Single Axis Spindle Controller
DMM-201

Product User Guide
November 20, 2013
Revision D

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# Record of Revisions

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<th>Date</th>
<th>Valid For</th>
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<td>A1</td>
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1. Introduction:
The Dover Motion DMM101/201 was designed to be the next generation in spindle controller following extensive research with the data storage industry.

Some of the key items that customers asked for were:

A combined spindle, controller, software and cable solution:
- The Dover Motion spindle air bearing is known for its cutting edge error motion performance and unmatched reliability. The DMM101/201 package complements our spindle to provide a simple pre-tested solution that eliminates the need to figure out how to piece things together.

Improved Velocity Stability throughout the spindle speed range:
- The DMM101/201’s Phase Locked Loop (PLL) technology rotates the spindle with such speed precision that the Index to Index jitter from 3600RPM to 20KRPM is <50nseconds*.
  - At 3600RPM that’s >0.0003% velocity stability!

Drop in replacement of older technology:
- The DMM101/201’s interface is compatible with both MCS-LA2000 and MFM-BDC-610.
  - We have added features for the external frequency mode control.
    - Adjustable slew rate to tame fast changing frequency inputs.
    - Scalable input to increase the top speed capability of the older frequency limited testers.

User adjustable PID gain adjustments for optimal performance with any payload:
- The Proportional, Integral and Derivative gains are all user adjustable.

Built-in Phase Advance for optimal performance at higher velocities:
- The DMM101/201 has phase advance features.

Field programmable software:
- The user can download software updates over the DMM101/201 serial interface.

Simplify commutation by eliminating the need to align the encoder index to a motor pole:
- Sine or hall commutation is available without the need to align the index.
  - Auto-commutation on power-up is an option.

Provide positioning control:
- The DMM101/201 can position a spindle to any encoder count within one revolution relative to the index.
  - A position capture feature is available as well.

Improved Reliability over existing technology:
- The DMM101/201 utilizes the same bulletproof Linear Amplifier technology used in the Dover Motion Compact Spinstands.
  - Amplifier thermal switches.
  - High speed & low speed amplifier current limits.
  - Safe Operating Area (SOA) protection virtually eliminates amplifier power device failures.

* Tested with a Dover Motion Revolution XLIII spindle, single 65mm media payload with a disk flutter device installed over 10KRPM
1.1 Safety Information

Read this information before operating this system.

1.1.1 Grounding

The AC power connection to DMM101/201 must have a connection to ground.

⚠️ CAUTION ⚠️

The DMM101/201 must be plugged into a properly grounded AC outlet to be grounded. Failure to ground the DMM101/201 could result in a fatal electric shock. Verify ground continuity to all metal pieces on the system. Metal components bolted only to granite may not be grounded. Black anodized and painted surfaces are not conductive.

1.1.2 Hazardous Voltage Information

⚠️ CAUTION ⚠️

Hazardous voltages are present at the motor output terminals and within the sheetmetal enclosure. Disconnect the AC power before plugging / unplugging any connections or before servicing or disassembling the enclosure.
2 System Installation:

2.1 Specifications:

- **Fuse:** 8A, 250V, Slow Blow
- **Power Requirements:** 120VAC, 10A or 230VAC, 5A
- **Power Output:** 15A (peak), 5A (cont), 75V nominal bus at full load
- **Weight:** 10 lbs (Driver Box, 33065-00)
  - 13.5 lbs (Power Supply Box, 33066-00)

Dimensions:

**Figure 1a:** DMM201 Driver Box Dimensions
Figure 1b: DMM201 Power Supply Box Dimensions
2.2 Selecting a mounting area:

The DMM201 should be mounted in a solid, clean, dry location with adequate ventilation.

Avoid mounting areas that:
- Obstruct the intake or exhaust of the internal forced air cooling.
- Allow dust, debris to enter and contaminate the cooling capability of the drive.
- Have humidity above 80% or are susceptible to moisture or coolant.
- Are prone to corrosive or flammable materials.
- Have an ambient temperature higher than 85°F (30°C).
- Vibrate, are susceptible to vibration or that could transmit the cooling fan vibration to sensitive test equipment.

Note: The DMM201’s allowable output power is limited by the amplifier heatsink temperature. Any reduction in cooling capability will be directly proportional to a reduction in performance.
2.3 DMM201 Power Supply Box Connections:

Figure 2: DMM201 Connections, Power Supply Box
2.4 AC Input:

The DMM101/201 can accept AC input voltages of 100 – 120 and 208 - 240VAC at 47 – 63Hz.

Note that the DMM101/201 utilizes an unregulated linear power supply. Therefore a higher AC input (for a given range) will provide a higher voltage to the spindle and allow the spindle to reach higher velocities.

The AC Inlet should be configured per the table below.

<table>
<thead>
<tr>
<th>Fuse Value</th>
<th>115V / 230V</th>
<th>Input AC Voltage Ranges (47-63 Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8A</td>
<td>115</td>
<td>Input Minimum 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input Maximum 120</td>
</tr>
<tr>
<td>4A</td>
<td>230</td>
<td>Input Minimum 208</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input Maximum 240</td>
</tr>
</tbody>
</table>

**Figure 3a:** Suggested Fusing for AC Input

2.4.1 Changing the AC inlet configuration:

1. Remove power from the AC Inlet
2. Use a flat tipped screwdriver to open the window that covers the red voltage value.
3. Use the screwdriver to remove the fuse block.
4. Use the table above to determine the correct fuse value.
5. Reinstall the fuse module such that the correct voltage value will show through the window.
6. Close the window.

**Figure 3b:** Fuse block removal from the AC inlet
2.5 DMM201 Driver Box:

![DMM201 Driver Box Diagram]

- **BNC Interface Legend**
- **Encoder Output / Freq. Input BNC Interface**
- **RS232 communication Interface**
- **Aux. I/O Interface**
- **AC Power Input**
- **DC Power Input**
- **MFM Style Signal Interface**
- **MFM Style Motor / Hall / Enc Interface**
- **25D Enc / Hall / I/O Interface**
- **14 Pin CPC Motor Interface**

---

**Figure 4a: DMM201 Driver Box**
## 2.6  Driver Box Interface Connections:

### 2.6.1 Motor Connector (J13)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motor Phase W</td>
</tr>
<tr>
<td>6</td>
<td>Motor Phase V</td>
</tr>
<tr>
<td>8</td>
<td>Motor Phase U</td>
</tr>
<tr>
<td>14</td>
<td>GND</td>
</tr>
</tbody>
</table>

