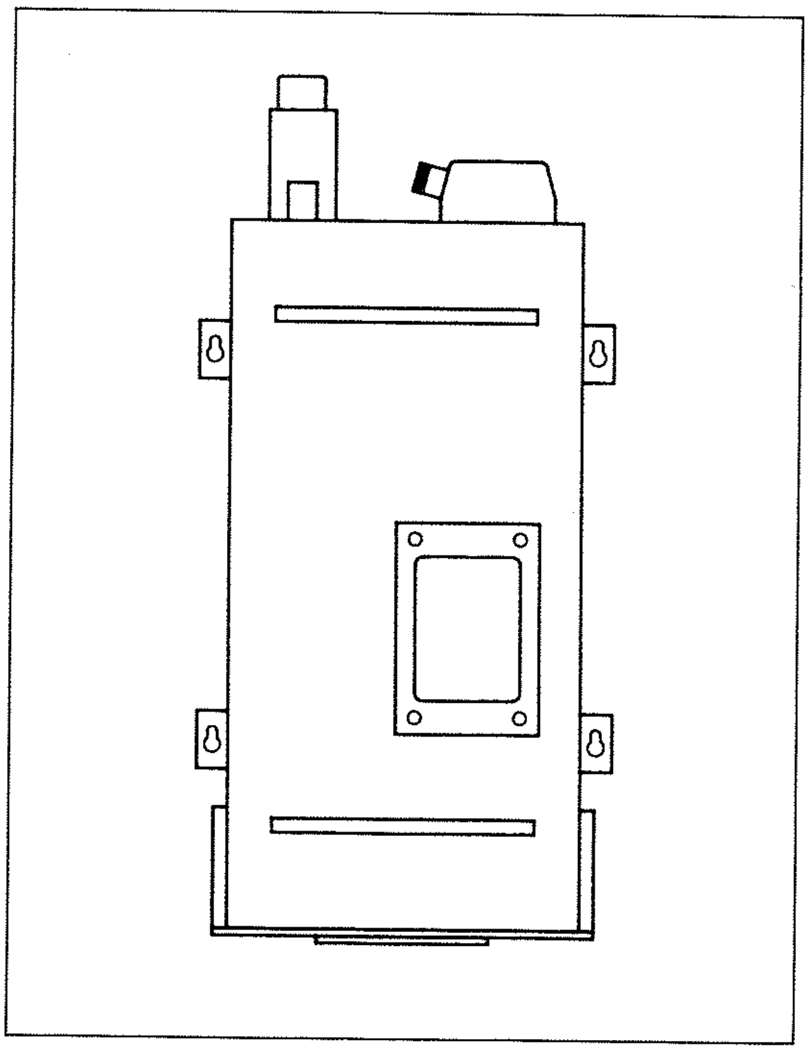
$35.00

DSC 3.X SERVO AMPLIFIERS USER'S MANUAL



REXROTH INDRAMAT

No. IA 74720
Revision A, 7/88
(Includes Update A.2, 5/92)

Precision Control For Automation

PUBLICATION NUMBER IA 74720

REVISION A, JULY 1988

INCLUDES UPDATES A.1 (AUG. 1991) AND A.2 (MAY 1992)

WARNING

THIS MANUAL DESCRIBES EQUIPMENT IN WHICH DANGEROUS VOLTAGE AND TEMPERATURE LEVELS ARE PRESENT. SERVICE SHOULD BE PERFORMED ONLY BY QUALIFIED PERSONNEL TAKING APPROPRIATE CAUTIONS.

THIS EQUIPMENT CONTROLS MACHINE MOTION. HIGH SPEEDS AND FORCES ARE POSSIBLE, WHICH MAY ENDANGER PERSONNEL IF PRECAUTIONS ARE NOT TAKEN.

IMPORTANT

PLEASE COMPLETE THIS REVISION REGISTRATION FORM TO AUTOMATICALLY RECEIVE NOTIFICATIONS OF CHANGES TO THIS MANUAL.

RETURN THIS FORM TO:

Indramat Division of the Rexroth Corporation
Marketing Communications Department
225 Mittel Drive
Wood Dale, Illinois 60191

PUBLICATION: DSC 3.X SERVO AMPLIFIERS USER'S MANUAL
Publication No. IA 74720
Revision A.2, May 1992

NAME ____

COMPANY ____

ADDRESS ____

CITY ____________________ STATE ______ ZIP ________

TELEPHONE (____) ____________________________________

COMMENTS

FOREWARD

Special Notations:

Special notations are used in this manual to assist the reader in identifying a unique condition or important information. The three categories of notations are listed below in ascending order of importance.

NOTE -- A tip, suggestion or emphasized procedure for operating the equipment.

CAUTION -- Appears when a condition exists which could cause damage to the equipment.

WARNING -- Identifies conditions which could cause bodily harm and/-or severe damage to equipment if the operator is not careful. A WARNING typically describes the potential hazard, its possible effect and measures that must be taken to avoid the hazard(s).

Because of variations found in the operating conditions of certain applications and their working environments, the notations in this manual cannot identify all potential problems or hazards. Caution and discretion must always be used when operating machinery, especially when using electrical power. Equipment should only be installed and operated by trained personnel. Installation and training services are available from Rexroth-Indramat.

RECORD OF REVISIONS

Revision Level	Date	Description of Change
A	7/88	Initial Release.
A.1	8/91	Renumbered page iii to iv. Added new page iii (Foreward). Revised pages 6-1, 6-2 and 6-3.
A.2	5/92	Minor corrections to pages 3-10, 5-6 & 6-2. Updated two drawings in Appendix C. Updated all drawings in Appendix D.

DSC 3.X SERVO AMPLIFIER MODULE USER'S MANUAL

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

CHAPTER 1. DESCRIPTION

1.1 INTRODUCTION

This document provides a functional description, plus a description of installation, startup, operation and maintenance of the Indramat DSC 3.X brushless AC servo amplifier.

The DSC 3.X amplifier is a four-quadrant, pulse-width-modulated (PWM) servo amplifier, designed to be used in high performance speed and position control systems with Indramat MAC permanent magnet brushless (3-phase) AC servomotors. These systems are suitable for all existing NC applications, particularly for positioning systems for machine tools.

The control interface and drive function of AC servo drive systems is identical to that of conventional DC servo drive systems. However, Indramat AC servomotors contain no parts which require routine maintenance. AC drive systems also offer a greater utilization factor and a more favorable weight-to-power output ratio than DC drives, because they have no commutation limits.

In contrast to DC drive systems, AC drive systems are distinguished by a greater acceleration capacity, lower temperature rise during acceleration, a diminished power loss (up to a factor of 5-10) and diminished energy consumption (up to a factor of 3) during servo applications.

AC servomotors with surface cooling (air-over) offer extremely high torques in relation to the rotor moment of inertia, so they are especially well suited for demanding applications with extreme dynamic loads, such as feed drives for transfer lines, flexible NC machines, and high speed perforating presses (up to 600 strokes per minute); and as oscillating drives for grinding machines. Indramat AC servomotors are sealed for high protection (IP 65 rating) and require no air filtering.

The DSC amplifier is part of the motion control system. Indramat supplies a wide range of power supplies, servo amplifiers, and AC servomotors so that an optimum system can be assembled for each application.

The DSC 3.X follows its predecessor, the DSC 1.X, with the same environmental characteristics. The DSC 3.X is fully sealed for operation in harsh environments, has quick disconnects on all cable assemblies and is designed to be mounted at the machining station without the need of a cabinet.

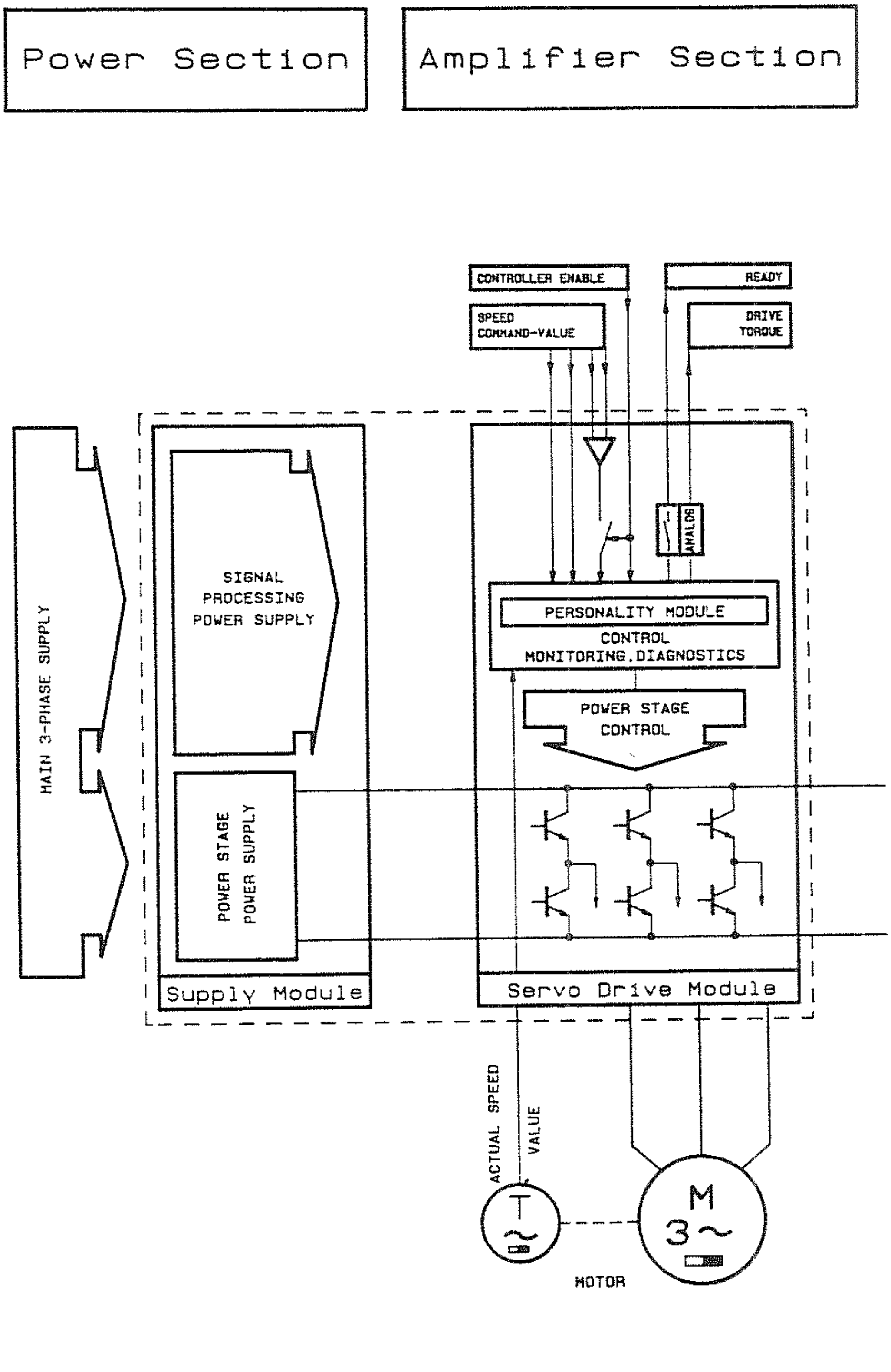


Figure 1-1. AC Servo System Functional Diagram

1.2 SYSTEM DESCRIPTION

An Indramat DSC 3.X Brushless Servo System is illustrated in Figure 1-1. It consists of:

* A power supply section
* An amplifier section

A 3-phase transformer changes the line voltage to 220 Vac for the power supply section and also provides a ground referenced neutral required by the power supply.

A transformer is always required if the line voltage is other than 220 Vac 3-phase or if the line is not ground referenced. If the line is not ground referenced, the transformer must be an isolation type (normally delta to wye) with the secondary neutral grounded. If the line is ground referenced (i.e., only the voltage level needs to be changed), an autotransformer may be used.

No transformer is necessary if a ground referenced, 220 Vac line is available.

The Power Supply Section supplies power to the servo amplifier section over a 300 Vdc bus. Although power is normally delivered from the power supply to the servo amplifier, the power supply section also regulates the 300 Vdc bus voltage during regeneration. This occurs when a motor is being slowed down rapidly acting as a generator and the servo amplifier is delivering power back to the power supply. The power supply also provides all control voltages used by the servo amplifier section (+24 Vdc and +/-15 Vdc) and continuously monitors itself for faults.

The Servo Amplifier Section consists of a pulse width modulated (PWM) converter and the associated control, feedback and monitoring circuitry. It controls the speed and direction of an Indramat MAC motor in proportion to a velocity command input voltage. This is done by regulating motor current based on feedback from a brushless analog tachometer and from an absolute rotor position sensor.

A personality module is included in the servo amplifier. This module contains fixed resistors and capacitors that control the response of the amplifier, the current limits, etc., matching it to the characteristics of its connected servomotor. Personality modules are available from Indramat for virtually any combination of servo amplifier, motor and load. This eliminates the need for adjustments and allows for extremely easy field replacement of servo amplifiers.

The DSC 3.X servo amplifier has extensive fault detection circuitry. This provides easy interlocking with the Numerical Control (NC) E-stop circuits.

The MAC AC Servomotor is a 3-phase AC servomotor chosen for optimum performance for each application. It has a permanent magnet rotor, an integral feedback unit for absolute rotor position sensing, a tachometer for velocity feedback, and an optional rotor position sensor for axis position sensing and feedback.

Indramat AC servomotors incorporate no electromechanical parts that are subject to wear. The motor and tachometer are brushless and the bearings are lubricated for the life of the motor so they require no maintenance.

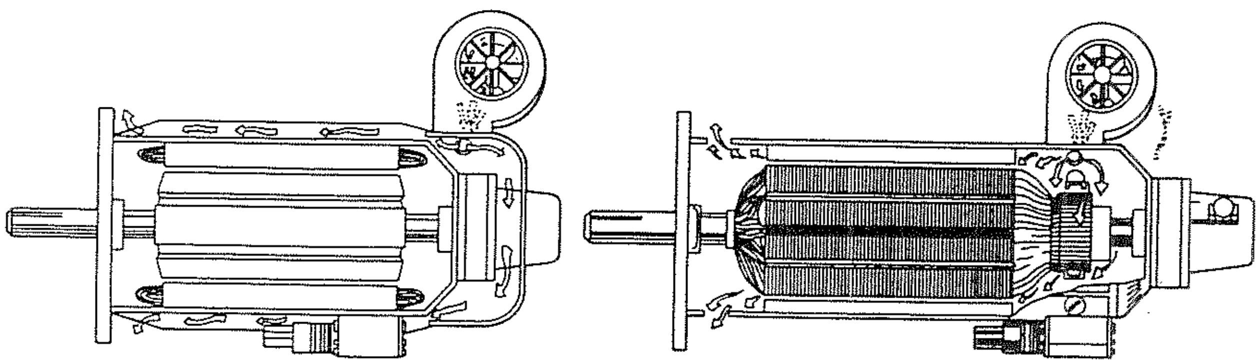
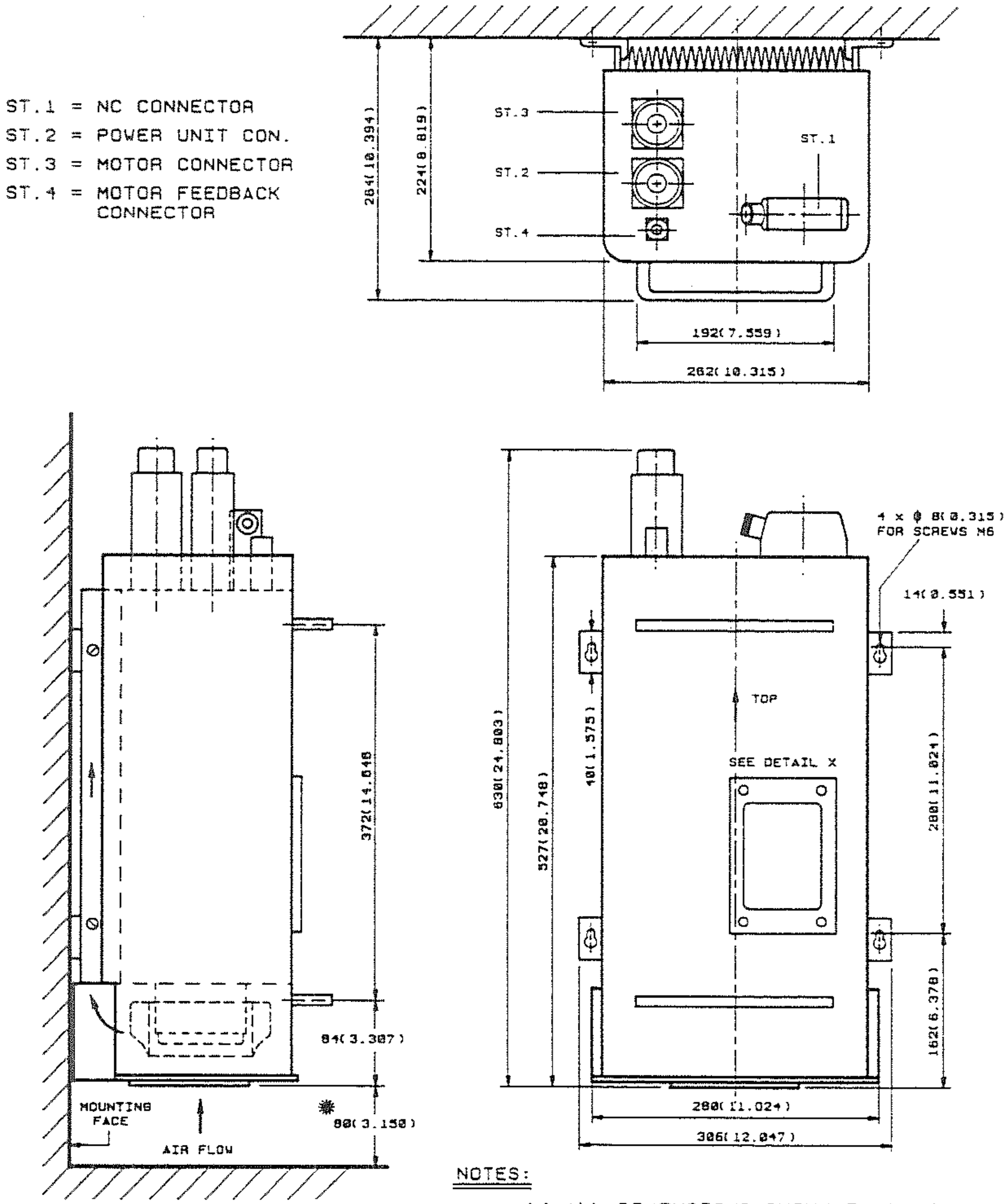


Figure 1-2. Comparison of AC vs DC Servomotor

The heat-generating coils in a MAC servomotor are mounted to the frame rather than to the rotor as in DC servomotors. This allows the rotor to be built with a much lower inertia for a given amount of torque, thus improving response. This also makes MAC AC servomotors much easier to cool than DC servomotors because the heat is generated close to the surface of the motor. When a cooling blower is required, it merely blows air over the frame and the motor remains sealed. Figure 1-2 is a comparison of MAC AC servomotor to a DC servomotor.

The Indramat AC Servo System is assembled to meet the specific requirements of each application.

Figure 1-3 is a drawing of an Indramat DSC 3.X AC servo system.



NOTES:

1) ALL DIMENSIONS SHOWN IN "mm". (inches) FOR REFERENCE ONLY.
2) WEIGHT = 57 lbs

✳ INDICATES MIN. DISTANCE FOR COLL AIR INLET.

Figure 1-3. Indramat DSC 3.X Servo Amplifier

1.3 PRINCIPLES OF OPERATION AND FUNCTIONAL DESCRIPTION

1.3.1 Theory of Operation

1.3.1.1 Power Supply Section

Figure 1-4 shows a block diagram of the DSC 3.X power supply section. It contains a conventional 3-phase bridge rectifier with a filter capacitor and functions as an unregulated supply. The filtered bridge produces approximately 300 Vdc from a 220 Vac line.

The power supply has provisions for limiting the voltage level during regeneration when the motor is acting as a generator (such as during rapid deceleration). The energy delivered to the bus from the motor causes the voltage to rise. Circuitry monitors the bus voltage and switches a bleeder resistor across the bus if its voltage ever exceeds 425 Vdc. The bleeder resistor drains charge from the filter capacitor and remains connected across the bus until the voltage falls to 400 Vdc.

The DC control power is derived from a single phase line that is separate from the main 3-phase line.

1.3.1.2 Amplifier Section

Figure 1-5 shows a block diagram of an AC brushless servo amplifier. The two main functional parts are the velocity loop and the current loop.

The velocity loop compares the velocity command signal with the velocity feedback signal from the tachometer and speeds up or slows down the motor as required to match the commanded velocity.

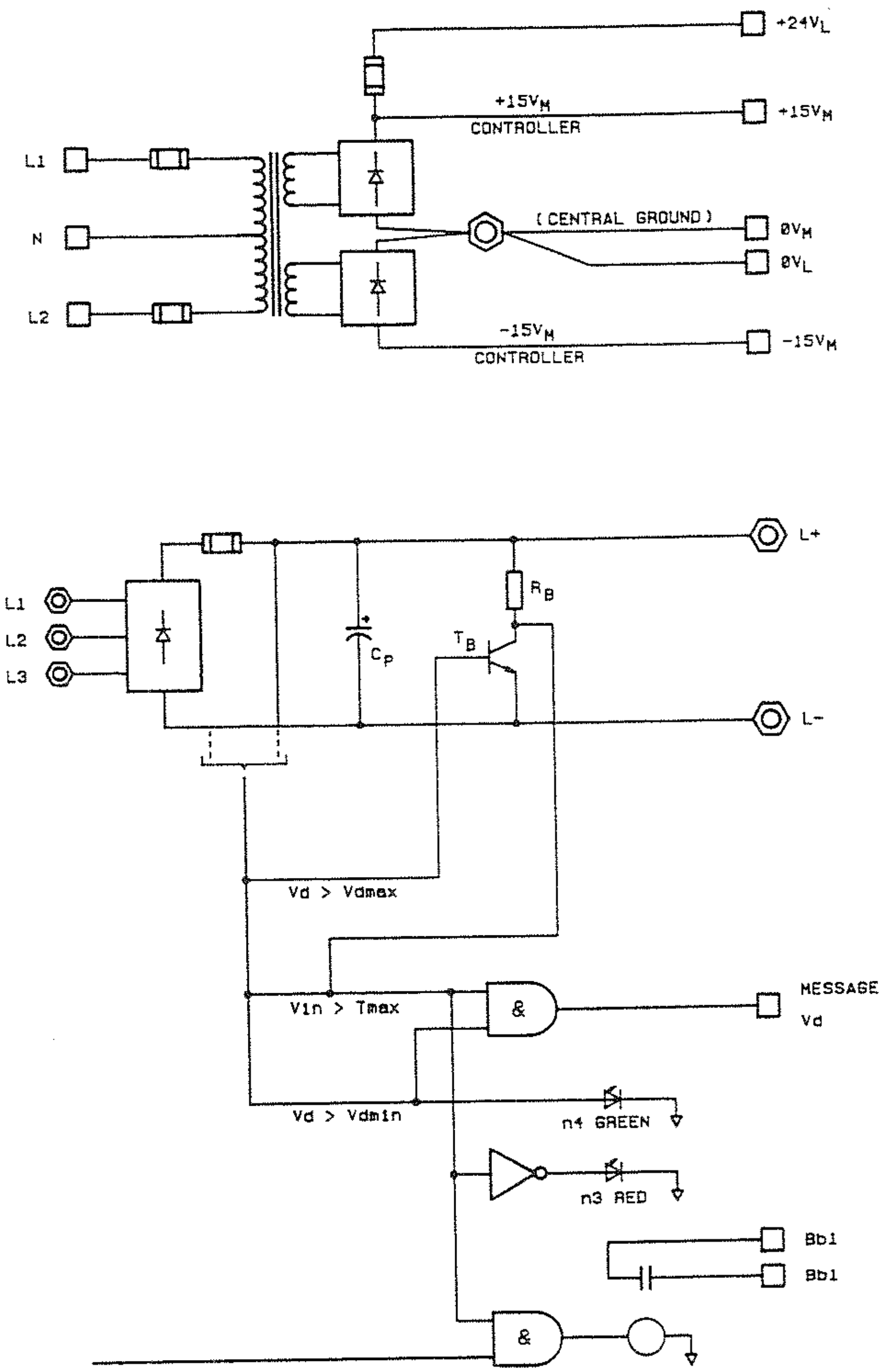


Figure 1-4. DSC Power Supply Schematic

The velocity loop speeds the motor up by sending a higher signal level to the current loop and slows the motor by calling for reduced or reversed motor current.

The motor torque is proportional to current in any servo systems. The current loop compares the actual current in each motor winding with the desired current as commanded by the velocity loop. If the current is too low, the motor current is increased and if it is too high it is reduced. This allows motor current and therefore motor torque to be closely regulated.

Each section of the servo amplifier is described in detail in the following sections.

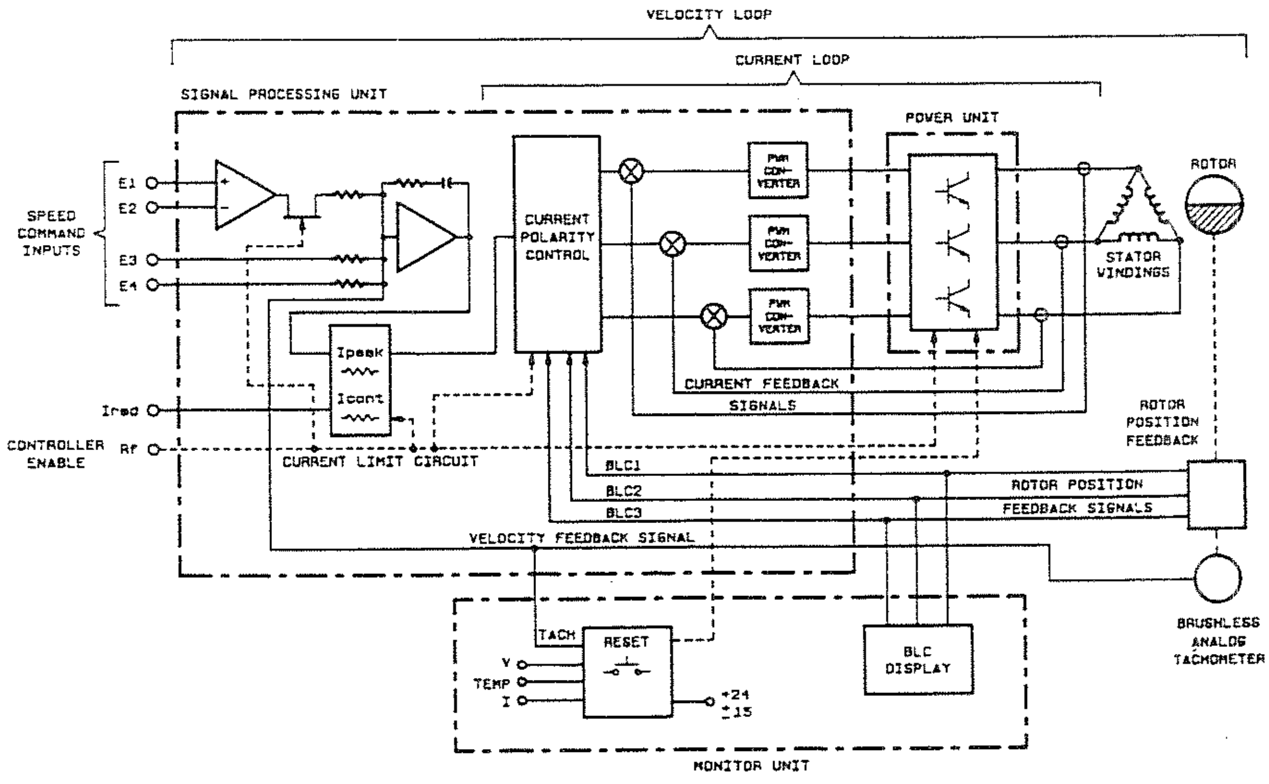


Figure 1-5. Servo System Block Diagram

1.3.2 Signal Processing Unit

The speed controller compares the commanded speed with the actual speed to form a current command signal. This signal becomes the input for the current limit circuit. The current command signal ultimately determines the level of the motor current.

The current limit circuit limits the maximum value of the current command signal and therefore the motor current. The current command signal is limited to one of three different values.

* Peak Acceleration Current. For periods up to 1 second, the motor current is allowed to reach this high level. This allows for quick acceleration and deceleration. The level of peak acceleration current is determined by the personality module.

* Preset Rated Current. This is the continuous rated current of the servo amplifier. It is the normal current limit level. The level of preset rated current is determined by the personality module.

