FCUFLEX

Active Force Device Controller

User's Manual

PUSHCORP, INC.

Dallas, Texas

December, 2017 PAR01622-1 Patent No. 5,448,146

CAUTION

Force Control Units contain calibrated electronics.

HANDLE WITH CARE DO NOT DROP

WARNING

Do not connect the TCP IP port to a Gigabit (1000BaseT) Router

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.

Table of Contents

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 MERCHANT-ABILITY 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. FCUFLEX* controller coupled with any *PushCorp* active tool provides a superior force application system. The *FCUFLEX* 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 *FCUFLEX* 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 *FCUFLEX* is setup through a USB or Ethernet interface. Once configured, the controller can be operated via USB, Ethernet, field bus, or 24VDC digital interfaces.

PushCorp's AFD Dashboard is provided to allow interactive control from any PC. This program has on-screen controls that provide an intuitive graphical interface to configure and control every function of the *FCUFLEX* controller. *AFD Dashboard* can be downloaded free of charge from the *PushCorp* web site at www.pushcorp.com.

The *FCUFLEX* is packaged in a rugged and compact industrial 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 *FCUFLEX* quick and easy.

The *PushCorp FCUFLEX* is a cost-effective solution providing the ultimate in flexibility and ease-of-use. Combined with any PushCorp active force control tool, the *FCUFLEX* 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 AFD Adjustable Force Device System up and running for a quick test of its capabilities. Complete details on the *FCUFLEX* 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 *FCUFLEX* 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 Dashboard* configuration software. This software is available at www.pushcorp.com.

Step 3: Connect electrical power and control cables per Section 4.2.

Step 4: If the user is running Windows 10 or greater, it will automatically install the software when the FCUFLEX USB is detected.

If the user is running an older version of Windows than Windows 10, it is necessary to install the generic USB serial driver from the "pciusb.inf" installation file located in the AFD Dashboard program folder where the afddash.exe program is located.

Step 5: Pressurize the air supply, and apply power to the controller. Verify the unit is communicating by observing that *AFD Dashboard* displays the unit's AFD model name.

Step 6: Perform the payload weigh procedure for by clicking the *Weigh Payload* button in the *AFD Dashboard*. Make sure the tool slide is oriented in the vertical direction.

Step 7: Select desired Command Force clicking the force display gauge in *AFD Dashboard*.

Step 8: 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 *FCUFLEX*

The *FCUFLEX* 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.

