value in the *No. of Points* input box.

- ❑ **Number Of Points**: Determines the number of sample points to be recorded by the data logger in the cycle period, range: 1-512. (The cycle period can be set in the Function Generator Dialog Box FIGURE 4.37)

- ❑ **Logging Rate**: The logging rate determines how frequently data samples are recorded by the data logger. Both the logging rate and the number of points determine the resolution of the data logger. Longer time periods reduce the accuracy of the logged data. Shorter time periods return improved data accuracy yet provide less information about the system response over time (Range: 1-1000). To calculate the time base (x-axis), use the following formula:
  [No. of Points]x[Logging Rate]x[Sample Period (.45 mS)]= Time Base Full Scale (sec)

- ❑ **Logged Variable**: This option determines what system variable is plotted on the y-axis of the data logger plot (i.e.: actual velocity). Time, in seconds, is always plotted on the x-axis.

⇒ If *IDC.CURRENT MONITOR* is selected the plot will yield a value on the Y axis as follows:
(+/-8192) is full scale demand current which is scaled to the minimum of the drive or motor peak current.

⇒ If velocity (speed in RPM) is selected the plot will yield a value on the Y-axis as follows:
2x[Y-Axis Value] = Velocity (RPM)

❑ **Trigger**: The trigger parameter is used to establish the point from which data logging begins. Set to one (1) of the following three (3) triggers:

⇒ *DLOG.SYNCFLAG* (Data logger sync-flag):

⇒ *FG.TRIGGER* (Function generator trigger): Data logging begins when the function generator output signal starts.

⇒ *TRIGGER.FLAG:* allows user to select trigger from a list of system variables in the *DATA TRIGGER* dialog box. (see section 4.1.9.1.2)

4.1.9.1.2 DATA TRIGGER SETUP

Open the *Data Trigger* dialog box from the **Data Trigger** option in the **Data Logger** menu.

> **NOTE**
> *In order to select a system variable as the trigger the user must define the* ***Trigger*** *to be TRIGGER.FLAG in the* Data Logger Setup *dialog box. (see section 4.1.9.1.1).*

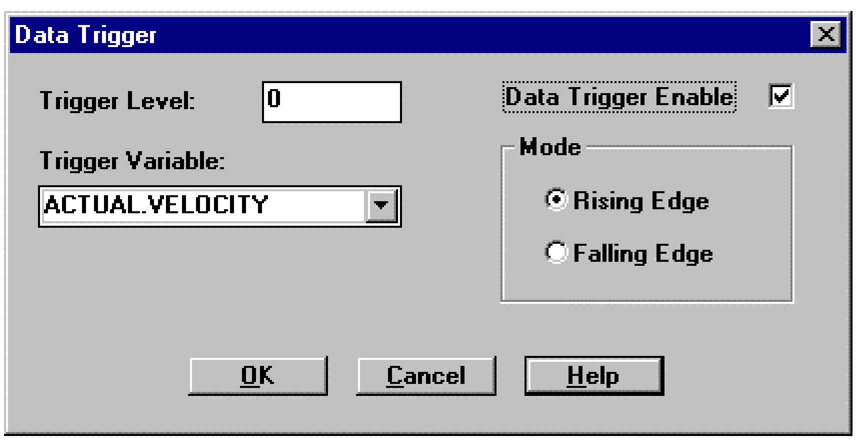


FIGURE 4.14 Data Trigger Dialog Box

Configure each of the following items in the dialog box:

❑ **Data Trigger Enable**: Check box to enable Data Trigger.

- **Trigger Variable**: Select the system variable to be used as the trigger from the pull down list activated by the down arrow at the box end.

- **Trigger Level**: Enter a point (absolute number) within the trigger variable's operating range at which the data logger will begin collecting data. This point will have units corresponding to the Trigger Variable selected. For example, if "actual velocity" is the selected trigger variable, the trigger level is set to RPM, the unit of velocity used by WinDrive.

- **Mode** : Two (2) modes of triggering are available. Select one (1):

  ⇒ *Rising Edge* - A trigger variable rising above the trigger level will trigger the data logger to begin recording.

  ⇒ *Falling Edge* - A trigger variable falling below the trigger level will trigger the data logger to begin recording.

4.1.9.1.3 DATA LOGGER CONTROL

When set-up of the data logger is complete, the *Data Logger Control Panel* is used to start the data logger.

- Open the *DL Control Panel* by choosing **Control Panel** from the **Data Logger** menu.

- Select **Go** from the dialog box to ready the data logger for recording.

> **NOTE**
> *If the logging **Mode** is set to **One-Shot** the logger will start recording when the **Trigger** variable value becomes true.*

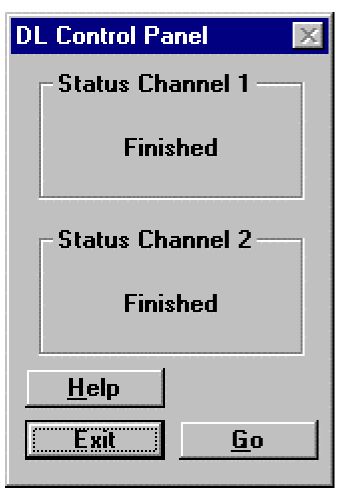


FIGURE 4.15 Data Logger Control Panel Dialog Box

4.1.9.2 DATA LOGGER PLOTS

Following the completion of data logging, the information is plotted on charts in the Data Logger Display Window. This information can be manipulated as follows:

4.1.9.2.1 FORMATTING DATA PLOTS

Plot data layout can be changed by selecting one (1) of the following plotting choices from the **Display** choice in the **Plot** menu, or the Plotting icons on the tool bar:

- ❑ **Superimposed**: Displays a single graph with two plots. (channel 1 and channel 2)
- ❑ **Individual**: Displays each channel plot on separate graphs. Channel one (1) is in the upper half or the display window, channel two (2) is in the lower half.
- ❑ **Blow Up**: Expands the selected graph to fill the data logger display window. (To select a graph left click the mouse while the pointer is over the graph).
- ❑ **Restore Graph**: Redraws current plots.
- ❑ **Keep Previous**: Select this to keep the previous set of plots. The next set of plots created will then be overlaid on the previous plots.

4.1.9.2.2 STORING PLOT DATA

To **Store** a plot select the **Keep Previous** option from the **Display** choice under the **Plot** menu. The previous plot will remain on the graph along with the current data superimposed over it.

4.1.9.2.3 SAVING PLOT DATA

Proceed with the following commands to save plot data to disk:

- ❑ Select **Save Plots** from the **Plots** menu.
- ❑ A *Plot Header* dialog box will appear. In it enter the heading for the plot you are saving.
- ❑ Next the *Save As* dialog box appears. In this box enter the following:
  - ⇒ In the **File name** field enter a 8.3 formatted name
  - ⇒ Use the **Drives** window to select the disk drive you wish to save to. If the drive is an unlisted network drive use the **Network** button to map the necessary drive.
  - ⇒ Use the **Folders** window to select the folder you wish to save in.
  - ⇒ Make sure the **Save file as type** is set to Moog Data Logger (*.mdl)
  - ⇒ Click the **OK** button to save the data.

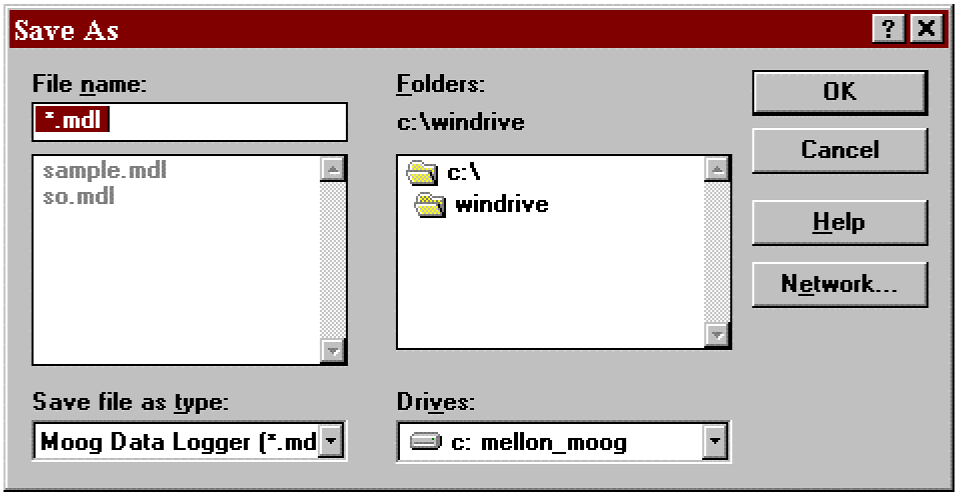


FIGURE 4.16 Save As Dialog Box

4.1.9.2.4 LOADING PLOT DATA

Proceed with the following commands to **Load** plot data from a disk:

❑ Select **Load Plots** from the **Plots** menu.

❑ A *Open* dialog box appears. Use this box to search for the *.mdl file you want to open.

Search using the following methods:

⇒ Use the **Drives** window to select the disk drive you wish to look for the file in. If the drive is an unlisted network drive use the **Network** button to map the necessary drive.

⇒ Use the **Folders** window to select the folder you wish to look in.

⇒ In the **File name** window enter the 8.3 formatted file name you wish to load. Or select the file from the window list of files below the **File name** header.

⇒ Make sure the **Save file as type** is set to Moog Data Logger (*.mdl)

⇒ Click the **OK** button to Load the data.

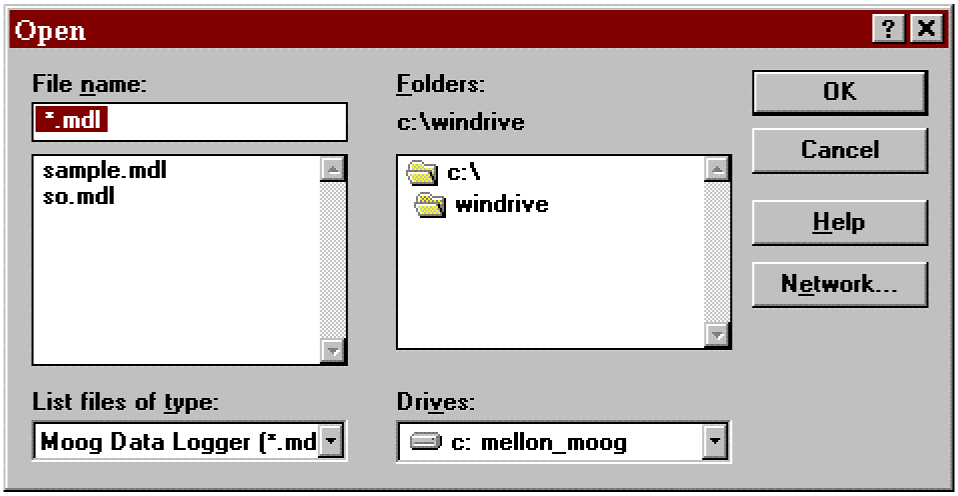


FIGURE 4.17 Open Dialog Box

4.1.9.2.5 MANIPULATING PLOT TEXT AND GRID LINES

- **Text Parameters**: To edit graph labels double click on the chosen label. A *Text Parameters* dialog box is displayed allowing the user to change: text, font and font color. (FIGURE 4.18)

- **Grid Lines**: Horizontal and Vertical grid lines can be added/removed using the **Grid Lines** choice in the **Plots** menu.

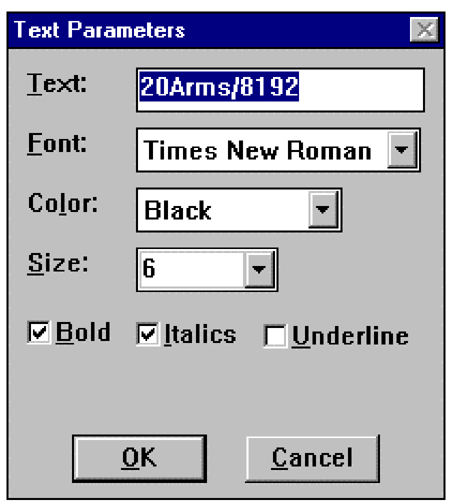


FIGURE 4.18 Text Parameters Dialog Box

4.1.9.3 ENGINEERING USER INTERFACE (EUI)

The EUI, or Engineering User Interface, provides access to individual drive parameters, which, depending on user access level, may be read from or written to the drive.

The Engineering User Interface (E.U.I) is opened by selecting the E.U.I. Icon or the **E.U.I Input** option from the **Low Level** menu.

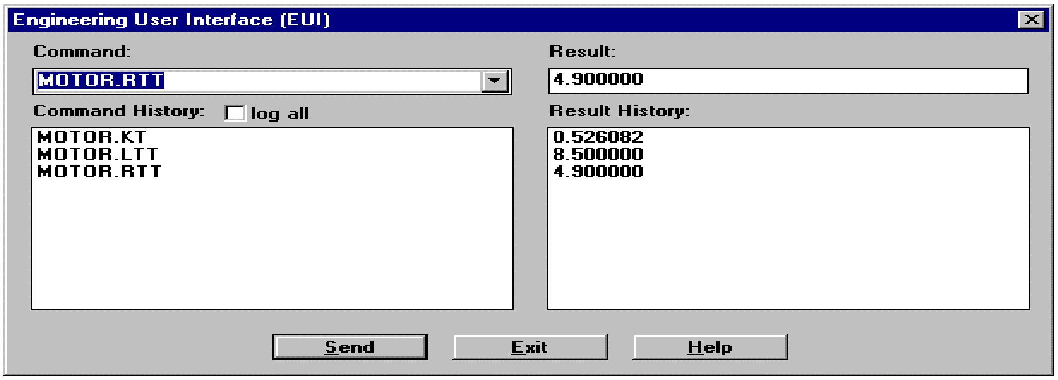


FIGURE 4.19 Engineering User Interface Dialog Box

- The *E.U.I.* dialog box has four (4) fields that function as follows:
  - ⇒ **Command:** User enters or selects (via arrow pull down menu) system variable.
  - ⇒ **Result:** Value of system variable in the Command field.
  - ⇒ **Command History**: List of system variables user has selected and sent from the command field.
  - ⇒ **Result History:** List of results returned from the system after a **send** instruction.
- The *E.U.I.* dialog box has three (3) buttons that function as follows:
  - ⇒ **Send:** Sends the value of the variable in the Command window to the drive for a response. (The response is then listed in the Result window)
  - ⇒ **Exit:** Closes the *E.U.I.* dialog box
  - ⇒ **Help:** Opens the help screen.

4.1.9.3.1 CHANGING A SYSTEM VARIABLE

To change the value of a system variable enter a space or "=" equal sign after the variable in the Command field followed by the desired value for the parameter. Press the send button to write the new variable to the drive.

4.1.9.4 BLOCK DATA

Block data is information about the motor type, drive model, firmware version and firmware version release date. This data is contained in the memory of the connected drive.

4.1.9.4.1 BLOCK DATA DIALOG BOX

Used to read block data from the connected drive.
Open from the **Low Level** menu.

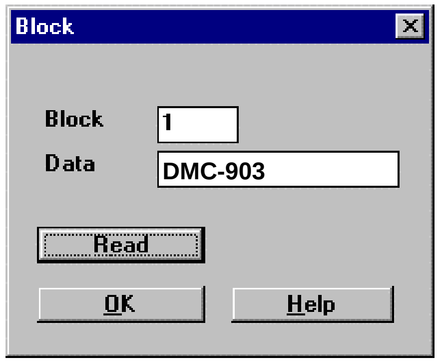


FIGURE 4.20 Block Data Dialog Box

- The *Block Data* dialog box contains two (2) windows that function as follows:
  - ⇒ **Block:** Integer (range: 1-5) used to reference a data block string in the attached drive.
  - ⇒ **Data:** String contained in the block number referenced in the **Block** window.
- Description of Data stored in corresponding data block:

  Block #0: Motor String

  Block #1: Controller String

  Block #2: Firmware ID

  Block #3: Release Date

  Block #4: Data Logger Channel #1

  Block #5: Data Logger Channel #2

4.1.9.4.2 MANUAL BLOCK SAVE TO FILE

Used to store Block Data to disk.
Open using the **Save Block To File** choice under the **Low Level** menu.

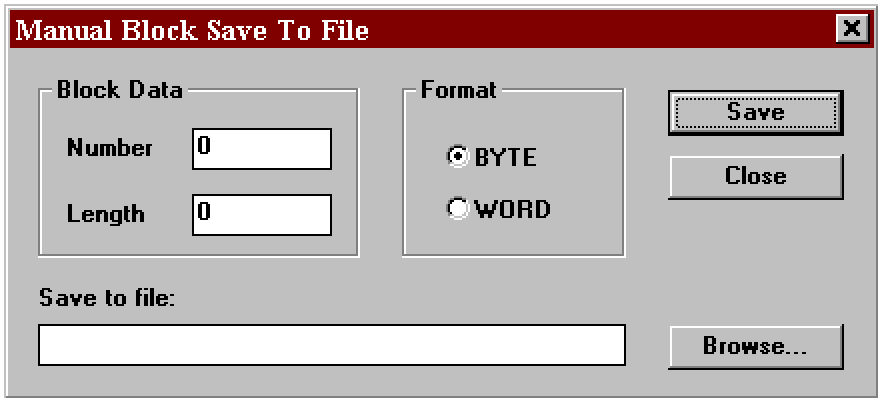


FIGURE 4.21 Manual Block Save To File Dialog Box

❑ Configure each of the following items in the dialog box:

⇒ **Number**: Enter the Block number to be saved.

⇒ **Length**: Enter the length of the byte/word to be saved.

⇒ **Format:** Select format to save Block Data in.

⇒ **Save to File:** Enter file name (8.3 format) and path where the data is to be saved. Use the browse command to find existing file or file folder.

When the above items are configured click the **Save** button to write the Block Data to disk.

4.1.9.5 FRONT PANEL TEST POINTS

Two (2) programmable analog output channels used to monitor system parameters are available with every WinDrive compatible drive.
The output at each of the channels is set with the *Front Panel Test Points* dialog box. Open using the **Setup** option in the **Drive** menu.

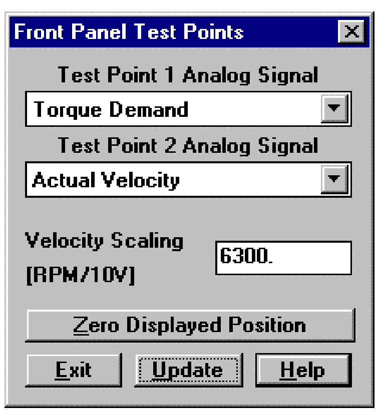


FIGURE 4.22 Front Panel Test Points Dialog Box

- The *Front Panel Test Points* dialog box has three (3) windows that function as follows:

  ⇒ **Test Point 1 Analog Signal**: Sets system variable to be monitored at test point 1. Select variable by clicking on down arrow at right side of window, this will bring up an alphabetical listing of system variables available.

  ⇒ **Test Point 2 Analog Signal** : Sets system variable to be monitored at test point 2. Select variable by clicking on down arrow at right side of window, this will bring up an alphabetical listing of system variables available.

  ⇒ **Velocity Scaling (RPM/10V)**: Enter maximum motor velocity (RPM) corresponding to a 10V analog reference source. (Note: If using an analog reference input signal this variable should be set the same as the Velocity Scaling variable in the *Analog Input* dialog box, see section 4.1.13.2).

- The *Front Panel Test Points* dialog box has four (4) buttons that function as follows:

  ⇒ **Zero Displayed Position**: Use when "Actual Position" is assigned to a test point. This function will then zero the displayed position to give a correct reading.

  ⇒ **Exit**: Close the dialog box.

  ⇒ **Update**: Sends dialog box data to drive to update test point signals.

  ⇒ **Help**: Opens on-line help screen.

4.1.9.6 DRIVE STATUS

The *Drive Status* dialog box provides a table of current drive and motor parameters and can be updated by the WinDrive software. This dialog box is useful in both diagnostic and system querying procedures.

Open by selecting **Drive Status** from the **Drive** menu.

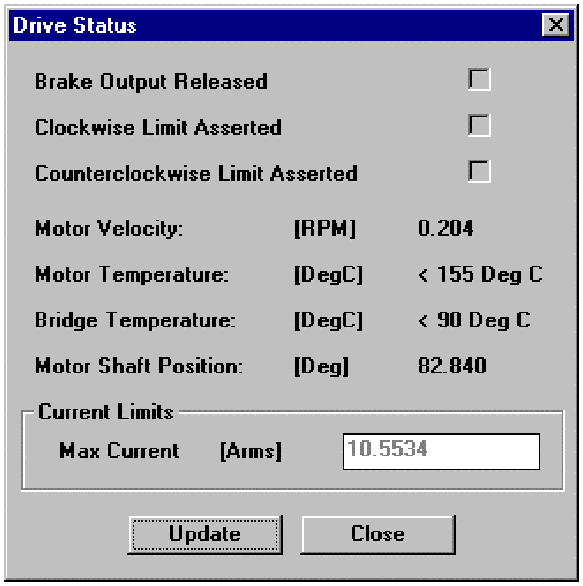


FIGURE 4.23 Drive Status Dialog Box

- ❑ **Update** button is used to display the latest parameter values in the dialog box.

4.1.10 LOG FILES

Log Files are a record of the parameter information used to setup the drive. Log Files are displayed in the Log File Display box in the lower left hand side of the WinDrive Main Screen (see FIGURE 4.11).

4.1.10.1 LOG FILE RECORDING

- ❑ To **begin** recording a **Log File** select **Start Record** from the **Log Files** menu.
- ❑ To **stop** recording a **Log File** select **Stop Record** from the **Log Files** menu.

NOTE
Tuning Parameters are only updated to the recording Log File after the ***Update*** *button is selected of if the* ***Return*** *key is pressed on entering a parameter.*

4.1.10.2 LOG FILE SAVING\LOADING

4.1.10.2.1 SAVING A LOG FILE

Proceed with the following commands to save a Log File to disk:

- ❑ Select **Save** from the File menu.
- ❑ Next the *File Save* dialog box appears. In this box enter the following:

⇒ In the **File name** window enter a 8.3 formatted name

⇒ Use the **Drives** window to select the disk drive you wish to save to. If the drive is an unlisted network drive use the **Network** button to map the necessary drive.

⇒ Use the **Folders** window to select the folder you wish to save in.

⇒ Make sure the **Save file as type** is set to (Log File) *.log

⇒ Click the **OK** button to save the data.

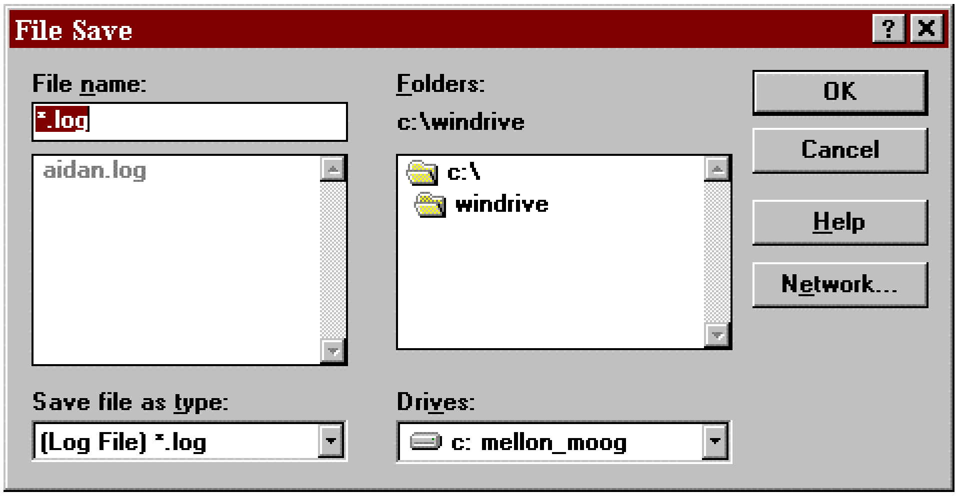


FIGURE 4.24 File Save Dialog Box

4.1.10.2.2 LOADING A LOG FILE

Proceed with the following commands to load a Log File from disk:

❑ Select **Open** from the **File** menu.

❑ A *MOOG GUI File Open* dialog box appears (FIGURE 4.25). Use this box to search for the *.log file you want to open.

Search using the following method:

⇒ Use the **Drives** window to select the disk drive you wish to look for the file in. If the drive is an unlisted network drive use the **Network** button to map the necessary drive.

⇒ Use the **Folders** window to select the folder you wish to look in.

⇒ In the **File name** window enter the 8.3 formatted file name you wish to load. Or select the file from the window list of files below the **File name** header.

⇒ Make sure the **Save file as type** is set to Moog Data Logger (*.log)

⇒ Click the **OK** button to load the data.

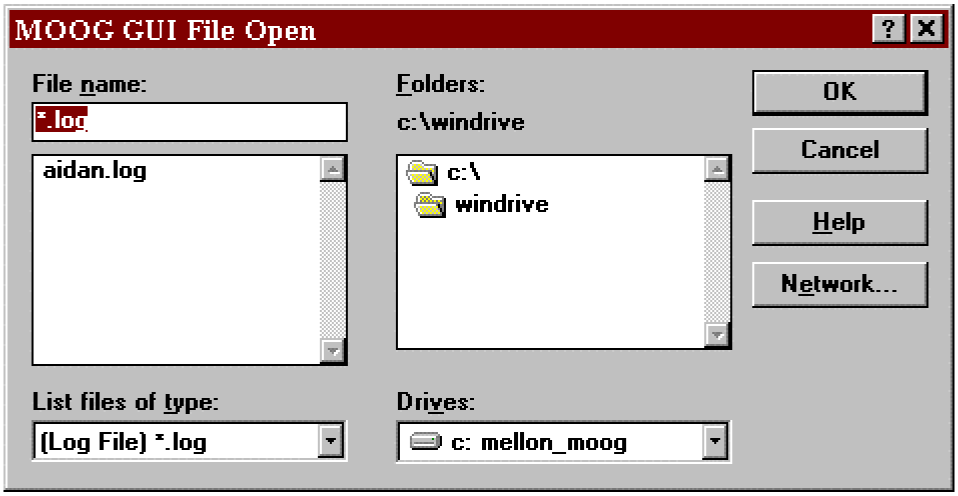


FIGURE 4.25 MOOG GUI File Open Dialog Box

4.1.10.3 LOG FILE PLAYING

Drives may be configured by “playing” the contents of the log file to their memory. To open the *Logfile Player* dialog box select the **Log File Player** option from the **Log Files Menu**.

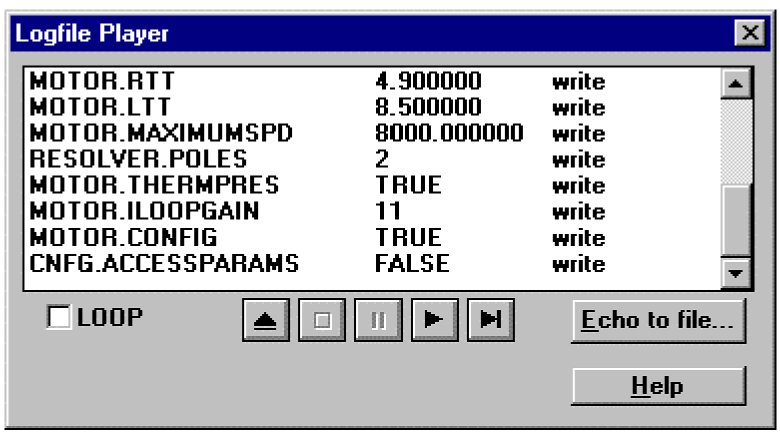
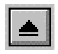
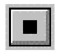
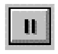
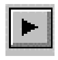
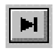


FIGURE 4.26 Logfile Player Dialog Box

Control the Logfile Player using the following:

- **Main Window**: List of Logfile variables divided into three (3) columns. The left column shows the parameter name, the center column gives the parameter value, and the right column indicates the parameter type (read or write).
- **Loop Box:** Check this box in order to play the log file continuously to the drive. Remove the check to break the play loop.

- **Close** Button :  Select to close *Logfile Player* dialog box.
- **Stop** Button:  Select to stop playing Logfile.
- **Pause** Button:  Select to pause playing of Logfile.
- **Play** Button:  Select to start playing Logfile.
- **Step** Button:  Select to play Logfile line by line.
- **Echo To File** Button: Select to save Logfile and drive response as a text file. This button opens a *Save As* dialog box. Follow instructions for saving a file found in sec. 4.1.9.2.3. Replace the **Save file as type** with *.out.
- **Help** Button: Select to view On-Line help.

4.1.11 DRIVE CONFIGURATION SAVING AND LOADING

4.1.11.1 CONFIGURATION DOWNLOAD

Writes a Logfile from disk directly to the connected drive.

To run a **Configuration Download** proceed as follows:

- Select **Configuration Download** from the **File** menu.
- The *File Open* dialog box appears (FIGURE 4.27). In the dialog box complete the following:
  - ⇒ Use the **Drives** window to select the disk drive you wish to look for the file in. If the drive is an unlisted network drive use the **Network** button to map the necessary disk drive.
  - ⇒ Use the **Folders** window to select the folder you wish to look in.
  - ⇒ In the **File name** window enter the 8.3 formatted file name you wish to load. Or select the file from the window list of files below the **File name** header.
  - ⇒ Make sure the **Save file as type** is set to *.log
  - ⇒ Click the **OK** button to load the data.

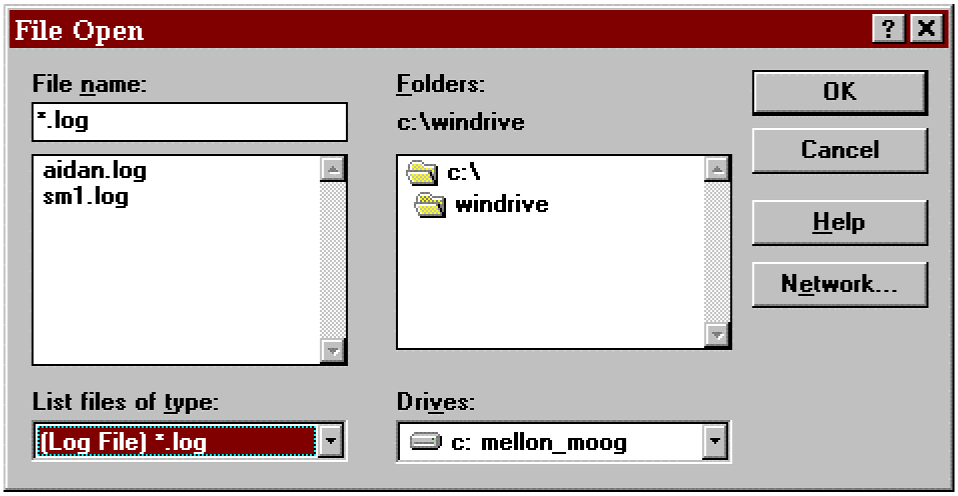


FIGURE 4.27 File Open Dialog Box

- ❑ The *Configuration Download* dialog box appears (FIGURE 4.28). This dialog box shows the file you selected in the top window. Proceed as follows based on the file name:

  ⇒ If the file name and path are correct select the **OK** button to download the file to the drive.

  ⇒ If a different file is desired select the **Browse** button to return to the *File Open* dialog box.

  ⇒ To exit the Configuration Download process select the **Cancel** button.

  ⇒ For On-Line Help select the **Help** button.

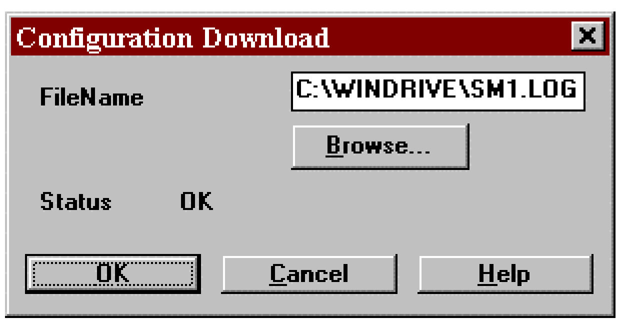


FIGURE 4.28 Configuration Download Dialog Box

4.1.11.2 CONFIGURATION UPLOAD

Copies the drive configuration data from connected drives' EEPROM to disk.

To run a **Configuration Upload** proceed as follows:

- ❑ Select **Configuration Upload** from the **File** menu.

- ❑ In the *Configuration Upload* dialog box (FIGURE 4.29) fill in the following information:

  - ⇒ Enter the **File Name** (*.log extension) you wish to save the uploaded data to.

  - ⇒ The following information is optional, it is only for user reference: **User Name, Company, Date, Application**, **Comment, Software Version** ,**Drive Type**, and **Comment**.

- ❑ Select the **OK** button to copy the drives EEPROM parameters to disk.

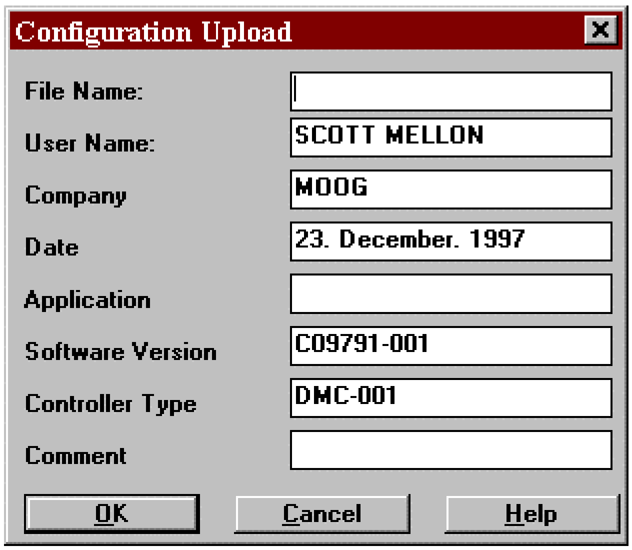


FIGURE 4.29 Configuration Upload Dialog Box

4.1.11.3 SAVE TO EEPROM

Use this function to write the fully configured drive parameters to the drives' non-volatile EEPROM memory.

Follow these steps to **Save To EEPROM**:

- ❑ Select **Save To EEPROM** from the **File** menu.

- ❑ Select **Save** in the *Save To EEPROM* dialog box (FIGURE 4.30).

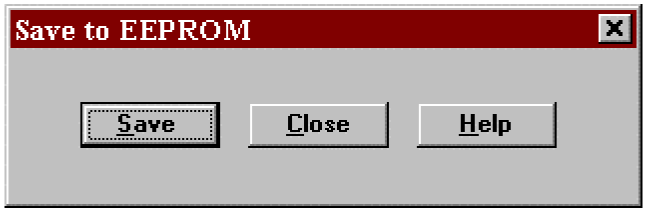


FIGURE 4.30 Save to EEPROM Dialog Box

- ❑ Wait for the Successfully saved to EEPROM! notice in the *Moog WinDrive for Windows* dialog box (FIGURE 4.31). Select **OK.**

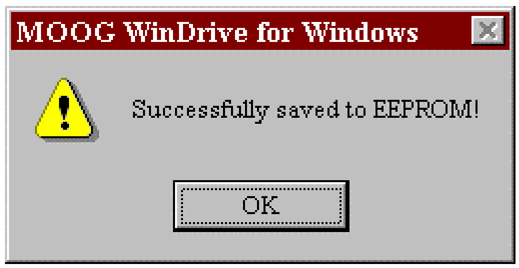


FIGURE 4.31 Successfully Saved To EEPROM Notice

4.1.12 UNITS SETUP

This function is used to select the units of measure associated to system variables. To open the *Units* dialog box select **Units** from the **Drive** menu.

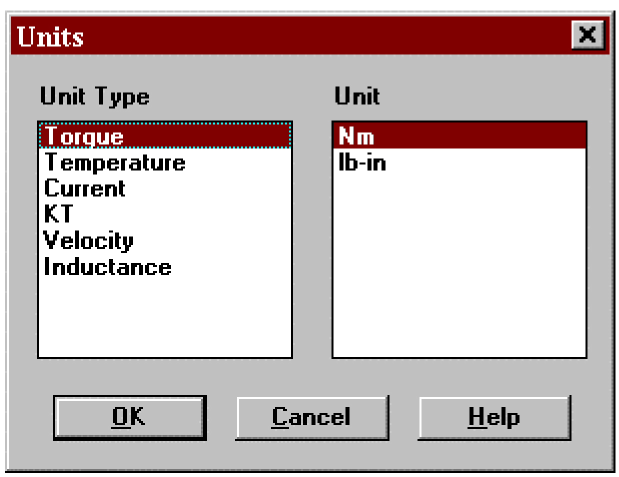


FIGURE 4.32 Units Dialog Box

To configure units of measure for each user variable:

- ❑ Select the Unit Type in the left window.

- ❑ Choose the required unit of measure from the Unit window on the right.

4.1.13 DRIVE TUNING

For optimum servo system performance the drive must first be tuned.
To allow WinDrive to automatically guide you through the basic tuning dialog boxes select **Basic DriveSetup** from the **Drives** menu and complete the setup in subsections 4.1.13.1 through 4.1.13.5.
Any stage of the tuning setup may be individually selected using the choices under the **Setup** option in the **Drive** menu, or selecting the corresponding buttons in the Windrive Main Window Button Console.

NOTE
*Prior to initial setup (sections 4.1.13.1 through 4.1.13.4) the drive should be disabled using one of the following: f4 key, disable button on the floating tool bar, or select **Disable** from the **Drive** menu.*

4.1.13.1 MOTOR SELECTION

Within the *Select Motor* dialog box select the servo-motor as follows:

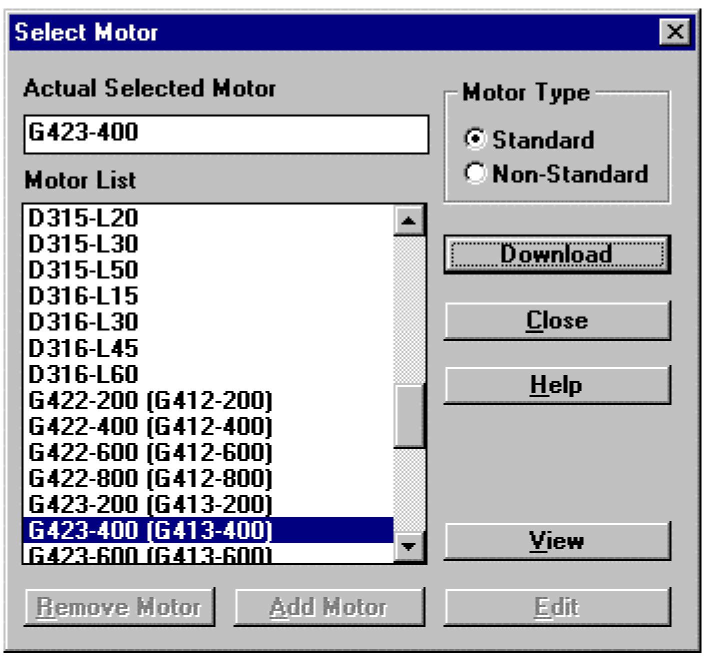


FIGURE 4.33 Select Motor Dialog Box

4.1.13.1.1 STANDARD MOTOR SELECTION

- ❑ Select **Standard** in the **Motor Type** section

- ❑ From the **Motor List** window select the Moog motor model number

- ❑ To view selected motor parameters select the **View** button.

- ❑ When the correct motor is chosen select the **Download** button.

4.1.13.1.2 NON-STANDARD MOTOR SELECTION

- ❑ Select **Non-Standard** in the **Motor-Type** section. This will allow the user to access the **Remove Motor, Add Motor** and **Edit** buttons. Proceed as follows:

  ⇒ Determine if a motor from the **Motor List** can be selected as the system motor (use the **View** button to see motor parameters). If a motor matches select it and press **Download**. Continue to section 4.1.13.2.

  ⇒ If no motor matches the system motor the motor parameters must be entered by one (1) of the following routines:

- ❑ Select the **Add Motor** button and enter the motor parameters in the *Nonstandard Motor Parameters* dialog box. Select **OK**. This will return you to the *Select Motor* dialog box. With the newly added motor highlighted select the **Download** button. Proceed to section 4.1.13.2.

- ❑ Select a motor from the **Motor List** window with parameters close to the system motors'. Select the Edit button. In the *Nonstandard Motor Parameters* dialog box change the necessary motor parameters to duplicate the system motor. Select **OK**. This will return you to the *Select Motor* dialog box. With the edited motor highlighted select the **Download** button. Proceed to section 4.1.13.2.

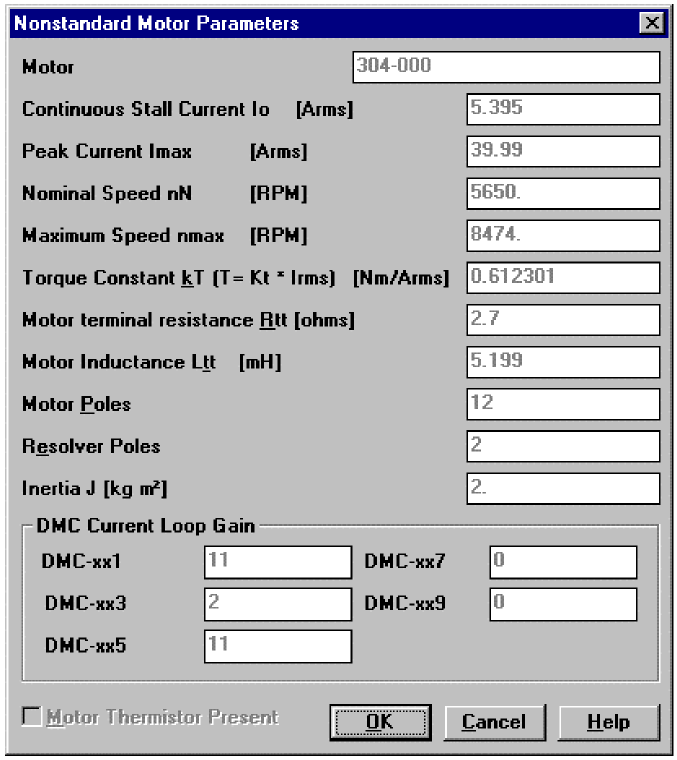


FIGURE 4.34 Nonstandard Motor Parameters Dialog Box

4.1.13.2 REFERENCE SOURCE

Select one (1) reference source in the *Reference Source* dialog box from the following options:

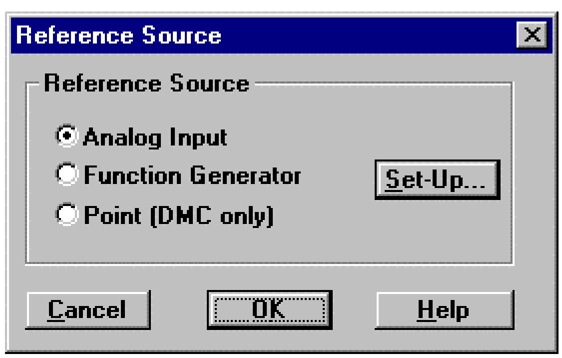


FIGURE 4.35 Reference Source Dialog Box

- ❑ **Analog Input**: This input is selected when the user is supplying a ±10 Vd.c reference. After **Analog Input** is selected press the **Set-Up** button to configure the analog input parameters in the *Analog Input* dialog box as follows:

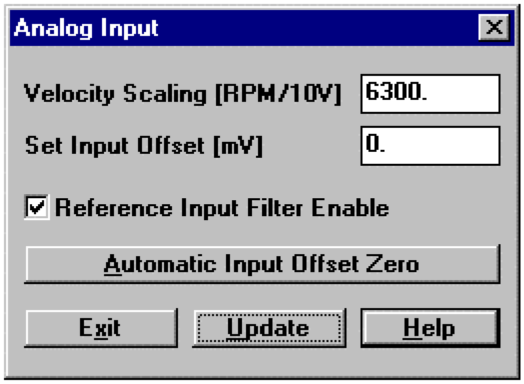


FIGURE 4.36 Analog Input Dialog Box

⇒ **Velocity Scaling**: Enter the maximum motor velocity (RPM) that will correspond to a 10V input signal.

⇒ **Set Input Offset** (mV): Enter the zero speed offset voltage if any. The factory default is 0 mV.

⇒ **Reference Input Filter Enable**: Check this box to enable a software based filter that attenuates high frequency noise components in the reference signal.

⇒ **Automatic Input Offset Zero**: Select this button to automatically null the analog input when internal and external offsets are present in the system with reference set to zero (0).

⇒ **Update**: Select the **Update** button to store the settings in memory.

⇒ **Exit**: Select the **Exit** button to return to the *Reference Source* dialog box.

❑ **Function Generator**: Select this reference source to use the software based function generator for drive tuning. After Function Generator is selected press the **Set-Up** button to configure the input parameters in the *Function Generator* dialog box as follows:

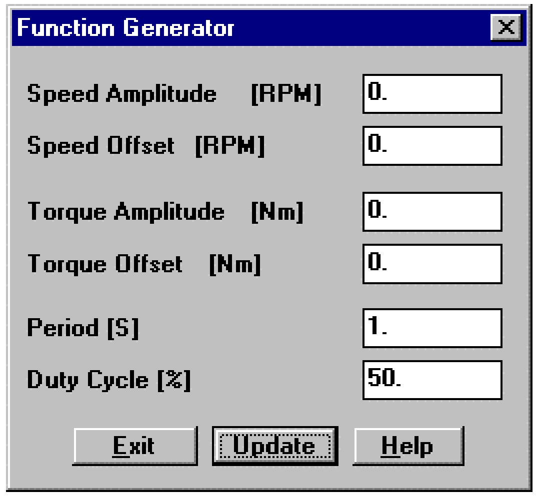


FIGURE 4.37 Function Generator Dialog Box

⇒ **Speed Amplitude** (RPM): Set the motor velocity in RPM. For tuning a value equal to 10% of the rated motor RPM should be used.

⇒ **Speed Offset** (RPM): This value, in RPM, is added to the Speed Amplitude for one direction of rotation and subtracted from the other. A factory default value of 0 results in equal movement of the motor shaft in both directions.

⇒ **Torque Amplitude**: Set the required motor torque.

NOTE
DO NOT EXCEED THE RATED MOTOR TORQUE.

⇒ **Torque Offset:** This value sets the torque bias for the motor in both directions of rotation.

⇒ **Period:** Enter the time, in seconds, for one cycle of motor operation.

⇒ **Duty Cycle:** This value determines what percentage of the Period the Velocity or Torque Amplitude is positive. The remaining portion of the period the amplitude is negative. For tuning a duty cycle of 50% should be entered to produce equal clockwise and counter-clockwise shaft rotation.

❑ **Point:** If the DMC drive contains a Point card the user may select this as the reference source. To program the Point control see the ***Point Users Manual***, Part # C05100.

4.1.13.3 SETTING TORQUE AND VELOCITY LIMITS

Setup the system torque and velocity limits as follows:

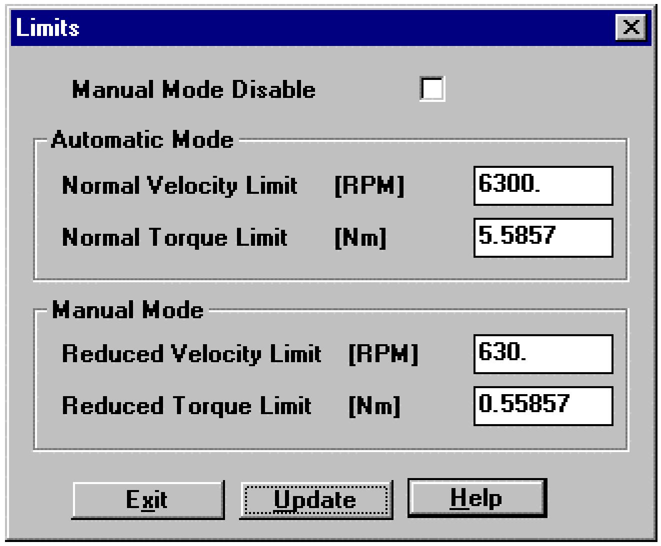


FIGURE 4.38 Limits Dialog Box

- ❑ **Manual Mode Disable**: Check this box to disable **Manual Mode** limits. The drive will then run using the values in the **Automatic Mode** section.

- ❑ **Automatic Mode**: Normal operating mode limit values.

  ⇒ **Normal Velocity Limit**: Enter maximum allowed motor speed (RPM) in normal operation. The default value is the same as the **Nominal Speed** value in the *Standard/Non-Standard Motor Parameters* dialog box (see section 4.1.13.1)

  ⇒ **Normal Torque Limit**: Enter maximum allowed motor torque (Nm) in normal operation. The default value is approximately ten (10) times the **Torque Constant** value in the *Standard/Non-Standard Motor Parameters* dialog box (see section 4.1.13.1)

- ❑ **Manual Mode**: Reduced operating limits. These limits are **not functional** on a DMC drive unless an extended I/O card or an extra inputs bracket is installed.

