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DCX-PC100

Modular Multi-Axis Motion Control Card

User's Manual
Revision 3.2a

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I **DCX-MF300** RS-232 Communication Interface Module
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1.0 INTRODUCTION

This document describes the installation and use of the **DCX-PC** Modular Multi-Axis Motion Controller. The **DCX-PC** is capable of controlling both servos and stepper motors interfaced to it.

The term **DCX-PC** is used to refer to a system consisting of from 1 to 9 circuit boards assembled together in order to form a single unit. The main circuit board, the "motherboard", is approximately 5" x 13" in overall size. On this motherboard, up to 8 smaller "daughterboards" or "modules" can be installed. There are numerous module types available which allow the **DCX-PC** to be configured for specific applications.

A key feature of the **DCX-PC** system is its ability to automatically determine what modules are present. This results in easy system configuration, simply install whatever modules the application calls for. The logic on the motherboard will adjust its operation accordingly.

In a typical application, the **DCX-PC** will be installed in a host computer such as an IBM-AT. The host computer will run an application program that issues motion commands to the DCX. Computer logic in the **DCX-PC** is programmed to interpret and execute these commands independent of the host. It is also possible to combine commands to form "macro commands". This provides the user with a powerful tool for implementing various control requirements.

If necessary, multiple **DCX-PC's** can be installed in a single host computer for applications that require more than 8 modules. In other applications where a host computer is not required, the **DCX-PC** can be operated in a stand-alone manner.

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1.1 DCX-PC SPECIFICATIONS

Function:	8 Axis Motion Controller
Installation:	IBM-AT or Compatible or Standalone
Configuration:	8 User Installed Modules

Motherboard:

Main Processor:	Mitsubishi M50734
Processor Clock:	7.3 MHZ
Code Memory:	32k x 8 EPROM
Data Memory:	32k x 8 bit Dual Ported Ram (non-vol. optional)
Undedicated Digital I/O Channels:	16 (TTL level)
Undedicated Analog Input Channels:	4, 8 bit resolution (0 - 5 vdc)
Standard Communication Interface:	ISA Bus (IBM-AT or Compatible)
Optional Communication Interfaces:	RS-232 Serial Port (Network capable) IEEE-488 Bus
ISA Bus Interface:	4 Kilobytes dual ported memory in Memory Address Space, rotary switch selection of base address
Required Supply Voltages:	+5,+12 and -12 vdc
Form Factor:	Full Size PC card (4.3" x 13.6")
Weight:	10 oz + 1.2 oz per module (approx.)

Servo Modules: (DCX-MC100,DCX-MC105,DCX-MC110,DCX-MC120, DCX-MC200,DCX-MC210 pending)

Function:	Closed Loop Servo Control module (DCX-MC1XX) Closed Loop Servo Control module with Aux. Encoder (DCX-MC2XX)
Operating Modes:	Position, Velocity (MC1XX & MC2XX) Torque and Gain (MC2XX)
Filter Algorithm:	PID (MC1XX) PID with Velocity and Acceleration Feed-Forwards (MC2XX)
Filter Update Rate:	3.3 KHz (MC1XX) 1 KHZ (MC2XX)
Trajectory Generator:	Trapezoidal with Independent Accel. and Decel. (MC200) Trapezoidal (MC1XX)
Position Feedback:	Dual Incremental Encoder with Index (MC2XX) Single Incremental Encoder with Index (MC1XX)

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DCX-PC SPECIFICATIONS (cont.)

Servo Modules (cont.)

Output: Analog Signal:	+/- 10 vdc @ 10 ma, 12 bit (MC100, MC200) +10 vdc @ 10 ma with direction (MC105) +12 vdc @ .500 amp (MC110,MC210) TTL level PWM with direction (DCX-MC120)
Encoder and Index Inputs:	Differential or single ended, -7 to +7 vdc max.
Encoder Supply Voltage:	+5 or +12 vdc, user configurable
Encoder Count Rate:	750,000 Quadrature Counts / Sec. (MC1XX) 1,360,000 Quadrature Counts / Sec. (MC2XX)
Position and Velocity Resolution:	32 bit
Joystick Control Input:	Analog (0 to 5 volts, 8 bit) (MC2XX)
Jog Control Input:	Analog (switched 0 or 5 volts) (MC1XX)
Other Outputs:	Amplifier Enable (TTL compatible)
Other Inputs:	Limit+, Limit-, Coarse Home, Amplifier Fault, optical isolation available on BF100 interconnect board) 2 User Inputs-TTL compatible (MC2XX)

Stepper Motor Modules: (DCX-MC150,DCX-MC160,DCX-MC260)

Function: Open Loop Stepper Motor Control module (MC150)
Open Loop Stepper Motor Controller with Aux. Encoder (MC160,MC260)

Stepper Operating Modes:	Position and Velocity
Trajectory Generator:	Trapezoidal (MC150,MC160) Trapezoidal with Independent Acceleration and Deceleration (MC260)
Step Outputs:	Pulse and Direction, or CW and CCW Step (Open Collector Drivers) 50% Duty Cycle (MC260)
Step Rates:	20 Steps/Sec - 20.0K Steps/Sec (MC150,MC160)
Software Selectable: (DCX-MC260)	
High Speed Range:	1.0K Steps/Sec - 1.25M Steps/Sec
Medium Speed Range:	125 Steps/Sec - 156K Steps/Sec
Low Speed Range:	15 Steps/Sec - 19.5K Steps/Sec
Auxiliary Encoder Input:	Incremental Encoder with Index (MC160,MC260)
Encoder and Index Inputs:	Differential or single ended, -7 to +7 vdc max.
Encoder Supply Voltage:	+5, or +12

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Stepper Motor Modules (cont.)

Encoder Count Rate:	1,000,000 Quadrature Counts / Sec. (MC160) 1,360,000 Quadrature Counts / Sec. (MC260)
Resolution:	32 bit position, 8 bit velocity (MC150,MC160) 32 bit position, 32 bit velocity (MC260)
Joystick Control Input:	Analog (0 to 5 volts, 8 bit) (MC260)
Jog Control Input:	Analog (switched 0 or 5 volts) (MC150,MC160)
Other Outputs:	Motor On, Full/Half Step, Full/Half Current, Stopped (all TTL compatible)
Other Inputs:	Home, Limit+, Limit-, Coarse Home, Null (all TTL compatible, optical isolation available on BF160 interconnect board)

Digital I/O Modules:

Function: 16 Individually programmable inputs or outputs (TTL level)

Analog I/O Modules:

Function: 4 Analog inputs and 4 Analog Outputs

Input Resolution:	12 bits
Input Range:	0 to 5 VDC
Output Resolution:	12 bits
Output Range:	0 to 5 VDC, or -10 to 10 VDC
Output Offset Adjustment:	20 turn trim pot
Output Full Scale Adjustment:	single turn trim pot

RS-232 Communications Interface Module:

Function: RS-232 Serial Port for ASCII Commands

Baud Rates:	300 - 19,200
Handshake Protocol:	Hardware or XON-XOFF

IEEE-488 Communications Interface Module:

Function: IEEE-488 Bus Interface for ASCII Commands

Address Selection:	DIP switch on module
Data Bus Drivers:	Push-Pull or Open Collector

1.2 OVERVIEW

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This manual covers the installation and use of the **DCX-PC** Motion Controller.
Chapter 1 includes an introduction and specification of the controller, this overview of the manual, and a theory of operation.

Chapter 2 covers installation of the **DCX**, and includes sections for each of the available plug in modules.

Chapter 3 describes the different communication interfaces of the **DCX**.

Chapter 4 describes the basic operation of the **DCX-PC** including macro commands. Chapter 5 describes servo operation, and chapter 6 describes stepper motor operation, while chapter 7 describes specific motion functions common to both servo and stepper motors.

Chapters 8 and 9 cover the 'undedicated' digital and analog I/O available on the **DCX**.

Chapter 10 explains the User Registers on the controller, and how to access motor data using Read and Write commands.

Chapter 11 contains a complete reference for all of the **DCX-PC** commands available to the user.

Appendix A includes a summary listing of the **DCX-PC** commands, and a cross reference showing which commands are valid for the different types of modules installed on the **DCX.**

Appendix B details the purpose and location of the indicators, connectors and jumpers on the **DCX-PC** motherboard.

Appendices C, D, E, F, G, H, I, and J include details on the available plug-in modules, including signal descriptions, jumpers, connectors, and physical layouts. Appendices K, L and M cover the interface and interconnect boards available.

Appendix N provides details about the **DCX**'s dual ported memory. Appendix O describes the **DCX-PC** Binary Command Interface for communicating with a host computer. Appendix P lists the power supply requirements for the **DCX-PC** motherboard and modules. And appendix Q lists the default settings of motor data in the controller and error codes returned by the command interpreter.

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1.3 THEORY OF OPERATION

The **DCX-PC** motherboard contains a 8 bit micro controller which is programmed to perform motion control tasks. Specially designed servo or stepper motor control modules are installed on the motherboard to configure it for controlling from 1 to 8 servos or stepper motors. Each module installed on the motherboard provides the circuitry to control one motor.

The motherboard processor implements a trajectory generator which calculates the desired position and velocity of each servo or stepper motor at fixed time intervals. These values are sent to the respective servo or stepper module installed on the motherboard. Each servo or stepper module has a processor which is programmed to provide the appropriate control of the servo or stepper motor interfaced to the module.

Servo Control

The servo modules uses a position feedback loop (DCX-MC1XX modules) or a velocity feed-forward and a position feedback loop (DCX-MC2XX only) to control the servo. The modules provide a control signal output to an external servo amplifier (no amplifier required when using the DCX-MC110). An incremental encoder input to the module provides feedback information for closing the position loop. In operation, the servo module subtracts the actual position (feedback position) from the desired position (trajectory generator position), and the resulting position error is processed by the digital filter on the module. The output of the digital filter and the velocity feed-forward are combined to set the modules control signal output. The external amplifier uses this signal to drive the motor to the desired position.

The module processor monitors the motor's position via an incremental encoder. The two quadrature signals from the encoder are used to keep track of the absolute position of the motor. Each time a logic transition occurs at one of the quadrature inputs, the servo controller position counter is incremented or decremented accordingly. This provides four times the resolution over the number of lines provided by the encoder. The encoder inputs are buffered by a differential line receiver on the module. Configuration jumpers on the module allow this receiver to be configured for single ended input signals.

A digital "Proportional Integral Derivative" (PID) filter on the module is used to compensate the servo feedback loop. The motor is held at the desired position by applying a restoring force to the motor that is proportional to the position error, plus the integral of the error, plus the derivative of the error. The following discrete-time equation illustrates the control performed by the servo controller:

$$u(n) = Kp*E(n) + Ki \text{ sum } E(n) + Kd[E(n') - E(n' - 1)]$$

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where u(n) is the module's output signal output at sample time n, E(n) is the position error at sample time n, n' indicates sampling at the derivative sampling rate, and kp, ki, and kd are the discrete-time filter parameters loaded by the users.

The first term, the proportional term, provides a restoring force proportional to the position error. The second term, the integration term, provides a restoring force that grows with time. The third term, the derivative term, provides a force proportional to the rate of change of position error. It provides damping into the feedback loop. The sampling interval associated with the derivative term is user-selectable; this capability enables the servo controller to control a wider range of inertial loads.

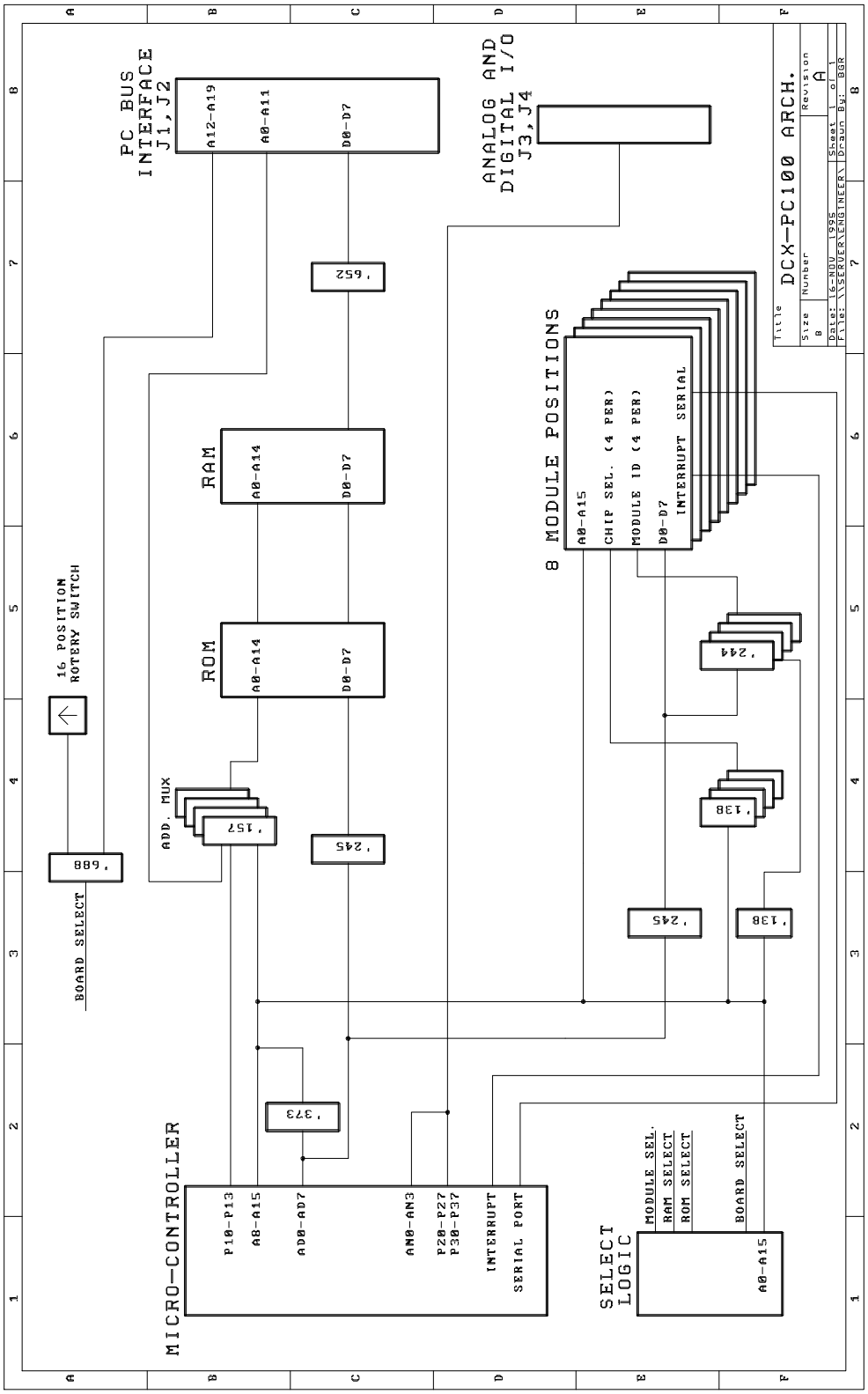
Stepper Motor Control

The stepper modules contains a pulse generator which is used to provide step signals to an external stepper motor driver. In addition to auto calibration on power up, the module has an internal feedback loop which accurately maintains the output pulse frequency. Inputs on the module can be connected to an optional encoder for motor position verification.

The block diagram on the next page shows the architecture of the **DCX-PC** controller.

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1.3 THEORY OF OPERATION (cont.)



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2.0 DCX-PC CONTROLLER INSTALLATION

The **DCX-PC** may be installed in any available backplane connector of an IBM-AT or compatible 'host' computer, or it may be used in a completely stand-alone configuration.

When installed in a host computer, power and communications will be supplied through the edge connectors of the **DCX-PC**.

When used in the stand-alone configuration, power can be provided to the **DCX-PC** using the edge connector or an 4 pin connector (J7). In this configuration, one of the available communication interface modules can be used to send commands to the controller. In this case, a mating edge connector with specific pins grounded or pulled high (connected to the 5 volt supply through a resistor) should be used to properly disable the host interface. See the appendix detailing the **DCX-PC**'s connectors for further information.

A **DCX-PC** may have more than one type of the available communication interfaces installed without conflict. However, the **DCX-PC** will only be able to receive commands through one interface at a time.

When a **DCX-PC** board is plugged in to an IBM-AT or compatible host computer, it is necessary for the **DCX-PC**'s dual ported memory to be configured to occupy a portion of the host computer's memory map. The configuration of the **DCX-PC**'s dual ported memory is described in the next 2 paragraphs.

A 4096 byte portion of the controllers's dual ported memory will be accessible in the host's memory space. If the rotary switch SW1 on the motherboard is set to 0 (default configuration), the **DCX-PC** will occupy D0000 hex through D0FFF hex. If it is set to 1, it will occupy D1000 hex through D1FFF hex, and so on. In the host's memory map, the lowest numbered memory location that a **DCX-PC** board occupies is referred to as the 'base' address. If the boards rotary switch is set to 0, its base address will be D0000h.

The utility and sample programs that are supplied with the **DCX-PC** assume that the board is set for the D0000 through D0FFF address range. This means that the rotary switch SW1 should be set to 0. The remainder of this manual assumes this is the current configuration of the **DCX-PC**.

Note that some IBM-AT and compatible host computer operating systems have memory managers that place memory in the same range as the default **DCX-PC** configuration. These memory managers must be configured to prevent them from using the same memory space that the **DCX-PC** occupies. Refer to the memory manager documentation for information on how to do this.

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2.0 DCX-PC CONTROLLER INSTALLATION (cont.)

DCX-PC Modules can be placed in any open position on the **DCX-PC** motherboard. If there are fewer than eight modules to be installed on the **DCX-PC**, spread them out as much as possible. This will allow easier installation and removal of the modules as well as mating cables.

If there are to be motor control modules installed on the **DCX-PC**, and you want them to be numbered in a specific order, install them in module positions on the **DCX-PC** in that order. For example, the module that is to control motor number 1 could be installed in module position number 1 (see numbers on **DCX-PC** circuit board). The module controlling motor number 2 could be installed in position number 2, and so on. Alternatively, the second module could be installed in any other module position and it will still be assigned number 2 since it is the second motor module on the **DCX-PC**.

Once the position for each module has been determined, the modules can be installed on the **DCX-PC**, one at a time. Lay the **DCX-PC** on a flat surface in such a way that the numbers printed on the circuit board in each module position are right side up (the edge connector will be on the lower right corner of the board). Lay a module in its' target position on the **DCX-PC**. The header pins of the module should be aligned with mating connectors on the **DCX-PC** motherboard. If you look straight at the board, you should see that the standoffs in the upper corners of the module should be aligned with the mounting holes in the **DCX-PC**. When you are satisfied that the module is properly aligned, carefully press the module into the **DCX-PC**. The header pins of the module should seat completely into the mating connectors on the **DCX-PC** motherboard. Two nylon mounting screws are supplied with each **DCX-PC** module. These should be installed from the backside of the motherboard, into the standoffs on the modules.

Repeat this process for installing modules on the **DCX-PC** until all modules are in place. Next the **DCX-PC** should be installed in the system chassis and interfacing cables connected. Refer to the following sections in this chapter for specific information on the types of modules that are being used. When cabling has been completed, power can be applied to the system and initial checkout begun.

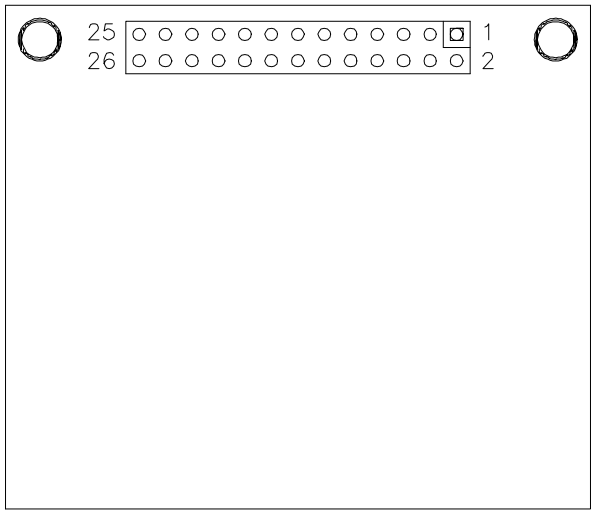
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2.0 DCX-PC CONTROLLER INSTALLATION (cont.)

Please note that all **DCX-PC** modules contain a 26 pin shrouded header for I/O. The pins of this connector are numbered from 1 to 26. The diagram below shows the location of pins 1, 2, 25 and 26. The other 22 pins are numbered and located respectively:

DCX-PC MODULE CONNECTOR PIN NUMBERING

TOP SIDE



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2.1 SERVO MODULE INSTALLATION

One to eight servo modules can be installed in the **DCX-PC** as described in the first section of this chapter. However, depending on the type of servo module to be installed there may be jumpers on the module that must be configured prior to connecting the module to the encoder.

DCX-MC100, DCX-MC105, DCX-MC110, DCX-MC120 servo modules

The DCX-MC1XX servo modules configuration options allow the user to configure the module to match the encoder type. These options (JP2, JP3, JP4, and JP5) are selected by leaving intact or cutting PCB traces. An appendix of this manual which covers the servo modules, includes a description of these jumpers and a diagram showing their locations. Note that the pins of the three jumpers are numbered sequentially from 1 to 3, with pin 1 being shown as a square.

Jumper JP2 and JP3 configures the module's encoder phase inputs for 'single ended' or 'differential' type signals. If an encoder with single ended phase outputs is to be connected to the module (default configuration), no configuration change is required. In this case, the A and B signals from the encoder should be connected to the A+ and B+ inputs of the module. The threshold level for single ended encoder inputs is + 2.5 volts. The threshold voltage determines at what voltage the input changes between on and off. If an encoder with differential phase outputs is to be connected to the module, cut the PCB traces (solder side of board) between JP2 pins 1 & 2 and JP3 pins 1 & 2.

Jumper JP4 selects whether +5 volts or +12 volts will be used for the encoder supply connection on the module. This should be set to the supply voltage required by the encoder. To select an encoder supply of +5 volts, no configuration change is required (default configuration). To select +12 volts, cut the PCB trace between JP4 pins 2 and 3.

Jumper JP5 selects standard or reversed encoder phasing. This jumper configures the relationship between voltage command output and reported encoder position. Standard phasing (default configuration) is defined as " 1) commanded motion is in the positive direction, and 2) command voltage output increasing, and 3) reported encoder position increases (more positive). To select reversed phasing cut the PCB traces between JP5 pin 1 and 2 and JP5 pins 3 and 4.

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2.1 SERVO MODULE INSTALLATION (cont.)

DCX-MC200 & DCX-MC210 servo modules

The DCX-MC2XX configuration options allow the user to configure the module to match the encoder type. These options (JP1, JP2, and JP3) are selected by installing shorting blocks on the pins of the jumpers, or leaving them open. An appendix of this manual which covers the servo module, includes a description of these jumpers and a diagram showing their locations. Note that the pins of the three jumpers are numbered sequentially from 1 to 3, with pin 1 being shown as a square.

Jumper JP1 configures the module's encoder phase inputs for 'single ended' or 'differential' type signals. If an encoder with single ended phase outputs is to be connected to the module, a 3 hole shorting block supplied with the module, should be installed across all 3 pins of jumper JP1. In this case, the A and B signals from the encoder should be connected to the A+ and B+ inputs of the module. If an encoder with differential phase outputs is to be connected to the module, the 3 pins of jumper JP1 should be unconnected (no shorting block installed).

Jumper JP2 is used to configure the module's encoder index input. Either a single ended or differential index signal can be connected to the module. The table below lists the possible combinations:

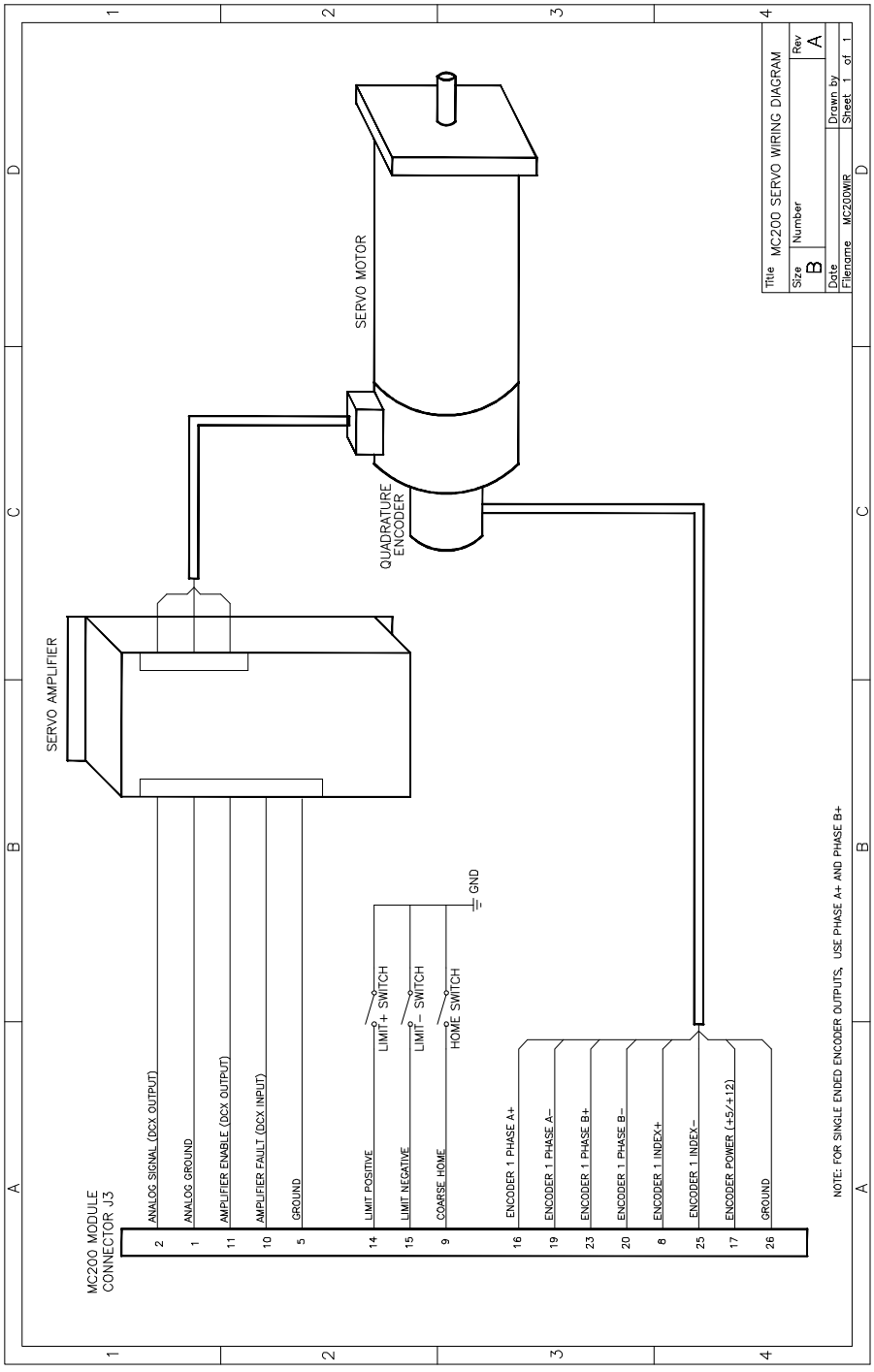
Input Type	Active Level	JP2 pins shorted	Module Input
Single Ended	High	1 and 2	Index+
Single Ended	Low	2 and 3	Index-
Differential	N/A	none	Index+ and Index-

Jumper JP3 selects whether +5 volts or +12 volts will be used for the encoder supply connection on the module. This should be set to the supply voltage required by the encoder. The setting of this jumper also selects the threshold voltage for the modules's single ended phase and index encoder inputs. When JP1 is set for +5 volts, the threshold will be 2.5 volts, for +12 volts, the threshold will be +6 volts. The threshold voltage determines at what voltage the input changes between on and off. To select an encoder supply of +5 volts, connect pins 1 and 2 of jumper JP3 with a shorting block. These are the two pins closest to the module connector J3. To select +12 volts, connect pins 2 and 3 of JP3.

After configuring the jumpers of the module, the servo encoder, amplifier and limit switches can be connected to the module. A wiring diagram on the following page shows a typical installation. It is up to the user to determine whether the external signals are suitable for direct connection to the module, or if additional interface circuits are required.

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2.1 SERVO MODULE INSTALLATION (cont.)



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2.2 STEPPER MODULE INSTALLATION

One to eight stepper modules can be installed in the **DCX-PC** as described in the first section of this chapter. However, depending on the type of stepper module to be installed there may be jumpers on the module that must be configured prior to usage.

DCX-MC150, DCX-MC160 stepper modules

The DCX-MC1XX stepper modules configuration options allow the user to configure the module to match the I/O requirements of the application. These options (JP2, JP3, JP4, and JP5) are selected by installing shorting blocks on the pins of the jumpers, or leaving them open
An appendix of this manual which covers the stepper modules, includes a description of these jumpers and a diagram showing their locations. Note that the pins of the three jumpers are numbered sequentially from 1 to 3, with pin 1 being shown as a square.

Jumpers JP2 and JP3 configure the module's motor control outputs. If the stepper motor driver requires both Clockwise and Counter Clockwise outputs (default configuration) then shorting blocks should be installed on JP2 and JP3 pins 1 and 2. If the stepper motor driver requires Pulse and Direction outputs then shorting blocks should be installed on JP2 and JP3 pins 2 and 3.

Jumper JP4 terminates the module's Limit Switch inputs with either 4.7K ohm pull-up or 4.7K ohm pull-down resistors. To terminate the Limit Switch inputs with pull-down resistors install the shorting block on JP4 pins 1 and 2. To terminate the Limit Switch inputs with pull-up resistors install the shorting block on JP4 pins 2 and 3 (default configuration)..

Jumper JP5 (DCX-MC160 stepper module only) selects standard or reversed encoder phasing. This jumper configures the relationship between step direction and reported encoder position. Standard phasing (default configuration) is defined as “ 1) move in the positive direction and 2) reported encoder position increases (more positive). To select reversed phasing cut the PCB traces between JP5 pin 1 and 2 and JP5 pins 3 and 4.

DCX-MC260 stepper module

The DCX-MC260 stepper module configuration option allows the user to configure the module to accept the outputs from an optical encoder. This jumper is configured by installing a shorting block on the pins of the jumper, or leaving them open. An appendix of this manual which covers the stepper module, includes a description of this jumper and a diagram showing its' location. Note that the pins of the jumper are numbered sequentially from 1 to 3, with pin 1 being shown as a square.

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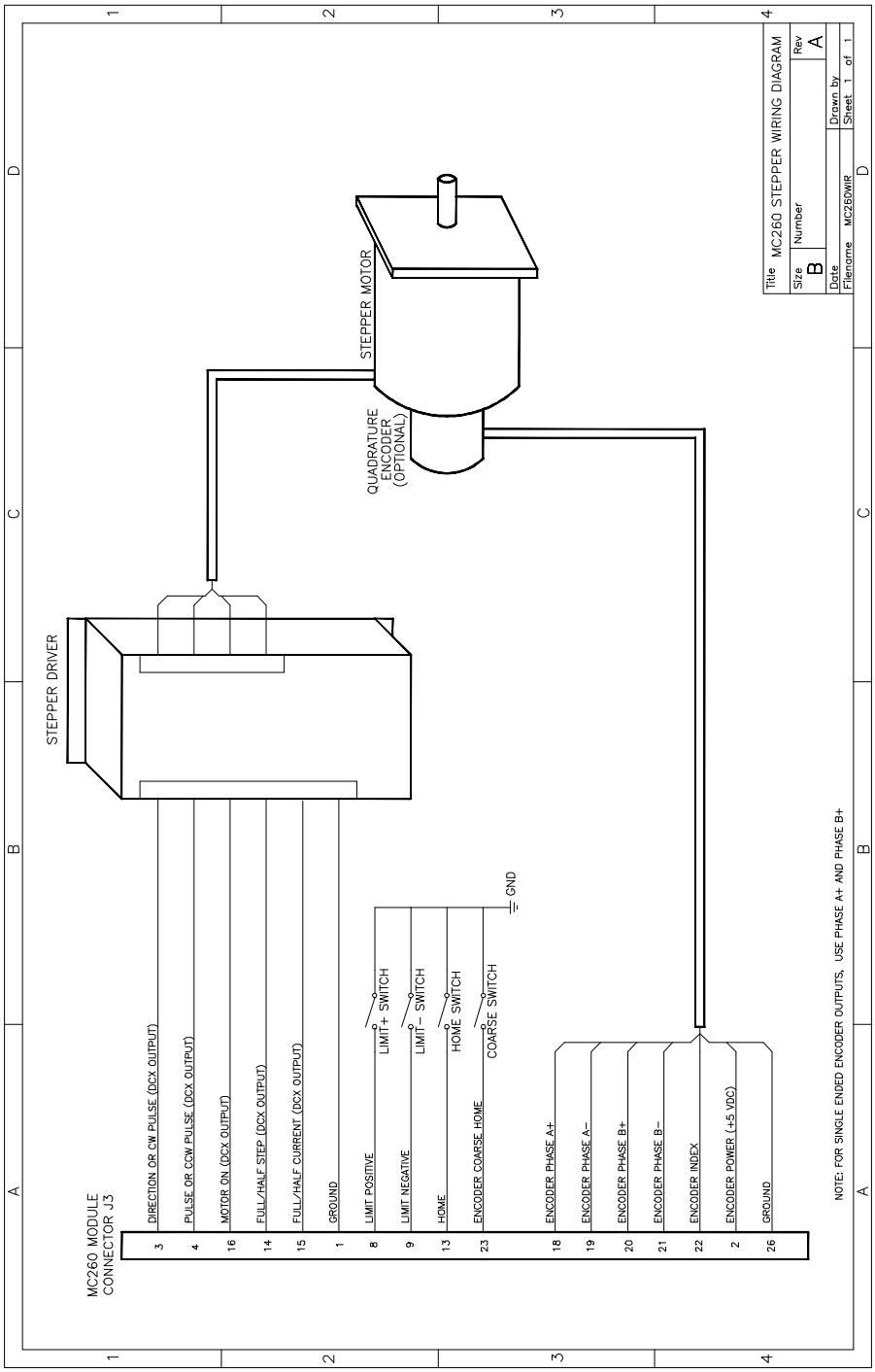
2.2 MC260 STEPPER MODULE INSTALLATION (cont.)

Jumper JP1 configures the module's encoder phase inputs for 'single ended' or 'differential' type signals. If an encoder with single ended phase outputs is to be connected to the module, a 3 hole shorting block supplied with the module, should be installed across all 3 pins of jumper JP1. In this case, the A and B signals from the encoder should be connected to the A+ and B+ inputs of the module. If an encoder with differential phase outputs is to be connected to the module, the 3 pins of jumper JP1 should be unconnected (no shorting block installed).

After configuring the jumper of the module, the stepper driver, limit switches and optional encoder can be connected to the module. A wiring diagram on the following page shows a typical installation. It is up to the user to determine whether the external signals are suitable for direct connection to the module, or if additional interface circuits are required.

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2.2 MC260 STEPPER MODULE INSTALLATION (cont.)



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2.3 MC400 DIGITAL I/O MODULE INSTALLATION

One or more MC400 digital I/O modules can be installed in the **DCX-PC** as described in the first section of this chapter. There are no jumpers on this module to be configured. The module's I/O signals can be connected directly to the user's circuits if output loading and input voltages are within acceptable limits. Alternatively, a BFO22 interface board can be used to connect the module's I/O to a relay rack in order to provide optically isolated inputs and outputs.

The BFO22 interface board provides a convenient means of connecting the MC400's I/O channels to a 16 position relay rack available from two manufacturers, Opto22 (P/N PB16H) and Grayhill (P/N 70RCK16-HL). These relay racks accept up to 16 optically isolated input or output modules for interfacing with external electrical systems. Using one of these relay racks and a BFO22, an optically isolated I/O module can be connected to each of the MC400's digital I/O channels.

For installation, the BFO22 plugs directly into the relay rack's 50 pin header connector and then connects to the MC400 via a 26 conductor ribbon cable with header connectors. Note that the relays are numbered sequentially starting from 0, while the **DCX-PC** digital I/O channels are numbered sequentially starting with 1.

Although the relay rack has screw terminals for connecting a logic supply, it is not necessary to make this connection. By installing a shorting block on jumper JP17 of the BFO22, the 5 volt supply of the **DCX-PC** will be supplied to the relay rack.

For each I/O module position on the relay rack, there is a corresponding jumper on the BFO22. By placing a shorting block in one of two positions on each of these jumpers, the BFO22 circuitry is configured for connection to either an input or output module. The BFO22 jumper JP1 is used to configure the circuitry for module position 0, jumper JP2 is for module position 1, and so on. If a module position has an output relay, a shorting block should be placed on pins 1 and 2 of the corresponding jumper. Conversely, if a module position has an input signal conditioner, the shorting block should be placed between pins 2 and 3. Note that pin 1 of each jumper is the one closest to the jumper label.

2.4 MC500 ANALOG I/O MODULE INSTALLATION

One or more MC500 analog I/O modules can be installed in the **DCX-PC** as described in the first section of this chapter. There are no jumpers on this module to be configured. The module's I/O signals can be connected directly to the user's circuits as long as output loading is not excessive and input voltages are maintained within the specified limits (see the MC500 appendix).

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2.5 MF300 RS-232 MODULE INSTALLATION

A single DCX-MF300 RS-232 interface module can be installed in any module position on the **DCX-PC**. Configuration jumpers on the module should be set before connecting the module to an external device. These jumpers are configured by installing shorting blocks on the pins of the jumpers, or leaving them open. Appendix I of this manual which covers the RS-232 module, includes a description of these jumpers and a diagram showing their locations. In addition, a portion of the module schematic is included in the appendix to help in configuring the module. Note that the pins of each jumper are numbered sequentially from 1, with pin 1 being shown as a square.

The MF300 J3 connector pinout is designed to allow a cable to be assembled from ribbon cable and Insulation Displacement Connectors (IDC). The RS-232 interface cable should be constructed using one 25 pin D-subminiature IDC connector on one end and a 26 contact, .025" square post IDC connector with a center polarizing tab.

The MF300 module will support a simple three wire cable, however hardware handshaking will not be supported. The required connection for a three wire cable is shown below:

Host interface DB25	DCX-MF300 J3
2	3
3	5
7	13

Note: The following modifications must be made to the DCX-MF300 module:

1) Add a jumper wire from JP13 pins 1 and 2
2) Add a jumper wire from J3 pins 11 and 23

For a terminal device with a 9 pin D-Subminiature connector the following cable interconnect is required:

Terminal Device DB9	DCX-MF300 J3
2	5
3	3
4	7
5	13
6	14
7	11
8	9

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2.5 MF300 RS-232 MODULE INSTALLATION (cont.)

The RS-232 interface cable can now be directly connected to a terminal or host computer serial port. If the external device is considered to be Data Terminal Equipment (DTE), then the RS-232 module should be configured as Data Communications Equipment (DCE). This is the default configuration of the RS-232 module as shipped from the factory, and should have the jumpers set as follows:

JP3	1-2	JP9	open
JP4	1-2	JP10	1-2
JP5	open	JP11	open
JP6	1-2	JP12	open
JP7	open	JP13	open
JP8	1-2	JP14	open

A single shorting block installed in one position of jumper JP1 will select the initial baud rate for the serial port when the **DCX-PC** is turned on. The module is shipped from the factory with a shorting block installed on pins 9 and 10 for a default setting of 9600 baud. The appendix which covers this module lists the other available baud rates and respective jumper settings.

Jumper JP2 on the RS-232 module is used to select whether internal control signals are used for hardware handshaking, or for networking. When a single **DCX-PC** is connected to the communicating device, this jumper should be configured for handshaking. This is done by installing a shorting block on pins 1 and 3, and another on pins 2 and 4 (shorting blocks will be perpendicular to 'JP2' label). For configuration of the module for use on a RS-232 network, a shorting block should be installed on pins 1 and 2, and another on pins 3 and 4.

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2.6 MF310 IEEE-488 MODULE INSTALLATION

A single MF-310 IEEE-488 module can be installed in any module position on the **DCX-PC**. There are two jumpers on the module that should be configured before connecting the module to an external device. These jumpers are configured by installing a shorting block on the pins of the jumpers, or leaving them open. An appendix of this manual which covers the IEEE-488 module, includes a description of these jumpers and a diagram showing their locations.

The IEEE-488 module connector J3 pinout, is designed to allow a cable to be assembled from ribbon cable and Insulation Displacement Connectors (IDC). Such a cable, with a IEEE-488 connector on one end, can be directly connected to a IEEE-488 controller.

Jumper JP1 should have a shorting block installed to provide open collector drivers on the module. Leaving the pins of jumper JP1 open will configure the module drivers as push-pull for high speed communications.

Installing a shorting block on jumper JP2, will connect the IEEE-488 connectors shield signal to the **DCX-PC**'s ground. Since the IEEE-488 controller should provide the grounding point for the cable shields, this jumper should be left open.

The other jumpers on the IEEE-488 module are for production options, and should be left as shipped from the factory (JP3 hardwired, JP4 and JP5 open).

The DIP switch on IEEE-488 module is used to set the address of the **DCX-PC** on the IEEE-488 bus. The appendix which covers the IEEE-488 module includes a list of all possible address settings. As an example, to set the **DCX-PC**'s address to 4 (talk address = 'D', listen address = '$'), switches 1, 2, 4, 5 and 6 should be in the off position, and switch 3 should be in the on position.

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3.0 COMMUNICATION INTERFACES

In order to send commands to the **DCX-PC** controller, any of the available communication interfaces can be used. The IBM-AT or compatible host computer interface comes standard with all **DCX-PC** boards, and provides the fastest means for transferring data to and from the board. The **DCX-PC** board also comes with a serial communications interface. In order to make this interface compatible with RS-232 requires the MF300 RS-232 interface module available from PMC. For interfacing to the **DCX-PC** board over the IEEE-488 Bus, the MF310 IEEE-488 module is available from PMC.

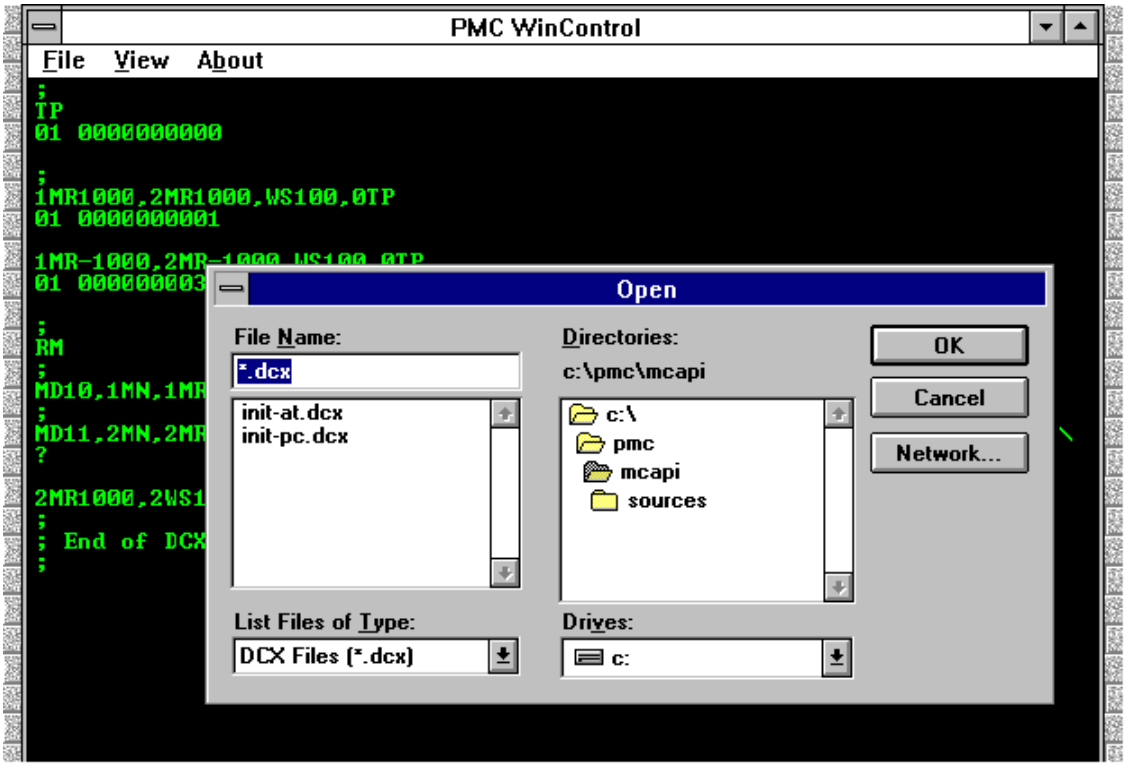
Commands sent to the **DCX-PC** through any of the communication interfaces must be followed by a carriage return (ASCII 13). A linefeed (ASCII 10) is not required at the end of command lines, and should not be sent.

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3.1 PC COMMUNICATIONS INTERFACE

If the **DCX-PC** board is installed in an IBM-AT or compatible host computer, communications utilities are provided for both Windows and DOS based installations.

For systems using Microsoft Windows, after installing the **DCX WINDOWS UTILITIES**, the user can select **PMC WinControl**. This Windows based Terminal Emulator implements communications with the **DCX-PC** through the host interface. In addition to sending command lines typed at the keyboard to the **DCX-PC** and displaying responses on the host's monitor, this program can also be used to send a text file containing **DCX-PC** commands to the controller. This file download feature supports a range of capabilities from initializing motor parameters each time the **DCX-PC** is powered up, to sending a complete ASCII format motion control program. Simply store the command lines in a file using a text editor, then select **FILE** and **OPEN** from the Windows menu. Enter the name of the file to be sent to the **DCX-PC** and select **OK** from the Windows dialog box.



DCX-PC WinControl; a Windows based motion control command interface

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3.1 PC COMMUNICATIONS INTERFACE (cont.)

For DOS based systems Terminal Emulator found on the "**DCX-PC** Utility Disk" implements communications with the **DCX-PC** through the host interface. This program can be run by inserting the "**DCX-PC** Utility Disk" in a disk drive and typing DCXCNTRL. In addition to sending command lines typed at the keyboard to the **DCX-PC** and displaying responses on the host's monitor, this program can also be used to send a text file containing **DCX-PC** commands to the controller. This file download feature supports a range of capabilities from initializing motor parameters each time the **DCX-PC** is powered up, to sending a complete ASCII format motion control program. Simply store the command lines in a file using a text editor and then include the name of the file when invoking the DCXCNTRL program. For example, if the **DCX-PC** commands were stored in file called INIT.DCX, type:

DCXCNTRL INIT.DCX.

If the application requires a program running on the host to issue commands to the **DCX-PC**, the programmer should examine the Windows utilities and interface libraries that are supplied on the utility tools disks. Device drivers and Interface libraries for popular programming languages (Visual C, Visual BASIC, 'C', Pascal and BASIC) can be found on the disks. The 'READ.ME' files on the disks list what files are associated with each driver or interface library.

The Windows utilities and interface libraries are implemented using the '**DCX-PC** Binary Command Interface'. This interface uses binary formatted commands and replies and provides the most efficient means for the host to communicate with the **DCX-PC**. It is described in full detail in an appendix of this manual. In some situations, it is preferable for the host to send commands to the **DCX-PC** in an ASCII character format, and for the board to send replies as ASCII characters. This can be done through the 'ASCII Command Interface' of the **DCX-PC**. This interface is described below.

In order for the host computer to communicate to the **DCX-PC** in ASCII characters, two mailbox locations have been defined. The data input mailbox is used to send data to the **DCX-PC**. This mailbox is the byte located at 800 hex from the base address. For a **DCX-PC** controller with the default configuration, this will be absolute address D0800 hex. The data output mailbox is used to receive data from the **DCX-PC**. This mailbox is the byte located at 804 hex from the base address. This will be absolute address D0804 hex.

A simple protocol allows ASCII characters to be transferred to and from **DCX-PC** boards. In order to send an ASCII character to a board, first read the contents of its data input mailbox, if it is 0, write the data into the mailbox. If the contents are non-zero, the previous data put in the mailbox has not yet been processed by the **DCX-PC** board. The host should continue

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checking the mailbox until the contents become 0, and then write the data.

In order to receive ASCII characters from a **DCX-PC** board, read the contents of its data output mailbox. If the value read is non zero, it is a valid character and the host should save the character and then write a 0 to the data output mailbox to indicate it has received the data. If the contents of the mailbox is 0, the **DCX-PC** has not placed new data in the mailbox. In this case the host can continue checking the mailbox for new data.

In addition to the command interfaces, the host can read motor information directly from the **DCX-PC**'s memory. An appendix of this manual details the contents of the "**DCX-PC** Dual Port RAM".

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3.2 RS-232 COMMUNICATIONS INTERFACE

The DCX-PC supports an RS-232 serial interface when the DCX-MF300 module is installed. Communications programs including PROCOMM are supported. For Windows based applications the DCX-PC Windows Utilities support not only a Terminal Emulator (PMC WIN CONTROL) for command level execution but also application programming in Visual C and Visual BASIC.

The interface has been designed to use either software or hardware handshaking for its' operation. Hardware handshaking can be enabled or disabled by use of the **HN** and **HF** commands. Software handshaking can be enabled or disabled by use of the **XN** and **XF** commands.

Set the configuration of the communicating device to 8 data bits, one stop bit and no parity. The **DCX-PC** is normally shipped with this default configuration. Also set the device to translate carriage returns received into carriage return and linefeed. The baud rate of device should be set to match the baud rate selected when the RS-232 module was installed (9600 is the default).