* Reduced Current. The current limit may also be controlled by applying a DC control voltage to the 'Ired' terminal of the DSC. This could be used, for example, when the axis is to be run against a positive stop and the motor torque must be reduced to a very low value. See Section 3.3.6 for more details on this signal.

The limited current command signal is the input for the current polarity control. This circuit controls the direction of the current in each winding by monitoring the three BLC lines (which indicate rotor position). This is done such that the magnetic field generated by the three motor windings is always at right angles to the magnetic field of the rotor, assuring that the motor torque will be proportional to the motor current.

The current command signal for each winding is then converted to a PWM signal for the drive pulse section and the power unit. The actual current in each winding is constantly monitored for closed loop regulation.

The controller enable signal must be present for the speed controller, the current limit circuit, current polarity control and the power unit (Section 1.3.3) to operate. See Section 3.3.5 for more details on this signal.

1.3.3 Power Unit

The power unit consists of a bridge of six power transistors and six flyback protection diodes. Each of the six transistors controls the current for one motor winding in one direction. The transistors receive their control signals from the drive pulse section of the signal processor unit.

1.3.4 Overview of Monitoring Functions

The DSC 3.X servo amplifier contains a number of internal diagnostic monitoring functions. The following functions are monitored:

- DC Control Voltages +24v/±15v
- Tachometer Feedback Signal
- Controller Overtemperature
- Bridge Fuse (continuous overcurrent or short circuit)
- Overvoltage
- DC Bus Voltage
- Controller Enable (RF)
- Single Phase Power
- Drive Ready (Bb)
- Commutation Signal

Each of these conditions has an LED indicator to show normal or fault condition. Some fault conditions disable the DSC and require a manual reset. If all functions are normal, the controller closes an interlocking contact for use by the NC controller. These functions are described in detail in Section 6.3.1.

1.3.5 Input and Output Signal Overview

Each input and output signal is briefly described in the following paragraphs. A complete description follows in Section 3.3.

Velocity Command Inputs

Two different inputs are provided for the velocity command. One is a differential input, i.e., the difference of the voltage between the two terminals controls the motor speed. The other input is a single-ended or non-differential input. This input has a different scale factor so a given voltage produces a different motor speed. Either or both inputs may be used together in which case all of the velocity commands are added.

Controller Enable Input (RF)

This input is used to enable and disable the DSC amplifier. If this signal is removed while the motor is running, the controller disables the drive in an orderly fashion to guarantee that the motor comes to a halt in the shortest possible time.

External Current Limit Control Input (Ired)

A DC voltage applied to this terminal causes the motor current to be limited to a value lower than the preset rated current set in the personality module.

Ready for Operation (Bb1) and BB drive)

These are two separate isolated dry relay contacts that close when no error conditions exist in the Power Supply Section and Drive Amplifier Section.

Tachometer Output (Tsense)

This signal is proportional to the speed of the motor as sensed by the tachometer.

Motor Current Output (Imess)

The voltage at this output is for monitoring purposes and is proportional to the current command signal. See Table A-1 in Appendix A for the voltage to current scaling.

Current Command Output (MA)

The voltage at this terminal is proportional to the current command signal. It is used for connecting two or more amplifiers together in tandem.

Motor Temperature Switch

This contact opens when the motor temperature has exceeded 105°C. The amplifier should be turned off at the soonest possible time (not to exceed 15 minutes) so that the part, amplifier, or motor will not be damaged.

Controller Overtemperature Monitor

This contact opens when the safe operating temperature of the heatsink exceeds 85°C. The DSC will shut down 30 seconds after this contact has opened.

Control Voltage Output +/-15Vm, OVm, +24VL, OVL

Control voltages are available for monitoring uses or external use. See Table A-2 in Appendix A for information on exact current capabilities and requirements.

Brake Control

Due to the fully connectorized cables that interconnect the DSC 3.X to the motor, the brake release inputs are made available through the DSC. These inputs can be connected on the St1 connector pins A9 = + brake, C9 = brake common.

CHAPTER 2. GENERAL APPLICATION GUIDELINES

2.1 INTRODUCTION

This chapter describes how to determine the drive requirements in a specific application. If you are familiar with these calculations, go on to Chapter 3 where the results are applied to the DSC servo amplifier.

In a typical axis drive application, the slide is moved by a ballscrew driven by an Indramat MAC motor. A timing belt reduction is often used to make better use of available motor rpm and torque, but is not required.

The general procedure for picking the best servo amplifier and motor for a specific application is as follows:

1. Determine the torque required at the ballscrew including average and peak (intermittent) values.

2. Determine the moment of inertia at the ballscrew.

3. Determine the reduction ratio based on desired rapid traverse speed and reflected moment of inertia.

4. Select the motor and servo amplifier based on the above calculations.

2.2 TORQUE REQUIRED AT THE BALL SCREW

The torque requirement has three components. The first is the basic load torque which is made up of the frictional loads and any unbalanced weights. The second is the maximum load torque which is made up of the basic load torque (above) and the maximum feed torque required. The third component is the effective load torque which takes into account the duration of the first two torques along with any idle times. This last value is used to determine the amount of heat that will be generated in the motor.

2.2.1 Basic Load Torque

The basic load torque T_o is calculated as follows:

$$T_o = T_{o\text{-}screw} + (h \times M1 \times u)/2pi + (h \times M2 \times \sin a)/2pi$$
(lb-in)

Where:

$T_{o\text{-}screw}$ = The torque required to turn the ballscrew without additional load. It is generated by the preloaded ballscrew bearings and the preloaded screw nut as well as the seals on the nut and bearing. A good rule of thumb for screws with preloaded nuts and bearings is that $T_{o\text{-}screw}$ is 22 lb-in per inch of screw diameter. This figure may be reduced by up to 50% if little or no preloading is used.

The efficiency of the ballscrew can be assumed to be one if this basic torque is taken into consideration.

M1 = Slide weight. (pounds)

M2 = Slide weight less any counterbalancing force. (pounds)

u = Frictional coefficient of the slide way. If specific values are not known, use:

u = 0.05 for roller ways and perfect air or hydrostatic ways.

u = 0.15 for oil-lubricated steel ways.

h = Pitch of the ballscrew. (inches per revolution).

a(angle) = Gradient of the slide ways with respect to the horizontal. (degrees)

NOTE: The angle of the slide ways does not appear in the first term of the equation, since the reduced holding in force of a non-horizontal slide is compensated by the force of the supporting members of the slide.

The last term of the equation takes into account the downhill force if the slide ways are not arranged in the horizontal direction. This part of the equation becomes zero when the slide ways are horizontal or when a perfect weight balance has been reached.

In the case of a counterbalance, unavoidable deviations in the counter-balancing forces must be taken into account, as well as possibly substantial friction in the balancing equipment. The latter applies especially to hydraulic or pneumatic balancing cylinders.

2.2.2 Maximum Load Torque

The maximum load torque at the ballscrew is calculated as follows:

For horizontal or upward application of maximum thrust:

$T_{LM} = T_o + [(F_t \times h) / 2pi$ (lb-in)

For downward application of maximum thrust:

$T_{LM} = T_o + [(F_t -(2 \times M2 \times \sin a)) \times h] / 2pi$ (lb-in)

Where:

F_t = Maximum thrust. (pounds)

T_o, m2, a and h are defined in the previous section.

NOTE: The second equation accounts for the fact that when the maximum thrust is applied downward, the weight of the slide aids the motor. Since the previous expression for T_o treats the weight as a force that must be overcome to move the slide, it must be subtracted from our previous result. In addition, the weight reduces the net maximum force compared to level or uphill operation. Hence the (2 x M2 x sin a) term in the second equation.

2

2.2.3 Effective Load Torque

The effective load torque at the ballscrew is calculated as follows:

$$T_E = \sqrt{\frac{(T1^2 \times t1) + (T2^2 \times t2) + \ldots + (Tn^2 \times tn)}{(t1 + t2 + \ldots + tn)}}$$

Where:

T1, T2, ... Tn are the different torques that must be supplied at different times in the machining cycle.

t1, t2, ... tn are the durations of the various torques above.

An exact calculation must take the following into account:

* All acceleration torques.
* Excessive ballscrew drag during rapid traverse.
* Torque required if the servo holds the slide in position when stopped (T_o may be assumed).
* Basic load torque for all non-machining motions.
* Torques during machining. This takes the required thrust into account but may be less than maximum load torque if the thrust is correspondingly less.

However, an exact calculation of the effective torque is necessary only in special cases with peak dynamic loads. For conventional NC feed applications with machine tools, the following simplified calculation will suffice.

$$T_E = \sqrt{\frac{T_o^2\ (100 - ED) + T_{LM}^2\ (ED)}{100}}$$

Where:

T_o and T_{LM} are defined in the previous sections.

ED = Percentage of time that T_{LM} occurs within the total operating cycle. For turning, milling and machining centers, ED = 40% is a good estimate. For some applications such as transfer machines, ED may be as high as 90%. This should be evident from the processing program.

2.3 LOAD MOMENT OF INERTIA

The load moment of inertia at the ballscrew is the sum of the mass moment of inertia of the rotating parts of the ballscrew and pulleys and the moment of inertia of slide as seen by the ballscrew. In most cases, the effect of the slide is small in relation to the rotating masses -- even with carriages weighing several tons.

The moment of inertia of the ballscrew is calculated as follows:

$$J_s = D^4 \times L \times (7.2 \times 10^{-5}) \quad \text{(lb-in-sec}^2\text{)}$$

Where:

D = Ballscrew diameter (inches)
L = Ballscrew length (inches)

The moment of inertia of a steel pulley can be calculated if one is being used. Apply the same formula using the diameter and length of the pulley in place of the D and L given. This should be added to the result of J_s above.

The moment of inertia of the slide as seen by the ballscrew is calculated as follows:

$$J_M = M3 \times h^2 \times (6.56 \times 10^{-5}) \quad \text{(lb-in-sec}^2\text{)}$$

Where:

M3 = The total weight of all mass moving linearly. This includes the slide plus any counter-balancing weight. (pounds)

h = Pitch of the ballscrew. (inches per revolution)

2.4 SELECTION OF REDUCTION RATIO

There are opposing considerations to keep in mind when selecting a reduction ratio between the motor and ballscrew. A low reduction will allow greater rapid traverse speed but will also increase the required motor torque and the moment of inertia reflected to the motor. The previous selection of ballscrew pitch affects these calculations as well, since the overall reduction (inches of slide travel per motor revolution) and load moment of inertia depend on ballscrew pitch.

The first step in this process is to calculate the required ballscrew speed for rapid traverse as follows:

$$n_E = V_E / h \quad \text{(rpm)}$$

Where:

VE = Rapid traverse speed of the slide. (in per min.)
h = Pitch of the ballscrew. (inches per revolution)

The next step is to find a reduction ratio that will produce this speed at the ballscrew while using the full performance of the motor. This is calculated as follows:

$$i = n_n / n_E$$

Where:

n_n = Useful servo motor speed per specifications. (rpm)

nE = Rapid traverse speed of the ballscrew. (rpm)

The final step in this process is to verify that the reflected moment of inertia is not too large. The moment of inertia as seen by the motor with all reduction taken into account should preferably be less than or equal to the moment of inertia of the motor shaft. This recommendation is made because oscillations in the load mass can be better absorbed by the motor mass in this way. However, this is not an absolute rule.

The load moment of inertia as seen by the motor shaft is calculated as follows:

$$J_{red} = J_L / i^2 \quad (\text{lb-in-sec}^2)$$

Where:

J_L and i are defined in previous sections.

At this point it may be necessary to re-evaluate the ballscrew pitch that was previously selected. A larger ballscrew pitch allows for a higher reduction which in turn reduces the value of Jred above. On the other hand, too large a pitch may require a larger ballscrew diameter which increases the moment of inertia and the basic load torque.

The general rule is to increase the pitch of the ballscrew, the ballscrew diameter, and the reduction ratio as the size of the machine increases. Larger machines should use 3000 rpm motors rather than 2000 rpm motors.

2.5 AMPLIFIER CURRENT

Having calculated the torque requirements of your application, it now becomes necessary to determine the motor/amplifier combination that has a sufficient peak and average current (and hence torque) rating to satisfy the requirements.

These conditions that must be satisfied are:

$$T_o / i \leq 60\% \times T_n$$

$$T_{LM} / i \leq 75\% \times T_{KB}$$

$$T_E / i \leq T_n$$

Where:

T_O / i = Basic load torque as seen by the motor. (lb-in)

T_{LM} / i = Maximum load torque as seen by the motor. (lb-in)

T_E / i = Effective load torque as seen by the motor. (lb-in)

i = Reduction ratio

T_n = Servo controller and motor continuous torque rating. (lb-in)

T_{KB} = Servo controller and motor peak torque rating. (lb-in)

Notes:

1. If a mechanical brake is used to hold the slide in position rather than the servo amplifier, the first equation may be modified to allow 75% of the peak torque rating as in the second equation. The controller enable signal must be removed while the brake is applied. In such a case, the other restrictions still apply.

2. When comparing the specifications of Indramat servo amplifiers and motors with those from other manufacturers, it is important to keep in mind that Indramat's specifications are <u>operating</u> specifications and not absolute maximum ratings.

   For instance, some manufacturers' torque specifications are given for 25°C ambient temperature (as opposed to Indramat's 45°C). Other manufacturers may also specify performance with a motor case value temperature less than Indramat's 105°C specification. These factors may reduce the actual useful torque for those machines by up to 50%. Furthermore, the specifications for other manufacturers often do not take into consideration under-voltages and commutation limits for DC servo drives. If these data are used without conversion to useful data, one could easily arrive at expectations for motor performance which are three to four times too high.

2.6 CALCULATING AVERAGE REGENERATIVE POWER

The average regenerative power is important because it determines the heating effect on the bleeder resistor.

The average regenerative power for one motor is calculated as follows:

$$P_B = [(J_{total} \times N^2) / 1614 - (J_{total}{}^2 \times a \times N) / (T_o \times 84.52)] \times F_d$$

Where:

P_B = Average regenerative power. (Watts)

J_{total} = Total inertia including motor rotor inertia plus the reflected inertia of the load. (lb-in-sec²)

N = Speed from which the motor will decelerate. (rpm)

a = Rate of angular acceleration. (radians per sec²)

To = Short circuit torque of the motor from the motor data sheet. (Not the same To as basic load torque) (lb-in/sec/rad)

Fd = Repetition rate of decelerations. Determine by adding the number of decels over one machine cycle and dividing by the cycle time in seconds. (decels per sec)

2.7 LINE VOLTAGE SUPPLY

2.7.1 3-Phase Transformer

The 3-phase transformer changes the line voltage to 220 Vac for the power supply and also provides a ground referenced neutral required by the power supply.

A transformer is always required if the line voltage is other than 220 Vac 3-phase or if the line is not ground referenced. If the line is not ground referenced, the transformer must be an isolation type (normally delta to wye) with the secondary neutral grounded. If the line is ground referenced (i.e., only the voltage level needs to be changed), an autotransformer may be used.

No transformer is necessary if a ground referenced, 220 Vac line is already available.

The 3-phase transformer (if used) must be able to provide at least the average calculated power and must have a 3 percent impedance. If an isolation transformer is used, it should have an electrostatic shield.

2.7.2 Inrush Current

The inrush current upon power up (caused by the initial charging of the filter capacitors) is high enough in some applications to damage the bridge diodes. Normally in such cases, it is necessary to add a soft start circuit to the power supply. In the case of the DSC 3.X, the soft start circuit is not needed because the DSC already has a soft start circuit installed. This makes it possible to have a large transformer so that several DSC 3.X's can be connected at the same time.

2.7.3 Single Phase Power

Single phase line power is required in addition to the 3-phase line. This is used for the DC control power supply, blower and other equipment. Voltages required depend on the specific DSC being used. DSC 3.X can be ordered as either 115 Vac or 220 Vac control power input.

The recommended procedure is to add the power requirements of all single phase loads and install a single phase transformer to supply the required power. If the machine has a control voltage supply, it may be used to power the servo system single phase loads. Verify that there is sufficient spare power capacity.

A permissible (but not recommended) method is to select components with 220 Vac single phase requirements and connect them across one phase of the 3 phase line. Noise and voltage fluctuations due to the motor loads may cause problems with this method.

If an isolation transformer is used and the 3-phase primary voltage is 220 Vac, it is possible to connect single phase loads to the primary side of the transformer. This is preferred to direct connection at the power supply line terminals because of less line noise and voltage fluctuation.

Table A-6 in Appendix A gives power requirements for various single phase loads.

2.8 FUSING

Externally, the user must fuse the primary of any transformers. Time-delay fuses should be sized at 3-4 times the primary rated current of the transformer. If circuit breakers are used, they must be sized at 1.5 times the calculated average current. The protection devices are oversized to avoid nuisance tripping.

CHAPTER 3. DSC 3 APPLICATION GUIDELINES

3.1 INTRODUCTION

This chapter describes important considerations for applying the Indramat DSC 3.X servo amplifier in your system. It is assumed that you are familiar with the general servo application guidelines of Chapter 2.

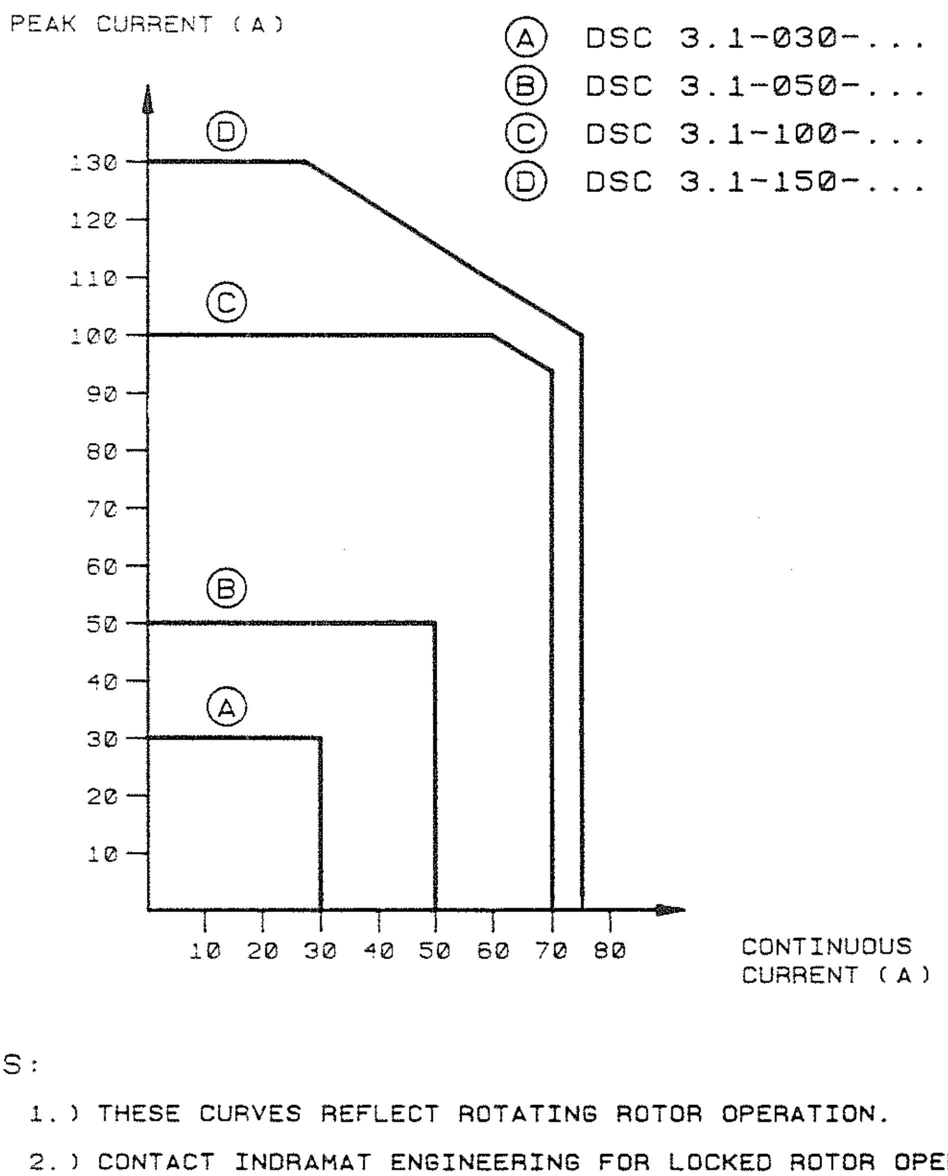


Figure 3-1. DSC Amplifier -- Peak vs. Average Current

3.2 DSC PEAK CURRENT CAPACITY

The peak current that a DSC 3.X servo amplifier can deliver (and the associated peak torque) depends on the continuous current that the amplifier is providing. Figure 3-1 shows the derating curves for each model of DSC servo amplifier.

3.3 CONTROL SIGNAL INTERFACING

Each of the input and output signals for the DSC 3.X servo amplifier is described in detail in the following sections. The interconnect drawings in Appendix C show the terminal locations for each of these signals.

3.3.1 Differential Velocity Command Input (E1/E2)
Pins A5, B5 Connector St1

The voltage difference between terminals E1 and E2 is used as the velocity command value. The voltage applied between E1 and E2 is assumed to be symmetrical with respect to control signal ground, but a common mode voltage of up to 2V is ignored when these inputs are used. (Common mode voltage is defined as the average of the voltages at the two differential input terminals.)

A differential voltage of 10 Vdc normally corresponds to the nominal motor rpm. Changing resistor R8 in the personality module will change this scale factor. (See Section 3.3.3 for details.) The differential voltage must never exceed 10 Vdc and if the differential inputs are not used, resistor R8 in the personality module should be removed to prevent drift.

Terminal E1 positive with respect to E2 corresponds to clockwise (CW) motor rotation.

3.3.2 Summing Velocity Command Input (E4)
Pin A4 connector St1

Input E4 may be used for the velocity command signal input in place of the differential inputs or may be used to add a value to the speed command signal derived from the differential inputs. Positive voltages cause CCW rotation and negative voltages cause CW rotation.

Normally, a voltage of 10 Vdc (with respect to control signal ground) on terminal E4 corresponds to 1500 rpm. Resistor R10 in the personality module control these scale factors. (See Section 3.3.3 for details on different scale factors.)

3.3.3 Velocity Command Signal Scaling

See Figure 3-2 for an illustration of the velocity command input circuits and the associated personality module components

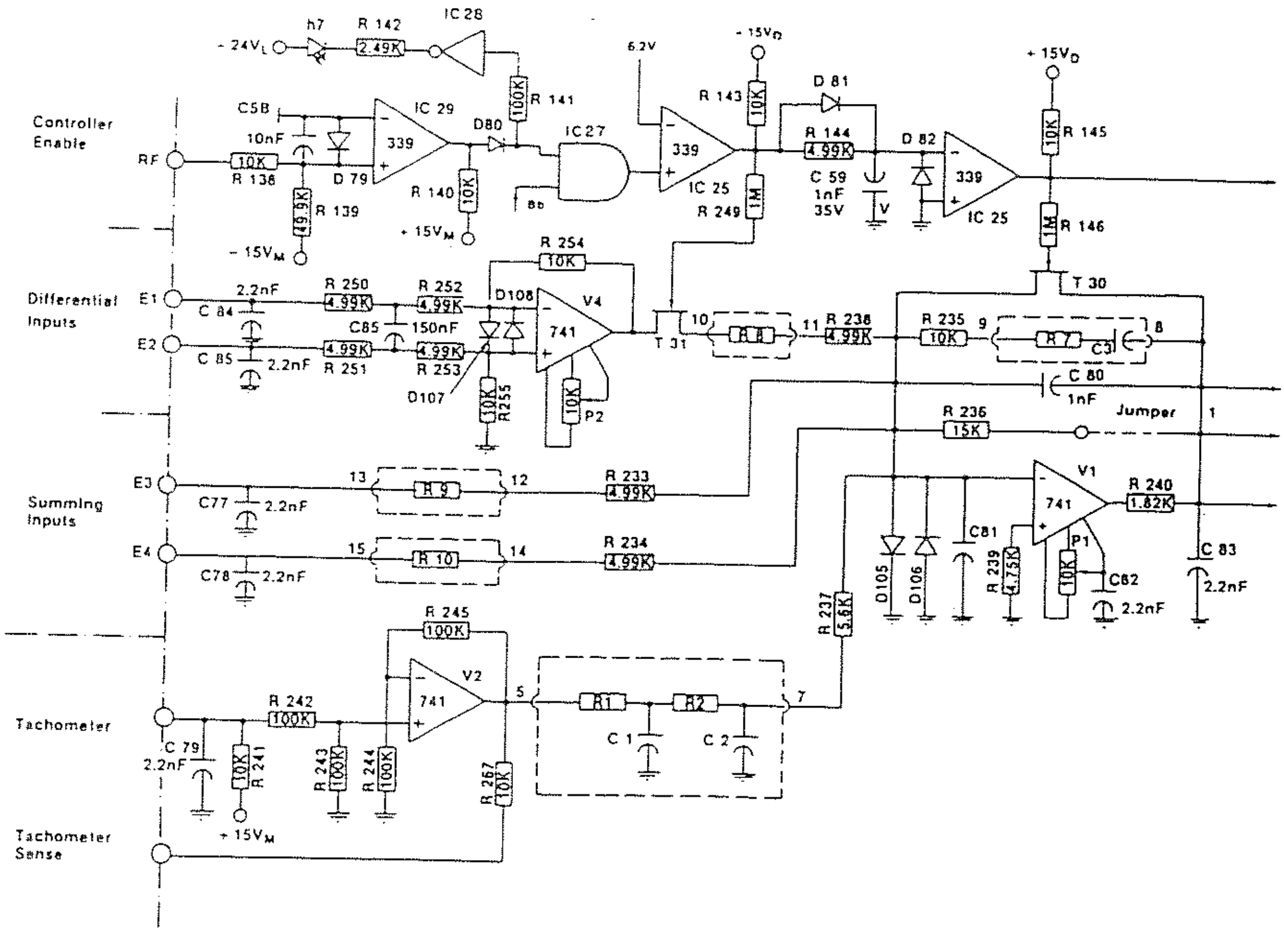


Figure 3-2. Design and Components of Speed Controller

Resistors R8 and R10 in the personality module control the scale factors of the three velocity command inputs (the differential input and the single-ended input respectively.) If a velocity factor other than standard is desired, contact Indramat for availability of a personality module to give the scale factor you desire.

Alternately, any personality module may be modified to change the scale factor by replacing R8, R9 and/or R10. The value of resistance to use is calculated as follows:

$$R = \frac{V \times 1000}{n \times .33} - 5$$ (for 3V per 1000 rpm Tach's)

OR

$$R = \frac{V \times 1000}{n \times .16} - 5$$ (for 1.5V per 1000 rpm Tach's)

Where:

R = Resistance of R8 or R10 (kohm)
V = Command voltage desired for full speed. (Volts)
n = Desired Full speed rpm.

3.3.4 Motor Direction

As noted above, the polarity of the velocity command voltages affect the direction of the motor rotation. That is, if E1 is positive with respect to E2 or if E4 is negative, the motor will rotate clockwise. Reversing these polarities will reverse motor rotation. Alternately, connecting pin 3 on connector A of the motor feedback unit (on the motor) to control signal ground will reverse the rotation of the motor.

CAUTION
REVERSING MOTOR LEADS AND/OR TACHOMETER LEADS TO REVERSE THE MOTOR ROTATION IS NOT PERMITTED WITH INDRAMAT BRUSHLESS AC SERVO AMPLIFIERS.

3.3.5 Controller Enable Input (RF)
Pin - A6 connector St1

A positive voltage of 3-30 Vdc on this terminal (referenced to control signal ground) is required to enable the drive. When this signal is applied, the speed controller, current limit circuit, current polarity control and the power unit all function normally.

When the controller enable signal is removed, the differential speed input is disabled immediately. After a .3 second delay, the current limit circuit, current polarity control and the power unit are disabled. This sequence keeps the motor from coasting in an emergency stop (E-Stop) situation.

3

Neither of the single-ended inputs are disabled by removing the controller enable signal. This means that the motor will coast in an E-Stop if the speed command signal is connected to one of these inputs and there is no dynamic braking resistor in the servo systems.

3.3.6 External Current Limit Control Input (Ired)
Pin - C6 on connector St1

A DC voltage applied to this terminal (referenced to control signal ground) causes the motor current to be limited to a value lower than the Preset Rated Current set in the personality module. Zero volts allows 100% of the Preset Rated Current and 10 Vdc limits the motor current to near zero with approximately proportional control between these two limits.

3.3.7 Ready for Operation Contact (Bb Contact)
Pins - G, H on connector St2

These are the two connections of an isolated dry relay contact that closes when no error conditions exist for the low voltage sections. The contact is rated at 24V and 1 Amp. Section 6.3.1 contains a complete description of the logic that controls this contact.

