DOF-5

User Guide

P/N 41-1114 Rev. B

March 2019

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About This Guide

Introduction

This guide describes the installation of the DOF-5 and its operation. The intended audiences are software and hardware engineers, and technicians responsible for performing installation.

"About This Guide," covers the following topics.

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Chapters and Appendixes in This Guide

This guide contains the following chapters. It does not cover advanced topics such as debugging the system or editing configuration files.

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Chapter 1 Site Planning Describes the responsibilities of the customer and the requirements for the installation site and includes an installation process flow and installation guidelines.	12
Chapter 2 Technical Overview Describes the functionality of the DOF-5 and its main components.	23

About This Release

This version of the startup guide is for the DOF-5 product series.

Viewing the PDF Version

The PDF version of this guide provides a number of ways to navigate through the content. Blue text indicates links to related topics. You can also do the following:

- Click the Bookmarks tab in the left pane to view the list of bookmarks and click any bookmark to navigate to that topic. If the Bookmarks tab is not visible, choose **View > Navigation > Bookmarks** from the menu bar.

- Click on the Contents bookmark. Pick any entry in the Contents and click either the entry text or its page number to go to that topic.

- Scroll to the end of the Contents to the List of Figures. Pick any entry in the list and click either the figure number and title or its page number to go to that topic.

- Scroll to the end of the List of Figures to the List of Tables. Pick any entry in the list and click either the table number and title or its page number to go to that topic.

- Click on the Index bookmark. Pick any index entry and click its page number to go to that topic.

Symbols

This guide uses the following symbols.

	Note: Indicates neutral or positive information that emphasizes or supplements important points of the main text.
	Caution: Advises users that failure to take or avoid a specified action could result in unintended operation.
	Warning: Advises users that failure to take or avoid a specified action could result in physical harm to the user or hardware.

Contact Information

The Business Unit of Dover Motion in Boxborough, MA is the manufacturer of the DOF-5 and is located at the address:

Dover Motion

159 Swanson Rd.

Boxborough, MA 01719 USA

The Dover Motion website is located at:

http://www.dovermotion.com

If you have questions or comments, contact:

Phone: (508) 475-3400
Email: service@dovermotion.com

Chapter 1: Site Planning

About This Chapter

Introduction

This chapter describes the responsibilities of the customer and the requirements for the installation site.

Topics

This chapter covers the following topics:

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Unboxing the DOF-5

Information for Receiving and Shipping Stop Removal

Receiving

When you receive your DOF-5, do the following:

1. Inspect the package for damage.

Caution: If you suspect damage, take pictures of the location where you suspect there is damage. A representative of the shipping carrier may need to be present during the unpacking process for insurance purposes.

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2. Remove the shipping stop using a 2mm hex wrench
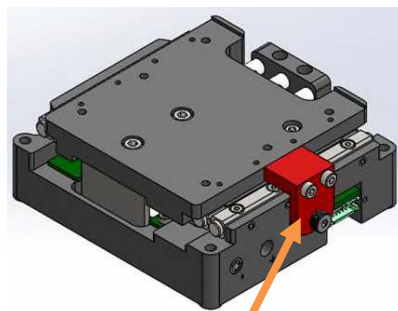
Remove: (2) M2.5X16

(1) Shoulder screw
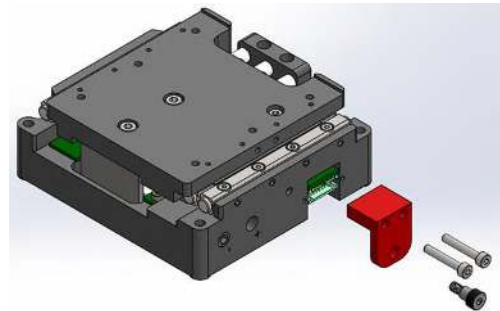
Note: Save the shipping stop and screws, they can be reused for shipping. Shipping without this stop in place can lead to damage of the stage.

⚠ **Warning:** If the stage is turned on without removing the shipping stop the stage may be damaged.

Specifications for Power, Communications, and Environment

Electrical Power

The DOF-5 requires both a logic and motor bus power source, as specified in Table 1. Note, the return (ground) is shared on the board for these supplies.

Table 1   Specifications for Electrical Power

Specification	
Recommended Voltage (Logic and Motor Bus)	24VDC ± 10%
Logic Power	2W Peak, 1.5W Typical
Motor Bus Power	25W Peak
Current (Nominal Voltage, 24VDC)	Max = 1.125A Typical = 0.200A

Grounding

Certain types of electrical noise are greatly exaggerated by poor or improper electrical ground connections. Be sure to consider this when supplying power to the DOF-5.

Warning: Do not connect the DOF-5 to the same dedicated line and ground that is used to power a device with a high current.

Warning: Use qualified personnel for installation of all electrical fixtures and ensure that all installations follow local bylaws.

Operating Environment

Table 2 lists the specifications for the environment in which the DOF-5 will be fully operational and compliant with its performance specifications.

<p align="center">**Table 2 Specifications for the Operating Environment**</p>

Specification	Acceptable Range
Temperature	5-40˚ C 41-104˚ F
Relative humidity	20-80% non-condensing

Mounting Surface

The DOF when mounted, should be mated with a surface that has a maximum flatness of 25µm (.001")
over the 70mm x 75mm surface of the DOF-5. Mounting pads are located on the back of the stage as
shown in Figure 1. The suggested torque (stainless steel hardware) is 1.0N/m for M3 hardware
mounting from the front, and 2.5N/m for M4 hardware mounting from the rear.

