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BA-INTELLIDRIVE

USER'S MANUAL

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If you should have any questions about the BA-Intellidrive or comments regarding the documentation, please refer to Aerotech online at:
http://www.aerotech.com.

For your convenience, a product registration form is available at our web site.

Our web site is continually updated with new product information, free downloadable software and special pricing on selected products.

The BAI amplifier and BAI software are products of Aerotech, Inc.
Windows 95/NT are products of Microsoft Corporation.

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TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION 1-1

1.1. Product Overview 1-1
1.2. Indexer 1-2
1.2.1. Teach Mode 1-4
1.2.2. Clock and Direction 1-6
1.3. BAI DOS Software 1-6
1.4. Hardware Overview and Function 1-7
1.4.1. Motor and AC Power Connections 1-8
1.4.1.1. BAI 10/20/30 1-8
1.4.1.2. BAI 50/75/100 1-9
1.4.2. Fusing and Inrush Limiting 1-10
1.4.2.1. BAI 10/20/30 1-10
1.4.2.2. BAI 50/75/100 1-11
1.4.3. 20 - 80 Volt Option – BAI 10/20/30 1-12
1.4.4. COM Port 1-13
1.4.5. RS232 Daisy Chain Configuration 1-13
1.4.6. LED Status Indicators 1-14
1.4.7. The I/O Port (P1) 1-14
1.4.8. Encoder/Limits/Hall Effects Port (P3) 1-15
1.5. Safety Procedures and Warnings 1-17

CHAPTER 2: GETTING STARTED 2-1

2.1. Introduction 2-1
2.2. Unpacking the BA-Intellidrive 2-2
2.3. Minimum Hardware Requirements and Recommended System Configurations 2-2
2.4. Inspection of the BAI 2-3
2.5. Physical Setup of the Motion Controller 2-3
2.5.1. BAI Cable Connections 2-4
2.5.2. Local Mode 2-4
2.5.3. Standard Installation of the Software 2-5
2.5.3.1. Writing a Short BAI Program 2-7
2.5.3.2. BAI Windows Software Interface 2-11
2.5.3.3. BAI MMI Windows Software Installation 2-13
2.6. Parameters Screen - BAI MMI 2-17
2.7. Axis Scope Tuning Window 2-19
2.7.1. Tuning Procedure for Servo Loops 2-21
2.8. Autotuning 2-29
2.9. Tuning Tips 2-33

CHAPTER 3: COMMUNICATION AND COMMANDS 3-1

3.1. Introduction 3-1
3.2. BAI Communications Modes 3-1
3.2.1. Local Mode 3-1
3.2.2. Remote Mode 3-2
3.2.2.1. Enabling RS232 Remote Communications 3-2
3.2.2.2. Daisy Chain 3-3
3.3. Menu Commands 3-4

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3.3.1. C-Change Parameter 3-4
3.3.2. D-Display Tracking Information 3-6
3.3.3. O-Other Menus 3-7
3.3.3.1. Running a Program 3-7
3.3.3.2. Read Register 3-8
3.3.3.3. Read/Write Parameter 3-8
3.3.3.4. Display Error Message 3-8
3.3.4. F-File Operations 3-9
3.3.5. F1- Abort Entry/Up One Menu Level 3-9
3.3.6. F2/F3 - Previous/Next Menu 3-9
3.3.7. F5 – Aborts Motion and Programs 3-10
3.3.8. I – Enter Motion Command 3-10
3.3.9. S – Save Parameters to Flash 3-10
3.3.10. T-Teach Mode 3-11
3.3.11. Space Bar 3-12
3.4. BAI System Commands 3-13
3.4.1. Program/Motion Abort 3-14
3.4.2. Program Execution 3-14
3.4.3. DF Delete File 3-14
3.4.4. File Transfers – Download File to PC 3-14
3.4.5. Format 3-15
3.4.6. Get Message Command 3-15
3.4.7. HOLD/TRIGGER/CANCEL 3-15
3.4.8. Execute Immediate Command 3-16
3.4.9. Print Directory 3-16
3.4.10. Return Error Message String 3-16
3.4.11. Print Program "file" to Port 3-17
3.4.12. Print Status 3-17
3.4.13. Return Axis Position 3-18
3.4.14. Serial Poll command 3-18
3.4.15. Hardware Reset 3-19
3.4.16. Parameter Editing 3-19
3.4.17. Read/Write Register 3-20
3.4.18. Save Program/Parameters to Flash Memory 3-20
3.4.19. Service Request Mode (SRQ) 3-20
3.4.20. File Transfers – Upload File to BAI 3-21
3.4.21. ; Comment 3-22
3.5. BAI Motion and Program Commands 3-23
3.5.1. Acceleration Command 3-24
3.5.2. Clear Limit 3-24
3.5.3. Conditional Gosub 3-24
3.5.4. Conditional Goto 3-24
3.5.5. Disable Amplifier 3-25
3.5.6. Dwell Command 3-25
3.5.7. Enable Amplifier 3-25
3.5.8. Fault Acknowledge 3-25
3.5.9. Freerun 3-26
3.5.10. Gain Command 3-26
3.5.11. Gosub Command 3-27
3.5.12. Goto Command 3-27
3.5.13. Home Command 3-27

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3.5.14. Index Command 3-28
3.5.15. IT Command 3-29
3.5.16. Label – Define a Label 3-29
3.5.17. Load Position Register 3-29
3.5.18. Loop Start and Loop End 3-30
3.5.19. Motor Commutate 3-30
3.5.20. Change opto-isolated outputs 3-30
3.5.21. Print Message 3-30
3.5.22. Position Mode – Absolute or Incremental 3-31
3.5.23. Program Stop 3-31
3.5.24. Ramp Time 3-31
3.5.25. Register Functions 3-32
3.5.26. Run the teach program 3-32
3.5.27. Return from subroutine 3-32
3.5.28. WM/WA – Wait Move 3-32
3.6. Teach Mode 3-33
3.6.1. Using the Teach Program 3-33
3.6.1.1. +/- Increment/Decrement Current Position 3-34
3.6.1.2. F2/F3 Next/Previous Index 3-34
3.6.1.3. 1,2,3 Learn the Current Position/Feedrate/Bit Pattern 3-34
3.6.1.4. I-Change the Index 3-35
3.6.1.5. Z-Zero the Teach Program 3-35
3.6.1.6. S-Save the Teach Program 3-35
3.7. Sample Programs 3-36

CHAPTER 4: PARAMETERS 4-1

4.1. Introduction 4-1
4.2. Servo Loop Parameters 4-4
4.2.1. PRM:0 Proportional Velocity Gain KP 4-5
4.2.2. PRM:1 Integral Velocity Gain KI 4-5
4.2.3. PRM:2 Proportional Position Gain KPOS 4-5
4.2.4. PRM:3 Incremental Change for KP 4-6
4.2.5. PRM:4 Incremental Change for KI 4-6
4.2.6. PRM:5 Incremental Change for KPOS 4-7
4.2.7. PRM:6 Servo "In Position" Tolerance 4-7
4.2.8. PRM:7 Servo Peak Current Limit 4-8
4.2.9. PRM:8 Servo RMS Limit 4-8
4.2.10. PRM:9 Servo RMS Current Timeout 4-9
4.2.11. PRM:10 Servo Velocity Trap 4-9
4.2.12. PRM:11 Integral Clamp 4-10
4.2.13. PRM:12 Position Error Trap 4-10
4.2.14. PRM:13 Servo Update Rate 4-11
4.2.15. PRM:14 Encoder Resolution 4-11
4.2.16. PRM:15 Electrical Cycles/Mechanical Revolution 4-12
4.2.17. PRM:16 Hall Effects Available 4-13
4.2.18. PRM:17 Initialization Current 4-13
4.2.19. PRM:18 Velocity Feedforward VFF 4-14
4.2.20. PRM:20 Operating Mode 4-14
4.2.21. PRM:22 Position Save 4-15
4.2.22. PRM:23 Reload Saved Position on Power-Up 4-15

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4.2.23. PRM:24 Saved Position 4-16
4.2.24. PRM:26 Low Pass Filter 4-16
4.2.25. PRM:27 Phase Offset 4-17
4.2.26. PRM:29 Input Command Offset 4-17
4.2.27. PRM:30 Default Velocity 4-18
4.2.28. PRM:31 Jog Value 4-18
4.2.29. PRM:32 In Position Bit 4-19
4.2.30. PRM:33 Dead Band Wait Time 4-19
4.2.31. PRM:34 Thermistor Polarity 4-19
4.2.32. PRM:36 Position Mode 4-20
4.2.33. PRM:37 Estop Action 4-21
4.2.34. PRM:38,39 Current Offset Adjustment 4-21
4.2.35. PRM:40 Registration Input 4-21
4.2.36. PRM:41 Encoder Scale Factor 4-22
4.2.37. PRM:42 I/O Read Time Delay 4-22
4.2.38. PRM:43 Trajectory Type 4-23
4.2.39. PRM:44 Encoder Fault Enable 4-23
4.2.40. PRM:45 Estop Polarity 4-23
4.2.41. PRM:46 Send ACK after move completes 4-24
4.2.42. PRM:47 In Position Output Polarity 4-24
4.2.43. PRM:52 RMS Method 4-24
4.3. Limit Parameters 4-25
4.3.1. PRM:60 Limit Check 4-25
4.3.2. PRM:61 Limit Type 4-25
4.3.3. PRM:62 Home Direction 4-25
4.3.4. PRM:63 Home Type 4-26
4.3.5. PRM:64 Home Velocity 4-26
4.3.6. PRM:65 Home Ending Offset 4-26
4.3.7. PRM:66 Home Marker Velocity 4-27
4.3.8. PRM:67 Negative Software Limit 4-27
4.3.9. PRM:68 Positive Software Limit 4-27
4.3.10. PRM:69 Deceleration Distance 4-28
4.3.11. PRM:70 +/- Limit Reset Distance 4-28
4.3.12. PRM:71 Check Move Against Software Limits 4-28
4.3.13. PRM:72 Marker Type 4-29
4.3.14. PRM:73 Offset to Marker 4-29
4.3.15. PRM:74 Program Execution 4-29
4.3.16. PRM:75 Home Velocity Out 4-30
4.3.17. PRM:76 Marker Polarity 4-30
4.3.18. PRM:77 Output Disable 4-30
4.4. Communications/Startup Parameters 4-31
4.4.1. PRM:90 Baud Rate 4-31
4.4.2. PRM:91 Service Request (SRQ) Character 4-31
4.4.3. PRM:92 Displayable Digits 4-31
4.4.4. PRM:94 Unit Address 4-32
4.4.5. PRM:95 Enable/Disable Daisy Chain - Places in Remote Mode 4-32
4.4.6. PRM:96 Autorun Program on Power-Up 4-32
4.4.7. PRM:97 Bootup Program Name 4-33
4.4.8. PRM:98 Status on Power-Up 4-33
4.4.9. PRM:99 External Enable Polarity 4-33

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4.4.10. PRM:100 Display Type 4-34
4.4.11. PRM:101 General Fault Output 4-34
4.4.12. PRM:102 Fault Output Polarity 4-34
4.5. Miscellaneous 4-35
4.5.1. PRM:200 Position Scale Factor 4-35
4.5.2. PRM:201 Default Ramp Time 4-35
4.5.3. PRM:202 Filter Cutoff 4-35
4.5.4. PRM:204 Autotune Distance 4-36
4.5.5. PRM:205 Autotune Velocity Loop Bandwidth 4-36
4.5.6. PRM:206 Autotune Damping Factor 4-37
4.5.7. PRM:207 Start Frequency 4-37
4.5.8. PRM:208 Autotune Sampling Time 4-37
4.5.9. PRM:209 Clock/Direction Multiplier 4-38
4.5.10. PRM:210 Acceleration 4-38

CHAPTER 5: REGISTERS 5-1

5.1. Introduction 5-1
5.1.1. RG1 Program Bytes Remaining 5-1
5.1.2. RG2 BAI Status 5-1
5.1.3. RG3 Position Feedback 5-2
5.1.4. RG4 Velocity Feedback 5-2
5.1.5. RG5 Position Command 5-2
5.1.6. RG6 Position Error 5-2
5.1.7. RG7 Current Command 5-2
5.1.8. RG8 Firmware Version 5-2
5.1.9. RG9 Velocity Command 5-3
5.1.10. RG12 A/D Input 5-3
5.1.11. RG14, RG15 Timers 5-3

CHAPTER 6: MODE OF OPERATION 6-1

6.1. Introduction 6-1
6.2. Modes of Operation 6-1
6.3. Indexing Mode 6-1
6.4. Clock and Direction 6-3

CHAPTER 7: TECHNICAL DETAILS 7-1

7.1. Introduction 7-1
7.2. BAI Control Board Jumper Selections 7-1
7.3. The I/O Port 7-2
7.3.1. Restore/Reset Signal 7-3
7.3.2. Clock/Direction Inputs Signals 7-3
7.3.3. Estop Input Signal 7-3
7.3.4. Thermistor Input Signal 7-4
7.3.5. Analog Inputs 7-4
7.3.6. Opto-Isolated Inputs 7-4
7.3.7. Opto-Isolated Outputs 7-5
7.4. Encoder/Limits/Hall Effects Port P3 7-7
7.4.1. Encoder Interface 7-8
7.4.2. Limits Interface 7-8
7.4.3. Hall Effect Interface 7-9
7.5. Servo Amplifier Specifications 7-13

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7.6. AC Input and Motor Wiring 7-15
7.6.1. Minimizing EMI Interference 7-15
7.6.2. Minimizing 50/60 HZ Line Interference 7-17
7.7. BAI Amplifier Dimensions 7-19
7.7.1. Mounting Procedures for the BAI 10/20/30/50 7-21
7.7.2. Mounting Procedures for the BAI 75/100 7-23

CHAPTER 8: TROUBLESHOOTING 8-1

8.1. Amplifier Related Problems 8-1

APPENDIX A: GLOSSARY OF TERMS A-1

APPENDIX B: WARRANTY AND FIELD SERVICE B-1

INDEX

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LIST OF FIGURES

Figure 1-1. BA-Intellidrive Amplifiers 1-1
Figure 1-2. BAI Indexer/Positioner Mode 1-2
Figure 1-3. Illustration of Local and Remote Mode 1-3
Figure 1-4. Teach Mode (using DOS-based COM_BAI) 1-4
Figure 1-5. Teach Mode (using BAI MMI) 1-5
Figure 1-6. Teach Mode (using a Hand Held Terminal) 1-5
Figure 1-7. Operating Mode (Clock and Direction) 1-6
Figure 1-8. BA-Intellidrive Hardware – 10/20/30 A Models 1-7
Figure 1-9. BA-Intellidrive Hardware – 50/75/100 Models 1-7
Figure 1-10. Motor and AC Power Connections – 10/20/30 Models 1-8
Figure 1-11. Motor and AC Power Connections – 50/75/100 Models 1-9
Figure 1-12. Fuse and Inrush Limiting – 10/20/30 Models 1-10
Figure 1-13. AC Input Fusing – 50/75/100 Models 1-11
Figure 1-14. 20 – 80V Option 1-12
Figure 1-15. RS232 Daisy Chain 1-14

Figure 2-1. Physical Setup of the BAI and Aerotech Motors (Application 1) 2-3
Figure 2-2. Remote Mode Configuration 2-4
Figure 2-3. Local Mode Configuration 2-4
Figure 2-4. RS-232 Connection 2-5
Figure 2-5. BAI Display Window 2-6
Figure 2-6. BAI Resetting Window 2-6
Figure 2-7. Enter Immediate Command Screen 2-7
Figure 2-8. DOS Editor Screen 2-7
Figure 2-9. File Operations Screen 2-8
Figure 2-10. File and Parameters Transfer Screen 2-8
Figure 2-11. File Upload Screen 2-9
Figure 2-12. Other Menu Options Screen 2-9
Figure 2-13. Auto Run/Block Run Option Screen 2-10
Figure 2-14. Enter File Screen 2-10
Figure 2-15. Main Screen 2-11
Figure 2-16. Programs Window 2-12
Figure 2-17. Parameters Screen 2-12
Figure 2-18. MMI Main Screen 2-13
Figure 2-19. MMI Text Editor Window 2-14
Figure 2-20. File Transfer Window (MMI) 2-14
Figure 2-21. Main Screen (Run Mode) 2-15
Figure 2-22. Display Code (Main Screen) 2-16
Figure 2-23. Parameters Screen (BAI MMI) 2-17
Figure 2-24. Motor Profiles Selection (Parameter Screen) 2-18
Figure 2-25. Axis Scope Window (BAI MMI) 2-19
Figure 2-26. Axis Scope Toolbars 2-20
Figure 2-27. Cursors Toolbar (Axis Scope Screen) 2-21
Figure 2-28. Flowchart of Overall Tuning Process 2-22
Figure 2-29. Maximize Button on the Axis Scope Window 2-23
Figure 2-30. Unacceptable Velocity Error 2-25
Figure 2-31. Acceptable Velocity Error (When Adjusting Kp) 2-25
Figure 2-32. Unacceptable Position Error (When Adjusting Ki) 2-26
Figure 2-33. Plot Showing an Appropriate Value for Kpos 2-27

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Figure 2-34. Plot Showing Overall Effects When Kpos is High 2-28
Figure 2-35. The "Gains" and "Auto Tune" Toolbars..... 2-29
Figure 2-36. Autotune Plot where "Dist" Has Been Set Too Low 2-30
Figure 2-37. Autotune Plot where "Dist" Has Been Set Too High..... 2-31
Figure 2-38. Autotune Plot Showing Proper Calibration 2-32
Figure 2-39. Tuning Plot of an AC Brushless Motor 2-33

Figure 3-1. Tracking Screen..... 3-1
Figure 3-2. The Change Parameter Screen..... 3-5
Figure 3-3. Example of Changing a Parameter in the Change Parameter Screen 3-5
Figure 3-4. Display Tracking Screen..... 3-6
Figure 3-5. Other Menu Options 3-7
Figure 3-6. Auto Run/ Block Run Option Screen..... 3-7
Figure 3-7. Read Register Screen..... 3-8
Figure 3-8. File Operation Screen 3-9
Figure 3-9. Enter Immediate Command Screen 3-10
Figure 3-10. Teach Mode (using DOS-based COM_BAI)..... 3-11
Figure 3-11. Teach Mode (using BAI MMI)..... 3-12
Figure 3-12. Teach Mode screen (COM_BAI.exe)..... 3-12
Figure 3-13. Parameters Affecting the Home Cycle..... 3-28
Figure 3-14. Teach Mode Screen 3-33
Figure 3-15. Teach Screen for Position "0" (Showing Current Position and Teach, POS, VEL, and I/O Pattern)..... 3-34
Figure 3-16. Teach Screen for Position "0" (Showing Current Position and Teach, POS, VEL, and I/O Pattern)..... 3-35

Figure 4-1. PID Control Loop 4-4
Figure 4-2. Thermistor Input Circuit 4-20

Figure 6-1. Trapezoidal Motion Profile 6-2
Figure 6-2. Sinusoidal Motion Profile (S-curve)..... 6-2

Figure 7-1. BAI Jumper Locations..... 7-2
Figure 7-2. Clock/Direction Input Circuit 7-3
Figure 7-3. Over Temperature Circuitry..... 7-4
Figure 7-4. Electrical Characteristics of Opto-Isolated Input..... 7-5
Figure 7-5. Electrical Characteristics of Opto-Isolated Output 7-6
Figure 7-6. CW Motor Rotation (Viewed from the Mounting Flange End) 7-8
Figure 7-7. Limit Switch Input Circuit 7-8
Figure 7-8. Hall Effect Input Circuit 7-9
Figure 7-9. Hall Effect Motor Phasing 7-10
Figure 7-10. Motor Rotation (From Mounting Flange End)..... 7-10
Figure 7-11. Motor Phase Voltage Observation Scheme 7-12
Figure 7-12. Encoder Phase Voltage Observation Scheme 7-12
Figure 7-13. Wiring to Minimize EMI and Capacitive Coupling..... 7-16
Figure 7-14. Wiring to Minimize EMI and Capacitive Coupling (BAI 50) 7-16
Figure 7-15. Back-Propagation Line Filter Connection 7-17
Figure 7-16. Isolation Transformer Connection (eliminates torque disturbance) 7-18
Figure 7-17. BAI Amplifier Dimensions – 10/20/30..... 7-19

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Figure 7-18. BAI Amplifier Dimensions – 50/75/100 7-20
Figure 7-19. BAI Side View (10/20/30/50) 7-21
Figure 7-20. BAI Top View (Preferred Mounting – 10/20/30/50) 7-22
Figure 7-21. Preferred Mounting of BAI Amplifiers (10/20/30/50) 7-23
Figure 7-22. Preferred Mounting - 75/100 7-24
Figure 7-23. BAI Side View (75/100) 7-25
Figure 7-24. BAI Top View (75/100) 7-25

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LIST OF TABLES

Table 1-1. COM Port Pinouts 1-13
Table 1-2. I/O Connector Pinouts (P1) 1-15
Table 1-3. Pinouts for the Encoder/Limits/Hall Effects Port (P3) 1-16

Table 2-1. Minimum Hardware Requirements and Recommendations 2-2
Table 2-2. Initial Servo Parameter Values 2-23

Table 3-1. Bit Patterns 3-6
Table 3-2. System Commands 3-13
Table 3-3. BAI File Transfers Transmit Sequence 3-14
Table 3-4. Hold/Trigger/Cancel Variables 3-15
Table 3-5. Bit Definitions for the PS Print Status Command 3-17
Table 3-6. Return Axis Position Type Variables 3-18
Table 3-7. Return Axis Position Type Variables 3-18
Table 3-8. SRQ Service Request Variables 3-20
Table 3-9. BAI File Transfer Receive Sequence 3-21
Table 3-10. Motion Commands 3-23

Table 4-1. BAI Parameters 4-1
Table 4-2. Settings for Proportional Velocity Gain PRM:0 4-5
Table 4-3. Settings for Integral Velocity Gain PRM:1 4-5
Table 4-4. Settings for Proportional Position Gain PRM:2 4-5
Table 4-5. Settings for Incremental Change for KP PRM:3 4-6
Table 4-6. Settings for Incremental Change for KI PRM:4 4-6
Table 4-7. Settings for Incremental Change for KPOS PRM:5 4-7
Table 4-8. Settings for Servo "In Position" Tolerance PRM:6 4-7
Table 4-9. Settings for Servo Peak Current Limit PRM:7 4-8
Table 4-10. Settings for Servo RMS Limit PRM:8 4-8
Table 4-11. Settings for Servo RMS Current Timeout PRM:9 4-9
Table 4-12. Settings for Servo Velocity Trap PRM:10 4-9
Table 4-13. Settings for Integral Clamp PRM:11 4-10
Table 4-14. Settings for Position Error PRM:12 4-10
Table 4-15. Settings for Servo Update Rate PRM:13 4-11
Table 4-16. Values for Parameter PRM:14 4-12
Table 4-17. Settings for Encoder Resolution PRM:14 4-12
Table 4-18. Settings for Electrical Cycles/Mechanical Revolution PRM:15 4-12
Table 4-19. Settings for Hall Effects Available PRM:16 4-13
Table 4-20. Settings for Initialization Current PRM:17 4-14
Table 4-21. Settings for VFF – Velocity Feedforward PRM:18 4-14
Table 4-22. Operating Modes PRM:20 4-14
Table 4-23. Settings for Operating Mode PRM:20 4-15
Table 4-24. Settings for Position Save PRM:22 4-15
Table 4-25. Settings for PRM:23 4-15
Table 4-26. Settings for Saved Position PRM:24 4-16
Table 4-27. Settings for Low Pass Filter PRM:26 4-16
Table 4-28. Settings for Phase Offset PRM:27 4-17
Table 4-29. Settings for Input Command Offset PRM:29 4-17
Table 4-30. Settings for Default Velocity PRM:30 4-18
Table 4-31. Settings for Jog Value PRM:31 4-18

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Table 4-32. Settings for In Position Bit PRM:32 4-19
Table 4-33. Settings for Dead Band Wait Time PRM:33 4-19
Table 4-34. Settings for Thermistor Polarity PRM:34 4-20
Table 4-35. Settings for Position Mode PRM:36 4-20
Table 4-36. Settings for Estop Action PRM:37 4-21
Table 4-37. Settings for Current Offset Adjustment PRM:38, PRM:39 4-21
Table 4-38. Settings for Registration Input PRM:40 4-21
Table 4-39. Settings for Encoder Scale Factor PRM:41 4-22
Table 4-40. Settings for I/O Read Time Delay PRM:42 4-22
Table 4-41. Settings for Trajectory Type PRM:43 4-23
Table 4-42. Settings for Encoder Fault Enable PRM:44 4-23
Table 4-43. Settings for Estop Polarity PRM:45 4-23
Table 4-44. Settings for Send ACK after move completes PRM:46 4-24
Table 4-45. Settings for In Position Output Polarity PRM:47 4-24
Table 4-46. Settings for RMS Method PRM:52 4-24
Table 4-47. Settings for Limit Check PRM:60 4-25
Table 4-48. Settings for Limit Type PRM:61 4-25
Table 4-49. Settings for Home Direction PRM:62 4-25
Table 4-50. Settings for Home Type PRM:63 4-26
Table 4-51. Settings for Home Velocity PRM:64 4-26
Table 4-52. Settings for Home Ending Offset PRM:65 4-26
Table 4-53. Settings for Home Marker Velocity PRM:66 4-27
Table 4-54. Settings for Negative Software Limit PRM:67 4-27
Table 4-55. Settings for Positive Software Limit PRM:68 4-27
Table 4-56. Settings for Deceleration Distance PRM:69 4-28
Table 4-57. Settings for +/- Limit Reset Distance PRM:70 4-28
Table 4-58. Settings for Check Move Against Software Limits PRM:71 4-28
Table 4-59. Settings for Marker Type PRM:72 4-29
Table 4-60. Settings for Offset to Marker PRM:73 4-29
Table 4-61. Settings for Program Execution PRM:74 4-29
Table 4-62. Settings for Home Velocity Out PRM:75 4-30
Table 4-63. Settings for Marker Polarity PRM:76 4-30
Table 4-64. Settings for Output Disable PRM:77 4-30
Table 4-65. Settings for Baud Rate PRM:90 4-31
Table 4-66. Settings for Service Request Character PRM:91 4-31
Table 4-67. Settings for Displayable Digits PRM:92 4-31
Table 4-68. Settings for Unit Address PRM:94 4-32
Table 4-69. Settings for Enable/Disable Daisy Chain PRM:95 4-32
Table 4-70. Settings for Autorun Program PRM:96 4-32
Table 4-71. Settings for Bootup Program Name PRM:97 4-33
Table 4-72. Settings for Amplifier Status on Power-Up PRM:98 4-33
Table 4-73. Settings for External Enable Polarity PRM:99 4-33
Table 4-74. Settings for Display Type PRM:100 4-34
Table 4-75. Settings for General Fault Output PRM:101 4-34
Table 4-76. Settings for PRM:102 4-34
Table 4-77. Settings for Position Scale Factor PRM:200 4-35
Table 4-78. Settings for Default Ramp Time PRM:201 4-35
Table 4-79. Settings for Filter Cutoff PRM:202 4-35
Table 4-80. Settings for Autotune Distance PRM:204 4-36
Table 4-81. Settings for Autotune Velocity Loop Bandwidth PRM:205 4-36
Table 4-82. Settings for Autotune Damping Factor PRM:206 4-37

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Table 4-83. Settings for Start Frequency PRM:207 4-37
Table 4-84. Settings for Autotune Sampling Time PRM:208 4-37
Table 4-85. Settings for Clock/Direction Multiplier PRM:209 4-38
Table 4-86. Settings for Acceleration 4-38

Table 7-1. BAI Board Jumper Selections 7-1
Table 7-2. I/O Connector Pinouts (P1) 7-2
Table 7-3. Pinouts for the Encoder/Limits/Hall Effects Port (P3) 7-7
Table 7-4. Electrical Specifications for BAI 10/20/30 7-13
Table 7-5. Electrical Specifications for BAI 50/75/100 7-14

Table 8-1. Amplifier Faults, Causes, and Solutions 8-1

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DECLARATION OF CONFORMITY

Manufacturer's Name and Address

Aerotech, Inc.
101 Zeta Drive
Pittsburgh, PA 15238-2897

Declares that the product:

Product Name: BA Intellidrive/BA Sinedrive

Conforms to the following product specifications:

EMC: EN 55011: Class B Emissions
EN 50082-1: Immunity
EN61000-4-2
EN61000-4-3
EN61000-4-4
EN61000-4-11
EN50141
LVD: IEC 204-1

and complies with EMC directive 89/336/EEC.

Pittsburgh, PA
October 8, 1998

David F. Kincel
Quality Assurance Manager

Robert Novotnak
Engineer Verifying Compliance

General notes concerning the test setup.

This product was tested at Compliance Labs, Middlefield, OH on October 8, 1998.

The brushless amplifier was tested with a brushless servo motor. To ensure that the product passes the conducted emissions tests, a line filter and common mode choke must be connected to the main inputs. The filter is a Schaffner FN 2070-10-06 and the common mode choke is a Renco Electronics RL-1329-1200. Ferrite must be added to each line of the main inputs but not earth ground. In order for the product to conform to the radiated emission standards, the motor cable must be shielded and the shield must be tied to the earth ground. Ferrite must also be added (in common mode) to the motor cable but not around the shield. Finally, a metal 25-pin connector with a metal backshell must be used when making a connection to the 25-pin receptacle on the amplifier. The shield of the feedback cable must be tied to the metal backshell. Failure to follow the described procedures may cause the amplifier/motor to exceed emission limits.

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PREFACE

This section gives you an overview of topics covered in each of the sections of this manual as well as conventions used in this manual. This manual contains information on the following topics:

CHAPTER 1: INTRODUCTION

This chapter contains an introduction to the hardware and software architecture of the BA-Intellidrive.

CHAPTER 2: GETTING STARTED

Chapter 2 contains information about the components of the BAI, unpacking and inspecting the equipment, and minimum hardware and software requirements for proper operation. In addition, Chapter 2 walks the user through physically setting up the BAI, connecting the signal cables, installing the software, and using the software (COM_BAI.exe and MMI) for simple motion applications.

CHAPTER 3: COMMUNICATION AND COMMANDS

This chapter covers information regarding the communication modes, the COM_BAI menu commands, and the programming commands.

CHAPTER 4: PARAMETERS

Chapter 4 describes the various parameters used on the BAI.

CHAPTER 5: REGISTERS

This chapter contains information about the registers on the BAI that allow the user to read various operating parameters.

CHAPTER 6: MODE OF OPERATION

This chapter contains all information regarding the BAI's modes of operation.

CHAPTER 7: TECHNICAL DETAILS

Contained in Chapter 7 is detailed technical information regarding the BA-Intellidrive.

CHAPTER 8: TROUBLESHOOTING

Chapter 8 provides a reference tool if problems with the BA-Intellidrive arise.

APPENDIX A: GLOSSARY OF TERMS

Appendix A contains a list of terminology and abbreviations used in this manual.

APPENDIX B: WARRANTY AND FIELD SERVICE

Appendix B contains the warranty and field service policy for Aerotech products.

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INDEX

The index contains a page number reference of topics discussed in this manual. Locator page references in the index contain the chapter number (or appendix letter) followed by the page number of the reference.

CUSTOMER SURVEY FORM

A customer survey form is included at the end of this manual for the reader's comments and suggestions about this manual. Readers are encouraged to critique the manual and offer their feedback by completing the form and either mailing or faxing it to Aerotech.

Throughout this manual the following conventions are used:

- The terms BA-Intellidrive and BAI are used interchangeably throughout this manual.
- The text <ENTER> is used to indicate that the Enter/Return key on the keyboard is to be pressed.
- Hexadecimal numbers are listed using a preceding "0x" (for example, 0x300, 0x12F, 0x01EA, etc.,) to distinguish them from decimal numbers
- Graphic icons or keywords may appear in the outer margins to provide visual references of key features, components, operations or notes.
- This manual uses the symbol "∇ ∇ ∇" to indicate the end of a chapter.

Although every effort has been made to ensure consistency, subtle differences may exist between the illustrations in this manual and the component and/or software screens that they represent.

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CHAPTER 1: INTRODUCTION

In This Section:

- Product Overview 1-1
- Indexer 1-2
- Clock and Direction 1-6
- BAI DOS Software 1-6
- Hardware Overview and Function 1-7
- Safety Procedures and Warnings 1-17

1.1. Product Overview

The BA-Intellidrive (BAI) is a single-axis indexer (refer to Figure 1-1). The indexer card is coupled with Aerotech's BA Series amplifiers and can control either brush or brushless motors. The BAI consists of an amplifier, control board, and internal power supply.



BAI 10/20/30

BAI 50/75/100



Figure 1-1. BA-Intellidrive Amplifiers

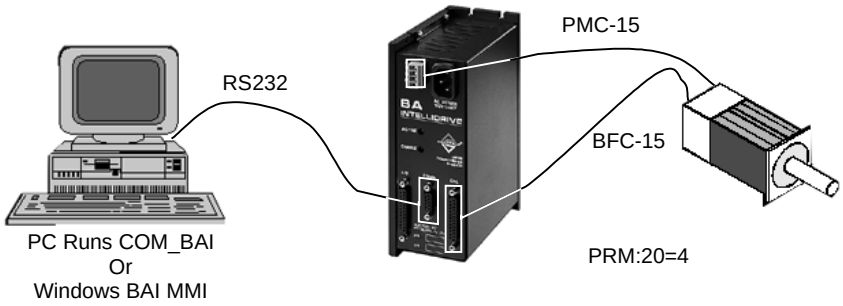
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1.2. Indexer

The BAI can act as a single-axis indexer. This means that it is capable of doing point-to-point motion by specifying a reference position, velocity, and acceleration. Some of the other commands available are freerun (**FR**), home (**HO**), change outputs, and teach mode. The BAI can also execute programs stored in flash memory.

The BAI is capable of operating in two different communications modes, one is local mode and the other is remote mode. In either mode, all commands are sent via the RS232 interface.

Local mode allows the user to control the BAI through a hand held terminal (HT) or a DOS emulation program. In this mode, a menu driven interface is used to communicate to the BAI. The menu driven interface allows the user to change parameters, run programs, teach the unit, execute motion commands, upload and download programs (DOS emulation only), display a tracking screen, and other functions, refer to Figure 1-2.



- the BAI is a fully programmable positioner (runs in "Local" mode)
- uses a PC to setup and program

Figure 1-2. BAI Indexer/Positioner Mode

Remote mode is intended for users who wish to embed Intellidrive commands into their own programs or connect multiple units in a daisy chain. Interacting with the unit is done via the remote command set. Remote mode allows the user to run programs, change parameters, execute motion commands, print error messages, request status, and other functions. Refer to Figure 1-3 for an illustration of remote mode and local mode.

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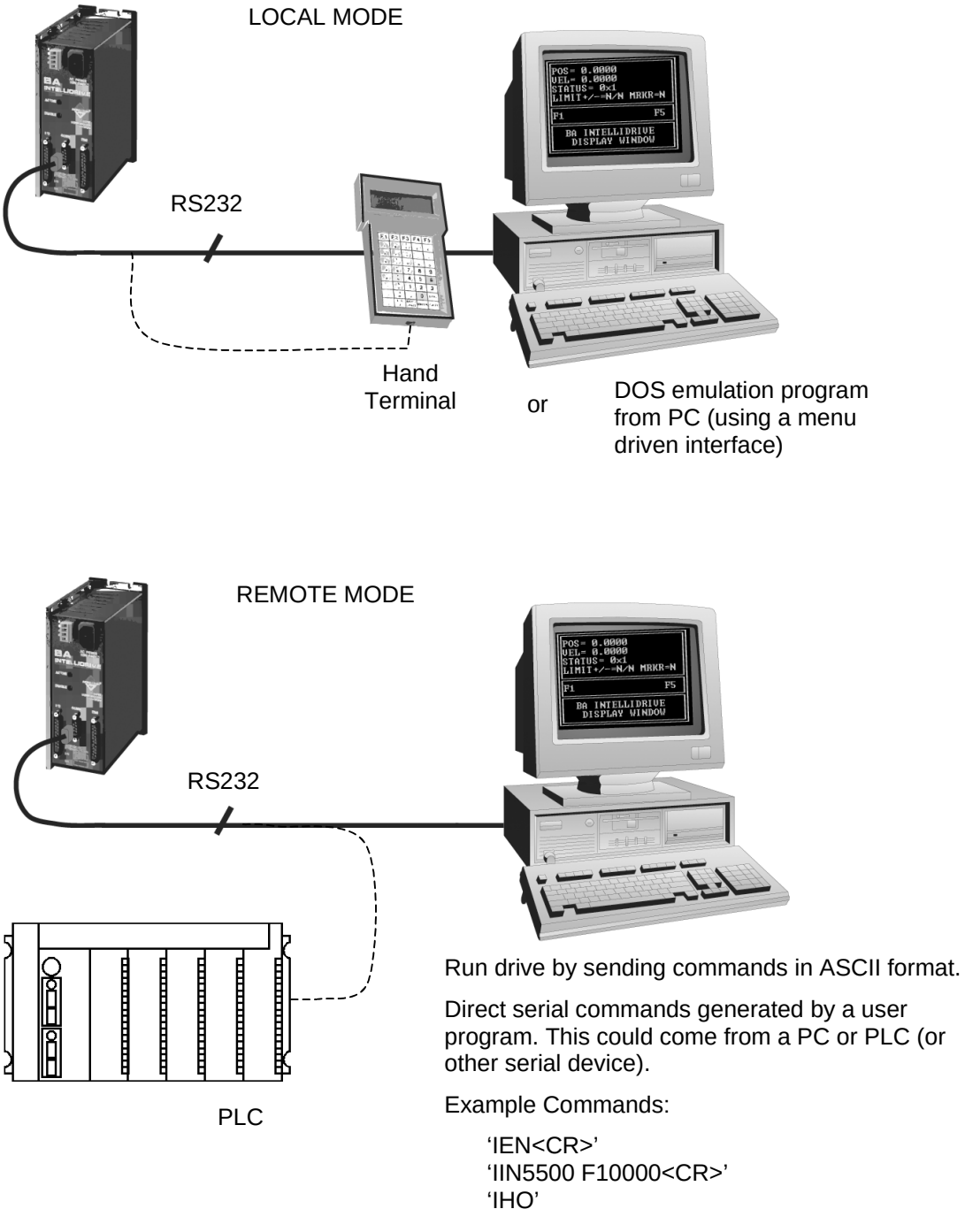


Figure 1-3. Illustration of Local and Remote Mode

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1.2.1. Teach Mode

Teach mode allows the user to teach the BAI up to 100 positions. A move from one point to the next is accomplished by changing the opto-isolated inputs. This bit pattern is specified by the user while teaching the unit. The user can specify either a binary 1, 0 or X (don't care) as the bit pattern for each of the three inputs. Each of the 100 moves has a bit pattern associated with it. When the pattern is satisfied (see Figure 1-5), the motor makes a move at the user specified velocity to the specified position. The present position of the motor is displayed in the "Position" window.



The moves are sequential, meaning, they will execute in order (0, 1, 2, 3, …98, 99). The user cannot jump out of sequential order.

Since the learned positions are absolute, running the teach program forces the unit into absolute position mode. The Teach mode can be executed using the "COM_BAI" DOS emulation program (refer to Figure 1-4) or through the BAI Man Machine Interface (MMI [refer to Figure 1-5]). In addition, the BAI can operate in the Teach mode using the HT (Hand held Terminal), refer to Figure 1-6.

