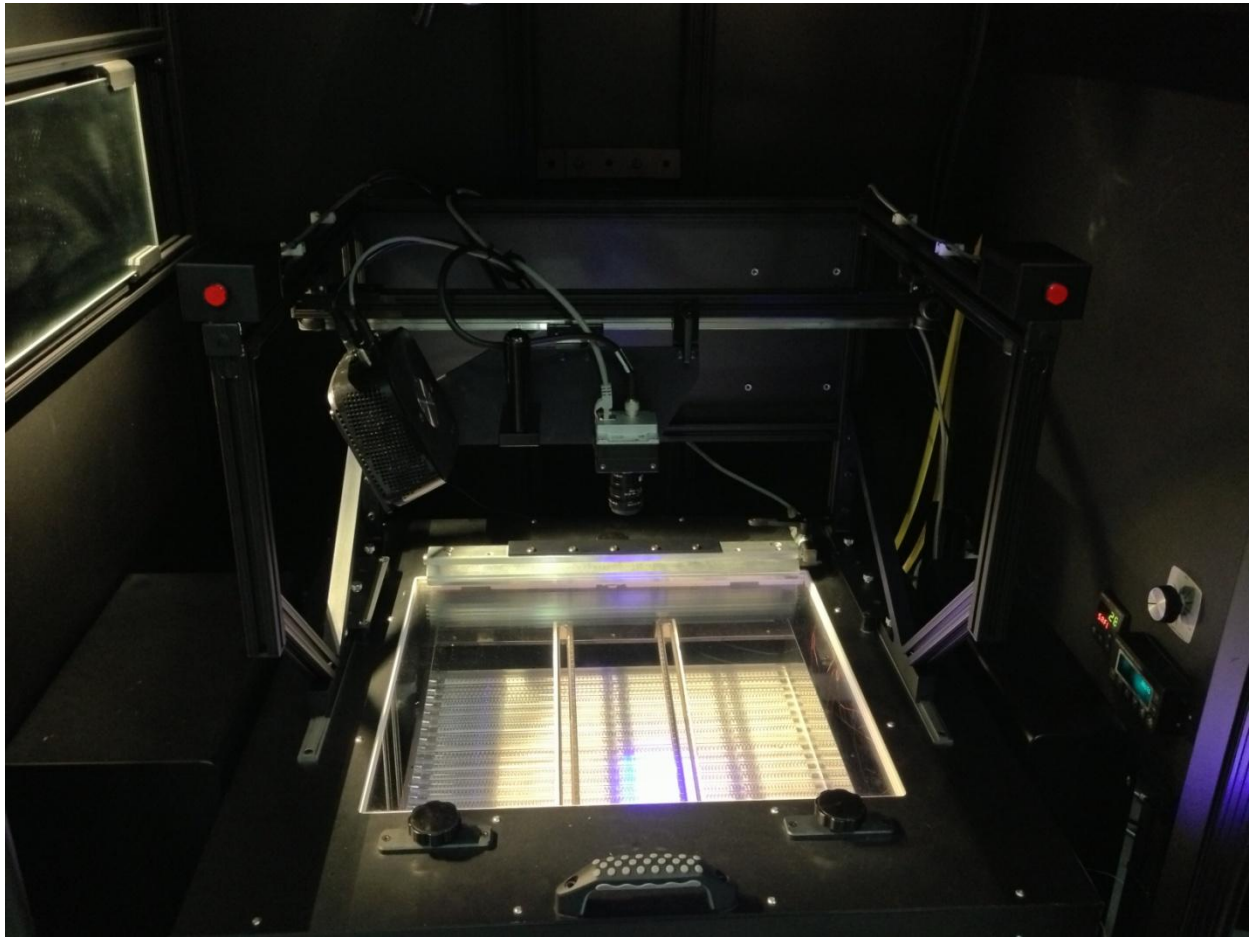




DFP



USER MANUAL

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1 Introduction

1.1 Overview

The DFP (Digital Fringe Projection) module is an add-on to complement the Akrometrix TherMoiré Model AXP or Studio upgraded PS400. It is used for measuring warpage and step heights of samples ranging from 0.5 x 0.5 mm up to 60 x 45 mm over temperature. It utilizes a full-field, non-contact optical technique called digital fringe projection in combination with a phase-shifting algorithm. Samples are measured inside a computer-controlled oven chamber with a temperature range from ambient to 300°C.