Note that input characters are only echoed through the RS-232 interface when enabled by the **E**cho o**N** (**EN**) command.

Please refer to Appendix I for cabling information.

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3.3 IEEE-488 COMMUNICATIONS INTERFACE

In order to send commands to the **DCX-PC** via the GPIB (IEEE-488) bus interface it must first be addressed to listen. The command line is then sent in ASCII format, including the ending carriage return (no line feed). The **DCX-PC** should then be unaddressed as a listener and addressed as a talker. If the **DCX-PC** has a response to the command ready, it will send it at that time. If the **DCX-PC** has no response ready within 10 milliseconds of being addressed to talk, it will respond with a NULL (ASCII 0) character in order to prevent "hanging" the bus. The controller should then un-address the **DCX-PC** and repeat the process if a response is expected. Note that the **DCX-PC** will not accept a new command line until the responses to the previous command has been accepted.

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4.0 DCX-PC OPERATION

In order for the **DCX-PC** to perform any operation, it must execute a command. This command can be any one of the predefined commands described later in this manual. If the command is sent to the **DCX-PC** through one of the available communication interfaces, it will be executed as soon as it is received. Alternatively, the command can be stored in the **DCX-PC**'s own memory and caused to be executed by external signals. But no matter where the command originates from, it will be executed by the **DCX-PC** in the same way.

Because the commands consist of standard alphanumeric characters and are built with two key characters from the description of the operation (e.g. "**MR**" for **M**ove **R**elative), they are easy to use and remember. In order to become familiar with the operation of the **DCX-PC**, it is suggested that the user have a means of sending commands to it by typing at a keyboard (**DCXCNTRL** or **DCX WIN CONTROL**).

If the **DCX-PC** is installed in a PC, run the program called DCXCNTRL supplied on the utility disk. This will allow commands to be entered at the keyboard and responses displayed on the screen. Alternatively if the **DCX-PC** has an RS-232 communications interface, a computer terminal connected to it provides a convenient means of sending commands to the **DCX-PC**.

For those **DCX**'s connected directly to a computer through the RS-232 or GPIB interfaces, there may be programs which allow the computer to emulate a terminal (PROCOMM or Windows Terminal for RS-232, Lab View for IEEE-488). For further information contact PRECISION MICRO CONTROL CORP.

Once power has been applied to the **DCX-PC**, you can begin issuing commands to it. A good command for verifying correct operation of the communications link is the **VE**rsion command. This command should generate a response regardless of what modules are installed in the **DCX-PC**. Type '**VE**' followed by the return key. In response, the controller should display the revision level of the firmware in the ROM.

Note that each character typed at the keyboard should be echoed to your display (this requires **E**cho o**N** for the RS-232 interface). If you enter an illegal character or an illegal series of valid characters, the **DCX-PC** will echo a question mark character, followed by a carriage return and a line feed. On receiving this response, you should re-enter the entire command string. If you make a mistake in typing, the backspace can be used to correct it.

Once you are satisfied that the communication link is correctly conveying your commands and responses, you are ready to check the motor interface. When the **DCX-PC** is powered up or reset, each module is automatically set to the "motor off" state. In this state, there should be no drive current to the motors. For DC servos it is possible for a small offset voltage to be

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present. This is usually too small to cause any motion, but some systems have so little friction that a few millivolts can cause them to drift in an objectionable manner. If this is the case, the "null" voltage can be minimized by adjusting the offset adjustment potentiometer on the respective module.

Before a motor can be controlled, certain parameters must be set by issuing commands to the **DCX-PC**. These include acceleration, maximum velocity, filter gains, etc.. Depending on the type of motor being controlled, not all parameters will have meaning.

At this point the user should refer to the appendices of this manual pertaining to the types of modules installed in the board. There the user will find more specific information for each type of module, including which parameters must be set before a motor should be turned on.

Assuming that the motor parameters have now been set, it can be change to the **M**otor o**N** (**MN**) state. All axes can be turned on with a single command, or a single axis can be enabled as desired. To enable all, enter the **MN** command without an axis number preceding it, or enter 0**MN**. To enable only axis 2, for example, enter 2**MN**.

After turning a particular axis on, it should hold steady at one position without moving. The **T**ell **T**arget (**TT**) and **T**ell **P**osition (**TP**) commands should report the same number. There are several commands which are used to cause motion, including the **M**ove **A**bsolute (**MA**), **M**ove **R**elative (**MR**), **M**ove to **P**oint (**MP**), **M**ove to point and **I**ncrement (**MI**), and **G**o **H**ome (**GH**) commands. To move axis 2 by 1000 encoder counts, enter 2MR1000 and a carriage return. If the axis is in the "**M**otor o**N**" state, it should move in the direction defined as positive for that axis. To move back, enter 2**MR**-1000 and a carriage return.

With the **DCX-PC** controller, it is possible to group together several commands. This is not only useful for defining a complex motion which can be repeated by a single keystroke, but is also useful for synchronizing multiple motions. To group commands together simply place a comma between each command, pressing the return key only after the last command.

A repeat cycle can be set up with the following compound command:

2**MR**1000,**WS**32,**MR**-1000,**WS**32,**RP**6(return)

This command string will cause axis 2 to cycle 7 times. (One time by command, repeated 6 more times.) The **W**ait for **S**top (**WS**) commands are required so that the motion will be completed before the return motion is started. The number 32 following the **WS** command specifies the number of milliseconds to wait after the axis has ceased motion to allow some time for the mechanical components to come to rest and reduce the stresses on them that could

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occur if the motion were reversed instantaneously. Notice that the axis number need be specified only once on a given command line.

A more complex cycle could be set up involving multiple axes. In this case, the axis to be controlled is assumed to be the last one specified in that command string. Whenever a new command string is entered, the axis is assumed to be 0 (all) until one is specified.

Entering the following command:

2**MR**1000,3**MR**-500,0**WS**,**WA**300,2**MR**1000,3**MR**500,0**WS**,**WA**300,**RP**4

followed by return will cause axis 2 to move in the positive direction and axis 3 to move in the negative direction. When both axes have stopped moving, the **WA** command will cause a 300 millisecond delay after which the remainder of the command line will be executed.

After going through this complex motion 5 times, it can be repeated another 5 times by simply entering a return character. All command strings are retained by the controller until some character other than a return is entered. This allows a great reduction in typing or communications overhead. It comes in very handy for observing the position display during a move, for instance.

If you enter:

1MR1000(ret)
1TP(ret)
(ret)
(ret)
(ret)
(ret)

the **DCX-PC** will respond with a succession of numbers indicating the position of the axis at that time. Many terminals have an "auto-repeat" feature which allows you to track the position of the axis by simply holding down the return key.

Another way to monitor the progress of a movement is to use the RP command without a value. This will repeat until stopped by the operator. You may stop it by entering any character through the communications interface.

If you enter:

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1MR10000(ret)
1TP,RP(ret)

the position will be displayed continuously until you stop it. The user may also specify the number of times the sequence is to be repeated, or it may be repeated indefinitely. Pauses lasting from 1 millisecond to over 65 seconds may be inserted between elements of the sequence at the user's option. The sequence may be repeated using the repeat (RPn) command, or it can be repeated any number of times by simply entering the carriage return when desired.

While the **DCX-PC** is executing commands, the user can abort command execution (all motion will continue) by pressing any key other than the space bar. If the user wishes only to pause the execution of commands, the user should press the space bar. In order to restart command execution press the space bar again. If after pausing command execution, the user decides to abort execution, this can be done by pressing any key other than the space bar.

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4.1 MACRO COMMANDS

A powerful feature of the **DCX-PC** is the ability to define macro commands. This simply means giving a short name to a sequence of commands to form a new command defined by the user. For example:

1**MR**1000,**WS**250,**MR**-1000,**WS**250

may be entered as a command sequence. It causes the motor attached to axis 1 to move 1000 counts in the positive direction, waits one quarter second after it has reached the destination, then moves back to the original position followed by a similar delay. If this sequence were to represent a frequently desired motion for the system, it could be defined as a macro command. This is done by inserting a **M**acro **D**efinition (**MD**) command as the first command in the command string. For example:

MD3,1**MR**1000,**WS**250,**MR**-1000,**WS**250

will define macro #3. Whenever it is desired to perform this motion sequence, just issue the command: **MC**3.

There are 8192 bytes of memory allocated to macro storage. Each defined macro requires one byte for overhead, plus 6 bytes per command in the string. The example given above for macro #3 would use 4 x 6 + 1, for a total of 25 bytes. (Only the parameter of the Macro Define command is stored, in this example the number 3.)

Since the **DCX-PC** provides no protection against overflowing the macro storage space, it is suggested that the user keep track of the amount of memory required by the programmed macros.

Macro Commands:

MC*n* **M**acro **C**all
MD*n* **M**acro **D**efinition
MJ*n* **M**acro **J**ump
RM*n* **R**eset **M**acros
TM*n* **T**ell **M**acros

Note: For stand-alone applications (with the non-volatile memory option), if a macro 0 has been defined (**MD0**), it will be executed after a PC bus reset or power good reset.

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5.0 SERVO OPERATION

After connecting the servo's encoder to the module, the **DCX-PC** should report its position each time the **T**ell **P**osition (**TP**) command is issued. If the servo is manually turned in either direction, the position reported should increment or decrement accordingly.

Example:

TP
01 0

Next the output signal from the module can be connected to the external amplifier. Use the **S**top on **E**rror (**SE**) command to set the maximum following error of the servo. This will stop the servo and set the motor error bit in the servo status word in the case that it is 'reverse phased'.

Example:

1**SE**1000

Next set the gain of the servo loop to a very low value.

Example:

1**SG**50

Now turn the specific axis on using the **M**otor o**N** (**MN**) command.

Example: 1**MN**

Manually move the servo from its present position. If the motor is properly phased, it should resist movement away from its current position. Be aware that if the servo is reverse phased, it may jump to full torque or speed. In this case, the **S**top on **E**rror command should stop the servo before it travels very far (and set the Motor Error bit of the status word). If this happens, the servo phasing must be changed. Depending on the type of servo module installed, servo phasing is changed by:

DCX-MC1XX servo modules: Cutting the PCB traces JP5 pins 1 and 2 and JP5 pins 3 and 4 (or reversing the encoder inputs or the motor leads).

DCX-MC2XX servo modules: Issuing the **PH**ase command to the axis with a parameter of 1 (or reversing the encoder inputs or the motor leads).

The user can then begin increasing the gain of the servo loop. As the servo becomes "tighter" it may have a tendency to oscillate. This oscillation can be dampened by adding "derivative"

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gain to the servo loop. This is done with the **S**et **D**erivative command.

Example:

1**SD**100

In some high inertia applications, increasing the sampling period for the derivative gain can help to dampen oscillation, see the Frequency (**FR**) command for further information.

In order to decrease static error, integral gain can also be added to the servo loop using the **S**et **I**ntegral (**SI**) and **I**ntegration **L**imits (**IL**) commands.

Example:
1**IL**20
1**SI**5

If the servo is being driven by a velocity mode amplifier, the velocity feed-forward term should be set with the **V**elocity **G**ain (**VG**) command (**DCX-MC2XX** modules only).

Once the servo is properly "tuned", the operating mode is selected. Use the **P**osition **M**ode (**PM**) command for point to point motion.

Example:
1**PM**

The maximum velocity and acceleration can now be set using the **S**et **V**elocity (**SV**), **S**et **A**cceleration (**SA**) and **D**eceleration **S**et (**DS**) [1] . These commands should always be used before issuing any motion commands to the axis. If this is not done, the motor will not move as expected. The parameters for each of these commands are in units of encoder counts per sample (velocity command), or encoder counts per sample per sample (acceleration and deceleration commands).

Example:
1**SV**100000
1**SA**100000
1**DS**100000

Note [1]: The **DCX-MC1XX** modules do not support independent acceleration and deceleration. The **S**et **A**cceleration sets both the acceleration and deceleration value.

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5.0 SERVO OPERATION (cont.)

And finally, the **M**ove **R**elative (**MR**) and **M**ove **A**bsolute (**MA**) commands can be used to cause the motor to move from point to point.

Example:

1**MR**1000
1**MR**-1000
1**MA**1000

Position Feedback Interface

The servo controller interfaces to a motor via an incremental encoder. The two quadrature signals from the encoder are used to keep track of the absolute position of the motor. Each time a logic transition occurs at one of the quadrature inputs, the servo controller position counter is incremented or decremented accordingly. This provides four times the resolution over the number of lines provided by the encoder. The encoder inputs are buffered by a differential line receiver on the module. Configuration jumpers on the module allow this receiver to be configured for single ended input signals.

Velocity Profile (Trajectory) Generation

The trapezoidal velocity profile generator computes the desired position of the motor versus time. In the position mode of operation, the host processor specifies acceleration, maximum velocity, and position. The servo controller uses this information to affect the move by accelerating as specified until the maximum velocity is reached or until deceleration must begin to stop at the specified final position. At any time during the move the maximum velocity and/or the target position may be changed “on-the-fly”, and the motor will accelerate or decelerate accordingly. When commanding “on-the fly” changes using a MC1XX servo module, the change will not take effect until the **GO** command has been issued.

When operating in the velocity mode, the motor accelerates to the specified velocity at the specified acceleration rate and maintains the specified velocity until commanded to stop. The velocity is maintained by advancing the desired position at a constant rate. If there are disturbances to the motion during velocity mode operation, the long-time average velocity remains constant. If the motor is unable to maintain the specified velocity (which could be caused by a locked rotor, for example), the desired position will continue to be increased, resulting in a very large position error. If this condition goes undetected, and the impeding

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force on the motor is subsequently released, the motor could reach a very high velocity in order to catch up to the desired position (which is still advancing as specified).

All trajectory parameters are 32-bit values. Position is a signed quantity. Acceleration and velocity are specified as 16-bit, positive-only integers having 16-bit fractions. The integer portion of velocity specifies how many counts per sampling interval the motor will traverse. The fractional portion designates an additional fractional count per sampling interval. Although the position resolution of the servo controller is limited to integer counts, the fractional counts provide increased average velocity resolution. Acceleration is treated in the same manner. Each sampling interval the commanded acceleration value is added to the current desired velocity to generate a new desired velocity (unless the command velocity has been reached).

One determines the trajectory parameters for a desired move as follows. If, for example, one has a 500-line shaft encoder, desires that the motor accelerate at one revolution per second per second until it is moving at 600 rpm, and then decelerate to a stop at a position exactly 100 revolutions from the start, one would calculate the trajectory parameters as follows:

let P = target position (units = encoder counts)
let R = encoder lines * 4 (system resolution)
then R = 500 * 4 = 2000

and P = 2000 * desired number of revolutions
P = 2000 * 100 revs = 200,000 counts (value to load)

let V = velocity (units = counts/sample)
let T = sample time (seconds) = 341 us (MC1XX servo module)
let C = conversion factor = 1 minute/60 seconds
then V = R * T * C * desired rpm

and V = 2000 * 341E-6 * 1/60 * 600 rpm
V = 6.82 counts/sample
V (scaled) = 6.82 * 65,536 = 446,955.52
V (rounded) = 446,956 (value to load)

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let A = acceleration and deceleration (units = counts/sample/sample)
A = R * T * T * desired acceleration (rev/sec/sec)
then A = 2000 * 341E-6 * 341E-6 * 1 rev/sec/sec

and A = 2.33E-4 counts/sample/sample
A = (scaled) = 2.33E-4 * 65,536 = 15.24
A = (rounded) = 15 (value to load)

The values shown for velocity and acceleration must be multiplied by 65,536 (as shown) to adjust for the required integer/fraction format of the input data. The factor of four increase in system resolution is due to the method used to decode the quadrature encoder signals.

PID Compensation Filter

The servo controller uses a digital **P**roportional **I**ntegral **D**erivative (**PID**) filter to compensate the control loop. The motor is held at the desired position by applying a restoring force to the motor that is proportional to the position error, plus the integral of the error, plus the derivative of the error. The following discrete-time equation illustrates the control performed by the servo controller:

$$u(n) = Kp*E(n) + Ki \text{ sum } E(n) + Kd[E(n') - E(n' - 1)] \qquad \text{(Eq.1)}$$

where u(n) is the motor control signal output at sample time n, e(n) is the position error at sample time n, n' indicates sampling at the derivative sampling rate, and kp, ki, and kd are the discrete-time filter parameters loaded by the users.

The first term, the proportional term, provides a restoring force proportional to the position error, just as does a spring obeying Hooke's law. The second term, the integration term, provides a restoring force that grows with time, and thus ensures that the static position error is zero. If there is a constant torque loading, the motor will still be able to achieve zero position error.

The third term, the derivative term, provides a force proportional to the rate of change of position error. It acts just like viscous damping in a damped spring and mass system (like a shock absorber in an automobile). The sampling interval associated with the derivative term is user-selectable; this capability enables the servo controller to control a wider range of inertial loads (system mechanical time constants) by providing a better approximation of the continuous derivative. In general, longer sampling intervals are useful for low-velocity operations.

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6.0 STEPPER MOTOR OPERATION

Since a stepper motor runs open loop (i.e. without feedback), there is no servo "tuning" that needs to be performed. However, there are a few steps that must be performed in order to setup a stepper motor on the **DCX-PC**.

DCX-MC150/MC160 stepper modules

The first step is to select the mode of motion; **P**osition **M**ode (**PM**) for point to point motion or **V**elocity **M**ode (**VM**) for constant velocity motion.

Example:

1**PM**

The following commands are used to set the stepper motor velocity and acceleration: **S**et **I**nitial step rate (**SI**), **S**et **V**elocity (**SV**), **S**et **A**cceleration / deceleration (**SA**) commands. The parameters for each of these commands can be found in the Step Rate Tables in Appendix D.

Example:

1**SI**10
1**SV**100
1**SA**150

Before any motion commands can be issued to the stepper motor, it must be placed in the **M**otor o**N** state. The following commands do this and perform some simple moves:

1**MN**
1**MR**100000
1**MA**0

DCX-MC260 stepper module

The first step is to set the **O**utput **M**ode (**OM**). This command configures the module output signals for compatibility with the external driver. The two output options are Pulse and Direction (default) or Clockwise and Counter Clockwise pulses.

Example:

1**OM**0

The second step is to select a speed range for the axis using either the **H**igh **S**peed (**HS**),

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6.0 STEPPER MOTOR OPERATION (cont.)

Medium **S**peed (**MS**) or **L**ow **S**peed (**LS**) command.

Example:

1**LS**

The final step is to select the mode of motion; **P**osition **M**ode (**PM**) for point to point motion or **V**elocity **M**ode (**VM**) for constant velocity motion.

Example:

1**PM**

After these steps, the following commands are used to set the stepper motor velocity and acceleration: **S**et **V**elocity (**SV**), **S**et **A**cceleration (**SA**) and **D**eceleration **S**et (**DS**) commands. The parameters for each of these commands are in units of steps per millisecond (velocity commands), or steps per millisecond per millisecond (acceleration and deceleration commands).

Example:

1**SV**10000
1**SA**20000
1**DS**20000

Before any motion commands can be issued to the stepper motor, it must be placed in the **M**otor o**N** state. The following commands do this and perform some simple moves:

1**MN**
1**MR**100000
1**MA**0

Position Feedback Interface

The MC160/260 stepper control modules support (but do not require) an interface to a auxiliary incremental encoder. The two quadrature signals from the encoder are used to keep track of the absolute position of the motor. Each time a logic transition occurs at one of the quadrature inputs, the servo controller position counter is incremented or decremented accordingly. This provides four times the resolution over the number of lines provided by the encoder. The encoder inputs are buffered by a differential line receiver on the module. Configuration jumpers on the module allow this receiver to be configured for single ended input signals.

Velocity Profile (Trajectory) Generation

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6.0 STEPPER MOTOR OPERATION (cont.)

The trapezoidal velocity profile generator computes the desired position of the motor versus time. In the position mode of operation, the host processor specifies acceleration, maximum velocity, deceleration, and position. The stepper controller uses this information to affect the move by accelerating as specified until the maximum velocity is reached or until deceleration must begin to stop at the specified final position. At any time during the move the maximum velocity and/or the target position may be changed “on-the-fly”, and the motor will accelerate or decelerate accordingly (MC150/160 stepper modules do not support “on-the-fly” changes) .

When operating in the velocity mode, the motor accelerates to the specified velocity at the specified acceleration rate. The motion will continue at the specified velocity until commanded to stop. The motion will then decelerate at the specified rate.

For MC260 stepper modules , all trajectory parameters are 32-bit values. Position is a signed quantity. Acceleration, Deceleration, and velocity are specified as 16-bit, positive-only integers having 16-bit fractions. The integer portion of velocity specifies how many steps per sampling interval (1 msec.) the motor will traverse. The fractional portion designates an additional fractional count per sampling interval. Although the position resolution of the stepper controller is limited to integer counts, the fractional counts provide increased average velocity resolution. Acceleration and Deceleration is treated in the same manner. For Acceleration, each sampling interval the commanded acceleration value is added to the current desired velocity to generate a new desired velocity (unless the command velocity has been reached). For Deceleration, each sampling interval the commanded deceleration value is subtracted from the current desired velocity to generate a new desired velocity.

The example that follows can be used to determine the trajectory parameters for a desired move:

The selected stepper motor has a resolution of 1.8° per step (200 steps per revolution). The micro stepping driver is set for 100 micro steps for each full steps. The desired trajectory requires that the motor accelerate at one revolution per second per second until it is moving at 600 rpm, and then decelerate to a stop at a position exactly 100 revolutions from the start, one would calculate the trajectory parameters as follows:

let P = target position (units = steps)
let R = steps per revolution
then R = 20,000

and P = steps * desired number of revolutions
P = 20,000 * 100 revs = 2,000,000 steps (value to load)

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6.0 STEPPER MOTOR OPERATION (cont.)

let V = velocity (units = steps/sample)
let T = sample time (seconds) = 1 msec.
let C = conversion factor = 1 minute/60 seconds
then V = R * T * C * desired rpm

and V = 20,000 * 1E-3 * 1/60 * 600 rpm

V = 199.92 steps/sample
V (scaled) = 199.92 * 65,536 = 13101957.12
V (rounded) = 13101957 (value to load).

let A = acceleration and deceleration (units = steps/sample/sample)
A = R * T * T * desired acceleration (rev/sec/sec)
then A = 20000 * 1E-3 * 1E-3 * 1 rev/sec/sec

and A = 2.00E-2 counts/sample/sample
A = (scaled) = 2.00E-2 * 65,536 = 1310.72
A = (rounded) = 1310 (value to load)

The values shown for velocity, acceleration, and deceleration must be multiplied by 65,536 (as shown) to adjust for the required integer/fraction format of the input data.

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7.0 MOTION CONTROL

The sections in this chapter cover various topics related to motion on the **DCX-PC**. In general, these functions are common to both servo and stepper motors, with specific differences detailed in the text.

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7.1 POINT TO POINT MOTION

To perform point to point motion of a servo or stepper motor, follow the steps below (examples assume axis 1):

1. Issue the **M**otor o**N** (**MN**) command to the selected axis (if it isn't already on).

Example: 1**MN**

2. Issue the **P**osition **M**ode (**PM**) command to the axis.

Example: 1**PM**

3. Issue the **S**et **V**elocity (**SV**), **S**et **A**cceleration (**SA**) and **D**eceleration **S**et (**DS**) [1] commands for the desired motion. The default units for the parameters are:

DCX-MC2XX modules

Velocity parameter	Acceleration & Deceleration parameter
Encoder counts or steps per millisecond	Encoder counts or steps per millisecond per millisecond

DCX-MC1XX servo modules

Velocity parameter	Acceleration & Deceleration parameter
Encoder counts per 341 usec.	Encoder counts per 341 usec. per 341 usec.

DCX-MC1XX stepper modules

Velocity parameter	Acceleration & Deceleration parameter
Refer to Step Rate table in Appendix D	Refer to Step Rate table in Appendix D

Example: 1**SV**100000,1**SA**100000,1**DS**100000

Note [1]: The **D**eceleration **S**et command is supported by the **DCX-MC2XX** modules. The **DCX-MC1XX** modules do not support independent acceleration and deceleration. For DCX-MC1XX modules the **S**et **A**cceleration sets both the acceleration and deceleration value.

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7.1 POINT TO POINT MOTION (cont.)

4. Use the **M**ove **A**bsolute (**MA**) command to start the servo or stepper motor moving towards a position the given distance from its' zero position. Use the **M**ove **R**elative (**MR**) command to start the servo or stepper motor moving to a position the given distance from its' current target position. Use the **G**o **H**ome (**GH**) command to start the servo or stepper moving to its' zero position. The default units for the parameters to these commands are encoder counts or steps. After a command is issued, the motion will complete with no further commands from the user.

Example: 1**MA**85000
1**MR**12000
1**GH**

5. Repeat step 4 to start motions to other positions.

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7.2 CONTINUOUS VELOCITY MOTION

To cause a servo or stepper motor to move at a continuous velocity until commanded to stop, follow the steps below (examples assume axis 1):

1. Issue the **M**otor o**N** (**MN**) command to the selected axis (if it isn't already on).

Example: 1**MN**

2. Issue the **V**elocity **M**ode (**VM**) command to the axis.

Example: 1**VM**

3. Issue the **S**et **V**elocity (**SV**), **S**et **A**cceleration (**SA**) and **D**eceleration **S**et (**DS**) [1] commands for the desired motion. The default units for the parameters are:

DCX-MC2XX modules

Velocity parameter	Acceleration & Deceleration parameter
Encoder counts or steps per millisecond	Encoder counts or steps per millisecond per millisecond

DCX-MC1XX servo modules

Velocity parameter	Acceleration & Deceleration parameter
Encoder counts per 341 usec.	Encoder counts per 341 usec. per 341 usec.

DCX-MC1XX stepper modules

Velocity parameter	Acceleration & Deceleration parameter
Refer to Step Rate table in Appendix D	Refer to Step Rate table in Appendix D

Example: 1**SV**100000,1**SA**100000,1**DS**100000

Note [1]: The **D**eceleration **S**et command is supported by the **DCX-MC2XX** modules. The **DCX-MC1XX** modules do not support independent acceleration and deceleration. For DCX-MC1XX modules the **S**et **A**cceleration sets both the acceleration and deceleration value.

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7.2 CONTINUOUS VELOCITY MOTION (cont.)

4. Use the **DI**rection command to select positive or negative motion. A command parameter of 0 selects motion in the positive direction (increasing position reading), while 1 selects motion in the negative direction (decreasing position reading).

Example: 1**DI**0 or 1**DI**1

5. Use the **GO** command to start the servo or stepper motor moving in the specified direction. The servo or stepper motor will accelerate at the specified rate until it reaches the specified maximum velocity.

Example: 1**GO**

6. Issue the **ST**op (**ST**) command to cause the servo or stepper motor to decelerate and stop. Repeat steps 4 and 5 to start motion in the opposite direction.

Example: 1**ST**

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7.6 JOGGING

In some applications it may be necessary to have a means of manually positioning the motors. Since the **DCX-PC** is able to control the motion of servos and steppers with precision at both low and high speeds, all that is required is a manual command input.

JOYSTICK CONTROL (DCX-MC2XX modules)

The DCX-MC2XX modules support manual positioning using a analog joystick. A joystick provides a manual command input with natural hand to motion coordination.

A Typical joystick controls 2 axes with 2 potentiometers, one for each axis of motion. Each 'pot' of a joystick can be connected to one servo or stepper module. Pots with a total resistance between 10K and 100K ohms are suitable for use with the **DCX-PC** motor modules. By connecting the end taps of one pot to pins 3 and 4 of a motor module's J4 connector, and the center tap to pin 1, the module is able to read the pot's position.

To test the connection of the joystick to a module's analog input, use the **G**et **A**nalog and **T**ell **R**egister commands as in the following example:

GA1,**TR**

Since the analog inputs are measured by an 8 bit Analog to Digital Converter (ADC) the input voltage will be converted to a number between 0 and 255. With the joystick at its center position, the potentiometer will have a voltage of 2.5 volts (8 bit conversion = 128) at its center tap. Most joysticks have centering adjustments to correct offsets if necessary. As the joystick is moved from one extreme to the other, the analog input reading should range from 0 to 255.

Once operation of the joystick is verified, control of the axis can be initiated. An axis is configured for joystick motion by issuing, **S**et **V**elocity **0, V**elocity **M**ode, and the **GO** commands.

1SV0,1VM,1GO

At this point, the servo should be holding position, but there will be no joystick response until the **J**og **G**ain command (with a non-zero parameter) is issued. The units of this parameter is 0.015 encoder counts (or stepper pulses) per second per ADC unit. An ADC unit is 5VDC / 256 = 0.019 Volts, this results is a Jog Gain parameter with units of 0.78 encoder counts (or stepper pulses) per second per volt. Given the desired maximum velocity when the joystick is

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7.6 JOGGING (cont.)

pushed to the extreme, the corresponding Jog Gain can be calculated by the following equation:

Jog Gain = Desired Velocity / (0.78 * 2.5)

For example, if the desired maximum velocity is 1000 encoder counts (or stepper pulses) per second, the Jog Gain should be set to 1000 / (0.78 * 2.5) = 513. After issuing the Jog Gain command with the calculated parameter, the axis should move with a velocity proportional to the deflection of the joystick.

1**JG**513

To increase or decrease the maximum velocity of the axis the Jog Gain can be adjusted up or down at any time.

Depressing the joystick in the opposite direction should cause the axis to reverse direction. To change the direction that an axis moves in response to the joystick, reverse the leads on the end taps of the potentiometer.

Because of mechanical and electrical variations, the joystick reading may dither around 128 when the joystick returns to its' center position. This may cause undesirable drifting of the servos or steppers when the joystick is enabled. To prevent this, another parameter called Jog Deadband can be adjusted. The parameter to the **J**og **D**eadband command is in ADC units (ADC unit = 5VDC / 256 = 0.019 Volts) and specifies the amount that the joystick reading can very from the center before motion will begin. Once the reading exceeds the deadband level, it will increase linearly from zero. The following command sequence will provide a 0.06 volt deadband in the joystick operation:

1**JB**3

It was stated earlier that most joysticks have adjustments for setting the center positions. The **DCX-PC** also has a parameter for adjusting the center position of the joystick. The **J**og **O**ffset command is used to set the center position in units of volts. This value defaults to 2.5 volts. Changing the Jog Offset to a different value will provide an increased velocity range in one direction, but a reduced range in the opposite direction. For example, the following command would set the center voltage to 2.0 volts:

1**JO**102

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7.6 JOGGING (cont.)

To disable joystick control for an axis, set the Jog Gain back to zero, and stop the axis with the following command sequence:

1**JG**0,1**ST**

JOG SWITCH CONTROL (DCX-MC1XX modules)

The DCX-MC1XX servo modules and the DCX-MC1XX stepper module support manual positioning using Jog Switches.

The DCX-MC1XX servo modules provide two TTL level jog switch inputs, Jog Right and Jog Left. Each is input is active low and has a 4.7K ohm pull-up resistor.

The DCX-MC1XX stepper modules provide one Jog Switch input. To jog clockwise the input is connected to ground. To jog counter clockwise the input is connected to +5 volts.

To test the connection of the jog switches the **T**ell **S**tatus command is used. When the jog switches are not active axis status bits 21 and 23 will be cleared (0). Activate the jog right switch then issue the **T**ell **S**tatus command. The 32 bit value returned should indicate that bit 21 is set. Activate the jog left switch then issue the Tell Status command and verify that bit 23 is set. Please note that status bits 21 and 23 are not latched, once the switch is deactivated the status bits will be cleared.

Prior to implementing manual control, it is necessary to enable the jog switch mode (DCX-MC1XX servo modules only). This is accomplished with the **J**og switch o**N** command. This command is used to enable one or both of the jog switch inputs of a DC servo module. If a jog switch input goes active after it has been enabled by this command, the motor will move in the respective direction at the set jog velocity and acceleration. At the same time the Jog Switch Input Active Flag will be set in servo status. The active flag will remain set until the motor comes to a stop. At that time the motors acceleration and velocity will be set back to there regular values. While the motor is jogging its target position will follow its current position. The parameter to this command determines which of the jog switch inputs will be enabled. The coding is as follows:

n jog switch inputs enabled

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7.6 JOGGING (cont.)

0,3 or not used	right & left
1	right
2	left

This command is valid only for MC100/110/120 servo modules, it will have no effect on the MC150/160 stepper modules (their jog switch inputs are always enabled).

Once operation of the jog inputs is verified and the jog switch inputs have been enabled (DCX-MC1XX servo modules only), the parameters for jog motion must be set prior to enabling jog motion. For DCX-MC1XX servo modules the, **J**og **V**elocity command sets the maximum jogging velocity to be used when the jog switch is activated. The command parameter has a 16 bit fractional part. The integer part is defined to be the number of encoder counts per sample period. The sample period is 341 microseconds. The following example would be used to set a Jog Velocity of 1000 encoder counts per second for axis 1:

Jog Velocity = V * T * S where:

V = desired Velocity (1000 encoder counts per second)
T = sample time (seconds) = 341 usec = 341E-6
S = scaling factor = 65,536

Jog Velocity = $1000*341^{-6} * 65,536$

Jog Velocity = 22,347.776 (rounded to 22,348)

Jog Velocity =1JV22348

The DCX-MC1XX stepper module jog velocity is derived from the parameter of the **S**et **I**nitial pulse rate command. When the DCX-MC1XX stepper module jog input is activated a continuous velocity move will begin. The jog velocity is equal to the **S**et **I**nital parameter / 20.
Use the following example to program axis 1 with a jog velocity of 50 steps per second:

Jog Velocity = 1SIp / 20 where:

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7.6 JOGGING (cont.)

1SIp = axis 1 **S**et **I**nitial = 1SI28 ** = 1000 steps per second

Jog Velocity = 1000 / 20

Jog Velocity = 50

** Please refer to the Step Rate Table in the DCX-MC150/DCX-MC160 Stepper Motor Module appendix.

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7.7 TEACHING

Points can be stored in the **DCX-PC**'s point memory with the **L**earn **P**oint (**LP**) and **L**earn **T**arget (**LT**) commands. And then the motors commanded to move to those positions by issuing **M**ove to **P**oint commands using the point numbers as the command parameter, rather than the true positions.

Example:

MF
1**MA**0,2**MA**0,0**LT**1
1**MA**1000,2**MA**2000,0**LT**2
1**MA**3000,2**MA**3000,0**LT**3
1**MA**2000,2**MA**1000,0**LT**4
1**MN**,2**MN**,**AL**1
1**MP**@0,2**MP**@0,0**WS**0.1,**AA**1,**RP**3

This example begins by issuing a motor off command to the **DCX-PC**. Move commands are then issued to axes 1 and 2. No motion will occur because the motors are in the off state, but the target positions will be updated. After each move, a **L**earn **T**arget command is issued with an axis specifier of 0. This will cause the respective motor target positions to be stored in the DCX's memory. After teaching 4 position pairs, the motors are turned back on and a command sequence that will move axes 1 and 2 to positions 1,2,3 and 4 is issued. The axes will stop for 1 tenth second at each position before continuing to the next point. The axes will move with the accelerations and velocities that were set for those axes prior to the **MP** command being issued.

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7.8 HOMING

When the **DCX-PC** is turned on or reset, all servo and stepper positions are initialized to zero. If they are subsequently moved, the controller will report their positions relative to the position where they were initialized.

In many applications, there is some position of the motor that is considered 'home'. When the motor is at this position, it is desirable to have the controller report its' position as zero.
With the **DCX-PC** there are several ways to achieve this. One method is to physically move the motor to the home position, and then to issue a **D**efine **H**ome (**DH**) command to the axis.
In automated system, there are advantages to having electro-mechanical devices in the system signal the **DCX-PC** when a motor is at its home position, and programming the controller to find the home position on its' own. The remainder of this section describes how this can be done for servos and stepper motors.

For servo motors control (using DCX-MC1XX and DCX-MC2XX servo modules) and stepper motor control (using the DCX-MC260 stepper module) the **DCX-PC** is not shipped from the factory with pre-programmed homing functions. Instead, it has been designed to allow the user to define a custom homing sequence that is specific to the system requirement. Using any of the built-in motion commands as part of a homing macro, the user can write a sequence of moves to perform the necessary homing operation. **DCX-PC** systems using the DCX-MC150/160 stepper modules use a pre-programmed homing procedure initiated by the **F**ind **E**dge command.

In addition to the **D**efine **H**ome command, there are two other commands that are used to set a motors position. The **F**ind **I**ndex (**FI**) command is used to zero a servo's position when its' encoder 'Index' input goes active. The **F**ind **E**dge (**FE**) command is used to zero a stepper's position when its' 'Home' input goes active. Neither of these commands will start or stop any motor motions, it is up to the user to initiate motion prior to issuing the commands, and stopping motion after they complete.

For **DCX-PC** systems using **DCX-MC2XX** modules, an additional set of commands allow the user to implement a “hands off “ approach to simultaneous multi-axes homing. After starting Velocity Mode moves on one or more axes, the commands listed below begin a background monitoring function for each axis. Once the input condition is satisfied, the axis will decelerate using the slope specified by the **D**eceleration **S**et command.

GE **G**o until home input **E**dge occurs
GF **G**o until coarse home input is o**F**f
GI **G**o until encoder **I**ndex is on
GN **G**o until coarse home input is o**N**

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7.8 HOMING (cont.)

Since an index pulse may occur at numerous points of a servo's travel (once per revolution in rotary encoders), a typical servo application will require a coarse home signal to "qualify" the index pulse. In this situation the following command string could be used to initialize servo 1:

1**MN**,**PM**,**SV**1000,**MR**1000000,**WE**1,**ST**,**WS**0.1,**MR**-1000000,
WE0,**FI**,**ST**,**WS**0.1,**MN**,**MA**0,**WS**0.1

Here the servo is placed in position mode and moves out of the coarse home region and then back into it (**WE** commands). As soon as the servo re-enters the coarse home range it is commanded to find the index pulse (**FI** command). At that point the current position will be captured in an internal register of the module. After the find index command completes, the servo is commanded to stop. After the wait stop command, a motor on command is issued to adjust the servos position relative to where the index mark was activated. As a final step the servo is moved back to the "home" position.

For stepper control using the DCX-MC260 module, the following command string could be used to initialize motor 1:

1**MN**,**PM**,**SV**1000,**MR**1000000,**WE**1,**ST**,**WS**0.1,**MR**-1000000,
FE,**ST**,**WS**0.1,**MN**,**MA**0

Note that the motor is moved in the positive direction until the home input goes inactive (**WE** command). Next the motor is moved in the negative direction until the home input goes active (**FE** command). At soon as the home is sensed, the current position is defined to be 0. Finally the motor is stopped, and then moved back to the "home" position.

The two previously described homing command sequences can be preceded with a **M**acro **D**efine (**MD**) command to convert them into macros. For use with the **HO**me (**HO**) command, macro 1 should be defined to home motor 1, macro 2 should be defined to home macro 2, and so on. The macros can then be call directly with the **M**acro **C**all (**MC**) command, indirectly with the **HO**me command, or spawned as a background task with the **G**enerate **T**ask command.

In order to home a stepper motor using the DCX-MC150/MC160 module, the **F**ind **E**dge (**FE**) command should be used. The function of this command differs from it's operation for other motor control modules. This command will cause the motor to move at a constant speed equal to the initial step rate divided by 20. If the "home" input of the module (pin 13 of connector J3) is active (low) the motor will begin moving in the counter-clockwise direction. It will continue moving is this direction until the home input goes inactive (high). At that point the motor will be stopped and then moved in the clockwise direction until the home input goes active (low). At that point the motor will be stopped and the motor position initialized to 0 or the position specified when the Find Edge command was issued. Using this procedure will cause the motor position to

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be initialized with the motor moving in the same direction each time. This should eliminate inaccuracies caused by mechanical backlash in the system. Note that the **F**ind **I**ndex (**FI**) and **W**ait **E**dge (**WE**) commands perform no function for the stepper module.

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7.9 MOTION LIMITS

The **DCX-PC** Motion Controller supports dedicated inputs for limit switches.

If a limit switch input goes active after it has been enabled by the motion **L**imits o**N** command, and the motor has been commanded to move in the direction of that switch, the Motor Error and one of the Limit Tripped Flags will be set in the motor status. At the same time the motor will be turned off or stopped.

Once motion limit condition exists, the error flags will remain set until the motor is turned back on with the **MN** command. When the motor is turned back on, it can be moved out of the limit region with any of the standard motion commands.

The action that a motor takes when it encounters a motion limit can be selected with the **L**imit **M**ode command. The default action is to turn the motor off. Alternatively, the motor can be stopped abruptly, or decelerated to a stop at the current deceleration rate.

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8.0 MOTHERBOARD DIGITAL INPUT/OUTPUT

The **DCX-PC** Motion Controller motherboard has 16 undedicated digital I/O channels. These signals can be accessed on connector J3 of the motherboard. Appendix B includes a pinout for this connector.

There are numerous commands available for monitoring and controlling the digital I/O channels. Each of these commands uses a channel number from 1 to 16 as a parameter. The **C**hannel **I**n, **C**hannel ou**T** commands can be used to configure the channels individually as inputs or outputs. The **C**hannel **H**igh true logic and **C**hannel **L**ow true logic commands configures the I/O channels for "High True" or Low True" logic.

After configuration, the **T**ell **C**hannel, **C**hannel o**N**, **C**hannel of**F** commands can monitor and control the I/O channels. The sequence commands: **D**o if channel o**N**, **D**o if channel of**F**, **I**f channel o**N**, **I**f channel of**F**, **W**ait for channel o**N**, and **W**ait for channel of**F** are also available for controlling command execution.

8.1 MODULE DIGITAL INPUT/OUTPUT

Each digital I/O module that is installed in the **DCX-PC** provides an additional 16 digital I/O channels. Since the 16 I/O channels that are standard on the **DCX-AT200** motherboard are identified as 1 through 16, the I/O channels on the installed modules will be assigned to succeeding channel/numbers in blocks of 16 (e.g. 17-32, 33-48, etc.). These I/O channels accept the same configuration, monitoring, control and sequencing commands as the motherboard digital I/O.

If a BFO22 interface and relay rack are connected to the **DCX-PC** motherboard or a MC400 module, a global **C**hannel **L**ow command should be issued to the **DCX-PC**. This will cause "normally open" relays to turn on when the **C**hannel o**N** command is issued, and off when the **C**hannel o**F**f command is issued. For input modules, the **T**ell **C**hannel command will return a "1" when the signal is present, and a "0" when it is not. By default, all I/O channels on the **DCX-PC** are changed to inputs during power-up or reset. For input modules installed in the relay rack, no further configuration is necessary. In order to configure any channels as outputs, individual **C**hannel ou**T** commands should be issued to the **DCX-PC**.

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9.0 MOTHERBOARD ANALOG INPUT

The **DCX-PC** Motion Controller motherboard has 4 undedicated 8 bit analog input channels. These signals can be accessed on connector J3 of the motherboard. Appendix B includes a pinout for this connector.

The analog input channels on the motherboard are numbered from 1 to 4. Each of these inputs can accept an analog input signal from 0 to +5 volts. To prevent damage to the **DCX-PC** circuitry, the input signal must be limited to this range by external circuits.

A 5.00 volt output (from host power supply) is available on the pin 1 of connector J3. This voltage supply can be used as a reference for both an analog device (such as a potentiometer) and the Analog Reference Input (pin 23 connector J3). Alternatively, an external reference voltage between 0 and +5 volts can be connected to pin 23 of connector J3.

The **DCX-PC** will perform a ratiometric conversion of the four input channels periodically. The result of each conversion will be a number between 0 and 255. If the on-board reference is used, the value will be the ratio of the input voltage to 5.0 volts, times 255. If an external reference voltage is used, the value will be the ratio of the input voltage to the reference voltage, times 255.

Two commands are provided on the **DCX-PC** for reading analog inputs. The **T**ell **A**nalog command can be used to display the current readings from the analog inputs. The **G**et **A**nalog command will load a channels current reading into the accumulator (user register 0).

In addition to the commands, the host computer can read the on-board analog input readings directly from dual port memory. These 4 readings are update by the **DCX-PC** every 4 milliseconds (one millisecond per channel). The appendix describing the **DCX-PC**'s dual ported memory details the location of these readings.

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9.1 MODULE ANALOG INPUT/OUTPUT

Description:

The DCX-MC500 Analog I/O Module provides additional analog I/O capability to a **DCX-PC** Motion Controller. One or more of these modules can be installed in any available position on a **DCX-PC** motherboard. Analog input channels can be used to monitor signal levels from external sensors. Output channels can be used to control external devices.

Three models of the DCX-MC500 are available:

DCX-MC500	4 Inputs and 4 Outputs
DCX-MC510	4 Inputs
DCX-MC520	4 Outputs

On each DCX-MC500 Analog I/O Module all analog input channels are numbered sequentially as a group. Likewise, all analog output channels are numbered sequentially as a group.

When installed in the **DCX-PC**, since there are already 4 analog input channels on the motherboard, the analog I/O channels on the DCX-MC500's start with number 5.

Because the **DCX-PC** controller board is implemented in digital electronics, all analog input signals must be converted into a representative numerical value. This function is done by an Analog to Digital Converter (ADC) on the DCX-MC500. Similarly, analog output signals originate on the **DCX-PC** board as numerical values. These numbers must be written to a Digital to Analog Converter (DAC) on the DCX-MC500, which converts them to a corresponding analog output signal level.

The DCX-MC500 is designed to accurately measure voltage levels on the input channels. These inputs are very high impedance with leakage currents less then 10 nanoamps. The output channels are designed to provide signals with accurate voltage levels. The current from these outputs should not exceed 10 milliamp.

Each of the analog input and analog output channels has 12 bits of resolution. This means that the digital value read from the ADC, or the digital value written to the digital to the DAC, must be in the range 0 to 4095. For both inputs and outputs, a digital value of 0 translates to the lowest analog voltage. A digital value of 4095 translates to the highest analog voltage.

Input signals on pins 1, 3, 5 and 7 of the module J3 connector are wired directly to the ADC. No amplification or clamping to the input voltage range is provided on the module. Inputs with voltages exceeding the input range may cause damage to ADC and must be prevented.

In some applications, the signals from a sensor may not be absolute voltage levels, but

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proportional to some reference voltage. In these cases, it may be desirable to supply the reference signal to the ADC on the module through pin 18 of the J3 connector (and setting jumper JP1 accordingly). This will result in a "ratiometric" conversion of the input signal relative to the reference voltage.

The outputs from the DAC on the DCX-MC500 module are voltage levels in the range 0 to +5 volts. These outputs have no gain or offset adjustment. These signals are available on pins 10, 12, 14 and 16 of the module J3 connector.

The outputs from the DAC are also connected to operational amplifiers on the module which offset and amplify them to provide a -10 to +10 volt range. Each of these outputs has a 20 turn trim pot for offset adjustment, and a single turn pot for gain adjustment. The offset pot provides a minimum ±0.5 volt adjustment, and the gain pot provides a nominal ±2% range adjustment. These output signals are available on pins 2, 4, 6 and 8 of the module J3 connector.

After reset the outputs of the DCX-MC500 will be initialized to their mid-scale point. For the 0 to +5 volt outputs, this will be 2.5 volts. For the -10 to +10 volt outputs, this will be 0.0 volts.

Calibration:

The analog input of the DCX-MC500 needs has no adjustments, and the only option is use of the internal +5, or an external, reference voltage.

The analog outputs with the 0 to +5 volt range also have no adjustments. The reference for the DAC is fixed to the internal reference voltage.

Calibration of the analog outputs with the -10 to +10 volt range is accomplished using the 8 trim pots located on the module. There are four single turn trim pots which adjust the gain of each of the four analog outputs. There are also four 20 turn trim pots for adjusting the offsets of each of the analog outputs. Refer to the module layout diagram at the end of the appendix describing the MC500 module for pot locations and assignments.

Using the following command sequence, and reading the analog output voltage level with a voltmeter, an analog output can be calibrated to provide the specified -10 to +10 volt range:

AL0,**OA**n,**WA**2,**AL**2048,**OA**n,**WA**2,**AL**4095,**OA**n,**WA**2,**RP**

where: n = channel number = 1, 2, 3, 4, ...

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9.1 MODULE ANALOG INPUT/OUTPUT (cont.)

This command sequence will cycle the specified analog output from the minus limit, to the mid-point, to the positive limit. There is a 2 second delay at each voltage level, during which the voltmeter can settle and display the current reading.

The first step in calibrating an analog output is to adjust the gain using the single turn pot to achieve a 20.00 volt "swing". This is the difference between the most positive level reading, and the most negative level reading. It is not necessary for the two readings to be centered about 0 volts for this step.

The second step is to adjust the offset using the 20 turn pot. This adjustment will place the mid-point of analog output at the 0 volt level. When the output changes to the mid-point level turn the pot to achieve a 0.000 volt reading.

After the second step of the calibration procedure, the output swing should still be 20.00 volts. If not, repeat steps 1 and 2 again.

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10.0 USER REGISTERS

The **DCX-PC** contains 256 general purpose registers. These registers can be used for many purposes, including holding command parameters, performing math computations and controlling command execution.

The registers are numbered 0 through 255, with register 0 being the 'accumulator'. The accumulator (register 0) is used in most commands that manipulate the registers. Each register can hold a 32 bit integer.

Typically the user issues commands with 'immediate' parameters (ie. the parameter is a constant). The user can also issue commands, specifying that the parameter is the contents of a register. This is done by replacing the command parameter with the register number preceded with an '@' sign. For example, the command "1**MR**@10" will cause the **DCX-PC** to move axis 1 by the number stored in register 10. The use of a register specifier can be used in any command as the parameter. The **DCX-PC** does NOT support the use of the '@' sign in front of an axis number.

