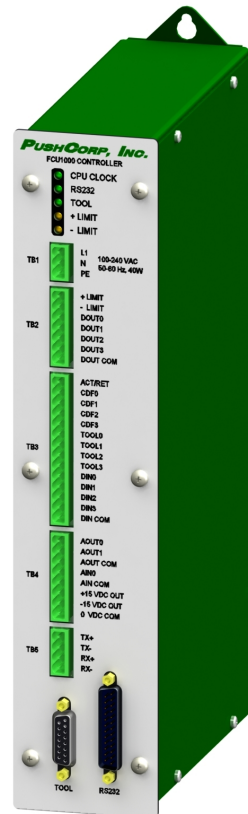


# ***FCU1000***

## Active Force Device Controller

# User's Manual



***PUSHCORP, INC.***

Dallas, Texas

## **CAUTION**

**Force Control Units contain  
calibrated electronics.**

**HANDLE WITH CARE DO NOT DROP**

**All fasteners, mounting holes and  
pipe threads on this tool are  
METRIC.**

**All *PushCorp, Inc.* electrical cables are rated for  
high twist and flex robotic applications with a  
minimum cable bending radius specification of  
125mm (5 in). Cable damage resulting from  
failure to abide by this specification will not be  
covered under warranty.**

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## **1.0 Limited Warranty**

Duration:

One year from date of delivery to the original purchaser.

**Who gives this warranty (warrantor):**

*PushCorp, Inc.*

Telephone: (972) 840-0208

Corporate Address:

P. O. Box 181915

Dallas, Texas 75218

Shipping Address:

3001 W. Kingsley Rd.

Garland, Texas 75041

**Who receives this warranty (purchaser):**

The original purchaser (other than for purposes of resale) of the *PushCorp, Inc.* product

**What products are covered by this warranty:**

Any *PushCorp, Inc.* Adjustable Force Device or Adjustable Force Device accessory supplied or manufactured by the Warrantor.

**What is covered under this warranty:**

Defects in material and/or workmanship which occur within the duration of the warranty period.

**What is NOT covered in this warranty:**

- A. IMPLIED WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE LIMITED TO ONE YEAR FROM THE DATE OF ORIGINAL PURCHASE. Some states do not allow limitations on how long an implied warranty lasts, so the above limitations may not apply to you.
- B. ANY INCIDENTAL, INDIRECT, OR CONSEQUENTIAL LOSS, DAMAGE or EXPENSE THAT MAY RESULT FROM ANY DEFECT, FAILURE, MALFUNCTION OF THE *PUSHCORP, INC.* PRODUCT. Some states do not allow the exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you.
- C. Any failure that results from an accident, purchaser's abuse, neglect, unauthorized repair or failure to operate the products in accordance with the instructions provided in the owner's manual(s) supplied with the product.

**Responsibilities of the Warrantor under this warranty:**

Repair or replace, at Warrantor's option, products or components which have failed within the duration of the warranty period.

**Responsibilities of the purchaser under this warranty:**

- A. Deliver or ship the *PushCorp, Inc.* product or component to PushCorp, Inc. Service Center, Dallas, TX. Freight and insurance costs, if any, must be borne by the purchaser.
- B. Use reasonable care in the operation and maintenance of the product as described in the owner's manual(s).

**When warrantor will perform repair or replacement under this warranty:**

Repair or replacement will be scheduled and serviced according to the normal work flow at the service center, and depending on the availability of replacement parts. Purchasers requiring quicker repair may receive such with payment of a *PushCorp, Inc.* predetermined expediting fee.

This Limited Warranty gives you specific legal rights and you may also have other rights which vary from state to state.

## **2.0 General Overview**

The *PushCorp, Inc. FCU1000* controller coupled with any *PushCorp* active tool provides a superior force application system. The Series 1000 control unit contains a microprocessor executing proprietary control algorithms. The microprocessor enables complete stand-alone operation and provides several advanced features unique to the Active Adjustable Force System. These functions include automatic motor/tool weighing, automatic motor weight compensation, and automatic compensation of acceleration induced forces.

The *FCU1000* provides the computer control for all *PushCorp* active force tools. It is designed to easily interface to a robot controller, remote host computer or PLC. The *FCU1000* is setup through an RS-232 or RS-485 serial port. Once configured, the controller can be operated via analog or digital interfaces, or through either of the serial ports using simple ASCII commands. These commands can originate from any serial port equipped PC or robot controller.

*PushCorp's AFD Windows*, is provided to allow interactive control from any PC compatible computer running Microsoft Windows 95/98/NT™. This program has on-screen buttons, sliders and bar graphs that provide an intuitive graphical interface to configure and control every function of the *FCU1000* controller. *AFD Windows* can be downloaded free of charge from the *PushCorp* web site at [www.pushcorp.com](http://www.pushcorp.com).

In addition to the serial interface, the *FCU1000* also has  $\pm 10$  VDC analog and 24 VDC digital I/O. These standard industrial interfaces allow the *FCU1000* to directly interface to most any PLC or robot controller. A common factory floor implementation is to use *AFD Windows* to setup the initial configuration and then use the analog and/or digital interfaces for the control interface during processing.

The *FCU1000* is packaged in a rugged, compact enclosure with all electrical connections located on the front panel so that the control unit may be mounted almost anywhere. Snap-in front panel electrical connectors make installing the *FCU1000* quick and easy.

The *PushCorp FCU1000* is a cost-effective solution providing the ultimate in flexibility and ease-of-use. Combined with any *PushCorp* active force control tool, the *FCU1000* system provides the ultimate state-of-the-art in force control.

### 3.0 Quick Start

This section gives step-by-step instructions on how to quickly get the Series 1000 Adjustable Force Device System up and running for a quick test of its capabilities. Complete details on the *FCU1000* features are described in the sections that follow. It is recommended that the user read the entire manual to fully understand all the aspects and features of the *FCU1000* controller.

- Step 1: Consult the appropriate tool *User's Manual* for pneumatic and mechanical hook-up instructions for the Active Force Tool.
- Step 2: Install the *PushCorp AFD Windows* configuration software on a PC compatible computer. This software is shipped on floppy disk with the *FCU1000* or is available via the Internet at [www.pushcorp.com](http://www.pushcorp.com).
- Step 3: Connect electrical power and control cables per Section 4.5.
- Step 4: Connect a PC compatible running the *PushCorp AFD Windows* software to the controller with a standard serial NULL MODEM cable.
- Step 5: Pressurize the air supply, and apply power to the controller. Verify the unit is communicating over the serial port by observing that *AFD Windows* indicates that the unit is "ONLINE."
- Step 6: Perform the Auto Weigh procedure for Tool 1 by clicking the *Weigh Tool* button in the *AFD Windows* program. Make sure the tool slide is oriented vertically downward (Plus sign down).
- Step 7: Select desired Command Force using the slider bar in *AFD Windows*.
- Step 8: Set the unit to Active mode by clicking the *Activate* button in *AFD Windows*.
- Step 9: Verify that the force tool carriage is now exerting the desired force.