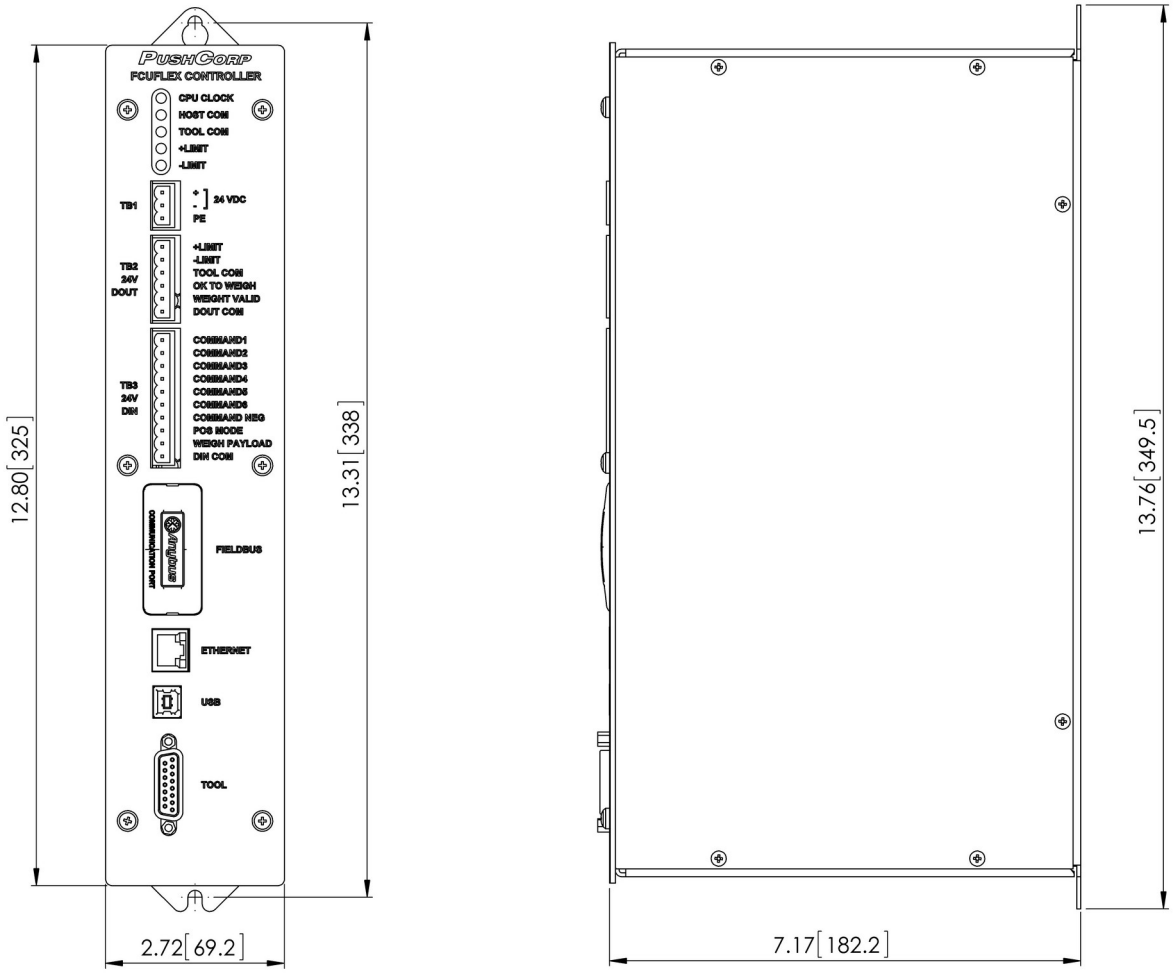


Figure 1: FCUFLEX Mounting Dimensions

4.2 Electrical Connections

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

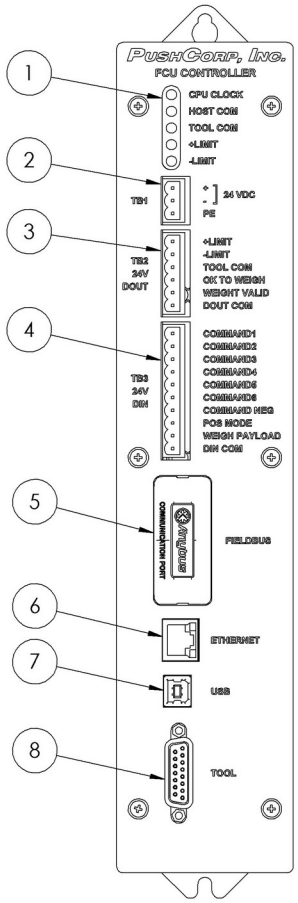


Figure 2: FCUFLEX Front Panel

(1) LED Indicators – Indicate the basic operational status of the *FCUFLEX* controller. The specific LED indicators are described below:

LED	Color	Description
CPU CLOCK	GREEN BLINKING	*FCUFLEX* "Heartbeat" indicates controller is operating normally.
HOST COM	GREEN	ON indicates USB or Ethernet connection is established.
TOOL COM	GREEN	ON indicates *FCUFLEX* is connected and communicating with the AFD tool.
+LIMIT	YELLOW	ON indicates that the AFD carriage is positioned beyond the current positive limit setting.

LED	Color	Description
-LIMIT	YELLOW	ON indicates that the AFD carriage is positioned beyond the current negative limit setting.

(2) Electrical Power Cable Connection - The supply voltage is connected via this terminal block (TB1). Care should be taken to ensure proper polarity and that a proper earth ground is connected at terminal PE. The unit accepts a nominal supply voltage of 24VDC, 2 Amps max.

(3) Digital Outputs – 24VDC digital outputs are connected via this terminal block (TB2). Please refer to Section *5.1 Digital I/O Interface*, for intput descriptions.

(4) Digital Inputs – 24VDC digital inputs are connected via this terminal block (TB3). Please refer to Section *5.1 Digital I/O Interface*, for output descriptions.

(5) Fieldbus Connection – This connector accepts an optional *HMS Industrial Network AnyBus™* modules to provide a wide variety of fieldbus connection options. Please refer to the *FCUFLEX Tech Note* specific to the particular installed module if used.

(6) Ethernet Connection – This is a standard RJ-45 Ethernet connector that provides standard HTTP, Telnet, and UDP communication to the FCUFLEX controller. Please refer to Section *5.2 Ethernet Interface* for details on configuring the Ethernet interface and communication protocols.

(7) USB Connection – This is a receptacle that accepts a standard USB Type-B connector. Once the appropriate *PushCorp* device driver is installed, the USB connection creates a virtual “serial port” that can be accessed with the *AFD Dashboard* or any serial terminal software. Please refer to Section *5.3 Console Command Interface* for details regarding the specific commands to configure and control the FCUFLEX.

(8) TOOL Connection – A *PushCorp* proprietary cable is connected between this connector and the electrical connector on the AFD tool. When properly connected the TOOL LED will illuminate.

5.0 Remote Operation

5.1 Digital I/O Interface

The controller digital interface provides a number of inputs to set the control to operational mode, set the command force, and weigh the AFD tool's payload. Digital outputs are also provided to indicate when a carriage position limit has been exceeded, tool communication status, and payload weight status. Figure 3 and Tables 1 and 2 describe the functional details of these signals.