### 2.6.2 MFM Style Motor Connector (J10)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+5VDC @ 100mA)</td>
</tr>
<tr>
<td>2</td>
<td>Enc A Input</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
</tr>
<tr>
<td>4</td>
<td>Enc B Input</td>
</tr>
<tr>
<td>5</td>
<td>Hall Y</td>
</tr>
<tr>
<td>6</td>
<td>Encoder Index</td>
</tr>
<tr>
<td>7</td>
<td>Hall Z</td>
</tr>
<tr>
<td>8</td>
<td>Clamp Air Fault</td>
</tr>
<tr>
<td>9</td>
<td>Hall X</td>
</tr>
<tr>
<td>10</td>
<td>Not Used</td>
</tr>
<tr>
<td>11-15</td>
<td>Motor Phase X</td>
</tr>
<tr>
<td>16-20</td>
<td>Motor Phase X/</td>
</tr>
<tr>
<td>21-25</td>
<td>Motor Phase Y</td>
</tr>
<tr>
<td>26-30</td>
<td>Motor Phase Y/</td>
</tr>
<tr>
<td>31-35</td>
<td>Motor Phase Z</td>
</tr>
<tr>
<td>35-40</td>
<td>Motor Phase Z/</td>
</tr>
</tbody>
</table>

### 2.6.3 Signal Connector (J12)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+5VDC @ 100mA)</td>
</tr>
<tr>
<td>2</td>
<td>Enc A Input</td>
</tr>
<tr>
<td>3</td>
<td>Enc B Input</td>
</tr>
<tr>
<td>4</td>
<td>Encoder Index</td>
</tr>
<tr>
<td>5</td>
<td>External Torque Input</td>
</tr>
<tr>
<td>6</td>
<td>External Enable Input</td>
</tr>
<tr>
<td>7</td>
<td>Aux. Interlock</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
</tr>
<tr>
<td>9</td>
<td>Encoder GND</td>
</tr>
<tr>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>Clamp Output</td>
</tr>
<tr>
<td>12</td>
<td>Encoder I/ Input</td>
</tr>
<tr>
<td>13</td>
<td>External Direction Input</td>
</tr>
<tr>
<td>14</td>
<td>Main Air Fault</td>
</tr>
<tr>
<td>15</td>
<td>Hall Sensor 1 Input</td>
</tr>
<tr>
<td>16</td>
<td>Hall Sensor 2 Input</td>
</tr>
<tr>
<td>17</td>
<td>Hall Sensor 3 Input</td>
</tr>
<tr>
<td>18</td>
<td>Bearing Air Fault</td>
</tr>
<tr>
<td>19</td>
<td>Clamp Air Fault</td>
</tr>
<tr>
<td>20</td>
<td>Encoder A/ Input</td>
</tr>
<tr>
<td>21</td>
<td>Encoder B/ Input</td>
</tr>
<tr>
<td>22</td>
<td>-15VDC @ 50mA</td>
</tr>
<tr>
<td>23</td>
<td>+15VDC @ 100mA</td>
</tr>
<tr>
<td>24</td>
<td>Encoder A Output</td>
</tr>
<tr>
<td>25</td>
<td>GND</td>
</tr>
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</table>
### MFM Style Interface Connector (J11)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Opto Common (See Input Schematic)</td>
</tr>
<tr>
<td>2</td>
<td>Opto Common (See Input Schematic)</td>
</tr>
<tr>
<td>3</td>
<td>N/C</td>
</tr>
<tr>
<td>4</td>
<td>Reference Frequency Input</td>
</tr>
<tr>
<td>5</td>
<td>N/C</td>
</tr>
<tr>
<td>6</td>
<td>Direction (GND = CCW)</td>
</tr>
<tr>
<td>7</td>
<td>Common Ground (See 2.6.8)</td>
</tr>
<tr>
<td>8</td>
<td>Common Ground (See 2.6.8)</td>
</tr>
<tr>
<td>9</td>
<td>Interlock</td>
</tr>
<tr>
<td>10</td>
<td>Interlock</td>
</tr>
<tr>
<td>11</td>
<td>+5VDC @100mA</td>
</tr>
<tr>
<td>12</td>
<td>+5VDC @100mA</td>
</tr>
<tr>
<td>13</td>
<td>ENC A Output</td>
</tr>
<tr>
<td>14</td>
<td>At Speed Output (See ATSPDLVL Common)</td>
</tr>
<tr>
<td>15</td>
<td>Index Output</td>
</tr>
<tr>
<td>16</td>
<td>ENC B Output</td>
</tr>
<tr>
<td>17</td>
<td>GND</td>
</tr>
<tr>
<td>18</td>
<td>GND</td>
</tr>
<tr>
<td>19</td>
<td>N/C</td>
</tr>
<tr>
<td>20</td>
<td>N/C</td>
</tr>
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### Auxiliary I/O Connector (J4)

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<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>User Analog Output (optional)</td>
</tr>
<tr>
<td>2</td>
<td>Ready Output</td>
</tr>
<tr>
<td>3</td>
<td>User_1_IN</td>
</tr>
<tr>
<td>4</td>
<td>User_2_IN</td>
</tr>
<tr>
<td>5</td>
<td>Fault_Out</td>
</tr>
<tr>
<td>6</td>
<td>User_2_Out</td>
</tr>
<tr>
<td>7</td>
<td>At_Speed_Out</td>
</tr>
<tr>
<td>8</td>
<td>Zero_Speed_Out</td>
</tr>
<tr>
<td>9</td>
<td>User_1_Out (Clamp Out)</td>
</tr>
<tr>
<td>10</td>
<td>LA Amplifier IRMS Out</td>
</tr>
<tr>
<td>11</td>
<td>Clamp Air Fault</td>
</tr>
<tr>
<td>12</td>
<td>Reset</td>
</tr>
<tr>
<td>13</td>
<td>Opto Common</td>
</tr>
<tr>
<td>14</td>
<td>DSP Program</td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
</tr>
</tbody>
</table>

### RS232 Connection (J5)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>Receive*</td>
</tr>
<tr>
<td>3</td>
<td>Transmit*</td>
</tr>
<tr>
<td>4</td>
<td>Receive*</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>At Zero Speed</td>
</tr>
<tr>
<td>7</td>
<td>Transmit*</td>
</tr>
<tr>
<td>8</td>
<td>At Speed</td>
</tr>
<tr>
<td>9</td>
<td>+5VDC @100mA</td>
</tr>
</tbody>
</table>

*Configured by JP1 & 2 for cross connection
### DC Power IN (J14)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DC Buss + (12 – 75VDC)*</td>
</tr>
<tr>
<td>2</td>
<td>DC Buss Common</td>
</tr>
<tr>
<td>3</td>
<td>DC Buss – (12 – 75VDC)*</td>
</tr>
<tr>
<td>4</td>
<td>+15VDC (Regulated 14.5 – 16V) @300mA</td>
</tr>
<tr>
<td>5</td>
<td>+5VDC (for encoder and halls)</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>-15VDC (Regulated 14.5 – 16V) @300mA</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
</tr>
</tbody>
</table>

*Current requirement is dependent on motor torque, payload, desired velocity and acceleration rate.