Please read the following sections to learn the full potential and features of the *PushCorp, Inc.* Active Force System.

## 4.0 Installation

### 4.1 Mounting the FCU1000

The *FCU1000* is designed to mount to the back panel of most any standard control box enclosure. The controller has a key holed tab at the top and a slotted tab at the bottom. This allows the installer to mount two (2) fasteners in the back panel with the controller removed. With these fasteners mounted in the correct location, the installer can then easily slide the tabs over and down on to the fasteners. The drawing in Figure 1 shows overall dimensions and the proper location for the recommended M5 or 10-32 caphead fasteners.

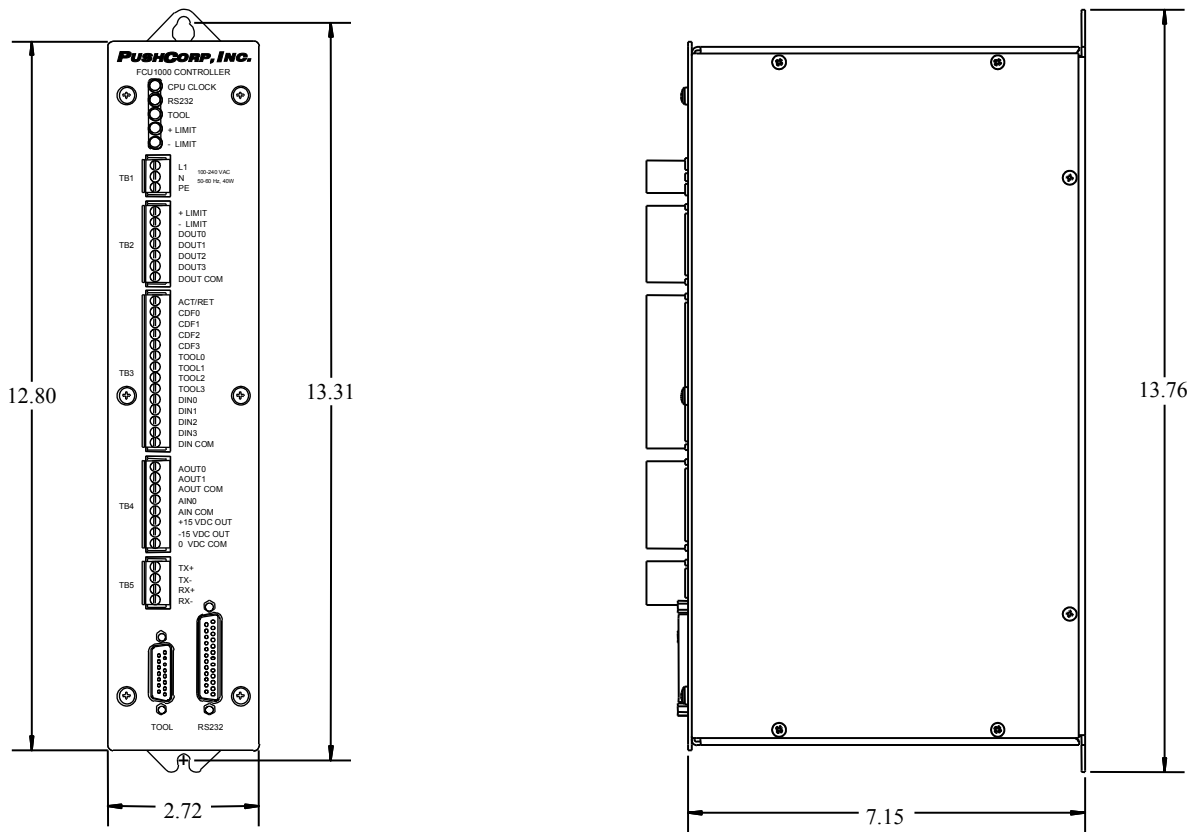


Figure 1. FCU1000 mounting dimensions



**4.2 Electrical Connections**

Figure 2 shows the location of important connectors and terminal blocks on the FCU1000 controller.

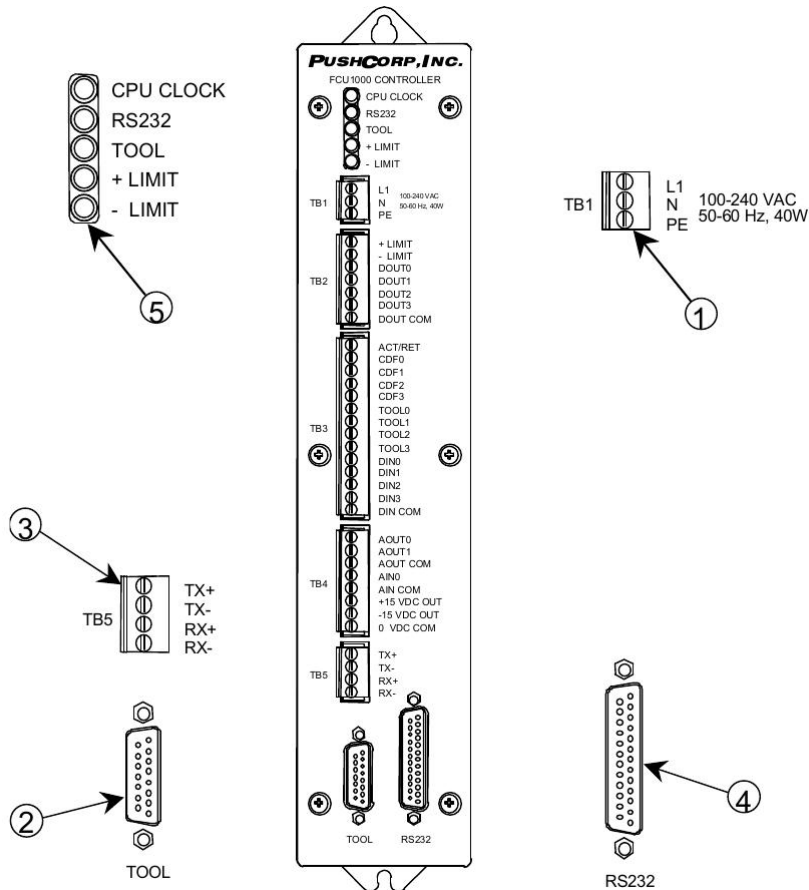


Figure 2. FCU1000 Front Panel

- ① Electrical Power Cable Connection - The supply voltage should be connected via this terminal block (TB1). Care should be taken to ensure a proper earth ground is connected at terminal PE. The unit contains a universal power supply that can accept input voltages from 100 - 240 VAC, 40 W, 50 - 60 Hz, 90% Efficiency.
- ② Force Unit Cable Connection – A cable is connected between this point on the controller front panel and the electrical connector on the active force tool itself. This is a standard DB15 female connector.
- ③ RS-485 Serial Connection - This terminal block (TB5) provides RS-485 multi-drop serial communications access to the controller. This allows multiple FCU1000's to be controlled from a single PC computer.
- ④ RS-232 Serial Connection - This DB25 (RS232) female connector provides serial communications access to the controller. The connector uses a DCE serial configuration and has the pin out shown in Table 1.