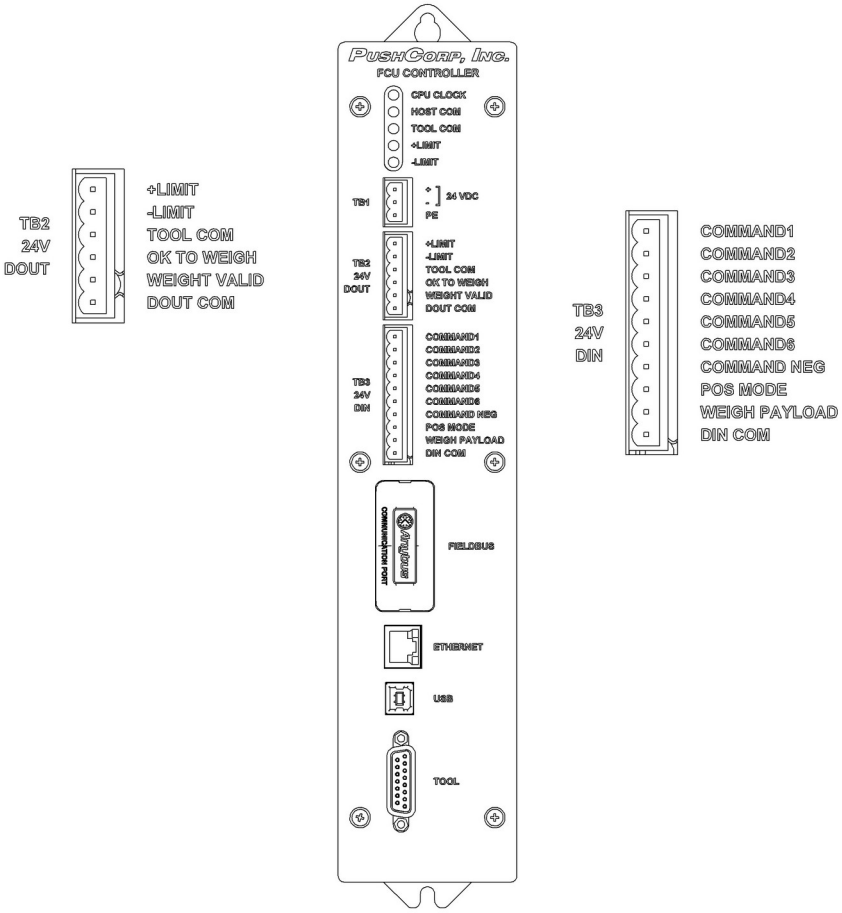


Figure 3: Digital I/O Connections

Table 1: Digital Outputs (TB2)

Terminal	Label	Signal Description
1	+ LIMIT	POSITIVE POSITION LIMIT EXCEEDED
2	- LIMIT	NEGATIVE POSITION LIMIT EXCEEDED
3	TOOL COM	AFD TOOL CONNECTED AND COMMUNICATING
4	OK TO WEIGH	AFD TOOL IN PROPER POSITION TO WEIGH PAYLOAD
5	WEIGHT VALID	CURRENT PAYLOAD WEIGHT IS VALID
6	DOUT COM	DIGITAL OUTPUT COMMON RETURN

Table 2: Digital Inputs (TB3)

Terminal	Label	Signal
1	COMMAND1	0.01563 COMMAND MULTIPLIER
2	COMMAND2	0.03125 COMMAND MULTIPLIER
3	COMMAND3	0.06250 COMMAND MULTIPLIER
4	COMMAND4	0.1250 COMMAND MULTIPLIER
5	COMMAND5	0.2500 COMMAND MULTIPLIER
6	COMMAND6	0.5000 COMMAND MULTIPLIER
7	COMMAND NEG	COMMAND NEGATIVE DIRECTION
8	POS MODE	SET POSITION MODE
9	WEIGH PAYLOAD	INITIATE PAYLOAD WEIGH PROCEDURE
10	DIN COM	DIGITAL INPUT COMMON RETURN

Digital Command Calculations

Digital input terminals 1 through 7 may be used to set the desired command force be applied. To calculate the resulting command force value, simply add up the associated COMMAND MULTIPLIER for each bit that is turned ON. Then multiply the resulting sum by the maximum capacity of the AFD tool being used.

For example, if inputs COMMAND2, COMMAND3, and COMMAND6 are turned on then the COMMAND MULTIPLIER would be 0.03125 + 0.0625 + 0.500 = 0.5938. If the *FCUFLEX* controller were connected to an AFD310 compliant tool, the maximum capacity would be 267 Newtons. Therefore the resulting COMMAND FORCE would be 0.594 x 267 Newtons = 158.6 Newtons. Turning on the COMMAND NEG input will negate the COMMAND FORCE value.