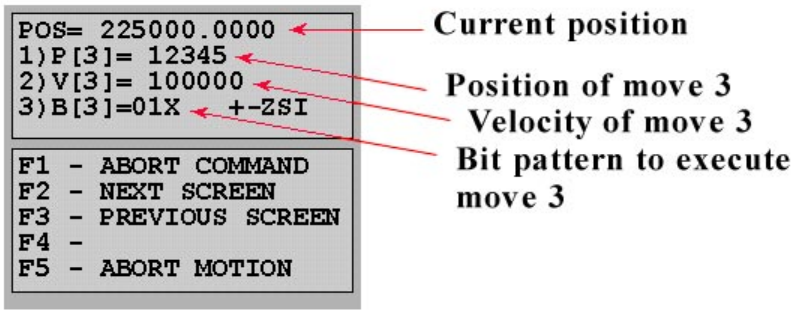


Figure 1-4. Teach Mode (using DOS-based COM_BAI)

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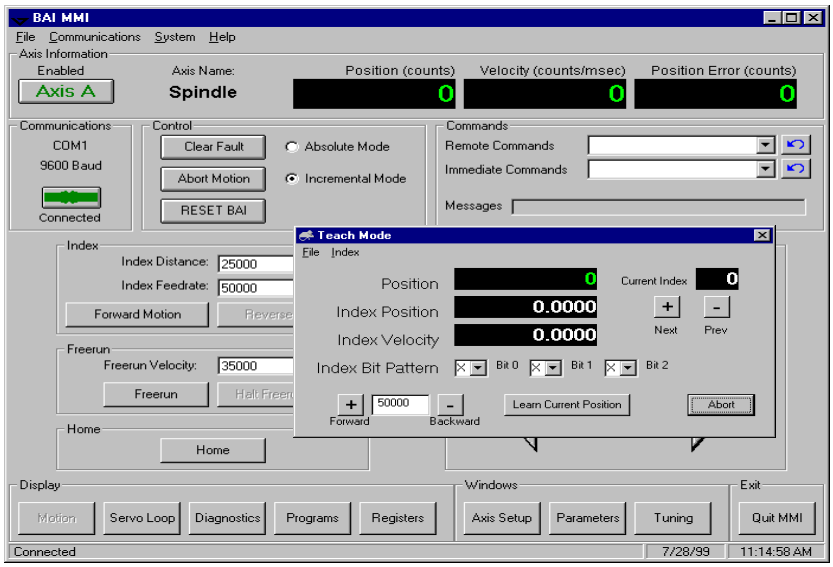


Figure 1-5. Teach Mode (using BAI MMI)

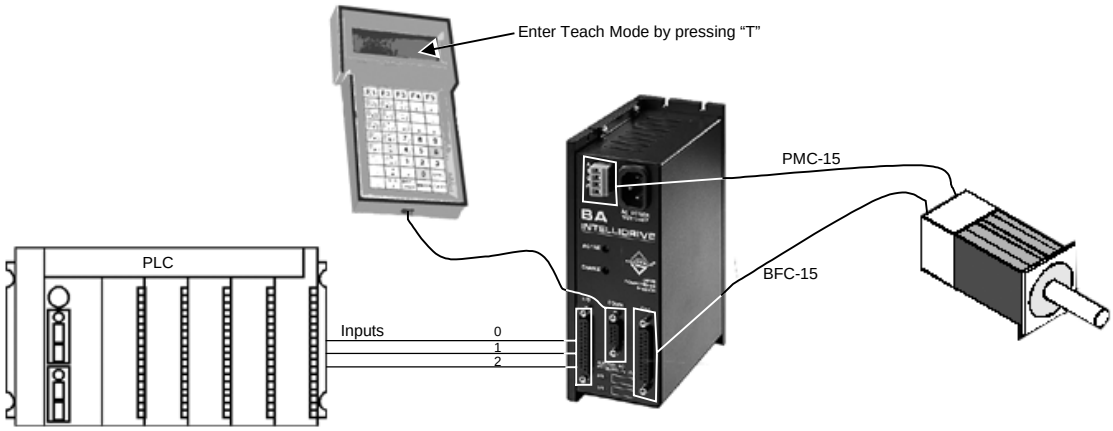


Figure 1-6. Teach Mode (using a Hand Held Terminal)

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1.2.2. Clock and Direction

The BAI can also operate in clock and direction mode. In this mode, the user sends a clock (pulse train) and direction signal, refer to Figure 1-7. During each servo loop update (1 ms default), the BAI reads the number of new clocks and uses this as the position command. By default, each clock represents one count from the feedback device. However, the user can modify this so that each clock pulse represents more than one count from the encoder.

This mode allows the user who has past experience with stepper motor systems to upgrade to a servo system without having to change their controller.

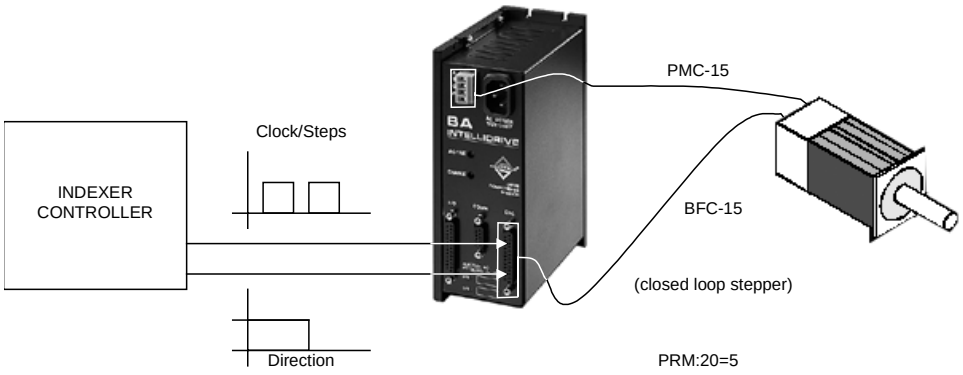


Figure 1-7. Operating Mode (Clock and Direction)

1.3. BAI DOS Software

The BAI software package is stored on a 1.44MB floppy disk, labeled "BAI Software Package." The software includes a HT terminal emulator (COM_BAI.exe), a program to control the BAI in remote mode (daisy chain mode) and the source files. The purpose of the COM_BAI.exe is to execute programs or individual commands and check the BAI's status information through a menu driven interface.

In order for the COM_BAI.exe to function correctly in DOS, the **ansi.sys** driver must be added to the **config.sys** file.

```
DEVICE=c:\dos\ansi.sys
```

These programs can also run in a DOS shell under Windows 95/NT. Again, in order for the COM_BAI.exe file to run correctly, the **ansi.sys** driver must be loaded. The following examples illustrate how to load **ansi.sys** in Windows 95/NT.

For Windows 95, add the following line to the **config.sys** file.

```
DEVICE=c:\win95\command\ansi.sys
```

For Windows NT, add the following line to the **config.nt** file in the winnt\system32 directory.

```
DEVICE=%SystemRoot%\system32\ansi.sys
```

Restart the PC after making these changes.

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1.4. Hardware Overview and Function

The BA-Intellidrive consists of two power connections (motor power and input power), two LED indicator lamps, and three "D" style connectors. Refer to Figure 1-8 and Figure 1-9 for locations.

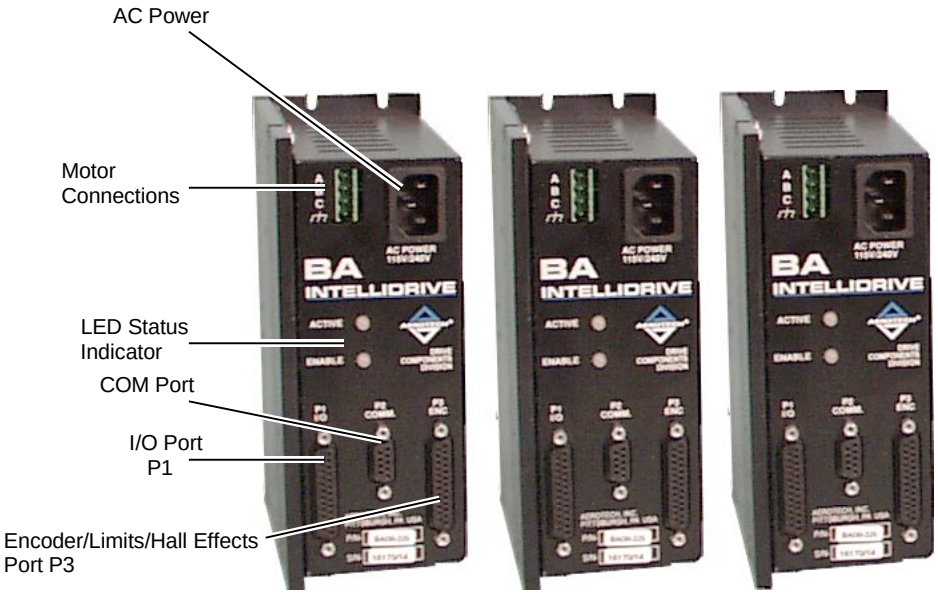


Figure 1-8. BA-Intellidrive Hardware – 10/20/30 A Models



Figure 1-9. BA-Intellidrive Hardware – 50/75/100 Models

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1.4.1. Motor and AC Power Connections

1.4.1.1. BAI 10/20/30

AC power is applied to the BAI through the AC receptacle located on the front of the unit. The power cord is similar to the type used with personal computers. The motor connection is made through the terminal strip located on the front of the BAI. This connector contains the motor connections along with the earth ground connection.

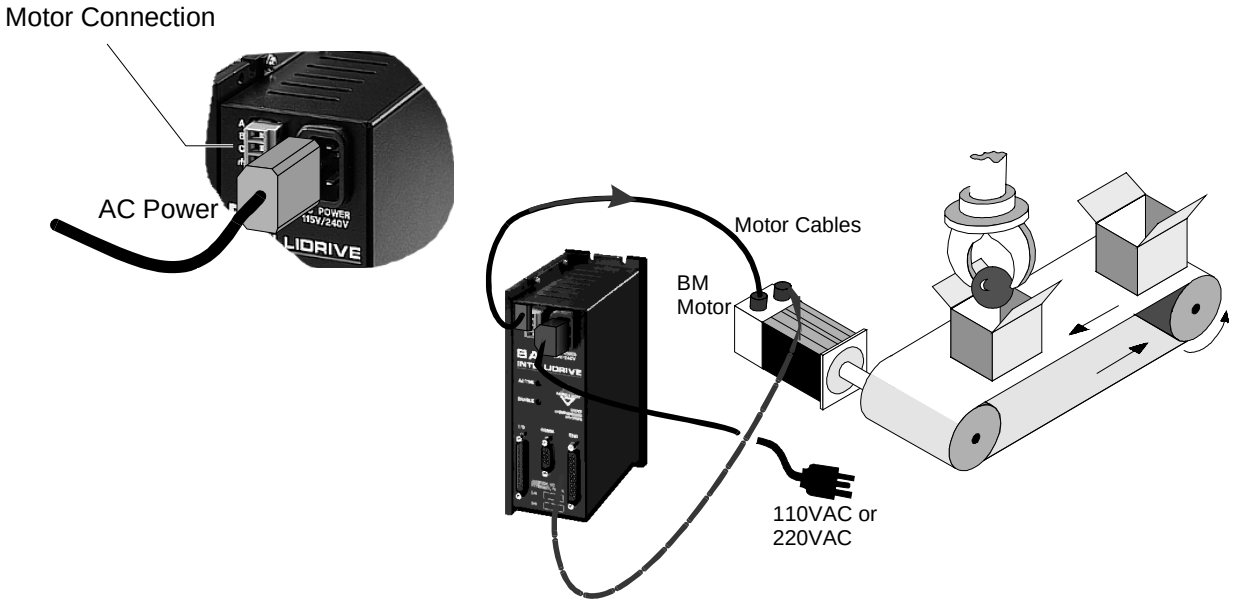


Figure 1-10. Motor and AC Power Connections – 10/20/30 Models

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1.4.1.2. BAI 50/75/100

AC power is applied to the BAI through the terminal strip located on the front to the unit. The motor and ground connections are also made through this terminal strip.

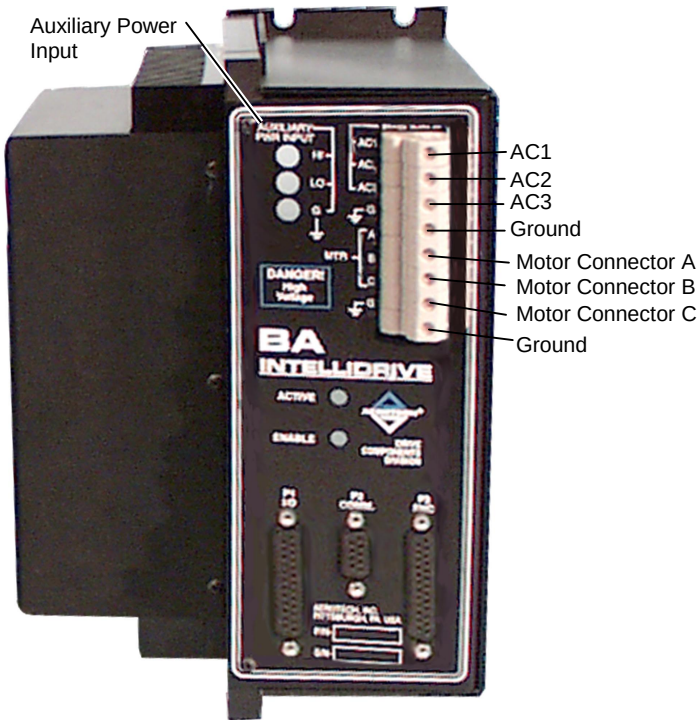


Figure 1-11. Motor and AC Power Connections – 50/75/100 Models

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1.4.2. Fusing and Inrush Limiting

1.4.2.1. BAI 10/20/30

The BAI 10/20/30 do not contain a fuse or any inrush limiting internally. These can be added externally to the AC input as shown in Figure 1-12.

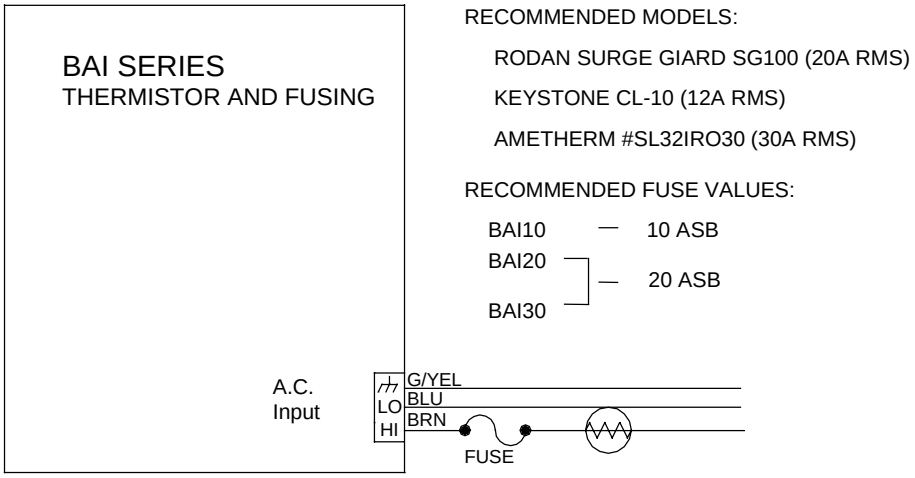


Figure 1-12. Fuse and Inrush Limiting – 10/20/30 Models

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1.4.2.2. BAI 50/75/100

The BAI 50/75/100 contain inrush limiting internally. Fusing can be added if needed externally (refer to Figure 1-13). The BAI 50 requires 2 phase input power while the BAI 75/100 require 3 phase input power. Earth ground should be connected to the earth ground connection on the unit. Motor connections are made through the A, B, and C connections on the front of the unit.

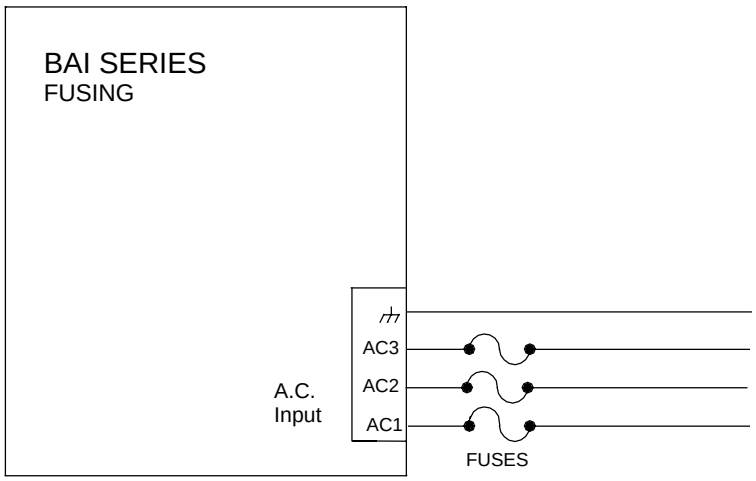
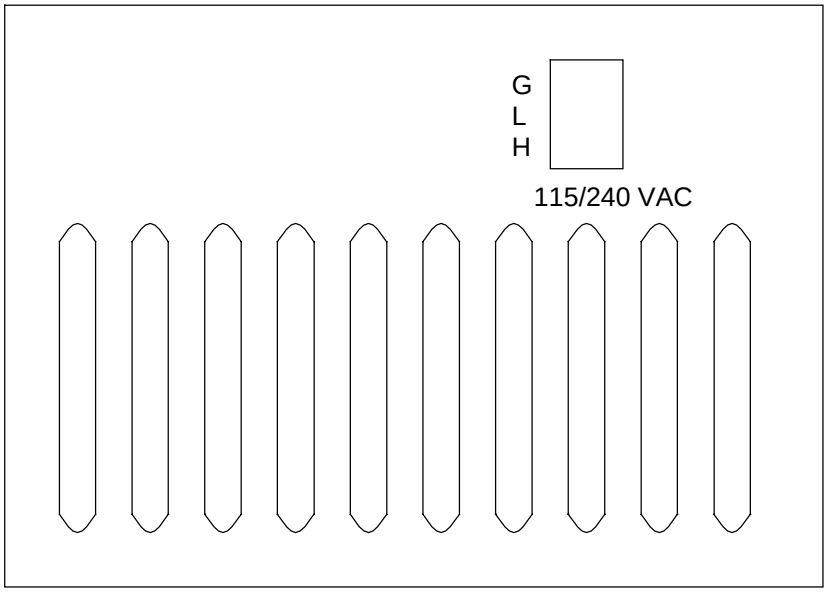


Figure 1-13. AC Input Fusing – 50/75/100 Models

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1.4.3. 20 - 80 Volt Option – BAI 10/20/30

If a BAI 10/20/30 - 80 amplifier was purchased, a separate AC input has been included on the side of the amplifier. The internal power supply of the BA amplifier requires a minimum of 80VAC input to operate properly. Figure 1-14 shows the connection to the separate AC power board. The connection is made to the AC input board with a three terminal connector (Aerotech Part # ECK00213).



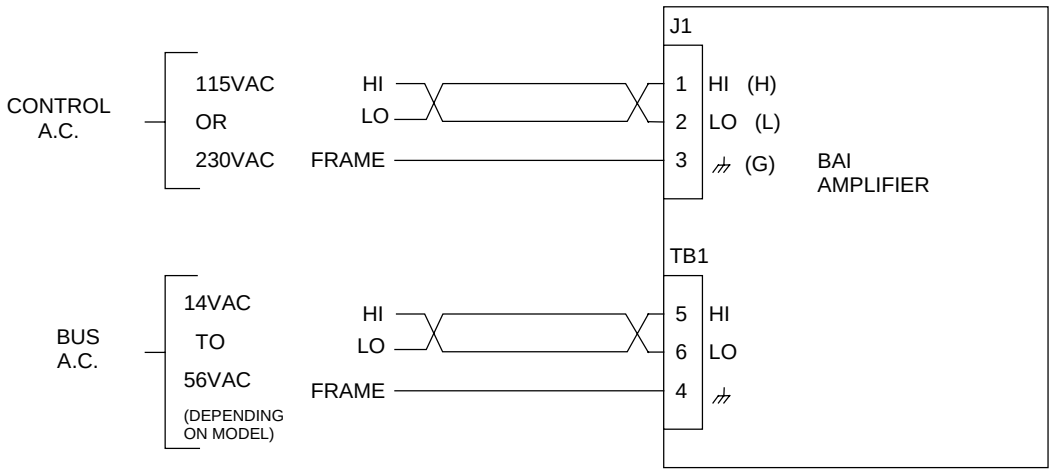


Figure 1-14. 20 – 80V Option

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1.4.4. COM Port

The BAI is a Data Terminal Equipment (DTE) device. Consequently, the user must connect to the COM ports with a NULL modem cable or adapter. The COM port is a standard 9-pin "D" style connector located on the front of the BAI, refer to Figure 1-8. It consists of two signal lines; transmit (TXD) and receive (RXD); a ground, shield, and a 5V power supply line used to power the Aerotech HT. Table 1-1 contains the connector pinouts.

Table 1-1. COM Port Pinouts

Pins	Function
1	Shield
2	Receive (RXD)
3	Transmit (TXD)
4,6,7,8	NC
5	Ground (GND)
9	+5 V

The 5-Volt connection on COM port is for the hand held terminal and is a non-standard connection.



1.4.5. RS232 Daisy Chain Configuration

When connecting multiple BAIs in a RS232 daisy chain, the units must be connected so that the transmit (TXD) of unit A connects to the receive (RXD) of unit B, and the transmit of unit B connects to the receive of unit C. The last unit in the chain must connect its transmit to the receive of the PC (Figure 1-15). Refer to Chapter 3: Communication and Commands for setup of the daisy chain configuration.

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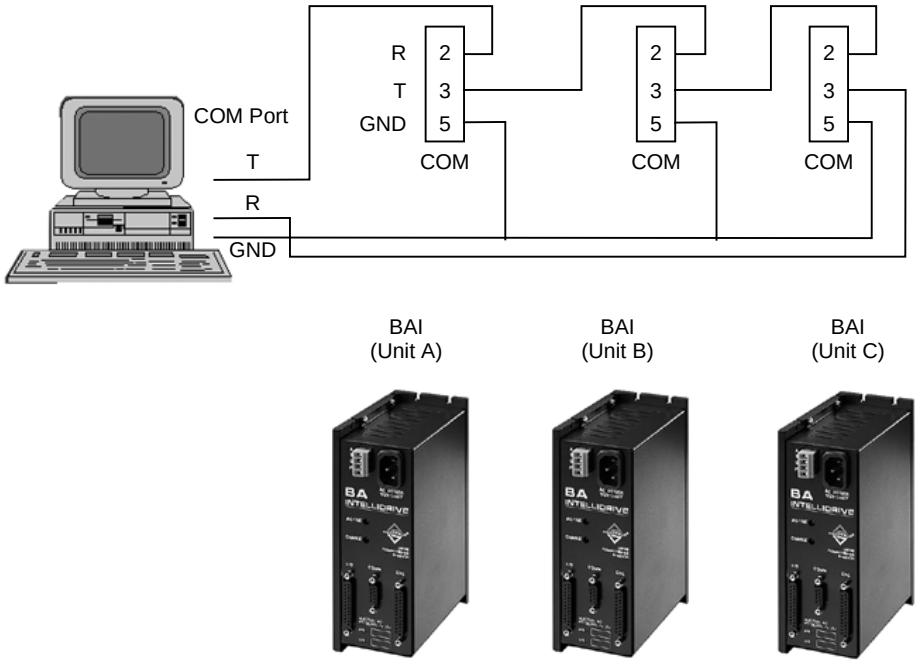


Figure 1-15. RS232 Daisy Chain

1.4.6. LED Status Indicators

The BAI contains two LED's located on the front of the unit that indicate the fault status of the unit, refer to Figure 1-8. One of the LED's indicates if power is applied to the unit, the second indicates the status of the amplifier. A green light indicates the amplifier is in the ready state, while a red light indicates a fault or the power stage is disabled.

1.4.7. The I/O Port (P1)

The I/O port is a 25-pin "D" style connector that contains all of the general-purpose I/O functions. These include:

- six non-dedicated digital I/O signals (3 input/3 output)
- two dedicated digital I/O signals (External Enable/Amp Fault)

All of the digital I/O is opto-isolated inputs and outputs. One of the two dedicated I/O signals enables/disables the power stage externally and the second indicates the fault status in the amplifier.

The pinouts for the 25-pin connector are shown in Table 1-2. More detailed information about pin functions is in Chapter 7: Technical Details.

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Table 1-2. I/O Connector Pinouts (P1)

Pin	Function	Pin	Function
1	Shield	13	Out3
2	Input1	14	Estop
3	Input2	15, 25	Ground
4	Input3	16	+5V
5	External Enable	17	NC
6	Input Common	18	NC
7	Direction	19	Thermistor
8	Clock	20	Restore/Reset
9	Output Common	21	NC
10	Amplifier Fault Out	22	NC
11	Out1	23	NC
12	Out2	24	NC

1.4.8. Encoder/Limits/Hall Effects Port (P3)

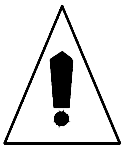
The 25-pin "D" style connector contains all of the necessary feedback inputs to complete a servo loop. This port has inputs for a 3-channel encoder, three limit switches, and three Hall effect devices. Each of these inputs provides feedback for the microprocessor controlled position and velocity loops. The three encoder signals consists of the following: sine (SIN), cosine (COS), and marker (MKR) as well as their complimentary signals: sine-n (SIN-N), cosine-n (COS-N), and marker-n (MKR-N).

Two of the three limit inputs are end-of-travel sensing (CW Limit and CCW Limit) while the third is a reference limit (Home Limit). The Hall effect switch inputs are recommended for AC brushless motor commutation but not required. The pinouts for the connector is shown in Table 1-3.

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Table 1-3. Pinouts for the Encoder/Limits/Hall Effects Port (P3)

Pin	Function	Pin	Function
1	Shield	13	NC
2	NC	14	COS
3	Encoder +5	15	COS-N
4	NC	16	Limit +5
5	Hall Effect B	17	SIN
6	MKR-N	18	SIN-N
7	MKR	19	NC
8	NC	20	Limit Com.
9	NC	21	Encoder Com.
10	Hall Effect A	22	Home Limit-N
11	Hall Effect C	23, 25	NC
12	CW Limit-N	24	CCW Limit-N



The maximum encoder frequency input is 2.5 MHz per signal.

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1.5. Safety Procedures and Warnings

The following statements apply wherever the Warning or Danger symbol appears within this manual. Failure to observe these precautions could result in serious injury to those performing the procedures and/or damage to the equipment.

To minimize the risk of electrical shock and bodily injury, ensure that the motor is decoupled from the mechanical system and no harm to personnel will result if the motor begins to spin.



Before performing the following steps, ensure that the motor is completely disconnected from the amplifier and the associated mechanical system.



To minimize the risk of electrical shock and bodily injury when any electrical circuit is in use, ensure that no person comes in contact with the circuitry.



To minimize the risk of bodily injury, make certain that all electrical power switches (all switches external to the amplifier) are in the off position prior to making any mechanical adjustments.



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CHAPTER 2: GETTING STARTED

In This Section:

- Introduction 2-1
- Unpacking the BA-Intellidrive 2-2
- Minimum Hardware Requirements.....2-2
- Recommended System Configurations.....2-2
- Inspection of the BAI 2-3
- Physical Setup of the Motion Controller 2-3
- Local Mode 2-4
- Standard Installation of the Software 2-5
- Parameters Screen - BAI MMI.....2-17
- Axis Scope Tuning Window.....2-19
- Autotuning.....2-29
- Tuning Tips 2-33

2.1. Introduction

Chapter 2 contains information about the components of the BA-Intellidrive, unpacking and inspecting the equipment, and minimum hardware and software requirements for proper operation. In addition, this chapter walks the user through physically setting up the BAI, connecting the signal cables, installing the software, using the software for simple motion applications, and configuring the BAI for daisy chain operation.

This chapter is designed for technically oriented individuals familiar with computers and software that want a quick setup of the BAI. This chapter is also for users that want a simple systematic setup of the BAI. More detailed explanations about the BAI, programming commands, and parameters are in Chapter 3 through Chapter 8.



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2.2. Unpacking the BA-Intellidrive

Before unpacking any components, visually inspect the containers of the BAI for any evidence of shipping damage. If any such damage exists, notify the shipping carrier immediately.



All electronic equipment is wrapped in antistatic material and packaged with desiccant (a drying agent used to reduce moisture). Make certain that the antistatic material is not damaged during unpacking.

Remove the packing list from the BAI container. Make certain that the items listed on the packing slip are contained within the package. The following items should be found in every BAI package:

- The indexer (BAI)
- BAI User's Manual (optional)
- BAI software (on one CD)
- Indexer packing slip (listing products shipped with the order)

The following list of additional items may be included with the BAI, depending on the options and accessories that have been specified:

- Hand held terminal (HT)
- BAI MMI software

2.3. Minimum Hardware Requirements and Recommended System Configurations

Minimum hardware requirements and recommended system configurations for the BAI are shown in Table 2-1.

Table 2-1. Minimum Hardware Requirements and Recommendations

Equipment	Minimum	Recommended
Computer (microprocessor)	IBM PC AT or PS/2 80486 (or higher) or 100% compatible	80486 or higher
Computer Memory	4 MB of memory (conventional & extended)	4 MB memory (conventional & extended)
Graphics Display	EGA/VGA	VGA
Hard Disk Space	4 MB	5 MB or more
Mouse	Any mouse supported by the computer	Any mouse supported by the computer
Floppy Disk Drives	3 1/2" DSHD	CD-ROM
Windows	Windows 95/98 or NT	Windows 95/98 or NT
DOS	5.0 or higher	5.0 or higher

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2.4. Inspection of the BAI

All products undergo a total quality inspection before they are shipped from Aerotech. Even with a stringent quality assurance program, however, it is still possible that a product will arrive in less than perfect condition due to improper handling during shipment. After unpacking the BAI, check to ensure that there are no visible signs of damage.

2.5. Physical Setup of the Motion Controller

This section explains how to setup the BAI to a PC or Hand held Terminal (HT), an applicable motor, and install the system software. In addition, some simple applications are provided so the user can become familiar with using the BAI software.

The electrical signal connections between the BAI and Aerotech's motors are shown in Figure 2-1.

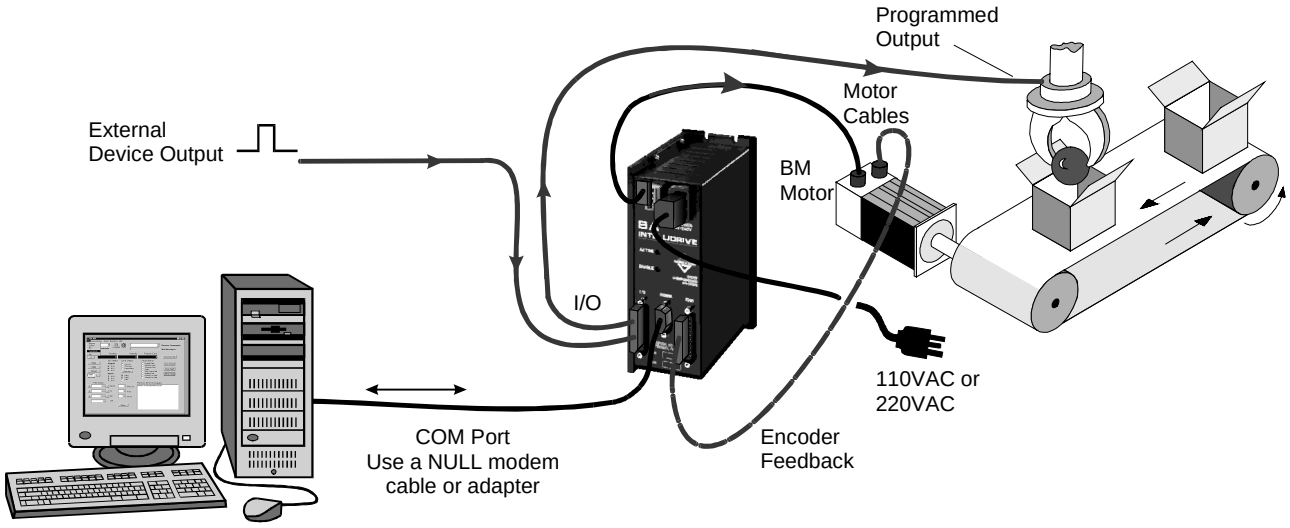


Figure 2-1. Physical Setup of the BAI and Aerotech Motors (Application 1)

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2.5.1. BAI Cable Connections

Commands can be sent to the BAI with one of two methods: 1) Local mode and 2) Remote mode. Local mode relies on menu screens to control the BAI, whereas remote mode (see Figure 2-2) relies on the user sending commands through the use of an external device acting as a host to control the BAI (e.g., PC or PLC).

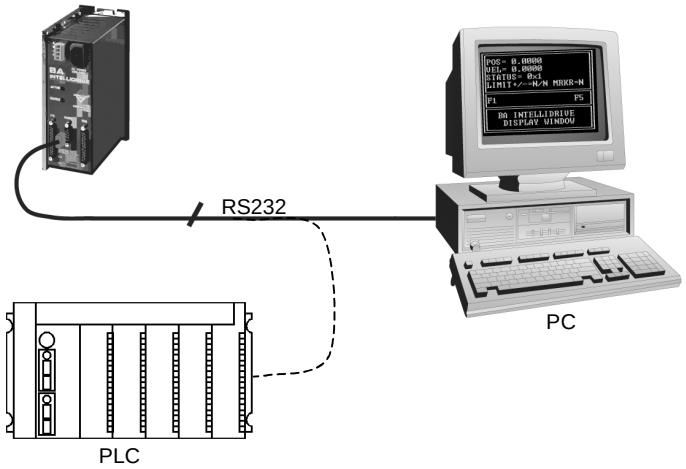


Figure 2-2. Remote Mode Configuration

2.5.2. Local Mode

When the user uses the local mode, all menus and commands generation resides in the BAI (the most common mode). The menu driven interface is done using a Handheld Terminal or a DOS-based emulation program on a PC, refer to Figure 2-3. This program is the COM_BAI.exe and is used to execute programs or individual commands and checks the BAI's status information.

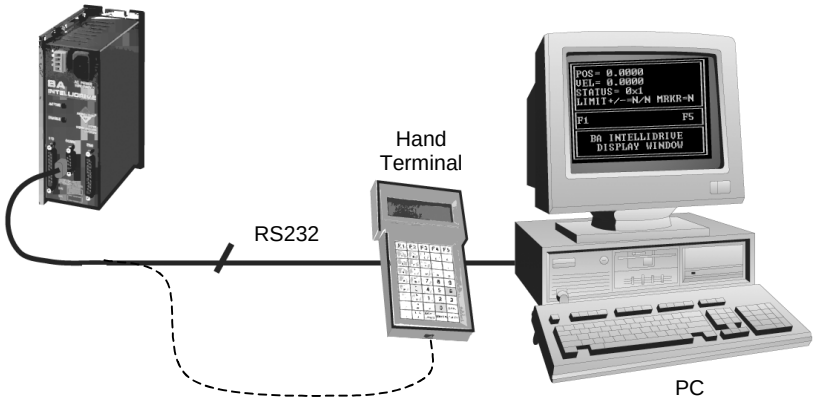


Figure 2-3. Local Mode Configuration

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2.5.3. Standard Installation of the Software

To install the software, the operator must follow the steps listed below.

1. Connect the RS-232 cable between COM1 or COM2 on the PC and the COM port on the BAI (refer to Figure 2-4).

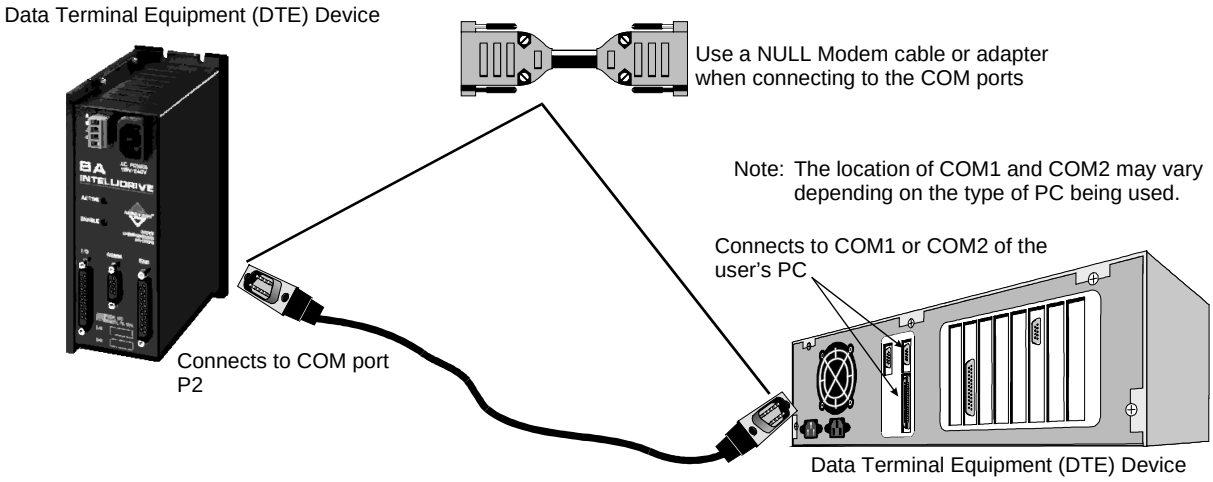


Figure 2-4. RS-232 Connection

Since the BAI is a DTE device, the user must connect to the COM ports of the BAI and PC with a NULL modem cable or adapter. This will ensure proper connection of the transmit (TX) and receive (RX) signals.



2. Insert the BAI software CD.

3. Copy all files from the CD in to the hard drive.

In order for the COM_BAI.exe program to function correctly in DOS, the **ansi.sys** drive must be added to the **config.sys** file.

4. Using an editor, add the following command to the **config.sys** file:

```
DEVICE=c:\dos\ansi.sys
```


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These programs can also run in a DOS shell under Windows 95/98/NT. Again, in order for the COM_BAI.exe program to run correctly, the **ansi.sys** driver must be loaded. Using an editor, perform the following:

5. For Windows 95/98, add the following line to the **config.sys** file.

   DEVICE =c:\win95\command\ansi.sys

6. For Windows NT, add the following line to the **config.nt** file in the winnt\system32 directory.

   DEVICE =%SystemRoot%\system32\ansi.sys

7. Restart the system PC after making these changes.

8. Using DOS (or a DOS shell under Windows 95/98/NT), run the COM_BAI.exe from the PC by typing "COM_BAI.exe 1 (if connected to COM 1 port). If connected to COM 2 port, type "COM_BAI.exe 2." The screen in Figure 2-5 is the first screen to appear.



Figure 2-5. BAI Display Window

9. Hit CTRL-D to reset the BAI. The display window will read "RESETTING", see Figure 2-6.



Figure 2-6. BAI Resetting Window

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10. To establish some type of motion with the system, type F4 - JOG (or index). The motor should rotate approximately one quarter turn (or 1000 counts, this is the default).
11. Next, enter **I** to display the Enter Command screen. Enter "IN 200000" to perform a simple point-to-point move. Refer to Figure 2-7.



Figure 2-7. Enter Immediate Command Screen

2.5.3.1. Writing a Short BAI Program

The following steps will walk through the steps of writing a simple program, uploading the program (file) to the BAI, and then running the program.

1. Exit the COM_BAI and start a pure ASCII text editor such as MS-DOS Editor, type in the program shown in Figure 2-8.

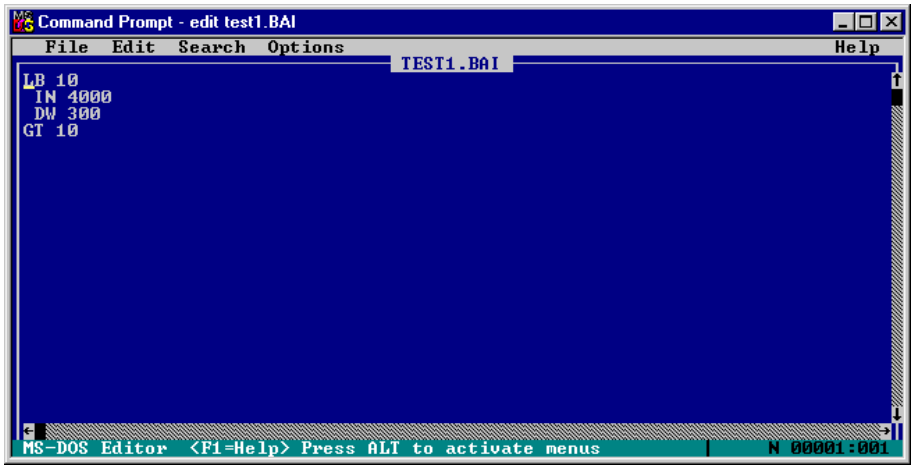


Figure 2-8. DOS Editor Screen

2. Save the program to the same directory containing the COM_BAI.exe file. The file name must follow the eight-character name, three-character extension (8.3 DOS) format. The extension must be "BAI." The filename can consist of characters or numbers, no other symbols are allowed. So, save this program to file by calling it "TEST1.BAI."

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3. Exit the MS-DOS Editor program and restart the COM_BAI.exe.
4. Then type **F** to access the File Operation screen, refer to Figure 2-9.



Figure 2-9. File Operations Screen

5. Type **U** to upload the program file just created. The screen in Figure 2-10 appears.



Figure 2-10. File and Parameters Transfer Screen

6. Type **F** and the File Upload screen appears, refer to Figure 2-11.

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Figure 2-11. File Upload Screen

7. Type in TEST1.BAI and hit return or <ENTER>. The file will upload from the PC to the BAI. The screen should display "file transferred."
8. Type **O** to access the Other Menu Options screen, refer to Figure 2-12.



Figure 2-12. Other Menu Options Screen

20. Press **1** to run the program just uploaded to the BAI. Pressing **1** advances the user to the following screen in Figure 2-13. This screen permits an auto run or block run of a program. Block run steps through the program line by line, whereas, auto run executes the program without user interaction.

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Figure 2-13. Auto Run/Block Run Option Screen

21. Select **1** to perform an auto run of the program just uploaded. The Enter File screen appears, refer to Figure 2-14.



Figure 2-14. Enter File Screen

22. Type in "TEST1.BAI" and hit <ENTER>. The program should run and the motor should have motion.
23. Press **F1** until the top menu appears.
24. Press **D** to enter the Display screen. The user should see the position and velocity displays change.

This is a simple looping program, so the motor moves a distance of 4000 counts, stops for 300 milliseconds, then repeats another move of 4000 counts.

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2.5.3.2. BAI Windows Software Interface

Included in the standard software package is the BAI Windows Software Interface. This compact windows program is intended to take the place of the COM_BAI.EXE program for users of Windows 95/98/NT.

To install the BAI Windows Software Interface:

1. Insert the BAI software CD into the CD-ROM drive of the PC.
2. From Windows 95/98/NT select the start button, then click Run, and type "X:\Install.exe" (where X is the drive letter corresponding to the CD-ROM drive).

If the BAI MMI was purchased, this may start the MMI installation and not the software interface. Since the BAI MMI contains advanced features not available in the standard software package, it is the preferred interface.

The BAI Software Interface program is designed to have all its features right at your fingertips. A view of the Software Interface screen can be seen in Figure 2-15.