3.3.7.1 Ready for Operation Contact (Bb for Amplifier Section)
Pins A3, A7 on connector St1

These are the two connections of an isolated dry relay contact that closes when the 3-phase has been applied to the unit and no error condition exists. The contact is rated at 24V and 1 Amp. Section 6.3.1 contains a complete description of the logic that controls this contact.

3.3.8 Tachometer Output (Tsense)
Pin - C5 on connector St1

This is a -10 Vdc to 10 Vdc signal (with respect to the control signal ground) that is proportional to the speed of the motor as sensed by the tachometer. The scaling of this signal is the same as that of the tachometer. Typical tachometer scalings are:

3 Vdc per 1000 rpm for motors rated at 3000 rpm or less

OR

1.5 Vdc per 1000 rpm for motors rated at more than 3000 rpm

There is an internal 20 kohm limiting resistor on this output to provide short circuit protection. It is therefore recommended that this voltage be measured with a meter with $\geq$ 1 Megohm impedance to reduce measurement error.

3.3.9 Motor Current Output (Imess)
Pin B6 on connector St1

The voltage at this output is for monitoring the motor current. This signal is proportional to the current command signal. See Table A-1 in Appendix A for the voltage to current scaling.

3.3.10 Current Command Output (MA)
Pin - B4 on Connector St1

The voltage at this terminal is proportional to the motor current. It is used for connecting two or more controllers together in tandem.

3.3.11 Motor Temperature Switch
Pin A8 = Motor TAS supply, Connector St1
Pin B8 = Motor TAS return, Connector St1

This contact opens when the motor temperature has exceeded 105°C. This contact is rated for 24 Vdc, 10 mA. The amplifier should be turned off at the soonest possible time (not to exceed 15 minutes) so that the part, amplifier or motor will not be damaged.

3.3.12 Controller Overtemperature Monitor
Pin B3 - Connector St1
Pin C3 - Connector St1

This contact opens when the safe operating temperature of the heatsink exceeds 85°C. This contact is rated for 24 Vdc, 1 amp. The DSC will shut down 30 seconds after this contact has opened.

3.3.13 Control Voltage Outputs +15Vm, -15Vm, OVm (+24V_L, OV_L)

For monitoring purposes, terminals are provided to supply the +/-15 Vdc and +24 Vdc control signal for the customer. Care must be taken, however, to assure that the total current for each voltage does not exceed the capacity of the power supply in the servo system. Refer to power supply current specifications in Table A-2 in Appendix A.

3.3.14 Brake Control

Pin A9 = +Brake, Connector St1
Pin C9 = Brake common, Connector St1

Due to the fully connectorized cables that interconnect the DSC 3.X to the motor, the brake release inputs are made available through the DSC. These inputs can be connected via the St1 connector.

3.3.15 Master-Slave Configuration

In this configuration, two motors are mechanically coupled to the same load. One of the motors with its servo amplifier is the master and functions in the normal velocity command mode. The other functions as the slave and is used to provide additional torque. Refer to drawing # AE-1014 for further details of amplifier interconnection, Appendix C.

The slave servo amplifier uses a special personality module with the velocity feedback signal and the integral part of the speed controller circuit disconnected. This causes the servo amplifier to behave as a current (torque) controlled amplifier.

The MA terminal (whose voltage is proportional to motor current) of the master amplifier is connected to the E4 terminal of the slave amplifier (now functioning as the current command input). When the master amplifier increases the master motor current, the voltage on the MA terminal increases causing the slave amplifier to increase its motor current. Thus the slave motor shares the load torque while the master controls the speed.

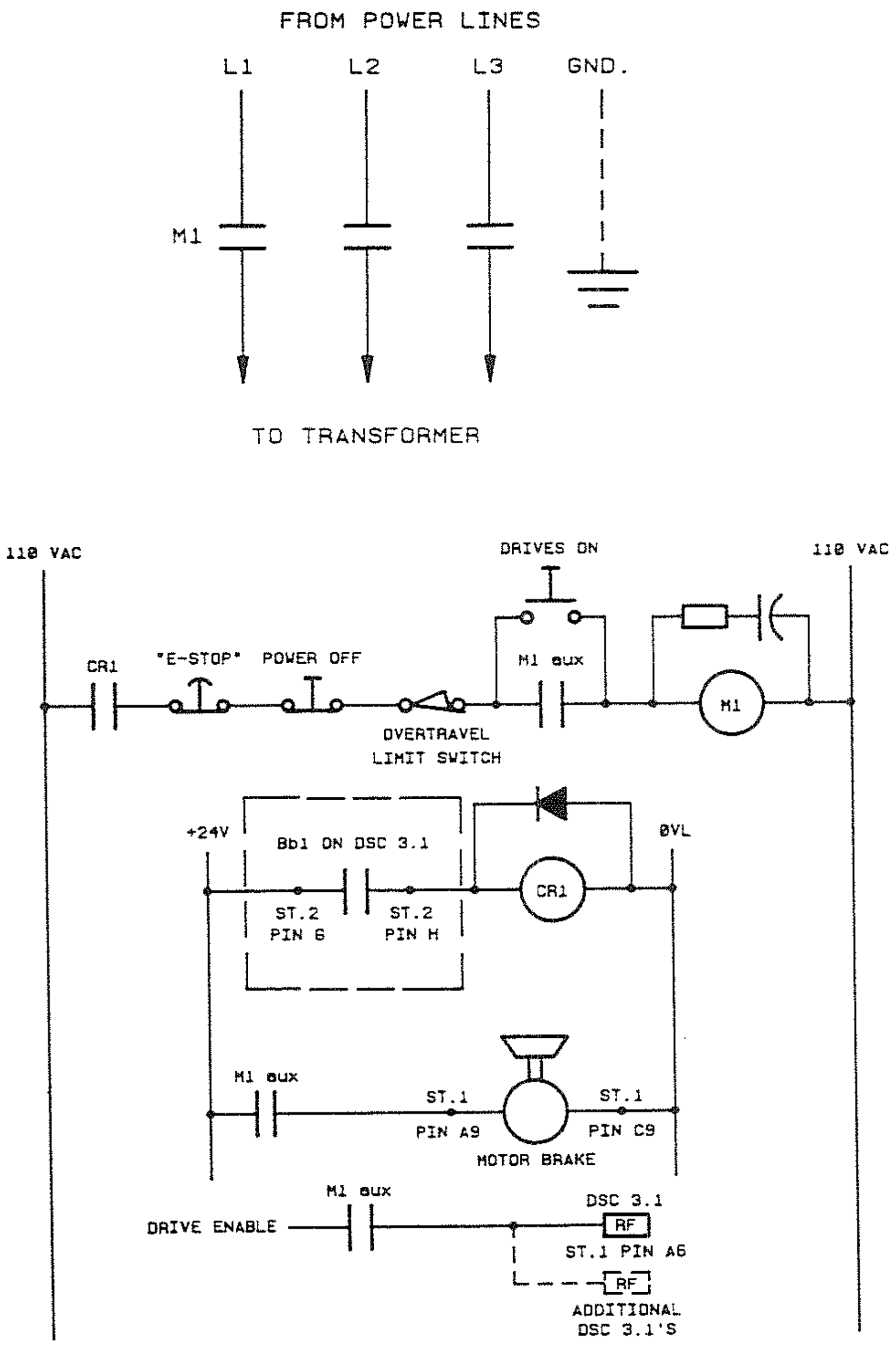


Figure 3-3. Power Contactor Schematic

3.4 POWER CONTACTOR INTERFACING

Figure 3-3 shows the suggested schematic for power contactors associated with the servo system. Contactor M1 controls the 3-phase line voltage supply to the servo system.

Note that the Bb1 contact controls CR1 which in turn controls contactor M1. The Bb1 contact on the DSC 3.X closes only when the power supply section and the servo amplifier section have passed their internal tests. This assures that 3-phase power will not be applied to the system unless each module is functioning correctly.

3.5 POSITION CONTROL LOOP

3.5.1 Theory of Operation

Figure 3-4 illustrates the block diagram of a typical position control loop. The actual position value (X) is subtracted from the position reference value (W) so that the speed reference value (V_{ref}) increases proportionally with the difference between the actual slide position and the desired slide position. Thus, as the slide moves closer to the desired position, the speed reference value gets smaller and the motor gradually slows down until the slide comes to rest exactly at the desired position.

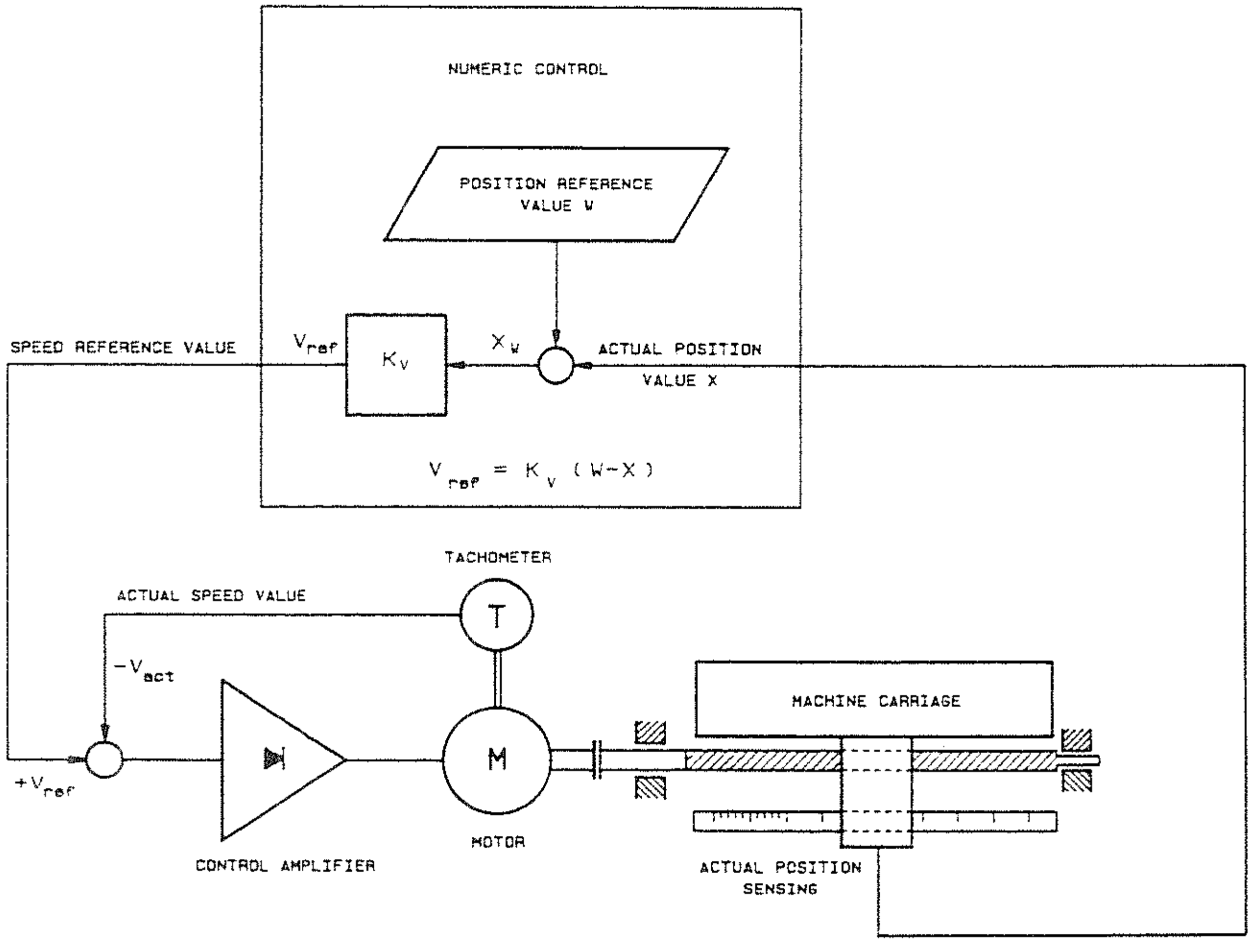


Figure 3-4. Position Control Loop Block Diagram

The position loop gain (K_v) controls the speed of the motor for a given amount of position error. A high value of K_v will cause quick response, but if it is too high, oscillations or overshooting will occur. If K_v is too small, there will be a large following error which means the slide will never reach its commanded position.

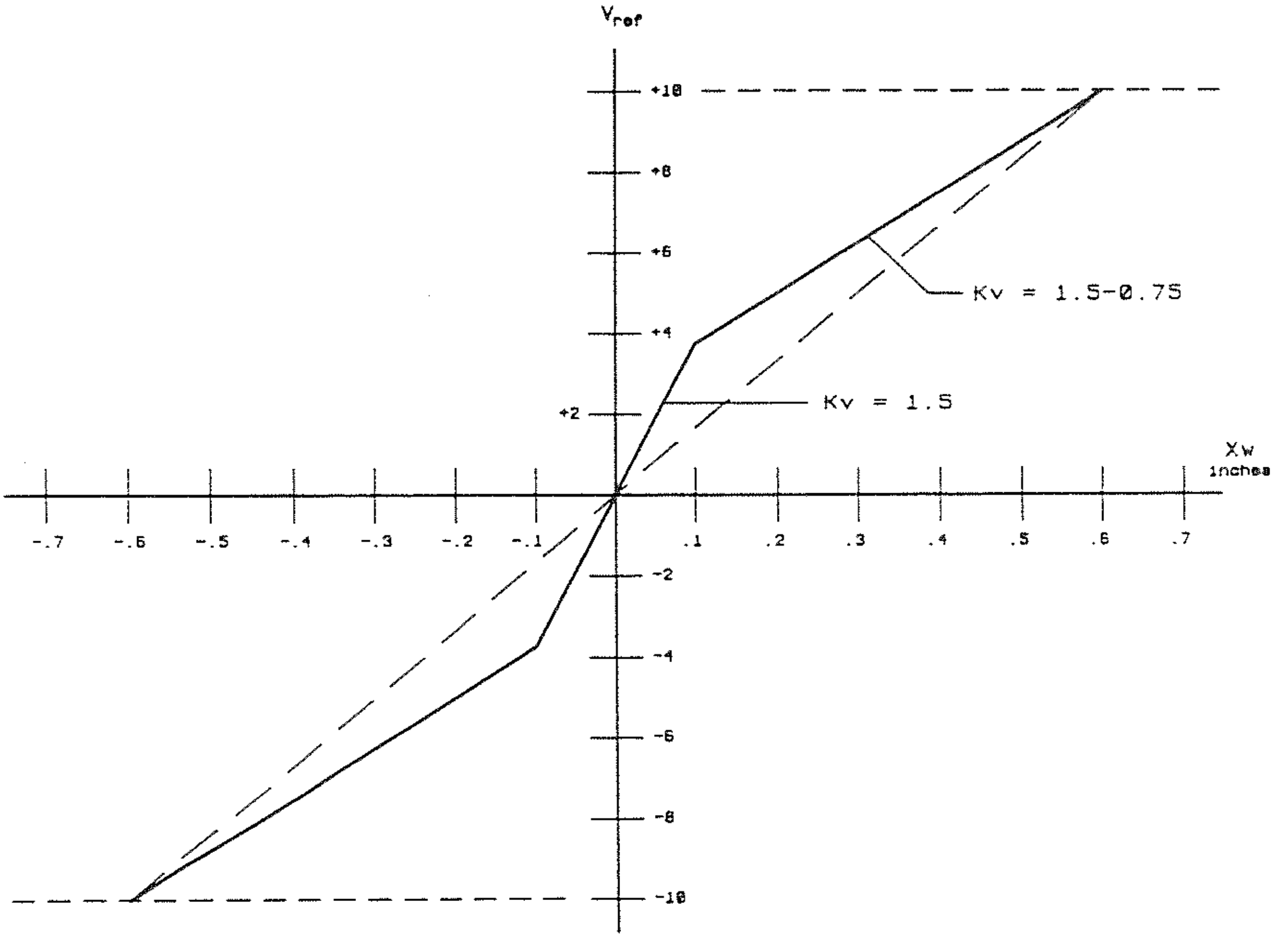


Figure 3-5. Gain Break Diagram

3.5.2 Gain Break

One way to keep the servo system responsive (keeping following error small) but to avoid unstable operation (oscillations or overshooting) is illustrated in Figure 3-5. This shows a non-linear position loop gain, also called gain break. For small differences between desired and actual position, the NC controller generates a relatively large speed reference value. For larger differences, K_v is smaller so the speed reference value is not proportionally as large. K_v factors between .75 and 1.0 in the rapid traverse range (larger position differences) and between 1.0 and 2.0 in the feed range (smaller position differences) generally produce stable operation with acceptable following error.

Using gain break may allow smaller peak torque, thus a smaller motor and amplifier.

3.5.3 Miscellaneous Considerations

1. The speed reference value from the NC controller and the scaling of the speed command input on the servo amplifier should be adjusted so that 90% of the speed reference value from the NC controller causes maximum slide speed.

2. The peak-to-peak ripple voltage must be limited as follows:

$$V_{rip} \leq .01 \times f \times V_{ref}$$

Where:

V_{rip} = Peak to peak value of the ripple voltage. (Volts)

f = Ripple voltage frequency. (kHz)

V_{ref} (max) = Maximum value of the speed reference value from the NC controller. (rpm)

The ripple is caused by the discrete voltage steps that are generated by the D/A converter in the NC controller. Excessive ripple voltage can be transmitted to the slide and can show on the workpiece.

If the ripple voltage is greater than the amount shown in the equation above, it may be reduced somewhat by a low-pass filter, but this also causes a lag in response. Thus, following error may be higher.

3. The polarity of the position feedback signal from the slide must be opposite from the polarity of the speed reference value from the NC controller. That is, if a positive speed reference value makes the slide move to the right, the position feedback signal should become more negative as the slide moves right.

3.6 CABINET SIZING

The temperature difference between the inside and outside of the enclosure is dependent on the power dissipated inside the enclosure and the surface area of the enclosure. The relationship for non-ventilated enclosures is:

$$\text{Temp Rise } (^\circ F) = \frac{.21 \text{ Watt}}{Ft^2}$$

OR

$$\text{Temp Rise } (^\circ C) = \frac{4 \text{ Watt}}{M^2}$$

This figure is the rise above the ambient temperature.

The surface areas for some common cabinet sizes are shown below:

Dimensions (inches)	Surface Area (Ft^2)
24 x 20 x 16	16.4
24 x 24 x 16	18.7
30 x 24 x 16	22.0
36 x 30 x 16	29.7
72 x 30 x 16	52.7
42 x 36 x 16	38.3
48 x 36 x 16	42.7
60 x 36 x 16	51.3
96 x 48 x 16	96.0
30 x 24 x 20	25.0
36 x 30 x 20	33.3
72 x 30 x 20	58.3
48 x 36 x 20	47.3
60 x 36 x 20	56.7
96 x 48 x 20	104.0
30 x 24 x 24	28.0
72 x 30 x 24	64.0

CHAPTER 4. INSTALLATION

4.1 GENERAL CONSIDERATIONS

4.1.1 Mounting of DSC

The DSC 3.X is designed to be mounted directly to the machine without the need for a NEMA 12 enclosure. It is completely enclosed and fully sealed with a protection class of IP 54 and blower type cooling. All cables are interconnected by means of connectorized cables.

The unit can be mounted in any position since it is blower cooled; however, it must be mounted to a solid flat surface in order to help the heatsink and blower conduct the heat generated.

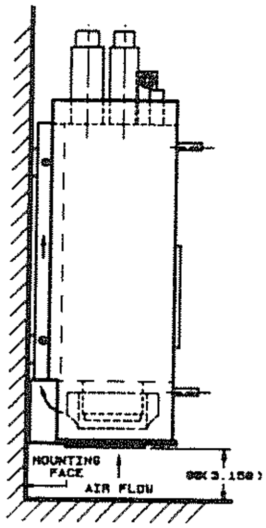


Figure 4-1. Typical Installation

A minimum of 80mm (3.15 in) of distance must be left open in order to allow unobstructed air flow for the heat sink and to also stop large foreign matter from being 'sucked' up into the blower.

NOTE: To help prolong the life of the blower, be careful to not mount the DSC over open coolant returns or oil returns due to the mist that can collect on the fan blade of the blower. This will eventually stop it's operation.

The ambient operating temperature for the DSC is 40°C (104°F) and this temperature <u>should</u> <u>not</u> be exceeded. It is <u>not</u> recommended to mount the DSC 3.X in a Nema type 12 or any other type of enclosure that will inhibit air flow or increase the ambient temperature above 40°C (104°F).

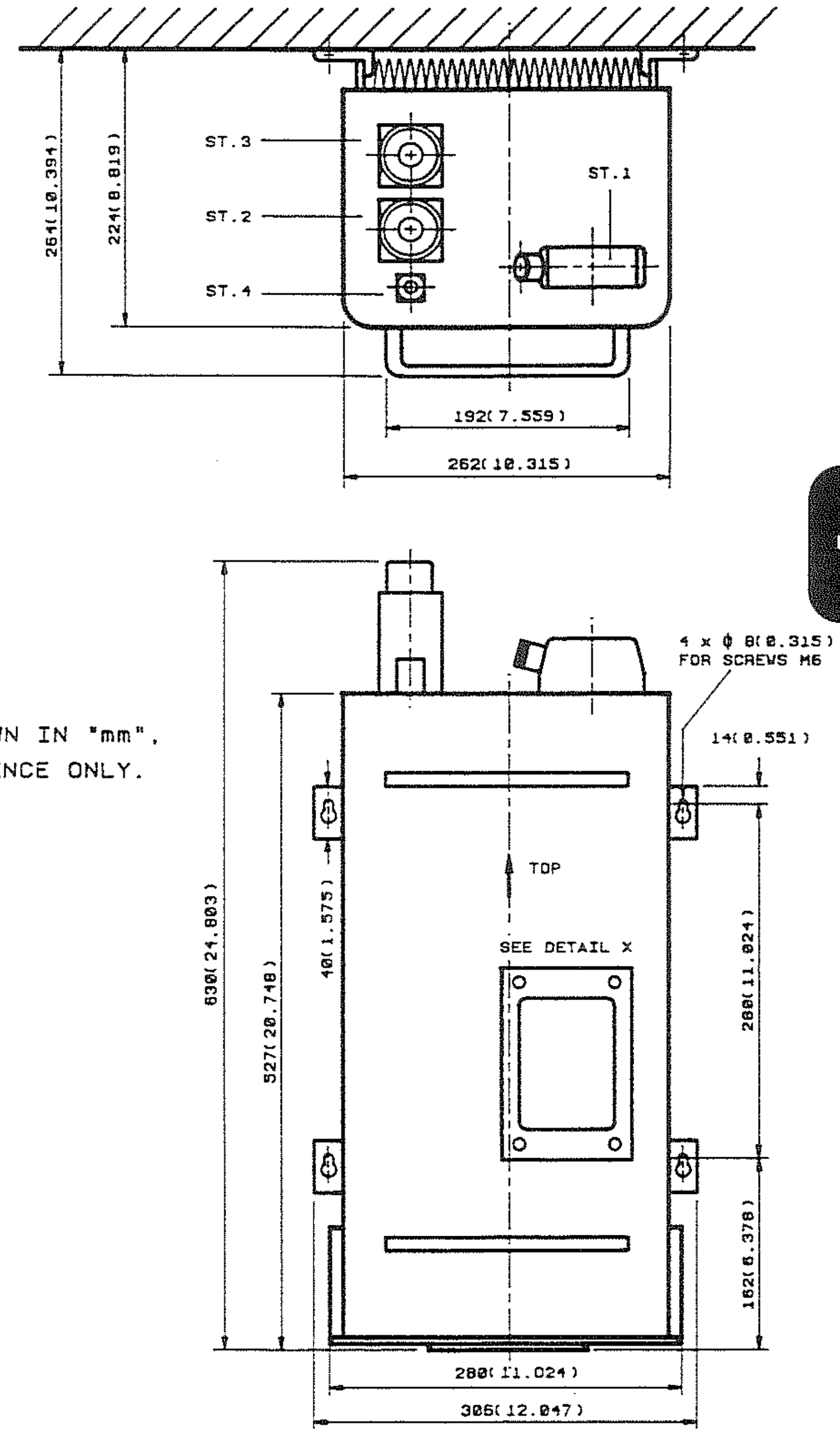
4.1.2 Signal Wiring

Care must be taken to assure that electrical noise is not induced into the signal wiring. Do this by: 1. Routing signal wiring separately from power wiring and
2. Following good shielding and grounding practice.

Signal wiring should never be run in the same conduit as power wiring. If necessary, power and signal wiring may share the same square wire trough, provided a metal dividing wall separates the two. Power wiring and signal wiring should also be separated as much as possible within the enclosure. Do this by running these wires as far apart as possible from each other, avoiding parallel runs, and making sure that any required intersections are at right angles.

Signal wiring should be run with twisted, shielded wire; #20AWG or larger. Connect the shield to ground at only one end. Normally the shield would be connected to the ground terminal of the servo amplifier.

ST.1 = NC CONNECTOR
ST.2 = POWER UNIT CON.
ST.3 = MOTOR CONNECTOR
ST.4 = MOTOR FEEDBACK CONNECTOR



NOTES:

1) ALL DIMENSIONS SHOWN IN "mm", (inches) FOR REFERENCE ONLY.
2) WEIGHT = 57 lbs

Figure 4-2. Mechanical Mounting -- Outline Drawing

In general, avoid making ground connections at more than one point as this creates 'ground loops' which are a potential source for the introduction of electrical noise.

4.1.3 Power Wiring

Follow the interconnection drawing for specific instructions on power wiring. Pay special attention to these notes:

1. Use either twisted wires or a 4-wire cable for the motor power connections. Make this line as short as possible.

2. Carefully follow local codes for fusing and grounding.

CHAPTER 5. STARTUP

5.1 EQUIPMENT REQUIREMENTS

* Analog or Digital Multimeter 20,000 Ohm per Volt or greater sensitivity.
* Oscilloscope.
* Battery box for adjustable command signals up to 10 Vdc and a switch for the controller enable signal. See Figure 5-1.

> **WARNING**
>
> LIFE THREATENING VOLTAGES PRESENT ON CONNECTORS. DO NOT CONNECT OR DISCONNECT WHILE POWERED.
>
> UNEXPECTED AND DANGEROUS MACHINE MOVEMENTS MAY RESULT IF SERVICE IS ATTEMPTED BY UNQUALIFIED PERSONNEL.

5

5.2 CHECK-OUT

5.2.1 Power-Off Checks

Remove power from the servo amplifier and perform these checks.

1. Check for the correct personality module. The specifications should agree with the type designations of the servo amplifier and motor.

2. Ensure that external wiring agrees with the wiring diagram. Check for open circuits, short circuits and crossed connections.

3. Check the external wiring to ensure that the wires are securely held in the terminals.

4. Check for compliance with local wiring codes and safety regulations. Pay special attention to earth grounding, wire sizing and fusing.

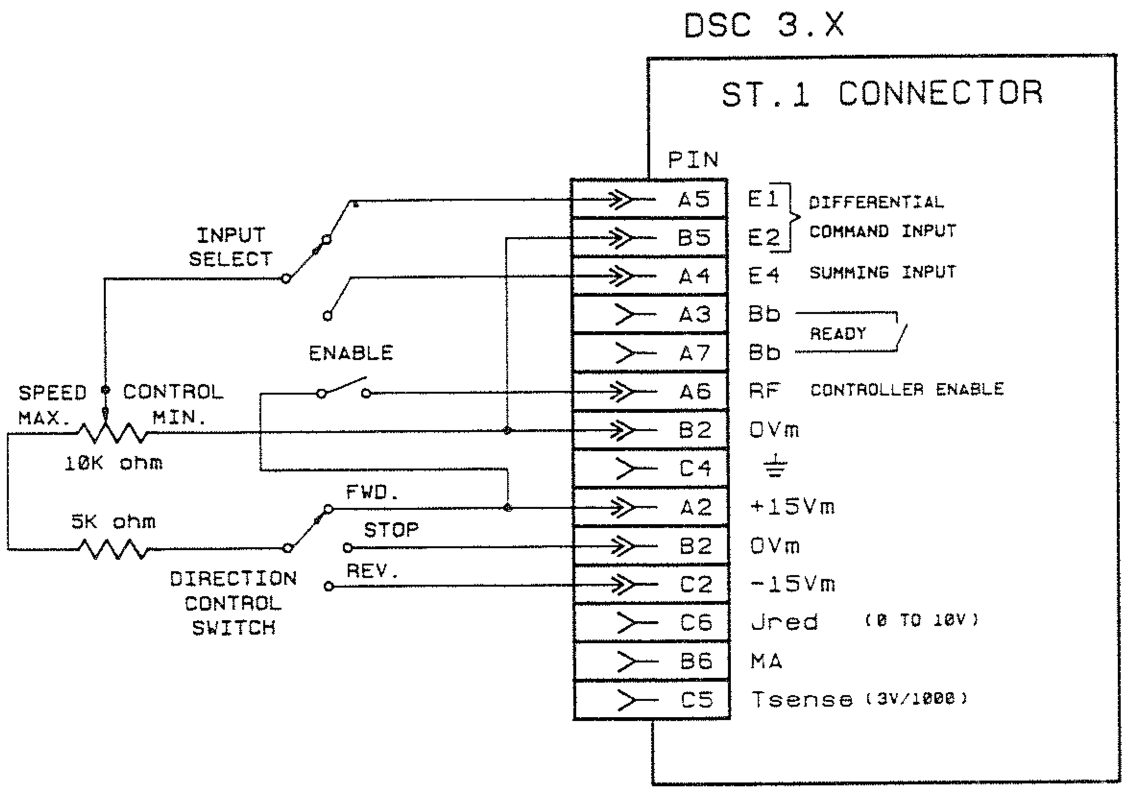


Figure 5-1. Simplified Battery Box

5. Check for proper shielding of the signal lines. The shield must be connected to ground at only one end.

6. Grounding must conform precisely to the relevant Indramat wiring diagrams.

7. Check that the motor power leads are either all in one cable or twisted together. They should also be routed along the shortest possible path.