This manual mainly describes the DFP system hardware. Data acquisition using the DFP module is described in the Surface Measurement User Manual and data analysis is described in the Surface Analysis User Manual. Because the Surface Measurement software requires the physical hardware (AXP or Studio Upgraded PS400 and DFP module) to operate, it will only be installed on Akrometrix equipment and not as a standalone application on a desktop or laptop. However, Surface Analysis may reside on the equipment computer and/or on a remote computer.

Before operating the DFP system, the user should first be familiar with operation and safety precautions for the base TherMoiré system. Please see the appropriate User Manual for the piece of equipment being used. In addition, the user should also read **Section 1.2.1** in this manual, which describes health and safety hazards associated with the DFP module. The TherMoiré system contains a high temperature oven, motorized sample stages, and electrical systems. All of these components have the potential to injure if used or maintained improperly.

Section 1.3 shows a system diagram and component locations. **Section 2** describes basic procedures for system setup, alignment, and shutdown. **Section 3** presents failures, causes, and solutions to common problems.

Appendix A describes recommended procedures for transport, disassembly, and maintenance of the DFP system. This section also contains equipment ratings.

1.2 Warnings and Precautions

1.2.1 Health and Safety Hazards

- The DFP module is designed to work with the TherMoiré AXP or Studio upgraded PS400. Do not operate the DFP module separately. Doing so can cause damage to the DFP or main system components.
- Always keep the six thumb screws on the triangle supports while installing or using the DFP module (**Figure 2.7**).
- During installation or removal of the DFP unit, the user is required to lean inside the TherMoiré system. Overhead obstacles such as the light source can cause slight head injury. Be careful and aware of any overhead obstacles during installation.

- Make sure to slide the DFP inspection assembly all the way back before attempting to lift the module into or out of the system. Failure to do this will make lifting the module much more difficult.

1.2.2 Warnings and Notes in this Manual

Warnings and Notes are marked throughout the manual with these icons:



Figure 1.1 Warning Icon



Figure 1.2 Note Icon

Warnings are specific health hazards for the operator or potential sources of system damage. Notes highlight system limitations or automatic responses that may require corrective action by the operator for successful operation.