**NOTE: If one wishes to connect the Control Unit to a PC compatible computer a NULL Modem Serial cable must be used.**

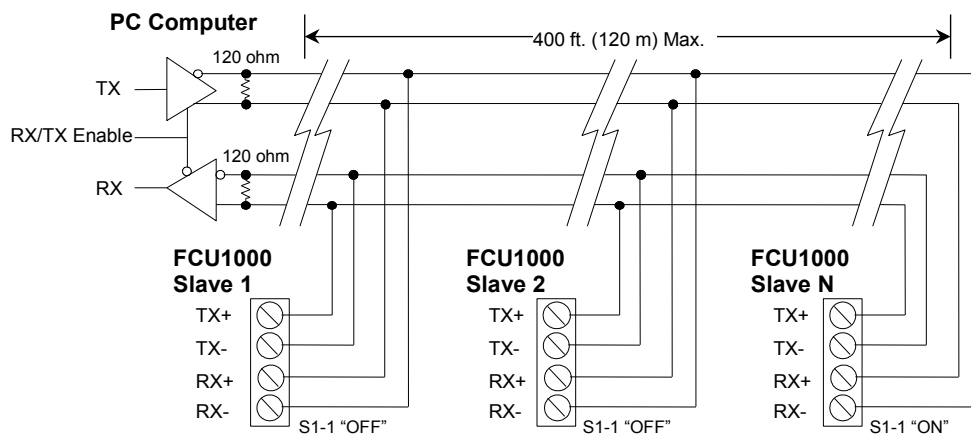
- ⑤ Status Display – These LEDs indicate the current controller status. Under normal operation the *CPU CLOCK* LED will be flashing to indicate that the unit is operating. The *RS232* LED will illuminate when a properly configured serial connection is made to the *RS232* connector. The *TOOL* LED will illuminate when an AFD tool is properly connected to the *TOOL* connector. Finally, the *+LIMIT* and *-LIMIT* LEDs will illuminate when the AFD Tool Carriage exceeds the defined positive (extend) or negative (retract) limits.

| <i>Pin</i> | <i>Name</i> | <i>Function</i>     |
|------------|-------------|---------------------|
| 1          | GND         | Protective Ground   |
| 2          | TD          | Transmit Data       |
| 3          | RD          | Receive Data        |
| 4          | RTS         | Request To Send     |
| 5          | CTS         | Clear To Send       |
| 6          | DSR         | Data Set Ready      |
| 7          | SG          | Signal Ground       |
| 8          | DCD         | Data Carrier Detect |
| 20         | DTR         | Data Terminal Ready |
| 22         | RI          | Ring Indicator      |

Table 1. Serial port pin out

To disable hardware handshaking, connect pins 4 and 5 together, and also connect 6, 8, and 20 together. This will allow the use of a simple "3-wire" (TD, RD, and SG) serial connection.

It is also possible to network several controllers together so that a single PC can control multiple FCU1000's. This is accomplished by utilizing the RS-485 multi-drop serial interface on TB5. Figure 3 illustrates how to wire up to 16 FCU1000's together in a multi-drop configuration.



NOTE: Up to N = 15 controllers may be connected. PC Computer must be terminated with 120 ohm resistor. The last FCU1000 Slave N in link must have the termination resistor switch S1-1 set to "ON". All other slaves must have termination resistor switch S1-1 set to "OFF". This switch is found on the FCU1000 motherboard near the RS-485 terminal connector.

Figure 3. RS-485 Electrical Diagram

## 5.0 Remote Operation

### 5.1 AFD Windows Control Panel

*AFD Windows* is a user-friendly graphical interface to the *FCU1000* controller that runs in the Microsoft Windows 95/98/NT™ operating environment. Every aspect of the *FCU1000* controller can be configured and controlled from this application program. This section describes the installation procedure and minimum system requirements. Specific operating instructions can be found through the online help available under the *Help* menu in the *AFD Windows* program.

#### Installing AFD Windows Control Panel

1. Insert the AFD Windows disk into the appropriate floppy disk drive or download the installations files from [www.pushcorp.com](http://www.pushcorp.com).
2. Choose the *Run* command from the File menu in Windows Program Manager or File Manager.
3. Type *A:\INSTALL* (substitute the appropriate drive letter for A: if necessary) and click *OK*.
4. When you run Install a dialog box appears. The default directory for installing the AFD Windows Control Panel is *C:\AFDWIN*. If adequate space is not available (0.5 MB), or you prefer to install the program in a different location, enter an alternate path in the Install Directory field. Click *Continue*.
5. Another dialog box will appear displaying the progress as the installation program copies the necessary files from the floppy disk.
6. The Install program will also create a Program Manager group and icon so that you may quickly access the AFD Windows Control Panel. The Install program will then display a dialog box indicating the installation is complete. Click *OK* to acknowledge it.

#### Minimum System Requirements

Processor: 80 Mhz 486 or higher

Hard Drive: 1. Mb

RAM: 8 Mb

Windows 95, 98, Me, 2000 or Windows NT 4.0

### 5.2 Serial Port Command Interface

All commands are standard ASCII strings. Upon power up the following sign message is transmitted:

```
PushCorp Series 1000 Adjustable Force Device<CR><LF>
```

```
Remote Serial Interface<CR><LF>
```

```
Version: 3.0 August 1999<CR><LF>
```

**NOTE: <CR> is ASCII 0D hex or 13 decimal. <LF> is ASCII Line Feed, ASCII 0A hex or 10 decimal. Version date will vary depending on software revision.**

This message is then followed by the command prompt: "OK<CR><LF>". This prompt indicates that the AFD is ready to accept serial interface commands.

All commands must be in the following format:

*Command* [*Arguments*]<LF>

where "*Command*" is a command mnemonic and "*Arguments*" is optional data representing any necessary arguments for the given command. Each character of the transmitted string is echoed back to the sender (including the terminating <LF>). This provides a mechanism to verify accurate data transmission.

Upon reception of the terminating <LF>, the AFD may respond to a command in one of three possible ways:

1. A successful command with no returned data:

Response String: OK<CR><LF>

2. A successful command returning parameter data:

Response String: *Data*<CR><LF>OK<LF>

3. An unsuccessful command:

Response String:

*Error* [*Error Number*]: [*Error String*][BEL]<CR><LF>OK<CR><LF>

**NOTE: Examining the fourth from last response character can quickly check for success. If it is a [BEL] (ASCII 7) character then the command was unsuccessful. The error can then be parsed to examine the reason for the error.**

This format allows readable commands for use with a dumb serial terminal as well as efficient communications with a remote computer host. Also note that the consistent data format allows one to easily parse data and error responses programmatically.