8. Verify that the servo amplifier and transformer ratings agree with the available line voltage. Check both the 3-phase input and the single phase control and blower power.

5.2.2 Power-On Checks

Do the following before proceeding with the power-on checks:

1. Uncouple the servo motor from the mechanical load.

2. Remove the fuses from the 3-phase supply.

Apply control (single phase) power to the servo system and perform the following checks (3-phase power remains disconnected for these checks):

a. Check the forced air cooling system.

b. Check +24 and the +/-15 vdc supply voltages with respect to ground.

c. Verify that the Emergency Stop circuit (including the overtravel limit switch) is functional.

d. Check for correct functioning of the controller enable circuit and that the power contactors sequence properly. (It is especially important that the 3-phase transformer fuses are removed for this test.) Check for correct operation of the mechanical brake. The motor shaft should spin freely by hand when the brake is released.

e. Verify that the position feedback signals are working correctly. See Section 6.3.2.1 and 6.3.2.2 for details on these operations.

f. Check to make sure the correct personality module has been installed in the drive. The controller type and motor type must match what is on the personality module in order to insure correct operation.

Motor Label

INDRAMAT GmbH Lohr/Main	BRUSHLESS-SERVODRIVE
MAC 112C-0-ED-4-C/130-A-0/W 1520_/S05	
Serial No.: 9041	Comm. No.: 243330
Cont. Torque 212.6 ① lbin	Torque Const.: 4.1 lbin/A
Cont. Current 57 ① A	Peak Current 312 A
Sensitivity 0.47 VS/rad	Insulation Class F
$n_{max.}$ 3000 rpm	Protective System IP 65
Tacho Sensitivity 0.0286 VS/rad	
Brake: Mo lbin	U_N V I_N A
① surface cooled Made in W. Germany	IN 85 E

Personality Module Label

INDRAMAT	MOD 15/1X006-001	
Contr.: DSC 3.1-100	Input	rpm/V
Motor: MAC 112C-.-ED-.-C	E1/E2	3000/10
Current (A): Peak/cont: 100/60	E3	-------
Operating rpm: 3000//MA:0.075V/A	E4	1500/10

Unlike the DSC 1 (predecessor to the DSC 3.X) the personality module is now accessible without having to remove the entire DSC cover. Refer to Figure 6-1 for further details.

g. Check for the proper LED state (on/off).

DSC INDICATOR LED

#1	Overvoltage	Red	Off
#2	Bridge Fuse (BS)	Red	Off
#3	Overtemperature Fuse (TS)	Red	Off
#4	Overtemperature Monitor (TU)	Red	Off
#5	Ready to Operate (Bb)	Green	Off (No 3-phase)
#6	Controller Enable (RF)	Green	Off (No enable)
#7	Power on	Green	Off (No 3-phase)
#8	Tach	Green	On
#9	BLC 1	Green	
#10	BLC 2	Green	Any 1 or 2 of the 3
#11	BLC 3	Green	LED's can be on
#12	+24 +/-15V	Green	On
#13	115/220 Vac	Green	On (Single phase on)
#14	115/220 Vac	Green	On (Single phase on)

5.3 INITIAL OPERATION

Reconnect all electrical lines. Replace the 3-phase transformer fuses.

Connect the battery box as illustrated in Figure 5-1.

Leave the motor shaft uncoupled from the mechanical load for the initial operation.

It is very important that the Emergency Stop circuit is functional at this point.

1. Apply power to the servo system

2. Energize the power contactors. The brake should release. All the power LED's and Bb LED's on the servo amplifiers should now be lit.

3. Close the controller enable switch on the battery box and turn the pot slightly to apply a small velocity command signal to the amplifier. The motor should run at a slow, constant speed. Verify that the motor responds correctly to the speed command signal in both the forward and reverse directions.

> **WARNING**
>
> IF THE MOTOR POWER LEADS OR THE FEEDBACK LINES ARE NOT CONNECTED PROPERLY, THE MOTOR MAY SPEED UP OUT OF CONTROL. IF THIS HAPPENS, IMMEDIATELY ACTUATE THE EMERGENCY STOP AND CORRECT THE PROBLEM.

4. Check the scaling of the velocity reference signal against the data on the personality module. This can be done at 10 to 20% of maximum speed.

5.4 CHECKING THE LOAD TORQUE

The motor should now be re-coupled to the mechanical load. Continue to use the battery box to provide the velocity command signal.

In this check, the motor current will be used as an indication of load torque. This is possible because the motor current is directly proportional to the motor torque. The motor current is measured via the Imess terminal. The voltage at this terminal is proportional to the motor current. See Table A-1 in Appendix A for the scale factor for each servo amplifier module.

Perform the following steps:

1. Determine the motor torque at a very slow speed (approximately 5 inches per minute for conventional axis feed applications). This corresponds to the basic load torque. The current required at this speed should not exceed 60% of the rated motor current.

   Measured Speed: ________ Measured Current: ________

2. Determine the motor torque at the rapid traverse speed of the servo motor. The current required at this speed should not exceed 75% of the rated peak motor current.

   Measured Speed: ________ Measured Current: ________

If the measured torques are higher than expected, one or more of the following may be the cause.

1. The counterweight may not be adjusted properly. When the counterweight is working properly, the torque (current) required should be the same in both directions.

2. There may be inadequate ball return movement in the nut of the ball screw.

3. Slide lubrication system may be turned off or inoperative.

4. Slide may be misaligned or gibbs may be too tight.

5.5 POSITION CONTROL LOOP

5.5.1 Feedback Polarity

Perform the following check with the battery box connected to the speed command input of the servo amplifier.

> Verify that the polarity of the position feedback signal is correct. The polarity should always be opposite that of the velocity command signal. That is, if a negative velocity command signal causes the slide to move left, a slide movement to the left should cause the position feedback signal to go positive.

5

5.5.2 Position Loop Gain

Connect the velocity command signal line for the position control loop to the velocity command input of the servo amplifier. (Terminals E1, E2, E4.) Connect the controller enable signal from the NC to the RF terminal.

To verify that K_v is adjusted properly, command several changes in position. The slide should respond smoothly and quickly with little or no overshoot. If the slide oscillates or overshoots badly, reduce the K_v factor on the NC controller. If the slide does not reach the correct commanded position or if the response is too slow, increase the K_v factor slightly.

Verify that the following error is as expected based on the value of K_v. It is calculated as follows:

$$FE = \frac{CS}{K_v \times 1000}$$

Where:

FE = Following Error (in/min/mil)
CS = Commanded Speed (in/min)
Kv = Position Loop Gain (no units)

If your NC controller uses gain breaks, check the response with both large and small changes in commanded position.

CHAPTER 6. MAINTENANCE AND TROUBLESHOOTING

6.1 MAINTENANCE

Indramat 3-phase drives operate with no electromagnetic parts that are subject to wear and are therefore totally maintenance-free.

Drives cooled by a separate blower do not have a filter and the blower function is monitored by a temperature sensor.

6.2 SERVICING

> **WARNING**
>
> LIFE THREATENING VOLTAGES PRESENT ON CONNECTORS DO NOT CONNECT OR DISCONNECT WHILE POWERED.
>
> UNEXPECTED AND DANGEROUS MACHINE MOVEMENTS MAY RESULT IF SERVICE IS ATTEMPTED BY UNQUALIFIED PERSONNEL.

An NC machine is a costly item of capital equipment and it must be possible to repair any faults in its functional units quickly and effectively. Lengthy fault-tracing and repair work on the machine is therefore unacceptable in view of the loss of production time. This section of the manual, therefore, will allow you to trace a fault to the correct module so it may be replaced. Indramat AC servo drives are designed for easy replacement of single function modules without the need for adjustment.

6

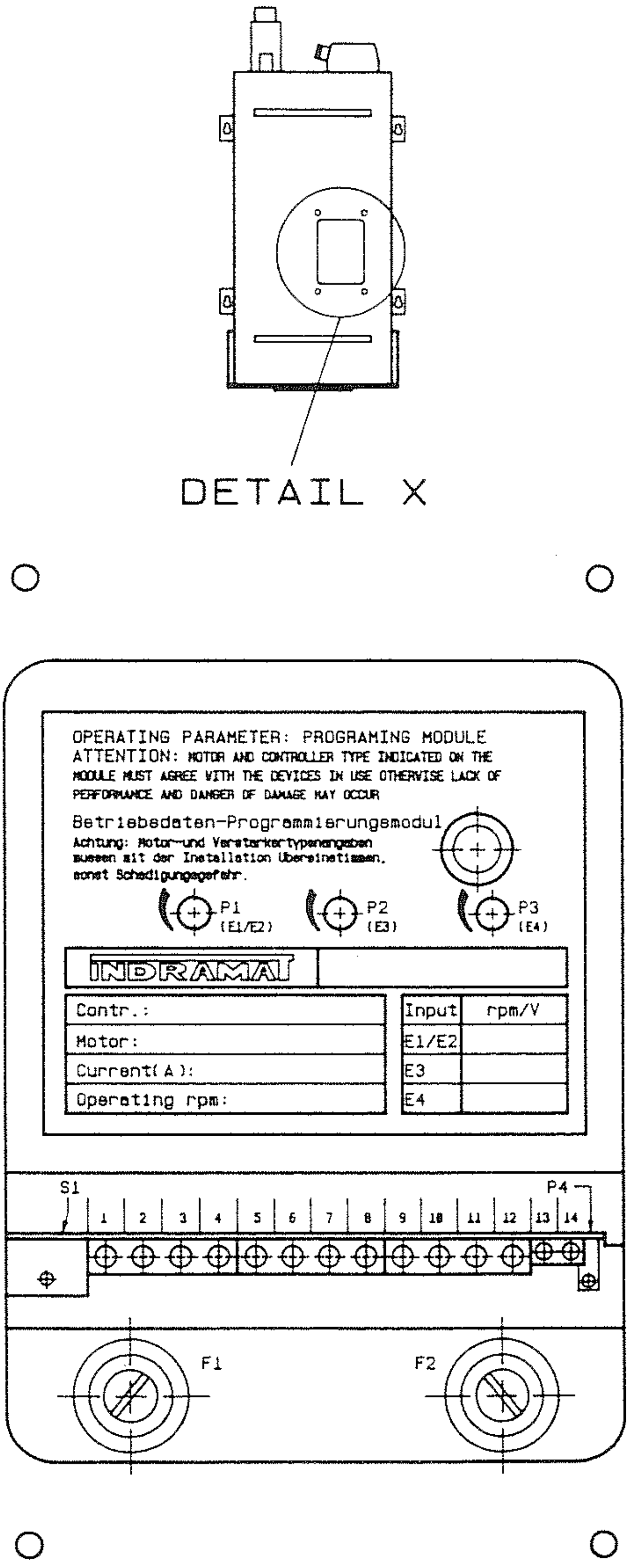
6.3 TROUBLESHOOTING

Read Chapter 1 before troubleshooting the servo amplifier system. This will acquaint you with the proper operation of the system and the function of each part.

Section 6.3.1 describes each of the diagnostic indicators on the servo amplifier. Section 6.3.2 provides instructions for more detailed tests on various parts of the system. Section 6.3.3 describes other common problems and possible causes.

6.3.1 Diagnostic Indicators

Figure 6-1 illustrates the diagnostic indicators on the DSC. Green LED's (except the three BLC indicators) indicate normal operation and red LED's indicate fault conditions. Each diagnostic indicator is described in detail on the following pages. The three BLC indicators operate differently and are described in Section 6.3.2.2.



DSC-INDICATOR DIRECTORY

1) OVERVOLTAGE
2) BS (BRIDGE FUSE)
3) TS (OVERTEMP SHUTDOWN)
4) TU (OVERTEMP WARNING)
5) Bb (DRIVE READY)
6) RF (CONTROLLER ENABLE)
7) POWER ON
8) TACH
9) BLC 3
10) BLC 2
11) BLC 1
12) + $24V_L$
$\pm$ $15V_M$
13) 115/220V∿F
14) 115/220V∿L

S1 = RESET
P4 = ZERO ADJUST
F1 = LINE VOLTAGE INPUT FUSE
F2 = CONTROL VOLTAGE FUSE

Figure 6-1. Diagnostic Indicators/Personality Module

Indicator	Condition Indicated by LED.	Action to Correct Fault.
Green LED - +24V +/-15V	+/-15Vm is within .25V of specified value and symmetry is less than 250 mV. $+24V_L$ is greater than 22.5 Vdc and less than 32V dc.	* Measure the control voltages. * Check fuses F1, F2. * Disconnect the tach cable from motor to DSC and measure the control voltages.
Green LED - Tacho	Tachometer is connected and operating normally. (Controller Power Unit will be disabled if a fault is detected.)	* Check tachometer line for open circuit or wrong connection. (Sec. 6.3.2.1) * Press Reset button.
Green LED - Power	DC voltage from power supply is greater than 250 Vdc.	* Check 3-phase line voltage. * Check power supply voltage with servo amplifier(s) disconnected.
Green LED - Rf	Controller Enable signal from NC controller is present.	* Determine if controller enable signal should be present. * Measure controller enable signal voltage. Should be between +3 and +30Vdc.
Green LED - Bb	No fault conditions are detected. Bb relay contact is closed indicating that the amplifier is ready for operation. (See Figure 6-2.)	* Check other fault conditions.
Red LED - BS	Motor overcurrent is detected. (Controller Power Unit is disabled.)	* Check for cause of motor overcurrent. (Section 6.3.2.3) * Press Reset button.
Red LED - TU	The amplifier temperature is above 85°C.	* Check blower operation. * Check ambient temperature. * Check load cycle. * Check personality module for correct amplifier/motor combination.
Red LED - TS	The amplifier temperature has exceeded 85°C. (Amplifier Power Unit is disabled.)	* See TU above

6.3.2 Testing Procedures

6.3.2.1 Tachometer

* Disconnect the 'Controller Enable' signal.
* Disconnect the motor power cable (St.3).
* Release the brake.
* Connect the drive control voltage supply.
* Connect oscilloscope to the tachometer input of the servo amplifier.
* Turn the motor by hand at a uniform rate.

The oscilloscope should display an uninterrupted DC voltage that is proportional to the speed of the motor shaft. If the signal is not present at the amplifier, check for DC power to the motor feedback unit and for the tach signal at the motor. If there is DC power and the signal is present at the motor, the cable should be replaced. If there is no signal at the motor but the DC power is reaching the motor feedback unit, replace the motor assembly.

6.3.2.2 Rotor Position (BLC) Signals

* Disconnect the 'Controller Enable' signal.
* Disconnect the motor power connector (St.3).
* Release the brake.
* Connect the drive control voltage supply.
* Turn the motor by hand at a uniform rate.

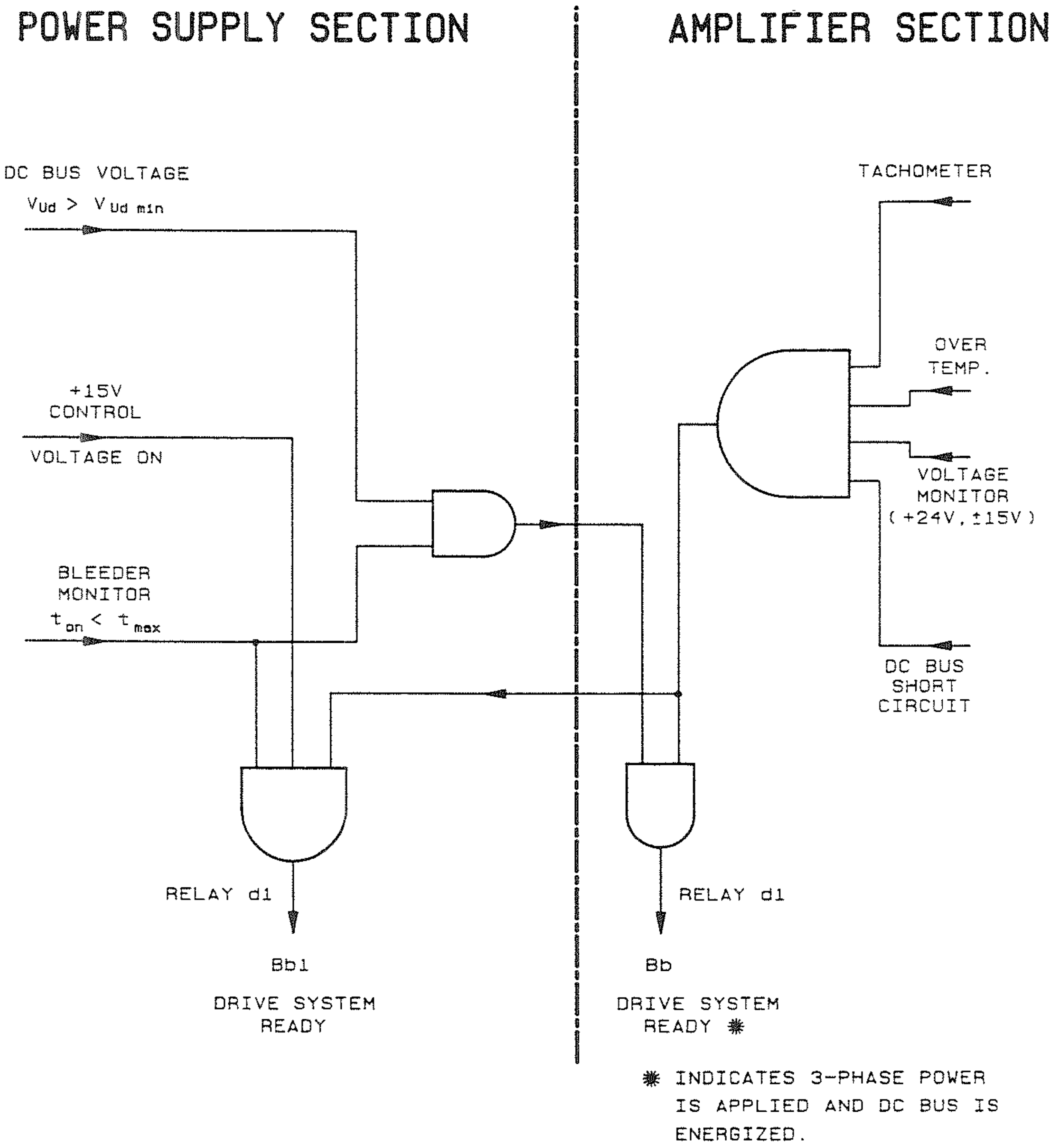


Figure 6-2. Bb/Amplifier Monitoring Diagram

The green LED's BLC1, BLC2 and BLC3 must each light up and go out alternately. There must never be more than two or less than one of these three LED's on at one time. When the motor is rotated clockwise, BLC1 should light up first followed by the other two as shown in Figure 6-3. If the BLC signals do not operate properly, check the BLC signals at the amplifier and at the motor. Also verify that there is DC power at the motor feedback unit. Replace the cable or motor assembly as required.

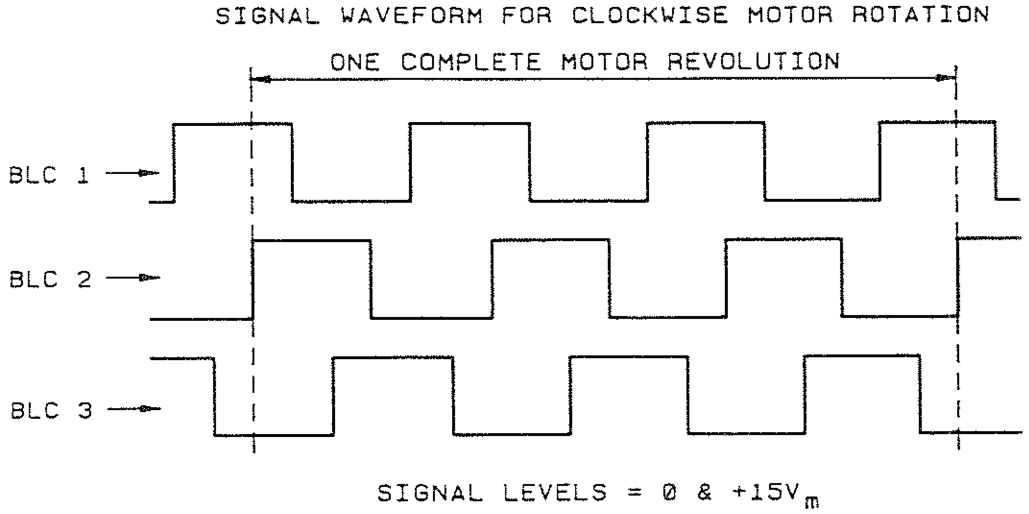


Figure 6-3. BLC Signals

6.3.2.3 Motor Windings

* Remove all power from the amplifier.
* Disconnect the motor power cable (St.3).
* Measure the resistance of all three motor windings.
  (Terminals U to V; V to W; and W to U.)
* Measure the resistance between each motor winding and the motor body.
  (Maximum test voltage is 500V.)

The resistance of the three windings should be equal. The resistance between any winding and the motor body should be greater than 20 Megohm.

6.3.2.4 Incremental Encoder Signals

* Disconnect NC velocity command signal from terminals E1, E2 or E4 (St.1).
* Connect an external reference voltage (battery source) to the velocity command inputs E1 and E2.
* Mechanically disconnect the motor from the load.
* Run the motor clockwise at a constant speed.

The signals from the incremental encoder must be as shown in Figure 6-4. If these signals are not present, check for the signals and DC power at the encoder as above and replace the cables or incremental encoder as required.

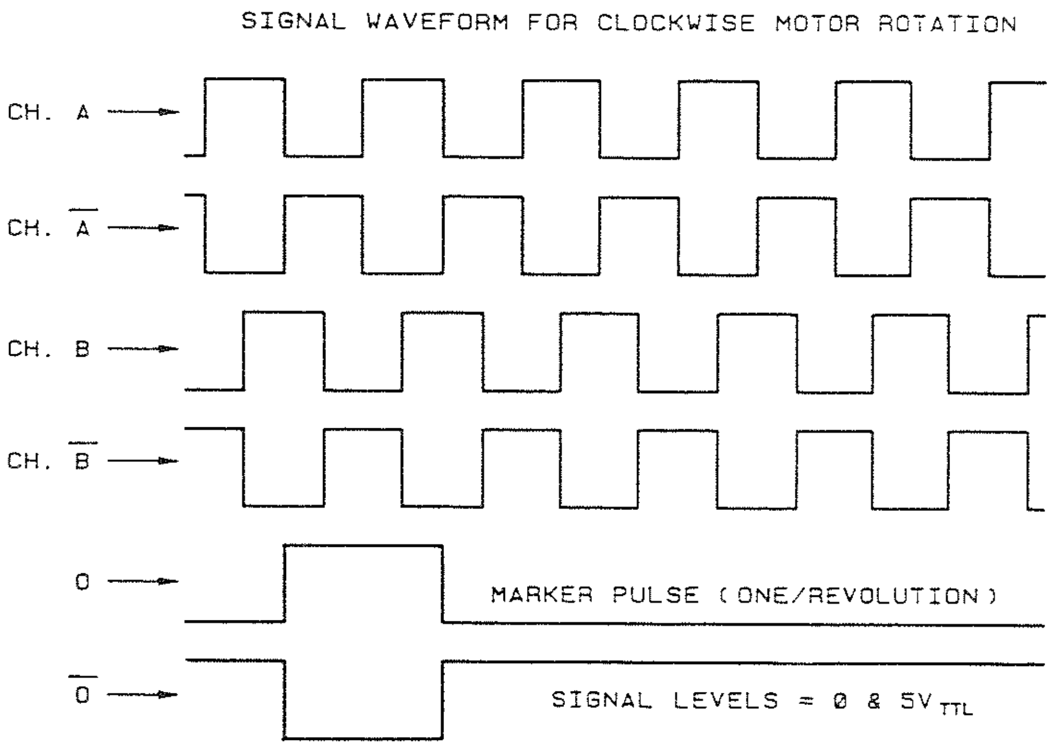


Figure 6-4. Incremental Encoder Signals

6.3.2.5 Rotor Magnetization

* Remove all electrical and mechanical connections from the motor.
* Drive the motor at a relatively high speed. (An electric drill can be connected to the motor shaft to do this).
* Connect an oscilloscope to any motor winding.
* Measure the peak-to-peak voltage and period as shown in Figure 6-5.

The rotor magnetization can be determined by calculating the voltage constant as follows:

$$K_T \text{ (lb-in/A)} = V_{pp} \times T_{sec} \times 1.965$$

OR

$$K_T \text{ (N-m/A)} = V_{pp} \times T_{sec} \times 0.222$$

Where:

K_T = Rotor Magnetization factor.

V_{pp} and T_{sec} are defined in Figure 6-5.

This figure should closely agree with the specification on the motor nameplate. If the value is too low the motor should be replaced.

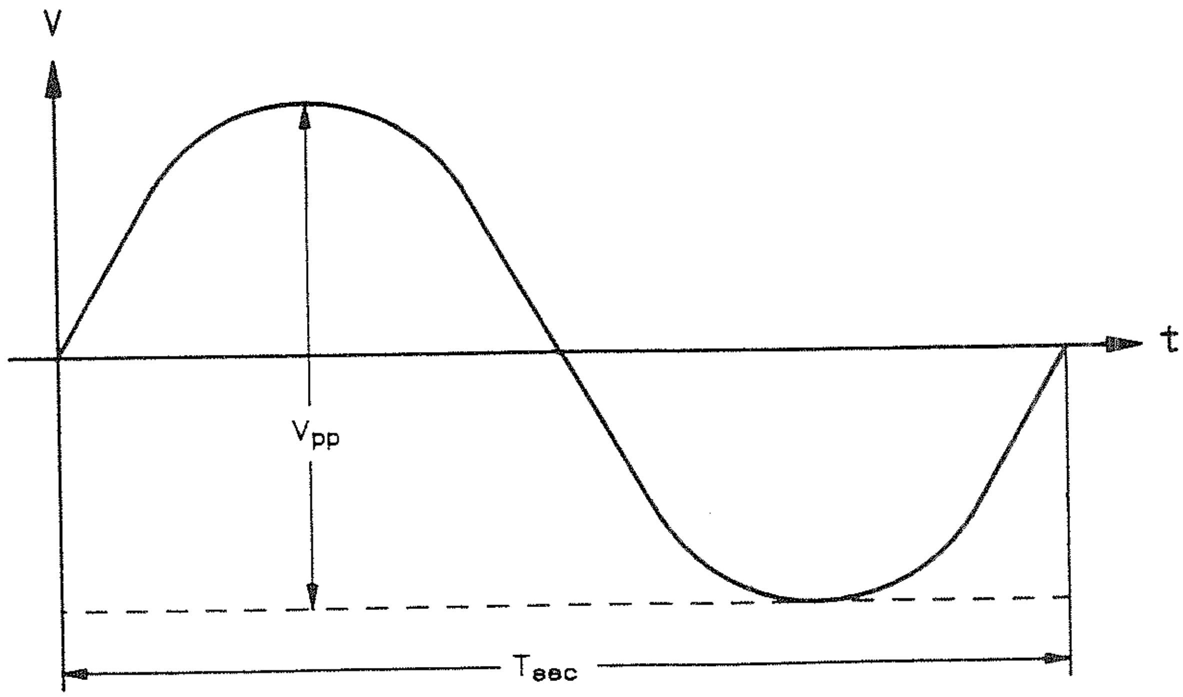


Figure 6-5. Rotor Magnetization

6.3.3 Common Problems

Problem: Irregular feed movement.

