

# **DMC-21x2/21x3**

**Manual Rev. 1.0h**

**By Galil Motion Control, Inc.**

***Galil Motion Control, Inc.  
270 Technology Way  
Rocklin, California 95765  
Phone: (916) 626-0101  
Fax: (916) 626-0102  
Internet Address: [support@galilmc.com](mailto:support@galilmc.com)  
URL: [www.galilmc.com](http://www.galilmc.com)***

***Rev 4/09***

## Using This Manual

This user manual provides information for proper operation of the DMC-21x2 and DMC-21x3 controllers. A separate supplemental manual, the Command Reference, contains a description of the commands available for use with this controller.

**Note: The DMC-21x2 and DMC-21x3 controllers are identical except the DMC-21x2 has 100 pin high-density connectors for breaking out the signals and the DMC-21x3 has 96 pin DIN connectors for breaking out the signals. The ICM/AMP-1900 and the ICM-2900 do not interface to the DMC-21x3. Look in the appendix for the pin-outs for the DMC-21x2 and DMC-21x3 controllers.**

Your DMC-21x2/21x3 motion controller has been designed to work with both servo and stepper type motors. Installation and system setup will vary depending upon whether the controller will be used with stepper motors or servo motors. To make finding the appropriate instructions faster and easier, icons will be next to any information that applies exclusively to one type of system. Otherwise, assume that the instructions apply to all types of systems. The icon legend is shown below.



Attention: Pertains to servo motor use.



Attention: Pertains to stepper motor use.



Attention: Pertains to controllers with more than 4 axes.

Please note that many examples are written for the DMC-2142 four-axes controller or the DMC-2182 eight axes controller. Users of the DMC-2132 3-axis controller, DMC-2122 2-axes controller or DMC-2112 1-axis controller should note that the DMC-2132 uses the axes denoted as XYZ, the DMC-2122 uses the axes denoted as XY, and the DMC-2112 uses the X-axis only.

Examples for the DMC-2182 denote the axes as A,B,C,D,E,F,G,H. Users of the DMC-2152 5-axes controller denotes the axes as A,B,C,D,E. DMC-2162 6-axes controller denotes the axes as A,B,C,D,E,F. DMC-2172, 7-axes controller denotes the axes as A,B,C,D,E,F,G. The axes A,B,C,D may be used interchangeably with X, Y, Z, W.

**WARNING: Machinery in motion can be dangerous! It is the responsibility of the user to design effective error handling and safety protection as part of the machine. Galil shall not be liable or responsible for any incidental or consequential damages.**

# Contents

<b>Contents</b>	<b>i</b>
<b>Chapter 1 Overview</b>	<b>1</b>
Introduction .....	1
Overview of Motor Types.....	2
Standard Servo Motor with +/- 10 Volt Command Signal .....	2
Brushless Servo Motor with Sinusoidal Commutation.....	2
Stepper Motor with Step and Direction Signals .....	2
Overview of Amplifiers.....	3
Amplifiers in Current Mode .....	3
Amplifiers in Velocity Mode.....	3
Stepper Motor Amplifiers.....	3
DMC-21x2/21x3 Functional Elements .....	3
Microcomputer Section .....	4
Motor Interface.....	4
Communication .....	4
General I/O.....	4
System Elements .....	4
Motor.....	5
Amplifier (Driver).....	5
Encoder.....	5
Watch Dog Timer .....	5
<b>Chapter 2 Getting Started</b>	<b>7</b>
The DMC-2112 through DMC-2142 Main Board.....	7
Elements You Need for DMC-2112 to 2142 .....	8
The DMC-2152 through DMC-2182 Main Board.....	9
Elements You Need for DMC-2152 to 2182 .....	10
Installing the DMC-21x2 .....	11
Step 1. Determine Overall Motor Configuration .....	12
Step 2. Install Jumpers on the DMC-21x2.....	12
Step 3. Configure Communication Jumpers on the DMC-21x2.....	13
Step 4. Install the Communications Software.....	13
Step 5. Connect +5V, 12V DC Power to the Controller .....	14
Step 6. Establish Communications with Galil Software.....	14
Step 7. Determine the Axes to be Used for Sinusoidal Commutation .....	16
Step 8. Make Connections to Amplifier and Encoder .....	17
Step 9a. Connect Standard Servo Motors .....	19
Step 9b. Connect Sinusoidal Commutation Motors.....	22
Step 9c. Connect Step Motors .....	25
Step 10. Tune the Servo System.....	25
The DMC-2113 through DMC-2143 Main Board.....	27
The DMC-2153 through DMC-2183 Main Board.....	28
Installing the DMC-21x3 .....	29

Step 1. Determine Overall Motor Configuration .....	30
Step 2. Install Jumpers on the DMC-21x3 .....	31
Step 3. Configure Communication Jumpers on the DMC-21x3 .....	31
Step 4. Install the Communications Software .....	32
Step 5. Connect +5V, 12V DC Power to the Controller .....	32
Step 6. Establish Communications with Galil Software .....	32
Step 7. Determine the Axes to be Used for Sinusoidal Commutation .....	34
Step 8. Make Connections to Amplifier and Encoder .....	35
Step 9a. Connect Standard Servo Motors .....	37
Step 9b. Connect Sinusoidal Commutation Motors .....	40
Step 9c. Connect Step Motors .....	43
Step 10. Tune the Servo System .....	43
Design Examples .....	44
System Set-up .....	44
Profiled Move .....	45
Multiple Axes .....	45
Independent Moves .....	45
Position Interrogation .....	45
Absolute Position .....	46
Velocity Control .....	46
Operation Under Torque Limit .....	47
Interrogation .....	47
Operation in the Buffer Mode .....	47
Using the On-Board Editor .....	47
Motion Programs with Loops .....	48
Motion Programs with Trippoints .....	48
Control Variables .....	49
Linear Interpolation .....	49
Circular Interpolation .....	50

### **Chapter 3 Connecting Hardware 51**

Overview .....	51
Using Inputs .....	51
Limit Switch Input .....	51
Home Switch Input .....	52
Abort Input .....	52
Uncommitted Digital Inputs .....	53
Amplifier Interface .....	53
TTL Inputs .....	54
The Auxiliary Encoder Inputs: .....	54
TTL Outputs .....	55
General Use Outputs .....	55
Output Compare .....	55
Error Output .....	55
Extended I/O of the DMC-21x2/21x3 Controller .....	55

### **Chapter 4 Communication 57**

Introduction .....	57
RS232 Port .....	57
RS232 – Serial Port DATATERM .....	57
RS-232 Configuration .....	57
Ethernet Configuration .....	58
Communication Protocols .....	58
Addressing .....	58

Communicating with Multiple Devices.....	59
Multicasting.....	61
Using Third Party Software.....	61
Data Record.....	61
Data Record Map.....	62
Explanation of Status Information and Axis Switch Information.....	64
Notes Regarding Velocity and Torque Information.....	66
QZ Command.....	66
Controller Response to Commands.....	66
Unsolicited Messages Generated by Controller.....	66
Galil Software Tools and Libraries.....	67

## **Chapter 5 Command Basics 69**

Introduction.....	69
Command Syntax - ASCII.....	69
Coordinated Motion with more than 1 axis.....	70
Command Syntax - Binary.....	71
Binary Command Format.....	71
Binary Command Table.....	72
Controller Response to DATA.....	73
Interrogating the Controller.....	74
Interrogation Commands.....	74
Summary of Interrogation Commands.....	74
Interrogating Current Commanded Values.....	74
Operands.....	75
Command Summary.....	75