---

**Figure 4b:** DMM201 Driver Box Interface Connections

2.7 **System Interconnect:**

2.7.1 **Air Interlock Hardware**

A normally open air interlock switch should be used within the pneumatic interconnect as shown.
Several different interlock options are available. Reference the connector interface and I/O diagrams and the DISFAULTS? command for more information.

**NOTE:** All of the interlock options simply disable the amplifier motor outputs, activate the fault line and provide error messages over the RS232 port. If a spindle is running it will coast to a stop. The interlocks are not designed or intended for system power removal or otherwise required for a machine EMO condition.

![Air Pressure Switch Diagram](image)

**Figure 5:** Air Pressure Switch

### 2.7.2 DMM201 Interconnect

The DMM201 consists of 2 boxes with a set of cables connecting them together. The Power Supply box, contains the linear and switching power supplies. It converts the inlet AC power into usable AC and DC used by the Driver box. The Driver box, contains the amplifier and control card. It is powered by the power supply box and runs the spindle motor.

![DMM-201 Interconnect Diagram](image)

**Figure 6a:** DMM-201 Interconnect

### 2.7.3 Standard System Interconnect
The diagram below depicts the most common interconnect to the DMM. Additional connections may be desired for I/O such as media clamps and sensors.

**Figure 6b:** Standard Interconnect
MFM BDC-610 Retrofit Interconnect

The diagram below depicts the typical interconnect to replace a MFMBDC610 style controller. Additional connections may be desired for I/O such as media clamps and sensors. Reference the connector interface, I/O diagrams and the DISFAULTS? command to understand the options.

Note that a communication line is not required but can be used to change parameters as desired.

![MFM Retrofit Interconnect Diagram](image)

**Figure 6c:** MFM Retrofit Interconnect

### 2.7.4 Input Connections:

#### 2.7.4.1

There are several “opto” inputs available for use in the DMM101/201. JP2 is factory configurable to determine “Opto Common”. All opto Inputs need to use the same logic as determined by JP2.

Jumping JP2-A and JP2-C provides an internal 5VDC through the optos to all of the inputs. Grounding the input pin will activate the input. JP2-C also needs to be on properly route the current through the 750 ohm resistors. DO NOT connect anything to the External Opto Common in this configuration.

Jumping JP2-B connects ground through the opto. Therefore a 5-24VDC signal needs to be provided externally to activate the input. See schematic below for details.

Jumping JP2-C only allows the user to have control of both the common leg and the individual input leg of the opto. See schematic below for details.
Front Panel Connectors

- **OPTO COMMON**: J11-13, J11-12
- **DIRECTION**: J11-6, J12-13
- **ENABLE**: J12-6
- **USER 1 INPUT**: J4-3
- **USER 2 INPUT**: J4-4
- **AIR 1 (Leading AV)**: J12-14
- **AIR 2 (Sailing AV)**: J12-18
- **AIR 3 (Climb AV)**: J10-8, J4-11, J12-19

**COMMON GROUND**: J11-7-8

**REFERENCE FREQUENCY**: J11-4


**BNC**: J6-1

**GND**: J4-13, J11-17, J12-25

[Diagram of front panel connectors]
2.7.5.2 Non Opto User Input: Typically used as an optional interlock. See DISFAULTS to activate.

2.7.5.3 Frequency Input Circuitry:

! Be sure to select the correct jumper configuration for JP4. Do not use a TTL or other sourcing input source if JP4:A is in place.

2.7.5.4 Typical Hall and Encoder Input Circuitry:
2.7.6 User Outputs:

Several outputs are available for status monitoring. The Fault, Zero-Speed and Ready outputs provide a logic high (5VDC) when true.

The At-Speed output and the two user outputs are configurable with the JP1 jumpers to provide 5VDC or to be open collector.
2.7.7 Circuitry for BNC Encoder Outputs:

![Diagram of BNC outputs for encoder signals]

2.7.8 Circuitry for J11 Encoder Outputs:

![Diagram of J11 pins 13, 15 & 16]
2.8 Modes of Operation:

In almost all cases the user will want to utilize the serial communications (at least initially) to take advantage of the extended features of the DMM101 / 201. Commands will be accepted regardless of the mode of operation.

2.8.1 NORMAL Mode: A user friendly interface that operates at 38400 Baud and utilizes local echo.

2.8.2 MFM Mode: Automatically configures the parameters to make the DMM-101 work like a MFM BDC-610. **NOTE*** The ENCODERCOUNT and TYPE still needs to be set by the user***.

2.8.3 (EXTEN) External Enable and Direction Mode: Expects external control of the enable and direction lines. In this mode a predetermined velocity, acceleration and deceleration can be saved. Host I/O lines can be used to run the spindle without a serial communication interface.

2.8.4 External Reference Modes: An external analog voltage or frequency command is provided by the user to determine spindle velocity.

- **FLEXTERNAL** is the command to select External Frequency Mode. A TTL level frequency is applied to either J11-4 or the frequency input BNC. **MINSPDIN** can be used to command an auto commutation when the reference frequency is above the STOPS speed. The conversion for input frequency vs. spindle velocity is determined by the encoder line count and the scaling variable REFNUM.
  - Frequency Input = ((Desired RPM/60) * Encoder Line Count) / (REFNUM / 4)

- **ANALOGIN** is the command to select torque mode which expects an external +/-10VDC analog voltage at the 25D (J12) pin 5. This mode of operation bypasses the internal PLL circuitry and runs the controller in “open loop”. Also see the ANALOGSCALE, CW and CCW commands. **NOTE**: The ANALOGIN command automatically sets EXTEN. Likewise the ANALOGOUT command automatically sets INTEN.

2.8.5 MCS Mode: Mimics the communication interface of the MCS-LA2000 controller. In this mode only line feeds are sent for screen control. Carriage returns and local echo are suppressed. The Baud Rate is 9600.

2.8.6 Positioning Mode: The GOTO:xxx command (where xxx is a number of degrees from the encoder index signal) will position the spindle to a certain location within a revolution.

- The PID gains for positioning mode control the speed of the move. See PP, PD & PDGAIN.
- Also see the STOPHOLD command
- Note that the DMM-101 cannot be in an external reference mode. See ANALOGOUT and FLEXTERNAL.