<p align="center">**Figure 1 DOF-5 Mounting Pads**</p>
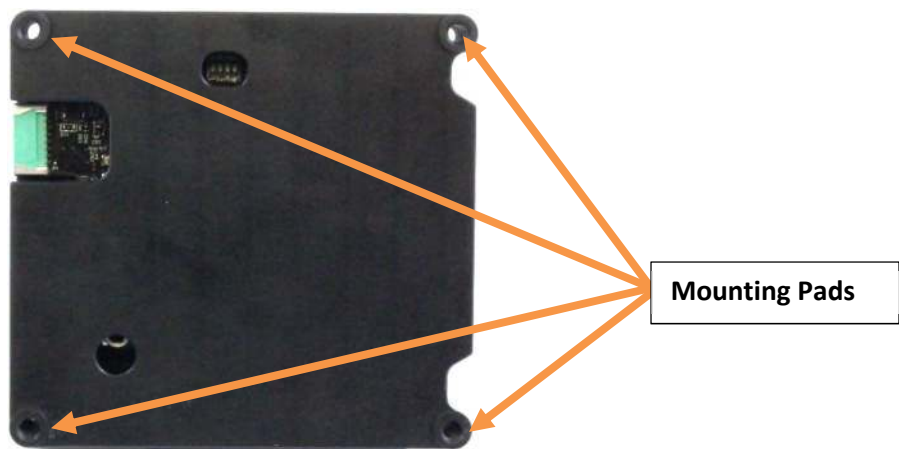
Objective and Stage Alignment

The axis of motion is defined by the base of the DOF-5 and its referenced crossed roller rail (see Figure 2).

It is recommended to use the objective bracket provided by Dover Motion. The objective bracket is installed at the factory to ensure that the objective optical axis is precisely parallel to the axis of motion.

<p align="center">**Figure 2 Objective Mount Banking Surface**</p>

Proud Banking Surface
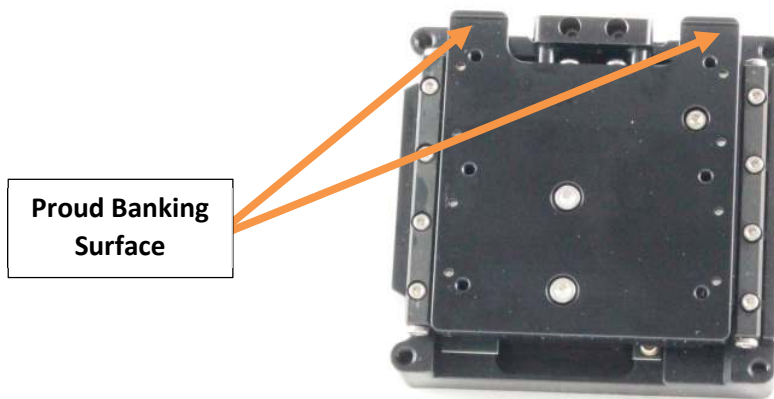
If the objective mounting bracket is removed from the DOF-5 moving carriage for any reason, angular alignment between the objective and the motion axis can be restored by banking the mount against the DOF-5 moving carriage proud banking lip (see Figure 2). If the objective mounting bracket location is such that it does not directly contact this banking lip, use a suitably wide machinist's parallel to align the objective mounting bracket.

The reference rail (see Figure 3) can be banked against pins or a flat mating surface in your assembly to align the DOF-5 to your optical system. See the optional banking pins described below.

Figure 3 DOF-5 Banking / Alignment Pins
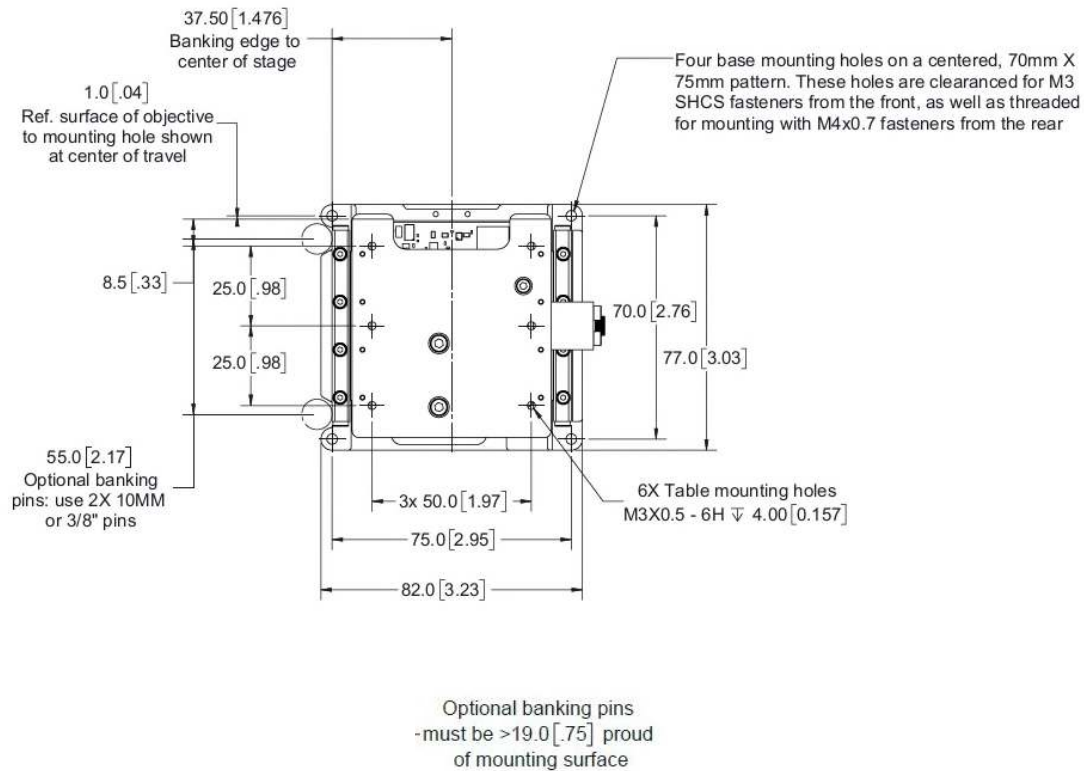
Communications (RS-232, RS-485, and CAN) Setup