## **Chapter 6 Programming Motion 77**

Overview.....	77
Independent Axis Positioning.....	79
Command Summary - Independent Axis.....	79
Operand Summary - Independent Axis.....	79
Examples.....	80
Independent Jogging.....	81
Command Summary - Jogging.....	81
Operand Summary - Independent Axis.....	82
Examples.....	82
Position Tracking.....	83
Example Motion 1:.....	84
Example Motion 2:.....	84
Example Motion3:.....	85
Trip Points.....	87
Command Summary – Position Tracking Mode.....	87
Linear Interpolation Mode.....	88
Specifying the Coordinate Plane.....	88
Specifying Linear Segments.....	88
Additional Commands.....	88
Command Summary - Linear Interpolation.....	90
Operand Summary - Linear Interpolation.....	90
Example.....	90
Vector Mode: Linear and Circular Interpolation Motion.....	93
Specifying the Coordinate Plane.....	93
Specifying Vector Segments.....	94
Additional commands.....	94

Command Summary - Coordinated Motion Sequence .....	95
Operand Summary - Coordinated Motion Sequence .....	96
Example .....	96
Electronic Gearing .....	98
Ramped Gearing .....	98
Example – Electronic Gearing Over a Specified Interval .....	100
Command Summary - Electronic Gearing .....	100
Electronic Cam .....	102
Command Summary - Electronic CAM .....	105
Operand Summary - Electronic CAM .....	106
Example .....	106
Contour Mode .....	107
Specifying Contour Segments .....	107
Additional Commands .....	108
Command Summary - Contour Mode .....	109
General Velocity Profiles .....	109
Example .....	109
Virtual Axis .....	112
Ecam master example .....	112
Sinusoidal Motion Example .....	112
Stepper Motor Operation .....	113
Specifying Stepper Motor Operation .....	113
Stepper Motor Smoothing .....	113
Monitoring Generated Pulses vs Commanded Pulses .....	113
Motion Complete Trippoint .....	114
Using an Encoder with Stepper Motors .....	114
Command Summary - Stepper Motor Operation .....	114
Operand Summary - Stepper Motor Operation .....	115
Stepper Position Maintenance Mode (SPM) .....	115
Error Limit .....	116
Correction .....	116
Dual Loop (Auxiliary Encoder) .....	119
Additional Commands for the Auxiliary Encoder .....	120
Backlash Compensation .....	120
Example .....	121
Motion Smoothing .....	122
Using the IT and VT Commands: .....	122
Example .....	122
Using the KS Command (Step Motor Smoothing): .....	123
Homing .....	124
Example .....	124
Command Summary - Homing Operation .....	126
Operand Summary - Homing Operation .....	126
High Speed Position Capture (The Latch Function) .....	126
Example .....	127

## Chapter 7 Application Programming

129

Overview .....	129
Using the DOS Editor to Enter Programs .....	129
Edit Mode Commands .....	130
Example .....	130
Program Format .....	131
Using Labels in Programs .....	131
Special Labels .....	131
Commenting Programs .....	132

Executing Programs - Multitasking .....	133
Debugging Programs .....	134
Trace Commands.....	134
Error Code Command.....	134
Stop Code Command.....	135
RAM Memory Interrogation Commands .....	135
Operands.....	135
Example.....	135
Program Flow Commands .....	136
Event Triggers & Trippoints.....	136
Conditional Jumps.....	140
If, Else, and Endif.....	143
Subroutines.....	144
Stack Manipulation.....	144
Auto-Start Routine .....	145
Automatic Subroutines for Monitoring Conditions.....	145
Mathematical and Functional Expressions .....	150
Mathematical Operators .....	150
Bit-Wise Operators.....	150
Functions .....	152
Variables.....	152
Programmable Variables .....	152
Operands.....	154
Special Operands (Keywords).....	154
Arrays .....	154
Defining Arrays.....	155
Assignment of Array Entries .....	155
Uploading and Downloading Arrays to On Board Memory.....	156
Automatic Data Capture into Arrays .....	156
Deallocating Array Space.....	157
Input of Data (Numeric and String) .....	158
Input of Data.....	158
Operator Data Entry Mode .....	159
Using Communication Interrupt.....	159
Output of Data (Numeric and String) .....	161
Sending Messages .....	161
Displaying Variables and Arrays.....	162
Interrogation Commands.....	163
Formatting Variables and Array Elements .....	164
Converting to User Units.....	165
Hardware I/O .....	166
Digital Outputs .....	166
Digital Inputs.....	167
Analog Inputs .....	167
The Auxiliary Encoder Inputs .....	168
Input Interrupt Function .....	169
Extended I/O of the DMC-21x2/21x3 Controller.....	170
Configuring the I/O of the DMC-21x2/21x3.....	170
Saving the State of the Outputs in Non-Volatile Memory.....	170
Accessing Extended I/O .....	171
Interfacing to Grayhill or OPTO-22 G4PB24 .....	171
Example Applications.....	171
Wire Cutter.....	171
A-B Table Controller.....	173
Backlash Compensation by Sampled Dual-Loop .....	175

<b>Chapter 8 Hardware &amp; Software Protection</b>	<b>177</b>
Introduction .....	177
Hardware Protection .....	177
Output Protection Lines.....	177
Input Protection Lines .....	178
Software Protection .....	178
Programmable Position Limits .....	179
Off-On-Error .....	179
Automatic Error Routine .....	179
Limit Switch Routine .....	180
Amplifier Error Routine .....	181
 <b>Chapter 9 Troubleshooting</b>	 <b>183</b>
Overview .....	183
Installation .....	183
Communication.....	184
Stability.....	184
Operation .....	184
 <b>Chapter 10 Theory of Operation</b>	 <b>185</b>
Overview .....	185
Operation of Closed-Loop Systems .....	187
System Modelling.....	188
Motor-Amplifier.....	189
Encoder.....	191
DAC .....	192
Digital Filter .....	192
ZOH.....	193
System Analysis.....	194
System Design and Compensation.....	196
The Analytical Method.....	196
 <b>Appendices</b>	 <b>199</b>
Electrical Specifications .....	199
Servo Control .....	199
Stepper Control.....	199
Input / Output .....	199
Power (Molex 26-03-4061) .....	200
Performance Specifications .....	200
Minimum Servo Loop Update Time: .....	200
Fast Update Rate Mode .....	201
Connectors for DMC-21x2 and DMC-21x3 Main Boards .....	202
DMC-21x2 Axes A-D High Density Connector J4 .....	202
DMC-21x2 Axes E-H High Density Connector J5 .....	203
DMC-21x3 Axes A-D 96 Pin DIN Connector J4 .....	204
DMC-21x3 Axes E-H 96 Pin DIN Connector J5 .....	205
DMC-21x2/21x3 Auxiliary Encoders C-D IDC pins JP6.....	206
DMC-21x2/21x3 Auxiliary Encoders G-H IDC pins JP8 .....	206
RS-232 Serial Port.....	207
Ethernet .....	207
96-pin Motor, Encoder, and I/O Connectors .....	207
Mating Power Connectors .....	207
Cable Connections for DMC-21x2/21x3 .....	208