2.8.7 Motor Commutation Modes and Considerations

**Hall Commutation (TYPE:6)**

*Advantage:* Spindle starts rotation without any commutation delay

*Disadvantages:*
- Spindle motor needs to have hall sensors with additional wiring and connections
- Motor harmonics may be increased
- Hall sequence must be known (Example: HALLS: BAC)
- When spindle velocity is >15krpm the ANGLE and OFFSET may need to be optimized
  - If many or a mix of spindles are involved some may require different optimization angles
  - Failure to optimize may cause inefficient operation, overheating and or amplifier overload
  - Reference Section 5.1

**Encoder Commutation (TYPE:7)**

*Advantage:* Commutates motor efficiently regardless of halls

*Disadvantages:* Motor needs to move back and forth a small amount (“Wake-and-Shake” commutation) the first time it is commanded to run. The commutation motion does not occur again unless the DMM-101 / 201 is reset or power cycled.
3 Establishing Communications:

The DMM101/201 communicates via the RS232 port at either 9600 or 38400 baud rate. This is software configurable where the default setting is 38400 baud unless otherwise specified.

3.1 Serial Interface

A serial communication program such as HyperTerminal can be used for communications. The standard settings are 8 data bits, 1 stop bit, no parity and no hardware or software handshaking. Settings → Emulation = ANSIW. ASCII Setup → No boxes checked, 100msec delay,

HyperTerminal Note: When changing baud rates or establishing communication for the first time use the call: disconnect and then call: call tab prior to cycling power to the DMM-101/201.

A standard three wire cross over serial cable is the standard requirement unless otherwise specified.

![Serial Data Cable Diagram](image)

Figure 7: Serial Data Cable Diagram

3.2 Configuration Setup

Once the communication program is properly configured and power is applied to the DMM101/201 it will reply with the firmware version (Normal and MFM modes only). Commands can then be entered as desired. The example below shows the reply from the CONFIG? command. It is recommended to confirm the configuration of the controller to make sure it matches the spindle and the expected running parameters.

![Serial Communications Interface](image)

Figure 8: Serial Communications Interface

If any of the configuration parameters are not correct reference the command list for the proper syntax and enter the correct value. Use the WRITE command to save the changes.
3.3 System Fault Monitoring Setup

In most cases the DMM101/201 will be paired with an air bearing spindle. Therefore an air switch monitoring the air pressure is required. The switch should be wired to the interlock pins of either the 25pin D or 20 pin header such that the controller will fault if the pressure falls below the minimum recommended value for the spindle.

The software enabled interlock pins of the 25pin D expect a N.O. (closed with adequate pressure) dry contact to ground through the pressure switch for normal operation. If the loop to ground in opened the controller will disable the amplifier output, set the fault line and send the appropriate error message via the serial port.

The DISFAULTS (i.e. disable faults) command word represents the bits that are DISABLED. See the figure below showing the DISFAULTS? command and bit layout where each group of four bits create the Hexadecimal word.

```
>DISFAULTS?
>DISFAULTS=ab8e
>Bearing Air = bit0
>Clamp Air   = bit1
>Main Air    = bit2
>Overspeed   = bit3
>Ampl Fault  = bit4
>NVM         = bit5
>I2C         = bit6
>Encoder     = bit7
>Motor temp. = bit8
>Motor temp. = bit9
>Logic Power = bit10
>Aux Fault1  = bit11
>Checksum    = bit12
>Halls       = bit13
>Reserved    = bit14
>GeneralFault= bit15
```

Figure 9: Fault Monitoring Setup – the DISFAULTS? command.

Unless otherwise specified the standard wiring configuration will use the “Bearing Fault” interlock (pin 18) of the 25pin D connector. The Overspeed fault is also normally active. The Clamp and Main Air faults are disabled. Therefore the first character in the Hex word is a 6.

Only bit 7 is disabled in the next 4 bit group. Therefore the second character is 8.

Bits 8, 9 & 11 are disabled. Therefore the third character is B.

Bits 13 and 15 are also disabled. Therefore the fourth character is A.

The complete command is DISFAULTS:AB86.

NOTE: All of the interlock options simply disable the amplifier motor outputs, activate the fault line and provide error messages over the RS232 port. If a spindle is running it will coast to a stop. The interlocks are not designed or intended for system power removal or otherwise required for a machine EMO condition.
The following commands can be entered over the serial interface and are not case sensitive. When a string of n’s (nnnnn) are shown a value would be entered by the user. The user interface does not care if more or less characters are entered. Leading “0’s” on numbers are not needed.

All of the commands are listed in alphabetical order. The underlined commands are specific to the DMM101/201.

**ACCEL:**nnnnn
Set this value to the desired acceleration rate in RPM/sec with a range from 1 to 20000 RPM/Sec.

**ACCEL?**
Replies with the currently set acceleration rate in RPM/sec

**ALARMRESET**
Resets faults in the controller.

**ANALOGIN**
Enables torque mode using the analog input. Sets **EXTEN**.

**ANALOGOUT**
Disables torque mode and returns to PLL control. Sets **INTEN**.

**ANALOGSCALE:**n
Used to scale the analog input to current output. Default is 1 for 1VDC = 1Amp. The range is 0 – 10.

**ANGLE:**nnn
Sets the motor commutation angle from 1 – 359 degrees.

**ATSPDLVL:**n
Sets the active state for the At Speed Output. Range is 0 or 1.

**ATSPD?**
Replies with YES if the spindle is running within the at speed range. Also see the **LOKDLY** and **ATSPDLVL** commands.

**CAP:**nn
Sets the Integral Limit while in phase lock. This command can be used to adjust how the spindle locks into a commanded velocity and or reacts to a small velocity change. Standard values are between 50 and 150.

**CCW**
Sets the commanded spindle direction to Counter-Clockwise. In ANALOGIN mode this command will set the spindle direction to CCW for a positive input voltage.

**CLAMP**
Activates the clamp output on the MCS Signal Connector (Pin 11).

**CLAMPRUN**
Activates the CLAMP output and starts the spindle with one command

NOTE: There is only a 35msec delay between the CLAMP and RUN command. If the Clamp Air Fault (See **DISFAULTS**) is active this dwell may not be enough time for the sensor to activate

**CLAMPLVL:**n
Used to set the logic state of the Clamp command when compared to the **SETOUTPUTS:**1 command. 0 will sink current with the CLAMP command. 1 will sink current with the UNCLCLAMP command.

Note that this is dependent on the I/O jumper configuration. See the schematics in this manual.

This command is active for units with FW 2.02.02 and above.
**COMMITATION?**  Replies with a 6 (Hall Mode) or a 7 (Encoder / Sine) representing the presently set commutation mode.