  ⇒ **Reduced Velocity Limit**: Enter a reduced motor speed limit to ensure proper tuning and safe system operation.

  ⇒ **Reduced Torque Limit**: Enter a reduced motor torque limit to ensure proper tuning and safe system operation.

4.1.13.4 LIMIT SWITCHES

If the drive system has limit switches connected configure them as follows:

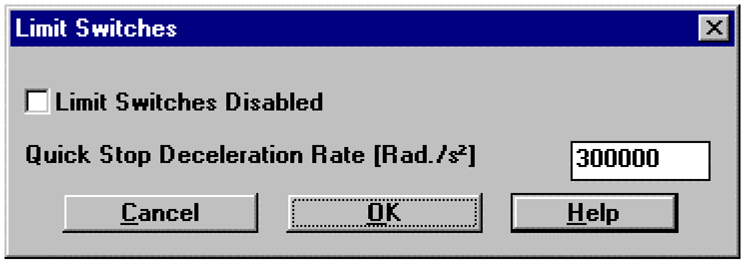


FIGURE 4.39 Limit Switches Dialog Box

- ❑ **Limit Switches Disabled**: Check box to disable limit switch inputs.
- ❑ **Quick Stop Deceleration Rate**: If limit switch inputs are enabled this variable determines the rate at which the drive decelerates the motor after a limit switch is tripped.

4.1.13.5 TUNING

In the Tuning dialog box select **Torque** or **Velocity Mode** based on the systems operating mode. Based on your selection go to the corresponding tuning mode section below.

4.1.13.5.1 BASIC VELOCITY MODE TUNING

This section provides a recommended velocity mode standard tuning procedure for use with WinDrive. The procedure should be followed in the sequence listed below:

NOTE

The two principle parameters affecting the velocity loop dynamics are the Velocity Loop Proportional Gain (P) and the Integral Time Constant (I).
The proportional gain term P acts on the measured velocity error, which is the difference between the requested velocity and the actual velocity. High P gain gives the system a faster response and tighter velocity control, but if the gain is set too high the system may become unstable. For best results the P gain should be set as high as possible without inducing severe overshoot or oscillation.

The Integral Time Constant I sets the gain for the integral term in the velocity error compensation. Integral gain is used to remove any steady state error. Integral gain also provides disturbance rejection or 'stiffness' in the motor's reaction to an external torque load.

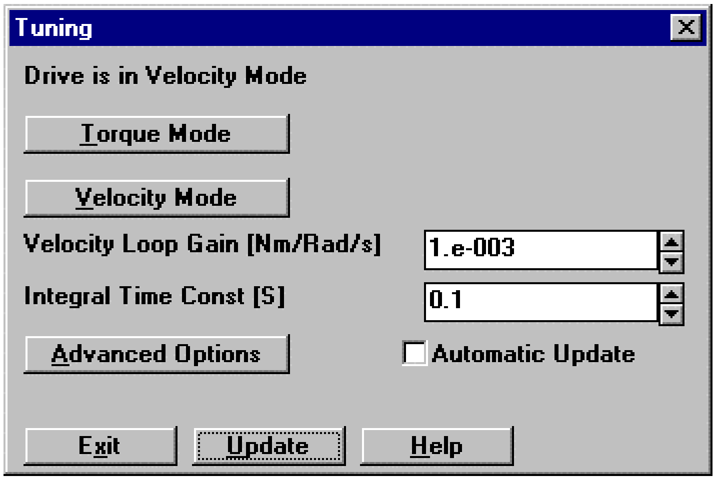


FIGURE 4.40 Tuning Dialog Box

WARNING
The motor should be uncoupled if incorrect movements during the drive tuning procedure can damage the machine. If this is not possible, the safety limit switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.

- ❑ Disable the drive, using the hardware enable switch.
- ❑ Confirm that the message "Drive is in Velocity Mode" is displayed at the top of the *Tuning* dialog box (FIGURE 4.40). If it is not select the **Velocity Mode** button and reconfirm message.
- ❑ Confirm that the drive velocity and torque limits are set to 10% of normal system limits. (see section 4.1.13.3).

WARNING
During tuning set the drive to 10% of rated torque and speed via manual mode or by altering automatic mode parameters. Failure to do so might result in machine damage and/or personal injury.

- ❑ Apply a low frequency squarewave reference source. This source can be supplied from an external source or by the internal software Function Generator (see section 4.1.13.2). Set the command reference source to 10% of the rated motor RPM, 0 RPM offset, 1 second period, and 50% duty cycle.

WARNING

Ensure that the application allows using this speed amplitude and length of travel, (period, duty cycle), without damage to the machine before proceeding with the tuning procedure.

- ❑ Configure WinDrive so that the torque demand variable, IDC.CurrentMonitor, is monitored in one of the two Data Logger Channels (see section 4.1.9.1) or at one of the Front Panel Test Points (see section 4.1.9.5) via an oscilloscope. This signal must not saturate during motor acceleration/deceleration (i.e. must be less then 1 Vd.c). If the signal saturates then the Function Generator setup (see section 4.1.13.2) must be altered or the Drive Torque Limit increased (see section 4.1.13.3) until saturation does not occur.

- ❑ Configure WinDrive so that the actual velocity variable, ACTUAL.VELOCITY, is monitored in the second Data Logger Channel (see section 4.1.9.1) or at the second Front Panel Test Point (see section 4.1.9.5).

- ❑ Set the **Integral Time Constant** (I) in the *Tuning* dialog box to 3 seconds.

- ❑ Enable the drive: Hardware enable first using the External Enable input, then software enable using the **F3** Key, **Enable** button on floating tool bar, or **Enable Controller** option in the **Drive** menu.

- ❑ Check the **Automatic Update** box in the *Tuning* dialog box to force changes made to P or I to be immediately sent to the drive.

- ❑ Place the cursor in the **Velocity Loop Gain** field (P) and use either the up arrow at the right end of the field or the up arrow keyboard key to increase the P gain until the motor shaft begins turning.

- ❑ Continue increasing the Velocity Loop Gain (P) while monitoring the Actual Velocity on the Data logger Plot or via an oscilloscope from the Front Panel Test Point. Increase P until a slight overshoot occurs in the velocity response, as seen in
- ❑ FIGURE 4.41A.

- ❑ Decrease the Velocity Loop Gain (P) by using the down arrow at the right end of the field or the down arrow keyboard key. Decrease P until the overshoot just disappears (see
- ❑ FIGURE 4.41C).

- ❑ Place the cursor in the Integral Time Const field (I) while still monitoring the Actual Velocity. Decrease I using the down arrow or the down key until a slight overshoot occurs in the velocity response again.

- ❑ Place the cursor back in the **Velocity Loop Gain** (P) field and increase the value until the slope of the step response is similar to that in
- ❑ FIGURE 4.41D.

- For **Advanced Velocity Mode** tuning options see section 4.1.13.6.

- When finished **Tuning** select the **Exit** button and proceed to section 4.1.11.3 for directions on **Save to EEPROM**

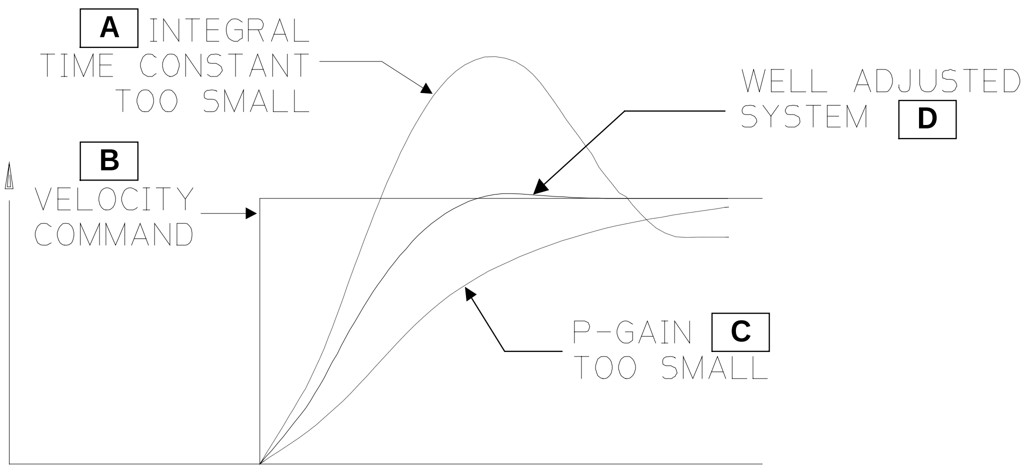


FIGURE 4.41 Velocity Mode Tuning Waveforms

> **Note**
> *If the Function Generator along with the Data Logger are used for tuning the user may choose to utilize the* Combined Tuning *dialog box via the* ***Setup*** *option in the* ***Drive*** *menu. This box contains both the Data Logger Control Panel and the Function Generator to simplify the user interface.*

4.1.13.5.2 TORQUE MODE TUNING

- To set the drive to Torque mode select the **Torque Mode** button in the *Tuning* dialog box (FIGURE 4.40).

- The tuning of the inner current loop in WinDrive compatible drives is pre-programmed during drive initialization. Hence, no parameter tuning is required in torque mode.

- Select the **Exit** button. The *Save to EEPROM* dialog box (FIGURE 4.30) will appear.

- See section 4.1.11.3 for directions on **Save to EEPROM**.

NOTE

In Torque Mode, the input command reference is a current command to the power amplifier that drives the motor. The term Torque Mode is adopted because the motor produces a nearly linear torque per ampere of input current.

4.1.13.6 ADVANCED OPTIONS

The Advanced Options dialog box allows the user to select the method of velocity estimation in order to refine velocity mode tuning.
Access the *Advanced Options* dialog box by selecting the **Advanced Options** button in the *Tuning* dialog box or under the **Setup** option in the **Drive** menu.

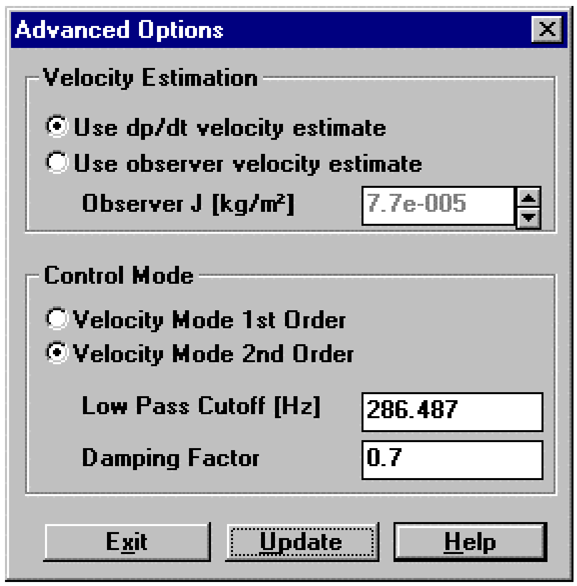


FIGURE 4.42 Advanced Options Dialog Box

In the *Advanced Options* dialog box there are two groups that function as follows:

❑ **Velocity Estimation**: Allows the user to select between one (1) of the following two (2) methods of motor velocity estimation:

⇒ **Use dp/dt velocity estimate**: The software uses a mathematical model to estimate the motor velocity from motor position and time data.

⇒ **Use observer velocity estimate**: Allows the user to input an observer inertia so that the software can simulate the drive and motor system and determine the motor velocity to a higher resolution.

- **Control Mode**: Allows the user to select between one (1) of the following two (2) methods for filtering noise in the current control loop:

  ⇒ **Velocity Mode 1st Order**: Allows the user to input a 1st order filter low pass cutoff parameter for filtering noise in the current control loop.

  ⇒ **Velocity Mode 2nd Order**: Allows the user to input a 2nd order filter **Low Pass Cutoff** and **Damping Factor** parameters for filtering noise in the current control loop.

4.1.13.6.1 VELOCITY LOOP TUNING USING THE VELOCITY OBSERVER

In order to determine the velocity to a higher resolution follow the tuning steps below, which incorporate both the **Observer Velocity Estimate** and **Velocity Mode 2nd Order** filter in the *Advanced Options* dialog box (FIGURE 4.42).

- Tune the velocity loop as detailed in sections 4.1.13 through 4.1.13.5.1. FIGURE 4.43A shows a typically tuned velocity loop response to a step reference command input. The **Torque Response** and **Actual Velocity** are viewed via Front Panel Test Points TP1 and TP2 (see section 4.1.9.5). Note the single overshoot of about 24% in the velocity response and the 12mS settling time.

- Select **Use observer velocity estimate** in the *Advanced Options* dialog box FIGURE 4.42.

- Select **Velocity Mode 2nd Order** in the *Advanced Options* dialog box FIGURE 4.42. Leave the default settings in the Low Pass Cutoff and Damping Filter parameter windows.

- Configure front panel test point 1 (TP1) to monitor **Torque Response** and front panel test point 2 (TP2) to monitor **Observer Position Error**. View the output of these two test points with an oscilloscope, set the time base to 2 ms/div.

- Monitor the output from TP1 and TP2 as shown in FIGURE 4.43B.

NOTE
*Do NOT use the **Velocity Observer** if the plot of **Observer Position Error** oscillates excessively when the velocity makes a step chance as shown in FIGURE 4.43C. The load may not be adequately modeled by the observer.*

- Adjust the **Observer J** parameter in the *Advanced Options* dialog box according to “Jest TOO SMALL” or “Jest TOO BIG” Observer Position Error plots as shown in FIGURE 4.43B. After each **Observer J** adjustment select the **Update** button. Adjust until the Observer Position Error plot resembles the Jest CORRECT plot in FIGURE 4.43B. Typically there will be some viscous friction present so that the Observer Position Error plot will step appropriately when the shaft velocity makes a step change.

- ❑ Check for proper tuning by monitoring the Front Panel Test Points, via an oscilloscope or with the Data Logger, the Observer Estimate Velocity and the Actual Velocity response. These two plots should be identical. FIGURE 4.43D shows the velocity loop response with and without the observer switched on. Note the lack of overshoot in the velocity response.

- ❑ To achieve higher gains adjust the **Low Pass Cutoff** frequency in the *Advanced Options* dialog box.

- ❑ The P and I gains may now be tuned up, again, as described in section 4.1.13.5.1.

- ❑ Save final tuning configuration to EEPROM. See section 4.1.11.3 for directions on **Save to EEPROM**

- ❑ FIGURE 4.43E compares the response of an observer based system with a normal velocity loop system. Note that the response settles in just 2.2ms, whereas without the observer the step settled in about 12ms.

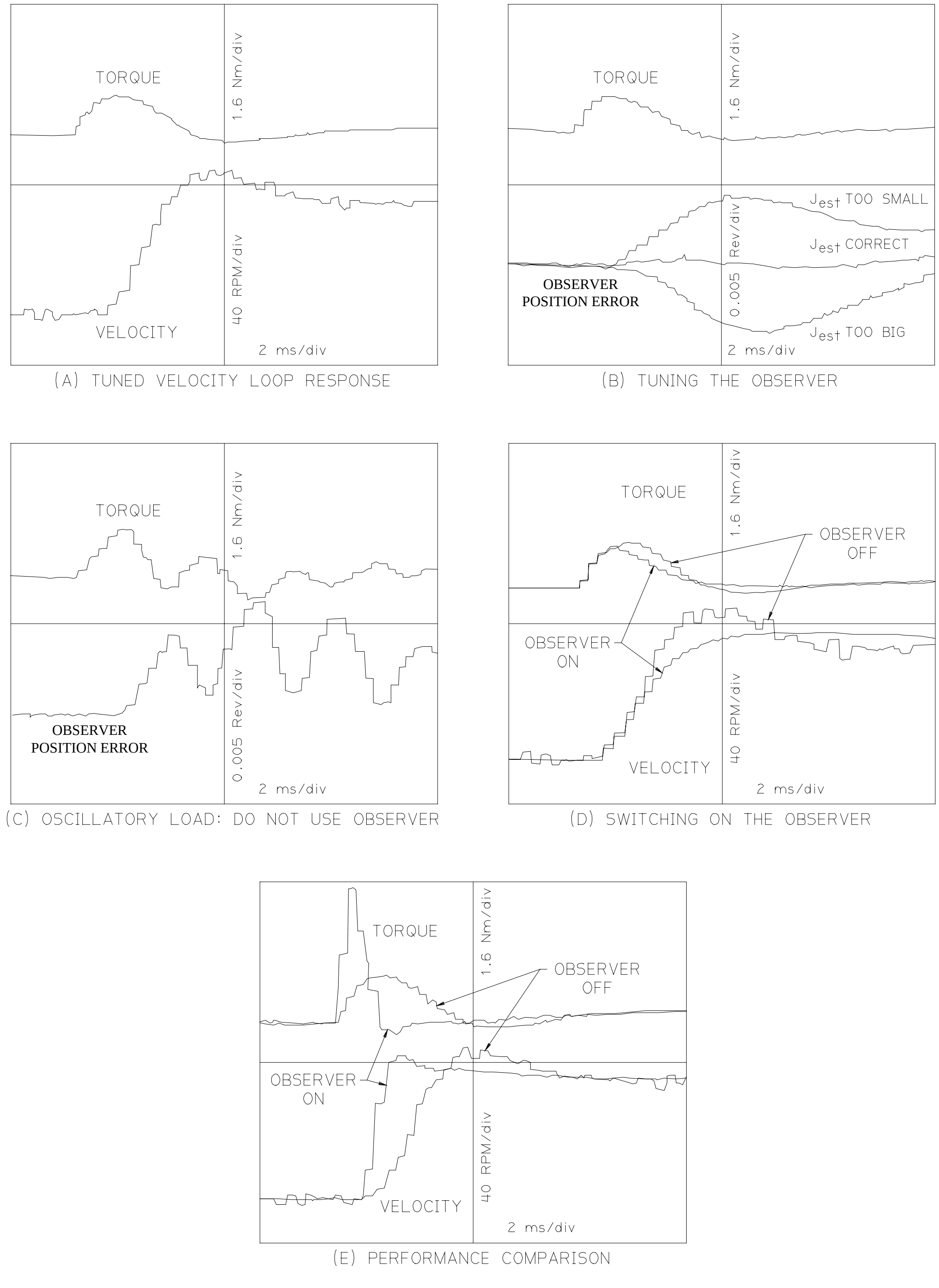


FIGURE 4.43 Velocity Observer Tuning Wave Forms

4.1.14 PASSWORD PROTECTION

This function is used to control a users access to functions within WinDrive.

4.1.14.1 USER ACCESS LEVELS

- ❑ Access level 0 = General user access (enable, disable, and monitor a drive).
- ❑ Access level 1 = Privileged user access (drive tuning and configuration)

4.1.14.2 PASSWORD SETUP CHANGE

The user may set a password in using one (1) of the following methods:

- ❑ At WinDrive Startup (On-line connection only)

  ⇒ Follow the On-Line Mode steps outlined in section 4.1.3.2. up to the *Password* dialog box (FIGURE 4.6) step.

  ⇒ At the *Password* dialog box enter the existing password (Factory default is 0). Select **OK.**

  ⇒ The *User Access Level* notification is displayed (FIGURE 4.7). Select **OK.**

  ⇒ In the *Password* dialog box select **Change**.

  ⇒ In the *Change Password* dialog box (FIGURE 4.44) enter a new password (Range: 0-9999). Select **OK**

  ⇒ In the *Password* dialog box select **Close**.

  ⇒ Save the Password to EEPROM, see section 4.1.11.3

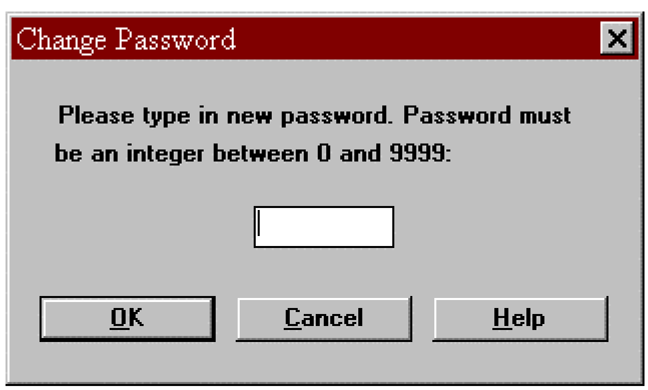


FIGURE 4.44 Change Password Dialog Box

- ❑ From within the WinDrive program:

  ⇒ Select **Passwords** from the **File** menu.

  ⇒ At the *Password* dialog box enter the existing password (Factory default is 0). Select **OK**

  ⇒ The *User Access Level* notification is displayed (FIGURE 4.7). Select **OK.**

  ⇒ In the *Password* dialog box select **Change**.

  ⇒ In the *Change Password* dialog box (FIGURE 4.44) enter a new password (Range: 0-9999). Select **OK**

  ⇒ In the *Password* dialog box select **Close**.

  ⇒ Save the Password to EEPROM, see section 4.1.11.3.

> **NOTE**
> *If a saved password is forgotten, Moog application engineering should be contacted to reset the saved user password to a known value.*

4.1.15 OPTION CARDS

4.1.15.1 EXTENDED FUNCTION CARDS

Open the *DMC Extended Function Cards* dialog box (FIGURE 4.45) from the **Drive** menu.
This dialog box shows the extended function cards installed in the drive being monitored.

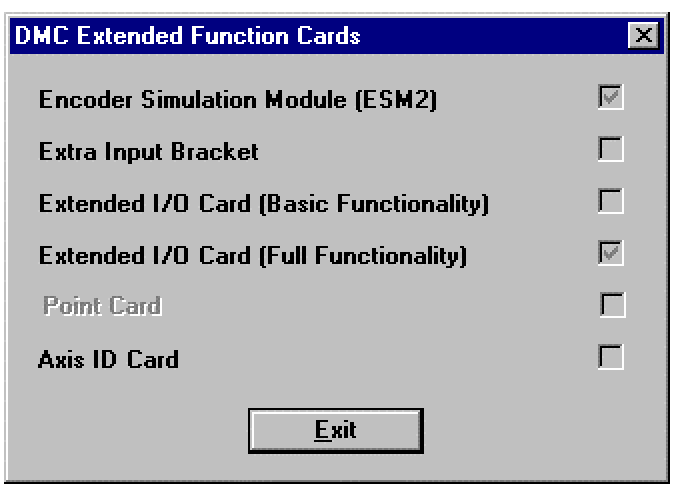


FIGURE 4.45 DMC Extend Function Cards Dialog Box

4.1.15.2 ENCODER SIMULATION

An optional Encoder Simulation Card may be set up using the *Encoder Simulation Card 2* dialog box. Open this dialog box via the **Encoder** button in the Main Window Button Console (FIGURE 4.11) or by selecting **Encoder** under the **Setup** option of the **Drive** menu.

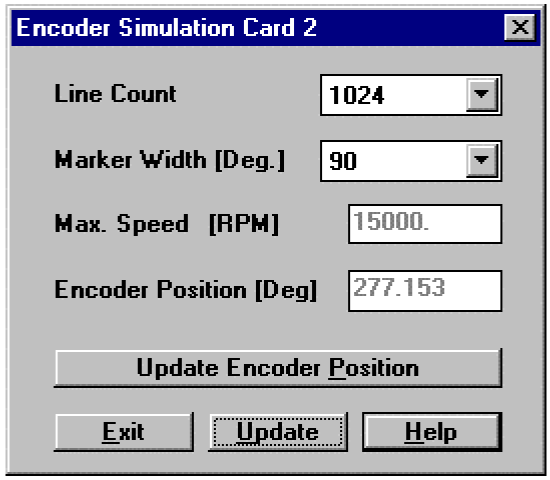


FIGURE 4.46 Encoder Simulation Card 2 Dialog Box

Configure the Encoder Simulation card (ESM) using the dialog box as follows:

- ❑ Choose the incremental **Line Count** from the pull down list via the arrow at the end of the **Line Count** window. (Discrete range: 128 - 16384)
- ❑ Select a **Marker Width** from the pull down list at the window end. The width choices are 90°, 180°, 360°. Factory default is 90°. See FIGURE 5.21.
- ❑ The **Max Speed** is determined in software and displayed. This window is not accessible by the user.
- ❑ The **Encoder Position** is determined from the system and can be updated using the **Update Encoder Position** button. This window is not accessible by the user.
- ❑ After configuration of the ESM card is complete select the **Update** button to save the configuration.
- ❑ Select **Exit** to close the dialog box.
- ❑ Save settings to EEPROM (see section 4.1.11.3)

4.1.16 EQUIPMENT AND PERSONAL SAFETY

WinDrive contains the following functions to ensure equipment and personal safety.

4.1.16.1 MANUAL MODE/AUTOMATIC MODE

Manual and Automatic mode operating limits can be set in the *Limits* dialog box (Section 4.1.13.3).
Manual limits are only accessible if an extended I/O card or a extra inputs bracket is installed.
The factory default **Manual Mode** values are 10% of the **Automatic Mode** limits.

4.1.16.2 IT THERMAL LIMITS

The *IT Thermal Limits* dialog box (FIGURE 4.47) is used to configure three (3) parameters that control current in the system. Access the *IT Thermal Limits* dialog box under the **Set-up** option in the **Drive** menu.

CAUTION

To maintain equipment and personal safety the values of Continuous Current, Peak Current and IT Time should be set less than the systems servo motor/s limits.

Enter the parameters as follows:

- **Continuous Current**: Enter the current magnitude during steady state operation.
- **Peak Current**: Enter the maximum current permissible to flow in the system at any time.
- **IT Time**: Enter the length of time the system is permitted to run a peak current.
- **Update**: Use the update button to sent the parameters to the drive.

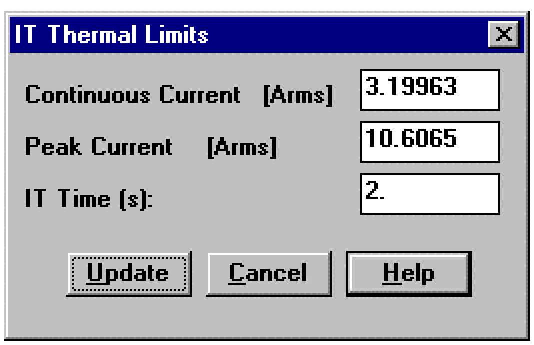


FIGURE 4.47 IT Thermal Limits Dialog Box

4.1.16.3 DRIVE DISABLING

4.1.16.3.1 SOFTWARE DISABLE

- ❑ To perform an **Emergency Stop** select one (1) of the following:
  - ⇒ **F2** key
  - ⇒ **Stop icon** on the floating tool bar, see section 4.1.7.5
  - ⇒ **Quick Stop** option from the **Drive** menu.
- ❑ To perform a **Servo Stop** select one (1) of the following:
  - ⇒ **F4** key
  - ⇒ **Disable icon** on the floating tool bar, see section 4.1.7.5.
  - ⇒ **Disable** option from the **Drive** menu.

4.1.16.3.2 HARDWARE DISABLE

- ❑ **Limit Switch** emergency braking: Accessed under the **Setup** option of the **Drive** menu this function allows the use of limit switches to limit the overall travel of a system (see Section 4.1.13.4)
- ❑ **Controller Hardware Enable**: The external enable input may be used as a hardware disable see section 2.10.2.

4.1.17 BRAKE APPLY/RELEASE

If the attached motor has a brake wired to the drive it can be operated from the **Drive** menu as follows:

- ❑ **Apply Brake**: Engages the attached brake to stop the motor.
- ❑ **Release Brake**: Disengages the attached brake to allow the motor shaft to move freely.

4.1.18 TROUBLE SHOOTING

4.1.18.1 COMMUNICATION PROBLEMS

- ❑ If WinDrive is unable to communicate with a T164 drive check the following:
  - ⇒ Confirm that the drive has control (24 Vd.c. logic) power.
  - ⇒ Check the serial communications cable for correct connection and wiring.
  - ⇒ Make sure the drive has finished booting up. The drive takes approximately 20 seconds to boot-up before WinDrive is able to communicate with it.
  - ⇒ Check that the RS232 communications mode jumper is in the correct position (See section 4.1.2.1)
- ❑ If a Time-out occurs during Log File upload/download or Save to EEPROM check the following:
  - ⇒ Make the RS232 cable is connected correctly.
  - ⇒ If the PC has an older processor the value of the "Timeout" parameter under [ComRS232] in the WinDrive.ini file may be increased.
- ❑ If you experience other WinDrive problems please note the error and contact an applications engineer.

4.2 TERMINAL EMULATION COMMUNICATIONS WITH H1 FIRMWARE

This section is intended to give the user a full understanding of programming a T164 DMC containing H1 firmware while using a terminal emulation program .
Subsection 4.2.2 describes using Moogterm with the T164 however the instructions in sections 4.2.3 through 4.2.9 can be used with any terminal emulation device for data transfer and drive programming.

CAUTION

Do not attempt configuration until at least Sections 4.2.1 through 4.2.5 have been read and understood. Do not apply power until it is called for in the configuration procedure.

Throughout Section 4.2, references to the terminal apply to either a hand held terminal or a personal computer (PC) being used as a terminal.
Responses from the T164 Series Drive appearing on the terminal are shown indented in the following font:

```
20 Dec 96
C09791-001
EEPROM ID     0
- more -
```

The characters to be entered are designated by the following type font:

1.000
Y
N

The RETURN or ENTER key on the terminal is designated by the following symbol:

<CR>

NOTE

The procedures in section 4.2 are written for use with:

- *DMC firmware version H1 dated 12/20/96*

The user must consult Moog for updates to the procedure for drives with any other software or firmware version/date.

The T164 Series Drives utilize principally metric units. TABLE 4-1 provides descriptions of the abbreviations used for units throughout Section 4.2.

Abbreviation	Unit	Measure of
Nm	Newton-meters	Torque
kg-cm^2	Kilogram-cm^2	Inertia
Rads/sec	Radians per second	Velocity
RPM	Revolutions per minute	Velocity
Rads/sec^2	Radians per second^2	Acceleration
Hz	Hertz	Frequency
s	Seconds	Time
Aeff	Effective Amperes	Current
Apeak	Peak of Wave Form Amperes	Current
Arms	Root Mean Square Amperes	Current

TABLE 4-1 Description of Units

4.2.1 SERIAL COMMUNICATIONS

The communication link between the T164 Series Drive and the terminal is half duplex, the drive ignores commands when writing to the terminal.

WARNING

A hardware enable/disable switch wired so that the motor can be stopped quickly in a emergency must be provided at all times. Software enable/disable commands do not meet safety requirements and should never be used instead of a hardware circuit.

For individual drive communication the RS232 interface should be used. "MoogTerm" software which runs on IBM compatible PCs is available for RS232 applications. In addition to providing a full screen interface, "Moogterm" allows downloading and uploading of drive parameters. Instructions for use of "MoogTerm" are included on the "MoogTerm" distribution disk available from your Moog Sales Representative.
Connect the terminal to the T164 Series Drive J3 Communications Connector using the cable described in Section 2.10.3. Set the terminal serial interface parameters to 9600 baud, 1 start bit, 7 data bits, no parity, and 2 stop bits. There is no hardware handshaking.

4.2.1.1 COMMUNICATION HARDWARE SETUP

Use an RS232 serial cable. Before a drive can be configured the hardware should be setup (see FIGURE 4.1) as outlined below:

4.2.1.1.1 RS232 COMMUNICATION MODE JUMPER SETUP

Set the drives RS communication mode position jumper W2 for RS232 as in FIGURE 4.2. See FIGURE 5.3 for jumper location. (The **Factory Default** is RS232, jumper pins 1-2)

4.2.1.1.2 RS232 SETUP

In order for the PC to communicate with the drive in RS232 mode proceed as follows:

- ❑ Connect an RS232 cable with the wiring as shown in FIGURE 2.23. The cable is connected from one of the communications ports of the PC to the serial port of the drive.

- ❑ Configure the W2 jumper for RS232 communications as shown in FIGURE 4.2.

4.2.2 MOOGTERM TERMINAL INTERFACE

NOTE
The procedures in section 4.2.2 are written for use with:
Moogterm software version 3.0 dated 11/10/97
DMC firmware version H1 dated 12/20/96
The user must consult Moog for updates to the procedure for drives with any other software or firmware version/date.

4.2.2.1 MINIMUM SYSTEM REQUIREMENTS FOR MOOGTERM

- ❑ IBM compatible PC with:
  - ⇒ 386 or higher processor running MS DOS 6.1 or higher with 2MB RAM, and 500K of free hard disk space.
- ❑ VGA display with a resolution of at least 640 x 480 pixels.
- ❑ A Moog Moogterm System Disk
- ❑ An RS232 Communication Interface Cable.

4.2.2.2 MOOGTERM STARTUP

To run the Moogterm software, place the Moogterm disk in drive A:
Type “a:Moogterm” on the command line and press return.

The text file "Readme.txt" describes the operation of the setup file.

Follow the configuration steps shown below:

- ❑ In the Configuration screen select
    - ⇒ “C” to proceed to the communications mode configuration.
    - ⇒ “ESC” to exit Moogterm.
  - ⇒ Pressing Return sets the communications and port ID to the defaults in the “.cfg” file. If a “.cfg” file does not exist the user is sent to the communication mode screen.

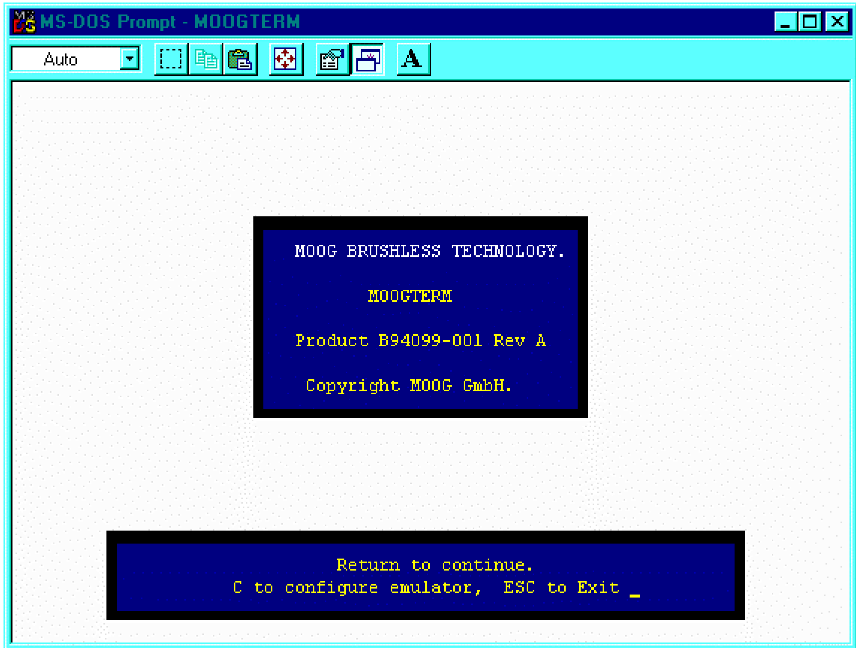


FIGURE 4.48 Configuration Select Screen

❑ In the **Communications Mode** screen enter the number corresponding to the RS mode of communication (FIGURE 4.49).

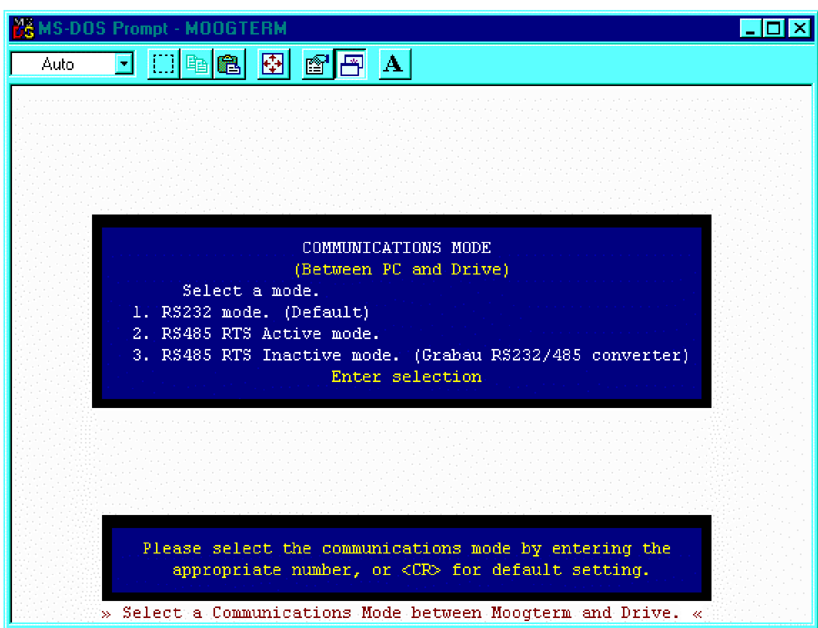


FIGURE 4.49 Communications Mode Screen

- ❑ In the **Communications Port Selection** screen enter the number of the PC communication port linked to the drive (FIGURE 4.50)

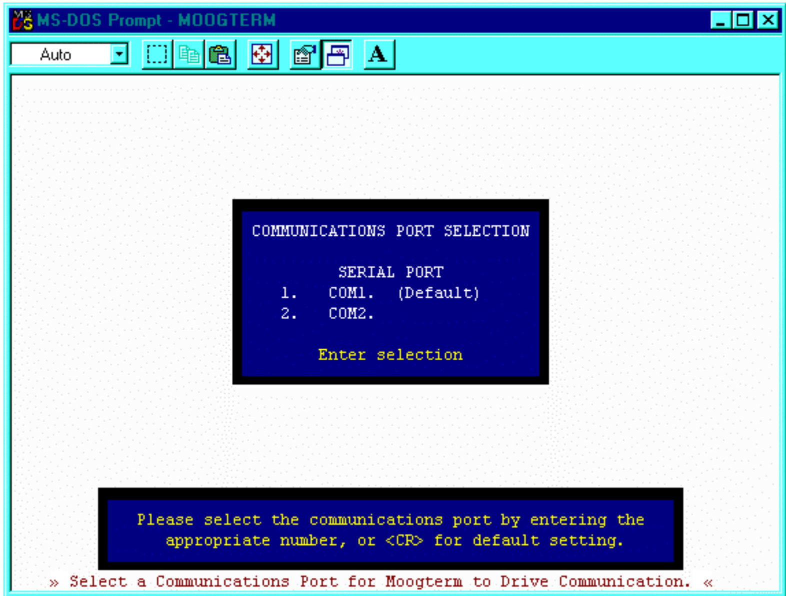


FIGURE 4.50 Communications Port Selection Screen

- ❑ A Controller Type Selection screen will appear. Select option two (2) from the list.

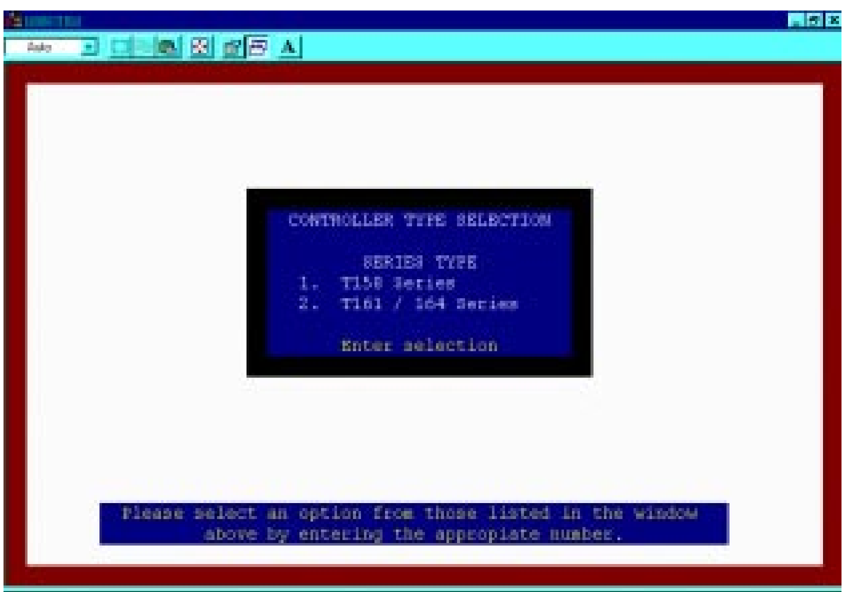


FIGURE 4.51 Controller Type Selection Screen

4.2.2.3 MAIN EMULATOR SCREEN FEATURES

The Moogterm Main Emulator Screen provides a User Interface to setup and monitor the system drive/s.

4.2.2.4 SCREEN LAYOUT

- ❑ Screen Footer: List of available commands.
- ❑ Center of Screen: Used to input command set and view drive data.

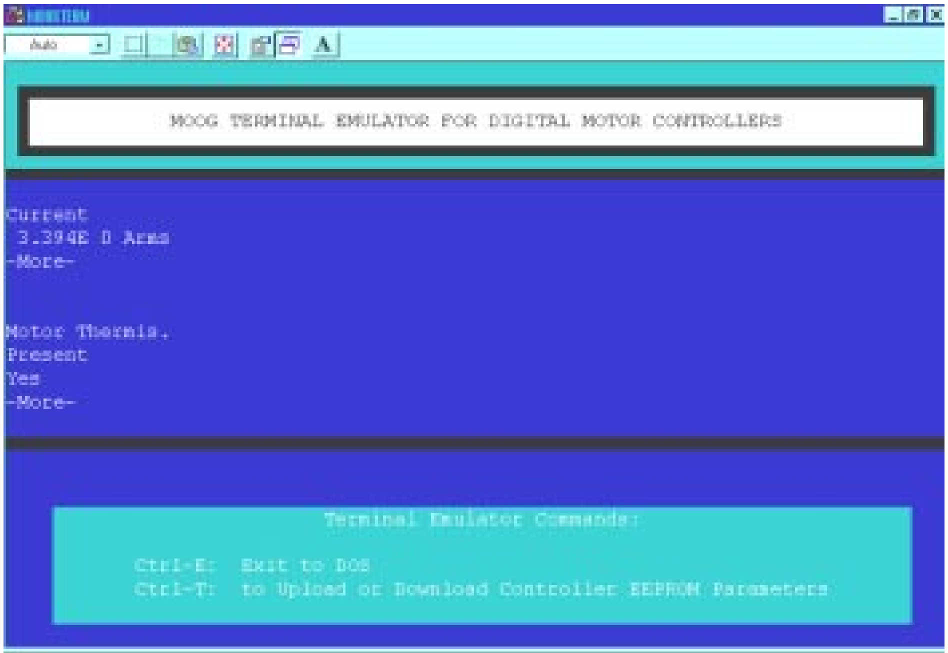


FIGURE 4.52 Main Emulator Screen

4.2.2.5 FUNCTION KEYS

- **Ctrl-E**: Used to exit Moogterm.

- **Ctrl-T**:Opens the File Transfer Function window so the user may choose one (1) of the following:

  ⇒ **D**: To download a parameter file from disk to the drive EEPROM. After selecting "D" you will be asked to enter the file name (8 characters), without the file extension, where the parameters are stored.

  ⇒ **U**: To upload from the drive EEPROM to disk. After selecting "U" the user will be asked to enter a file name (8 characters), without a file extension, where the parameters are to be saved.

  ⇒ **E**: To return to the Main Emulator Screen.

4.2.3 COMMAND LINE FORMAT

Communication to the T164 Series Drive is via a terminal interface using the main menu. The main menu will prompt you to enter a letter in the following format:

>

All main menu command sequences can be recognized by the (**>**) prompt.

Commands use two or sometimes three letters, e.g. [**LP**] or [**STA**]. The first letter is common to a group of parameters and determines the action desired. The second and third letters determine parameters.

The first set of letters acceptable to the main menu are:

[**C**]	Change or Store Configuration Parameters in EEPROM
[**SSM**]	Standard Motor Configuration
[**SNM**]	Non-Standard Motor Configuration
[**I**]	Velocity Loop Integral Time Constant
[**J**]	Observer Inertia
[**L**]	List Parameter
[**M**]	Motor Operational Modes
[**O**]	Options
[**P**]	Velocity Loop Proportional Gain
[**S**]	Set Parameter
[**?**]	Query Operating Conditions

Numbers may be entered using decimal or scientific notation with up to six significant digits.

Examples of valid numeric entries:

> ***-2.9E-2<CR>*** *Enter numbers and press RETURN.*
> ***.029<CR>***
> ***0.029<CR>***
> ***203789<CR>***
> ***203.789E3<CR>***

All numeric entry should be terminated by pressing the RETURN (***<CR>***) key.

Invalid
Command

>

If a mistake is made entering a number, entry may be aborted by making a deliberate error, such as typing x instead of a digit. There is no provision for editing entries.

All numeric parameters entered are compared against an acceptable range. If a parameter is outside this range, then the value is clamped to the appropriate limit of the range. Note, that no message is displayed when entries are truncated. Thus, it is good practice to list all parameters using the appropriate **L** command after they have been entered.

All parameters may be set or listed when the motor is running. However, it is advisable to avoid large changes in parameters when the motor is running.

Other features of the main menu are:

- The [**CTRL X**] key combination will reset the T164 Series Drive and has the same effect on drive firmware as turning the power off then on.
- Commands entered are not case sensitive, e.g. [**SP**] and [**sp**] are both recognized.
- When (**- more -**) is displayed enter any character to continue.
- When current values of parameters are presented, they may be accepted by pressing RETURN (***<CR>***) **.**

4.2.4 DRIVE INITIALIZATION

> **NOTE**
> *The installation and wiring described in Section 2 should be completed and verified before proceeding with drive initialization.*

> **CAUTION**
> *The T164 Series Drives should not be enabled during a.c. power up until the Power Supply Fault Output clears. The user must supply the logic to accomplish this interlock. Failure to delay enabling of the Drives, or having any other external load on the T150-901 Power Supply, on a.c. power up will defeat the proper operation of the soft start circuitry in the T150-901 Power Supply and can result in tripping of the a.c. input circuit breaker and/or damage to the T150-901 Power Supply.*

WARNING

Perform all drive initialization and configuration with the drive hardware enable OFF and power ON. Failure to follow the correct procedure might result in machine damage and/or personal injury.

- ❑ Apply power to the T164 Series drive. Immediately check the T150-901 Power Supply for any fault indications. TURN POWER OFF IF ANY RED LEDs ILLUMINATE ON THE T150-901 POWER SUPPLY. Correct the problem before proceeding.

If the EEPROM contains configuration data, the drive will display the following message:

EEPROM Start

Wait...

The drive saves data in its EEPROM, which is a non-volatile memory. When power is applied the drive will attempt to initialize itself using the data in its EEPROM. If a valid set of parameters is in EEPROM, the following message is then displayed:

Parameters Set
from EEPROM

The drive will be ready to enable once the red SYSTEM FAULT LED stops flashing. The drive will then print its sign-on message which identifies the firmware version and EEPROM ID number.

20 Dec 96	*Firmware Release Date*
C09792-001	*Firmware Version*
EEPROM ID 0	
- more ***-<CR>***	*Press RETURN or any key to proceed.*

If the user knows the configuration and parameters are satisfactory the drive may be enabled without any further input from the terminal. This would be the normal procedure after initialization and tuning have been completed. After the user presses any key to continue, the drive proceeds to the main menu.

>

4.2.4.1 STANDARD MOTOR CONFIGURATION

Drive configuration identifies what motor is connected to the T164 Series Drive. The user must perform drive configuration during initial commissioning or replacement of the equipment and any time a different motor is connected to the drive. The command **SSM** is used for standard motor configuration.

The T164-90X has motor parameters installed for the 300 A, G4XX and D31X series motors. These are considered "standard motors".

Example of standard motor configuration:

> ***SSM<CR>***	*Enter Standard Motor Configuration Command.*
Motor G412-204 ?	*Enter Standard Motor Model Number*
Wait…	
Defaults Set >	

The SYSTEM FAULT LED will flash until drive initialization is complete.

The drive is pre-programmed with all motor parameters for standard motor models, (refer to TABLE 5-4 and TABLE 5-6). For non-standard motor models the user must manually enter the motor parameters, (refer to Section 4.2.4.2).

NOTE

It is very important that the motor model number is entered correctly as the T164 Series Drive sets many parameters automatically based on this configuration. This is also a good point to confirm that the proper drive model is connected to the proper motor.

The T164 Series Drive has now initialized and has set its parameters to the following safe values before returning to the main menu:

- Drive in Velocity Mode.
- Thermal protection enabled.
- Brake control (full extended I/O option card).
- Analog Reference Filter enabled..
- Limit switches disabled (enabled if Extended I/O option card present).
- Manual mode disabled (enabled if Extended I/O option card present).
- Speed scaling set to nominal value of motor speed.
- Low **P** gain and long **I** time constant for velocity loop compensator.