The following commands are available for working with the registers:

AA*n*	**A**ccumulator **A**dd (ACC = ACC + *n*)
AC*n*	**A**ccumulator **C**omplement, bit wise (ACC = !ACC)
AND	**A**ccumulator **D**ivide (ACC = ACC / *n*)
AE*n*	**A**ccumulator logical **E**xclusive or with *n*, bit wise (ACC = ACC eor *n*)
AL*n*	**A**ccumulator **L**oad with constant *n* (ACC = *n*)
AM*n*	**A**ccumulator **M**ultiply(ACC = ACC x *n*)
AN*n*	**A**ccumulator logical a**N**d with *n*, bit wise (ACC = ACC and *n*)
AO*n*	**A**ccumulator logical **O**r with *n*, bit wise (ACC = ACC or *n*)
AR*n*	copy **A**ccumulator to **R**egister *n* (REG*n* = ACCn)
AS*n*	**A**ccumulator **S**ubtract (ACC = ACC - *n*)
GA*x*	**G**et **A**nalog value (ACC = channel *x*)
*a***GX**	**G**et au**X**iliary encoder position (ACC = axis *a* auxiliary encoder)
IB*n*	**I**f accumulator is **B**elow (less than) constant *n*, do next command, else skip 2 commands
IC*n*	**I**f bit *n* of accumulator is **C**lear, do next command, else skip 2 commands
IE*n*	**I**f accumulator **E**quals constant *n*, do next command, else skip 2 commands
IG*n*	**I**f accumulator is **G**reater than constant *n*, do next command, else skip 2 commands

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10.0 USER REGISTERS (cont.)

Is*n*	**I**f bit *n* of accumulator is **S**et, do next command, else skip 2 commands
Iu*n*	**I**f accumulator is **U**nequal to constant *n*, do next command, else skip 2 commands
OA*x*	**O**utput **A**nalog value (channel *x* = ACC)
RA*n*	copy **R**egister *n* to **A**ccumulator (ACC = REG*n*)
SL*n*	**S**hift **L**eft accumulator *n* bits (ACC = ACC << *n*)
SR*n*	**S**hift **R**ight accumulator *n* bits (ACC = ACC >> *n*)
TR*n.p*	**T**ell contents of **R**egister *n*
TR.*p*	**T**ell contents of accumulator (register 0)

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10.1 READING AND WRITING MEMORY

A group of read and write commands are available for accessing the **DCX-PC**'s internal memory. These commands provide an easy method of moving motor data in and out of the Accumulator (user register 0). To use a read or write command for this purpose, it should include an axis specifier and a parameter selected from the motor table offsets listed below. The type of command to use (byte, long, or word), is determined by the type of data to be accessed and is listed below.

In general, the motor tables should not be modified with the write commands, this should only be done by the appropriate Parameter Setup commands. Using the write commands to modify the motor tables may neglect performing the necessary internal operations associated with a motor parameter.

An example of using the read commands to access the motor tables is shown below.

To read motor two's status into the accumulator, issue the following command:

2**RL**0

where:

2 = motor #2
RL = Read 32 bit value from the **Motor Table** and store in the accumulator
0 = Motor Table offset, 0 = motor status (the Motor Table is on the next page)

Memory read/write commands:

*a***RB***n*	**R**ead **B**yte (8 bit) at memory location *n* into accumulator (ACC = (*n*))
*a***RL***n*	**R**ead **L**ong (32 bit) at memory location *n* into accumulator (ACC = (*n*))
*a***RW***n*	**R**ead **W**ord (16 bit) at memory location *n* into accumulator (ACC = (*n*))
*a***WB***n*	**W**rite accumulator low **B**yte (8 bit) to memory location *n* ((*n*) = ACC)
*a***WL***n*	**W**rite accumulator **L**ong (32 bit) to memory location *n* ((*n*) = ACC)
*a***WW***n*	**W**rite accumulator low **W**ord (16 bit) to memory location *n* ((*n*) = ACC)

where:

long = 32 bit integer
word = 16 bit integer
byte = 8 bit integer

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10.1 READING AND WRITING MEMORY (cont.)

Motor Table Offsets:

Motor Status	= 0h
Current Position	= 04h
Target Position	= 08h
Programmed Velocity	= 0Ch
Programmed Acceleration	= 14h
Programmed Deceleration	= 18h
Move Delta	= 24h
Slewing Velocity	= 34h
Index Register	= 38h
Slewing Acceleration	= 40h
Stop On Error	= 44h
	= 4Ch
Trajectory Generator	= 50h
Position Gain	= 60h
Derivative Gain	= 62h
Integral Gain	= 64h
Integrating Limit	= 66h
Sampling Frequency	= 68h
Positive Torque Limit	= 6Ah
Wait stopped timer	= 6Eh
Master Axis	= 70h

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11.0 COMMAND SET

An easy-to-remember set of two letter commands has been implemented on board the **DCX-PC**. The commands are preceded by an axis number (*a*) and/or followed by a number (*n*) as required. The following sections group the commands according to their purpose, describing each in detail.

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11.1 PARAMETER SETUP COMMANDS

*a***AH** **A**uxiliary encoder define **H**ome (MC2XX modules only)

This command causes axis *a* auxiliary encoder position to be set to 0. This encoder input is not used for loop closure. For defining the home position of the primary encoder, see the **D**efine **H**ome command. For defining the home position of the auxiliary encoder input of the MC160 module, see the **F**ind **I**ndex command.

BR*n* **B**aud **R**ate

Used to change the programmed baud rate for the RS-232 interface. The actual baud rate is determined by using the value *n* in a countdown circuit.

Example: **BR**23 (sets the baud rate to 2,400 baud)

Note: This command takes effect immediately, so use with caution. Any value entered will result in some baud rate but not necessarily a standard one. (see codes below)

Codes for the standard baud rates:

Baud Rate	*n*
19,200	2
9,600	5
4,800	11
2,400	23
1,200	47
600	95
300	91

The values given are decimal numbers. If you are in hex mode, be sure to enter the hexadecimal equivalent, or momentarily change to decimal mode.

CF*x* **C**hannel of**F**

Causes digital I/O channel *x* to go to "off" state. If the channel has been configured for "high true", the channel will be at a logic low (less than 0.4 volts DC) after this command is executed. If it has been configured for "low true", the channel will be at a logic high (greater than 2.4 volts DC).

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11.1 PARAMETER SETUP COMMANDS (cont.)

CH*x* **C**hannel **H**igh true logic

Causes digital I/O channel *x* to be configured for "high true" logic. This means that the I/O channel will be at a high logic level (greater than 2.4 volts DC) when the channel is "on", and at low logic level (less than 0.4 volts DC) when the channel is "off". Note that issuing this command will not cause the I/O channel to change its current state. Issuing this command without specifying a channel will cause all channels present on the **DCX-PC** to be configured as "high true".

CI*x* **C**hannel **I**n

Used to configure digital I/O channel *x* as an input. See the description of the **T**ell **C**hannel command for more details.

CL*x* **C**hannel **L**ow true logic

Causes digital I/O channel *x* to be configured for "low true" logic. This means that the I/O channel will be at a low logic level (less than 0.4 volts DC) when the channel is "on", and at high logic level (greater than 2.4 volts DC) when the channel is "off". Note that issuing this command will not cause the I/O channel to change its current state. Issuing this command without specifying a channel will cause all channels present on the **DCX-PC** to be configured as "low true".

CN*x* **C**hannel o**N**

Causes channel *x* to go to "on" state. If the channel has been configured for "high true", the channel will be at a logic high (greater than 2.4 volts DC) after this command is executed. If it has been configured for "low true", the channel will be at a logic low (less that 0.4 volts DC).

CT*x* **C**hannel ou**T**

Used to configure digital I/O channel *x* as an output. The **DCX-PC** will turn the channel "off" before changing it to an output.

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11.1 PARAMETER SETUP COMMANDS (cont.)

*a***DH***n* **D**efine **H**ome

Defines the current position of a motor to be *n*. From then on, all positions reported for that motor will be relative to that point.

*a***DI***n* **DI**rection (*n* = 1 or 0)

Sets the move direction of a motor when in velocity mode.

*a***DS***n* **D**eceleration **S**et (0 <= *n* < 1,073,741,823) (MC2XX modules only)

Defines the deceleration rate for a given axis. The command parameter has a 16 bit fractional part. The integer part is defined to be the number of encoder counts per sample period per sample period. The sample period is 1000 microseconds.

EF **E**cho of**F** (*n* = 0, 1, 2 or 3)

Causes **DCX-PC** not to echo characters received through an ASCII command port. Only data specifically requested from the **DCX-PC** will be transmitted. Normally used when operating the host or terminal in half duplex mode. The parameter to this command selects the terminating character or characters that will be transmitted with command replies. The table shown with the **E**cho o**N** command lists the available options.

EN **E**cho o**N** (*n* = 0, 1, 2 or 3)

Causes all characters received through an ASCII command port to be echoed to that port as received. Normally used when operating with the host or terminal in full duplex mode. The parameter to this command selects the terminating character or characters that will be transmitted with command replies. The table below list the available options.

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n	Terminating Characters
0	No change from current setting
1	Carriage Return (ASCII 13) Only
2	Linefeed (ASCII 10) Only
3	Carriage Return and Linefeed (ASCII 13 and 10)

*a***FC** **F**ull **C**urrent

Causes Full/Half Current output signal of stepper module to go low.

*a***FF** amplifier **F**ault input of**F**

Disables the Amplifier Fault input of a servo module. See description of amplifier **F**ault input o**N** command (**FN**), for further details. This command has no effect on stepper motors.

*a***FN** amplifier **F**ault input o**N**

Enables the Amplifier Fault input of a servo module. If the input goes active after this command is executed, the motor will be turned off and the amplifier fault tripped flag in the servo status word will be set.

*a***FR***n* set derivative sampling period (0 <= *n* <= 255)

Helps tune servo loop to the inertial characteristics of system. High inertial loads normally require longer period and low inertial loads a shorter period. Default value is zero. For a value of *n*, the sampling period will be (*n* +1) * sample period (341 microseconds for MC1XX servo modules, 1 msec for MC2XX modules). This command will only have effect for servo modules.

*a***HC** **H**alf **C**urrent

Causes Full/Half Current output signal of stepper module to go high.

HF **H**andshake of**F**

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11.1 PARAMETER SETUP COMMANDS (cont.)

Disables hardware handshake of serial communications through the RS-232 module.

HN **H**andshake o**N**

Enables hardware handshake of serial communications through the RS-232 module.

*a***HS** **H**igh **S**peed (MC260 module only)

This command sets the MC260 pulse output range from 1.0 thousand steps /sec to 1.25 million steps / sec.

*a***IL***n* set **I**ntegration **L**imit (0 < *n* < 32,767)

Limits level of power that integral gain can use to reduce error to zero. This command will only have effect for servo modules.

*a***JB***n* **J**og deab**B**and (0 <= *n* <= 127) (MC2XX modules only)

Sets jogging joystick input deadband. See the section on jogging for details.

*a***JF***n* **J**og switch of**F** (MC1XX servo modules only)

Disables one or more both switch inputs of a servo module. The parameter to this command determines which inputs will be disabled. The coding of the parameter is the same as for the **J**og switch o**N** command (**JN**). See description of **JN** command for further details. This command will have no effect on the MC150/160 stepper modules (MC150/150 jog switch inputs are always enabled).

*a***JG***n* **J**og proportional **G**ain (0 <= *n* <= 65535) (MC2XX modules only)

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11.1 PARAMETER SETUP COMMANDS (cont.)

Sets jogging joystick proportional gain. See the section on jogging for details.

*a***JN***n* **J**og switch o**N** (MC1XX servo modules only)

This command is used to enable one or both of the jog switch inputs of a servo module. If a jog switch input goes active after it has been enabled by this command, the motor will move in the respective direction at the set jog velocity and acceleration. At the same time the Jog Switch Input Active Flag will be set in servo status. The active flag will remain set until the motor comes to a stop. At that time the motors acceleration and velocity will be set back to there regular values. While the motor is jogging its target position will follow its current position. The parameter to this command determines which of the jog switch inputs will be enabled. The coding is as follows:

n	jog switch inputs enabled
0, 3 or no parameter	right & left
1	right
2	left

This command will have no effect on the MC150/160 stepper modules (MC150/160 jog switch inputs are always enabled).

*a***JO***n* **J**og **O**ffset (0 <= *n* <= 255) (MC2XX modules only)

Sets jogging joystick input offset. See the section on jogging for details.

*a***JV***n* **J**og **V**elocity (0 <= *n* < 1,073,741,823) (MC1XX servo modules only)

Sets maximum jogging velocity to be used when jog switch is activated. The parameter to this command has the same units as the **S**et **V**elocity command.

*a***LF***n* **L**imit switch of**F**

Disables one or more limit switch inputs of a servo or stepper module. The parameter to this

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command determines which inputs will be disabled. The coding of the parameter is the same as for the **L**imit switch o**N** command (**LN**). See description of **LN** command for further details. This command has no effect on the DCX-MC150/160 stepper modules (MC150/160) limit switch inputs are always enabled.

*a***LM***n* **L**imit **M**ode

This command is used to select how the **DCX-PC** will react when a limit switch is activated. The parameter coding is as follows:

n	Limits enabled
0	turn motor off
1	stop abruptly
2	stop smoothly

in all cases the **M**otor **O**n flag in the status word will be cleared. This will prevent the **DCX-PC** from moving the motor until the **M**otor **O**n command is issued.

This command has no effect on the DCX-MC150/160 stepper modules (the MC150/160 will always stop abruptly when a limit switch is activated).

*a***LN***n* **L**imit switch o**N**

This command is used to enable one or both of the limit switch inputs of a servo or stepper module. If a limit switch input goes active after it has been enabled by this command, and the motor has been commanded to move in the direction of that switch, the motor will be turned off. At the same time the Limit Switch Input Tripped Flag will be set in servo status. The tripped flag will remain set until the motor is turned back on with the **MN** command. Once the motor is turned back on, it can be moved out of the limit switch region with any of the standard motion commands. The parameter to this command determines which of the limit switch inputs will be enabled. the coding is as follows:

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n	limit switch inputs enabled
0, 3 or no parameter	positive & negative
1	negative
2	negative

This command has no effect on the DCX-MC150/160 stepper modules (MC150/160 limit switch inputs are always enabled).

***a*LS** **L**ow **S**peed (MC260 module only)

This command sets the MC260 pulse output range from 15 steps /sec to 19.5 thousand steps / sec.

***a*MS** **M**edium **S**peed (MC260 module only)

This command sets the MC260 pulse output range from 125 steps /sec to 156 thousand steps / sec.

***a*OM*n* **O**utput **M**ode (MC260 module only)

This command is used to set a stepper's output mode. The available modes are listed in the table below:

n	Module Output Mode
0	PULSE and DIRECTION OUTPUTS (default)
1	CW and CCW PULSE OUTPUTS

a*PH*n Set Servo Output **PH**ase (n = 0 or 1) (MC2XX servo modules only)

This command is used to set the servo's output phasing. The phase of the output will determine whether the module drives the servo in a direction that reduces position error, or

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increases it. The module defaults to standard phasing, which is the same as issuing this command with a parameter of 0. The module output can be set to reverse phase by issuing this command with a parameter of 1.

RT **R**ese**T** system

Performs a complete restart of the system, including restoration of all default conditions, such as acceleration and velocity, and leaves all axes in the "off" condition.

*a***SA***n* **S**et **A**cceleration
(0 <= *n* < 1,073,741,823 for DCX-MC1XX servo modules)
(0 <= *n* <= 4,294,967,295 for DCX-MC2XX modules)
(0 <= *n* <= 255 for MC150/160 stepper modules)

Defines the acceleration rate for a given axis. For the command parameter has a 16 bit fractional part. The integer part is defined to be the number of encoder counts per sample period per sample period. The sample period is 341 microseconds for the DCX-MC1XX servo modules and 1000 microseconds for the MC2XX modules. For the DCX-MC150/160 stepper modules see the Step Rate Table in the Stepper Motor Module Appendix D.

*a***SD***n* **S**et **D**erivative gain (0 <= *n* <= 32,767) (servo modules only)

Dampens oscillation. Default value is zero.

*a***SE***n* **S**top on **E**rror (0 <= *n* <= 32767) (servo modules only)

Used to set the maximum following or position error for a servo module. Once this command is issued and the motor is on, if the servo position error exceeds the specified value it will be turned off. At the same time the motor error flag in servo status will be set. This flag will remain set until the motor is turned back on with the **MN** command. This command has no effect for the stepper module. A parameter of *n* = 32767 sets an infinite following error (DCX-MC2XX servo modules only).

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11.1 PARAMETER SETUP COMMANDS (cont.)

*a***SF** **S**tep **F**ull

Causes Full/Half Step output signal of stepper module to go low.

*a***SG***n* **S**et proportional **G**ain of motor (0 <= *n* <= 32,767)

Control the responsiveness of the servo loop. Default value is zero.

*a***SH** **S**tep **H**alf

Causes Full/Half Step output signal of stepper module to go high.

*a***SI***n* **S**et **I**ntegral gain of servo (0 <= *n* <= 32,767)

Accumulates dynamic and static error and outputs command to reduce error to zero. Default value is zero. Note that **I**ntegration **L**imit (**IL**) command must be set to a nonzero value before integral gain will have any effect.

*a***SI***n* **S**et **I**nitial pulse rate of Stepper (0 <= *n* <= 255)
(MC150/160 stepper modules only)

See the Step Rate Table in the Stepper Motor Module appendix for interpretation of this command parameter.

*a***SQ***n* **S**et tor**Q**ue (-2047 <= n <= 2047) (MC2XX servo modules only)

Limits maximum output level for servo drives. When an axis is placed in torque mode, this command sets the continuous output level.

*a***SV***n* **S**et **V**elocity (0 <= *n* < 1,073,741,823 for DCX-MC1XX servo module)
(0 <= *n* <= 4,294,967,295 DCX-MC2XX modules)
(0 <= *n* <= 255 for DCX-MC150/160 stepper)

The command parameter has a 16 bit fractional part. The integer part is defined to be the

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number of encoder counts or steps per sample period. The sample period is 341 microseconds for the MC100/110/120 modules and 1000 microseconds for the MC2XX module. For the DCX-MC150/160 stepper module see the Step Rate Table in the Stepper Motor Module appendix.

a*VG*n Set **V**elocity **G**ain (0 <= *n* <= 32,767) (MC2XX servo modules only)

Sets feed forward term of servo PID-FF loop.

XF*n* set **X**of**F** code (0 <= *n* <= 255)

This command sets the 8-bit code that will be sent out an ASCII command port when the **DCX-PC** begins executing a command issued through that port. The parameter defaults to 0 which inhibits any code from being sent. The primary purpose of this function of the **DCX-PC** is to support communications over the serial port with host computers that require **XON**/**XOFF** protocol. The standard **XOFF** code is 19 decimal.

Example: **XF**19

Note that each ASCII command port (PC, GPIB, Serial) maintains it's own **XOFF** code. This command has no effect when issued from the direct access command port.

XN*n* set **X**o**N** code (0 <= *n* <= 255)

This command sets the 8-bit code that will be sent out an ASCII command port when, a command issued through that port has completed. This parameter defaults to 0 which inhibits any code from being sent. The standard **XON** code is 17 decimal.

Example: **XN**17

One use of this command is to provide a prompt character when the **DCX-PC** is ready for the next command.

Example: **XN**62 ;Display ">" when ready for next command

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11.2 MOTION COMMANDS

*a***AB** **AB**ort motion

This command is used for stopping an undesired motion. For servo axes the motor will stop abruptly but leaves the servo control loop enabled. For **MC260** controlled stepper axes the motor will stop abruptly but status word (**TS**) will indicate that the motor is still on. For the **MC150/160** stepper module this command will turn the motor off. The optimal position (**aTO**) for the selected axis or axes is changed to be equal to the present position. After executing this command, and waiting for motor to stop, the user should issue the **M**otor o**N** command or the **P**osition **M**ode command to re-initialize the axis.Note that the **W**ait **S**top command will not work after an **AB**ort command until the **P**osition **M**ode command is issued.

Example: 2AB,WA1000,2MN

*a***AF** **A**uxiliary encoder **F**ind index (MC160, and MC2XX modules only)

This command is used to initialize a motor's auxiliary encoder at a given position. This command will not cause any motor motion to be started or stopped. It is up to the user to initiate motor motion before issuing the command, and to stop any motion after it completes. Issuing this command does not delay additional command execution, it remains active in background waiting for the index pulse to occur. At that time the current position of the auxiliary encoder will be set to 0.

Exception: **DCX-MC160** stepper module: Both the Home and Encoder Index inputs are required to initialize the auxiliary encoder position. Issuing the **AF** command will enable the coarse home and index inputs to the module. Once both of these inputs are active (low) for a minimum of 75 nanoseconds, the encoder count will be reset to 0. After the encoder count has been reset the coarse home and index inputs are disabled.

AP **A**djust **P**osition

Used to modify a previously stored position to a modified new position. This command will update the currently active position (i.e. the last position moved to).

Example: Assume **MP**10 was X1, Y1
MN,**MP**10
MR10,2**MR**20
AP
The new location of position 10 will now be (X1 + 10), (Y1 + 20).

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11.2 MOTION COMMANDS (cont.)

*a***FE***n* **F**ind **E**dge

This command utilizes the Home input to initialize a stepper motor at a given position. This command does not support servo motor initialization.

DCX-MC260 Stepper module

Once the **F**ind **E**dge command is issued no other commands will be processed until the course home input goes active. At that time the current position of the motor will be defined to be *n*. This command will not cause any motor motion to be started or stopped. It is up to the user to initiate motor motion before issuing the command, and to stop any motion after it completes. With this command, the following command string could be used to initialize motor 1:

1**MN**,1**PM**,1**SV**1000,1**MR**1000000,1**WE**1,1**ST**,**WA**1000,1**PM**,1**MR**-1000000,
1**FE**,1**ST**,**WA**1000,1**PM**,1**MA**0

Note that the motor is moved in the positive direction until the course home input goes inactive (**WE** command). Next the motor is moved in the negative direction until the course home input goes active (**FE** command). As soon as the course home is sensed, the current position is defined to be 0. Finally the motor is stopped, put into position mode, and then moved back to the "home" position. To save typing, this command sequence can be placed into a macro and executed using the **EM** or **HO** commands.

Note that in the example, **P**osition **M**ode commands were included each time the motor was commanded to stop, or the find edge command executed. It is necessary to issue the Position Mode command in these cases in order to set the target position to it's current position. If this is not done, subsequent move commands will cause the motor to move to unexpected positions. Also note that the **W**ait **S**top command is not used after the **F**ind **E**dge command. This is due to the fact that the target changes once the edge is found. The **W**ait **S**top will not work until after the **P**osition **M**ode command has been issued.

DCX-MC150/160 stepper modules

This command is used to initialize a stepper motor at a given position. The **F**ind **E**dge command will cause the motor to move at a constant speed equal to the initial step rate divided by 20. If the "home" input of the module (pin 13 of connector J3) is active (low) the motor will begin moving in the counter-clockwise direction. It will continue moving is this direction

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until the home input goes inactive (high). At that point the motor will be stopped and then moved in the clockwise direction until the home input goes active (low). At that point the motor will be stopped and the motor position initialized to 0 or position ***n***, specified when the Find Edge command was issued. Using this procedure will cause the motor position to be initialized with the motor moving in the same direction each time. This should eliminate inaccuracies caused by mechanical backlash in the system. Note that the **W**ait **E**dge (**WE**) command is not supported by the **DCX-MC150/160** stepper modules.

*a***FI***n* **F**ind **I**ndex

This command utilizes the Encoder Index input to initialize a servo motor at a given position. This command does not support stepper motor initialization. For servo motors without an Encoder Index please see below **Exception: Servo axes without an Encoder Index input**.

Once the **F**ind **I**ndex command is issued no other commands will be processed until the encoder index input goes active. At that time the current position of the motor will be defined to be *n*. This command will not cause any motor motion to be started or stopped. It is up to the user to initiate motor motion before issuing the command, and to stop any motion after it completes. Since the index pulse may occur at numerous points of the motors travel (once per revolution in rotary encoders), a typical application will require a course home signal to "qualify" the index pulse. In this situation the following command string could be used to initialize motor 1:

1**MN**,1**PM**,1**SV**10000,1**MR**1000000,1**WE**1,1**ST**,**WA**1000,1**PM**,1**MR**-1000000,
1**WE**0,1**FI**,1**ST**,**WA**1000,1**PM**,1**MA**0

Here the motor is placed in position mode and moves out of the course home range and then back into it (**WE** commands). As soon as the motor re-enters the course home range it is commanded to find the index pulse (**FI** command). At that point the current position will be set to 0. As a final step the motor is stopped, and moved back to the "home" position.

Note that in the example, **P**osition **M**ode commands were included each time the motor was commanded to stop, or the find index command executed. It is necessary to issue the **P**osition **M**ode command in these cases in order to set the servo's target position to it's current position. If this is not done, subsequent move commands will cause the motor to move to unexpected positions. Also note that the **W**ait **S**top command is not used after the **F**ind **I**ndex command. This is due to the fact that the target changes once the index is found. The **W**ait **S**top will not work until after the **P**osition **M**ode command has been issued.

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Exception: Servo axes without an Encoder Index signal. Maximum positioning accuracy and repeatability requires an Encoder Index signal. For applications where no Encoder Index signal is available, the DCX-MC1XX and DCX-MC2XX servo modules support position initialization using only the output from a Home switch or sensor. This output should be connected to both the module Encoder Index input and Coarse Home input. As in the example above, the course home signal is used to "qualify" the index pulse. The difference being in this case, the coarse home signal is used to simulate an index pulse. In this situation the following command string could be used to initialize motor 1:

1**MN**,1**PM**,1**SV**10000,1**MR**-1000000,1**WE**0,1**ST**,**WA**1000,1**PM**,1**MR**1000000,
1**WE**1,1**MR**-100000,1**FI**,1**ST**,**WA**1000,1**PM**,1**MA**0

a**GE** **G**o until home **E**dge occurs (MC260 module only)

This command is used for simultaneous homing of stepper motors. The command begins a velocity mode move. The Home input is then monitored in background so additional command execution is not delayed. The move will continue until the Home input (J3 pin 13) goes active (low). The following command strings will initialize (home) axes one, two, and three:

1**MN**,2**MN**,3**MN,**1**VM**,2**VM**,3**VM**,
1**DI**0,2**DI**0,3**DI**0,1**GE**,2**GE**,3**GE**
1**FE**0,2**FE**0,3**FE**0,0**WS**100,0**PM**
1**MA**0,2**MA**0,3**MA**0

Prior to beginning the moves velocity, acceleration, and deceleration parameters must be set.

*a***GF** **G**o until home input of**F** (MC2XX modules only)

This command is used for simultaneous homing of motors. The command begins a velocity mode move. The Coarse Home (servo modules) or Encoder Coarse Home (stepper module) input is then monitored in background by the module. The move will continue until the input goes inactive (high). To properly home the axes, the **G**o until home input o**N** (**GN**) should be used in conjunction with the **G**o until home input of**F** (**GF**) command. The following command strings will initialize (home) axes one, two, and three:

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11.2 MOTION COMMANDS (cont.)

1**MN**,2**MN**,3**MN,**1**VM**,2**VM**,3**VM**,
1**DI**1,2**DI**1,3**DI**1,1**GF**,2**GF**,3**GF**,0**WS**100
1**GN**,2**GN**,3**GN**,1**FE**0,2**FE**0,3**FE**0,0**WS**100,0**PM**
1**MA**0,2**MA**0,3**MA**0

Prior to beginning the moves velocity, acceleration, and deceleration parameters must be set.

a**GH** **G**o **H**ome

Causes the specified axis or axes to move to the position that was specified when the last **DH**, **FI** or **FE** command was issued. This is equivalent to a **M**ove **A**bsolute command, where the destination is 0.

*a***GI** **G**o until encoder **I**ndex occurs (MC2XX modules only)

This command is used for simultaneous homing of motors. The command begins a velocity mode move. The Encoder Index input is then monitored in background by the module. The move will continue until the Encoder Index input goes active. To properly home the axes, the **G**o until coarse home input o**N** (**GN**) command should be used in conjunction with the **G**o until encoder **I**ndex occurs (**GI**) command. The following command strings will initialize (home) axes one, two, and three:

1**MN**,2**MN**,3**MN,**1**VM**,2**VM**,3**VM**,
1**DI**0,2**DI**0,3**DI**0,1**GN**,2**GN**,3**GN**,0**WS**100
1**GI**,2**GI**,3**GI**,1**FI**0,2**FI**0,3**FI**0,0**WS**100,0**PM**
1**MA**0,2**MA**0,3**MA**0

Prior to beginning the moves velocity, acceleration, and deceleration parameters must be set.

*a***GM** **G**ain **M**ode (MC2XX servo modules only)

This command places a servo in the Gain Mode of operation. In this mode, the servo can be commanded to execute moves to specific positions. However, no velocity profile will be generated. The servo will be driven to the new target based only upon the of the PID loop.

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11.2 MOTION COMMANDS (cont.)

*a***GN** **G**o until coarse home input o**N** (MC2XX modules only)

This command is used for simultaneous homing of servo motors. The command begins a velocity mode move. The Coarse Home (servo modules) or Encoder Coarse Home (stepper module) input is then monitored in background by the module. The move will continue until the Coarse Home input goes active (low). To properly home the axes, the **G**o until encoder **I**ndex occurs (**GI**) command should be used in conjunction with the **G**o until coarse home input o**N** (**GN**) command. The following command strings will initialize (home) axes one, two, and three:

1**MN**,2**MN**,3**MN,**1**VM**,2**VM**,3**VM**,
1**DI**0,2**DI**0,3**DI**0,1**GN**,2**GN**,3**GN**,0**WS**100
1**GI**,2**GI**,3**GI**,1**FI**0,2**FI**0,3**FI**0,0**WS**100,0**PM**
1**MA**0,2**MA**0,3**MA**0

Prior to beginning the moves velocity, acceleration, and deceleration parameters must be set.

*a***GO** **GO**

Begins a velocity mode move for one or all axes (after issuing commands setting the velocity, acceleration, and direction). For a MC1XX servo modules, the GO command is also required to implement on-the-fly velocity or acceleration changes (position or velocity mode).

*a***HO** **HO**me

This command will cause a specified macro to be executed. It is up to the user to define the macro to carry out the appropriate homing sequence for that motor (see **F**ind **E**dge and **F**ind **I**ndex commands). Issuing 1**HO** will cause macro 1 to be executed, issuing 2**HO** will cause macro 2 to be executed, and so on. Issuing this command with no motor specified will cause macro 9 to be executed. This macro can be defined to **HO**me the individual motors in some predefined sequence.

*a***IA***n* **I**ndex **A**rm (MC2XX modules only)

This command is used to arm the index capture function of an axis. The **I**ndex **A**rm performs a similar function as the **F**ind **I**ndex command but it does not delay additional command

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execution, it remains active in background waiting for the index pulse to occur. After issuing the **I**ndex **A**rm command and the index pulse occurs, a new absolute position *0 + n* will not be defined until the **W**ait for **I**ndex and the **M**otor o**N** commands have been issued.

LI*n* **L**earn position **I**ncrementing (0 <= *n* <=(4096/# of axes))

This command allows a series of sequential positions to be stored as a string starting at *n* and having a number of points as defined by repeat command. This command is especially useful for storing a series of traced points that later want to be repeated. **LI** can be implemented with motor on or motor off. All axes are stored.

Example: **LI**1,**WA**100,**RP**99

This will store a position every 100 milliseconds up to position 100. A subsequent command **MI**1,**WA**100,**RP**99, will move to the 100 defined positions in sequence, from 1 to 100.

*a***LP***n* **L**earn **P**osition (0 <= *n* < (1536 / # of axes on DCX board))

Used for storing the current position of one or more axes in the **DCX-PC**'s point memory. Positions stored in the point memory can be used by the **M**ove to **P**oint command to repeat a stored motion pattern. The command parameter *n* specifies the entry in the point memory where the position will be stored.

If the **LP** command is issued with an axis specifier of 0, the positions of all axes on the **DCX-PC** board will be stored in the point memory. If the command is issued with a non-zero axis specifier, only the position of that axis will be stored in the point memory. No other positions in the point memory will be changed.

The number of points that can be stored in the **DCX-PC** is determined by the number of axes installed on the board. Each point stored uses 8 bytes of memory for each axis on the board. Since there are 12,288 bytes of RAM available for point storage, the number of points that can be saved will vary from 1536 for a single axis board, to 192 for a eight axis board.

Example:

1**MA**0,2**MA**0,0**WS**1000
AL1
1**LP**@0,2**LP**@0,1**MR**1000,2**MR**1000,0**WS**1,**AA**1,**RP**5

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In this example, axes 1 and 2 are first moved to absolute position 0. In the second command line, the accumulator (register 0) is loaded with the value 1. It will be used as a point index in the following line. The third command line uses the **LP** command to store the current positions of axes 1 and 2 in 6 consecutive entries in the point memory. Between teaching each point the axes are moved 1000 counts each, and the accumulator is increment by one to index the next point. The **M**ove to **P**oint command described below, shows how these points can be used as targets of motion commands.

*a***LT***n* **L**earn **T**arget (0 <= *n* < (1536 / # of axes on DCX board))

Similar to the **LP** command, but stores the axes' current target position. This command does not require actually moving to the position to store the point. This makes it possible to download coordinates from a host computer or CAD system. To do this, turn off the motor drive outputs with the **MF** command, then send motion commands prior to the **LT** command.

Example:

MF
1**MA**nnnn,2**MA**nnnn,3**MA**nnnn,4**MA**nnnn,0**LT**1
1**MA**nnnn,2**MA**nnnn,3**MA**nnnn,4**MA**nnnn,0**LT**2
etc.

*a***MA***n* **M**ove **A**bsolute

Generates a motion to absolute position *n*. The absolute position is relative to the point of initialization. A motor number must be specified and that motor must be in the "on" state for this command to have any effect. While *n* can be any number between -2.0 x 10e9 and 2.0 x 10e9 the actual distance moved from the current position must be less that 1.07 x 10e9 for DCX-MC1XX and DCX-MC2XX servo modules and DCX-MC260 stepper modules, and 16.7 x 10e6 for DCX-MC150/160 stepper motors.

Example: 2**MA**0,4**MA**10000

*a***MF** **M**otor of**F**

Issuing this command will place one or all motors in the "off" state. For servo motors, the module output will go to the null level and the amplifier inhibit line will go active. This command can be used to prevent unwanted motion or to allow manual positioning of the unit.

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11.2 MOTION COMMANDS (cont.)

MI*n* **M**ove to point, **I**ncrementing (0 <= *n* <= (4096/# of axes))

Used for moving to a previously stored set of coordinates. The first point to be moved to is specified by *n*. Each time this command is executed in a repeat loop, it will advance to the next higher count stored point. Points are stored with the **L**earn **P**oint (**LP**) and **L**earn **T**arget (**LT**) commands.

Example: **MI**7,0**WS**32,**RP**5

will move to points 7,8,9,10,11,and 12, stopping for 32 milliseconds at each point. Bear in mind that each point stores a position for each axis. If you do not want a given axis to move, you must turn off the motor before issuing this command.

This command may be used for repeating fixed motion patterns at various reference positions. Any number of points may be stored, up to the capacity of available memory. Each point stored uses 4 bytes of memory for each axis on the board. Since there are 20K bytes of RAM available for point storage, the number of points that can be saved will vary from 5120 for a single axis board to 640 for an eight axis board.

*a***MN** **M**otor o**N**

Use this command to place one or all motors in the on state. When a motor is turned on, its target position is set to its current position so that the motor has no tendency to move. For servo modules, the amplifier inhibit signal will go inactive enabling an external amplifier to drive the motor.

*a***MP***n* **M**ove to **P**oint (0 <= *n* < (1536 / # of axes on **DCX-PC** board))

Used for moving one or more axes to a previously stored point. The command parameter *n* specifies which entry in the **DCX-PC**'s point memory is to be used as the destination of the move. If the **MP** command is issued with an axis specifier of 0, all axes will move to the positions stored in the point memory for that point. If the command is issued with a non-zero axis specifier, only that axis will move to the position in the point memory. No other axes will be commanded to moved. Points are stored in the point memory by the **L**earn **P**oint (**LP**) and **L**earn **T**arget (**LT**) commands.

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Example:

AL1
1**MP**@0,2**MP**@0,0**WS**32,**AA**1,**RP**5

will move axes 1 and 2 to positions 1,2,3,4,5,and 6 previously stored in the point memory. The axes will stop for 32 milliseconds at each position before continuing to the next point. The axes will move at whatever acceleration and velocities were set for those axes prior to the **MP** command.

*a***MR***n* **M**ove **R**elative

This command generates a motion of relative distance of *n* counts/steps in the specified direction. A motor number must be specified and that motor must be in the on state for this command to have any effect. *n* may be a positive or negative number and is limited to 1.07 x 10e9 for DCX-MC1XX and DCX-MC2XX servo modules and DCX-MC260 stepper modules, 16.7 x 10e6 for DCX-MC150/160 stepper motors.

Example: 1**MR**12345,6**MR**-87654

*a***PM** **P**osition **M**ode

This command places a motor in the Position Mode of operation. In this mode, the motor can be commanded to execute moves to specific positions. The moves will be carried out using a trapezoidal velocity profile. When in the **P**osition **M**ode using DCX-MCXXX servo modules and DCX-MC2XX stepper module, the move destination (target) can be modified while the move is in progress. The DCX-MC150/160 stepper modules do not have this capability, the motor must come to a stop before a new destination can be given. Upon power up, or after a Reset, all axes default to **P**osition **M**ode.

Example: 1**MN**,1**PM**,1**SV**10000,1**SA**100,1**MR**1000

*a***QM** Tor**Q**ue **M**ode (MC2XX servo modules only)

This command places a servo in the Torque Mode of operation. In this mode, the output drive signal to the motor will hold a constant voltage level specified by the **S**et Tor**Q**ue command.

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11.2 MOTION COMMANDS (cont.)

*a***SM***n* **S**et **M**aster (MC1XX servo modules only)

This command causes axis *a* to be "slaved" to a "master" axis *n* with a one-to-one ratio. Before issuing this command the slave axis parameters should be initialized. For best performance the acceleration and velocity of the slave axis should be set higher than the expected acceleration and velocity of the master axis. The slave axis must also be turned on before any motion will occur. The master axis can be moved either manually with the motor off, or under **DCX-PC** control in either position, velocity or jog mode, and the slave will follow.

*a***ST** **ST**op

Used to bring one or all motors to a halt. This command differs from the **AB**ort command in that motors will decelerate at their preset rate instead of stopping abruptly. This command can be used to begin stopping all motors at the same time or to stop one specific motor. After executing this command, and waiting for motor to stop, the user should issue the **M**otor o**N** command or the Position Mode command. This will set the target position to the current position. Note that the **W**ait **S**top command will not work after a **ST**op command until the **P**osition **M**ode command is issued.

*a***VM** **V**elocity **M**ode

This command places a motor in the **V**elocity **M**ode of operation. In this mode, the motor can be commanded to move in either direction with a set velocity. The motor will move in that direction until commanded to stop. When using **V**elocity **M**ode the user can specify the direction for the motor to move using the **DI**rection (**DI**) command. While the module is moving a motor in **V**elocity **M**ode, the user can change the velocity by issuing new **Di**rection, **S**et **V**elocity, and **GO** commands ("on-the-fly" velocity changes are not supported on the MC150/160 stepper modules). The acceleration rate at which the motor velocity will change is determined by the **S**et **A**cceleration (**SA**) command. After the motor has started moving, the acceleration rate cannot be changed for either the servo or stepper modules.

Example:

```
1MN,1SV10000,1SA100,1DI1,1VM,1GO          ;starts motor moving
1SV10100,1GO,WA100,1SV10200,1GO           ;"on-the-fly" velocity
                                          ;changes
1ST,WA1000,PM                             ;stop motor; wait for stop
                                          ;back to position mode
```


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11.3 REPORTING COMMANDS

*a***AT** **A**uxiliary encoder **T**ell position (MC2XX modules only)

Reports the absolute position of axis *a* auxiliary encoder input. To read the primary encoder position, see the **T**ell **P**osition command. For reading the auxiliary encoder input of the MC160 module, see the **T**ell **O**ptimal command.

HE **HE**lp

Reports the valid **DCX-PC** command mnemonics for the installed software version.

TA*x* **T**ell **A**nalog to digital converter

Reports the digitized analog input signals to the **DCX-PC**. The four 8-bit analog input channels, accessed on connectors J3 and J4 are numbered 1,2,3 and 4. For each of these channels, the **TA** command will display a number between 0 and 255. These numbers are the ratio of the analog input voltage to the reference input voltage multiplied by 256. The reference for the first four channels must be supplied to the **DCX-PC** on connector J3 or J4, and can be any voltage between 0 and +5 volts DC. The analog input channels on any installed MC500 modules will be numbered starting with channel 5.

Example: **TA**3

DCX-PC reports: 3 165

If the reference input to the **DCX-PC** is supplied with 5.0 volts DC, then the input to channel 3 must be 165/256 x 5.0 = 3.2 volts.

TC*x* **T**ell **C**hannel

Reports the on/off status on each digital I/O line. This data is reported separately for each channel. The **DCX-PC** responds by displaying the channel number and a "1" if the channel is "on", or a "0" if the channel is "off"

Example: **TC**6,**TC**7

DCX-PC returns: 6 1
7 0

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Channels 6 is on, while channel 7 is off. Note that whether a channel reports on or off when the voltage on the input line is high or low depends on the setup of the channel. When a channel has been setup as "high true" logic using the **CH** command, the **TC** command will report a "1" when the input signal is greater than 2.0 volts DC and a "0" when it is less than 0.8 volts DC. When a channel has been setup as "low true" logic using the **CL** command, the **TC** command will report a "1" when the input signal is less than 0.8 volts DC and a "0" when it is greater than 2.0 volts DC. The default setup of all digital I/O lines is for "high true" logic.

*a***TD** **T**ell **D**erivative gain (servo modules only)

Reports the last derivative gain value programmed.

*a***TF** **T**ell **F**ollowing error (servo modules only)

Reports following error for servo modules. The value reported is the difference between the last servo update desired position from the trajectory generator and the servos current position.

*a***TG** **T**ell position **G**ain (MC2XX servo modules only)

Reports the last position gain value programmed.

*a***TI** **T**ell **I**ntegral gain (servo modules only)

Reports the last integral gain value programmed.

*a***TL** **T**ell integration **L**imit (servo modules only)

Reports the last integration limit value programmed.

*a***TO** **T**ell **O**ptimal

Reports the last servo update desired position for servo modules. The reported value is does not address the actual position reported by the **TP** command. The difference between the

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optimal position and the actual position is the current following error. For the DCX-MC160 stepper motor module, this command reports the reading from the auxiliary encoder.

*a***TP** **T**ell **P**osition

Reports the absolute position of axis *a*. It may be used to monitor motion during both **M**otor o**N** (**MN**) and **M**otor of**F** (**MF**) states.

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11.3 REPORTING COMMANDS (cont.)

*a***TS** **T**ell **S**tatus

Reports certain status information pertaining to operation of the specified axis. The response is coded into a single 32 bit value. The meaning of each bit is listed below:

0 = Busy (servo parameters being updated) *
1 = Motor On *
2 = Velocity Mode *
3 = Trajectory Complete *
4 = Direction (0 = positive, 1 = negative) *
5 = Phasing (0 = standard, 1 = reverse)
6 = Motor Homed *
7 = Motor Error
8 = Look for Index **
9 = Look for Edge **
10 = Moving Positive Direction (Full Step) *
11 = Moving Negative Direction (Full Current) *
12 = Breakpoint Reached **
13 = Indicates Motor is Jogging **
14 = Amplifier Fault Enable (Null Position) *
15 = Amplifier Fault Tripped
16 = Limit Right Enabled **
17 = Limit Right Tripped *
18 = Limit Left Enabled **
19 = Limit Left Tripped *
20 = Jog Right Enable ***
21 = Jog Right Active ***
22 = Jog Left Enable ***
23 = Jog Left Active ***
24 = Index **
25 = Course Home **
26 = Amplifier Fault
27 = Reserved
28 = Limit Right **
29 = Limit Left **
30 = Jog Right ***
31 = Jog Left ***

* Valid for all stepper modules
** Valid for DCX-MC260 stepper modules
*** Not valid for DCX-MC2XX modules

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11.3 REPORTING COMMANDS (cont.)

*a***TT** **T**ell **T**arget

Reports target position. This is the absolute position to which the axis was last commanded to move to. It may be specified directly with the **M**ove **A**bsolute (**MA**) command or indirectly with **M**ove **R**elative (**MR**) command. If the system is in the decimal mode, ten digits will be reported with a leading minus sign (-) if the position is less than 0. When the hex mode is in effect, eight hex digits are reported in two's complement notation. In both cases, the data is preceded by the axis number (two digits) and a space, and followed by a carriage return and a line feed character.

Example:	(command)	**TT**
	(system returns)	01 0000000000
		02 0000000000
		03 0000000000
		04 0000000000
	(command)	2**TT**,4**TT**
	(system returns)	02 0000000000
		04 0000000000
	(command)	**DM**,1**MA**1024,**TT**,**HM**,**TT**
	(system returns)	01 0000001024
		01 000000400
	(command)	**DM**,1**GH**,**MR**-1024,**TT**,**HM**,**TT**
	(system returns)	01 0000001024
		01 FFFFC00

*a***TV** **T**ell **V**elocity

Reports the number of encoder counts received by axis *a* during the last service interval. The service interval for MC1XX servo modules is 341 microseconds. The service interval for MC160 and MC2XX modules is 1 millisecond * # of all installed motion modules.

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11.3 REPORTING COMMANDS (cont.)

*a***TZ** **T**ell index

Reports the position where the index pulse was observed. This position is relative to the encoder's position when the controller was last reset or the a **D**efine **H**ome command was issued to the axis.

VE **T**ell **VE**rsion

Reports the revision level of the firmware in the ROM.

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11.4 REGISTER COMMANDS

Registers

The **DCX-PC** contains 256 general purpose registers. These registers can be used for many purposes, including holding command parameters, performing math computations and controlling command execution. Each register is 32 bits and can hold a number between 2147483647 and -2147483648.

The registers are numbered 0 through 255, with register 0 being the 'accumulator'. The accumulator (register 0) is used in most commands that manipulate the registers.

The user can also issue commands, specifying a register number as the parameter instead of a constant. This is done by placing an '@' sign in front of the command parameter. For example, the command "1**MR**@10" will cause the **DCX-PC** to move axis 1 by the number stored in register 10. The use of a register specifier can be used in any command as the parameter. The **DCX-PC** does NOT support the use of the '@' sign in front of an axis number.

The following commands are available for working with the registers:

AA*n* **A**ccumulator **A**dd (ACC <- ACC + *n*)

AC*n* **A**ccumulator **C**omplement, bit wise (ACC <- !ACC)

AE*n* **A**ccumulator logical **E**xclusive or with *n*, bit wise (ACC <- ACC eor *n*)

AI*n* **A**ccumulator load **I**ndirect (ACC <- REG*n*)

AL*n* **A**ccumulator **L**oad with constant *n* (ACC <- *n*)

AM*n* **A**ccumulator **M**ultiply (ACC <- ACC x *n*)

This command performs a 32 bit by 32 bit signed multiply, with a 64 bit result. The low 32 bits of the result are stored in the accumulator (register 0), the high 32 bits are stored in register 1.

AN*n* **A**ccumulator logical a**N**d with *n*, bit wise (ACC <- ACC and *n*)

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11.4 REGISTER COMMANDS (cont.)

AO*n* **A**ccumulator logical **O**r with *n*, bit wise (ACC <- ACC or *n*)

Ar*n* copy **A**ccumulator to **R**egister *n* (ACC -> REG*n*)

AS*n* **A**ccumulator **S**ubtract (ACC <- ACC - *n*)

GA*x* **G**et **A**nalog value (channel *x* -> ACC)

Performs analog to digital conversion on specified input channel and places result into the accumulator (user register 0). Analog channels are numbered starting with 1. See the **T**ell **A**nalog command for more detials on analog channel numbering.

OA*x* **O**utput **A**nalog value (ACC -> channel *x*)

Sets the specified analog output channel to the value stored in the accumulator (user register 0). The analog output channels on any installed MC500 modules will be numbered consecutively starting with channel 1. The contents of the accumulator should be a value between 0 and 4095.

RB*n* **R**ead **B**yte at absolute memory location *n* into accumulator (ACC <- (*n*))

RL*n* **R**ead **L**ong at absolute memory location *n* into accumulator (ACC <- (*n*))

RW*n* **R**ead **W**ord at absolute memory location *n* into accumulator (ACC <- (*n*))

SL*n* **S**hift **L**eft accumulator *n* bits (ACC <- ACC << *n*)

SR*n* **S**hift **R**ight accumulator *n* bits (ACC <- ACC >> *n*)

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11.4 REGISTER COMMANDS (cont.)

TR*n* **T**ell contents of **R**egister *n*

TR **T**ell contents of the accumulator (register 0)

Wb*n* **W**rite accumulator low **B**yte to absolute memory location *n* (ACC -> (*n*))

Wl*n* **W**rite accumulator **L**ong to absolute memory location *n* (ACC -> (*n*))

WW*n* **W**rite accumulator low **W**ord to absolute memory location *n* (ACC -> (*n*))

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11.5 MACRO COMMANDS

MC*n* **M**acro **C**all (0 < = n < = 255)

This command is used to execute a previously defined macro command. If there is no macro defined by the number (*n*), no action will be taken. Macro Commands (**MC**) can also be used in compound commands with other commands in the command set. In addition, a macro command can call another macro command, which in turn can call another macro, and so on. Each level of macro "nesting" uses 8 bytes of macro storage when the commands are executed.