**CONFIG?**  Replies with a list representing the present controller configuration

- Drive parameters:
  - Speed: 5000
  - Torque: 100
  - Direction: CW
  - Acceleration: 5000
  - Acceleration: on
  - Top Speed: 25000
  - Stop Speed: 10
  - Frequency: internal
  - System Control: remote
  - Pole count: 8
  - Encoder Linecount: 1024
  - Commutation Type: 7
  - Angle: 0 Angle Offset: 0
  - Deceleration: 2000
  - Encoder Type: Differential
  - BNC Output: all
  - Feedback Divisor: 1

**CL**  Sets closed loop mode. (Only needed if OL is used for Open Loop).

**CONFIGURE**  Not used.

**CW**  Sets the commanded spindle direction to Clockwise. In ANALOGIN mode this command will set the spindle direction to CW for a positive input voltage.

**DECEL**:nnnnn  Set this value to the desired deceleration rate in RPM/sec with a range from 1 to 20000 RPM/Sec.

**DEFAULTS**  Sets the factory defaults for all parameters.

**DGAIN**:nnnn  Sets derivative gain for rough/acceleration control. Range is 0 to 65535

**DIR?**  Returns the actual motor direction as “CW” or “CCW”.
DISFAULTS?
Displays the DISFAULT value and lists the bit positions for each fault.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Fault</th>
<th>Bit</th>
<th>Fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Bearing</td>
<td>8</td>
<td>Amp Temp.</td>
</tr>
<tr>
<td>1</td>
<td>Clamp Air</td>
<td>9</td>
<td>Motor Temp.</td>
</tr>
<tr>
<td>2</td>
<td>Main Air</td>
<td>10</td>
<td>Logic Power</td>
</tr>
<tr>
<td>3</td>
<td>Overspeed</td>
<td>11</td>
<td>Aux Fault1</td>
</tr>
<tr>
<td>4</td>
<td>Amp Fault</td>
<td>12</td>
<td>Checksum</td>
</tr>
<tr>
<td>5</td>
<td>NVM</td>
<td>13</td>
<td>Halls</td>
</tr>
<tr>
<td>6</td>
<td>I2C</td>
<td>14</td>
<td>FollowError</td>
</tr>
<tr>
<td>7</td>
<td>Encoder</td>
<td>15</td>
<td>GeneralFault</td>
</tr>
</tbody>
</table>

DIS
Disables the amplifier (kills motor power). No deceleration is performed.

DISABLE
Same as DIS.

DISFAULTS:nnnn
Creates a bit mask for maskable faults within the controller. See DISFAULTS? for the bit definitions.

DUMPALL
Lists all commands in a format that can be copied and saved into a text file for a controller backup.

DUMP3
Emulates the MCS DUMP3 command.

EDIV:n
Divides the encoder input from the spindle into the PID. Does not change the encoder output signal or velocity reporting. Set to 1 for 512 or 1024 line encoders. Set to 4 for 2048 or 4096 line encoders. Slightly higher Fine Gains may be required when set to 4.

EN
Enables the motor and accelerates to the commanded speed set by the SPEED command. If the motor is not commutated, commutation is performed before accelerating based on the TYPE setting.

ENABLE
Same as EN.

ENABLE?
Returns the enabled state as either “ENABLED” or “DISABLED”.

ENCODERCOUNT:nnnnn
Set the encoder line count. Range is 500 to 16384.

ENCODERTYPE:n
Set the encoder electrical type as either “S” for single ended, or “D” for differential.

EXTEN
Configures the controller to use the external enable input.

EXIT
Not Used.

FAULT?
Display fault status, either “FAULT”, or “OK”.

FAULTS?
Lists any faults present in the controller, otherwise returns “No Faults”

FILTER:n
Enables (1) or disables (0) the frequency input filter. This will help the controller understand what velocity to settle on if the input has high jitter. Also see SD:n.

FPGAIN:nnnnn
Sets the fine mode proportional gain. Range is 0 to 65535.

FIGAIN:nnnnn
Sets the fine mode integral gain. Range is 0 to 65535.
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDGAIN:nnnn</td>
<td>Sets the fine mode derivative gain. Range is 0 to 65535.</td>
</tr>
<tr>
<td>FLEXTERNAL</td>
<td>Configures the controller for external frequency input. See MINSPDIN.</td>
</tr>
<tr>
<td>FLLINTERNAL</td>
<td>Configures the controller for internal frequency generation. See MINSPDOUT.</td>
</tr>
<tr>
<td>FLT?</td>
<td>Displays faults as a bit encoded binary word.</td>
</tr>
<tr>
<td>FLTA?</td>
<td>Displays faults as a bit encoded ASCII word.</td>
</tr>
<tr>
<td>FLTQREAD?</td>
<td>Not used.</td>
</tr>
<tr>
<td>FOLLOWERROR:n</td>
<td>Sets the allowable error limit between the desired and actual velocity.</td>
</tr>
<tr>
<td></td>
<td>The amplifier will disable and a fault message sent if the limit is exceeded.</td>
</tr>
<tr>
<td></td>
<td>The range is 0 to the TOPSPEED setting (20000 for example).</td>
</tr>
<tr>
<td>GAINS?</td>
<td>Lists the gain settings.</td>
</tr>
<tr>
<td>PGAIN: 3000</td>
<td></td>
</tr>
<tr>
<td>IGAIN: 3000</td>
<td></td>
</tr>
<tr>
<td>DGAIN: 0</td>
<td></td>
</tr>
<tr>
<td>FPGAIN: 3000</td>
<td></td>
</tr>
<tr>
<td>FIGAIN: 3000</td>
<td></td>
</tr>
<tr>
<td>FDGAIN: 0</td>
<td></td>
</tr>
<tr>
<td>PPGAIN: 50</td>
<td></td>
</tr>
<tr>
<td>PIGAIN: 100</td>
<td></td>
</tr>
<tr>
<td>PDGAIN: 100</td>
<td></td>
</tr>
<tr>
<td>INTLIMIT: 50000</td>
<td></td>
</tr>
<tr>
<td>GOTO:nnnn</td>
<td>Range = 0 thru encoder quadrature count (i.e. 2048 for a 512 line encoder).</td>
</tr>
<tr>
<td></td>
<td>Used to position the spindle within one revolution where GOTO:0 is the index</td>
</tr>
<tr>
<td></td>
<td>mark. Also see the STOPHOLD command.</td>
</tr>
<tr>
<td>GSCH:n</td>
<td>Gain Scheduling enable (1) or disable (0). With gain scheduling on the</td>
</tr>
<tr>
<td></td>
<td>proportional gain is reduced while under 7000RPM.</td>
</tr>
<tr>
<td>HALLS?</td>
<td>Returns the present hall state. Can be used for troubleshooting hall</td>
</tr>
<tr>
<td></td>
<td>connections.</td>
</tr>
<tr>
<td>HALLS:ccc</td>
<td>Used to set the hall relationship to the motor phases. Same as swapping the</td>
</tr>
<tr>
<td></td>
<td>hall wires. Example HALLS:ABC or HALLS:ACB.</td>
</tr>
<tr>
<td>HELP</td>
<td>Lists the available commands.</td>
</tr>
<tr>
<td>ID?</td>
<td>Not Used.</td>
</tr>
<tr>
<td>I?</td>
<td>Displays the present command current to the amplifier.</td>
</tr>
<tr>
<td>IGAIN</td>
<td>Sets integral gain for rough/acceleration control. Range is 0 to 65535.</td>
</tr>
</tbody>
</table>
INPUTS?