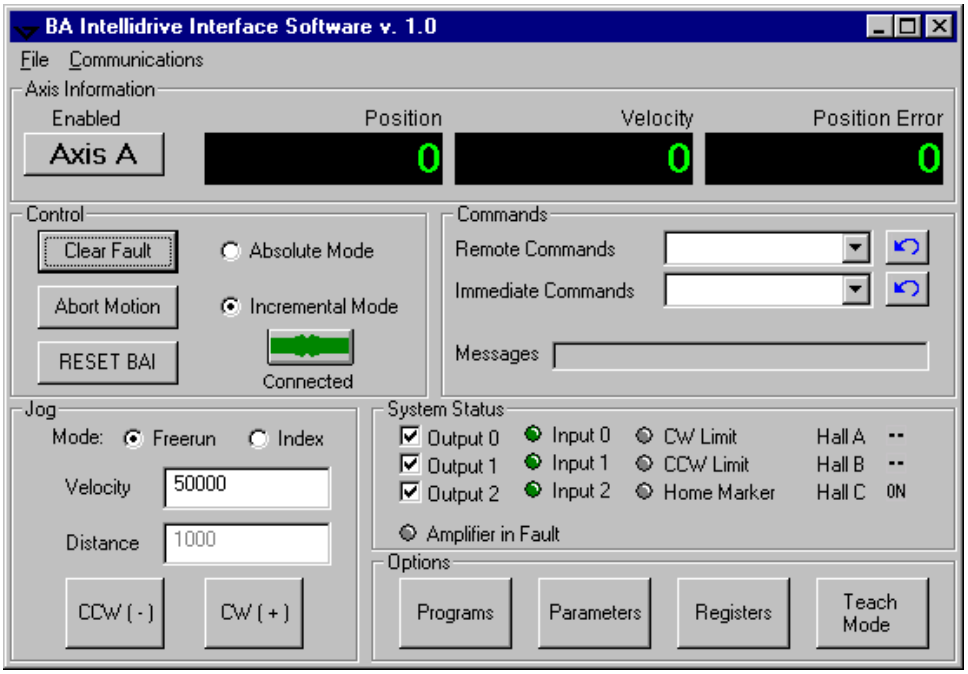


Figure 2-15. Main Screen

Editing Programs in the BAI Software Interface is done similar to COM_BAI. Use any text editor (such as Notepad) to create your program and save the file with a .BAI extension.

Uploading/Downloading and Running programs is taken care of in the Programs window. Figure 2-16 shows the Programs window.

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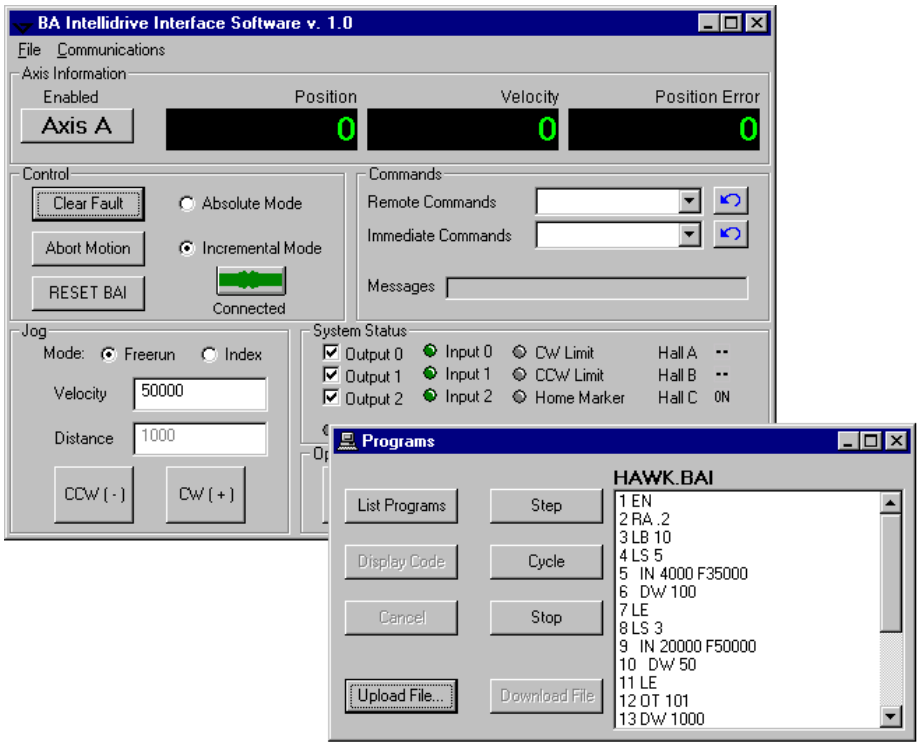


Figure 2-16. Programs Window

Editing Parameters on the BAI is as easy as the click of a button. The parameters screen brings up a listing of common parameters, as well as allowing the user to change any parameter documented in this manual. Figure 2-17 shows the BAI Software Interface Parameters Screen.

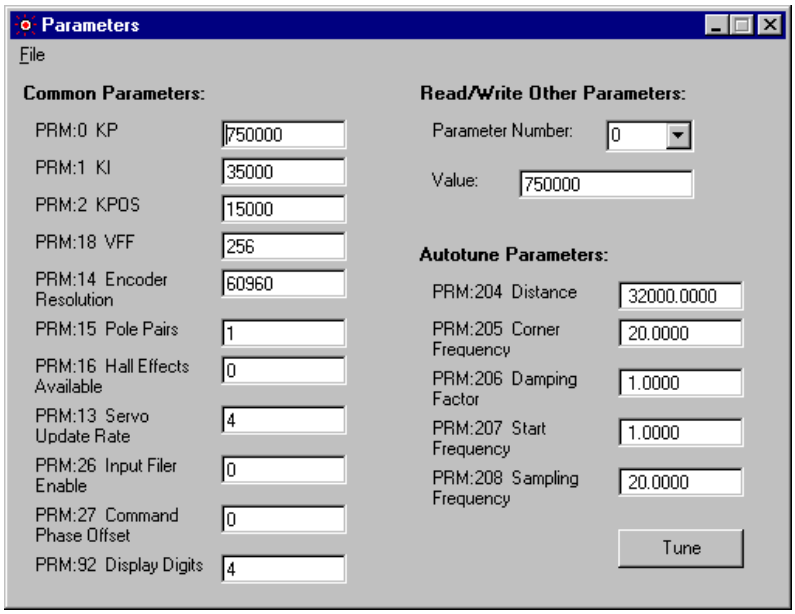


Figure 2-17. Parameters Screen

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2.5.3.3. BAI MMI Windows Software Installation

To install the BAI MMI software, perform the following.

1. Insert the BAI software CD into the floppy drive of the system PC (e.g., X:\).
2. From Windows 95/98 (or Windows NT 4.0) select the Start button, then click the Run icon, type in X:\install.exe in the Open box and Click OK.
3. A new pop-up window will be displayed. Enter the name of the target sub-directory of the installation. By default, the Install.EXE program will install the BAI software under the C:\ProgramFiles\BA IntellidriveMMI sub-directory. If a different sub directory is desired, change the target directory from this pop-up window. If a new sub-directory does not exist, the installation program will automatically create it.
4. Follow any subsequent instructions that are displayed on the screen.

When installation is complete, a "BAI MMI" entry is placed under the Programs menu, which appears after pushing the Start button. This indicates that the installation was successful and that the program is ready to be started.

To write and run a program using the MMI is very simple.

1. To start the BAI MMI software, push the Start button, then select Programs and find the program group "Bai". Figure 2-18 is the main screen that appears after starting the MMI software.

The  button indicates a successful communication link to the BAI. A  button indicates that no link was established with the BAI. Press the red link button to attempt establishing communication again. If the button stays red, check the RS232 cable and ensure a NULL modem cable is being used. Also, check to make sure the correct COM port on the PC is selected under the communication menu.



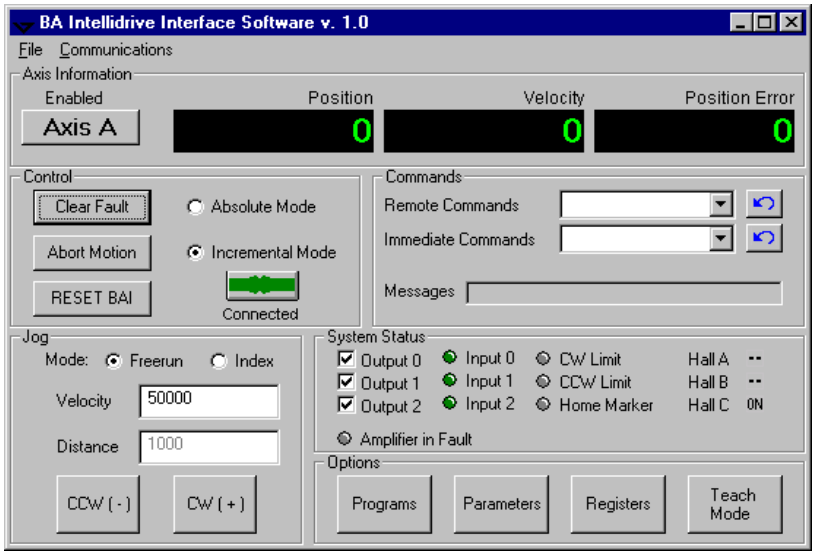
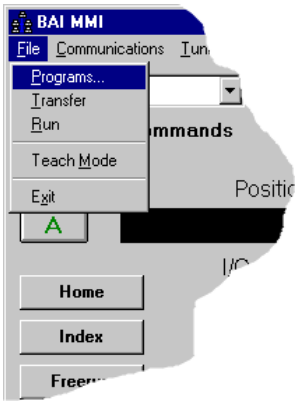


Figure 2-18. MMI Main Screen

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2. To write a program using the MMI, select File and Programs… from the pull-down menu. This will start the text editor, refer to Figure 2-19.

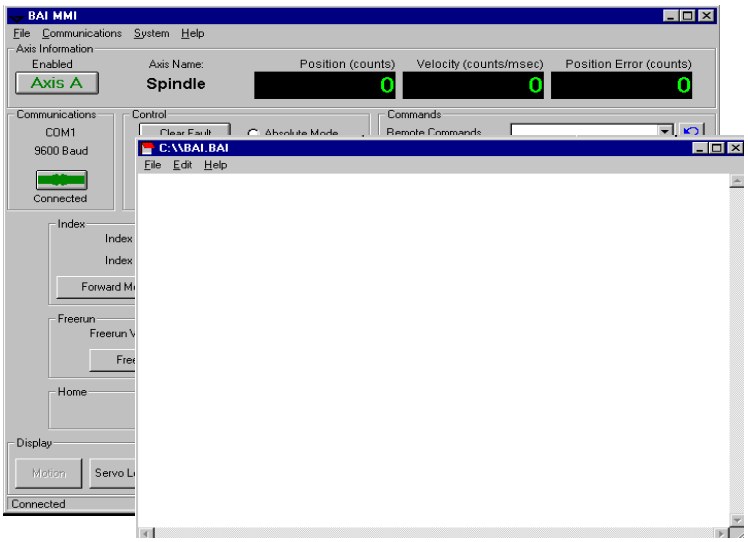
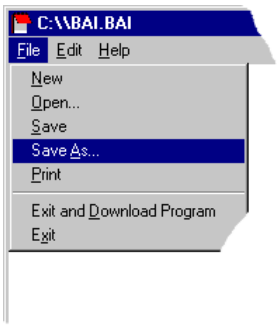


Figure 2-19. MMI Text Editor Window

3. As with the COM_BAI.exe, type in the same program code in the text editor. Save this one as "TEST2.BAI" using the Save As… function from the File pull-down menu on the text editor.

4. Open the transfer window (Figure 2-20) by selecting File, then Transfer from the File pull-down menu.



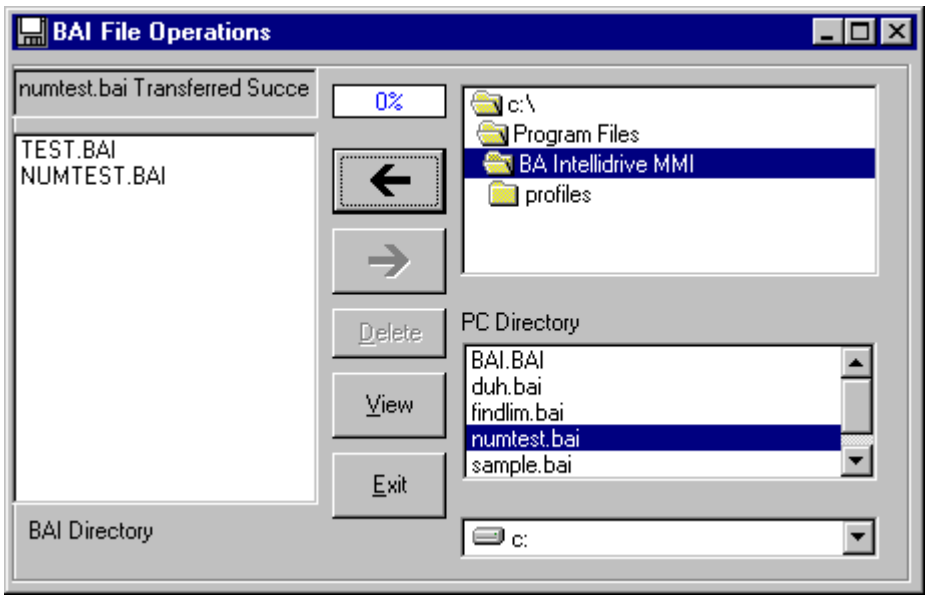


Figure 2-20. File Transfer Window (MMI)

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5. Select (or highlight) the file just created from the PC directory, then select the "✓" key to transfer the file to the BAI directory.

6. Select File, then Run from the File pull-down menu.

Notice that the Previous Error Message box in the lower right changes to a smaller box with five buttons to the left of it, refer to Figure 2-21.

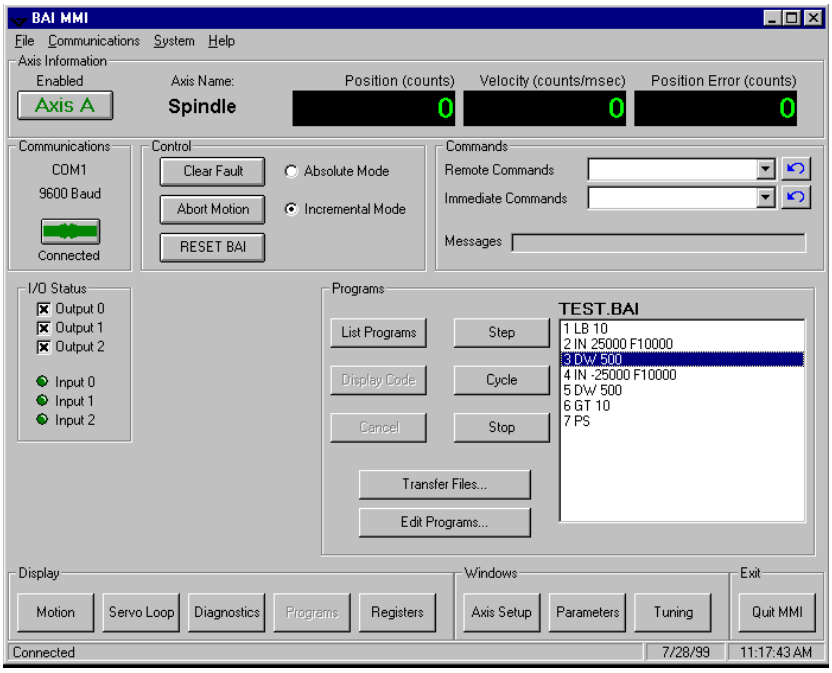


Figure 2-21. Main Screen (Run Mode)

7. Select the "Program List" button, the program(s) transferred to the BAI should be displayed in the box to the right of the button.

Notice that the "Program List" button changes; it now reads Display Code. Also, notice that the Step, Cycle, and Stop buttons are half-toned.

8. Highlight the "test2.bai" program in the box, then select the "Display Code" button. The lines of code for test2.bai are displayed in the box, refer to Figure 2-22.

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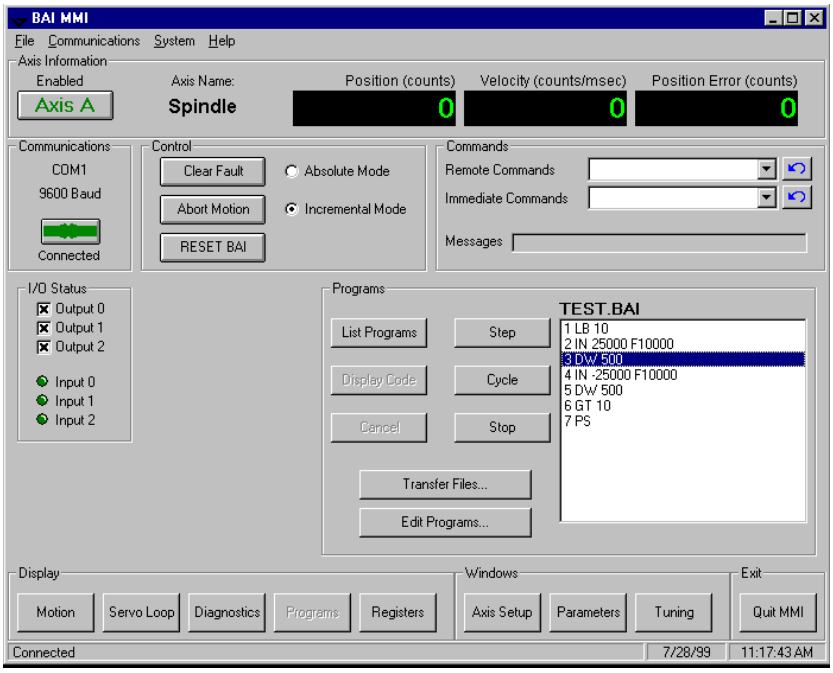


Figure 2-22. Display Code (Main Screen)

The previous two buttons that were displayed in half tone are now selectable.

9. To run the program, select the Cycle button.

Notice that the program cycles through the lines of code in the box as it cycles through the moves.

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2.6. Parameters Screen - BAI MMI

The Parameters screen contains four tabs labeled Motion Parameters, Limits, Communications, and Miscellaneous. From these four groups of parameters, the user can change the value of a specific parameter, refer to Figure 2-23. Also, there is a Motor Profiles pull-down menu that permits the user to select a motor profile and type if using Aerotech's motors or a generic motor profile if using non-Aerotech motors, refer to Figure 2-24.

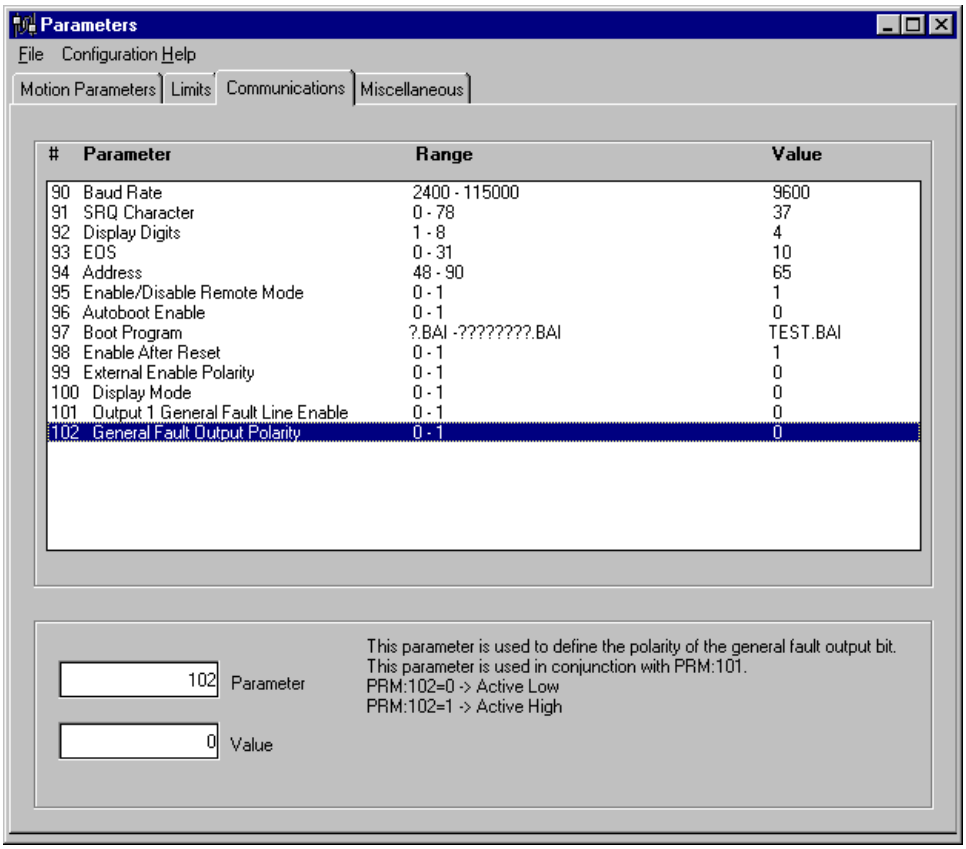


Figure 2-23. Parameters Screen (BAI MMI)

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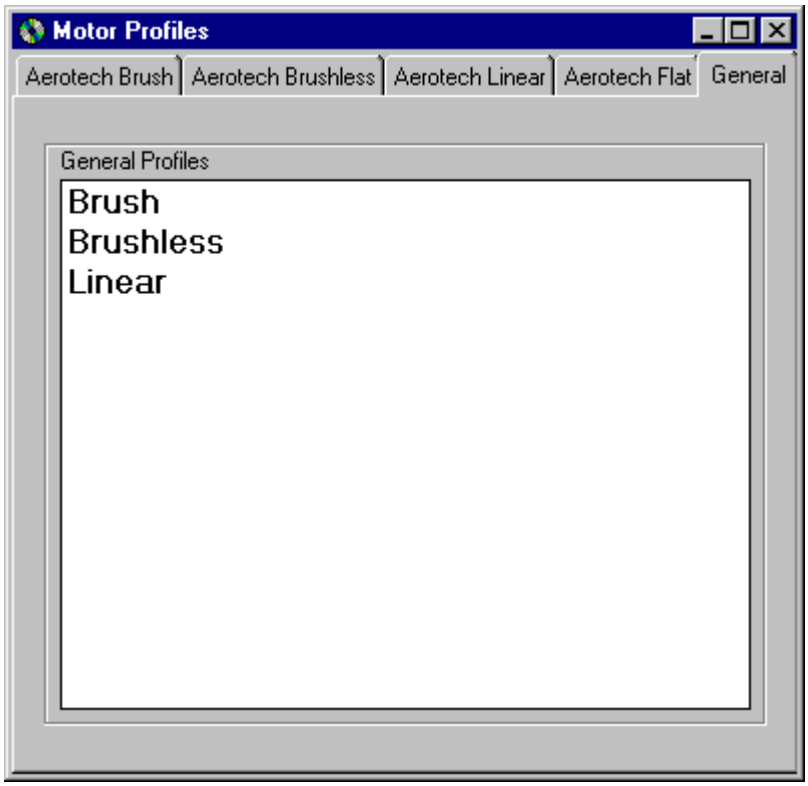
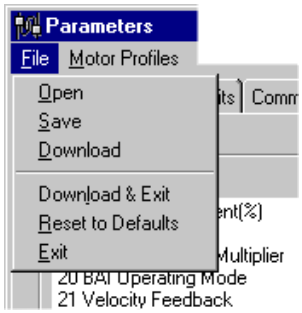


Figure 2-24. Motor Profiles Selection (Parameter Screen)



From the File pull-down menu, the user can:

- Open - opens a parameter file (i.e., PARAMS.PRM)
- Save - saves new parameter values on PC
- Download - downloads new parameter values to the BAI
- Download & Exit - downloads parameter values and exits parameter screen
- Reset to Defaults - resets all parameter settings to default values
- Exit - exits parameter screen



It is very important that user download all new parameter settings before exiting the parameter screen. If the parameter settings are not downloaded, the previous settings are used and all new settings are lost.

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2.7. Axis Scope Tuning Window



The Axis Scope window is a tool that aids the user in improving the performance of the control-system servo loop. The Axis Scope window is accessed by the Tuning selection from the main menu across the top of BAI MMI main screen. When tuning an axis, Axis Scope is used to move the axis in a forward direction and then in a reverse direction. As the axis moves, servo data such as Position Error, Velocity Error, Velocity Command, etc., is collected. The Axis Scope window allows the user to analyze these signals and adjust the servo gains appropriately, thus improving an axis to its realistic optimal performance. Refer to Figure 2-25 for an illustration of the Axis Scope screen.

There are seven menu options available to the user on the Axis Scope window, the options are:

- File
- Plot - permits the operator to specify plot options and which signals to plot
- Trigger - permits the operator to specify a data collection method, motion options, and control options
- Collect - used to specify the number of data points to be collected in a single set
- Display - used to specify the number of data points displayed or plotted
- Units - specifies distance and time measurement units for the plot display
- Tools - used to enable and disable the display of four toolbars

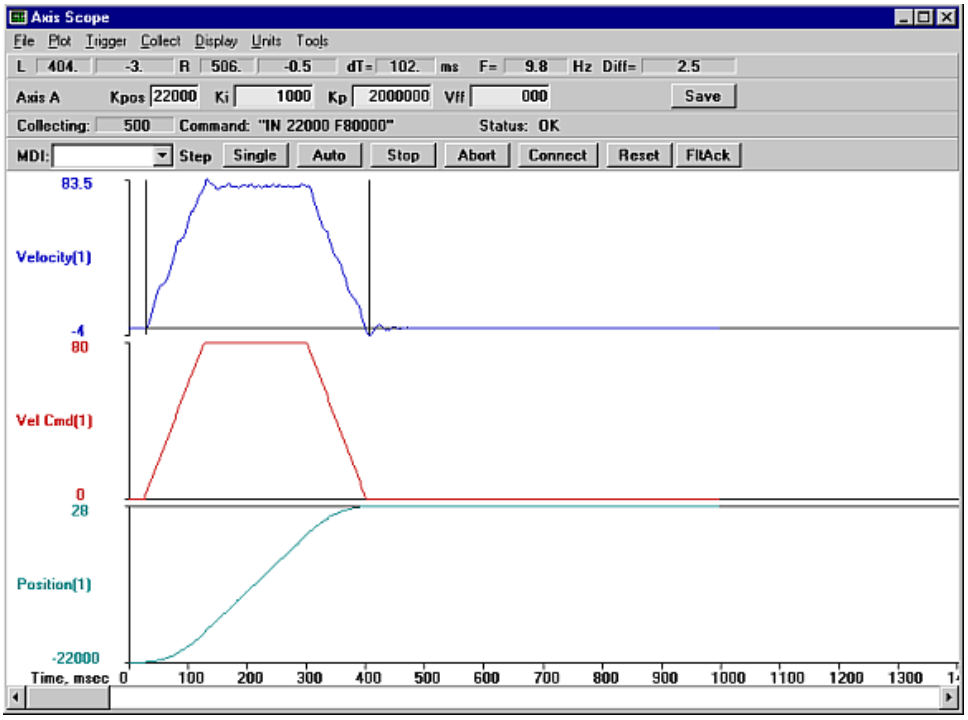


Figure 2-25. Axis Scope Window (BAI MMI)

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The Axis Scope toolbars that are enabled and disabled with the Tools menu are illustrated in Figure 2-26.

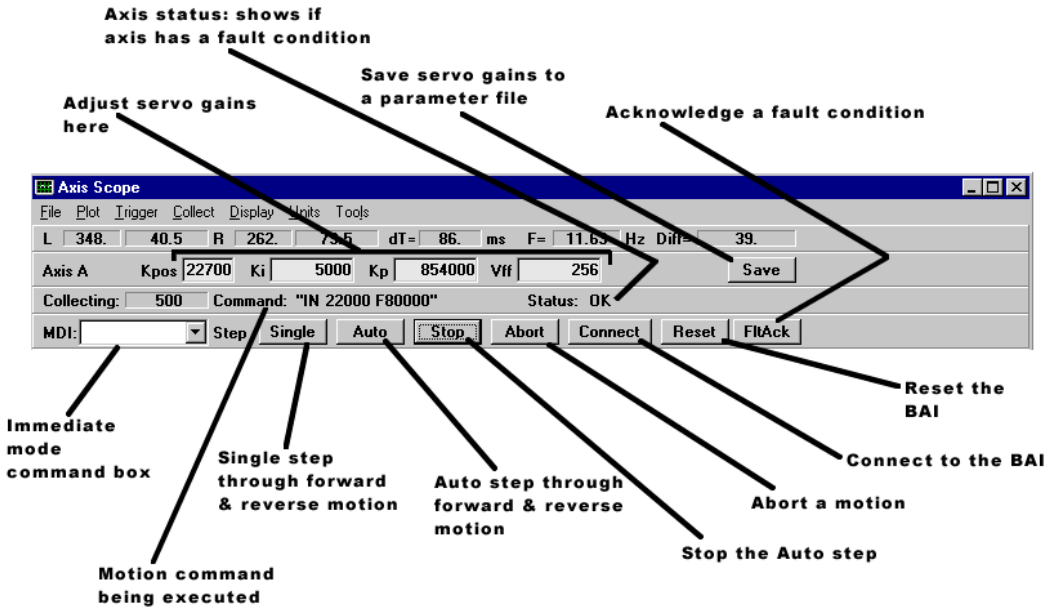


Figure 2-26. Axis Scope Toolbars

The Cursors option is used to display/hide the Cursors tool bar. This tool bar contains features that assist the operator in determining time differences between points on the plot as well as frequency information. The Cursors tool bar is illustrated in Figure 2-27.

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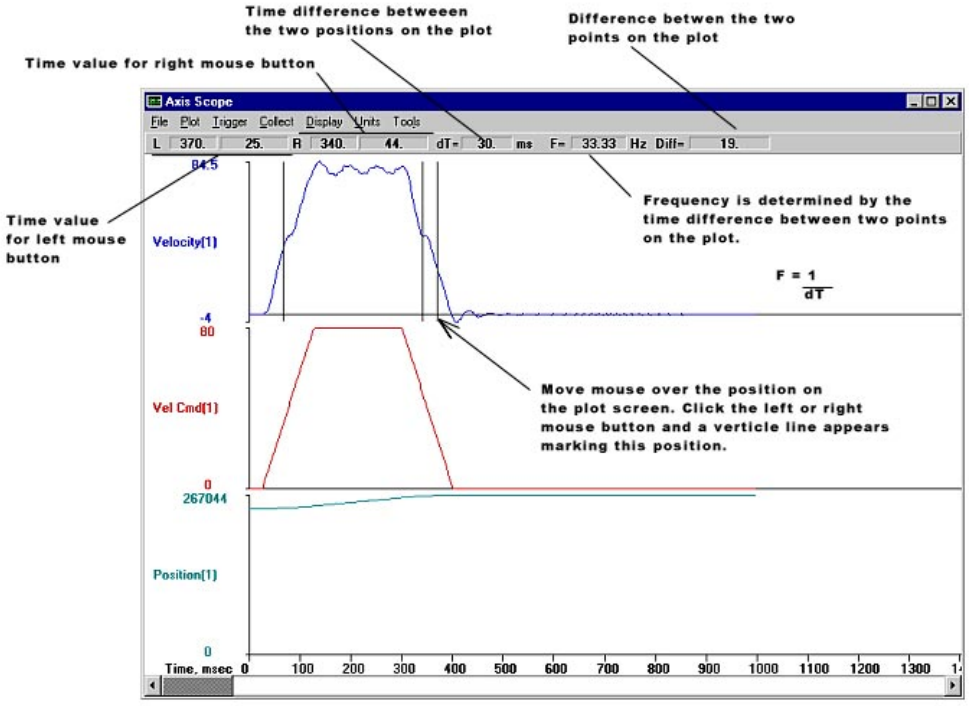


Figure 2-27. Cursors Toolbar (Axis Scope Screen)

2.7.1. Tuning Procedure for Servo Loops

The following procedure can be used as a guide when tuning the BAI servo loop. This procedure does not apply to motors with tachometers. Figure 2-28 shows the overall tuning process with the Axis Scope window. The user's system may behave differently and have different values for servo gains. However, the overall process is the same and the same process can be repeated for the other axes in the system. When adjusting each of the servo gains, the user will essentially be following the procedure below:

1. Press the Single button on the Control toolbar to step through a forward or reverse motion.
2. Observe the signal plots on the Axis Scope window.
3. Make a decision on whether to increase or decrease the value of the servo gain and if the observed signal is acceptable to move on to the next servo gain.
4. Repeat.

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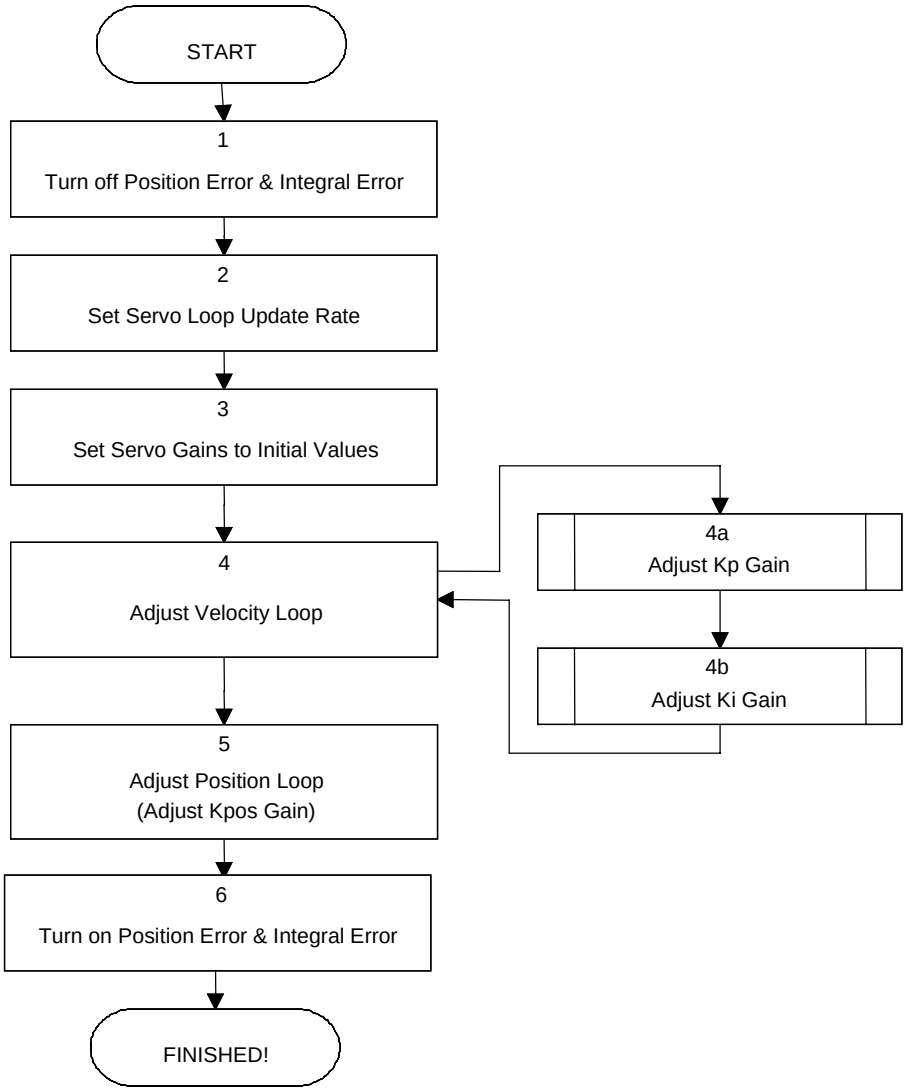


Figure 2-28. Flowchart of Overall Tuning Process

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The following is a step-by-step procedure for tuning motors without tachometers.

Please read each step thoroughly before performing the task.



1. Turn off the "Position Error" fault by setting PRM:12 to 0 (zero).
2. The "Servo loop update rate" (PRM:13) must be set appropriately in order to get optimal performance from the system. The default update rate is 1 ms (1 kHz) and the user would put a 4 as that parameter's value. Another common choice is .25ms (4 kHz) and the user would put a 1 as that parameter's value. Some low resolution systems (500 line encoders, etc.), high inertia systems, or low velocity systems perform better at a lower update rate such as 1 kHz. If the update rate is changed, the tuning process must be repeated.
3. Set servo parameters to initial value in the Parameters screen, refer to Figure 2-23. Table 2-2 has the initial values for these servo gains.

Table 2-2. Initial Servo Parameter Values

Kpos	Ki	Kp
0	0	≤100000

4. Prepare the Axis Scope Screen for tuning by performing the following functions:
   a. Press the maximize button on the Axis Scope Window, shown in Figure 2-29 so the Axis Scope window fills the entire screen.



Figure 2-29. Maximize Button on the Axis Scope Window

   b. In the Collect menu select "2500 points."
   c. In the Display menu select "2500 points."
   d. In the Plot menu, select Velocity Command, Velocity Error, and Position Error.
   e. In the Trigger menu, set the Forward Motion... and Reverse Motion... to a typical move such as *IN 50000 F50000* for Forward Motion... and *IN -50000 F50000* for Reverse Motion... Also set the Sample Rate to 1.
   f. In the Tools menu select Status, Control, and Gains.

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When the "Single" button is pressed, the motor will first move as specified by Forward Motion... When the Single button is pressed again, the motor will move as specified by Reverse Motion...

5. Adjust the Velocity Loop using "Kp". The Kpos and Ki have been set to zero (0) to eliminate the Position Loop and half of the Velocity Loop. Thus, the only gain that is having an effect is Kp, which is the other half of the Velocity Loop.



Even though the user may only be concerned with how well the stage positions, the Velocity Loop cannot be overlooked as it is interrelated to positioning. The better a stage tracks velocity, the closer it will be to its correct position.

The objective in adjusting Kp, is to reduce the velocity error to 5-10 units. The velocity must not be eliminated completely because Ki will do that. Also, the user wants the axis to feel "snug". As Kp is increased, observe that the motor shaft (or ball screw) becomes increasingly snug. The user can turn the shaft manually and it won't move back to its original position, but it becomes harder to turn.

In between pressing the Single button, the operator should observe no screeching and howling from the motor . Noise means Kp is set too high causing it to oscillate. It may screech a little during the move, but not when at a standstill.



If the motor doesn't move, Kp is too low. Increase the value of Kp and try again by pressing the Single button.



If you are adjusting the gains that Aerotech has setup for your system, use the existing Kp as your starting point.

Once the motor is moving back and forth, the user should see a graph similar to Figure 2-30. From this graph, it is seen that there are 20 to 30 units of velocity error. "Kp" must be increased to reduce the amount of velocity error. After repeating this process a few times, the velocity error will look similar to Figure 2-31. From this graph the user can observe that the average velocity error during the move is about 6 units. Moreover the motor does not oscillate when it is stopped.

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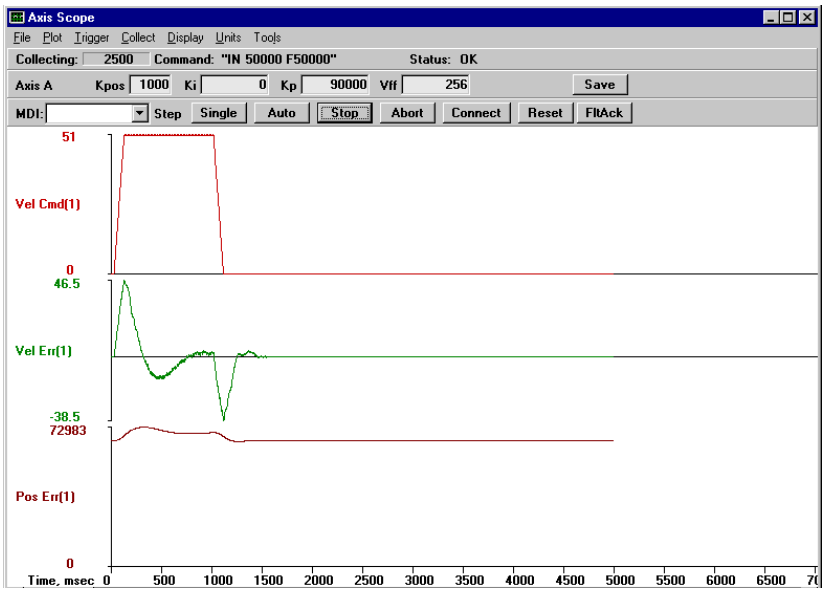


Figure 2-30. Unacceptable Velocity Error

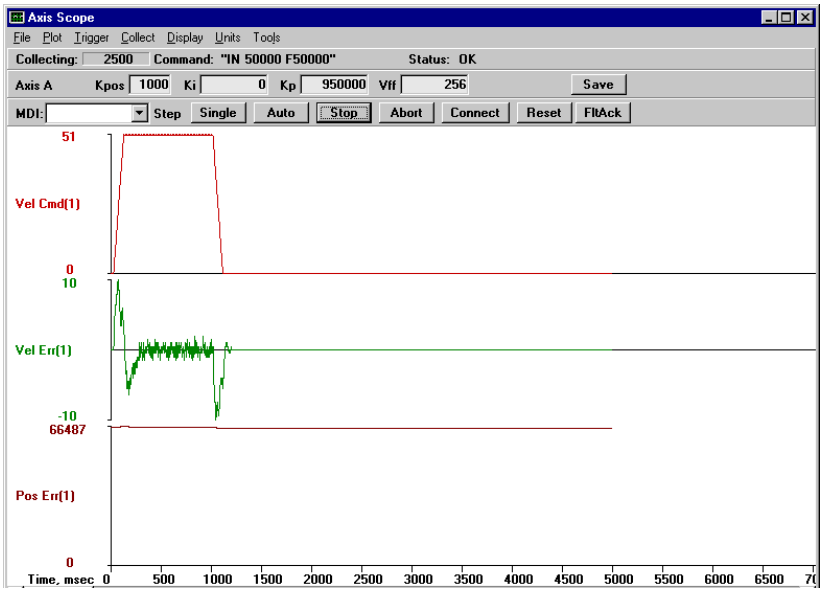


Figure 2-31. Acceptable Velocity Error (When Adjusting Kp)

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The user can stop adjusting "Kp" and start adjusting "Ki".