MD*n* **M**acro **D**efinition (0 <= *n* <= 255)

Used to define a new macro. Any duplication of numbers will simply result in the loss of the previously defined macro using that number.

Example: **MD**4,**TT**,**TP** (return)
MD4,1**MR**10000 (return)

will define macro #4 twice, but only the most recent macro definition is retained. When a macro is redefined, the memory containing the previous version of the command is not reused by the **DCX-PC**. This lost memory will not be available to the **DCX-PC** until the **R**eset **M**acros command is issued.

Note: For stand-alone applications (with the non-volatile memory option), if a macro 0 has been defined (**MD0**), it will be executed after a PC bus reset or power good reset.

Mj*n* **M**acro **J**ump (0 <= n <= 255)

Jumps to a previously defined macro. This command differs from the Execute Macro and Macro Call commands in that execution will not return to the command following the **MJ** command.

RM **R**eset **M**acros

Used to initialize the memory space reserved for macro commands. It is the only way in which macro commands may be removed after they are defined. This method removes all macro commands currently defined, so those macro commands still desired must be reprogrammed. It is always a good idea to use the **R**eset **M**acro command (**RM**) before setting up a new set of macro commands.

TM*n* **T**ell **M**acros (-1 <= *n* <= 255)

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5.5 MACRO COMMANDS (cont.)

Displays the commands which make up any macros which have been defined. If n = -1, all macros will be displayed. Since macros may be defined in any sequence, the **TM** command is useful for confirming the existence and/or contents of macro commands.

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11.6 SEQUENCE COMMANDS

DF*x* **D**o if channel of**F**

Used for conditional execution of commands. If specified digital I/O channel is "off", commands that follow on the command line or in the macro will be executed. Otherwise the rest of the command line or macro will be skipped.

DN*x* **D**o if channel o**N**

Used for conditional execution of commands. If specified digital I/O channel is "on", commands that follow on the command line or in the macro will be executed. Otherwise the rest of the command line or macro will be skipped.

Example: **DN**2,1**MR**1000 ;If channel 2 is on move;
;1000, otherwise no move is;
;made

IB*n* **I**f accumulator is **B**elow (less than) constant *n*, do next command, else skip 2 commands

IC*n* **I**f bit *n* of accumulator **C**lear, do next command, else skip 2 commands

IE*n* **I**f accumulator **E**quals constant *n*, do next command, else skip 2 commands

IF*x* **I**f channel of**F** do next command, else skip two 2 commands

Used for conditional execution of commands. If specified digital I/O channel is "off", commands that follow on the command line or in the macro will be executed. Otherwise the next two commands of the command line or macro will be skipped.

IG*n* **I**f accumulator is **G**reater than constant *n*, do next command, else skip next 2 commands

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11.6 SEQUENCE COMMANDS (cont.)

In*x* **I**f channel o**N** do next command, else skip two commands

Used for conditional execution of commands. If specified digital I/O channel is "on", commands that follow on the command line or in the macro will be executed. Otherwise the next two commands of the command line or macro will be skipped. See also **N**o **O**peration and **B**rea**K** commands.

Example: **IN**3,**MC**1,**BK**,**MC**2 ;If channel 3 on then execute macro 1, else
;execute macro 2.

1**SV**1000,**IN**4,1**SV**100,**NO**,1**MR**500 ;Set velocity to 1000, if channel 4 on, lower
;velocity to 100, move 500. Note use of **NO**
;command to fill command space.

*a***IP***n* **I**nterrupt on absolute **P**osition

This command is used to indicate when an axis has reached a specific position. The position is relative to the point defined as home. When the specified position has been reached, the **DCX-PC** will set the "breakpoint reached" flag in the servo status for that axis. The **IP** command can be issued to an axis before or after it has been commanded to move. (This command will only have effect for DC servo modules.) See also, commands **IR**, **WP** and **WR**.

*a***IR***n* **I**nterrupt on **R**elative position

This command is used to indicate when an axis has reached a specific position. The position is relative to the target position when a move command is issued. When the specified position has been reached, the **DCX-PC** will set the "breakpoint reached" flag in the servo status for that axis. The **IR** command can be issued to an axis before or after it has been commanded to move. (This command will only have effect for DC servo modules.) See also, commands **IP**, **WP** and **WR**.

IS*n* **I**f bit *n* of accumulator **S**et, do next command, else skip 2 commands

IU*n* **I**f accumulator is **U**nequal to constant *n*, do next command, else skip next 2 commands.

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11.6 SEQUENCE COMMANDS (cont.)

JP*n* **J**um**P** to command absolute (0 <= n <= 40)

Jumps to the specified command in the current command string or macro. Commands are numbered consecutively starting with 0.

JR*n* **J**ump to command **R**elative (-40 <= n <= 40)

Jumps forward or backward by the specified number of commands in the current command string or macro. Specifying a positive value will cause a forward jump in the command string or macro. Specifying a negative value will cause a backward jump. A jump of relative 0 will cause the command to jump to itself.

RP*n* **R**e**P**eat (0 <= *n* <= 65,535)

This command causes the command string to repeat *n* times. If *n* is not specified or is 0 then commands are repeated indefinitely. (See also 4.0, page 29).

Example: 1**TP**,**RP**999 will display the position of axis 1, 1000 times.

WA*n* **WA**it (1 <= *n* <= 65,535)

Insert a wait period of *n* milliseconds before going on to the next command.

Example: 1**TP**,**WA**1000,**RP**9 will display the position of axis 1, 10 times with a delay of approximately one second between displays.

*a***WE***x* **W**ait for **E**dge

Wait until the course home input on axis *a* module is at specified logic level, and then continue operation. If *x* is not specified or is 0, wait for course home to go active. If *x* is 1 wait for course home to go inactive.

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11.6 SEQUENCE COMMANDS (cont.)

WF*x* **W**ait for channel of**F**

Wait until digital I/O channel *x* is "off" before continuing to next command on command line or in macro.

*a***WI** **W**ait for **I**ndex (MC2XX modules only)

Wait for the index pulse has been observed on axis *a*. This command should be used after the **I**ndex **A**rm command has been issued to the axis, even if it is known that the index pulse has occurred (the **I**ndex **A**rm command performs necessary internal operations). To complete the indexing function, a **M**otor o**N** command should be issued to the axis.

WN*x* **W**ait for channel o**N**

Wait until digital I/O channel *x* is "on" before continuing to next command on command line or in macro.

*a***WP***n* **W**ait for **A**bsolute position

This command works the same as the **I**nterrupt on absolute **P**osition command except that the command remains in effect until the specified position is reached. (This command will only have effect for servo modules.) See the description of the **IP** command for further details.

*a***WR***n* **W**ait for **R**elative position

This command works the same as the **I**nterrupt on **R**elative position command except that the command remains in effect until the specified position is reached. (This command will only have effect for DC servo modules.) See the description of the **IR** command for further details.

*a***WS***n* **W**ait for **S**top (0 <= *n* <= 255)

Wait until axis *a* (*a* = 0 means all axes) has stopped moving for *n* milliseconds before continuing to the next command. Used for synchronizing motion and for specifying complex motions. This command should not be used after issuing a **ST**op, **F**ind **I**ndex or **F**ind **E**dge command to an axis.

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11.6 SEQUENCE COMMANDS (cont.)

Example: 3**MR**1000,**WS**120,**MR**-1000

will cause axis 3 to move positive then negative by equal amounts.

If the **W**ait **S**top (**WS**) command was not used in the example, there would be no motion of the axis. The reason being that the target position would simply be changed twice. The computer would add 1000 counts to the target position then subtract the same amount. This would take place far quicker than the axis could begin moving.

For the MC150/160 stepper modules, which cannot accept new move commands until it completes the previous move, the **W**ait **S**top command may or may not be necessary.

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11.7 MISCELLANEOUS COMMANDS

BK **B**rea**K**

Execution of this command will cause the rest of the command line or macro to be skipped. This command is used in conjunction with the **I**f o**N** and **I**f of**F** commands to implement conditional execution.

DM **D**ecimal **M**ode

Input and output numbers in decimal format.

Example: **DM**,**SV**12700

HM **H**exadecimal **M**ode

Input and output in hexadecimal format.

Example: **HM**,**SV**7FFF

NO **N**o **O**peration

This command does nothing. It can be used to cause short delays in command line executions or as a filler in sequence commands.

SB*n* **S**elect **B**ank (0 <= *n* <= 15)

This command is used to select which 4 kilobyte (4096) block of the **DCX-PC**'s memory is accessible to the host computer. The host computer can read and write this memory through the dual port memory. The primary use of this command is for fast loading of the **DCX-PC**'s point storage.

Since the **DCX-PC** contains 64 kilobytes of ROM or RAM, the parameter for this command can range from 0 to 15. After reset of the **DCX-PC**, bank 1 is selected by default. This allows the host access to the area of the **DCX-PC**'s memory where servo data is stored and host communication buffers are located.

Once the **SB** command is issued, the host computer will no longer have access to the

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communication buffers on the **DCX-PC**. Thus, it will not be able to send commands to the **DCX-PC**. For this reason, a protocol has been defined which will cause the **DCX-PC** to switch back to bank 1 when the host computer finishes accessing the alternate bank.

On the host computer side the protocol for using the **SB** command is as follows:

1. Write a binary 1 to the byte at offset FF0h in the default bank.

2. Issue the **SB** command to the **DCX-PC** specifying the desired bank to switch to.

3. Wait for the byte at offset FF0h to change to 0. This indicates that the **DCX-PC** has switched banks, and the host is now accessing the new bank.

4. Make any desired modifications to the memory in the selected bank. Note that no commands can be issued to the **DCX-PC**.

5. When ready to switch back to the default bank, write a binary 1 to the byte at offset FF0h in the current bank.

6. Wait for the byte at offset FF0h to change back to 0. This indicates that the host is now accessing the default bank. Commands can now be sent to the **DCX-PC** as usual.

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APPENDIX A

COMMAND SET SUMMARY

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APPENDIX A: COMMAND SET SUMMARY

The first five pages (A-2 thru A-6) of this command summary lists all the **DCX-PC** supported command functions. Included with each DCX-PC command is the Command Code. The command code is only used when communicating with the **DCX-PC** via the Direct Binary Interface An example of the command listing is shown below:

AH 234 **A**uxiliary encoder define **H**ome

where:

AH is the command mnumonic

234 is the command code (please refer to appendix 0)

Auxiliary encoder define **H**ome is the command description

The last seven pages (A-7 thru A-13) use a Command Matrix format to associate **DCX-PC** "plug in" modules with command functions.

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APPENDIX A: COMMAND SET SUMMARY

Parameter Setup Commands

AH	234	**A**uxiliary encoder define **H**ome
BR	30	**B**aud **R**ate
CF	31	**C**hannel of**F**
CH	66	**C**hannel **H**igh true logic
CI	32	**C**hannel **I**n
CL	67	**C**hannel **L**ow true logic
CN	33	**C**hannel o**N**
CT	34	**C**hannel ou**T**
DH	35	**D**efine **H**ome
DI	36	**DI**rection
DS	117	**D**eceleration **S**et
EF	37	**E**cho of**F**
EN	38	**E**cho o**N**
FC	64	**F**ull **C**urrent
FF	51	amplifier **F**ault input of**F**
FN	50	amplifier **F**ault input o**N**
FR	39	set derivative sampling period
HC	65	**H**alf **C**urrent
HF	48	**H**andshake of**F**
HN	49	**H**andshake o**N**
HS	232	**H**igh **S**peed
IL	40	set **I**ntegration **L**imit
JB	223	**J**og dead**B**and
JF	58	**J**og switch of**F**
JG	220	**J**og proportional **G**ain
JN	57	**J**og switch o**N**
JO	222	**J**og **O**ffset
JV	55	**J**og **V**elocity
LF	54	**L**imit switch of**F**
LM	52	**L**imit **M**ode
LN	53	**L**imit switch o**N**
LS	230	**L**ow **S**peed
MS	231	**M**edium **S**peed
OM	216	**O**utput **M**ode
PH	115	set servo output **PH**ase
RT	42	**R**ese**T** system
SA	43	**S**et **A**cceleration

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APPENDIX A: COMMAND SET SUMMARY

Parameter Setup Commands (cont.)

SD	44	**S**et **D**erivative gain
SE	25	**S**top on **E**rror
SF	62	**S**tep **F**ull
SG	45	**S**et prop. **G**ain of motor
SH	63	**S**tep **H**alf
SI	46	**S**et **I**ntegral gain of DC servo or **S**et **I**nitial pulse rate of stepper (MC150/160)
SQ	116	**S**et **T**orque
SV	47	**S**et **V**elocity
VG	119	set **V**elocity **G**ain
XF	125	set **X**of**F** code
XN	126	set **X**o**N** code

Motion Commands

AB	10	**Ab**ort
AP	110	**A**djust **P**osition
AF	235	**A**ux. Encoder **F**ind index
FE	11	**F**ind **E**dge
FI	12	**F**ind **I**ndex
GE	169	**G**o until **E**dge occurs
GF	167	**G**o until home input **O**ff
GH	13	**G**o **H**ome
GI	168	**G**o until **I**ndex
GM	8	**G**ain **M**ode
GN	166	**G**o until home input o**N**
GO	14	**GO**
HO	15	**Ho**me
IA	93	Index Arm
LI	111	**L**earn position **I**ncrementing
LP	112	**L**earn **P**osition
LT	113	**L**earn **T**arget
MA	16	**M**ove **A**bsolute
MF	17	**M**otor of**F**
MI	18	**M**ove to point, **I**ncrementing
MN	19	**M**otor o**N**
MP	20	**M**ove to **P**oint

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Motion Commands (cont.)

MR	21	**M**ove **R**elative
PM	23	**P**osition **M**ode
QM	9	tor**Q**ue **M**ode
SM	26	**S**et **M**aster
ST	22	**ST**op
VM	24	**V**elocity **M**ode

Reporting Commands

AT	233	**A**uxiliary encoder **T**ell position
HE	72	**HE**lp
TA	73	**T**ell **A**nalog to digital converter
TC	74	**T**ell **C**hannel
TD	75	**T**ell **D**erivative gain
TF	77	**T**ell **F**ollowing error
TG	78	**T**ell position **G**ain
TI	79	**T**ell **I**ntegral gain of DC servo or
TL	80	**T**ell integration **L**imit
TO	89	**T**ell **O**ptimal
TP	82	**T**ell **P**osition
TS	83	**T**ell **S**tatus
TT	84	**T**ell **T**arget
TV	85	**T**ell **V**elocity
TZ	90	**T**ell **I**ndex
VE	86	tell **VE**rsion

Register Commands

AA	133	**A**ccumulator **A**dd
AC	140	**A**ccumulator **C**omplement, bit wise
AE	143	**A**ccumulator logical **E**xclusive or with *n*, bit wise
AI	131	**A**ccumulator load **I**ndirect
AL	130	**A**ccumulator **L**oad with constant *n*
AM	135	**A**ccumulator **M**ultiply
AN	141	**A**ccumulator logical a**N**d with *n*, bit wise
AO	142	**A**ccumulator logical **O**r with *n*, bit wise

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Register Commands (cont.)

AR	132	copy **A**ccumulator to **R**egister *n*
AS	134	**A**ccumulator **S**ubtract
GA	248	**G**et **A**nalog value
OA	249	**O**utput **A**nalog value
RB	150	**R**ead **B**yte
RL	152	**R**ead **L**ong at absolute memory location *n* into accumulator
RW	151	**R**ead **W**ord at absolute memory location *n* into accumulator
SL	144	**S**hift **L**eft accumulator *n* bits
SR	145	**S**hift **R**ight accumulator *n* bits
TR	87	**T**ell contents of **R**egister *n* **T**ell contents of accumulator (register 0)
WB	153	**W**rite accumulator low **B**yte to absolute memory location *n*
WL	155	**W**rite accumulator **L**ong to absolute memory location *n*
WW	154	**W**rite accumulator low **W**ord to absolute memory location *n*

Macro Commands

MC	2	**M**acro **C**all
MD	3	**M**acro **D**efinition
MJ	5	**M**acro **J**ump
RM	4	**R**eset **M**acros
TM	81	**T**ell **M**acros

Sequence Commands

DF	107	**D**o if channel of**F**
DN	106	**D**o if channel o**N**
IB	165	**I**f accumulator is **B**elow (less than) constant *n*, do next command, else skip 2 commands
IC	161	**I**f bit *n* of accumulator **C**lear, do next command, else skip 2 commands
IE	162	**I**f accumulator **E**quals constant *n*, do next command, else skip 2 commands
IF	109	**I**f channel of**F** do next command, else skip two 2 commands
IG	164	**I**f accumulator is **G**reater than constant *n*, do next command, else skip 2 commands
IN	108	**I**f channel o**N** do next command, else skip two 2 commands
IP	96	**I**nterrupt on absolute **P**osition

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Sequence Commands (cont.)

IR	97	**I**nterrupt on **R**elative position
IS	160	**I**f bit *n* of accumulator **S**et, do next command, else skip 2 commands
IU	163	**I**f accumulator is **U**nequal to constant *n*, do next command, else skip 2 commands
JP	6	**J**um**P** to command absolute
JR	7	**J**ump to command **R**elative
RP	100	**R**e**P**eat
WA	101	**WA**it (time)
WE	102	**W**ait for **E**dge
WF	103	**W**ait for channel of**F**
WI	94	**W**ait for **I**ndex
WN	104	**W**ait for channel o**N**
WP	98	**W**ait for absolute **P**osition
WR	99	**W**ait for **R**elative position
WS	105	**W**ait for **S**top

Miscellaneous Commands

BK	121	**B**rea**K**
DM	60	**D**ecimal **M**ode
HM	61	**H**exadecimal **M**ode
NO	120	**N**o **O**peration
SB	122	**S**elect **B**ank

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Parameter Setup Commands

Command Type Module(s) Used on

Parameter Setup Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	**MC260**	**MC400**	**MC500**	**CF300 MF300**	**MF310**
AH			X	X				
BR							X	
CF					X			
CH					X			
CI					X			
CL					X			
CN					X			
CT					X			
DH	X	X	X	X				
DI	X	X	X	X				
DS			X	X				
EF							X	
EN							X	
FC		X		X				
FF	X		X	X				
FN	X		X	X				
FR	X		X					
HC		X		X				
HF							X	
HN							X	
HS				X				
IL	X		X					
JB			X	X				
JF	X							
JG			X	X				
JN	X							

*** General Usage Commands**

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Parameter Setup Commands (Cont.)

Command Type — Module(s) Used On

Parameter Setup Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	MC260	**MC400**	**MC500**	**CF300 MF300**	**MF310**
JO			X	X				
JV	X							
LF	X		X	X				
LM	X		X	X				
LN	X		X	X				
OM				X				
PH			X					
RT*								
SA	X	X	X	X				
SD	X		X					
SE	X		X					
SF		X		X				
SG	X		X					
SH		X		X				
SI	X		X					
SQ			X					
SV	X	X	X	X				
VG			X					
XF							X	X
XN							X	X

*** General Usage Commands**

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Motion Commands

Command Type — Module(s) Used On

Motion Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	MC260	**MC400**	**MC500**	**CF300 MF300**	**MF310**
AB	X	X	X	X				
AP	X	X	X	X				
AF				X				
FE	X	X		X				
FI	X	X	X					
GE				X				
GF			X	X				
GH	X	X	X					
GI			X	X				
GM			X					
GN			X	X				
GO	X	X	X	X				
HO	X	X	X	X				
IA			X	X				
LI	X	X	X	X				
LP	X	X	X	X				
LT	X	X	X	X				
MA	X	X	X	X				
MF	X	X	X	X				
MI	X	X	X	X				
MN	X	X	X	X				
MR	X	X	X	X				
PM	X	X	X	X				
QM			X					
SM	X							
ST	X	X	X	X				
VM	X	X	X	X				

*** General Usage Commands**

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Reporting Commands

Command Type Module(s) Used On

Reporting Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	MC260	**MC400**	**MC500**	**CF300 MF300**	**MF310**
AT			X	X				
HE*								
TA						X		
TC					X			
TD	X		X					
TF	X		X					
TG	X		X					
TI	X	X	X					
TL	X		X					
TO	X	X	X	X				
TP	X	X	X	X				
TS	X	X	X	X				
TT	X	X	X	X				
TV	X		X	X				
TZ			X	X				
VE*								

*** General Usage Commands**

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Register Commands

Command Type — Module(s) Used On

Register Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	**MC260**	**MC400**	**MC500**	**CF300 MF300**	**MF310**
AA*								
AC*								
AE*								
AI*								
AL*								
AM*								
AN*								
AO*								
AR*								
AS*								
GA						X		
OA						X		
RB*								
RL*								
RW*								
SL*								
SR*								
TR*								
WB*								
WL*								
WW*								

COMMAND MODULE MATRIX: Macro Commands

Command Type — Module(s) Used On

Macro Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	MC260	**MC400**	**MC500**	**CF300 MF300**	**MF310**
MC*								
MD*								
MJ*								
RM*								
TM*								

*** General Usage Commands**

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Sequence Commands

Command Type Module(s) Used On

Sequence Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**	MC260	**MC400**	**MC500**	**CF300 MF300**	**MF310**
DF					X			
DN					X			
IB								
IC								
IE								
IF					X			
IG								
IN					X			
IP	X		X	X				
IR	X		X	X				
IS								
IU								
JP*								
JR*								
RP*								
WA*								
WE	X							
WF					X			
WN					X			
WP	X		X	X				
WR	X		X	X				
WS	X	X	X	X				

*** General Usage Commands**

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APPENDIX A: COMMAND SET SUMMARY

COMMAND MODULE MATRIX: Miscellaneous Commands

Command Type Module(s) Used On

Miscellaneous Commands	**MC100 MC110 MC120**	**MC150 MC160**	**MC200**		**MC400**	**MC500**	**CF300 MF300**	**MF310**
BK*								
DM*								
HM*								
NO*								
SB*								

*** General Usage Commands**

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APPENDIX B

DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES

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APPENDIX B: DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES

(Refer to diagram at the end of this appendix)

IBM-PC INTERFACE EDGE CONNECTORS J1/J2

Component Side	Solder Side
A01 - NC	B01 - GROUND (+5 VOLT RETURN)
A02 - BUS DATA 7 (HIGH TRUE)	B02 - RESET (HIGH TRUE)
A03 - BUS DATA 6	B03 - +5 VDC
A04 - BUS DATA 5	B04 - NC
A05 - BUS DATA 4	B05 - NC
A06 - BUS DATA 3	B06 - NC
A07 - BUS DATA 2	B07 - -12 VDC
A08 - BUS DATA 1	B08 - NC
A09 - BUS DATA 0	B09 - +12 VDC
A10 - IORDY	B10 - GROUND(+,-,12 VOLT RETURN)
A11 - AEN	B11 - SMEMW (LOW TRUE)
A12 - BUS ADR. 19 (HIGH TRUE)	B12 - SMEMR (LOW TRUE)
A13 - BUS ADR. 18	B13 - NC
A14 - BUS ADR. 17	B14 - NC
A15 - BUS ADR. 16	B15 - NC
A16 - BUS ADR. 15	B16 - NC
A17 - BUS ADR. 14	B17 - NC
A18 - BUS ADR. 13	B18 - NC
A19 - BUS ADR. 12	B19 - NC
A20 - BUS ADR. 11	B20 - NC
A21 - BUS ADR. 10	B21 - IRQ7
A22 - BUS ADR. 09	B22 - IRQ6
A23 - BUS ADR. 08	B23 - IRQ5
A24 - BUS ADR. 07	B24 - IRQ4
A25 - BUS ADR. 06	B25 - IRQ3
A26 - BUS ADR. 05	B26 - NC
A27 - BUS ADR. 04	B27 - NC
A28 - BUS ADR. 03	B28 - NC
A29 - BUS ADR. 02	B29 - NC
A30 - BUS ADR. 01	B30 - NC
A31 - BUS ADR. 00	B31 - NC

Note: When IBM interface is not used: Connect B11 and B12 to +5V through 4.7K ohm resistor, Connect B2, A2 - A9 and A11 - A31 to ground

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APPENDIX B: DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES

ANALOG AND DIGITAL I/O CONNECTORS J3/J4

J3,J4	01	+5 VDC
J3,J4	02	ANALOG INPUT #1
J3,J4	03	DIGITAL I/O, CHANNEL 16
J3,J4	04	ANALOG INPUT #3
J3,J4	05	DIGITAL I/O, CHANNEL 15
J3,J4	06	DIGITAL I/O, CHANNEL 14
J3,J4	07	DIGITAL I/O, CHANNEL 13
J3,J4	08	DIGITAL I/O, CHANNEL 12
J3,J4	09	DIGITAL I/O, CHANNEL 11
J3,J4	10	DIGITAL I/O, CHANNEL 10
J3,J4	11	DIGITAL I/O, CHANNEL 09
J3,J4	12	DIGITAL I/O, CHANNEL 08
J3,J4	13	DIGITAL I/O, CHANNEL 07
J3,J4	14	DIGITAL I/O, CHANNEL 06
J3,J4	15	DIGITAL I/O, CHANNEL 05
J3,J4	16	DIGITAL I/O, CHANNEL 04
J3,J4	17	DIGITAL I/O, CHANNEL 03
J3,J4	18	DIGITAL I/O, CHANNEL 02
J3,J4	19	DIGITAL I/O, CHANNEL 01
J3,J4	20	ANALOG INPUT #4
J3,J4	21	+12 VDC
J3,J4	22	ANALOG INPUT #2
J3,J4	23	ANALOG REF.
J3,J4	24	GROUND
J3,J4	25	-12 VDC
J3,J4	26	GROUND

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX B: DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES

ASYNCRONOUS SERIAL I/O CONNECTOR J5

J5	01	GROUND
J5	02	SERIAL DATA INPUT (TTL LEVEL)
J5	03	GROUND
J5	04	SERIAL DATA OUTPUT (TTL LEVEL)
J5	05	GROUND
J5	06	TRANSMIT ENABLE
J5	07	+5 VDC
J5	08	+12 VDC
J5	09	-12 VDC
J5	10	NC

Mating Connector: 10-pin dual-row IDC female, Circuit Assembly
P/N CA-10IDS2-F-SPT or equivalent

EXTERNAL POWER CONNECTOR J7

J7	01	POWER: +12V DC
J7	02	POWER: -12V DC
J7	03	POWER: GROUND
J7	04	POWER: + 5V DC

Mating Connector (assembly): Shell, AMP P/N 1-480424-0
Mating Connector (assembly): Pins (4 each), AMP P/N 614731

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APPENDIX B: DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES

CONFIGURATION JUMPERS

JP1 IBM-PC INTERFACE INTERRUPT
(Select PC Interrupt Level)

Connect pins 1 and 2 for level 7
Connect pins 3 and 4 for level 6
Connect pins 5 and 6 for level 5
Connect pins 7 and 8 for level 4
Connect pins 9 and 10 for level 3

JP3 ROTARY SWITCH PULL UP/PULL DOWN SELECT
Production option, not user configurable

JP4 DCX RESET SOURCE

Connect pins 1 and 2 for IBM-PC controlled reset
Connect pins 3 and 4 for resistor/capacitor reset
Connect pins 5 and 6 for IBM-PC bus reset (factory configuration)

JP6 Reserved for factory use

JP7 EPROM TYPE IN U8 SOCKET

Connect pins 1 and 2 if 256K EPROM is installed in U8
Connect pins 2 and 3 if 512K EPROM is installed in U8 (factory configuration)

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APPENDIX B: DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES

DCX ROTARY SWITCH SETTING

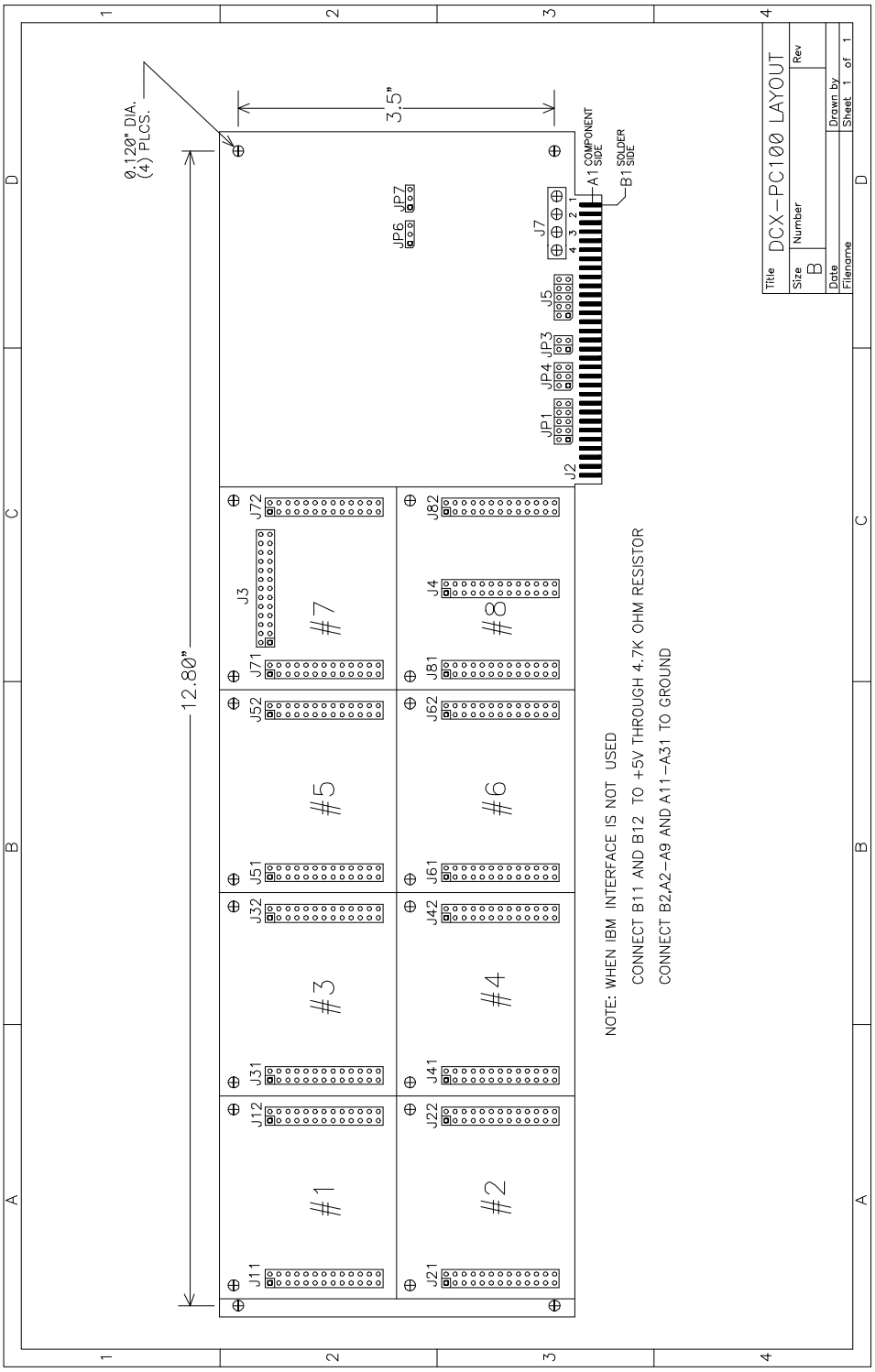
The 16 bit position rotary switch at the lower right end of the dcx board selects where the dual port RAM appears in the host computer's memory map. The default setting for the switch is 0. If multiple boards are used in a single host, no two boards should have the same switch setting.

Switch Setting	Host Address Range
0	D0000h - DOFFFh (factory configuration)
1	D1000h - D1FFFh
2	D2000h - D2FFFh
3	D3000h - D3FFFh
4	D4000h - D4FFFh
5	D5000h - D5FFFh
6	D6000h - D6FFFh
7	D7000h - D7FFFh
8	D8000h - D8FFFh
9	D9000h - D9FFFh
A	DA000h - DAFFFh
B	DB000h - DBFFFh
C	DC000h - DCFFFh
D	DD000h - DDFFFh
E	DE000h - DEFFFh
F	DF000h - DFFFFh

Note: This switch is also used to select the DCX-PC's I.D. when multiple boards are connected together on a serial network.

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APPENDIX B: DCX-PC100 CONNECTORS, JUMPERS AND SWITCHES



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APPENDIX C

DC SERVO MODULES

DCX-MC100 (ANALOG SIGNAL OUTPUT)
DCX-MC105 (ANALOG SIGNAL OUTPUT, UNIPOLAR)
DCX-MC110 (ANALOG MOTOR OUTPUT)
DCX-MC120 (PWM SIGNAL OUTPUT)
DCX-MC120E (ENCODER INTERFACE)

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

SIGNAL DESCRIPTIONS:

ANALOG COMMAND RETURN - (MC100, MC105) Provides the signal ground for the modules Analog Command Signal ouput. This return path is common to the ground plane of the DCX motherboard, but is connected in such a way as to reduce digital noise. Typical servo amplifiers will have a connection for the analog command return where this signal should be connected.

ANALOG COMMAND SIGNAL - (MC100, MC105) This module output signal is used to control the servo amplifier's output. When connected to the command input of a velocity mode amplifier, the voltage level on this signal should cause the amplifier to drive the servo at a proportional velocity. For current mode amplifiers, the voltage level should cause a proportional current to be supplied to the servo. The MC100 module provides an Bipolar analog signal (-10 to +10 volts), with 0 volts being the null output level. Positive voltages indicate a desired velocity or current in one direction, negative voltages indicate velocity or current in the opposite direction. The MC105 module provides a Unipolar output, where the analog siganl range is 0 to +10 volts, and a seperate signal (Analog Signal Polarity) is used to indicate the desired direction of velocity or current. The maximum drive current of this signal is +/-10 milliamps.

PWM MAGNITUDE and SIGN - (MC120) These module output signals are used to control the servo amplifier's output. When connected to the PWM Magnitude input of a velocity mode amplifier, the duty cycle of this output should cause the amplifier to drive the servo at a proportional velocity. For current mode amplifiers, the duty cycle of the PWM Magnitude output should cause a proportional current to be supplied to the servo. The PWM Sign output is used to specify the direction (positive or negative) of motor rotation.

COARSE HOME - This module input is used to determine the proper zero position of the servo. In servo systems that use rotary encoders with index outputs, an index pulse is generated once per rotation of the encoder. While this signal occurs at a very repeatable angular position on the encoder, it may occur many times within the motion range of the servo. In these cases, a Coarse Home switch connected to this module input can be used to qualify which index pulse is the true zero position of the servo. By setting this switch to be activated near the end of travel of the servo, and using DCX motion commands to position the servo within this region prior to searching for the index pulse, a unique zero posiiton for the servo can be determined.

AMPLIFIER FAULT - This module input is designed to be connected to the servo amplifiers Fault or Error output signal. The state of this signal will appear as a status bit in the servo's status word. Using the **F**ault o**N** command, this signal can be enabled to shut the axis off if the input goes active low. In this condition, no further servo motion will occur until the fail signal is deactivated and the **M**otor o**N** command is issued. The **F**ault o**F**f command can be used to disable this signal.

SIGNAL DESCRIPTIONS (cont.):

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

AMPLIFIER INHIBIT - This TTL level module output signal should be connected to the enable input of the servo amplifier. When the DCX is turned on or reset, this signal will immediatly go to its' active low level (disabling the amplifier). When the **M**otor o**N** command is issued to the DCX, this signal will go to its' inactive high level. Anytime there is an error on the respective servo axis, including exceeding the following error, a limit switch trip or the amplifier fault input is activated, the Amplifier Inhibit signal will be activated. This signal can also be activated by the **M**otor o**F**f command.

LIMIT POSITIVE and LIMIT NEGATIVE - The limit switch inputs are used to cause the DCX to stop a servo's motion when it reaches the end of travel. If the servo is in position mode, the axis will only be stopped if it is moving in the direction of an activated limit switch. In all other modes, the servo will be stopped regardless of the direction it is moving if either limit switch is activated. There are three modes of stopping the can be configured by the **L**imit **M**ode command. The limit switch inputs can be enabled and disabled with the **L**imits o**N** and **L**imits o**F**f commands respectively. See the section on limit switches for full details on limit switch functions.

ENCODER 1 SIGNALS (PHASE A+, PHASE A-, PHASE B+, PHASE B-, INDEX+, INDEX-) - These input signals should be connected to an incremental quadrature encoder that supplies position feedback information for the servo. The plus (+) and minus (-) signs refer to the two sides of differential inputs. The modules are shipped configured for single ended inputs. To configure the module for differential inputs cut the traces on the bottom side of the module the between jumpers **JP2** and **JP3**.

ENCODER POWER - This module pin provides a convient supply voltage connection for the encoders. The module is shipped configured for a +5 volt encoder supply. To configure the module for +12 volt encoder, cut the trace on the bottom side of the board between JP4 pins 2 and 3.

SUPPLY CONNECTIONS (+5, +12, -12, GROUND) - These module pins provide access to the DCX supply voltages.

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC100 MODULE CONNECTOR J3

J3	01	ANALOG GROUND (ANALOG SIGNAL RETURN)
J3	02	ANALOG SIGNAL (OUTPUT, +/-10 V)
J3	03	+12 VDC
J3	04	-12 VDC
J3	05	GROUND
J3	06	+5 VDC
J3	07	RESERVED
J3	08	RESERVED
J3	09	COARSE HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	AMPLIFIER FAULT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	11	AMPLIFIER INHIBIT (OUTPUT, ACTIVE LOW, TTL LEVEL)
J3	12	JOG RIGHT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	13	JOG LEFT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	14	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	15	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	16	ENCODER PHASE B+ (INPUT)**
J3	17	ENCODER POWER*
J3	18	GROUND
J3	19	ENCODER PHASE B- (INPUT)
J3	20	ENCODER PHASE A- (INPUT)
J3	21	GROUND
J3	22	ENCODER POWER*
J3	23	ENCODER PHASE A+ (INPUT)**
J3	24	ENCODER POWER*
J3	25	ENCODER INDEX (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)***
J3	26	GROUND

* ENCODER POWER is +5VDC or +12VDC, jumper selectable
** Use A+ and B+ for single-ended ENCODER INPUTS
*** Index must be low coincident with phase A and phase B low to be recognized

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC100 MODULE JUMPERS

JP1 MODULE I.D. SELECT

Production option, not user configurable.

JP2,**JP3** DIFFERENTIAL VERSUS SINGLE ENDED ENCODER INPUTS

Connect pins 1 and 2 for single ended inputs, leave open for differential inputs.

Note: Modules are shipped with PCB traces between pins 1 and 2. These traces should be cut for differential encoder inputs. See DC Servo module layout diagram at end of manual.

JP4 ENCODER POWER SELECT

Connect pins 1 and 2 for +12 VDC encoder power.
Connect pins 2 and 3 for +5 VDC encoder power.

Note: Modules are shipped with PCB traces between pins 2 and 3. These traces should be cut if +5 VDC encoder supply is not desired.

JP5 ENCODER PHASE SELECT

Connect pins 1 and 2, pins 3 and 4 for standard phasing.
Connect pins 1 and 3, pins 2 and 4 for reverse phasing.

Note: Modules are shipped with PCB traces between pins 1 and 2 and pins 3 and 4 for standard phasing. These traces should be cut in order to change phasing.

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DCX-MC100 MODULE JUMPERS (cont.)

JP6 DIGITAL I/O PULL-UP/PULL-DOWN SELECT

Production option, not user configurable

JP7 GROUND DAC 0 OUTPUT

Production option, not user configurable

JP8 DIGITAL VERSUS ANALOG GROUND SELECT

Production option, not user configurable

DCX-MC100 MODULE POTENTIOMETERS

POT1 ANALOG OUTPUT OFFSET ADJUSTMENT

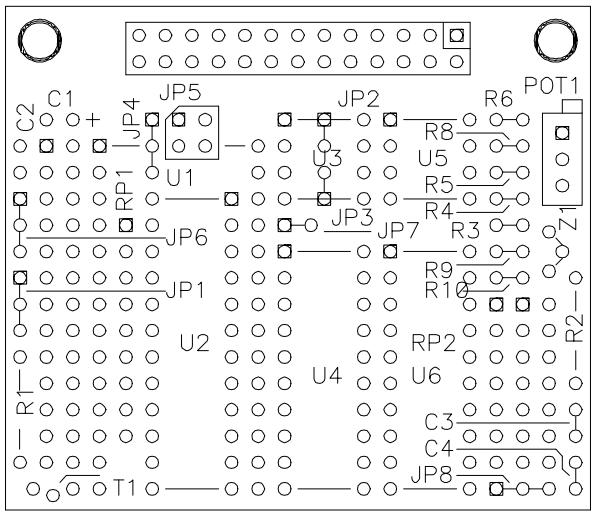
This multi-turn trimming potentiometer can be used to add an offset to the module's analog output. The range of this adjustment is approximately +/-0.75 volts.

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

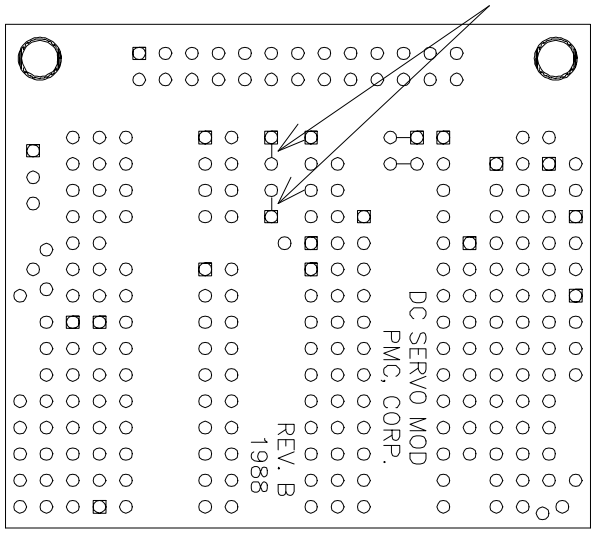
DCX-MC100 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE

NOTE 1



NOTE 1: CUT TRACES FOR DIFFERENTIAL ENCODER INPUTS, 2 PLACES

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC105 MODULE CONNECTOR J3

J3	01	ANALOG GROUND
J3	02	ANALOG SIGNAL
J3	03	+12 VDC
J3	04	-12 VDC
J3	05	GROUND
J3	06	+5 VDC
J3	07	RESERVED
J3	08	ANALOG SIGNAL POLARITY (OUTPUT, TTL)
J3	09	COARSE HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	AMPLIFIER FAULT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	11	AMPLIFIER INHIBIT (OUTPUT, ACTIVE LOW, TTL LEVEL)
J3	12	JOG RIGHT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	13	JOG LEFT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	14	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	15	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	16	ENCODER PHASE B+ (INPUT)**
J3	17	ENCODER POWER*
J3	18	GROUND
J3	19	ENCODER PHASE B- (INPUT)
J3	20	ENCODER PHASE A- (INPUT)
J3	21	GROUND
J3	22	ENCODER POWER*
J3	23	ENCODER PHASE A+ (INPUT)**
J3	24	ENCODER POWER*
J3	25	ENCODER INDEX (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)***
J3	26	GROUND

* ENCODER POWER is +5VDC or +12VDC, jumper selectable
** Use A+ and B+ for single-ended ENCODER INPUTS
*** Index must be low coincident with phase A and phase B low to be recognized

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC105 MODULE JUMPERS

JP1 MODULE I.D. SELECT

Production option, not user configurable

JP2,**JP3** DIFFERENTIAL VERSUS SINGLE ENDED ENCODER INPUTS

Connect pins 1 and 2 for single ended inputs, leave open for differential inputs.

Note: Modules are shipped wiht PCB traces between pins 1 and 2. These traces should be cut for differential encoder inputs. See diagram 2 at end of manual.

JP4 ENCODER POWER SELECT

Connect pins 1 and 2 for +12 VDC encoder power
Connect pins 2 and 3 for +5 VDC encoder power

Note: Modules are shipped with PCB traces between pins 2 and 3. These traces should be cut if +5 VDC encoder supply is not desired.

JP5 ENCODER PHASE SELECT

Connect pins 1 and 2, pins 3 and 4 for standard phasing
Connect pins 1 and 3, pins 2 and 4 for reverse phasing

Note: Modules are shipped with PCB traces between pins 1 and 2 and pins 3 and 4 for standard phasing. These traces should be cut in order to change phasing.

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DCX-MC105 MODULE JUMPERS (cont.)

JP6 DIGITAL I/O PULL-UP/PULL-DOWN SELECT

Production option, not user configurable

JP7 GROUND DAC 0 OUTPUT

Production option, not user configurable

JP8 DIGITAL VERSUS ANALOG GROUND SELECT

Production option, not user configurable

DCX-MC105 MODULE POTENTIOMETERS

POT1 ANALOG OUTPUT OFFSET ADJUSTMENT

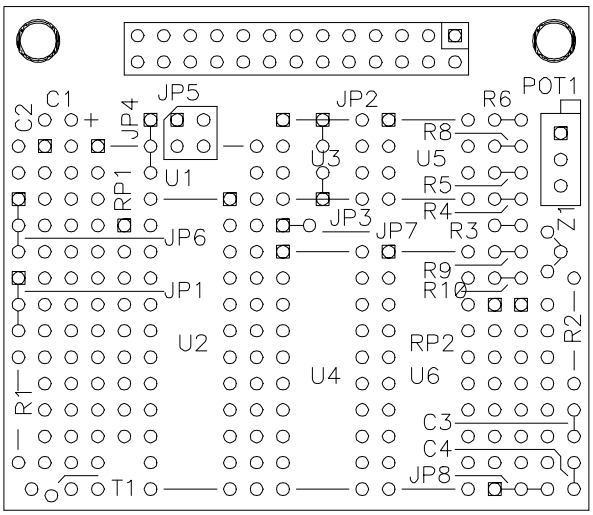
This multi-turn trimming potentiometer can be used to add an offset to the module's analog output. The range of this adjustment is approximately +/-0.75 volts.

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

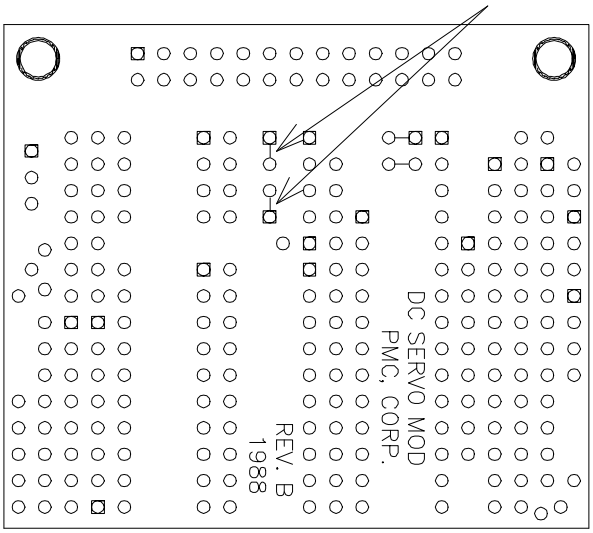
DCX-MC105 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE

NOTE 1



NOTE 1: CUT TRACES FOR DIFFERENTIAL ENCODER INPUTS, 2 PLACES

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC110 MODULE CONNECTOR J3

J3	01	MOTOR +
J3	02	ENCODER POWER
J3	03	ENCODER PHASE A+
J3	04	ENCODER PHASE B+
J3	05	GROUND
J3	06	MOTOR -
J3	07	POSITIVE SUPPLY
J3	08	NEGATIVE SUPPLY
J3	09	COARSE HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	AMPLIFIER FAULT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	11	AMPLIFIER INHIBIT (OUTPUT, ACTIVE LOW, TTL LEVEL)
J3	12	JOG RIGHT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	13	JOG LEFT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	14	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	15	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	16	ENCODER PHASE B+ (INPUT)**
J3	17	ENCODER POWER*
J3	18	GROUND
J3	19	ENCODER PHASE B- (INPUT)
J3	20	ENCODER PHASE A- (INPUT)
J3	21	GROUND
J3	22	ENCODER POWER*
J3	23	ENCODER PHASE A+ (INPUT)**
J3	24	ENCODER POWER*
J3	25	ENCODER INDEX (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)***
J3	26	GROUND

* ENCODER POWER is +5VDC or +12VDC, jumper selectable
** Use A+ and B+ for single-ended ENCODER INPUTS
*** Index must be low coincident with phase A and phase B low to be recognized

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC110 MODULE JUMPERS

JP1 MODULE I.D. SELECT

Production option, not user configurable.

JP2,**JP3** DIFFERENTIAL VERSUS SINGLE ENDED ENCODER INPUTS

Connect pins 1 and 2 for single ended inputs, leave open
for differential inputs.

Note: Modules are shipped with PCB traces between pins 1 and 2. These traces should be cut for differential encoder inputs. See diagram 2B at end of manual.

JP4 ENCODER POWER SELECT

Connect pins 1 and 2 for +12 VDC encoder power.
Connect pins 2 and 3 for +5 VDC encoder power.

Note: Modules are shipped with PCB traces between pins 2 and 3. These traces should be cut if +5 VDC encoder supply is not desired.

JP5 ENCODER PHASE SELECT

Connect pins 1 and 2, pins 3 and 4 for standard phasing.
Connect pins 1 and 3, pins 2 and 4 for reverse phasing.

Note: Modules are shipped with PCB traces between pins 1 and 2 and pins 3 and 4 for standard phasing. These traces should be cut in order to change phasing

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DCX-MC110 MODULE JUMPERS (cont.)

JP6 DIGITAL I/O PULL-UP/PULL-DOWN SELECT

Production option, not user configurable.

JP7 VOLTAGE / CURRENT MODE SELECT

Connect pins 1 and 2 for voltage mode.
Connect pins 2 and 3 for current mode.