1.3 System Configuration

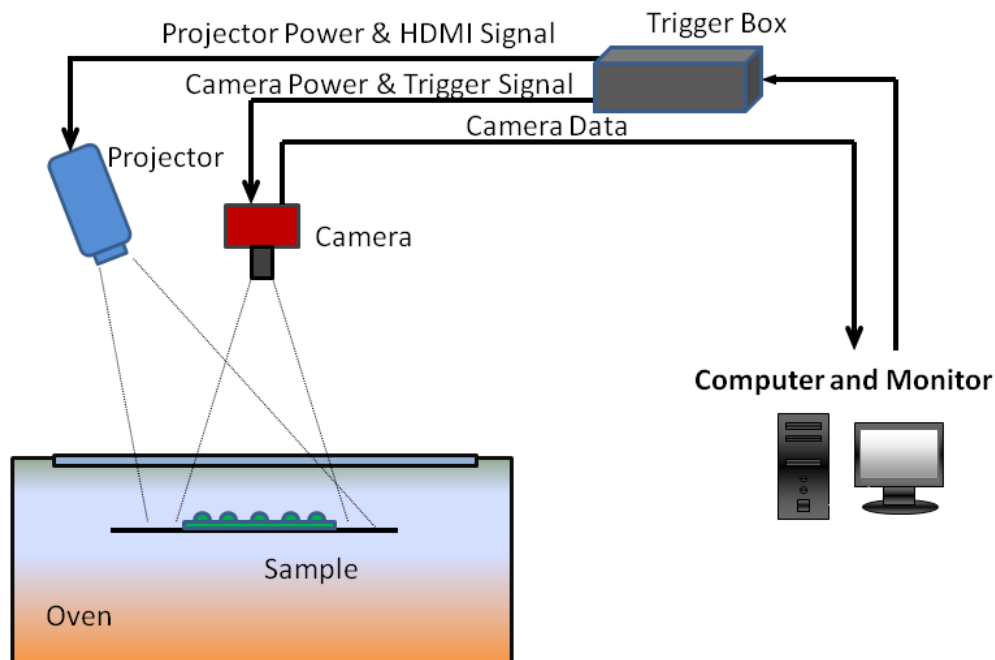


Figure 1.3 DFP System Diagram

Figure 1.3 shows the system configuration of the DFP in the TherMoiré system. The primary optical components of DFP are: a digital projector, and a camera with lens. The projector is mounted so that light is projected at a 62.5° angle with respect to the sample support plane. A fringe pattern is created in software and passed to the projector for display. The camera above the sample acquires a series of images, while phase shifting and other fringe patterns are changed digitally by altering the projector image. The images are then used to calculate the vertical displacement at each pixel position relative to the camera position. Samples are placed inside the AXP oven chamber and can be heated from ambient to 300°C. The TherMoiré translation stage is used to move the sample support vertically to focus the image on the camera.

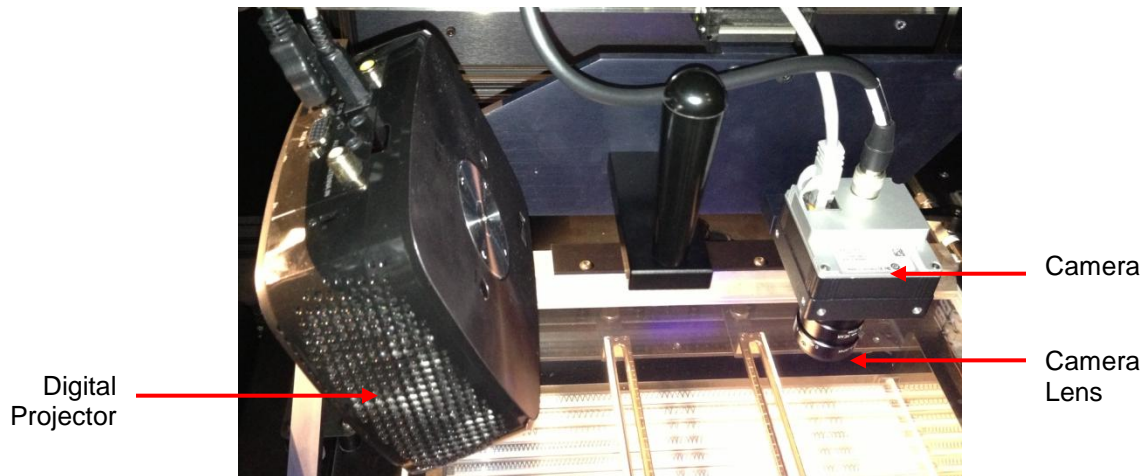


Figure 1.4 DFP Inspection Assembly

1.4 Technical Support

For technical support, contact Akrometrix:

Akrometrix 404-486-0880

support@akrometrix.com

2700 NE Expressway 404-486-0890 (fax)

<http://www.akrometrix.com>

Building B, Suite 500

Atlanta, GA 30345

When contacting Akrometrix, please provide the system serial number, the version numbers of the Akrometrix software being used, a description of the problem or question, and contact information for reply. If the question concerns a particular measurement or analysis, please provide electronic copies of the phase images, reference images, and final results and a description of data acquisition and/or analysis conditions. If the problem concerns changes or failure in general system operation, please describe any events or system modifications that occurred immediately before the problem arose.

2 Basic System Set-up

2.1 System Set-up

2.1.1 Loading the DFP System



Warning: The user should carefully read **Section 1.2** (Warnings and Precautions) before installing the DFP.

1. Ensure that any other modular systems, such as the DIC System, have been completely removed per its removal instructions. The instructions to follow assume the system is in its basic shadow moiré state.
2. Remove the TherMoiré grating from the oven lid before mounting the DFP system. The DFP cannot be operated with the TherMoiré grating in place.



Warning: The DFP Module is heavy. Accidentally dropping the whole assembly or components from it could damage the components themselves or the glass lid.