This new configuration data will be lost when power is removed until it is saved to EEPROM, (refer to Section 4.2.5.7). However, this step should wait until all setup and tuning procedures of Sections 4.2.4 and 4.2.5 are completed.

> **NOTE**
> *Re-configuring the drive by changing the motor type, the compensator etc. will cause all previous tuning information to be lost. Option Card parameters, including Encoder Simulation, will also be lost. It is therefore desirable to follow Sections 4.2.4 and 4.2.5 in sequence.*

4.2.4.2 NON-STANDARD MOTOR CONFIGURATION

Applications employing non-standard motor models require the data listed on the following two (2) pages. Skip this Section if using a standard motor.

> **NOTE**
> *The following conversions are useful for motor parameters:*
>
> K_t *(Nm/Arms) = .113 ** K_t *(lb-in/Arms)*
>
> I_c *(Arms) =* T_c *(Nm) /* K_t *(Nm/Arms)*
>
> I_p *(Arms) =* T_p *(Nm) /* K_t *(Nm/Arms)*
>
> *where:*
>
> I_c *= Rated Continuous Motor Phase Current*
>
> T_c *= Rated Continuous Torque*
>
> I_p *= Rated Peak Motor Phase Current*
>
> T_p *= Rated Peak Motor Torque*

To configure for a non-standard motor, proceed with drive initialization as outlined in Section 4.2.4.1 above. Enter the non-standard motor model number when prompted for the motor model number. After confirming the model number entered, the drive will recognize a non-standard motor model number and prompt for entry of motor parameters as shown below.

Example of entering non-standard motor parameters using the ***SNM*** *command:*

> ***SNM<CR>***	*Enter Drive Configuration Command.*
Motor Parameters	
Motor G423-600 ?	*Enter Motor ID Number and Press RETURN*

-More-	*Press RETURN*
Motor Poles 8 ?	*Enter Number of Motor Poles and press RETURN*
-More-	*Press RETURN*
Kt 7.642E-1 Nm/Arms ?	*Enter Torque Constant and press RETURN*
-More-	*Press RETURN*
Rtt 5.099E 0 Ohms ?	*Enter Terminal Resistance and press RETURN*
-More-	
Ltt 1.030E 1 mH ?	*Enter Terminal Inductance and press RETURN*
-More-	*Press RETURN*
Nominal Speed 4.799E 3 RPM ?	*Enter Max Speed at Rated Torque and Press RETURN*
-More-	*Press RETURN*
Maximum Speed 5.500E 3 RPM ?	*Enter Max Motor Speed and Press RETURN*
-More-	*Press RETURN*
Peak Current Limit 9.98E 0 Arms ?	*Enter Peak Current and Press RETURN*
-More-	*Press RETURN*
I gain [0-15] 10 ?	*Enter Current Loop Gain Setting and Press RETURN*
-More-	*Press RETURN*
Resolver Poles 2 ?	*Enter Number of Resolver Poles and Press RETURN*
-More-	*Press RETURN*

Contin. Stall Current 3.99E 0 Arms ?	*Enter Continuous Current and Press RETURN*
-More-	*Press RETURN*
Motor Thermis. *Present (Y/N)* Yes ?	*Enter "Y" if Therm. Present/ Enter "N" if not and Press RETURN*
-More-	*Press RETURN*
Observer Inertia 1.248E 0 Kg cm^2 ?	*Enter Motor Inertia and Press RETURN*
-More-	*Press RETURN*
Wait…	
Defaults Set	
>	

4.2.5 DRIVE TUNING

4.2.5.1 BASIC CONTROL LOOP CONCEPTS

4.2.5.1.1 VELOCITY MODE

FIGURE 4.53 is a block diagram depicting the T164 Series Drive control loop in velocity mode. Software commands are shown outlined above or below the appropriate block which they affect.

The analog input command is input to an analog to digital converter (A/D) either directly or through an input reference filter, as determined by the **OA** command software switch. The **OR** command software switch allows command reference source selection of the digitized input command, (normal operation), or a software programmable function generator, (used for tuning). A programmable offset is summed with the command reference to null offsets in the loop. The digitized command is then scaled by the velocity scale factor, which determines the maximum motor speed for a 10 volt command input. After scaling, the digital velocity command is passed through either the automatic mode velocity limiter or the manual mode velocity limiter depending upon the **OM** command software switch.

The position feedback from the motor mounted resolver is demodulated and passed through an A/D converter. The resulting digital position information is differentiated to obtain motor velocity feedback. The **OO** software switch allows selection of the normal position to velocity conversion or the velocity observer method, (described in Section 4.2.5.5).

The digital velocity feedback and command are compared to generate a velocity error, (torque command), which is passed through a loop compensation network consisting of a proportional gain (**P** term) with a lowpass filter (1^{st} or 2^{nd} order) and an integral gain (**I** term) block. The **P** and **I** terms must be tuned for a particular application.

The torque command is passed through either the automatic mode torque limiter or the manual mode torque limiter, depending upon the **OM** command software switch. The resulting torque command, (current command), is input to the IT foldback block, which protects the motor and the drive from delivering excessive peak currents. Finally the current command enters a digital to analog (D/A) converter after which the analog current command is passed to the power amplifier stage to drive the motor.

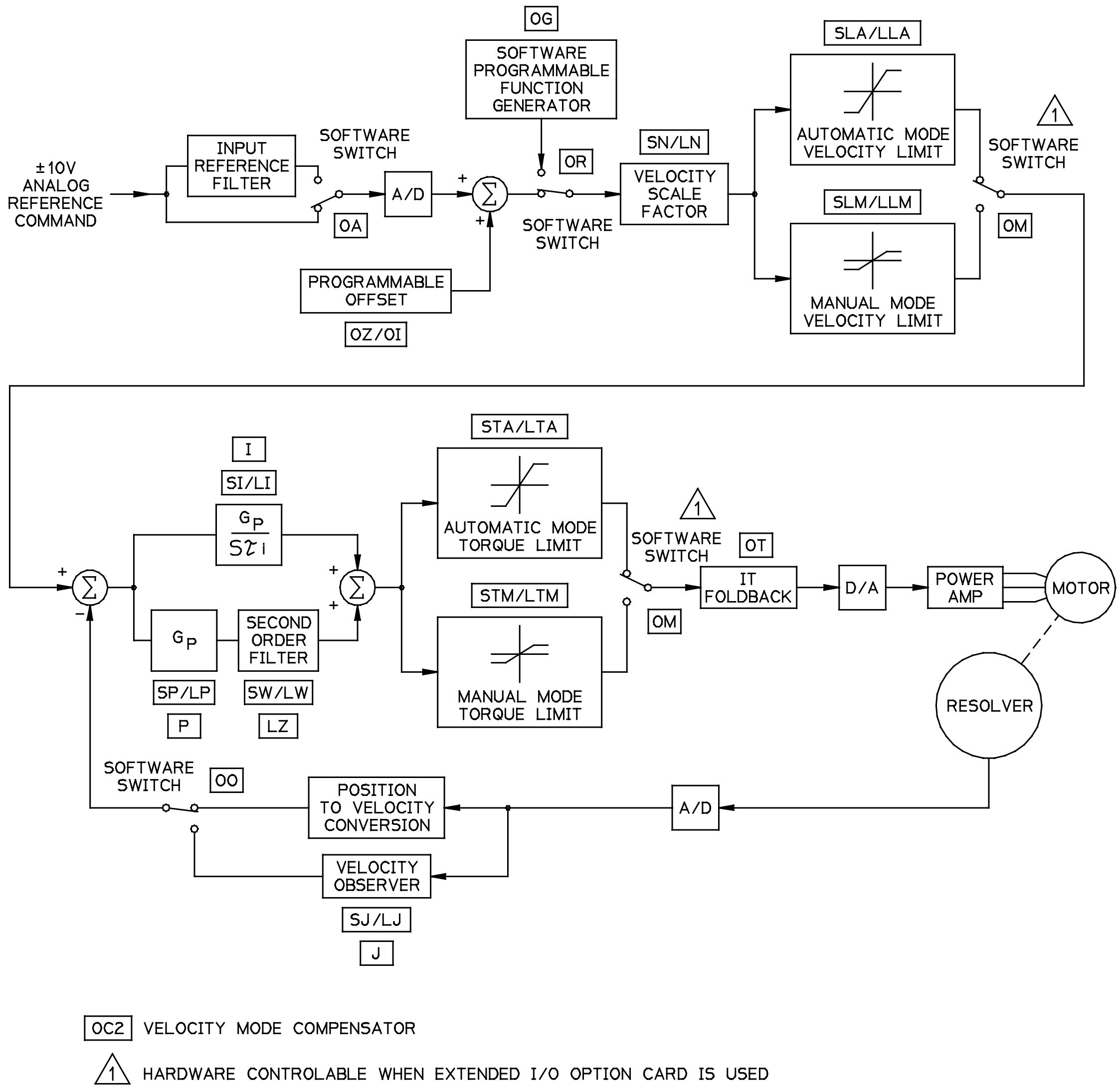


FIGURE 4.53 Velocity Mode Block Diagram

4.2.5.1.2 TORQUE MODE

FIGURE 4.54 is a block diagram depicting the T164 Series Drive control loop in torque mode. Software commands are shown outlined above or below the appropriate block which they affect. Operation is the same as explained above in Section 4.2.5.1.1, except that the input command reference is now a torque command instead of a velocity command, and the velocity scale factor, velocity observer, and **P** and **I** loop compensation networks are not used.

4.2.5.1.3 AUTOMATIC/MANUAL MODE

Automatic and manual modes pertain to the torque and velocity limits. In automatic mode the normal torque and velocity limits are in effect. In manual mode the torque and velocity limits are reduced from the normal (automatic mode) limits.
The manual mode is useful during commissioning to limit available torque and velocity while tuning the drive, or other situations in which full power could present personnel or equipment hazards. Manual mode is enabled or disabled using the **OM** command, and if an Extended I/O Option card is installed, by the absence (manual mode) or presence (automatic mode) of current flowing in the AUTO/MANUAL input. Refer to Section 4.2.6.4.1 for information on enabling and disabling manual mode, Section 4.2.6.1.3 for setting/listing the automatic/manual mode velocity limits and Section 4.2.6.1.7 for setting/listing the automatic/manual mode torque limits.

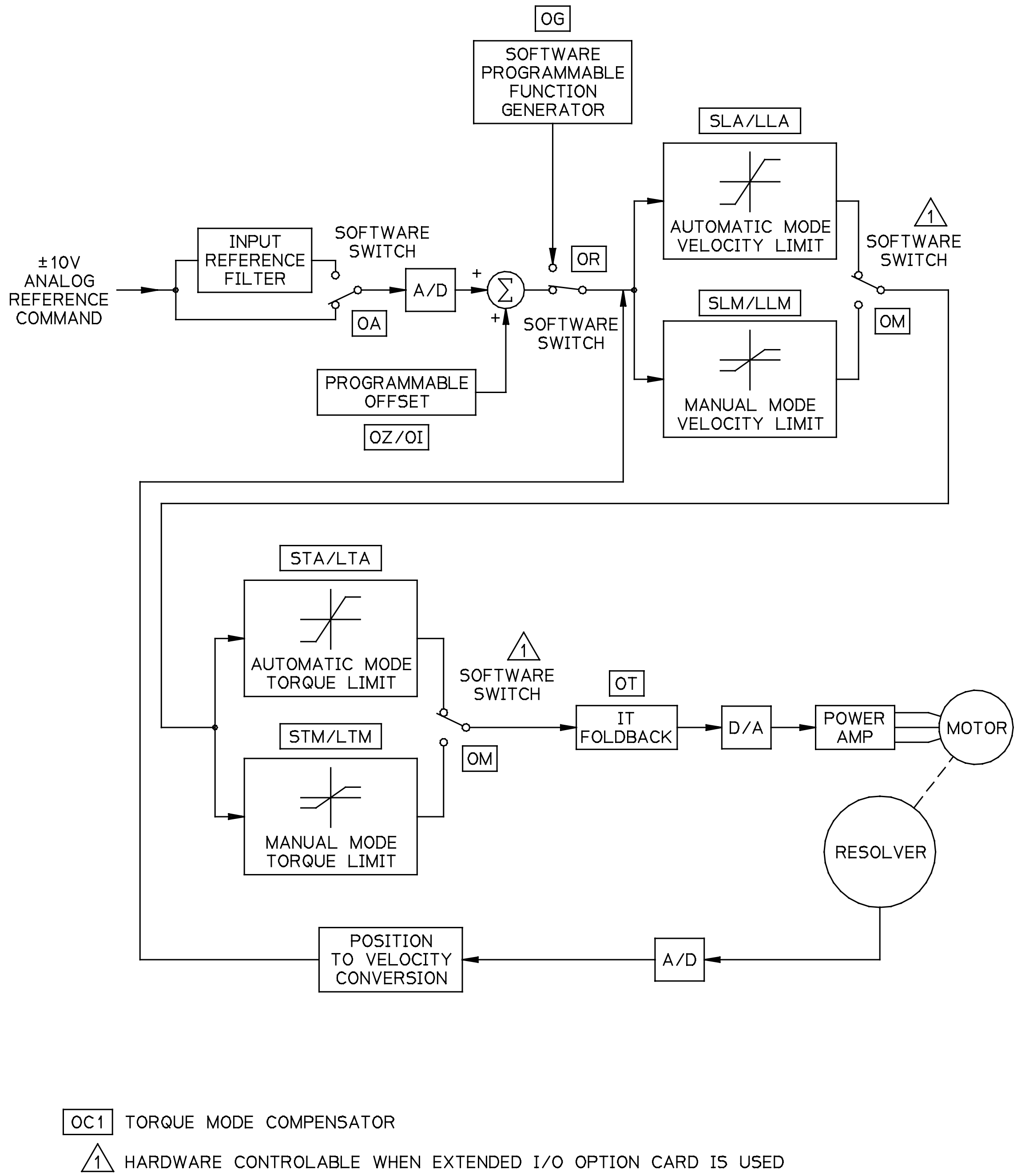


FIGURE 4.54 Torque Mode Block Diagram

4.2.5.2 GAIN ADJUST MODE

The gain adjust mode is for use during tuning of the velocity loop parameters; Integral Time Constant (**I**), the Observer Inertia (**J**), the Velocity Loop Proportional Gain (**P**), and the Position Mode loop gain (**G**).

Use the following list of functions to perform the described action to the gain variables:

- **S** to set the parameter directly (ie: >SP to set the Velocity Loop Proportional Gain)
- **L** to list the present value of the parameter (ie: >LP to list the Velocity Loop Proportional Gain)
- **U** to increase the parameter incrementally (ie: >PU to incrementally increase the velocity loop gain)
- **D** to decrease the parameter incrementally (ie: >PD to incrementally decrease the velocity gain)

Both the X**U** (substitute either **P,I or J** for X) and the X**D** commands operate in an incremental mode that acts like a non-linear software potentiometer. Each time the X**U** command is successively issued, the gain increase factor becomes 5% larger than the previous gain increase factor. Thus, after issuing one X**U** command the second gain value is 1.05 times the first gain value, and after issuing a second X**U** command the third gain value is 1.1025 times the second gain value and 1.158 times the first gain value. This process continues until the gain increase factor reaches 2.0 at which point it is held constant for successive X**U** commands. The X**D** command functions analogously except each successive gain decrease factor becomes 1/1.05 times the previous gain decrease factor, until the gain decrease factor becomes 1.0 E-6 at which value it remains constant.

Example use of the gain adjust mode to set the Velocity Loop Proportional Gain parameter:

> ***LP<CR>***	*List Proportional Gain*
Vel. Loop Gain 7.00e-3 Nm/Rad/S >	
>***SP<CR>***	*Directly Set Proportional Gain*
Vel. Loop Gain 7.00e-3 Nm/Rad/S ?	 *Current Proportional Gain* *Enter New Proportional Gain*
>***PU<CR>***	*Incrementally increase P gain one (1) time*
Velocity Loop Gain Up >	

4.2.5.3 PARAMETER SET-UP

TABLE 4-2 Software Configurable Parameters lists parameters which may be optionally re-configured. Moog recommends that the default configuration of the parameters listed in TABLE 4-2 be used. This Section may be skipped unless special application requirements exist. If the user does desire to change any of these parameters, it should be done before proceeding with loop tuning.

Command	Parameter	Reference Section
SLA/SLM	Automatic and/or Manual Speed Limit	4.2.6.1.3
STA/STM	Automatic and/or Manual Torque Limit	4.2.6.1.7
SW	Compensator Filter Bandwidth	4.2.6.1.8
OA	Enable/Disable Reference Input Filter	4.2.6.4.3
OD	Enable/Disable Thermal Protection	4.2.6.4.9
OT	IT Foldback Limit Settings	4.2.6.4.10

TABLE 4-2 Software Configurable Parameters

4.2.5.4 VELOCITY MODE STANDARD TUNING

After completing drive initialization as described in Section 4.2.4, and changing any other parameters to match specific application requirements as described in Section 4.2.5.3, the user needs to tune the velocity loop to optimize performance. This Section provides a recommended velocity mode standard tuning procedure. The procedure should be followed in the sequence listed. For torque mode applications proceed to Section 4.2.5.6.

WARNING
The motor should be uncoupled if incorrect movements during the drive tuning procedure can damage the machine. If this is not possible, the safety limit switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.

- ❑ Disable the drive, using the hardware enable switch.

- ❑ Set the Control Compensator to Velocity Mode using the **OC2** command, (refer to Section 4.2.6.4.2).

- ❑ Set the Velocity Scale Factor to match the RPM of the motor to a given velocity command input using the **SN** command, (refer to Section 4.2.6.1.5). This step is only necessary if the input command range is less than 10 volts or the desired maximum motor speed is less than the motor no-load speed.

- ❑ Set the drive to manual mode using the **OM** command, (refer to Section 4.2.6.4.11).

- ❑ The drive is tuned using a low frequency square wave command while observing the velocity response on an oscilloscope. The low frequency square wave can be supplied from an external source, or by the internal software function generator as described below.

- ❑ Set the command reference source to the function generator using the **OR** command, (refer to Section 4.2.6.4.1). Set up the function generator parameters to 10% of rated motor speed amplitude, 0 RPM speed offset, 1 second period, and 50% duty cycle.

WARNING
Ensure that the application allows using this speed amplitude and length of travel, (period, duty cycle), without damage to the machine before proceeding with the tuning procedure.

- ❑ For monitoring velocity, connect an oscilloscope to TP2 with common on TP3 with the following settings:

Horizontal Amp:	20 ms/Division
Vertical Amp:	1 V/Division

- ❑ Direct the velocity feedback signal to TP2 using the **OFB2** command, (refer to Section 4.2.6.4.8).

The two (2) principle parameters affecting the velocity loop dynamics are the Velocity Loop Proportional Gain (**P**) and the Integral Time Constant (**I**).

The proportional gain term affects the amplification of the error between actual velocity and reference velocity. The higher the P term the more the error is amplified. A high gain produces a “stiff” velocity loop response.. Generally, axes with higher inertia need higher gain settings. Gain can not be increased without bound, as excessive gain will cause the loop to become unstable.

The integral time constant affects the loop response, or how fast an axis will respond to a velocity disturbance. If response is too low, (**I** too high), the axis will be slow to react and might start oscillating because it can't keep up with the disturbance. If response is too high, (**I** too low), the axes will respond to almost any disturbance, (including electrical noise), and may start a higher frequency resonance or chatter.

- ❑ The **P** term should be adjusted first. Turn off the **I** gain by using the **SI** command, (refer to Section 4.2.6.1.1), to set **I** equal to 3 seconds. Use the **LI** command to confirm a value for the integral time constant of Infinity, indicating the integrator is turned off.

- ❑ Enable the drive, hardware enable first then **MI** software enable, with the function generator initialized as detailed above.

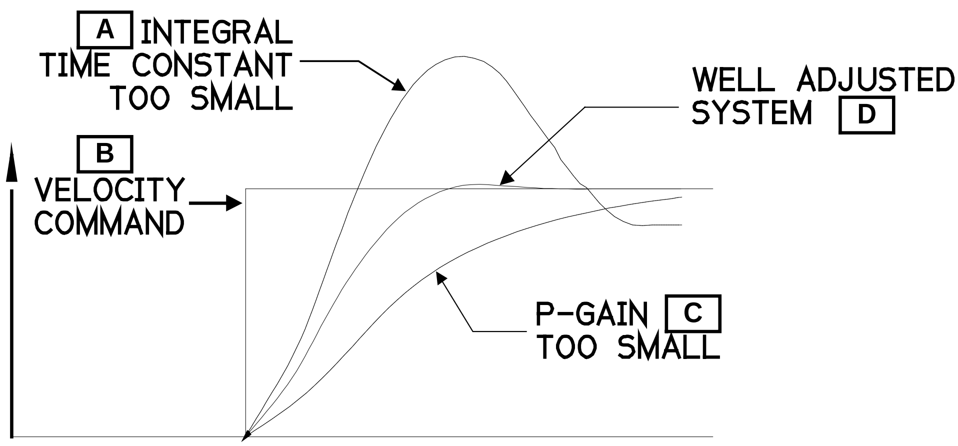


FIGURE 4.55 Standard Velocity Mode Tuning Waveforms

- ❑ Use the **PU** command to (refer to Section 4.2.5.2).increase the **P** gain until the shaft is turning.

- ❑ Set the drive to automatic mode, (disable manual mode), using the **OM** command, (refer to Section 4.2.6.4.11).

- ❑ Use the **PU** command while monitoring the velocity response on the oscilloscope, to increase the **P** gain until a slight overshoot occurs in the velocity response. Use the **PD** command to decrease the **P** gain until the overshoot just disappears.

- ❑ Use the **IU** command to adjust the velocity loop integral time constant, (refer to Section 4.2.5.2). Using the **IU** command increase the loop response until a slight overshoot occurs again.

- ❑ Use the **PU** command to improve the slope of the step response. FIGURE 4.55 illustrates the velocity wave form for a properly tuned loop.

- ❑ Use the **OR** command to set the command reference to the analog reference, (refer to Section 4.2.6.4.1).

- ❑ Offsets in the drive and the users' velocity command may be trimmed out with the automatic offset command. Apply the desired zero speed command to the drive and issue the **OZ** command, (refer to Section 4.2.6.4.6).

- ❑ Use the **C** command to save configuration data in EEPROM, (refer to Section 4.2.5.7).

4.2.5.5 VELOCITY OBSERVER TUNING

This Section explains the set-up and tuning of the velocity observer. The use of the observer will usually allow significantly higher velocity loop gains and bandwidths to be achieved. The observer uses a software model of the motor and load to calculate a velocity estimate. The user needs to tune only one additional parameter to use the observer. The observer is set up using the following procedure:

- ❑ Tune the velocity loop using the normal procedure described in Section 4.2.5.4. FIGURE 4.56(A) shows a typical tuned velocity loop response to a step reference command. It shows the torque response on the drives' TP1 test point and the actual velocity response on TP2. The size of the step velocity reference should be small enough to avoid saturation of the torque signal. Note the single overshoot of about 24% in the velocity response and the 12 ms settling time.

- ❑ Tune the observer by setting up the observer inertia parameter, J_{est}. Monitor the observer error signal θ_{err} at the drives' TP1 test point by using the **OFA5** command. FIGURE 4.56(B) shows the usual starting point for tuning: J_{est} is too small. Use the **JU**, **JD** or **SJ** commands to adjust J_{est} (refer to Sections 4.2.5.2 and 4.2.6.1.2). FIGURE 4.56(B) also shows θ_{err} when J_{est} is tuned correctly, θ_{err} steps with a slight ripple superimposed. θ_{err} is a measure of the model uncertainty, and of any disturbance torque which may be present. Normally there will be some viscous friction present, so that θ_{err} will step appropriately when the shaft velocity makes a step change.

> **NOTE**
> *If θ_{err} oscillates excessively when the velocity makes a step change, as shown in FIGURE 4.56(C), then do not use the observer, since the load may not be modeled adequately by the observer.*

- ❑ As a final check of proper tuning, enter **OFA4** to monitor observer velocity on TP1, and compare it with the actual velocity response which was shown on TP2 in FIGURE 4.56(A). These should be identical.

- ❑ Switch on the observer by using the **OO** command, (reference Section 4.2.6.4.4), and then **Y** to the subsequent prompt. FIGURE 4.56(D) shows the velocity loop response when the observer is switched into the loop. Note the lack of overshoot, because of a better measurement of velocity. The servo noise generated is also reduced.

- ❑ In order to achieve higher gains, the compensator filter frequency may now be set higher, using the **SW** command, (refer to Section 4.2.6.1.8). Typically this frequency may be set to 600 Hz, depending on motor servo noise. The **P** and **I** gains may now be tuned up again, in the normal fashion described in Section 4.2.5.4. FIGURE 4.56(E) compares the response of an observer based system with a normal velocity loop system. Now the response settles in just 2.2 ms, whereas without the observer the step settled in about 12 ms. The observer response also shows a smaller overshoot.

- ❑ Use the **C** command to save configuration data in EEPROM, (reference Section 4.2.5.7).

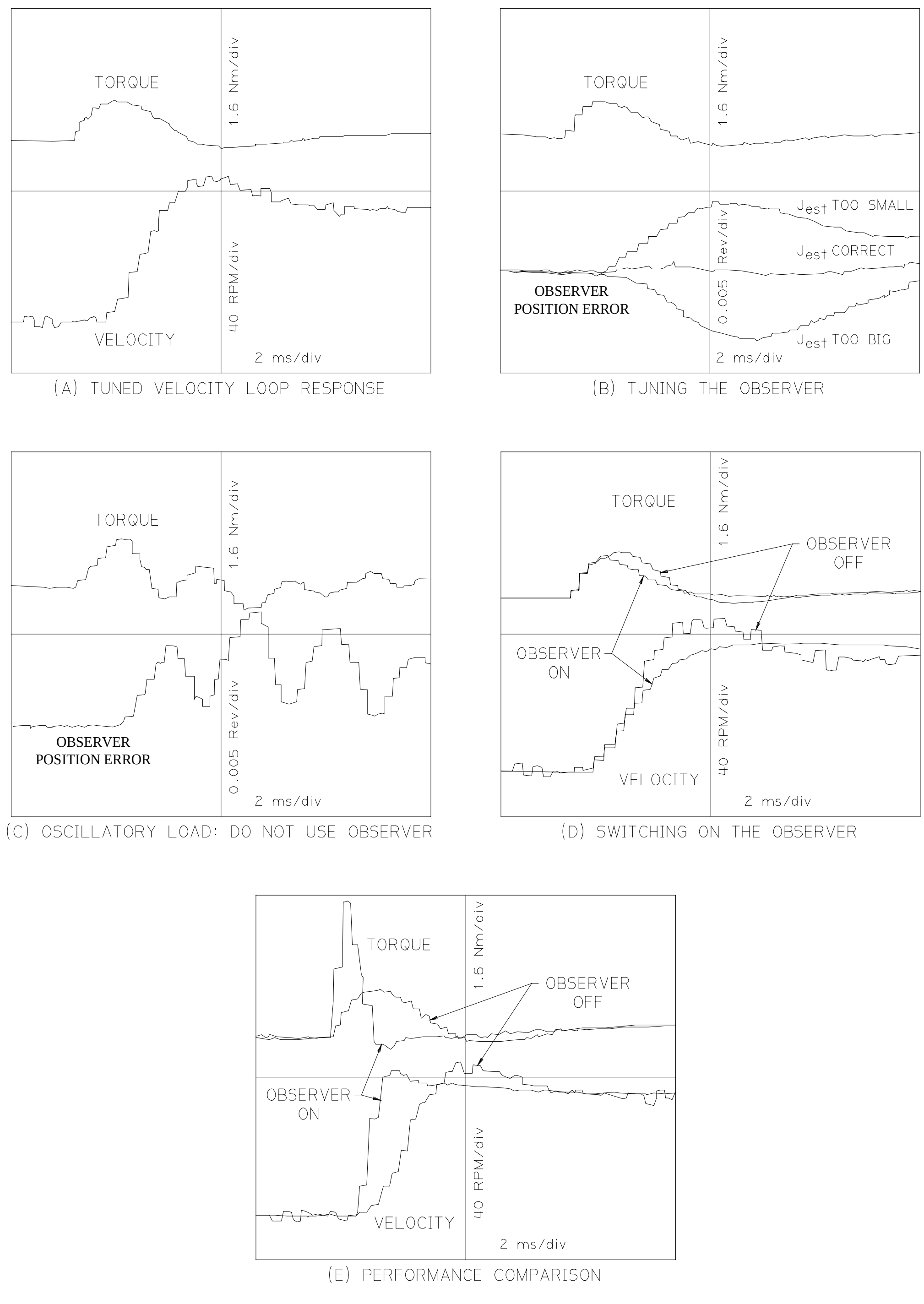


FIGURE 4.56 Velocity Observer Tuning Waveforms

4.2.5.6 TORQUE MODE TUNING

In torque mode, the input command reference is a current command to the power amplifier that drives the motor. The term torque mode is adopted because the motor produces a nearly linear torque per ampere of input current. The tuning of the inner current loops of the T164 Series drives is pre-programmed during drive initialization. Hence, no parameter tuning is required in torque mode. Skip this Section for standard or observer velocity mode applications.

> **WARNING**
>
> *The motor should be uncoupled if incorrect movements during the drive tuning procedure can damage the machine. If this is not possible, the safety limit switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.*

- ❑ Set the Control Compensator to Torque Mode using the **OC1** command, (refer to Section 4.2.6.4.2).
- ❑ Offsets in the drive and the users' torque command may be trimmed out with the automatic offset command. Apply the desired zero speed command to the drive and issue the **OZ** command, (refer to Section 4.2.6.4.6).
- ❑ Use the **C** command to save configuration data in EEPROM, (refer to Section 4.2.5.7).

4.2.5.7 SAVING CONFIGURATION DATA

Upon completion of drive parameter set-up and tuning, the configuration parameters should be permanently saved in EEPROM using the **C** command. Any parameter changes made will be lost when power is removed if they are not saved in EEPROM.

> **NOTE**
>
> *Only one set of parameters can be stored in EEPROM at a time.*

It is not recommended that a configuration with the function generator active be saved in EEPROM. The **OR** command, (refer to Section 4.2.6.4.1), can be used to switch off the function generator.

*Example usage of the **C** command:*

> ***C<CR>***	*Enter Save Configuration Command.*

EEPROM Save
Wait…

>

4.2.6 COMMAND REFERENCE (BASE DRIVE MODELS)

This Section provides detailed information on all T164 Series Drive H1 software commands including default values, limit values, and examples of usage, for base drive models. Additional commands and command extensions for the Encoder Simulation Option Card and the Extended I/O Option Card are detailed in Sections 4.2.7 and 4.2.8 respectively.

4.2.6.1 SETTING AND LISTING PARAMETERS

4.2.6.1.1 SETTING/LISTING [SI/LI] VELOCITY LOOP INTEGRAL TIME CONSTANT

The **SI** command sets the velocity loop integral time constant required for tuning in the velocity mode (refer to Section 4.2.5.4). Setting the velocity loop integral time constant greater than or equal to 3 seconds, turns off the velocity loop integrator.

Velocity Loop Integral Time Constant Units:	Seconds
Velocity Loop Integral Time Constant Default Value (Depends upon motor model):	
D312-L05 to D313-L40, 302-029A to 303-030A:	0.1
D314-L05 to D314-L40, 304-111A to 304-151A:	0.2
D315-L10 to D315-L50, 305-111A to 305-141A	0.2
D316-L15 to D316-L60, 306-111A to 306-141A:	0.5
Velocity Loop Integral Time Constant Min. Value:	0.5 E-3
Velocity Loop Integral Time Constant Max Value:	6

Issue **C** command to permanently save changes made using **SI**.

*Example usage of **SI** command:*

> ***SI<CR>***

Integral
Time Const
 2.000E-1 Secs
? ***.25<CR>***
>

The **LI** command lists the current velocity loop integral time constant. A value of Infinity is reported by the **LI** command when the integrator is off.

*Example usage of **LI** command:*

> ***LI<CR>***

Integral
Time Const
 2.500E-1 Secs
>

4.2.6.1.2 SETTING/LISTING [SJ/LJ] VELOCITY OBSERVER INERTIA

The **SJ** command sets the observer inertia parameter used for tuning in the optional velocity observer mode (refer to Section 4.2.5.5).

Velocity Observer Inertia Units:	Kilogram-cm^2
Velocity Observer Inertia Default Value:	2^*J_{motor}
Velocity Observer Inertia Min. Value:	None
Velocity Observer Inertia Max Value:	None

Issue **C** command to permanently save changes made using **SJ**.

*Example usage of **SJ** command:*

> ***SJ<CR>***

Observer Inertia
1.399E-4 kg m^2
? ***1.5E-4 <CR>***
>

The **LJ** command lists the current velocity observer inertia.

*Example usage of **LJ** command:*

> ***LJ<CR>***

Observer Inertia
1.499E-4 kg m^2
>

4.2.6.1.3 SETTING/LISTING [SLA/SLM/LLA/LLM] MOTOR VELOCITY LIMITS

The **SLA/SLM** commands set the automatic/manual mode motor velocity limits. Manual mode is intended to be a reduced power operating mode used for initial tuning or other situations in which full power could present personnel or equipment hazards, (refer to Section 4.2.5.1.3). Although it is possible to set manual velocity limits higher than automatic velocity limits, this is not recommended because it defeats the safety principle of manual mode being a reduced power mode.

Automatic/Manual Mode Velocity Limits Units:	Revolutions Per Minute
Automatic Mode Velocity Limit Default Value:	Velocity Scale Factor (N)*10 Volts (Max RPM)
Automatic Mode Velocity Limit Min. Value:	50
Automatic Mode Velocity Limit Max Value:	Motor Dependent
Manual Mode Velocity Limit Default Value:	10% * Automatic Mode Default Value
Manual Mode Velocity Limit Min. Value:	50
Manual Mode Velocity Limit Max Value:	Motor Max Speed

Issue **C** command to permanently save changes made using **SLA** and **SLM**.

*Example usage of **SLA** and **SLM** commands:*

> ***SLA<CR>***

Automatic Mode
Velocity Limit
5.800E 3 RPM
? ***4000 <CR>***

> ***SLM<CR>***

Manual Mode
Velocity Limit
5.800E 2 RPM
? ***400 <CR>***
>

The **LLA/LLM** commands list the automatic/manual mode motor velocity limits.
*Example usage of **LLA** and **LLM** commands:*

> ***LLA<CR>***

Automatic Mode
Velocity Limit
4.000E 3 RPM

> ***LLM<CR>***

Manual Mode
Velocity Limit
4.000E 2 RPM
>

4.2.6.1.4 LISTING [LM] MOTOR PARAMETERS

The **LM** command lists the current motor parameters:
*Example usage of **LM** command:*

> ***LM<CR>***

Motor:-
304-111A
- more -***<CR>*** *Press RETURN or any key to proceed.*

Motor Poles
12
- more -***<CR>*** *Press RETURN or any key to proceed.*

Kt
4.654E-1 Nm/Arms
- more -***<CR>*** *Press RETURN or any key to proceed.*

Rtt
5.099E 0 Ohms
-More- -***<CR>*** *Press RETURN or any key to proceed*

Ltt
1.030E 1 mH
-More--***<CR>*** *Press RETURN or any key to proceed*

Nominal Speed
5.800E 3 RPM
- more -***<CR>*** *Press RETURN or any key to proceed.*

Maximum Speed
5.500E 3 RPM
-More--***<CR>*** *Press RETURN or any key to proceed*

Peak Current
Limit
8.699E 0 Arms
- more -***<CR>*** *Press RETURN or any key to proceed.*

I gain
10
-More--***<CR>*** *Press RETURN or any key to proceed*

Resolver Poles
2
-More--***<CR>*** *Press RETURN or any key to proceed*

Cont. Stall
Current
3.394E 0 Arms
-More--***<CR>*** *Press RETURN or any key to proceed*

Motor Thermis.
Present
Yes

-More--***<CR>*** *Press RETURN or any key to proceed*
Observer Inertia
1.250E 0 Kg cm^2
>

4.2.6.1.5 SETTING/LISTING [SN/LN] VELOCITY SCALING

The **SN** command selects the velocity scaling. The velocity scaling is the speed that corresponds to a 10 volt input velocity command. Normally, this is the motor no-load speed. For a maximum input command less than 10 volts or a desired maximum speed less than the maximum rated motor speed use the following equation to calculate the velocity scaling RPM to enter:

$$VelocityScalingRPM = MaxrequiredRPM * \frac{10}{MaxInputCommandVoltage}$$

Where: Max Input Command Voltage < 10 and
Max Required RPM < Max Rated Motor RPM

Velocity Scale Factor Units:	Revolutions Per Minute at 10 Volt Command Input
Velocity Scale Factor Default Value:	Motor Nominal Speed
Velocity Scale Factor Min. Value:	200
Velocity Scale Factor Max Value:	15,000

Issue **C** command to permanently save changes made using **SN**.

*Example usage of **SN** command, set 5 volt maximum command input equal to 3000 RPM maximum required RPM:*

> ***SN<CR>***

Veloc. Scaling
5.800E 3 RPM/10V
? ***6000 <CR>*** *(3000 RPM at 5V)*
>

The **LN** command lists the current velocity scaling.

*Example usage of **LN** command:*

> ***LN<CR>***

Veloc. Scaling
4.799E 3 RPM/10V
>

4.2.6.1.6 SETTING/LISTING [SP/LP] VELOCITY LOOP PROPORTIONAL GAIN

The **SP** command sets the velocity loop proportional gain, required for tuning in velocity mode, (refer to Section 4.2.5.4).

Velocity Loop Proportional Gain Units:	Newton-meters / Radian per Second
Velocity Loop Proportional Gain Default Value (Depends upon motor model):	
D312-L05 to D313-L40	0.001
303-030A	0.001
D314-L05 to D314-L40, 304-111A to 304-151A:	0.01
D315-L10 to D315-L50, 305-111A to 305-141A:	0.05
D316-L15 to D316-L60, 306-111A to 306-141A:	0.2
Velocity Loop Proportional Gain Min. Value:	1 E-8
Velocity Loop Proportional Gain Max Value:	1 E8

Issue **C** command to permanently save changes made using **SP**.

*Example usage of **SP** command:*

```
> SP

Veloc. Loop Gain
 1.000E-2  Nm/Rad/s
 ?<CR>
>
```

The **LP** command lists the current velocity loop proportional gain.

*Example usage of **LP** command:*

```
> LP<CR>

Vel. Loop Gain
 1.000E-2 Nm/Rad/S
>
```

4.2.6.1.7 SETTING/LISTING [STA/STM/LTA/LTM] MOTOR TORQUE LIMITS

The **STA** command sets the automatic mode torque limit and the **STM** command sets the manual mode torque limit. The drive current limit value is the lesser of the drive current rating and the motor peak current rating. Manual mode is intended to be a reduced power operating mode used for initial tuning or other situations in which full power could present personnel or equipment hazards, (refer to Section 4.2.5.1.3). Although it is possible to set manual velocity limits higher than automatic velocity limits, this is not recommended because it defeats the safety principle of manual mode.

Automatic / Manual Mode Torque Limits Units:	Newton meters
Automatic Mode Torque Limit Default Value:	Drive Current Limit * K_t
Automatic Mode Torque Limit Min. Value:	0
Automatic Mode Torque Limit Max Value:	Drive Current Limit * K_t
Manual Mode Torque Limit Default Value:	10% * Drive Current Limit * K_t
Manual Mode Torque Limit Min. Value:	0
Manual Mode Torque Limit Max Value:	Drive Current Limit * K_t

Issue **C** command to permanently save changes made using **STA** and **STM**.

*Example usage of **STA** and **STM** commands:*

> ***STA<CR>***	*Enter command to set automatic mode torque limit.*
Automatic Mode Torque Limit 4.040E 0 Nm	
? ***<CR>***	*Accept the current value.*
> ***STM<CR>***	*Enter command to set manual mode torque limit.*
Manual Mode Torque Limit 4.000E-1 Nm	
? ***<CR>***	*Accept the current value.*
>	

The **LTA** command lists the current automatic mode torque limit and the **LTM** command lists the manual mode torque limit.
*Example usage of **LTA** and **LTM** commands:*

> ***LTA<CR>***	*Enter command to list automatic mode torque limit.*
Automatic Mode Torque Limit 4.040E 0 Nm	
> ***LTM<CR>***	*Enter command to list manual mode torque limit.*
Manual Mode Torque Limit 4.000E-1 Nm	
>	

4.2.6.1.8 SETTING/LISTING [SW/LW] COMPENSATOR FILTER BANDWIDTH

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The **SW** command sets the bandwidth parameter, Wn, of the second order compensator filter, (refer to Sections4.2.5.1.1 and 4.2.5.1.2).

Wn Units:	Hertz
Wn Default Value (Depends upon motor model):	
D312-L05 to D313-L40, 302-029A to 303-030A:	286.4
D314-L05 to D314-L40, 304-111A to 304-151A:	190.9
D315-L10 to D315-L50, 305-111A to 305-141A:	191
D316-L15 to D316-L60, 306-111A to 306-141A:	191
Wn Min. Value:	100.2
Wn Max Value:	599.8

Issue **C** command to permanently save changes made using **SW**.

*Example usage of **SW** command:*

> ***SW<CR>***	*Enter command to set filter freq.*
Second Order Filter Freq. 1.909E 2 Hz	
Wn ? ***200 <CR>***	*Set the Filter Freq to 200 Hz*
>	

The **LW** command lists the current second order filter bandwidth parameter, Wn.

*Example usage of **LW** command:*

> ***LW<CR>***	*Enter command to list filter freq.*
Second Order Filter Freq 1.999E 2 Hz >	

4.2.6.1.9 LISTING [LZ] FILTER DAMPING RATIO ZETA

The **LZ** command lists the current damping ratio parameter, Zeta, of the second order compensator filter, (refer to Sections 4.2.5.1.1 and 4.2.5.1.2).

Zeta Units:	Dimensionless
Zeta Default Value:	0.7

*Example usage of **LZ** command:*

> ***LZ<CR>***	*Enter command to list filter damping ratio.*
Filter Zeta 7.000E-1 >	

4.2.6.2 MOTOR OPERATIONAL MODES

4.2.6.2.1 STARTING/STOPPING [MI/MO] THE MOTOR

The **MI** command provides a software enable for the motor, while the **MO** command provides a software disable for the motor. The hardware enable input overrides the software enable **MI** command. The **MI** command is also used for enabling the motor when using the internal software function generator, (refer to Section 4.2.6.4.7).

*Example usage of **MI** and **MO** commands:*

> ***MI<CR>***	*Enter Command to Software Enable Motor.*
> ***MO<CR>***	***MO*** *will disable motor.*

Drive Disabled
>

WARNING

Rapid machine movement can result when the MI command is used. Issue this command only when ALL personnel are outside of the machine workcell and a hardware disable switch is directly accessible.

4.2.6.3 OPERATING CONDITIONS

4.2.6.3.1 MOTOR SHAFT POSITION [?P]

The **?P** command queries the motor shaft position.

*Example usage of **?P** command:*

> ***?P<CR>***

Motor Position
2.985E 2 Deg
>

4.2.6.3.2 MOTOR SHAFT VELOCITY [?V]

The **?V** command queries the motor shaft velocity. The speed reported is an average of the last one hundred sample periods.

*Example usage of **?V** command:*

> ***?V<CR>***
Average
Velocity
-4.861E 1 RPM
>

4.2.6.3.3 CURRENT LIMITS [?L]

The **?L** command lists the Max current limit setting:
Note that the current limits are the lesser of motor model limits or drive model limits.

*Example usage of **?L** command:*

> ***?L<CR>***
Max Current
8.690E 0 Arms
>

4.2.6.3.4 BRIDGE TEMPERATURE [?B]

The **?B** command lists the drive bridge temperature.

*Example usage of **?B** command:*

> ***?B<CR>***
Bridge
Temp.
(90.0) DegC
>

4.2.6.3.5 MOTOR TEMPERATURE [?M]

The **?M** command lists the motor thermistor temperature.. Note that the user must wire the motor thermistor wires to the T164 Series drive to detect a motor over temperature fault.

*Example usage of **?M** command:*

> ***?M<CR>***
Motor Temp.
(0.0) DegC
>

4.2.6.3.6 DRIVE STATE [?S]

The **?S** command lists the present state of the following drive parameters;

- Compensator
- Thermal Protection
- Brake Enable
- Velocity Observer
- Limit Switches
- Manual Mode
- Analog Reference Filter

*Example usage of **?S** command:*

> ***?S<CR>***	
Controller Status	
Compensator:- 1 Torque Mode 2 Velocity Mode 2	*(Displays configuration data)*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Limit Switches Disabled Yes	*Limit switch mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Thermal Protect Disabled No	*Motor Thermal Protection Mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Manual Mode Disabled Yes	*Manual Limit Mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Break Released No	*Brake Mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Analog Ref. Filter Enabled Yes	*Analog Filter Mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Observer Veloc Enabled No >	*Velocity Observer*

4.2.6.3.7 FAULTS [?F]

The **?F** command lists the present fault status including what faults have occurred and what faults are still present. Faults reported are:

- Resolver Fault
- Short Circuit Fault
- Motor Temp. Fault
- Drive Over Temperature
- Logic Power Supply Fault
- Bus Over Voltage Fault

*Example usage of **?F** command:*

> ***?F***
Parameter
Fault
-more ***<CR>***

Resolver
Fault Occurred
-more ***<CR>***

Resolver
Fault Present
-more-***<CR>***
>

4.2.6.4 OPTIONS

4.2.6.4.1 COMPENSATOR REFERENCE SOURCE [OR]

The **OR** command selects either the analog input ,software function generator or the point interface as the input command reference source.

Default State: Analog Input

The following example shows selection of the analog input as the reference source. (See Section 4.2.6.4.7 for example showing selection of the function generator as the input reference source.)

Issue **C** command to permanently save changes made using **OR**.

*Example usage of **OR** command:*

> **OR<CR>**
Options:-
1 Analog Ref
2 Function Gen.
3 Point I/F
? ***1<CR>*** *Enter 1,2, or 3 to choose command reference.*
>

4.2.6.4.2 CONTROL COMPENSATOR SELECTION [OC]

The **OC** command selects between torque (1), velocity (2) modes of operation.

Default State: Velocity Mode Compensator

> **NOTE**
> *Changing the compensator will reset all parameters to default values.*

Issue **C** command to permanently save changes made using **OC**.

*Example usage of **OC** command:*

> ***OC<CR>***	
Control	
Options:-	
1 Torque Mode	
2 Velocity Mode	
2	
?	*Enter 1 for Torque Mode, 2 for Velocity Mode, The SYSTEM FAULT LED flashes during reconfiguration.*

4.2.6.4.3 REFERENCE INPUT FILTER [OA]

The **OA** command enables or disables the command reference input filter. This is a low pass filter with a -3dB point of 1 KHz, (refer to Section 5.2.2.3). It is used to attenuate high frequency noise on the input command signal.

Default State: Reference Filter Enabled

Issue **C** command to permanently save changes made using **OA**.

*Example usage of **OA** command:*

> ***OA<CR>***	
Enable Analog	
Reference	
Filter (Y/N)	
Yes	
? ***Y<CR>***	*Reply Y to enable, N to disable filter*
>	

4.2.6.4.4 OBSERVER ENABLE/DISABLE [OO]

The **OO** command enables or disables the velocity observer software, (see Section 4.2.5.5).

Default State:	Observer Disabled

> Issue **C** command to permanently save changes made using **OO**.

*Example usage of **OO** command:*

> ***OO<CR>***
Enavle Observer
Velocity (Y/N)
No
? *Reply Y to enable, N to disable observer*
>

4.2.6.4.5 INPUT OFFSET ADJUST [OI]

The **OI** command adjusts the input offset voltage.

Offset Units:	mV
Default Offset Value:	0
Min. Offset Value:	-700
Max Offset Value:	700

> Issue **C** command to permanently save changes made using **OI**.

*Example usage of **OI** command:*

> ***OI<CR>***

Analog Input
Offset
(0.0) mV *Current value displayed.*
? ***100 <CR>*** *Enter desired offset value.*
>

4.2.6.4.6 AUTOMATIC OFFSET ADJUST [OZ]

The automatic offset adjust command [**OZ**] allows the input voltage to be automatically nulled to compensate external and internal offsets. The correct procedure for use is:

- Set command value from the host, (CNC, PLC, etc.) to zero.
- Issue the **OZ** command at the **>** prompt.

On receiving the **OZ** command, the drive takes 200 ms to determine the average of the next 100 samples of the analog reference voltage and place the negative of the result in the input offset register. The offset will be limited to a maximum value of +/- 700 mV. The default offset value is 0 mV.

Issue **C** command to permanently save changes made using **OZ**.