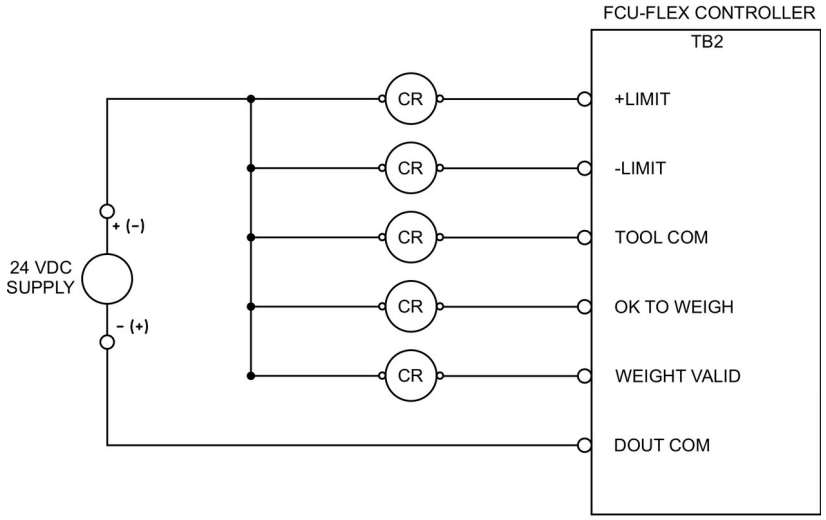
The AFD310's maximum position is 20mm. If the device is in POSITION MODE (possibly by turning ON the POS MODE input), then the resulting COMMAND POSITION would be 0.594 * 20mm = 11.9mm. COMMAND POSITION is always positive. Therefore the COMMAND NEG input has no effect on the COMMAND POSITION value.

Digital Electrical Connection

The *FCUFLEX* electrical connections are 24VDC. The digital inputs and outputs are non-polarized. The digital common terminals (DIN COM, DOUT COM) may be connected to the positive or negative side of the DC power supply. The *FCUFLEX* inputs and outputs are compatible with both Sinking (NPN) and Sourcing (PNP) switching devices.

For the *FCUFLEX* inputs, 24VDC (12 mA Max per input) being present across the respective input and DIN COM indicates an “ON” condition. An “ON” condition for the *FCUFLEX* outputs is indicated by electrical continuity being present the respective output (2 Ohm max resistance) and the DOUT COM terminal. An “OFF” condition is indicated by an open circuit.

DIGITAL OUTPUTS



DIGITAL INPUTS

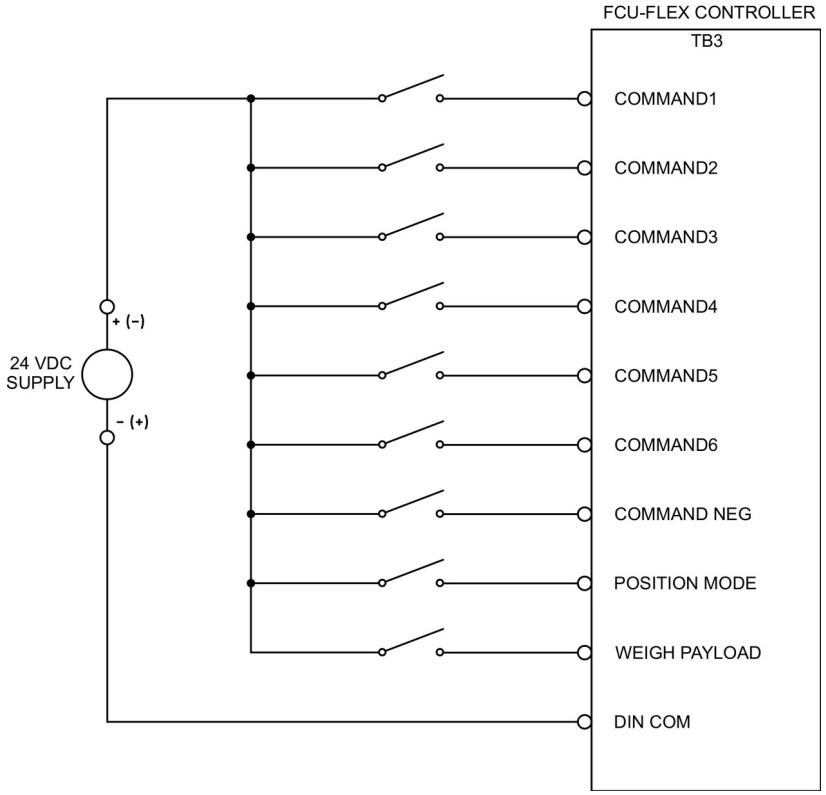


Figure 4: Digital I/O Circuit Diagram

5.2 Ethernet Interface

The *FCUFLEX* has an ethernet network connection that may be used to configure and control all aspects of the controller. The factory default network configuration is to request an IP address via DHCP, if this fails then the FCUFLEX next attempts to set an IP address based on the AutoIP protocol. If the AutoIP configuration is successful, the *FCUFLEX* will be assigned an IP address with a link-local 169.254/16 prefix (169.254.xxx.xxx).