Pin-Out Description for DMC-21x2/21x3 .....	208
Jumper Description for DMC-21x2/21x3 .....	210
LED Description .....	211
Dimensions for DMC-21x2 .....	211
Accessories and Options .....	212
ICM-2900 Interconnect Module for DMC-21x2 .....	213
ICM-2900 Drawing: .....	216
PCB Layout of the ICM-2900: .....	217
ICM-1900 Interconnect Module for DMC-21x2 .....	218
Features .....	218
ICM-1900 Drawing: .....	221
AMP-19x0 Mating Power Amplifiers for DMC-21x2 .....	221
Features .....	221
Specifications .....	222
Opto-Isolated Outputs for ICM-2900 / ICM-1900 / AMP-19x0 .....	222
Standard Opto-Isolation and High Current Opto-isolation: .....	222
Configuring Amplifier Enable for ICM-2900 / ICM-1900 .....	223
-LAEN Option: .....	223
-Changing the Amplifier Enable Voltage Level: .....	223
Coordinated Motion - Mathematical Analysis .....	224
Example- Communicating with OPTO-22 SNAP-B3000-ENET .....	227
List of Other Publications .....	229
Training Seminars .....	229
Contacting Us .....	230
WARRANTY .....	230

## Index

**231**

**THIS PAGE LEFT BLANK INTENTIONALLY**

# Chapter 1 Overview

---

## Introduction

**Note: The DMC-21x2 and DMC-21x3 controllers are identical except the DMC-21x2 has 100 pin high-density connectors for breaking out the signals and the DMC-21x3 has 96 pin DIN connectors for breaking out the signals. All references to the DMC-21x2 in this manual also apply to the DMC-21x3.**

The DMC-21x2/21x3 is the Galil economy stand-alone multi-axis controller. The controller series offers many enhanced features, when compare to previous series, including high-speed communications, non-volatile program memory, faster encoder speeds, and options for bolt-on amplifiers or breakout boards.

Each DMC-21x2/21x3 provides two communication channels: RS-232 (up to 19.2K Baud) and 10BaseT Ethernet.

A 4Meg Flash EEPROM provides non-volatile memory for storing application programs, parameters, arrays and firmware. New firmware revisions are easily upgraded in the field.

The DMC-21x2/21x3 is available with up to eight axes in a single stand-alone unit. The DMC-2112, 2122, 2132, 2142 are one thru four axis controllers and the DMC-2152, 2162, 2172, 2182 are five thru eight axis controllers.

Designed to solve complex motion problems, the DMC-21x2/21x3 can be used for applications involving jogging, point-to-point positioning, vector positioning, electronic gearing, multiple move sequences, and contouring. The controller eliminates jerk by programmable acceleration and deceleration with profile smoothing. For smooth following of complex contours, the DMC-21x2/21x3 provides continuous vector feed of an infinite number of linear and arc segments. The controller also features electronic gearing with multiple master axes as well as gantry mode operation.

For synchronization with outside events, the DMC-21x2/21x3 provides uncommitted I/O, including 8 digital inputs (16 inputs for DMC-2152 thru DMC-2182) and 8 digital outputs (16 outputs for DMC-2152 thru DMC-2182). The DMC-21x2/21x3 also has an additional 40 I/O and 8 analog inputs when the DB-28040 is added to the controller. Further I/O is available if the auxiliary encoders are not being used (2 inputs / each axis). Dedicated TTL inputs are provided for forward and reverse limits, abort, home, and definable input interrupts.

Commands can be sent in either Binary or ASCII. Additional software is available for automatic-tuning, trajectory viewing on a PC screen, CAD translation, and program development using many environments such as Visual Basic, C, C++ etc. Drivers for DOS, Linux, Windows 3.1, 95, 98, 2000, ME, NT and XP are available.

---

## Overview of Motor Types

The DMC-21x2/21x3 can provide the following types of motor control:

1. Standard servo motors with +/- 10 volt command signals
2. Brushless servo motors with sinusoidal commutation
3. Step motors with step and direction signals
4. Other actuators such as hydraulics - For more information, contact Galil.

The user can configure the axes separately for any combination of motor types, providing maximum flexibility.

### Standard Servo Motor with +/- 10 Volt Command Signal

The DMC-21x2/21x3 achieves superior precision through use of a 16-Bit motor command output DAC and a sophisticated PID filter that features velocity and acceleration feedforward, an extra pole filter and integration limits.

The controller is configured by the factory for standard servo motor operation. In this configuration, the controller provides an analog signal (+/- 10Volt) to connect to a servo amplifier. This connection is described in Chapter 2.

### Brushless Servo Motor with Sinusoidal Commutation

The DMC-21x2/21x3 can provide sinusoidal commutation for brushless motors (BLM). In this configuration, the controller generates two sinusoidal signals for connection with amplifiers specifically designed for this purpose.

**Note:** The task of generating sinusoidal commutation may be accomplished in the brushless motor amplifier. If the amplifier generates the sinusoidal commutation signals, only a single command signal is required and the controller should be configured for a standard servo motor (described above).

Sinusoidal commutation in the controller can be used with linear and rotary BLMs. However, the motor velocity should be limited such that a magnetic cycle lasts at least 6 milliseconds with a standard update rate of 1 millisecond\*. For faster motors, please contact the factory.

To simplify the wiring, the controller provides a one-time, automatic set-up procedure. When the controller has been properly configured, the brushless motor parameters may be saved in non-volatile memory.

The DMC-21x2/21x3 can control BLMs equipped with Hall sensors as well as without Hall sensors. If hall sensors are available, once the controller has been setup, the brushless motor parameters may be saved in non-volatile memory. In this case, the controller will automatically estimate the commutation phase upon reset. This allows the motor to function immediately upon power up. The hall effect sensors also provide a method for setting the precise commutation phase. Chapter 2 describes the proper connection and procedure for using sinusoidal commutation of brushless motors.

\*The update rate can be modified using the TM command. Please see the *Command Reference* for more details.

### Stepper Motor with Step and Direction Signals

The DMC-21x2/21x3 can control stepper motors. In this mode, the controller provides two signals to connect to the stepper motor amplifier: Step and Direction. For stepper motor operation, the controller

does not require an encoder and operates the stepper motor in an open loop fashion. Chapter 2 describes the proper connection and procedure for using stepper motors.

---

## Overview of Amplifiers

The amplifiers should be suitable for the motor and may be linear or pulse-width-modulated. An amplifier may have current feedback, voltage feedback or velocity feedback.

### Amplifiers in Current Mode

Amplifiers in current mode should accept an analog command signal in the +/-10 Volt range. The amplifier gain should be set such that a +10V command will generate the maximum required current. For example, if the motor peak current is 10A, the amplifier gain should be 1 A/V.

### Amplifiers in Velocity Mode

For velocity mode amplifiers, a command signal of 10 Volts should run the motor at the maximum required speed. The velocity gain should be set such that an input signal of 10V runs the motor at the maximum required speed.

### Stepper Motor Amplifiers



For step motors, the amplifiers should accept step and direction signals.

---

## DMC-21x2/21x3 Functional Elements

The DMC-21x2/21x3 circuitry can be divided into the following functional groups as shown in Figure 1.1 and discussed below.