Use a starting value of 1000 for Ki. The main objective in adjusting Ki is to reduce velocity error and position error. As Ki is increased, the error is reduced. However, the position error should not cross its "zero line", otherwise it will increase the settling time of the axis. This is a point where the user can stop adjusting Ki. Also, a very large Ki will introduce low frequency oscillation in the position error. From the perspective of the stage, this is vibration. Lack of smoothness may or may not be acceptable to the user. Shown in Figure 2-32, is a plot showing Ki crossing its "zero line" and some oscillation.

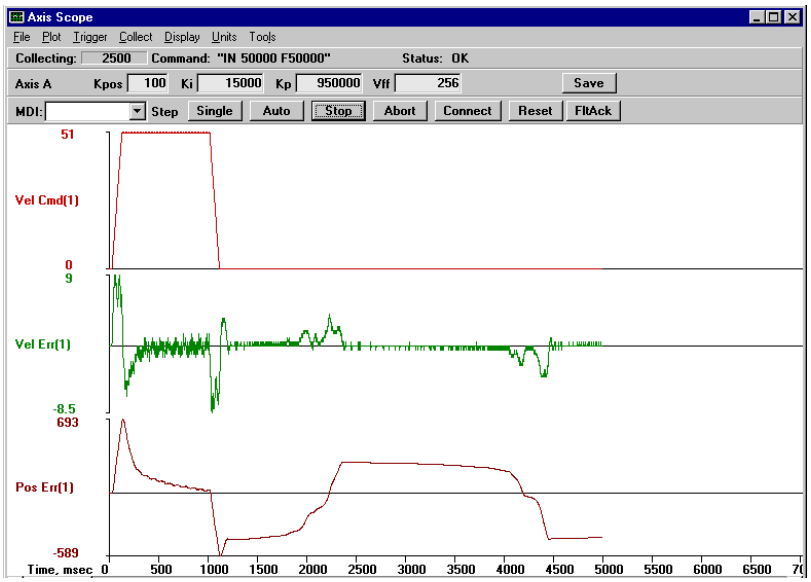


Figure 2-32. Unacceptable Position Error (When Adjusting Ki)

Depending on the application, the user may or may not be too concerned with vibration in the axis. However, the crossover of the position error means the Velocity Loop is too tight, especially if maintaining position is important to the user. Due to this cross-over, the settling time increases and the Kpos (which is in the Position Loop) must work harder to keep the motor in position. The two gains start working against each other instead of complimenting each other.

Shown in Figure 2-33 is a graph with a much better Ki. As can be observed from the position error, it is smoother and the position error does not cross over the horizontal axis. Moreover, the velocity error has been reduced as well.

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The user can stop adjusting "Ki" and start adjusting "Kpos."

6. Adjust the Position Loop using "Kpos." Use a starting value of 500-1000 for Kpos. As the user increases Kpos, it will be observed that the position error is reduced The main objective is to adjust Kpos until the position error is within user's tolerance or starts to oscillate; whatever comes first.

   As previously mentioned, if Kpos is too high, the user will encounter a high frequency oscillation (stage vibrates strongly). This will cause the BAI to have a *RMS Current Trap*, which essentially means that too much current is being sent to the motor (the RMS Current Trap acts the same way as a fuse).

   Shown in Figure 2-33 is a plot of a good Kpos. From this graph it can be seen that there is little settling time. In other words, the position error ends near the same time the Velocity Command ends; so the move is "in position" at the end of the commanded move. For comparison, Figure 2-34 illustrates a plot where Kpos is too high.

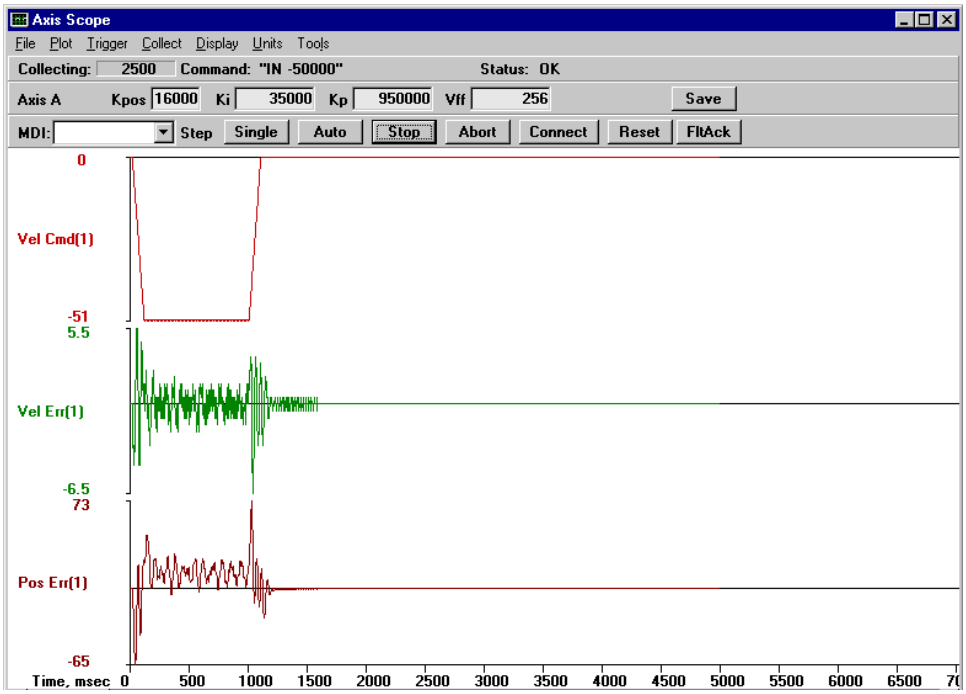


Figure 2-33. Plot Showing an Appropriate Value for Kpos

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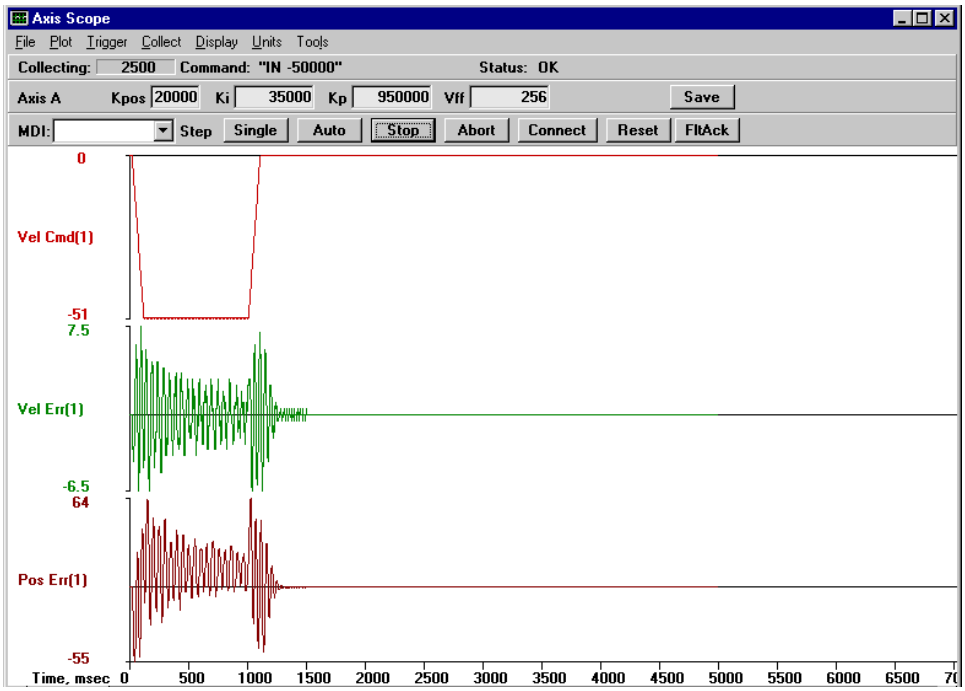


Figure 2-34. Plot Showing Overall Effects When Kpos is High

7. Turn the Position Error and Integral Error Traps on by returning to the Parameters window and selecting the Parameter tab called "Faults." Turn the "Position Error" and the "Integral Error" back on by checking the boxes. This will reactivate these traps.

   Save and exit the Parameters window.

   Reinitialize the BAI.

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2.8. Autotuning

Autotuning is a procedure that automatically identifies motor parameters and determines the motor gains. The process involves giving a sinusoidal velocity command to an axis. From the voltage and current used by the motor, motor parameters are identified and the motor gains are determined from the motor parameters.

To autotune an axis, use the following procedure:

1. From the Tools menu of the Windows software, select the Axis Tuning... option. The Axis Scope screen will appear.
2. From the Tools menu of the Axis Scope screen, select the Gains option and the Auto Tune option. The Gains and Auto Tune toolbars will be displayed on the screen. See Figure 2-35.



Figure 2-35. The "Gains" and "Auto Tune" Toolbars

3. Make sure the gains are not set too high. Lower the Kpos value if the axis goes into oscillations or the axis traps during the autotuning procedure.
4. On the Auto tune panel, there are two text boxes that affect the motion of the axis. One of these boxes is the frequency or "Freq" box. Autotuning will excite the axis with a sinusoidal command of three different frequencies. The first frequency is displayed in the frequency box. The second frequency is twice that of the first frequency, and the third frequency is twice that of the second frequency. When first starting, set the first frequency to 1 Hz.

5 The "Dist" text box is the number of machine steps the axis will go for the first frequency. When first starting, set this value to approximately two revolutions of the motor shaft.

6 When these values are set, hit the Tune button and the sinusoidal commands will be given to the axis. Following the completion of the motion, a pop up window showing the gains determined by the autotuning procedure should be displayed. Selecting OK will write the gains to the parameter file.

7. If an error occurs, examine the torque output. The output should be a sinusoid. If the torque appears to be clipped near 10V, lower either the number of steps or the frequency and retry the procedure. If the torque is low with a peak of less than a volt, increase the number of steps or the frequency.

The torque should be examined even if gains were determined. Autotuning should be run again to achieve a better tuned system, if the torque is not generally sinusoidal with a peak value greater than one volt.

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The other text boxes on the Auto Tune panel, bandwidth (BW) and damping, affect the calculation of the gains. These values refer to the desired frequency response of the velocity loop.

Three autotuning plots are shown in the following Figures. Figure 2-36 shows results of an autotune where "Dist" was set too low. The torque output is generally less than a volt and the commanded velocity plot is not sinusoidal. This stage should be retuned with the number of steps increased.

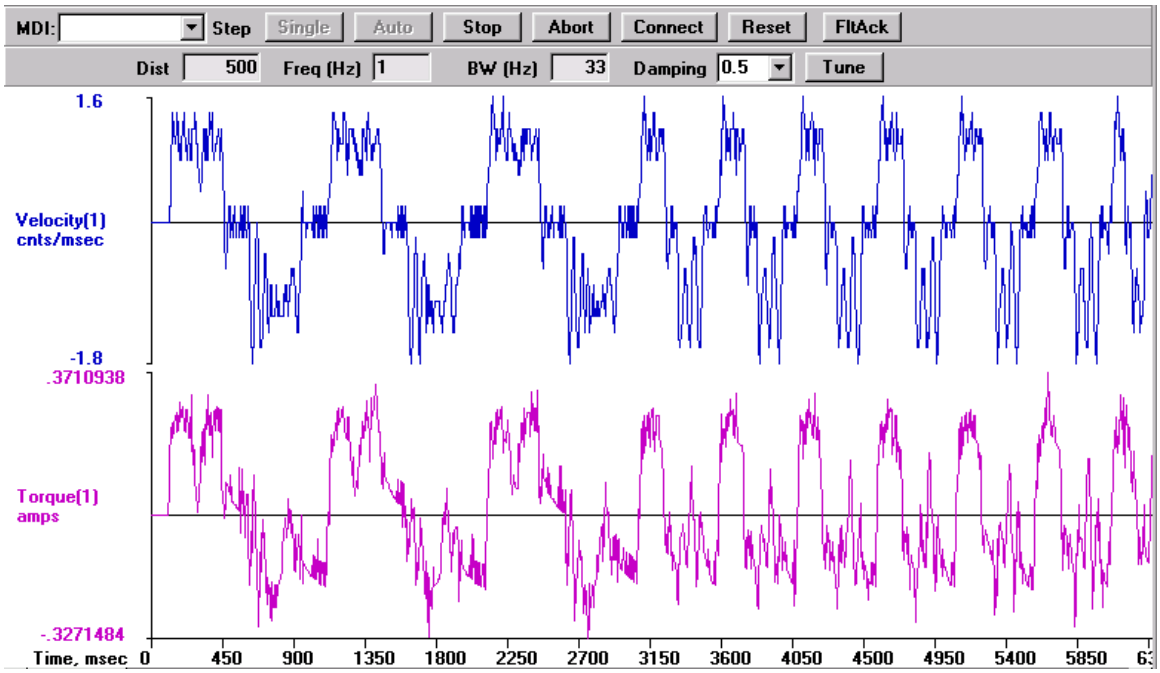


Figure 2-36. Autotune Plot where "Dist" Has Been Set Too Low

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Figure 2-37 shows an autotune plot where there are too many steps. The plot shows that the torque output becomes clipped at 10V. This stage should be re-tuned with the number of steps decreased, so that the torque output is no longer clipped.

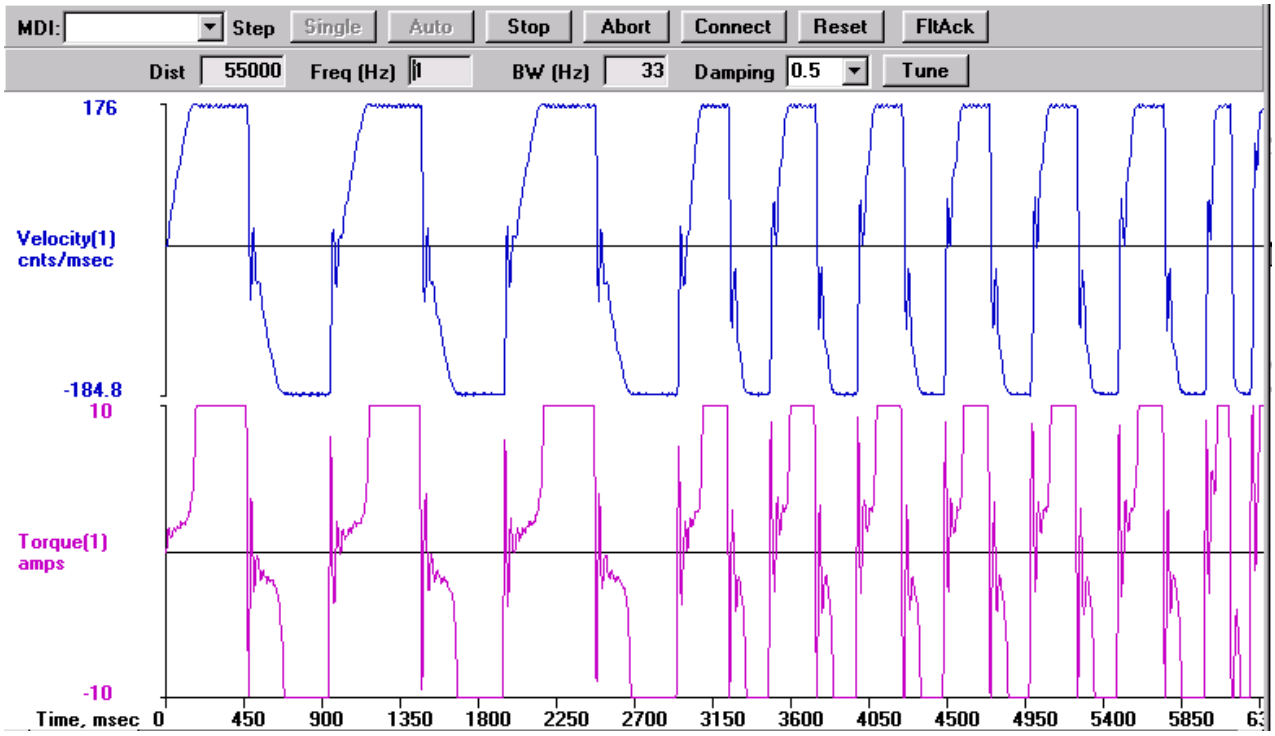


Figure 2-37. Autotune Plot where "Dist" Has Been Set Too High

Figure 2-38 shows a proper autotuning procedure. Both the torque and velocity command are sinusoidal and the torque output peak is greater than one volt. A resulting plot similar to this should identify the parameters of the motor/stage and produce gains that will allow the stage to be run adequately.

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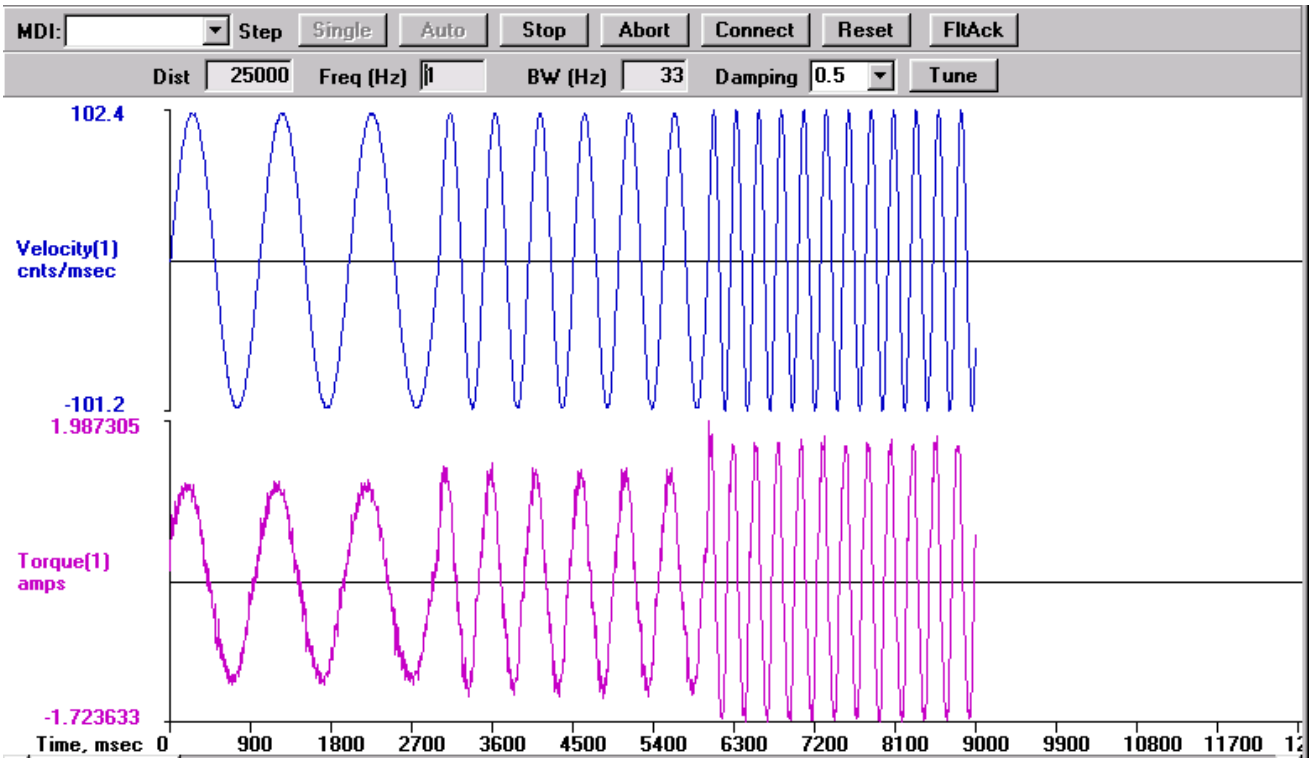


Figure 2-38. Autotune Plot Showing Proper Calibration

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2.9. Tuning Tips

Shown in Figure 2-39 is a tuning plot of an AC brushless motor. Notice the ripple effect during the move. This is normal since AC brushless motors usually have a larger torque ripple than DC brush motors. This ripple effect has been observed to be 10 machine steps peak with an unloaded AC brushless motor.

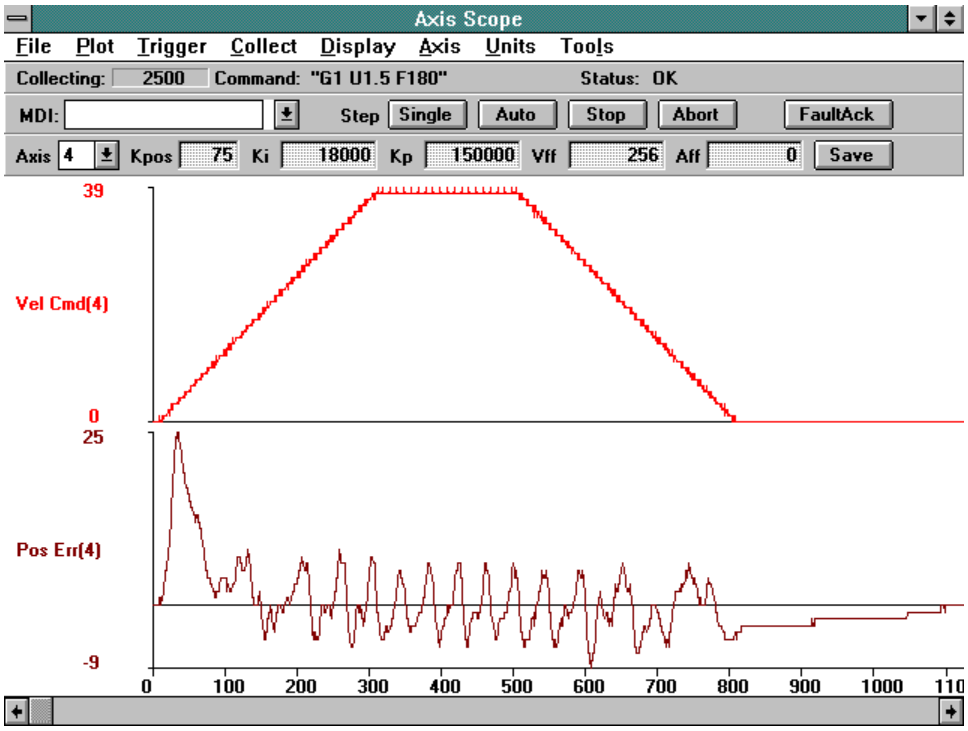


Figure 2-39. Tuning Plot of an AC Brushless Motor

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CHAPTER 3: COMMUNICATION AND COMMANDS

In This Section:

- Introduction 3-1
- BAI Communications Modes 3-1
- Menu Commands.....3-4
- BAI System Commands 3-13
- BAI Motion and Program Commands.....3-23
- Teach Mode.....3-33
- Sample Programs.....3-36

3.1. Introduction

This chapter covers information regarding the communication modes, the COM_BAI menu commands, and the programming commands.

3.2. BAI Communications Modes

Commands can be sent to the BAI with one of two methods: 1) Local mode and 2) Remote mode. Local mode relies on menu screens to control the BAI, whereas remote mode relies on the user sending commands through the RS-232 port.

3.2.1. Local Mode

The default mode for the BAI is local. All menus and command generation resides in the BAI. The menu driven interface is done using a Hand held Terminal (HT) or a DOS-based emulation program on a PC. The first screen the user will see using the DOS emulation program is shown in . This is the tracking screen (COM_BAI).



Figure 3-1. Tracking Screen

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3.2.2. Remote Mode

The BAI can be completely controlled remotely. Remote commands are sent in ASCII format to the BAI followed by an End-Of-String (EOS) character (the line feed) <LF>[0x0A].

Some commands cause the BAI to return data. This data is in ASCII format terminated by the EOS character.

The RS232 interface does not use hardware handshake signals.

The BAI can also be put into service request mode (SRQ). SRQ mode sends a character to the host when an event occurred. The host should then poll the BAI to determine its status.

In RS232 remote mode, the SRQ is generated with a programmable character.

3.2.2.1. Enabling RS232 Remote Communications

Remote mode operation is enabled by setting PRM:95=1 and specifying the address of the unit. The default address is "A". The following sequence can be used to put the unit into remote mode.

1. Set PRM:95=1.
2. Set PRM:94=address (enter the numerical ASCII value).
3. Save parameters
4. Issue a reset.
5. Send 0x03 (CTRL-C).
6. Send 0x02 (CTRL-B).
7. Send the address defined by PRM:94.

Steps 1 and 2 only need to be done once, meaning, once PRM:95 is set to 1 and the address is defined, the unit will bootup in remote mode until PRM:95 is changed back to 0.



If part of this procedure fails and the user cannot regain control of the unit in remote mode, sending a CTRL-A (0x1) will put the unit back into local mode (if the baud rate is correct).

CTRL-A is a toggle between local and remote.

The DOS terminal program, TERM_BAI.exe, can be used to operate the BAI in remote mode.

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3.2.2.2. Daisy Chain

Daisy chain operation is similar to single unit remote operation except each unit must have a different address (PRM:94). The following procedure should be used to enable multiple units in a daisy chain. For each unit in the chain, do the following:

- Set PRM:95=1
- Set PRM:94=address (must be different for each unit)
- Save parameters
- Issue a reset

In order to address a BAI, the user must send the following commands:

- Send 0x03 (CTRL-C)
- Send 0x02 (CTRL-B)
- Send the address of the target unit defined in PRM:94
- Send a remote command

Each time a unit is opened, the above commands must be sent. These commands close the open unit and open a new unit.

If these commands are sent incorrectly, a reset will be sent to all units.

If part of this procedure fails and the user cannot regain control of the unit in remote mode, sending a CTRL-A (0x1) will put all of the units back into local mode.



Any non-printable character sent to the BAI will be sent back to the PC. Since the non-printable characters (0x00 to 0x1F) are global commands, (all the units in the chain [see Figure 1-15]) will be transmitted back to the PC.



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3.3. Menu Commands

The BAI uses certain menu commands that allow the user to perform specific functions, these include:

C - Change a parameter.

D - Display tracking information.

F – File operations.

I - Enter a motion command.

O – Other menu screens.

T - Enter the teach mode.

S – Save parameter to flash.

F1 – Abort entry/return to previous menu.

F2/F3 – Previous or Next menu.

F4 – Jog (at start up).

F5 – abort motion and program.

<space> - cycles through menu commands.

3.3.1. C-Change Parameter

This command allows the user to change a parameter displayed on the screen, refer to Figure 3-2. After pressing C, the user is prompted for the parameter they want to change. To change the parameter, type in the number, press return and the parameter is changed and saved to the flash memory. Some parameters may not take effect until issuing a reset. *These parameters are discussed in Chapter 4: Parameters.* Pressing the F1 key aborts changing the parameter. When changing the parameters, the user also sees the absolute parameter number.

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Figure 3-2. The Change Parameter Screen

The servo loop gains (i.e., KP, KI, and KPOS) can be changed in two different ways. They can be changed by entering in a number directly, or they can be incremented/decremented by pressing I (increment) or **D** (decrement). The amount they are changed is determined by three other parameters. They are KP_INC, KI_INC, and KPOS_INC. For convenience, these parameters are shown on the screen following the servo loop gain screen. The user can see this screen by pressing the 'F3' key (if the current screen shows the servo loop gains). This capability allows the user to dynamically change the servo loop gains. When using the increment/decrement mode, the gains are not saved to flash memory until pressing the enter key.

All parameters have upper and lower bounds. These bounds are provided in Chapter 4: Parameters. If the user enters a number for a parameter that is out of the allowable range, an error message appears.



Figure 3-3. Example of Changing a Parameter in the Change Parameter Screen

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3.3.2. D-Display Tracking Information

After pressing the D key, the user will see the following screen in Figure 3-4.



Figure 3-4. Display Tracking Screen

This screen shows the real time tracking display of the BAI. The position and velocity are the current position and velocity of the BAI scaled by the user defined scale factor parameter PRM:200. Status shows the current status of the BAI. The bit patterns are shown in Table 3-1. The last line shows whether or not the BAI is in a limit or if it is on the marker. Pressing F4 while in the tracking display will index the motor by the amount in PRM:31.

Table 3-1. Bit Patterns

Bit #	Function
bit 0:	1 = position error within limits set in PRM:6
bit 1:	1 = running program
bit 2:	1 = program execution error / immediate command error
bit 3:	1 = illegal remote command (cleared by serial poll 'Q')
bit 4:	1 = axis fault (cleared by FAULT ACK)
bit 5:	1 = command is executing
bit 6:	1 = service request pending
bit 7:	1 = any error

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3.3.3. O-Other Menus

These other available options are used to run programs, read registers, read/write parameters and examine system error messages. View Figure 3-5 for other available menu options.

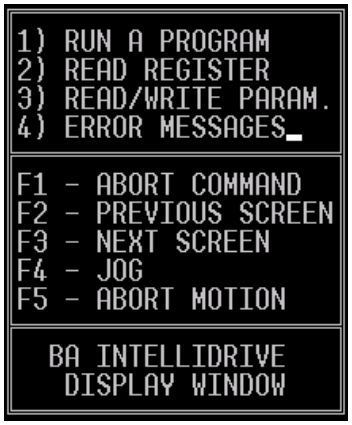


Figure 3-5. Other Menu Options

3.3.3.1. Running a Program

Pressing "**1**" in Figure 3-5 advances the user to the following screen in Figure 3-6 for running programs.

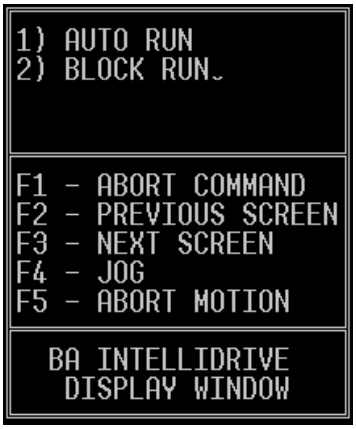


Figure 3-6. Auto Run/ Block Run Option Screen

The options in Figure 3-6 allow the user to auto run a program or block run a program. Block run mode steps through a program line by line, whereas, auto run mode executes the program without user interaction. Regardless of the option chosen, the user will be prompted to enter the filename. If any errors occur, a message will be displayed.

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3.3.3.2. Read Register

The read register selection can be used to examine the contents of the system registers. The registers can be found in Chapter 5: Registers. To re-display the contents of a register, press **R**, refer to Figure 3-7.

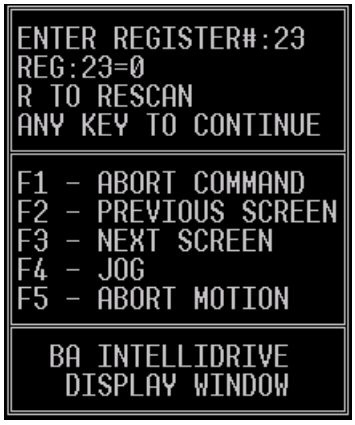


Figure 3-7. Read Register Screen

3.3.3.3. Read/Write Parameter

The read/write parameter screen is selected by pressing 3. The user has the option of reading a parameter, writing a parameter or saving the parameter(s) to flash memory.



After a parameter value has been changed, it is only changed in RAM. Also, certain parameters require a reset (CTRL-D) to be issued before they take effect.

3.3.3.4. Display Error Message

When an error occurs during operation, an error message will be generated. Errors can occur from invalid motion commands, amplifier faults or any other external fault. To display these error messages, the error message selection should be chosen from the menu.

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3.3.4. F-File Operations

This screen allows the user to upload/download files, parameters, and teach programs from the BAI to a PC, refer to Figure 3-8. Also, the user can delete programs and examine the file directory. This function requires the DOS emulation software COM_BAI.exe.



Figure 3-8. File Operation Screen

After pressing the 'F' key, the user will be prompted to upload a file (U), download a file (D) or quit (F1). For uploading or downloading, the user must enter a filename. All filenames follow the eight-character name, three-character extension (8.3 DOS) format for files. The file extension must be "BAI". The filename itself can consist of characters or numbers. No other symbols are allowed. For example, "**PROG1.BAI**" is allowed, whereas "**PRG_1.TST**" is not allowed.

The BAI and the COM_BAI.exe software accomplish all error checking.

3.3.5. F1- Abort Entry/Up One Menu Level

Pressing F1 aborts the current menu operation or moves up one level in the menu.

3.3.6. F2/F3 - Previous/Next Menu

This command allows the user to change the displayed parameters. The parameter screens are circular, (i.e., if the user continually presses F3 or F2, they will eventually return to the starting screen).

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3.3.7. F5 – Aborts Motion and Programs

Pressing F5 while motion is taking place will abort motion (decelerate the motor to zero (0).If programs are running, the programs will stop along with motion. The user must issue a **FA** (Fault Acknowledge) or reset after pressing F5.

3.3.8. I – Enter Motion Command

This mode allows the user to execute single motion commands from the command line, refer to Figure 3-9. Any valid motion command can be entered. See Section 2.7 for motion commands.



Figure 3-9. Enter Immediate Command Screen

3.3.9. S – Save Parameters to Flash

This command saves all parameters, programs, and teach programs to flash memory.

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3.3.10. T-Teach Mode

Teach mode allows the user to teach the BAI up to 100 positions. Movement from one position to the next is accomplished by setting the input bit pattern. This bit pattern is specified by the user while teaching the unit. The user can specify either a binary 1, 0 or X (don't care) as the bit pattern for each of the three inputs. Each of the 100 moves has a bit pattern associated with it. When the pattern is satisfied (see Figure 3-11), the motor makes a move at the user specified velocity position. The present position of the motor is displayed in the "Position" window.

The moves are sequential, meaning, they will execute in order (0, 1, 2, 3, …98, 99). The user cannot jump out of sequential order.



Since the learned positions are absolute, running the teach program forces the unit into absolute position mode. The Teach mode can be executed using the "COM_BAI" DOS emulation program (refer to Figure 3-10) or through the BAI Man Machine Interface (MMI [refer to Figure 3-11]).

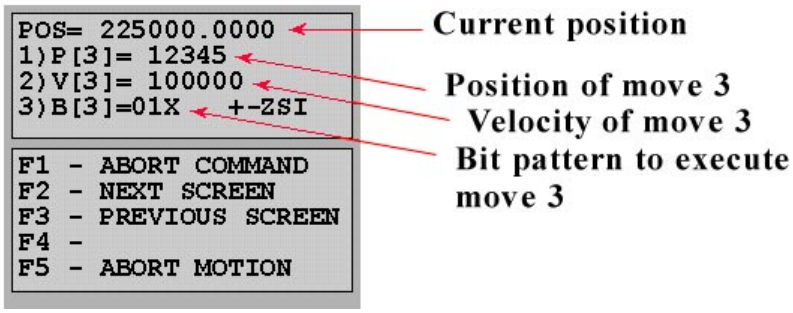


Figure 3-10. Teach Mode (using DOS-based COM_BAI)

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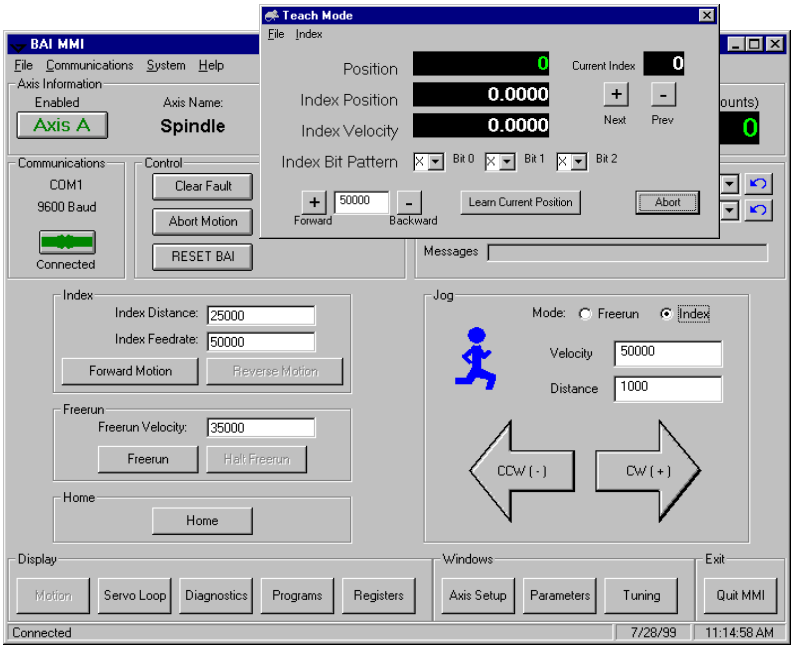


Figure 3-11. Teach Mode (using BAI MMI)

Teach mode is discussed in more detail in Section 3.5. Figure 3-12 is the Teach mode screen.



Figure 3-12. Teach Mode screen (COM_BAI.exe)

3.3.11. Space Bar

Pressing the space bar cycles through the available commands on the top-level menu.

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3.4. BAI System Commands

This section covers the system commands used by the BAI. These commands are typically used when using the BAI in remote mode. The host (PC/controller) can issue a system command via RS232 for various functions. The system commands are **not** used in BAI program. Commands used in BAI program are covered in Section 3.5.

Table 3-2. System Commands

Command	Function
AB	Abort program and or motion
AR	Autorun a program
BR	Block run a program
DF	Delete file
DL	Download file
FM	Format Data
GM	Get Message
HD	Enable/Disable hold mode
I	Execute immediate command
PD	Print Directory
PE	Display error message
PP	Print program
PS	Print Status
PX	Return axis position
Q	Serial poll
RE	Reset unit
RP	Read parameter
RR	Read Register
SP	Save parameters to flash
SR	Define service request character
TR	Trigger
UL	Upload file
WR	Write Register
WP	Write Parameter

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3.4.1. Program/Motion Abort

Command Syntax: **AB <LF>**

0x15 – Aborts motion to all axes in a daisy chain

This command causes a currently executing program to abort. All axes will stop and hold position and the program will unload itself.

3.4.2. Program Execution

Command Syntax: **AR** *prog.BAI* **<LF>** **Auto run a program.**

BR *prog.BAI* **<LF>** **Block run a program.**

Load program "prog" into memory. The program name can consist of numbers (0-9) and letters (A-Z, a-z). The extension must be ".BAI".

In AUTO run mode, the program begins execution immediately. A SRQ will be sent if there is a syntax error in the program. A SRQ can be sent if a run-time error occurs, otherwise the SRQ will be sent when the program completes. If in the HOLD mode, the BAI will not initiate execution of the program until receiving the "TR" command.

In BLOCK run mode, the program will not begin execution immediately. An SRQ will be sent if there is a syntax error. The program can be executed block by block by sending **TR** commands. The BAI generates SRQ's after each block.

3.4.3. DF Delete File

Command Syntax: **DF** *filename* **<LF>**

This command deletes the filename from the BAI directory.

3.4.4. File Transfers – Download File to PC

Command Syntax: **DL** *Filename*<**LF**> Send file from BAI to HOST (PC). (Download)

Table 3-3. BAI File Transfers Transmit Sequence

Direction of Transfer	Command
1) HOST > BAI	"**DL**filename<LF>"
2) HOST < BAI	"numbytes<LF>"
3) HOST > BAI	ACK/NAK
4) HOST < BAI	file data
5) HOST < BAI	"checksum<LF>"

The host sends a download file command and the file name (followed by < LF >) to the BAI. The "filename" is the file to transfer.

The BAI responds with the number of bytes that it is going to transmit. This is an ASCII string terminated by the < LF> character.

The host should then send the ACK (0x6) character when it is ready to accept the data. If the host does not want to download this data, it should send the NAK (0x18)

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character. If the file does not exist, the BAI returns a file size of "0" bytes. The host should send a NAK to abort transmission.

The BAI transmits the file data to the host.

The BAI transmits the checksum as an ASCII string terminated by the < LF> character. The checksum is calculated by accumulating each byte of the file data to a 16 unsigned integer.

3.4.5. Format

Command Syntax: **FM 0 <LF>**

FM 1 <LF>

This format command allows the user to control how numbers are returned from the BAI. IF the argument is 0, the returned data is an ASCII Dec. If the argument is 1, the data is returned as ASCII Hex.

3.4.6. Get Message Command

Command Syntax: **GM <LF>**

The GM command can be used to retrieve messages from the BAI under the following conditions:

1) a **PM** (motion level command) command is used in a program, and

2) the BAI is a daisy chain mode and the unit is not selected.

When the BAI is running in daisy chain mode and a particular unit tries to write a string to the serial port, the BAI verifies that it is the currently selected unit. If it is, it will send the string out of the serial port. If it is not, it will write the string to a buffer where it can be extracted at a later time with the **GM** command.

3.4.7. HOLD/TRIGGER/CANCEL

Command Syntax: **HD** x <**LF**>
TR <**LF**>

Table 3-4. Hold/Trigger/Cancel Variables

x	Service Request Mode
1	Enable hold mode
0	Cancel hold mode

When in the hold mode, programs will load, but not execute until issuing the **TR** command. If the Global trigger command is sent, all units in the chain will leave HOLD mode and begin execution. Refer to Table 3-4 for variable settings.

The trigger command (**TR**) is also used to advance a program when running in blockmode.

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3.4.8. Execute Immediate Command

Command Syntax: **I***cmdstring* <**LF**>

This command can be used to send motion commands to the BAI, primarily when sending ASCII strings to the BAI in remote mode (see Section 3.5 for the motion commands). A syntax error or execution error will be indicated by bit #2 of the status byte. A service request will be sent if enabled. The "PE" command can be given to retrieve an error message. Bit #5 of the status byte indicates that the command is executing. When the command is finished, a service request will be sent if enabled.