Causes:

Motor power connections switched.
Motor feedback connections switched.
Loose motor power or feedback connections.
Wrong personality module.
Load moment of inertia too high.
Load fluctuations.
Contactors not suppressed.
Command voltage with ripple.
Backlash between motor and position feedback.
Position loop gain (K_v factor) too high.
Missing phase in supply line.
Gaps in tachometer signal.
Brakes not fully released.
Defective motor.
Defective servo amplifier.

Problem: Overshoot during positioning.

Causes:

Position loop gain (K_v factor) too high.
Backlash between motor and position feedback.
Backlash between motor and slide.
Current limit triggered.
Incorrect personality module.

Problem: Drive does not follow command value. (Excessive following error.)

Causes:

Motor running against brake.
Current limiter triggered.
Incorrect personality module.
Load inertia or friction too high.
Position loop gain (K_v factor) too high.
Missing phase in supply line.

Problem: No feed movement.

Causes:

No line power.
No control power.
No controller enable signal.
No command value.
Interruption in motor feedback line.
Servo amplifier auto shutdown. (See diagnostic indicators)
Mechanically not free to move.
Brake not released.
Current limiter triggered.

Problem:	No feed movement.
Causes:	Defective servo amplifier. Defective feedback unit. Defective motor.

Problem:	Motor runs at uncontrollable high speed.
Causes:	Short circuit in tachometer line. Defective NC position controller. Break in cable of measuring system. Defective motor feedback. Defective servo amplifier.

Problem:	Motor does not turn when 3-phase applied.
Causes:	300V dc bus is overloaded. Short circuit between L+ and L-. Defective bleeder module. Defective servo amplifier.

Problem:	Power supply fuse F1 blown.
Causes:	24V supply is overloaded. External short circuit. Defective servo amplifier. +/- 15V supply is overloaded. External short circuit. Defective servo amplifier.

A

APPENDIX A. SPECIFICATIONS

Table A-1. Imess Terminal Scale Factor

The voltage at the Imess Terminal is proportional to the motor current. The constant of proportionality for each model amplifier is given below.

DSC 3.1-30	250 mV/amp
DSC 3.1-50	150 mV/amp
DSC 3.1-100	75 mV/amp
DSC 3.1-150	50 mV/amp

Table A-2. DC Control Voltage Currents

This table shows the amount of current available from the power supply section at the three control voltages. The currents listed below are the maximum permissible load.

	CURRENT AVAILABLE		
PIN	+15 Vdc	-15 Vdc	+24 Vdc
A2 on conn St 1	50 mA		
B2 on conn St 1		50 mA	
A1 on conn St 1			200 mA

Ovm is the reference point for the ± 15 Vm and OVL is the reference for the 24 VL.

A

Table A-3. Power Specifications

Servo Amplifier	Nominal Output Current	Peak Output Current	Peak Output Power	Max. Power Dissipation at Nominal Current External
DSC 3.1- 30-W1	30A	30A	9Kw	230W
DSC 3.1- 50-W1	50A	50A	15Kw	360W
DSC 3.1-100-W1	70A	100A	30Kw	470W
DSC 3.1-150-W1	75A	130A	39Kw	510W

NOTE:

The number after the first hyphen in the device number denotes the nameplate current. This is also the peak current. For example, DSC 3.1-50-115-W1 has a nameplate current of 50A.

Table A-4. Bleeder Specification

Servo Amplifier	Average Bleeder Power	Peak Bleeder Power
DSC 3.X	500W	20 Kw

Table A-5. Miscellaneous Specifications

Allowable ambient temperature range at rated values.	5 to 40°C (41 to 104°C)
Absolute maximum temperature. (Derated performance)	55°C (131°F)
Storage and transportation temperature range.	-30 to 85°C (-22 to 185°F)
Maximum operating altitude at rated values.	1000 meters (3280 ft.)
DC bus voltage.	300 Vdc +/- 15%.
DSC power consumption.	180 VA

Table A-6. Weights

Device	Weight (Kg)	Weight (lb.)
DSC 3.1- 30	26 Kg	57.3 lbs.
DSC 3.1- 50	26 Kg	57.3 lbs.
DSC 3.1-100	26 Kg	57.3 lbs.
DSC 3.1-150	26 Kg	57.3 lbs.

A

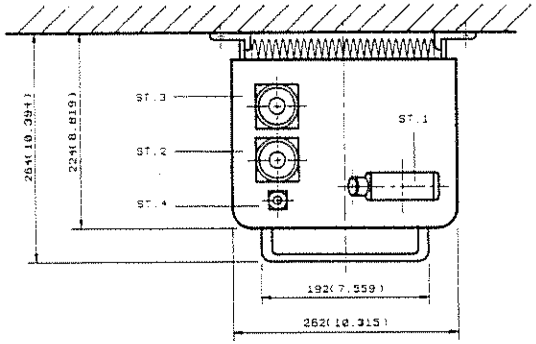
Table A-7. Fuses

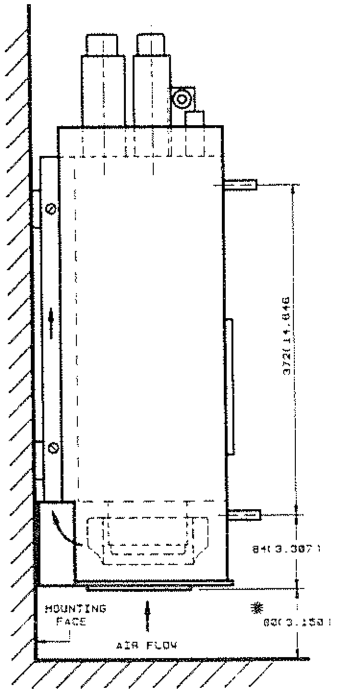
Fuse Number	Fuse Type	Function
F1	3.15A/250V	115 or 220 Vac
F2	6.3A/250V	Control Voltage

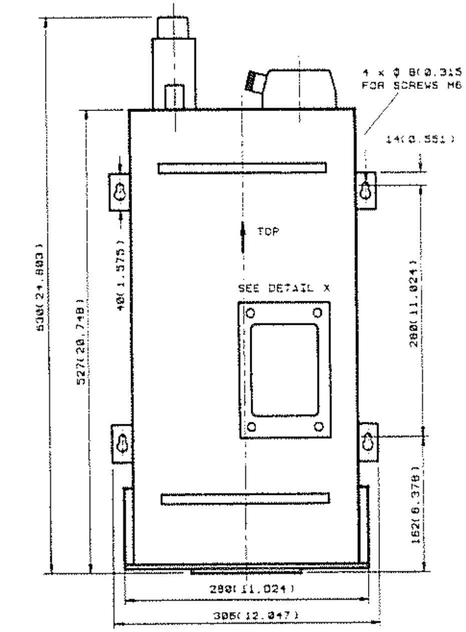
APPENDIX B. OUTLINE DRAWINGS

Drawing number 109-0645-3001-00A.

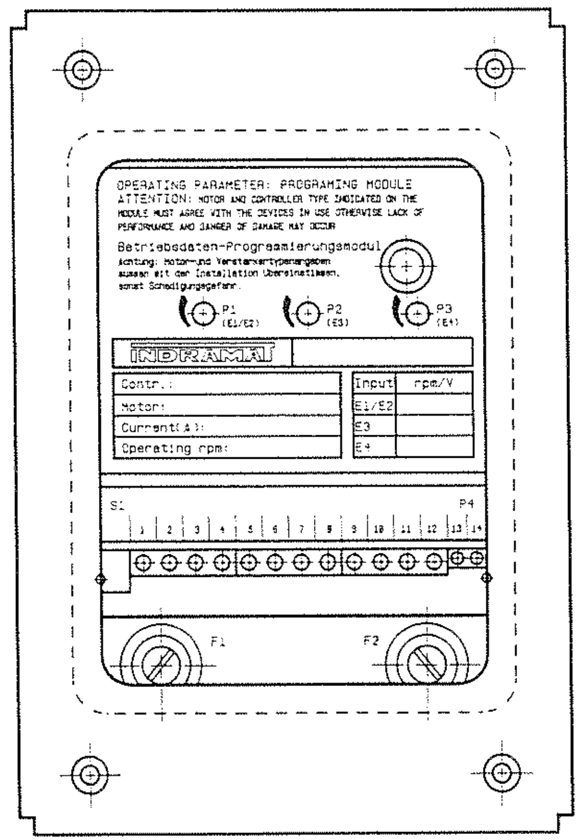
ST.1 = NC CONNECTOR
ST.2 = POWER UNIT CON.
ST.3 = MOTOR CONNECTOR
ST.4 = MOTOR FEEDBACK CONNECTOR







DETAIL X



DSC-INDICATOR DIRECTORY

1) OVERVOLTAGE
2) BS (BRIDGE FUSE)
3) TS (TEMPERATURE FUSE)
4) TU (TEMPERATURE MONITOR)
5) Bb (DRIVE READY)
6) RF (CONTROLLER ENABLE)
7) POWER ON
8) TACH
9) BLC 1
10) BLC 2
11) BLC 3
12) + 24V
± 15V
13) 115/220V~F
14) 115/220V~L

S1 = RESET
P4 = ZERO ADJUST
F1 = 115/220V
F2 = 24V

NOTES:

1) ALL DIMENSIONS SHOWN IN "mm". (inches) FOR REFERENCE ONLY.
2) WEIGHT = 57 lbs
✳ INDICATES MIN. DISTANCE FOR COOL AIR INLET.

REXROTH INDRAMAT CHICAGO, ILL.	DSC 3.1 OUTLINE COMPACT AC SERVO CONTROLLER
DRAWING NUMBER	109-0645-3001-00A
DRAWN BY /-3/-86 APPROVED BY	SCALE NTS
REVISION FOR / REVISED BY	SHEET 1 OF 1

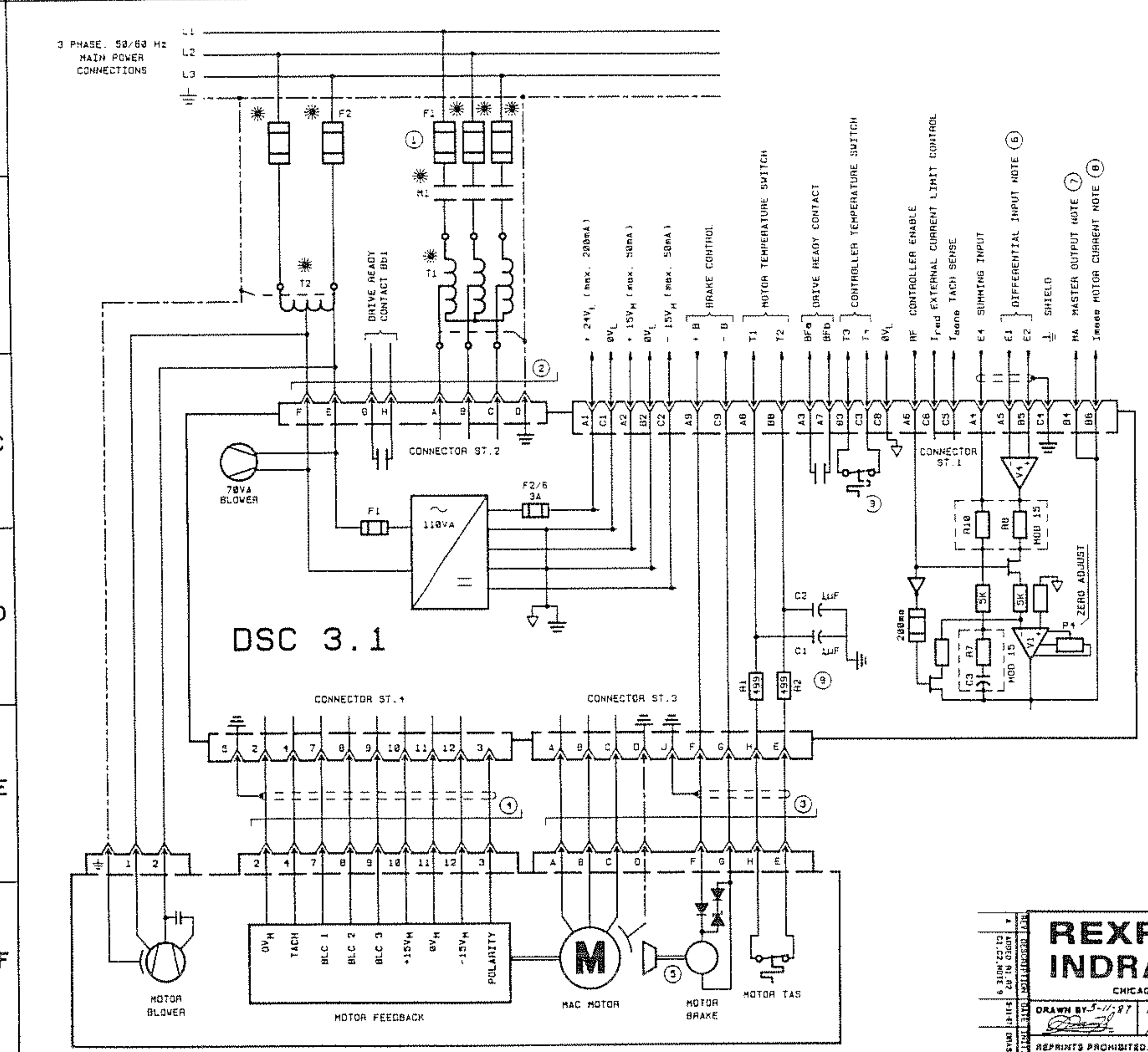
APPENDIX C. INTERCONNECT DRAWINGS

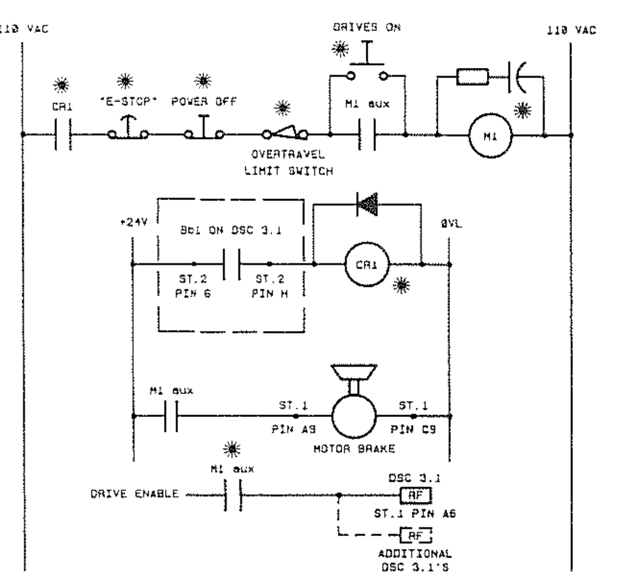
Drawing number 109-0645-3601-00A - DSC 3.1 Interconnect

Drawing number 209-0030-1715-02A - DSC 3.1/TRANS01 Interconnect

Drawing number AE-1014 - Master Slave Adapter

C





NOTES:

✳ DENOTES CUSTOMER SUPPLIED COMPONENTS AND ▽ INDICATES COMMON CONNECTIONS

1. DIRECT CONNECTION TO 220V 3Ø IS POSSIBLE. REFER TO DSC MANUAL.
2. FOR DSC 3.X POWER CABLE USE 01-0500
FOR ALL MAC 112C AND 112D MOTORS USE 01-0520.
3. MOTOR POWER CABLE WIRE SIZE DEPENDENT UPON MOTOR/ DSC 3.X COMBINATION. SEE MOTOR CABLE SELECTION LIST.
4. USE CABLE 03-0101 IF MOTOR HAS A BLOWER.
5. INTERNAL MAC MOTOR BRAKE, +24V ±10%. THE +24VOLTS FOR THE BRAKE MUST BE SUPPLIED BY AN EXTERNAL 24V POWER SUPPLY.
REFER TO MOTOR DOCUMENTATION FOR REQUIRED BRAKE COIL CURRENT.
6. E1,E2 DIFFERENTIAL INPUT: E1 POSITIVE WITH RESPECT TO E2=CW ROTATION
E4, SUMMING INPUTS: E4 NEGATIVE WITH RESPECT TO 0VM=CW MOTOR ROTATION.
7. OUTPUT USED ONLY FOR MASTER/SLAVE APPLICATION; WHERE MA OF THE MASTER IS USED FOR THE COMMAND FOR THE SLAVE.
8. MOTOR CURRENT OUTPUT. REFER TO DSC 3.X MANUAL FOR SCALING FACTOR.
9. USE EXTERNAL +24VDC FOR MOTOR AND CONTROLLER TEMPERATURE SWITCHES.

REV	DESCRIPTION	DATE	INIT.
A	ADDED R1,R2 C1,C2,NOTE 9	5-11-87	DRAS

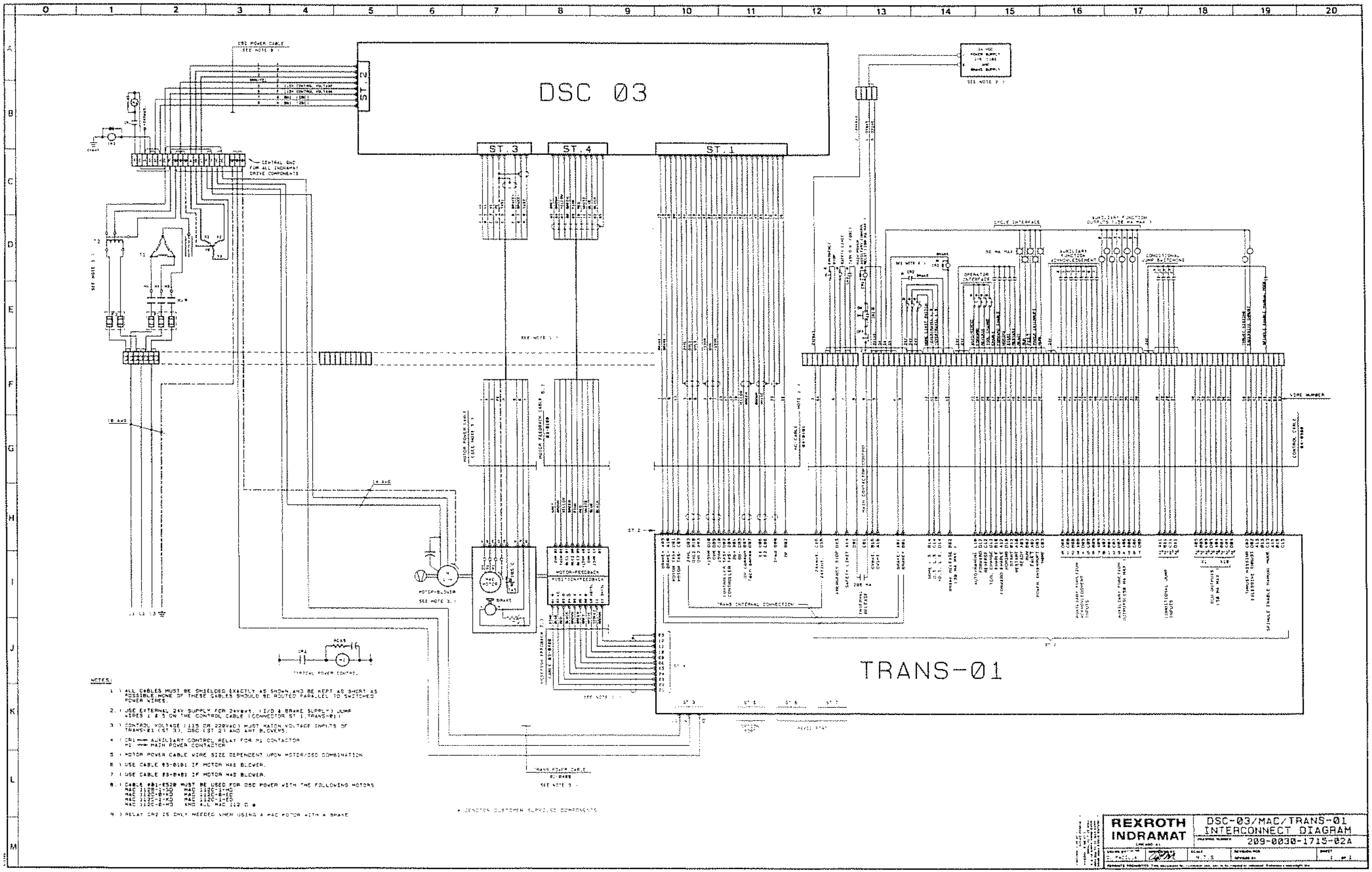
REXROTH INDRAMAT
CHICAGO, ILL.

DSC 3.1 INTERCONNECT

DRAWING NUMBER 109-0645-3601-00A

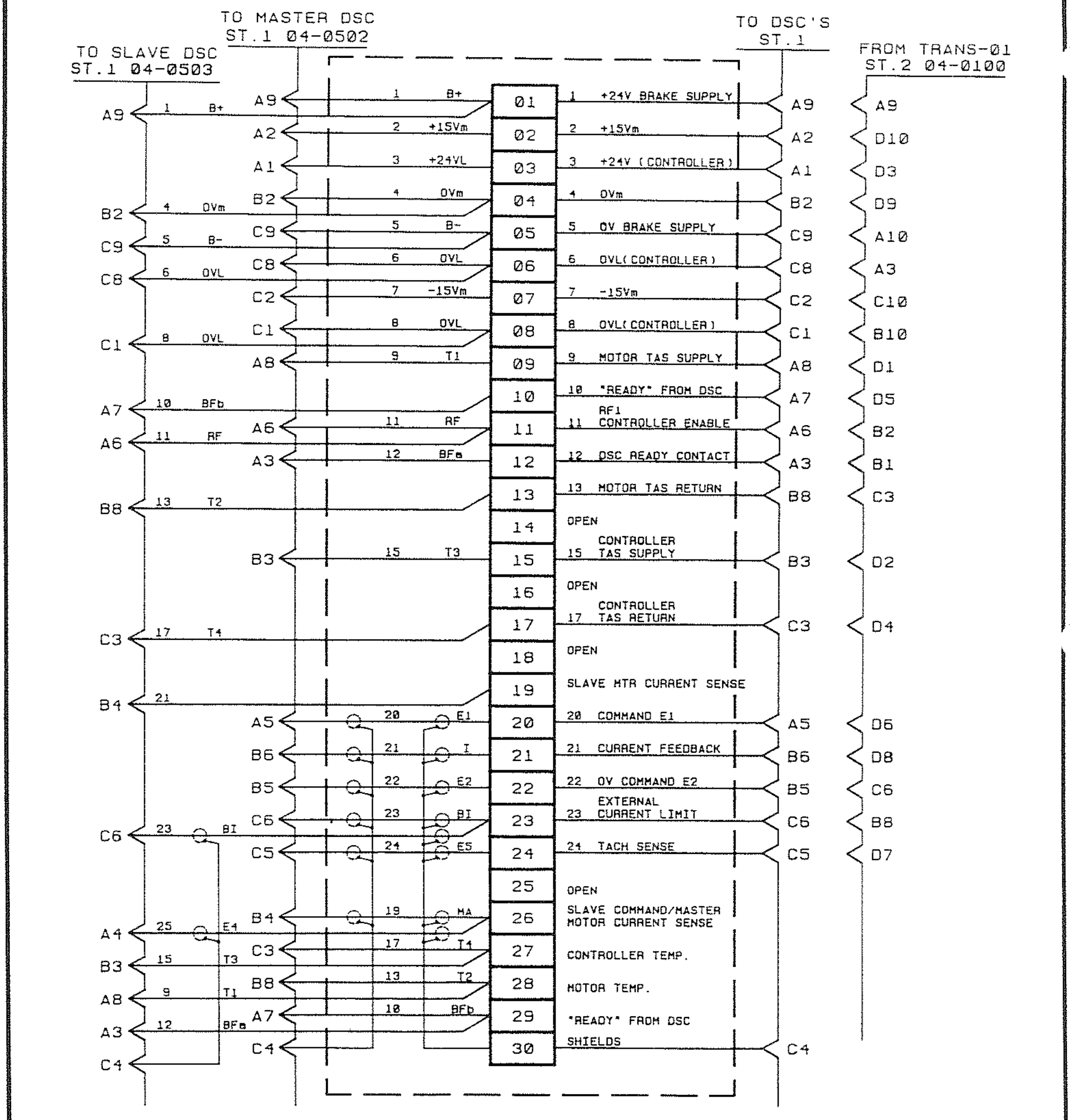
DRAWN BY 5-11-87 | APPROVED BY | SCALE NTS | REVISION FOR | REVISED BY | SHEET 1 OF 1

71017



DSC 03
ST.2
ST.3
ST.4
ST.1
TRANS-01
TYPICAL POWER CONTROL
NOTES:
1.) ALL CABLES MUST BE SHIELDED EXACTLY AS SHOWN AND BE KEPT AS SHORT AS POSSIBLE. NONE OF THESE CABLES SHOULD BE ROUTED PARALLEL TO SWITCHED POWER WIRES.
2.) USE EXTERNAL 24V SUPPLY FOR 24Vext. (I/O & BRAKE SUPPLY) JUMP WIRES 1 & 5 ON THE CONTROL CABLE (CONNECTOR ST 1, TRANS-01)
3.) CONTROL VOLTAGE (115 OR 220VAC) MUST MATCH VOLTAGE INPUTS OF TRANS-01 (ST 3), DSC (ST 2) AND ANY BLOWERS.
4.) CR1 —— AUXILIARY CONTROL RELAY FOR M1 CONTACTOR
M1 —— MAIN POWER CONTACTOR
5.) MOTOR POWER CABLE WIRE SIZE DEPENDENT UPON MOTOR/DSC COMBINATION
6.) USE CABLE 03-0101 IF MOTOR HAS NO BLOWER.
7.) USE CABLE 03-0401 IF MOTOR HAS BLOWER.
8.) CABLE 01-0520 MUST BE USED FOR DSC POWER WITH THE FOLLOWING MOTORS
MAC 112B-1-GD MAC 112C-1-HD
MAC 112C-0-KD MAC 112C-0-ED
MAC 112C-1-KD MAC 112C-1-ED
MAC 112C-0-HD AND ALL MAC 112 D
9.) RELAY CR2 IS ONLY NEEDED WHEN USING A MAC MOTOR WITH A BRAKE
REXROTH
INDRAMAT
DSC-03/MAC/TRANS-01
INTERCONNECT DIAGRAM
209-0030-1715-02A

C



REXROTH INDRAMAT CHICAGO ILL.	MSA-01 MASTER-SLAVE ADAPTER
	DRAWING NUMBER AE 1014

DRAWN BY	APPROVED BY	SCALE	REVISION FOR / REVISED BY	SHEET
1-28-87		N.T.S.		1 OF 1

Rev.	Description	Date	Init.
A	REDRAWN TO SHOW DSC CONNECTION	JUNE 25 1987	D.P.
B	CHANGED ST1 CABLE OF SLAVE	MAR 14 1989	C.M.