JP8 CURRENT SENSE RESISTOR DEFEAT

Connect pins 1 and 2 to short across current sense resistor (short resistor for voltage mode).

JP9 POSITIVE SUPPLY SELECT

Connect pins 1 and 2 when motor is to be supplied positive power from J3 connector.
Connect pins 2 and 3 when motor is to be supplied with +12 VDC from DCX motherboard.

JP10 NEGATIVE SUPPLY SELECT

Connect pins 1 and 2 when motor is to be supplied negative power or ground from J3 connector.
Connect pins 2 and 3 when motor is to be supplied ground from DCX mother board.
Connect pins 2 and 4 when motor is to be supplied with -12 VDC from DCX motherboard.

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC110 MODULE POTENTIOMETERS

POT1 ANALOG OUTPUT OFFSET ADJUSTMENT

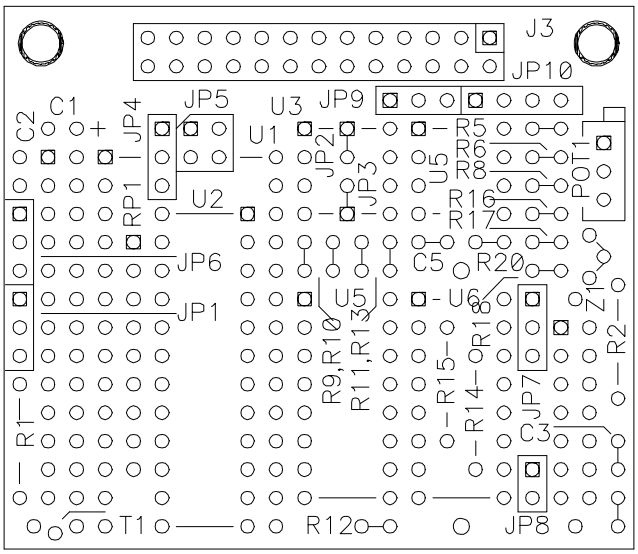
This multi-turn trimming potentiometer can be used to add an offset to the module's analog output. The range of this adjustment is approximately +/-0.75 volts.

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

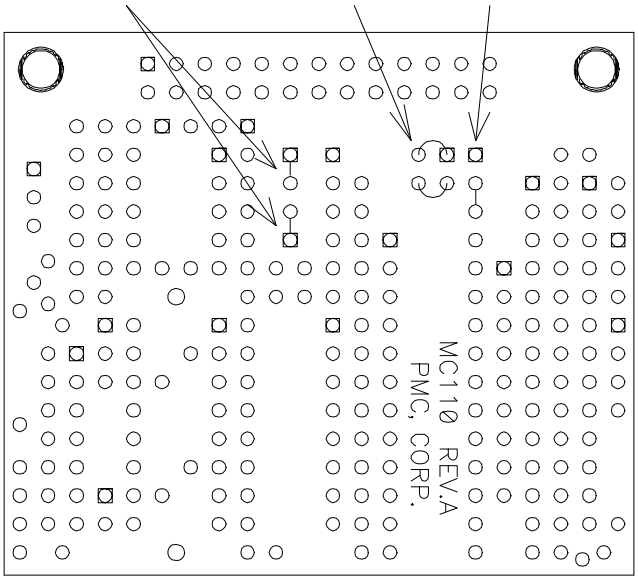
DCX-MC110 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE

NOTE 1 NOTE 2 NOTE 3



NOTE 1: CUT TRACES
FOR DIFFERENTIAL ENCODER INPUTS, 2 PLACES
NOTE 2: ENCODER PHASE SELECT
NOTE 3: ENCODER POWER SELECT

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC120 MODULE CONNECTOR J3

J3	01	ANALOG GROUND
J3	02	RESERVED
J3	03	+12 VDC
J3	04	-12 VDC
J3	05	GROUND
J3	06	+5 VDC
J3	07	PULSE WIDTH MODULATED MAGNITUDE (OUTPUT TTL LEVEL)
J3	08	PULSE WIDTH MODULATED SIGN (OUTPUT TTL LEVEL)
J3	09	COARSE HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	AMPLIFIER FAULT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	11	AMPLIFIER INHIBIT (OUTPUT, ACTIVE LOW, TTL LEVEL)
J3	12	JOG RIGHT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	13	JOG LEFT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	14	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	15	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	16	ENCODER PHASE B+ (INPUT)**
J3	17	ENCODER POWER*
J3	18	GROUND
J3	19	ENCODER PHASE B- (INPUT)
J3	20	ENCODER PHASE A- (INPUT)
J3	21	GROUND
J3	22	ENCODER POWER*
J3	23	ENCODER PHASE A+ (INPUT)**
J3	24	ENCODER POWER*
J3	25	ENCODER INDEX (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)***
J3	26	GROUND

* ENCODER POWER is +5VDC or +12VDC, jumper selectable

** Use A+ and B+ for single-ended ENCODER INPUTS

*** Index must be low coincident with phase A and phase B low to be recognized

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC120 MODULE JUMPERS

JP1 MODULE I.D. SELECT

Production option, not user configurable

JP2,**JP3** DIFFERENTIAL VERSUS SINGLE ENDED ENCODER INPUTS

Connect pins 1 and 2 for single ended inputs, leave open for differential inputs.

Note: Modules are shipped wiht PCB traces between pins 1 and 2. These traces should be cut for differential encoder inputs. See diagram 2 at end of manual.

JP4 ENCODER POWER SELECT

Connect pins 1 and 2 for +12 VDC encoder power
Connect pins 2 and 3 for +5 VDC encoder power

Note: Modules are shipped with PCB traces between pins 2 and 3. These traces should be cut if +5 VDC encoder supply is not desired.

JP5 ENCODER PHASE SELECT

Connect pins 1 and 2, pins 3 and 4 for standard phasing
Connect pins 1 and 3, pins 2 and 4 for reverse phasing

Note: Modules are shipped with PCB traces between pins 1 and 2 and pins 3 and 4 for standard phasing. These traces should be cut in order to change phasing.

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DCX-MC120 MODULE JUMPERS (cont.)

JP6 DIGITAL I/O PULL-UP/PULL-DOWN SELECT

Production option, not user configurable

JP7 GROUND DAC 0 OUTPUT

Production option, not user configurable

JP8 DIGITAL VERSUS ANALOG GROUND SELECT

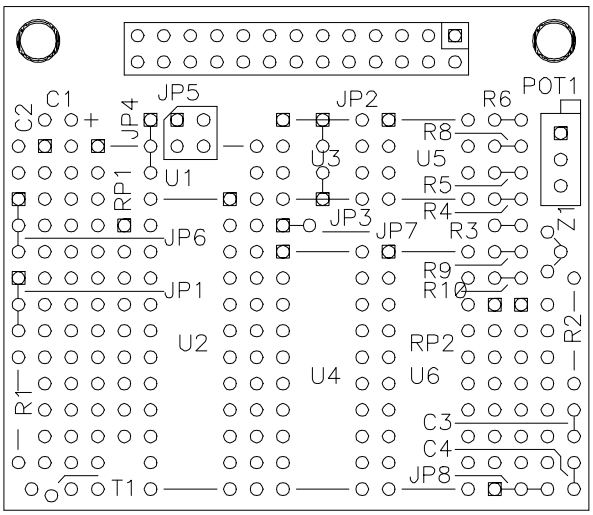
Production option, not user configurable

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

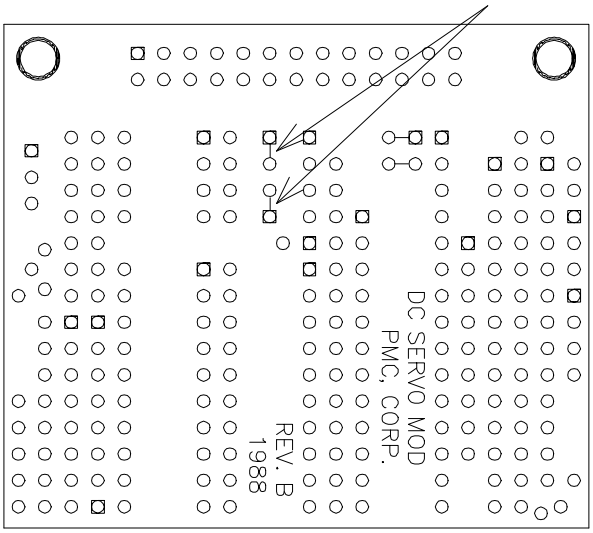
DCX-MC120 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE

NOTE 1



NOTE 1: CUT TRACES FOR DIFFERENTIAL ENCODER INPUTS, 2 PLACES

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC120E MODULE CONNECTOR J3

J3	01	ANALOG GROUND
J3	02	RESERVED
J3	03	+12 VDC
J3	04	-12 VDC
J3	05	GROUND
J3	06	+5 VDC
J3	07	RESERVED
J3	08	RESERVED
J3	09	COARSE HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	AMPLIFIER FAULT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	11	RESERVED
J3	12	RESERVED
J3	13	RESERVED
J3	14	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	15	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	16	ENCODER PHASE B+ (INPUT)**
J3	17	ENCODER POWER*
J3	18	GROUND
J3	19	ENCODER PHASE B- (INPUT)
J3	20	ENCODER PHASE A- (INPUT)
J3	21	GROUND
J3	22	ENCODER POWER*
J3	23	ENCODER PHASE A+ (INPUT)**
J3	24	ENCODER POWER*
J3	25	ENCODER INDEX (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)***
J3	26	GROUND

* ENCODER POWER is +5VDC or +12VDC, jumper selectable
** Use A+ and B+ for single-ended ENCODER INPUTS
*** Index must be low coincident with phase A and phase B low to be recognized

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

DCX-MC120E MODULE JUMPERS

JP1 MODULE I.D. SELECT

Production option, not user configurable

JP2,**JP3** DIFFERENTIAL VERSUS SINGLE ENDED ENCODER INPUTS

Connect pins 1 and 2 for single ended inputs, leave open for differential inputs.

Note: Modules are shipped wiht PCB traces between pins 1 and 2. These traces should be cut for differential encoder inputs. See diagram 2 at end of manual.

JP4 ENCODER POWER SELECT

Connect pins 1 and 2 for +12 VDC encoder power
Connect pins 2 and 3 for +5 VDC encoder power

Note: Modules are shipped with PCB traces between pins 2 and 3. These traces should be cut if +5 VDC encoder supply is not desired.

JP5 ENCODER PHASE SELECT

Connect pins 1 and 2, pins 3 and 4 for standard phasing
Connect pins 1 and 3, pins 2 and 4 for reverse phasing

Note: Modules are shipped with PCB traces between pins 1 and 2 and pins 3 and 4 for standard phasing. These traces should be cut in order to change phasing.

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DCX-MC120E MODULE JUMPERS (cont.)

JP6 DIGITAL I/O PULL-UP/PULL-DOWN SELECT

Production option, not user configurable

JP7 GROUND DAC 0 OUTPUT

Production option, not user configurable

JP8 DIGITAL VERSUS ANALOG GROUND SELECT

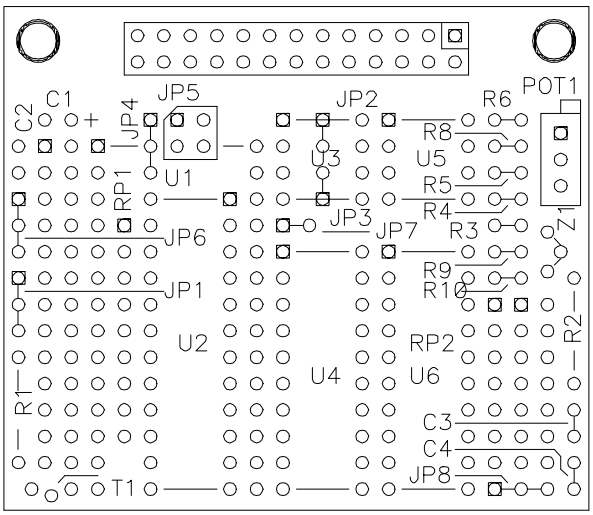
Production option, not user configurable

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APPENDIX C: DC SERVO MODULES DCX-MC100/105/110/120/120E

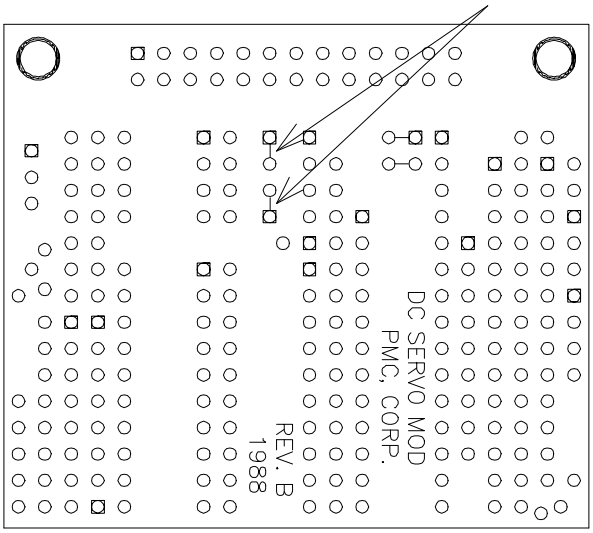
DCX-MC120E MODULE LAYOUT

TOP SIDE



BOTTOM SIDE

NOTE 1



NOTE 1: CUT TRACES FOR DIFFERENTIAL ENCODER INPUTS, 2 PLACES

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APPENDIX D

STEPPER MOTOR MODULES

DCX-MC150 OPEN LOOP STEPPER

DCX-MC160 OPEN LOOP STEPPER WITH ENCODER

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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

SIGNAL DESCRIPTIONS:

PULSE and DIRECTION - The two primary control signals for the motor are Pulse and Direction (or Pulse CW and Pulse CCW). These signals are connected to the external power driver that actually runs the motor. Every time the stepper controller wishes the motor to take a step, a signal is generated on the Pulse line.

The power driver should advance the motor by one increment for each pulse. Note that the stop increment could be a full step, half step, quad step, or micro step. This will be determined by the application and the power driver. The stepper controller does not know or care what the step size is. All position information is treated in terms of the step increment, not in terms of the linear displacement or degrees of rotation of the motor.

The Direction signal is a level active signal that tells the power driver in which direction to step the motor. When high, the driver should step counter clock-wise and when low, the driver should step clock-wise. Note that the physical rotation of the motor will depend on how the motor windings are connected to the power driver, not on the level of the Direction signal. When this signal is high, the stepper controller will decrement the current position for every step taken, and when the signal is low, it will increment the current position for every step taken.

The Pulse signal is normally high, and goes low at the beginning of a step. It stays low for a fixed amount of time, and then goes back high for the duration of the step time. When it is time for the next step, the signal will go low again.

When the step rate parameters are set to enable acceleration, the stepper controller will vary the step rate from the initial rate (**S**et **I**nitial command) to the maximum rate (**S**et **V**elocity command) for each motion it takes. This means the Pulse waveform will vary from the slower rate to the faster rate as the stepper controller accelerates the motor up to the slew rate, and then will be stable for the duration of the slewing period. The stepper controller will determine when to begin decelerating as the desired number of steps has expired.

For those power drivers requiring Pulse CW and Pulse CCW as the controlling signals, the stepper module contains configuration jumpers which will alter the output signals. See the list of configuration jumpers later in this appendix for further information.

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SIGNAL DESCRIPTIONS (cont.):

STOPPED - The Stopped signal is a status output from the stepper module, indicating when the motor is stepping. At the beginning of a motion, the Stopped signal is brought low. It will continue to stay low for the duration of that motion. At the end of the motion, the Stopped signal is brought high again. The low to high transition on Stopped indicates when the motion is over, and the high level indicates that the motor is no longer moving.

The Stopped signal may be used as a motion complete indication, it may also control the power selection for the stepper motor power driver, switching automatically between a high power selection while stepping, and a parking power selection while stopped. This can help prevent over heating of the motor while it is not moving, while still providing some holding torque, yet provide maximum torque during motions, for the best possible stepping performance.

CW LIMIT and CCW LIMIT - The stepper controller also provides two inputs for immediately stopping a motion, the CW_Limit and CCW_Limit signals. If the relevant signal goes low during a motion in that direction, the stepper controller immediately stops the motion. There will be no deceleration before the stop, the stepper controller simply abandons the motion.

Also, if a limit signal is low at the beginning of a motion, the motion will not start in that direction until the limit signal is removed. Normal motions are allowed in the opposite direction.

SLEW - Another status output from the stepper module is the Slew signal, which indicates when the maximum step rate (**SV** command) has been achieved. This signal is normally high, and goes low while the stepper controller is stepping the motor without acceleration or deceleration.

ABORT - The ABORT signal is a stepper module output. This signal will be on whenever the motor is in off state.

HOME - Module input that is used to reference the Stepper modules position counter. See the description of the **F**ind **E**dge command (**FE**) in this manual for further details.

FULL/HALF STEP - Module output that can be used to select the motor drivers stepping mode. This output can be set low or high using the **S**tep **F**ull (**SF**) and **S**tep **H**alf (**SH**) commands respectively.

SIGNAL DESCRIPTIONS:

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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

FULL/HALF CURRENT - Module output that can be used to control the motor drivers output current. This output can be set low or high using the **F**ull **C**urrent (**FC**) or **H**alf **C**urrent (**HC**) commands respectively. Normally a stepper motor driver will be set for full current while it is moving and half current while holding to reduce motor heating.

MOTOR ON - This module output will go low when the **M**otor o**N** (**MN**) command is issued. It will go high when the **M**otor o**F**f (**MF**) command is issued or the controller is reset.

NULL POSITION - In order to switch from micro stepping to full stepping without the motor shifting position, the motor should be micro stepped to the "Null" Position.

This is the position where the output of the amplifier will not change if it is switched between full and micro stepping. If the stepper amplifier provides an output signal that indicates when the motor is at a null position, the **DCX** can monitor this signal on the Null input of the MC150 module. The **I**f **I**ntermediate step (**IF**) command can be used to move a stepper motor to a null position. The **IF** command will execute the next command if the Null input for the selected axis is not active, otherwise it will skip two commands. The following command sequence can be used to move the motor to the next null position:

1**MR**1,1**WS**,1**II**,**RP**

This command will move the motor one step at a time until the Null input goes true. This command sequence typically takes less than one half second.

Jog Mode Operation

The stepper module provides a manual stepper control function through the Jog input signal. This signal is tested when ever the stepper controller is not executing a move command.

When the line is left floating, so the stepper controller can drive it both ways, the jog function is disabled, and stepping only occurs when the stepper controller is commanded to take a motion.

When the line is driven low, the stepper controller will jog the motor in the clockwise direction. The Direction signal will change state, if required, to select this direction.

Jog Mode Operation (cont.)

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When the line is driven high, the stepper controller will jog the motor in the counter clockwise direction. Again, the CCW signal will change state, if required, to select this direction. Note that the signal level on the JOG line matches the stepping direction selected by the CCW signal.

Normally, the JOG signal will be connected to a three position, center off switch. One side of the switch will be connected to ground, while the other side is connected to +5 volts. Jogging is enabled in each direction by pushing the switch from the center position to one side or the other.

While jogging, the stepper controller will use a step rate derived from the parameter of the initial rate command. The normal initial stepping rate for continuous motions is taken from the initial rate parameter value, and this rate is divided by 20. Note that the same step rate is used by the Home command. The stepper controller Step Rate Table lists the step rates for continuous motion. These rates should be divided by 20 to obtain the jogging step rate. With a 12 MHz clock, jog rates from about 1 step per second to about 1000 steps per second are possible. The stepper controller will not accelerate or decelerate during jogging, running only at the rate derived from the current value of the initial rate parameter.

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STEP RATE TABLE (pulses per second)

R	00	20									
R	01	25	R	41	1650	R	81	3597	R	121	5495
R	02	50	R	42	1701	R	82	3636	R	122	5525
R	03	75	R	43	1751	R	83	3676	R	123	5556
R	04	100	R	44	1799	R	84	3717	R	124	5587
R	05	125	R	45	1848	R	85	3759	R	125	5618
R	06	150	R	46	1901	R	86	3802	R	126	5650
R	07	175	R	47	1949	R	87	3846	R	127	5682
R	08	200	R	48	2000	R	88	3891	R	128	5714
R	09	225	R	49	2049	R	89	3937	R	129	5747
R	10	250	R	50	2101	R	90	3984	R	130	5780
R	11	275	R	51	2151	R	91	4032	R	131	5814
R	12	300	R	52	2198	R	92	4082	R	132	5848
R	13	325	R	53	2252	R	93	4132	R	133	5882
R	14	350	R	54	2299	R	94	4184	R	134	5917
R	15	375	R	55	2347	R	95	4237	R	135	5952
R	16	400	R	56	2398	R	96	4292	R	136	5988
R	17	450	R	57	2451	R	97	4348	R	137	6024
R	18	500	R	58	2500	R	98	4405	R	138	6061
R	19	550	R	59	2551	R	99	4464	R	139	6098
R	20	600	R	60	2597	R	100	4525	R	140	6135
R	21	650	R	61	2653	R	101	4566	R	141	6173
R	22	700	R	62	2703	R	102	4608	R	142	6211
R	23	750	R	63	2747	R	103	4651	R	143	6250
R	24	799	R	64	2801	R	104	4695	R	144	6289
R	25	851	R	65	2849	R	105	4739	R	145	6329
R	26	900	R	66	2899	R	106	4785	R	146	6369
R	27	950	R	67	2950	R	107	4831	R	147	6410
R	28	1000	R	68	3003	R	108	4878	R	148	6452
R	29	1050	R	69	3049	R	109	4926	R	149	6494
R	30	1100	R	70	3096	R	110	4975	R	150	6536
R	31	1149	R	71	3155	R	111	5025	R	151	6579
R	32	1200	R	72	3205	R	112	5076	R	152	6623
R	33	1250	R	73	3247	R	113	5128	R	153	6667
R	34	1300	R	74	3300	R	114	5181	R	154	6711
R	35	1350	R	75	3344	R	115	5236	R	155	6757
R	36	1404	R	76	3401	R	116	5291	R	156	6803
R	37	1449	R	77	3448	R	117	5348	R	157	6849
R	38	1499	R	78	3484	R	118	5405	R	158	6897
R	39	1550	R	79	3521	R	119	5435	R	159	6944
R	40	1600	R	80	3559	R	120	5464	R	160	6993

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STEP RATE TABLE (cont.)

R	161	7042	R	201	9804	R	241	16129
R	162	7092	R	202	9901	R	242	16393
R	163	7143	R	201	10000	R	243	16667
R	164	7194	R	204	10101	R	244	16949
R	165	7246	R	205	10204	R	245	17241
R	166	7299	R	206	10309	R	246	17544
R	167	7353	R	207	10417	R	247	17857
R	168	7407	R	208	10562	R	248	18182
R	169	7463	R	209	10638	R	249	18519
R	170	7519	R	210	10753	R	250	18868
R	171	7576	R	211	10870	R	251	19231
R	172	7634	R	212	10989	R	252	19608
R	173	7692	R	213	11111	R	253	20000
R	174	7752	R	214	11236	R	254	20408
R	175	7812	R	215	11364	R	225	20833
R	176	7874	R	216	11494			
R	177	7937	R	217	11628			
R	178	8000	R	218	11765			
R	179	8065	R	219	11905			
R	180	8130	R	220	12048			
R	181	8197	R	221	12195			
R	182	8264	R	222	12346			
R	183	8333	R	223	12500			
R	184	8403	R	224	12658			
R	185	8475	R	225	12821			
R	186	8547	R	226	12987			
R	187	8621	R	227	13158			
R	188	8696	R	228	13333			
R	189	8772	R	229	13514			
R	190	8850	R	230	13699			
R	191	8929	R	231	13889			
R	192	9009	R	232	14085			
R	193	9091	R	233	14286			
R	194	9174	R	234	14493			
R	195	9259	R	235	14706			
R	196	9346	R	236	14925			
R	197	9434	R	237	15152			
R	198	9524	R	238	15385			
R	199	9615	R	239	15625			
R	200	9709	R	240	15873			

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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

DCX-MC150 MODULE CONNECTOR J3

J3	01	GROUND
J3	02	+5 VDC
J3	03	DIRECTION OR CW PULSE (OUTPUT, OPEN COLLECTOR, CURRENT SINK, 24 mA - SEE JUMPERS JP2 AND JP3)
J3	04	PULSE OR CCW PULSE (OUTPUT, OPEN COLLECTOR, CURRENT SINK, 24 mA - SEE JUMPERS JP2 AND JP3)
J3	05	RESERVED
J3	06	RESERVED
J3	07	STOPPED (OUTPUT, 1.5 ma , LOW WHILE STEPPING)
J3	08	CW LIMIT (INPUT, ACTIVE LOW, 4.7K OHM, PULL-UP/ DOWN - SEE JUMPER JP4)
J3	09	CCW LIMIT (INPUT, ACTIVE LOW, 4.7K OHM, PULL-UP/ DOWN - SEE JUMPER JP4)
J3	10	JOG (INPUT, +5 VDC = CCW JOG, GROUND = CW JOG, OTHERWISE LEAVE UNCONNECTED)
J3	11	SLEW (OUTPUT, 1.5ma, LOW = MAX STEP RATE REACHED)
J3	12	ABORT (OUTPUT, 8 ma, LOW = AXIS OFF)
J3	13	HOME (INPUT, LOW = HOME REGION)
J3	14	FULL/HALF STEP (OUTPUT, 1.5 ma, LOW = FULL)
J3	15	FULL/HALF CURRENT (OUTPUT, 1.5 ma, LOW = MOVING)
J3	16	MOTOR ON (OUTPUT, 1.5 ma, LOW = MOTOR ON)
J3	17	NULL POSITION (INPUT, LOW = NULL POSITION)
J3	18	RESERVED
J3	19	RESERVED
J3	20	RESERVED
J3	21	NC
J3	22	NC
J3	23	ANALOG GROUND
J3	24	+12 VDC
J3	25	-12 VDC
J3	26	GROUND

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

DCX-MC150 MODULE JUMPERS

JP1 CRYSTAL VERSUS CLOCK

Production option, not user configurable.

JP2 PULSE AND DIRECTION VERSUS CW PULSE AND CCW PULSE

Connect pins 1 and 2 for CW PULSE and CCW PULSE.
Connect pins 2 and 3 for PULSE and DIRECTION.

JP3 PULSE AND DIRECTION VERSUS CW PULSE AND CCW PULSE

Connect pins 1 and 2 for CW PULSE and CCW PULSE.
Connect pins 2 and 3 for PULSE and DIRECTION.

JP4 PULL-UP VERSUS PULL-DOWN ON LIMIT INPUTS

Connect pins 1 and 2 for 4.7K ohm pull-downs,
Connect pins 2 and 3 for 4.7K ohm pull-ups,
on module connector pins 8 and 9.

JP5 MODULE I.D. SELECT

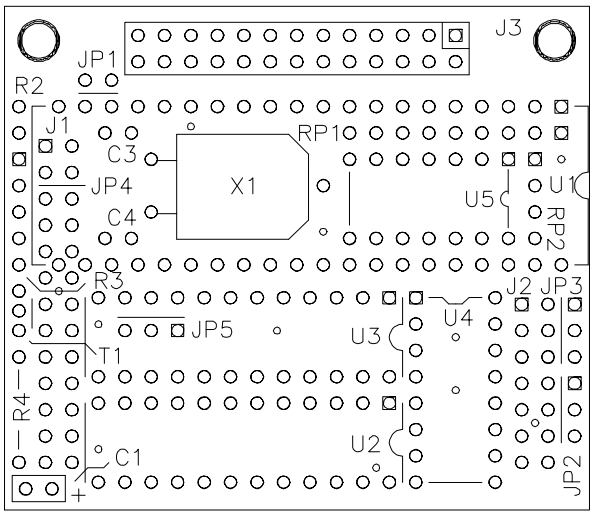
Production option, not user configurable.

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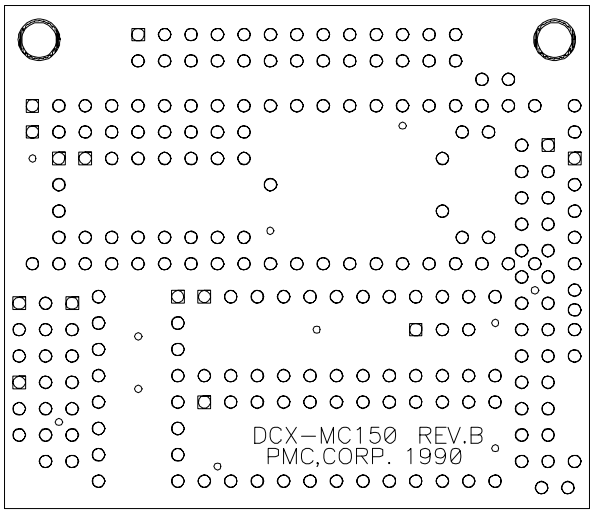
APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

DCX-MC150 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE



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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

DCX-MC160 MODULE CONNECTOR J3

J3	01	GROUND
J3	02	+5 VDC
J3	03	DIRECTION OR CW PULSE (OUTPUT, OPEN COLLECTOR, CURRENT SINK, 24 mA - SEE JUMPERS JP2 AND JP3)
J3	04	PULSE OR CCW PULSE (OUTPUT, OPEN COLLECTOR, CURRENT SINK, 24 mA - SEE JUMPERS JP2 AND JP3)
J3	05	RESERVED
J3	06	RESERVED
J3	07	STOPPED (OUTPUT, 1.5 ma, LOW = STEPPING)
J3	08	CW LIMIT (INPUT, ACTIVE LOW, 4.7K OHM, PULL-UP/ DOWN - SEE JUMPER JP4)
J3	09	CCW LIMIT (INPUT, ACTIVE LOW, 4.7K OHM, PULL-UP/ DOWN - SEE JUMPER JP4)
J3	10	JOG (INPUT, +5 VDC = CCW JOG, GROUND = CW JOG, OTHERWISE LEAVE UNCONNECTED)
J3	11	SLEW (OUTPUT, 1.5 ma, LOW = MAX STEP RATE REACHED)
J3	12	ABORT (OUTPUT, 8 ma, LOW = AXIS OFF)
J3	13	HOME (INPUT, LOW = HOME REGION)
J3	14	FULL/HALF STEP (OUTPUT, 1.5 ma, LOW = FULL)
J3	15	FULL/HALF CURRENT (OUTPUT, 1.5 ma, LOW = MOVING)
J3	16	MOTOR ON (OUTPUT, 1..5 ma, LOW = MOTOR ON)
J3	17	NULL POSITION (INPUT, LOW = NULL POSITION)
J3	18	ENCODER PHASE A+ (INPUT)
J3	19	ENCODER PHASE A- (INPUT)
J3	20	ENCODER PHASE B+ (INPUT)
J3	21	ENCODER PHASE B- (INPUT)
J3	22	ENCODER INDEX (INPUT, ACTIVE LOW)
J3	23	ENCODER COARSE HOME (INPUT, ACTIVE LOW)
J3	24	+12 VDC
J3	25	-12 VDC
J3	26	GROUND

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

DCX-MC160 MODULE JUMPERS

JP1 CRYSTAL VERSUS CLOCK

Production option, not user configurable.

JP2 PULSE AND DIRECTION VERSUS CW PULSE AND CCW PULSE

Connect pins 1 and 2 for CW PULSE and CCW PULSE.
Connect pins 2 and 3 for PULSE and DIRECTION.

JP3 PULSE AND DIRECTION VERSUS CW PULSE AND CCW PULSE

Connect pins 1 and 2 for CW PULSE and CCW PULSE.
Connect pins 2 and 3 for PULSE and DIRECTION.

JP4 PULL-UP VERSUS PULL-DOWN ON LIMIT INPUTS

Connect pins 1 and 2 for 4.7K ohm pull-downs,
Connect pins 2 and 3 for 4.7K ohm pull-ups,
on module connector pins 8 and 9.

JP5 ENCODER PHASE SELECT

Connect pins 1 and 2, pins 3 and 4 for standard phasing.
Connect pins 1 and 3, pins 2 and 4 for reverse phasing.

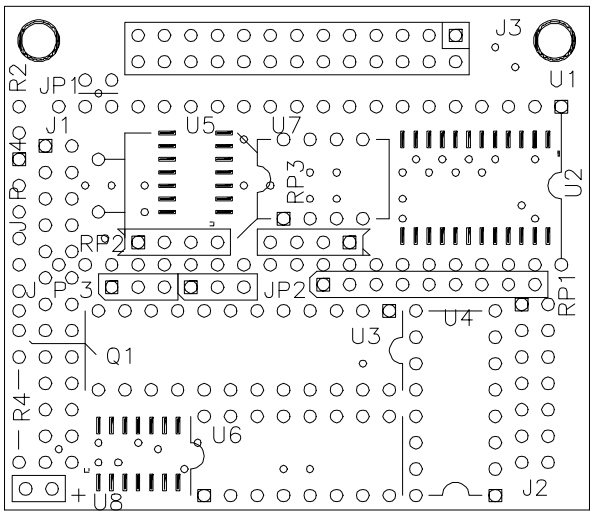
Note: Modules are shipped with PCB traces between pins 1 and 2 and pins 3 and 4 for standard phasing. These traces should be cut in be cut in order to change phasing.

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APPENDIX D: STEPPER MOTOR MODULES DCX-MC150/160

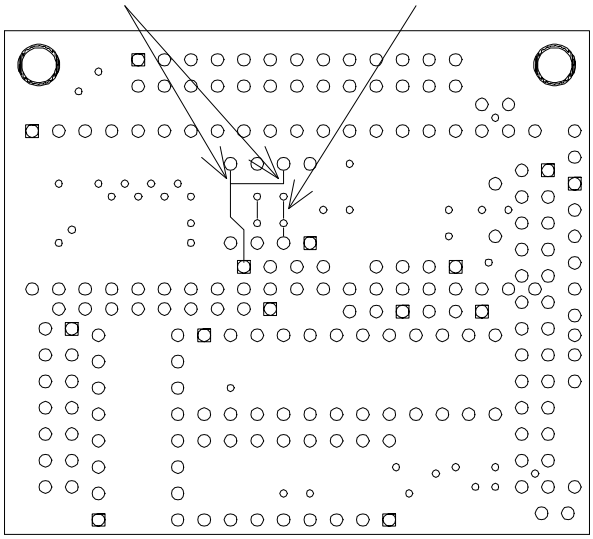
DCX-MC160 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE

NOTE 1 NOTE 2



NOTE 1: CUT TRACES
FOR DIFFERENTIAL ENCODER INPUTS, 2 PLACES
NOTE 2: JUMPER JP5

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APPENDIX E

ADVANCED SERVO MODULE

DCX-MC200 (ANALOG SIGNAL OUTPUT)

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APPENDIX E: ADVANCED SERVO MODULES DCX-MC200

SIGNAL DESCRIPTIONS:

ANALOG COMMAND RETURN - Provides the signal ground for the modules Analog Command Signal ouput. This return path is common to the ground plane of the DCX motherboard, but is connected in such a way as to reduce digital noise. Typical servo amplifiers will have a connection for the analog command return where this signal should be connected.

ANALOG COMMAND SIGNAL - This module output signal is used to control the servo amplifier's output. When connected to the command input of a velocity mode amplifier, the voltage level on this signal should cause the amplifier to drive the servo at a proportional velocity. For current mode amplifiers, the voltage level should cause a proportional current to be supplied to the servo. The module provides an analog signal that is in the range -10 to +10 volts, with 0 volts being the null output level. Positive voltages indicate a desired velocity or current in one direction, negative voltages indicate velocity or current in the opposite direction. The maximum drive current of this signal is +/-10 milliamps.

COARSE HOME - This module input is used to determine the proper zero position of the servo. In servo systems that use rotary encoders with index outputs, an index pulse is generated once per rotation of the encoder. While this signal occurs at a very repeatable angular position on the encoder, it may occur many times within the motion range of the servo. In these cases, a Coarse Home switch connected to this module input can be used to qualify which index pulse is the true zero position of the servo. By setting this switch to be activated near the end of travel of the servo, and using DCX motion commands to position the servo within this region prior to searching for the index pulse, a unique zero posiiton for the servo can be determined.

AMPLIFIER FAULT - This module input is designed to be connected to the servo amplifiers Fault or Error output signal. The state of this signal will appear as a status bit in the servo's status word. Using the **F**ault o**N** command, this signal can be enabled to shut the axis off if the input goes active low. In this codition, no further servo motion will occur until the fail signal is deactivated and the **M**otor o**N** command is issued. The **F**ault o**F**f command can be used to disable this signal.

AMPLIFIER ENABLE - This TTL level module output signal should be connected to the enable input of the servo amplifier. When the DCX is turned on or reset, this signal will immediatly go to its' inactive high level (disabling the amplifier). When the **M**otor o**N** command is issued to the DCX, this signal will go to its' active low level. Anytime there is an error on the respective servo axis, including exceeding the following error, a limit switch trip or the amplifier fault input is activated, the Amplifier Enable signal will be deactivated. This signal can also be deactivated by the **M**otor o**F**f command.

LIMIT POSITIVE and LIMIT NEGATIVE - The limit switch inputs are used to cause the DCX to stop a servo's motion when it reaches the end of travel. If the servo is in position mode, the axis will only be

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stopped if it is moving in the direction of an activated limit switch. In all other modes, the servo will be stopped regardless of the direction it is moving if either limit switch is activated. There are three modes of stopping the can be configured by the **L**imit **M**ode command. The limit switch inputs can be enabled and disabled with the **L**imits o**N** and **L**imits o**F**f commands respectively. See the section on limit switches for full details on limit switch functions.

ENCODER 1 SIGNALS (PHASE A+, PHASE A-, PHASE B+, PHASE B-, INDEX+, INDEX-) - These input signals should be connected to an incremental quadrature encoder that supplies position feedback information for the servo. The plus (+) and minus (-) signs refer to the two sides of differential inputs. The modules are shipped configured for single ended inputs. To configure the module for differential inputs cut the traces on the bottom side of the module the between jumpers **JP2** and **JP3**.

ENCODER POWER - This module pin provides a convient supply voltage connection for the encoders. The module is shipped configured for a +5 volt encoder supply. To configure the module for +12 volt encoder, cut the trace on the bottom side of the board between JP4 pins 2 and 3.

SUPPLY CONNECTIONS (+5, +12, -12, GROUND) - These module pins provide access to the DCX supply voltages.

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APPENDIX E: ADVANCED SERVO MODULES DCX-MC200

DCX-MC200 MODULE CONNECTOR J3

J3	01	ANALOG GROUND (ANALOG SIGNAL RETURN)
J3	02	ANALOG SIGNAL (OUTPUT, +/-10 V)
J3	03	+12 VDC
J3	04	-12 VDC
J3	05	GROUND
J3	06	+5 VDC
J3	07	RESERVED
J3	08	ENCODER 1 INDEX+ (INPUT, ACTIVE HIGH)
J3	09	COARSE HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	AMPLIFIER FAULT (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	11	AMPLIFIER ENABLE (OUTPUT, ACTIVE LOW, TTL LEVEL)
J3	12	RESERVED
J3	13	RESERVED
J3	14	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	15	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	16	ENCODER 1 PHASE A+ (INPUT)**
J3	17	ENCODER POWER*
J3	18	ENCODER 2 INDEX- (INPUT, ACTIVE LOW)
J3	19	ENCODER 1 PHASE A- (INPUT)
J3	20	ENCODER 1 PHASE B- (INPUT)
J3	21	ENCODER 2 PHASE A
J3	22	ENCODER 2 PHASE B
J3	23	ENCODER 1 PHASE B+ (INPUT)**
J3	24	ENCODER 2 INDEX+ (INPUT, ACTIVE HIGH)
J3	25	ENCODER 1 INDEX- (INPUT, ACTIVE LOW)
J3	26	GROUND

* ENCODER POWER is +5VDC or +12VDC, jumper selectable
** Use A+ and B+ for single-ended ENCODER INPUTS

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX E: ADVANCED SERVO MODULES DCX-MC200

DCX-MC200 MODULE CONNECTOR J4 (JOYSTICK INTERFACE)

J4	01	ANALOG INPUT 1
J4	02	ANALOG INPUT 2
J4	03	5 VOLT REF. OUTPUT
J4	04	ANALOG GROUND

DCX-MC200 MODULE JUMPERS

JP1 ENCODER INPUTS, DIFFERENTIAL VERSUS SINGLE ENDED

Connect pins 1,2 and 3 for single ended inputs, leave open for differential inputs

JP2 ENCODER INDEX ACTIVE LEVEL SELECT

Connect pins 1 and 2 for single ended, active high index on J3-8
Connect pins 2 and 3 for single ended, active low index on J3-25
Leave jumper pins open for differential index input on J3-8 and J3-25

JP3 ENCODER POWER SELECT

Connect pins 1 and 2 for +5 VDC encoder power on J3-17
Connect pins 2 and 3 for +12 VDC encoder power on J3-17

DCX-MC200 MODULE POTENTIOMETERS

POT1 ANALOG OUTPUT OFFSET ADJUSTMENT

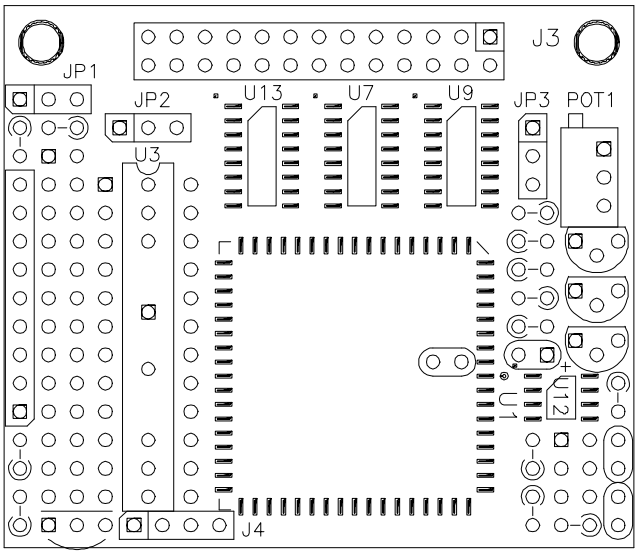
This multi-turn trimming potentiometer can be used to add an offset to the module's analog output. The range of this adjustment is approximately +/-1.0 volts.

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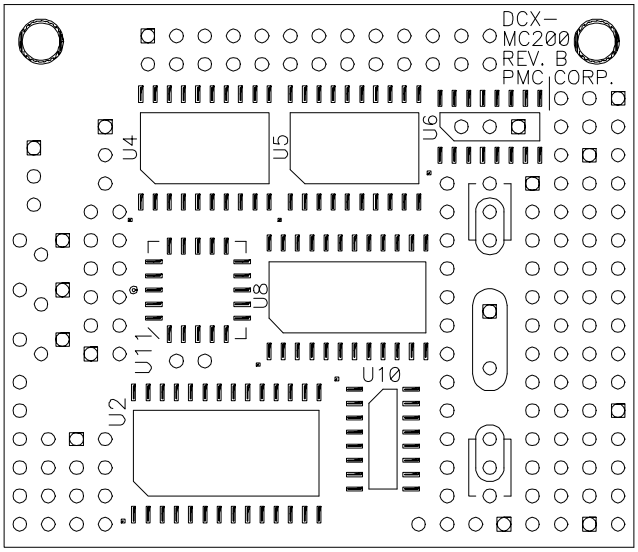
APPENDIX E: ADVANCED SERVO MODULES DCX-MC200

DCX-MC200 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE



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APPENDIX F

ADVANCED STEPPER MOTOR MODULE

DCX-MC260 OPEN LOOP STEPPER WITH ENCODER

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APPENDIX F: ADVANCED STEPPER MOTOR MODULES DCX-MC260

SIGNAL DESCRIPTIONS:

PULSE and DIRECTION - In the control of a stepper motor, the two primary control signals are Pulse and Direction (or CW Pulse and CCW Pulse). These signals are connected to the external stepper motor driver that supplies current to the motor windings. In order for the stepper module to move the motor one step, a pulse is generated on one of these signals.

The motor driver should advance the motor by one increment for each pulse. The motor may advance a full step, a half step, or a micro step. This is determined by the mode of the stepper motor driver.

The Pulse signal is normally high, and goes low at the beginning of a step. It stays low for one half the step period (ie. the time before the next pulse), and then goes back high. When it is time for the next step, the signal will go low again.

The Direction signal selects which direction the motor will move. When this signal is high, the stepper controller will decrement the current position for every step taken, and when the signal is low, it will increment the current position for every step taken.

The **O**utput **M**ode command can be used to change the operation of these signals to CW Pulse and CCW Pulse. In this mode, pulses will be generated on the CW Pulse output when the current position is increasing, and on the CCW Pulse output when the current position is decreasing.

Both of these signals have high current open collector drivers on the module and are suitable for direct connection to optically isolated inputs commonly found on stepper motor drivers. Because of the characteristics of open collector drivers, no voltages will be present on these output signals unless pull-up resistors are connected to them.

STOPPED - The Stopped signal is a status output from the stepper module, indicating when the motor is stepping. At the beginning of a motion, the Stopped signal is brought high. It will continue to stay high for the duration of that motion. At the end of the motion, the Stopped signal is brought low again. The high to low transition on Stopped indicates when the motion is over, and the low level indicates that the motor is no longer moving.

The Stopped signal may be used as a motion complete indication, it may also control the power selection for the stepper motor power driver, switching automatically between a high current while stepping, and low current while stopped. This will reduce power dissipation of the motor when it isn't moving.

SIGNAL DESCRIPTIONS:

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APPENDIX F: ADVANCED STEPPER MOTOR MODULES DCX-MC260

LIMIT POSITIVE and LIMIT NEGATIVE - The limit switch inputs are used to cause the DCX to stop a stepper motor's motion when it reaches the end of travel. If the motor is in position mode, the axis will only be stopped if it is moving in the direction of an activated limit switch. In all other modes, the motor will be stopped regardless of the direction it is moving if either limit switch is activated. There are three modes of stopping the can be configured by the **L**imit **M**ode command. The limit switch inputs can be enabled and disabled with the **L**imits o**N** and **L**imits o**F**f commands respectively. See the section on limit switches for full details on limit switch functions.

HOME - This input is used to set the stepper motors zero position. It is typically connected to a switch that is activated at a fixed position in the motors motion range.

FULL/HALF STEP - If the motor driver that this module is controlling has a digital input to select between full and half step modes, this module output that can be used to select between the modes. This output can be set low or high using the **S**tep **F**ull (**SF**) and **S**tep **H**alf (**SH**) commands respectively.

FULL/HALF CURRENT - If the motor driver that the module is controlling has a digital current control signal input, this module output can be used to control the motor drivers output current. This output can be set low or high using the **F**ull **C**urrent (**FC**) or **H**alf **C**urrent (**HC**) commands respectively. Normally a stepper motor driver will be set for full current while it is moving and half current while holding to reduce motor heating.

MOTOR ON - This module output will go low when the **M**otor o**N** (**MN**) command is issued. It will go high when the **M**otor o**F**f (**MF**) command is issued or the controller is reset. This signal can be connected to the enable signal input of the stepper driver so that it can be disabled by issuing commands to the DCX.

NULL POSITION - In order to switch from micro stepping to full stepping without the motor shifting position, the motor should be micro stepped to the "Null" Position. This is the position where the output of the amplifier will not change if it is switched between full and micro stepping. If the stepper amplifier provides an output signal that indicates when the motor is at a null position, the **DCX** can monitor this signal on the Null Position input of the module.

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APPENDIX F: ADVANCED STEPPER MOTOR MODULES DCX-MC260

DCX-MC260 MODULE CONNECTOR J3

J3	01	GROUND
J3	02	+5 VDC
J3	03	DIRECTION OR CW PULSE (OUTPUT, ACTIVE LOW OPEN COLLECTOR, CURRENT SINK 100 mA MAX.)*
J3	04	PULSE OR CCW PULSE (OUTPUT, ACTIVE LOW OPEN COLLECTOR, CURRENT SINK 100 mA MAX.)*
J3	05	RESERVED
J3	06	RESERVED
J3	07	STOPPED (OUTPUT, HIGH WHILE STEPPING)**
J3	08	LIMIT POSITIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	09	LIMIT NEGATIVE (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	10	RESERVED
J3	11	RESERVED, DO NOT CONNECT
J3	12	NO CONNECTION
J3	13	HOME (INPUT, ACTIVE LOW, 4.7K OHM PULL-UP)
J3	14	FULL/HALF STEP (OUTPUT, LOW WHEN FULL STEPPING)**
J3	15	FULL/HALF CURRENT (OUTPUT, LOW WHEN MOVING)**
J3	16	MOTOR ON (OUTPUT, LOW WHEN MOTOR ON)**
J3	17	NULL POSITION (INPUT, ACTIVE LOW AT NULL POSITION)
J3	18	ENCODER PHASE A+ (INPUT)
J3	19	ENCODER PHASE A- (INPUT)
J3	20	ENCODER PHASE B+ (INPUT)
J3	21	ENCODER PHASE B- (INPUT)
J3	22	ENCODER INDEX (INPUT, ACTIVE LOW)
J3	23	ENCODER COARSE HOME (INPUT, ACTIVE LOW)
J3	24	+12 VDC
J3	25	-12 VDC
J3	26	GROUND

* These signals default to DIRECTION and PULSE, use **O**utput **M**ode command to change to CW and CCW PULSE.