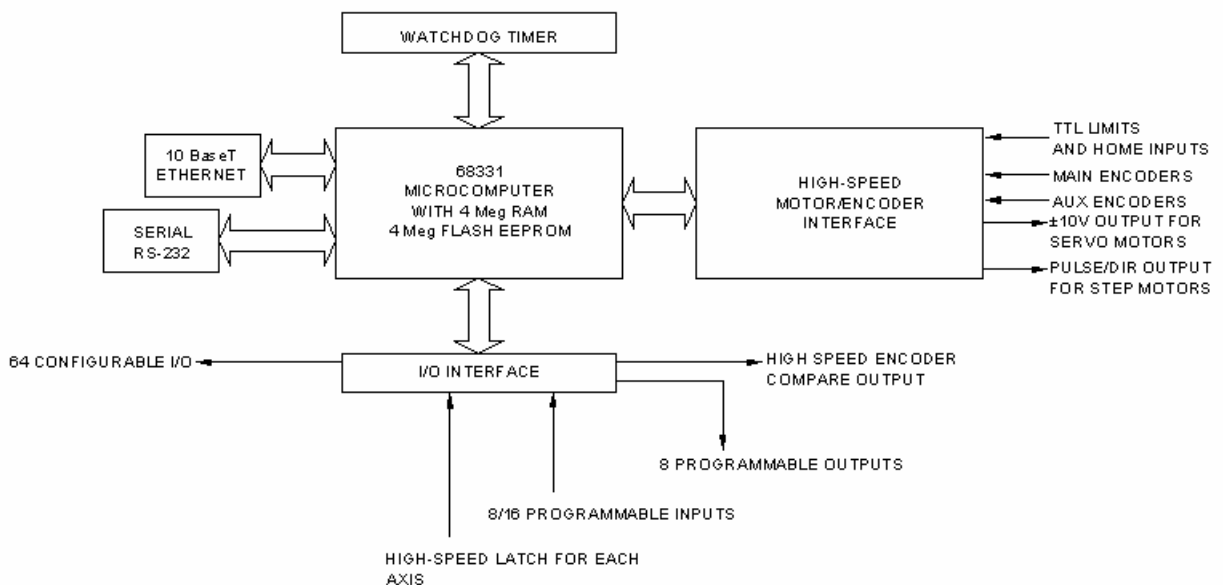


Figure 1.1 - DMC-21x2/21x3 Functional Elements

## Microcomputer Section

The main processing unit of the DMC-21x2/21x3 is a specialized 32-Bit Motorola 68331 Series Microcomputer with 4 Meg RAM and 4 Meg Flash EEPROM. The RAM provides memory for variables, array elements and application programs. The flash EEPROM provides non-volatile storage of variables, programs, and arrays. It also contains the DMC-21x2/21x3 firmware.

## Motor Interface

Galil's GL-1800 custom, sub-micron gate array performs quadrature decoding of each encoder at up to 12 MHz. For standard servo operation, the controller generates a +/-10 Volt analog signal (16 Bit DAC). For sinusoidal commutation operation, the controller uses 2 DACs to generate 2 +/-10Volt analog signals. For stepper motor operation, the controller generates a step and direction signal.

## Communication

The communication interface with the DMC-21x2/21x3 consists of a RS-232 port and 10 BaseT Ethernet port. The RS-232 channel can generate up to 19.2Kbaud.

## General I/O

The DMC-21x2/21x3 provides interface circuitry for 8 TTL inputs, 8 TTL outputs. The DMC-21x2 also has an additional 40 I/O daughterboard that can be ordered as an option. Unused auxiliary encoder inputs may also be used as additional inputs (2 inputs / each axis). The general inputs can also be used as high speed latches for each axis. A high speed encoder compare output is also provided.

**2182**

The DMC-2152 through DMC-2182 controller provides an additional 8 TTL inputs and 8 TTL outputs.

## System Elements

As shown in Fig. 1.2, the DMC-21x2/21x3 is part of a motion control system, which includes amplifiers, motors and encoders. These elements are described below.

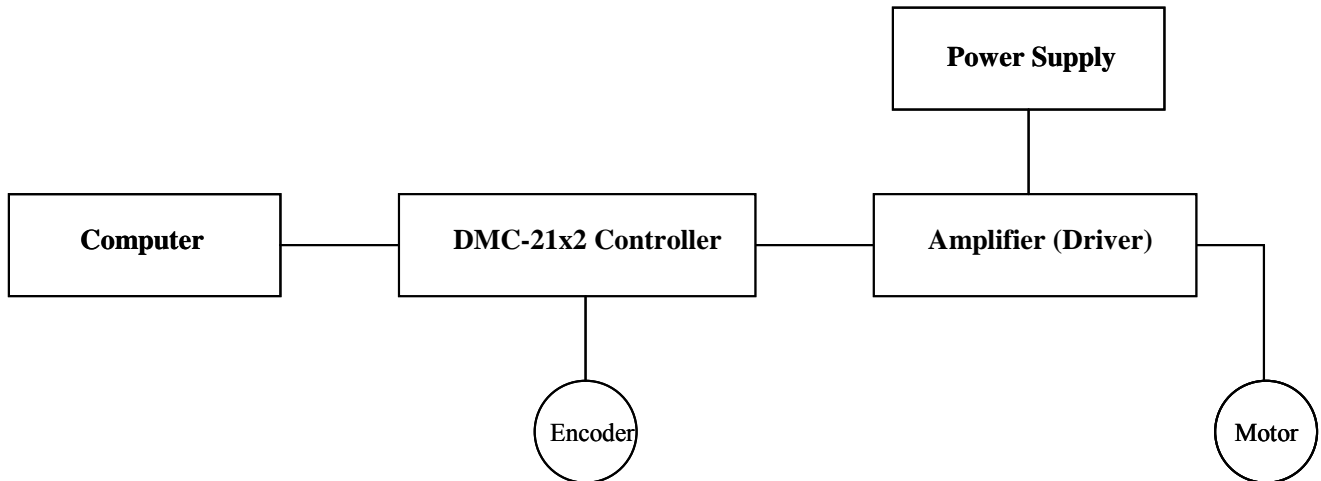


Figure 1.2 - Elements of Servo systems

## Motor

A motor converts current into torque which produces motion. Each axis of motion requires a motor sized properly to move the load at the required speed and acceleration. The Galil "Motion Component Selector" software can help with motor sizing. Contact Galil at 800-377-6329 if you would like this product.

The motor may be a step or servo motor and can be brush-type or brushless, rotary or linear. For step motors, the controller can be configured to control full-step, half-step, or microstep drives. An encoder is not required when step motors are used.

## Amplifier (Driver)

For each axis, the power amplifier converts a +/-10 Volt signal from the controller into current to drive the motor. For stepper motors, the amplifier converts step and direction signals into current. The amplifier should be sized properly to meet the power requirements of the motor. For brushless motors, an amplifier that provides electronic commutation is required or the controller must be configured to provide sinusoidal commutation. The amplifiers may be either pulse-width-modulated (PWM) or linear. They may also be configured for operation with or without a tachometer. For current amplifiers, the amplifier gain should be set such that a 10 Volt command generates the maximum required current. For example, if the motor peak current is 10A, the amplifier gain should be 1 A/V. For velocity mode amplifiers, 10 Volts should run the motor at the maximum speed.

## Encoder

An encoder translates motion into electrical pulses which are fed back into the controller. The DMC-21x2/21x3 accepts feedback from either a rotary or linear encoder. Typical encoders provide two channels in quadrature, known as CHA and CHB. This type of encoder is known as a quadrature encoder. Quadrature encoders may be either single-ended (CHA and CHB) or differential (CHA,CHA- and CHB,CHB-). The DMC-21x2/21x3 decodes either type into quadrature states or four times the number of cycles. Encoders may also have a third channel (or index) for synchronization.

For stepper motors, the DMC-21x2/21x3 can also interface to encoders with pulse and direction signals.

There is no limit on encoder line density, however, the input frequency to the controller must not exceed 3,000,000 full encoder cycles/second (12,000,000 quadrature counts/sec). For example, if the encoder line density is 10000 cycles per inch, the maximum speed is 300 inches/second. If higher encoder frequency is required, please consult the factory.

The standard voltage level is TTL (zero to five volts), however, voltage levels up to 12 Volts are acceptable. (If using differential signals, 12 Volts can be input directly to the DMC-21x2/21x3. Single-ended 12 Volt signals require a bias voltage input to the complementary inputs).