APPENDIX D. CABLE AND CONNECTOR DESCRIPTIONS

This appendix contains the following drawings:

No. AG 1027 (2 sheets) - System Cable Requirements

No. 209-0050-4801-00/236A - KSC Power Cable Term. Strip

No. 209-0050-4801-00/150A - KSC Power Cable - 16 mm^2

No. 209-0050-4801-00/103A - Motor Power Cable #02-0800

No. 209-0050-4801-00/123A - Motor Power Cable #02-0810

No. 209-0050-4801-00/143A - Motor Power Cable #02-0820

No. 209-0050-4801-00/163A - Motor Power Cable #02-0830

No. 209-0050-4801-00/068A - Motor Power Cable #02-0840

No. 209-0050-4801-00/086A - Motor Power Cable #02-0850

No. 209-0050-4801-00/257A - Motor Feedback Cable #03-0100

No. 209-0050-4801-00/260A - Motor Feedback Cable #03-0130

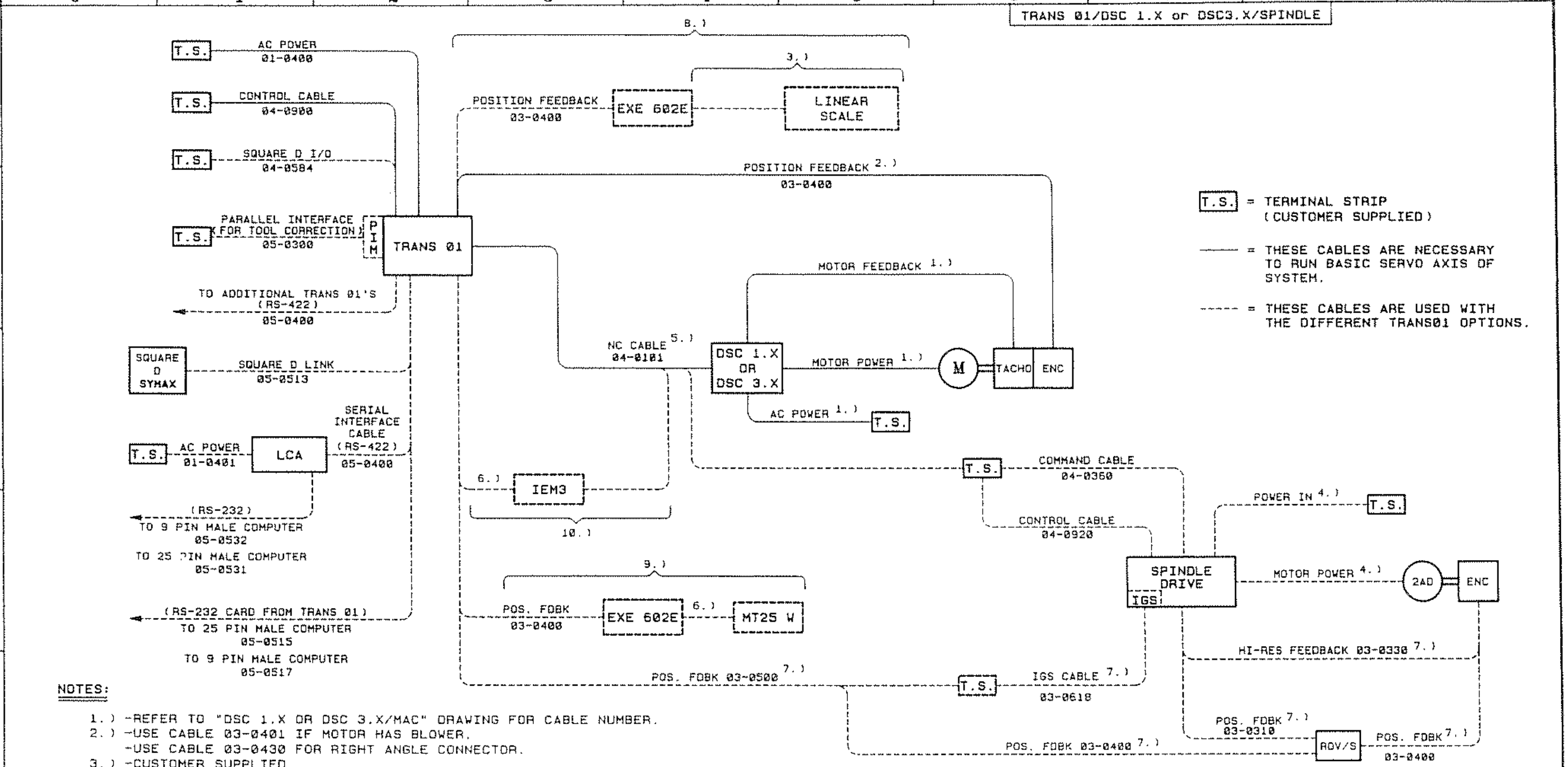
No. 209-0050-4801-00/251A - Motor Feedback Cable #03-0200

No. 209-0050-4801-00/259A - Motor Feedback Cable #03-0230

No. 209-0050-4801-00/540A (2 sheets) - DSC NC Cable #04-0101

No. 209-0050-4801-541A (2 sheets) - DSC NC Cable #04-0501

D



NOTES:

1.) -REFER TO "DSC 1.X OR DSC 3.X/MAC" DRAWING FOR CABLE NUMBER.
2.) -USE CABLE 03-0401 IF MOTOR HAS BLOWER.
-USE CABLE 03-0430 FOR RIGHT ANGLE CONNECTOR.
3.) -CUSTOMER SUPPLIED
4.) -REFER TO "KDA OR RAC/2AD MOTOR" DRAWING FOR CABLE NUMBER.
5.) -USE CABLE 04-0160 FOR SPINDLE AXIS CAPABILITIES.
-USE CABLE 04-0120 FOR TR24 ADAPTIVE FEED SOFTWARE (IEM3).
-USE CABLE 04-0170 FOR SPINDLE AND TR24 CAPABILITIES.
6.) -CABLE IS INCLUDED WITH THE IEM3 AND MT25W UNITS.
7.) -IF "TRANS 01 SPINDLE ORIENTATION" WILL NOT BE USED, THEN FOLLOW FEEDBACK CONFIGURATION SHOWN ON "KDA OR RAC/2AD MOTOR" DRAWING.
8.) -THIS OPTION REPLACES A ROTARY ENCODER WITH A LINEAR SCALE.
9.) -THIS IS USED WITH TR25/X.X ADAPTIVE DEPTH SOFTWARE. "SPINDLE ORIENTATION" IS NOT POSSIBLE WITH THIS OPTION.
10.) -THIS IS USED WITH TR24/X.X ADAPTIVE FEED SOFTWARE. "SPINDLE ORIENTATION" IS NOT POSSIBLE WITH THIS OPTION.

REXROTH INDRAMAT
WOOD DALE, IL

SYSTEM CABLE REQUIREMENTS

DRAWING NUMBER AG 1027

QUALITY DRIVES INDRAMAT

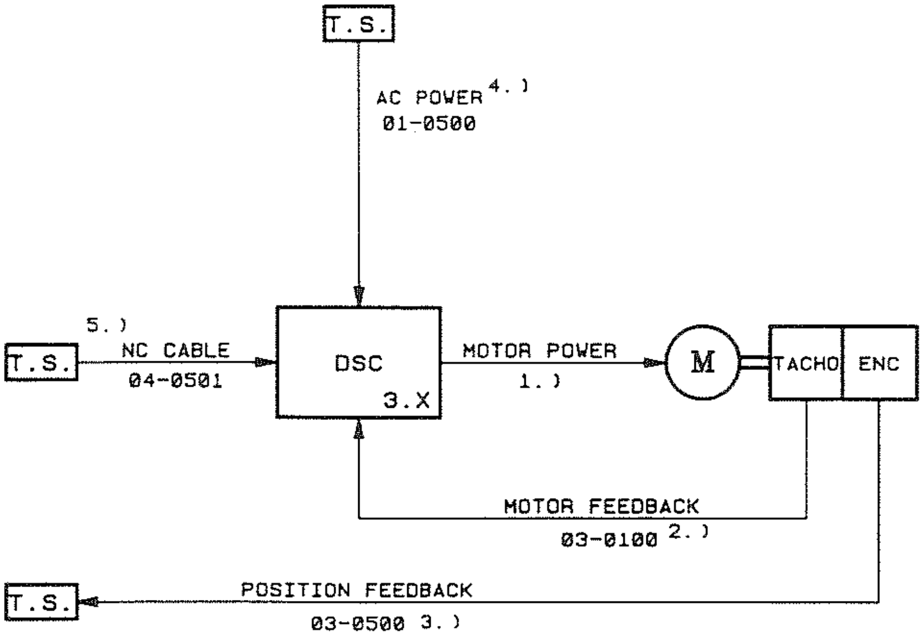
INFO	NAME	DATE	REV	DESCRIPTION	DATE	NAME	ECO NUMBER	PART NUMBER
DRAWN BY	C. MARTINEZ	2-25-92		REVISED PER E.C.O.	2/28	C.M.	920205-01	
CHECKED BY	[signature]	4-10-92						
ENGINEER APPROVAL	[signature]	4-10-92						

SCALE N.T.S. | SHEET 2 OF 24
REVISION FOR AG 1020
REVISED BY C. MARTINEZ

551202

DSC 3.X/MAC

T.S. = TERMINAL STRIP
(CUSTOMER SUPPLIED)



NOTES:

1.) -MOTOR POWER CABLES ARE SELECTED BASED ON SPECIFIC MOTOR/DRIVE COMBINATION.
REFER TO "MOTOR POWER CABLE SELECTION LIST" FOR PART NUMBERS.
2.) -USE CABLE 03-0101 IF MOTOR HAS BLOWER
-USE CABLE 03-0130 FOR RIGHT ANGLE CONNECTOR
-USE CABLE 03-0110 FOR SLAVE CONFIGURATION.
3.) -USE CABLE 03-0501 IF MOTOR HAS BLOWER
-USE CABLE 03-0530 FOR RIGHT ANGLE CONNECTOR
-ELIMINATE THIS CABLE IF POSITION FEEDBACK WILL NOT BE USED.
4.) -USE CABLE 01-0520 FOR ALL MAC112C AND MAC112D MOTORS.
5.) -USE CABLE 04-0503 ON SLAVE DRIVE FOR MASTER/SLAVE CONFIGURATION.

REXROTH INDRAMAT
WOOD DALE, IL.

SYSTEM CABLE REQUIREMENTS

DRAWING NUMBER AG 1027

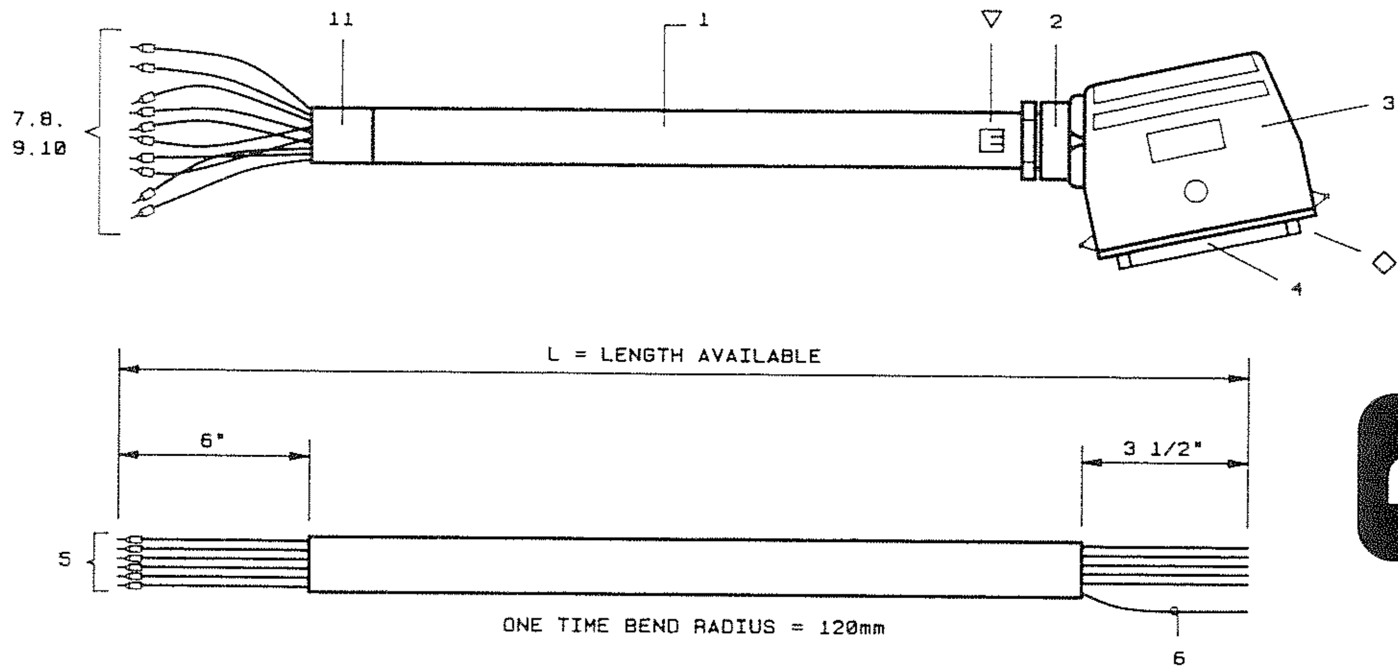
QUALITY DRIVES INDRAMAT

INFO.	NAME	DATE	REV.	DESCRIPTION	DATE	NAME	E.C.O. NUMBER	PART NUMBER	SCALE N.T.S.	SHEET 21 OF 24
DRAWN BY	C. MARTINEZ	2-25-92	A	REVISED PER E.C.O.	2/28	C.M.	920205-01		REVISION FOR AG 1020	
CHECKED BY	[signature]	4-10-92							REVISED BY C. MARTINEZ	
ENGINEER APPROVAL	[signature]	-1-10-92								

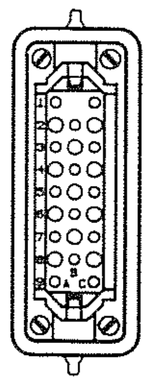
551202

D

DSC-TERM. STRIP 04-0501



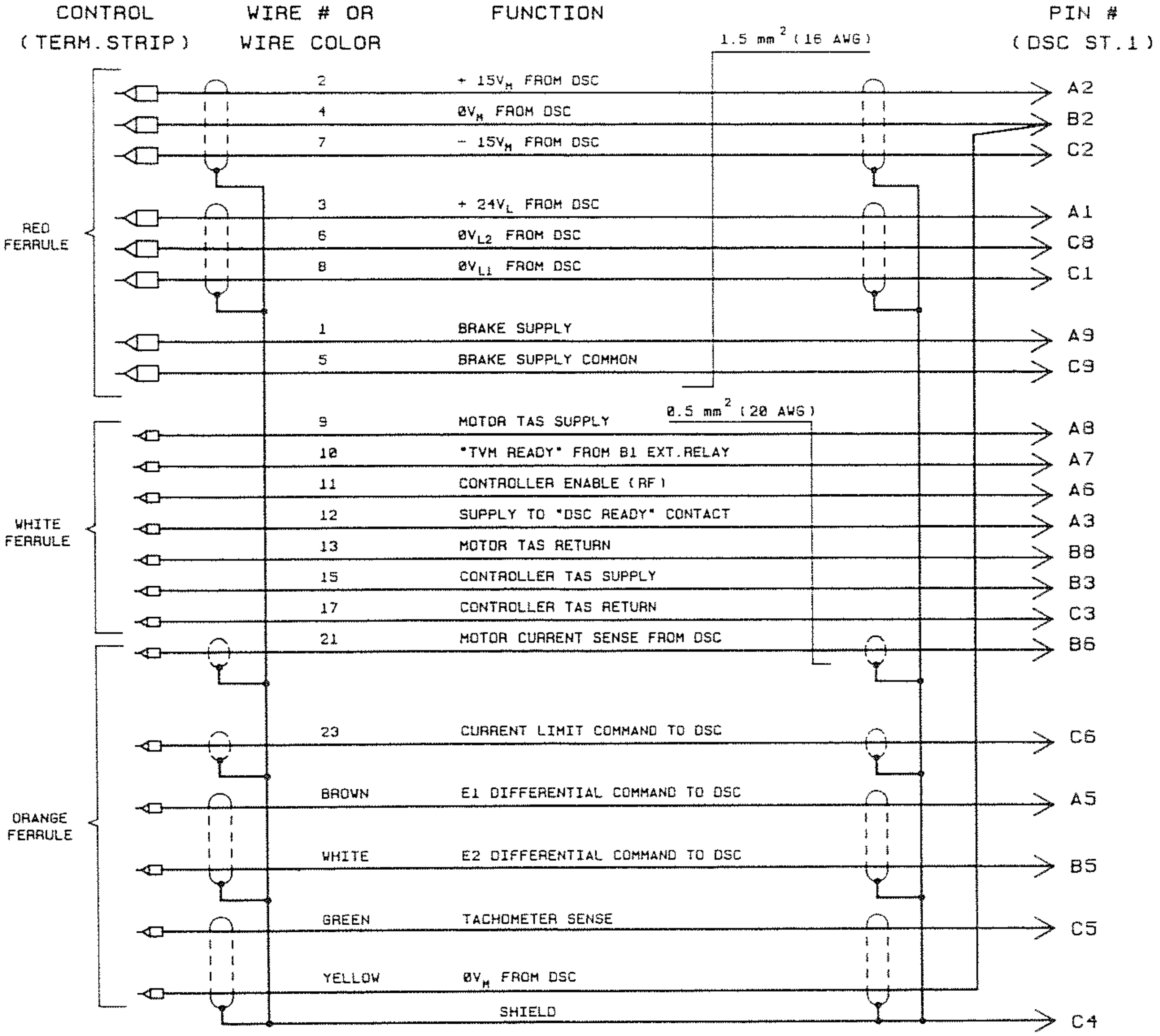
DETAIL OF IN 111
CONNECTOR



REXROTH INDRAMAT CHICAGO ILL.	DSC N.C. CABLE DSC-TERM. STRIP			Rev.	Description	Date	Init.
	DRAWING NUMBER 209-0050-4801-541A						
DRAWN BY 5-15-98 C. MARTINEZ	APPROVED BY	SCALE NTS	REVISION FOR 209-0030-4832-01A REVISED BY C. MARTINEZ	SHEET 1 OF 3			

529934

DSC-TERM. STRIP 04-0501



CABLE: 2x(3x1.5C) + 7x0.5 + 2x(2x0.34C) + 2x1.5 + 2x0.5Ce

REXROTH INDRAMAT CHICAGO ILL.	DSC N.C. CABLE DSC-TERM. STRIP			
	DRAWING NUMBER 209-0050-4801-541A			
DRAWN BY 5-15-98 C. MARTINEZ	APPROVED BY [signature]	SCALE NTS	REVISION FOR 209-0030-4832-01A REVISED BY C. MARTINEZ	SHEET 2 OF 3

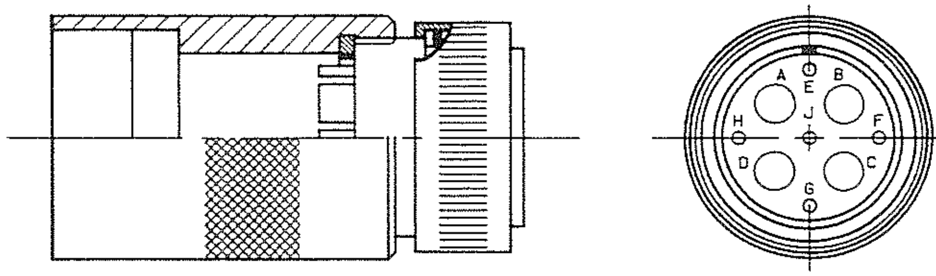
Rev.	Description	Date	Init.

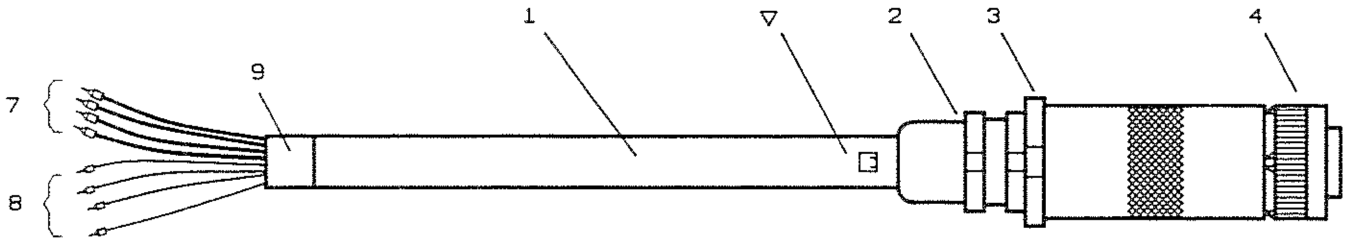
529934

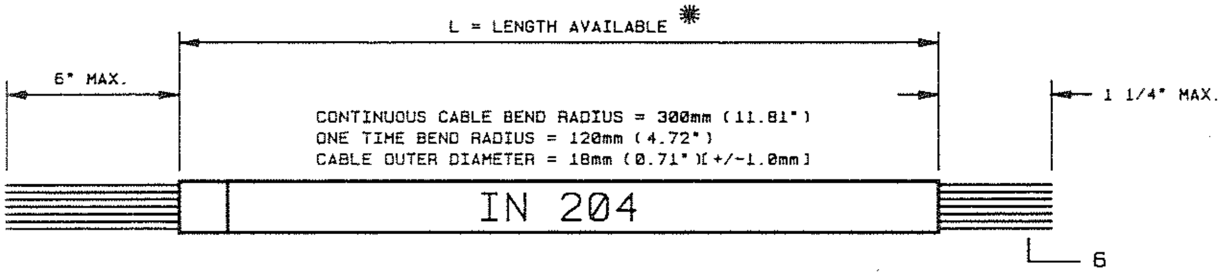
550539

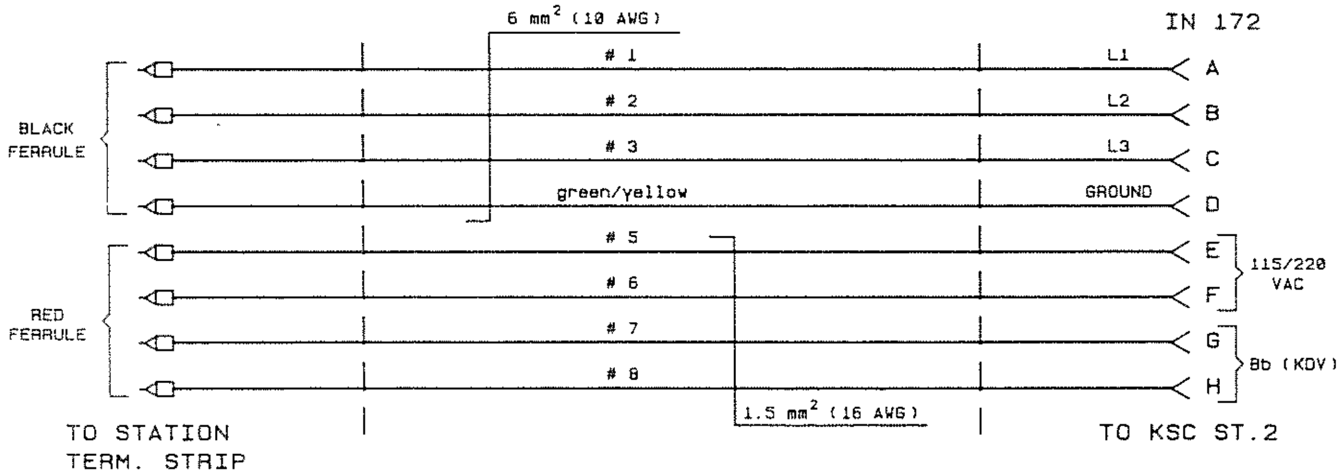
TERM STRIP-KSC 01-0500

DETAIL OF CONNECTOR IN 172









CABLE: $4 \times 6mm^2 + 2 \times (2 \times 1.5mm^2)$

⁕ MAXIMUM POWER CABLE LENGTH IS 50 METERS (164.04 FEET)

REXROTH INDRAMAT
CHICAGO ILL.

KSC POWER CABLE
TERM. STRIP-KSC

DRAWING NUMBER 209-0050-4801-00/236A

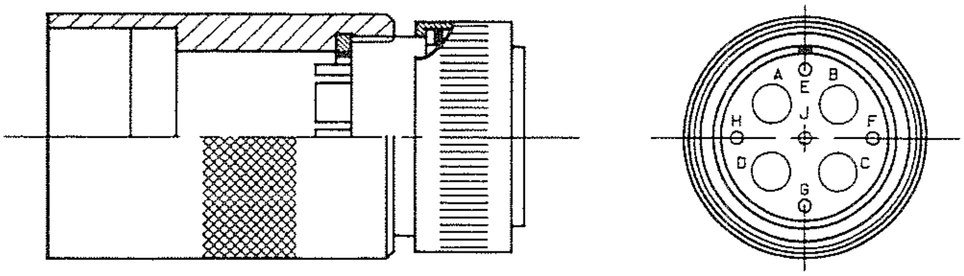
DRAWN BY 12-2-91	APPROVED BY	SCALE	REVISION FOR 209-0036-4862-00A	SHEET
D. PADILLA	(signature) 2-19-92	NTS	REVISED BY D. PADILLA	1 OF 2

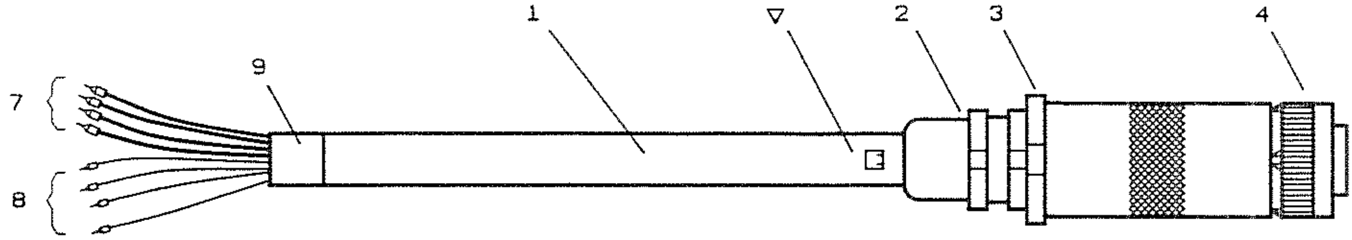
Rev.	Description	Date	Init.