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX F: ADVANCED STEPPER MOTOR MODULES DCX-MC260

DCX-MC260 MODULE CONNECTOR J4 (JOYSTICK INTERFACE)

J4	01	ANALOG INPUT 1
J4	02	ANALOG INPUT 2
J4	03	5 VOLT REF. OUTPUT
J4	04	ANALOG GROUND

DCX-MC260 MODULE JUMPERS

JP1 ENCODER INPUTS, DIFFERENTIAL VERSUS SINGLE ENDED

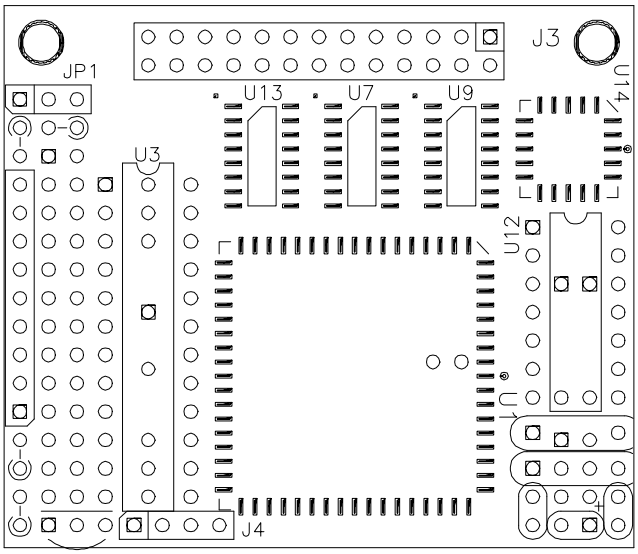
Connect pins 1, 2 and 3 for single ended encoder phase inputs, leave open for differential encoder phase inputs

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APPENDIX F: ADVANCED STEPPER MOTOR MODULES DCX-MC260

DCX-MC260 MODULE LAYOUT

TOP SIDE



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APPENDIX G

DIGITAL I/O MODULE DCX-MC400

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APPENDIX G: DIGITAL I/O MODULE DCX-MC400

Installation:

Each digital I/O module that is installed in the **DCX** provides an additional 16 discrete I/O "channels". Since the 16 I/O channels that are standard on the **DCX** motherboard are identified as 1 through 16, the I/O channels on the installed modules will be assigned to succeeding channel/numbers in blocks of 16 (e.g. 17-32, 33-48, etc.). Each I/O channel, on the **DCX** motherboard or Digital I/O module, can be individually configured as an input or output with "High True" or Low True" logic. See the **CI**, **CT**, **CH**, **CL** commands for more information.

Electrical Specifications

Parameter	Min.	Max.	Unit
Input High Voltage	2.0	5.3	V
Input Low Voltage	-0.3	0.8	V
Output High Voltage	2.4		V (IOH = -250 uA)
Output Low Voltage		0.4	V (IOL = +2.0 mA)
Input Leakage		±10.0	uA

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APPENDIX G: DIGITAL I/O MODULE DCX-MC400

DCX-MC400 MODULE CONNECTOR J3

J3	01	CHANNEL 01
J3	02	CHANNEL 02
J3	03	CHANNEL 03
J3	04	CHANNEL 04
J3	05	CHANNEL 05
J3	06	CHANNEL 06
J3	07	CHANNEL 07
J3	08	CHANNEL 08
J3	09	CHANNEL 09
J3	10	CHANNEL 10
J3	11	CHANNEL 11
J3	12	CHANNEL 12
J3	13	CHANNEL 13
J3	14	CHANNEL 14
J3	15	CHANNEL 15
J3	16	CHANNEL 16
J3	17	RESERVED
J3	18	RESERVED
J3	19	RESERVED
J3	20	+5 VDC
J3	21	GROUND
J3	22	RESERVED
J3	23	RESERVED
J3	24	RESERVED
J3	25	RESERVED
J3	26	GROUND

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX G: DIGITAL I/O MODULE DCX-MC400

DCX-MC400 MODULE JUMPERS

JP1 SELECT DIP SWITCH POLARITY

Production option, not user configurable

JP2 DEMULTIPLEXOR PAL BYPASS

Production option, not user configurable

JP3 J3 PIN 20 SUPPLY SELECT

Production option, not user configurable

JP4 J3 PIN 21 SUPPLY SELECT

Production option, not user configurable

JP5 DEMULTIPLEXOR PAL ENABLE

Production option, not user configurable

JP6 MODULE IDENTIFY

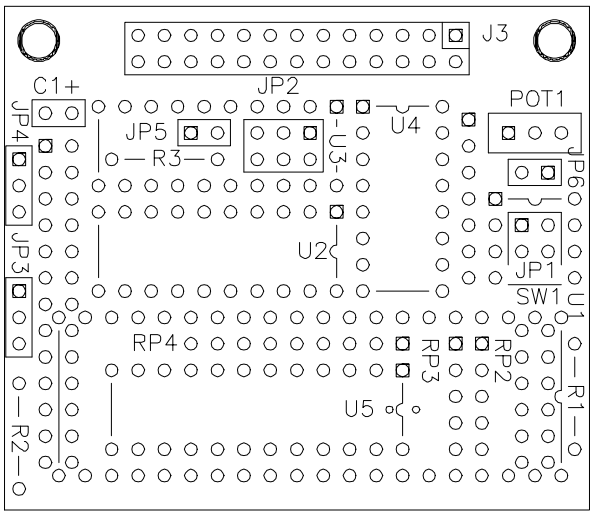
Production option, not user configurable

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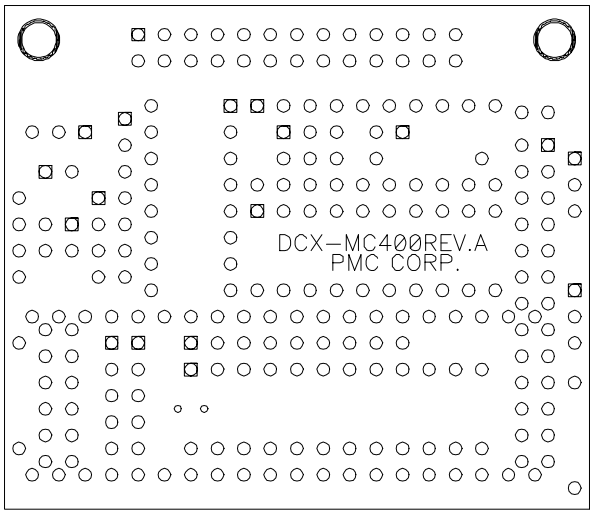
APPENDIX G: DIGITAL I/O MODULE DCX-MC400

DCX-MC400 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE



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APPENDIX H

ANALOG I/O MODULES
DCX-MC500 (4 INPUTS AND 4 OUTPUTS)
DCX-MC510 (4 INPUTS)
DCX-MC520 (4 OUTPUTS)

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APPENDIX H: ANALOG I/O MODULES DCX-MC500/510/520

Description:

The DCX-MC500 Analog I/O Module provides analog input and output capability to a DCX Controller. One or more of these modules can be installed in any available position on a DCX motherboard. Analog input channels can be used to monitor signal levels from external sensors. Output channels can be used to control external devices.

Three models of the DCX-MC500 are available:

DCX-MC500	4 Inputs and 4 Outputs
DCX-MC510	4 Inputs
DCX-MC520	4 Outputs

On each DCX-MC500 Analog I/O Module all analog input channels are numbered sequentially as a group. Likewise, all analog output channels are numbered sequentially as a group.

When installed in the DCX-VM100 (VMEbus version of the DCX) motherboard, the analog I/O channels on the DCX-MC500 modules start with number 1. The DCX-PC motherboard has already 4 eight bit analog input channels on the motherboard, so the analog I/O channels on the DCX-MC500's start with number 5.

Because the DCX controller board is implemented in digital electronics, all analog input signals must be converted into a representative numerical value. This function is done by an Analog to Digital Converter (ADC) on the DCX-MC500. Similarly, analog output signals originate on the DCX board as numerical values. These numbers must be written to a Digital to Analog Converter (DAC) on the DCX-MC500, which converts them to a corresponding analog output signal level.

The DCX-MC500 is designed to accurately measure voltage levels on the input channels. These inputs are very high impedance with leakage currents less then 10 nanoamps. The output channels are designed to provide signals with accurate voltage levels. The current from these outputs should not exceed 10 milliamps.

Each of the analog input and analog output channels has 12 bits of resolution. This means that the digital value read from the ADC, or the digital value written to the digital to the DAC, must be in the range 0 to 4095.

For both inputs and outputs, a digital value of 0 translates to the lowest analog voltage. A digital value of 4095 translates to the highest analog voltage.

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APPENDIX H: ANALOG I/O MODULES DCX-MC500/510/520

Input signals on pins 1,3,5 and 7 of the module J3 connector are wired directly to the ADC. No amplification or clamping to the input voltage range is provided on the module. Inputs with voltages exceeding the input range may cause damage to ADC and must be prevented.

In some applications, the signals from a sensor may not be absolute voltage levels, but proportional to some reference voltage. In these cases, it may be desirable to supply the reference signal to the ADC on the module through pin 18 of the J3 connector (and setting jumper JP1 accordingly). This will result in a "ratiometric" conversion of the input signal relative to the reference voltage.

The outputs from the DAC on the DCX-MC500 module are voltage levels in the range 0 to +5 volts. These outputs have no gain or offset adjustment. These signals are available on pins 10,12,14 and 16 of the module J3 connector.

The outputs from the DAC are also connected to operational amplifiers on the module which offset and amplify them to provide a -10 to +10 volt range. Each of these outputs has a 20 turn trim pot for offset adjustment, and a single turn pot for gain adjustment. The offset pot provides a minimum ±0.5 volt adjustment, and the gain pot provides a nominal ±2% range adjustment. These output signals are available on pins 2,4,6 and 8 of the module J3 connector.

After reset the outputs of the DCX-MC500 will be initialized to their mid-scale point. For the 0 to +5 volt outputs, this will be 2.5 volts. For the -10 to +10 volt outputs, this will be 0.0 volts.

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APPENDIX H: ANALOG I/O MODULES DCX-MC500/510/520

Calibration:

The analog input of the DCX-MC500 needs has no adjustments, and the only option is use of the internal +5, or an external, reference voltage.

The analog outputs with the 0 to +5 volt range also have no adjustments. The reference for the DAC is fixed to the internal reference voltage.

Calibration of the analog outputs with the -10 to +10 volt range is accomplished using the 8 trim pots located on the module. There are four single turn trim pots which adjust the gain of each of the four analog outputs. There are also four 20 turn trim pots for adjusting the offsets of each of the analog outputs. Refer to the module layout diagram at the end of this appendix for pot locations and assignments.

Using the following command sequence, and reading the analog output voltage level with a voltmeter, an analog output can be calibrated to provide the specified -10 to +10 volt range:

AL0,OAn,WA2000,AL2048,OAn,WA2000,AL4095,OAn,WA2000,RP

where: n = channel number = 1,2,3,4,...

This command sequence will cycle the specified analog output from the minus limit, to the mid-point, to the positive limit. There is a 2 second delay at each voltage level, during which the voltmeter can settle and display the current reading.

The first step in calibrating an analog output is to adjust the gain using the single turn pot to achieve a 20.00 volt "swing". This is the difference between the most positive level reading, and the most negative level reading. It is not necessary for the two readings to be centered about 0 volts for this step.

The second step is to adjust the offset using the 20 turn pot. This adjustment will place the mid-point of analog output at the 0 volt level. When the output changes to the mid-point level turn the pot to achieve a 0.000 volt reading.

After the second step of the calibration procedure, the output swing should still be 20.00 volts. If not, repeat steps 1 and 2 again.

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APPENDIX H: ANALOG I/O MODULES DCX-MC500/510/520

Electrical Specifications

PARAMETER	Min	Max	Units
Input Resolution	12		Bits
Input Conversion Rate		10	KHz
Input Zero Error Using Internal Reference Using External Reference		 ±3 ±1/2	 LSB LSB
Input Full-Scale Error Using Internal Reference Using External Reference		 ±15 ±1/2	 LSB LSB
Input Zero Temp. Coefficient		0.5	ppm/C
Input Differential Nonlinearity		±1	LSB
Input Total Unadjusted Error Using Internal Reference Using External Reference		 ±15 ±1	 LSB LSB
Input Voltage Range Using Internal Reference Using External Reference	 0.0 0.0	 5.0 Vref	 V V
Input Capacitance		8	pF
Input Leakage Current		100	nA
External Reference Voltage	4.0	6.0	V

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Electrical Specifications (cont.)

PARAMETER	Min	Max	Units
Output Resolution	12		Bits
Output Zero Code Error (note 1)		±3	LSB
Output Full Scale Error (note 1)		±10	LSB
Output Nonlinearity (note 1)		±1	LSB
Output Total Unadjusted Error (note 1)		±10	LSB
Output Voltage Range or	0.0 -10.0	5.0 +10.0	V V

Note 1: These values are for 0 to +5 volt outputs

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APPENDIX H: ANALOG I/O MODULES DCX-MC500/510/520

DCX-MC500 MODULE CONNECTOR J3

J3	01	CHANNEL 1 INPUT (0 to +5 volts)
J3	02	CHANNEL 1 OUTPUT (-10 to +10 volts)
J3	03	CHANNEL 2 INPUT (0 to +5 volts)
J3	04	CHANNEL 2 OUTPUT (-10 to +10 volts)
J3	05	CHANNEL 3 INPUT (0 to +5 volts)
J3	06	CHANNEL 3 OUTPUT (-10 to +10 volts)
J3	07	CHANNEL 4 INPUT (0 to +5 volts)
J3	08	CHANNEL 4 OUTPUT (-10 to +10 volts)
J3	09	RESERVED
J3	10	CHANNEL 1 OUTPUT (0 to +5 volts)
J3	11	RESERVED
J3	12	CHANNEL 2 OUTPUT (0 to +5 volts)
J3	13	RESERVED
J3	14	CHANNEL 3 OUTPUT (0 to +5 volts)
J3	15	RESERVED
J3	16	CHANNEL 4 OUTPUT (0 to +5 volts)
J3	17	ANALOG GROUND
J3	18	EXTERNAL ADC REFERENCE (See jumper JP1 below)
J3	19	+12 VDC
J3	20	-12 VDC
J3	21	NO CONNECT
J3	22	NO CONNECT
J3	23	+5 VDC
J3	24	+5 VDC
J3	25	DIGITAL GROUND
J3	26	DIGITAL GROUND

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

DCX-MC500 MODULE JUMPER

JP1 ADC REFERENCE SELECT

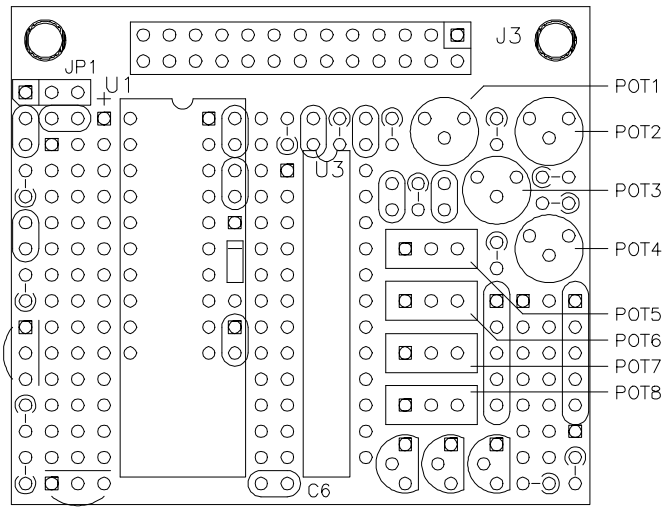
Connect pins 1 and 2 to use external reference (supplied by user on pin 18 of J3).
Connect pins 2 and 3 to use on board +5 volt reference.

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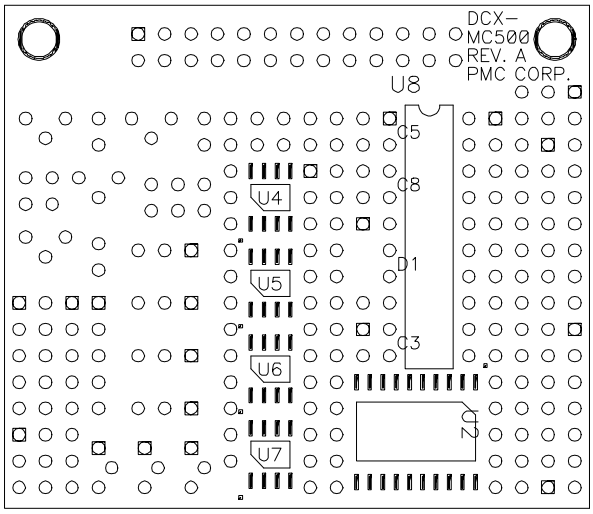
APPENDIX H: ANALOG I/O MODULES DCX-MC500/510/520

DCX-MC500 MODULE LAYOUT

TOP SIDE



BOTTOM SIDE



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APPENDIX I

RS-232 COMMUNICATION INTERFACE MODULE

DCX-MF300

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APPENDIX I: RS-232 COMMUNICATION INTERFACE MODULE DCX-MF300

DCX-MF300 MODULE CONNECTOR J3

J3	3	(DB25 pin 2)	RECEIVE
J3	5	(DB25 pin 3)	TRANSMIT
J3	7	(DB25 pin 4)	CLEAR TO SEND
J3	9	(DB25 pin 5)	REQUEST TO SEND
J3	11	(DB25 pin 6)	DATA SET READY
J3	13	(DB25 pin 7)	GROUND
J3	14	(DB25 pin 20)	DATA TERMINAL READY
J3	15	(DB25 pin 8)	DATA CARRIER DETECT

JP3 - JP10 DCE / DTE PORT CONFIGURATION

For DCE		For DTE	
JP3	1 TO 2	JP3	2 TO 3
JP4	1 TO 2	JP4	2 TO 3
JP6	1 TO 2	JP5	2 TO 3
JP7	1 TO 2	JP8	2 TO 3
JP9	1 TO 2	JP10	1 TO 2
JP10	1 TO 2		
JP5	1 TO 2 OR	JP6	2 TO 3 OR
JP8	1 TO 2	JP7	2 TO 3 OR
		JP9	2 TO 3

(See module diagram at end of Appendix H)

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APPENDIX I: RS-232 COMMUNICATION INTERFACE MODULE DCX-MF300

DCX-MF300 MODULE JUMPERS

JP1 BAUD RATE / NETWORK SELECT

Connect pin 1 to 2 for 300 baud
Connect pin 3 to 4 for 1200 baud
Connect pin 5 to 6 for 2400 baud
Connect pin 7 to 8 for 4800 baud
Connect pin 9 to 10 for 9600 baud (Factory configuration)
Connect pin 11 to 12 for 19200 baud
Connect pin 13 to 14 to enable network

JP2 HANDSHAKE / NETWORK SELECT

Connect pin 1 to 3 and 2 to 4 for handshake (Factory configuration)
Connect pin 1 to 2 and 3 to 4 for network

JP3 RECEIVE PIN SELECT

Connect pin 1 to 2 for data input on J3 pin 3 (Factory configuration)
Connect pin 2 to 3 for data input on J3 pin 5

JP4 TRANSMIT PIN SELECT

Connect pin 1 to 2 for data output on J3 pin 5 (Factory configuration)
Connect pin 2 to 3 for data output on J3 pin 3

JP5 J3 PIN 7 SELECT (DB25 PIN 4)

Connect pin 1 to 2 for DCE (input)
Connect pin 2 to 3 for DTE (output)

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DCX-MF300 MODULE JUMPERS (cont.)

JP6 J3 PIN 9 SELECT (DB25 PIN 5)

Connect pin 1 to 2 for DCE (output) (Factory configuration)
Connect pin 2 to 3 for DTE (input)

JP7 J3 PIN 11 SELECT (DB25 PIN 6)

Connect pin 1 to 2 for DCE (output)
Connect pin 2 to 3 for DTE (input) (Factory configuration)

JP8 J3 PIN 14 SELECT (DB25 PIN 20)

Connect pin 1 to 2 for DCE (input) (Factory configuration)
Connect pin 2 to 3 for DTE (output)

JP9 J3 PIN 15 SELECT (DB25 PIN 8)

Connect pin 1 to 2 for DCE (output)
Connect pin 2 to 3 for DTE (input)

JP10 READY SELECT

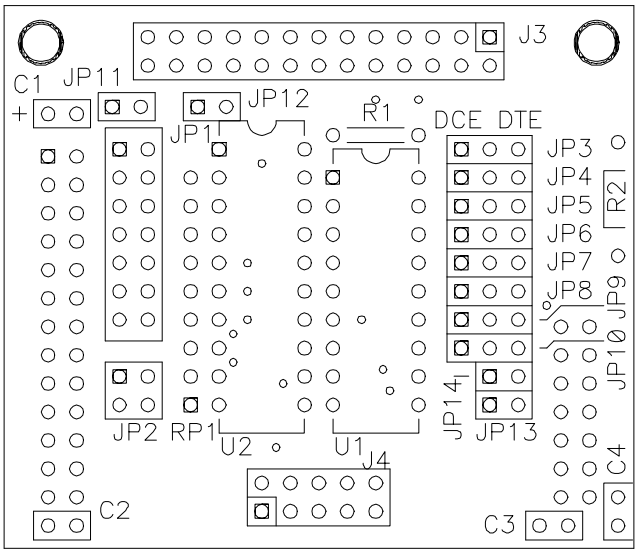
Connect pin 1 to 2 for DCX ready signal (Factory configuration)
Connect pin 2 to 3 for 100 ohm pull up to +12vdc
(This signal goes to JP5-3, JP6-1, JP7-1, JP8-3, JP9-1)

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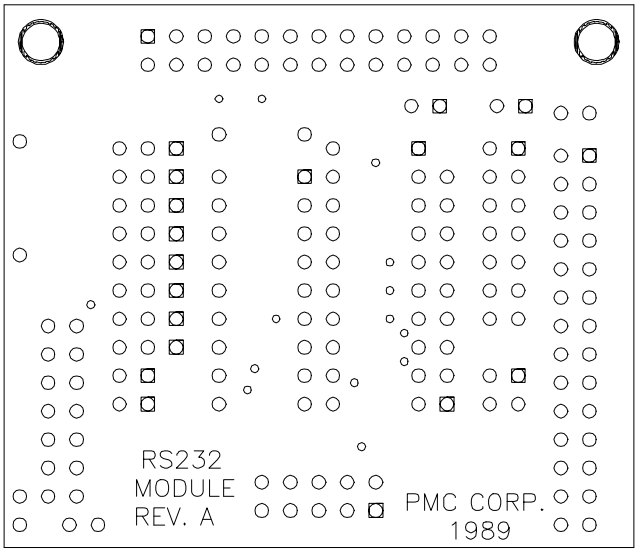
APPENDIX I: RS-232 COMMUNICATION INTERFACE MODULE DCX-MF300

DCX-MF300 MODULE LAYOUT

TOP SIDE

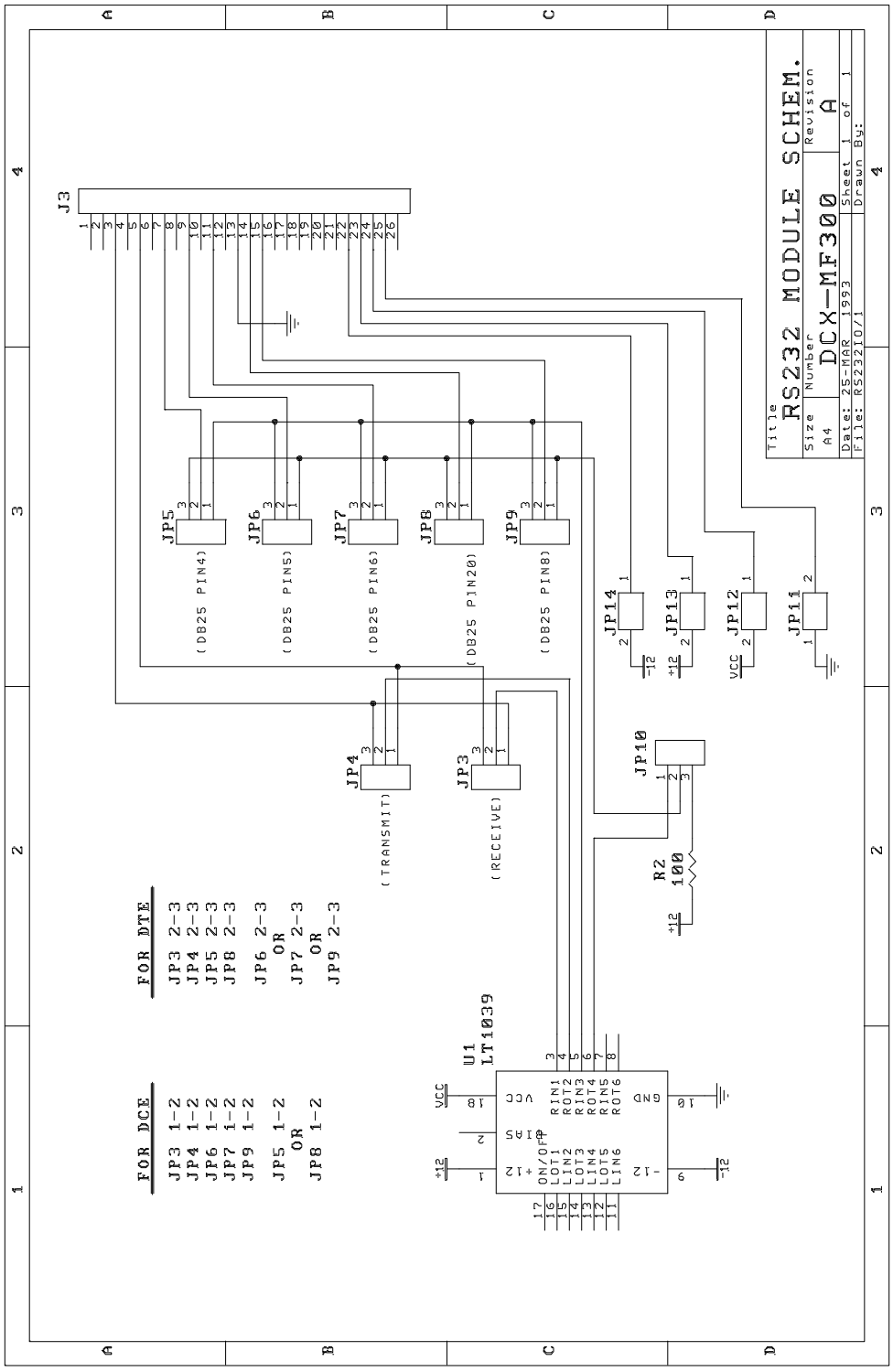


BOTTOM SIDE



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APPENDIX I: RS-232 COMMUNICATION INTERFACE MODULE DCX-MF300



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APPENDIX J

GPIB INTERFACE MODULE DCX-MF310

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APPENDIX J: GPIB INTERFACE MODULE DCX-MF310

DCX-MF310 MODULE CONNECTOR J3

The signals are arranged so that the connection to a standard IEEE-488 connector will be straight through a ribbon cable.

J3	01	IEEE-488: D101
J3	02	IEEE-488: D105
J3	03	IEEE-488: D102
J3	04	IEEE-488: D106
J3	05	IEEE-488: D103
J3	06	IEEE-488: D107
J3	07	IEEE-488: D104
J3	08	IEEE-488: D108
J3	09	IEEE-488: E01
J3	10	IEEE-488: REN
J3	11	IEEE-488: DAV
J3	12	IEEE-488: GROUND
J3	13	IEEE-488: NRFD
J3	14	IEEE-488: GROUND
J3	15	IEEE-488: NDAC
J3	16	IEEE-488: GROUND
J3	17	IEEE-488: IFC
J3	18	IEEE-488: GROUND
J3	19	IEEE-488: SRQ
J3	20	IEEE-488: GROUND
J3	21	IEEE-488: ATN
J3	22	IEEE-488: GROUND
J3	23	IEEE-488: SHIELD
J3	24	IEEE-488: GND
J3	25	IEEE-488: NOT USED
J3	26	IEEE-488: NOT USED

Mating Connector: 26-pin dual-row IDC female, Circuit Assembly
P/N CA-26IDS2-F-SPT or equivalent

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APPENDIX J: GPIB INTERFACE MODULE DCX-MF310

DCX-MF310 MODULE JUMPERS

JP1 PUSH-PULL BUS DRIVER ENABLE

Connect pins 1 and 2 for open collector drivers,
leave disconnected for push-pull drivers

Note: Push-pull used for high speed bus operation

JP2 SELECT CABLE SHIELD TO GROUND

Connect pins 1 and 2 to tie cable shield to DCX ground

Note: Cable shield should only be grounded at one point

JP3 SELECT DIP SWITCH POLARITY

Production option, not user configurable

JP4 DMA SIGNAL CONNECT

Production option, not user configurable

JP5 DMA SIGNAL CONNECT

Production option, not user configurable

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APPENDIX J: GPIB INTERFACE MODULE DCX-MF310

GPIB ADDRESS SELECTION

BUS ADDRESS

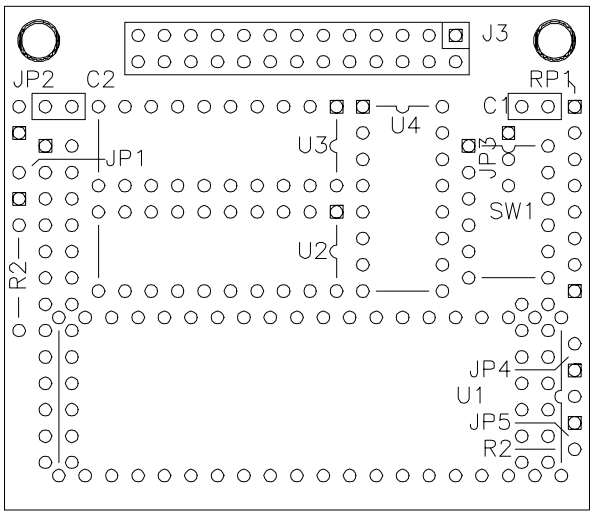
Dip Switch Setting							Listen		Talk	
6	5	4	3	2	1					
OFF	OFF	OFF	OFF	OFF	OFF	" "	(20h)		(40h)	
OFF	OFF	OFF	OFF	OFF	ON		"!"	(21h)	"A"	(41h)
OFF	OFF	OFF	OFF	ON	OFF	"""	(22h)	"B"	(42h)	
OFF	OFF	OFF	OFF	ON	ON		"#"	(23h)	"C"	(43h)
OFF	OFF	OFF	ON	OFF	OFF	"$"	(24h)	"D"	(44h)	
OFF	OFF	OFF	ON	OFF	ON		"%"	(25h)	"E"	(45h)
OFF	OFF	OFF	ON	ON	OFF	"&"	(26h)	"F"	(46h)	
OFF	OFF	OFF	ON	ON	ON			(27h)	"G"	(47h)
OFF	OFF	ON	OFF	OFF	OFF	"("	(28h)	"H"	(48h)	
OFF	OFF	ON	OFF	OFF	ON		")"	(29h)	"I"	(49h)
OFF	OFF	ON	OFF	ON	OFF	"*"	(2Ah)		"J"	(4Ah)
OFF	OFF	ON	OFF	ON	ON		"+"	(2Bh)	"K"	(4Bh)
OFF	OFF	ON	ON	OFF	OFF	","	(2Ch)		"L"	(4Ch)
OFF	OFF	ON	ON	OFF	ON		"-"	(2Dh)	"M"	(4Dh)
OFF	OFF	ON	ON	ON	OFF		"."	(2Eh)	"N"	(4Eh)
OFF	OFF	ON	ON	ON	ON		"/"	(2Fh)	"O"	(4Fh)
OFF	ON	OFF	OFF	OFF	OFF	"0"	(30h)	"P"	(50h)	
OFF	ON	OFF	OFF	OFF	ON		"1"	(31h)	"Q"	(51h)
OFF	ON	OFF	OFF	ON	OFF	"2"	(32h)	"R"	(52h)	
OFF	ON	OFF	OFF	ON	ON		"3"	(33h)	"S"	(53h)
OFF	ON	OFF	ON	OFF	OFF	"4"	(34h)	"T"	(54h)	
OFF	ON	OFF	ON	OFF	ON		"5"	(35h)	"U"	(55h)
OFF	ON	OFF	ON	ON	OFF		"6"	(36h)	"V"	(56h)
OFF	ON	OFF	ON	ON	ON		"7"	(37h)	"W"	(57h)
OFF	ON	ON	OFF	OFF	OFF	"8"	(38h)	"X"	(58h)	
OFF	ON	ON	OFF	OFF	ON		"9"	(39h)	"Y"	(59h)
OFF	ON	ON	OFF	ON	OFF		":"	(3Ah)	"Z"	(5Ah)
OFF	ON	ON	OFF	ON	ON		";"	(3Bh)	"["	(5Bh)
OFF	ON	ON	ON	OFF	OFF		"<"	(3Ch)	"\"	(5Ch)
OFF	ON	ON	ON	OFF	ON		"="	(3Dh)	"]"	(5Dh)
OFF	ON	ON	ON	ON	OFF		">"	(3Eh)	" "	(5Eh)
OFF	ON	ON	ON	ON	ON		"?"	(3Fh)	" "	(5Fh)

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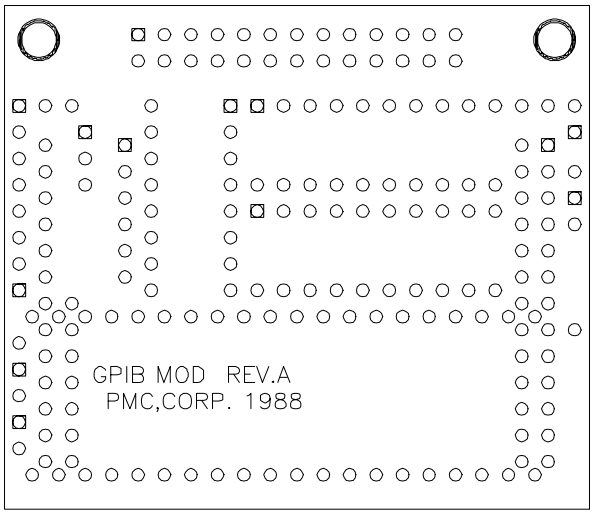
APPENDIX J: GPIB INTERFACE MODULE DCX-MF310

MODULE LAYOUT

TOP SIDE



BOTTOM SIDE



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APPENDIX K

DIGITAL I/O to RELAY RACK INTERFACE
DCX-BF022

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APPENDIX K: DIGITAL I/O to RELAY RACK INTERFACE DCX-BF022

Installation:

Please refer to the figure at the end of this appendix.

The BFO22 interface board available from PMC provides a convienent means of connecting the **DCX**'s I/O channels to a 16PBH relay rack available from Opto22. The 16PBH accepts up to 16 optically isolated input or output modules for interfacing with external electrical systems. Using the 16PBH and a BFO22, each installed module will be connected to one of the **DCX**'s digital I/O channels.

For installation, the BFO22 plugs directly into the 16PBH and then connects to the **DCX** via a 26 conductor ribbon cable with IDC connectors. Note that the relay rack modules are numbered 0 through 15, while the **DCX** I/O channels are numbered 1 through 16.

Although the relay rack has screw terminals for connecting a logic supply, it is not necessary to make this connection. By installing a shorting block on jumper JP17 of the BFO22, the logic supply of the **DCX** will be supplied to the 16PBH.

For each I/O module position on the 16PBH relay rack, there is a corresponding jumper on the BFO22. By placing a shorting block in one of two positions on each of these jumpers, the BFO22 circuitry is configured for connection to either input or output modules. The BFO22 jumper JP1 is used to configure the circuitry for module position 0, jumper JP2 is for module position 1, and so on. If a module position has an output relay, a shorting block should be placed on pins 1 and 2 of the corresponding jumper. Conversely, if a module position has an input signal conditioner, the shorting block should be placed between pins 2 and 3. Note that pin 1 of each jumper is the one closest to the jumper label.

Before setting the individual I/O channels as inputs or outputs, a global **C**hannel **L**ow command should be issued to the **DCX**. This will cause "normally open" relays to turn on when the **C**hannel o**N** command is issued, and off when the **C**hannel o**F**f command is issued. For input modules, the **T**ell **C**hannel command will return a "1" when the signal is present, and a "0" when it is not.

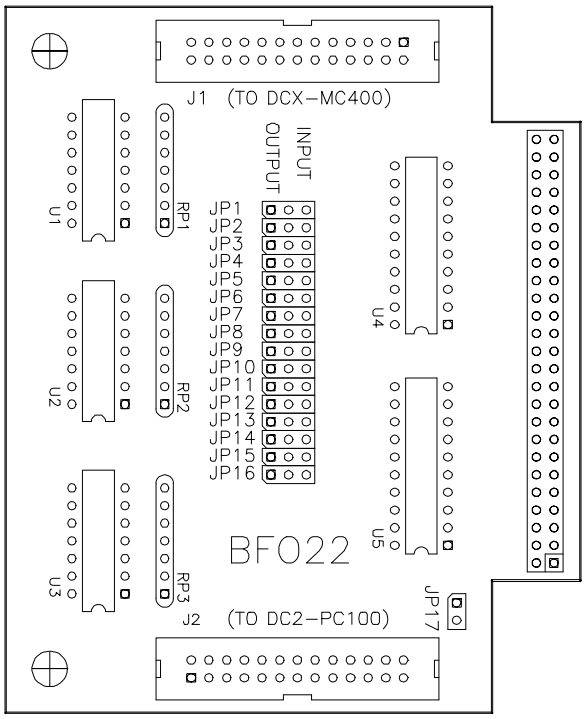
By default, all I/O channels on the **DCX** are changed to inputs during power-up or reset. For input modules installed in the relay rack, no further configuration is necessary. In order to configure any channels for output modules, individual **C**hannel ou**T** command should be issued to the **DCX**.

Example:
If module positions 0 and 1 are inputs, 2 and 3 are outputs,
use the following commands to configure them: **CL**,**CT**3,**CT**4

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APPENDIX K: DIGITAL I/O to RELAY RACK INTERFACE DCX-BF022

DCX-BF022 LAYOUT



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APPENDIX L

SERVO MODULE INTERCONNECT BOARD
DCX-BF100

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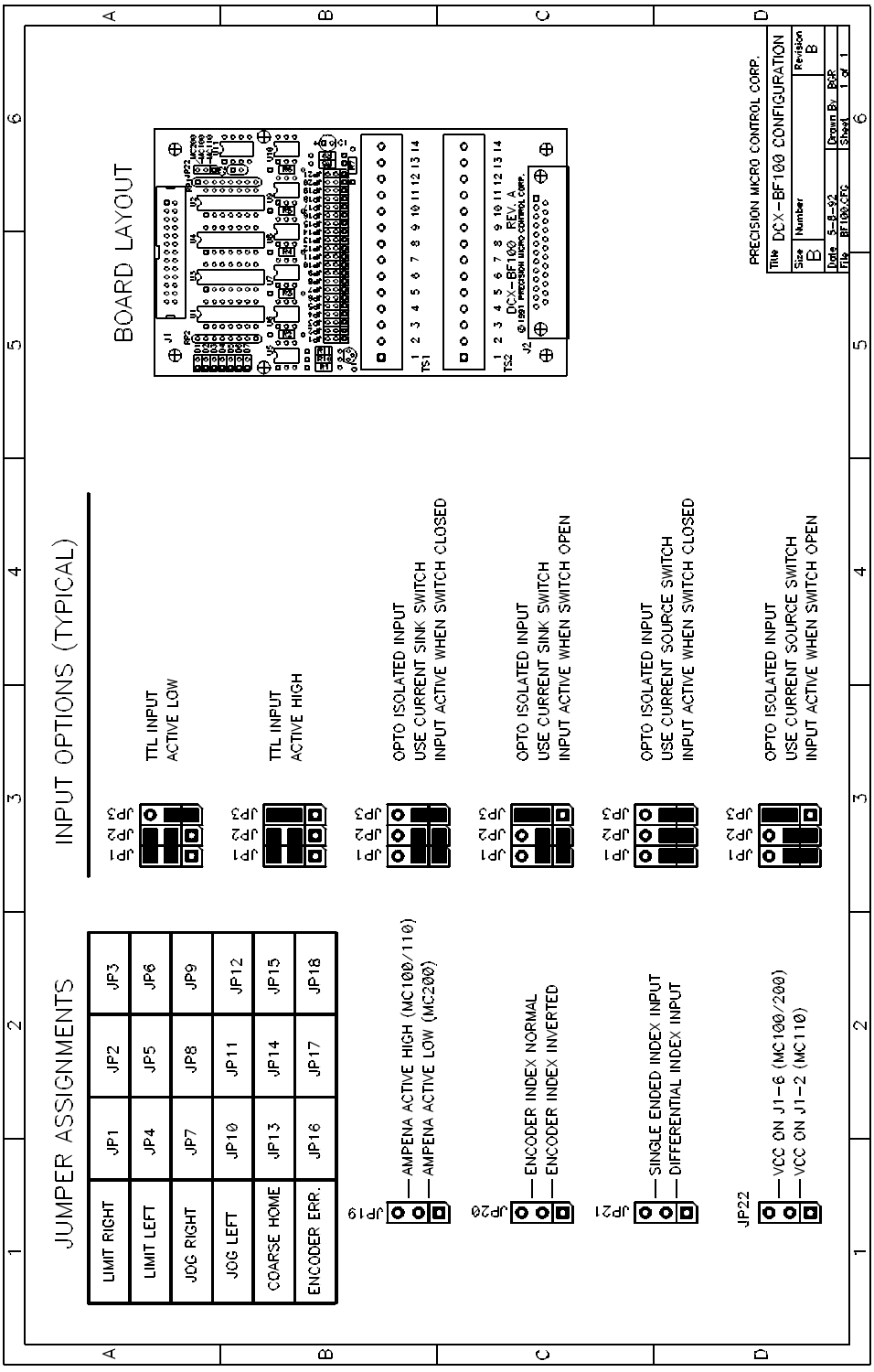
APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100

INSTALATION

Text to be added.

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APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100



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APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100

DCX-BF100 CONNECTIONS

WHEN INTERFACED TO DCX-MC100:

J1	
01	ANALOG GROUND
02	ANALOG SIGNAL
03	+12 VDC
04	-12 VDC
05	GROUND
06	+5 VDC
07	JOG RIGHT
08	JOG LEFT
09	COARSE HOME
10	AMPLIFIER FAULT
11	AMPLIFIER INHIBIT
12	RESERVED
13	RESERVED
14	LIMIT POSITIVE
15	LIMIT NEGATIVE
16	ENCODER PHASE B+
17	ENCODER POWER
18	GROUND
19	ENCODER PHASE B-
20	ENCODER PHASE A-
21	GROUND
22	ENCODER POWER
23	ENCODER PHASE A+
24	ENCODER POWER
25	ENCODER INDEX-
26	GROUND

J2	
01	ANALOG GROUND
02	+12 VDC
03	GROUND
04	OPTO SUPPLY
05	COARSE HOME
06	AMPLIFIER ENABLE
07	JOG LEFT
08	LIMIT NEGATIVE
09	ENCODER POWER
10	ENCODER PHASE B-
11	GROUND
12	ENCODER PHASE A+
13	ENCODER INDEX-
14	ANALOG SIGNAL
15	-12 VDC
16	+5 VDC
17	ENCODER INDEX+
18	AMPLIFIER FAULT
19	JOG RIGHT
20	LIMIT POSITIVE
21	ENCODER PHASE B+
22	GROUND
23	ENCODER PHASE A-
24	ENCODER POWER
25	ENCODER POWER

CONNECTOR SHELL = SHIELD

TS1	
01	SHIELD
02	ANALOG GROUND
03	ANALOG SIGNAL
04	+5 VDC
05	+5 VDC
06	AMPLIFIER ENABLE
07	COARSE HOME
08	AMPLIFIER FAULT
09	JOG RIGHT
10	JOG LEFT
11	LIMIT POSITIVE
12	LIMIT NEGATIVE
13	OPTO SUPPLY
14	GROUND

TS2	
01	SHIELD
02	ENCODER POWER
03	ENCODER PHASE B+
04	ENCODER PHASE B-
05	ENCODER PHASE A+
06	ENCODER PHASE A-
07	ENCODER INDEX+
08	ENCODER INDEX-
09	GROUND
10	ENCODER POWER
11	ENCODER POWER
12	GROUND
13	+5 VDC
14	GROUND

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APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100

DCX-BF100 CONNECTIONS (cont.)

WHEN INTERFACED TO DCX-MC110:

J1	
01	MOTOR +
02	ENCODER POWER
03	ENCODER PHASE A+
04	ENCODER PHASE B+
05	GROUND
06	MOTOR -
07	POSITIVE SUPPLY
08	NEGATIVE SUPPLY
09	COARSE HOME
10	AMPLIFIER FAULT
11	AMPLIFIER ENABLE
12	JOG RIGHT
13	JOG LEFT
14	LIMIT POSITIVE
15	LIMIT NEGATIVE
16	ENCODER PHASE B+
17	ENCODER POWER
18	GROUND
19	ENCODER PHASE B-
20	ENCODER PHASE A-
21	GROUND
22	ENCODER POWER
23	ENCODER PHASE A+
24	ENCODER POWER
25	ENCODER INDEX-
26	GROUND

J2	
01	MOTOR +
02	ENCODER PHASE A+
03	GROUND
04	OPTO SUPPLY
05	COARSE HOME
06	AMPLIFIER INHIBIT
07	JOG LEFT
08	LIMIT NEGATIVE
09	ENCODER POWER
10	ENCODER PHASE B-
11	GROUND
12	ENCODER PHASE A+
13	ENCODER INDEX-
14	ENCODER POWER
15	ENCODER PHASE B+
16	MOTOR -
17	ENCODER INDEX+
18	AMPLIFIER FAULT
19	JOG RIGHT
20	LIMIT POSITIVE
21	ENCODER PHASE B+
22	GROUND
23	ENCODER PHASE A-
24	ENCODER POWER
25	ENCODER POWER

CONNECTOR SHELL = SHIELD

TS1	
01	SHIELD
02	MOTOR +
03	ENCODER POWER
04	+5 VDC
05	MOTOR -
06	AMPLIFIER ENABLE
07	COARSE HOME
08	AMPLIFIER FAULT
09	JOG RIGHT
10	JOG LEFT
11	LIMIT POSITIVE
12	LIMIT NEGATIVE
13	OPTO SUPPLY
14	GROUND

TS2	
01	SHIELD
02	ENCODER POWER
03	ENCODER PHASE B+
04	ENCODER PHASE B-
05	ENCODER PHASE A+
06	ENCODER PHASE A-
07	ENCODER INDEX+
08	ENCODER INDEX-
09	GROUND
10	ENCODER POWER
11	ENCODER POWER
12	GROUND
13	+5 VDC
14	GROUND

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APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100

DCX-BF100 CONNECTIONS (cont.)