The factory default *FCUFLEX* host name is “FCU-xxxxx” where “xxxxx” is the serial number of the *FCUFLEX* controller.

The easiest way to discover and connect to the *FCUFLEX* network interface is with the *AFD Dashboard* application. When the *AFD Dashboard* program is started it will automatically discover all of the *FCUFLEX* equipment on the same network segment. Once a given *FCUFLEX* controller is found, its default network configuration can be changed as desired.

5.3 Console Command Interface

The Console Command Interface can be accessed via the USB serial interface or over ethernet via a standard Telnet session (TCP Port 23). All commands are standard ASCII strings. Upon power up the following sign message is transmitted:

```
FCUFLEX Console Interface[CR][LF]
HW Version: 1.0  SW Version: 1.0[CR][LF]
Build Date: Jan 01 1994, 00:00:00[CR][LF]
```

NOTE: [CR] is ASCII 0D hex or 13 decimal. [LF] is ASCII Line Feed, ASCII 0A hex or 10 decimal. HW and SW Versions and Build Date will vary depending on software revision.

This message is then followed by the command prompt: ">>". This prompt follows all command and indicates that the previous command is complete and that the unit is ready to accept additional 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 unit 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]

3. An unsuccessful command:

Response String:

Error: Error Object [Error No]: Error Description[[CR][LF]

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

5.4 Web and UDP Command Interface

The FCUFLEX can be configured and controlled via web (TCP Port 80) and UDP (Port 1993) socket requests. For both of these interfaces all returned data will be formatted as a JSON object.

The returned JSON object will always have two top level keys: “status” and “data”. The “status” key will always have one of two values. A value of “success” indicates that the command was successful and the “data” value will be either the requested parameter value or “OK” for commands that return nothing.

A “status” value of “fail” indicates that there was an error. In this case the “data” key will contain a string describing the failure.

UDP Socket Example

A UDP message with an ASCII (UTF-8) text string containing the command to be executed should be sent to port 1993 on the FCUFLEX.

Requesting a parameter

Send string:

```
/afd/commandForce
```

Reply string:

```
{"data":{"/afd/commandForce":12.0000},"status":"success"}
```

Setting a parameter

Send string:

```
/fcu/deviceName=fred
```

Reply string:

```
{"data":{"/fcu/deviceName":”OK”},"status":"success"}
```

Command Failure

Send string:

```
/fcu/badCommand=24.2
```

Reply string:

```
{"data":{"/fcu/badCommand":"Error: RpcObject[1]: Unknown Method"},"status":"fail"}
```

Web Request Example

A request can be sent from a web browser to the FCUFLEX with URL string containing the command to be executed.

Requesting a parameter

Send string:

```
http://fcu-00000/afd/commandForce
```

Reply string:

```
{"data":{"commandForce":12.0000},"status":"success"}
```

Setting a parameter

Send string:

```
http://fcu-00000/fcu/deviceName=fred
```

Reply string:

```
{"data":{"/fcu/deviceName":"OK"},"status":"success"}
```

Command Failure

Send string:

```
http://fcu-00000/fcu/badCommand=24.2
```

Reply string:

```
{"data":{"/fcu/badCommand":"Error: RpcObject[1]: Unknown Method"},"status":"fail"}
```

5.5 *FCUFLEX* Command Descriptions

The parameters and commands of the *FCUFLEX* are organized in a hierarchical directory tree structure to access various system components as shown below:

/fcu (or "/")

/fcu/afd

/fcu/anybus

/fcu/net

The top-level or root is the initial working directory and allows access to the *FCUFLEX* top-level commands. The root directory also can be accessed either explicitly by "/fcu" by its default alias "/".

A command or parameter can always be accessed be specifying its complete canonical name starting from the root. For example, to access the *FCUFLEX*'s Serial Number the canonical command would be "/fcu/serialNo". Alternatively, to access the AFD tool's serial number the canonical command would be "/afd/serialNo".

The parameters and commands themselves are descriptive "Camel Case" strings (individual words delineated by capital letters, e.g. "camelCase") and starting with a

lower case letter. The command or parameter can be abbreviated by using the first letter followed by each of the remaining capitalized letters. For example the "weighingInProgress" parameter is abbreviated "wip". If there are no capital letters, then the entire parameter or command name must be used.