The status of all commands can be requested, updated or both as indicated by the arrow in the *Data Direction* field. *HOST*  $\Leftarrow$  *AFD* indicates that the command status can only be requested from the AFD controller (i.e., requesting the current applied force). *HOST*  $\Rightarrow$  *AFD* indicates the command can only be sent to the AFD controller, no value can be requested (i.e., saving configuration). *HOST*  $\Leftrightarrow$  *AFD* is the most common case, where values can be sent to and requested from the control unit.

To send new command values to the control unit, the command mnemonic is sent (letter case is ignored) followed by the space-separated data value. For example:

Host sends: CF 10.0<LF>

AFD Control unit responds: CF10.0<CR><LF>OK<CR><LF>

This sets the command force to 10.0 lbs. It should be noted that some commands can only be executed when the controller command interface is set to *SERIAL*. If this is not the case an error will be returned.

Command values can be requested at any time and in any mode. To request the current value of any parameter the command mnemonic is followed immediately by

a question mark ('?') (no space separator). The AFD control unit will then respond with the value. For example:

Host sends: CF?<LF>

AFD Control unit responds: CF?<LF>10.0<CR><LF>OK<CR><LF>

The following section describes the various commands to control and configure the AFD controller.

### 5.3 Serial Command Descriptions

This section describes some of the commands used to control and configure the AFD controller. A complete listing of commands can be displayed by using the "HELP" command at the RS-232 interface. Each command description has a header that summarizes the command. The header has the following format:

| Command Description | Command String | Data Direction | Data (if applicable) |
|---------------------|----------------|----------------|----------------------|
|---------------------|----------------|----------------|----------------------|

|                  |     |            |                         |
|------------------|-----|------------|-------------------------|
| Software Version | VER | HOST ← AFD | "X.XX" Firmware Version |
|------------------|-----|------------|-------------------------|

This is a read only command which returns a string indicating the current controller software version.

|               |    |            |            |
|---------------|----|------------|------------|
| Command Force | CF | HOST ↔ AFD | -MF ... MF |
|---------------|----|------------|------------|

This is a read/write command that controls the magnitude of the force that is applied by the force control tool. The force values can range from –Max Force to Max Force in Metric (N) or English (lbf.) units. (See the "CU" Controller Units command) The sign indicates the direction in which the force will be applied with respect to the plus (+) and minus (-) markings located on the force control tool.

If the force control tool is active, then sending the CF command with new data will immediately cause the tool to apply the new revised force. If the tool is retracted, then the command force will take effect when the tool is activated.

|                     |     |            |          |
|---------------------|-----|------------|----------|
| Command Force Level | CFL | HOST ↔ AFD | 0 ... 15 |
|---------------------|-----|------------|----------|

This is a read/write command that enables the command force associated with the force level parameter. The AFD controller is capable of storing up to sixteen force levels. These levels are typically used in conjunction with the controller digital interface. (See Section 5.5) The force levels and their associated command forces are configured via the FL (Force Level) command.

If the force control tool is active, then sending the CFL command with new data will immediately cause the tool to apply the new revised force. If the tool is retracted, then the command force will take effect when the tool is activated.

|             |    |            |          |
|-------------|----|------------|----------|
| Tool Number | TN | HOST ⇔ AFD | 0 ... 15 |
|-------------|----|------------|----------|

This read/write command changes the current tool weight to the tool weight associated with the tool indicated in the data parameter. The AFD controller is capable of storing up to sixteen tool weights. The current tool weight is used by the AFD controller to automatically compensate for gravitational and inertial effects. The weight associated with a given tool number can be entered manually via the *TW* command or a tool can be automatically weighed using the *ATW* command.

|               |    |            |            |
|---------------|----|------------|------------|
| Applied Force | AF | HOST ⇐ AFD | -MF ... MF |
|---------------|----|------------|------------|

This is a read only command that requests the force currently being applied by the AFD tool in Metric (N) or English (lbf.) units. This value is based on actual readings from the load cell force sensor located within the tool. Therefore the data returned by the *AF* command may vary slightly from the current command force.

|                   |     |            |             |
|-------------------|-----|------------|-------------|
| Carriage Position | POS | HOST ⇐ AFD | 0.00 ... MP |
|-------------------|-----|------------|-------------|

This is a read only command that requests the current position of the AFD tool carriage in Metric (mm) or English (in.) units. This value is based on readings from a linear potentiometer located within the tool. A position of 0.00 corresponds to the slide's most retracted position (negative direction) and a max position reading corresponds to the slide's most extended position (positive direction).

|                       |     |            |              |
|-----------------------|-----|------------|--------------|
| Carriage Acceleration | ACC | HOST ⇐ AFD | -2.0 ... 2.0 |
|-----------------------|-----|------------|--------------|

This is a read only command that requests the current acceleration affecting the AFD tool carriage. This value is based on readings from the accelerometer located within the AFD tool. The units of acceleration are g's, where +1.0g corresponds to the positive carriage axis pointing downward. Zero g means the carriage is horizontal, and -1.0g means the positive carriage axis is pointed upward. The value can be greater than +1.0 or less than -1.0 if inertial effects are also present.

|                  |     |            |                       |
|------------------|-----|------------|-----------------------|
| Active / Retract | ACT | HOST ⇔ AFD | 0- Retract, 1- Active |
|------------------|-----|------------|-----------------------|

This is a read/write command that enables or disables the AFD tool. A parameter value of 1 enables the AFD tool and causes the tool to begin applying the current command force. A parameter value of 0 disables the tool and causes the tool slide to retract in the opposite direction of the current command force.

|                |     |            |              |
|----------------|-----|------------|--------------|
| Position Limit | LIM | HOST ⇐ AFD | -1 or 0 or 1 |
|----------------|-----|------------|--------------|

This is a read only command that returns the current limit status of the AFD tool carriage. The AFD controller is capable of monitoring whether the carriage position exceeds either a extend or retract limit. The limit set points can be changed via the *ELP* (Extend Limit Position) or *RLP* (Retract Limit Position) commands. The *LIM* command returns a data value of -1, 0, or 1. A -1 indicates that the carriage is outside the retract limit. Likewise a return value of 1 indicates the extend limit is

exceeded. A return value of 0 means that the carriage position is currently in range between the retract and extend limits. The return value will correspond to the limit LEDs on the controller front panel.

|                |    |            |        |
|----------------|----|------------|--------|
| Emergency Stop | ES | HOST ⇔ AFD | 0 or 1 |
|----------------|----|------------|--------|

This is a read/write command that initiates or reads the emergency stop status of the AFD controller. A return value of 1 indicates that an emergency stop condition currently exists. A 0 indicates no emergency stop. Sending the *ES* command with a data parameter of 1 will E-Stop the device. When the device is E-Stopped the slide is immediately retracted. Sending the *ES* command with a data value of 0 returns the unit to normal operation.

|                  |     |            |          |
|------------------|-----|------------|----------|
| Auto Tool Weight | ATW | HOST ⇒ AFD | 0 ... 15 |
|------------------|-----|------------|----------|

This is a write only command that initiates the automatic tool weight sequence of the AFD tool. The data parameter determines which of the sixteen tools numbers will be associated with the resulting weight.