WHEN INTERFACED TO DCX-MC200:

J1	
01	ANALOG GROUND
02	ANALOG SIGNAL
03	+12 VDC
04	-12 VDC
05	GROUND
06	+5 VDC
07	RESERVED
08	RESERVED
09	COARSE HOME
10	AMPLIFIER FAULT
11	AMPLIFIER ENABLE
12	RESERVED
13	RESERVED
14	LIMIT POSITIVE
15	LIMIT NEGATIVE
16	ENCODER 1 PHASE A+
17	ENCODER POWER
18	ENCODER 2 INDEX-
19	ENCODER 1 PHASE A-
20	ENCODER 1 PHASE B-
21	ENCODER 2 PHASE A
22	ENCODER 2 PHASE B
23	ENCODER 1 PHASE B+
24	ENCODER 2 INDEX+
25	ENCODER 1 INDEX
26	GROUND

J2	
01	ANALOG GROUND
02	+12 VDC
03	GROUND
04	OPTO SUPPLY
05	COARSE HOME
06	AMPLIFIER ENABLE
07	RESERVED
08	LIMIT NEGATIVE
09	ENCODER POWER
10	ENCODER 1 PHASE A-
11	ENCODER 2 PHASE A
12	ENCODER 1 PHASE B+
13	ENCODER 1 INDEX-
14	ANALOG SIGNAL
15	-12 VDC
16	+5 VDC
17	ENCODER 1 INDEX+
18	AMPLIFIER FAULT
19	RESERVED
20	LIMIT POSITIVE
21	ENCODER 1 PHASE A+
22	ENCODER 2 INDEX-
23	ENCODER 1 PHASE B-
24	ENCODER 2 PHASE B
25	ENCODER 2 INDEX+

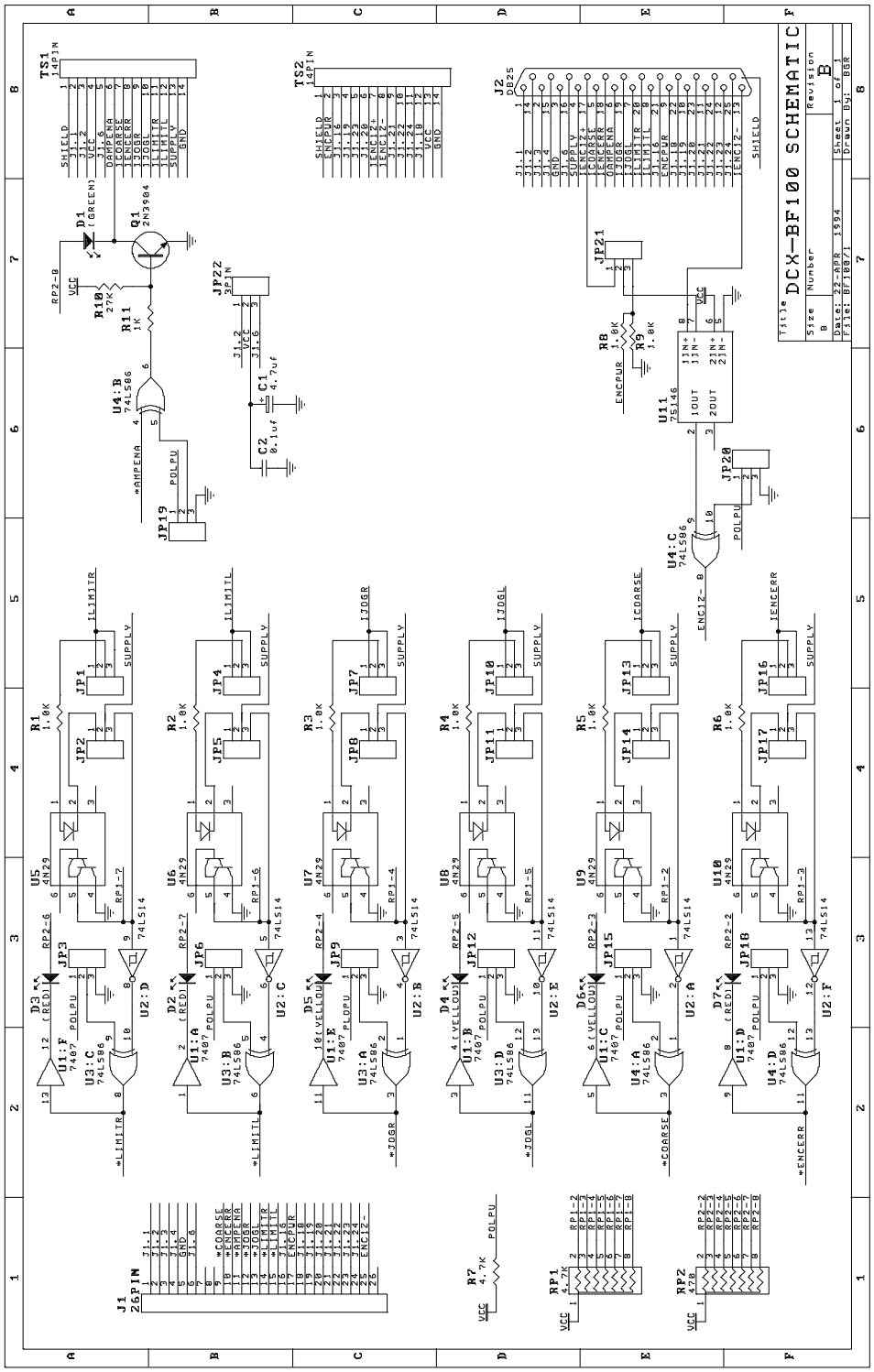
CONNECTOR SHELL = SHIELD

TS1	
01	SHIELD
02	ANALOG GROUND
03	ANALOG SIGNAL
04	+5 VDC
05	+5 VDC
06	AMPLIFIER ENABLE
07	COARSE HOME
08	AMPLIFIER FAULT
09	RESERVED
10	RESERVED
11	LIMIT POSITIVE
12	LIMIT NEGATIVE
13	OPTO SUPPLY
14	GROUND

TS2	
01	SHIELD
02	ENCODER POWER
03	ENCODER 1 PHASE A+
04	ENCODER 1 PHASE A-
05	ENCODER 1 PHASE B+
06	ENCODER 1 PHASE B-
07	ENCODER 1 INDEX+
08	ENCODER 1 INDEX-
09	ENCODER 2 PHASE A
10	ENCODER 2 PHASE B
11	ENCODER 2 INDEX+
12	ENCODER 2 INDEX-
13	+5 VDC
14	GROUND

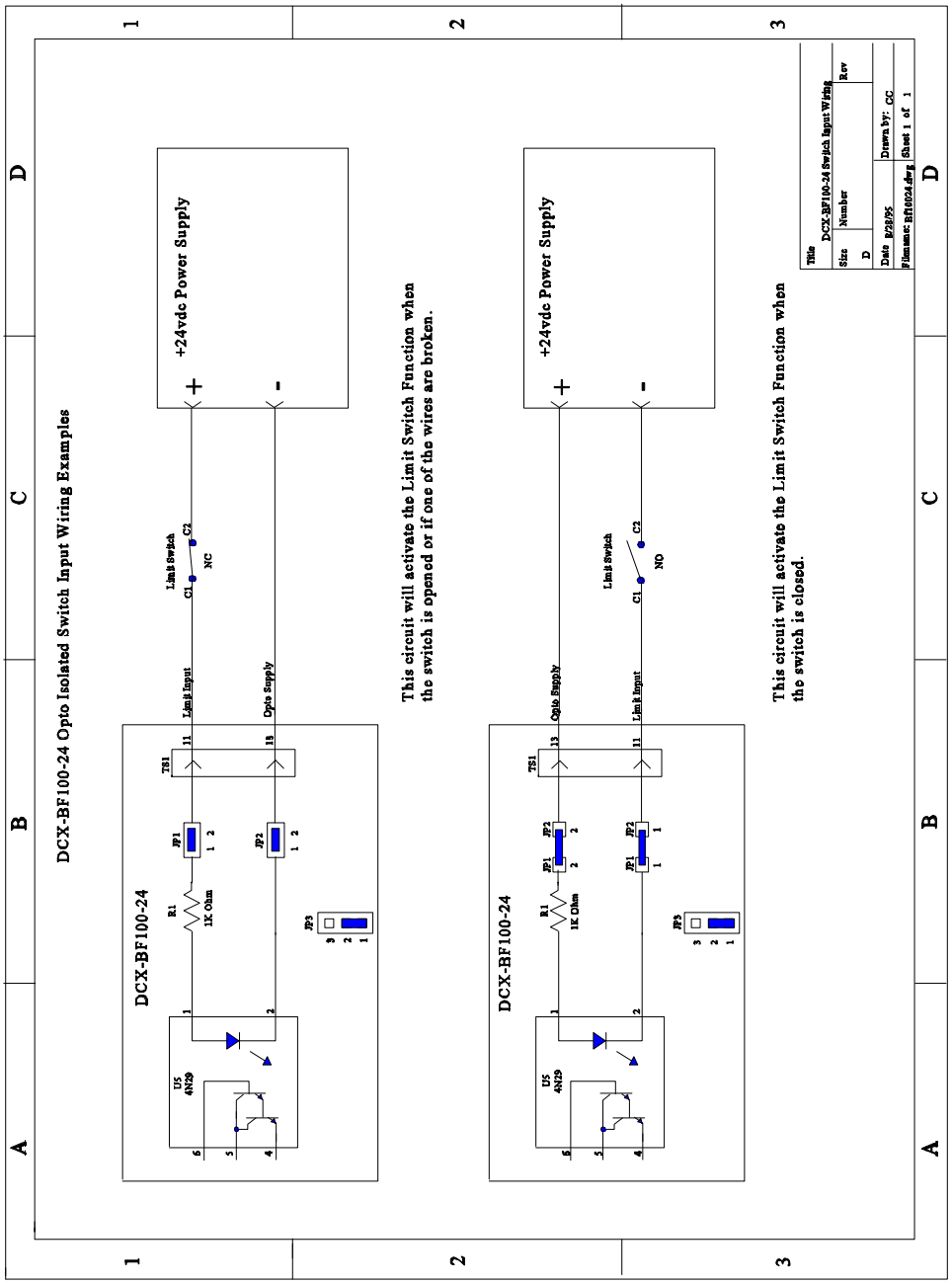
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APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100



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APPENDIX L: SERVO MODULE INTERCONNECT BOARD DCX-BF100

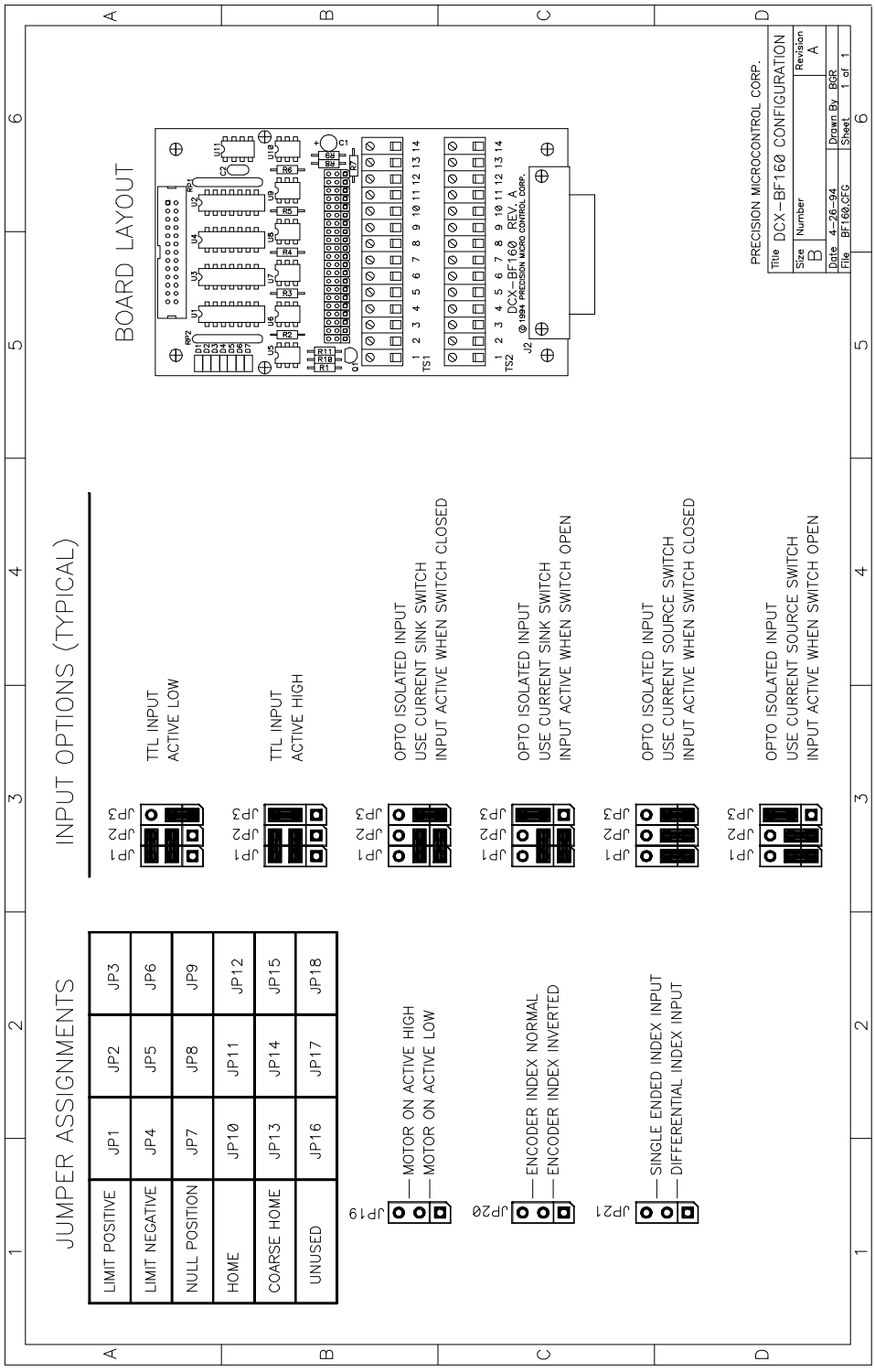
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APPENDIX M

STEPPER MODULE INTERCONNECT BOARD
DCX-BF160

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APPENDIX M: STEPPER MODULE INTERCONNECT BOARD DCX-BF160



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APPENDIX M: STEPPER MODULE INTERCONNECT BOARD DCX-BF160

DCX-BF160 CONNECTIONS

WHEN INTERFACED TO DCX-MC150:

J1	
01	GROUND
02	+5 VDC
03	DIRECTION OR CW PULSE
04	PULSE OR CCW PULSE
05	RESERVED
06	RESERVED
07	STOPPED
08	CW LIMIT
09	CCW LIMIT
10	JOG
11	NO CONNECT
12	NO CONNECT
13	HOME
14	FULL/HALF STEP
15	FULL/HALF CURRENT
16	MOTOR ON
17	NULL POSITION
18	RESERVED
19	RESERVED
20	RESERVED
21	NC
22	NC
23	NC
24	+12 VDC
25	-12 VDC
26	GROUND

J2	
01	GROUND
02	DIRECTION OR CW PULSE
03	RESERVED
04	STOPPED
05	CCW LIMIT
06	OPTO SUPPLY
07	HOME
08	FULL/HALF CURRENT
09	NULL POSITION
10	RESERVED
11	NC
12	NC
13	-12 VDC
14	+5 VDC
15	PULSE OR CCW PULSE
16	RESERVED
17	CW POSITIVE
18	JOG
19	NC
20	FULL/HALF STEP
21	MOTOR ON
22	RESERVED
23	RESERVED
24	NC
25	+12 VDC

CONNECTOR SHELL = SHIELD

TS1	
01	SHIELD
02	DIRECTION OR CW PULSE
03	PULSE OR CCW PULSE
04	RESERVED
05	RESERVED
06	MOTOR ON
07	STOPPED
08	NULL POSITION
09	FULL/HALF STEP
10	FULL/HALF CURRENT
11	CW LIMIT
12	CCW LIMIT
13	OPTO SUPPLY
14	GROUND

TS2	
01	SHIELD
02	+12 VDC
03	-12 VDC
04	RESERVED
05	JOG
06	RESERVED
07	NC
08	NC
09	NC
10	NC
11	HOME
12	R E S E R V E D
13	+5 VDC
14	GROUND

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APPENDIX M: STEPPER MODULE INTERCONNECT BOARD DCX-BF160

DCX-BF160 CONNECTIONS

WHEN INTERFACED TO DCX-MC160:

J1	
01	GROUND
02	+5 VDC
03	DIRECTION OR CW PULSE
04	PULSE OR CCW PULSE
05	RESERVED
06	RESERVED
07	STOPPED
08	CW LIMIT
09	CCW LIMIT
10	JOG
11	NO CONNECT
12	NO CONNECT
13	HOME
14	FULL/HALF STEP
15	FULL/HALF CURRENT
16	MOTOR ON
17	NULL POSITION
18	ENCODER PHASE A+
19	ENCODER PHASE A-
20	ENCODER PHASE B+
21	ENCODER PHASE B-
22	ENCODER INDEX
23	ENCODER COARSE HOME
24	+12 VDC
25	-12 VDC
26	GROUND

J2	
01	GROUND
02	DIRECTION OR CW PULSE
03	RESERVED
04	STOPPED
05	CCW LIMIT
06	OPTO SUPPLY
07	HOME
08	FULL/HALF CURRENT
09	NULL POSITION
10	ENCODER PHASE A-
11	ENCODER PHASE B-
12	COARSE HOME
13	-12 VDC
14	+5 VDC
15	PULSE OR CCW PULSE
16	RESERVED
17	CW LIMIT
18	JOG
19	ENCODER INDEX+
20	FULL/HALF STEP
21	MOTOR ON
22	ENCODER PHASE A+
23	ENCODER PHASE B+
24	ENCODER INDEX-
25	+12 VDC

CONNECTOR SHELL = SHIELD

TS1	
01	SHIELD
02	DIRECTION OR CW PULSE
03	PULSE OR CCW PULSE
04	RESERVED
05	RESERVED
06	MOTOR ON
07	STOPPED
08	NULL POSITION
09	FULL/HALF STEP
10	FULL/HALF CURRENT
11	CW LIMIT
12	CCW LIMIT
13	OPTO SUPPLY
14	GROUND

TS2	
01	SHIELD
02	+12 VDC
03	-12 VDC
04	ENCODER PHASE A-
05	JOG
06	ENCODER PHASE B+
07	ENCODER INDEX+
08	ENCODER INDEX-
09	ENCODER PHASE B-
10	COARSE HOME
11	HOME
12	ENCODER PHASE A+
13	+5 VDC
14	GROUND

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APPENDIX M: STEPPER MODULE INTERCONNECT BOARD DCX-BF160

DCX-BF160 CONNECTIONS

WHEN INTERFACED TO DCX-MC260:

J1	
01	GROUND
02	+5 VDC
03	DIRECTION OR CW PULSE
04	PULSE OR CCW PULSE
05	RESERVED
06	RESERVED
07	STOPPED
08	LIMIT POSITIVE
09	LIMIT NEGATIVE
10	RESERVED
11	NO CONNECT
12	NO CONNECT
13	HOME
14	FULL/HALF STEP
15	FULL/HALF CURRENT
16	MOTOR ON
17	NULL POSITION
18	ENCODER PHASE A+
19	ENCODER PHASE A-
20	ENCODER PHASE B+
21	ENCODER PHASE B-
22	ENCODER INDEX
23	ENCODER COARSE HOME
24	+12 VDC
25	-12 VDC
26	GROUND

J2	
01	GROUND
02	DIRECTION OR CW PULSE
03	RESERVED
04	STOPPED
05	LIMIT NEGATIVE
06	OPTO SUPPLY
07	HOME
08	FULL/HALF CURRENT
09	NULL POSITION
10	ENCODER PHASE A-
11	ENCODER PHASE B-
12	COARSE HOME
13	-12 VDC
14	+5 VDC
15	PULSE OR CCW PULSE
16	RESERVED
17	LIMIT POSITIVE
18	RESERVED
19	ENCODER INDEX+
20	FULL/HALF STEP
21	MOTOR ON
22	ENCODER PHASE A+
23	ENCODER PHASE B+
24	ENCODER INDEX-
25	+12 VDC

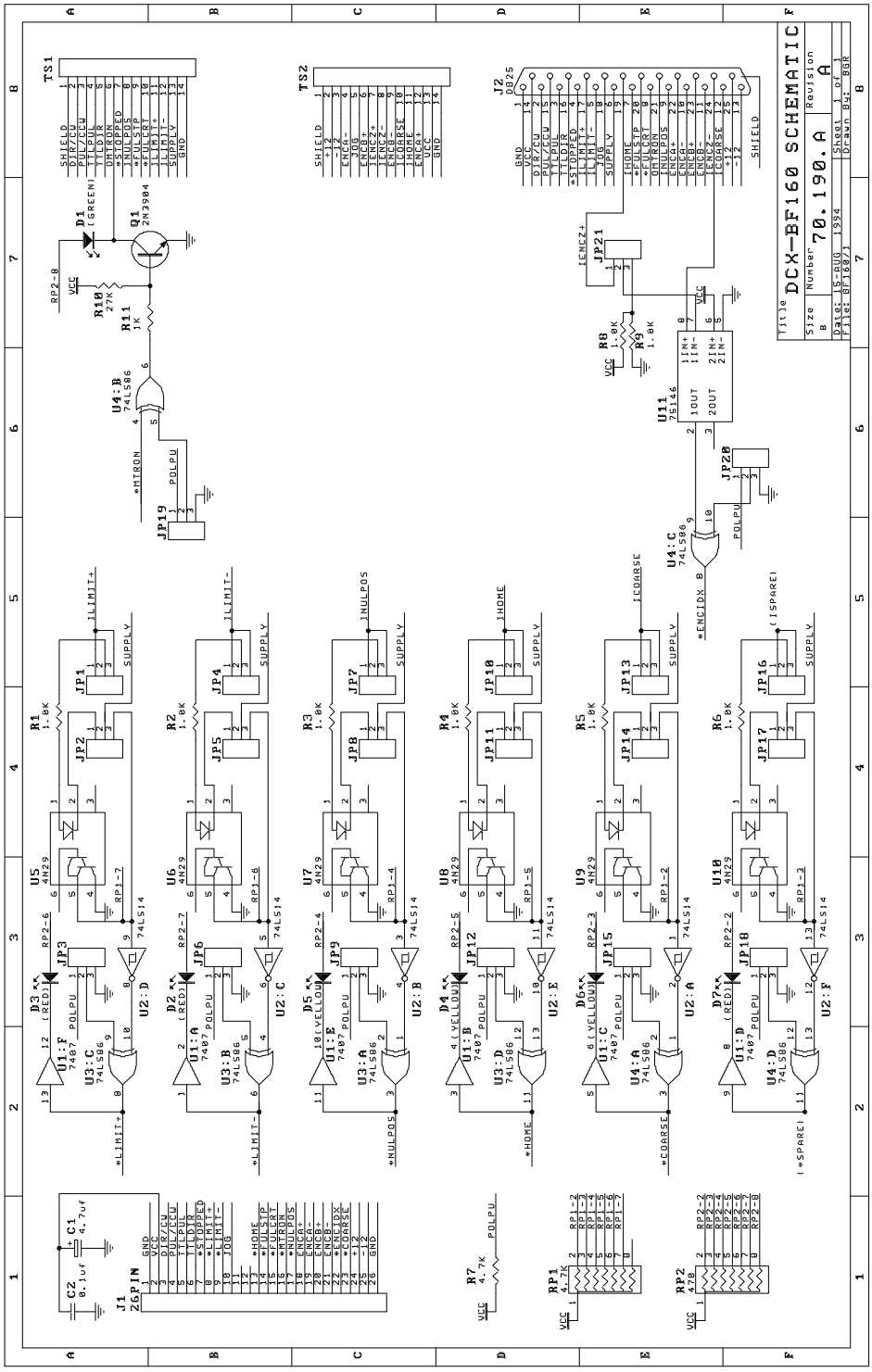
CONNECTOR SHELL = SHIELD

TS1	
01	SHIELD
02	DIRECTION OR CW PULSE
03	PULSE OR CCW PULSE
04	RESERVED
05	RESERVED
06	MOTOR ON
07	STOPPED
08	NULL POSITION
09	FULL/HALF STEP
10	FULL/HALF CURRENT
11	LIMIT POSITIVE
12	LIMIT NEGATIVE
13	OPTO SUPPLY
14	GROUND

TS2	
01	SHIELD
02	+12 VDC
03	-12 VDC
04	ENCODER PHASE A-
05	RESERVED
06	ENCODER PHASE B+
07	ENCODER INDEX+
08	ENCODER INDEX-
09	ENCODER PHASE B-
10	COARSE HOME
11	HOME
12	ENCODER PHASE A+
13	+5 VDC
14	GROUND

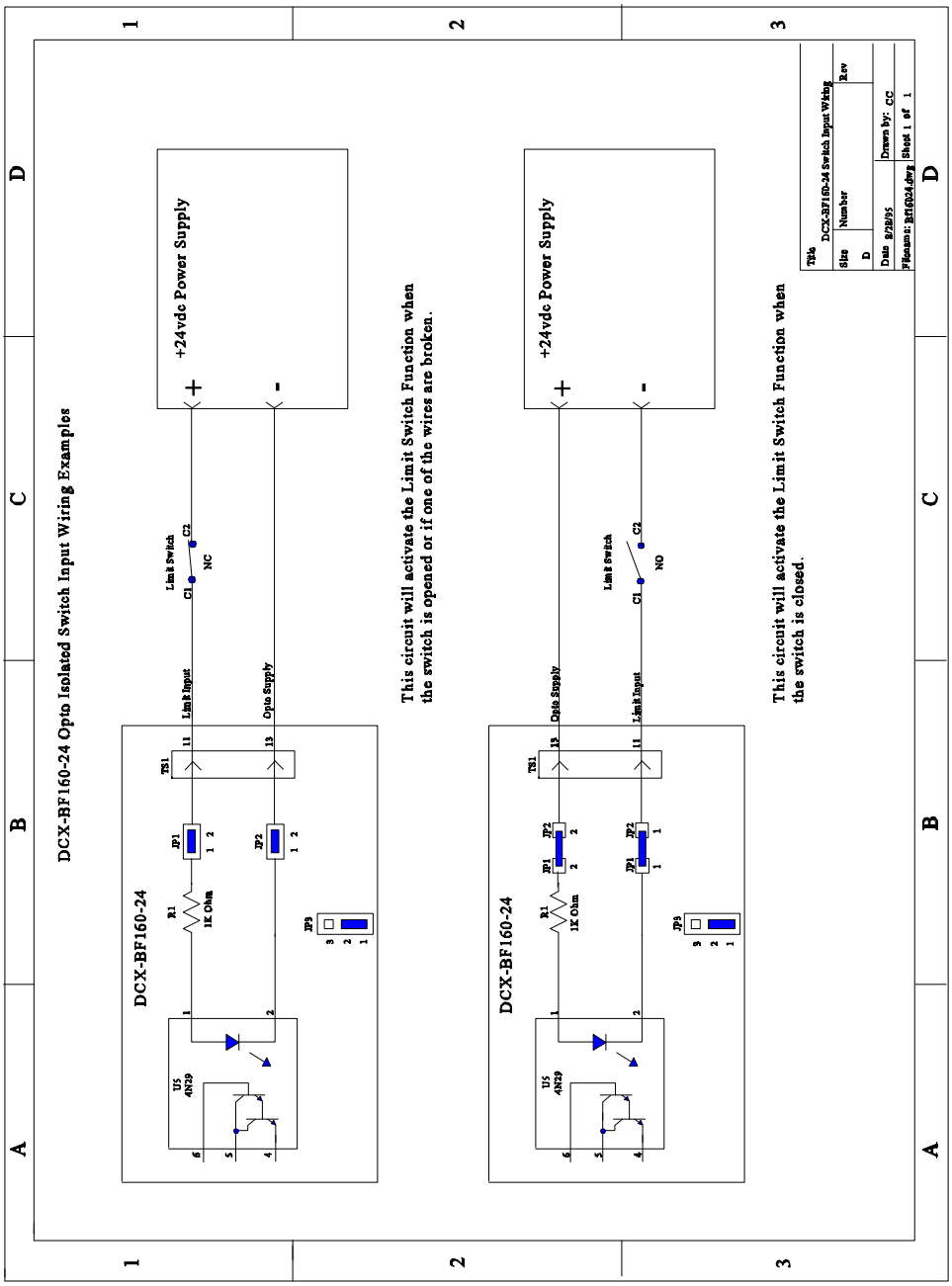
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APPENDIX M: STEPPER MODULE INTERCONNECT BOARD DCX-BF160



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APPENDIX M: STEPPER MODULE INTERCONNECT BOARD DCX-BF160



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APPENDIX N

PC DUAL PORT RAM

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APPENDIX N: PC DUAL PORT RAM

When a **DCX** board is plugged in to an IBM-PC or compatible, a portion of the **DCX**'s memory appears in the PC's memory map. Depending on the setting of the rotary switch on the **DCX**, the board will occupy a 4K byte space in the range from D0000h to DFFFFh. If the rotary switch is set to 0 (factory configuration), the **DCX** will occupy D0000h through D0fffh. If it is set to 1, it will occupy D1000h through D1FFFh, and so on. In the PC's memory map, the lowest numbered memory location that a **DCX** board occupies is referred to as the base address. If the boards rotary switch is set to 0, its base address will be D0000h.

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APPENDIX N: PC DUAL PORT RAM

SERVO TABLES:

Axis #	Parameter Base Address
1	0h
2	100h
3	200h
4	300h
5	400h
6	500h
7	600h
8	700h

Motor Status	= 0h
Current Position	= 04h
Target Position	= 08h
Programmed Velocity	= 0Ch
Programmed Accelaration	= 14h
Programmed Deceleration	= 18h
Move Delta	= 24h
Slewing Velocity	= 34h
Index Register	= 38h
Slewing Acceleration	= 40h
Stop On Error	= 44h
Encoder Change	= 4Ch
Trajectory Generator	= 50h
Position Gain	= 60h
Derivative Gain	= 62h
Integral Gain	= 64h
Integrating Limit	= 66h
Sampling Frequency	= 68h
Positive Torque Limit	= 6Ah
Wait stopped timer	= 6Eh
Master Axis	= 70h

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APPENDIX N: PC DUAL PORT RAM

SERVO STATUS BIT DEFINITIONS:

Busy (servo parameters being updated) *	= 0
Motor On *	= 1
Velocity Mode *	= 2
Trajectory Complete *	= 3
Direction (0 = positive, 1 = negative) *	= 4
Phasing (0 = standard, 1 = reverse)	= 5
Motor Homed *	= 6
Motor Error	= 7
Look For Index **	= 8
Look For Edge **	= 9
Moving Positive Direction (Full Step) *	= 10
Moving Negative Direction (Full Current) *	= 11
Breakpoint Reached **	= 12
Indicates Motor Is Jogging	= 13
Amplifier Fault Enable	= 14
Amplifier Fault Tripped	= 15
Limit Positive Enabled **	= 16
Limit Positive Tripped **	= 17
Limit Negative Enabled **	= 18
Limit Negative Tripped **	= 19
Jog Right Enable	= 20
Jog Right Active	= 21
Jog Left Enable	= 22
Jog Left Active	= 23
Index (Aux. Enc. Index) **	= 24
Course Home (Home) **	= 25
Amplifier Fault	= 26
Reserved	= 27
Limit Positive **	= 28
Limit Negative **	= 29
Jog Right	= 30
Jog Left	= 31

* valid for all stepper modules
** valid for DCX-MC260 stepper modules

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APPENDIX N: PC DUAL PORT RAM

GENERAL USE VARIABLES:

Command Char. Input Mailbox	= 800h
Command Char. Output Mailbox	= 804h
Command Interpreter Status	= 808h
0	= idle
1-6	=interpreting commands
> 6	= executing commands

Position of Motor 1 Module	= 80Ah
Position of Motor 2 Module	= 80Bh
Position of Motor 3 Module	= 80Ch
Position of Motor 4 Module	= 80Dh
Position of Motor 5 Module	= 80Eh
Position of Motor 6 Module	= 80Fh
Position of Motor 7 Module	= 810h
Position of Motor 8 Module	=811h

Type of Module in Position 1	= 812h
Type of Module in Position 2	= 813h
Type of Module in Position 3	= 814h
Type of Module in Position 4	= 815h
Type of Module in Position 5	= 816h
Type of Module in Position 6	= 817h
Type of Module in Position 7	= 818h
Type of Module in Position 8	= 819h

* (See Module Types on following page.)

Digital I/O Channels 1-16	= 81Ah

Analog Input Channel 1	= 81Ch
Analog Input Channel 2	= 81Eh
Analog Input Channel 3	= 820h
Analog Input Channel 4	= 822h
Contouring Count Max.	= 828h
Contouring Count	= 82Ch

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GENERAL USE VARIABLES: (cont.)

Module Types:
0 = MC200 Advanced Servo, analog signal output
1 = MC260 Advanced Stepper
2
3
4 = MC110 DC servo, motor output
5 = MC100/120 DC servo, analog signal output
6 = MC150 Stepper motor
7 = MC160 Stepper motor with encoder
8 = MC400 Digital I/O Module
9 = MF310 GPIB Communications
10 = MF300 RS-232 Communications
11
12 = MC500 Analog I/O Module
13
14
15 = No module present

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APPENDIX O

PC TO DCX-PC

DIRECT ACCESS COMMAND INTERFACE

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APPENDIX O: PC TO DCX DIRECT ACCESS COMMAND INTERFACE

In order to achieve the fastest PC to **DCX-PC** command throughput, the **DCX-PC** supports a "Direct Access" command interface. This technique allows the PC to write binary coded commands directly into a command buffer in the **DCX-PC**'s dual port memory, thus bypassing the command interpreter. Using this method, any command replies the **DCX-PC** generates will be returned in binary format to the PC through a reply buffer in the **DCX-PC**'s dual port memory.

The procedure for using this interface is as follows:

1. Beginning at the start of the command buffer in the **DCX-PC**'s dual port memory, write in from 1 to 40 commands using the following format for each command:

   Byte 1 command code (listed in appendix A)
   Byte 2 axis # (binary 0-8, 0 for all, bit 7 set for register parameter)
   Byte 3-6 command parameter (binary, LSB first)

2. Write in the number of bytes written to the command buffer (i.e., # of commands x 6) into the command count location.

3. Wait for the **DCX-PC** to change the value in the command count location back to 0. This indicates that the commands in the buffer have been executed. At that time the **DCX-PC** will cause the PC's interrupt line to go from low to high.

4. Any reply to the commands can be read from the reply buffer, with the value stored in the reply counter indicating the number of valid bytes. After reading the reply, set the reply counter back to 0. Each reply will have the following format:

   Byte 1 command code
   Byte 2 axis # (binary 0-8, 0 for all)
   Byte 3-6 reply value (binary, LSB first)

5. If it is necessary for the PC to terminate command execution before the **DCX-PC** has set the command count back to 0, write a binary FFh into the command counter.

6. In order to clear the interrupt line, the PC can issue the next group of commands or write a binary FFh to the command counter location.

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APPENDIX O: PC TO DCX DIRECT ACCESS COMMAND INTERFACE

The address offsets of the command and reply buffers in the **DCX-PC**'s dual port memory are as follows:

Command Count	900h
Command Buffer	901-9FFh
Reply Count	A00h
Reply Buffer	A01-AFFh

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APPENDIX P

POWER SUPPLY REQUIREMENTS

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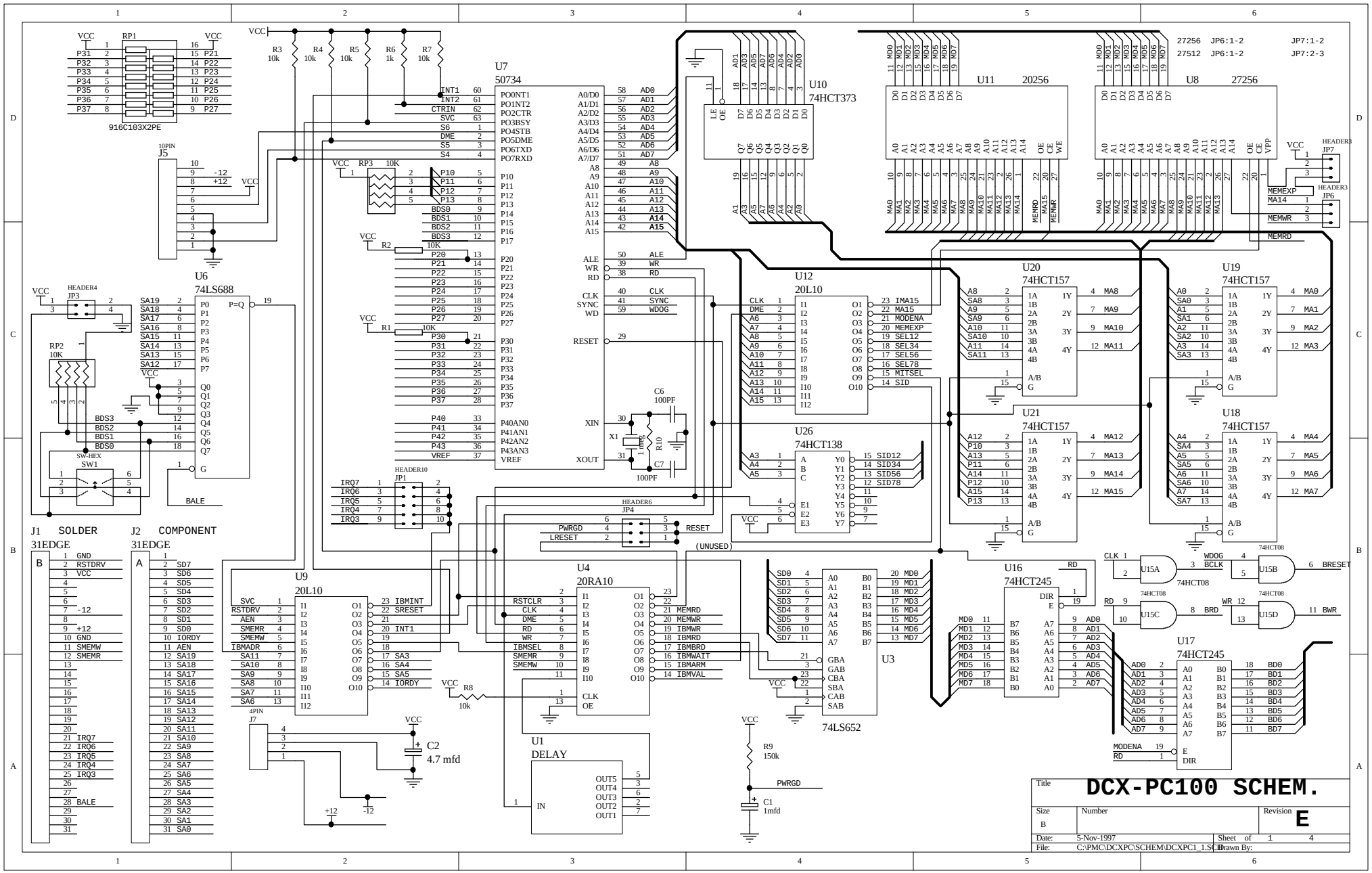
APPENDIX P: POWER SUPPLY REQUIREMENTS

Product Number	+5	+12	-12	Unit
DCX-PC100	0.51	----	----	A
DCX-MC100	0.26	*	*	A
DCX-MC110	0.26	*	*	A
DCX-MC120	0.26	----	----	A
DCX-MC150	0.12	----	----	A
DCX-MC160	0.12	----	----	A
DCX-MC200	0.21	*	*	A
DCX-MC260	0.21	----	----	A
DCX-MC400	0.25	----	----	A
DCX-MC500	0.10	*	*	A
DCX-MF300	0.01	*	*	A
DCX-MF310	0.16	----	----	A

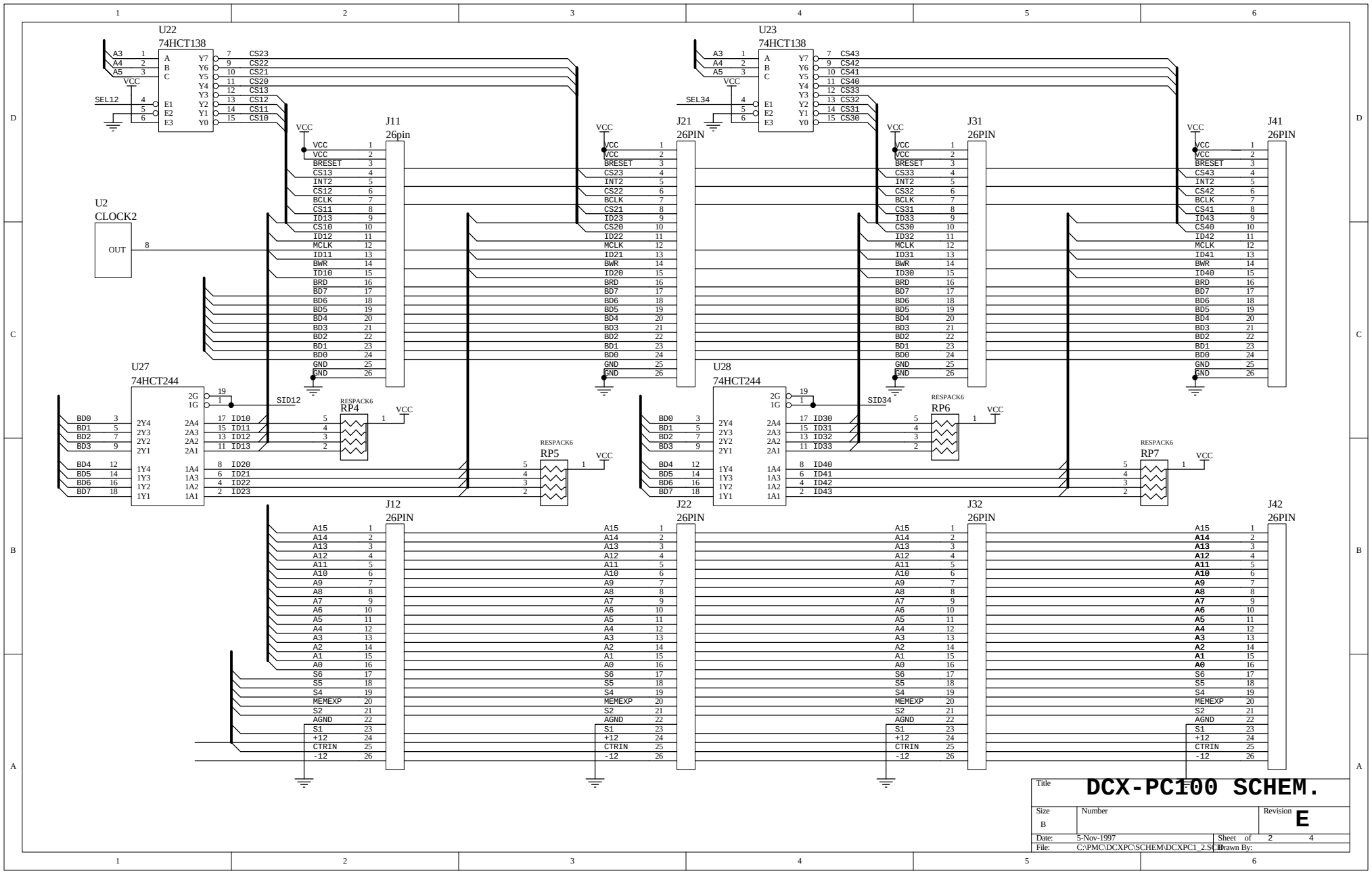
* Current depends on output loading

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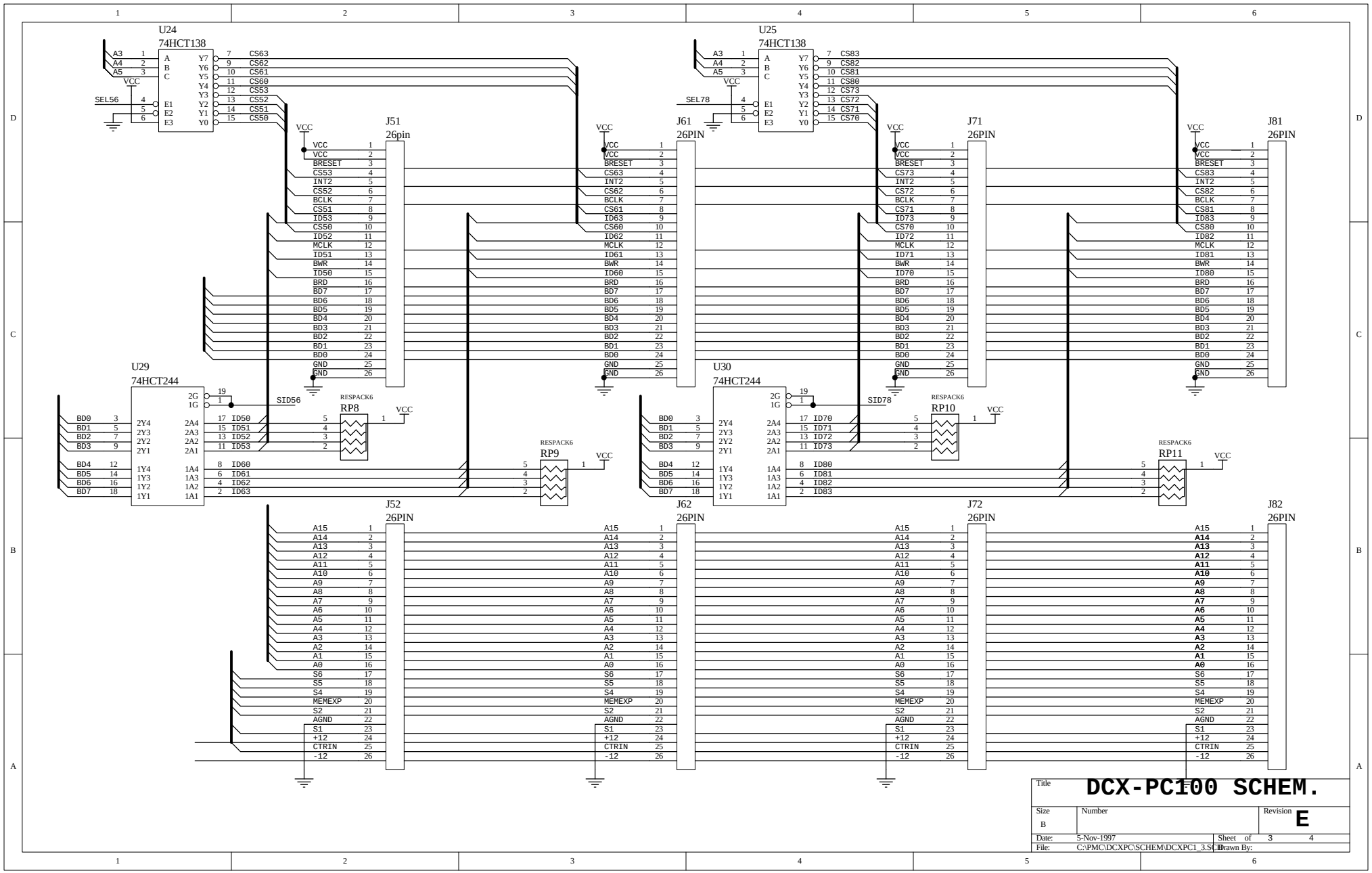
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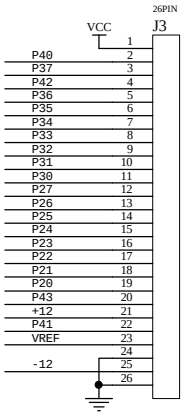


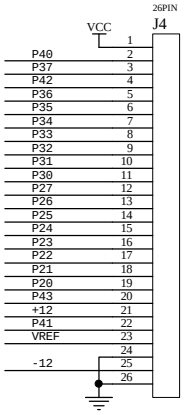
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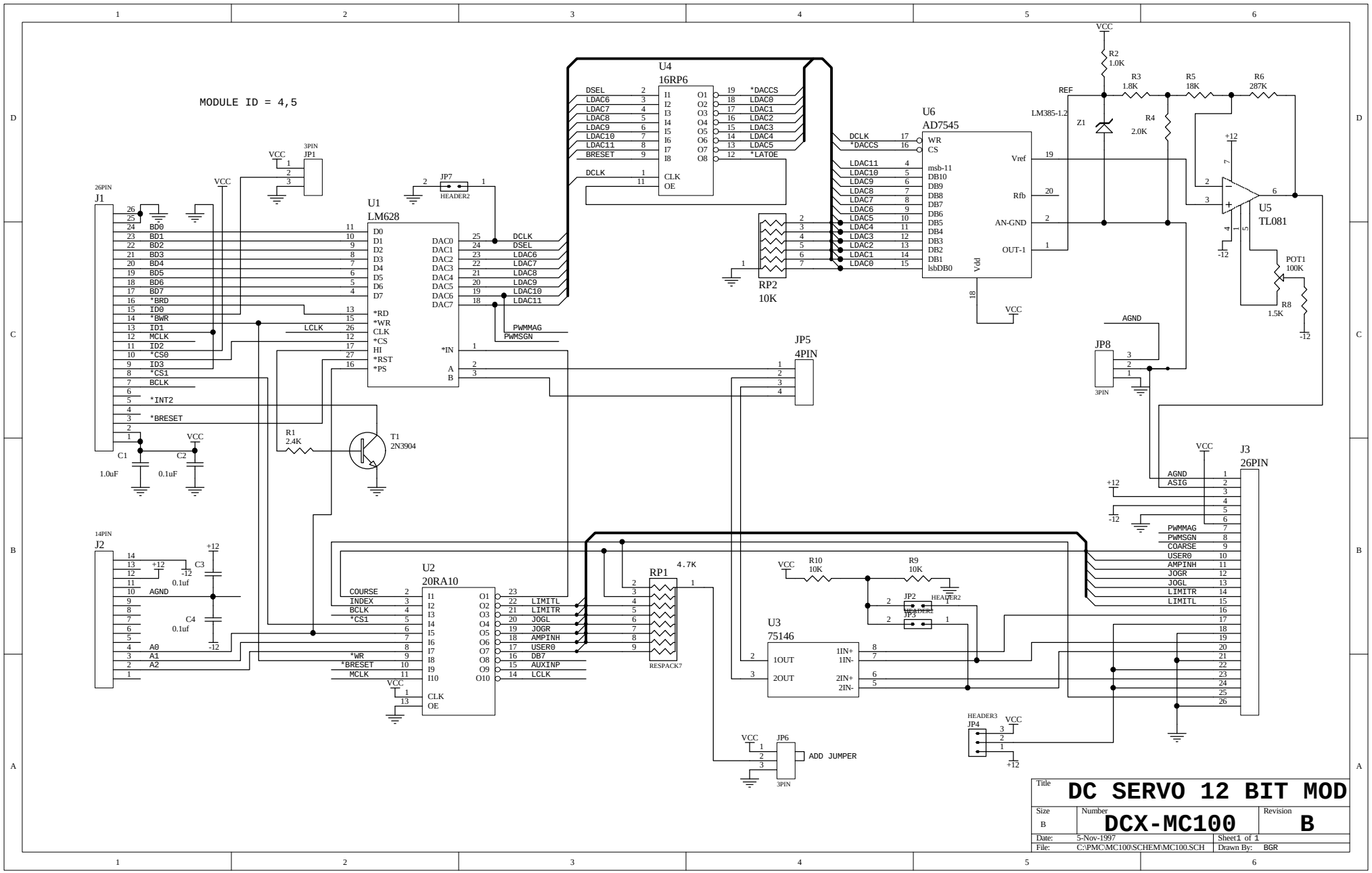
REV.	DATE	DESCRIPTION
E	7/92	1.REMOVE U6-1 FROM NET GND 2.CONN. J1-28 TO U6-1 (NET NAME: BALE) 3.REMOVE JP7-3 FROM NET MA14 4.CONN. JP7-3 TO NET MEMEXP 5.CONN.U12-15 TO NET MITSEL