5.5.1 *FCUFLEX* Root Commands

Table 3: FCUFLEX Root Commands

Command	*Command Description*	*Data Type*	*Read/Write*
/fcu/help	Displays all available commands	LIST	Read
/fcu/firmWareVersion	Device firmware version	FLOAT	Read
/fcu/hardWareVersion	Device hardware version	FLOAT	Read
/fcu/modelName	Device model name (e.g. "FCUFLEX")	STRING	Read
/fcu/serialNo	Device serial number	INTEGER	Read
/fcu/deviceName	User assignable device name	STRING	Read/Write
/fcu/toolCom	Tool connection status 0: Not Connected, 1: Connected	INTEGER	Read
/fcu/hostCom	USB or Network interface connection status 0: Not Connected, 1: Connected	INTEGER	Read
/fcu/ioState	Returns a binary representation of the current *FCUFLEX* front panel digital I/O states	STRING	Read
/fcu/stateObject	Return JSON object representing the current device state	JSON	Read
/fcu/dumpCfg	Dumps the current *FCUFLEX* user configuration	LIST	Read
/fcu/saveConfig	Save the current *FCUFLEX* user configuration to non-volatile FLASH memory	NONE	Write

5.5.2 *FCUFLEX* Network Commands

Table 4: FCUFLEX Network Commands

Command	*Command Description*	*Data Type*	*Read/Write*
/net/help	Displays all available commands	LIST	Read
/net/hostName	Network host name	STRING	Read/Write
/net/dhcp	Set to use DHCP server to obtain IP address 0: Static IP, 1: DHCP	INTEGER	Read/Write
/net/timeout	Time out for DHCP server (Seconds)	INTEGER	Read/Write
/net/ipAddress	Returns currently assigned IP address	STRING	Read
/net/gateway	Returns currently assigned network gateway IP address	STRING	Read
/net/netMask	Returns currently assigned network mask	STRING	Read
/net/macAddress	Returns Ethernet hardware (MAC) address	STRING	Read
/net/linkStatus	Returns link status of Ethernet interface 0: Disconnected, 1: Waiting for IP address, 2: Connected	INTEGER	Read

5.5.3 *FCUFLEX* AnyBus Commands

Table 5: FCUFLEX AnyBus Commands

Command	Command Description	Data Type	Read/Write
/anybus/help	Displays all available commands	LIST	Read
/anybus/moduleType	Returns currently installed module type	STRING	Read
/anybus/baudRate	Fieldbus baud rate (if applicable) 0: 125 kbps, 1: 250 kbps, 2: 400 kbps, Default: 0	INTEGER	Read/Write
/anybus/nodeAddress	Fieldbus node address (if applicable)	INTEGER	Read/Write

5.5.4 *FCUFLEX* AFD Command

Table 6: FCUFLEX AFD Commands

Command	Command Description	Data Type	Read/Write
/afd/help	Displays all available commands	LIST	Read
/afd/firmWareVersion	Device firmware version	FLOAT	Read
/afd/hardWareVersion	Device hardware version	FLOAT	Read
/afd/modelName	Device model name (e.g. “AFD310”)	STRING	Read
/afd/serialNo	Device serial number	INTEGER	Read
/afd/metricUnits	0: English, 1: Metric	INTEGER	Read/Write
/afd/maxForce	Maximum force capacity 0: English, 1: Metric	FLOAT	Read
/afd/maxPosition	Maximum position capacity	FLOAT	Read
/afd/deviceName	User assignable device name	STRING	Read/Write
/afd/initialWeigh	Enable/disable weigh payload on power-on 0: Disabled, 1: Enabled	INTEGER	Read/Write
/afd/initialMode	Sets initial power-on controlMode 0: Position Mode, 1: Force Mode, 3: Soft Touch Mode	INTEGER	Read/Write
/afd/initialForce	Sets initial power-on commandForce.	FLOAT	Read/Write
/afd/initialPosition	Sets initial power-on commandPosition	FLOAT	Read/Write
/afd/posLimitPosition	Sets the positive position limit threshold	FLOAT	Read/Write
/afd/negLimitPosition	Sets the negative position limit threshold	FLOAT	Read/Write
/afd/posLimit	Position Limit status -1: Neg Limit, 0: In Range, 1: Pos Limit	INTEGER	Read
/afd/softTouchEnabled	Enable/disable Soft Touch feature 0: Disabled, 1: Enabled	INTEGER	Read/Write
/afd/softTouchForce	Set soft touch force as multiplier of comandForce 0.1 – 1.0	FLOAT	Read/Write
/afd/softTouchPosition	Set soft touch position as multiplier of maxPosition 0.1 – 1.0:	FLOAT	Read/Write
/afd/softTouchActive	Soft Touch feature is currently in effect 0: Inactive, 1: Active	INTEGER	Read
/afd/controlMode	Sets basic mode of operation 0: Position Mode, 1: Force Mode, 3: Soft Touch Mode	INTEGER	Read/Write