To interface with other types of position sensors such as resolvers or absolute encoders, Galil can customize the controller and command set. Please contact Galil and talk to one of our applications engineers about your particular system requirements.

## Watch Dog Timer

The DMC-21x2/21x3 provides an internal watch dog timer which checks for proper microprocessor operation. The timer toggles the Amplifier Enable Output (AMPEN) which can be used to switch the amplifiers off in the event of a serious DMC-21x2/21x3 failure. The AMPEN output is normally high. During power-up and if the microprocessor ceases to function properly, the AMPEN output will go low. The error light will also turn on at this stage. A reset is required to restore the DMC-21x2/21x3 to normal operation. Consult the factory for a Return Materials Authorization (RMA) Number if your DMC-21x2/21x3 is damaged.

**THIS PAGE LEFT BLANK INTENTIONALLY**



# Chapter 2 Getting Started

## The DMC-2112 through DMC-2142 Main Board

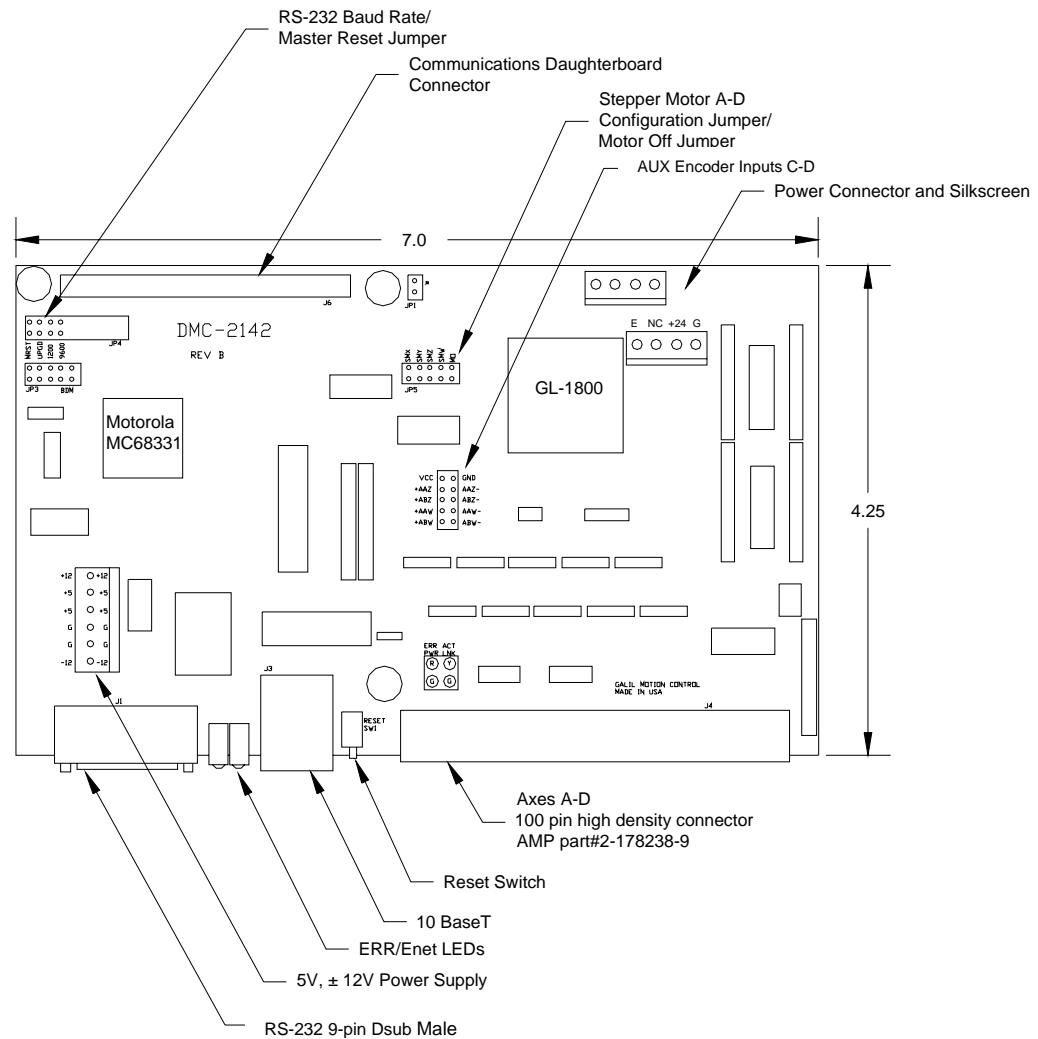


Figure 2-1 - Outline of the main board of the DMC-2112-2142

# Elements You Need for DMC-2112 to 2142

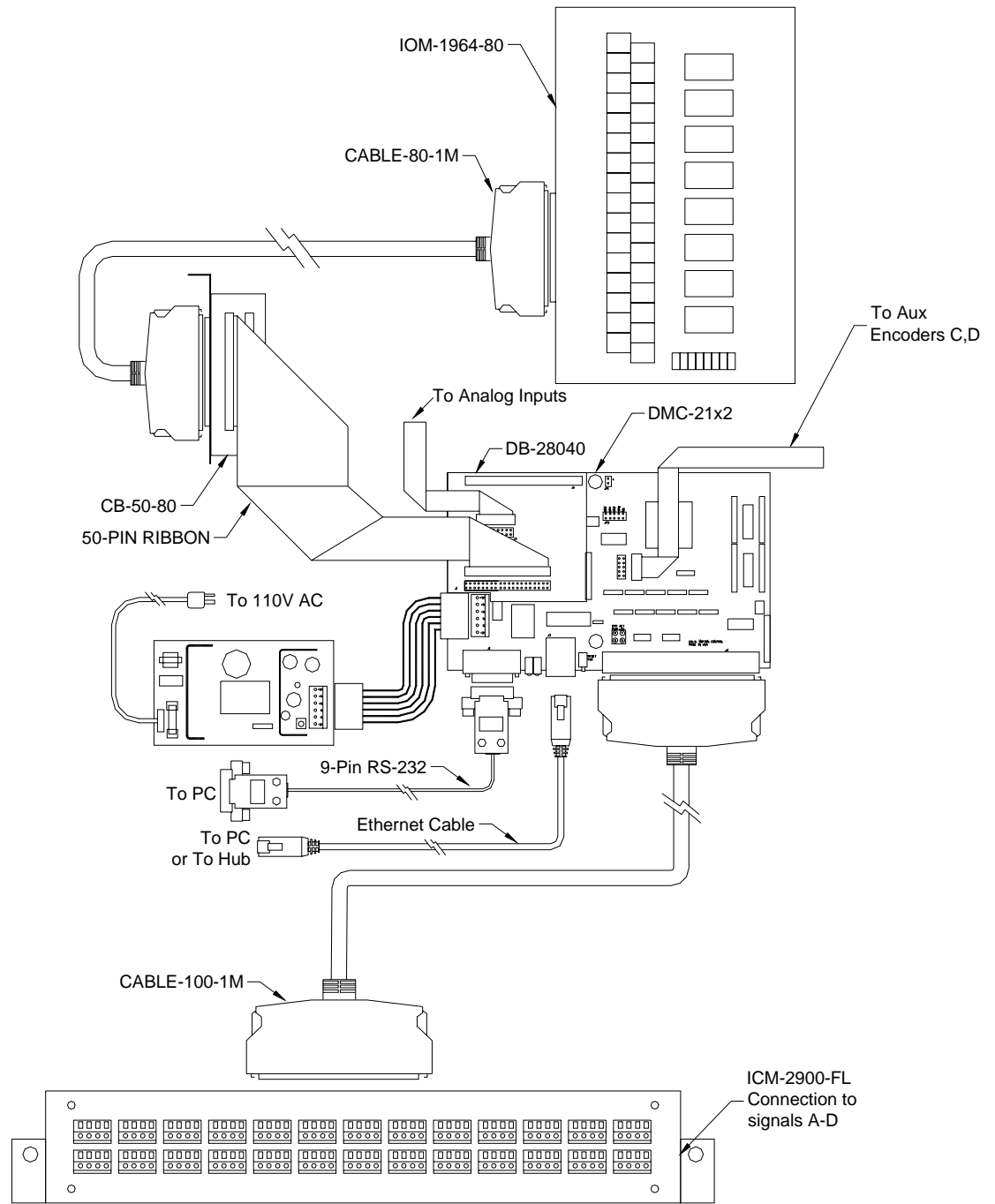


Figure 2-2 Recommended System Elements of DMC-2112-2142

# The DMC-2152 through DMC-2182 Main Board

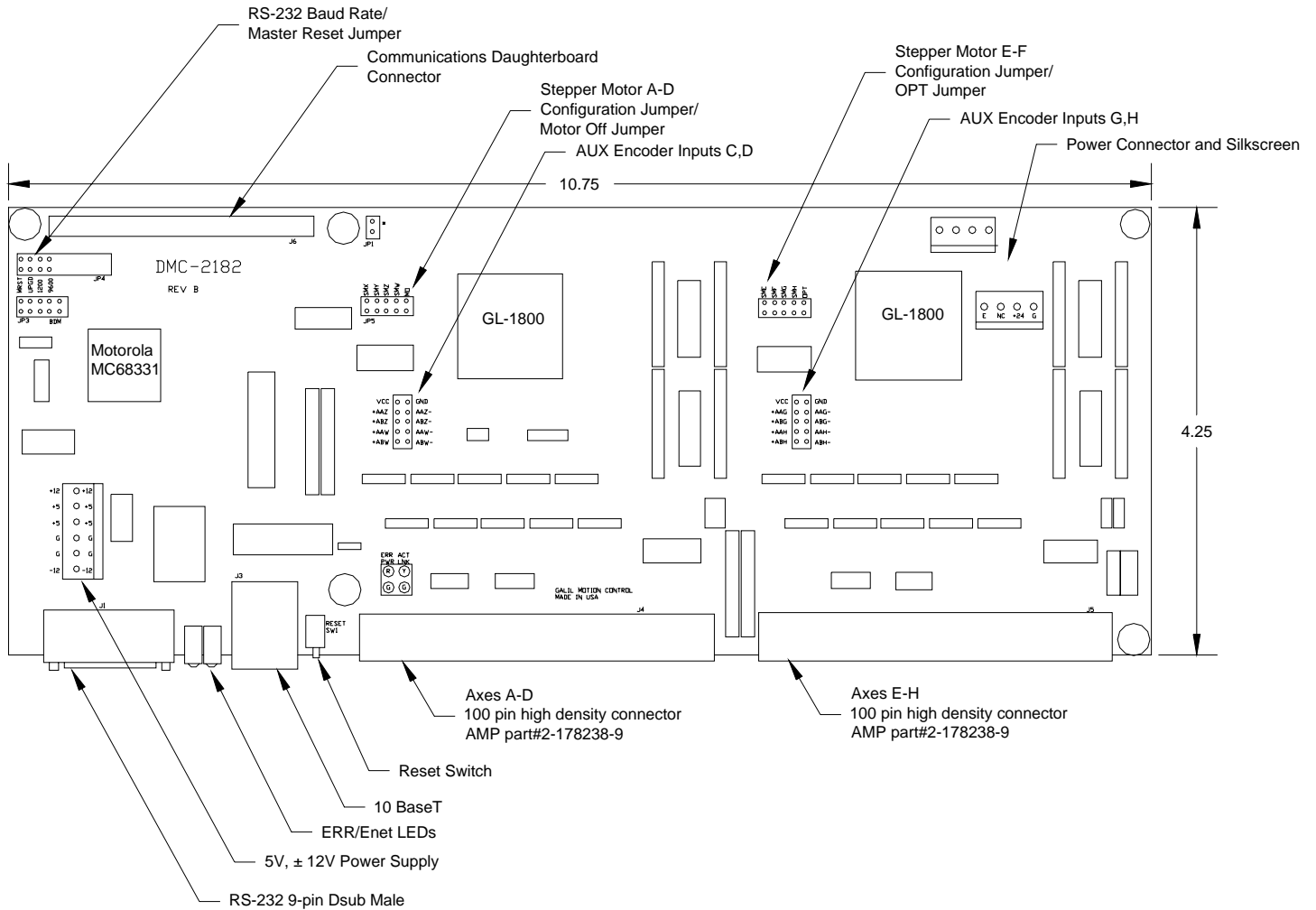


Figure 2-3 - Outline of the main board of the DMC-2152-2182

# Elements You Need for DMC-2152 to 2182

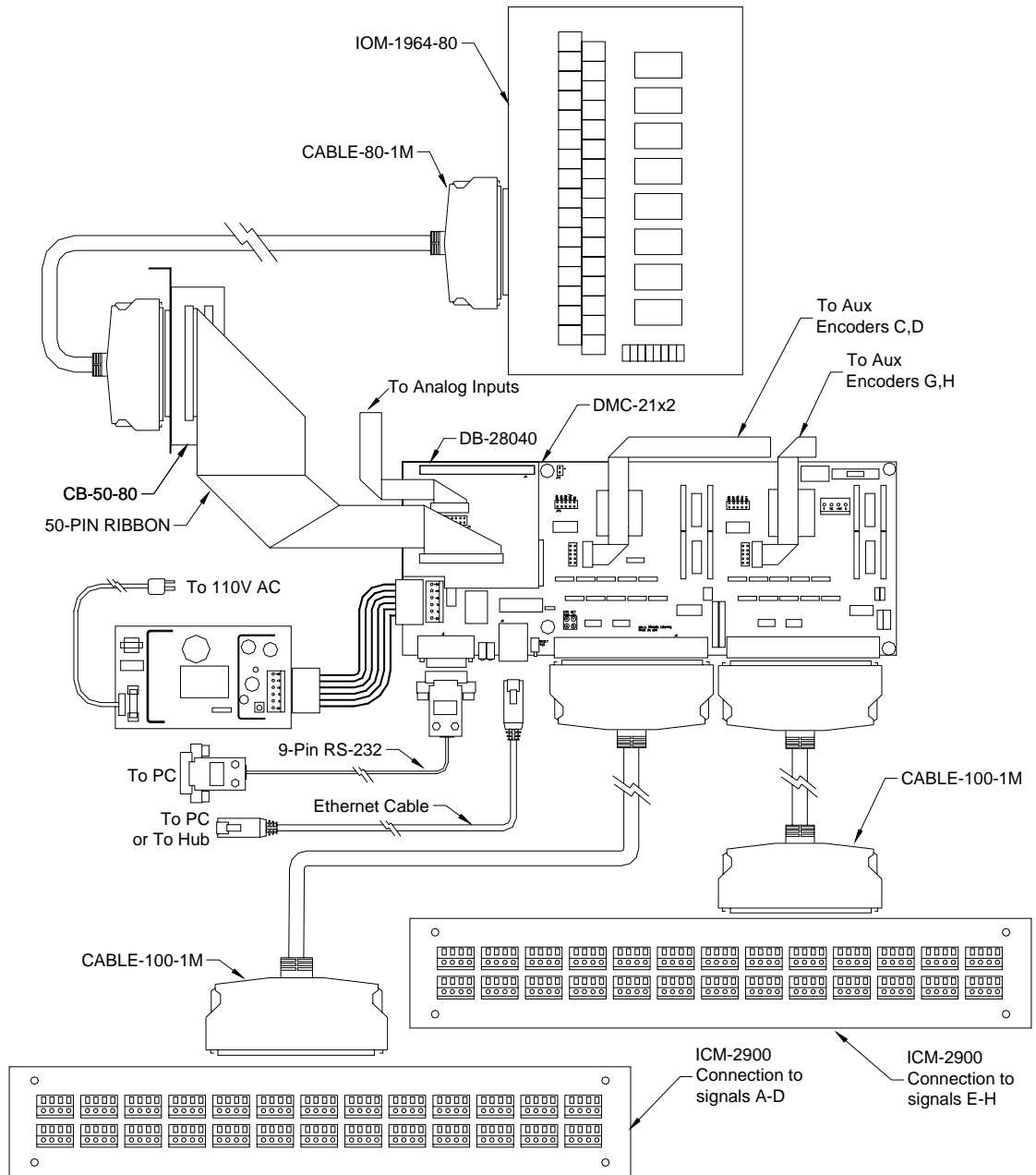


Figure 2-4 Recommended System Elements of DMC-2152-2182

For a complete system, Galil recommends the following elements:

- 1a. DMC-2112, 2122, 2132, or DMC-2142 Motion Controller
- or
- 1b. DMC-2152, 2162, 2172 or DMC-2182
  
- 2a. (1) ICM-2900 and (1) CABLE-100 for controllers DMC-2112 through DMC-2142
- or
- 2b. (2) ICM-2900's and (2) CABLE-100's for controllers DMC-2152 through DMC-2182.
- or
- 2c. An interconnect board provided by the user.
- 3. Motor Amplifiers.
- 4. Power Supply for Amplifiers.
- 5. Brush or Brushless Servo motors with Optical Encoders or stepper motors.
- 6. PC (Personal Computer - RS232 or Ethernet for DMC-21x2/21x3)
- 9a. WSDK-16 or WSDK-32 (recommend for first time users.)
- or
- 9b. DMCWIN16, DMCWIN32, Galil SmartTerminal or DMCDOS communication software.

The WSDK software is highly recommended for first time users of the DMC-21x2. It provides step-by-step instructions for system connection, tuning and analysis.

---

## Installing the DMC-21x2

Installation of a complete, operational DMC-21x2 system consists of 9 steps.

- Step 1.** Determine overall motor configuration.
- Step 2.** Install Jumpers on the DMC-21x2.
- Step 3.** Install communication Jumpers on the DMC-21x2.
- Step 4.** Install the communications software.
- Step 5.** Connect +5V, 12V DC power to controller. (Or correct DC voltage for –DC option)