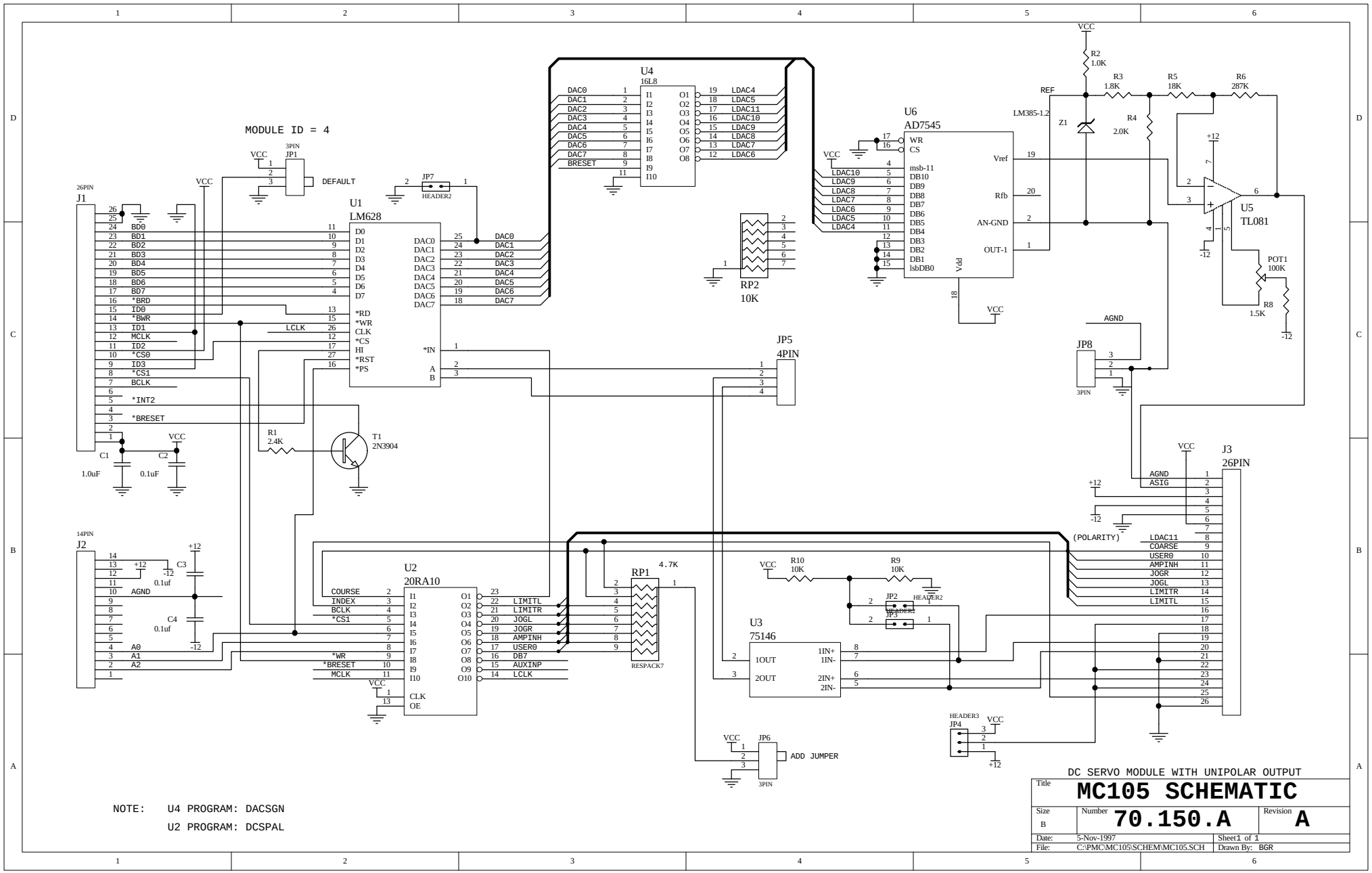


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Date: 5-Nov-1997	Sheet of 4 4	
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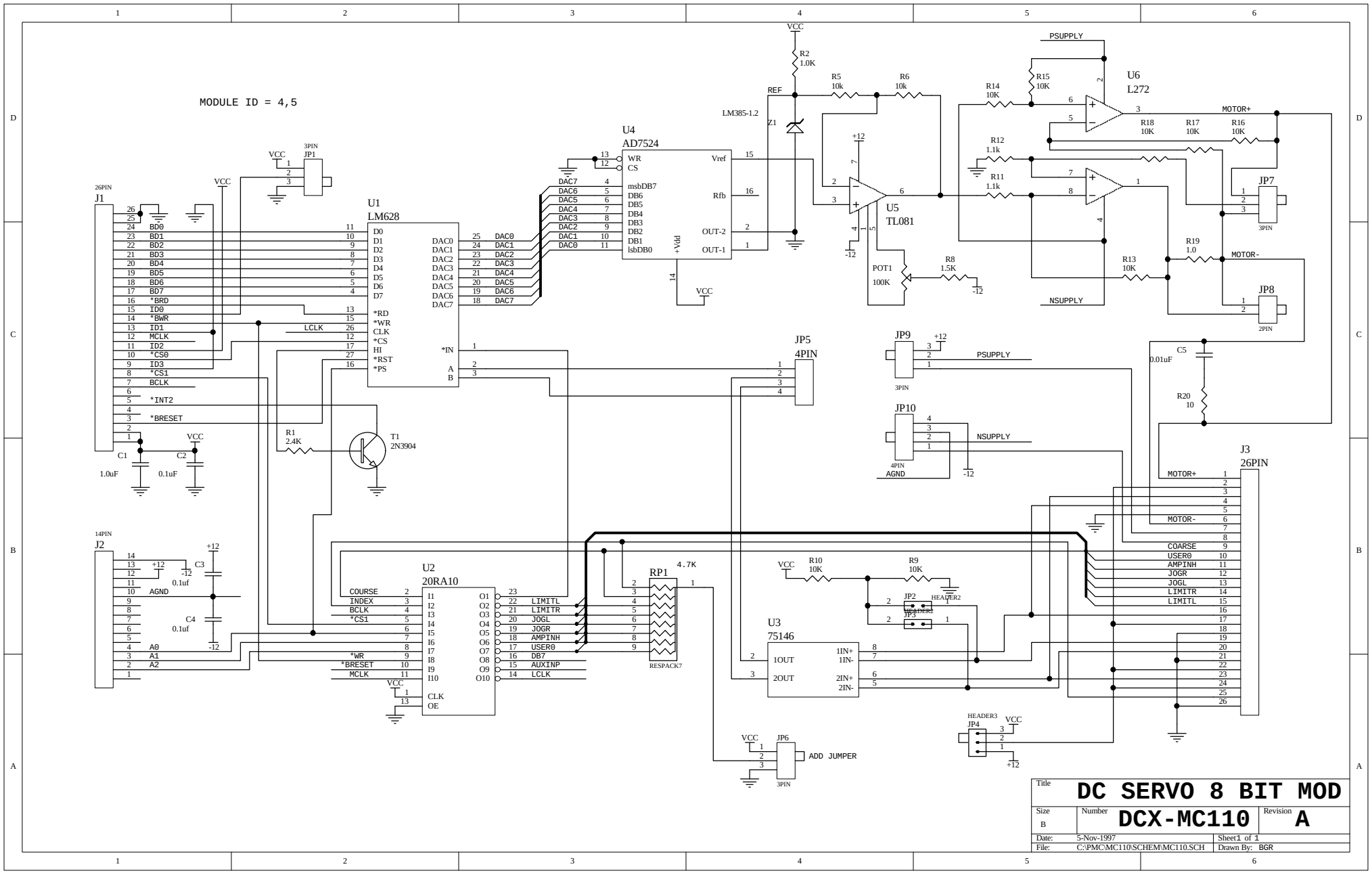


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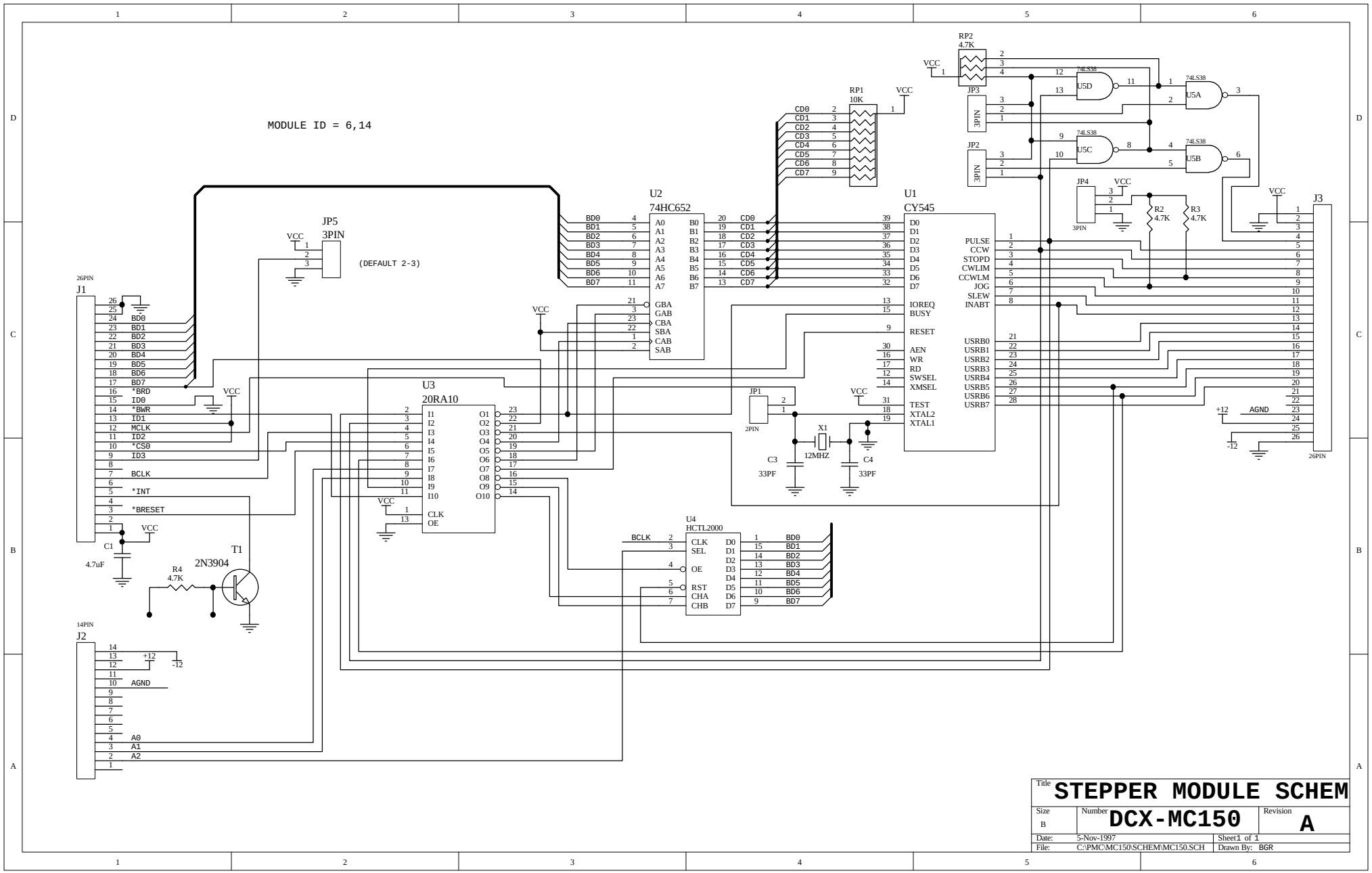


NOTE: U4 PROGRAM: DACSGN
U2 PROGRAM: DCSPAL

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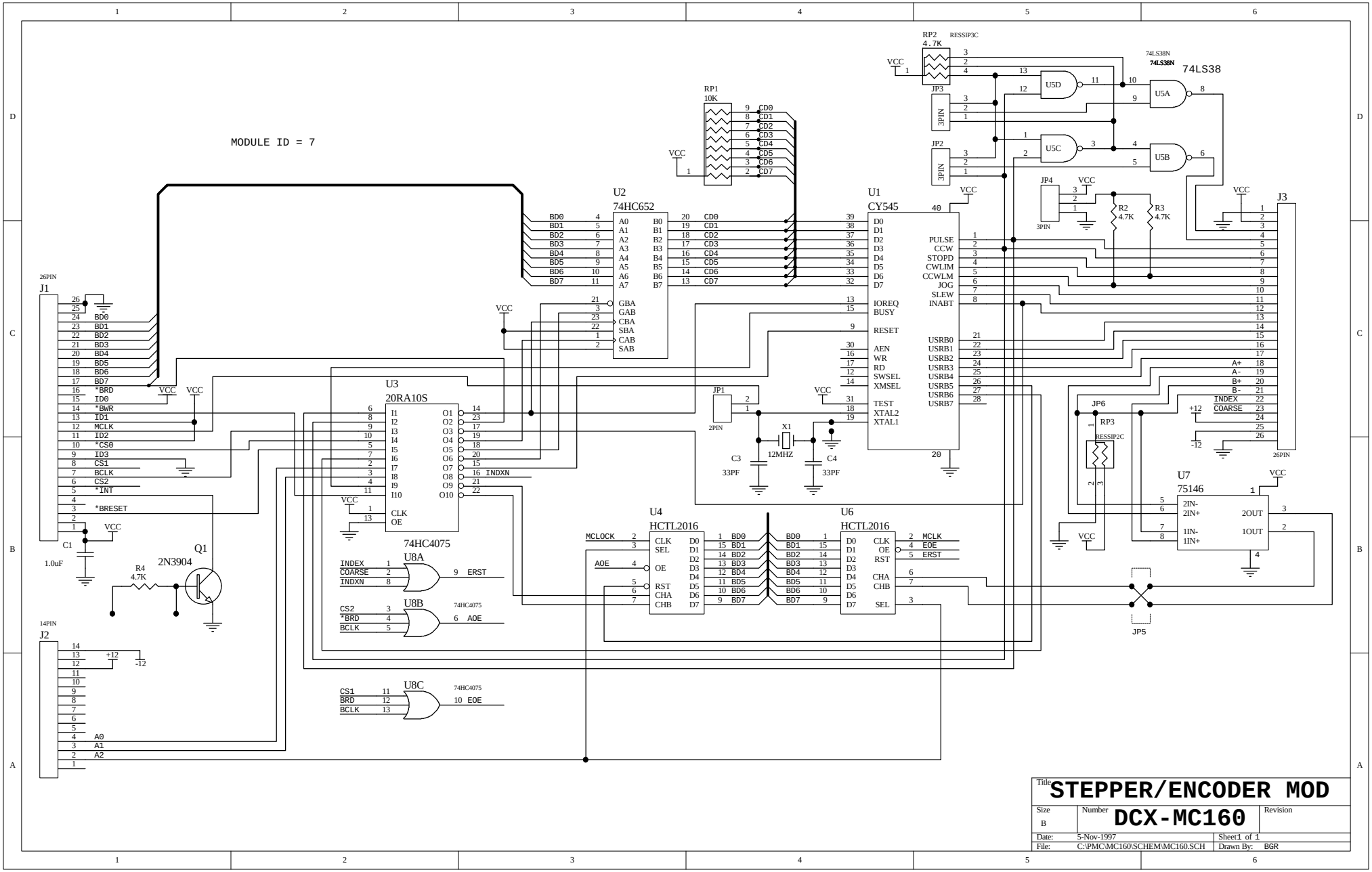


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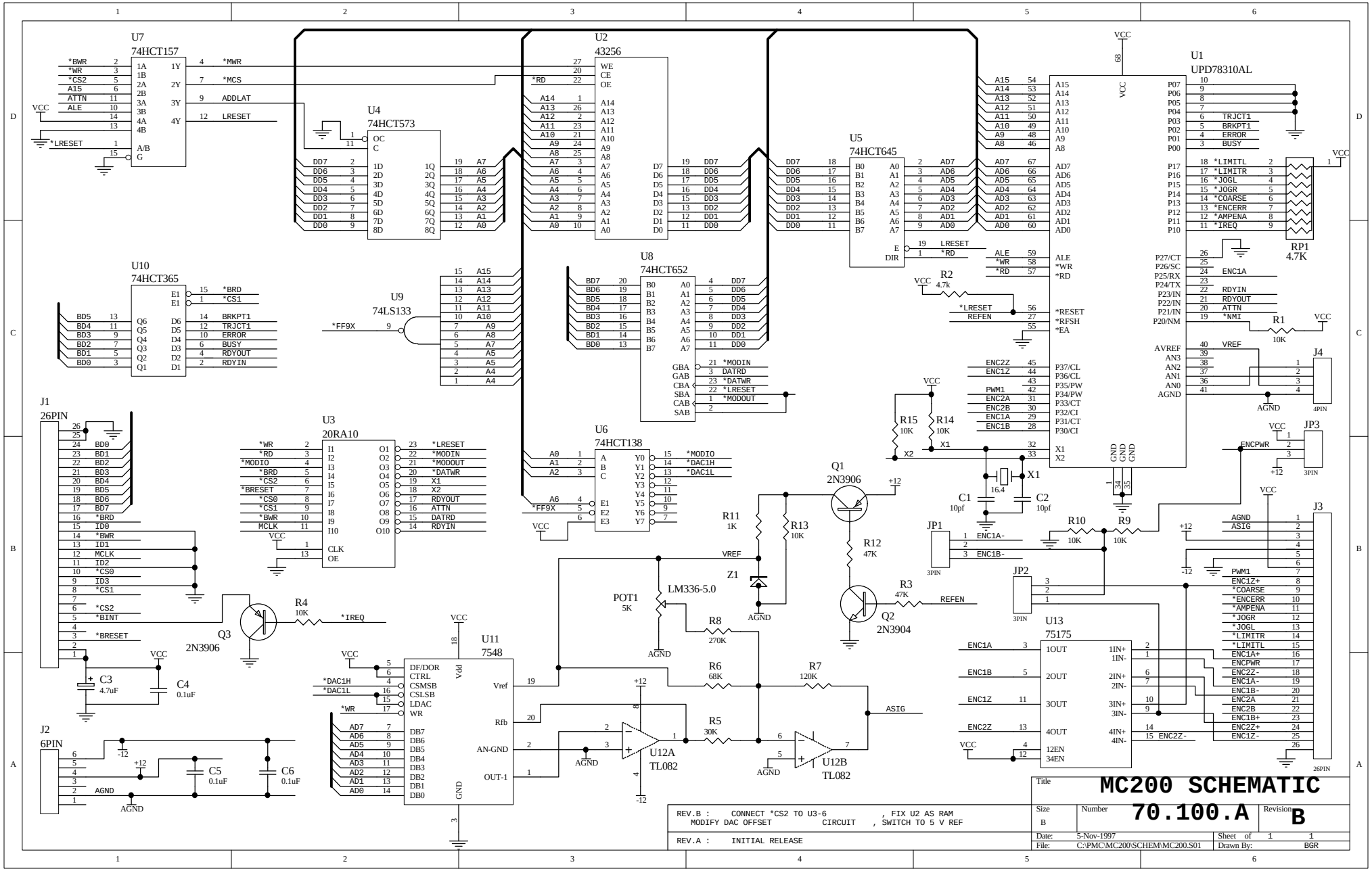
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Size: B	Number: DCX-MC150	Revision: A	
Date: 5-Nov-1997	Sheet1 of 1		
File: C:\PMC\MC150\SCHEM\MC150.SCH	Drawn By: BGR		

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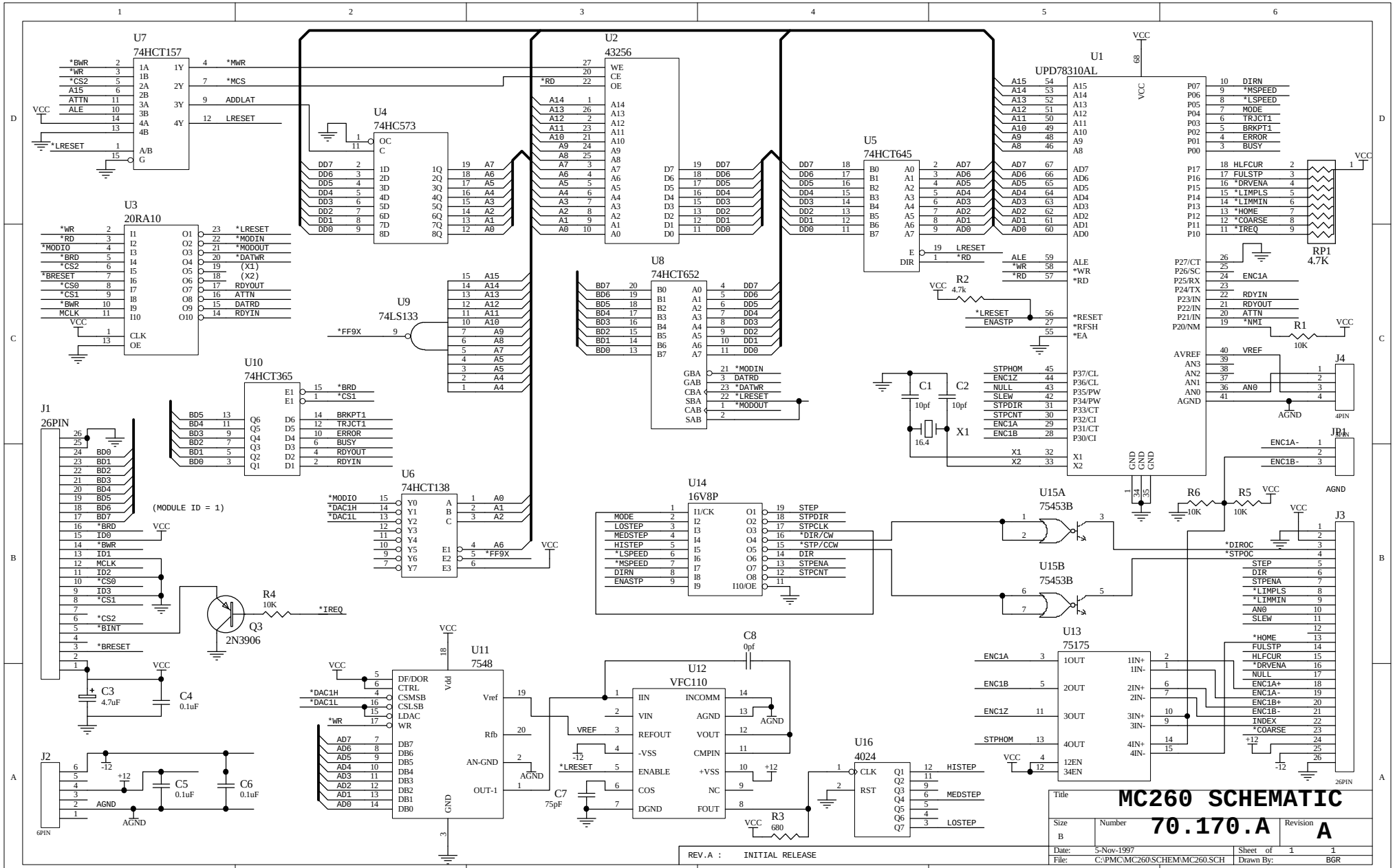


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Date: 5-Nov-1997		Sheet1 of 1	
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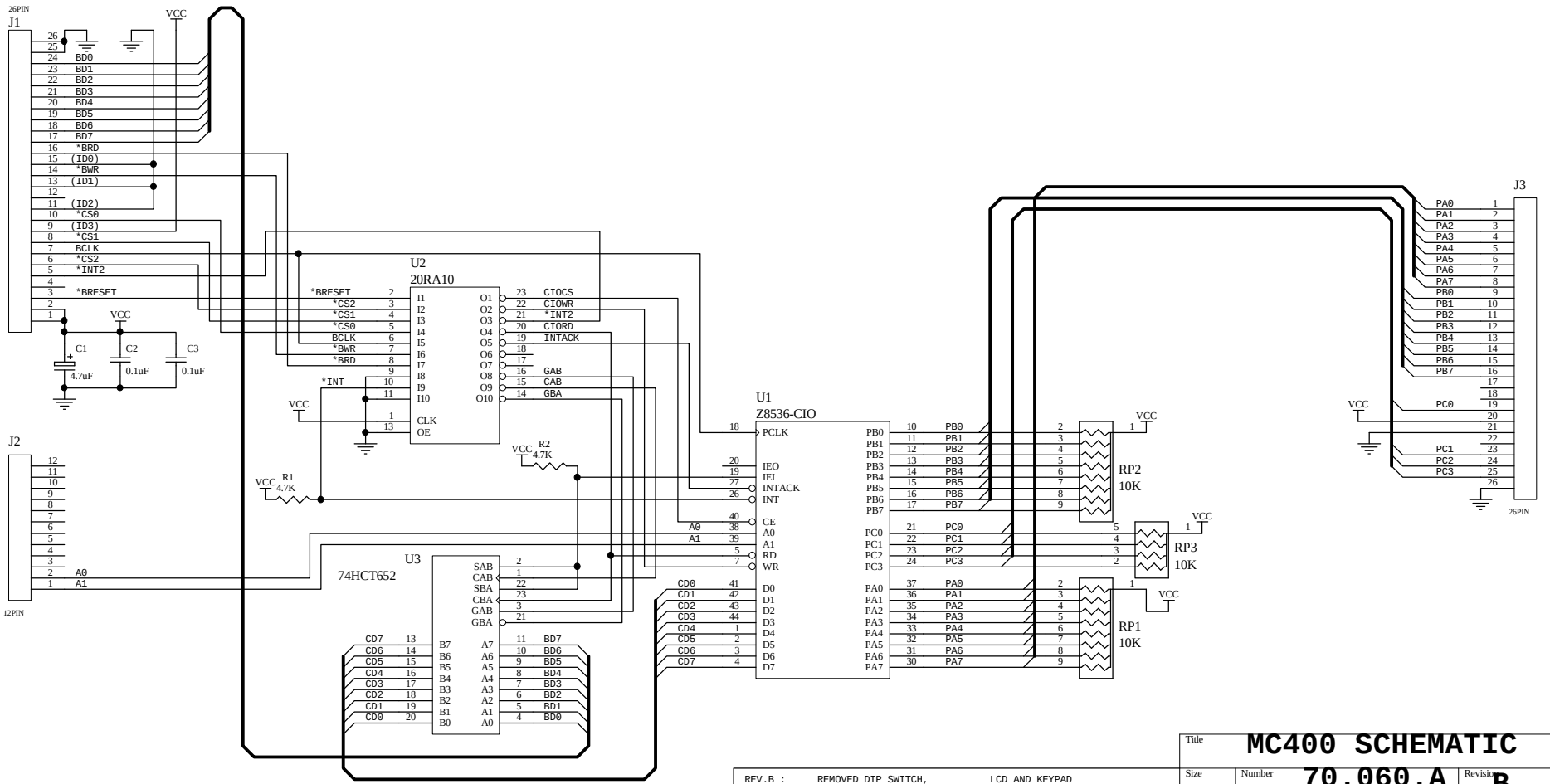
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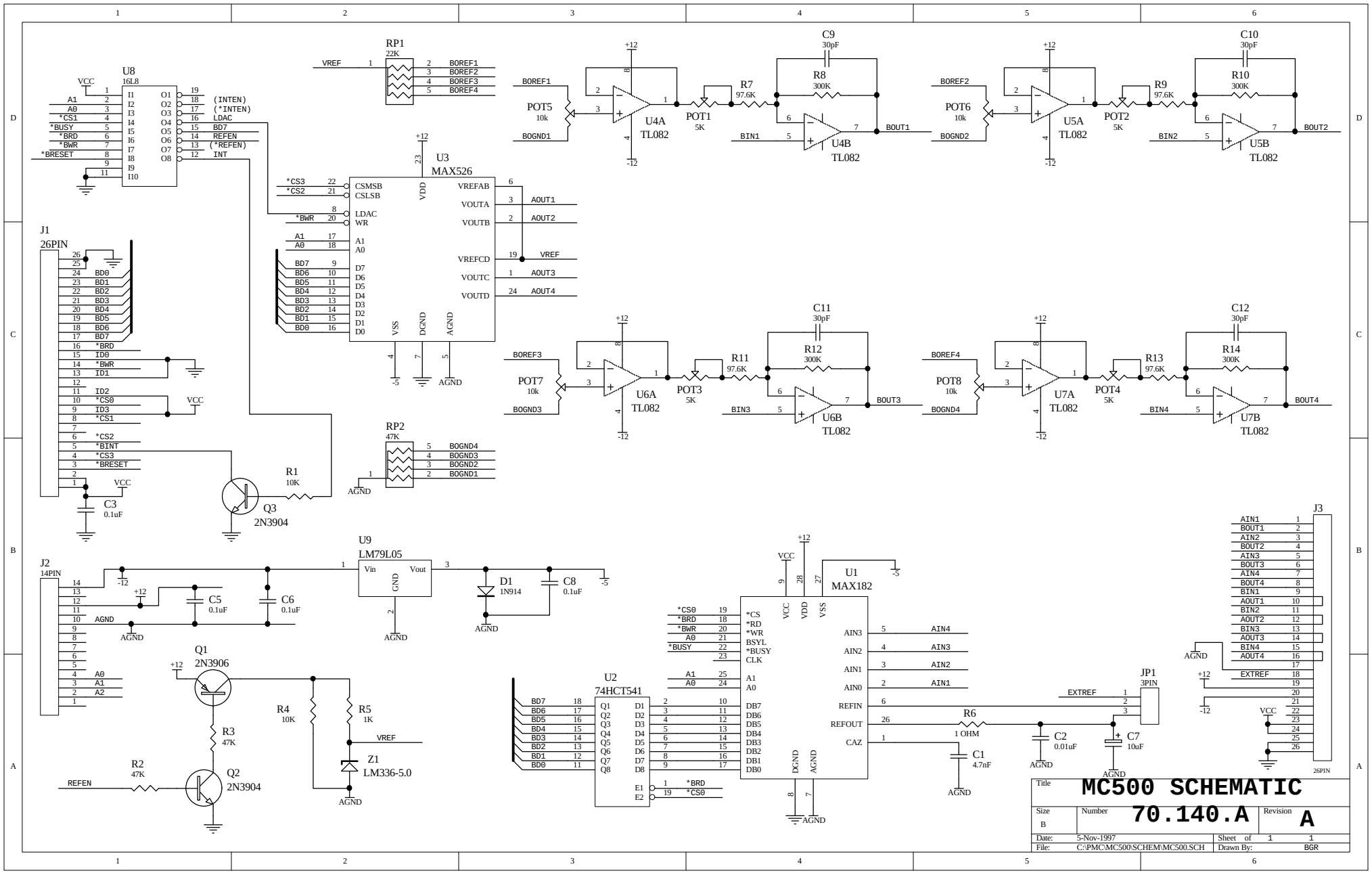


REV.B : REMOVED DIP SWITCH, LCD AND KEYPAD INTERFACE COMPONENTS, REPLACE 16RA8 WITH 20RA10

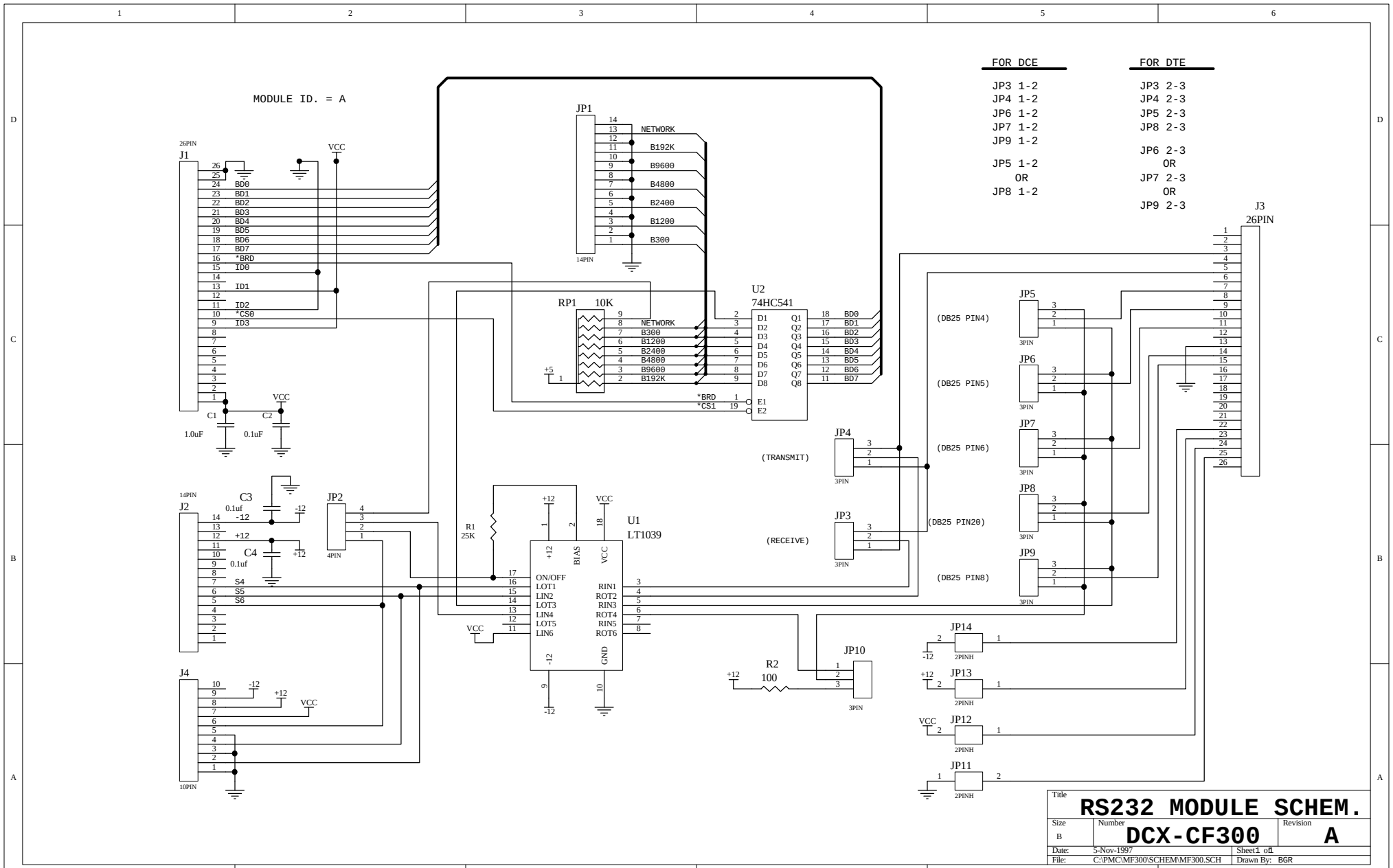
REV.A : INITIAL RELEASE

Title	MC400 SCHEMATIC		
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Date: 5-Nov-1997	Sheet of 1 1		
File: C:\PMC\MC400\SCHEM\MC400.SCH	Drawn By: BGR		

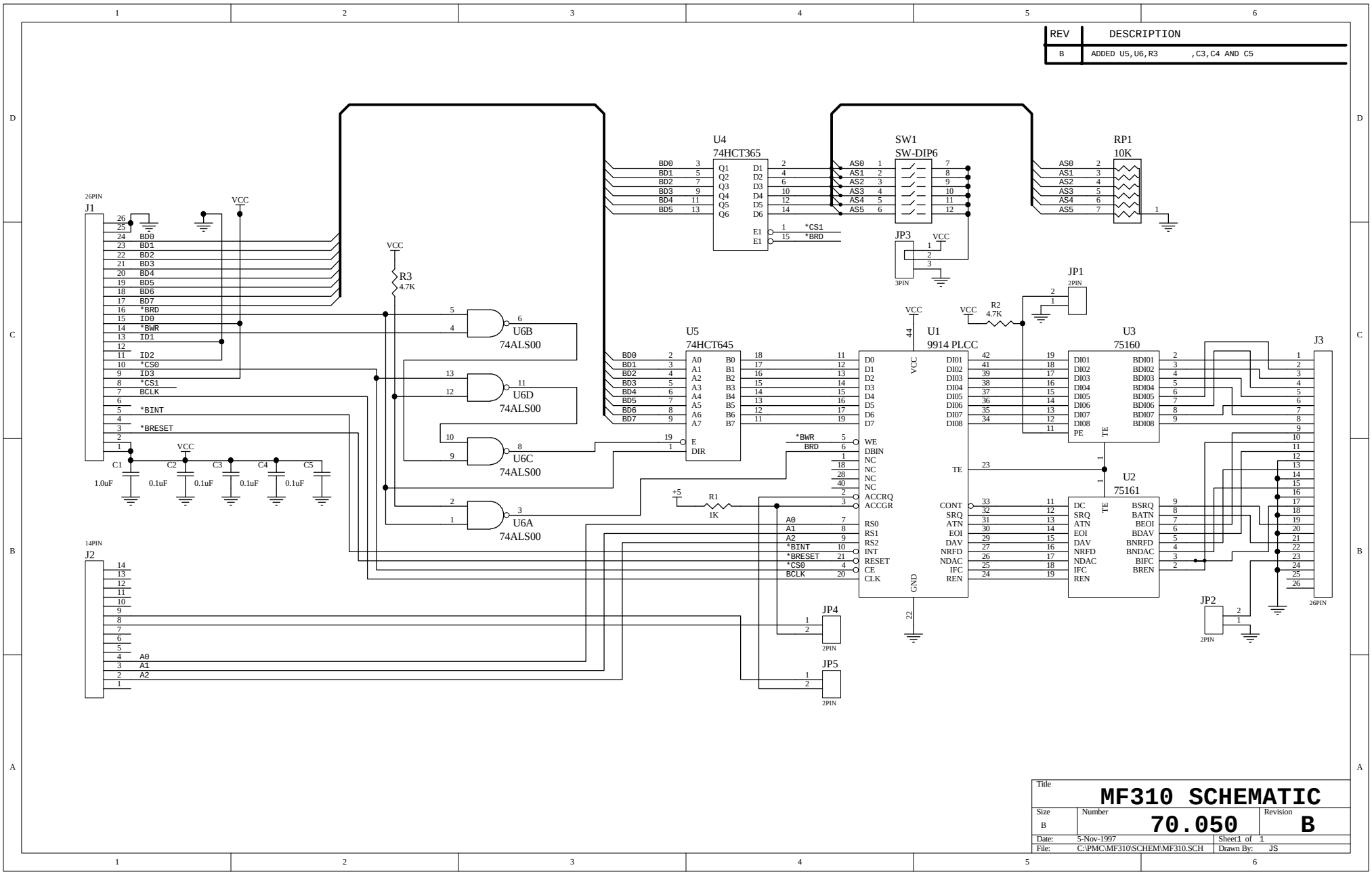
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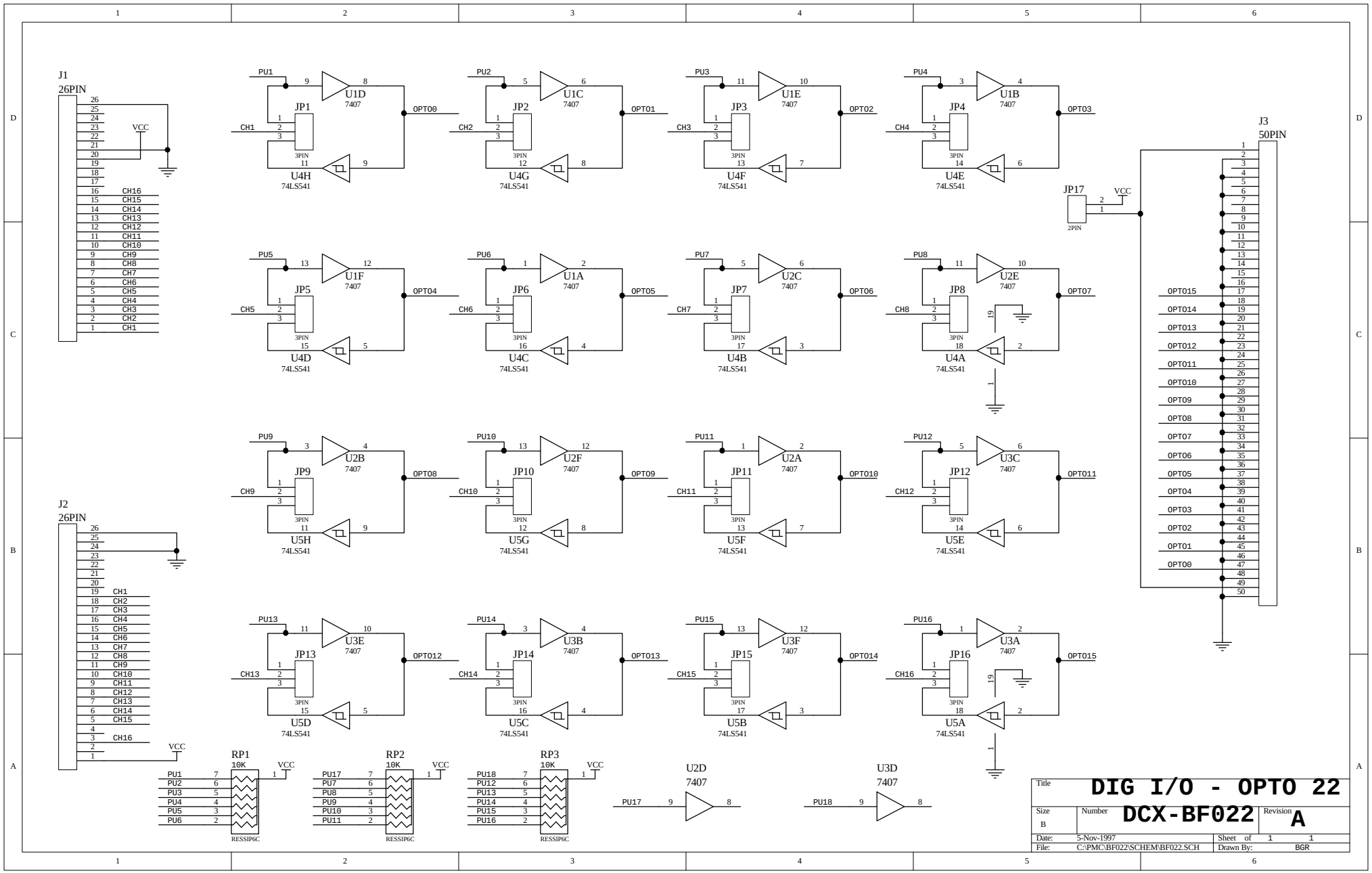
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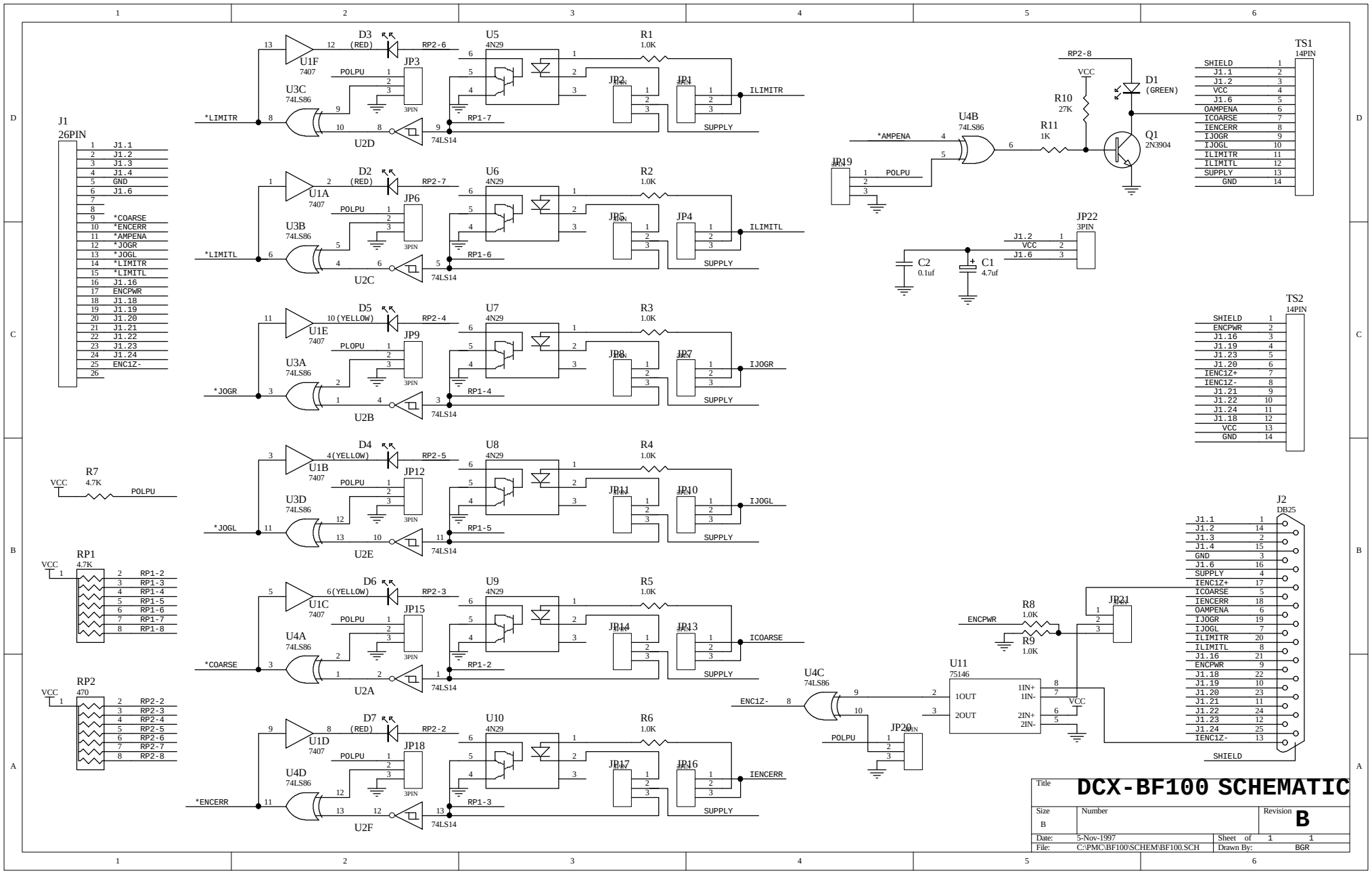
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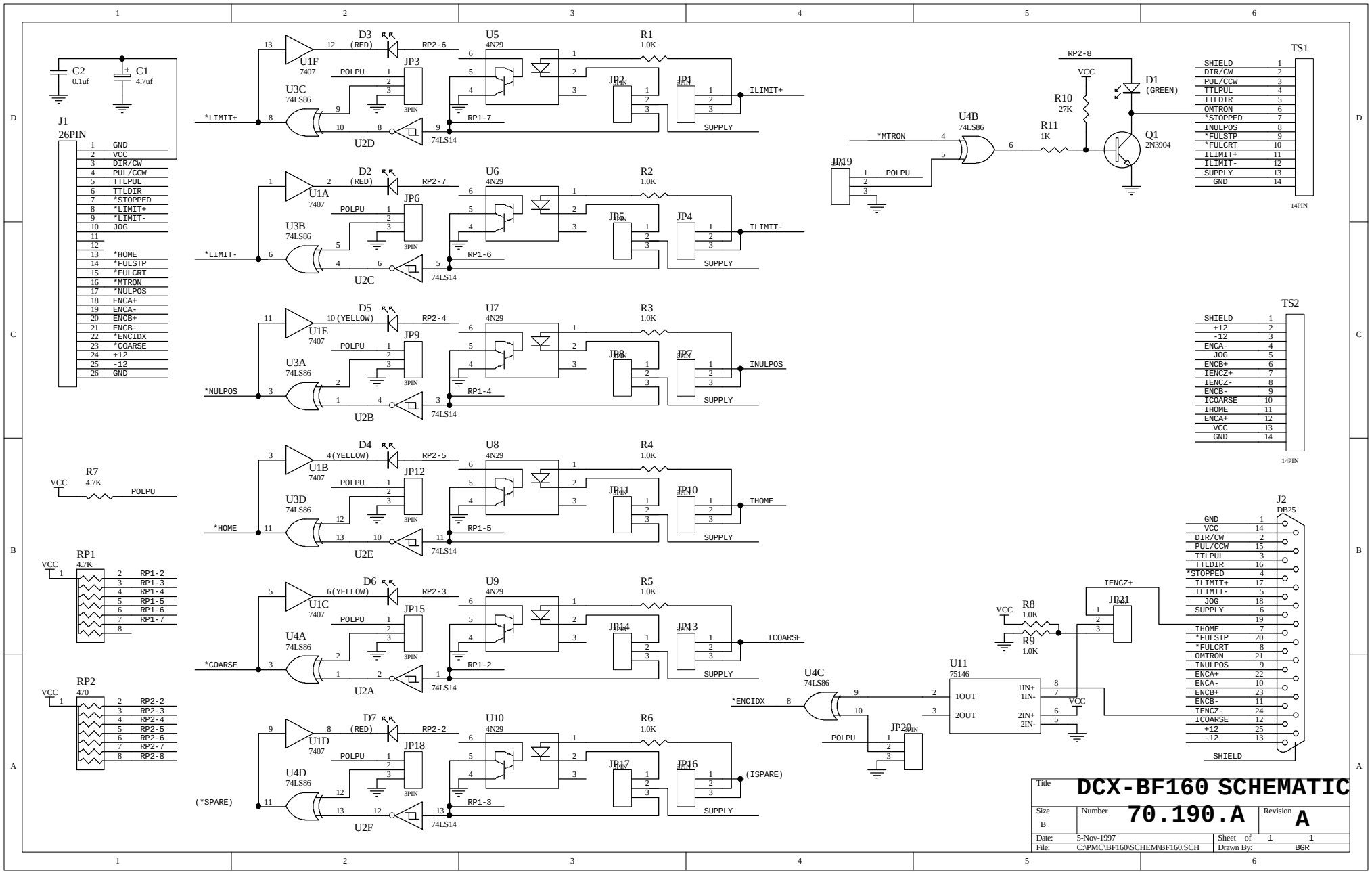
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