*Example usage of **OZ** command:*

> ***OZ<CR>***
Zero Analog
Input Offset
>

4.2.6.4.7 FUNCTION GENERATOR OPTIONS [OF]

A software function generator, intended to be used for tuning of the drive, is available to be used as the reference command source. The function generator provides a square wave, programmable in amplitude, offset, period, and duty cycle.

The function generator has the following parameters:

Parameter	Units	Range	Default Value
Speed Amplitude	RPM	0 to 18,000	0
Speed Offset	RPM	±18,000	0
Torque Amplitude	Nm	0 to Peak Torque	0
Torque Offset	Nm	-Peak Torque to Peak Torque	0
Period	s	0 to 10 Seconds	1
Duty Cycle	%	0 to 99.9	50

TABLE 4-3 Function Generator Parameters

The duty cycle parameter specifies the percentage of the period that the speed or torque amplitude is positive. For the rest of the period, the speed or torque amplitude is negative.

The speed and torque offsets, allow unequal speeds or torques in both directions, or unipolar speeds.

Speed Amplitude and Offset parameters are only activated when the drive is operating in velocity mode. Similarly, Torque Amplitude and Offset parameters are only activated when the drive is operating in torque mode.

The function generator is set up from the main menu using the following command sequence. The command reference must be initialized to the function generator using the **OR** command.

*Example usage of **OR** command:*

> ***OR<CR>***
Options:-
1 Analog Ref
2 Function Gen.
3 Point I/F
? ***2<CR>*** *Select Function Generator as Reference Source*

>

As long as the function generator is selected as the command reference, and after initially setting parameters, the **OFN** command can be used to edit speed amplitude, the **OFT** command can be used to edit torque amplitude, and the **OFP** command can be used to edit the period (see section 4.2.9.2.6 for complete list of commands). When function generator parameter initialization is selected the motor is software disabled. Issue an **MI** command to re-enable after changing parameters.

CAUTION

Function generator changes can result in dangerous machine movement. It is preferable to not make large changes in parameters.

The function generator parameters can be stored in EEPROM, using the **C** command, but this means that the function generator will be activated upon power up.

4.2.6.4.8 PROGRAMMABLE ANALOG TEST POINTS [OT]

Two programmable test points, TP1 and TP2, are accessible through the drive front cover, to aid in set-up and troubleshooting of the drives, (refer to FIGURE 5.3). The signals at TP1 and TP2 are referenced to the common test point.
There are five signals which can be programmed to either of the two test points.

Default TP1 Signal: Actual Velocity
Default TP2 Signal: Id.c. (Current Command)

The command syntax consists of the following four character string:

OT	**A** - TP1	**1** - Actual Velocity
	B - TP2	**2** - Filtered Velocity
		3 - Idc (Current Command)
		4 - Observer Estimated Velocity
		5 - Observer Position Error

Issue **C** command to permanently save changes made using **OT**.

*Example usage of **OT** command:*

> ***OTB<CR>***	*Program TP2 to observer estimated velocity.*
Signal to Test Point B 3	*Signal at test point B*
?	*Input number corresponding to test point B signal*
>	

4.2.6.4.9 THERMAL PROTECTION [OD]

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The **OD** command disables drive and motor thermal protection. When thermal protection is disabled, the drive does not undergo a fatal fault shutdown when drive and / or motor over temperature occurs. However, the appropriate over temperature front panel LED illuminates, as does the FOLDBACK ACTIVE LED and the FOLDBACK optoisolator output, indicating a non-fatal fault. User hardware can detect the FOLDBACK output, while a **?F** query can determine what non-fatal fault occurred, allowing the user hardware to initiate a safe machine shutdown.

Default State: Thermal Protection Enabled

CAUTION

Disabling drive and/or motor thermal protection can lead to drive and/or motor damage.

Issue **C** command to permanently save changes made using **OD**.

*Example usage of **OD** command:*

> ***OD<CR>*** Disable Thermal Protection (Y/N) No	
? ***N<CR>***	*Enter Y to disable, any other key to enable.*
>	

4.2.6.4.10 IT FOLDBACK CURRENT LIMITING [IT]

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The **IT** Foldback feature is intended to protect the drive and/or motor from overheating due to excessive operation at peak current. The product of the peak current limit, I_{peak}, and the maximum time at I_{peak} determines the value called Max_It. When the current command exceeds the continuous current setting, I_{cont}, the product of current and time is computed. When this IT product becomes greater than the Max_It value, the drive enters foldback and the output current is reduced down to the continuous current level. The drive remains in foldback until the current level goes below the continuous current rating.

Using the **OT** command the user may configure three parameters, Ipeak, Max Time at I_{peak}, and I_{cont} as follows:

Foldback Parameter	Acceptable Range	Default Value
I_{peak}	0 to Drive Rated I_{peak}	Drive Rated I_{peak}
Max Time at I_{peak}	0.1 to 5 Seconds	2 Seconds
I_{cont}	0 to Drive Rated I_{cont}	Drive Rated I_{cont}

TABLE 4-4 IT Foldback Settings

Issue **C** command to permanently save changes made using **IT**.

*Example usage of **IT** command:*

> ***IT***
IT Protection
Ipeak
 7.997E 1 Arms
 ? ***60 <CR>*** *Set the peak current limit to 60 amps.*

-More-***<CR>***

Icont
3.394e 0 Arms
?

-More-***<CR>***

Max. Time
at Ipeak
2.000E 0 [S]
T ? ***1 <CR>*** *Set the time at peak current to 1 second.*
Set the continuous limit to 30 amps.
>

4.2.6.4.11 MANUAL MODE, ENABLE / DISABLE [OM]

The **OM** command enables / disables manual mode.
In manual mode the velocity and torque limits are set to preset manual mode values, (refer to Section 4.2.5.1.3).
Manual mode may also be enabled/disabled by hardware if an Extended I/O Option card is installed, (refer to Section 4.2.8.1.4).

Default State: Manual Mode Disabled

Issue **C** command to permanently save changes made using **OM**.

*Example usage of **OM** command:*

> ***OM<CR>***

Disable Manual
Mode (Y/N)
Yes
? ***Y<CR>*** *Enter Y to disable, any other key to enable.*
>

4.2.7 COMMAND REFERENCE (ENCODER SIMULATION OPTION)

This Section details the additional commands and command extensions activated when an Encoder Simulation Option card is installed. For a description of the Encoder Simulation Option refer to Section 5.5

4.2.7.1 SETTING/LISTING (SN/LN) VELOCITY SCALING

When an Encoder Simulation Option card is installed the maximum speed is constrained to the lesser of the encoder maximum speed or the motor maximum speed. The encoder maximum speed limitation is listed in TABLE 5-14, and is inversely proportional to line count. For an application that is speed limited by the encoder, the encoder line count must be reduced to overcome the maximum speed limitation.

*Example usage of **SN** command, when encoder speed limitation occurs:*

> ***SN<CR>***

Vel. Scaling
1.000E 4 RPM/10V
? ***15000 <CR>*** *input a speed less than or equal to encoder speed limitation*
>

4.2.7.2 LINE COUNT (OELA)

The **OELA** command allows the user to modify the Encoder Simulation Module's line count. The user is not allowed to enter a line count that has a higher encoder maximum speed limitation than the maximum speed scaling set with the **SN** command, see Section 4.2.7.1. The **OELA** command can only be issued when the motor is disabled.

Line Count Units:	None
Line Count Default Value:	1024
Line Count Acceptable Values:	256,512,1024,2048,4096,8192,16384

*Example usage of **OELA** command:*

> ***OELA<CR>***

ESM2 Line Count
256 Lines
? ***4096<CR>*** *Set line count to 4096.*

>

4.2.7.3 MARKER WIDTH (OEMA)

The **OEMA** command allows the user to modify the Encoder Simulation Module's marker width. The **OEMA** command can only be issued when the motor is disabled.

Marker Width Units:	Degrees
Marker Width Default Value:	90
Marker Width Acceptable Values:	90,180,360

*Example usage of **OEMA** command:*

> ***OEMA***

ESM2 Marker
width
90 Deg
?
>

4.2.7.4 ENCODER SIMULATION OPTION STATUS (OESA)

The **OESA** command displays the status of the Encoder Simulation Module. The status displays the maximum speed of operation.

Example usage of ***OESA*** *command:*

> ***OESA<CR>***

ESM2 Max Speed 1.500E 4 RPM >	*Present Encoder Status is displayed*.

4.2.7.5 FAULTS (?F)

In addition to the faults described in Section 4.2.6.3.7, when an Encoder Simulation Option Card is present an Encoder Simulation Fault is also listed.

4.2.7.6 ENCODER POSITION (?E)

The Encoder Simulation Option maintains a digital representation of position. The **?E** command allows the user to query this parameter.

Example usage of ***?E*** *command:*

> ***?E<CR>***

Encoder Position
1.607E2
>

4.2.8 COMMAND REFERENCE (EXTENDED I/O OPTION)

This Section details the additional commands and command extensions activated when an Extended I/O Option card is installed. For a description of the Extended I/O Option Card, refer to Section 5.6.

4.2.8.1 SETTING AND LISTING PARAMETERS (EXTENDED I/O OPTION)

4.2.8.1.1 SETTING/LISTING [SE/LE] LIMIT SWITCH EMERGENCY BRAKING DECELERATION

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The limit switch emergency braking deceleration parameter determines the deceleration rate of the motor when a limit switch is activated in either the CW or CCW direction. Due to shaft loads, (inertia, friction), the desired deceleration rate may not be reached in actual application. Limit switches are only functional when the Extended I/O option card is used.

The **SE** command sets the braking deceleration.

Braking Deceleration Units:	Radians/Second^2
Braking Deceleration Default Value:	3 E5
Braking Deceleration Min. Value:	500
Braking Deceleration Max Value:	1 E6

Issue **C** command to permanently save changes made using **SE**.

*Example usage of **SE** command:*

> ***SE<CR>***

Quick Stop
Deceleration
3.000e 5 Rads/s^2 — *The current deceleration value is displayed.*
? ***10E4 <CR>*** — *Enter new deceleration value.*

>

The **LE** command lists the current braking deceleration.

*Example usage of **LE** command:*

> ***LE<CR>***

Quick Stop
Deceleration
1.000E 5 Rad/s^2
>

4.2.8.1.2 DRIVE STATE (?S)

In addition to the drive parameters listed in Section 4.2.6.3.6, the **?S** command lists the present state of the following parameter when an Extended I/O Option card is installed:

- Limit Switches Enabled/Disabled

4.2.8.1.3 LIMIT SWITCHES [OL]

The **OL** command enables/disables the clockwise (CW) and counterclockwise (CCW) limit switch functions of the Extended I/O Option card. When enabled, the CW (CCW) motor rotation is inhibited whenever the CW Limit (CCW Limit) input is not asserted.

Default State with Extended I/O Present: Limit Switches Enabled

Issue **C** command to permanently save changes made using **OL**.

*Example usage of **OL** command:*

> ***OL<CR>***

Disable Limit
Switches (Y/N)
Yes
? ***N*** *Enter Y to disable, N to enable.*
>

4.2.8.1.4 ENABLE / DISABLE MANUAL MODE [OM]

When an Extended I/O card is used, the drive defaults to manual mode enabled. Automatic mode, (manual mode disabled), is activate by current flow in the AUTO/MANUAL input of the Extended I/O card. The **OM** command, (refer to Section 4.2.6.4.11), can still be used to disable automatic mode.

4.2.9 CONFIGURATION COMMANDS SUMMARY

4.2.9.1 MOOG COMMAND FORMAT

Certain conventions are used in the command set for the Drive. The First Letter of a Command generally indicates a functional group:-

S	: Set Parameter	**L**	: List Parameter
O	: Set/List Drive Option	**M**	: Drive Commands
?	: Inquire Commands		

NOTE
While using a POD the backspace function is implemented using a Cntrl-H.

4.2.9.2 COMMAND SET LIST

4.2.9.2.1 CONFIGURATION COMMANDS

Command	Description
SC/LC	Indicates RMC or DMC Drive String. T161-90[1,2,3,4] if HardWare_Platform is RMC and DMC-90[1,3,5,7,9] if HardWare_Platform is DMC
LV	Displays firmware version of embedded code

4.2.9.2.2 MOTOR COMMANDS

Command	Description
SNM/LM	This String is written to when initializing a NON-STANDARD motor via the pod.
SSM/LM	This String is written to when initializing a STANDARD motor via the pod..
SU	This String is used to alter the displayed units of for example Torque, Current, Kt. The units available include {Nm, lb-in} {Nm/A, Nm/Arms, lb-in/Arms} {A, Arms}.

4.2.9.2.3 COMPENSATOR COMMANDS

Command	Description
OC	Compensator Type:- Selects between Torque and Velocity Modes of operation. Changing the compensator will cause the system fault led to flash during reconfiguration and parameters will be reset to default values. Note:- (1) Torque Mode. (2) Velocity Compensator 2nd Order. (3) Velocity Compensator 1st Order.
MV/MT	Velocity Mode,Torque Mode Select
SP/LP	Velocity Loop Gain Set/List
PU/PD	Incremental Adjust mode:- Velocity Loop Gain. PU:- the present value of Velocity Loop Gain will increase by 5%. PD:- the value will decrease by 5%.
SI/LI	Integral Time Constant Set/List
IU/ID	Incremental Adjust mode:- Integral Time Constant IU:- the present value will increase by 5%. ID:- the value will decrease by 5%.
?L	Max Current

4.2.9.2.4 FILTER COMMANDS

Command	Description
SW/LW	Compensator Filter Bandwidth
SZ/lZ	Compensator Filter Damping Ratio, only valid if Second order filter.

4.2.9.2.5 TORQUE AND SPEED LIMITS COMMANDS

Command	Description
OM	Manual Mode Enable/Disable. Mode also depends on setting of the H/W Switch.
STA/LTA	Automatic Mode Torque Limit. Set/List
STM/LTM	Manual Mode Torque Limit. Set/List
SLA/LLA	Automatic Mode Velocity limit. Set/List
SLM/LLM	Manual Mode Velocity Limit. Set/List

4.2.9.2.6 FUNCTION GENERATOR COMMANDS

Command	Description
OR	Defines the source from which the Drive derives its reference variables for its loop closure algorithms. 1:- Analogue Reference Source. 2:- Function Generator Source. 3:-Point I/F
OFT	Function Generator Torque Amplitude
OFTO	Function Generator Torque Offset
OFN	Function Generator Speed Amplitude
OFNO	Function Generator Speed Offset
OFP	Function Generator Period
OFD	Function Generator Duty Cycle

4.2.9.2.7 LIMIT SWITCH COMMANDS

Command	Description
OL	Enable/Disable Limit switches
SE/LE	Limit Switch Braking Deceleration

4.2.9.2.8 THERMAL PROTECTION COMMANDS

Command	Description
OD	Disable Thermal Protection
?M	Motor Temperature.
?LM	Motor Limit. (Thermal Foldback Only)
?LB	Bridge Limit
?B	Bridge Thermistor Temperature
?LR	RMS Limit

4.2.9.2.9 IT THERMAL PROTECTION COMMANDS

Command	Description
IT	IT Thermal Parameter. Prompted for IT Time, Peak current and Continuous Current.

4.2.9.2.10 VELOCITY OBSERVER COMMANDS

Command	Description
OO	Use Observer Velocity estimate
SJ/LJ	Observer Inertia
JU/JD	Incremental Adjust Mode:- Observer Inertia adjusted by 5%

4.2.9.2.11 ENCODER SIMULATION COMMANDS

Command	Description
OELA	ESM2 Encoder Line count
OEMA	ESM2 Encoder Marker width
OESA	ESM2 Encoder Maximum Speed
?E	ESM2 Encoder Position

4.2.9.2.12 ANALOG I/O COMMANDS

Command	Description
SR/LR	Position Scaling defining Revs/10Volts on test points.
SN/LN	Velocity Scaling defining RPM/10Volts on test points, and analog velocity reference.
OTA	Signal to Test Point A (DMC = Tp1, RMC = Tp10).
OTB	Signal to Test Point B (DMC = Tp2, RMC = Tp3)
OTP0	Zero Test Point Position, when Actual Position displayed on test points.
OI	Analog Input Offset
OZ	Automatic Analog Input Offset Calculation.
OA	Enable/Disable Reference Input Filter.

4.2.9.2.13 POSITION AND VELOCITY COMMANDS

Command	Description
?P	Motor Shaft Position.
?PR	Motor Shaft Revolutions.
?V	Motor Shaft Velocity.

4.2.9.2.14 DRIVE COMMANDS

Command	Description
MB	Break Set/Release.
MI/MO	Drive Enable/Disable
CntrlX	Drive Reset.
MQ	Drive Quick Stop:- Used to servo stop the motor. The drive stays enabled, in order to reset the flag the Drive must be disabled
?S	List a Number of Drive Parameters Status, Compensator, Limit Switches, Manual Mode etc.

4.2.9.2.15 EEPROM FUNCTION COMMANDS

Command	Description
C	Save Parameter set to EEPROM. The Drive saves the configured parameters to non-volatile storage

4.2.9.2.16 FAULT DIAGNOSTIC COMMANDS

Command	Description
?F	Faults Status
?FL	Latched Fault Status

4.2.9.2.17 POINT OPTION CARD COMMANDS

Command	Description
OPA	POINT Diagnostic Channel A
OPB	POINT Diagnostic Channel B
?D	POINT Dual Port RAM Status

4.3 TERMINAL EMULATION COMMUNICATIONS WITH C4 FIRMWARE

This section is intended to give the user a full understanding of programming a T164 DMC containing C4 firmware while using a terminal emulation program.
Subsection 4.3.2 describes using Moogterm with the T164 however the instructions in sections 4.3.3 through 4.3.9 can be used with any terminal emulation device for data transfer and drive programming.

CAUTION

Do not attempt configuration until at least Sections 4.3.1 through 4.3.4.1 have been read and understood. Do not apply power until it is called for in the configuration procedure.

Throughout Section 4.3, references to the terminal apply to either a hand held terminal or a personal computer (PC) being used as a terminal.
Responses from the T164 Series Drive appearing on the terminal are shown indented in the following font:

20 Dec 96
C09791-001
EEPROM ID 0
- more -

The characters to be entered are designated by the following type font:

1.000
Y
N

The RETURN or ENTER key on the terminal is designated by the following symbol:

<CR>

NOTE

The procedures in section 4.3 are written for use with:
DMC firmware version C4 dated 01/15/98.
The user must consult Moog for updates to the procedure for drives with any other software or firmware version/date.

The T164 Series Drives utilize principally metric units. TABLE 4-5 provides descriptions of the abbreviations used for units throughout Section 4.3.

Abbreviation	Unit	Measure of
Nm	Newton-meters	Torque
kg-m^2	Kilogram-meter^2	Inertia
Rads/sec	Radians per second	Velocity
RPM	Revolutions per minute	Velocity
Rads/sec^2	Radians per second^2	Acceleration
Hz	Hertz	Frequency
s	Seconds	Time
Aeff	Effective Amperes	Current
Apeak	Peak of Wave Form Amperes	Current
Arms	Root Mean Square Amperes	Current

TABLE 4-5 Description of Units

4.3.1 SERIAL COMMUNICATIONS

The communication link between the T164 Series Drive and the terminal is half duplex, the drive ignores commands when writing to the terminal.

WARNING

A hardware enable/disable switch wired so that the motor can be stopped quickly in an emergency must be provided at all times. Software enable/disable commands do not meet safety requirements and should never be used instead of a hardware circuit.

For individual drive communication the RS232 interface should be used. "Moogterm" software which runs on IBM compatible PCs is available for RS232 applications. In addition to providing a full screen interface, "Moogterm" allows downloading and uploading of drive parameters. Instructions for use of "Moogterm" are included on the "Moogterm" distribution disk available from your Moog Sales Representative.
Connect the terminal to the T164 Series Drive J3 Communications Connector using the cable described in Section 2.10.3. Set the terminal serial interface parameters to 9600 baud, 1 start bit, 7 data bits, no parity, and 2 stop bits. There is no hardware handshaking.

4.3.1.1 COMMUNICATION HARDWARE SETUP

Use an RS232 serial cable. Before a drive can be configured the hardware should be setup (see FIGURE 4.1) as outlined below:

4.3.1.1.1 RS232 COMMUNICATION MODE JUMPER SETUP

Set the drives RS communication mode position jumper W2 for RS232 as in FIGURE 4.2. See FIGURE 5.3 for jumper location. (The **Factory Default** is RS232, jumper pins 1-2)

4.3.1.1.2 RS232 SETUP

In order for the PC to communicate with the drive in RS232 mode proceed as follows:

- ❑ Connect an RS232 cable with the wiring as shown in FIGURE 2.23. The cable is connected from one of the communication ports of the PC to the serial port of the drive.

- ❑ Configure the W2 jumper for RS232 communications as shown in FIGURE 4.2.

4.3.2 MOOGTERM TERMINAL INTERFACE

NOTE
The procedures in section 4.3.2 are written for use with:
• *Moogterm software version 3.0 dated 11/10/97*
• *DMC firmware version C4 dated 1/15/98*
The user must consult Moog for updates to the procedure for drives with any other software or firmware version/date.

4.3.2.1 MINIMUM SYSTEM REQUIREMENTS FOR MOOGTERM

- ❑ IBM compatible PC with:
  - ⇒ 386 or higher processor running MS DOS 6.1 or higher with 2MB RAM, and 500K of free hard disk space.

- ❑ VGA display with a resolution of at least 640 x 480 pixels.

- ❑ A Moog Moogterm System Disk

- ❑ An RS232 Communication Interface Cable.

4.3.2.2 MOOGTERM STARTUP

To run the Moogterm software, place the Moogterm disk in drive A:
Type “a:Moogterm” on the command line and press return.

The text file "Readme.txt" describes the operation of the setup file.

Follow the configuration steps shown below:

- ❑ In the Configuration screen select
    - ⇒ "C" to proceed to the communication mode configuration.
    - ⇒ "ESC" to exit Moogterm.

  ⇒ Pressing RETURN sets the communication and port ID to the defaults in the ".cfg" file. If a ".cfg" file does not exist the user is sent to the communication mode screen.

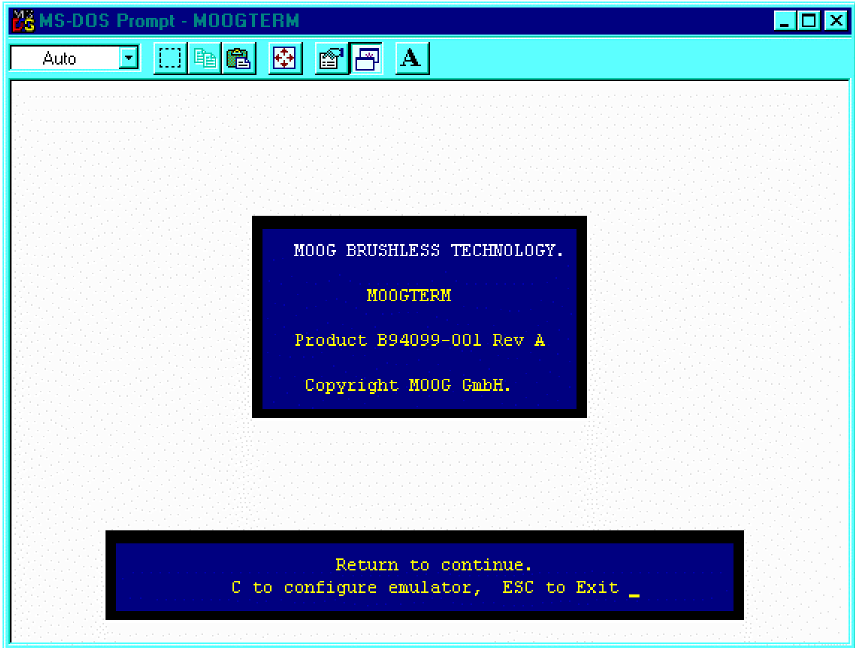


FIGURE 4.57 Configuration Select Screen

- ❑ In the **Communications Mode** screen enter the number corresponding to the RS mode of communication (FIGURE 4.58).

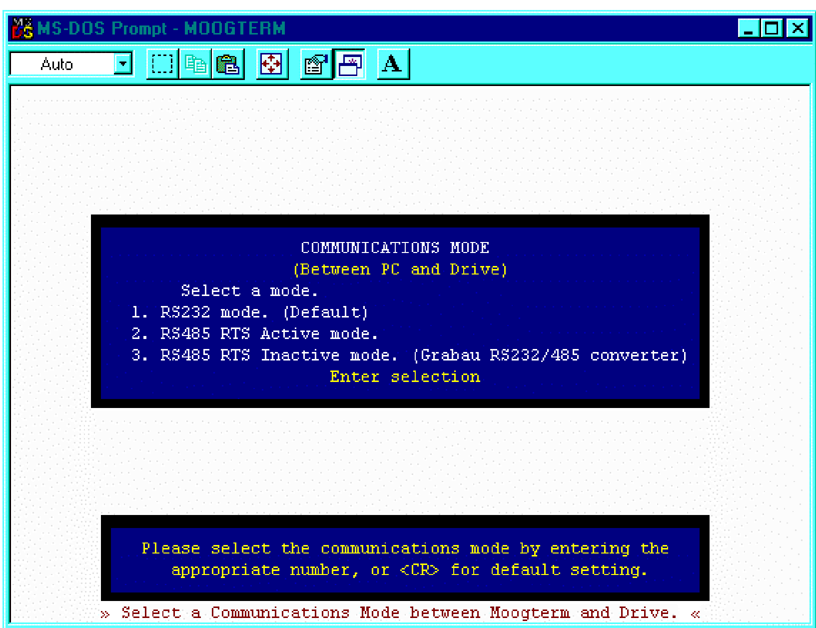


FIGURE 4.58 Communications Mode Screen

- ❑ In the **Communications Port Selection** screen enter the number of the PC communication port linked to the drive (FIGURE 4.59)

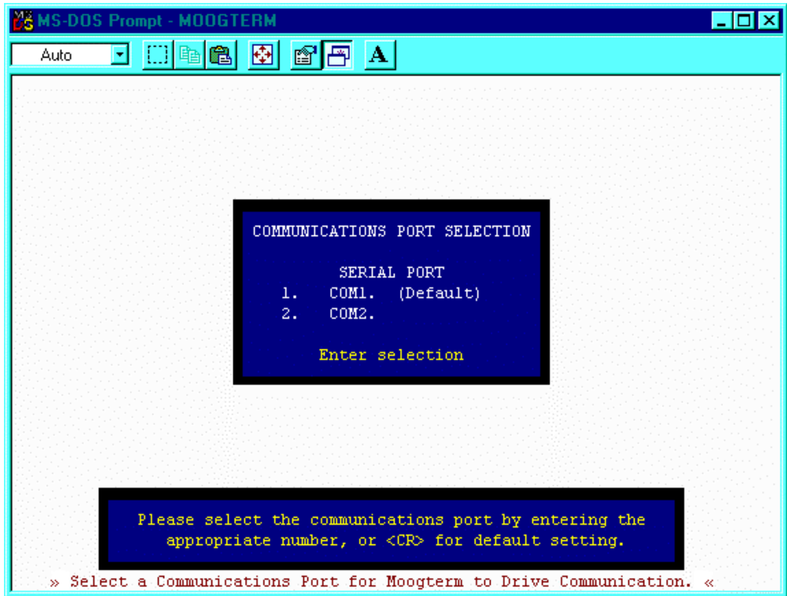


FIGURE 4.59 Communications Port Selection Screen

- **A Controller Type Selection** screen will appear. Select option two (2) from the list.

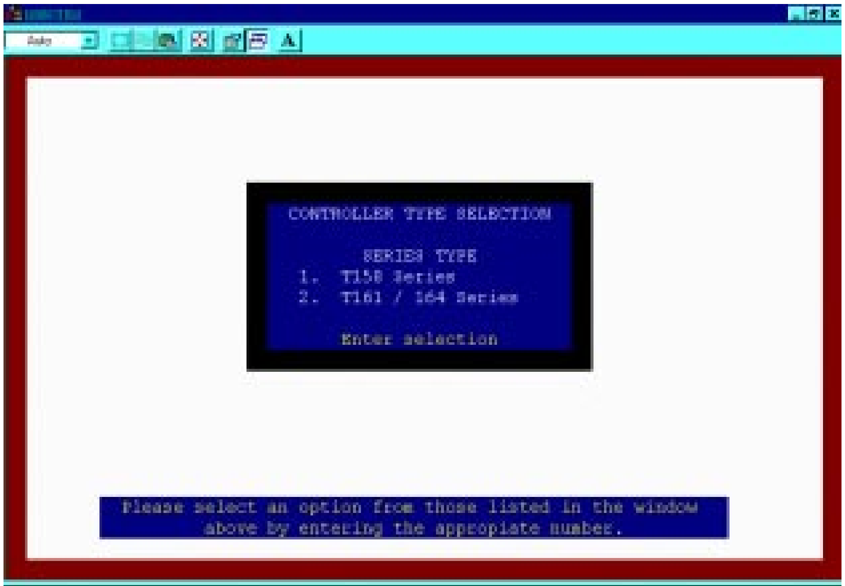


FIGURE 4.60 Controller Type Selection Screen

4.3.2.3 MAIN EMULATOR SCREEN FEATURES

The Moogterm Main Emulator Screen provides a User Interface to setup and monitor the system drive/s.

4.3.2.4 SCREEN LAYOUT

- Screen Footer: List of available commands.
- Center of Screen: Used to input command set and view drive data.

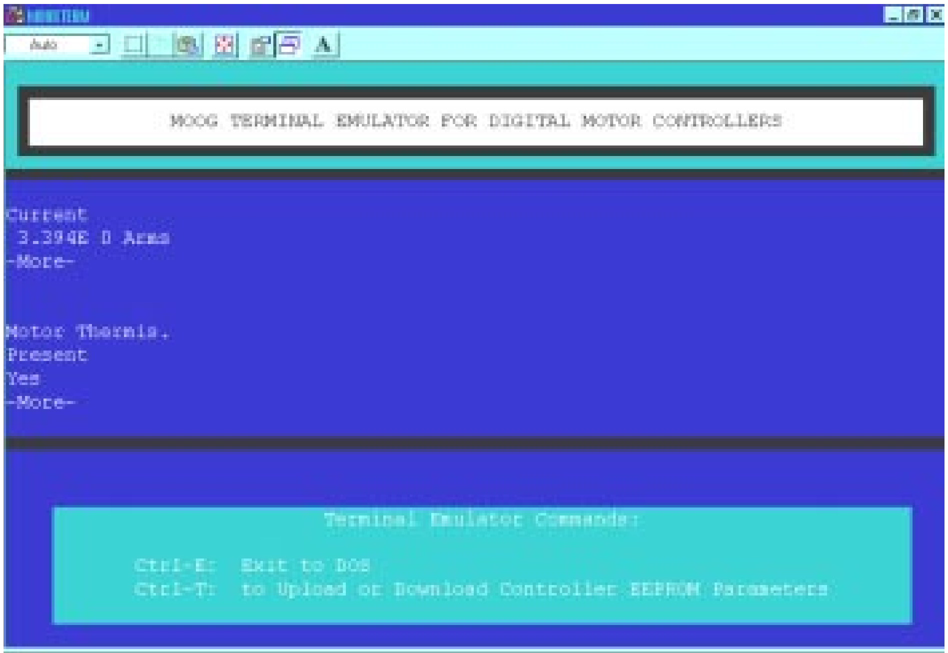


FIGURE 4.61 Main Emulator Screen

4.3.2.5 FUNCTION KEYS

- ❑ **Ctrl-E**: Used to exit Moogterm.

- ❑ **Ctrl-T**:Opens the File Transfer Function window so the user may choose one (1) of the following:

  ⇒ **D**: To download a parameter file from disk to the drive EEPROM. After selecting “D” you will be asked to enter the file name (8 characters), without the file extension, where the parameters are stored.

  ⇒ **U**: To upload from the drive EEPROM to disk. After selecting “U” the user will be asked to enter a file name (8 characters), without a file extension, where the parameters are to be saved.

  ⇒ **E**: To return to the Main Emulator Screen.

4.3.3 COMMAND LINE FORMAT

Communication to the T164 Series Drive is via a terminal interface using the main menu. The main menu will prompt you to enter a letter in the following format:

Enter first
letter of a
command or H
for help >

All main menu command sequences can be recognized by the (**>**) prompt.

Commands use two or sometimes three letters, e.g. [**LP**] or [**STA**]. The first letter is common to a group of parameters and determines the action desired. The second and third letters determine parameters.

The first set of letters acceptable to the main menu are:

- [**C**] Change or Store Configuration Parameters in EEPROM
- [**D**] Drive Initialization
- [**H**] Help
- [**I**] Velocity Loop Integral Time Constant
- [**J**] Observer Inertia
- [**L**] List Parameter
- [**M**] Motor Operational Modes
- [**O**] Options
- [**P**] Velocity Loop Proportional Gain
- [**S**] Set Parameter
- [**?**] Query Operating Conditions
- [**+**] Increase Help Mode
- [**-**] Decrease Help Mode

Most parameters are entered as real numbers and stored accurate to 1 percent. Numbers may be entered using decimal or scientific notation with up to six significant digits.

Examples of valid numeric entries:

> ***-2.9 E -2<CR>*** *Enter numbers and press RETURN.*
> ***.029<CR>***
> ***0.029<CR>***
> ***203789<CR>***
> ***203.789E3<CR>***

All numeric entry should be terminated by pressing the RETURN (***<CR>***) key.

If an entry error is detected by the software, the following message will be displayed along with a prompt to reenter:

```
> Q

Invalid
Selection

>
```

If a mistake is made entering a number, entry may be aborted by making a deliberate error, such as typing x instead of a digit. There is no provision for editing entries.

All numeric parameters entered are compared against an acceptable range. If a parameter is outside this range, then the value is clamped to the appropriate limit of the range. Note, that no message is displayed when entries are truncated. Thus, it is good practice to list all parameters using the appropriate **L** command after they have been entered.

All parameters may be set or listed when the motor is running. However, it is advisable to avoid large changes in parameters when the motor is running.

Other features of the main menu are:

• The letter [H] can be typed at any time to request help about a suitable command.

• The [CTRL **X**] key combination will reset the T164 Series Drive and has the same effect on drive software as turning the power off then on.

• Commands entered are not case sensitive, e.g. [SP] and [sp] are both recognized.

• When (- **more -**) is displayed enter any character to continue.

• When current values of parameters are presented, they may be accepted by pressing RETURN (***<CR>***) **.**

4.3.3.1 FULL HELP / REDUCED HELP MODE [H/+/-]

The main menu may be used in either full help or reduced help mode. In the full help mode, the user is individually prompted for each letter of a command. In the reduced help mode, the user must enter all letters of a command at the **>** prompt.

Example of setting the Velocity Loop Proportional Gain in full help mode:

Enter first letter of a command or H for help > ***S***	*Enter Set Command.*
Enter second letter of a command or H for help >> ***P***	*Enter Proportional Gain Command.*

Example of the same command in reduced help mode:

>***SP<CR>***	*Enter Set Proportional Gain Command.*

The help level may be increased or decreased by typing [**+**] or [**-**] after the main menu prompt (**>**).

Example of reducing help level:

Enter first
letter of a
command or H
for help > ***-***
\>

Example of increasing help level:

\>***+***
Enter first
letter of a
command or H
for help >

In either full or reduced help mode, entering **H** will cause the drive to output a list of context sensitive command choices.

4.3.4 DRIVE INITIALIZATION

> **NOTE**
> *The installation and wiring described in Section 2 should be completed and verified before proceeding with drive initialization.*

CAUTION

The T164 Series Controllers should not be enabled during a.c. power up until the Power Supply Fault Output clears. The user must supply the logic to accomplish this interlock. Failure to delay enabling of the Controllers, or having any other external load on the T150-901 Power Supply, on a.c. power up will defeat the proper operation of the soft start circuitry in the T150-901 Power Supply and can result in tripping of the a.c. input circuit breaker and/or damage to the T150-901 Power Supply.

WARNING

Perform all drive initialization and configuration with the drive hardware enable OFF and power ON. Failure to follow the correct procedure might result in machine damage and/or personal injury.

- ❑ Apply power to the T164 Series Drive. Immediately check the T150-901 Power Supply for any fault indications. TURN POWER OFF IF ANY RED LEDs ILLUMINATE ON THE T150-901 POWER SUPPLY. Correct the problem before proceeding.

If the EEPROM contains configuration data, the drive will display the following message:

EEPROM Start

Wait...

The drive saves data in its EEPROM, which is a non-volatile memory. When power is applied the drive will attempt to initialize itself using the data in its EEPROM. If a valid set of parameters is in EEPROM, the following message is then displayed:

Parameters Set
from EEPROM

The drive will be ready to enable once the red SYSTEM FAULT LED stops flashing. The drive will then print its sign-on message which identifies the software version and EEPROM ID number.

Moog T164-00X	*Drive Model Number*
Ver02 04/05/93	*Software Version Date*
EEPROM ID 0	
- more -***<CR>***	*Press RETURN or any key to proceed.*

If the user knows the configuration and parameters are satisfactory the drive may be enabled without any further input from the terminal. This would be the normal procedure after initialization and tuning have been completed. After the user presses any key to continue, the drive proceeds to the main menu.

Enter first
letter of
command or H
for help >

4.3.4.1 STANDARD MOTOR CONFIGURATION

The T164-90X has motor parameters installed for the 300 series, D31X series and G4XX series motors. These are considered "standard motors". For non-standard motors parameters are required to be entered manually.

Drive configuration identifies what motor is connected to the T164 Series Drive. The user must perform drive configuration during initial commissioning or replacement of the equipment and any time a different motor is connected to the drive. The command **D** is used for drive initialization.

Example of drive configuration:

> ***D***	*Enter Drive Configuration Command.*
Drive Initialization	
Sure (Y/N) ? ***Y***	*Enter Y to Continue, any other key to abort.*

If the drive does not have valid configuration data in EEPROM, a cold start will occur upon power-up. When a cold start occurs the drive automatically executes a drive configuration command. The Drive Initialization Sure prompt described above does not occur for a cold start.

The SYSTEM FAULT LED will flash until drive initialization is complete. The drive then prints its sign on message to identify itself and asks the user for the motor type as follows:

Moog T164-90X Ver02 04/05/93 EEPROM ID 0 - more - ***<CR>***	*Press RETURN or any key to proceed.*
Drive Disabled Motor:- e.g. D314..L10 304-111A ?***305-121A***	*Enter appropriate motor model number here.*

The drive is pre-programmed with all motor parameters for standard motor models. For non-standard motor models the user must manually enter the motor parameters, (refer to Section 4.3.4.2).

The choice of motor is displayed next and the user is asked to confirm it.

305-121A OK (Y/N)? ***Y***	*Enter Y if model number is correct.*

NOTE

It is very important that the motor model number is entered correctly as the T164 Series Drive sets many parameters automatically based on this configuration. This is also a good point to confirm that the proper drive model is connected to the proper motor.

If you reply [**N**] to the above question you will be asked to re-enter. If you are satisfied with the motor and drive configuration enter [**Y**] and the T164 Series Drive will respond as follows:

Wait...

Defaults Set

Enter first
letter of
command or H
for help >

The T164 Series Drive has now initialized and has set its parameters to the following safe values before returning to the main menu:

- Drive in Velocity Mode.
- Thermal Protection Enabled
- Reference Filter Enabled
- Manual mode disabled (enabled if Extended I/O option card present).
- Speed scaling set to nominal value of motor speed.
- Low **P** gain and long **I** time constant for velocity loop compensator.

This new configuration data will be lost when power is removed until it is saved to EEPROM, (refer to Section 4.3.5.7). However, this step should wait until all setup and tuning procedures of Sections 4.3.4 and 4.3.5 are completed.

NOTE

Re-configuring the drive by changing the motor type, the compensator etc. will cause all previous tuning information to be lost. Option Card parameters, including Encoder Simulation, will also be lost. It is therefore desirable to follow Sections 4.3.4 and 4.3.5 in sequence.

4.3.4.2 NON-STANDARD MOTOR CONFIGURATION

Applications employing non-standard motor models require the data listed on the following page. Skip this Section if using a standard motor.

NOTE

The following conversions are useful for motor parameters:

$$K_t \text{ (Nm/Arms)} = .113 * K_t \text{ (lb-in/Arms)}$$

$$I_c \text{ (Arms)} = T_c \text{ (Nm)} / K_t \text{ (Nm/Arms)}$$

$$I_p \text{ (Arms)} = T_p \text{ (Nm)} / K_t \text{ (Nm/Arms)}$$

where:

I_c = *Rated Continuous Motor Phase Current*

T_c = *Rated Continuous Torque*

I_p = *Rated Peak Motor Phase Current*

T_p = *Rated Peak Motor Torque*

To configure for a non-standard motor, proceed with drive initialization as outlined in Section 4.3.4.1 above. Enter the non-standard motor model number when prompted for the motor model number. After confirming the model number entered, the drive will recognize a non-standard motor model number and prompt for entry of motor parameters as shown below.

*Example of entering non-standard motor parameters using the **D** command:*

> ***D*** Drive Initialization	*Enter Drive Configuration Command.*
Sure (Y/N) ? ***Y***	*Enter Y to continue, any other key to abort.*
Moog T164-00X VerC4 02/15/98 EEPROM ID 0 - more -***<CR>***	*Press RETURN or any key to proceed.*
Drive Disabled Motor:- e.g. D314..L10 304-111A ? ***304-000<CR>***	*Enter non-standard motor model number here.*
304-000 OK (Y/N) ? ***Y***	*Enter Y to continue, any other key to abort.*
Non Standard Motor. Enter Parameters (Y/N)? ***Y***	*Enter Y to continue, any other key to abort.*
Kt [Nm/Arms] ? ***1.5<CR>***	*Enter Torque Constant and press RETURN.*
Number	

Motor Poles	
? ***12<CR>***	*Enter Number of Poles and press RETURN.*
Ic [Arms]	
? ***20<CR>***	*Enter Continuous Current and press RETURN.*
Ip [Arms]	
? ***40<CR>***	*Enter Peak Current and press RETURN.*
Max Speed	
[RPM]? ***3000<CR>***	*Enter Max Speed at Rated Torque and press RETURN.*
Ltt[mH]	*Enter Terminal Inductance and press RETURN*
?***2.1<CR>***	
Rtt[Ohms]	*Enter Terminal Resistance and press RETURN*
?.***15<CR>***	
Wait…	
Defaults Set	
Programmable current loop settings ...	
I Gain [0-15]	
? ***5<CR>***	*Enter Current Loop Gain Setting and press RETURN.*
Observer Inertia [kg m^2]	
? ***.001<CR>***	*Enter Motor Inertia and press RETURN.*
Max-Speed	
[RPM]?**3000<CR>**	*Enter Motor Maximum Speed and press RETURN.*
Resolver Pole Pairs	*Enter Resolver Pole Pairs and press RETURN.*
? ***1<CR>***	
>	

4.3.5 DRIVE TUNING

4.3.5.1 BASIC CONTROL LOOP CONCEPTS

4.3.5.1.1 VELOCITY MODE

FIGURE 4.62 is a block diagram depicting the T164 Series Drive control loop in velocity mode. Software commands are shown outlined above or below the appropriate block which they affect.

The analog input command is input to an analog to digital converter (A/D) either directly or through an input reference filter, as determined by the **OA** command software switch. The **OR** command software switch allows command reference source selection of the digitized input command, (normal operation), or a software programmable function generator, (used for tuning). A programmable offset is summed with the command reference to null offsets in the loop. The digitized command is then scaled by the velocity scale factor, which determines the maximum motor speed for a 10 volt command input. After scaling, the digital velocity command is passed through either the automatic mode velocity limiter or the manual mode velocity limiter depending upon the **OM** command software switch.

The position feedback from the motor mounted resolver is demodulated and passed through an A/D converter. The resulting digital position information is differentiated to obtain motor velocity feedback. The **OO** software switch allows selection of the normal position to velocity conversion or the velocity observer method, (described in Section 4.3.5.5).

The digital velocity feedback and command are compared to generate a velocity error (torque command), which is passed through a loop compensation network consisting of a proportional gain (**P** term) with a first or second order low pass filter and an integral gain (**I** term) block. The **P** and **I** terms must be tuned for the particular application.

The torque command is passed through either the automatic mode torque limiter or the manual mode torque limiter, depending upon the **OM** command software switch. The resulting torque command, (current command), is input to the IT foldback block, which protects the motor and the drive from delivering excessive peak currents. Finally the current command enters a digital to analog (D/A) converter after which the analog current command is passed to the power amplifier stage to drive the motor.

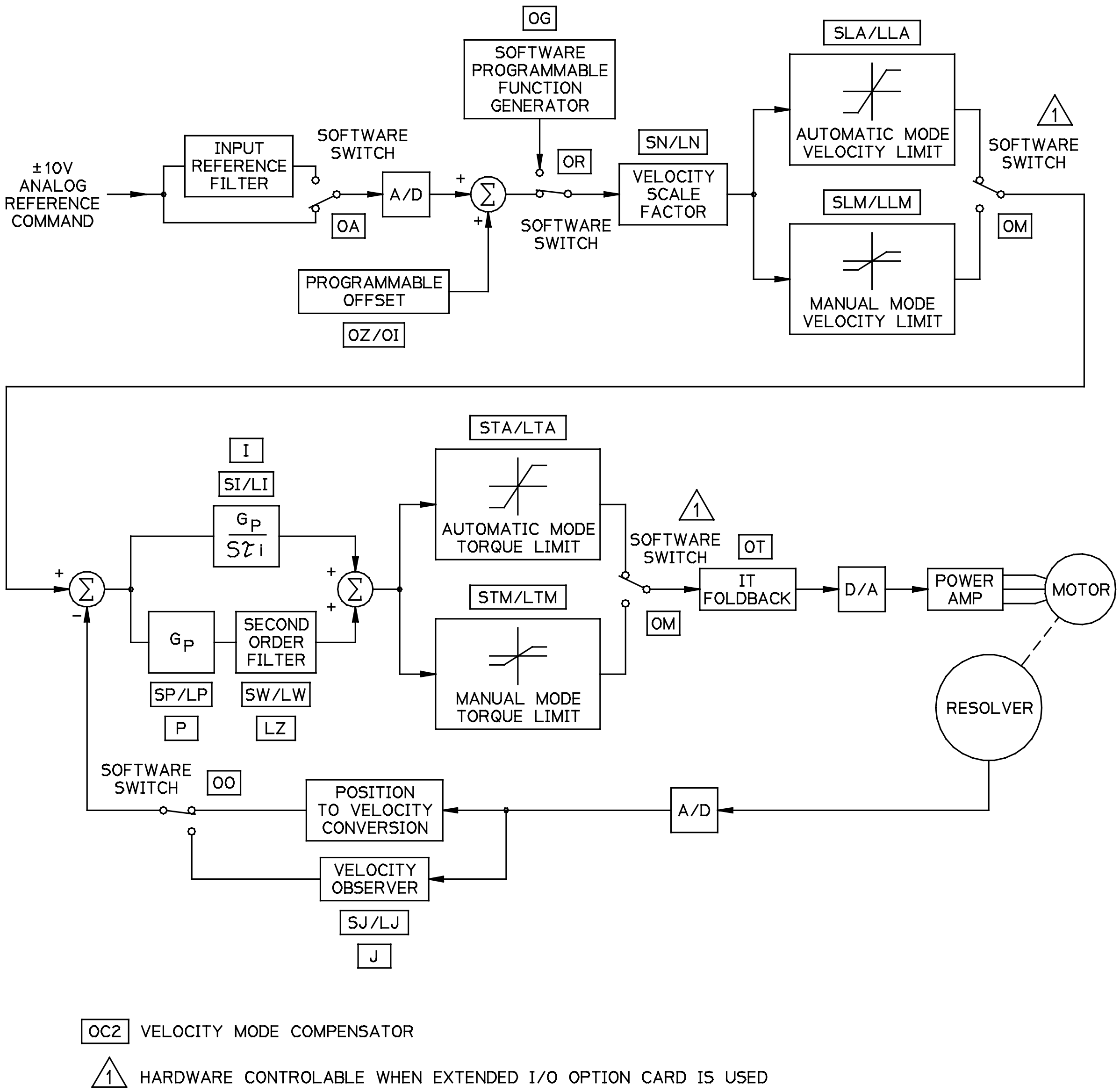


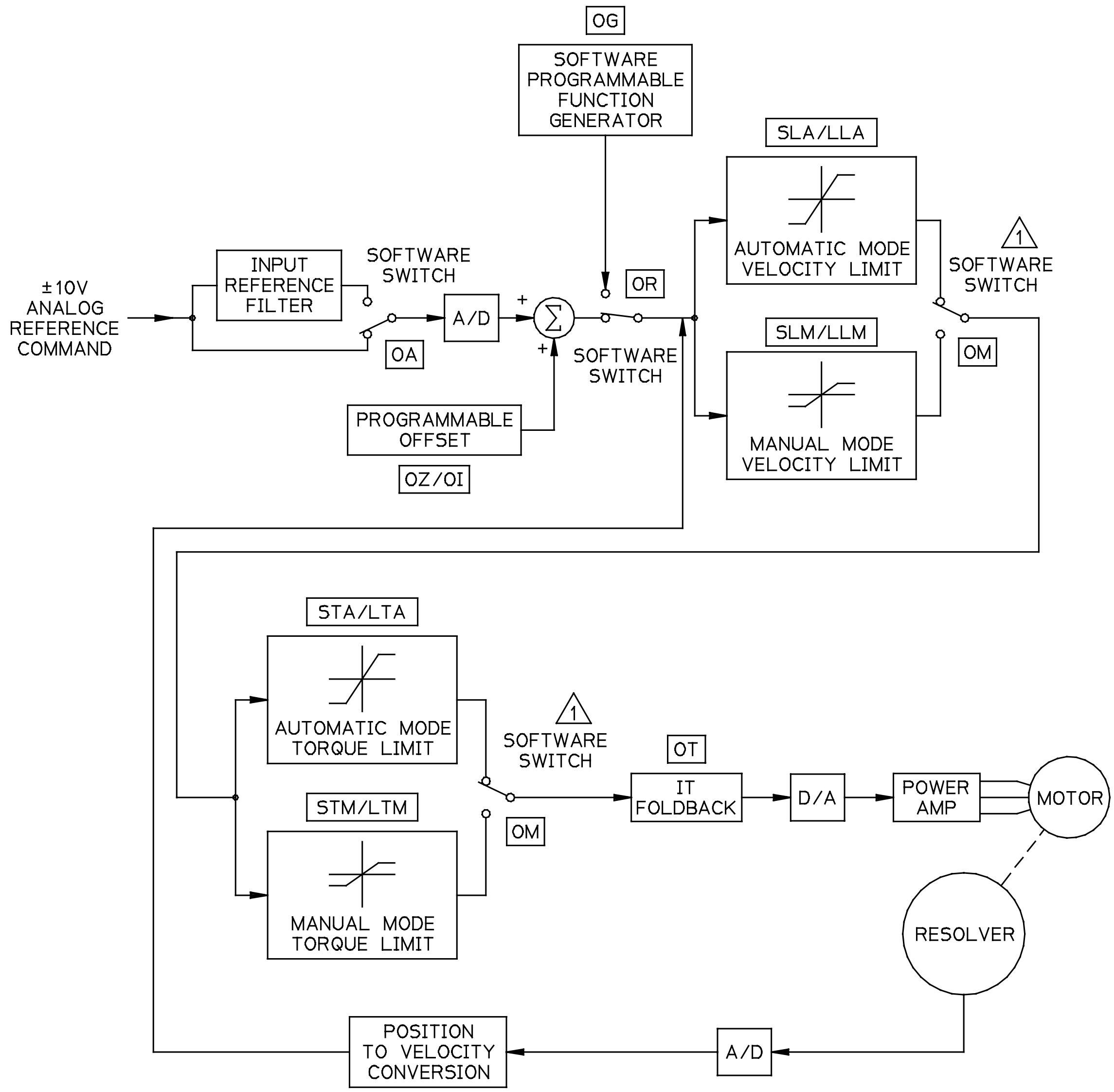
FIGURE 4.62 Velocity Mode Block Diagram

4.3.5.1.2 TORQUE MODE

FIGURE 4.63 is a block diagram depicting the T164 Series Drive control loop in torque mode. Software commands are shown outlined above or below the appropriate block which they affect. Operation is the same as explained above in Section 4.3.5.1.1, except that the input command reference is now a torque command instead of a velocity command, and the velocity scale factor, velocity observer, and **P** and **I** loop compensation networks are not used.