RS-232, RS-485, and CAN communication for the DOF-5 are DIP switch selectable. Communications DIP switches are accessible on the back of the DOF-5 stage and are preset at the factory. If needed, set the communication DIP switches before mounting the stage. All communication signals are referenced to pin 14, digital return on the DOF controller connector.
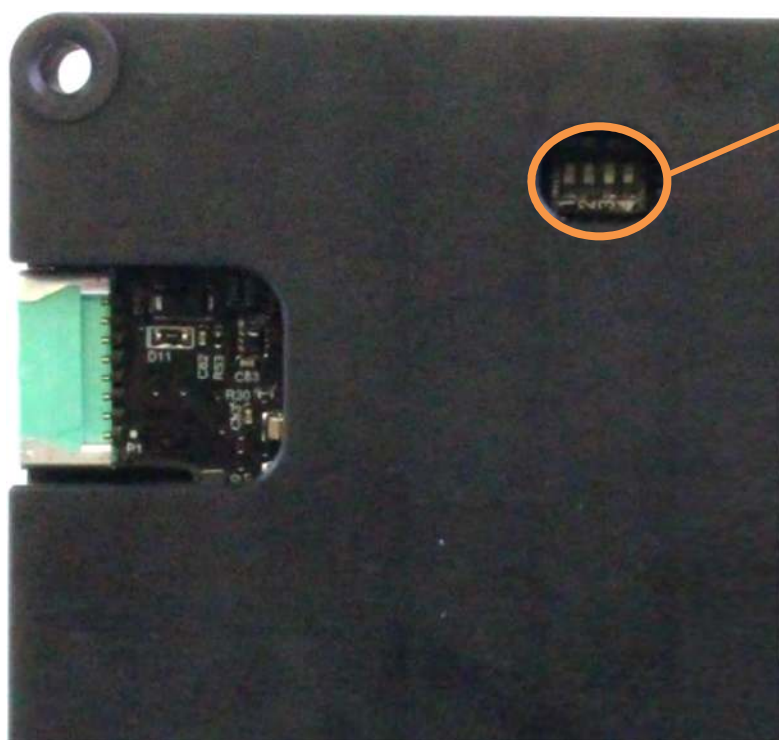
Figure 4 DOF-5 DIP Switch Location
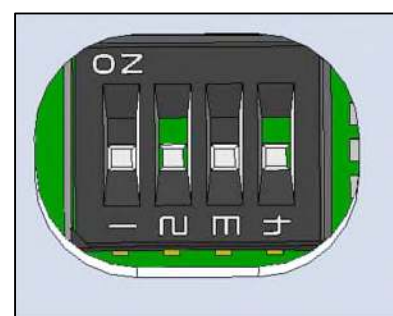
Table 3 Communication DIP Switch Definition

Switch	On	Off
1	Serial	CAN
2	RS232	RS485
3	High Z	Low Z
4	Full Duplex	Half Duplex

Note: High Z is 125KΩ termination resistance, and low Z is 120Ω termination resistance (for RS-485 and CAN).

RS-232

To communicate to the stage using RS-232, set switches 1 and 2 to the "ON" state. Switches 3 and 4 are ignored and can be at any state. The DOF-5 can handle all voltage types of RS-232 communication.

DOF-5 has a default baud rate of 57600.

RS-485

To communicate to the stage using RS-485, set switch 1 to the "ON" state and switch 2 to the "OFF" state. Switches 3 and 4 depend on your type of communication as detailed below.

The DOF-5 has the capability of reading both 4-wire and 2-wire RS-485. This allows for communication to the on-board, integrated controls in both a point to point and multi-drop fashion. When there is only one system connected to a 4-wire RS-485 bus, it is recommended that the user uses "point to point" mode to ignore all addressing during communication.   As in RS-232, the baud rate will be default set to 57600. 2-wire RS-485 communication is slightly different, however, and will only accept "multi-drop" mode. Note: the default address on the DOF-5 will be set to 0 on delivery unless otherwise specified.

When communicating with a single axis, it is also important to set the DOF-5 to low impedance on the communication line to allow successful communication at higher baud rates. This can be done by setting pin 3 to the off position as defined from the picture below.

Figure 5 DIP Switch Selectable Communication Impedance

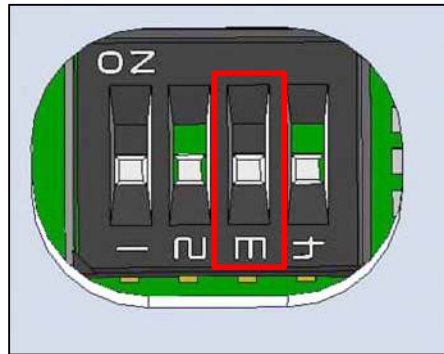Multi-drop RS-485 communication may also be used in the DOF-5 to allow serial commands to be sent by address. The on-board controller in the DOF-5 has a default address of 0. It is important to change the address of each DOF-5 to something unique or communication issues will arise.