Example:

```
IEN
IHO
IIN 10000 F50000
IFA
etc.
```

3.4.9. Print Directory

Command Syntax: **PD <LF>**

Prints a list of all files currently in the BAI's flash memory.

Example:

```
To BAI      PD<LF>
From BAI    TEST1.BAI
            PROG1.BAI
```

3.4.10. Return Error Message String

Command Syntax: **PE < LF >**

This command returns the last error message in the system. Error messages will be generated under the following conditions:

- When a syntax error occurs with an immediate command or a statement in a program
- When a runtime error occurs while executing a program, such as an axis limit
- When an invalid remote command is sent.

The error message is cleared when a successful command is sent. The BAI will return the message followed by a <LF>.

Example:

"Error: Axis in limit"

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3.4.11. Print Program "file" to Port

Command Syntax: **PP** *filename* <**LF**>

This command returns an ASCII output of the specified file. The file name is output first. Line numbers are also added at the beginning of each line. This command is useful when using a terminal emulator to check a file's content.

3.4.12. Print Status

Command Syntax: **PS <LF>**

The **PS** command returns a 32-bit number that contains all of the status bits of the BAI. The first byte (8 bits) contains the data found in the serial poll status (Section 3.4.14.). These bits allow the user to interrogate the unit to determine the source of an error. The bit definitions can be found in Table 3-5. This data can also be found reading REG:2.

Table 3-5. Bit Definitions for the PS Print Status Command

Bit Number	If Bit = 1
0-7	Status
8-10	Opto Input Status
11	External enable signal asserted
12-14	Opto output status
15	Fault out active
16	Invalid Hall state (brushless motors only)
17	RMS fault
18	Position error fault
19	Velocity error fault
20	Amplifier fault
21	Encoder fault
22	Flash memory fault
23	Estop fault
24	Thermistor fault
25	Hall A
26	Hall B
27	Hall C
28	CCW limit encountered
29	CW limit encountered
30	Home Marker active
31	Amp active

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3.4.13. Return Axis Position

Command Syntax: **PX**n < **LF**>

All positions are scaled to user units. "n" is the position type. If "n" is omitted, the BAI will feedback case 8, the encoder position.

Table 3-6. Return Axis Position Type Variables

n	Feedback type
4	Scaled by PRM:200
8	Encoder position in counts
0	Encoder position in counts (default)

Example:

```
PX4<CR>
10247850.123
PX8<CR>
250075680
```

3.4.14. Serial Poll command

Command Syntax: **Q < LF >**

This is the serial poll status byte initiated by a "Q" command in RS232 mode. The BAI is requesting service if bit #6 is set. Reading the serial poll byte clears this bit. The data is returned in ASCII hex.

Example:

Q <**LF**>

Table 3-7. Return Axis Position Type Variables

Bit	If Bit = 1
bit 0:	1 = position error within limits set in PRM:6
bit 1:	1 = running program
bit 2:	1 = program execution error / immediate command error "i..."
bit 3:	1 = illegal remote command (cleared by serial poll 'Q')
bit 4:	1 = axis fault (cleared by fault acknowledge)
bit 5:	1 = command is executing
bit 6:	1 = service request pending
bit 7:	1 = any error

bit 0: 1 = If set, the position error is within the limits set in PRM:6
bit 1: 1 = program is currently running
bit 2: set when:
1) Program runtime error.
2) Immediate command syntax error ("I...").

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This bit is cleared when a new program is loaded or a new immediate ("I...") command is sent to the BAI. Use the "PE" command to get an ASCII error message.

bit 3: illegal remote command was sent to the BAI or a syntax error occurred with that command. This bit is cleared by the serial poll command 'Q'. Use the "PE" command to get an ASCII error message.

bit 4: axis fault occurred, i.e. position error, rms current error, limit, etc. This bit is cleared by the fault acknowledge command "IFA".

Use the "PE" command to get an ASCII error message.

bit 5: command is executing

bit 6: service request sent

bit 7: any error

3.4.15. Hardware Reset

Command Syntax: **RE <LF>**

0x4 (CTRL - D) – Global Reset

The BAI does a hardware reset, this is the same as cycling the power.

3.4.16. Parameter Editing

Command Syntax:	**WP***n value* <**LF**>		:set parameter "n" as "*value*"
	RP*n*	<**LF**>	:return parameter "n"
	SP	**<LF>**	:saves parameter data to disk

The **WP** command changes parameter "n" to a specified value "*value"*.

The **RP** returns the ASCII value of the parameter specified.

The **SP** command saves the file back to the flash memory. The save process can take several seconds. During this time serial communications are blocked out. The BAI sends a service request when finished. It is recommended that the service request mode be enabled when saving the parameters.

After changing a parameter, an **SP** must be issued to save the parameter to flash memory.



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Example:

```
To BAI     WP5 1000<LF>  (write 1000 to parameter 5)
           RP14<LF>      (read parameter 14, encoder
                         resolution)
From BAI   4000<LF>
To BAI     SP<LF>        (save parameters)
```

3.4.17. Read/Write Register

Command Syntax: **RR***n* < **LF**>

WR*n* <**LF**>

Where *x* is a register number to read.

BAI registers contain remote configuration and status information. Each register is a 32-bit number that can be read using the **RR** command. The BAI registers can be found in Chapter 4. All registers can be written to, however, Registers 0-29 are for system use and their contents are not guaranteed.

Example:

```
To BAI      RR2 <LF>
From BAI    123456 <LF>

To BAI      WR 32 10000 <LF>
```

3.4.18. Save Program/Parameters to Flash Memory

Command Syntax: **SP** <**LF**>

Must be sent after issuing **WP** commands, to save the parameters to flash memory.

3.4.19. Service Request Mode (SRQ)

Command Syntax: **SR**x < **LF** >

Table 3-8. SRQ Service Request Variables

x	Service Request Mode
1	Turn on SRQ
0	Turn off SRQ
c	Set service request character to "c"

This command turns the service request mode (SRQ) on or off. Also used to set the SRQ character for RS232 mode "c", refer to Table 3-8. The BAI generates a service request (SRQ) under the following conditions:

- Program is finished executing in AUTO mode
- Block has finished executing in BLOCK mode
- Immediate command has finished execution
- Runtime error in the program
- Syntax error in the program

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- An axis error such as a limit or position error occurs
- An illegal remote command is sent

The normal response to a service request (SRQ) is to serial poll the BAI ("Q"). The user can then determine the source of the error from the status byte.

3.4.20. File Transfers – Upload File to BAI

Command Syntax: **UL** *filename*<LF> Send file from HOST (PC) to BAI (upload)

Table 3-9. BAI File Transfer Receive Sequence

Direction of Transfer	Command
1)HOST-->BAI	"**UL**filename<LF>"
2)HOST-->BAI	"numbytes<LF>"
3)HOST<--BAI	ACK/NAK
4)HOST-->BAI	file data
5)HOST<--BAI	"checksum<LF>"

The host sends an upload file command and file name (followed by an end of string character < LF > to the BAI. The "filename" is the file to transfer.

The host sends the number of bytes to upload to the BAI. This is an ASCII string terminated by < LF >.

The BAI responds with one character. If it is ready to accept the data, the BAI sends the ACK (0x6) character. If there is a problem, the BAI sends the NAK (0x18) character and file transfer aborts.

This step may take several seconds since the BAI is preparing to write to flash memory.



Host sends file data to the BAI.

The BAI returns an ASCII string with the 16-bit checksum.

The checksum is calculated by accumulating each byte of the file data to a 16-bit unsigned integer. The BAI returns either a checksum of 0 or 1 if a file write error occurred.

The maximum file size = 5KB with out comments. The total number of lines in a page is 500. 1 byte = 1 char.

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3.4.21. ; Comment

Comments can be added to the program with the semicolon ";". During file transfer to the BAI, everything after the ";" is ignored and not stored in the flash memory. This was done to conserve memory.

EXAMPLE:

```
HO                ;home axis
RA 0.1            ;0.1 second ramp
IN 1000 F2000     ;move 1000 units @2500 feedrate
```


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3.5. BAI Motion and Program Commands

This section covers the programming commands used by the BAI. The programming commands alphabetically listed in Table 3-10 can be used in a program or remote mode by adding the letter "I" to the front of the command.

Table 3-10. Motion Commands

Command	Function
AC	Set Acceleration
CL	Clear Limit
CS	Conditional gosub
CT	Conditional goto
DI	Disable amplifier
DW	Dwell for x milliseconds
EN	Enable amplifier
FA	Fault Acknowledge
FR	Freerun
GA	Set loop gains
GS	Goto subroutine
GT	Goto label
HO	Home an axis
IN	Point-to-point move
IT	Wait for input to change
LB	Program label
LE/LS	Loop ending Loop starting
LD	Load position register
MC	Motor commutate
OT	Change output
PM	Print message
PR AB	Absolute mode
PR IN	Incremental mode
PS	Program stop
RA	Set the ramp time
RG	Register function
RT	Run teach program
SR	Return from subroutine
WM	Wait Move
WA	Wait for move to finish

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3.5.1. Acceleration Command

Command Syntax: **AC** acceleration

This command can be used to set the acceleration of the motor in user units/s^2. If the acceleration is set to a non-zero value, acceleration will be used instead of the ramp time. Note that using the AC command also changes PRM:210.

3.5.2. Clear Limit

Command Syntax: **CL**

This command will clear a limit from within a program. Note that PRM:74 must be set to a 1 for this work from within a program.

3.5.3. Conditional Gosub

Command Syntax: **CS** *label ARG1*

This command is a conditional gosub based on the ARG1. ARG1 can be either a bit pattern of the opto-isolated inputs or a conditional compare based on register contents. When this statement is reached in a program, the BAI will branch to *label* if the condition is true, otherwise it will continue with the next statement. The *label* must be defined elsewhere in the program. The subroutine must be defined after the **PS** statement and contain an **SR**.

Where *bitpattern* is $I_2I_1I_0$

Example:

```
CS 20 X01          ;wait here for input1=0 and input0=1
:
LB 20              ;beginning of subroutine

CS 33 RG33<20000   ;if RG33 is less than 20000, gosub
                   ;to label 33
CS  44 RG53~RG45   ;if RG53 is not equal to RG45, then
                   ;gosub to label 44
```

When using compare statements, the register must always be on the left-hand side of the compare statement. The valid compare statements are <(less), >(greater than), = (equal to), and ~ (not equal to).

3.5.4. Conditional Goto

Command Syntax: **CT** *label ARG1*

This command is a conditional goto based on the ARG1. ARG1 can be either a bit pattern (where *bitpattern* is $I_2I_1I_0$) of the opto-isolated inputs or a conditional compare based on register contents. When this statement is reached in a program, the BAI will branch to *label* if the condition is true, otherwise it will continue with the next statement. The *label* must be defined elsewhere in the program.

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Example:

```
CT 30 101
:
LB 30                ;CT 30 branches to LB 30 line and
                     ;continues execution
CT 20 X01            ;wait here for input1=0 and
                     ;input0=1
CT 33 RG33<20000     ;if RG33 is less than 20000, goto
                     ;to table 33
CT 44 RG53~RG45      ;if RG53 is not equal to RG45,
                     ;then goto to label 44
```

3.5.5. Disable Amplifier

Command Syntax: **DI**

This command disables the power stage on the amplifier. When the power stage is disabled, the servo loop continually updates the position feedback register, consequently, it does not forget its location. After disabling the power stage, the enable LED will turn red.

3.5.6. Dwell Command

Command Syntax: **DW** *x*

This command stops program execution for *x* milliseconds. "*x*" is the amount of time to dwell in msec.

Example:

```
DW 150       ;Dwell for 150ms
```

3.5.7. Enable Amplifier

Command Syntax: **EN**

This command enables the power stage on the amplifier. When the power stage is enabled, the enable LED will turn green.

If a fault has not been acknowledged (with a **FA** command), the amplifier will not enable.

3.5.8. Fault Acknowledge

Command Syntax: **FA**

If a fault occurs during operation, it must be cleared before any motions commands can be executed or any programs can be run. Faults can occur from:

- an amplifier fault
- position errors
- velocity overspeed
- over travel limit switch encountered.

If the axis is in a limit, the **FA** command attempts to clear the limit by moving the motor in the reverse direction to back off of the limit switch.

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3.5.9. Freerun

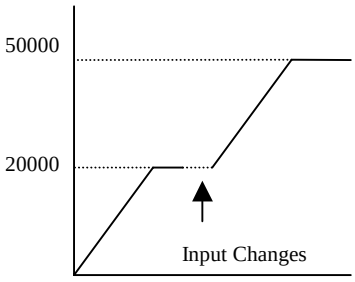
Command Syntax: **FR** *ARG 1*

FR 0

The freerun command commands the motor to move at the feedrate given by *ARG 1*, where ARG1 can be a number or a register. The motor continues to move at this feedrate until a fault occurs, the **FR 0** command is issued or another freerun command is issued. During acceleration/deceleration, the trajectory generator uses the current ramp time to accelerate the motor.

Example:

```
FR 30000        ;freerun motor to 30,000 counts/sec.
FR RG66         ;freerun motor to contents of RG66
```



It is possible to do simple velocity profiling with the freerun command. For example, the velocity can be changed by us of an input.

Example:

```
FR 20000        ;start a free run of 20,000 counts/sec
IT 101          ;wait for input 101
FR 50000        ;move to a velocity of 50,000 counts/sec
```

The commands between the freeruns can be non-motion commands. For example, the velocity can be changed when the position reaches a certain value:

```
FR RG77             ;start freerun
LB 20
CT 20 RG3<100000    ;wait until position exceeds 100,000 counts
FR 20000            ;change speed
```

When using the freerun for velocity profiling, the speeds must be the same polarity.



This command should be used with caution on motors connected to linear stages.

3.5.10. Gain Command

Command Syntax: **GA KP***x* **KI***x* **KPOS***x* **Vff***x*

This command changes the PID gains for the controller. The user can change either one or more of the gains. The gains can be listed in any order.



The gains are not saved to flash memory after issuing this command.

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3.5.11. Gosub Command

Command Syntax: **GS** *label*

This command calls a subroutine from within a program. The *label* must be defined elsewhere in the program. All subroutines must also have an **SR** statement. [Subroutines must appear after the **PS** (program stop command)].

EXAMPLE:

```
IN 2000 F2000
DW 100
GS 20
PS

LB 20
FR 20000
SR
```

3.5.12. Goto Command

Command Syntax: **GT** *label*

This command forces a branch in program execution. The *label* must be defined elsewhere in the program.

EXAMPLE:

```
GT 10
:
:
LB 10
IN 2000 F2000
```

3.5.13. Home Command

Command Syntax: **HO**

The home cycle is used to move the motor to a hardware-referenced position.

Figure 3-13 hows where each parameter affects the home cycle.

1. The axis moves towards the home limit switch in the direction specified by PRM:62 at a feedrate provided by PRM:64.
2. When the BAI encounters the home limit switch (PRM:63 and PRM:61), it decelerates the motor to 0 speed.
3. The motor reverses direction at a speed provided by PRM:75.
4. Once the motor leaves the home limit, it moves a distance provided by PRM:73 at velocity provided by PRM:64.
5. The BAI searches for the marker pulse (PRM:72) at feedrate given by PRM:64.
6. After the marker is found, the motor moves an extra distance provided by PRM:65.

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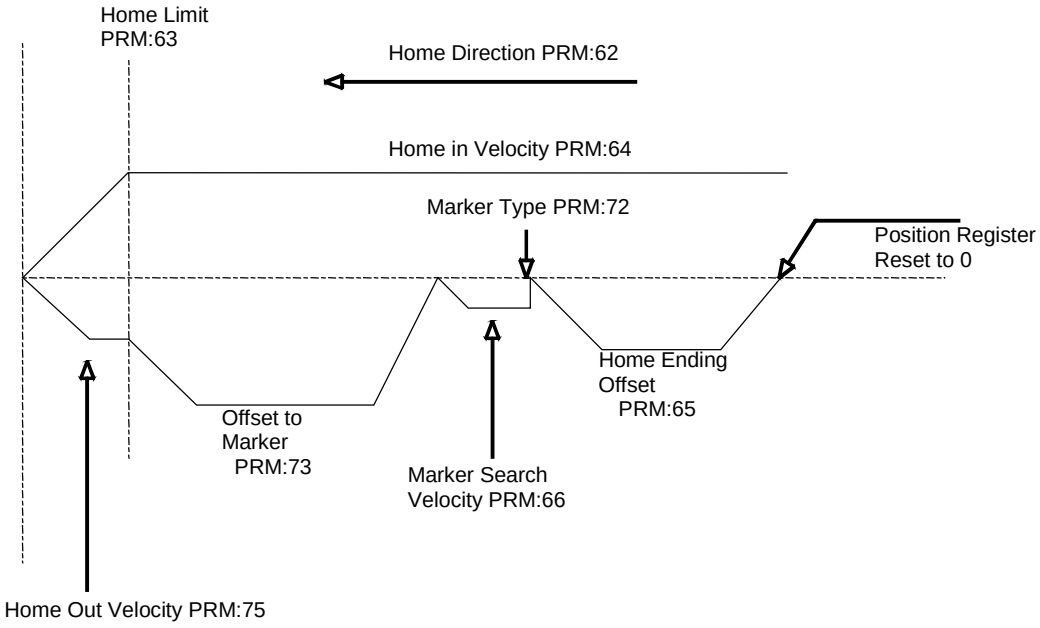


Figure 3-13. Parameters Affecting the Home Cycle

3.5.14. Index Command

Command Syntax: **IN** *distance* **F** *feedrate*

This command will move the motor a distance of *distance* at a feedrate of *feedrate.* The distance and/or feedrate can be either numbers or registers. If the BAI is in incremental mode, the motor will move the full distance. If the BAI is in absolute mode, the motor will move the *distance*. Incremental or absolute mode can be selected with the **PR** command.

The acceleration is determined from the ramp time or from PRM:212. The ramp time can be specified with the **RA** command or the acceleration from the **AC** command. If a ramp time is not specified, the default ramp time is used (PRM:201).

Before motion takes place, the trajectory generator determines if the move can be made with the given parameters. If the move cannot be made with the given parameters, adjustments are made to ensure that the final position is met.

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EXAMPLE:

```
IN 25000 F10000
IN RG55 F RG45
```

3.5.15. IT Command

Command Syntax: **IT** $I_2I_1I_0$

Wait for input to change to state $I_2I_1I_0$. This command, when used in a program, halts execution of the program until the inputs match the state given by "$I_2I_1I_0$", where **I**=0,1,X (don't care). For example, assume the following program is executing.

EXAMPLE:

```
IN 10000 F10000
IT X01            ;Wait for Bit2 = don't care, Bit1
                  = ;0, Bit0 =1
IN –100000        ;index at last feedrate
```

After executing the first command, the BAI waits until the input is 01. Since the first digit is a don't care (X), only two of the three inputs must match to continue program execution.

3.5.16. Label – Define a Label

Command Syntax: **LB** *label*

This command defines labels in programs for branching. Branches are required for goto (**GT**), gosub (**GS**). Conditional goto (**CT**) and conditional gosub (**CS**); only numbers can be used as labels.

EXAMPLE:

```
GT 10
:
:
LB 10
IN 2000 F2000
```

3.5.17. Load Position Register

Command Syntax: **LD** *x*

This command allows the user to load the position feedback with a register with an arbitrary value (*x*).

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3.5.18. Loop Start and Loop End

Command Syntax LE ;loop end

LS ;loop start

The LS/LE command set allow a sequence of moves to execute x number of times.

Where x equals 1 to 500.



Loops cannot be nested.

The example makes five incremental moves.

EXAMPLE:

```
:
:
LS 5
IN 10000 F25000
LE
:
:
```

3.5.19. Motor Commutate

Command Syntax: **MC** *volts*

MC 0

This command outputs a voltage given by *volts* to the amplifier. When issued, this command disables the PID loop. Issuing a value of zero disables the amplifier and resets the servo loop.

3.5.20. Change opto-isolated outputs

Command Syntax: **OT** $O_2O_1O_0$

Change the opto-isolated output to $O_2O_1O_0$, where O=0,1,X (no change made).

EXAMPLE:

```
OT X01      ;set OUTPUT0=1, OUTPUT1=0,
            ;OUTPUT2=Don't Care
```

3.5.21. Print Message

Command Syntax: PM "String

PM RGxx

This command can be used to print messages to the RS232 port from a program. If trying to print a string, a beginning quote " must be used. The contents of registers can also be printed.

PM "Hello World <LF>

PM RG38 <LF>

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3.5.22. Position Mode – Absolute or Incremental

Command Syntax: **PR AB** (Absolute)

PR IN (Incremental)

This mode defines how the BAI interprets a move. If set to absolute mode, the BAI interprets indexing commands as the final position. For example, the command IN 100000 F100000 will move the motor to position 100000 regardless of where the motor is currently sitting. If the mode is incremental, this same command will move the motor 100000 user units.

3.5.23. Program Stop

Command Syntax: **PS**

This command signifies the end of the program and must be used before subroutines.

Ex:

```
GS 20


PS
LB 20
…
SR
```

3.5.24. Ramp Time

Command Syntax: **RA** *time*

This command sets the ramp time for trajectory generator. The Ramp Time is used during acceleration and deceleration. The unit for the ramp time is seconds. Note that if the acceleration command AC is used or PRM:210 ≠ 0, the ramp time will be ignored.

EXAMPLE:

```
RA .015     ;set ramp time to 15 milliseconds
```


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3.5.25. Register Functions

The BAI supports a number of register (integer) based operations. These include assignment, compare, and integer math. Registers are named by combining **RG** with a specific number. The system registers are RG0-RG29 and the general purpose registers are RG30-RG70. The system registers should not be used to store results as they will be overwritten by the system, unless the registers are being reset.

Assignment: Registers are loaded with a value or the contents of another register.

RG30 = RG33
RG30 = -30000

Integer Math: The BAI supports +, -, /, and * for mathematical operations.

RGxx = ARG1 + ARG2
RGxx = ARG1 - ARG2
RGxx = ARG1 * ARG2
RGxx = ARG1 / ARG2 – integer result only, fractions are lost

Where ARG1, ARG2 can be either integers or other registers. Note the system registers, RG0-RG29, should only appear on the right hand side of the equals sign.

3.5.26. Run the teach program

Command Syntax: **RT**

This command runs the learned teach program (see Section 2.7.).

3.5.27. Return from subroutine

Command Syntax: **SR**

This command specifies the end of a subroutine and causes program flow to return back to the calling program.

3.5.28. WM/WA – Wait Move

Command Syntax: **WM** ARG 1 **F** ARG2 – start move
WA – wait for move to complete

The **WM** command is similar to the **IN** command in that it can be used to define a point-to-point move, however, unlike the **IN** command, which stops program execution until the move is complete, execution will continue. Between the **WA** and **WM** commands, the user can change outputs, change registers, wait for inputs and other non-motion commands. The **WA** will halt program execution until the move completes.

EXAMPLE:

```
WA 50000 F RG33     ;start a move
OT 110              ;change outputs
IT  001             ;wait for input
WA                  ;wait for move to complete
```


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3.6. Teach Mode

Teach mode allows the user to specify up to 100 learned positions. Each learned point consists of a position , a feedrate and a bit pattern. A move from one position to the next is initiated by toggling the I/O lines. Up to three I/O lines can be specified for the move to occur. Each move is equivalent to the following lines of a program:

IT $I_1I_2I_3$

IN *distance* **F** *feedrate*

This means, move distance user units at a feedrate of user units/sec. For example, IT 101 IN 20000 F5000. Wait until the inputs are 101 and then move the motor 20000 user units.

The teach mode can only be run in local mode, (i.e., the user must use either a Handheld ASCII terminal or the DOS program COM_BAI.exe). Teach mode is entered by pressing T.

3.6.1. Using the Teach Program

After entering teach mode on the BAI, the user will see the following screen in Figure 3-14. A teach program "ends" when both position and feedrate are zero. The user can upload and download teach programs to and from the PC.

When teaching programs, the unit will default to incremental mode, however, all the positions are interpreted as absolute positions when the program is run.



Figure 3-14. Teach Mode Screen

The first line of this screen shows the motors current position (scaled by PRM:200). The second, third and fourth lines show the position, velocity and I/O pattern for the current index. In this case, the index is zero. The bottom right part of the screen shows the various options available to the user. The following sections describe these options.

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3.6.1.1. +/- Increment/Decrement Current Position

Hitting the +/- key on the keypad moves the motor by the amount defined in PRM:31 at a feedrate defined by PRM:30.

3.6.1.2. F2/F3 Next/Previous Index

Pressing the F2 or F3 key increments or decrements through the learned positions.

3.6.1.3. 1,2,3 Learn the Current Position/Feedrate/Bit Pattern

This command teaches the current position to the BAI. At each position, the BAI can learn a position, a feedrate or the bit pattern. To change the position, feedrate, or bit pattern, enter a 1, 2 or 3. For example, pressing 1 will provide the screen in Figure 3-15.



Figure 3-15. Teach Screen for Position "0" (Showing Current Position and Teach, POS, VEL, and I/O Pattern)

The current position of the motor is copied to the location and the cursor is placed in the line. At this point, the user has the option of either accepting this position (pressing Enter) or entering a new value. A new value is added by typing in the number. As soon as the first key is pressed, the line will clear and the entered number will be displayed. This can be seen in Figure 3-16.



Figure 3-16. Teach Screen for Position "0" (Showing Current Position and Teach, POS, VEL, and I/O Pattern)

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Pressing enter will teach the BAI that position. The same pattern can be followed for the velocity and I/O pattern. When the velocity is changed, the previous velocity entered is displayed on the screen. The user then has the option of accepting this velocity or typing in a new value. When changing the bit pattern, the user can only enter 1, 0 or X (don't care).

3.6.1.4. I-Change the Index

Pressing "I" allows the user to change the current index.

3.6.1.5. Z-Zero the Teach Program

Pressing "Z" resets the teach program to zero's.

3.6.1.6. S-Save the Teach Program

Pressing "S" saves the teach program to the flash memory.

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3.7. Sample Programs

The motion commands given above can be placed in program form. The programs can be written on a PC and uploaded to the BAI through the COM_BAI.exe or term_bai.exe software. For example, consider the following program named "**TESTPRG.BAI**".

The program will move the axis, set outputs and wait for inputs.

```
HO                          ;home the axis
RA .1                       ;change the ramp time to .1
                            ;seconds
PR AB                       ;put in absolute mode
LB 50
                            ;move the motor 100000 user
IN 100000 F45000            ;units at a feedrate of 45000
                            ;user units/second
OT X01                      ;Change output 0 to 1, output 1
                            ;to 0
IT 011                      ;Wait for the inputs to change
                            ;to 011
                            ;move the motor back to position
                            ;0 at a feedrate is of 45000
IN 0                        ;user units/second (if the
                            ;feedrate is not included in the
                            ;command, the last entered
                            ;feedrate is used
IN 20000 F1000              ;move the motor
GS 20                       ;gosub 20
GT 50
PS                          ;restart the program from the
                            ;beginning
LB 20                       ;label 20
IN 34000 F20000
SR                          ;return from sub routine
```


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This program will move to one of eight positions based on the user input:

```
HO                          ;Go home
PR AB                       ;Set for absolute positioning
LB 10                       ;Define Label 10
CS 000 20                   ;Execute a conditional GOSUB
CS 001 30                   ;based on the user inputs
CS 010 40
CS 011 50
CS 100 60
CS 101 70
CS 110 80
CS 111 90
GT 10
PS
LB 20
IN 20000 F30000
SR
LB 30
IN -20000 F20000
SR
LB 40
IN 50000 F60000
SR
LB 50
IN 1000 F600
SR
LB 60
IN 90000 F60000
SR
LB 70
IN -50000 F60000
SR
LB 80
IN 0 F60000
SR
LB 90
IN -5000 F10000
SR
```

This program will execute the move 10 times and after each, pulse output 0. After all 10 moves have completed, it returns home and sets output 1.

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```
LB 10
HO                          ;Go home
OT 000                      ;Change all of the outputs to ;zero
LS 10                       ;Loop start
   IN 100000 F100000        ;move the motor 100000 counts
   OT XX0                   ;Pulse OUTPUT 0
   DW 1000                  ;for 1 second
   OT XX0
LE                          ;End loop
OT X1X                      ;Change OUTPUT 2
GT 10                       ;Restart loop
```

This program will simply execute a freerun while INPUT 0 is low.