Returns a binary word (16 bits) that is bit encoded with the inputs states.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>AIR_2</td>
</tr>
<tr>
<td>1</td>
<td>AIR_3</td>
</tr>
<tr>
<td>2</td>
<td>AIR_1</td>
</tr>
<tr>
<td>3</td>
<td>DIRECTION</td>
</tr>
<tr>
<td>4</td>
<td>LA_AMP_FAULT</td>
</tr>
<tr>
<td>5</td>
<td>ENABLE</td>
</tr>
<tr>
<td>6</td>
<td>USER_1</td>
</tr>
<tr>
<td>7</td>
<td>USER_2</td>
</tr>
<tr>
<td>8</td>
<td>RESET_BUTTON</td>
</tr>
<tr>
<td>9</td>
<td>MOTOR_TEMP (AUX1)</td>
</tr>
<tr>
<td>10</td>
<td>MCS_SETUP</td>
</tr>
<tr>
<td>11-15 Reserved</td>
<td></td>
</tr>
</tbody>
</table>

INPUTS?

Returns an ASCII list of the input states as follows:
- AIR1=1
- AIR2=1
- AIR3=1
- DIRECTION=1
- ENABLE=1
- USER1=1
- USER2=1
- RESET=1
- AUX1=1
- SETUP=0

INTEN

Configures the controller for internal enable using EN, ENABLE or RUN commands.

INTLIMIT:nnnnnn

Integration gain limit. 0 – 500,000. Used to “shape” the initial current profile ramp during acceleration or deceleration. A lower value will “roll on” the current while a higher value will be more “snappy”.

LARESET

Resets the amplifier within the controller. This can be used to reset an amplifier fault without resetting the controller.

LAENABLE

Enables the amplifier within the controller.

LOKDLY?

Requests the present setting of LOKDLY.

LOKDLY:nnnnnn

Sets the delay time in msec for the “At Speed” output activation. The range is 0 – 30000, where each count represents 200usec.

M195?

Returns the present spindle velocity in RPM. Used to mimic a Dover Motion DMM.

MAXDELTA

In FLLEXTERNAL mode, this command sets how much of a change in input frequency is required before the controller will act upon the new frequency. Higher values allow the system to ignore small changes in frequency that can happen with older MG250 type clock generators. Range is 1 – 100.

MCS

Configures the controller to emulate an MCS LA-2000 over the serial interface. Note that the Baud rate is changed to 9600 following execution of the RESET command.

MFM:1

Automatically configures the parameters to make the DMM-101/201 work like a MFM BDC-610. Typing MFM:1 will change the following:
- FLLEXTERNAL  → External frequency IN mode
- REFNUM:8  → Frequency IN to spindle RPM ratio
- INTEN  → Enable is handles internally.
- MINSPDIN  → Auto enable the motor when a frequency is applied.
- HALLS:BAC  → Halls configuration matches the MFM controller at J10.
NOTE: The encoder count still needs to be set by the user.

**MINSPDIN**

In external frequency mode (**FLLEXTERNAL**), commands the motor to auto commutate and run when the frequency input is greater than the **STOPS** setting. The motor will disable when the frequency is below the **STOPS** setting.

**MINSPDOUT**

Disables the **MINSPDIN** function.

**NORMAL**

Returns the controller to the normal mode of serial operation. Note that the Baud rate is changed to 38400 following execution of the **RESET** command.

**NOSWAP**

Disables encoder channel swap.

**OFFSET:nnn**

Sets the commutation offset angle. Similar to **ANGLE**

**OL:nnnn**

Sets open loop mode and DAC voltage. Range is 0.000v to 5.000v

**OSPD:nnnnn**

Same as **OVERSPEED**.

**OVERSPEED:nnnnn**

Sets the speed in RPM for an overspeed fault condition. Range is 1 to 32767.

**P2=n**

Run (1) or Stop (0) the spindle.

**P3=n**

Sets the spindle direction to CW (0) or CCW (1).

**P4=n**

Sets the spindle velocity in RPM. \( P4=5400 \)

**P5=n**

Sets the spindle acceleration & deceleration rate in RPM/sec. \( P5=6000 \)

**PD:n**

Sets the “PD” (Phase Detect) value for the currently set speed. This is an internal PLL algorithm value that the user should not need to adjust.

**PD?**

Returns the present PD value for the current speed.

**PDCLEAR**

Clears all of the stored PD values forcing the default values to be used.

**PGAIN:nnnnn**

Sets proportional gain for rough/acceleration control. Range is 0 to 65535.

**POLES:nn**

Sets the number of mechanical motor poles.

**POLES?**

Responds with the **POLES** value.

**POS:nnnnnn**

Sets the encoder position counter within 1 revolution. Range is 0 to line count *4.

**POS?**

Returns the encoder position counter value.

**PPGAIN:nnnnn**

Sets the positioning mode proportional gain. Range is 0 to 65535. This setting is proportional to the **PGAIN**.

**PIGAIN:nnnnn**

Sets the positioning mode integral gain. Range is 0 to 65535. This setting is proportional to the **PGAIN**.

**PDGAIN:nnnnn**

Sets the positioning mode derivative gain. Range is 0 to 65535. This setting is proportional to the **PGAIN**.
POWERUPVA  Not Used.

RAMPIN  Enables the acceleration and deceleration ramping as set by the ACCEL, DECEL and JERK values.

RAMPOUT  Disables programmable ramping. Sets the ramps to 10000 RPM/Second.

READ  Reads the stored NVM values for all parameters.

READY?  Responds with “YES” when the controller is ready, “NO” otherwise.

REFNUM?  Requests the present setting of REFNUM.

REFNUM:nn  This value scales the external reference frequency when in MFM or FLLEXTERNAL modes. The range is 1 to 64.
• Reference Frequency = User Supplied \( F_n \) / (REFNUM/4).

Note that the REFNUM setting is scaled and reported in the CONFIG? listing as FEEDDIV to be consistent with the MCS reply. REFNUM:4 = FEEDDIV:1.

REFSEL:n  In FLLEXTERNAL mode, this command controls the source for the PLL clock, either from the internal DDS (1) or from the external clock (0). The software automatically switches to DDS mode when FLLINTERNAL is selected.