> **Note:** The address will need to be saved to NVRAM of the DOF-5 after it is changed. For more information on how to make these changes, reference the DOF-5 Programming Guide.

Once every DOF-5 on the RS-485 bus has been assigned a distinct address using the above steps, the hardware will need to be configured correctly before communication over the network is ready. It is important that all of the DOF-5's, except the last system in the network, set DIP switch 3 to the "ON" state to provide high impedance to the communication line. The last system on the network should be set to the low impedance state to allow for proper communication at the highest baud rates.

CAN2.0B

To communicate to the stage using CAN2.0B, set switch 1 to the "OFF" state. Switch 2 and 4 are ignored when in CAN mode and be set to any state. As with RS-485, only one DOF-5 on a communication network should have pin 3 set to the low impedance state to avoid communication confusion. It is recommended that the pin is set low for point to point communication to allow for all baud rates.

Messages are transmitted and received using the standard format identifier length of 11 bits. All network messages that use the extended format 29-bit identifier are ignored. The data formats for the three message types are expressed in terms of the byte sequences for the parallel interface. Commands have varying data lengths; see the programming reference for more detail on individual commands. Bytes that are required regardless of the command sent are marked as such.

The default settings on the DOF-5 revert to a baud rate of 1Mbaud and a Node ID of 0.

Note: More information on the data packet structure in the Word Structure App Note (P/N 41-1207).

Step & Direction Setup

The DOF-5 can be set up to receive pulse and direction inputs to control motion of the stage. See the DOF-5 Programming Guide for more information on setting up the pulse and direction inputs. The step and direction input lines expect TTL signals from 3.3V to 5V. The maximum allowable frequency for the DOF-5 is 4.8MHz and that rate should not be exceeded.

Chapter 2: Technical Overview

Introduction

This chapter describes the functionalities, capabilities, and main components of the DOF-5 from a technical perspective. This chapter should provide the user with more detail and familiarity regarding the operating the DOF-5.

Topics

This chapter covers the following topics:

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DOF-5 Features

The DOF-5 is a family of single axis stages. It is highly customizable with a variety of counterbalances and objective threads to configure each DOF-5 to a specific user's application.

Figure 6 DOF-5 with Dover Bracket

Configurator

See the configurator for part number detailed information:

Model
Dover Objective Focuser — DOF-

Travel
5 mm Travel — 5

Encoder Resolution
5 nm — E38
1.25 nm — E39

Communications Switch Setup
RS-232 — G01
RS-485(half duplex), low impedance — G02
CAN 2.0B, low impedance — G03
RS-485(half duplex), high impedance — G05
RS-485(full duplex), low impedance — G06
RS-485(full duplex), high impedance — G07
CAN 2.0B, high impedance — G08
*Indicates communication switch configuration as shipped. All communications options are available using a dip switch on the back of the stage

Payload
0 - 1000 : grams Payload
Payload orderable in 10g multiples

Objective Orientation & Position
R1 Vertical, Regular, Position 1
R2 Vertical, Regular, Position 2
R3 Vertical, Regular, Position 3
F1 Vertical, Inverted, Position 1
F2 Vertical, Inverted, Position 2
F3 Vertical, Inverted, Position 3
H1 Horizontal, Regular, Position 1
H2 Horizontal, Regular, Position 2
H3 Horizontal, Regular, Position 3
H5 Horizontal, Inverted, Position 1
H6 Horizontal, Inverted, Position 2
H7 Horizontal, Inverted, Position 3

Objective Thread
TH00 No objective bracket
TH01 M25 x 0.75
TH02 M26 x 0.706
TH03 M27 x 0.75
TH04 SM1
TH05 RMS
TH06 M32 x 0.75

Specifications

<div align="center">Table 4   Specifications</div>

Description	Value
Travel (mm)	5
Payload Mass (g) [1]	0 - 1,000
Bi-directional Repeatability (nm, 2σ) [2,3]	25
Servo Bandwidth (Hz) [3]	≥ 225
Encoder Feedback Resolution (nm)	1.25 or 5
Position Holding Stability (nm RMS)	5
Max Velocity (1.25nm resolution) (mm/s)	30
Max Velocity (5nm resolution) (mm/s)	125
Maximum Acceleration w/ 1kg payload (m/s^2)	6
Step and Settle (100 nm within ± 15 nm) [3]	< 15 ms
Dimensions (mm) (excluding objective mount)	77H x 82W x 30D
Communications options: RS232, RS485, CAN, SPI, Step & Direction	

[1] Other loads can be supported, for info contact Dover Motion

[2] Tested according to ISO230-2 standard, using 100nm moves

[3] Specifications based on a 250g payload

Mechanical Information

<div align="center">Table 5   Weights and Measurements</div>

Specification	
DOF-5 (with standard objective mount)	
Weight	0.5Kg (approx. 1.1 lbs)
Dimensions (maximum):	
Width	82mm (approx. 3.2 inches)
Depth	31mm (approx. 1.2 inches)
Height	77mm (approx. 3.0 inches)