The weigh sequence starts immediately after the command is sent. When an equilibrium force is reached, the AFD slide will fall slightly and then return to its retracted position. The *OK* command prompt will return when the sequence is complete. The process may be repeated for another tool number.

**NOTE: The AFD carriage angle must be positioned with the positive direction downward and should be less than 10 degrees off of vertical to perform the automatic weighing process optimally, although the weighing process will work with a carriage angle as much as 45 degrees. The weighing procedure will check to ensure the angle is less than the 45 degrees and will not allow the auto-weigh procedure to continue if the angle requirement is exceeded.**

**Any auxiliary wires or hoses connected to the motor / tool may cause the weight value to vary. It is therefore important to secure these auxiliary wires or hoses as well as possible without restricting the range of motion of the tool carriage.**

|             |    |            |                      |
|-------------|----|------------|----------------------|
| Tool Weight | TW | HOST ⇔ AFD | 0 ... 15, 0.0 ... MW |
|-------------|----|------------|----------------------|

This is a read/write command that is used to manually set or request the tool weight associated with a given tool number. To request the weight of a tool the *TW* command is sent with a single tool number data parameter.

Host sends: TW? 1<LF>  
 Controller replies: TW? 1<LF>10.0<CR><LF>OK<CR><LF>

To associate a tool weight with a tool number, two data parameters are used. The first is the tool number, and the second is the desired tool weight.

Host sends: TW 1 10.0<LF>  
 Controller replies: TW 1 10.0<LF>OK<CR><LF>

|             |    |            |                   |
|-------------|----|------------|-------------------|
| Force Level | FL | HOST ⇔ AFD | 0...15, -MF... MF |
|-------------|----|------------|-------------------|

This is a read/write command that is used to manually set or request the command force associated with a given force level. To request the command force associated with a force level the *FL* command is sent with a single force level data parameter.

Host sends: FL? 1<LF>

Controller replies: FL? 1<LF>10.0<CR><LF>OK<CR><LF>

To associate a command force with a force level, two data parameters are used. The first is the force level, and the second is the desired command force.

Host sends: FL 1 10.0<LF>

Controller replies: FL 1 10.0<LF>OK<CR><LF>

|              |    |            |                         |
|--------------|----|------------|-------------------------|
| Contour Mode | CM | HOST ⇔ AFD | 0- Disabled, 1- Enabled |
|--------------|----|------------|-------------------------|

This is a read/write command which is used to enable or disable the Contour Mode feature of the AFD controller. Force Contour Mode enables the AFD controller to automatically adjust the command force based on the current AFD tool carriage position. This feature is useful for processes such as grinding off flashing, drilling (minimizing breakout), or any other process which would need a varying force based on carriage position. The contour mode force is configured via the *CMF* command.

**NOTE: When in *Force Contour Mode* the normal command force will no longer be in effect. This is because in contour mode the command force is calculated based on the slide position. To return to normal operation disable Contour Mode.**

|                    |     |            |                      |
|--------------------|-----|------------|----------------------|
| Contour Mode Force | CMF | HOST ⇔ AFD | 0 ... 10, -MF ... MF |
|--------------------|-----|------------|----------------------|

This is a read/write command that is used to configure the Contour Mode feature of the AFD controller. Force Contour Mode works by setting different command force values along the carriage stroke at 11 increments. To set this up, the *CMF* command requires two data parameters. The first parameter indicates the position of the slide and the second sets the desired command force to be enabled at that position. Position 0 corresponds to the most retracted slide position. Position 10 corresponds to the extended position. Intermediate Positions are at equally spaced intervals between the Retract and Extend positions. At each of these 11 positions a different force can be set anywhere from –Max Force to Max Force.

|                        |     |            |             |
|------------------------|-----|------------|-------------|
| Retract Limit Position | RLP | HOST ⇔ AFD | 0.00 ... MP |
|------------------------|-----|------------|-------------|

This is a read/write command that is used to configure the AFD controller retract limit position. The *RLP* command has a single data parameter which sets the limit position. The retract limit position must be less than the extend limit position. If at any time the carriage position is less than the configured retract limit then the limit status returned by the *LIM* command will change to a -1 and the AFD controller will enable the retract limit digital output. An external robot controller or PLC can monitor this output. The output will correspond with the –*LIMIT* front panel LED indicator.



|                       |     |            |             |
|-----------------------|-----|------------|-------------|
| Extend Limit Position | ELP | HOST ↔ AFD | 0.00 ... MP |
|-----------------------|-----|------------|-------------|

This is a read/write command that is used to configure the AFD controller extend limit position. The *ELP* command has a single data parameter which sets the limit position. The extend limit position must be greater than the retract limit position. If at any time the carriage position is greater than the configured extend limit then the limit status returned by the *LIM* command will change to a 1 and the AFD controller will enable the extend limit digital output. An external robot controller or PLC can monitor this output. The output will correspond with the *+LIMIT* front panel LED indicator.

|                         |     |            |                                  |
|-------------------------|-----|------------|----------------------------------|
| Command Force Interface | CFI | HOST ↔ AFD | 0- Serial, 1- Digital, 2- Analog |
|-------------------------|-----|------------|----------------------------------|

This is a read/write command that is used to configure the AFD controller command force interface. The default command force interface is the RS-232 serial port, however the controller can be configured to accept force commands from either the analog interface or the digital interface terminals.

**It should be noted that if the command force interface is set to something other than the Serial interface, then issuing the *CF* command will result in an error.**

If the command force interface is set to the digital interface then command forces will be based on the 3 bit binary code that selects one of the seven possible command force levels. (See Section 5.5)

|                            |     |            |                       |
|----------------------------|-----|------------|-----------------------|
| Active / Retract Interface | ARI | HOST ↔ AFD | 0- Serial, 1- Digital |
|----------------------------|-----|------------|-----------------------|

This is a read/write command that is used to configure the AFD controller active/retract command interface. The default active / retract interface is the RS-232 serial port, however the controller can be configured to accept these commands from either the RS-232 serial port or the digital input terminals. The single data parameter indicates which interface to use according to the following: 0 - Serial interface, 1 - Digital interface.

**It should be noted that if the active/retract interface is set to something other than the Serial interface, then issuing the *ACT* command will result in an error.**

|                       |     |            |                       |
|-----------------------|-----|------------|-----------------------|
| Tool Number Interface | TNI | HOST ↔ AFD | 0- Serial, 1- Digital |
|-----------------------|-----|------------|-----------------------|

This is a read/write command that is used to configure the AFD controller tool number command interface. The default tool number interface is the RS-232 serial port, however the controller can be configured to accept these commands from either the RS-232 serial port or the digital input terminals.