```
FR 50000                    ;Start freerunning at 50000
                            ;CNTS/SECONDS
IT XX1
FR 0                        ;Change all of the outputs to zero
```

∇ ∇ ∇

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CHAPTER 4: PARAMETERS

In This Section:

- Introduction 4-1
- Servo Loop Parameters 4-4
- Limit Parameters 4-25
- Communications/Startup Parameters.....4-31
- Miscellaneous.....4-35

4.1. Introduction

This chapter describes the various parameters used on the BAI, refer to Table 4-1. All parameters are entered as numbers. For example, parameter 94 selects the address of the unit. It should be entered as its ASCII decimal equivalent (i.e., A=65, B=66, etc..).

Table 4-1. BAI Parameters

Servo Loop Parameters		
Parameter	**Title**	**Page**
PRM:0	Proportional Velocity Gain KP	4-5
PRM:1	Integral Velocity Gain KI	4-5
PRM:2	Proportional Position Gain KPOS	4-5
PRM:3	Incremental Change for KP	4-6
PRM:4	Incremental Change for KI	4-6
PRM:5	Incremental Change for KPOS	4-7
PRM:6	Servo "In Position" Tolerance	4-7
PRM:7	Servo Peak Current Limit	4-8
PRM:8	Servo RMS Limit	4-8
PRM:9	Servo RMS Current Timeout	4-9
PRM:10	Servo Velocity Trap	4-9
PRM:11	Integral Clamp	4-10
PRM:12	Position Error Trap	4-10
PRM:13	Servo Update Rate	4-11
PRM:14	Encoder Resolution	4-12
PRM:15	Electrical Cycles/Mechanical Revolution	4-12
PRM:16	Hall Effects Available	4-13
PRM:17	Initialization Current	4-14
PRM:18	Velocity Feedforward VFF	4-14
PRM:19	Moved to PRM:209	4-38
PRM:20	Operating Mode	4-15
PRM:22	Position Save	4-15
PRM:23	Reload Saved Position on Powerup	4-15

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Table 4-1. BAI Parameters (cont'd)

Parameter	Title	Page
PRM:24	Saved Position	4-16
PRM:26	Low Pass Filter	4-16
PRM:27	Phase Offset	4-17
PRM:29	Input Command Offset	4-17
PRM:30	Default Velocity	4-18
PRM:31	Jog Value	4-18
PRM:32	In Position Bit	4-19
PRM:33	Dead Band Wait Time	4-19
PRM:34	Thermistor Polarity	4-20
PRM:36	Position Mode	4-20
PRM:37	Estop Action	4-21
PRM:38,39	Current Offset Adjustment	4-21
PRM:40	Registration Input	4-21
PRM:41	Encoder Scale Factor	4-22
PRM:42	I/O Read Time Delay	4-22
PRM:43	Trajectory Type	4-22
PRM:44	Encoder Fault Enable	4-23
PRM:45	Estop Polarity	4-23
PRM:46	Send ACK after move completes	4-24
PRM:47	In Position Output polarity	4-24
PRM:52	RMS Method	4-24
PRM:60	Limit Check	4-25
Parameter	**Title**	**Page**
Limit Parameters		
PRM:61	Limit Type	4-25
PRM:62	Home Direction	4-25
PRM:63	Home Type	4-26
PRM:64	Home Velocity	4-26
PRM:65	Home Ending Offset	4-26
PRM:66	Home Marker Velocity	4-27
PRM:67	Negative Software Limit	4-27
PRM:68	Positive Software Limit	4-27
PRM:69	Deceleration Distance	4-28
PRM:70	+/- Limit Reset Distance	4-28
PRM:71	Check Move Against Software Limits	4-28

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Table 4-1. BAI Parameters (cont'd)

Parameter	Title	Page
Limit Parameters		
PRM:72	Marker Type	4-29
PRM:73	Offset to Marker	4-29
PRM:74	Program Execution	4-29
PRM:75	Home Velocity Out	4-30
PRM:76	Marker Polarity	4-30
PRM:77	Output Disable	4-30
Communications/Startup Parameters		
PRM:90	Baud Rate	4-31
PRM:91	Service Request (SRQ) Character	4-31
PRM:92	Displayable Digits	4-31
PRM:94	Unit Address	4-32
PRM:95	Enable/Disable Daisy Chain – Places in Remote Mode	4-32
PRM:96	Autorun Program on Powerup	4-32
PRM:97	Bootup Program Name	4-33
PRM:98	Amplifier Status on Power up	4-33
PRM:99	External Enable Polarity	4-33
PRM:100	Display Type	4-34
PRM:101	General Fault Output	4-34
Miscellaneous		
Parameter	**Title**	**Page**
PRM:200	Position Scale Factor	4-35
PRM:201	Default Ramp Time	4-35
PRM:202	Filter Cutoff	4-35
PRM:204	Autotune Distance	4-36
PRM:205	Autotune Velocity Loop Bandwidth	4-36
PRM:206	Autotune Damping Factor	4-37
PRM:207	Start Frequency	4-37
PRM:208	Autotune Sampling Time	4-37
PRM:209	Clock Direction Multiplier	4-38
PRM:210	Acceleration	4-38

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4.2. Servo Loop Parameters

The servo loop parameters dictate the performance of the BAI's servo loop. A block diagram of the BAI's servo loop can been seen in Figure 4-1.

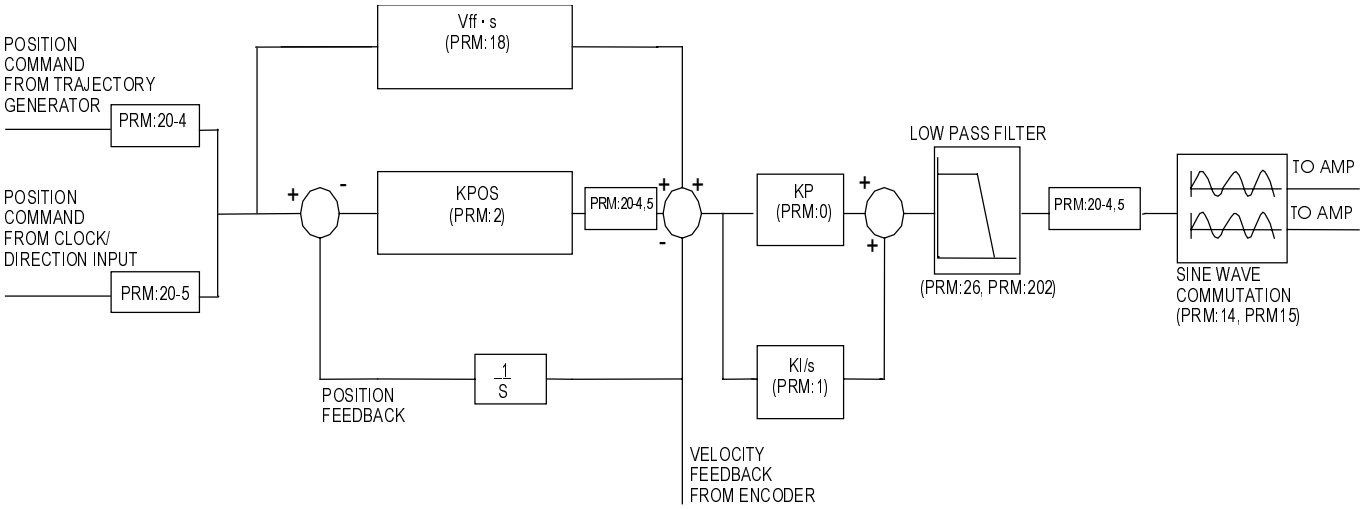


Figure 4-1. PID Control Loop

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4.2.1. PRM:0 Proportional Velocity Gain KP

This parameter provides proportional gain adjustment to the velocity error mode of the PID Control loop, refer to Table 4-2.

Table 4-2. Settings for Proportional Velocity Gain PRM:0

PRM:0	Settings
Default Value	750000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.2. PRM:1 Integral Velocity Gain KI

This parameter provides integral gain adjustment to the velocity error mode of the PID Control loop, refer to Table 4-3.

Table 4-3. Settings for Integral Velocity Gain PRM:1

PRM:1	Settings
Default Value	35000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.3. PRM:2 Proportional Position Gain KPOS

This parameter provides proportional gain adjustment to the position error mode of the PID Control loop, refer to Table 4-4.

Table 4-4. Settings for Proportional Position Gain PRM:2

PRM:2	Settings
Default Value	15000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	-

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4.2.4. PRM:3 Incremental Change for KP

When changing KP from the menus, the user has the option of either entering the gain or modifying the gain by a fixed amount. To modify the gain by a fixed amount, the user presses the **I** (increment) key or the **D** (decrement) key. The gain immediately changes by the value in PRM:3, refer to Table 4-5. The gain change is dynamic, meaning that the servo loop is immediately affected. When return is hit, the gain, PRM:0, is automatically saved to flash memory.

Table 4-5. Settings for Incremental Change for KP PRM:3

PRM:3	Settings
Default Value	1000
Maximum Value	100000
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.5. PRM:4 Incremental Change for KI

When changing KI from the menus, the user has the option of either entering the gain or modifying the gain by a fixed amount. To modify the gain by a fixed amount, the user presses the **I** (increment) key or the **D** (decrement) key. The gain immediately changes by the value in PRM:4, refer to Table 4-6. The gain change is dynamic, meaning that the servo loop is immediately affected. When return is hit, the gain, PRM:1, is automatically saved to flash memory.

Table 4-6. Settings for Incremental Change for KI PRM:4

PRM:4	Settings
Default Value	100
Maximum Value	100000
Minimum Value	0
Type	Long (32bit)
Units	-

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4.2.6. PRM:5 Incremental Change for KPOS

When changing KPOS from the menus, the user has the option of either entering the gain or modifying the gain by a fixed amount. To modify the gain by a fixed amount, the user presses the **I** (increment) key or the **D** (decrement) key. The gain immediately changes by the value in PRM:5, refer to Table 4-7. The gain change is dynamic, meaning that the servo loop is immediately affected. When return is hit, the gain, PRM:2, is automatically saved to flash memory.

Table 4-7. Settings for Incremental Change for KPOS PRM:5

PRM:5	Settings
Default Value	10
Maximum Value	100000
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.7. PRM:6 Servo "In Position" Tolerance

This parameter controls the amount of position error to recognize as the "in position" indication. When the BAI is in position as defined by PRM:6, bit 0 of the status will turn to 1 (or bit 0 of REG:1). Also, if PRM:32=1, bit 2 of the opto-isolated output will go active high. Refer to Table 4-8.

Table 4-8. Settings for Servo "In Position" Tolerance PRM:6

PRM:6	Settings
Default Value	2
Maximum Value	1000
Minimum Value	1
Type	Long (32bit)
Units	Counts

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4.2.8. PRM:7 Servo Peak Current Limit

This parameter controls the maximum allowable current that the PID loop can output. The value is expressed in % of the amplifiers peak current output. For example, if the amplifier can output a peak current of 20 Amps, and PRM:7 is 50%, then the peak current from the PID loop will be 10 Amps. Refer to Table 4-9. for parameter settings.

Table 4-9. Settings for Servo Peak Current Limit PRM:7

PRM:7	Settings
Default Value	100
Maximum Value	100
Minimum Value	0
Type	Long (32bit)
Units	Percent (%)



Requires a reset (CTRL-D) before taking effect.

4.2.9. PRM:8 Servo RMS Limit

This parameter sets the RMS current limit that the PID loop can output before a fault occurs. The value is expressed in % of the amplifiers RMS current capability. For example, if the amplifier has an RMS current rating of 10 Amps, and PRM:8 is 50%, then the controller will generate a fault if the RMS current exceeds 5 Amps for longer than the time given in PRM:9. See also PRM:52 for different methods to compute the RMS. Refer to Table 4-10 for parameter settings.

Table 4-10. Settings for Servo RMS Limit PRM:8

PRM:8	Settings
Default Value	20
Maximum Value	100
Minimum Value	0
Type	Long (32bit)
Units	Percent (%)



Requires a reset (CTRL-D) before taking effect.

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4.2.10. PRM:9 Servo RMS Current Timeout

This parameter determines how long the current can remain above the RMS threshold (given in PRM:8) before a fault is generated. Refer to Table 4-11 for parameter settings.

Table 4-11. Settings for Servo RMS Current Timeout PRM:9

PRM:9	Settings
Default Value	2
Maximum Value	10
Minimum Value	0
Type	Long (32bit)
Units	Seconds

Requires a reset (CTRL-D) before taking effect.



4.2.11. PRM:10 Servo Velocity Trap

This parameter defines the maximum allowable velocity error before a fault occurs. The absolute value of the velocity error is compared against PRM:10. If it exceeds PRM:10, a fault occurs. Setting this parameter to zero disables the velocity error check.

If the velocity error exceeds this value, the amplifier will be disabled and it issues a fault. Refer Table 4-12 for parameter settings.

Table 4-12. Settings for Servo Velocity Trap PRM:10

PRM:10	Settings
Default Value	0
Maximum Value	65535
Minimum Value	0
Type	Long (32bit)
Units	Counts/Samples

Requires a reset (CTRL-D) before taking effect.



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4.2.12. PRM:11 Integral Clamp

This parameter clamps the maximum value of the integrator term in the PID loop. This prevents the PID controller from saturating in the presence of large position or velocity errors. Refer to Table 4-13 for parameter settings.

Table 4-13. Settings for Integral Clamp PRM:11

PRM:11	Settings
Default Value	5000
Maximum Value	65535
Minimum Value	0
Type	Long (32bit)
Units	Counts-Samples



Requires a reset (CTRL-D) before taking effect.

4.2.13. PRM:12 Position Error Trap

The position error fault, like the velocity error fault, defines the maximum allowable position error before a fault occurs. In the event of a position error fault, the amplifier will be disabled and generate a fault. Refer to Table 4-14 for parameter settings.

Table 4-14. Settings for Position Error PRM:12

PRM:12	Settings
Default Value	100
Maximum Value	65535
Minimum Value	0
Type	Long (32bit)
Units	Counts



Requires a reset (CTRL-D) before taking effect.

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4.2.14. PRM:13 Servo Update Rate

This parameter determines the servo loop update time. The default value of 4 corresponds to a servo loop update time of 1ms. Refer to Table 4-15 for parameter settings. To compute the servo loop update time, use the following formula:

Servo loop update time = PRM:13/4000



Requires a reset (CTRL-D) before taking effect.

Table 4-15. Settings for Servo Update Rate PRM:13

PRM:13	Settings
Default Value	4 (1 ms)
Maximum Value	20
Minimum Value	1 (0.25ms)
Type	Long (32bit)
Units	-

4.2.15. PRM:14 Encoder Resolution

The encoder resolution is only needed for commutation (brushless motors). For rotary motors, this value represents the line count of the encoder times 4 (for quadrature). For example, for standard BM motors, resolution of the encoder is 1000 (1000 lines/revolution), the user would enter 4000 for this parameter. The multiplication by four is done in hardware on the controller.

For linear motors, this number represents the number of counts for one electrical cycle. For example, if a BLM linear motor has an electrical cycle of 2.4 inches (60.96mm), and the encoder resolution is 1µm, then PRM:14 would be set to:

$$2.4in\left(\frac{25.4mm}{in}\right)\left(\frac{1count}{0.001mm}\right)=60{,}960$$

Refer to Table 4-16 for parameter settings.



Requires a reset (CTRL-D) before taking effect.

Table 4-17 shows values for PRM:14 when using Aerotech linear motors and common encoder resolutions.

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Table 4-16. Values for Parameter PRM:14

Motor	Encoder Resolution (After Quadrature)						MAG Cycle
	0.1µm	0.5µm	1.0µm	5.0µm	10.0µm	20.0µm	
BLMUC	320000	64000	32000	6400	3200	1600	32mm
BLMC	500000	100000	50000	10000	5000	2500	50mm
BLM	609600	121920	60960	12192	6096	3048	60.96mm
BLMH	600000	120000	60000	12000	6000	3000	60mm
BLMF	600000	120000	60000	12000	6000	3000	60mm
BLMX	600000	120000	60000	12000	6000	3000	60mm

Table 4-17. Settings for Encoder Resolution PRM:14

PRM:14	Settings
Default Value	4000
Maximum Value	2147483647
Minimum Value	300
Type	Long (32bit)
Units	Counts

4.2.16. PRM:15 Electrical Cycles/Mechanical Revolution

This parameter is the number of electrical cycles of the motor/mechanical revolution for brushless motors. Also known as the number of pole-pairs. For linear motors, this number should be one. For BM series motors up to BM1400, this parameter is 4. For BM2000 and larger, PRM:5 = 3. Refer to Table 4-18 for parameter settings.



Requires a reset (CTRL-D) before taking effect.

Table 4-18. Settings for Electrical Cycles/Mechanical Revolution PRM:15

PRM:15	Settings
Default Value	4
Maximum Value	20
Minimum Value	1
Type	Long (32bit)
Units	-

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4.2.17. PRM:16 Hall Effects Available

If the motor has Hall effects available (PRM:16=1), the controller uses the halls to initialize the commutation table. If the hall signals are not available or are not recognized by the controller, the user should set this value to 0. If this value is 0, the controller attempts to initialize the motor by energizing the phases to a known rotor position and then commutate via the encoder from this known value. The peak current used to energize the phases is given in PRM:17. Refer to Table 4-19 for parameter settings.

Requires a reset (CTRL-D) before taking effect.



If the user uses this method to initialize the motor on a linear stage, ensure that the stage is not near a hardware limit.

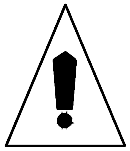
Table 4-19. Settings for Hall Effects Available PRM:16

PRM:16	Settings
Default Value	1(Halls available)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

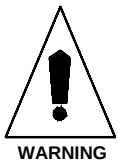
This method may not work on vertical stages.

4.2.18. PRM:17 Initialization Current

This parameter defines the peak current sent to the motor during an initialization. This only applies to brushless motors without hall signals (PRM:16=0). The value of this parameter is in percent (%). Refer to Table 4-20 for parameter settings.



Care must be taken to ensure that the peak current applied to the motor does not exceed the motor's ratings.



Motor may jump during initialization.

Requires a reset (CTRL-D) before taking effect.



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Table 4-20. Settings for Initialization Current PRM:17

PRM:17	Settings
Default Value	20
Maximum Value	100
Minimum Value	0
Type	Long (32bit)
Units	% of Peak

4.2.19. PRM:18 Velocity Feedforward VFF

This parameter enables velocity feedforward compensation to the PID control loop. The velocity command from the trajectory generator is multiplied by PRM:18 and added to the PID loop, refer to Figure 4-1. Refer to Table 4-21 for parameter settings.

The feedforward term is divided by 256 to give more dynamic range.

Table 4-21. Settings for VFF – Velocity Feedforward PRM:18

PRM:18	Settings
Default Value	256
Maximum Value	1000
Minimum Value	0
Type	Long (32bit)
Units	-



PRM:19 Clock Direction Multiplier had been changed to parameter #209, page 4-38.

4.2.20. PRM:20 Operating Mode

The BAI has four operating modes, refer to Table 4-22.

Table 4-22. Operating Modes PRM:20

Operating Mode	PRM:20
Default value	4
Position command from trajectory generator	4
Position command from Clock/Dir	5

Operating mode 4 uses the trajectory generator to generate motion.

Operating mode 5 uses the an external clock/direction input to generate motion. Refer to Table 4-23 for parameter settings.

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Requires a reset (CTRL-D) before taking effect.



Table 4-23. Settings for Operating Mode PRM:20

PRM20	Settings
Default Value	4
Maximum Value	5
Minimum Value	1
Type	Long (32bit)
Units	-

4.2.21. PRM:22 Position Save

When set, the last commanded position is saved to the flash memory at the end of the move. Due to the save, there may be a delay between the end of one move and the start of the next move. Refer to Table 4-24 for parameter settings.

Table 4-24. Settings for Position Save PRM:22

PRM:22	Settings
Default Value	0 (position is not saved)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.22. PRM:23 Reload Saved Position on Power-Up

When set, this parameter reloads the position feedback register with the saved value. The saved position can be found in PRM:24. Refer to Table 4-25 for parameter settings.

Table 4-25. Settings for PRM:23

PRM:23	Settings
Default Value	0 (position is not reloaded)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.2.23. PRM:24 Saved Position

This is the saved value of the last commanded position. Refer to Table 4-26 for parameter settings.

Table 4-26. Settings for Saved Position PRM:24

PRM:24	Settings
Default Value	0
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.24. PRM:26 Low Pass Filter

A lowpass filter can be inserted after the output of the PID controller by setting this parameter to 1. The cutoff frequency is given in PRM:202. This can be used to smooth out PID noise on the current command. Refer to Table 4-27 for parameter settings.



Requires a reset (CTRL-D) before taking effect.

Table 4-27. Settings for Low Pass Filter PRM:26

PRM:26	Settings
Default Value	0 (filter is not enabled)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.2.25. PRM:27 Phase Offset

This parameter allows the user to shift the commutation table by the value in PRM:27. This parameter can be used if phase offsets occur in the current commands, (i.e., if the current commands are out of phase with the back-emf of the motor). A phase shift can occur if the hall signals are not aligned properly. Refer to Table 4-28 for parameter settings.

This parameter can also be used to shift the commutation table for different Hall effect schemes.

Requires a reset (CTRL-D) before taking effect.



Table 4-28. Settings for Phase Offset PRM:27

PRM:27	Settings
Default Value	0
Maximum Value	359
Minimum Value	-359
Type	Long (32bit)
Units	Degrees

4.2.26. PRM:29 Input Command Offset

This parameter allows the user to correct for offsets in the external analog circuitry. Refer to Table 4-29 for parameter settings.

Table 4-29. Settings for Input Command Offset PRM:29

PRM:29	Settings
Default Value	0
Maximum Value	1000
Minimum Value	-1000
Type	Long (32bit)
Units	-

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4.2.27. PRM:30 Default Velocity

This parameter specifies the default velocity when the user fails to specify the velocity during motion. Refer to Table 4-30 for parameter settings.



This only applies if the velocity is not specified for the first index move.



Requires a reset (CTRL-D) before taking effect.

Table 4-30. Settings for Default Velocity PRM:30

PRM:30	Settings
Default Value	50000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	Counts/second

4.2.28. PRM:31 Jog Value

This parameter defines the distance the motor will move in teach mode if the + or – keys are pressed. Refer to Table 4-31 for parameter settings.

Table 4-31. Settings for Jog Value PRM:31

PRM:31	Settings
Default Value	1000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	Counts

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4.2.29. PRM:32 In Position Bit

This parameter, when set, will use output 3 (P1.13) as an in position indicator. When the position error is within the limits defined by PRM:6 after a move completes, this bit will be set by the BAI. An additional wait time to check the position error can be added by setting PRM:33 to a value other than zero. Refer to Table 4-32 for parameter settings.

In position can also be checked by examining Bit 0 of the status register.

Table 4-32. Settings for In Position Bit PRM:32

PRM:32	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.30. PRM:33 Dead Band Wait Time

This parameter, used in conjunction with PRM:32, defines the amount of time the BAI will wait after a move completes before it begins checking for "in position". Although the trajectory generator may have completed the move, the motor may not be in its final position. As a result, the position error may oscillate around the zero point before settling to its final position. This parameter allows the addition of settling time for the motor. Refer to Table 4-33 for parameter settings.

This parameter also effects Bit 0 of the status register.

Table 4-33. Settings for Dead Band Wait Time PRM:33

PRM:33	Settings
Default Value	0
Maximum Value	50,000
Minimum Value	0
Type	Long (32bit)
Units	milliseconds

Requires a reset (CTRL-D) before taking effect.



4.2.31. PRM:34 Thermistor Polarity

This parameter sets the polarity of the thermistor input. The thermistor input can be used to detect an over temperature condition in a motor. A typical motor thermistor is a positive temperature coefficient device, that is, as the temperature of the device increases, so does the resistance of the device. The thermistor input on the BAI assumes this type of device is used in the motor. Under normal operating conditions, the resistance of the thermistor is low (i.e., 100 ohms). The BAI will see this as a low signal. As the

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thermistor resistance increases, (i.e., 10K ohms), the internal pull-up on the BAI will dominate and the BAI will see this as a high signal. The BAI will then disable the power stage. If the thermistor is not present (i.e., infinite resistance), the BAI will see this as an over temperature condition and generate a fault. Consequently, this parameter should be set to 1 if a thermistor is not present. Refer to Table 4-34 for parameter settings and Figure 4-2 for an illustration of the thermistor input circuit.

Table 4-34. Settings for Thermistor Polarity PRM:34

PRM:34	Settings
Default Value	1
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

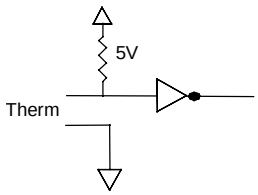


Figure 4-2. Thermistor Input Circuit

4.2.32. PRM:36 Position Mode

This parameter sets the positioning mode on the BAI after reset or power up. The options are incremental (PRM:36=0) or absolute (PRM:36=1). When set to incremental mode, all moves are interpreted as relative moves, meaning, the command **IN** 100000 F100000 will move the motor 100000 user units, regardless of its present location. If the mode is absolute, this move will send the motor to position 100000, regardless of its location. Refer to Table 4-35 for parameter settings.

Table 4-35. Settings for Position Mode PRM:36

PRM:36	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.2.33. PRM:37 Estop Action

This parameter defines the action the BAI takes when the estop input is pulled low. If PRM:37 is zero, an Estop will disable the power stage. If PRM:37 equals 1, the Estop will cause the BAI to execute a fast feedhold. If PRM:37=2, the BAI will stop the motor, then disable the power stage. Refer to Table 4-36 for parameter settings.

Table 4-36. Settings for Estop Action PRM:37

PRM:37	Settings
Default Value	0
Maximum Value	2
Minimum Value	0
Type	Long (32bit)
Units	-

4.2.34. PRM:38,39 Current Offset Adjustment

This parameter can be used to null out an offset in the current commands. PRM:38 is for phase A (brush/brushless) and PRM:39 (brushless only) is for phase B. This value is added (or subtracted) before the current commands are sent to the DAC. Refer to Table 4-37 for parameter settings.

Table 4-37. Settings for Current Offset Adjustment PRM:38, PRM:39

PRM:38, PRM:39	Settings
Default Value	0
Maximum Value	2048
Minimum Value	-2048
Type	Long (32bit)
Units	-

4.2.35. PRM:40 Registration Input

This parameter, when set, uses Input 3 (P1.4) as a registration input. When P1.4 is pulled low, the BAI captures the position feedback register, decelerates the motor to zero and moves the motor back to the captured position. Refer Table 4-38 for parameter settings.

Table 4-38. Settings for Registration Input PRM:40

PRM:40	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.2.36. PRM:41 Encoder Scale Factor

Parameter PRM:41 can be used to change the polarity of the encoder without having to change the wiring. Meaning, positive motion can be redefined with this parameter. When changing this for brushless motors, the user must also change the motor and Hall connections of the motor. Usually, this requires swapping phase B and C of the motor leads and Hall B and C on the feedback cable. Refer to Table 4-39 for parameter settings.

Table 4-39. Settings for Encoder Scale Factor PRM:41

PRM:41	Settings
Default Value	1
Maximum Value	1
Minimum Value	-1
Type	Long (32bit)
Units	-

4.2.37. PRM:42 I/O Read Time Delay

Parameter PRM:42 can be used to insert a delay into the BAI when reading the inputs. Inputs that do not change at the same time can cause the BAI to incorrectly read the status of the input signals. The BAI reads the inputs, waits for x (PRM:42) milliseconds and rereads the inputs. If the state has not changed, it continues on with the command. If the input state changed, the process is repeated until the inputs are the same for two consecutive reads. Refer to Table 4-40 for parameter settings.

Table 4-40. Settings for I/O Read Time Delay PRM:42

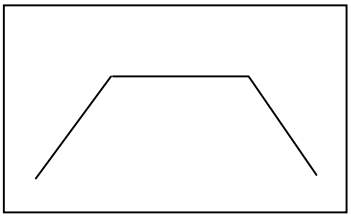
PRM:42	Settings
Default Value	0
Maximum Value	15000
Minimum Value	0
Type	Long (32bit)
Units	Milliseconds

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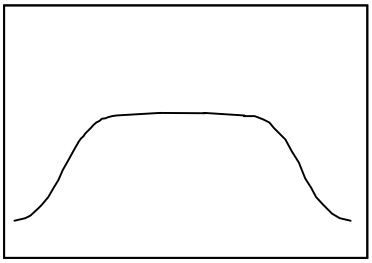
4.2.38. PRM:43 Trajectory Type

This parameter is used to select the type of trajectory used for the motor profile. If PRM:43 = 0, a trapezoidal profile is used, If PRM:43 =1, a S-curve is used. Refer to Table 4-41 for parameter settings.

This only affects motion initiated with **IN** command.



PRM:43 = 0



PRM:43 = 1

Table 4-41. Settings for Trajectory Type PRM:43

PRM:43	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	-
Units	-

4.2.39. PRM:44 Encoder Fault Enable

This parameter specifies whether or not the BAI will generate a fault if the encoder is faulty or missing. This parameter is usually to zero when a single-ended encoder is used. Refer to Table 4-42 for parameter settings.

Table 4-42. Settings for Encoder Fault Enable PRM:44

PRM:44	Settings
Default Value	1
Maximum Value	1 (Encoder fault checking enabled)
Minimum Value	0
Type	Long
Units	-

4.2.40. PRM:45 Estop Polarity

This parameter allows the user to define the polarity of the ESTOP input signal. Refer to Table 4-43 for parameter settings.

Table 4-43. Settings for Estop Polarity PRM:45

PRM:45	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long
Units	-

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4.2.41. PRM:46 Send ACK after move completes

When set, the BAI will send a 0x6 through the serial port to indicate that a move has completed and the position error is with the limits set by PRM:6. Refer to Table 4-44 for parameter settings.

Table 4-44. Settings for Send ACK after move completes PRM:46

PRM:46	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long
Units	-

4.2.42. PRM:47 In Position Output Polarity

This parameter specifies whether or not the BAI will generate a fault if the encoder is faulty or missing. This parameter is usually to zero when a single-ended encoder is used. Refer to Table 4-45 for parameter settings.

Table 4-45. Settings for In Position Output Polarity PRM:47

PRM:47	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	-
Units	-

4.2.43. PRM:52 RMS Method

This parameter selects the method used for RMS calculation. With PRM:52=0, the RMS is calculated by looking at the average value of current, based on PRM:8 and PRM:9. With PRM:52=1, the RMS is calculated as I*I*t, again using PRM:8 and PRM:9. This calculation is closer to I*I*R, which is the power loss in the motor. Refer to Table 4-46 for parameter settings.

Table 4-46. Settings for RMS Method PRM:52

PRM:52	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Integer
Units	-

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4.3. Limit Parameters

4.3.1. PRM:60 Limit Check

This parameter determines whether or not the limits should be checked during motion. If PRM:60=0, no limits are checked and homing is not allowed. If PRM:60=1, limits are checked and homing is allowed. If PRM:60=2, limits are not checked, but homing is allowed. Refer to Table 4-47 for parameter settings.

Table 4-47. Settings for Limit Check PRM:60

PRM:60	Settings
Default Value	1 (enabled)
Maximum Value	2
Minimum Value	0
Type	Long (32bit)
Units	-

4.3.2. PRM:61 Limit Type

This parameter defines the polarity of the hardware limits. Refer to Table 4-48 for parameter settings.

Table 4-48. Settings for Limit Type PRM:61

PRM:61	Settings
Default	0
Active High	1
Active Low	0

Requires a reset (CTRL-D) before taking effect.



4.3.3. PRM:62 Home Direction

This is the initial direction the axis takes to seek the home limit switch. Refer to Table 4-49 for parameter settings.

Table 4-49. Settings for Home Direction PRM:62

PRM:62	Settings
Default	0
CCW	0
CW	1

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4.3.4. PRM:63 Home Type

This parameter selects which switch to search for as the Home Limit Switch. . Refer to Table 4-50 for parameter settings.

Table 4-50. Settings for Home Type PRM:63

PRM:63	Settings
Default	1
CW	0
CCW	1
Home	2
Marker	3



Requires a reset (CTRL-D) before taking effect.

4.3.5. PRM:64 Home Velocity

This parameter is the velocity at which the axis moves when seeking the home limit. A high value of the home velocity could cause the BAI to miss the home switch. Refer to Table 4-51 for parameter settings.

Table 4-51. Settings for Home Velocity PRM:64

PRM:64	Settings
Default Value	10000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	Counts/sec.

4.3.6. PRM:65 Home Ending Offset

This parameter is the distance at which the axis moves after the axis has reached the home marker position. The "Home" is then defined at the end of this move. Refer to Table 4-52 for parameter settings.

Table 4-52. Settings for Home Ending Offset PRM:65

PRM:65	Settings
Default Value	0
Maximum Value	2147483647
Minimum Value	-2147483647
Type	Long (32bit)
Units	Counts

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4.3.7. PRM:66 Home Marker Velocity

This parameter selects the rate at which the BAI searches for the marker pulse after detection of the home limit switch. This velocity should be set no greater than ½ of the servo update rate. For example, if the servo update rate is 1 KHz, velocity should be set no higher than 500counts/sec. Refer to Table 4-53 for parameter settings.

Table 4-53. Settings for Home Marker Velocity PRM:66

PRM:66	Settings
Default Value	500
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	Counts/sec.

4.3.8. PRM:67 Negative Software Limit

This parameter sets the negative software limit threshold. Refer to Table 4-54 for parameter settings.

Table 4-54. Settings for Negative Software Limit PRM:67

PRM:67	Settings
Default Value	-2147483647
Maximum Value	2147483647
Minimum Value	-2147483647
Type	Long (32bit)
Units	Counts

4.3.9. PRM:68 Positive Software Limit

This parameter sets the positive software limit threshold. Refer to Table 4-55 for parameter settings.

Table 4-55. Settings for Positive Software Limit PRM:68

PRM:68	Settings
Default Value	2147483647
Maximum Value	2147483647
Minimum Value	-2147483647
Type	Long (32bit)
Units	Counts

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4.3.10. PRM:69 Deceleration Distance

This parameter defines the maximum distance the motor will travel after an abort command is issued, or the axis enters a limit. Refer to Table 4-56 for parameter settings.

Table 4-56. Settings for Deceleration Distance PRM:69

PRM:69	Settings
Default Value	4000
Maximum Value	2147483647
Minimum Value	1
Type	Long (32bit)
Units	Counts

4.3.11. PRM:70 +/- Limit Reset Distance

This parameter defines the distance that the axis moves when a fault acknowledge (FA) is issued while the axis is in a software or hardware limit. Refer to Table 4-57 for parameter settings.

Table 4-57. Settings for +/- Limit Reset Distance PRM:70

PRM:70	Settings
Default Value	4000
Maximum Value	2147483647
Minimum Value	0
Type	Long (32bit)
Units	Counts

4.3.12. PRM:71 Check Move Against Software Limits

This parameter, when set, will check the index move against the software limits from the motors present location. If the move would cause the motor to enter a software limit, the command is aborted. Refer to Table 4-58 for parameter settings.

Table 4-58. Settings for Check Move Against Software Limits PRM:71

PRM:71	Settings
Default Value	0 (distance not checked)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.3.13. PRM:72 Marker Type

This parameter defines the marker type during a home cycle. The options are CW limit, CCW limit, home limit, and maker pulse. Refer to Table 4-59 for parameter settings.

Table 4-59. Settings for Marker Type PRM:72

PRM:72	Settings
Default Value	3
CW Limit	0
CCW Limit	1
Home Limit	2
Marker	3

4.3.14. PRM:73 Offset to Marker

This parameter is the distance at which the axis moves after finding the home limit switch. This is before searching for the home marker. Refer to Table 4-60 for parameter settings.

Table 4-60. Settings for Offset to Marker PRM:73

PRM:73	Settings
Default Value	0
Max. Value	2147483647
Min. Value	-2147483647
Units	counts

4.3.15. PRM:74 Program Execution

This parameter determines how the BAI responds when a software or hardware limit is reached when a programming is running. If set to 0 (zero), all motion and program execution stops. If set to 1, motion stops, but program execution continues. Refer to Table 4-61 for parameter settings.

Table 4-61. Settings for Program Execution PRM:74

PRM:74	Settings
Default Value	0
Max. Value	1
Min. Value	0
Units	-

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4.3.16. PRM:75 Home Velocity Out

Defines the velocity at which the motor leaves the home limit before searching for the marker. Refer to Table 4-62 for parameter settings.

Table 4-62. Settings for Home Velocity Out PRM:75

PRM:75	Settings
Default Value	10000
Max. Value	2147483647
Min. Value	0
Units	Counts/Sec

4.3.17. PRM:76 Marker Polarity

The parameter defines the polarity of the marker signal. Refer to Table 4-63 for parameter settings.

Table 4-63. Settings for Marker Polarity PRM:76

PRM:76	Settings
Default Value	1 (active high)
Max. Value	1 (active high)
Min. Value	0 (active low)
Type	-
Units	-

4.3.18. PRM:77 Output Disable

This parameter, when set, will turn off all outputs if a fault occurs. Refer to Table 4-64 for parameter settings.

Table 4-64. Settings for Output Disable PRM:77

PRM:77	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long
Units	-

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4.4. Communications/Startup Parameters

4.4.1. PRM:90 Baud Rate

This parameter selects the baud rate. Refer to Table 4-65 for parameter settings.

Table 4-65. Settings for Baud Rate PRM:90

PRM:90	Settings
Default Value	9600
Allowable Values	1200, 2400, 4800, 9600, 19200, 38400
Type	Long (32bit)
Units	bps

4.4.2. PRM:91 Service Request (SRQ) Character

The SRQ character is used by the BAI when running in remote mode. Refer to Table 4-66 for parameter settings.

Table 4-66. Settings for Service Request Character PRM:91

PRM:91	Settings
Default Value	%
Maximum Value	Any printable character
Minimum Value	0x20
Type	Long (32bit)
Units	-

4.4.3. PRM:92 Displayable Digits

This parameter is used to control the number of printable digits after the decimal point for floating point numbers. This only controls the printing in local mode. Refer to Table 4-67 for parameter settings.

Table 4-67. Settings for Displayable Digits PRM:92

PRM:92	Settings
Default Value	4
Maximum Value	8
Minimum Value	1
Type	Long (32bit)
Units	-

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4.4.4. PRM:94 Unit Address

This parameter defines the address for the unit. When operating in daisy chain, each unit in the chain must have a unique address. Refer to Table 4-68 for parameter settings.

Table 4-68. Settings for Unit Address PRM:94

PRM:94	Settings
Default Value	0x41 (A)
Allowable Values	0-Z (0x30-0x5A)
Type	Char (8 bit)

4.4.5. PRM:95 Enable/Disable Daisy Chain - Places in Remote Mode

This parameter enables/disables daisy chain operation. If daisy chain is disabled, the BAI operates in local mode. Refer to Table 4-69 for parameter settings.

Table 4-69. Settings for Enable/Disable Daisy Chain PRM:95

PRM:95	Settings
Default Value	0 (daisy chain not enabled, Local mode)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

4.4.6. PRM:96 Autorun Program on Power-Up

This parameter determines if the BAI should begin execution of a program after reset. The boot program can be found in PRM:97. Refer to Table 4-70 for parameter settings.

Table 4-70. Settings for Autorun Program PRM:96

PRM:96	Settings
Default Value	0 (do not autoboot)
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.4.7. PRM:97 Bootup Program Name

If autorun (PRM:96=1) is selected, the BAI will be execution of the program given in PRM:97. Refer to Table 4-71 for parameter settings.

Table 4-71. Settings for Bootup Program Name PRM:97

PRM:97	Settings
Default Value	""
Format	8.3
Type	12 byte string
Units	-

4.4.8. PRM:98 Status on Power-Up

This parameter defines the state of the power amplifier after a reset or power cycle. The default is enabled. Refer to Table 4-72 for parameter settings.

Table 4-72. Settings for Amplifier Status on Power-Up PRM:98

PRM:98	Settings
Default Value	1
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

4.4.9. PRM:99 External Enable Polarity

This parameter defines the logic value of the external enable signal for the power stage. The external enable is found on P1-5. Refer to Table 4-73 for parameter settings.

Table 4-73. Settings for External Enable Polarity PRM:99

PRM:99	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long (32bit)
Units	-

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4.4.10. PRM:100 Display Type

This parameter controls the format of the numbers when reading parameters and registers. Refer to Table 4-74 for parameter settings.

Table 4-74. Settings for Display Type PRM:100

PRM:100	Settings
Default Value	0 (decimal ASCII)
Maximum Value	1 (Hex ASCII)
Minimum Value	0
Units	-

4.4.11. PRM:101 General Fault Output

When this parameter is set, it uses Output 2 (P1.12) as a general fault indicator. The fault output signal is active high. A fault signal is generated whenever any internal fault occurs (i.e., position error fault, amp fault, etc). This is different from the amplifier fault output signal (P1.10) that only changes when an amplifier fault occurs. Refer to Table 4-75 for parameter settings.

Table 4-75. Settings for General Fault Output PRM:101

PRM:101	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Units	-

4.4.12. PRM:102 Fault Output Polarity

This parameter is used to define the polarity of the general fault output bit. This parameter is used in conjunction with PRM:101. Refer to Table 4-76 for parameter settings.

Table 4-76. Settings for PRM:102

PRM:102	Settings
Default Value	0
Maximum Value	1
Minimum Value	0
Type	Long
Units	-

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4.5. Miscellaneous

4.5.1. PRM:200 Position Scale Factor

This parameter allows the user to convert the encoder counts to user units, (i.e., inches, mm). Refer to Table 4-77 for parameter settings.

Table 4-77. Settings for Position Scale Factor PRM:200

PRM:200	Settings
Default Value	1.00
Maximum Value	5.0e10
Minimum Value	-5.0e10
Type	Float
Units	-

4.5.2. PRM:201 Default Ramp Time

This is the default ramp time the trajectory generator uses to accelerate the motor if the ramp time had not been specified (RA command). Refer to Table 4-78 for parameter settings.

Table 4-78. Settings for Default Ramp Time PRM:201

PRM:201	Settings
Default Value	.1000
Maximum Value	2.000
Minimum Value	.25e-3
Type	Float
Units	Seconds

4.5.3. PRM:202 Filter Cutoff

This parameter defines the cutoff frequency for the lowpass filter. The low pass filter filters the current command before it is sent to the amplifier. Refer to Table 4-79 for parameter settings.

Table 4-79. Settings for Filter Cutoff PRM:202

PRM:202	Settings
Default Value	500.0
Maximum Value	20000.0
Minimum Value	0
Type	Float
Units	Hz

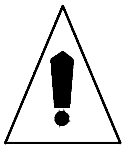
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4.5.4. PRM:204 Autotune Distance

This parameter specifies the distance the motor will move when autotuning. During the autotuning procedure, sinusoidal velocity profile is fed to the PID controller. The motor will move the distance given in PRM:204 (counts). Refer to Table 4-80 for parameter settings.

Table 4-80. Settings for Autotune Distance PRM:204

PRM:204	Settings
Default Value	32000
Maximum Value	1000000
Minimum Value	100
Type	Long
Units	Counts



When the motor is connected to a linear stage, the table should be placed at the center of travel and PRM:204 should be set such that the motor does not travel into the limits or hardstop.

4.5.5. PRM:205 Autotune Velocity Loop Bandwidth

This parameter specifies the velocity loop bandwidth and is used by the autotuning procedure to determine the closed loop poles of the velocity loop. Refer to Table 4-81 for parameter settings.

Table 4-81. Settings for Autotune Velocity Loop Bandwidth PRM:205

PRM:205	Settings
Default Value	20
Maximum Value	100
Minimum Value	1
Type	Float
Units	Hz

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4.5.6. PRM:206 Autotune Damping Factor

This parameter sets the damping factor for the velocity loop. The value of this parameter must be greater than zero. The closed loop poles of the velocity loop are modeled as a second order system. That is, the closed loop poles are given by the solution to $s^2+2\zeta\omega_n+\omega^2_n$. PRM:206 is the damping factor (ζ). If the value of PRM:206 is less than 1, the system is under-damped and the poles are complex. If PRM:206>1, the system is over-damped and the poles are real and if PRM:206=1, the system is critically damped and the poles are real. Refer to Table 4-82 for parameter settings.

Table 4-82. Settings for Autotune Damping Factor PRM:206

PRM:206	Settings
Default Value	1
Maximum Value	100
Minimum Value	0.01
Type	Float
Units	-

4.5.7. PRM:207 Start Frequency

This parameter sets the starting frequency for the autotuning algorithm. During the tuning process, this frequency is doubled and then quadrupled. For example, if PRM:207 is set to 1, the motor will be excited with frequencies of 1.0Hz, 2.0Hz and 4.0Hz. Refer to Table 4-83 for parameter settings.

Table 4-83. Settings for Start Frequency PRM:207

PRM:207	Settings
Default Value	1
Maximum Value	1000
Minimum Value	.001
Type	Float
Units	Hz

4.5.8. PRM:208 Autotune Sampling Time

This parameter is used by the autotuning algorithm to determine when to sample the torque and velocity. Refer to Table 4-84 for parameter settings.

Table 4-84. Settings for Autotune Sampling Time PRM:208

PRM:208	Settings
Default Value	20
Maximum Value	1000
Minimum Value	1
Type	Integer
Units	Milliseconds

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4.5.9. PRM:209 Clock/Direction Multiplier

This parameter replaces PRM:19 and allows fractional scaling of the clock input pulses when the BAI is operating in clock/direction mode. Refer to Table 4-85 for parameter settings.

Table 4-85. Settings for Clock/Direction Multiplier PRM:209

PRM:209	Settings
Default Value	1
Maximum Value	1000
Minimum Value	.001
Type	Float
Units	-

4.5.10. PRM:210 Acceleration

This parameter is used to define the acceleration. It is scaled by the user defined scale factor in PRM:200. If the acceleration is zero, then the ramp time is used to calculate the acceleration. Refer to Table 4-86 for parameter settings.

Table 4-86. Settings for Acceleration

PRM:210	Settings
Default Value	0
Maximum Value	$5.1x10^8$
Minimum Value	0
Type	Float
Units	User units/sec^2

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CHAPTER 5: REGISTERS

In This Section:

- Introduction 5-1

5.1. Introduction

The registers on the BAI allow the user to interrogate the unit in real time. Registers can be read (in remote mode) by sending the "RR" command.

There are 70 registers available for use in programs. The first thirty registers are modified by the system and can be used for interrogation, consequently, they should not be used for storage. The remaining registers, RG30-RG69, can be used for storage and manipulation. When referring to registers in a program, the syntax is **RGxx**, where **xx** is a number between zero and sixty-nine.

5.1.1. RG1 Program Bytes Remaining

This register indicates the number of bytes remaining for program storage.

Example:

RR 1 <ENTER> PC
4200 <LF> BAI responds with this

5.1.2. RG2 BAI Status

This register returns the 32-bit status register of the BAI. Reading this register is equivalent to issuing the **PS** command.

Example:

RR 2 <ENTER> PC
13562 <LF> BAI

If the "FM 1" command is issued, the status returns as a hex number that is easier to interrogate.



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5.1.3. RG3 Position Feedback

This register contains the position feedback in encoder counts. Reading this register is equivalent to issuing the **PX** command.

Example:

RR 3 <ENTER> PC
50000 <LF> BAI

5.1.4. RG4 Velocity Feedback

This register contains the velocity feedback in user units/sample.

Example:

RR 4 <ENTER> PC
2344 <LF> BAI

5.1.5. RG5 Position Command

This register contains the servo commanded position as a 32-bit decimal number.

Example:

RR 5 <ENTER> PC
50000 <LF> BAI

5.1.6. RG6 Position Error

This register contains the position error.

Example:

RR 6 <ENTER> PC
0 <LF> BAI

5.1.7. RG7 Current Command

This register contains the current command from the PID loop. This value will be between I4096.

Example:

RR 7 <ENTER> PC
153 <LF> BAI

5.1.8. RG8 Firmware Version

This register contains the current version of the firmware in flash memory.

Example:

RR 8 <ENTER> PC
241 <LF> BAI

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5.1.9. RG9 Velocity Command

This register contains the velocity command from the trajectory generator.

Example:

```
RR 9 <ENTER>  PC
225 <LF> BAI
```

5.1.10. RG12 A/D Input

This register contains the data read from the 10 bit A/D converter. The analog signal is applied on Pins 17 and 18 of P1. The signal input range is 10 V.

5.1.11. RG14, RG15 Timers

Registers 14 and 15 are .25ms independent timers that can be used to time an event. These registers can be zeroed with RG 14=0 or RG 15 =0.

Example:

```
RG14=0              ;reset timer 1
FR 35000            ;start motor moving at 35000 units/sec
LB 10
CT 10 RG14<20000    ;stay at this speed for 5 seconds
FR 0                :decel motor to zero
```

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CHAPTER 6: MODE OF OPERATION

In This Section:

- Introduction 6-1
- Modes of Operation 6-1
- Indexing Mode 6-1
- Clock and Direction.....6-3

6.1. Introduction

This chapter contains all information regarding the BAI's modes of operation.

6.2. Modes of Operation

The BAI has two modes of operation:

1) Indexing

2) Clock and Direction

The different modes can be selected by changing the parameter, PRM:20. Indexing mode relies on the internal trajectory to generate motion. Clock and direction mode requires an external controller to output clock pulses and a direction pulse.

6.3. Indexing Mode

When operating in indexing mode (PRM:20=4), the BAI acts as a stand alone motion controller. The only peripheral the user needs is a hand-held terminal. The reference position and feedrate are specified through the motion commands. All motion profiles are generated internally by the trajectory generator. The trajectory generator utilizes a trapezoidal profile (PRM:43 = 0) or S-curve (PRM:43 = 1) to generate the velocity and motion profiles. This can be seen in Figure 6-1, which shows an example move. Figure 6-2 shows the same move with the S-curve profile.

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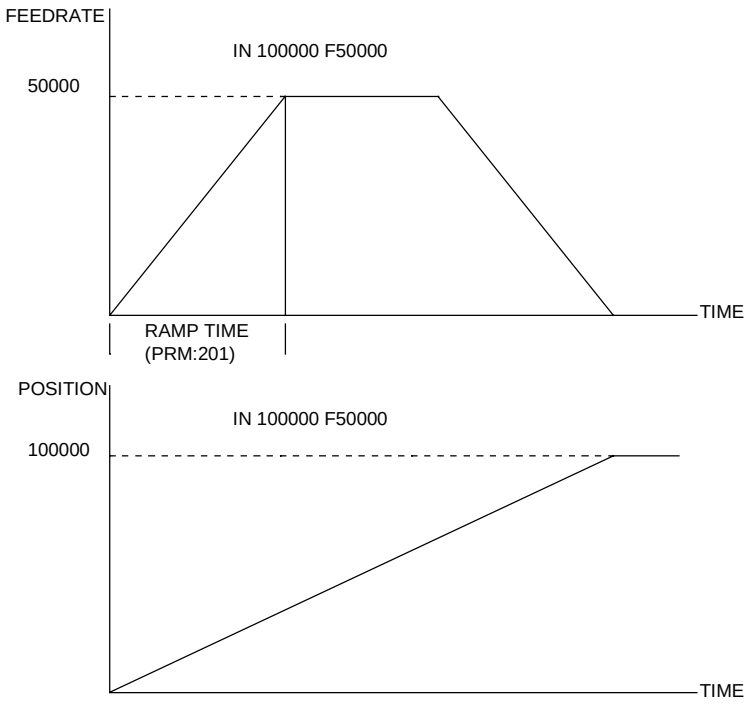


Figure 6-1. Trapezoidal Motion Profile

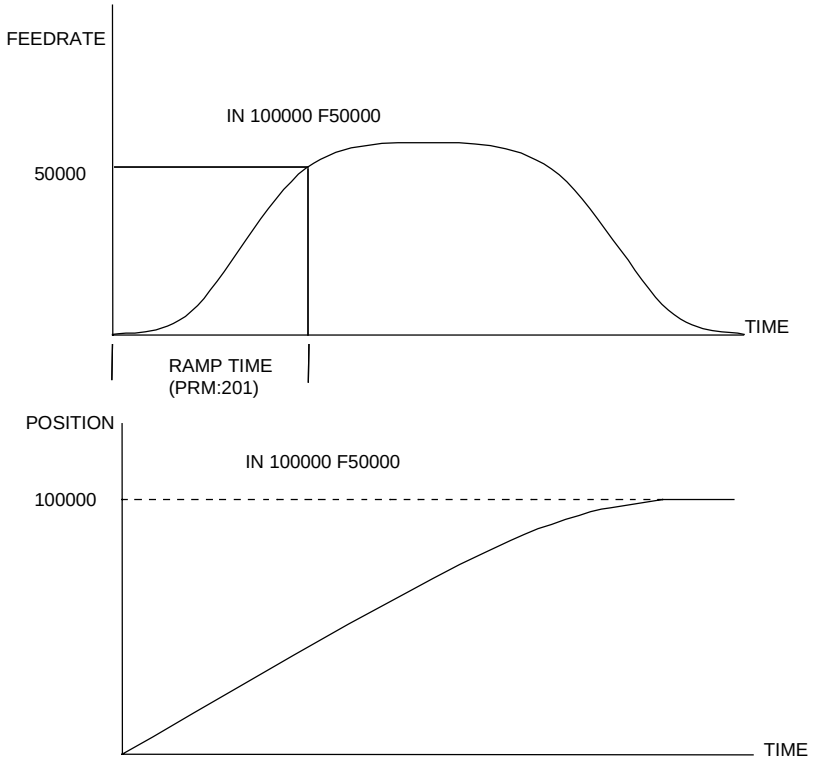


Figure 6-2. Sinusoidal Motion Profile (S-curve)

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If a move is programmed where the ramp distance (the distance the motor would move during ramping) is greater than half of the total distance, the trajectory generator modifies the feedrate so that the velocity profile is triangular. This results in a move with a feedrate that is less than the programmed one. However, the specified position is always reached.

The PID controller is shown in Chapter 4.

6.4. Clock and Direction

Clock and direction is selected by changing PRM:20 to 5 and issuing a reset (CTRL-D). In this mode of operation, the BAI is controlled by sending clock and direction pulses on P1-8 clock) and P1-7 direction). During each servo cycle, the BAI reads the clock counter and uses this information as the position/velocity command. The maximum clock frequency into P1-8 is 1 MHz.

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CHAPTER 7: TECHNICAL DETAILS

In This Section:

- Introduction 7-1
- BAI Control Board Jumper Selections 7-1
- The I/O Port 7-2
- Encoder/Limits/Hall Effects Port P3 7-7
- Servo Amplifier Specifications 7-13
- AC Input and Motor Wiring 7-15
- BAI Amplifier Dimensions 7-19

7.1. Introduction

This chapter contains all detailed technical information regarding the BA-Intellidrive.

7.2. BAI Control Board Jumper Selections

The only user selectable jumper on the BAI control board is JP3. The jumper selects between brush and brushless motors. Refer to Figure 7-1 for jumper locations.

If the user is switching between brushless motors, the power board jumpers must be reconfigured on the amplifier.



The user selectable jumpers on the power board are shown in Table 7-1.

Table 7-1. BAI Board Jumper Selections

Jumper	Position	Mode
JP1	-	NA
	-	NA
JP3	1-2	5V Input common
	2-3	24V Input common
JP7	-	NA
	-	NA
JP8	1-2	Brushless
	2-3	Brush

Remove power from unit before changing jumpers.



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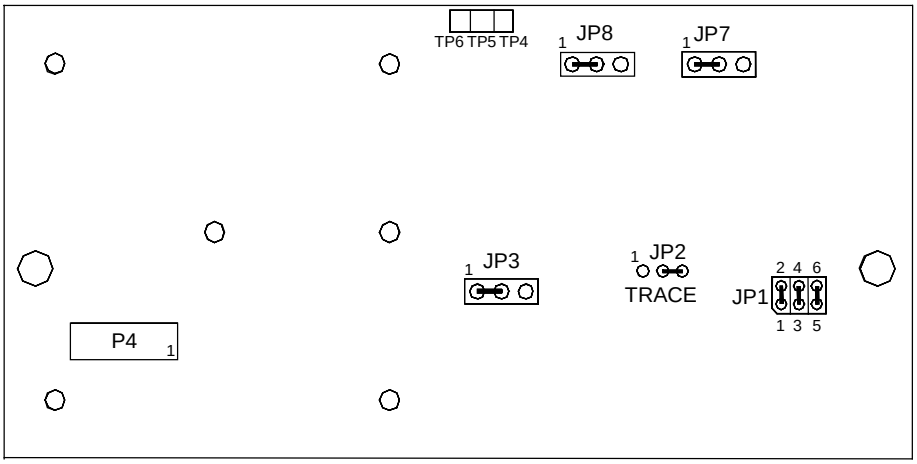


Figure 7-1. BAI Jumper Locations

7.3. The I/O Port

The I/O port is a 25-pin "D" style connector that contains all of the general purpose I/O functions. These include:

- 6 non-dedicated digital I/O signals (3 input/3 output)
- 2 dedicated digital I/O signals (External Enable)
- 1 general purpose analog input

The pinouts for the 25-pin connector is shown in Table 7-2.

Table 7-2. I/O Connector Pinouts (P1)

Pin	Function	Pin	Function
1	Shield	13	Out3
2	Input1	14	Estop
3	Input2	15, 25	Ground
4	Input3	16	+5V
5	External Enable	17	Analog Input +
6	Input Common	18	Analog Input -
7	Direction	19	Thermistor
8	Clock	20	Restore/Reset
9	Output Common	21	NC
10	Amplifier Fault Out	22	NC
11	Out1	23	NC
12	Out2	24	NC

* Do not connect to the NC pins.

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7.3.1. Restore/Reset Signal

This signal can be used to restore the parameters to their default settings during powerup. To restore the parameters, tie this signal to signal common (P1-20 to P1-15) and turn on power to the unit. The user will be prompted for a course of action to take. After power up, this signal can be used to reset the BAI.

All programs are erased during this operation.

7.3.2. Clock/Direction Inputs Signals

The BAI can accept clock and direction inputs as a position command to emulate a stepper translator. The input signals must be a 0V to +5V level. Maximum clock speed is 1 MHz. Refer to Figure 7-2 for circuit.

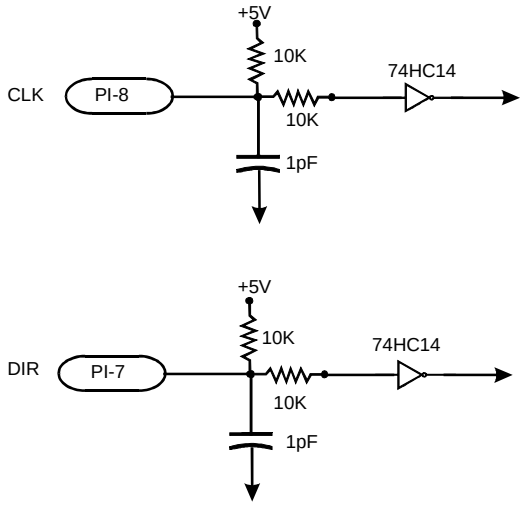


Figure 7-2. Clock/Direction Input Circuit

7.3.3. Estop Input Signal

The Estop input can be used to abort motion and disable the power stage. The signal is sampled by the BAI every 1ms. PRM:37 controls the Estop function. When PRM:37=0, the Estop input will disable the BAI power stage allowing the motor to coast.

With PRM:37=1 the Estop input will act a fastfeed hold and the motor will servo to a controlled stop. With PRM:37=2, the motor will servo to a controlled stop, and then the amp. will disable. The rate of deceleration is determined by the ramp time parameter PRM:201.

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7.3.4. Thermistor Input Signal

A thermistor can be connected to the BAI as a means of detecting a motor over temperature condition. If over temperature occurs, the BAI aborts motion and shuts down the power stage. This is a latching condition, (i.e., a fault acknowledge command [FA] must be issued before the amp can be re-enabled). Figure 7-3 shows the circuitry used to detect the over temperature. While the temperature is low, so is the resistance of the thermistor. Consequently, the input to the inverter is pulled low and its output is high. As the temperature increases, so does the thermistor resistance. Once the resistance of the thermistor increases beyond 1.5K Ohms, the input to the inverter will pull high and generate a fault in the controller.

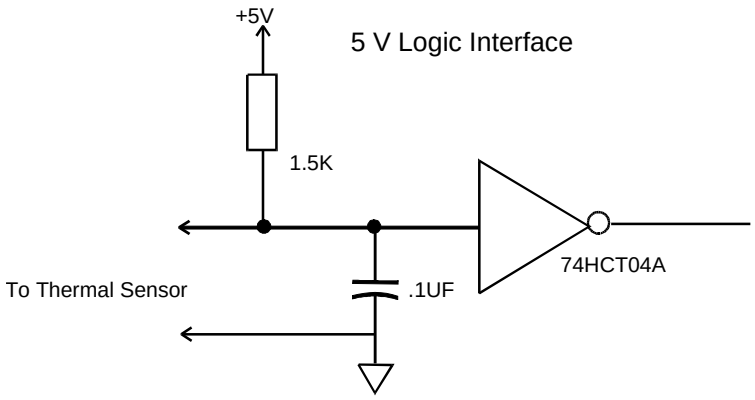


Figure 7-3. Over Temperature Circuitry

7.3.5. Analog Inputs

The BAI can accept a differential +/-10V analog input on Pins 17 and 18 of P1. The digitzed value is stored in Register 12. The data can be used to dictate program flow.

7.3.6. Opto-Isolated Inputs

There are three general purpose opto-isolated inputs on the BAI. Figure 7-4 shows the electrical characteristics of each input.

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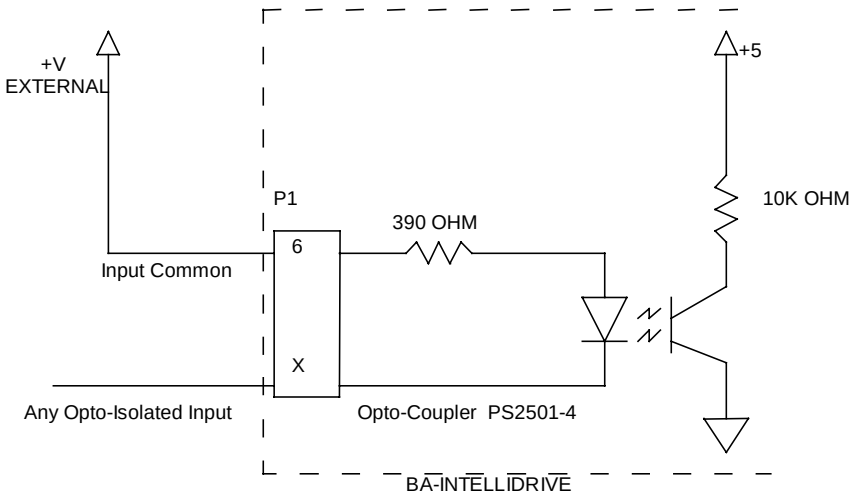
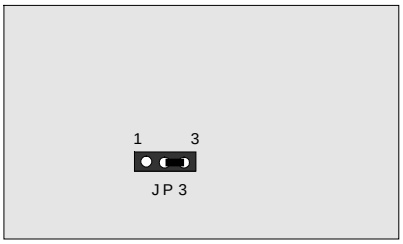


Figure 7-4. Electrical Characteristics of Opto-Isolated Input

All digital inputs must operate from the same power supply, since they all reference the same INPUT COMMON (P1-6).

To add an external power supply that is greater than 9 volts, a resistor must be added to input feed. Place the resistor in series with each input to limit the current to a safe 20mA.

The Rev B version of the board contains a jumper (JP3), that allows the user to put 24 VDC on the input common without external resistors. JP3 must be set to 2-3 to use this option.



The external enable signal is also an opto-isolated input.

7.3.7. Opto-Isolated Outputs

The BAI also has three general purpose opto-isolated outputs. The fault output signal should only be used to determine the status of the amplifier. It does not indicate the status of the controller (i.e., if a position error fault occurs, the fault output signal will not be active). See Section 4.4.11. for details on how to set the BAI up for a general purpose fault output. The electrical characteristics of each output is shown in the Figure 7-5.

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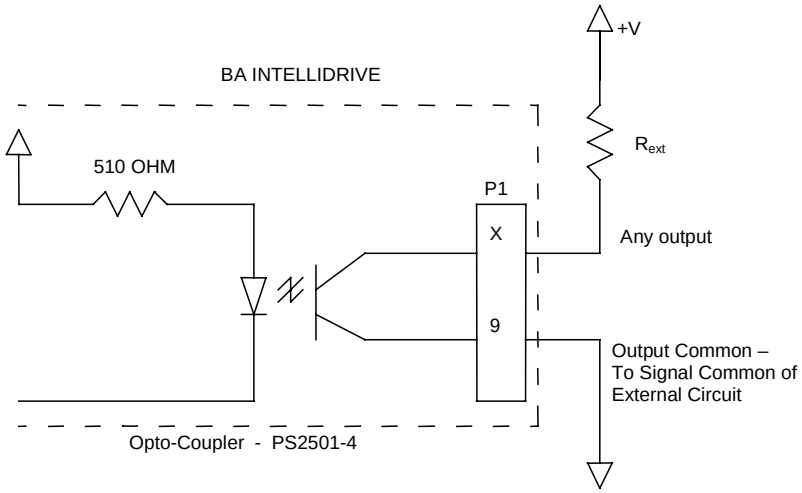


Figure 7-5. Electrical Characteristics of Opto-Isolated Output

All digital outputs must operate from the same power supply, since they all reference the same OUTPUT COMMON (P1-9).

The following formula calculates the added pull-up resistor value for the external circuitry

Rext > (External Power Supply Voltage-(Voutput_common+.4))/.02

The maximum external power supply voltage is 80 volts.

EXAMPLE:

Using a 24Vdc external supply, find R_{ext}.

$$R_{ext} = \frac{24V - (0 + 0.4)}{0.02} = 1180\ ohms$$

The fault output signal is also an opto-isolated output.

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7.4. Encoder/Limits/Hall Effects Port P3

The 25-pin "D" style connector contains all of the necessary feedback inputs to complete a servo loop. This port has inputs for a 3-channel encoder, 3 limit switches, and 3 Hall effect devices. Each of these inputs provide feedback for the microprocessor controlled position and velocity loops. The three encoder signals consists of the following: sine (SIN), cosine (COS), and marker (MKR) as well as their complimentary signals: sine-n (SIN-N), cosine-n (COS-N), and marker-n (MKR-N).

Two of the three limit inputs are end-of-travel sensing (+ Limit and –Limit) while the third is a reference limit (Home Limit). The Hall effect switch inputs are recommended for AC brushless motor commutation but not required. The pinouts for the connector is shown in Table 7-3.

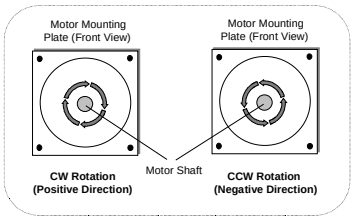
Table 7-3. Pinouts for the Encoder/Limits/Hall Effects Port (P3)

Pin	Function	Pin	Function
1	Shield	13	NC
2	Thermistor	14	COS
3	Encoder +5	15	COS-N
4	NC	16	Limit +5
5	Hall Effect B	17	SIN
6	MKR-N	18	SIN-N
7	MKR	19	NC
8	NC	20	Limit Com.
9	NC	21	Encoder Com.
10	Hall Effect A	22	Home Limit-N
11	Hall Effect C	23, 25	NC
12	CW Limit-N	24	CCW Limit-N

The maximum encoder frequency input is 2.5 MHz per signal.



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7.4.1. Encoder Interface

The encoder interface requires square wave signals from a line driver differential output encoder. Figure 7-6 illustrates the encoder phasing with relation to motor rotation.

Additionally, as part of each encoder interface, there are inputs for marker signals that are received by a differential input comparator circuit. These signals are standard on incremental encoders and provide a reference point for the mechanical system driven by the BAI. The maximum encoder input frequency is 2.5 MHz (theoretically). The minimum edge separation is 1/10MHz.

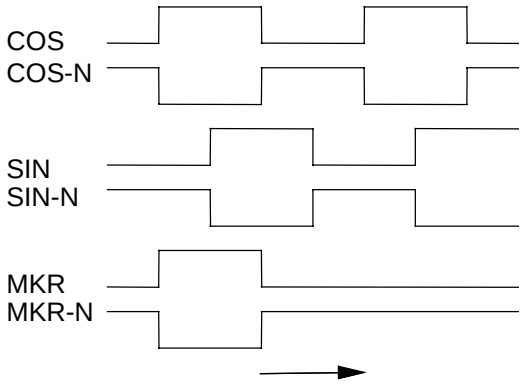


Figure 7-6. CW Motor Rotation (Viewed from the Mounting Flange End)

7.4.2. Limits Interface

Three limit inputs are incorporated into the BAI, the first two are end-of-travel limits and the third is the home limit. The end-of-travel limits are designated as "CWlimit" and "CCWlimit". Clockwise (CW) motor rotation is inhibited by the "CWlimit", while counterclockwise (CCW) is inhibited by the "CCWlimit". Refer to Figure 7-7 for limit switch circuitry.

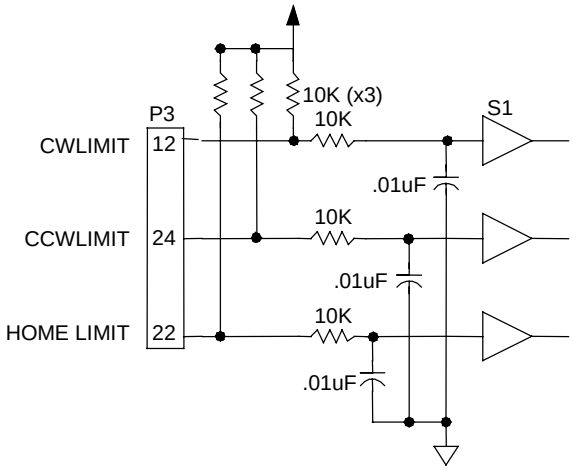


Figure 7-7. Limit Switch Input Circuit

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The home limit acts as a reference point so that motion may always begin from the same physical point in a system. When the controller receives a "Home" command (**HO**), the system moves the motor in a preset direction in search of a home limit activation. When the controller finds the home limit, the motor reverses direction and stops on a preset occurrence, generally the first occurrence of the encoder's marker signal after the home limit has deactivated.

There are two choices to consider when wiring the three limits: active high (normally closed limit switch) or active low (normally open limit switch). To establish limit polarity with the controller, follow procedures for setting parameters in Chapter 4: Parameters.

7.4.3. Hall Effect Interface

AC brushless systems are the only systems that use the Hall effect inputs on P3 of the controller. The Hall effect switches form a digital representation of the motor phasing that the microprocessor uses to commutate the motor. This digital representation comprises three 5 volt signals that form a digital six step pattern. The controller receives these signals with a circuit that is electrically identical to the limit input circuit. Refer to Figure 7-8 for Hall effect input circuitry.

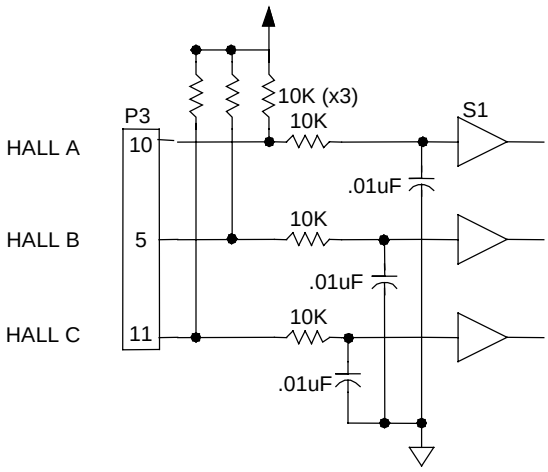


Figure 7-8. Hall Effect Input Circuit

Aerotech brushless rotary motors are shipped from the factory with the correct motor phase to Hall effect device relationship established. This is essential for proper motor commutation. The parameter that affects this relationship is PRM:27 and is set at "0". Figure 7-9 and Figure 7-10 illustrate the proper Hall effect and motor phasing for both CW and CCW motor rotation (viewed looking into the mounting flange of the motor).

During CW motor rotation each Hall effect signal is at a logic low state when its corresponding motor phase is at a positive voltage. During CCW rotation each Hall effect signal is at a logic high state when its corresponding motor phase is at a positive voltage.

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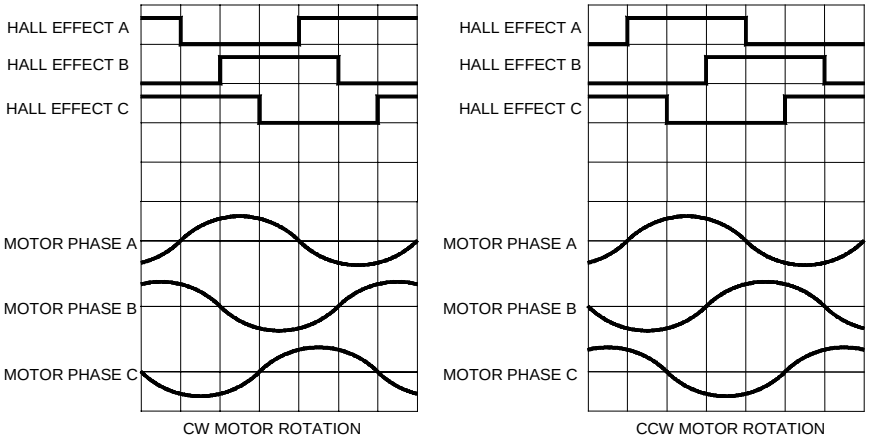


Figure 7-9. Hall Effect Motor Phasing

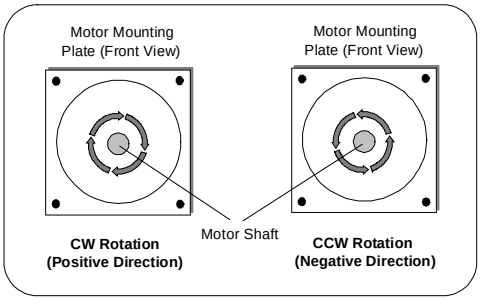


Figure 7-10. Motor Rotation (From Mounting Flange End)

The wave forms created by the motor phasing can be observed using a wye resistor network, a dual trace oscilloscope, and performing the following steps.



The following procedure is only necessary if the user has to replace a defective encoder or is using their own motors.



Motor voltage is monitored without power applied to the motor.

Before performing the following steps, remove all connections to the motor except the wye resistor network. Remove all mechanical connections to the motor shaft.

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1. Connect the ends of three resistors to motor terminals A, B, C. Refer to Figure 7-11.
2. Use one channel of the oscilloscope to monitor motor terminal A with respect to the "Wye" neutral (the point where all resistors are connected together), refer to Figure 7-11.
3. Connect a 5V power supply to the power pins of the encoder, refer to Figure 7-12.
4. Connect the second channel of the oscilloscope to Hall effect A on the encoder.
5. Once the oscilloscope is connected with one probe monitoring a motor phase and the other monitoring a Hall effect signal, rotate the motor by hand using the motor shaft. The motor will generate a voltage upon rotation.
6. Observe the phase relationship of the motor phase to the Hall effect signal.

It is necessary for the voltage generated by the motor phase A to be in phase with signal used as Hall effect A, refer to Figure 7-9.



7. Move the probe on the Hall effect line to the other two Hall effect lines, observing their phase relationship to the motor voltage.
8. Repeat this process for the other two motor phases

Using this procedure, connect the Hall effect signals with the appropriate motor phases as shown in Figure 7-8.

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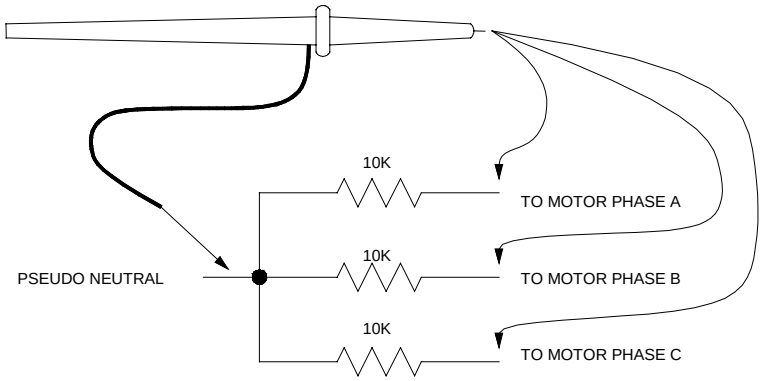


Figure 7-11. Motor Phase Voltage Observation Scheme

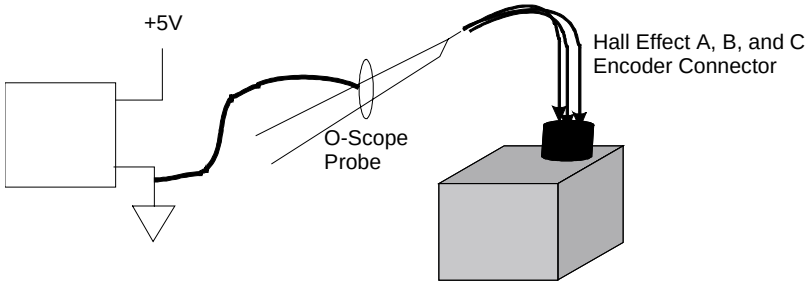


Figure 7-12. Encoder Phase Voltage Observation Scheme

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7.5. Servo Amplifier Specifications

The electrical and controller specifications for all BAI drive models are listed in Table 7-4 (BAI 10/20/30) and Table 7-5 (BAI 50/75/100).

Table 7-4. Electrical Specifications for BAI 10/20/30

Model	Units	BAI10	BAI20	BAI30
Output Voltage (brushless)	VDC	40 to 320 [1]		
Input Voltage	VAC	28 to 240 [1]		
Peak Output Current	A(peak)	10	20	30
Continuous Output Current	A(peak)	5	10	15
Peak Power Output	Watts	2720	5440	8160
Continuous Power Output	Watts	1360	2720	4080
Power Amplifier Bandwidth	kHz	1		
PWM Switching Frequency	kHz	20		
Minimum Load Inductance	mH	.8		
Operating Temperature	deg C°	0 to 50		
Storage Temperature	deg C°	-30 to 85		
Weight	lb (kg)	2.5 (1.1)		
Controller Section				
Microprocessor	16-bit 80C166			
Servo Update Rate	1 to 4 kHz			
Clock Speed	20 MHz			
Command Set	Two character nuemonics			
Length of Program	Up to 5k bytes			
Operating Modes	Indexer, Clk/Dir, Teach			
Maximum Clock Input Rate	1MHz			
Move Types	Index, Free-running, Homing			
Programmable Inputs	3			
Programmable Outputs	3			
Standard Outputs	Fault			
Standard Inputs	Enable			

[1] The input and output voltages require different units, consult the factory for more information.

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Table 7-5. Electrical Specifications for BAI 50/75/100

Model	Units	BAI50	BAI75	BAI100
Output Voltage (brushless)	VDC	40 to 320 [1]		
Input Voltage	VAC	28 to 240 [1]		
Peak Output Current	A(peak)	50	75	100
Continuous Output Current	A(peak)	25	37	50
Peak Power Output	Watts	13600	20160	28800
Continuous Power Output	Watts	6800	10080	14400
Power Amplifier Bandwidth	kHz	1		
PWM Switching Frequency	kHz	20		
Minimum Load Inductance	mH	.8		
Operating Temperature	deg C°	0 to 50		
Storage Temperature	deg C°	-30 to 85		
Weight	lb (kg)	2.5 (1.1)		
Controller Section				
Microprocessor	16-bit 80C166			
Servo Update Rate	1 to 4 kHz			
Clock Speed	20 MHz			
Command Set	Two character nuemonics			
Length of Program	Up to 5k bytes			
Operating Modes	Indexer, Clk/Dir, Teach			
Maximum Clock Input Rate	1MHz			
Move Types	Index, Free-running, Homing			
Programmable Inputs	3			
Programmable Outputs	3			
Standard Outputs	Fault			
Standard Inputs	Enable			

[1] The input and output voltages require different units, consult the factory for more information.

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7.6. AC Input and Motor Wiring

To reduce electrical noise in the BAI Series amplifiers, the user should observe the motor and input power wiring techniques explained in the following sections. Suitable for use on circuit capable of delivering not more than 5000A, 240VAC.

7.6.1. Minimizing EMI Interference

The BAI Series are high efficiency PWM amplifiers operating at a 20K Hz switching rate.

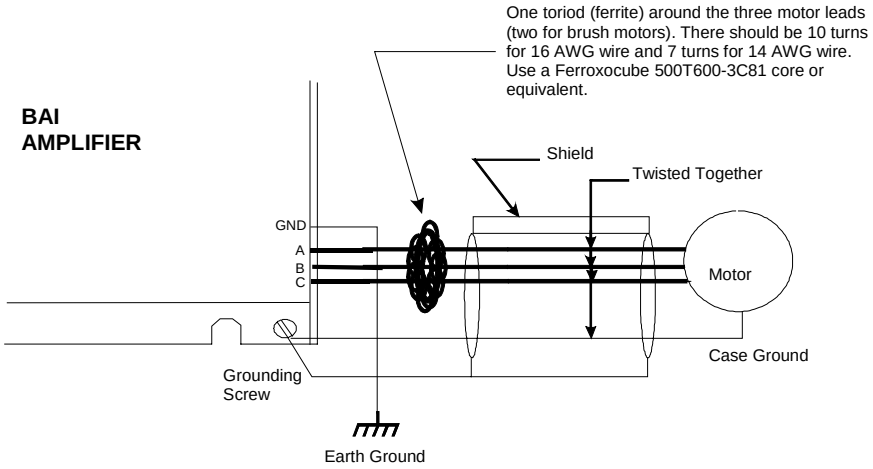
The switching time between positive and negative rails on each of the motor leads is less than 50 nano-seconds for a 320 VDC bus. This switching rate can generate Electromagnetic Interference (EMI) into the Mega Hz Band. To minimize this EMI, it is recommended that the motor leads be twisted together with the motor cable grounding wire and surrounded with a foil shield. Refer to Figure 7-13.

In addition to the EMI effects, electro-static (capacitive) coupling to the motor frame is very high requiring the frame to be grounded in order to eliminate a shock hazard. Additional electro-static coupling exists between the three twisted motor leads and the foil shield of the motor cable.

This coupling forces high frequency currents to flow through the returning earth ground of the motor cable. To minimize this problem and maintain low levels of EMI radiation, perform the following.

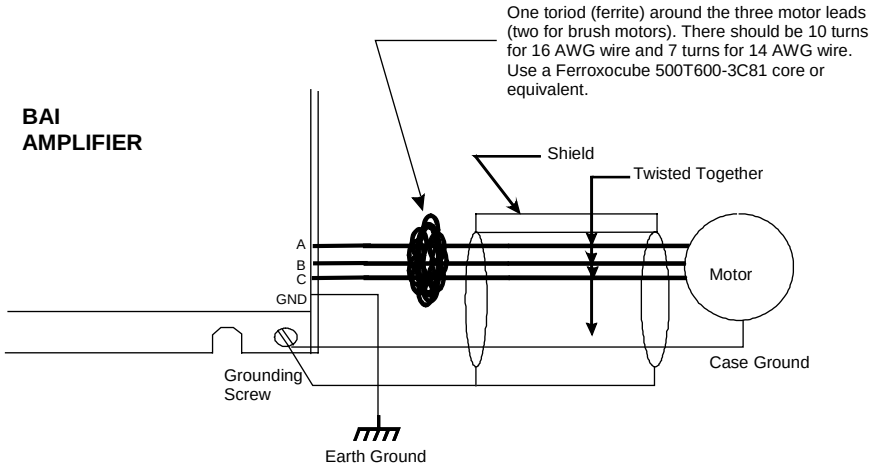
1. Use shielded cable to carry the motor current and tie the shield to earth ground. Refer to Figure 7-13.
2. Place one toriod (ferrite) around the three motor leads (two leads for brush motors). The toriod should have 10 turns for 16 AWG wire or 7 turns for 14 AWG wire. This helps reduce the harmonics generated by the 20 KHz switching waveform. Use a Ferroxcube 500T600-3C81 core or equal. Refer to Figure 7-13.
3. Use a cable with sufficient insulation. This will reduce the capacitive coupling between the leads which in turn reduces the current generated in the shield wire.
4. Provide strong earth ground connections to the amplifier, additional heat sink, and the motor. Offering electrical noise a low impedance path to earth ground not only reduces radiated emissions, but also improves system performance.
5. If possible, do not route motor cables near cables carrying logic signals and use shielded cable to carry logic signals.

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This configuration is especially important if the BAI amplifier is operating at DC bus voltages of 160 VDC or 320 VDC (e.g., 115 VAC or 230 VAC input power).

Figure 7-13. Wiring to Minimize EMI and Capacitive Coupling



This configuration is especially important if the BAI amplifier is operating at DC bus voltages of 160 VDC or 320 VDC (e.g., 115 VAC or 230 VAC input power).

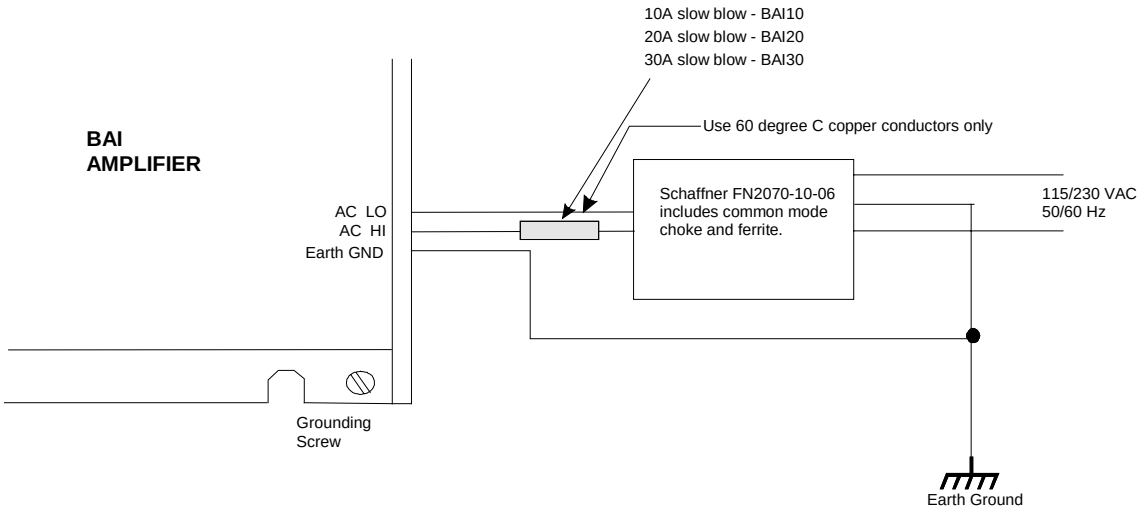
Figure 7-14. Wiring to Minimize EMI and Capacitive Coupling (BAI 50)

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7.6.2. Minimizing 50/60 HZ Line Interference

Operating the BAI series amplifiers from an off-line source of 115 VAC or 230 VAC creates some additional problems.

First, there is a potential problem of EMI generated from the switching power stage of the BAI amplifier propagating through the bridge rectifier and out through the **HI** and **LO** input AC line connections. Back-propagation of noise into the AC lines can be minimized using a line filter. An example of such a filter and proper connection to the BAI amplifier is shown in Figure 7-15.



This configuration is especially important if the BAI amplifier operating at DC bus voltages of 160 VDC or 320 VDC (e.g., 115 VAC or 230 VAC input power).

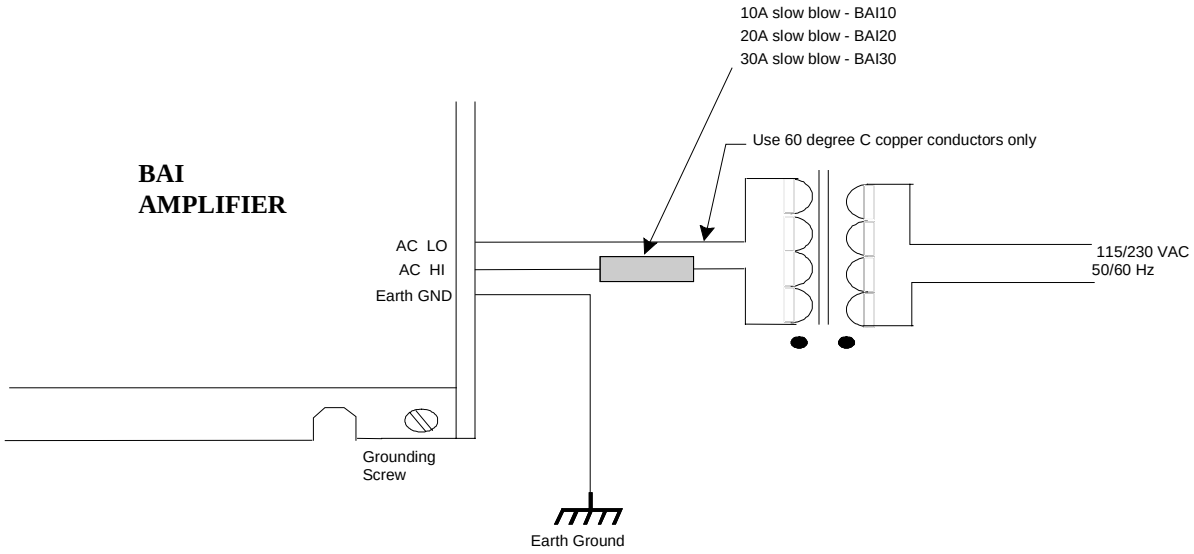
Figure 7-15. Back-Propagation Line Filter Connection

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Second, another problem that potentially exists with off line connections is 50/60 Hz electrostatic coupling between the frame of the AC motor and the **HI/LO** AC input power. Since **LO** is referenced to earth ground back at the source, the DC bus of the amplifier "swings" at 50/60 Hz with respect to the motor frame.

The path of current caused by this coupling between the motor frame and the amplifier stage passes through the current feedBAck sensing devices of the amplifier. Depending on the magnitude of this current, a 50/60 Hz torque disturbance may be present in the position loop.

To eliminate this problem, an isolation transformer can be used to block the 50/60 Hz from being seen by the motor frame. Refer to Figure 7-16 for connection of this transformer.



This configuration is especially important if the BAI amplifier is operating at DC bus voltages of 160 VDC or 320 VDC (e.g., 115 VAC or 230 VAC input power).

Figure 7-16. Isolation Transformer Connection (eliminates torque disturbance)

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7.7. BAI Amplifier Dimensions

The outline dimensions for the BAI amplifiers (BAI 10/20/30) are shown in Figure 7-17.
The outline dimensions for the BAI amplifiers (BAI 50/75/100) are shown in Figure 7-18.

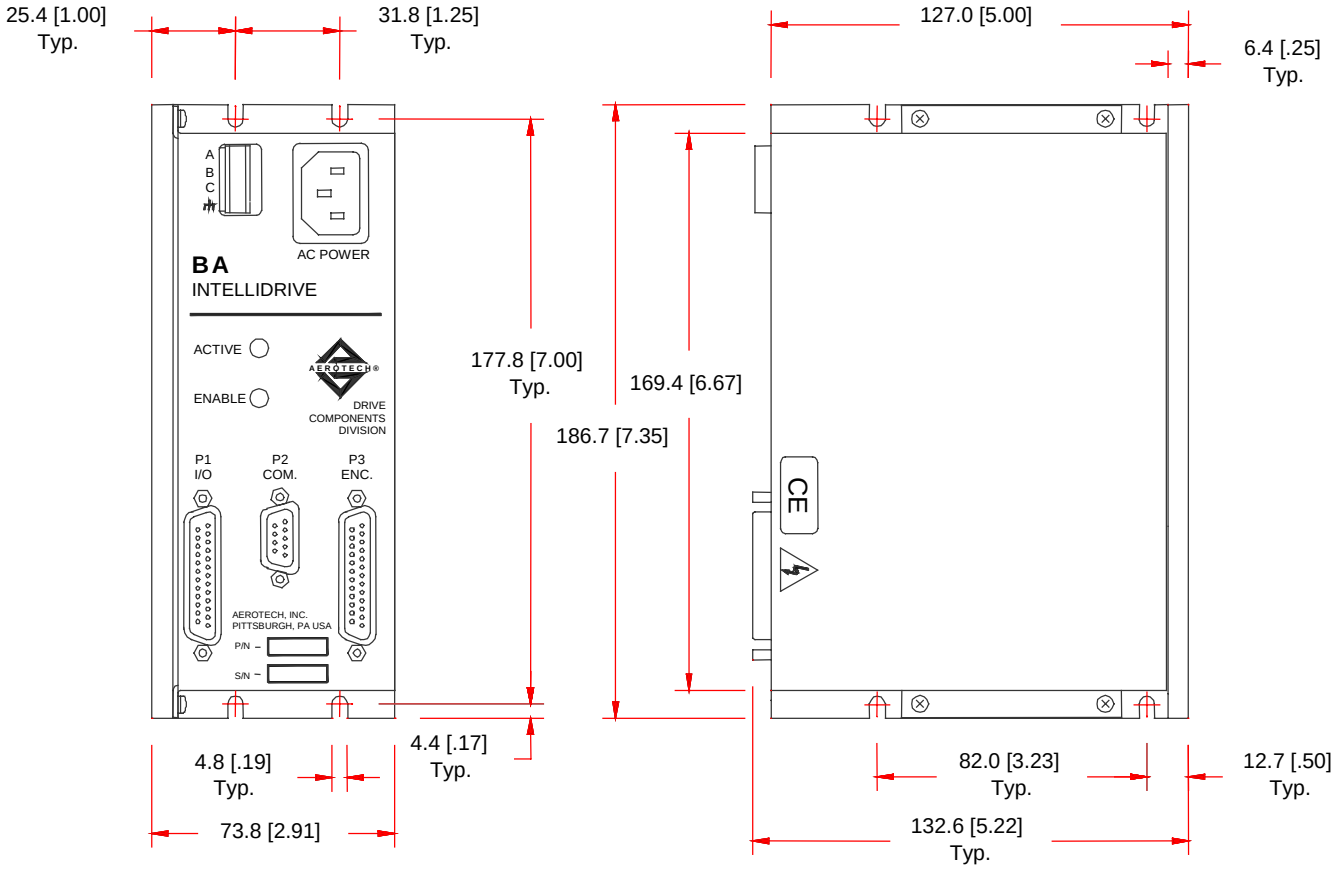


Figure 7-17. BAI Amplifier Dimensions – 10/20/30

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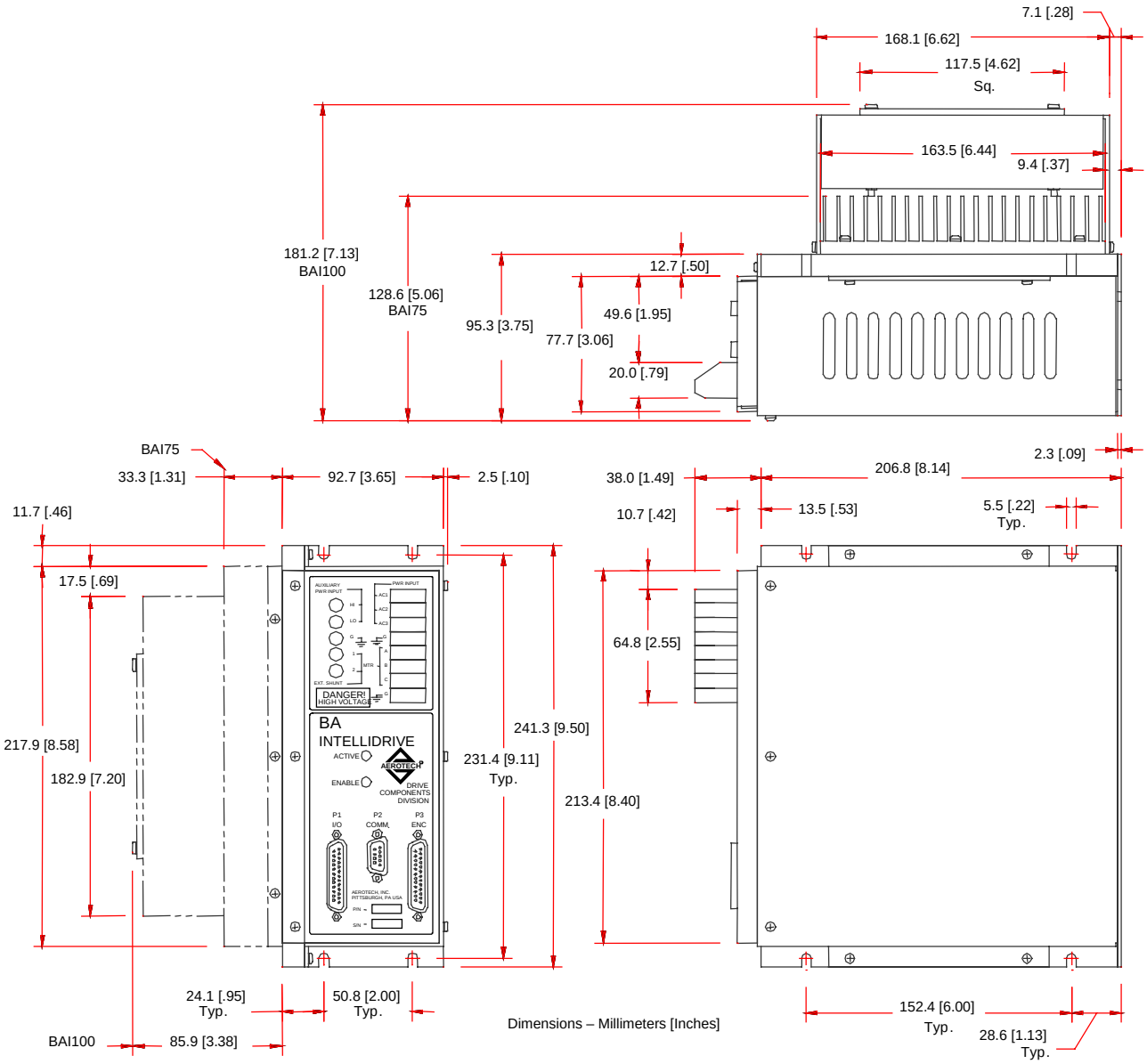


Figure 7-18. BAI Amplifier Dimensions – 50/75/100

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7.7.1. Mounting Procedures for the BAI 10/20/30/50

To ensure proper heat dissipation, Aerotech recommends the following procedures (for the BAI 10/20/30/50):

1. Use the mounting procedure shown in Figure 7-20. The wider part of the amp should be mounted to the heat sink.
2. Heat sink should be at least 2 feet^2 x0.25" thick minimum.
3. The heat sink should be free of paint or any other thermal barrier.
4. The heat sink must be flat to allow good thermal conductivity between the heat sink and the amplifier.
5. If possible, add a thermal conductivity enhancer (i.e., thermal grease between the heat sink and the amplifier).
6. Adding an external fan will remove a considerable amount of heat from the heat sink and allow the amplifier to operate at a much cooler temperature.

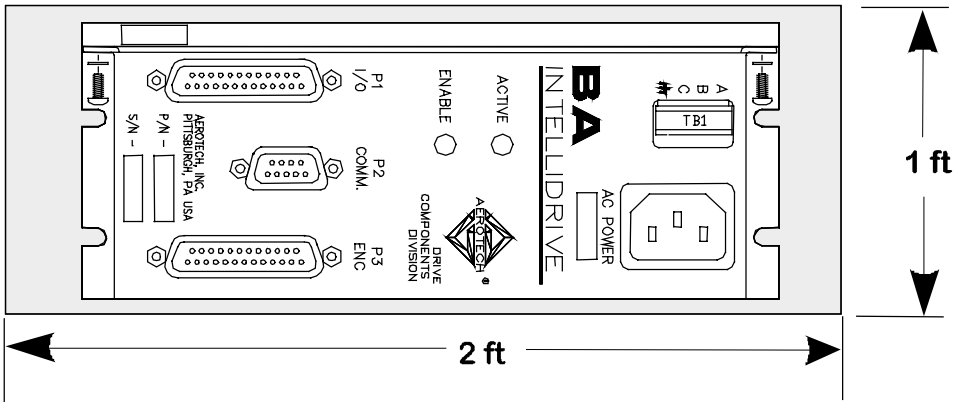


Figure 7-19. BAI Side View (10/20/30/50)

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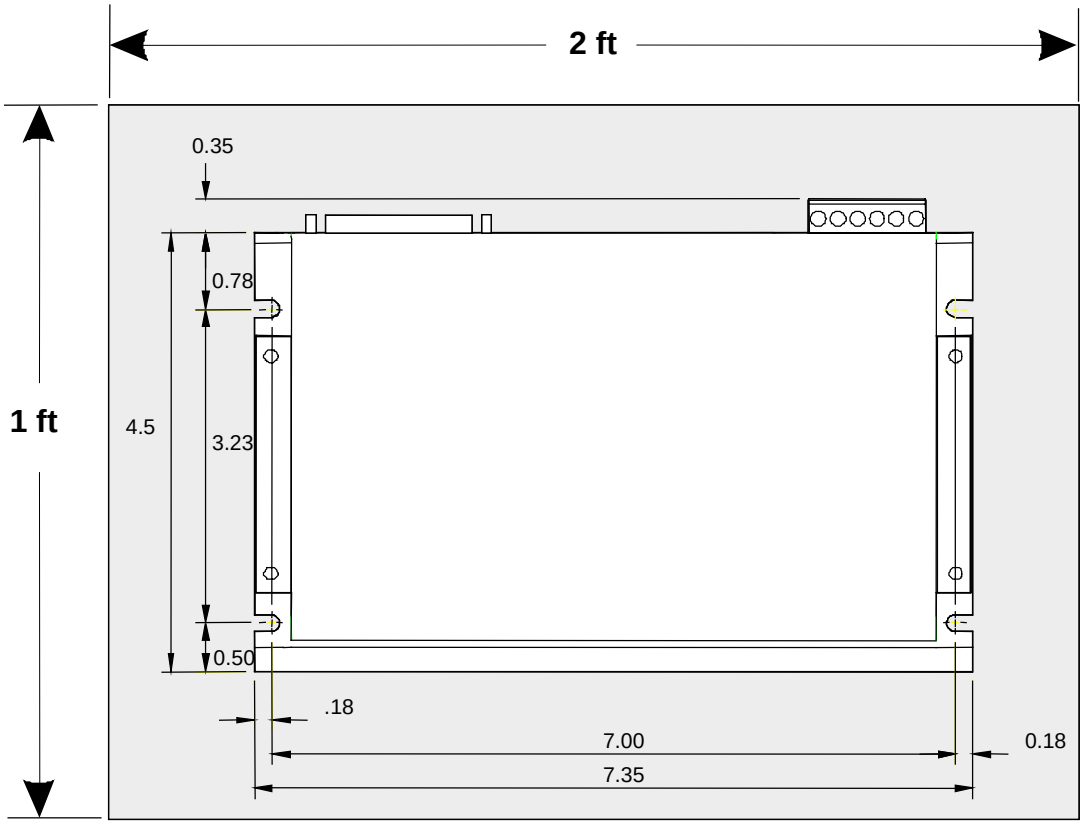


Figure 7-20. BAI Top View (Preferred Mounting – 10/20/30/50)

It is advisable that the amplifier be mounted lying flat on a metal panel not less than two square feet for better heat dissipation. Refer to Figure 7-21.

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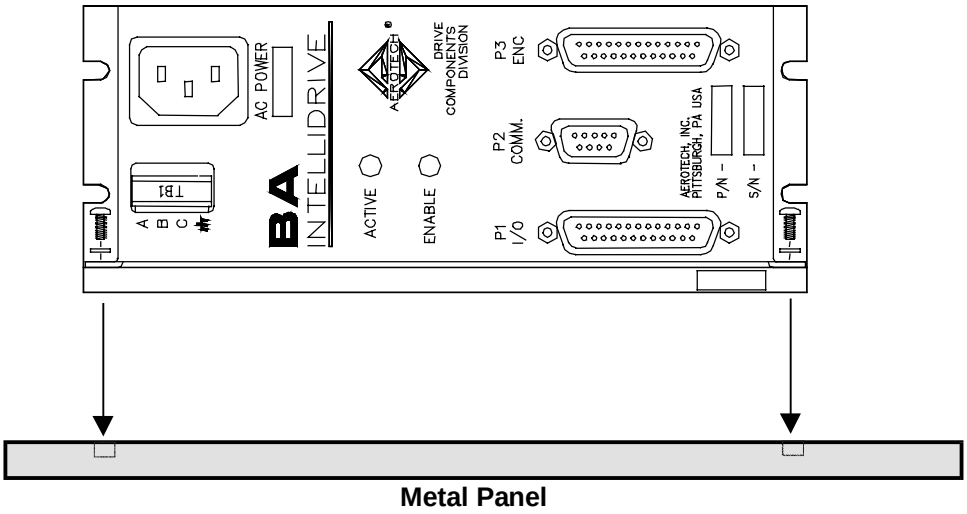


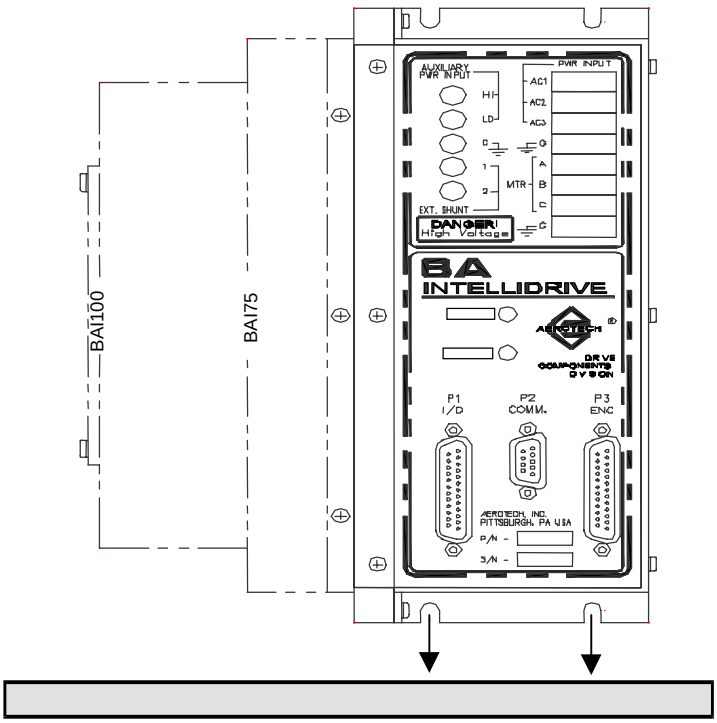
Figure 7-21. Preferred Mounting of BAI Amplifiers (10/20/30/50)

7.7.2. Mounting Procedures for the BAI 75/100

To ensure proper heat dissipation, Aerotech recommends the following procedures:

1. Use the mounting procedure shown in Figure 7-22. The wider part of the amp should be mounted to the heat sink.
2. Heat sink should be at least 2 feet^2 x 0.25" thick minimum.
3. The heat sink should be free of paint or any other thermal barrier.
4. The heat sink must be flat to allow good thermal conductivity between the heat sink and the amplifier.
5. If possible, add a thermal conductivity enhancer (i.e., thermal grease between the heat sink and the amplifier).
6. Adding an external fan (already included in the BAI 100) will remove a considerable amount of heat from the heat sink and allow the amplifier to operate at a much cooler temperature.

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(Preferred mounting for better heat dissipation)

Figure 7-22. Preferred Mounting (75/100)

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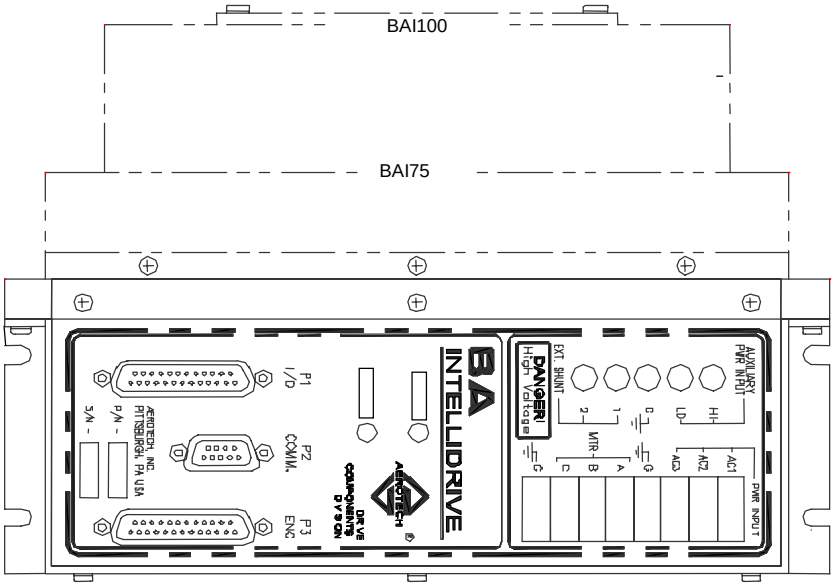


Figure 7-23. BAI Side View (75/100)

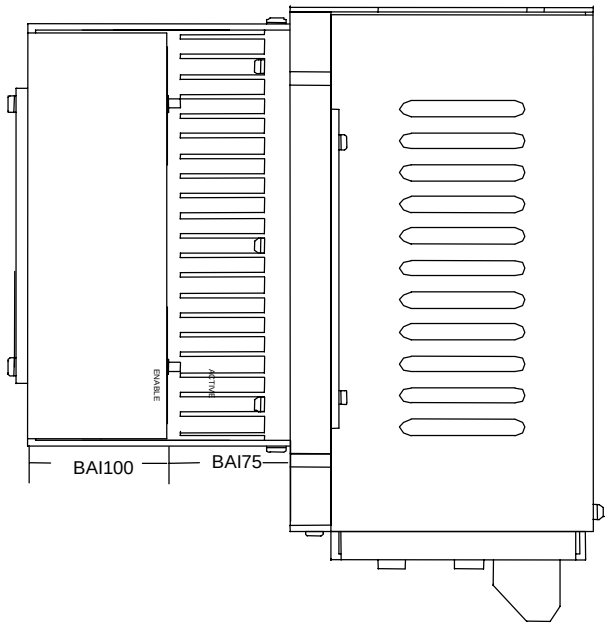


Figure 7-24. BAI Top View (75/100)

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CHAPTER 8: TROUBLESHOOTING

In This Section:

- Amplifier Related Problems 8-1

8.1. Amplifier Related Problems

This section covers symptoms, probable causes and solutions related to the BAI amplifier operation. Table 8-1 lists the most common symptoms of irregular operation and the possible causes and solutions for these faults.

Before performing the tests described in Table 8-1, be aware that lethal voltages exist on the amplifier's PC board and at the input and output power connections. A qualified service technician or electrician should perform these tests.



Table 8-1. Amplifier Faults, Causes, and Solutions

Symptom	Possible Cause and Solution
Receive a "BAI not connected" error when the MMI software loads.	1. The BAI is not on. Turn on the BAI, and click the button. If this does not work, exit and restart the BAI. 2. The BAI is not connected to the COM port. Check to be sure the proper COM port is selected in the MMI software and the BAI is connected to it. 3. There is a conflict with the current COM port. If there is a conflict with the selected COM port, the software automatically switches to a COM port it can open. Try moving the BAI connection to another COM port and restart the MMI software. 4. The communications parameters do not match between the MMI interface and the BAI, because either the MMI software was just installed or the BAI's firmware was upgraded. Enter the MMI interface by clicking YES to close the COM port. Select communications parameters to match the BAI settings from the menu and press the reset button. Then select Connect from the Communications menu. 5. The BAI is not in the proper mode (Local vs. Remote mode). To insure the BAI is in remote mode, open the COM_BAI DOS software and press the space bar. If the text appears, the BAI is in the wrong mode. Switch to remote mode by setting parameter 95 to 1, save parameters and reset the BAI. 6. The BAI's unit address has been changed. From the Communications menu, select Open BAI. Type in another address and click OK to attempt another connection to the BAI. 7. No COM port can be found (both COM1 and COM2 are in use). Close the BAI MMI and find the conflict on the port the BAI is attached to.