DOF-5 Product User Guide
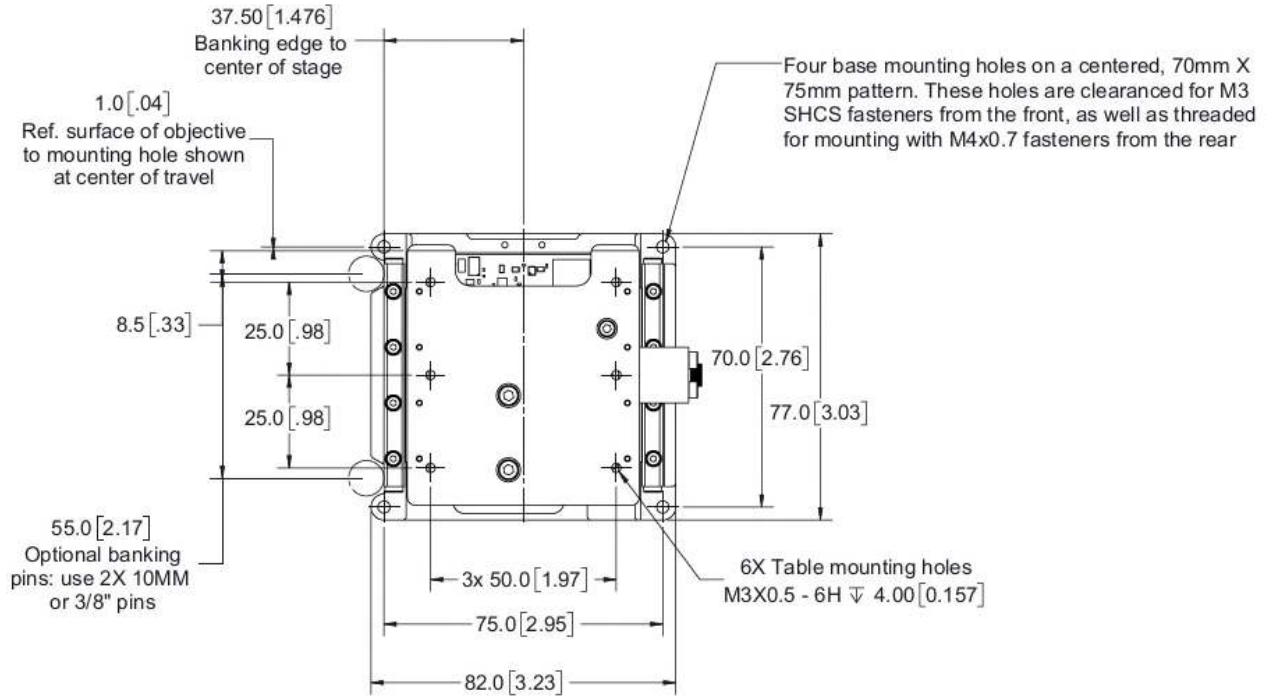
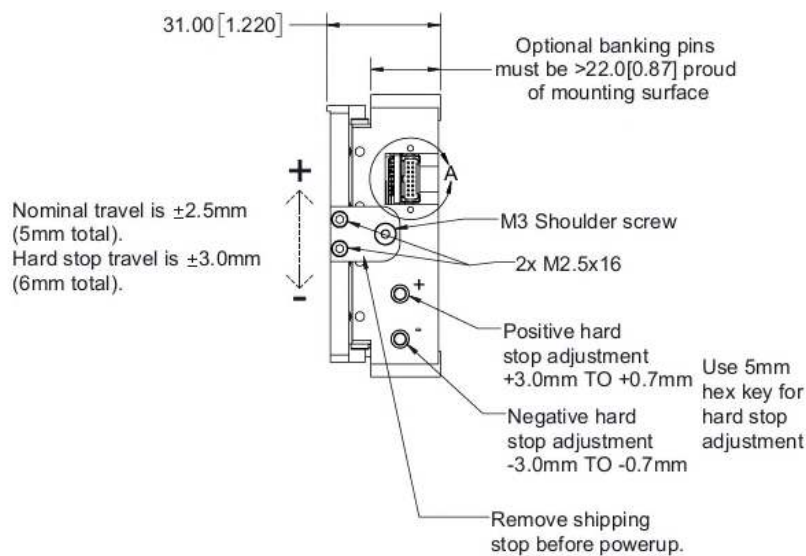Figure 7 DOF-5 Front View

Figure 8 DOF-5 Side View

Figure 9 Side View

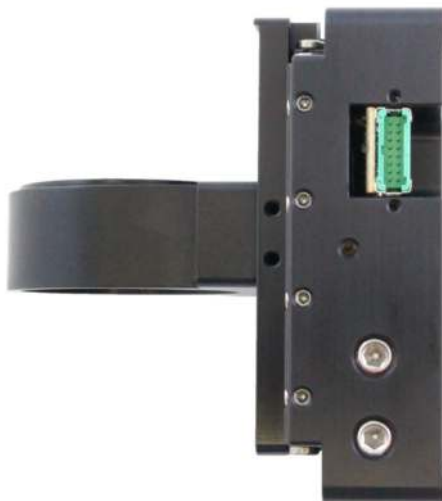**Figure 10 Inverted Objective Orientations**

Inverted Objective Position 1 (F1)	Inverted Objective Position 2 (F2)	Inverted Objective Position 3 (F3)