**It should be noted that if the tool number interface is set to something other than the serial interface, then issuing the *TN* command will result in an error.**

**If the tool number interface is set to the digital interface then the tool number will be based on the 3 bit binary code which selects one of the sixteen possible tools. (See Section 5.5)**

|               |    |            |                  |
|---------------|----|------------|------------------|
| Maximum Force | MF | HOST ⇐ AFD | 0.0 to Max Force |
|---------------|----|------------|------------------|

This is a read only command that returns the maximum force capacity of tool currently connected to the controller.

|                  |    |            |                     |
|------------------|----|------------|---------------------|
| Maximum Position | MP | HOST ⇐ AFD | 0.0 to Max Position |
|------------------|----|------------|---------------------|

This is a read only command that returns the maximum position of the tool carriage currently connected to the controller.

|                |    |            |                   |
|----------------|----|------------|-------------------|
| Maximum Weight | MW | HOST ⇐ AFD | 0.0 to Max Weight |
|----------------|----|------------|-------------------|

This is a read only command that returns the maximum weight capacity of the tool currently connected to the controller.

|           |    |            |                       |
|-----------|----|------------|-----------------------|
| Tool Type | TT | HOST ⇐ AFD | Tool Type Description |
|-----------|----|------------|-----------------------|

This is a read only command that returns a string indicating the tool type model currently connected to the controller.

|               |    |            |                         |
|---------------|----|------------|-------------------------|
| Position Mode | PM | HOST ⇔ AFD | 0- Disabled, 1- Enabled |
|---------------|----|------------|-------------------------|

This is a read/write command that enables or disables the position control mode of the controller. The Position Mode command allows one to position the tool carriage anywhere in its range of travel via the “CP” command. While in Position Mode, force control is disabled and the carriage will apply whatever force is necessary to achieve the commanded position.

|                  |    |            |            |
|------------------|----|------------|------------|
| Command Position | CP | HOST ⇔ AFD | 0.00 .. MP |
|------------------|----|------------|------------|

This is a read/write command that sets the carriage command position when in Position Mode. The carriage will move to the specified position when the controller is set to Active via the “ACT” command.

|                  |    |            |                       |
|------------------|----|------------|-----------------------|
| Controller Units | CU | HOST ⇔ AFD | 0- Metric, 1- English |
|------------------|----|------------|-----------------------|

This is a read/write command that determines what engineering units are used by the controller. If Metric units are selected then Newtons, kilograms, and millimeters are used for force, mass, and position respectively. If English units are selected, then Pounds Force, Pounds Mass, and Inches are used.

|                 |    |            |         |
|-----------------|----|------------|---------|
| Network Address | NA | HOST ⇔ AFD | 1 .. 15 |
|-----------------|----|------------|---------|

This is a read/write command that sets the network address of the controller if multiple controllers are used in an RS-485 multidrop installation. It is necessary that each controller on the network have a unique address to function properly. Address 0 is reserved and should not be used.

|                 |    |            |             |
|-----------------|----|------------|-------------|
| Controller Name | CN | HOST ⇔ AFD | Name String |
|-----------------|----|------------|-------------|

This is a read/write command that specifies a user friendly name for the controller. This name will be displayed in the *AFD Windows* program when the controller is addressed on a multidrop installation.

|      |      |            |     |
|------|------|------------|-----|
| Help | HELP | HOST ⇒ AFD | N/A |
|------|------|------------|-----|

This command will display a complete listing of all available serial commands including their appropriate parameters.

|                    |    |            |     |
|--------------------|----|------------|-----|
| Save Configuration | SC | HOST ⇒ AFD | N/A |
|--------------------|----|------------|-----|

This is a write only command which is used to save the current AFD configuration information to non-volatile EE<sup>2</sup>PROM so that the configuration will be retained through a power off period.

### 5.4 Serial Command Interface Summary

| <b>Command Description</b> | <b>Command Code</b> | <b>Data Direction</b> | <b>Data</b>                      |
|----------------------------|---------------------|-----------------------|----------------------------------|
| Software Version           | VER                 | HOST ← FCU            | "X.XX" Firmware Version          |
| Command Force              | CF                  | HOST ⇔ FCU            | -MF .. +MF                       |
| Command Force Level        | CFL                 | HOST ⇒ FCU            | 0 .. 15                          |
| Tool Number                | TN                  | HOST ⇔ FCU            | 0 .. 15                          |
| Applied Force              | AF                  | HOST ← FCU            | -MF .. +MF                       |
| Carriage Position          | POS                 | HOST ← FCU            | 0.00 .. MP                       |
| Carriage Acceleration      | ACC                 | HOST ← FCU            | -2.000 .. +2.000                 |
| Active / Retract           | ACT                 | HOST ⇔ FCU            | 0 or 1                           |
| Extend / Retract Limit     | LIM                 | HOST ← FCU            | 1 or 0 or -1                     |
| E-Stop                     | ES                  | HOST ⇔ FCU            | 0 or 1                           |
| Auto Tool Weigh            | ATW                 | HOST ⇒ FCU            | 0 .. 15                          |
| Tool Weight                | TW                  | HOST ⇔ FCU            | 0 .. 15, 0.0 – MW                |
| Force Level                | FL                  | HOST ⇔ FCU            | 0 .. 15, -MF .. +MF              |
| Contour Mode               | CM                  | HOST ⇔ FCU            | 0- Disabled, 1- Enabled          |
| Contour Mode Force         | CMF                 | HOST ⇔ FCU            | 0 .. 10, -MF .. +MF              |
| Retract Limit Position     | RLP                 | HOST ⇔ FCU            | 0.00 .. MP                       |
| Extend Limit Position      | ELP                 | HOST ⇔ FCU            | 0.00 .. MP                       |
| Command Force Interface    | CFI                 | HOST ⇔ FCU            | 0- Serial, 1- Digital, 2- Analog |
| Active / Retract Interface | ARI                 | HOST ⇔ FCU            | 0- Serial, 1- Digital            |
| Tool Number Interface      | TNI                 | HOST ⇔ FCU            | 0- Serial, 1- Digital            |
| Maximum Force              | MF                  | HOST ← FCU            | 0.0 to Max Force                 |
| Maximum Position           | MP                  | HOST ← FCU            | 0.0 to Max Position              |
| Maximum Weight             | MW                  | HOST ← FCU            | 0.0 to Max Weight                |
| Tool Type                  | TT                  | HOST ← FCU            | Tool Type                        |
| Position Mode              | PM                  | HOST ⇔ FCU            | 0- Disabled, 1- Enabled          |

| <b>Command Description</b> | <b>Command Code</b> | <b>Data Direction</b> | <b>Data</b>            |
|----------------------------|---------------------|-----------------------|------------------------|
| Command Position           | CP                  | HOST ⇔ FCU            | 0.0 .. MP              |
| Controller Units           | CU                  | HOST ⇔ FCU            | 0- Metric, 1- English  |
| Network Address            | NA                  | HOST ⇔ FCU            | 1 .. 15                |
| Controller Name            | CN                  | HOST ⇔ FCU            | Name String Identifier |
| Help                       | HELP                | HOST ⇐ FCU            | Command Help Listing   |
| Save Configuration         | SC                  | HOST ⇒ AFD            | N / A                  |

Table 2. ASCII Controller Commands

**5.5 Analog I/O Interface**

The control unit analog interface provides analog voltage inputs and outputs to control and monitor a variety of functions on the *FCU1000* Controller. The single analog input can be configured to control either the desired *COMMAND FORCE* or *COMMAND POSITION*. A -10V input corresponds to a maximum negative command. A +10V input corresponds to a maximum positive command. Between the minimum and maximum inputs, the Command Force or Position will correspond in a linear fashion. Figures 4, 5 and 6 and Table 3 show the details on how this signal is connected.