Receive a "Scope Timeout Error" after issuing a reset command (RE) in the remote command window.	1. The BAI does not respond to serial port commands while it is resetting. Click YES to close the COM port and select Connect from the Communications menu to reconnect. .
Receive an "Error Loading from File" error when attempting to open the parameters screen.	1. There is problem with the system registry. Run REG95.BAT or REGNT.BAT file that are included in the installation. For more information, refer to the README.TXT file.

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Table 8-1. Amplifier Faults, Causes, and Solutions (Continued)

Symptom	Possible Cause and Solution
Receiving "Data Transfer Timeouts" on the Tuning screen.	1. Serial data has been lost in transfer from the BAI to the local PC. When prompted to close the COM port, select no. The Tuning screen should resume normal operation. The newest firmware upgrade works with the newest version of the MMI to insure this no longer happens. Make sure the latest firmware is installed by contacting Aerotech.
Nothing appears in the window when starting the COM_BAI.exe or when using the Hand held Terminal (HT).	1. The BAI is sitting idle waiting for a keystroke. Press the space bar and observe if anything appears. If it does, the unit is fine, if it does not; it may be in remote mode. 2. The BAI is in remote mode. Press CNTRL-A and wait for text to appear. If it does, proceed to use the unit normally. 3. The BAI is not communicating correctly due to the firmware being damaged. Try reinstalling the firmware using the UPGRADE.EXE software (included with both the COM_BAI.exe and MMI software packages). If this does not work, the unit needs to be bootstrapped. For more information, contact Aerotech.
Receive "RMS current" error every time trying to move the motor.	1. The gains are set too high. Try turning down the values Kp, Ki, and Kpos. 2. The drive needs to be tuned. Follow the procedure for tuning the drive to receive decent values for Kp, Ki, and Kpos. 3. There are offsets in the D/A converters. Adjusting parameters 38 and 39 can help null out these offsets, however, it is a precarious process. For additional help, contact Aerotech.
When I connect the serial cable to the unit, the PC freezes.	1. Problem with the serial cable. Make sure that a null modem cable is being used and the cable is intact. Ensure the cable is wired properly. See Section 1.4.2. for correct pinouts.
The amplifier will not enable.	1. The external enable line is disabling the amplifier. If an external enable line is not being used, check to be sure that the external enable polarity is set to low (PRM:99 = 0). 2. The thermistor is disabling the amplifier. Check to be sure the correct polarity is being used for the thermistor (PRM:34). 3. There is a hardware problem on the amplifier. Reset the BAI and observe if the Enable LED blinks and/or the stage jumps before the amplifier disables. If it does, the problem is likely phasing or tuning. If it does not, either the thermistor or the external enable line is pulled, or there is problem with the BAI.

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APPENDIX A: GLOSSARY OF TERMS

In This Section:
- Terms Used In This Manual
- Definitions

This appendix contains definitions of terms that are used throughout this manual.

absolute positioning - Absolute positioning is positioning that is done with respect to an initial starting position (typically referred to as the home position) and typically uses a standard coordinate system (using [X,Y] coordinates is an example of absolute positioning). In contrast, incremental (or relative) positioning is done using a series of relative moves. These moves are relative to the previous location rather than a single reference point (for example, relative changes in position [ΔX,ΔY] are examples of incremental positioning).

amplifier - An amplifier is a hardware device having an output that is a function of the input signal.

axis - An axis is a direction along which movement occurs.

base address - A base address is a number that represents the memory location in the computer where input/output (I/O) information can be stored. All devices (e.g., the U100 card, network cards, tape backup cards, etc.) within a computer must have unique I/O base addresses.

bit - The term bit is an acronym for "Binary digIT" and represents a single binary number (i.e., a "1" or a "0"). In digital computers, a bit's two states can represent an off state and an on state, a high voltage and a low voltage, the numbers 0 and 1, etc.

brushless motor - Aerotech brushless motors are three-phase, rare earth permanent magnet servo motors which generate a sinusoidal back EMF voltage and are usually referred to as AC brushless motors. Another type, usually referred to as the DC brushless motors, generate a trapezoidal back EMF and produce more torque ripple.

byte - A byte is a common unit of information storage made up of eight binary digits (bits). A byte can be used to represent a single ASCII character (e.g., "A"= 10000001 [binary]) or binary numbers from 00000000 to 11111111 (from 0 to 255 decimal), depending on how it is used.

commutation - Commutation refers to the process by which every other cycle of an alternating current is reversed so that a single unidirectional current is supplied. In the case of motors, commutation refers to the switching of current to motor windings that causes the motor to rotate. In a DC servomotor, this is done mechanically using brushes and a commutator. A brushless motor is electronically commutated using a position feedback device such as an encoder that is mounted to the rotor. Stepping motors are electronically commutated without feedback (in an open loop fashion).

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constant velocity motion - Constant velocity motion refers to the controller's ability to perform motion while maintaining a constant velocity during the motion. For an application example, consider an irregularly shaped pattern that requires a series of *perforations* (made using a series of on/off laser pulses, for example). Constant velocity motion ensures that the length of each perforation is the same.

derivative gain - Derivative gain is a dimensionless motor tuning parameter that serves to dampen the system response by producing a dampening force as long as the system is progressing toward error reduction.

DOS - DOS is an acronym for Disk Operating System--a master control program that runs a computer and acts as a scheduler, providing job, task, data and device management. DOS is a generic term that refers to an operating system. MS-DOS is a single-user operating system for PCs that was designed by Microsoft Corporation. Since the DOS and MS-DOS programs are very, the terms DOS and MS-DOS are frequently interchanged.

encoder - An encoder is a rotary device that transmits a pulsed signal based on the number of revolutions of the device.

faults - A fault is an error condition that occurs when a component of the controller system operates outside certain parameters. Fault masks are used to allow the controller system to detect and act on any fault condition of the system. Examples of major fault conditions include position faults, velocity faults, integral faults, RMS over current faults, amplifier faults, and feedback faults.

feedrate error - A feedrate error is a type of fault that is generated by the controller if the current speed of an axis exceeds a programmable maximum speed. Feedrate errors are necessary because certain stages or motors have a maximum operating speed above which components may be damaged.

floating point number format - Floating point number format is a method of representing numbers without defining a fixed number of decimal places. Two common forms of floating point number format are fixed-style format (e.g., 12.345, 0.000001, -2, etc.) and scientific notation (e.g., 12.3E4, -1.2E-3, etc.). The controller uses fixed-style format for floating point numbers.

Hall effect switch - A Hall effect switch is a solid state switch that is activated by a magnetic field. Some AC brushless motors use Hall effect switches.

hexadecimal number format - Hexadecimal number format is a method of representing large numbers using base 16 rather than the standard base 10. In base 16 or hexadecimal number format (often abbreviated "hex"), the number positions represent powers of 16 (rather than powers of 10 in decimal). The decimal number positions (1's, 10's, 100's, 1,000's, 10,000's, etc.) are replaced with hexadecimal number positions (1's, 16's, 256's, 4096's, etc.). Also, while the individual numerals for the decimal system are 0-9, the numerals for the hexadecimal number system (which requires 16 unique "numerals") are 0-9 then A-F (where $A_{16}=10_{10}$, $B_{16}=11_{10}$, $C_{16}=12_{10}$, $D_{16}=13_{10}$, $E_{16}=14_{10}$, and $F_{16}=15_{10}$). For simplicity in this manual, hexadecimal numbers are written with a preceding "0x" rather than using the subscript 16. For example, the hexadecimal number 12A5 is written 0x12A5. Numbers without the preceding "0x" are assumed to be decimal unless otherwise indicated.

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home cycle - The home cycle is series of motions that are used to move the specified axes to a hardware referenced position. There are two feedrates (in the form of parameters) associated with the home cycle: the Power On Feedrate and the Normal Home Feedrate. The power on home cycle (the first commanded home cycle following a power up) uses the Power On Feedrate parameter and the normal home cycle (all subsequent home cycles) uses the Normal Home Feedrate parameter.

in-position integrator - An in-position integrator is a motor tuning adjustment that can be used to help remove steady-state position errors as well as reduce the effects of tachometer loop drift. In-position integration is accomplished at a rate that is directly proportional to the integral gain value (Ki).

incremental positioning - Incremental (or relative) positioning is done using a series of relative moves. These moves are relative to the previous location rather than a single reference point (for example, relative changes in position [ΔX,ΔY] are examples of incremental positioning). In contrast, absolute positioning is positioning that is done with respect to an initial starting position (typically referred to as the home position) and typically uses a standard coordinate system (using [X,Y] coordinates is an example of absolute positioning).

integral error - Integral error is the summation of position errors over time. An integral error fault is generated if the integral error for an axis exceeds a programmable maximum integral error value. Integral error is reset every time the axis is reset.

integral gain - Integral gain is a dimensionless motor tuning parameter that serves to help remove steady-state position errors as well as reduce the effects of tachometer loop drift.

jog move - A jog move is a momentary movement of an servo drive to provide manual control of axis motion.

jumpers - Jumpers are hardware *ties* that you manually position into different sockets to configure the hardware platform. Jumpers on the controller board are used to configure the motor type, current output, communication mode, and other features.

LED - LED is an acronym for light-emitting diode. An LED is a semiconductor diode that converts electrical energy into visible electromagnetic radiation. The controller has LEDs located on the front panel that are used for diagnostic purposes.

machine step - A machine step is the smallest feedback device step that can be taken. This is the smallest possible increment of movement as measured by the feedback device.

point-to-point motion - Point-to-point motion simply involves specifying a target position. After the target position is commanded, the controller strives to attain that position with no time or path constraints.

popup window - A popup window is a box that appears "on top of" the existing screen or display. Popup windows typically contain fields (for additional information to be supplied), buttons (to acknowledge or cancel a particular operation, for example) or a combination of both.

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position error - Position error is the difference between the commanded position of an axis and the feedback position (i.e., the difference between the desired position and the actual position). A position error fault occurs if the current position error exceeds a programmable maximum position error. Position error is measured in machine steps.

proportional gain - Proportional gain is a dimensionless motor tuning parameter that produces an output which is related to the Velocity Error in the servo loop.

pull-down menu - A pull-down menu is a vertical list of commands. When the menu is closed (or "rolled up"), only the menu name is visible on the menu bar. When the menu name is selected, the menu "unrolls" and the list of commands is displayed. Some options in pull-down menus are the names of other menus (called *cascading menus*).

quadrature - Quadrature is the state of two signals that are displaced 90 degrees with respect to each other. In most rotary incremental optical encoders, light (from an LED, for example) is measured after it is passed through slits in a grating disk (which is attached to the axis being measured). Typically, two tracks on the disk have their gratings displaced 90 degrees with respect to each other (that is, the tracks are said to be in quadrature).

resolver - A resolver is a two-phase, rotary, electromagnetic transducer in which inductive coupling (between the rotor and stator windings) and trigonometric principles are employed to provide absolute position information over one electrical cycle (which is one revolution for "single-step" resolvers)

RMS current trap - RMS current trap is an error that occurs if the current being commanded to a motor exceeds a programmable limit (see parameters x48 and x49). RMS current trap is analogous to a software "fuse". Essentially, this fault functions the same as a physical fuse, but is done through software. One obvious advantage is that a "software fuse" does not have to be replaced like a physical fuse.

software - The term software refers to a computer program. Contrast software with hardware, the physical machinery, components and support peripherals through which the software runs.

traps -*See* faults.

tuning - Tuning is the process of optimizing the operation of a servo system.

velocity error - Velocity error is the difference between the commanded velocity and the velocity derived from the feedback position (i.e., the difference between the desired velocity and the actual velocity). Velocity error is measured in machine steps per quarter millisecond (machine steps/qms). A velocity error fault occurs if, at any time, the velocity error of the system exceeds a programmable velocity error.

velocity feed forward - Velocity feed forward is a control strategy (represented as a dimensionless gain value that is sometimes used during the motor tuning process) in which current velocity disturbances are converted into corrective actions now in order to minimize the future effects of the disturbances.

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velocity profiled motion - Velocity profiled motion is a move of a programmed distance and speed from the current position. Velocity profiled motions are executed only after the previous motion has reached its deceleration point.

word - A word is a number of bytes that are processed as a single unit by a computer. In the U100, a word consists of two bytes or 16 bits.

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APPENDIX B: WARRANTY AND FIELD SERVICE

In This Section:

- Laser Products.....B-1
- Return Procedure.....B-1
- Returned Product Warranty Determination.....B-2
- Returned Product Non-warranty Determination.....B-2
- Rush Service.....B-2
- On-site Warranty Repair B-2
- On-site Non-warranty Repair B-2

Aerotech, Inc. warrants its products to be free from defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products that are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, whether or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability or any claim for loss or damage arising out of the sale, resale or use of any of its products shall in no event exceed the selling price of the unit.

Laser Products

Aerotech, Inc. warrants its laser products to the original purchaser for a minimum period of one year from date of shipment. This warranty covers defects in workmanship and material and is voided for all laser power supplies, plasma tubes and laser systems subject to electrical or physical abuse, tampering (such as opening the housing or removal of the serial tag) or improper operation as determined by Aerotech. This warranty is also voided for failure to comply with Aerotech's return procedures.

Return Procedure

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within (30) days of shipment of incorrect materials. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. Any returned product(s) must be accompanied by a return authorization number. The return authorization number may be obtained by calling an Aerotech service center. Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than (30) days after the issuance of a return authorization number will be subject to review.

Returned Product Warranty Determination

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warranted defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an air freight return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

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Returned Product Non-warranty Determination

After Aerotech's examination, the buyer shall be notified of the repair cost. At such time the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within (30) days of notification will result in the product(s) being returned as is, at the buyer's expense. Repair work is warranted for (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

Rush Service

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

On-site Warranty Repair

If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty-related, then the following policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special service rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

On-site Non-warranty Repair

If any Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

Company Address

Aerotech, Inc.
101 Zeta Drive
Pittsburgh, PA 15238-2897
USA

Phone: (412) 963-7470
Fax: (412) 963-7459

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A

AB
  Motion abort, 3-14
Abort, 3-9
Abort motion, 3-10
Absolute, 3-31
Amplifier faults, 8-1
Amplifier related problems, 8-1
Amplifier Status, 4-33
AR
  Program execution, 3-14
Auto run, 3-7
Autorun Program, 4-32
Autotune Damping Factor
  PRM
    206, 4-37
Autotune distance
  PRM
    204, 4-36
Autotune Sampling Time
  PRM
    208, 4-37
Autotune Velocity Loop Bandwidth
  PRM
    205, 4-36
Autotuning, 2-29
Axis Scope window, 2-19, 2-21

B

Baud Rate, 4-31
Bit pattern, 1-4
Bit Patterns, 3-6
Block run, 3-7
Bootup Program Name, 4-33
BR, 3-14

C

Call subroutines, 3-27
Capacitive coupling, 7-15, 7-17
C-Change Parameter, 3-4
Change parameter, 3-4
Check Move Against Software Limits, 4-28
Clock and direction, 6-3
Clock and Direction, 1-6
Clock/Direction, 4-38
Clock/Direction Inputs Signals, 7-3
COM port, 1-13
COM_BAI.exe, 1-6
Commands, 3-1, 3-23
Comment, 3-22
Communication, 3-1
Communication modes, 1-2
Conditional command, 3-24
Conditional gosub, 3-24
Config.nt file, 1-6
Config.sys file, 1-6
Connector, 1-7
Coprocessor, Recommended, 2-2
CS
  Conditional gosub, 3-24
Current Offset adjustment
  PRM
    38 and PRM
      39, 4-21
Cursor option, 2-20

D

Daisy Chain, 3-3
Daisy chain configuration, 1-13
Dead Band Wait Time, 4-19
Deceleration Distance, 4-28
Decrement, 3-34
Default Ramp Time, 4-35
Default Velocity, 4-18
Define a Lable, 3-29
Definitions of Terms, A-1
Delete file, 3-14
DF
  Delete file, 3-14
DI
  Disable amplifier, 3-25
Digital I/O, 1-14
Digital I/O signals, 7-2
Dimensions, 7-19
Disable Amplifier, 3-25
Disk Space, Recommended, 2-2
Display Tracking, 3-6
Display type, 4-34
Display, Recommended, 2-2
Displayable Digits, 4-31
DL
  Download file, 3-14
DOS emulation program, 1-6
DOS Version, Recommended, 2-2
Download files, 3-14
DW
  Dwell command, 3-25
Dwell command, 3-25

E

Electrical Cycles, 4-12
electrical specifications, 7-13
EMI, 7-17
EMI interference, 7-15
Enable Amplifier, 3-25
Enable/Disable Daisy Chain, 4-32

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Enabling RS232, 3-2
Encoder Interface, 7-8
Encoder marker signal, 7-9
Encoder port, 1-15, 7-7
Encoder Resolution, 4-11
Encoder Scale factor
PRM
41, 4-22
Enter Immediate Command, 3-10
Error messages, 3-8
Estop Action
PRM
37, 4-21
Estop Input Signal, 7-3
Execute Immediate Command, 3-16
External Enable Polarity, 4-33

F

FA
Fault acknowledge, 3-25
Fault Acknowledge, 3-25
Field Service Policy, B-1
File Operations, 3-9
File transfer, 3-14, 3-21
Filter Cutoff, 4-35
Flash memory, 3-8
Floppy Disk Drive, Recommended, 2-2
Flowchart Overall tuning process, 2-22
FR
Freerun, 3-26
Freerun, 3-26

G

GA
gain, 3-26
Gain, 3-26
General fault output, 4-34
Getting Started, 2-1
Glossary of Terms, A-1
Goto command, 3-27
Graphics Display, Recommended, 2-2
Grounding techniques, 7-15
GS, 3-27
GS Command, 3-27
GT
Goto, 3-27

H

Hall Effect Input Circuitc, 7-9
Hall Effect Interface, 7-9
Hall Effects Available, 4-13
Hall effects port, 1-15, 7-7
Hand held Terminal, 2-3
Hard Disk Space, Recommended, 2-2
Hardware function, 1-7
Hardware overview, 1-7
Hardware reset, 3-19
HD
Hold mode, 3-15
Heatsink information, 7-21
HO
Home axis, 3-27
Hold mode, 3-15
Home axis, 3-27
Home Direction, 4-25
Home Ending Offset, 4-26
Home limit, 7-9
Home Marker Velocity, 4-27
Home Type, 4-26
Home Velocity, 4-26
Home velocity out, 4-30

I

I
Immediate command, 3-16
I/O Port, 1-14, 7-2
I/O read time delay
PRM
42, 4-22
IN
Index, 3-28
In Position Bit, 4-19
Increment, 3-34
Incremental, 3-31
Incremental Change for KI, 4-6
Incremental Change for KP, 4-6
Incremental Change for KPOS, 4-7
Index command, 3-28
Indexer information, 1-2
Indexing mode, 6-1
Initialization Current, 4-13
Input Command Offset, 4-17
Integral Clamp, 4-10
Integral Velocity Gain, 4-5
IT
Wait for input, 3-29

J

Jog Value, 4-18
Jumper selections, 7-1

K

Ki Integral gain, 2-26
Kp Proportional gain, 2-24
Kpos Position gain, 2-27

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L

Labels, 3-29
LB
  Label, 3-29
LE
  Loop end, 3-30
Learn current position, 3-34
LED indicator, 1-7
LED status indicators, 1-14
Limit Check, 4-25
Limit Reset Distance, 4-28
Limit Switch Input Circuit, 7-8
Limit Type, 4-25
Limits Interface, 7-8
Limits port, 1-15, 7-7
Line filter connection, 7-17
Line interference, 7-17
Load position register, 3-29
Local mode, 1-2, 2-4
Local Mode, 3-1
Loop end command, 3-30
Loop start command, 3-30
Low Pass Filter, 4-16
LS
  Loop start, 3-30

M

Marker polarity, 4-30
Marker Type, 4-29
MC
  Motor commutate, 3-30
Memory
  conventional (recommended), 2-2
  extended, 2-2
Menu Commands, 3-4
Microprocessor, Recommended, 2-2
Minimum Hardware requirements, 2-2
Modes of operation, 6-1
Motion Abort, 3-14
Motor commutate, 3-30
Motor phasing, 7-9
Mouse, Recommended, 2-2

N

Negative Software Limit, 4-27
Next menu, 3-9
Noise
  Back-propagation, 7-17
Null modem cable, 2-5

O

Offset to Marker, 4-29
Operating Mode, 4-14
Opto isolated outputs, 3-30
Opto-Isolated Inputs, 7-4
Opto-Isolated Outputs, 7-5
OT, 3-30
Overtemperature Circuitry, 7-4

P

Parameter Editing, 3-19
Parameter Summary, A-1
Parameters, 4-1
Parameters screen, 2-17
PC, 2-3
PD
  Print directory, 3-16
PE
  Return error message, 3-16
Phase Offset, 4-17
Physical setup, 2-3
Position Error, 2-19, 2-26, 4-10
Position Error Trap, 2-23
Position Loop, 2-26, 2-27
Position mode, 3-31
Position Mode, 4-20
Position Save, 4-15
Position Scale Factor, 4-35
Positive Software Limit, 4-27
Power connections, 1-7, 1-8
PR AB, 3-31
Precautions, 1-17
Previous menu, 3-9
Print Directory, 3-16
Print program file, 3-17
Print Status, 3-17
PRM
  0, 4-5
  1, 4-5
  10, 4-9
  100, 4-34
  101, 4-34
  11, 4-10
  12, 4-10
  13, 4-11
  14, 4-11
  15, 4-12
  16, 4-13
  17, 4-13
  18, 4-14
  19, 4-38
  2, 4-5
  20, 4-14
  200, 4-35
  201, 4-35
  202, 4-35
  204
    Autotune distance, 4-36
  205

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Autotune Velocity Loop Bandwidth, 4-36
206
Autotune Damping Factor, 4-37
207
Start Frequency, 4-37
208
Autotune Sampling Time, 4-37
22, 4-15
23, 4-15
24, 4-16
26, 4-16
27, 4-17
29, 4-17
3, 4-6
30, 4-18
31, 4-18
32, 4-19
33, 4-19
34, 4-19
36
Position Mode, 4-20
37, 4-21
38, 4-21
39, 4-21
4, 4-6
40, 4-21
41, 4-22
42, 4-22
43, 4-23
5, 4-7
6, 4-7
60, 4-25
61, 4-25
62, 4-25
63, 4-26
64, 4-26
65, 4-26
66, 4-27
67, 4-27
68, 4-27
69, 4-28
7, 4-8
70, 4-28
71, 4-28
72, 4-29
73, 4-29
74, 4-29
75, 4-30
76
Marker polarity, 4-30
8, 4-8
9, 4-9
90, 4-31
91, 4-31
92, 4-31
94, 4-32
95, 4-32
96, 4-32
97, 4-33
98, 4-33
99, 4-33
Product Overview, 1-1
Program Execution, 3-14, 4-29
Programming commands, 3-13, 3-23
Proportional Position Gain, 4-5
Proportional Velocity Gain, 4-5
PS
Print status, 3-17
PX
Return axis position, 3-18

Q

Q
Serial poll, 3-18

R

RA
Ramp time, 3-31
Ramp time, 3-31
RE
Hardware reset, 3-19
Read register, 3-20
Read registers, 3-8
Read/write parameters, 3-8
REG
7, 5-2
Registers, 5-1
Registration Input
PRM
40, 4-21
Reload Saved Position, 4-15
Remote mode, 1-2, 3-2
Remote Mode, 3-2
Reset teach program, 3-35
Restore Signal, 7-3
Return Axis Position, 3-18
Return Error Message, 3-16
RR
Read register, 3-20
RS-232, 1-13, 3-2
RT
Run teach program, 3-32
Run teach program, 3-32
Running programs, 3-7

S

Safety procedures, 1-17
Safety Procedures, 1-17
Sample programs, 3-36
Save parameters, 3-10
Save programs, 3-20

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Save teach program, 3-35
Saved Position, 4-16
Send motion, 3-16
Serial Poll, 3-18
Service Request (SRQ) Character, 4-31
Service Request Mode, 3-20
Servo "In Position" Tolerance, 4-7
Servo loop gains, 3-5
Servo loop parameter, 4-4
Servo parameters, 2-23
Servo Peak Current Limit, 4-8
Servo RMS Current Timeout, 4-9
Servo RMS Limit, 4-8
Servo Update Rate, 4-11
Servo Velocity Trap, 4-9
Shielding techniques, 7-15
Signal connections, 2-3
Single button, 2-24
Software installation, 2-5
  MMI for Windows, 2-13
SP
  Save parameter to disk, 3-19
  Save program, 3-20
Space Bar, 3-12
SR
  Service request, 3-20
Start Frequency
  PRM
    207, 4-37
STARTUP.EXE, 2-13

T

Target directory, 2-13
Teach mode, 1-4
Teach Mode, 3-11, 3-33
Teach program, 3-33
Technical details, 7-1
Thermistor Input Signal, 7-4
Thermistor Polarity, 4-19
TR
  Trigger, 3-15
Tracking, 3-6
Trajectory type
  PRM
    43, 4-23
Trapezoidal motion profile, 6-3
Trigger commnad, 3-15
Troubleshooting, 8-1
Tuning procedures for Servo Loops, 2-21
Tuning tips, 2-33

U

Uload files, 3-21
Unit Address, 4-32
Unpacking the UNIDEX 100, 2-2
Using the MMI, 2-13

V

Velocity Command, 2-19, 2-27
Velocity Error, 2-19, 2-24
Velocity Feedforward, 4-14
Velocity loop adjustment, 2-24

W

Wait for input, 3-29
Warnings, 1-17
Warranty Policy, B-1
Windows, 2-2
Wiring techniques, 7-15
WP
  Set parameter, 3-19
Writing a program, 2-7, 2-14

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