- Step 6.** Establish communications with the Galil Communication Software.
- Step 7.** Determine the Axes to be used for sinusoidal commutation.
- Step 8.** Make connections to amplifier and encoder.
- Step 9a.** Connect standard servo motors.
- Step 9b.** Connect sinusoidal commutation motors
- Step 9c.** Connect step motors.
- Step 10.** Tune the servo system

## Step 1. Determine Overall Motor Configuration

Before setting up the motion control system, the user must determine the desired motor configuration. The DMC-21x2 can control any combination of standard servo motors, sinusoidally commutated brushless motors, and stepper motors. Other types of actuators, such as hydraulics can also be controlled, please consult Galil.

The following configuration information is necessary to determine the proper motor configuration:

### *Standard Servo Motor Operation:*

The DMC-21x2 has been setup by the factory for standard servo motor operation providing an analog command signal of +/- 10V. No hardware or software configuration is required for standard servo motor operation.

### *Sinusoidal Commutation:*

Sinusoidal commutation is configured through a single software command, BA. This configuration causes the controller to reconfigure the number of available control axes.

Each sinusoidally commutated motor requires two DAC's. In standard servo operation, the DMC-21x2 has one DAC per axis. In order to have the additional DAC for sinusoidal commutation, the controller must be designated as having one additional axis for each sinusoidal commutation axis. For example, to control two standard servo axes and one axis of sinusoidal commutation, the controller will require a total of four DAC's and the controller must be a DMC-2142.

Sinusoidal commutation is configured with the command, BA. For example, BAA sets the A axis to be sinusoidally commutated. The second DAC for the sinusoidal signal will be the highest available DAC on the controller. For example: Using a DMC-2142, the command BAA will configure the A axis to be the main sinusoidal signal and the 'D' axis to be the second sinusoidal signal.

The BA command also reconfigures the controller to indicate that the controller has one less axis of 'standard' control for each axis of sinusoidal commutation. For example, if the command BAA is given to a DMC-2142 controller, the controller will be re-configured to a DMC-2132 controller. By definition, a DMC-2132 controls 3 axes: A,B and C. The 'D' axis is no longer available since the output DAC is being used for sinusoidal commutation.

Further instruction for sinusoidal commutation connections are discussed in Step 6.

### *Stepper Motor Operation*

To configure the DMC-21x2 for stepper motor operation, the controller requires a jumper for each stepper motor and the command, MT, must be given. The installation of the stepper motor jumper is discussed in the following section entitled "Installing Jumpers on the DMC-21x2". Further instruction for stepper motor connections are discussed in Step 9.