4.3.5.1.3 AUTOMATIC/MANUAL MODE

Automatic and manual modes pertain to the torque and velocity limits. In automatic mode the normal torque and velocity limits are in effect. In manual mode the torque and velocity limits are reduced from the normal (automatic mode) limits.
The manual mode is useful during commissioning to limit available torque and velocity while tuning the drive, or other situations in which full power could present personnel or equipment hazards. Manual mode is enabled or disabled using the **OM** command, and if an Extended I/O Option card is installed, by the absence (manual mode) or presence (automatic mode) of current flowing in the AUTO/MANUAL input. Refer to Section 4.3.6.4.11 for information on enabling and disabling manual mode, Section 4.3.6.1.5 for setting/listing the automatic/manual mode velocity limits and Section 4.3.6.1.9 for setting/listing the automatic/manual mode torque limits.



OC1 TORQUE MODE COMPENSATOR

1 HARDWARE CONTROLABLE WHEN EXTENDED I/O OPTION CARD IS USED

FIGURE 4.63 Torque Mode Block Diagram

4.3.5.2 GAIN ADJUST MODE

The gain adjust mode is for use during tuning of the velocity loop parameters; Integral Time Constant (**I**), the Observer Inertia (**J**), the Velocity Loop Proportional Gain (**P**), and the Position Mode loop gain (**G**).

The gain adjust mode is entered by entering the appropriate letter, **I**, **J**, **P**, **or G** depending upon the velocity loop tuning parameter to be adjusted.

Once in the gain adjust mode the user can enter:

- **S** to set the parameter directly
- **L** to list the present value of the parameter
- **U** to increase the parameter incrementally
- **D** to decrease the parameter incrementally
- **Z** to essentially zero the parameter
- **H** for help on gain adjust mode commands
- **E** or any other non defined gain adjust mode key to exit gain adjust mode

Both the **U** and the **D** commands operate in an incremental mode that acts like a non-linear software potentiometer. Each time the **U** command is successively issued, the gain increase factor becomes 5% larger than the previous gain increase factor. Thus, after issuing one **U** command the second gain value is 1.05 times the first gain value, and after issuing a second **U** command the third gain value is 1.1025 times the second gain value and 1.158 times the first gain value. This process continues until the gain increase factor reaches 2.0 at which point it is held constant for successive **U** commands. The **D** command functions analogously except each successive gain decrease factor becomes 1/1.05 times the previous gain decrease factor, until the gain decrease factor becomes 1.0 E-6 at which value it remains constant.

The **Z** command is actually a special case of the **D** command in which the gain decrease factor is 1.0 E-4, which quickly reduces, but does not actually zero the parameter. As a precaution several **Z** commands in succession will ensure a parameter is lowered to its minimum value.

Note that both the Observer Inertia (**J**), and the Velocity Loop Proportional Gain (**P**) parameters increase in value when the **U** command is used and decrease in value when the **D** command is used. However, the Integral Time Constant (**I**) parameter decreases in value when the **U** command is used and increases in value when the **D** command is used. This is because decreasing the Integral Time Constant increases the drive response.

Example use of the gain adjust mode to set the Velocity Loop Proportional Gain parameter:

> ***P***	*Enter Proportional Gain Adjust Mode Command.*
Gain Adjust Mode	
P>>***L*** 1.000E-2	*Note double >> prompt indicating gain adjust mode.* *List the current P gain.*
P>>***S***	*Directly set a new P gain.*
Vel. Loop Gain 1.000E-2 [Nm/(Rad/Sec)] P ?***.02<CR>***	
P>>***L*** 2.000E-2	*List current P gain to check entry.*
P>>***U*** P>>***U*** P>>***U*** P>>***L*** 2.680E-2	 *Incrementally increase P gain 3 times.* *List current P gain to view result.*
P>>***D*** P>>***D*** P>>***D*** P>>***L*** 2.000E-2	 *Incrementally decrease P gain 3 times.* *List current P gain to view result.*
P>>***Z*** P>>***L*** 2.000E-6	*Zero the P gain.* *List current P gain to view result.*
P>>***Z*** P>>***L*** 1.000E-8	*Zero the P gain again.* *List and note truncation at minimum value.*
P>>***E*** >	*Exit the Gain Adjust Mode.*

4.3.5.3 PARAMETER SET-UP

TABLE 4-6 lists parameters which may be optionally re configured. Moog recommends that the default configuration of the parameters listed in TABLE 4-6 be used. This Section may be skipped unless special application requirements exist. If the user does desire to change any of these parameters, it should be done before proceeding with loop tuning.

Command	Parameter	Reference Section
SLA/SLM	Automatic and/or Manual Speed Limit	4.3.6.1.5
STA/STM	Automatic and/or Manual Torque Limit	4.3.6.1.9
SW	Compensator Filter Bandwidth	4.3.6.1.10
OA	Enable/Disable Reference Input Filter	4.3.6.4.3
OD	Enable/Disable Thermal Protection	4.3.6.4.9
OT	IT Foldback Limit Settings	4.3.6.4.10

TABLE 4-6 Software Configurable Parameters

4.3.5.4 VELOCITY MODE STANDARD TUNING

After completing drive initialization as described in Section 4.3.4, and changing any other parameters to match specific application requirements as described in Section 4.3.5.3, the user needs to tune the velocity loop to optimize performance. This Section provides a recommended velocity mode standard tuning procedure. The procedure should be followed in the sequence listed. For torque mode applications proceed to Section 4.3.5.6.

WARNING

The motor should be uncoupled if incorrect movements during the drive tuning procedure can damage the machine. If this is not possible, the safety limit switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.

- ❑ Disable the drive, using the hardware enable switch.
- ❑ Set the Control Compensator to Velocity Mode using the **OC2** command, (refer to Section 4.3.6.4.2).
- ❑ Set the Velocity Scale Factor to match the RPM of the motor to a given velocity command input using the **SN** command, (refer to Section 4.3.6.1.7). This step is only necessary if the input command range is less than 10 volts or the desired maximum motor speed is less than the motor no-load speed.
- ❑ Set the drive to manual mode using the **OM** command, (refer to Section 4.3.6.4.11).

The drive is tuned using a low frequency square wave command while observing the velocity response on an oscilloscope. The low frequency square wave can be supplied from an external source, or by the internal software function generator as described below.

- ❑ Set the command reference source to the function generator using the **OR** command, (refer to Section 4.3.6.4.1). Set up the function generator parameters to 10% of rated motor RPM speed amplitude, 0 RPM speed offset, 1 second period, and 50% duty cycle.

WARNING

Insure that the application allows using this speed amplitude and length of travel, (period, duty cycle), without damage to the machine before proceeding with the tuning procedure.

- ❑ For monitoring velocity, connect an oscilloscope to front panel test point TP2 with common with the following settings:

Horizontal Amp:	20 mS/Division
Vertical Amp:	1 V/Division

- ❑ Direct the velocity feedback signal to TP2 using the **OFB2** command, (refer to Section 4.3.6.4.8).

The two (2) principle parameters affecting the velocity loop dynamics are the Velocity Loop Proportional Gain (**P**) and the Integral Time Constant (**I**).

The proportional gain term affects the amplification of the error between actual velocity and reference velocity. The higher the P term the more the error is amplified. A high gain produces a “stiff” velocity loop response.. Generally, axes with higher inertia need higher gain settings. Gain can not be increased without bound, as excessive gain will cause the loop to become unstable.

The integral time constant affects the loop response, or how fast an axis will respond to a velocity disturbance. If response is too low, (**I** too high), the axis will be slow to react and might start oscillating because it can't keep up with the disturbance. If response is too high, (**I** too low), the axes will respond to almost any disturbance, (including electrical noise), and may start a higher frequency resonance or chatter.

- ❑ The **P** term should be adjusted first. Turn off the **I** gain by using the **SI** command, (refer to Section 4.3.6.1.3), to set **I** equal to 3 seconds. Use the **LI** command to confirm a value for the integral time constant of Infinity, indicating the integrator is turned off.

- ❑ Enable the drive, hardware enable first then **MI** software enable, with the function generator initialized as detailed above.

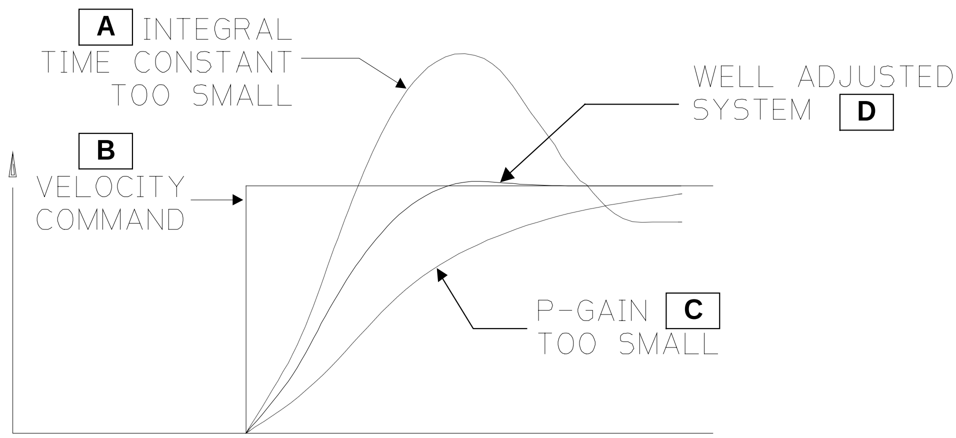


FIGURE 4.64 Standard Velocity Mode Tuning Wave Forms

- ❑ Use the **P** command to enter the gain adjust mode for the velocity loop proportional gain term, (refer to Section 4.3.5.2). Using the **U** command increase the **P** gain until the shaft is turning. Use the **E** command to exit the gain adjust mode.

- ❑ Set the drive to automatic mode, (disable manual mode), using the **OM** command, (refer to Section 4.3.6.4.11).

- ❑ Use the **P** command to re-enter the gain adjust mode. Use the **U** command, while monitoring the velocity response on the oscilloscope, to increase the **P** gain until a slight overshoot occurs in the velocity response. Use the **D** command to decrease the **P** gain until the overshoot just disappears. Use the **E** command to exit the gain adjust mode.

- ❑ Use the **I** command to enter the gain adjust mode for the velocity loop integral time constant, (refer to Section 4.3.5.2). Using the **U** command increase the loop response until a slight overshoot occurs again. Use the **E** command to exit the gain adjust mode.

- ❑ Use the **P** command to re-enter the gain adjust mode. Use the **U** command to improve the slope of the step response. FIGURE 4.64 illustrates the velocity wave form for a properly tuned loop.

- ❑ Use the **OR** command to set the command reference to the analog reference, (refer to Section 4.3.6.4.1).

- ❑ Offsets in the drive and the users' velocity command may be trimmed out with the automatic offset command. Apply the desired zero speed command to the drive and issue the **OZ** command, (refer to Section 4.3.6.4.6).

- ❑ Use the **C** command to save configuration data in EEPROM, (refer to Section 4.3.5.7).

4.3.5.5 VELOCITY OBSERVER TUNING

This Section explains the set-up and tuning of the velocity observer. The use of the observer will usually allow significantly higher velocity loop gains and bandwidths to be achieved. The observer uses a software model of the motor and load to calculate a velocity estimate. The user needs to tune only one additional parameter to use the observer. The observer is set up using the following procedure:

- ❑ Tune the velocity loop using the normal procedure described in Section 4.3.5.4. FIGURE 4.65(A) shows a typical tuned velocity loop response to a step reference command. It shows the torque response on the drives' TP1 test point and the actual velocity response on TP2. The size of the step velocity reference should be small enough to avoid saturation of the torque signal. Note the single overshoot of about 24% in the velocity response and the 12 ms settling time.

- ❑ Tune the observer by setting up the observer inertia parameter, Jest. Monitor the observer error signal θerr at the drives' TP1 test point by using the OFA5 command. FIGURE 4.65(B) shows the usual starting point for tuning: J_{est} is too small. Use the **J** command to enter the gain adjust mode, (refer to Section 4.3.5.2). J_{est} may be adjusted in this mode using **U** and/or **D** commands followed by **E** to exit gain adjust mode, or using the **SJ** / **LJ** commands,(refer to Section 4.3.6.1.4). FIGURE 4.65(B) also shows θ_{err} when J_{est} is tuned correctly, θ_{err} steps with a slight ripple superimposed. θ_{err} is a measure of the model uncertainty, and of any disturbance torque which may be present. Normally there will be some viscous friction present, so that θ_{err} will step appropriately when the shaft velocity makes a step change.

> **NOTE**
>
> *If θ_{err} oscillates excessively when the velocity makes a step change, as shown in FIGURE 4.65 (C), then do not use the observer, since the load may not be modeled adequately by the observer.*

- ❑ As a final check of proper tuning, enter **OFA4** to monitor observer velocity on TP1, and compare it with the actual velocity response which was shown on TP2 in FIGURE 4.65(A). These should be identical.

- ❑ Switch on the observer by using the **OO** command, (reference Section 4.3.6.4.4), and then **Y** to the subsequent prompt. FIGURE 4.65(D) shows the velocity loop response when the observer is switched into the loop. Note the lack of overshoot, because of a better measurement of velocity. The servo noise generated is also reduced.

❑ In order to achieve higher gains, the compensator filter frequency may now be set higher, using the **SW** command, (refer to Section 4.3.6.1.10). Typically this frequency may be set to 600 Hz, depending on motor servo noise. The **P** and **I** gains may now be tuned up again, in the normal fashion described in Section 4.3.5.4.
FIGURE 4.65(E) compares the response of an observer based system with a normal velocity loop system. Now the response settles in just 2.2 mS, whereas without the observer the step settled in about 12 mS. The observer response also shows a smaller overshoot.

❑ Use the **C** command to save configuration data in EEPROM, (refer to Section 4.3.5.7).

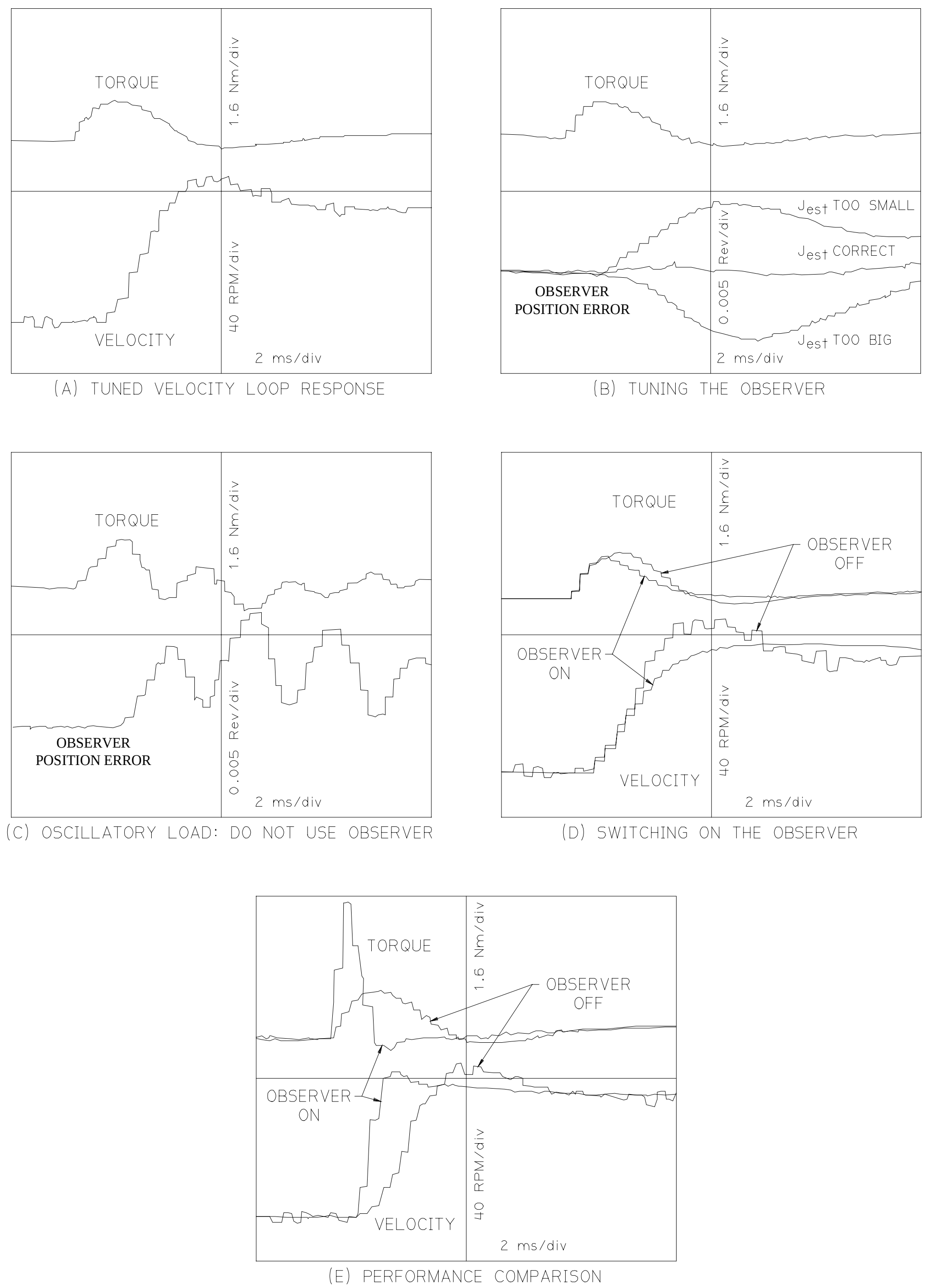


FIGURE 4.65 Velocity Observer Tuning Wave Forms

4.3.5.6 TORQUE MODE TUNING

In torque mode, the input command reference is a current command to the power amplifier that drives the motor. The term torque mode is adopted because the motor produces a nearly linear torque per ampere of input current. The tuning of the inner current loops of the T164 Series drives is pre-programmed during drive initialization. Hence, no parameter tuning is required in torque mode. Skip this Section for standard or observer velocity mode applications.

WARNING

The motor should be uncoupled if incorrect movements during the drive tuning procedure can damage the machine. If this is not possible, the safety limit switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.

- ❑ Set the Control Compensator to Torque Mode using the **OC1** command, (refer to Section 4.3.6.4.2).

- ❑ Offsets in the drive and the users' torque command may be trimmed out with the automatic offset command. Apply the desired zero speed command to the drive and issue the **OZ** command, (refer to Section 4.3.6.4.6).

- ❑ Use the **C** command to save configuration data in EEPROM, (refer to Section 4.3.5.7).

4.3.5.7 SAVING CONFIGURATION DATA

Upon completion of drive parameter set-up and tuning, the configuration parameters should be permanently saved in EEPROM using the **C** command. Any parameter changes made will be lost when power is removed if they are not saved in EEPROM.

The **C** command provides for an identification (ID) number to be stored with the parameter set. This is useful to distinguish sets of parameters, e.g. for different axes. Valid ID numbers range from 0 to 9999. Non-numeric characters should not be used for ID numbers.

NOTE

Only one set of parameters can be stored in EEPROM at a time.

A warning will be displayed if the function generator is set up as the command reference source when the **C** command is issued. It is not recommended that a configuration with the function generator active be saved in EEPROM. The **OR** command, (refer to Section 4.3.6.4.1), can be used to switch off the function generator.

*Example usage of the **C** command:*

> ***C<CR>***	*Enter Save Configuration Command.*
Save Parameters	
Sure (Y/N) ? ***Y<CR>***	*Enter Y to continue, any other key to abort.*
EEPROM ID ?***1 <CR>***	*Enter desired ID number and press RETURN.*
Wait :- Saving Drive Parameters in EEPROM	
EEPROM Written	
>	

4.3.6 COMMAND REFERENCE

This Section provides detailed information on all T164 Series Drive C4 software commands including default values, limit values, and examples of usage, for base drive models. Additional commands and command extensions for the Encoder Simulation Option Card and the Extended I/O Option Card are detailed in Sections 4.3.7 and 4.3.8 respectively.

4.3.6.1 SETTING AND LISTING PARAMETERS

4.3.6.1.1 LISTING [L-] MOTOR AND DRIVE CONFIGURATION

The **L-** command lists the following current motor and drive configuration data:

- EEPROM ID Number
- Controller Model Number
- Motor Model Number
- RS485 Multidrop Axis Number
- Command Source
- Compensator Mode (Velocity or Torque)
- Option Card Status

*Example usage of **L-** command:*

> ***L-***

EEPROM ID Number: 10	*(Displays only after configuration data saved.)*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Controller:- T164-007	*Controller Model Number*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Motor:- 304-111A	*Motor Model Number*
- more -***<CR>***	*Press RETURN or any key to proceed.*
RS485 Multidrop Axis Number 0	
- more -***<CR>***	*Press RETURN or any key to proceed.*
Command Source: an Analog Reference.	*Command Source* *(Analog Reference or Function Generator)*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Controller in Velocity Mode	*(Velocity or Torque Mode)*
- more -***<CR>***	*Press RETURN or any key to proceed.*
No Option Card Installed >	*(List of Installed Option Cards)*

4.3.6.1.2 SETTING/LISTING [S*/L*] ALL APPLICATION PARAMETERS

> **NOTE**
> *The application parameters can also be set and/or listed on an individual basis using other commands described throughout Section 4.3.6.1.*

The **S*** command sets all application parameters.
The **L*** command lists all application parameters. The application parameters are:

- Motor No-Load Speed (Velocity Scaling) [RPM] *(Velocity mode only).*
- Velocity Loop Proportional Gain [Nm/(Rad/sec)] *(Velocity mode only).*
- Velocity Loop Integral Time Constant [sec] *(Velocity mode only).*
- Compensator Filter Bandwidth [Hz] *(Velocity mode only).*
- Braking Mode Velocity Limit ([RPM]/[%])
- Braking Mode Torque Limit ([Nm]/[%])
- Automatic/Manual Speed Limits [RPM]
- Automatic/Manual Torque Limits [Nm]
- Observer Inertia [kg-m^2]
- Function Generator Speed Amplitude (*Velocity and Function Gen. Modes only).*
- Function Generator Speed Offset (*Velocity and Function Gen. Modes only).*
- Function Generator Torque Amplitude (*Torque and Function Gen. Modes only).*
- Function Generator Torque Offset (*Torque and Function Gen. Modes only).*
- Function Generator Period *(Function Generator Mode Only).*
- Function Generator Duty Cycle *(Function Generator Mode Only).*
- Position Loop Proportional Gain [Rad/s] (*Rel. and Abs. Position Mode Only)*
- Position Scale Factor [in] (*Rel. and Abs. Position Mode Only*
- Max Position Command Difference [in] (*Rel. and Abs. Position Mode Only*
- RS485 Multidrop Axis Number

Issue **C** command to permanently save changes made using **S***.

*Example usage of **L*** command:*

> ***L****

Vel. Scaling 5800 [RPM at 10V]	*Only displayed when in velocity and position mode.*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Vel Loop Gain 1.000E-2 [Nm/(Rad/Sec)]	*Only displayed when in velocity and position mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Integral Time Const 2.000E-1 [s]	*Only displayed when in velocity and position mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Second Order Filter Freq 1.909E 2 [Hz]	*Only displayed when in velocity and position mode*
- more -***<CR>***	*Press RETURN or any key to proceed.*
Automatic Mode Velocity Limit 5.800E 3 [RPM]	
- more -***<CR>***	*Press RETURN or any key to proceed.*

Manual Mode
Velocity Limit
5.800E 2 [RPM]
- more -***<CR>*** *Press RETURN or any key to proceed.*

Braking Mode
Torque Limit
5.800E 2 [RPM]

- more -***<CR>*** *Press RETURN or any key to proceed.*

Braking Mode
Velocity Limit
100 [%]

- more -***<CR>*** *Press RETURN or any key to proceed.*

Automatic Mode
Torque Limit
4.048E 0 [Nm]
- more -***<CR>*** *Press RETURN or any key to proceed.*

Manual Mode
Torque Limit
4.048E-1 [Nm]
- more -***<CR>*** *Press RETURN or any key to proceed.*

Observer Inertia
1.399E-4
[kg m^2]
- more -***<CR>*** *Press RETURN or any key to proceed.*

RS485 Multidrop
Axis Number
1
>

4.3.6.1.3 SETTING/LISTING [SI/LI] VELOCITY LOOP INTEGRAL TIME CONSTANT

The **SI** command sets the velocity loop integral time constant, required for tuning in the velocity mode, (refer to Section 4.3.5.4). Setting the velocity loop integral time constant greater than or equal to 3 seconds, turns off the velocity loop integrator.

Velocity Loop Integral Time Constant Units:	Seconds
Velocity Loop Integral Time Constant Default Value (Depends upon motor model):	
D312-L05 to D313-L40, 302-111A to 303-030A:	0.1
D314-L05 to D314-L40, 304-111A to 304-151A:	0.2
D315-L10 to D315-L50, 305-111A to 305-141A	0.2
D316-L15 to D316-L60, 306-111A to 306-141A:	0.5
Velocity Loop Integral Time Constant Min. Value:	0.5 E-3
Velocity Loop Integral Time Constant Max Value:	3

Issue **C** command to permanently save changes made using **SI**.

*Example usage of **SI** command:*

> ***SI***

Integral
Time Const
 2.000E-1 [s]
Ti? ***.25<CR>***
>

The **LI** command lists the current velocity loop integral time constant. A value of Infinity is reported by the **LI** command when the integrator is off.

*Example usage of **LI** command:*
> ***LI***

Integral
Time Const
 2.500E-1 [s]
>

4.3.6.1.4 SETTING/LISTING [SJ/LJ] VELOCITY OBSERVER INERTIA

The **SJ** command sets the observer inertia parameter used for tuning in the optional velocity observer mode, (refer to Section 4.3.5.5).

Velocity Observer Inertia Units:	Kilogram-meter^2
Velocity Observer Inertia Default Value:	$2*J_{motor}$
Velocity Observer Inertia Min. Value:	None
Velocity Observer Inertia Max Value:	9.999E5

Issue **C** command to permanently save changes made using **SJ**.

*Example usage of **SJ** command:*

> ***SJ***

Observer Inertia
 1.399E-4
[kg m^2]
? ***1.5E-4 <CR>***
>

The **LJ** command lists the current velocity observer inertia.
*Example usage of **LJ** command:*

> ***LJ***

Observer Inertia
1.499E-4
[kg m^2]
>

4.3.6.1.5 SETTING/LISTING [SLA/SLM/LLA/LLM] MOTOR VELOCITY LIMITS

The **SLA/SLM** commands set the automatic/manual mode motor velocity limits. Manual mode is intended to be a reduced power operating mode used for initial tuning or other situations in which full power could present personnel or equipment hazards, (refer to 4.3.5.1.3). Although it is possible to set manual velocity limits higher than automatic velocity limits, this is not recommended because it defeats the safety principle of manual mode being a reduced power mode.

Automatic/Manual Mode Velocity Limits Units:	Revolutions Per Minute
Automatic Mode Velocity Limit Default Value:	Velocity Scale Factor (N)*10Vd.c. (Max RPM)
Automatic Mode Velocity Limit Min. Value:	50
Automatic Mode Velocity Limit Max Value:	Depependent on Motor
Manual Mode Velocity Limit Default Value:	10% * Automatic Mode Default Value
Manual Mode Velocity Limit Min. Value:	50
Manual Mode Velocity Limit Max Value:	Dependent on Motor

Issue **C** command to permanently save changes made using **SLA** and **SLM**.

*Example usage of **SLA** and **SLM** commands:*

> ***SLA***

Automatic Mode
Velocity Limit
 5.800E 3 [RPM]
? ***4000 <CR>***
> ***SLM***

Manual Mode
Velocity Limit
 5.800E 2 [RPM]
? ***400 <CR>***
>

The **LLA/LLM** commands list the automatic/manual mode motor velocity limits.
*Example usage of **LLA** and **LLM** commands:*

> ***LLA<CR>***

Automatic Mode
Velocity Limit
 4.000E 3 [RPM]

> ***LLM<CR>***

Manual Mode
Velocity Limit
 4.000E 2 [RPM]
>

4.3.6.1.6 LISTING [LM] MOTOR PARAMETERS

The **LM** command lists the current motor parameters:

- Motor Model Number
- Motor Torque Constant, K_t
- Number of Motor Poles
- Motor Maximum No-Load Speed
- Motor Peak Current, I_p
- Motor Continuous Current, I_c

*Example usage of **LM** command:*

> ***LM<CR>***

Motor:-
G422-200
- more -***<CR>*** *Press RETURN or any key to proceed.*

Kt [Nm/Arms]
3.699E-1
- more -***<CR>*** *Press RETURN or any key to proceed.*

Number
Motor Poles
8
- more -***<CR>*** *Press RETURN or any key to proceed.*

Resolver
Pole Pairs
1

- more -***<CR>*** *Press RETURN or any key to proceed.*

Max. Speed [RPM]
8.100E 3
- more -***<CR>*** *Press RETURN or any key to proceed.*

Ip [Arms]
1.899E 0
- more -***<CR>*** *Press RETURN or any key to proceed.*

Ic [Arms]
6.499E –1

- more -***<CR>*** *Press RETURN or any key to proceed.*

Prog. Current
Loop Gain
11 E0

- more -***<CR>*** *Press RETURN or any key to proceed.*

Ltt [mH]
 29.7 E0

- more -***<CR>*** *Press RETURN or any key to proceed.*

Rtt [Ohms]
 50.9E0

- more -***<CR>*** *Press RETURN or any key to proceed.*

Current Control
Max Speed [RPM]
 8.100E3
>

4.3.6.1.7 SETTING/LISTING [SN/LN] VELOCITY SCALING

The **SN** command selects the velocity scaling. The velocity scaling is the speed that corresponds to a 10 volt input velocity command. Normally, this is the motor no-load speed. For a maximum input command less than 10 volts or a desired maximum speed less than the maximum rated motor speed use the following equation to calculate the velocity scaling RPM to enter:

$$VelocityScalingRPM = MaxrequiredRPM * \frac{10}{MaxInputCommandVoltage}$$

Where: Max Input Command Voltage < 10 and
Max Required RPM < Max Rated Motor RPM

Velocity Scale Factor Units:	Revolutions Per Minute at 10 Volt Command Input
Velocity Scale Factor Default Value:	Motor Max Speed
Velocity Scale Factor Min. Value:	200
Velocity Scale Factor Max Value:	20,000

Issue **C** command to permanently save changes made using **SN**.

*Example usage of **SN** command, set 5 volt maximum command input equal to 3000 RPM maximum required RPM:*

> ***SN<CR>***

Vel. Scaling
 5.800E 3
[RPM at 10V]
RPM ? ***6000 <CR>*** *(3000 RPM at 5V)*
>

The **LN** command lists the current velocity scaling.

*Example usage of **LN** command:*

> ***LN<CR>***

Vel. Scaling
 6000
[RPM at 10V]
>

4.3.6.1.8 SETTING/LISTING [SP/LP] VELOCITY LOOP PROPORTIONAL GAIN

The **SP** command sets the velocity loop proportional gain, required for tuning in velocity mode, (refer to Section 4.3.5.4).

Velocity Loop Proportional Gain Units:	Newton-meters / Radian per Second
Velocity Loop Proportional Gain Default Value (Depends upon motor model):	
D312-L05 to D313-L40	0.01
303-030A	0.05
D314-L05 to D314-L40, 304-111A to 304-151A:	0.05
D315-L10 to D315-L50, 305-111A to 305-141A:	0.2
D316-L15 to D316-L60, 306-111A to 306-141A:	0.2
Velocity Loop Proportional Gain Min. Value:	1 E-8
Velocity Loop Proportional Gain Max Value:	1 E8

Issue **C** command to permanently save changes made using **SP**.

*Example usage of **SP** command:*

> ***SP<CR>***

Vel. Loop Gain
 1.000E-2
[Nm/(Rad/Sec)]
P ?***<CR>***
>

The **LP** command lists the current velocity loop proportional gain.

*Example usage of **LP** command:*

> ***LP<CR>***

Vel. Loop Gain
 1.000E-2
[Nm/(Rad/Sec]
>

4.3.6.1.9 SETTING/LISTING [STA/STM/LTA/LTM] MOTOR TORQUE LIMITS

The **STA** command sets the automatic mode torque limit and the **STM** command sets the manual mode torque limit. The drive current limit value is the lesser of the drive current rating and the motor peak current rating. Manual mode is intended to be a reduced power operating mode used for initial tuning or other situations in which full power could present personnel or equipment hazards, (refer to Section 4.3.5.1.3). Although it is possible to set manual velocity limits higher than automatic velocity limits, this is not recommended because it defeats the safety principle of manual mode.

Automatic / Manual Mode Torque Limits Units:	Newton meters
Automatic Mode Torque Limit Default Value:	Drive Current Limit * K_t
Automatic Mode Torque Limit Min. Value:	0
Automatic Mode Torque Limit Max Value:	Drive Current Limit * K_t
Manual Mode Torque Limit Default Value:	10% * Drive Current Limit * K_t
Manual Mode Torque Limit Min. Value:	0
Manual Mode Torque Limit Max Value:	Drive Current Limit * K_t

Issue **C** command to permanently save changes made using **STA** and **STM**.

*Example usage of **STA** and **STM** commands:*

> ***STA<CR>***	*Enter command to set automatic mode torque limit.*
Automatic Mode Torque Limit 4.040E 0 [Nm]	
? ***<CR>***	*Accept the current value.*
> ***STM<CR>***	*Enter command to set manual mode torque limit.*
Manual Mode Torque Limit 4.000E-1 [Nm]	
? ***<CR>***	*Accept the current value.*
>	

The **LTA** command lists the current automatic mode torque limit and the **LTM** command lists the manual mode torque limit.

*Example usage of **LTA** and **LTM** commands:*

> ***LTA<CR>***	*Enter command to list automatic mode torque limit.*
Automatic Mode Torque Limit 4.040E 0 [Nm]	
> ***LTM<CR>***	*Enter command to list manual mode torque limit.*
Manual Mode Torque Limit 4.000E-1 [Nm]	

>

4.3.6.1.10 SETTING/LISTING [SW/LW] COMPENSATOR FILTER BANDWIDTH

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The **SW** command sets the bandwidth parameter, Wn, of the second order compensator filter, (refer to Sections 4.3.5.1.1 and 4.3.5.1.2).

Wn Units:	Hertz
Wn Default Value (Depends upon motor model):	
D312-L05 to D313-L40, 302-111A to 303-030A:	286.5
D314-L05 to D314-L40, 304-111A to 304-151A:	191
D315-L10 to D315-L50, 305-111A to 305-141A:	191
D316-L15 to D316-L60, 306-111A to 306-141A:	191
Wn Min. Value:	100.2
Wn Max Value:	599.8

Issue **C** command to permanently save changes made using **SW**.

*Example usage of **SW** command:*

> ***SW<CR>***	*Enter command to set filter freq.*
Second Order Filter Freq. 1.909E 2 [Hz]	
Wn ? ***200 <CR>***	*Set the Filter Freq to 200 Hz*
>	

The **LW** command lists the current second order filter bandwidth parameter, Wn.

*Example usage of **LW** command:*

> ***LW<CR>***	*Enter command to list filter freq.*
Second Order Filter Freq 1.999E 2 [Hz] >	

4.3.6.1.11 LISTING [LZ] FILTER DAMPING RATIO ZETA

The **LZ** command lists the current damping ratio parameter, Zeta, of the second order compensator filter, (refer to Sections 4.3.5.1.1 and 4.3.5.1.2).

Zeta Units:	Dimensionless
Zeta Default Value:	0.7

*Example usage of **LZ** command:*

> ***LZ<CR>*** *Enter command to list filter damping ratio.*

Filter Zeta
 7.000E-1
>

4.3.6.2 MOTOR OPERATIONAL MODES

4.3.6.2.1 STARTING / STOPPING [MI/MO] THE MOTOR

The **MI** command provides a software enable for the motor, while the **MO** command provides a software disable for the motor. The hardware enable input overrides the software enable **MI** command. The **MI** command is also used for enabling the motor when using the internal software function generator, (refer to Section 4.3.6.4.7).

*Example usage of **MI** and **MO** commands:*

> ***MI*** *Enter Command to Software Enable Motor.*

> ***MO*** ***MO*** *or* ***M*** *and any other key except* ***H*** *or* ***I*** *will disable*
>

WARNING
Rapid machine movement can result when the MI command is used. Issue this command only when ALL personnel are outside of the machine workcell and a hardware disable switch is directly accessible.

4.3.6.3 OPERATING CONDITIONS

4.3.6.3.1 MOTOR SHAFT POSITION [?P]

The **?P** command queries the motor shaft position.
*Example usage of **?P** command:*

> ***?P<CR>***

Shaft Angle
 2.985E 2 [Deg]
>

4.3.6.3.2 MOTOR SHAFT VELOCITY [?V]

The **?V** command queries the motor shaft velocity. The speed reported is an average of the last one hundred sample periods.

*Example usage of **?V** command:*

> ***?V<CR>***
Wait..
Av. Motor
Velocity
-4.861E 1 [RPM]
>

4.3.6.3.3 CURRENT LIMITS [?L]

The **?L** command lists the current limit settings, for IT Foldback, (refer to Section 4.3.6.4.10):

• Continuous Current Limit • Peak Current Limit • Maximum Time at I_{peak}

Note that the current limits are the lesser of motor model limits or drive model limits.

*Example usage of **?L** command:*

> ***?L<CR>***
Ipeak Limit
8.690E 0 [Arms]
- more -***<CR>*** *Press RETURN or any key to proceed.*

Max Time at Ip
5.000E 0 [s]
- more -***<CR>*** *Press RETURN or any key to proceed.*

Icont Limit
8.680E 0 [Arms]
>

4.3.6.3.4 BRIDGE TEMPERATURE [?B]

The **?B** command lists whether the drive bridge temperature is below or above the 90° C drive over temperature set point.

*Example usage of **?B** command:*

> ***?B<CR>***
Bridge Temp.
< 90 [C]

>

4.3.6.3.5 MOTOR TEMPERATURE [?M]

The **?M** command lists whether the motor thermistor is below or above the 155° C motor over temperature set point. Note that the user must wire the motor thermistor or thermostat wires to the T164 Series drives to detect a motor over temperature fault.

*Example usage of **?M** command:*

> ***?M<CR>***
Motor Temp.
< 155 [C]

>

4.3.6.3.6 DRIVE STATE [?S]

The **?S** command lists the present state of the following drive parameters;

- Compensator Mode
- Thermal Protection Enabled/Disabled
- Manual Mode Enabled/Disabled
- Reference (Analog Command) Filter In/Out
- Velocity Observer On/Off

*Example usage of **?S** command:*

> ***?S<CR>***

Controller Mode
Velocity
- more -***<CR>*** *Press RETURN or any key to proceed.*

Thermal
Protection
Enabled
- more -***<CR>*** *Press RETURN or any key to proceed.*

Manual Mode
Disabled
- more -***<CR>*** *Press RETURN or any key to proceed.*

Reference
Filter In
- more -***<CR>*** *Press RETURN or any key to proceed.*

Velocity
Observer
Disabled
>

4.3.6.3.7 FAULTS [?F]

The **?F** command lists the present fault status including what faults have occurred and what faults are still present. Faults reported are:

- Resolver Fault
- Short Circuit Fault
- Motor Over temperature
- Controller Over temperature
- Logic Power Supply Fault
- Bus Over voltage

*Example usage of **?F** command:*

> ***?F***

Resolver
Fault Occurred
-more ***<CR>***

Resolver
Fault Present
-more-***<CR>***
>

4.3.6.4 OPTIONS

4.3.6.4.1 COMPENSATOR REFERENCE SOURCE [OR]

The **OR** command selects either the analog input or the software function generator as the input command reference source.

Default State: Analog Input

Issue **C** command to permanently save changes made using **OR**.

*Example usage of **OR** command:*

> ***OR<CR>***	
Command	
Reference	
Initialization	
Sure (Y/N) ? Y	*Enter Y to continue, any other key to abort*
Options:-	
1 Analog Ref	
2 Function Gen.	
3 Point I/F	
? (1/2) >> ***1***	*Enter 1 ,2 or 3 for Reference mode selection..*
Analog	
Initialization	*The SYSTEM FAULT LED flashes during reconfiguration.*
>	

4.3.6.4.2 CONTROL COMPENSATOR SELECTION [OC]

The **OC** command selects between torque (1), velocity (2), relative position (3), and absolute position (4) modes of operation.

Default State: Velocity Mode Compensator

NOTE
Changing the compensator will reset all parameters to default values.

Issue **C** command to permanently save changes made using **OC**.

*Example usage of **OC** command:*

> ***OC<CR>*** Select Command Mode	
Sure (Y/N) ? ***Y***	*Enter Y to continue, any other key to abort*
Option ? ***2***	*Enter 1 for Torque Mode, 2 for Velocity Mode, 3 for Relative Position Mode, 4 for Absolute Position Mode or H for Help.* *The SYSTEM FAULT LED flashes during reconfiguration.*
Controller in Velocity Mode	
>	

4.3.6.4.3 REFERENCE INPUT FILTER [OA]

The **OA** command enables or disables the command reference input filter. This is a low pass filter with a -3dB point of 1 KHz, (refer to Section 5.2.2.3). It is used to attenuate high frequency noise on the input command signal.

Default State: Reference Filter Enabled

Issue **C** command to permanently save changes made using **OA**.

*Example usage of **OA** command:*

> ***OA<CR>*** Enable Analog Filter on Reference	
Input (Y/N) ? ***Y***	*Reply Y to enable, any other key to disable filter*
>	

4.3.6.4.4 OBSERVER ENABLE/DISABLE [OO]

The **OO** command enables or disables the velocity observer software, (see Section 4.3.5.5).

Default State: Observer Disabled

Issue **C** command to permanently save changes made using **OO**.

*Example usage of **OO** command:*

> ***OO<CR>***
Use Observer
Velocity
Estimate
(Y/N)? ***Y*** *Reply Y to enable, any other key to disable observer*

>

4.3.6.4.5 INPUT OFFSET ADJUST [OI]

The **OI** command adjusts the input offset voltage.

Offset Units:	mVolts
Default Offset Value:	0
Min. Offset Value:	-700
Max Offset Value:	700

Issue **C** command to permanently save changes made using **OI**.

*Example usage of **OI** command:*

> ***OI<CR>***

Input Offset
(0.0) [mV] *Current value displayed.*
? ***100 <CR>*** *Enter desired offset value.*
>

4.3.6.4.6 AUTOMATIC OFFSET ADJUST [OZ]

The automatic offset adjust command [**OZ**] allows the input voltage to be automatically nulled to compensate external and internal offsets. The correct procedure for use is:

- Set command value from the host, (CNC, PLC, etc.) to zero.
- Issue the **OZ** command at the **>** prompt.

On receiving the **OZ** command, the drive takes 200 ms to determine the average of the next 100 samples of the analog reference voltage and place the negative of the result in the input offset register. The offset will be limited to a maximum value of +/- 700 mV. The default offset value is 0 mV.

Issue **C** command to permanently save changes made using **OZ**.

*Example usage of **OZ** command:*

> ***OZ<CR>***
Offset Nulled
C to Save!

\>

4.3.6.4.7 FUNCTION GENERATOR OPTIONS [OR/OG]

A software function generator, intended to be used for tuning of the drive, is available to be used as the reference command source. The function generator provides a square wave, programmable in amplitude, offset, period, and duty cycle.
The function generator has the following parameters:

Parameter	Units	Range	Default Value
Speed Amplitude	RPM	0 to 10,000	0
Speed Offset	RPM	±10,000	0
Torque Amplitude	Nm	0 to Peak Torque	0
Torque Offset	Nm	-Peak Torque to Peak Torque	0
Period	s	0 to 10 Seconds	1
Duty Cycle	%	0 to 99.9	50

TABLE 4-7 Function Generator Settings

The duty cycle parameter specifies the percentage of the period that the speed or torque amplitude is positive. For the rest of the period, the speed or torque amplitude is negative.

The speed and torque offsets, allow unequal speeds or torques in both directions, or unipolar speeds.

Speed Amplitude and Offset parameters are only activated when the drive is operating in velocity mode. Similarly, Torque Amplitude and Offset parameters are only activated when the drive is operating in torque mode.
The function generator is set up from the main menu using the following command sequence. The command reference must be initialized to the function generator using the **OR** command, after which the user will be immediately prompted to enter the function generator parameters. In this example the function generator will be set up for a ±100 RPM, 1 Hz, 50% duty cycle square wave, in velocity mode:

*Example usage of **OR** command:*

> ***OR<CR>***	
Command Reference Initialization	
Sure (Y/N) ? ***Y***	*Enter Y to continue, any other key to abort*
Options:- 1 Analog Ref 2 Function Gen. 3 Point I/F	
?(1/2)>> ***2***	*Select Function Generator as Reference Source*
Func. Generator Speed Amplitude (0.0) [RPM]	(*Torque Amplitude when in torque mode.)*
? ***100 <CR>***	*Set Speed to 100 RPM*
Func. Generator Speed Offset (0.0) [RPM]	*(Torque Offset when in torque mode.)*
? ***<CR>***	*Accept Current Value - No Speed Offset*
Func. Generator Period 1.000E 0 [s]	
? ***<CR>***	*Accept Current Value - Period of 1 Second*
Func. Generator Duty Cycle 5.000E 1 [%]	
? ***<CR>***	*Accept Current Value - Duty Cycle of 50%*
Function Generator Initialization	*The SYSTEM FAULT LED flashes during reconfiguration.*
>	

As long as the function generator is selected as the command reference, and after initially setting parameters, the **OGN** command can be used to edit speed amplitude and offset, the **OGT** command can be used to edit torque amplitude and offset, and the **OGP** command can be used to edit duty cycle and period.
When function generator parameter initialization is selected the motor is software disabled. Issue an **MI** command to re-enable after changing parameters.