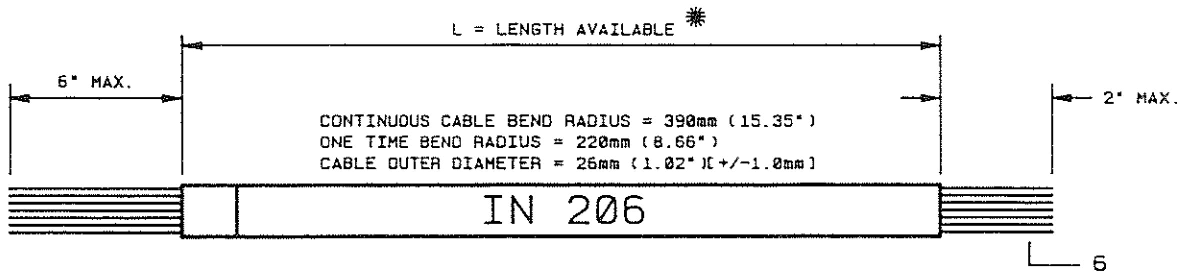
550539

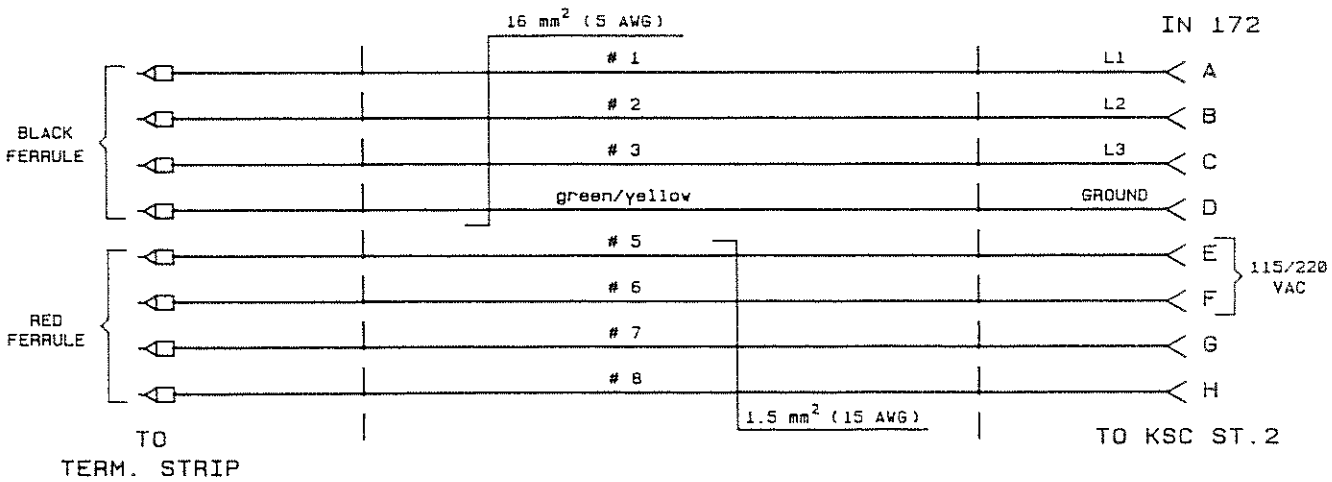
TERM STRIP-KSC 01-0520

DETAIL OF CONNECTOR IN 172







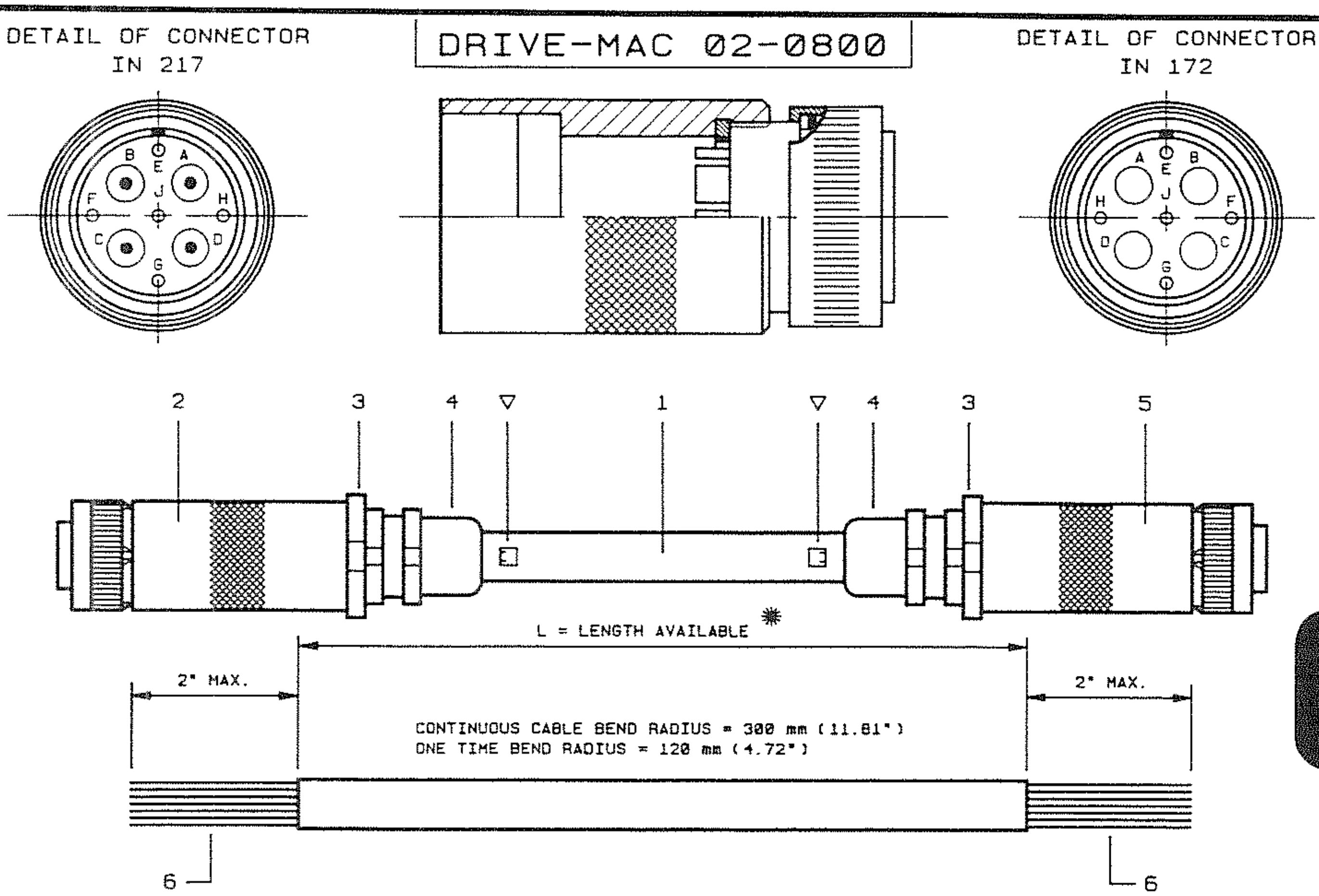


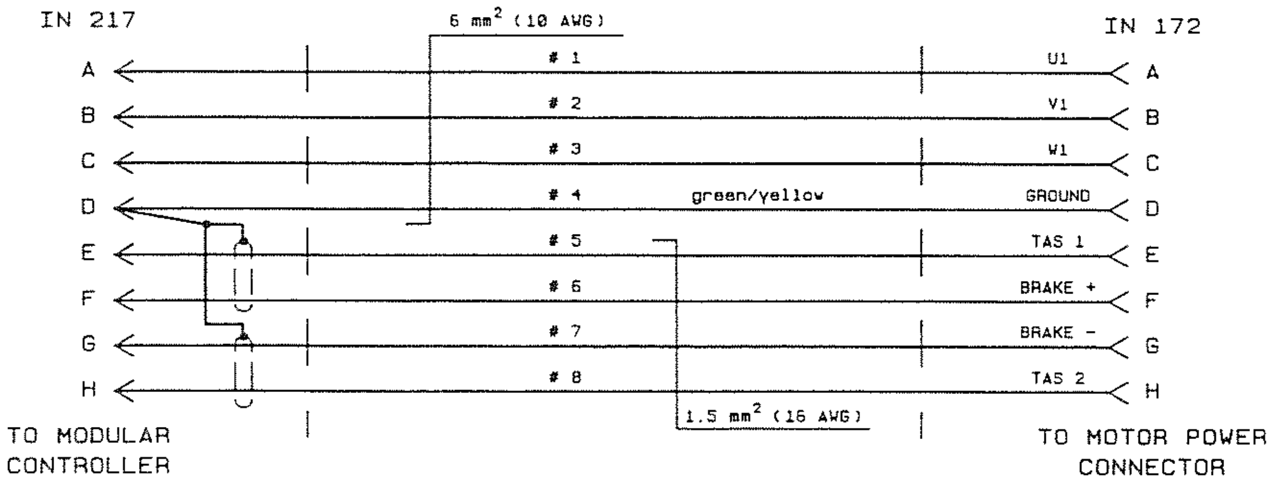
CABLE: 4x16mm² + 2x(2x1.5mm²)

⁕ MAXIMUM POWER CABLE LENGTH IS 50 METERS (164.04 FEET)

REXROTH INDRAMAT CHICAGO ILL.	KSC POWER CABLE 16mm²			
	DRAWING NUMBER 209-0050-4801-00/150A			
DRAWN BY 12-11-86 D. AVILA	APPROVED BY [signature] 2-19-92	SCALE N.T.S.	REVISION FOR / REVISED BY	SHEET 1 OF 2

Rev.	Description	Date	Init.
A	ADDED 115 VAC	FEB. 1987	DRAS
B	CHANGED DRAWING NUMBER	AUG. 9-91	D.P.
C	ADDED ITEM 9 AND CABLE INFO.	DEC. 2-91	D.P.





CABLE: 4 x 6 mm² + 2 x (2x1.5 mm²)

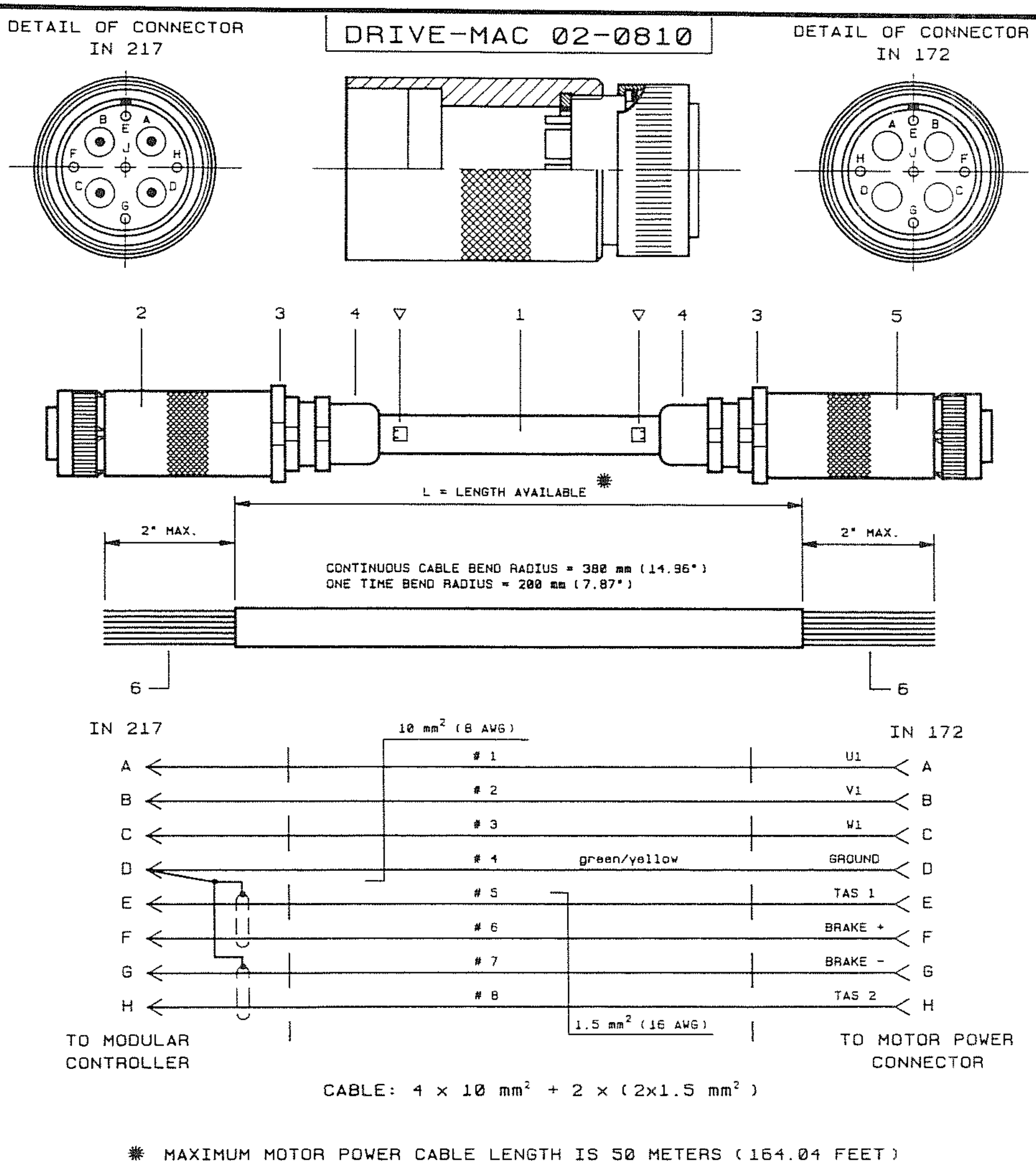
✱ MAXIMUM MOTOR POWER CABLE LENGTH IS 50 METERS (164.04 FEET)

D

REXROTH INDRAMAT CHICAGO ILL.		MOTOR POWER CABLE			
		DRAWING NUMBER	209-0050-4801-00/103A		
DRAWN BY 6-06-90 C. MARTINEZ	APPROVED BY [signature]	SCALE N.T.S.	REVISION FOR 209-0030-4061-01A REVISED BY C. MARTINEZ	SHEET 1 OF 2	

Rev.	Description	Date	Init.

528934



REXROTH INDRAMAT

CHICAGO ILL.

MOTOR POWER CABLE

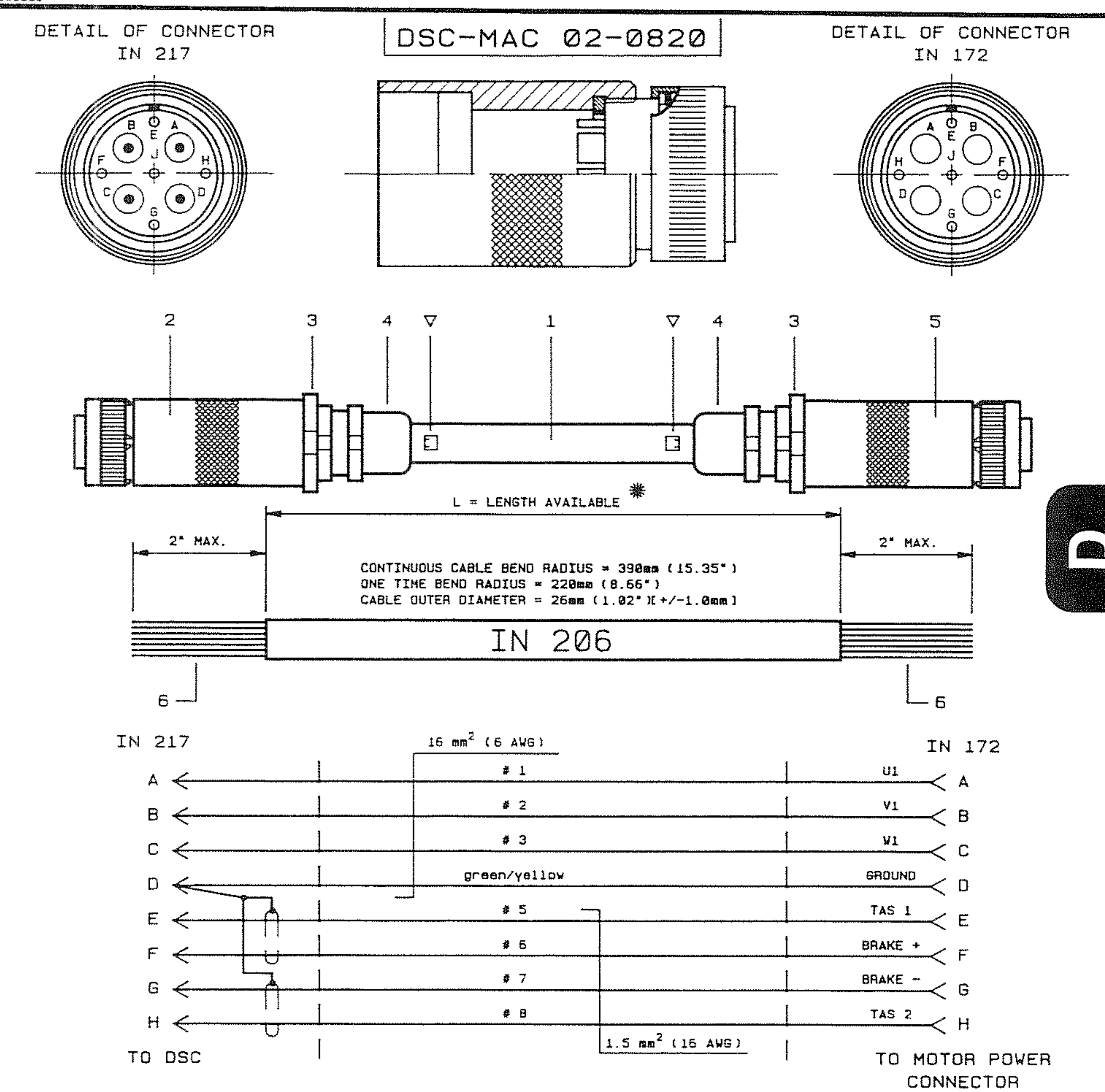
DRAWING NUMBER 209-0050-4801-00/123A

DRAWN BY 06-06-98	APPROVED BY	SCALE	REVISION FOR 209-0030-4862-01A	SHEET
C. MARTINEZ	(W h)	N.T.S.	REVISED BY C. MARTINEZ	1 OF 2

Rev.	Description	Date	Init.

529934

550539



CABLE: $4 \times 16mm^2 + 2 \times (2 \times 1.5mm^2)$

✱ MAXIMUM MOTOR POWER CABLE LENGTH IS 75 METERS (246 FEET)

REXROTH INDRAMAT
CHICAGO ILL.

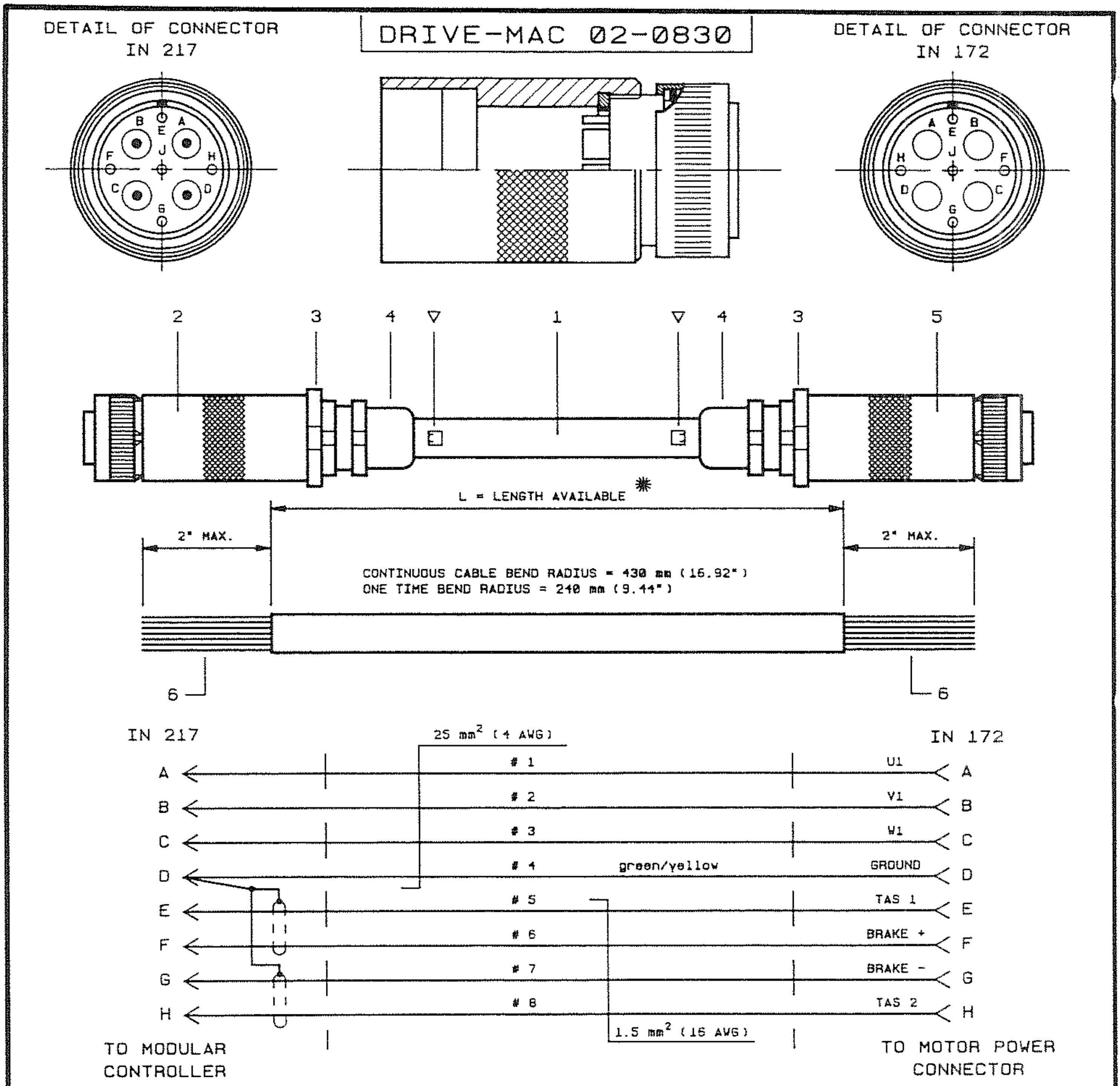
MOTOR POWER CABLE DSC-MAC

DRAWING NUMBER: 209-0050-4801-00/143A

DRAWN BY 06-06-90	APPROVED BY	SCALE	REVISION FOR 209-0030-4063-01A	SHEET
C. MARTINEZ	GC JN 2-19-92	N.T.S.	REVISED BY C. MARTINEZ	1 OF 2

Rev.	Description	Date	Init.
A	ADDED CABLE INFO.	DEC. 3-91	D.P.

D



CABLE: 4 x 25 mm² + 2 x (2x1.5 mm²)

✱ MAXIMUM MOTOR POWER CABLE LENGTH IS 50 METERS (164.04 FEET)

REXROTH INDRAMAT CHICAGO ILL.	MOTOR POWER CABLE			
	DRAWING NUMBER 209-0050-4801-00/163A			
DRAWN BY 06-06-98 C. MARTINEZ	APPROVED BY (signature)	SCALE NTS	REVISION FOR 209-0030-4804-01A REVISED BY C. MARTINEZ	SHEET 1 OF 2

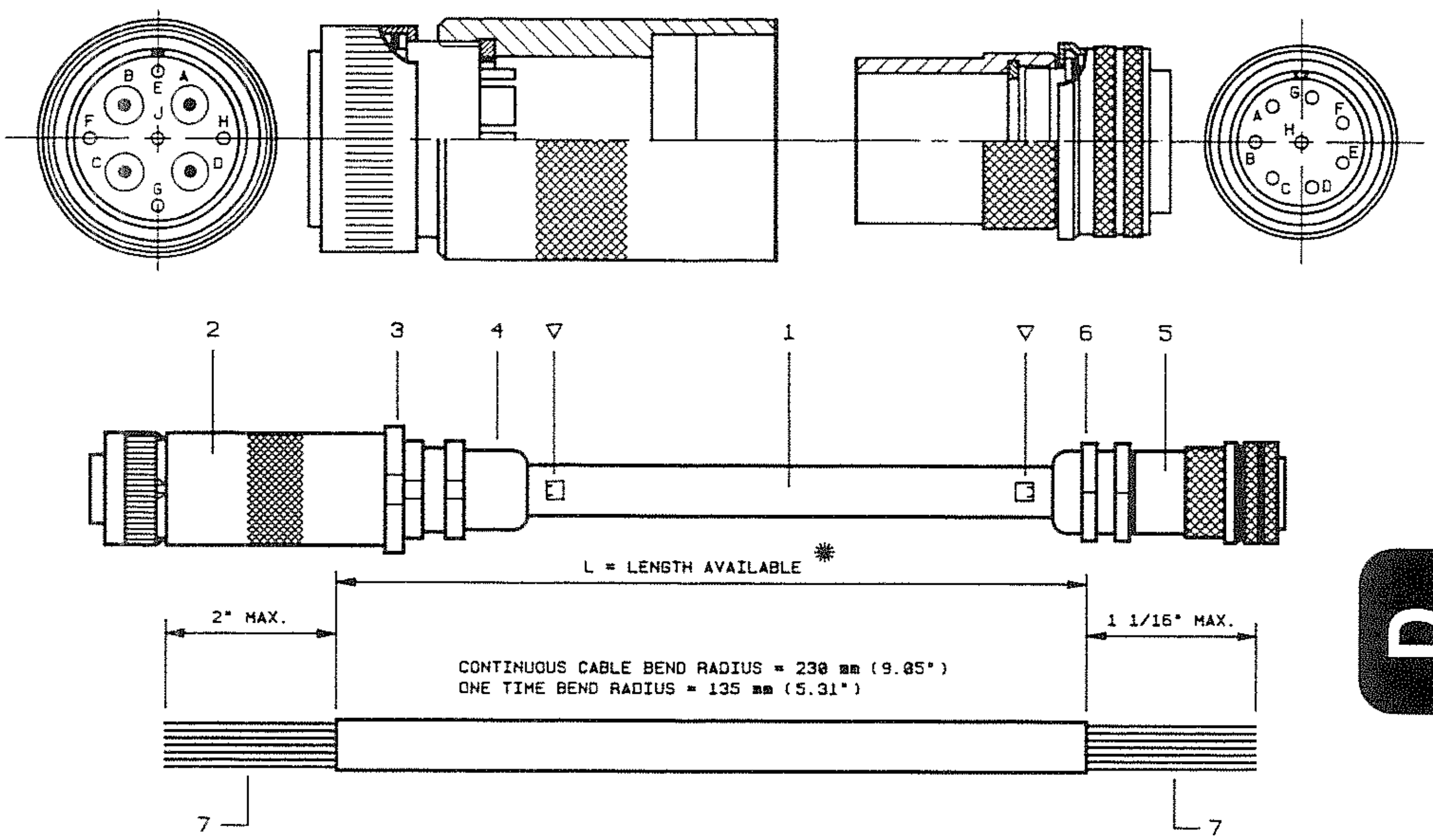
Rev.	Description	Date	Init.

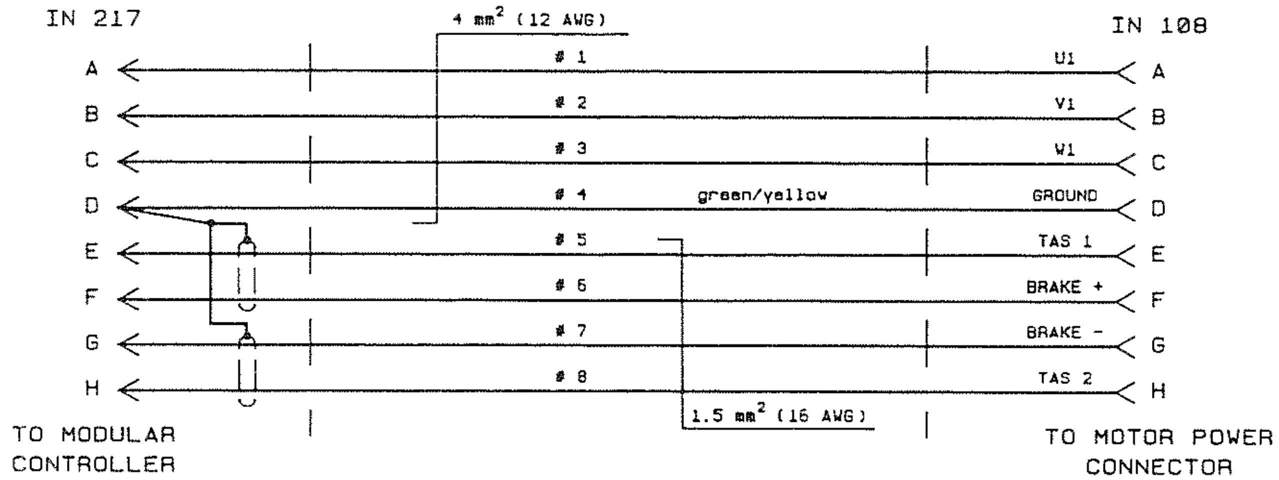
529934

DETAIL OF CONNECTOR IN 217

DRIVE-MAC 02-0840

DETAIL OF CONNECTOR IN 108





CABLE: 4 x 4 mm² + 2 x (2x1.5 mm²)

⁕ MAXIMUM MOTOR POWER CABLE LENGTH IS 50 METERS (164.04 FEET)

REXROTH INDRAMAT
CHICAGO ILL.

MOTOR POWER CABLE

DRAWING NUMBER 209-0050-4801-00/068A

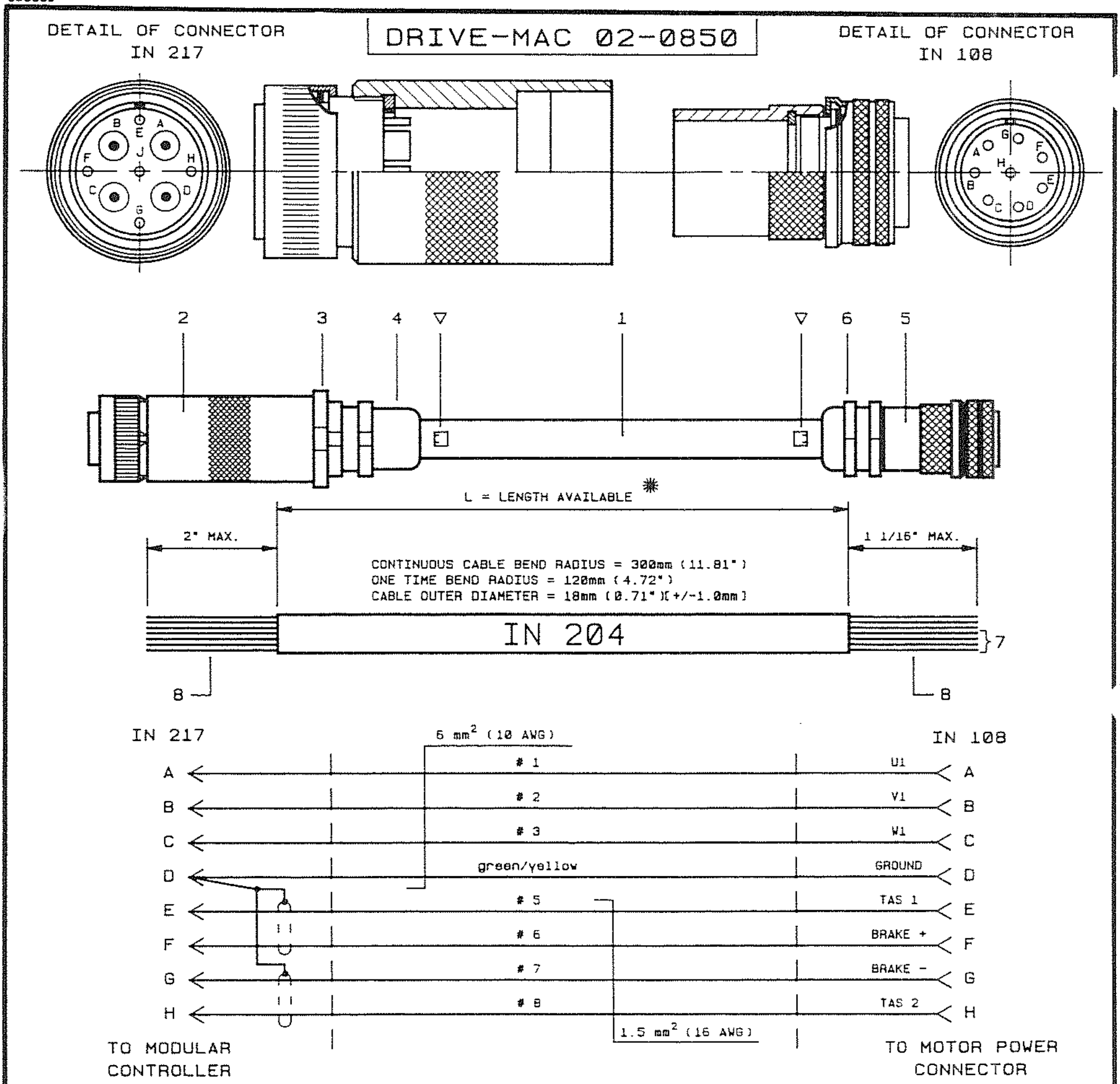
DRAWN BY 06-06-98	APPROVED BY	SCALE	REVISION FOR 209-0030-4878-00A	SHEET
C. MARTINEZ	[signature]	N.T.S.	REVISED BY C. MARTINEZ	1 OF 2

Rev.	Description	Date	Init.