## Step 2. Install Jumpers on the DMC-21x2

### *Master Reset and Upgrade Jumpers*

JP4 on the main board contains two jumpers, MRST and UPGRD. The MRST jumper is the Master Reset jumper. When MRST is connected, the controller will perform a master reset upon PC power up or upon the reset input going low. Whenever the controller has a master reset, all programs, arrays, variables, and motion control parameters stored in EEPROM will be ERASED.

The UPGRD jumper enables the user to unconditionally update the controller's firmware. This jumper is not necessary for firmware updates when the controller is operating normally, but may be necessary in cases of corrupted EEPROM. EEPROM corruption should never occur. However, it is possible if there is a power fault during a firmware update. If EEPROM corruption occurs, your controller may

not operate properly. In this case, install the UPGRD Jumper and use the update firmware function on the Galil Terminal to re-load the system firmware.

### ***Stepper Motor Jumpers***



For each axis that will be used for stepper motor operation, the corresponding stepper mode (SM) jumper must be connected. The stepper mode jumpers, labeled JP5 and JP7 are located directly beside the GL-1800 IC's on the main board (see the diagram of the DMC-21x2). The individual jumpers are labeled E thru H and configure the controller for 'Stepper Motors' for the corresponding axes X-W when installed. Contact the Galil factory if stepper motor jumpers should be placed on your controller with each order for special part numbers.

### ***(Optional) Motor Off Jumpers***

The state of the motor upon power up may be selected with the placement of a hardware jumper on the controller. With a jumper installed at the MO location, the controller will be powered up in the "motor off" state. The SH command will need to be issued in order for the motor to be enabled. With no jumper installed, the controller will immediately enable the motor upon power up. The MO command will need to be issued to turn the motor off. The MO jumper is always located on the same block of jumpers as the stepper motor jumpers (SM).

## **Step 3. Configure Communication Jumpers on the DMC-21x2**

The Baud rate of the RS-232 communication is set by installing jumpers on JP2. The following table describes the baud rate settings:

<b>1200</b>	<b>9600</b>	<b>BAUD RATE</b>
ON	OFF	1200
OFF	ON	9600
OFF	OFF	19200

## **Step 4. Install the Communications Software**

After applying power to the computer, you should install the Galil software that enables communication between the controller and PC.

### ***Using DOS:***

Using the Galil Software CD-ROM, go to the directory, DMCDOS. Type "INSTALL" at the DOS prompt and follow the directions.