Figure 11 Regular Objective Orientation

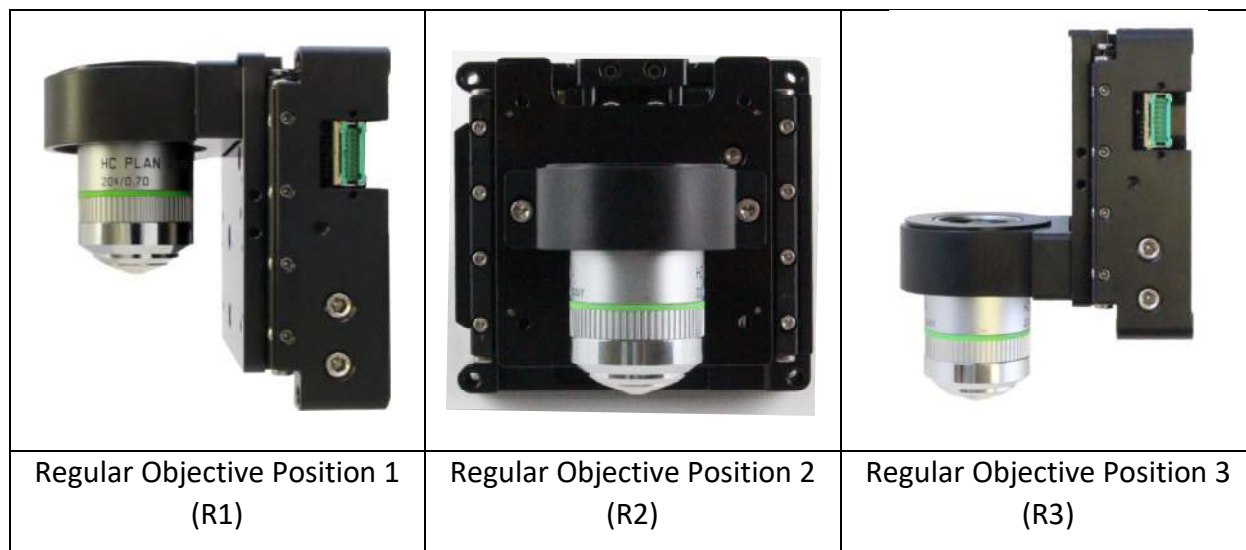| Regular Objective Position 1 (R1)	Regular Objective Position 2 (R2)	Regular Objective Position 3 (R3)

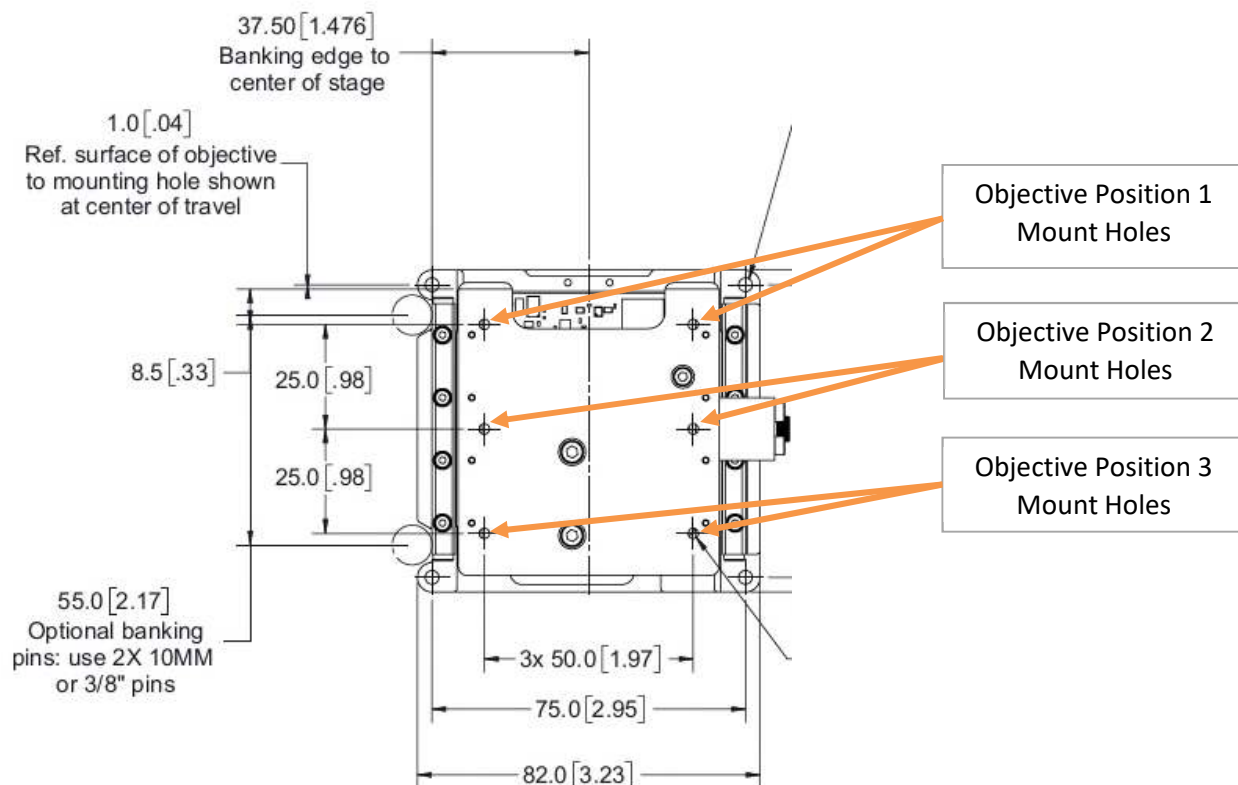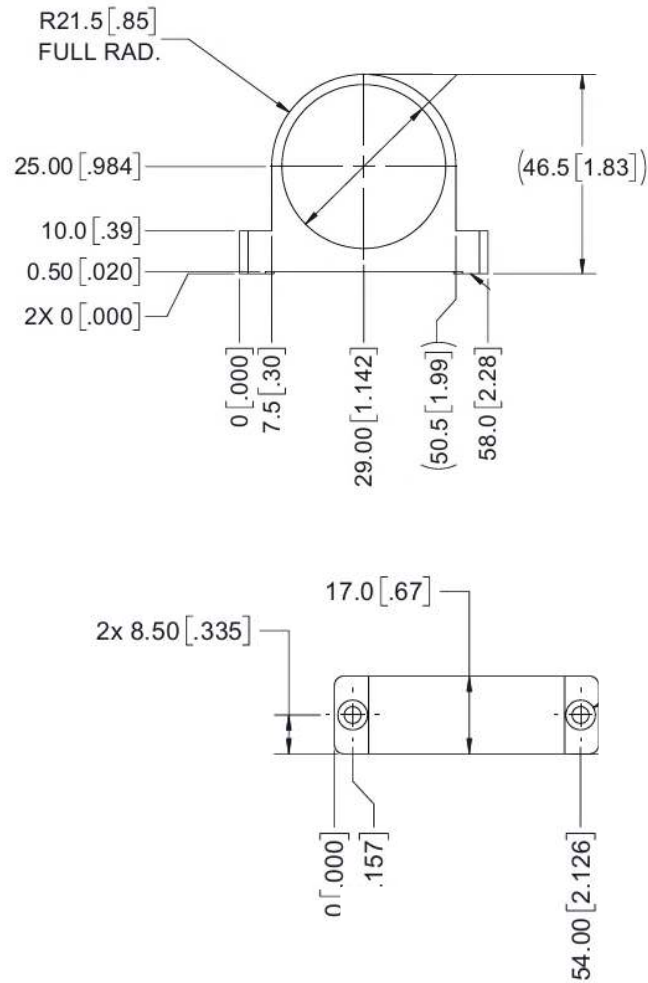Figure 12 Objective Mounting Location Positions