The two analog outputs can each be configured to output signals reflecting any of several real-time controller parameters. Some of these parameters include: *ACTUAL FORCE*, *CARRIAGE POSITION*, and *ACCELERATION*. The outputs are configured via the *AFD Windows* program. Consult the program for a complete list of available output parameters.

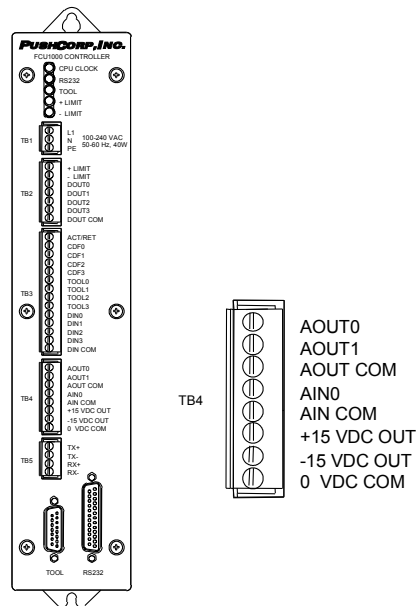


Figure 4. Analog I/O Connections

| <b>Function</b>            | <b>Terminal</b> | <b>Signal</b>      |
|----------------------------|-----------------|--------------------|
| <b>ANALOG OUTPUTS</b>      | AOUT0           | -10 VDC to +10 VDC |
|                            | AOUT1           | -10 VDC to +10 VDC |
|                            | AOUT COM        | OUTPUT COMMON      |
| <b>ANALOG INPUT</b>        | AIN             | -10 VDC to +10 VDC |
|                            | AIN COM         | INPUT COMMON       |
| <b>POWER SUPPLY OUTPUT</b> | +15 VDC OUT     | +15 VDC, 20mA Max. |
|                            | -15 VDC OUT     | -15 VDC, 20mA Max. |
|                            | 0 VDC COM       | SUPPLY COMMON      |

Table 3. Analog I/O Interface

**NOTE:** Analog signals are, by nature, very susceptible to electrical noise. *PushCorp, Inc.* therefore recommends using shielded cable for all analog input and output connections. However, even with shielded cable some noise will likely be present. Presence of any electrical noise will cause small but visible variations in the resulting command signals to the controller.

**NOTE:** When using the AIN analog input to control the Command Force, instability may occur when the voltage input is very close to zero volts and the unit is **RETRACTED**. The reason for this is that the **RETRACT** direction is defined to be the opposite direction of the current Command Force. Therefore, if the AIN voltage is very close to zero volts, electrical noise may cause the Command Force sign to change randomly positive or negative. While retracted the FCU1000 will react these random sign changes by rapidly moving between the positive and negative stops. The solution to this problem is to never allow the AIN voltage to be set to zero while the unit is retracted. Alternatively, one can simply maintain the FCU1000 in an **ACTIVE** state all the time and use the AIN input to directly control the direction and magnitude of the applied force.

**VOLTAGE OUTPUTS (-10 VDC to +10 VDC)**

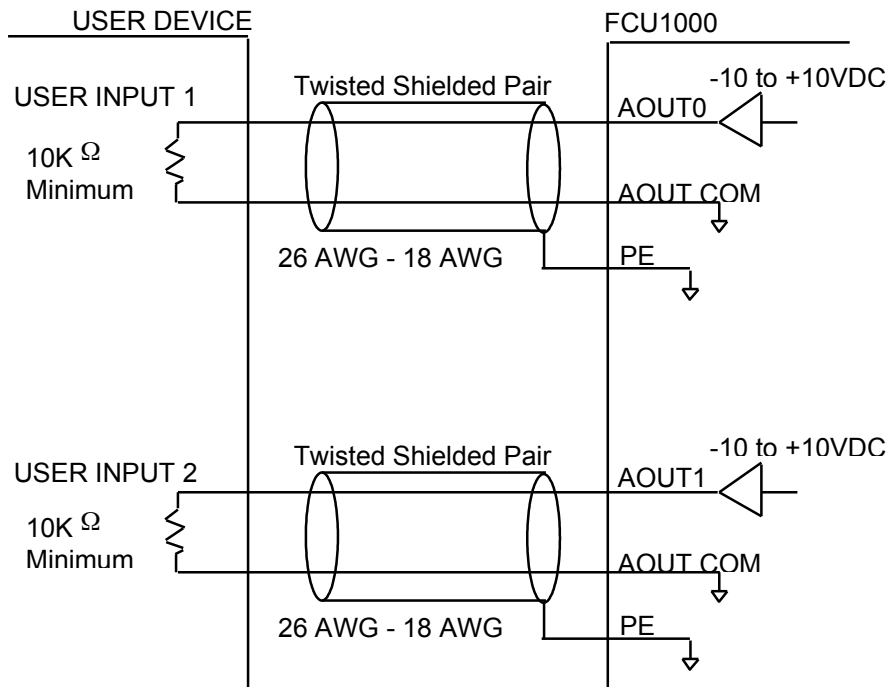
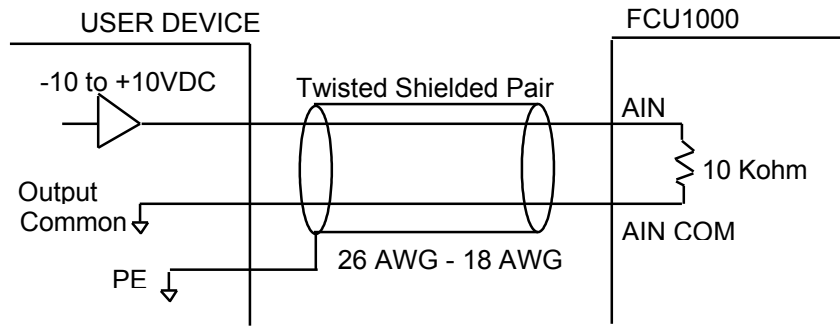