Command	Command Description	Data Type	Read/Write
/afd/commandForce	Sets desired level of force when in Force Mode. May be positive or negative to push in either direction.	FLOAT	Read/Write
/afd/commandPosition	Sets desired carriage position when in Position Mode. May be only be a positive number 0.0: Fully negative, *maxPosition*: Fully positive	FLOAT	Read/Write
/afd/payloadWeight	Sets the current payload weight. This parameter can be measured automatically by executing the *weighPayload* command.	FLOAT	Read/Write
/afd/weighPayload	The command initiates the automatic payload weight measurement sequence.	N/A	Read/Write
/afd/weighAtPosition	This parameter returns whether the AFD tool is in the vertical position needed to execute the *weighPayload* command. 0: Not in position, 1: In position	INTEGER	Read
/afd/weighingInProgress	Returns whether the *weighPayload* sequence is in process 0: Not in progress, 1: In progress	INTEGER	Read
/afd/weightValid	Indicates that the current *payloadWeight* status 0: Weight invalid (*weighPayload* was unsuccessful) 1: Weight valid, -1: *weighPayload* sequence is in process	INTEGER	Read
/afd/actualForce	Returns the current measured applied force	FLOAT	Read
/afd/actualPosition	Returns the current measured carriage position	FLOAT	Read
/afd/accelGravity	Returns the current measured Acceleration of Gravity in G's 1.0: Vertical + downward, 0.0: Horizontal, -1.0 Vertical upward	FLOAT	Read
/afd/stateObject	Return JSON object representing the current device state	JSON	Read
/afd/dumpCfg	Dumps the current *FCUFLEX* user configuration	LIST	Read
/afd/saveConfig	Save the current *FCUFLEX* user configuration to non-volatile FLASH memory	NONE	Write

5.5.5 *FCUFLEX* Fieldbus I/O Mapping

The FCUFLEX supports several fieldbus communication protocols including DeviceNet™, Ethernet/IP™, and ProfiNet®. The desired protocol is implemented via a plug-in AnyBus® interface module. Please refer to PushCorp's website *http://www.pushcorp.com* for protocol specific configuration files and instructions.

All of the communication protocols use the following generalized I/O mapping for the listed parameters:

Table 7: I/O Mapping

Data	*Parameter*	*Description*	*Type*	*Read/ Write*
WORD 1	statusWord	Current status bitmap: BIT0: CPU Heartbeat BIT1: Host Com BIT2: Tool Com BIT3: Metric Units BIT4: POS Limit BIT5: NEG Limit BIT6: At Weigh Position BIT7: Weighing in Progress BIT8: Weight Valid BIT9 – BIT15: Not Used	UINT16	Read
WORD 2	actualForce	Current measured applied force X 10	SINT16	Read
WORD 3	actualPosition	Current measured carriage position X 100	SINT16	Read
WORD 4	accelGravity	Current measured acceleration X 1000	SINT16	Read
WORD 5	commandForce	Current command force X 10	SINT16	Read
WORD 6	commandPosition	Current command position X 100	SINT16	Read
WORD 7	payloadWeight	Current payload weight X 100	SINT16	Read
WORD 8	controlMode	Current control mode bitmap: BIT0: ON – ForceMode OFF – PositionMode BIT1: SoftTouchEnabled BIT2: SoftTouchActive BIT3 – BIT7: SoftTouchPosition X 31 BIT8 – BIT12: SoftTouchForce X 31 BIT13 – BIT15: Ignored	UINT16	Read
WORD 9	maxForce	Maximum force capacity X 10	SINT16	Read
WORD 10	maxPosition	Maximum position X 100	SINT16	Read
WORD 11	setCommandForce	Set command force X 10	SINT16	Write
WORD 12	setCommandPositon	Set command position X 100	SINT16	Write
WORD 13	setPayloadWeight	Set payload weight X 100	SINT16	Write
WORD 14	setControlMode	Set control mode bitmap: BIT0: ON – ForceMode OFF – PositionMode BIT1: SoftTouchEnable BIT2: Ignored BIT3 – BIT7: SoftTouchPosition X 31 BIT8 – BIT12: SoftTouchForce X 31 BIT13 – BIT15: Ignored	UINT16	Write
WORD 15	weighPayload	BIT0: ON (Rising Edge) – Initiate weigh payload	UINT16	Write

6.0 Soft-touch Feature

PushCorp's Active Control Compliance makes possible the very convenient Soft-touch feature. When programming a robot to perform force compliant, material removal applications, often the most difficult task is transitioning on and off of a the part surface to create a nice blended finish with no gouging.

The Soft-touch feature makes this transition much easier by automatically ramping up the effective command force based on the carriage position. The Soft-touch force profile is illustrated by the graph in Figure 5 below.