Figure 13 DOF-5 Standard Objective Mount Dimensions

Adjustable Hard Stops

Finely adjustable hard stops at each end of travel allows travel to be limited, preventing objective-sample crashes. As shipped, these adjustable hard stops are set to the maximum value (+/- 3 mm). To adjust the hard stops use a 5mm hex key. Clockwise rotation will reduce the travel. For adjustment screw location, and travel range see Figure 14.

Figure 14 DOF-5 Adjustable Hard Stops
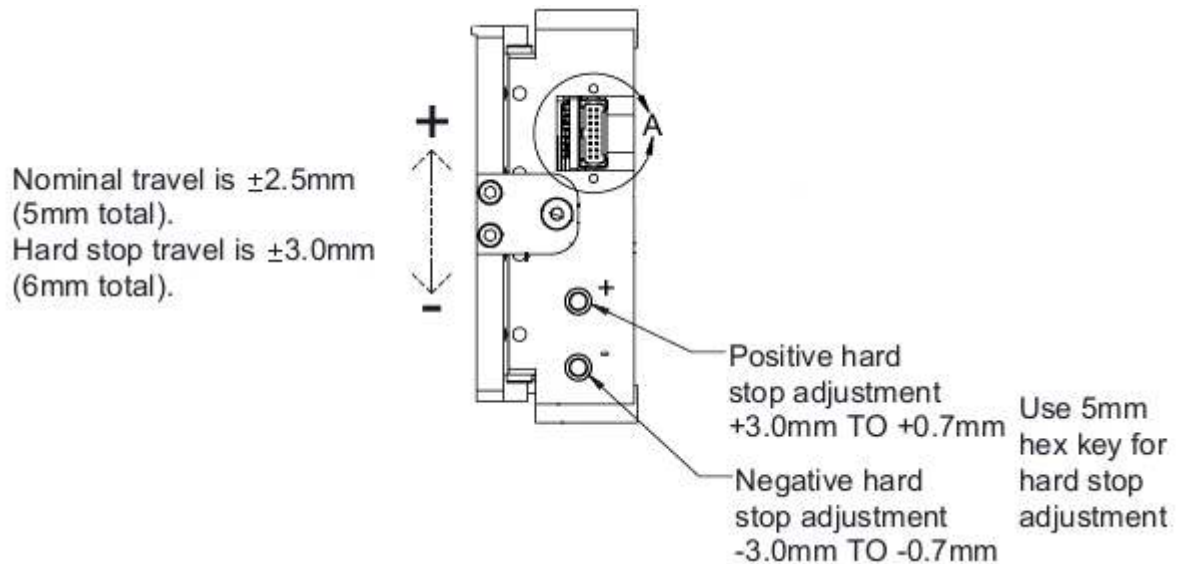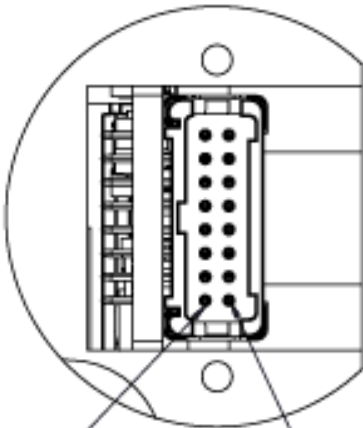
Half-Travel Vane

A half-travel vane flag and optical detector are located inside the stage of the DOF-5. It is intended to use the half travel vane for repeatable homing when the DOF-5 is powered up. The flag signal is connected to the "home" signal on the internal controller. The flag is designed to switch states at the midpoint of stage travel. The input will be set to 0 when the table is in the upper half of travel and flip to a 1 on the lower half of travel. For examples on how to create a homing routine using this signal, see the appropriate programming documentation available with the DOF-5.