CAUTION

Function generator changes can result in dangerous machine movement. It is preferable to not make large changes in parameters.

The function generator parameters can be stored in EEPROM, using the **C** command, but this means that the function generator will be activated upon power up.

4.3.6.4.8 PROGRAMMABLE ANALOG TEST POINTS [OF]

Two programmable test points, TP1 and TP2, are accessible through the drive front cover, to aid in set-up and troubleshooting of the drives, (refer to Figure 5.4). The signals at TP1 and TP2 are referenced to the common.
There are five signals which can be programmed to either of the two test points.

Default TP1 Signal:	Idc (Current Command)
Default TP2 Signal:	Actual Velocity

The command syntax consists of the following four character string:

OF	**A** - TP1	**1** - Actual Velocity
	B - TP2	**2** - Filtered Velocity
	H - Help	**3** - Idc (Current Command)
	? - List Assignments	**4** - Observer Estimated Velocity
		5 - Observer Position Error

An attempt to program a parameter to a test point that already appears at the other test point is not accepted and an appropriate message is displayed, e.g.;

```
Output 2
Set to this!!
No change made.
>
```

Issue **C** command to permanently save changes made using **OF**.

*Example usage of **OF** command:*

> ***OFB<CR>***	*Program TP2 to observer estimated velocity.*
Option >>> ***4***	
TP1 Current Cmd	*TP1 Signal Assignment.*
TP2 Obs Est Vel	*TP2 Signal Assignment.*
>	

4.3.6.4.9 THERMAL PROTECTION [OD]

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The **OD** command disables drive and motor thermal protection. When thermal protection is disabled, the drive does not undergo a fatal fault shutdown when drive and / or motor over temperature occurs. However, the appropriate over temperature front panel LED illuminates, as does the FOLDBACK ACTIVE LED and the FOLDBACK optoisolator output, indicating a non-fatal fault. User hardware can detect the FOLDBACK output, while a **?F** query can determine what non-fatal fault occurred, allowing the user hardware to initiate a safe machine shutdown.

Default State: Thermal Protection Enabled

CAUTION

Disabling drive and/or motor thermal protection can lead to drive and/or motor damage.

Issue **C** command to permanently save changes made using **OD**.

*Example usage of **OD** command:*

> ***OD<CR>***
Disable
Thermal
Protection
(Y/N) ? ***N*** *Enter Y to disable, any other key to enable.*
>

4.3.6.4.10 IT FOLDBACK CURRENT LIMITING [OT]

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The IT Foldback feature is intended to protect the drive and/or motor from overheating due to excessive operation at peak current. The product of the peak current limit, I_{peak}, and the maximum time at I_{peak} determines the value called Max_It. When the current command exceeds the continuous current setting, I_{cont}, the product of current and time is computed. When this IT product becomes greater than the Max_It value, the drive enters foldback and the output current is reduced down to the continuous current level. The drive remains in foldback until the current level goes below the continuous current rating.

Using the **OT** command the user may configure three parameters, I_{peak}, Max Time at I_{peak}, and I_{cont} as follows:

Foldback Parameter	Acceptable Range	Default Value
I_{peak}	0 to Drive Rated I_{peak}	Drive Rated I_{peak}
Max Time at I_{peak}	0.1 to 5 Seconds	2 Seconds
I_{cont}	0 to Drive Rated I_{cont}	Drive Rated I_{cont}

Issue **C** command to permanently save changes made using **OT**.

*Example usage of **OT** command:*

> ***OT<CR>***

Ipeak
7.997E 1 [Arms]
Ipeak ? ***60 <CR>*** *Set the peak limit to 60 amps.*

Max. Time
at Ipeak
2.000E 0 [S]
T ? ***1 <CR>*** *Set the time at peak to 1 second.*

Icont
3.498E 1 [Arms]
Icont ? ***30 <CR>*** *Set the continuous limit to 30 amps.*
>

4.3.6.4.11 MANUAL MODE, ENABLE / DISABLE [OM]

The **OM** command enables / disables manual mode.
In manual mode the velocity and torque limits are set to preset manual mode values, (refer to Section 4.3.5.1.3).
Manual mode may also be enabled/disabled by hardware if an Extended I/O Option card is installed, (refer to Section 4.3.8.2.2).

Default State: Manual Mode Disabled

Issue **C** command to permanently save changes made using **OM**.

*Example usage of **OM** command:*

> ***OM<CR>***

Disable Manual
Mode
(Y/N) ? ***Y*** *Enter Y to disable, any other key to enable.*
>

4.3.7 COMMAND REFERENCE (ENCODER SIMULATION OPTION)

This Section details the additional commands and command extensions activated when an Encoder Simulation Option card is installed. For a description of the Encoder Simulation Option refer to Section 5.4.

4.3.7.1 SETTING AND LISTING PARAMETERS (ENCODER SIMULATION OPTION)

4.3.7.1.1 LISTING [L-] MOTOR AND DRIVE CONFIGURATION

In addition to the data described in Section 4.3.6.1.1, presence of an Encoder Simulation Option card is reported.

*Example of additional data listed by usage of **L-** command:*

> ***L- <CR>***

Same listings as shown in Section 4.3.6.1.1., except for "No Option Card Installed".

Encoder
Simulation
Installed
>

4.3.7.1.2 SETTING/LISTING (SN/LN) VELOCITY SCALING

When an Encoder Simulation Option card is installed the maximum speed is constrained to the lesser of the encoder maximum speed or the motor maximum speed. The encoder maximum speed limitation is listed in TABLE 5-14, and is inversely proportional to line count. For an application that is speed limited by the encoder, the encoder line count must be reduced to overcome the maximum speed limitation.

*Example usage of **SN** command, when encoder speed limitation occurs:*

> ***SN<CR>***

Vel. Scaling
1.000E 4
[RPM at 10V]
RPM ? ***20000 <CR>*** *User inputs speed higher than encoder speed limitation.*

>

4.3.7.1.3 LINE COUNT (OEL)

The **OEL** command allows the user to modify the Encoder Simulation Module's line count. The user is not allowed to enter a line count that has a higher encoder maximum speed limitation. The **OEL** command can only be issued when the motor is disabled.

Line Count Units:	None
Line Count Default Value:	1024
Line Count Acceptable Values:	128,256,512,1024,2048,4096,8192,16384

*Example usage of **OEL** command:*

> ***OE<CR>***

Encoder Options	
-more-	
L: Line Count:	
M: Marker Width	
S: ESM Status	
>>> L	
? ***3***	*Set line count to 4096.*
Encoder Status	*Present Encoder Status is displayed*.
Marker Width:	
90 Degrees	
- more -***<CR>***	*Press RETURN or any key to proceed.*
Line Count:	
4096	
- more -***<CR>***	*Press RETURN or any key to proceed.*
Speed Range:	
0 - 6000 RPM	
-more-***<CR>***	
Enter First Letter…	
>	

4.3.7.1.4 MARKER WIDTH (OEM)

The **OEM** command allows the user to modify the Encoder Simulation Module's marker width. The **OEM** command can only be issued when the motor is disabled.

Marker Width Units:	Degrees
Marker Width Default Value:	90
Marker Width Acceptable Values:	90,180,360

*Example usage of **OEM** command:*

> ***OEM***

Input Encoder	
Marker Width	
? ***2<CR>***	*Set marker width to 180 degrees.*
Marker Width:	
180 Degrees	
>	

4.3.7.1.5 ENCODER SIMULATION OPTION STATUS (OES)

The **OES** command displays the status of the Encoder Simulation Module. The status displays the line count, marker width, and maximum speed of operation.

*Example usage of **OES** command:*

> ***OES<CR>***

Encoder Status	*Present Encoder Status is displayed*.
Marker Width:	
90 Degrees	
- more -***<CR>***	*Press RETURN or any key to proceed.*
Line Count:	
1024	
- more -***<CR>***	*Press RETURN or any key to proceed.*
Speed Range:	
0 - 15000 RPM	

>

4.3.7.1.6 FAULTS (?F)

In addition to the faults described in Section 4.3.6.3.7, when an Encoder Simulation Option Card is present an Encoder Simulation Fault is also listed.

4.3.7.1.7 ENCODER POSITION (?E)

The Encoder Simulation Option maintains a digital representation of position. The **?E** command allows the user to query this parameter.

*Example usage of **?E** command:*

> ***?E<CR>***

Encoder
Position
4.102E 1 [Deg]

>

4.3.8 COMMAND REFERENCE (EXTENDED I/O OPTION)

This Section details the additional commands and command extensions activated when an Extended I/O Option card is installed. For a description of the Extended I/O Option Card, refer to Section 5.6

4.3.8.1 SETTING AND LISTING PARAMETERS (EXTENDED I/O OPTION)

4.3.8.1.1 LISTING [L-] MOTOR AND DRIVE CONFIGURATION

In addition to the data described in Section 4.3.6.1.1, presence of an extended I/O option card is reported.

*Example of additional data listed by usage of **L-** command:*

> ***L-<CR>***

Same listings as shown in Section 4.3.6.1.1., except for "No Option Card Installed".

>

4.3.8.1.2 SETTING/LISTING (S*/L*) ALL APPLICATION PARAMETERS

In addition to the parameters listed in Section 4.3.6.1.2, the following parameter is added to the **S*** and **L*** commands when an Extended I/O Option card is installed:

- Limit Switch Emergency Braking Deceleration [rad/sec^2]

*Example of additional parameter listed by **S*** command:*

Emergency Decel
5.000E 4
[Rad/Sec^2]
- more -***<CR>*** *Press RETURN or any key to proceed.*

4.3.8.1.3 SETTING/LISTING [SE/LE] LIMIT SWITCH EMERGENCY BRAKING DECELERATION

FOR MOST APPLICATIONS THE USER SHOULD NOT NEED TO ALTER THIS PARAMETER.

The limit switch emergency braking deceleration parameter determines the deceleration rate of the motor when a limit switch is activated in either the CW or CCW direction. Due to shaft loads, (inertia, friction), the desired deceleration rate may not be reached in actual application. Limit switches are only functional when the Extended I/O option card is used.

The **SE** command sets the braking deceleration.

Braking Deceleration Units:	Radians/Second^2
Braking Deceleration Default Value:	5 E4
Braking Deceleration Min. Value:	1 E3
Braking Deceleration Max Value:	1 E6

Issue **C** command to permanently save changes made using **SE**.

*Example usage of **SE** command:*

> ***SE<CR>***

Emergency Decel 5.000E 4 [Rad/Sec^2]	*The current deceleration value is displayed.*
? ***10E4 <CR>***	*Enter new deceleration value.*
>	

The **LE** command lists the current braking deceleration.

*Example usage of **LE** command:*

> ***LE<CR>***

Emergency Decel
1.000E 5
[Rad/Sec^2]
-more-**<CR>**
>

4.3.8.2 DRIVE STATE (?S)

In addition to the drive parameters listed in Section 4.3.6.3.6, the **?S** command lists the present state of the following parameter when an Extended I/O Option Card is installed:

- Limit Switches Enabled/Disabled

4.3.8.2.1 LIMIT SWITCHES [OL]

The **OL** command enables / disables the clockwise (CW) and counterclockwise (CCW) limit switch functions of the Extended I/O Option Card. When enabled, the CW (CCW) motor rotation is inhibited whenever the CW Limit (CCW Limit) input is not asserted.

Default State with Extended I/O Present:	Limit Switches Enabled

Issue **C** command to permanently save changes made using **OL**.

*Example usage of **OL** command:*

> ***OL<CR>***

Disable Limit Switches	
(Y/N) ? ***N***	*Enter Y to disable, any other key to enable.*
>	

4.3.8.2.2 ENABLE / DISABLE MANUAL MODE [OM]

When an Extended I/O card is used, the drive defaults to manual mode enabled. Automatic mode, (manual mode disabled), is activate by current flow in the AUTO/MANUAL input of the Extended I/O card. The **OM** command, (refer to Section 4.3.6.4.11), can still be used to disable automatic mode.

4.3.9 T164 SERIES DRIVE MAIN MENU C4 COMMAND SUMMARY

Initialization:

[**CTRL+X**] RE-INITIALIZE
C: STORE DRIVE PARAMETERS IN EEPROM
D: DRIVE INITIALIZATION

Help:

H: HELP ALWAYS
+: INCREASE HELP LEVEL
-: DECREASE HELP LEVEL

Adjustments:

I: INTEGRAL TIME-CONSTANT [Sec]
- **D**: Down (incremental adjust mode)
- **E**: Exit
- **H**: Help
- **L**: List
- **S**: Set (numerical input)
- **U**: Up (incremental adjust mode)
- **Z**: Zero

J: OBSERVER INERTIA
- **D**, **E**, **H**, **L**, **S**, **U**, **Z**

P: VELOCITY LOOP PROPORTIONAL GAIN [Nm/(rad/sec)]
- **D**, **E**, **H**, **L**, **S**, **U**, **Z**

Listing / Setting Parameters:

L: LIST PARAMETER
- **-**: show system configuration
- **M**: Motor parameters
- **Z**: Zeta (damping ratio) of velocity mode compensator filter

L: LIST PARAMETER
S: SET PARAMETER
- *****: All tuning parameters
- **D**: FUNCTION NOT SUPPORTED
- **E**: limit switch braking deceleration [rad/sec^2] (REQUIRES EXTENDED I/O OPTION)
- **H**: Help
- **I**: Integral time-constant [sec]
- **J**: velocity observer inertia
- **L**: velocity Limit [RPM]
  - **A**: Automatic mode velocity limit [RPM]
  - **M**: Manual mode velocity limit [RPM]
- **N**: velocity scale adjust
- **P**: velocity loop Proportional gain [Nm/(rad/sec)]
- **T**: Torque limit [Nm]
  - **A**: Automatic mode torque limit [Nm]
  - **M**: Manual mode torque limit [Nm]
- **W**: velocity mode compensator filter bandwidth [Hz]

<u>Setting Motor Operating Modes:</u>

M: MOTOR OPERATIONAL MODES
- **H**: Help
- **I**: Motor Enable (hardware enable must be asserted)
- **O**: Motor Disable (or any other non defined key for the **M** command)

<u>Setting Options:</u>

O: OPTIONS
- **A**: Analog reference input filter (enable/disable)
- **C**: control Compensator options:
  - **1**: torque mode
  - **2**: velocity mode
  - **3.** Relative Position mode
  - **4.** Absolute Position mode
- **D**: thermal protection (enable/disable)
- **E**: Encoder simulation options (REQUIRES ENCODER SIMULATION OPTION)
  - **L**: number of Lines (256,512,1024,2048,4096,8192,16384)
  - **M**: set Marker width (90,180,360 degrees)
  - **S**: Status of encoder simulation
- **F**: test point options:
  - **?**: list TP1 and TP2 currently programmed signals
  - **A**: assign signal to TP1 (Default: Idc (current monitor))
    - **1**: actual velocity
    - **2**: filtered velocity
    - **3**: Idc (current monitor)
    - **4**: observer estimated velocity
    - **5**: observer position error
  - **B**: assign signal to TP2 (Default: actual velocity)
    - **1**, **2**, **3**, **4**, **5**
- **G**: function Generator options
  - **N**: set function generator speed amplitude and offset
  - **P**: set function generator Period and duty cycle
  - **T**: set function generator Torque amplitude and offset

- **I**: Input offset
- **L**: Limit switches (REQUIRES EXTENDED I/O OPTION)
- **M**: Manual mode enable/disable
- **O**: enable/disable Observer
- **R**: input command Reference source
- **T**: IT limit settings
- **Z**: automatic input offset Zero

Query Operating Conditions:

?: OPERATING CONDITIONS
- **B**: Bridge (drive) temperature
- **E**: Encoder position [Degrees] (REQUIRES ENCODER SIMULATION OPTION)
- **F**: Faults
- **H**: Help
- **L**: current Limits
- **M**: Motor temperature
- **P**: motor shaft Position [Degrees]
- **S**: drive State
- **V**: motor shaft Velocity [RPM]

5. COMPONENT DESCRIPTION AND SPECIFICATION

This section provides descriptions and specifications for the T150-901 Power Supply, the T164 Series Drives, the Hand Held Service Terminal, the Encoder Simulation Option card, the Extended I/O Option Card(s), the CAN Interface card, the Extended Inputs Bracket and the G4XX Series Motors.

5.1 POWER SUPPLY DESCRIPTION, SPECIFICATIONS

The power supply has the following features:

- ❑ Integral Heat Sink and Cooling Fan
- ❑ Three Phase a.c. Operation
- ❑ Direct Off-Line 220 V r.m.s. Operation
- ❑ Soft Start (a.c. Inrush Current Limiting)
- ❑ Input MOV Transient Protection
- ❑ Integral Shunt Regulator
- ❑ Fast Bus Discharge
- ❑ Phase Loss Detection
- ❑ Provision for External Regen Resistor
- ❑ Regen Electronic Circuit Breaker
- ❑ Power Supply Fault Opto-isolator
- ❑ Diagnostic LEDs

WARNING
Power supplies contain large capacitors that maintain high voltage on the d.c.+ to d.c.- terminals for several minutes after input power is removed if the regen resistor circuit is open (fuse blown or wiring open).
Wait at least 5 minutes after power shutdown for capacitors to discharge. Then use a voltmeter to check for safe voltage from the d.c.+ terminal to the d.c.- terminal before contacting terminals or commencing any service or maintenance activities, to ensure that no lethal voltages are present .
Failure to follow this procedure can result in serious personal injury.

5.1.1 DIAGNOSTIC LEDS

The status of the power supply may be monitored using the diagnostic LED indicators on the front panel as listed in TABLE 5-1.

5.1.2 CIRCUIT DESCRIPTION

The power supply consists of four functional blocks:

- High voltage rectification and filtering
- Low voltage control power supply
- Shunt regulator circuit
- Monitoring and fault logic circuits

FIGURE 5.1 is a block diagram of the T150-901 Power Supply.

LED Color	Label	Condition Indicated
Green	BUS ACTIVE	Greater than 30 V d.c. is present on the d.c. bus.
Yellow	REGEN ACTIVE	The regen circuit is active because the bus voltage exceeds the regen cut-in threshold or a.c. power has been lost and a fast bus discharge is occurring.
Yellow	LOSS OF PHASE	Phase loss or power loss on a.c. mains.
Yellow	THERMAL FAULT	Base plate over temperature.
Yellow	REGEN FUSE	Regen circuit fuse blown.

TABLE 5-1 T150-901 Power Supply Status Indicators

5.1.2.1 HIGH VOLTAGE RECTIFICATION AND FILTERING

The a.c. mains input is rectified by a three phase diode bridge and filtered by a large bank of electrolytic capacitors to generate a nominal 325 V d.c. supply at 50 amps. This high power 325 V d.c supply is unregulated and will vary in direct proportion with the a.c. mains input. A d.c. bus fuse protects against long term overloads and d.c. output short circuits.

5.1.2.2 LOW VOLTAGE CONTROL POWER SUPPLY

Control power for the logic circuits is generated by a fly back switchmode converter. This control voltage also powers the cooling fan. There is no isolation from the a.c. mains provided by this supply.

5.1.2.3 SHUNT REGULATOR CIRCUIT

Rapid motor deceleration or an overhauling load creates a situation in which energy is regenerated back into the high voltage power supply. This regenerative energy will charge the power supply bus capacitors. To prevent capacitor over voltage a shunt regulator circuit senses when the bus voltage exceeds the regen cut-in voltage and via a regen transistor, switches a regen resistor across the d.c. bus, (in shunt), to dissipate the regen energy. Hysteresis in the shunt regulator circuit keeps the regen circuit active until the bus voltage is reduced below the regen cut-out voltage. The frequency at which the regen circuit operates is dependent upon the magnitude of the regen energy. If the regen energy exceeds the capacity of the regen circuit, a higher capacity regen resistor must be used. The T150-901 Power Supply includes an internal regen resistor with 40 watt capacity. Optional external regen resistors with higher capacities can be utilized, as explained in section 2.7

The T150-901 Power Supply can also provide 2500 watts of regen capability as explained in section 2.7.5.

An electronic circuit breaker protects the regen circuit against external short circuits and protects the regen resistor from exceeding its continuous rating. If the regen resistor continuous rating is exceeded the electronic circuit breaker disables the shunt regulator circuit. In this case, additional regen energy from the motor will cause the d.c. bus voltage to increase until a Drive over voltage fault occurs. Under this condition, the regen circuit is undersized for the application FIGURE 5.2 provides energy vs. time curves for the electronic circuit breaker. A regen fuse is provided to protect the regen resistor in case of failure of the regen circuit electronics. A monitoring circuit provides a REGEN FUSE fault if the regen fuse blows. The regen electronic circuit breaker prevents nuisance tripping of the regen fuse.

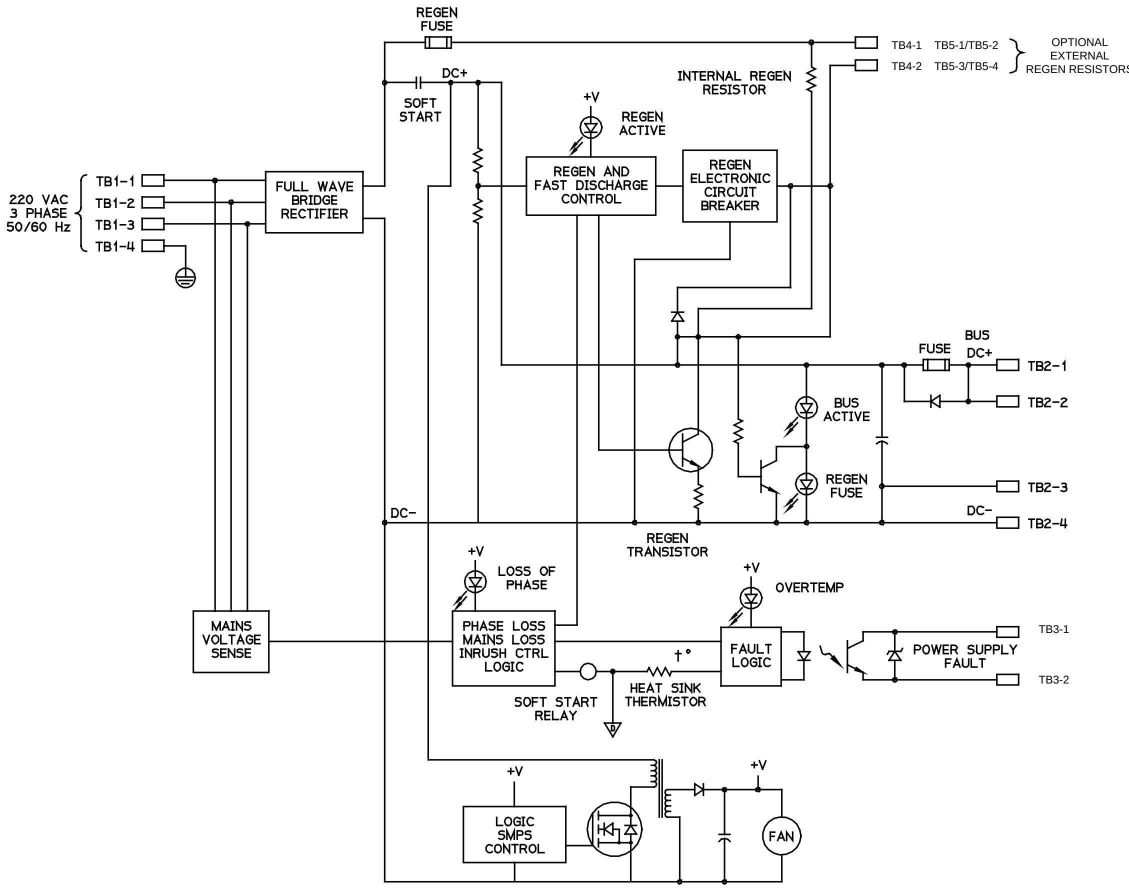


FIGURE 5.1 MODEL T150-901 POWER SUPPLY BLOCK DIAGRAM

5.1.2.4 MONITORING AND FAULTS

The a.c. mains are sensed to provide a PHASE LOSS FAULT. Jumper JW1 allows the user to disable the PHASE LOSS FAULT for single phase applications. The a.c. mains sense is also used to determine a.c. power loss and a.c. power present.

The a.c. power loss is used to activate the regen circuit to provide a fast bus discharge safety feature. The a.c. power present is used to control soft start. When a.c. power is first applied to the supply, the regen resistor is in series with the bus capacitors to limit the inrush charging current. At a fixed time delay after a.c. power present is sensed, the soft start relays energize to switch the regen resistor out of the bus capacitor charging path and into its normal configuration. Note that a blown regen fuse or an open regen resistor will prevent the power supply from starting up, and generate a REGEN FUSE fault indication.

A thermistor on the power supply base plate is used to generate a THERMAL FAULT if the temperature of the bridge rectifier exceeds its rating.

An opto-isolator provides a POWER SUPPLY FAULT output for the user. Under normal conditions the opto-isolator is energized providing a low impedance between terminals TB3-1 and TB3-2. Under fault conditions, the opto is turned off providing a high impedance between terminals TB3-1and TB3-2 A fault condition is caused by any of the following:

- Regen fuse blown
- Thermal fault
- Loss of Phase (Unless disabled by JW1)
- Soft-Start In Progress

The user must provide an isolated d.c. power source for the POWER SUPPLY FAULT output. It is recommended that the Drives not be enabled during a power supply fault. This is especially important during start-up to prevent load power from being drawn during the power supply soft start process.

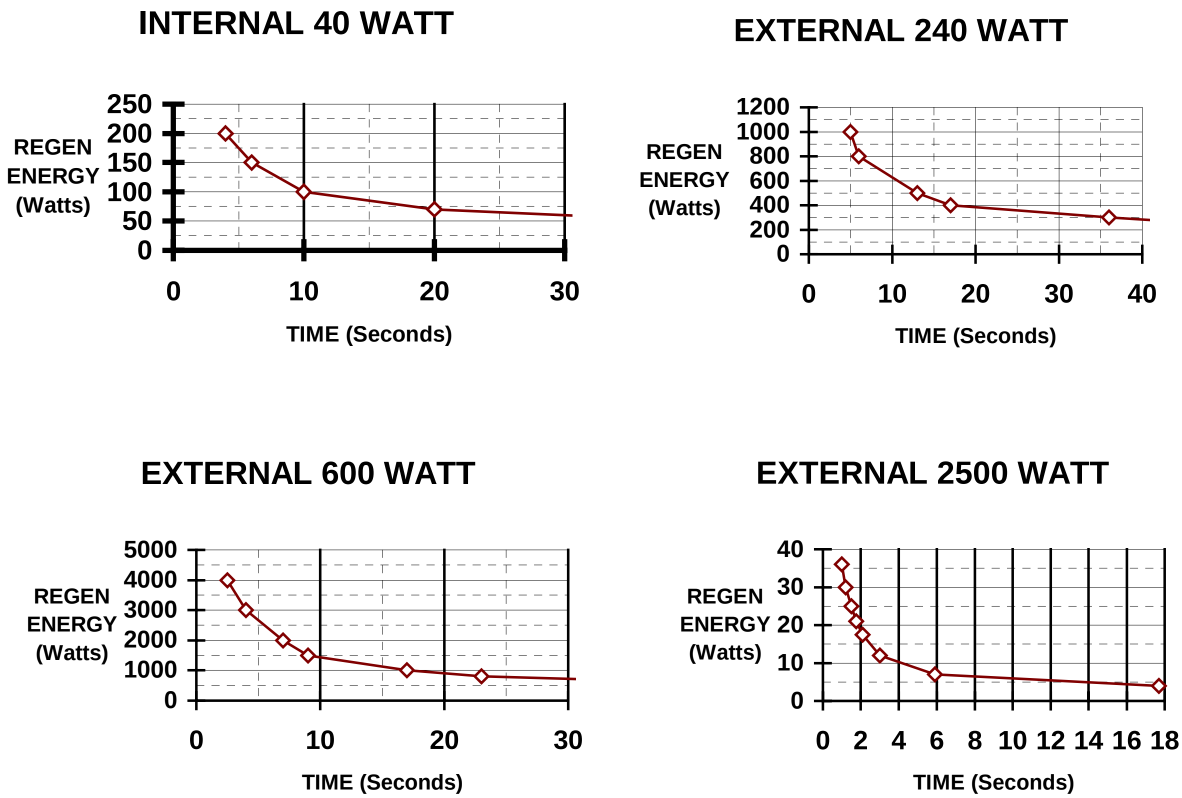


FIGURE 5.2 Model T150-901 Power Supply Regen Electronic Circuit Breaker Trip Characteristics

5.1.3 SPECIFICATIONS

a.c. Input Voltage Rating 220 V r.m.s.50/60 Hz

a.c. Input Power Rating 15 kW.

a.c. Input Current Rating 50 A r.m.s. max.

d.c. Output Voltage Rating 300-350 V d.c. No-Load Unregulated
≤ 20 Volt Ripple to 100 Amps
d.c. Bus Fuse Bussmann FWH-60A or equivalent

Three PhaseOperation

a.c. Input Current Rating	50 Amps r.m.s.
Continuous Output d.c. Current Rating	50 Amps d.c. max.
Peak Output d.c. Current (3 seconds)	75 Amps d.c.
Peak Output d.c. Current (1 second)	100 Amps d.c.
Regen Cut-in Voltage	380 V d.c. ±5%
Regen Hysteresis Voltage	7 V d.c. ±3 V d.c.

T150-901 POWER SUPPLY REGEN SPECIFICATIONS

	Internal **50Ω 55W Resistor**	**External** **10Ω 225W[1] Resistor[2]**	**External** **8Ω 750w Resistor[2]**	**External** **4Ω 3KW Resistor[3]**
Peak Regen Power	2.8 KW	17 KW	17.7 KW	36KW
Continuous Regen Power	40 W	240 W	600 W	2500 W
Regen Fuse	5M3FDC	5M10FDC	5M15FDC	5M25FDC

1 *In parallel with internal 50Ω55W resistor.*

2 *Requires optional external regeneration resistor.*

3 Requires two 8Ω 1500W resistors in parallel

	Max Supply Voltage[4]	Max Source Sink Current[5]
Power Supply Fault Output	35 V d.c.	50 mA

[4] *User must provide isolated power source.*

[5] *Output sources or sinks current with maximum 1.0 Vd.c. drop under normal operation. Output open circuits to indicate power supply fault.*

Base Plate Over Temperature Trip Point	90°C ±5°C
Operating Temperature Range	0 - 55 °C ambient
Humidity	5% to 95% non-condensing
Altitude	3300 feet[6]

[6] *Derate output 2% per 1000 feet above 3300 feet.*

Weight	4.88 kg (10.75 lb)

5.2 T164 SERIES DRIVES DESCRIPTION, SPECIFICATIONS

Drives have the following features:

- ❑ Integral Heat Sink and Cooling Fan
- ❑ Pluggable Solderless Connectors
- ❑ Sinusoidal Three Phase Drive
- ❑ Resolver Based System
- ❑ Microprocessor Based
- ❑ Digitally Tuned Current Loop
- ❑ No Personality Modules
- ❑ Configuration Stored in Non-Volatile E^2PROM
- ❑ Programmable Velocity or Current Control
- ❑ Programmable Analog Test Points
- ❑ RS232 Serial Port
- ❑ PC Set-up via "MOOGTERM" software
- ❑ Internal Logic Switchmode Supply
- ❑ Diagnostic LEDs
- ❑ 24 Vd.c. Control Power Input
- ❑ Extended I/O (Option Card)
- ❑ Encoder Simulation (Option Card)
- ❑ Point to Point Position Control (Option Card)

In addition, Drives incorporate the following protection features:

- ❑ Watchdog Timer
- ❑ Logic Under voltage
- ❑ I-T Current Foldback
- ❑ Short Circuit
- ❑ Motor Over temperature
- ❑ Drive Over temperature
- ❑ Resolver Loss
- ❑ d.c. Bus Over voltage

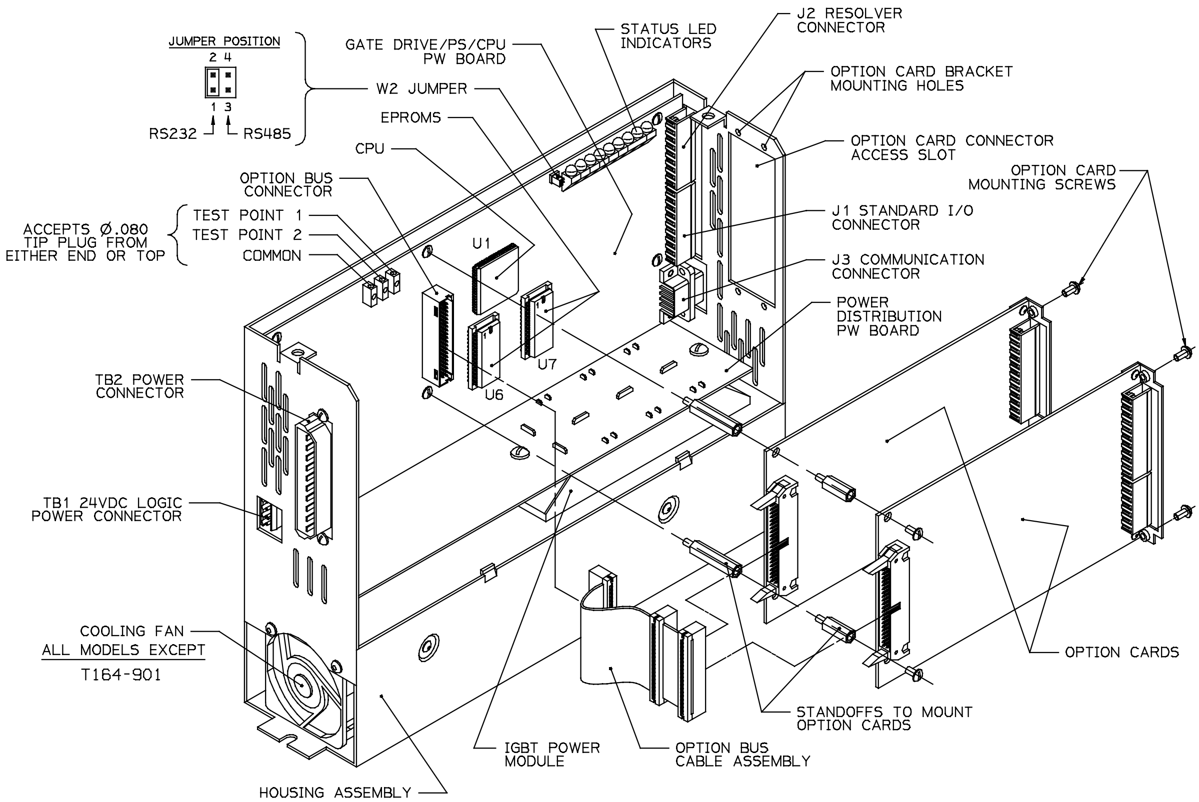


FIGURE 5.3 T164 SERIES DRIVE COMPONENT IDENTIFICATION

5.2.1 DIAGNOSTIC LEDS

The status of the Drive may be monitored using the diagnostic LED indicators on the front panel as listed in TABLE 5-2

LED Color	Label	Condition Indicated
Green	SYSTEM ENABLE	Power amplifier is activated.
Green	POWER SUPPLY OK	Logic supplies within normal operating range.
Yellow	FOLDBACK	Current output has been folded back due to excessive demand, or a non-fatal fault occurred, (when another Yellow LED is on).
Yellow	SYSTEM FAULT	A hardware or software fault has occurred.
Yellow	BUS OVER VOLTAGE	d.c. Bus voltage has exceeded maximum rating.
Yellow	SHORT CIRCUIT	Short Circuit in Motor, Motor Wiring or Drive Output Stage.
Yellow	RESOLVER LOSS	Resolver feedback signal out of specification or lost.
Yellow	BRIDGE OVERTEMP	Drive Base Plate over temperature.
Yellow	MOTOR OVERTEMP	Motor over temperature. (Motor thermistor must be connected to drive.)

TABLE 5-2 T164 Series Drive Status Indicators

5.2.2 CIRCUIT DESCRIPTION

This description of the T164 series drive refers to FIGURE 5.4 the drive block diagram.

5.2.2.1 LOGIC POWER SUPPLY

Logic power for the control is generated internally. It requires an externally provided 24 V d.c. It generates an isolated +5V d.c., +15V d.c., and -15V d.c. which are used to power the control circuitry and +12V d.c. to drive the drive's cooling fan(s)

WARNING

All external d.c. supply voltages must be derived from a Safety Extra Low Voltage (as defined by European standard EN 60950 - Refer to section 1.2.1). all external d.c supply voltages must be supplied from power supplies which are compliant with the requirements of the E.U. EMC Directive 89/336/EEC (As amended by E.U. Directive 92/31/EEC and 93/68/EEC).

5.2.2.2 CPU SECTION

The microprocessor (CPU) used in the control is an 80C186. It interfaces to 16K of RAM, 128K of EPROM, EEPROM, A/D converter, D/A converter, watchdog timer, fault detection and display circuitry, and UART serial communication device. The CPU stores setup parameters in EEPROM so that they are available after power is removed and reapplied. It takes in the discrete enable input and the analog command input from the customer interface.

Under the conditions of proper setup, no control faults, and valid enable, the CPU enables the output stage and provides the commutated phase current commands to drive the motor in either the torque controlled mode or the velocity controlled mode. One of these modes is selected by the user. The CPU accepts user setup information and provides status information via the UART serial interface. Faults are detected and processed by the CPU. A watchdog timer which has a time-out time of 2.5 milliseconds will disable the drive were the CPU to fail.

5.2.2.3 ANALOG TO DIGITAL SECTION

The analog command input (J1-9 and J1-8) has an input voltage level of +/-10 V d.c. It is brought in to a differential amplifier. The choice is available in software (see Section 4.2.6.4.3) to either use this command signal unfiltered or to use a low pass filter on the command. The filter has a -3dB point of 1 kHz and an inband time delay of 360µsec. The command signals are converted by the A/D converter, a 12 bit converter.

The resolver excitation signal is sinusoidal at 4.9 kHz, 4 V r.m.s. and can drive up to 100 mA. The resolver SIN and COS feedback signals are expected to be at a 2 V r.m.s. level. They are brought in to differential amplifiers, filtered, and converted by the A/D converter.

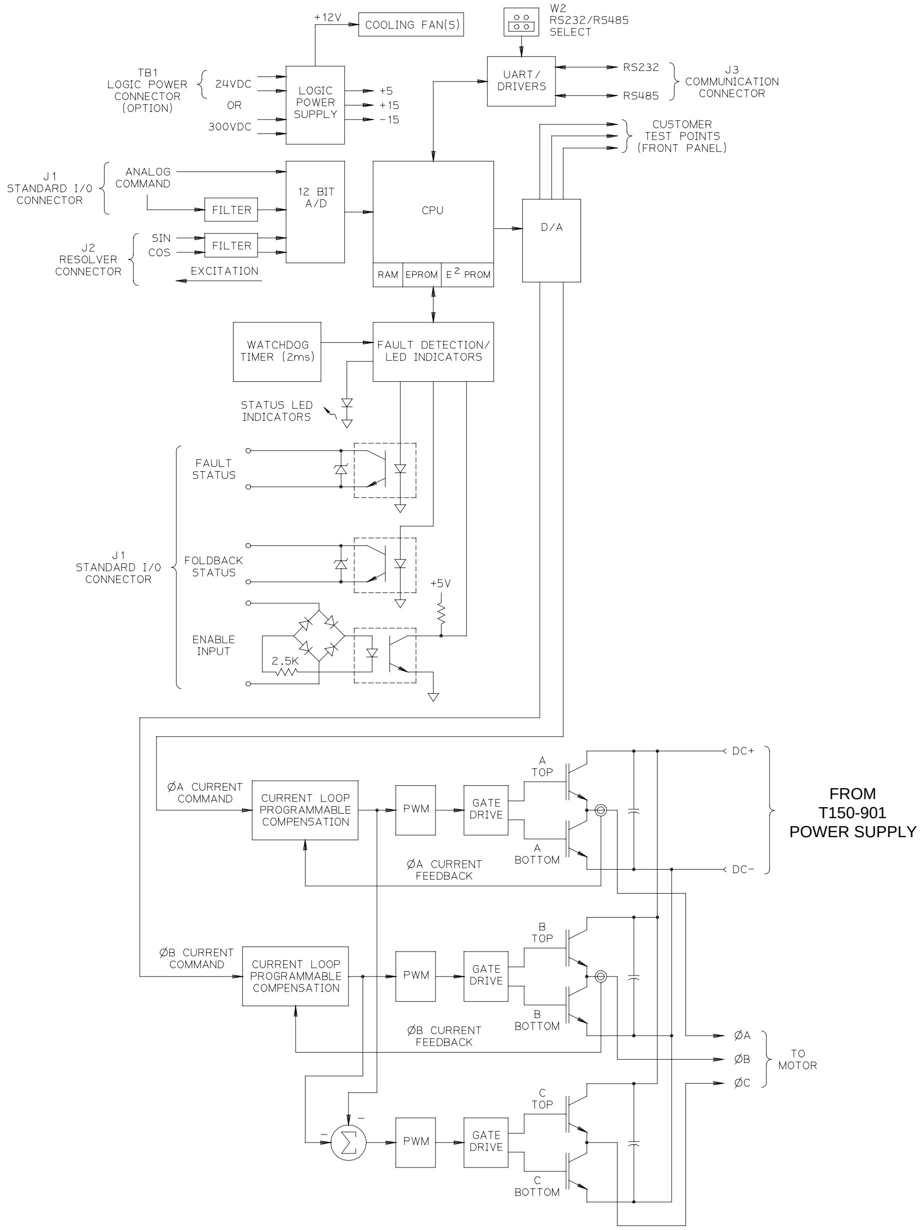


FIGURE 5.4 T164 SERIES DRIVE BLOCK DIAGRAM

5.2.2.4 DIGITAL TO ANALOG SECTION

The CPU outputs the properly commutated motor phase A and phase B current commands to the current loop through the D/A converter section. Two customer programmable test points are also provided by the D/A converter section.

5.2.2.5 CURRENT LOOP

The current loop takes the command signals from the D/A section and the motor phase current feedback signals and generates a closed loop current error signal which drives the PWM (pulse width modulation) stage. PWM is used to convert the analog current error into a digital command for the three phase inverter bridge. The setup parameters of the current loop are varied depending on the type of motor which is used. This motor specific information is contained in EPROM and is provided to the current loop upon power up. The gate drive takes the digital current loop PWM commands and level and amplitude shifts them to an appropriate voltage to drive the 6 high voltage IGBT transistors in the inverter output bridge.

5.2.2.6 UART

The UART (universal asynchronous receiver/transmitter) is used to provide the CPU with communication information from the user and to provide the user with drive status information. RS232 communication is available through the UART interface. RS232 is a 3 wire standard computer serial interface for communicating from one device (computer or terminal) to one other device (T164 Series Drive). Connecting the jumper across pins 1 and 2 will set the drive for RS232 communication.

5.2.2.7 FAULT DETECTION

The fault detection block contains 9 status LEDs that are described in Section 5.2.1. The d.c. Bus Overvoltage fault, Bridge Short Circuit fault, Logic Power Supply Status fault, Motor Overtemperature fault, Drive Overtemperature fault, and Watchdog Timer fault are detected in hardware and reported to the microprocessor for processing. In addition, Bus Overvoltage, Bridge Short Circuit, and Watchdog Timer faults immediately disable the drive independent of the microprocessor. The fault status and the motor current foldback status bits are reported to the user at the Standard I/O Connector (J1). Each output bit is optoisolated and can source or sink up to 50 mA at up to 35 V d.c.. The output transistors acts like switches.
The fault status output is normally "closed" (conducting current) and "opens" during a fault. The foldback status output is "closed" during foldback and "open" otherwise.

To source current and have active high outputs connect the output collectors (pins J1-2 and J1-4) to the excitation voltage that the interface logic works from (i.e. 24 V d.c.) and tie each emitter to the inputs that the logic looks at. To obtain active low outputs and sink current tie the output emitters (pins J1-1 and J1-3) to the excitation voltage return and tie each collector to the inputs that the logic looks at. refer to FIGURE 2.22 for an example of this.

The drive Enable input is found on J1-5 and J1-6 and is optoisolated. A valid enable signal is applied when 4.5 Vd.c. to 35 V d.c. is applied from pin 5 to pin 6 or from pin 6 to pin 5. The drive enable input goes to the microprocessor and informs it of the status of enable. The enable bit also goes directly to the drive drive logic and can disable the drive independently of the microprocessor.

5.2.3 SPECIFICATIONS

d.c. Input Voltage Rating 300 V d.c. - 350 V d.c. (310 V d.c. Nominal)

Input Current Ratings:

Model	r.m.s. Amps
T164-901	5
T164-903	10
T164-905	20
T164-907	40
T164-909	60

d.c. Peak Output Voltage Rating 350 V d.c.

Output Current Ratings:

	r.m.s. Amps Per Phase		Peak Amps Per Phase	
Model	Continuous	Peak (5 Sec)	Continuous	Peak (5 Sec)
T164-901	5	10	7	14
T164-903	10	20	14	28
T164-905	20	40	28	56
T164-907	40	80	56	113
T164-909	60	140	84	198

Output Current Ripple Frequency

T164-901 through -905 20 kHz

T164-907, -909 10 kHz

Analog Input Command (Differential)
±10 Volts = CW/CCW Max Speed (Velocity Mode)
±10 Volts = ± Peak Current (Torque Mode)
Input Impedance: 20 KΩ

Enable Input

Supply Voltage Range[1]	4.5 - 35 V d.c.
Input Impedance	2.3 KΩ Min
Polarity	Current Activated. Configurable as Source or Sink.

[1] *User must supply isolated power source.*

	Max Supply Voltage[2]	Max Source or Sink Current[3]
Drive Fault (System Ready) Output[4]	35 Vd.c.	50 mA
Drive Foldback Active Output[5]	35 Vd.c.	50 mA

[2] *User must supply isolated power source.*
[3] *Output sources or sinks current with maximum 1.0 V d.c. drop under normal operation.*
[4] *Output open circuits to indicate Drive fault.*
[5] *Output shorts to indicate foldback active.*

d.c. Bus Overvoltage Fault Trip Level 415 Vd.c. ±4%

Serial Interface

Type	RS232
Baud Rate	9600
Parity	None
Data word	10 bit (7 data, 1 start, 2 stop)

Resolver Interface

Excitation Frequency	4.9 kHz
Excitation Output	4.0 V r.m.s. @ 100 mA Max
Sine/Cosine Return	2.0 V r.m.s. 30 KΩ input impedance (differential)

Efficiency >95%[6]

[6] *Rated Continuous Current, 50% Rated Output Voltage.*

Velocity Loop Update Rate 2.5 kHz

24 V d.c. Control Power Input21 - 35 V d.c. , 1.5 Amp Min

Baseplate Overtemperature Trip Point 90°C ±5°C

Operating Temperature Range 0 - 55°C ambient

Humidity 5% to 95% non-condensing

Altitude 3300 feet[7]

[7] *Derate output 2% per 1000 feet above 3300 feet*

Weight

T164 -901 through -905	4.8 kg (10.5 lb)
T164-907,-909	5.9 kg (13 lb)

5.3 G400 SERIES MOTORS

The motor described in the following are standard motors. For special configurations like frameless motors, encoder attachments please consult Moog.

5.3.1 BRUSHLESS TECHNOLOGY

The mechanical design of the brushless (bl.) servomotor is similar to a synchronous machine, while its principle of operation corresponds with that of a conventional brush type d.c. motor where rotor and stator are exchanged. In a conventional d.c. motor, the rotor rotates in a stationary magnetic field whereas in the bl. servomotor this field is rotating with the rotor. This exciting field can be obtained by an ordinary winding as well as by a permanent magnet. For MOOG-Motors this is always a high-energy permanent magnet.