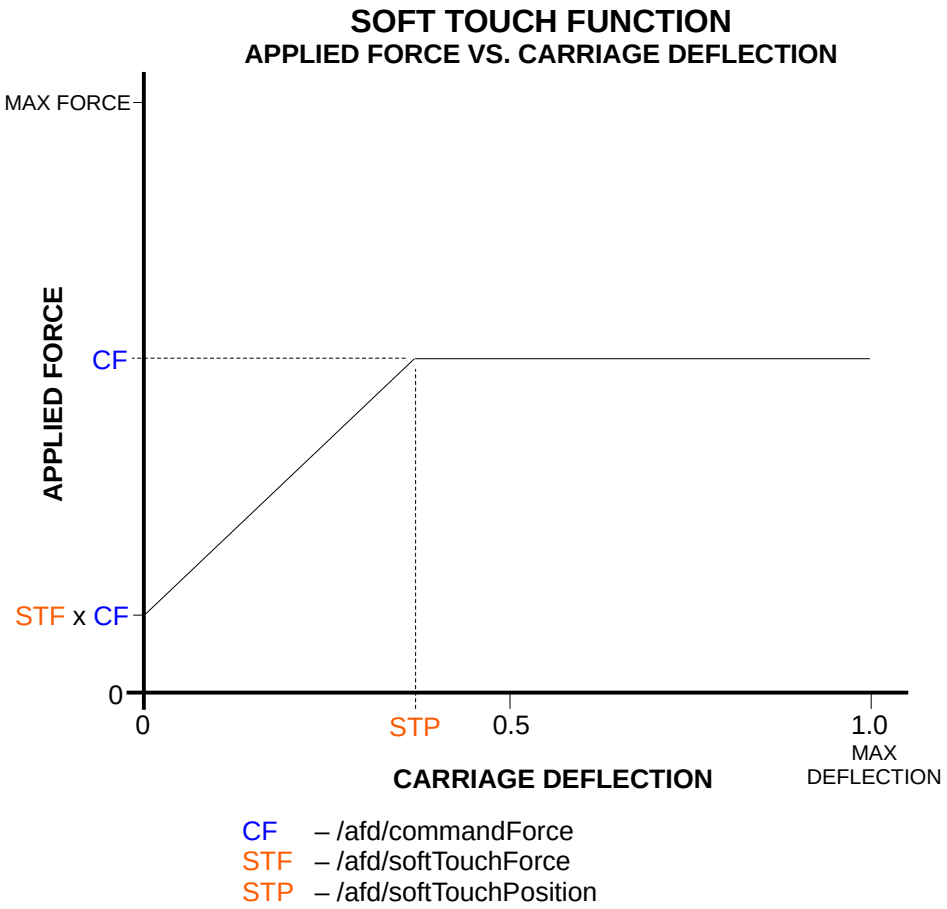


Figure 5: Soft-touch Function Force Profile

As is seen in the graph, the Soft-touch function is configured via two parameters: *softTouchForce* and *softTouchPosition*. Both of these parameters are scale factors that range in value from 0.0 to 1.0.

The *softTouchForce* parameter sets the force that is applied when the carriage is at the positive or negative end-stop. The net force actually applied is *softTouchForce* multiplied by the current *commandForce*. The *softTouchPosition* sets the carriage position region where the Soft-touch function is active. When the carriage is in the Soft-

touch region, the net force is automatically increased from the lighter *softTouchForce* to the current *commandForce* as the carriage position deflects from the end-stop position to the *softTouchPosition* (1.0 being the maximum possible deflection at the opposite end-stop position).

Once the *softTouchPosition* breakpoint is exceeded by the carriage, the Soft-touch functionality will be temporarily suspended. While suspended, the constant *commandForce* will maintained throughout the entire range of travel of the carriage. The Soft-touch function is re-activated when the carriage once again returns to the end-stop position.

The *softTouchEnabled* parameter enables(1) or disables(0) the Soft-touch functionality globally. The *softTouchActive* parameter indicates whether or not the Soft-touch function is currently in affect, scaling the net applied force based on the carriage position.

Also note that the net applied force at the end-top scales proportionally with the *commandForce* parameter. So, if for example, *commandForce* is 20 N and *softTouchForce* is 0.2, the net applied force at the end-stop will be 20 N x 0.2 = 4 N. If one were to increase the *commandForce* to 50 N, the net applied force at the end-stop will be 50 N x 0.2 = 10.0 N. This allows one to easily adjust the needed force level while maintaining optimal Soft-touch functionality.

7.0 Technical Specifications*

Electrical Supply:	24 VDC, +/-10%, 40 W Max
Digital Inputs:	5 – 24 VDC,Non-polarized (Sinking or Sourcing) 2.2 KΩ resistance
Digital Outputs:	24 VDC Max, Non-polarized (Sinking or Sourcing) 40mA Max On-state Current 2 Ω Max On-state resistance
Digital I/O Fuses:	Fast Acting, 1/4" x 1-1/4" Fuse, 250VAC Rated, 1/4A Littlefuse® P/N 312.250HXP or equivalent
USB:	B-Type Peripheral Connector
Ethernet:	RJ-45 Receptacle
Weight:	4 lbs. (1.8 Kg)
Overall Dimensions:	14in x 3in x 8in Depth (36mm x 8mm x 21mm Depth) *Dimensions do not include clearance for wiring and connectors*
Operating Environment:	0˚ to 122˚ F (10˚ to 50˚ C) Ambient Temperature 5% to 95% Relative Humidity, Non-Condensing

**Specifications subject to change without notice.*