REF?  Returns the reference frequency in RPM.

RESET  Resets the controller.

RUN  Same as EN and ENABLE.

SD:n  Sets the Hysteresis for the FILTER command when FILTER:1. Range is 1 to 10.

SETOUTPUTS:n  Manually sets/resets the User outputs.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>User 1</td>
</tr>
<tr>
<td>1</td>
<td>User 2</td>
</tr>
</tbody>
</table>

Examples: To activate output 1 the command is SETOUTPUTS:1
To activate output 2 the command is SETOUTPUTS:2
To Activate outputs 1 & 2 the command is SETOUTPUTS:3

SPEED:nnnnn  Sets the commanded run speed in RPM. Range is 1 to 30000 RPM.

SPD:nnnnn  Same as SPEED.

SPEED?  Responds with the set SPEED value in RPM.

SPDAVG  N/A

SPD?  Responds with the actual speed of the motor in RPM.

STAT?  Responds with the system status flags in a 16 bit (two 8 bit word) binary format.

<table>
<thead>
<tr>
<th>MSB of First Word</th>
<th>MSB of Second Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Fault</td>
</tr>
<tr>
<td>14</td>
<td>Reserved</td>
</tr>
<tr>
<td>13</td>
<td>Direction 0=CW, 1=CCW</td>
</tr>
<tr>
<td>12</td>
<td>At Speed</td>
</tr>
</tbody>
</table>
### STATA?
Responds with the system status flags in ASCII format.

### STOP
If running, the controller decelerates the motor to 0 RPM.

### STOPHOLD
If running, the controller decelerates the motor to 0 RPM and goes into **Positioning Mode**. See the **GOTO** command.

### STOPS:nnnnn
Sets the minimum velocity (in RPM) that the servo will try to control the spindle. This parameter can be used to “tune” how the spindle settles to a stop on deceleration. Also see the **MINSPDIN** command.

### STOPUNCLAMP
Performs a STOP and UNCLAMP in sequence.

### SWAP
Internally swap encoder channels A and B.

### SWAP?
Returns “TRUE” if SWAP is enabled and “FALSE” if NOSWAP is enabled.

### TOPSPEED:nnnnn
Sets the maximum value for the **SPEED** and **STOPS** commands in RPM. The range is stop speed to 32767.

### TORQUE:nnn
Sets the maximum torque output as a percentage of full scale. Range is 0 to 100%.

### TORQ:nnn
Same as **TORQUE** command.

### TYPE:n
Set the commutation type as either “6” for Halls or “7” for encoder.

### TORQUE?
Returns the value of the **TORQUE** setting in %

### UNCLAMP
Clears the clamp output on the MCS Signal Connector (Pin 11). Note that this command is not allowed when the spindle in running.

### WRITE
Saves all of the parameter settings to non-volatile memory.

### ZERO?
Returns “YES” if the motor is at zero speed and “NO” otherwise.

### ZSPDLVL:n
Sets the Zero Speed output polarity when the spindle is at zero speed. 1 or 0.
DMM-101 / 201 Command Quick Reference:

### Setup Parameters

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENCODERCOUNT:xxxx</td>
<td>Set the quadrature encoder count</td>
</tr>
<tr>
<td>SPEED:xxxx (or P4=xxxx)</td>
<td>Set the speed in RPM</td>
</tr>
<tr>
<td>ACCEL:xxxx (or P5=xxxx)</td>
<td>Set the acceleration in RPM/sec</td>
</tr>
<tr>
<td>DECEL:xxxx</td>
<td>Set the deceleration in RPM/sec</td>
</tr>
<tr>
<td>CW (or P3=0)</td>
<td>Set clockwise rotation</td>
</tr>
<tr>
<td>CCW (or P3=1)</td>
<td>Set counterclockwise rotation</td>
</tr>
<tr>
<td>TYPE:x</td>
<td>Commutation Method</td>
</tr>
<tr>
<td>TOPSPEED:xxxx</td>
<td>Set the max allowable speed in RPM</td>
</tr>
<tr>
<td>OVERSPEED:xxxx</td>
<td>Set the max allowable speed in RPM fault limit</td>
</tr>
<tr>
<td>STOPS:xx</td>
<td>Set the stop and settle speed</td>
</tr>
</tbody>
</table>

### Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRITE</td>
<td>Save all settings</td>
</tr>
<tr>
<td>RUN (or P2=1)</td>
<td>Run the spindle</td>
</tr>
<tr>
<td>STOP (or P2=0)</td>
<td>Stop the spindle</td>
</tr>
<tr>
<td>CW or CCW</td>
<td>Change the direction of rotation</td>
</tr>
<tr>
<td>STOPHOLD</td>
<td>Stop Spindle and servo for a position move</td>
</tr>
<tr>
<td>GOTO: 0</td>
<td>Position spindle at encoder reference</td>
</tr>
<tr>
<td>RESET</td>
<td>Reset the DMM-101</td>
</tr>
</tbody>
</table>

### Status

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONFIG?</td>
<td>Lists the present setup values</td>
</tr>
<tr>
<td>DUMPALL</td>
<td>List all of the setup parameters</td>
</tr>
<tr>
<td>SPD?</td>
<td>List the present speed in RPM</td>
</tr>
<tr>
<td>DIR?</td>
<td>Show the present direction of rotation</td>
</tr>
<tr>
<td>FAULTS?</td>
<td>List any faults</td>
</tr>
<tr>
<td>GAINS?</td>
<td>List the present PID settings</td>
</tr>
<tr>
<td>POS?</td>
<td>Show the present encoder position</td>
</tr>
</tbody>
</table>
5  **PID Parameters:**

The PID (Proportional, Integral and Derivative) gains are user settable. Three separate PID loops are utilized for maximum flexibility and performance. See the GAINS? command.

The typical gains settings for a Dover Motion Revolution XL3 spindle with a single disk payload are shown below. In general the Coarse and Fine gains are the same.

Higher P and I gains may be required for a low torque motor, larger payload or snappy settling time for small RPM changes.

![PID Parameters Diagram](image)

**Figure 10:** PID Parameters

5.1  **Utilizing the Current Output Test Point**

The current output to the motor can be viewed in real time with an oscilloscope at J4 pin 10. The output is the peak of the three motor phases where 100mV = 1Amp.

This signal is helpful for optimizing PID settings, optimizing hall ANGLE or OFFSET or general troubleshooting.

The raw current command has a wide band therefore it is recommended to use the averaging function of the scope for a cleaner signal. The sweep time in the figure below is set to 1sec/division.

![Current Command Output](image)

**Figure 11:** Current Command Output

Acceleration to 10K RPM then deceleration to a stop
The Figures show the current output when the following serial commands are entered:

SPEED:1000
RUN
SPEED:5000
SPEED:10000
SPEED:15000

With each command the spindle accelerates and settles to velocity.