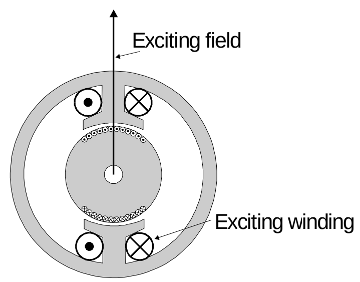


FIGURE 5.5 Principle of d.c. Motor

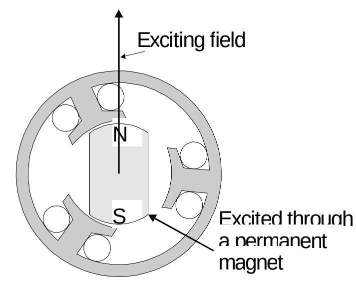


FIGURE 5.6 Principle of Servomotor

To obtain torque, the motor needs an additional winding. The current in this winding causes another magnetic field which has to be rectangular to the exciter field for maximum torque. When the rotor is turning, in this second winding a voltage is induced (BEMF). Those windings are called armature windings in literature. With the d.c.-motor this winding is in the rotor, whereas in the brushless servomotor it is in the stator.

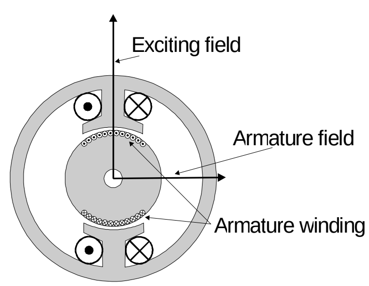


FIGURE 5.7 d.c. Motor with magnetic fields

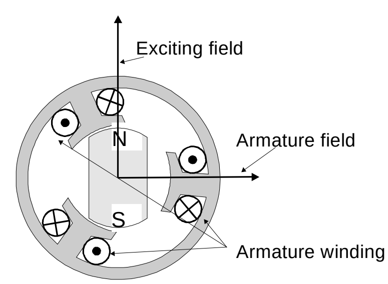


FIGURE 5.8 Servomotor with magnetic fields

The decisive disadvantages inherent in the underlying principle of a d.c. motor are:

- Limited static torque
- High degree of wear and mechanical friction
- Large size
- Limited resistance to overloading
- Poor transfer of dissipated heat from the rotor outwards.

In a brushless servomotor, the basic principles of the stator and rotor are exactly the other way round. The magnetic field of the rotor is the exciting field and rotates in accordance with the rotor speed. The rotor position is transmitted to the drive via a resolver and the stator winding is then connected in such a way as to yield a magnetic field which is always offset 90° in relation to the rotor field.

In this case, the winding is switched by the power electronics instead of being switched mechanically by the commutator, as in a conventional d.c. machine. Unlike the mechanical commutator, the power electronics is maintenance-free and wear-free.

Load fluctuations are controlled via the current intensity as in a conventional d.c. motor. The torque is once again proportional to the current, thus yielding equally good control capabilities. The following diagrams similarly illustrate two load cases:

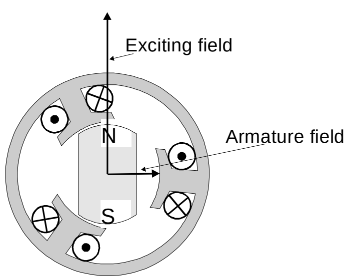


FIGURE 5.9 Bl. Servomotor low load

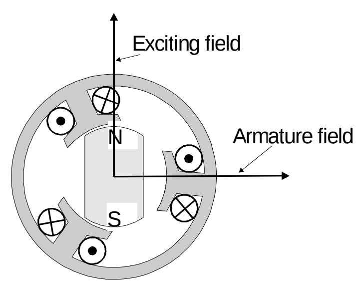


FIGURE 5.10 Bl. Servomotor high load

The synchronous motor (SM), with a mechanical design similar to the servomotor but rarely with permanent magnets, is used in a different operating mode.

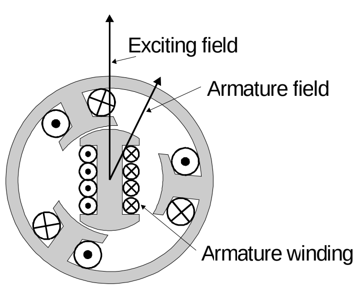


FIGURE 5.11 Synchronous Motor low load

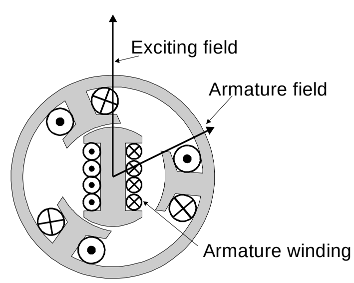


FIGURE 5.12 Synchronous Motor high load

Load fluctuations cause different angles between the two magnetic fields, whereas the armature field stays constant.

The decisive disadvantages inherent in the underlying principle of a synchronous motor are:

- ❑ Bad controllability
- ❑ Low efficiency due to reactance currents

The disadvantages listed above for conventional d.c. motors and synchronous motors do not apply for the brushless motor.

The MOOG motor is consequently characterized by the following points:

- ❑ High torque yield with small motor size
- ❑ High overload capacity
- ❑ Full torque over the entire speed range
- ❑ Highly dynamic due to the small motor inertia
- ❑ Good controllability
- ❑ High efficiency
- ❑ Little friction
- ❑ Maintenance-free operation
- ❑ Robust design

5.3.2 IDENTIFICATION

All motor specific data in this User Manual is associated to flange size and stack length of the motors.

Motor Size	Determined by the 4th character of the model number (e.g. Size G4x**2-**in the model number G42**2-**414)
Stack Length	Can be determined by means of the part number cross reference (see TABLE 5-3 Part Number Cross Reference) by the 6th character of the model number (e.g. length G4xx-**4**xx in the model number G422-**4**14).
Model Type	A model type designation (e.g. G2L10) is described by the following scheme: GxLyyz with x = motor size; yy = motor length; z = electric model (dropped for standard motors).
Brake	A description of an optional brake is added to the model type on the nameplate (for instance G2L10, **brake 0,9 Nm**).

5.3.2.1 NAMEPLATE

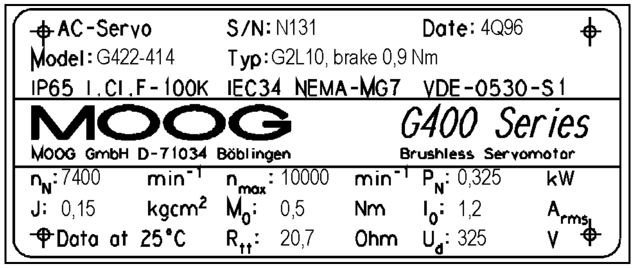


FIGURE 5.13 Example Nameplate

S/N:	serial number
Date:	production quarter and year
Model:	motor model number
Type:	electric model, description optional brake
n_N:	nominal speed (speed at P_N)
n_{max}:	maximum speed
P_N:	nominal power (maximum continuous power)
J:	moment of inertia
M_0:	continuous stall torque
I_0:	continuous stall current
R_{tt}:	terminal to terminal resistance
U_d:	bus voltage

Further electrical data can be found in the catalogue.

NOTE
The nameplate serves to identify the product. *For this reason:* *Check whether the nameplate on the device matches the nameplate illustrated above.* *This documentation must not be used for commissioning and startup if the nameplates do not match.* *Devices without nameplate are not covered by the manufacturer's warranty and must not be put into operation.*

5.3.2.2 PART NUMBER CROSS REFERENCE

The order number for motors is made up as follows:

G4xx - xxxR

Global Product

Series 4xx

configuration

Code	
0	Special design (s. note) *)
1	US
2	Europe

*) Model numbers are defined consecutively for special (customized) motors. The line number consequently does not give any indication of the model properties. These are defined by the Model Master File

Frame Size

Code	
2	55mm Flange
3	70mm Flange
4	100mm Flange
5	140mm Flange
6	190mm Flange

Revision Index

Configuration of shaft extension

Code	Run Out	Shaft Type	Shaft Sealing
4	Reduced	Key	No
5	Reduced	Key	Yes
6	Reduced	Plain	No
7	Reduced	Plain	Yes

Brake Options

Code	G4x2	G4x3	G4x4	G4x5	G4x6
0	-	-	-	-	-
1	0.9Nm	1.5Nm	6Nm	15Nm	25Nm
2	-	3Nm	15Nm	25Nm	50Nm

Active Length (in 0.1 inch)

Code	G4x2	G4x3	G4x4	G4x5	G4x6
2	L05	L05	L05	L10	L15
4	L10	L15	L10	L20	L30
6	L20	L25	L20	L30	L45
8	L40	L40	L40	L50	L60

TABLE 5-3 Part Number Cross Reference

5.3.3 MOTOR-DRIVE SELECTION

Possible motor and drive combinations are shown in following table. The shaded cells define the motor drive combination with highest performance.

MOTOR					T164 Series Controllers									
					T164-901		T164-903		T164-905		T164-907		T164-909	
Model Number	Torque Constant k_t		Continuous Stall Torque T_c		CURRENT RATINGS I_c / I_p									
					5 / 10 A_{rms}		10 / 20 A_{rms}		20 / 40 A_{rms}		40 / 80 A_{rms}		60 / 140 A_{rms}	
					T_c / T_p		T_c / T_p		T_c / T_p		T_c / T_p		T_c / T_p	
	Nm/A_{rms}	lb-in/A_{rms}	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in
G413-2XX	0.40	3.54	0.60	5.31	0.6/1.5	5/13								
G413-4XX	0.53	4.69	1.65	14.60	1.7/4.5	15/40	1.7/4.7	15/42						
G413-6XX	0.75	6.64	2.55	22.57	2.6/7.2	23/64	2.6/8.5	23/75						
G413-8XX	0.90	7.97	3.70	32.75	3.7/8.8	33/78	3.7/13.0	33/115						
G414-2XX	0.42	3.72	1.30	11.51	1.3/3.2	12/28								
G414-4XX	0.54	4.78	2.60	23.01	2.6/5.0	23/44	2.6/6.5	23/58						
G414-6XX	0.70	6.20	4.70	41.60	3.5/7.0	31/62	4.7/12.5	42/111						
G414-8XX	0.89	7.88	8.20	72.57	------	------	8.2/17.0	73/150	8.2/22.0	73/195				
G415-2XX	0.61	5.40	5.80	51.33	------	------	5.8/10.8	51/96	5.8/12.2	51/108				
G415-4XX	1.02	9.03	11.20	99.12	------	------	10.2/18.5	90/164	11.2/25.8	99/228				
G415-6XX	1.29	11.42	16.60	146.91	------	------	------	------	16.6/40.0	147/354				
G415-8XX	1.69	14.96	25.00	221.25	------	------	------	------	25.0/58.0	221/513	25/60	221/531		
G416-2XX	0.64	5.66	14.00	123.90	------	------	------	------	12.8/23.5	113/208	14/37	124/327		
G416-4XX	0.90	7.97	27.00	238.95	------	------	------	------	------	------	27/63	239/556	27/73	239/646
G416-6XX	1.03	9.12	39.00	345.15	------	------	------	------	------	------	39/78	345/690	39/108	345/956
G416-8XX	1.19	10.53	51.00	451.35	------	------	------	------	------	------	48/95	425/841	51/146	451/1292

TABLE 5-4 Motor-Drive Selection

NOTES:

1. Torques "T_c/T_p" are specified as "continuous/peak" stall ratings.

2. Drive currents “I_c/I_p “ are specified as “continuous/peak” rms amps per phase.

3. Motor peak torques are specified for at least 1 second out of 10 seconds and less than 15% saturation.
   Contact Moog for higher torque at lower duty cycle.

5.3.4 PERFORMANCE DATA

Temperature for Transport and Storage:	-25 °C to 90 °C
Operating Temperature:	-25 °C to 155 °C (higher temperature rating on demand)
Degree of Protection:	IP67 (DIN VDE 0470-1, EN 60529, IEC 529) (at shaft extension optional shaft seal is needed)
Installed Position:	Any (good heat dissipation permits higher continuous power)
Ambient temperature in Operation:	-25 °C to 55 °C (motor continuous power is automatically limited by drive at temperatures over 55 °C)
Runout:	Class R (DIN 42955-R, IEC72)

MOTOR MODEL	SUPPLY VOLTAGE (vdc)	STALL TORQUE (Nm)	INPUT POWER / CURRENT
G4X2-X1X	24	0.9	11 Watt/ 458 mA
G4X3-X1X	24	1.5	11 Watt/ 458 mA
-X2X	24	3	10 Watt/ 417 mA
G4X4-X1X	24	6	13 Watt/ 542 mA
-X2X	24	15	19 Watt/ 792 mA
G4X5-X1X	24	15	19 Watt/ 792 mA
-X2X	24	25	24 Watt/ 1 Amp
G4X6-X1X	24	25	24 Watt/ 1 Amp
-X2X	24	50	30 Watt/ 1.25 Amp

TABLE 5-5 Motor Brake Ratings

Motor type		Stall Data				Nominal Data				Miscellaneous Data						
		Continuous Stall Torque ①	Continuous Stall Current ①	Peak Stall Torque	Peak Stall Current	Rated Torque ②	Rated Current ②	Rated Power ②	Rated Speed ②	Theoret. No Load Speed ③	Maximum Permissible Speed ④	Torque Constant ⑤	Terminal to Terminal Resistance ⑥	Terminal to Terminal Inductance ⑥	Moment of Inertia w/o Brake	Weight w/o Brake
Model	Type	Mo [Nm]	Io [Arms]	Mmax [Nm]	Imax [Arms]	Mn [Nm]	In [Arms]	Pn [Watt]	Nn [rpm]	Ntheo [rpm]	Nmax [rpm]	kt [Nm/Arms]	Rtt [Ohm]	Ltt [mH]	J [kgcm²]	m [kg]
G4x2-2xx	G2L05	0.25	0.65	0.5	1.9	0.18	0.5	150	8100	10200	11500	0.37	50.90	29.7	0.09	1.0
G4x2-4xx	G2L10	0.5	1.2	1.4	3.7	0.42	1.0	325	7400	9000	10000	0.42	20.70	15.7	0.13	1.2
G4x2-6xx	G2L20	0.95	2.15	2.6	6.4	0.74	1.6	530	6800	7900	9000	0.46	9.90	9.1	0.22	1.5
G4x2-8xx	G2L40	1.7	2.85	5	8.3	1.26	2.1	820	6200	6300	7000	0.60	6.30	7.2	0.41	2.3
G4x3-2xx	G3L05	0.6	1.6	1.5	4.6	0.49	1.2	450	8800	9600	10500	0.40	15.20	18.8	0.16	1.4
G4x3-4xx	G3L15	1.65	3.2	4.7	10.6	1.44	2.7	950	6300	7200	8000	0.53	4.90	8.5	0.39	2.0
G4x3-6xx	G3L25	2.55	3.4	8.5	12.4	2.29	3.1	1150	4800	4900	5500	0.75	5.10	10.3	0.62	2.6
G4x3-8xx	G3L40	3.7	4.2	13	16.3	3.43	3.8	1400	3900	4100	4500	0.90	4.10	8.9	0.97	3.5
G4x4-2xx	G4L05	1.3	3.1	3.2	9.0	1.0	2.3	580	5800	8800	10000	0.42	5.10	8.52	1.05	3.0
G4x4-4xx	G4L10	2.6	4.8	6.5	15.0	1.7	3.1	950	5500	6900	8000	0.54	2.70	5.78	1.55	3.6
G4x4-6xx	G4L20	4.7	6.7	12.5	20.0	4.0	5.7	1800	4300	5200	5800	0.70	1.50	4.60	2.60	4.7
G4x4-8xx	G4L40	8.2	9.2	22	28.0	6.3	7.1	2310	3500	4200	4700	0.89	0.90	3.50	4.70	6.9
G4x5-2xx	G5L10	5.8	9.5	12.2	24	4.6	7.5	2310	4800	6100	6800	0.61	0.86	4.29	4.60	7.7
G4x5-4xx	G5L20	11.2	11	25.8	33	9.2	9.0	3370	3500	3800	4200	1.02	0.74	4.81	8.00	9.9
G4x5-6xx	G5L30	16.6	12.9	40	38	14.0	10.9	3960	2700	3000	3300	1.29	0.64	4.84	11.50	12.1
G4x5-8xx	G5L50	25	14.8	60	43	20.0	11.8	4610	2200	2200	2400	1.69	0.56	5.44	18.40	16.6
G4x6-2xx	G6L15	14	22	37	72	9.1	14.2	3810	4000	5700	6300	0.64	0.23	1.86	27.20	15.1
G4x6-4xx	G6L30	27	30	73	95	15.5	17.2	4870	3000	4200	4700	0.90	0.14	1.54	52.10	21.1
G4x6-6xx	G6L45	39	38	108	117	25.5	24.8	6680	2500	3500	3900	1.03	0.11	1.46	77.00	27.1
G4x6-8xx	G6L60	51	43	146	134	34.0	28.6	7830	2200	3000	3300	1.19	0.10	1.46	102.00	33.1

① Motor flanged onto a steel plate 300 x 300 x 12 mm with the maximum permissible overheating of the winding at 100 K over a still air environment (max. 40 °C)

② The nominal point is the point for maximum continuous power

③ Speed at which the EMF of the motor is equal to the d.c.-bus voltage

④ Speed at which the EMF of the motor reaches 360 V

⑤ $k_t = \frac{M_N}{I_N} = \frac{[Nm]}{[A_{RMS}]}$

⑥ Measured at 25 °C

conversions

1 Nm = 8.85 lb-in   1 kgcm^2 = 8.85x10^{-4} lb-in-sec^2 1 kg = 2.2 lb   1 kW = 1.341 hp

Note: Shaded data is printed on the nameplate.

TABLE 5-6 Motor Performance Data

5.3.5 MOUNTING AND INSTALLATION

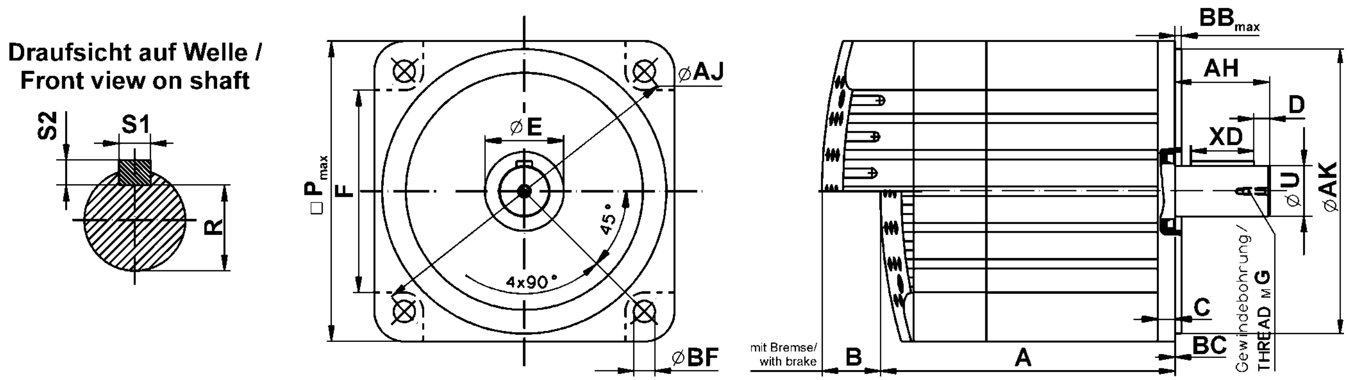
5.3.5.1 MOTOR DIMENSIONS

	P_{max}	A				B	C	øAJ	øAK	AH	øU	BB_{max}	øBF	XD	R	S1xS2	D	BC	øE	F	G	H	M
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			Nm
	ISO 286							ISO 286	ISO 286	ISO 286	DIN 748, ISO 286	ISO 286	ISO 286	ISO 286 DIN 6885	ISO 286	ISO 286 DIN 6885		ISO 286			DIN 13-1	DIN 912 8.8	DIN 912 8.8
Model		**-2xx**	**-4xx**	**-6xx**	**-8xx**																		
G4x2-	55	109,4	122,4	147,4	198,4	17,0	9,0	63	$40^{+0,011}_{-0,005}$	20	$9^{+0,010}_{+0,001}$	2,5	5,5	14	7,2	3x3	3	0	$24^{+0,033}_{-0}$	-	M2,5 x 8	M5 x 22	5
G4x3-	70	114,3	139,8	165,3	203,3	22,0	9,0	75	$60^{+0,012}_{-0,007}$	23	$11^{+0,012}_{+0,001}$	2,5	5,5	16	8,5	4x4	4	0	$24^{+0,033}_{-0}$	-	M2,5 x 8	M5 x 22	5
G4x4-	100	133,2	146,2	171,2	222,2	21,1	9,8	115	$95^{+0,013}_{-0,009}$	40	$19^{+0,015}_{+0,002}$	3	9	32	15,5	6x6	4	0	$35^{+0,039}_{-0}$	66,3	M4 x 16	M8 x 30	16
G4x5-	140	169,6	194,6	220,1	271,1	14,4	12,2	165	$130^{+0,014}_{-0,011}$	50	$24^{+0,015}_{+0,002}$	3,5	11	40	20	8x7	5	0	$47^{+0,039}_{-0}$	98,8	M4 x 16	M10 x 40	30
G4x6-	190	186,5	224,5	262,5	301,0	37,0	11,0	215	$180^{+0,014}_{-0,011}$	60	$32^{+0,018}_{+0,002}$	4	13,5	40	27	10x8	10	0	$50^{+0,039}_{-0}$	128	M4 x 16	M12 x 40	38

P_{max} Maximum width of motor (end view) excluding terminal housing etc.
A Motor length without shaft, pilot, mating connector
B Additional length of motor for motors with brake
C Thickness of flange plate of motor
øAJ Diameter of mounting bolt circle in flange of motor
øAK Diameter of pilot on flange of motor
AH Mounting surface of flange of motor to end of shaft
øU Diameter of shaft extension
BB_{max} Maximum height of pilot of mounting flange of motor
øBF Clearance hole in mounting flange of motor
XD Usable length of keyseat
R Bottom of keyseat to opposite side of shaft
S1 Width of key
S2 Height of key
D Distance between end of shaft and key
BC Distance between mounting flange of motor to shoulder on shaft (always =0 mm)
øE Diameter of hole for shaft in flange of motor
F Width of motor between recesses for mounting screws
G Thread in motor shaft (type and length)
H Recommended fixing screws (type and length)
M Tightening torque for flange screws

All dimensions without tolerance are according to DIN ISO 2768, part 1, category c

TABLE 5-7 Motor Dimensional Data



Additional dimensions, e.g. for connectors and mating connectors can be found in the catalogue

5.3.5.2 INSTALLATION GUIDELINE

MOOG recommends that hexagon socket head screws to DIN 912 8.8 (see column H in TABLE 5-7) be used to secure the motor. Assembly is made very much easier by using an Allen key with ball head, particularly in the cases of motor sizes 2 and 3. The screws used to install these motor sizes must not be more than 40 mm long.

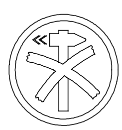
MOOG motors can become very hot (up to 150° C winding temperature) in operation. Good heat dissipation must therefore be ensured when installing the motor, i.e. it should be flanged onto a suitably solid metal part of the machine. Adequate convection must also be ensured. In individual cases, the motor must furthermore be protected against contact due to the risk of burns. Forced cooling (e.g. with fans) will increase the continuous power, while bad convection may decrease the continuous performance.

Before connecting a coupling to the motor shaft, the shaft must be thoroughly degreased. When using a degreasing agent, care must be taken to prevent it entering the bearing. Otherwise the bearings permanent lubrication can no longer be guaranteed. We recommend the use of a clamp coupling or shrink connection to ensure reliable torque transmission. An inexpensive and service friendly connection is possible with the slot and key option (ensure tight slot tolerances).

Impermissibly high axial and radial forces on the shaft can result in motor damage during installation. The service life of the motor is impaired if the bearing is damaged in any way. Adjusting the rotor shaft by force can impair the correct functioning of the optional brake to such an extent that it has little or no braking effect. Excessive pressure and impacts on the front end of the shaft and rear housing cover must therefore be avoided under all circumstances.

NOTE

Delicate part *(Sticker on servomotor)A hammer must not be used to force the gearing / gear wheel onto the shaft when installing such parts. The screw thread in the center of the shaft must be used for this purpose. An extractor supported on the center of the shaft must be used when dismantling the parts.*
The permissible axial and radial forces are ***in all cases exceeded*** *by the pulses due to hammering*



5.3.5.3 RATED BEARING LOAD CAPACITY

Radial load capacity shown in FIGURE 5.14 to FIGURE 5.18 are for a B10 life of 20,000 hours. applied at shaft extension midpoint. Curves are based on minor axial shaft loads.
Consult factory for other loading conditions.
Maximum permissible axial and radial forces for brushless MOOG servomotors during installation refer TABLE 5-8 .

Motor size	**G4x2**	**G4x3**	**G4x4**	**G4x5**	**G4x6**
Axial force 1)	150N	150N	300N	400N	500N
Radial force 1)	500N	500N	1000N	1600N	2000N
1): During installation. Lower loads apply for the rotating motor, see catalog.					

TABLE 5-8 Installation Loads

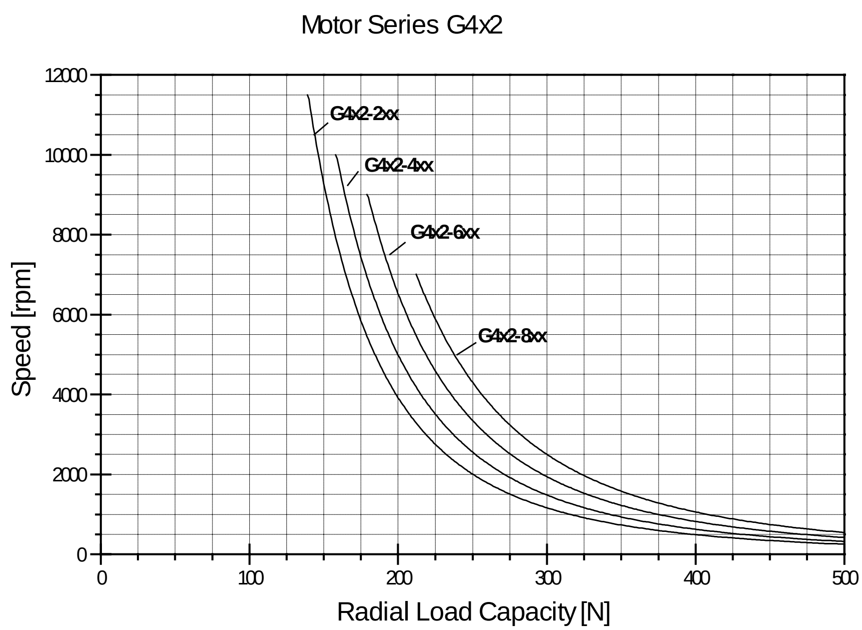


FIGURE 5.14 Radial Load Capacity G4x2

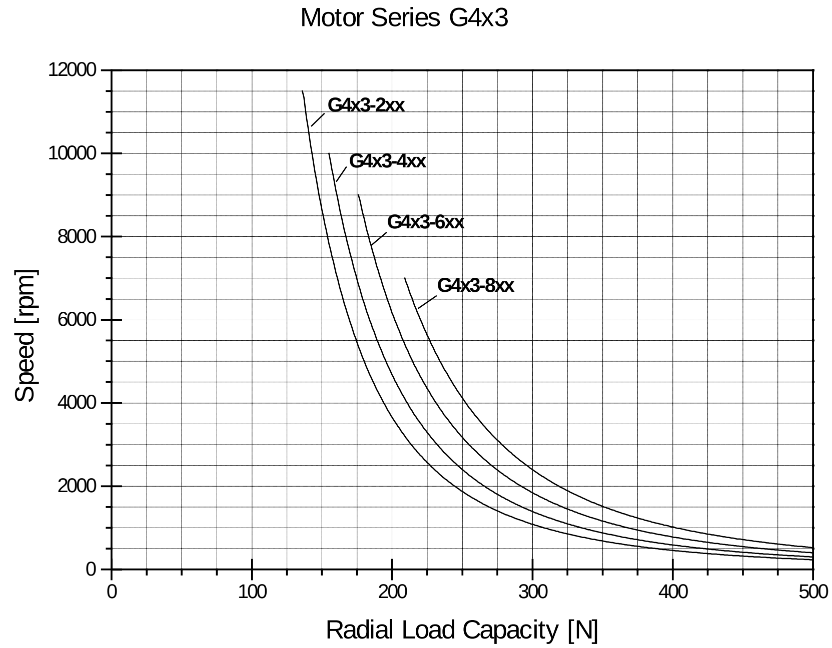


FIGURE 5.15 Radial Load Capacity G4x3

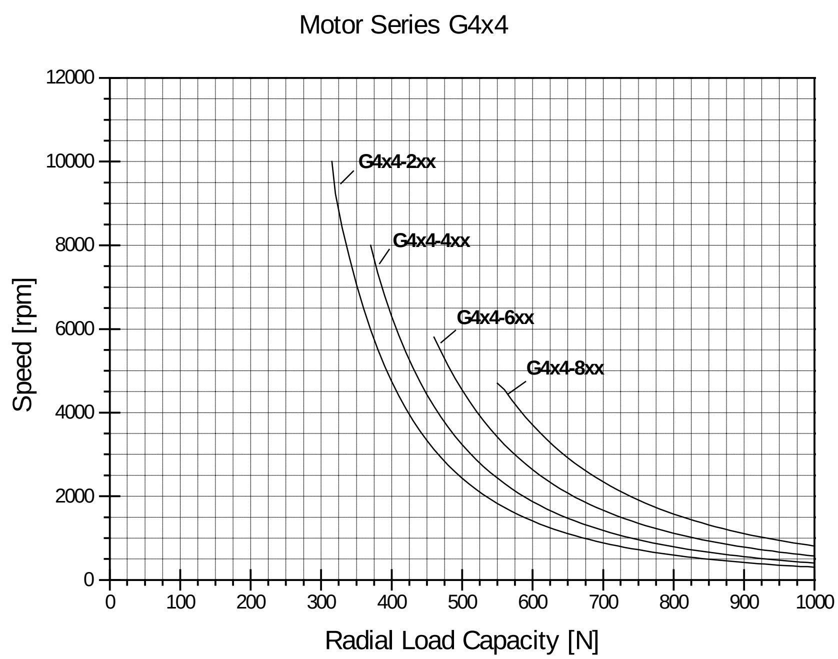


FIGURE 5.16 Radial Load Capacity G4x4

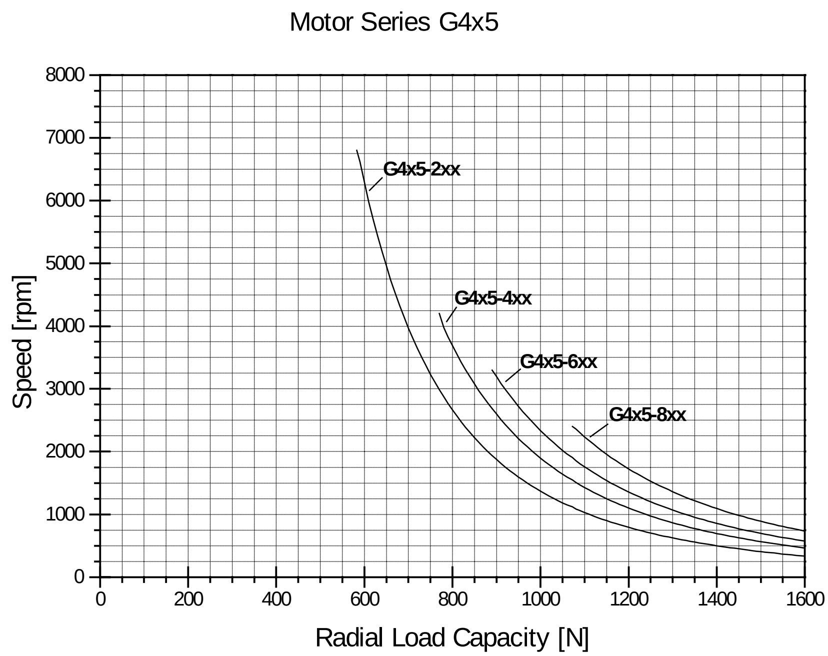


FIGURE 5.17 Radial Load Capacity G4x5

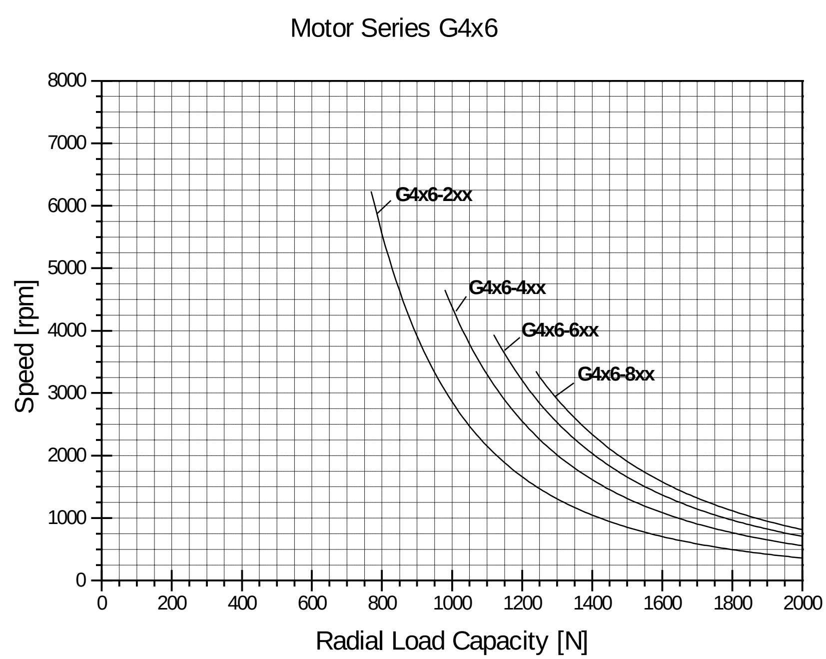


FIGURE 5.18 Radial Load Capacity G4x6

5.3.5.4 COUPLING

A flexible coupling offers the advantages of economy, allowance for misalignment, and reduction of backlash. Flexible disc or bellows style couplings are recommended. The couplings are available for both plain shaft as well as for slot and key configurations. The shaft key should then be a close clearance or light press fit into the coupling key way. Refer to FIGURE 5.19 for flexible coupling detail.

> **CAUTION**
> *A rigid coupling should not be used. Normal runouts and eccentricities will result in damage to motor and/or load shaft and bearings.*

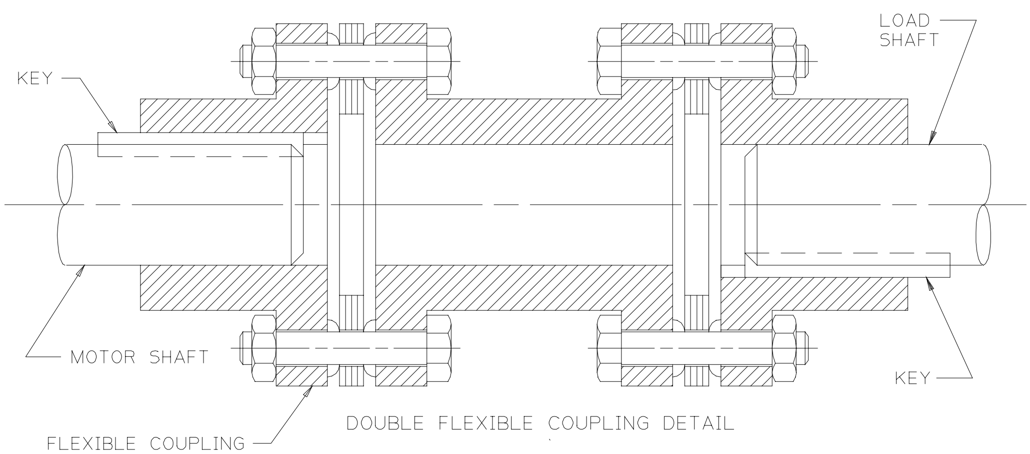
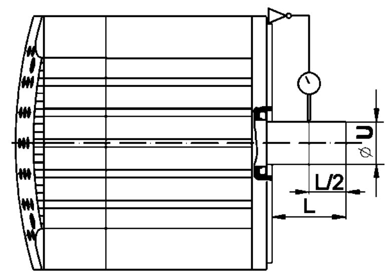


FIGURE 5.19 MOTOR LOAD COUPLING

5.3.5.5 RUNOUT

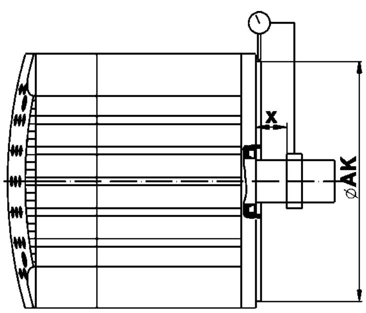
The reduced runout provided by MOOG motors allows the attachment of various gear heads. The precision manufacturing of the motor avoids loads caused by misalignments between motor and gear heads.

Diameter of the Shaft Extension øU [mm]	Maximum Runout Tolerance Class R [mm]
to 10	0.015
over 10 to 18	0.018
over 18 to 30	0.021
over 30 to 50	0.025
L = AH (see TABLE 5-7)	

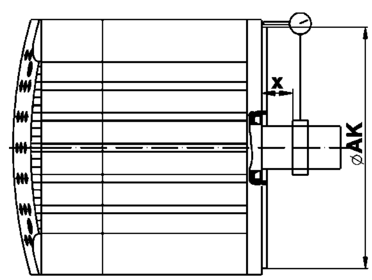


Rundlauf / runout

TABLE 5-9 Shaft Runout



Koaxialität / concentricity



Planlauf / perpendicularity

Pilot Diameter of Mounting Flange øAK [mm]	Maximum Concentricity and Perpendicularity Tolerance Class R [mm]
to 22	0.025
over 22 to <40	0.03
40 to 100	0.04
over 100 to 230	0.05
over 230 to 450	0.063
x = 10 ± 1 mm (see TABLE 5-7 for øAK values)	

TABLE 5-10 Flange Concentricity/Perpendicularity

5.3.6 DESIGN STANDARDS

The G400 series has been designed, assembled and tested in conformity with the following standards. (see TABLE 5-11, TABLE 5-12 and TABLE 5-13 for design standards)

Standard	**International**	**Europe**	**Germany**	**USA**
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechnische **N**ormung	**DIN** / **VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA** / **NEC** **N**ational **E**lectric **C**ode MG.-...
Certified company	ISO 9001	EN ISO 9001	DIN ISO 9001	ISO 9001
Quality systems - model for quality assurance in design / development, production, installation and servicing	ISO 9001	EN ISO 9001	DIN ISO 9001	ISO 9001
Machine guidelines (CE Machine safety directive)	89/392/EWG, 91/368/EWG, 93/44/EWG	89/392/EWG, 91/368/EWG, 93/44/EWG	89/392/EWG, 91/368/EWG, 93/44/EWG	
EMC guidelines (CE-EMC directive)	89/336/EWG, 93/68/EWG, 93/44/EWG	89/336/EWG, 93/68/EWG, 93/44/EWG	89/336/EWG, 93/68/EWG, 93/44/EWG	
Low voltage guidelines (CE - Low voltage directive)	73/23/EWG, 93/68/EWG, 93/44/EWG	73/23/EWG, 93/68/EWG, 93/44/EWG	73/23/EWG, 93/68/EWG, 93/44/EWG	
Standard for safety of electric motors				UL 1004 (1994)
Safety of machinery, electrical equipment of machines, part 1: general requirements	IEC 204-1	EN 60204-1	DIN EN 60204-1 VDE 0113-1	

TABLE 5-11 Motor Design Standards

Relevant standards for electrical equipment

Standard	International	Europe	Deutschland	USA
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechn. **N**ormung	**DIN** / **VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA** / **NEC** **N**ational **E**lectric **C**ode MG.- ...
Rotating electrical machines, Rating and performance	IEC 34-1 IEC 2/915/CDV: 1995	EN 60034-1	DIN EN 60034-1 VDE 0530-1	MG 1-1.65
Rotating electrical machines, Methods for determing losses and efficiency and performance	IEC 2G/73/FDIS	EN 60034-2	DIN EN 60034-2 VDE 0530-2	
Rotating electrical machines, Classification of degrees of protection provided by enclosure..	IEC 34-5	EN 60034-5	DIN EN 60034-5 VDE 0530-5	MG 1-1.25 MG 1-1.26
Rotating electrical machines, Methods of cooling“ (IC-Code)	IEC 34-6	EN 60034-6	DIN EN 60034-6 VDE 0530-6	MG 1-1.25 MG 1-1.26
Rotating electrical machines, Classification of types of construction and mounting arrangements (IM Code)	IEC 34-7	EN 60034-7	DIN EN 60034-7 VDE 0530-7	MG 1-4.03
Rotating electrical machines, Terminal markings and directions of rotation	IEC 34-8	EN 60034-8	DIN EN 60034-8 VDE 0530-8	MG 1-2.61
Rotating electrical machines, Noise limits	IEC 34-9	EN 60034-9	DIN EN 60034-9 VDE 0530-9	N/A.
Insulation coordination for equipment with low-voltage systems. Part 1 Principles, requirements and tests	IEC 664-1		VDE 0110-1	
Insulation coordinates for equipment with low-voltage systems. Part 2 Partial discharge tests, application guide	IEC 664-2		VDE 0110-2	
Connectors and plug-and-socket-devices, for rated voltages up to 1000V a/c., up to 1200 V d/c. and rated currents up to 500 A for each pole			DIN VDE 0627	

TABLE 5-12 Electrical Design Standards

Relevant standards for mechanical design

Standard	International	Europe	Deutschland	USA
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechn. **N**ormung	**DIN** / **VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA** / **NEC** **N**ational **E**lectric **C**ode MG.-...
Degrees of protection provided by enclosure (IP code)	IEC 529	EN 60529	DIN EN 60529 VDE 0470-1	
Cylindrical shaft ends for electrical machines	IEC 72 ISO/R 775-1969		DIN 748-1 & 3	MG- 11...
Mounting flanges for rotating electrical machinery			DIN 42948	
Dimensions, tolerances and mounting				NEMA MG-7
Tolerances of shaft extension run-out and of mounting flanges for rotating electrical machinery	IEC 72		DIN 42 955	
Mechanical vibration, balance quality requirements of rigid rotors, determination of permissible residual unbalance	ISO 1940-1		DIN ISO 1940-1	
Mechanical vibration, balance quality requirements of rigid rotors, Balance errors	ISO 1940-2		DIN ISO 1940-2	
Ball bearings, conrad type, for electrical machines, tolerances and radial clearance			DIN 42966	
Drive type fastenings without taper action, parallel keys, keyways, deep pattern			DIN 6885-1	
ISO general purpose metric screw threads. Part 1 coarse pitch threads in diameter range 1 mm to 68 mm, nominal sizes	ISO 724		DIN 13-1	
General tolerances, tolerances for linear and angular dimensions with-out individual tolerance indications	ISO 2768-1	EN 22768	DIN ISO 2768-1	

TABLE 5-13 Mechanical Design Standards

5.3.7 REPAIR HANDLING

Since correct disassembly cannot be guaranteed by MOOG, all the attachments not fitted by MOOG, such as gearboxes, gear wheels, pinions, etc. must be dismantled if a brushless MOOG servomotor has to be repaired.
Any dirt on the front flange of the motor must also be removed. Repairs by external personnel are excluded for reasons associated with product liability, since the applicable safety regulations (e.g. VDE guidelines) and MOOG quality standards cannot normally be met by the customer.

All warranty rights are voided if the sealing varnish on the screws of the servomotor is broken. If at all possible, a detailed description of the fault or failure should be enclosed with the shipping documents.

The words **"For repair"** should feature prominently on the delivery note. The motor must be packed so that it is protected against knocks and bumps, as well as against damage in transit. The shaft and connectors have to be protected using adequate packaging.

Please send the motor to the appropriate location outlined in Section 8.
(MOOG Repair Centers)

5.4 HAND HELD SERVICE TERMINALS

Hand held service terminals, may be used instead of a computer terminal for drive set-up and monitoring. All hand held terminals or similar equipment attached by the user to the T164 Series Drives must be CE marked as compliant with the requirements of the EU EMC Directive 89/336/EEC (as amended by EU Directive 92/31/EEC and 93/68/EEC).

All hand held terminals must have a shielded cable which has a DE9P connector to mate with the T164 Series Drive J3 communications connector. Metal connector hoods which make secure connections to the metal cable shield and to chassis earth of both the T164 drive and hand held terminal shall be used.

WARNING
The Hand Held Service Terminal allows control of the machine functions in the final product application and must be installed only as a service tool with access restricted to technically qualified service maintenance persons only. *Instructions on the use of key sequences for this hand held service terminal which allow changes to the control of the machine functions must be restricted to technically qualified service/maintenance persons only.*

If problems occur when attempting to communicate with a T164 Series Drive, the programmable parameters of the hand held service terminal are most likely set incorrectly. All hand held service terminal parameters should be set to their default values, with the exception of DATA BITS (set to 7) and STOP BITS (set to 2).

Contact Moog for further information on the use of hand held service terminals.

5.5 ENCODER SIMULATION OPTION CARD

The Encoder Simulation Option Card has the following features:

- Emulates Rotary Incremental Encoders
- Line Count and Marker Width programmability through User Interface Software
- Ability to read Digital Position information through User Interface Software
- Error status monitored by User Interface
- RS422 Differential Incremental Encoder Outputs (outputs are optically isolated)
- Customer supplied (V external) input is polarity protected
- Buffered Analog Velocity Output (Option - Consult Factory)

5.5.1 CIRCUIT DESCRIPTION

The Encoder Simulation emulates the functionality of a rotary incremental encoder. The differential outputs of the Encoder Simulation are A, A/, B, B/, MARKER and MARKER/.

The design is based on a Resolver to Digital (R/D) converter to generate rotor position data. The position data is then multiplexed and converted into optically isolated and buffered incremental encoder quadrature outputs. Power for the isolated outputs is provided by a user supplied +5 V d.c. power supply or the internal +5Vd.c. power.
The Built In Test (BIT) output of the R/D converter is monitored. Logic 0 for BIT condition indicates ±100 LSBs of error. Causes of BIT error are loss of signal inputs or loss of resolver reference. When this occurs, the Encoder Simulation outputs will go to a known state.

FIGURE 5.20 is a block diagram of the Encoder Simulation option card.

5.5.1.1 A AND B OUTPUTS

The A and B outputs are in quadrature, i.e. B will lead A by 90° when the motor is rotating clockwise (CW) as viewed looking at the motor front mounting plate and A will lead B by 90° when the motor is rotating counterclockwise (CCW). The phase relationship of A and B can be used to determine motor direction.
Since the Encoder Simulation outputs are in true quadrature, the ripple associated with the duty cycle variation of a normal encoder is avoided when using X2 or X4 counting schemes.

The resolution of the Encoder Simulation, in pulses per revolution (ppr), is programmable from 128 ppr to 16384 ppr. The factory default resolution is 1024 ppr. The allowable motor operating speed range is reduced at higher Encoder Simulation resolutions as indicated in TABLE 5-14

R/D Resolution (Bits)	Line Count (Pulse Per Rev)	Motor Speed Range (RPM)
16	16384	0-1400
16	8192	0-1400
14	4096	0-6000
14	2048	0-6000
12	**1024**	**0-15000**
12	512	0-15000
10	256	0-15000
10	128	0-15000

TABLE 5-14 ENCODER SIMULATION CONFIGURATION OPTIONS

5.5.1.2 MARKER PULSE

The MARKER, or INDEX pulse, is used to indicate a reference point within one mechanical revolution of the motor shaft.

NOTE

The marker pulse is not referenced to the key of the motor shaft or housing. The pulse is set at an arbitrary position that is determined by the resolver adjustment setting used for motor commutation. This is a factory setting and not user adjustable.

The electrical width of the MARKER pulse is selectable in pulse widths of 90°, 180° or 360. The factory default configuration is 90° marker width.

The output waveforms for the Encoder Simulation are shown in FIGURE 5.21.