3. Prep the DFP module for lifting by sliding the inspection assembly all the way back and locking it in position using the Y position locking handle on the far right side of the module (**Figure 2.2**). Lift the module by the aluminum braces located on either side of the inspection assembly as shown circled in red in **Figure 2.1**. Place the DFP Module onto the two glide rails located on both sides of the oven lid.

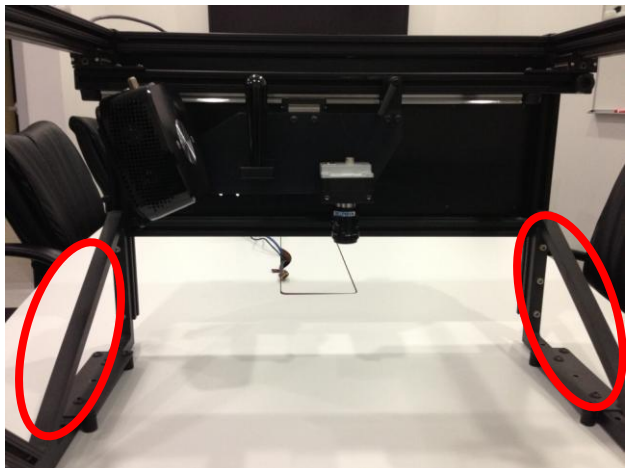


Figure 2.1 DFP Lift Points



Figure 2.2 Lock Handles

4. The front edge of the DFP glide rails should cover up half of the first mounting hole as shown in **Figure 2.3**. Attach the DFP structure with 6 supplied ¼-20 aluminum thumbscrews to the glide rails located underneath the lift points. Make sure that the glide rails are properly seated before tightening the thumbscrews.



Figure 2.3 DFP Glide Rail Position

5. Slide the inspection assembly to the middle of the oven window or wherever the desired field of view is for the sample to test. Lock it in position using the locking handle for each slide.

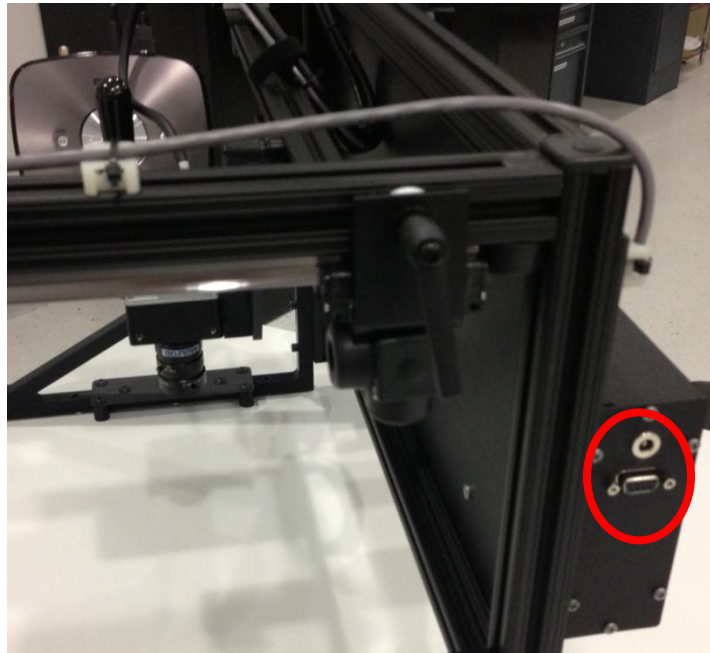


Figure 2.4 Trigger Box Connectors

6. Locate the serial cable connected to Comm 4 of the system computer, and one power cable for the trigger box. Plug them into the trigger box located on the back right side of the DFP module (**Figure 2.4**). Next locate the power cable for the lid latch release mechanism and plug it into the lid latch control box located on the back left side of the DFP module (**Figure 2.5**). Finally, locate the Ethernet cable and plug it into the camera. Secure the Ethernet cable to the camera trigger cable using the Velcro strap as shown in **Figure 2.6** **Figure 2.7**.