Connector Pinout

DOF-5 Stage Pinout

Figure 15 DOF-5 Stage Pinout

Pin Number	Function			Pinout Diagram (on DOF-5)
	RS-232	RS-485	CAN	
1	Factory Use Only			
2	Factory Use Only			
3	NC	Z RxD-	NC	
4	TX	Y RxD+	NC	
5	NC	B TxD-	CANH	
6	RX	A TxD+	CANL	
7	Supply Return			
8	Motor Bus Supply			
9	Factory Use Only			
10	Factory Use Only			
11	Digital Input A (Step)			
12	Digital Input B (Direction)			
13	Digital Output			
14	Digital Return			
15	Supply Return			
16	Logic Supply			
Connector: Harwin G125-MH11605L7P Mating Connector: Harwin G125-2241696F1				

Note: The Rx and Tx lines on the chart above are referenced from the perspective of the DOF-5.

DOF-5 Product User Guide

The logic supply (Pin 16) and motor bus supply (Pin 8) are isolated on the board and must both be supplied with power for the DOF-5 stage to operate. Pins 7 and 15 should be used as the supply returns. The return on Pin 14 should not be exposed to a lot of current and should mainly be used as the return in communication.

Warning: 26 AWG wires are required for Logic and Motor Bus power signals. Using higher gauge wires may result in an unsafe operating condition including overheating of the wires and a fire hazard.

Figure 16 DOF-5 Mating Connector

The Harwin Gecko[1] series connectors used on the DOF-5 (shown in figure 16) have the following technical characteristics.

Table 6   DOF Connector Specifications

Specification[2]	
Insertion Force	2.8N Max
Withdrawal Force	0.2N Min
Durability	1,000 operations
Current Rating (EIA-364-70A: 1998: Individual contact in isolation at 25 °C)	2.8A Max

[1] Gecko is a registered Trademark of Harwin Plc
[2] Specifications in this table are referenced from Harwin Plc documentation and are subject to change, see Harwin's latest Full component specification for the C125XX series for the latest specifications

The 16 pin Gecko connector also has screw locks that align with the DOF-5 (shown in figure 17). These screws should be screwed into the side of the stage as a strain relief for the cable before use of the DOF-5. Be sure to unscrew them before trying to remove the Gecko connector from the DOF-5.

Figure 17 DOF-5 with Cable Connected

Interface Cables for the DOF-5

There are a variety of options for interface cables to the DOF-5 (sold separately). All accessory cables for the DOF-5 are a meter long in length. Explanation of each cable below.

- HD-15 + Breakout Module Cable (36086-00).
    - This cable terminates the wires from the DOF-5 into a male HD-15. An HD-15 breakout module with screw terminals will also be provided to allow for quick connection of the wires. See pinout below.

Figure 18 - HD-15 Breakout Module Pinout

HD-15 Breakout Module (36086-00) Pinout				
Position	Signal		Position	Signal
1	Factory Use Only		9	Factory Use Only
2	Factory Use Only		10	Factory Use Only
3	NC / RxD- / NC		11	INPUT 1 (STEP)
4	TX / RxD+ / NC		12	INPUT 2 (DIR)
5	NC / TxD- / CANH		13	OUTPUT
6	RX / TxD+ / CANL		14	DGND
7	PGND		15	+VL
8	+VP			
Communication Signals (**3-6**) Dependent on DOF-5 DIP switch settings. Where "/" used it refers to communication: RS-232 / RS-485 / CAN				

- RS-232 Kit (36100-00)
    - This includes the HD-15 breakout module cable, a cable from the breakout module to the power supply, and a cable to the RS-232 standard (see below). It also includes the Moxa UPORT 1150 multi-protocol USB to Serial converter.

Figure 19 Breakout Module to RS-232 Pinout

HD-15 Breakout Module to RS-232	
Position	Signal
2	TX (DOF-5)
3	RX (DOF-5)
5	PGND

- RS-485 Kit (36101-00)
    - This includes the HD-15 breakout module cable, a cable from the breakout module to the power supply, and a cable to the 4-wire RS-485 pinout on the Moxa UPORT 1150 multi-protocol USB to Serial converter (see below) which is also included in this kit. This pinout is also compatible with 2-wire communication.

Figure 20 Breakout Module to RS-485 Pinout

HD-15 Breakout Module to RS-485	
Position	Signal
1	TxD-
2	TxD+
3	RxD+
4	RxD-
5	DGND

- CAN Kit (36102-00)
    - o This includes the HD-15 breakout module cable, a cable from the breakout module to the power supply, and a cable to the CAN pinout of the IXXAT USB-to-CAN V2 converter (see below) which is also included in this kit.

Figure 21 Breakout Module to CAN

HD-15 Breakout Module to CAN	
Position	Signal
2	CANL
3	DGND
7	CANH

Review/Revision History

Revision	Date	Summary	ECO Number	Writer / Reviser
A	03/7/19	Initial Release	DM10164	Brandon Tveito
B	06/17/19	REVISED LABEL DESCRIPTIONS, PAGE 36, FIG. 18. POSITIONS 3, 4, 5, 6	DM10497	J. Orciani