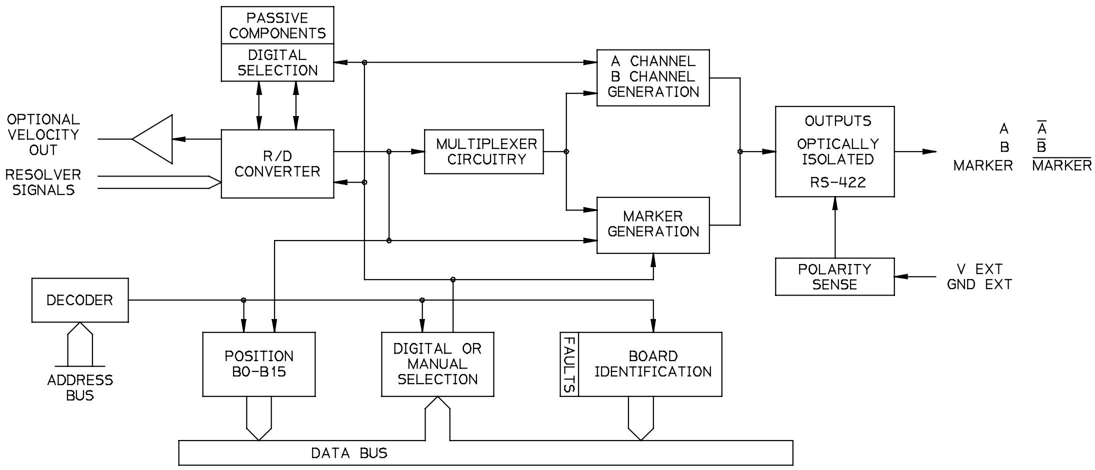


FIGURE 5.20 ENCODER SIMULATION OPTION CARD BLOCK DIAGRAM

5.5.2 SPECIFICATIONS

Resolver Reference Input	Differential ±10V d.c. max.
Signal Inputs (Sine+, Sine-, Cosine+, Cosine-)	Differential 2 Vr.m.s. ±15%
Input Power Requirements[1]	5 V d.c.±5%, 200 mA d.c. max.

[1]*User must supply isolated power source.*

Dynamic Characteristics (Line Count Selection vs. Bandwidth based on 5 kHz Resolver Reference):

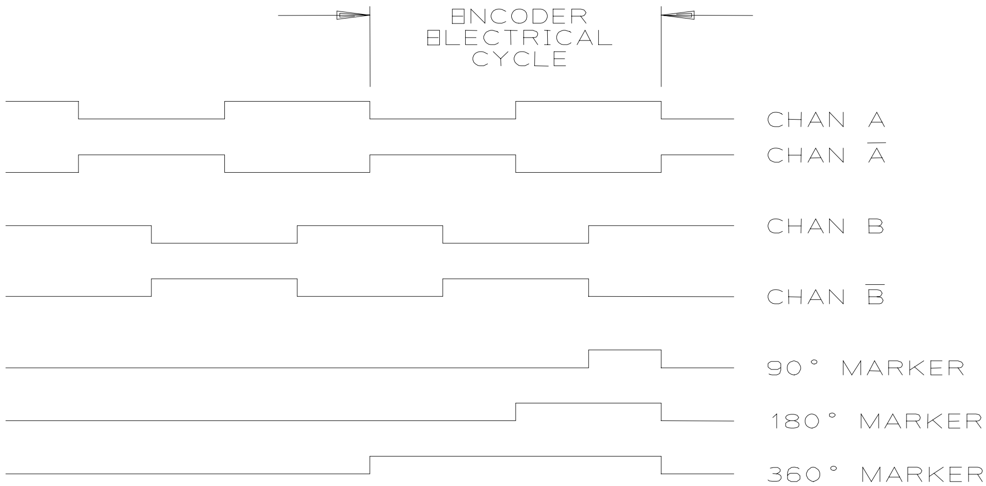
Line Count Selection (PPR)	3 dB Closed Loop Bandwidth (Hz)
16384, 8192	288
4096, 2048	564
1024, 512	1200
256	1100
128	1100

Digital Outputs A, A/, B, B/, MARKER and MARKER/
- Optically Isolated RS422 Differential
- Outputs capable of driving 100Ω terminated loads
- Output ' Logic High ' Voltage (Voh) 2.5V min.
- Output ' Logic Low ' Voltage (Vol) 0.5V max.

Operating Temperature Range 0-55°C ambient

COUNTERCLOCKWISE ROTATION

AS VIEWED FROM MOTOR SHAFT END



CLOCKWISE ROTATION

AS VIEWED FROM MOTOR SHAFT END

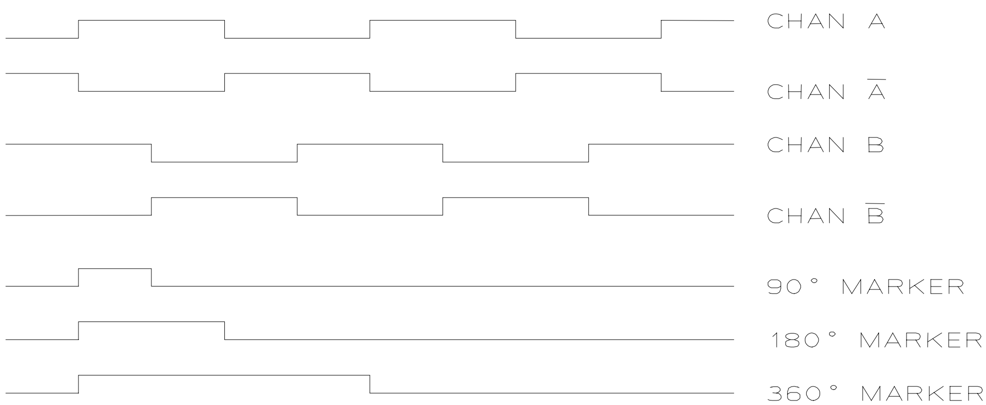


FIGURE 5.21 ENCODER SIMULATION OPTION OUTPUT WAVEFORMS

5.6 EXTENDED I/O OPTION CARD DESCRIPTION, SPECIFICATIONS

(Two cards are available B89666-002 and B89666-003). Both Extended I/O Option cards have the following features:

- ❑ Provides four digital input functions:
  1) Clockwise Limit
  2) Counter Clockwise Limit
  3) Torque/Velocity Loop Select
  4) Automatic/Manual Mode Select
- ❑ Inputs are source or sink current activated.
- ❑ Provides two output relay functions:
  1) System Ready Relay
  2) Thermal Limit Active

The B89666-003 card has the additional functionality

- ❑ Brake Control
- ❑ Analog Torque Limit Input
- ❑ ID Port (Toggle Switches)

5.6.1 CIRCUIT DESCRIPTION

The Extended I/O Option cards were designed to provide additional input and output functionality.

The input circuitry is optically isolated and can be source or sink current activated. This adds considerable flexibility when mating to different front-end systems.

The output circuitry utilizes reed relays to provide output contacts. These contacts can then be utilized to monitor axis status.

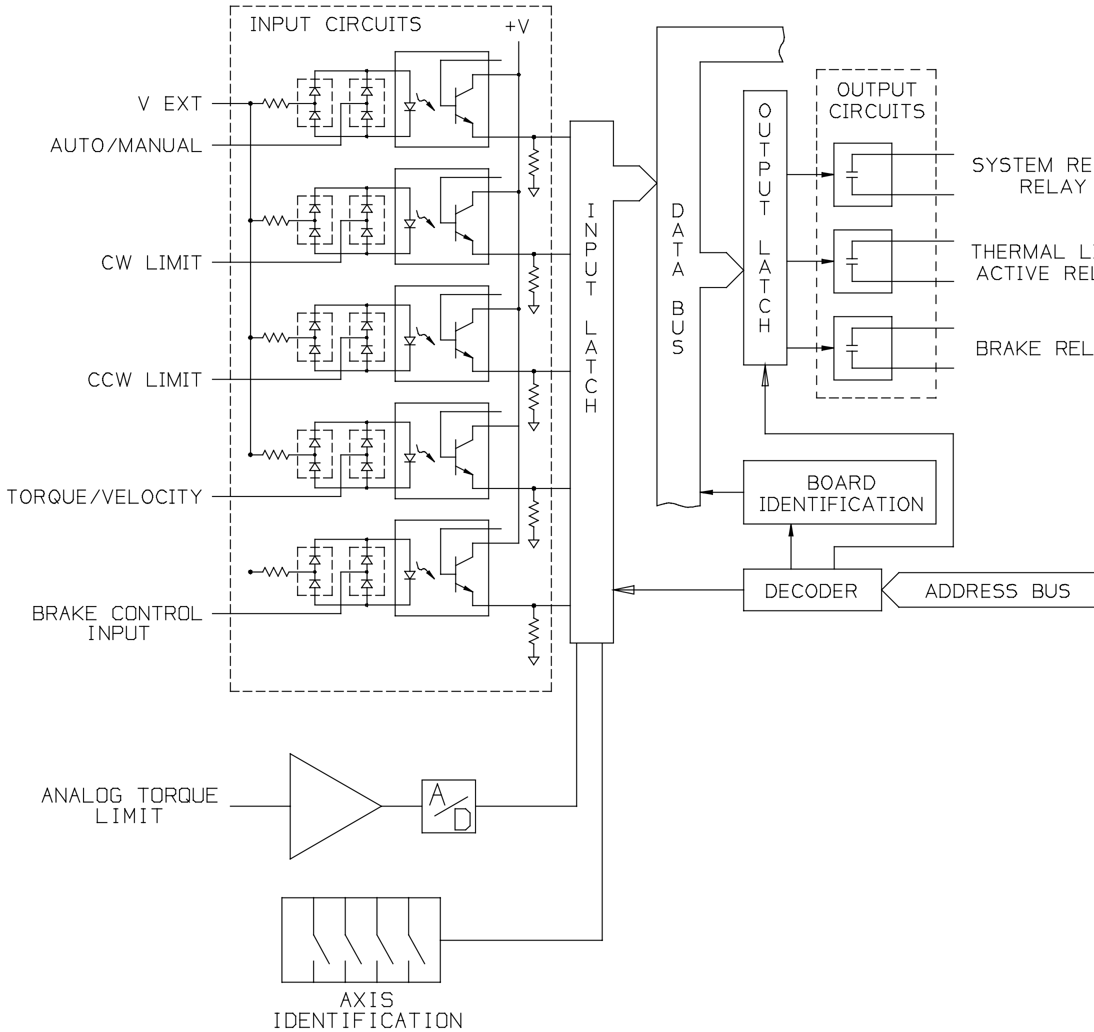


FIGURE 5.22 EXTENDED I/O OPTION CARD (FULL VERSION) BLOCK DIAGRAM (B89666-003)

5.6.2 SPECIFICATIONS

Inputs: CW Limit, CCW Limit, Torque/Velocity Select, Auto/Manual Select
Voltage range: 4.5 - 35 V d.c.
Current ratings, user must source or sink the following:
1.2 mA @ 5 V d.c. per-input
12.1 mA @ 30 V d.c. per-input

Outputs: Thermal Limit Active Relay, System Ready Relay
Relay Type: Reed
Maximum Specifications: 100 V d.c. or 70 V r.m.s. 0.5 Amps r.m.s.

Operating Temperature Range 0-55°C ambient

Electrical Specification: (B89666-003 only)

Brake Control Input :
Voltage range 4.5 - 35 V d.c., on a per input basis usermust source or sink the following current ratings.
1.0 mA @ 4.5 V d.c.
14.0 mA @ 35 V d.c.

Brake Control Output:
User must supply (+24 V d.c., Current Rating of supply to be sized to brake current specifications). Brake Output relay (Fuse Protected 3.0 A max.)

Spare Analog Input (currently being software assigned “ Analog Torque Limit ”
Electrical Specification (+/- 10 V d.c., input current requirement less then 5 mA)

Axis Identification:
This function allows a axis number assignment of (0-59), and is set with two dip-switch packages. One package assigns the “Tens” bit, the other the “Ones” bit.

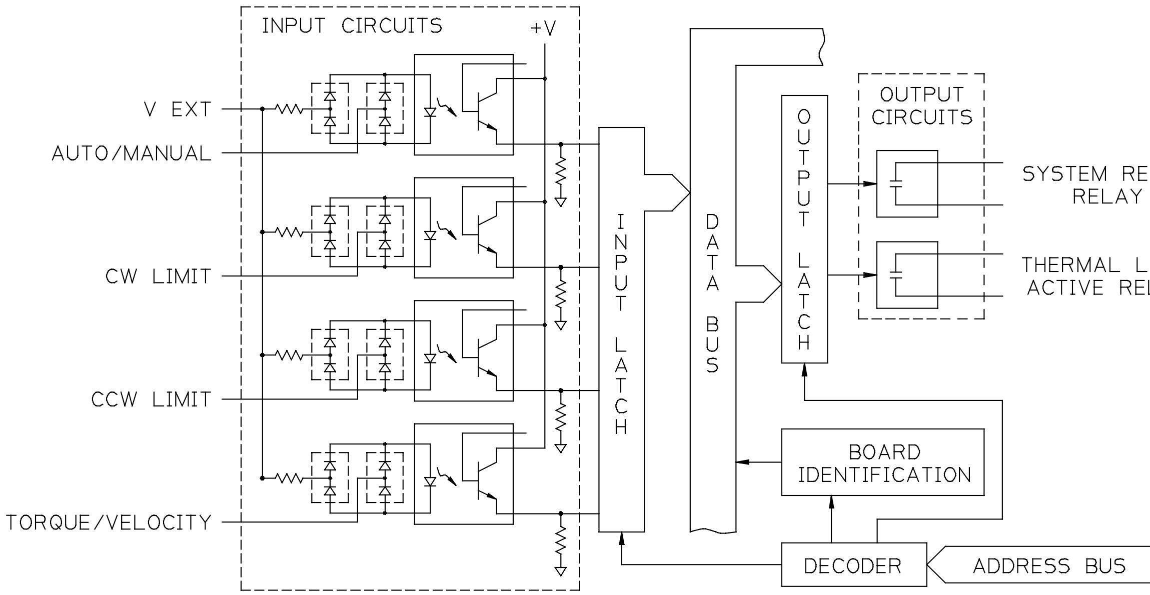


FIGURE 5.23. EXTENDED I/O OPTION CARD (STD. I/O) BLOCK DIAGRAM (B89666-002)

5.7 B92214-003 POINT MOTION CONTROL MODULE (OPTION)DESCRIPTION

The POINT motion control card is a programmable extended function card that can be interfaced to any Moog series T164 DMC motor drive. Addition of the POINT card allows the POINT/DMC system to execute point to point closed loop positioning under the direction of a user programmed application sequence. Isolated digital I/O and an analog input interface allows the system to react to external events and sensors. All servo loop algorithms and user defined program sequences are resident within the system for true stand-alone operation.

5.7.1 GENERAL FEATURES

- Plugs into T164 drive extended function slot
- Internal power from the T164 drive
- Field retrofit for existing T164 drives
- Pluggable I/O connector with screw clamp terminations
- Standard D connector for serial ports
- Non volatile memory for user program storage
- Expandable functionality with additional extended function card
- 0-55°C ambient operation

5.7.2 PERFORMANCE

- Absolute, relative and position in time motion profiles
- User defined motion profile acceleration and velocity
- 200 hertz position and 2000 hertz velocity loop update rates
- Data logging and display of motion parameters such as position versus time

For specification and detailed information, please consult the Sales Department.

5.8 C09242-00X CAN INTERFACE MODULE (OPTION)

The card will implement a C.A.N. Interface as well as provide digital I/O and node identification for each drive on the bus. The card has the following features:

- Allows electrical isolation to the bus
- Allows daisy-chaining of the bus from drive to drive
- Quick stop functionality implemented based on a digital input
- Brake control
- Hardware limit switches
- Home switch
- Axis ID Switches

5.8.1 CIRCUIT DESCRIPTION

The card implements three sets of functionality, Drive Area Network, C.A.N., interface, digital I/O and Axis ID switches.

The purpose of the I/O is to provide dedicated points from/to which an external control can influence the drive behavior for e.g., implement a controlled deceleration of the motor shaft via the Quick Stop digital input. The digital I/O are functionality is as follows:

- Quick Stop Input (Active when no current flows)
- Clockwise Limit switch
- Counter-Clockwise Limit switch
- Home Switch
- Brake Relay contacts (Note the relay must be used in conjunction with a correctly rated brake relay external to the drive)

C.A.N. is a 5V differential serial bus. The maximum baud rate is 1M Baud up to 40 metres. For a detailed explanation of C.A.N. please consult the Robert Bosch CAN Specification rev. 2.0 Part A 1991

All external connections to the drive via CAN are ISO 11898 compatible. Two 9 way D-sub type connectors are supplied for this purpose.

In order to set the address of the drive on the bus two ID switches are provided to allow the user to set the number on the bus. The switches are then read once on power up.

The card utilizes an Intel 82526 CAN drive which interfaces to the main processor used on the drive control card. The 82526 interfaces to the bus via a CAN transceiver which is ISO 11898 compliant.
It is possible to electrically isolate the transceiver and provide power to it either via an external supply located outside of the drive or locally from a d.c./d.c. converter which is supplied from the drive +5V supply.

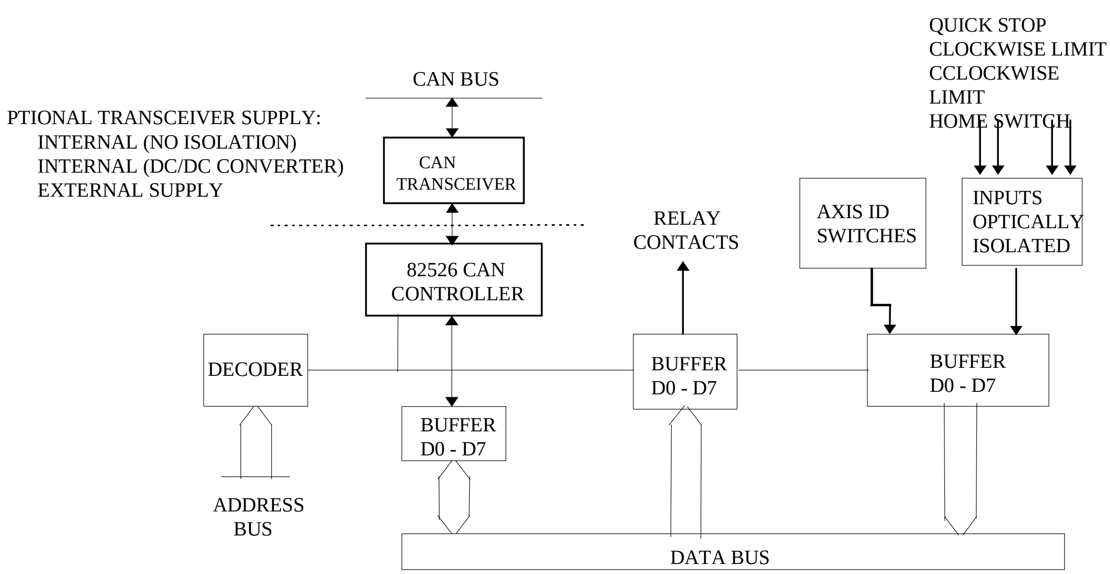


FIGURE 5.24 C09242-00X CAN INTERFACE MODULE (OPTION)

5.8.2 SPECIFICATIONS

Digital Inputs: Quick Stop, CW Limit, CCW Limit, Home

Voltage range:	5 - 30 Vd.c.
Current ratings, user must source or sink the following:	
	2 mA @ 5 Vd.c. per-input
	12 mA @ 30 Vd.c. per-input

Output: Brake Relay

Relay Type:	Reed
Maximum Specifications:	50 Vd.c. 500mA continuous.

Operating Temperature	0-55°C Ambient

CAN Transceiver External Supply (Optional)

Voltage range:	7-15 Vd.c.
Current rating:	250mA max. required

5.9 C09743-001 EXTENDED INPUTS BRACKET OPTION DESCRIPTION,

The Extended Inputs Bracket Option has the following features:

- ❑ Provides four digital input functions:
  - ⇒ Clockwise Limit
  - ⇒ Counter Clockwise Limit
  - ⇒ Torque/Velocity Loop Select
  - ⇒ Automatic/Manual Mode Select
- ❑ Inputs are source or sink current activated.

5.9.1 CIRCUIT DESCRIPTION

The Extended Inputs Bracket Option was designed to provide additional input functionality.

The input circuitry is optically isolated and can be source or sink current activated. This adds considerable flexibility when mating to different front-end systems.

FIGURE 5.25is a block diagram of the Extended Inputs Bracket Option.

5.9.2 SPECIFICATIONS

Inputs: CW Limit, CCW Limit, Torque/Velocity Select, Auto/Manual Select
Voltage range: 4.5 - 35 V d.c.
Current ratings, user must source or sink the following:
1.2 mA @ 5 V d.c. per-input
12.1 mA @ 30 V d.c. per-input

Operating Temperature Range 0-55°C ambient

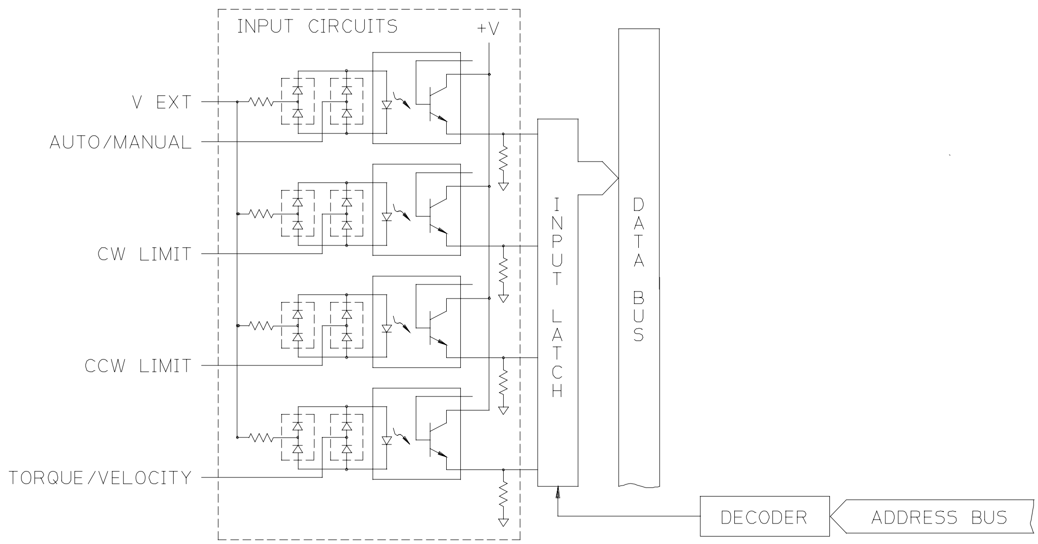


FIGURE 5.25 EXTENDED INPUTS BRACKET OPTION BLOCK DIAGRAM

6. TROUBLESHOOTING GUIDE

WARNING

Do not attempt to repair or make internal adjustments to the drive or power supply. Lethal voltages are present and changes to factory calibration can result in serious equipment and/or personnel risk and void the equipment warranty. All faulty items of this equipment must be returned to Moog Service Centers for maintenance and repair.

The following charts list typical system, power supply, drive, and motor troubleshooting conditions.

A list of possible cause(s) is given for each condition. For some conditions, there are multiple possible causes which are generally listed in order of increasing complexity for the stated conditions.

A list of check/correct action recommendations is listed below each possible cause(s).

The diagnostic LEDs visible through the Drive and Power Supply front panels indicate equipment status and are useful in troubleshooting. Additional Drive fault status information can be queried via a terminal or computer connected to the J3 Communications Connector serial port, (refer to Section 5).

It is important to note that this section describes Moogterm (commands) and WinDrive (commands/menus) when applicable.

When using C4 Moogterm compatible firmware, the query commands, **?S** and **?F**, are especially useful for drive troubleshooting.

When using H1 WinDrive compatible firmware in terminal emulation mode the query commands **?S** and **?F**, are especially useful for drive troubleshooting. When in WinDrive graphical user interface mode (GUI mode) select **DRIVE/DRIVE STATUS** or view the **FAULTS STATUS BAR.**

No Motion

Condition
T150-901 Power Supply
BUS ACTIVE LED is off
REGEN FUSE LED is off

YES ⇨

Possible Cause
a.c. Power off

Check/Correct
- ❑ Three Phase a.c. Plant Supply
- ❑ a.c. Input Circuit Breaker
- ❑ Optional a.c. Input Drive Contactor
- ❑ Optional Transformer Wiring
- ❑ User Control Circuits/Interlocks Preventing a.c. Power

NO ⇩

Condition
T150-901 Power Supply
BUS ACTIVE LED is off
REGEN ACTIVE LED is on
REGEN FUSE LED is on

YES ⇨

Possible Cause
REGEN FUSE blown

Check/Correct
- ❑ Check d.c. bus wiring from Power Supply to Drives.
- ❑ Replace REGEN FUSE. Unless the d.c. bus wiring to the Drives is found to be reversed, a blown fuse is a strong indication that the Power Supply is defective and should be returned for factory repair.

NO ⇩

Condition
T150-901 Power Supply
BUS ACTIVE LED is on
REGEN FUSE LED is off

YES ⇨

Possible Cause
d.c. BUS FUSE blown

Check/Correct
- ❑ Measure 300V d.c. from d.c.+ to d.c.- terminals of T150-901 Power Supply. Fuse blown if 300 V d.c. not present.
- ❑ Field replacement of the d.c. BUS FUSE is not recommended. A blown fuse is a strong indication that the Power Supply is defective and should be returned for factory repair.

NO ⇩

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No Motion (Continued from Previous Page)

Condition
T164 Series Drive(s)
SYSTEM ENABLE LED(s) off
POWER SUPPLY OK LED(s) on
All other Drive(s) LEDs off

YES ⇨

Possible Cause 1
No drive hardware enable(s) input to J1.
❑ **Check/Correct**
❑ User Vexternal Power Supply output
❑ Wiring to/from T164 Series Drive(s) J1 Connector(s)
❑ Enable output(s) from System Motion Drive
Possible Cause 2
No drive software enable(s).
Check/Correct
❑ Issue **MI** software command (when using Cx firmware).
❑ Issue **ENABLE or MI** command (when using Hx firmware).

NO ⇩

Condition
T164 Series Drive(s)
SYSTEM ENABLE LED(s) off
POWER SUPPLY OK LED(s) off
All other Drive(s) LEDs off

YES ⇨

Possible Cause
User External 24 V d.c. Supply Power Off
Check/Correct
❑ a.c. Input, Wiring, Fusing of 24 V d.c. Supply

NO ⇩

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No Motion (Continued from Previous Page)

Condition *T164 Series Drive(s)* *SYSTEM ENABLE LED(s) on* *POWER SUPPLY OK LED(s) on* *All other Drive(s) LEDs off*	
YES ⇨	**Possible Cause 1** No command input **Check/Correct** ❑ Command input from System Drive must not be 0 volts. **Possible Cause 2** Axis is Mechanically Bound/Jammed **Check/Correct** ❑ Mechanical Power Transmission Devices ❑ Interference With Other Machine Parts **Possible Cause 3** Optional Motor Brake Set **Check/Correct** ❑ User External Brake Power Supply ❑ Brake Control Circuitry and Interlocking **Possible Cause 4** Insufficient motor output torque **Check/Correct** ❑ Insufficient velocity loop gain, refer to Section 4.0. ❑ Uncouple motor from load and initiate command. ❑ Mechanical binding / excess friction ❑ Motor sizing improper **Possible Cause 5** Wrong Drive / Motor combination **Check/Correct** ❑ Proper motor model number programmed, (refer to Section 4.0)

Erratic motion

Condition *High frequency audible sound*	
YES ⇨	**Possible Cause 1** Wiring error **Check/Correct** ❑ Resolver wiring from motor to Drive J2 connector. ❑ Resolver shield connection, refer to FIGURE 2.31. ❑ Loose wiring connections. ❑ System earthing , refer to Section 2.9. **Possible Cause 2** Noisy input command **Check/Correct** ❑ Drive J1 connections, wiring, shield earthing, refer to FIGURE 2.22. **Possible Cause 3** Wrong Drive / Motor combination. **Check/Correct** ❑ Proper motor model number programmed, refer to Section 4. **Possible Cause 4** Improper Drive Set-up / Tuning **Check/Correct** ❑ Repeat Set-up / Tuning, refer to Section 4.0. **Possible Cause 5** Motor Fault **Check/Correct** ❑ Check motor winding d.c. resistance line-to-line. See motor data sheet for correct d.c. winding resistance values. ❑ Check motor winding d-c resistance line-to-earth. Line-to-earth resistance should measure infinity, i.e. open. ❑ Uncouple and disconnect motor, rotate shaft. Check for "lumpy" rotational resistance as shaft is rotated. If "lumpy", measure winding resistance. ❑ Replace motor as necessary with same model motor, retry.
NO ⇩	

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Erratic motion (Continued from Previous Page)

	Condition *Surging / Cogging* *Instability*
YES ⇨	**Possible Cause 1** Improper Shield Connections **Check/Correct** ❑ Assure shields are full length of cabling for Drive J1 and J2 cables; refer to FIGURE 2.22and FIGURE 2.31. ❑ Assure cables of option cards if used, refer to Section 2. **Possible Cause 2** Poor earthing **Check/Correct** ❑ System earthing, refer to Section 2.11.3. **Possible Cause 3** Wiring error / loose wiring and / or connectors. **Check/Correct** ❑ Review motor power wiring to Drive including earth wire and shield, refer to FIGURE 2.3, FIGURE 2.4, FIGURE 2.5, FIGURE 2.10, as appropriate. ❑ Review resolver wiring from motor to Drive. **Possible Cause 4** Binding / Backlash in mechanical power train **Check/Correct** ❑ Inspect for cyclical binding or looseness in power train. **Possible Cause 5** Noisy Input Command **Check/Correct** ❑ Drive J1 connections, wiring, shield earthing, refer to FIGURE 2.22. **Possible Cause 6** Wrong Drive / Motor combination. **Check/Correct** ❑ Proper motor model number programmed, refer to Section 4. **Possible Cause 7** Improper Drive Set-up / Tuning **Check/Correct** ❑ Repeat Set-up / Tuning, refer to Section 4 **Possible Cause 8** Motor Fault **Check/Correct** ❑ Check motor winding d-c resistance line-to-line. See motor data sheet for correct d.c. winding resistance values. ❑ Check motor winding d.c. resistance line-to-earth. Line-to-earth resistance should measure infinity, i.e. open. ❑ Uncouple and disconnect motor, rotate shaft. Check for "lumpy" rotational resistance as shaft is rotated. If "lumpy", measure winding resistance. ❑ Replace motor as necessary with same model motor, retry.
NO ⇩	

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Erratic motion (Continued from Previous Page)

	Condition *Motion Deadband*
YES ⇨	**Possible Cause 1** Improper Drive Set-up / Tuning **Check/Correct** ❑ Repeat Set-up / Tuning, refer to Section 4. **Possible Cause 2** Binding / backlash in mechanical power train **Check/Correct** ❑ Check for excessive friction. ❑ Check for mechanical backlash. **Possible Cause 3** Drive Failure **Check/Correct** ❑ Substitute same model drive, retry.
NO ⇩	

	Condition *Overshoot*
YES ⇨	**Possible Cause 1** Improper Drive Set-up / Tuning **Check/Correct** ❑ Repeat Set-up / Tuning, refer to Section 4. **Possible Cause 2** Binding / Backlash in mechanical power train. **Check/Correct** ❑ Check for excessive mechanical backlash or slipping / broken coupling. **Possible Cause 3** Excessive inertia in mechanical power train. **Check/Correct** ❑ Review load inertia reflected back to motor shaft.
NO ⇩	

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Erratic motion (Continued from Previous Page)

Condition *Speed Too Slow*	
YES ⇨ **NO** ⇩	**Possible Cause 1** Manual Mode Enabled or Automatic Mode Velocity Limit set too low. **Check/Correct** ❑ Automatic / Manual mode, Velocity Limits, refer to Section 4. **Possible Cause 2** T150-901 Power Supply d.c. Bus Voltage low **Check/Correct** ❑ Measure d.c. bus voltage from d.c.+ to d.c.- terminals of T150-901 Power Supply, should be above 300 V d.c.. ❑ Measure L1, L2 and L3 a.c. input voltages, nominal is 220 V r.m.s.. **Possible Cause 3** Drive Velocity Scaling set too low. **Check/Correct** ❑ Check Drive Velocity Scaling, refer to Section 4. **Possible Cause 4** Low Velocity Command from System Motion Drive **Check/Correct** ❑ Measure System Motion Drive command output. **Possible Cause 5** Drive Current Limits set too low. **Check/Correct** ❑ Check Drive Motor Torque Limit settings, refer to Section 4. **Possible Cause 6** Motor overload. **Check/Correct** ❑ Review sizing calculations. ❑ Check for excessive friction / binding.

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Erratic motion (Continued from Previous Page)

Condition *Excessive Speed/Runaway*	
YES⇨	**Possible Cause 1** Wiring error **Check/Correct** ❑ Check resolver cable and shields per J2 cable drawing, refer to FIGURE 2.31. **Possible Cause 2** Wrong Drive / Motor combination **Check/Correct** ❑ Proper motor model number programmed, refer to Section 4. **Possible Cause 3** Encoder Simulation Option / System Motion Drive phasing. **Check/Correct** ❑ Check motion drive encoder phasing. **Possible Cause 4** Drive Failure **Check/Correct** ❑ Substitute same model drive, retry. **Possible Cause 5** Motor Failure **Check/Correct** ❑ Substitute same model motor, retry.

T164 Series Drive Troubleshooting

	Condition *Yellow SYSTEM FAULT LED flashes.*
YES ⇨ **NO** ⇩	**Possible Cause** Drive has not been initialized. **Check/Correct** ❑ Perform Set-up / Tuning, refer to Section 4.

	Condition *Yellow BRIDGE OVERTEMPERATURE LED on* *Yellow SYSTEM FAULT LED on* ***?F** Query Lists Bridge Overtemperature Fault* (when using C4 firmware). View the **FAULTS STATUS BAR** (when using H1 firmware).
YES ⇨ **NO** ⇩	**Possible Cause 1** IT Foldback set too high. **Check/Correct** Use OT command to query IT settings (when using C4 firmware), refer to Section 4. View Drive/Setup/I-T Thermal Limits (when using H1 firmware). **Possible Cause 2** Cooling fan failure, or heat sink dirty / clogged. **Check/Correct** ❑ Heat sink air flow unrestricted. Clean as necessary. ❑ Cooling fan operation. ❑ Sufficient clearance above and below unit. **Possible Cause 3** Ambient Temperature Too High **Check/Correct** ❑ Temperature of Cabinet **Possible Cause 4** Wrong motor / drive combination. **Check/Correct** ❑ Proper motor model number programmed, refer to Section 4.

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T164 Series Drive Troubleshooting (from Previous Page)

Condition *Yellow MOTOR OVERTEMP LED on* *Yellow SYSTEM FAULT LED on* ***?F** Query Lists Bridge Overtemperature Fault* (when using C4 firmware). View the **FAULTS STATUS BAR** (when using H1 firmware).	
YES ⇨ **NO ⇩**	**Possible Cause 1** Motor Thermistor / Thermostat Not Connected. **Check/Correct** ❑ Thermistor / Thermostat Wiring, refer to FIGURE 2.31. **Possible Cause 2** Motor Overtemperature **Check/Correct** ❑ Refer to Motor Troubleshooting.

Condition *Yellow RESOLVER LOSS LED on* *Yellow SYSTEM FAULT LED on* ***?F** Query Lists Bridge Overtemperature Fault* (when using C4 firmware). View the **FAULTS STATUS BAR** (when using H1 firmware).	
YES ⇨ **NO ⇩**	**Possible Cause 1** J2 Resolver Cable miswired or poor connection. **Check/Correct** ❑ Cable wiring, refer to FIGURE 2.31. **Possible Cause 2** Excessive electrical noise pickup. **Check/Correct** ❑ J2 cable shielding, refer to FIGURE 2.31. **Possible Cause 3** Motor resolver failure **Check/Correct** ❑ Replace motor. **Possible Cause 4** Drive failure **Check/Correct** ❑ Replace drive.

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T164 Series Drive Troubleshooting (from Previous Page)

Condition
Yellow SHORT CIRCUIT LED on
Yellow SYSTEM FAULT LED on
***?F** Query Lists Bridge Overtemperature Fault* (when using C4 firmware).
View the **FAULTS STATUS BAR** (when using H1 firmware).

YES ⇨

Possible Cause 1
Short in Motor Wiring or Connector.
Check/Correct
❑ Motor power cable, wiring between drive and motor, refer to FIGURE 2.32, FIGURE 2.4, FIGURE 2.5, FIGURE 2.7 as appropriate.
Possible Cause 2
Motor Failure
Check/Correct
❑ Replace motor.
Possible Cause 3
Drive Failure - Output Bridge Shorted.
Check/Correct
❑ Replace Drive.

NO ⇩

Condition
Yellow BUS OVERVOLTAGE LED on.
Yellow SYSTEM FAULT LED on.
***?F** Query Lists Bridge Overtemperature Fault* (when using C4 firmware).
View the **FAULTS STATUS BAR** (when using H1 firmware).

YES ⇨

Possible Cause 1
Excessive regeneration, causing Power Supply regen electronic circuit breaker to trip.
Check/Correct
❑ Regeneration sizing, resistance value and or power rating wrong.
Possible Cause 2
Optional external regen resistor configured or wired wrong.
Check/Correct
❑ Configuration and wiring of optional external regen resistor, refer to Section 2.7.
Possible Cause 3
Three phase input voltage too high.
Check/Correct
❑ Three phase a.c. input voltage level to T150-901 Power Supply.
Possible Cause 4
T150-901 Power Supply failure.
Check/Correct
❑ Replace T150-901 Power Supply.

NO ⇩

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T164 Series Drive Troubleshooting (from Previous Page)

Condition *Yellow FOLDBACK LED is on.*	
YES⇨	**Possible Cause 1** Excessive Load **Check/Correct** ❑ Uncouple motor from load, retry. **Possible Cause 2** Wrong velocity scaling. **Check/Correct** ❑ Velocity scaling, refer to Section 4. **Possible Cause 3** Motor or Resolver wiring error. **Check/Correct** ❑ Motor Power cable wiring, refer to FIGURE 2.32, FIGURE 2.4, FIGURE 2.5, FIGURE 2.7 as appropriate. ❑ Resolver cable wiring, refer to FIGURE 2.31. **Possible Cause 4** Lack of 300 V d.c. Bus. **Check/Correct** ❑ Measure 300 V d.c. at Drive TB2.

T150-901 Power Supply Troubleshooting

Condition *Green BUS ACTIVE LED off*	
YES ⇨ NO ⇩	**Possible Cause 1** a.c. Power Off **Check/Correct** ❑ Three Phase a.c. Plant mains Supply ❑ a.c. Input Circuit Breaker ❑ Optional a.c. Input Drive Contactor ❑ Mains Isolation Transformer Wiring ❑ User Control Circuits / Interlocks Preventing a.c. Power

Condition *Yellow LOSS OF PHASE LED on*	
YES ⇨ NO ⇩	**Possible Cause** Loss of a phase of a.c. input power. **Check/Correct** ❑ Three Phase a.c. Plant Mains Supply ❑ Power Supply a.c. Input Wiring

Condition *Yellow THERMAL FAULT LED on*	
YES ⇨ NO ⇩	**Possible Cause 1** Ambient Temperature too high. **Check/Correct** ❑ Temperature of cabinet **Possible Cause 2** Cooling fan failure, or heat sink dirty / clogged. **Check/Correct** ❑ Heat sink air flow unrestricted. Clean as necessary. ❑ Cooling fan operation. ❑ Sufficient clearance above and below unit. **Possible Cause 3** Excessive system duty cycle **Check/Correct** ❑ Application sizing, power supply average current draw. **Possible Cause 4** Power Supply failure. **Check/Correct** ❑ Replace Power Supply.

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T150-901 Power Supply Troubleshooting (Continued from Previous Page)

	Condition *Yellow REGEN ACTIVE LED is on excessively.*
YES ⇨ **NO** ⇩	**Possible Cause 1** Regen fuse blown. **Check/Correct** ❑ REGEN FUSE **Possible Cause 2** Excessive aiding load. **Check/Correct** ❑ Review application sizing. **Possible Cause 3** Power Supply Failure **Check/Correct** ❑ Replace Power Supply.

	Condition *Yellow REGEN FUSE LED is on.*
YES ⇨	**Possible Cause 1** Regen circuit fuse blown. **Check/Correct** ❑ Check d.c. bus wiring from Power Supply to Drives. ❑ Replace REGEN FUSE. Unless the d.c. bus wiring to the Drives is found to be reversed, a blown fuse is a strong indication that the Power Supply is defective and should be replaced.

Motor Troubleshooting

	Condition *Motor Too Hot (Over 135°C on Housing) or Smoking*
YES ⇨ **NO** ⇩	**Possible Cause 1** Wired Wrong **Check/Correct** ❑ Motor Wiring, refer to Figure 2.7, 2.8, 2.9, 2.10, 2.33, 2.34 or Table 2-4 as appropriate. **Possible Cause 2** Overloaded, axis stalled or binding. **Check/Correct** ❑ Review motor sizing. ❑ Check for excessive load and / or friction. ❑ Interference with other machine parts. **Possible Cause 3** Ambient temperature too high. **Check/Correct** ❑ Measure ambient temperature. **Possible Cause 4** Motor connected to wrong drive. **Check/Correct** ❑ Proper motor model number programmed, refer to Section 4.0. **Possible Cause 5** Incorrect Drive Set-up / Tuning **Check/Correct** ❑ Repeat Set-up / Tuning, refer to Sections 4. **Possible Cause 6** Motor Failure **Check/Correct** ❑ Substitute same model motor, retry. **Possible Cause 7** Drive Failure **Check/Correct** ❑ Substitute same model drive, retry.

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Motor Troubleshooting (Continued from Previous Page)

Condition *Motor Noisy*	
YES ⇨ **NO** ⇩	**Possible Cause 1** Loose coupling or mounting **Check/Correct** ❑ Coupling stiffness **Possible Cause 2** Wrong drive / motor combination. **Check/Correct** ❑ Proper motor model number programmed, refer to Section 4. **Possible Cause 3** Improper Drive Set-up / Tuning **Check/Correct** ❑ Repeat Set-up / Tuning, refer to Sections 4. **Possible Cause 4** Bearing Failure **Check/Correct** ❑ Replace Motor **Possible Cause 5** Excessive electrical noise. **Check/Correct** ❑ Improper earthing and shielding.

Condition *Excessive Cogging (No System Power On and Unloaded Shaft)*	
YES ⇨ **NO** ⇩	**Possible Cause 1** Motor cable shorted. **Check/Correct** ❑ Check wiring, refer FIGURE 2.32, FIGURE 2.4, FIGURE 2.5, FIGURE 2.7 as appropriate. **Possible Cause 2** Motor stator winding shorted. **Check/Correct** ❑ Replace motor.

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Motor Troubleshooting (Continued from Previous Page)

Condition *Motor Shaft Won't Turn (When Disconnected from Load)*	
YES ⇨ **NO** ⇩	**Possible Cause 1** Motor or resolver cable wired wrong **Check/Correct** ❑ Motor Power Wiring, refer to FIGURE 2.32, FIGURE 2.4, FIGURE 2.5, FIGURE 2.7 as appropriate. ❑ Resolver Wiring, refer to FIGURE 2.31. **Possible Cause 2** Optional Brake Not Released. **Check/Correct** ❑ Brake Power Supply and Control Circuits. **Possible Cause 3** Motor Failure **Check/Correct** ❑ Replace Motor. **Possible Cause 4** Bearing Seized. **Check/Correct** ❑ Replace Motor.

Condition *Optional Brake Does Not Set*	
YES ⇨ **NO** ⇩	**Possible Cause 1** Control circuits **Check/Correct** ❑ d.c. Power to the brake must be removed to set the brake. **Possible Cause 2** Axis enabled **Check/Correct** ❑ Brake should normally be released when axis is enabled. **Possible Cause 3** Brake failure **Check/Correct** ❑ Replace motor

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Motor Troubleshooting (Continued from Previous Page)

Condition *Optional Brake Does Not Release*	
YES⇨	**Possible Cause 1** Brake d.c. Power Supply **Check/Correct** ❑ Not energized ❑ Fuse blown ❑ Improper voltage output or wrong polarity for brake coil **Possible Cause 2** Control Circuits **Check/Correct** ❑ d.c. Power must be applied to the brake to release the brake. ❑ Other interlocking of control circuits ❑ Proper voltage and current capacity ❑ Broken or missing wire **Possible Cause 3** Brake failure **Check/Correct** ❑ Replace motor

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7. SOFTWARE REVISION NOTES - NEW PRODUCT

The following firmware versions are compatible with the following option cards and hardware revisions.

Option Card	Software Revision	T164-90X(R) Hardware Revision R
Encoder Simulation Card	H1, C1 or later	A
CAN Interface Card	G2 or later	A
Point Card	H1, C3 or later	A
Extended I/O (Std Ver.)	H1, C1 or later	A
Extended I/O (Full Ver.)	H1, C1 or later	A
Extended Inputs Bracket	H1	A

TABLE 7-1 Software/Hardware Compatibility Table

The following tables describe the software change record per revision.

MOOGTERM (+/-10V) SOFTWARE				
SOFTWARE LETTER	SOFTWARE REVISION	SOFTWARE FACTORY KIT NUMBER	FIRMWARE EPROM NUMBERS	SOFTWARE CHANGE RECORD
C	1	C09476-002	C09477-002 C09478-002	Resolver position handling when the J2 is plugged and unplugged (derived from B2)
C	3	C090476-004	C09477-004 C09478-004	1) Added POINT functionality. 2) Added warning for unsupported motor/drive combinations. 3) Added warning for incompatible EEPROM versions. 4) Adjusted current loop gains for some motors. Changes made to 303-030,303-029 Data Base. 5) Added ability to enter G41X as well as G42X. 6) Added support for 128 Line Count for the ESMII Card.
C	4	C09475-005	C09477-005 C09478-005	1) Problem with Moogterm download with parameter files created from earlier versions of firmware has been corrected. 2) Extended I/O Board, System Ready relay problem corrected. 3) Motor Data base updated. 4) Reference filter turned off while in Torque Mode. 5) Velocity TP signal wrap around problem fixed.

CAN INTERFACE (PROFILE MODE SOFTWARE)				
SOFTWARE LETTER	SOFTWARE REVISION	SOFTWARE FACTORY KIT NUMBER	FIRMWARE EPROM NUMBERS	SOFTWARE CHANGE RECORD
G	2	C09244-002	C09355-002 C09356-002	
WinDrive (+\-10V) SOFTWARE				
SOFTWARE LETTER	SOFTWARE REVISION	SOFTWARE FACTORY KIT NUMBER	FIRMWARE EPROM NUMBERS	SOFTWARE CHANGE RECORD
H	1	C09792-001	C09789-001 C09790-001	

TABLE 7-2 Software Change Record Per Revision

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8. MOOG REPAIR CENTERS

WARNING
Repair or internal adjustments to the T150-901 Power Supply and T164 Series Drives must not be attempted. All faulty items must be returned to Moog Service Centers for maintenance and repair.

Moog Service Centers are located at the following addresses:

USA:
Moog Inc., North American Drives Operations Division, East Aurora, New York 14052-0018
Telephone: (716) 652-2000 Telefax: (716) 687-4870

Europe:
Moog GmbH Hanns-Klemm Strasse 28 D71034 Boblingen Germany
Telephone: +0049 (07031) 6220 Telefax: +0049 (07031) 622-100

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9. WARRANTY - NEW PRODUCT

This section provides the Moog Standard Product Warranty portion only of Moog Inc., North American Drives Operations Division, Terms and Conditions of Sale.
A complete copy of Terms and Conditions is available upon written request.

a) Moog warrants that each item of its manufacture shall, at the time of shipment to Buyer, conform to applicable specifications and drawings, and be free from defects in material and workmanship. Design, essential performance, or other provisions expressly stated to be goals or objectives shall not be deemed to be requirements subject to this Warranty.

b) Unless otherwise specified, Moog's obligation under this Warranty shall be limited to repair or replacement, at Moog's option, of any item which within twenty-four months from date of shipment to Buyer is proven to Moog's satisfaction to have been nonconforming at the time of shipment. As a condition of this Warranty, Buyer shall notify Moog in writing of any claimed nonconformance immediately upon discovery and shall return the item to Moog for inspection. Moog shall not be responsible for any work done or repairs made by others at any time. Disassembly by anyone other than persons authorized by Moog will void the terms of this Warranty.

c) Moog shall not be responsible for the performance of any product which incorporates items manufactured by Moog unless such performance is expressly designated as Moog's responsibility under the terms of the written agreement between Moog and the Buyer.

d) Moog shall not be liable for improper use, installation, accidents, operation or maintenance of items manufactured by Moog, nor for any damage resulting therefrom, or from negligence on the part of the Buyer's employees or agents.

e) Moog shall not be responsible for any consequential or incidental damages occasioned by failure of any item supplied by Moog, or by failure of any item in which a component manufactured by Moog is incorporated.

f) Unless previously agreed to in writing, Moog shall not provide field repairs, modifications, or any other field service under this Warranty.

g) the warranties contained herein are exclusive and are given instead of all other warranties, expressed, implied or statutory, including the implied warranty of merchantability or fitness for a particular purpose, and all other obligations and liabilities. With respect to contracts directly between moog and the u.s. government or any of its agencies, the rights and remedies afforded to the government or agency by this standard product warranty are in addition to and do not limit any rights afforded by any other provision or provisions of the contract.

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