529934

D

550539



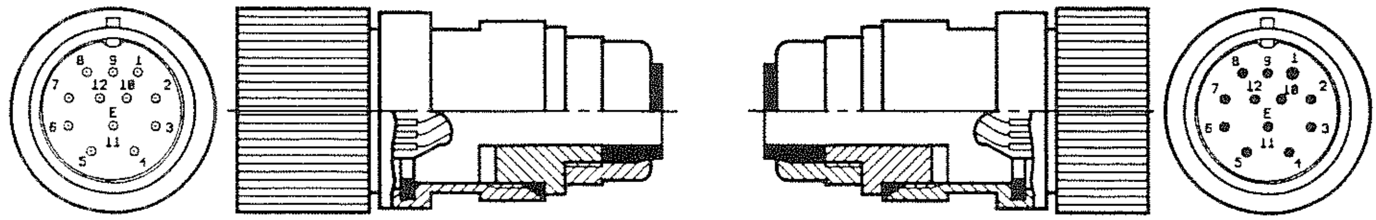
CABLE: 4x6mm² + 2x(2x1.5mm²)

⁕ MAXIMUM MOTOR POWER CABLE LENGTH IS 75 METERS (246 FEET)

REXROTH INDRAMAT CHICAGO ILL.	MOTOR POWER CABLE DRIVE-MAC				
	DRAWING NUMBER	209-0050-4801-00/086A			
DRAWN BY 05-05-90 C. MARTINEZ	APPROVED BY [handwritten] 2-19-92	SCALE N.T.S.	REVISION FOR / REVISED BY	SHEET 1 OF 2	

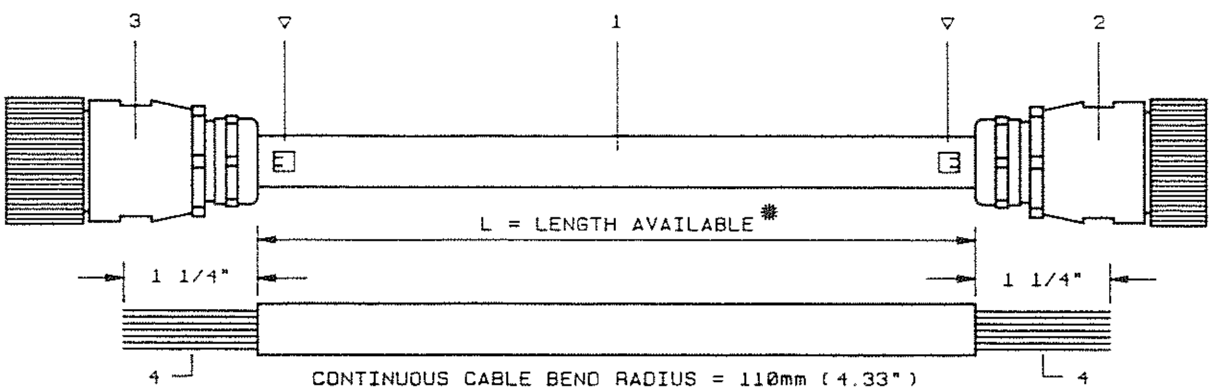
Rev.	Description	Date	Init.
A	ADDED WIRE PINS AND CABLE INFO.	DEC. 4-91	D.P.

DSC OR KSC-MAC 03-0100



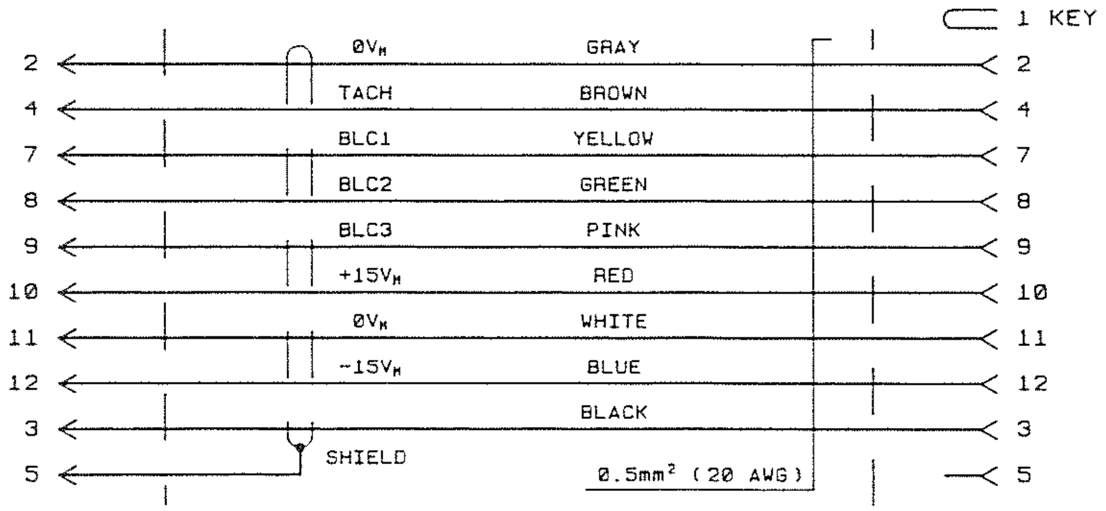
DETAIL OF IN 105 CONNECTOR
12 PIN MALE

DETAIL OF IN 102 CONNECTOR
12 PIN FEMALE KEY ON 1



TO DSC OR KSC
ST.4 CONNECTOR

TO MOTOR ST.A
CONNECTOR



NOTES:

1) THE BLACK WIRE MUST BE LEFT LONG ENOUGH INSIDE THE CONNECTOR SO THAT IF IT IS NEED IT CAN BE CONNECTED/INSULATE WITH HEAT SHRINK TUBING.

❋ MAXIMUM MOTOR FEEDBACK CABLE LENGTH IS 75 METERS (246 FEET) FROM AMPLIFIER TO MOTOR.

REXROTH INDRAMAT
CHICAGO ILL.

MOTOR FEEDBACK CABLE

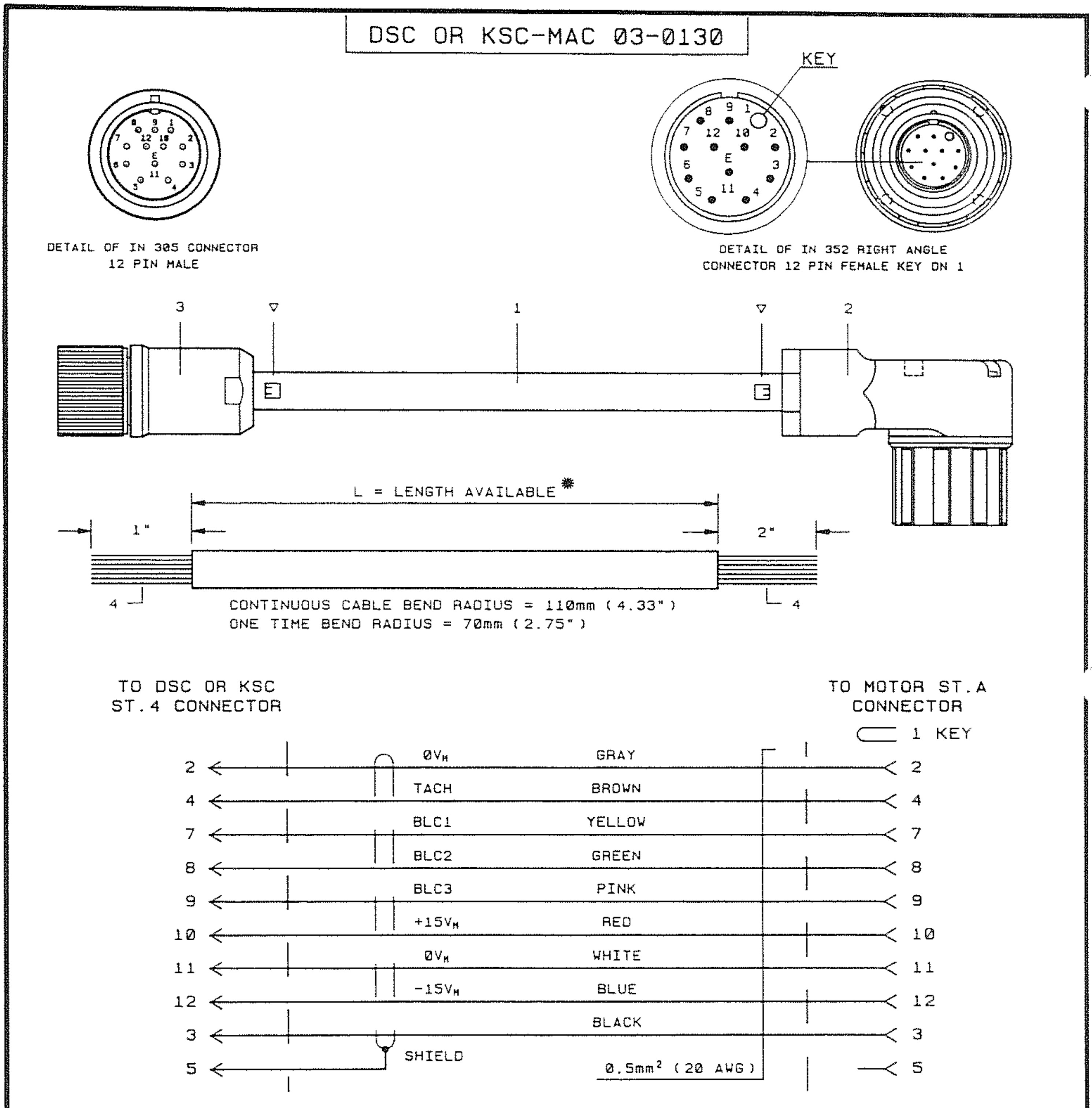
DRAWING NUMBER 209-0050-4801-00/257A

DRAWN BY 5-29-98 C. MARTINEZ
APPROVED BY [signature]
SCALE NTS
REVISION FOR 209-0030-4814-02A
REVISED BY C. MARTINEZ
SHEET 1 OF 2

Rev.	Description	Date	Init.

528934

D



* MAXIMUM MOTOR FEEDBACK CABLE LENGTH IS 75 METERS (246 FEET) FROM AMPLIFIER TO MOTOR.

REXROTH INDRAMAT
CHICAGO ILL.

MOTOR FEEDBACK CABLE WITH RIGHT ANGLE

DRAWING NUMBER 209-0050-4801-00/260A

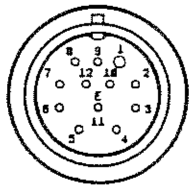
DRAWN BY 11-3-87	APPROVED BY	SCALE	REVISION FOR / REVISED BY	SHEET
D. AVILA	AL M	NTS		1 OF 2

Rev.	Description	Date	Init.
D	ADDED DRWG. #	MAY 29 98	CK

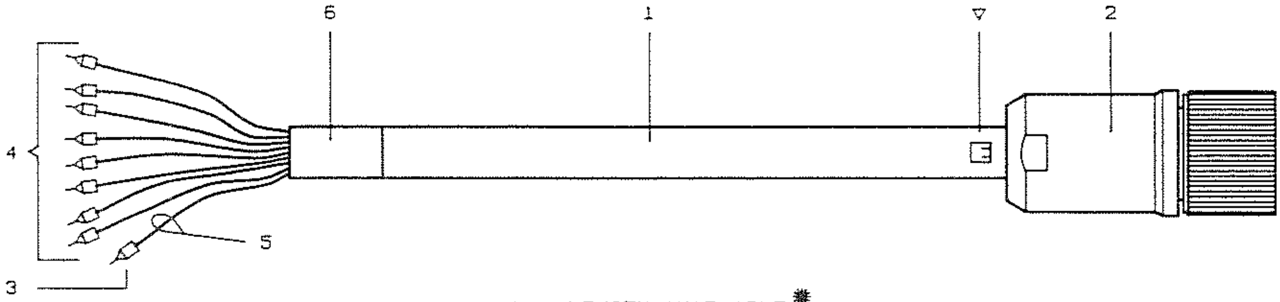
529034

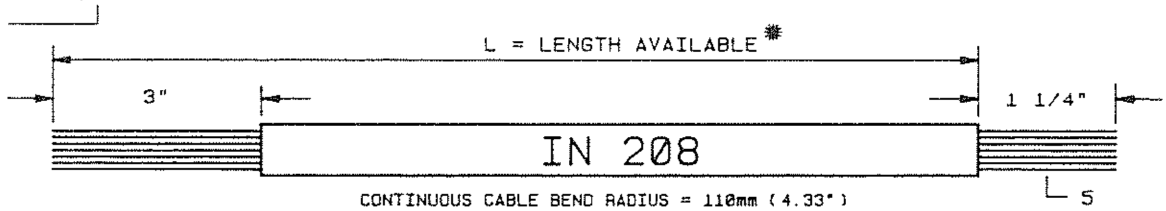
550539

MODULAR DRIVE-MAC 03-0200

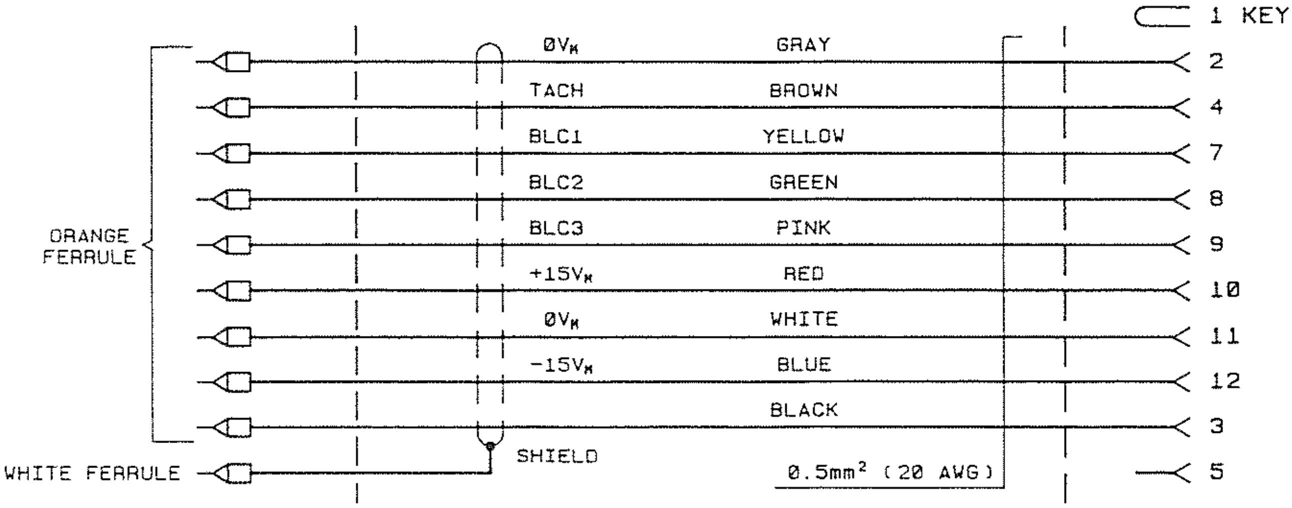


DETAIL OF IN 302 CONNECTOR
12 PIN FEMALE KEY ON 1





CONTINUOUS CABLE BEND RADIUS = 110mm (4.33")
ONE TIME BEND RADIUS = 70mm (2.75")
CABLE OUTER DIAMETER = 8.8mm (0.35")(+/- 0.3mm)



NOTES:

CABLE: (9x0.5mm²)

1) THE BLACK WIRE MUST BE LEFT THE SAME LENGTH AS ALL OTHER CONDUCTORS AND INSULATED WITH HEAT SHRINK TUBING OVER FERRULE.

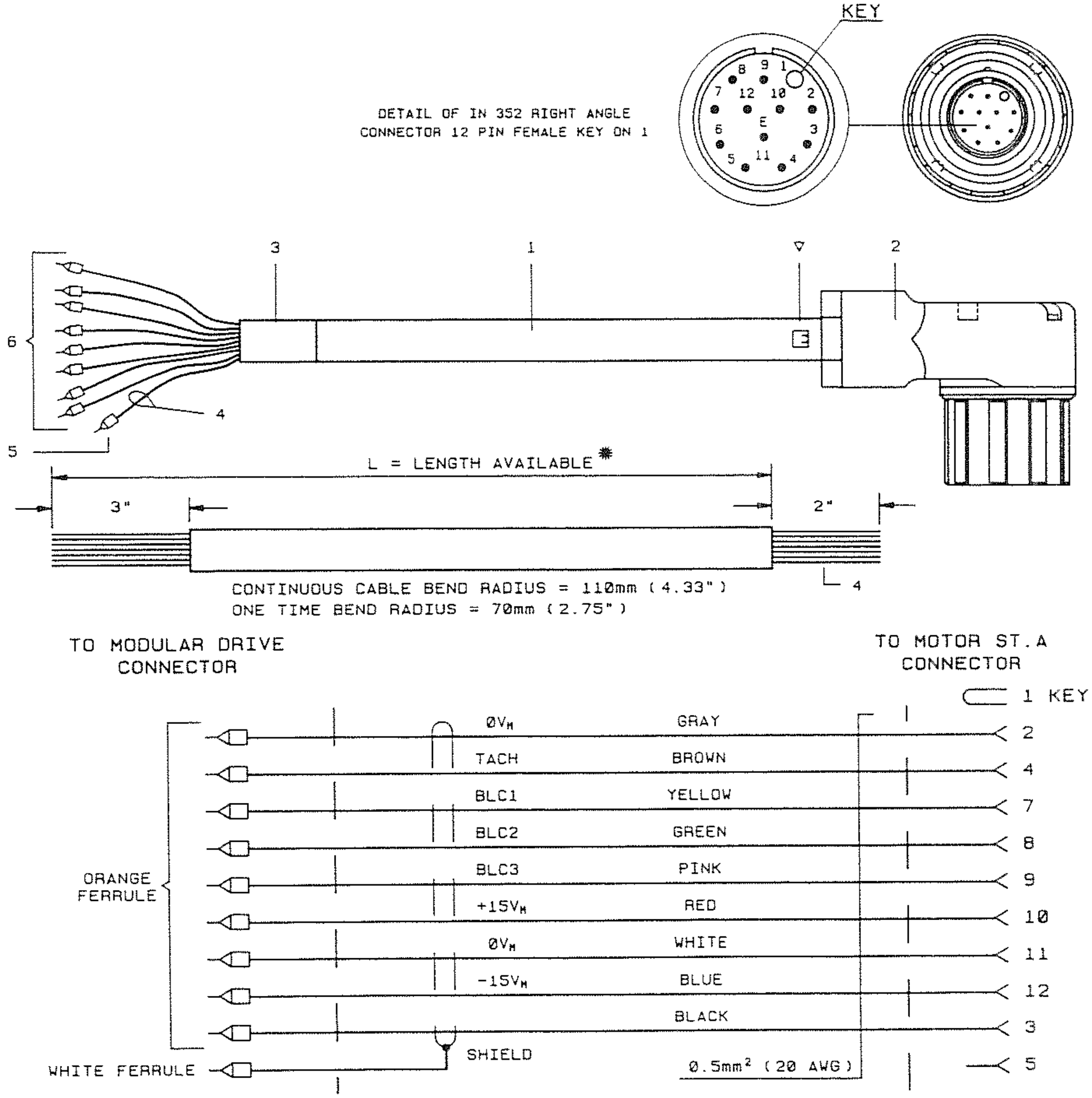
✱ MAXIMUM MOTOR FEEDBACK CABLE LENGTH IS 75 METERS (246 FEET) FROM AMPLIFIER TO MOTOR.

REXROTH INDRAMAT CHICAGO ILL.	MOTOR FEEDBACK CABLE
	DRAWING NUMBER 209-0050-4801-00/251A
DRAWN BY 8-12-91 D. PADILLA	APPROVED BY (signature) 2-19-92
SCALE N.T.S.	REVISION FOR 209-0020-4802-47A REVISED BY D. PADILLA
SHEET 1 OF 2	

Rev.	Description	Date	Init.
A	CHANGED CONNECTOR TYPE	DEC. 4-91	D.P.

D

MODULAR DRIVE-MAC 03-0230



NOTES:

1) THE BLACK WIRE MUST BE LEFT THE SAME LENGTH AS ALL OTHER CONDUCTORS AND INSULATED WITH HEAT SHRINK TUBING.

✱ MAXIMUM MOTOR FEEDBACK CABLE LENGTH IS 75 METERS (246 FEET) FROM AMPLIFIER TO MOTOR.

REXROTH INDRAMAT
CHICAGO ILL.

MOTOR FEEDBACK CABLE WITH RIGHT ANGLE

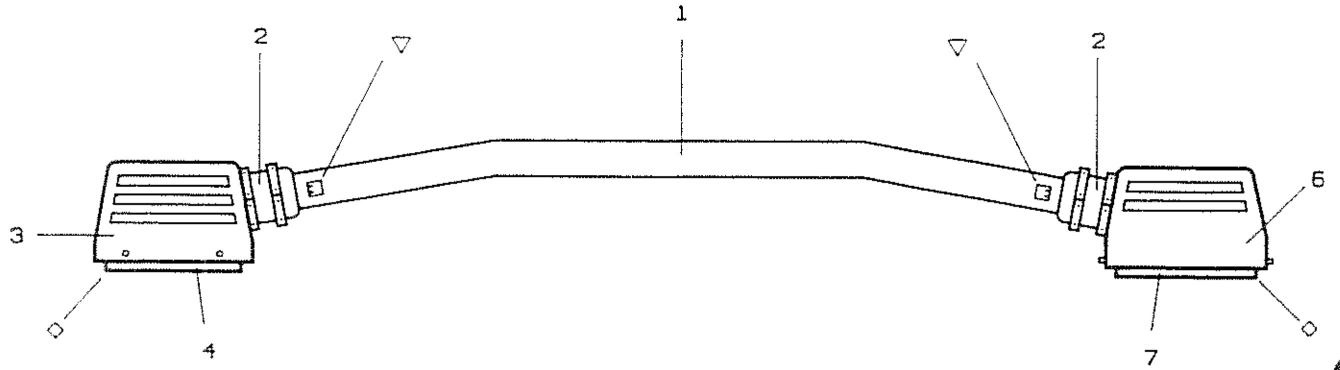
DRAWING NUMBER 209-0050-4801-00/259A

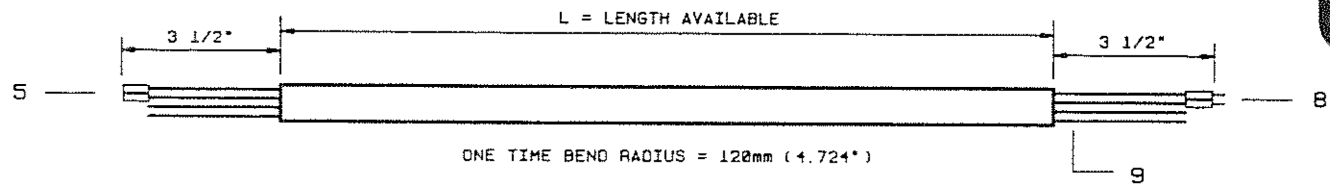
DRAWN BY 11-24-87	APPROVED BY	SCALE	REVISION FOR / REVISED BY	SHEET
D. AVILA	ai m	NTS		1 OF 2

Rev.	Description	Date	Init.
A	REDRAWN	NOV 87	DA
B	SEE PAGE 2	MAR 89	DA
C	REPLACED CONN. IN 102.	2/28 98	CM

529934

TRANS-DSC/KSC 04-0101

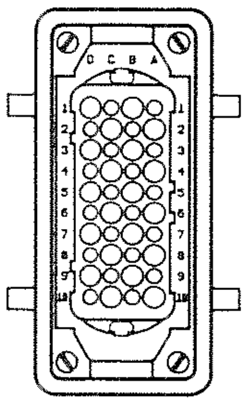




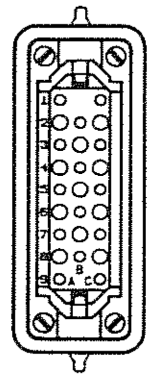
TO TRANS ST.2
CONNECTOR

TO DSC ST.1
CONNECTOR

DETAIL OF IN 113
CONNECTOR



DETAIL OF IN 111
CONNECTOR



REXROTH INDRAMAT
CHICAGO ILL.

DSC N.C. CABLE

Rev.	Description	Date	Init.

DRAWING NUMBER 209-0050-4801-00/540A

DRAWN BY 5-14-90	APPROVED BY	SCALE	REVISION FOR 209-0030-4816-03A	SHEET
C. MARTINEZ	[signature]	NTS	REVISED BY C. MARTINEZ	1 OF 3

529934

TRANS-DSC/KSC 04-0101

PIN # (DSC ST.1)	WIRE # OR WIRE COLOR	FUNCTION	PIN # (TRANS 01 ST.2)
A2	2	+ 15V_M FROM DRIVE	D10
B2	4	0V_M FROM DRIVE	D9
C2	7	- 15V_M FROM DRIVE	C10
A1	3	+ 24V_L FROM DRIVE	D3
C8	6	0V_{L2} FROM DRIVE	A3
C1	8	0V_{L1} FROM DRIVE	B10
A9	1	BRAKE SUPPLY	A9
C9	5	BRAKE SUPPLY COMMON	A10
A8	9	SERVO MOTOR TAS SUPPLY	D1
A7	10	"DRIVE READY" FROM B1 EXT.RELAY	D5
A6	11	CONTROLLER ENABLE (RF)	B2
A3	12	SUPPLY TO "DRIVE READY" CONTACT Bb1	B1
B8	13	SERVO MOTOR TAS RETURN	C3
B3	15	SERVO CONTROLLER TAS SUPPLY	D2
C3	17	SERVO CONTROLLER TAS RETURN	D4
B6	21	MOTOR CURRENT SENSE FROM DRIVE	D8
C6	23	CURRENT LIMIT COMMAND TO DRIVE	B8
A5	brown	E1 DIFFERENTIAL COMMAND TO DRIVE	D6
B5	white	E2 DIFFERENTIAL COMMAND TO DRIVE	C6
C5	green	TACH. SENSE	D7
B2	yellow	0V_M FROM DRIVE	B7
C4		SHIELD	

Wires 2–9: 1.5 mm^2 (16 AWG); wires 9–23: 0.5 mm^2 (20 AWG); brown–yellow: 0.34 mm^2 (20 AWG)

CABLE: 2x(3x1.50)+7x0.5+2x(2x0.340)+2x1.5+2x0.5Ce

REXROTH INDRAMAT CHICAGO ILL.	DSC N.C. CABLE			
	DRAWING NUMBER 209-0050-4801-00/540A			
DRAWN BY 5-14-90 C. MARTINEZ	APPROVED BY [signature]	SCALE NTS	REVISION FOR 209-0030-4816-03A REVISED BY C. MARTINEZ	SHEET 2 OF 3

Rev.	Description	Date	Init.

529934

DSC 3.1 AMPLIFIER

DSC 3.1-100-115

1. DSC = Model Name
2. Series = 3
3. Version = 1
4. Current Designation:
   - 30 = 30 Amps
   - 50 = 50 Amps
   - 100 = 100 Amps
   - 150 = 150 Amps
5. Control Voltage:
   - 115 = 115 VAC Control Voltage
   - 220 = 220 VAC Control Voltage

Also required: A personality module number should be included in the order of a DSC 3.X (MOD 15/MOD16). In the absence of the number, the model number of the motor with which it will be used is required.

The Rexroth Corporation, Indramat Division

Main Office
5150 Prairie Stone Parkway
Hoffman Estates, IL 60192
Tel: (847) 645-3600
FAX: (847) 645-3692

Rexroth/Indramat Technical Center
2110 Austin Avenue
Rochester Hills, MI 48309
Tel: (810) 853-8290
FAX: (810) 853-8298

PART NO. 400030

mannesmann technology