Figure 5. Analog Output Circuit Diagram

**VOLTAGE INPUT (-10 VDC to +10 VDC)**

Single Ended Driver



Differential Ended Driver

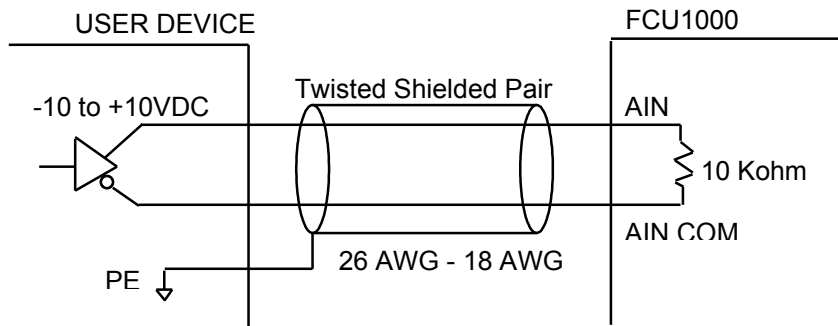


Figure 6. Analog Input Circuit Diagram

**5.6 Digital I/O Interface**

The controller digital interface can be used to provide inputs for *ACTIVE/RETRACT*, *COMMAND FORCE LEVEL*, *TOOL NUMBER* and *USER INPUTS* signals. Digital outputs are also provided to indicate when a carriage position limit has been exceeded. In addition, configurable *USER I/O* is provided to allow many other control and monitoring functions. Figures 7 and 8 and Tables 4 and 5 show the details on how these signals are connected to the control unit.

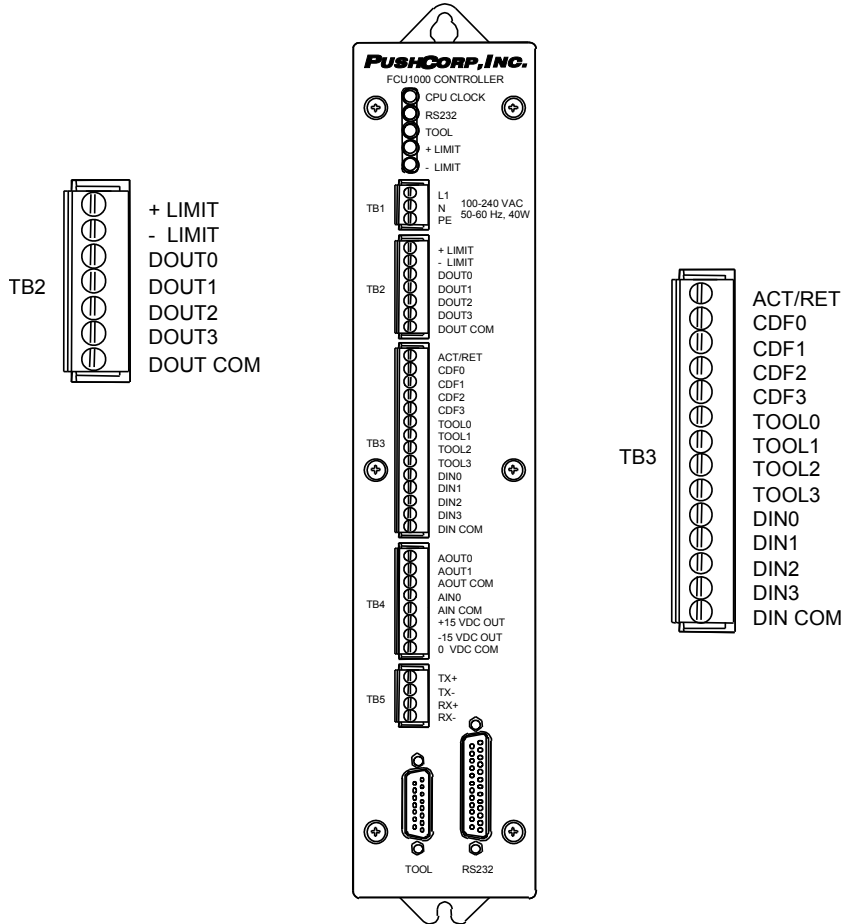


Figure 7. Digital I/O Connections

| <b>Function</b> | <b>Terminal</b> | <b>Signal</b>         |
|-----------------|-----------------|-----------------------|
| POSITION LIMITS | + LIMIT         | POS. POSITION LIMIT   |
|                 | - LIMIT         | NEG. POSITION LIMIT   |
| USER OUTPUTS    | DOUT0           | USER OUTPUT Bit 0     |
|                 | DOUT1           | USER OUTPUT Bit 1     |
|                 | DOUT2           | USER OUTPUT Bit 2     |
|                 | DOUT2           | USER OUTPUT Bit 3     |
| COMMON          | DOUT COM        | DIGITAL OUTPUT COMMON |

Table 4. Digital Outputs (TB2)



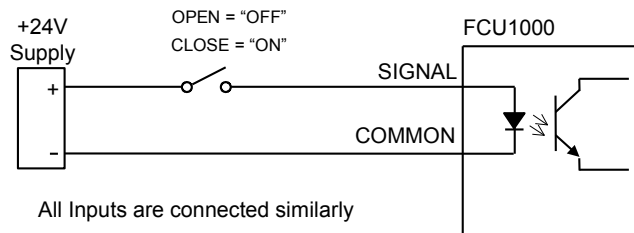
| Function            | Terminal | Signal                |
|---------------------|----------|-----------------------|
| ACTIVE / RETRACT    | ACT/RET  | SET ACTIVE OR RETRACT |
| COMMAND FORCE LEVEL | CDF0     | CDF Bit 0             |
|                     | CDF1     | CDF Bit 1             |
|                     | CDF2     | CDF Bit 2             |
|                     | CDF3     | CDF Bit 3             |
| TOOL NUMBER         | TOOL0    | TOOL Bit 0            |
|                     | TOOL1    | TOOL Bit 1            |
|                     | TOOL2    | TOOL Bit 2            |
|                     | TOOL3    | TOOL Bit 3            |
| USER INPUTS         | DIN0     | USER INPUT Bit 0      |
|                     | DIN1     | USER INPUT Bit 1      |
|                     | DIN2     | USER INPUT Bit 2      |
|                     | DIN3     | USER INPUT Bit 3      |
| COMMON              | DIN COM  | DIGITAL INPUT COMMON  |

Table 5. Digital Inputs (TB3)

The USER INPUT and OUTPUT terminals can be configured via the *AFD Windows* software to provide various control and monitoring functions. The software allows each I/O point to be individually configured to perform a specific function. The *AFD Windows* online Help documentation provides a complete list and descriptions of these functions.

In the digital interface, a +24V potential between a given input and common, terminals will indicate a logical "1". A 0V potential denotes a logical "0". The example circuits below indicate how this should be wired.

**Connecting Digital Inputs**



**Connecting Digital Outputs**

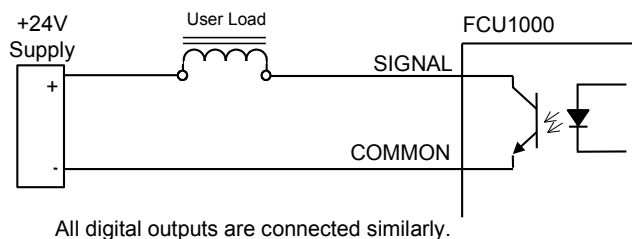


Figure 8. Digital I/O Circuit Diagram