In Fig.12 the Integral Gains (IGAIN and FIGAIN) are set too low. It takes too long to “pull into” the commanded velocity. See the AT SPEED output, SPD? command or Index to Index time (as measured with an o-scope) to verify that the spindle has reached the commanded velocity.

**Figure 13** depicts the settling performance when the Integral gains are too high. The spikes at the end of acceleration suggests that the control loop is “snapping” the spindle into the velocity too hard.

The following plot depicts course PID gains that are set correctly. There is little overshoot at the end of each new velocity request.

**Figure 14:** Current output with the Coarse PID gains optimized.
5.2 Fine Gain Adjustments

The Fine PID gains adjust the control loop performance when Phase Locked to the commanded velocity. The previous method can be used to determine if the “At Speed” current is settled or unstable. An alternate and more accurate method of viewing the Velocity Stability of the spindle is to utilize the encoder index output signal (available on the ENC I Output BNC and the MFM signal connector). The scope is setup to trigger on the index signal. However, the following index signal is used for velocity stability evaluation. This is also known as the Index to Index Jitter. The averaging function of the o-scope should not be active for these tests.

![Image of scope output showing index to index jitter measurement](image.png)

**Figure 15:** Index to Index Jitter Measurement. Spindle running at 10000RPM (6msec / revolution)

The scope plot below shows the next index (after the triggered index) zoomed in to 20nsec / division. The o-scope’s persist function in utilized to track the index jitter (or change in velocity) over a 30 second period.

The % velocity stability can be calculated as follows:

\[
\text{Index-Index Jitter} \div \text{Time for one revolution} \times 100 = \% \text{Velocity Stability}
\]

\[
0.000000020 \text{sec} \div 0.006 \text{sec} \times 100 = 0.00033\%
\]

![Image of scope output showing index jitter of second index at 10000RPM](image.png)

**Figure 16:** Index Jitter of Second Index at 10000RPM
5.3 Positioning Mode Gain Adjustments

The DMM101 has a simple positioning mode function. See the STOPHOLD and GOTO commands. In this mode the PID gain settings determine the velocity and settling time.

**PPGAIN** (Positioning Proportional Gain) will increase the velocity of the move to a position.

**PIGAIN** (Positioning Integral Gain) will adjust how quickly the spindle pulls into the commanded position. Keep in mind that too much integral gain can cause an unstable condition that may be mistaken for too little dampening (Derivative Gain).

**PDGAIN** (Positioning Derivative Gain) will adjust the dampening of the position move.
6 Troubleshooting:

6.1 Amplifier Fault:

The linear amplifier in the DMM-101/201 has a sophisticated fault protection circuit to ensure the longevity of the power devices and spindle motor.

The LED display on the amplifier (viewable if the top cover is removed) shows the status of the amplifier. The Revision C DMM-101/201’s (square ventilation holes) will display this information over the serial port. Below is a list of the amplifier status commands.

0 - Amp ok, enabled
1 - DSP Fault – Set when the internal DSP checksum fails following reset
2 - NVM Fault – Set when NVM checksum fails following reset. Parameter defaults set.
3 - External +5vdc – Set when on board +5v supply for Halls is out of range
4 - Autobalance Fault – Set when autobalance can’t balance amplifier outputs
S - ABS Overcurrent – Set when instantaneous overcurrent condition is detected
6 - SOA – Set when Safe Operating Area protection detects an over power condition. The SOA monitors the voltage and current being applied through the amplifier power devices as well as the temperature of the heatsink.

A - 5 VDC Reference error – Set when internal +5 reference supply is out of range
β - Bus Over Voltage – Set when Bus voltage is greater than maximum allowed (75 Vdc)
C - Amp ok, not enabled (Clamped)
E - Hall Error – Set when hall sequence is invalid (0 or 7 value is read on hall inputs)
F - Fatal Error – Set if the DSP encounters an unidentified problem.
H - Amplifier Over Temp – Set when amplifier heat sink temperature is above 70 C.
h - Motor Over Temp – Set when motor temperature input is open
Λ - RMS Overcurrent – Set if the motor current level and time exceeds that allowed by the jumper settings.
U - Bus Under Voltage – Set when Bus voltage is less than the minimum allowed (10 Vdc)
u - Bias error – Set when Bias voltage input +/-15 is outside allowable range
χ - 2.5 Vdc Reference error – Set when internal 2.5vdc supply is out of range.
. - (decimal point) Indicates RMS Overcurrent trip pending (timer has started).
- - Upper bar (segment a) indicates +Limit is active
- - Lower bar (segment d) indicates –Limit is active

6.2 Amplifier Setup Commands:

The linear amplifier in the DMM-101/201 can be setup to allow current for a specific duration. The setup can be done with jumper shunts on the amplifier or (with FW 2.01.07 or later installed) via RS232 commands if all of the jumpers are removed. The commands are as follows:

LSLEVEL:n Low speed circuit breaker level, where n = 2,3,4, or 5 amps
LSTIME:n Low speed cb time, where n = 1.25, 2.50, 5.00 or 10.0 (seconds)
HSLEVEL:n High speed cb level, where n = 12, 15, 18, or 20 (amps)
BANDWIDTH:n Bandwidth selection, where n = 0 or 1. (0 = <0.21mH motor, 1 = <0.35mH motor)
DISABLESOA Disable the Safe Operating Area (SOA) protection.
ENABLESOA Enable the Safe Operating Area (SOA) protection.
LACONFIG? Shows the above settings for the amp (These are also included in the DUMPALL command to allow the automated file to capture the settings.)
6.3 Amplifier Output Balance Procedure

The amplifier’s motor outputs have been phase balanced from the factory and should not require adjustment. In the event that the output do need to be rebalanced the following steps will be required:

1. Remove the DMM-101/201 top cover to expose the LED display.
2. Apply power and establish communications.
3. Type: **INTEN** (Internal enable mode)
4. Type **EN** (Enable command). This will commutate and run the motor.
5. Type **STOP** to stop the motor.
6. Type: **DIS** to disable the output.
7. Type: **OL:0**; Open Loop with Zero Output command.
8. Slowly spin the spindle by hand and note if the motor is "cogging" at all.
9. Apply tape or hold the spindle so it can't move at all for the next step. Verify that it cannot move.
10. Type: **LA:B**. This commands the amplifier to balance the output phases
11. Wait for the display to go from “-” to “O”.
   - If the display flashes anything else then the “Auto-balance” failed.
12. Remove the tape and verify that the spindle rotates freely without cogging.
13. Type **RESET**.
14. Put cover back on.

DONE
Sales and Service

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