### ***Using Windows 3.x (16 bit versions):***

Using the Galil Software CD ROM, go to the directory, DMCWIN16. Run DMCWIN16.exe at the Command prompt and follow the directions.

### *Using Windows 98, NT, ME, 2000 or XP (32 bit versions):*

The Galil Software CD-ROM will automatically begin the installation procedure when the CD-ROM is installed. After installing the Galil CD-ROM software on your computer, you can easily install other software components as desired. To install the basic communications software, run the Galil Software CD-ROM and choose “DMCSmartTerm”. This will install the Galil Smart Terminal which can be used for communication and programming of the controller.

## **Step 5. Connect +5V, 12V DC Power to the Controller**

Before applying power, connect the 100-pin cable between the DMC-21x2 and ICM-2900 interconnect module. If the –DC option was not ordered, then the DMC-21x2 requires +5V, 12V DC supply voltage. Confirm correct connections between the power supply pins and the controller. Serious damage will occur if the power supply is incorrectly wired. **Note:** If the –DC option was ordered, then the correct DC voltage should be connected (ie: 18-36V for –DC24 or 36-72V for -DC48 option) instead of the +5, 12V.

**WARNING: Dangerous voltages, current, temperatures and energy levels exist in this product and the associated amplifiers and servo motor(s). Extreme caution should be exercised in the application of this equipment. Only qualified individuals should attempt to install, set up and operate this equipment.**

The green power light indicator should go on when power is applied.

## **Step 6. Establish Communications with Galil Software**

### *Communicating through the Main Serial Communications Port*

Connect the DMC-21x2 serial port to your computer via the Galil CABLE-9PIN-D (RS-232 “Straight Through” Serial Cable).

### *Using Galil Software for DOS*

To communicate with the DMC-21x2, type TALK2DMC at the prompt. Once you have established communication, the terminal display should show a colon. If you do not receive a colon, press the carriage return. If a colon prompt is not returned, there is most likely an incorrect setting of the serial communications port. The user must ensure that the correct communication port and baud rate are specified when attempting to communicate with the controller. Please note that the serial port on the controller must be set for handshake mode for proper communication with Galil software. The user must also ensure that the proper serial cable is being used, see appendix for pin-out of serial cable.

### *Using Galil Software for Windows*

In order for the windows software to communicate with a Galil controller, the controller must be registered in the Windows Registry. To register a controller, you must specify the model of the controller, the communication parameters, and other information. The registry is accessed through the Galil software, such as WSDK or Galil Smart Terminal.

The registry window is equipped with buttons to Add a New Controller, change the Properties of an existing controller, Delete a controller, or Find an Ethernet Controller.

Use the “**New Controller**” button to add a new entry to the Registry. You will need to supply the Galil Controller model (eg: DMC-2102). Pressing the down arrow to the right of this field will reveal a menu of valid controller types. You then need to choose serial or Ethernet connection. The registry information will show a default Comm Port of 1 and a default Comm Speed of 19200 appears. This



information can be changed as necessary to reflect the computers Comm Port and the baud rate set by the controller's IDC jumpers (default is 19200). The registry entry also displays timeout and delay information. These are advanced parameters which should only be modified by advanced users (see software documentation for more information).

Once you have set the appropriate Registry information for your controller, Select OK and close the registry window. You will now be able to communicate with the DMC-21x2.

If you are not properly communicating with the controller, the program will pause for 3-15 seconds and an error message will be displayed. In this case, there is most likely an incorrect setting of the serial communications port or the serial cable is not connected properly. The user must ensure that the correct communication port and baud rate are specified when attempting to communicate with the controller. Please note that the serial port on the controller must be set for handshake mode for proper communication with Galil software. The user must also insure that a "straight-through" serial cable is being used (**NOT** a Null Modem cable), see appendix for pin-out of serial cable.

Once you establish communications, click on the menu for terminal and you will receive a colon prompt. Communicating with the controller is described in later sections.

### ***Using Non-Galil Communication Software***

The DMC-21x2 main serial port is configured as DATASET. Your computer or terminal must be configured as a DATATERM for full duplex, no parity, 8 data bits, one start bit and one stop bit.

Check to insure that the baud rate switches have been set to the desired baud rate as described above.

Your computer needs to be configured as a "dumb" terminal which sends ASCII characters as they are typed to the DMC-21x2. Use the EO command to specify if the characters should be echoed back from the controller.

## ***Communicating through the Ethernet***

### ***Using Galil Software for Windows***

The controller must be registered in the Windows registry for the host computer to communicate with it. The registry may be accessed via Galil software, such as WSDK or GALIL Smart Terminal.

Use the *New Controller* button to add a new entry in the registry or alternatively click on the *Find Ethernet Controller* to have the software search for controllers connected to the network. When adding a new controller, choose DMC-21x2 as the controller type. Enter the IP address obtained from your system administrator. Select the button corresponding to the UDP or TCP protocol in which you wish to communicate with the controller. If the IP address has not been already assigned to the controller, click on **ASSIGN IP ADDRESS**.

**ASSIGN IP ADDRESS** will check the controllers that are linked to the network to see which ones do not have an IP address. The program will then ask you whether you would like to assign the IP address you entered to the controller with the specified serial number. Click on **YES** to assign it, **NO** to move to next controller, or **CANCEL** to not save the changes. If there are no controllers on the network that do not have an IP address assigned, the program will state this.

When done registering, click on **OK**. If you do not wish to save the changes, click on **CANCEL**.

Once the controller has been registered, select the correct controller from the list and click on **OK**. If the software successfully established communications with the controller, the registry entry will be displayed at the bottom of the screen in the Status window.

**NOTE:** The controller must be registered via an Ethernet connection.

### ***Sending Test Commands to the Terminal:***

After you connect your terminal, press <return> or the <enter> key on your keyboard. In response to carriage return <return>, the controller responds with a colon. :

Now type

TPA <return>

This command directs the controller to return the current position of the A axis. The controller should respond with a number such as

0000000

After testing communication, enter <BN> to burn the IP address.

## **Step 7. Determine the Axes to be Used for Sinusoidal Commutation**

*\* This step is only required when the controller will be used to control a brushless motor(s) with sinusoidal commutation. Skip to Step 8 if you do not need sinusoidal commutation.*

The command, BA is used to select the axes of sinusoidal commutation. For example, BAAC sets A and C as axes with sinusoidal commutation.

### ***Notes on Configuring Sinusoidal Commutation:***

The command, BA, reconfigures the controller such that it has one less axis of 'standard' control for each axis of sinusoidal commutation. For example, if the command BAA is given to a DMC-2142 controller, the controller will be re-configured to be a DMC-2132 controller. In this case the highest axis is no longer available except to be used for the 2<sup>nd</sup> phase of the sinusoidal commutation. Note that the highest axis on a controller can never be configured for sinusoidal commutation.

The DAC associated with the selected axis represents the first phase. The second phase uses the highest available DAC. When more than one axis is configured for sinusoidal commutation, the controller will assign the second phases to the DACs which have been made available through the axes reconfiguration. The highest sinusoidal commutation axis will be assigned to the highest available DAC and the lowest sinusoidal commutation axis will be assigned to the lowest available DAC. Note that the lowest axis is the A axis and the highest axis is the highest available axis for which the controller has been configured.

### ***Example: Sinusoidal Commutation Configuration using a DMC-2172***

BAAC

This command causes the controller to be reconfigured as a DMC-2152 controller. The A and C axes are configured for sinusoidal commutation. The first phase of the A axis will be the motor command









































































































































































































































































































































































































































































