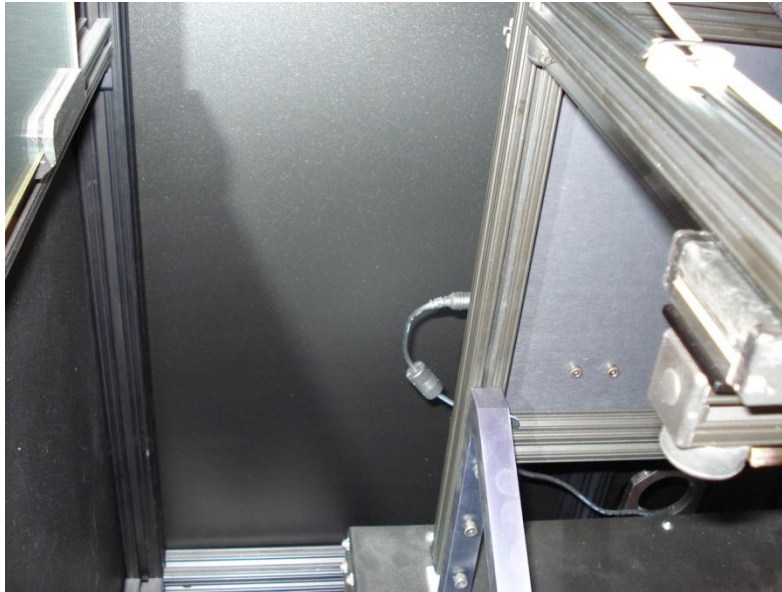


Figure 2.5 Lid Latch Power Cable

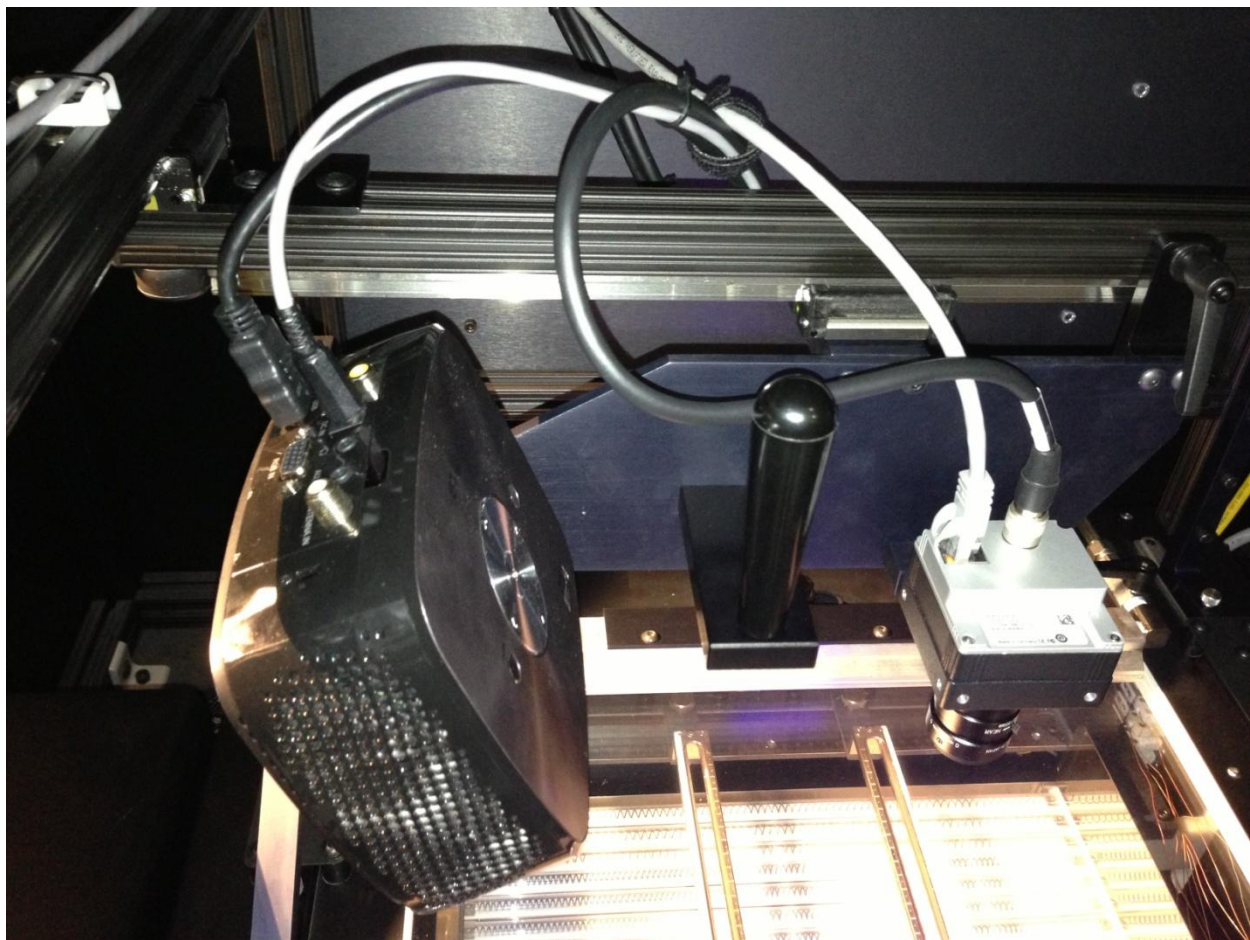


Figure 2.6 DFP Inspection Head Cabling

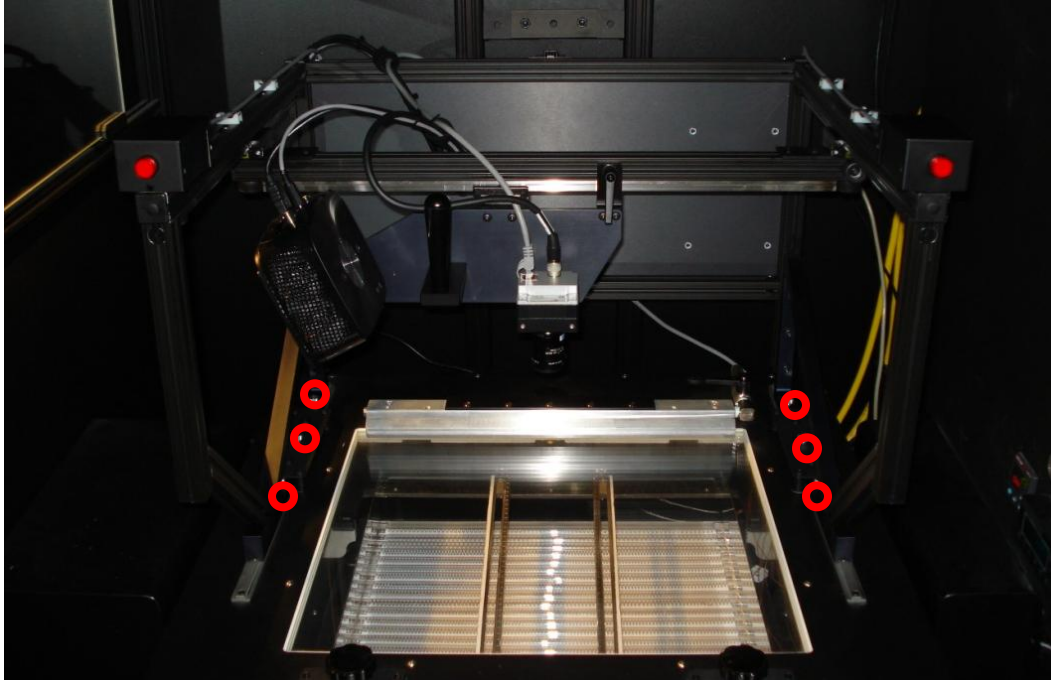


Figure 2.7 DFP in AXP, thumbscrews circled in red

7. Turn off both main light sources if they are on.

2.1.2 Lid Latch Operation

Due to the DFP module's size, the TherMoiré oven lid will not be able to open fully. As a result, a lid latch mechanism is included with the DFP module. Lid latch operation consists of the following steps:

1. Open the oven lid normally and the lid latch bolt will catch on the striker plate mounted at the back of the unit.
2. To release, simultaneously press and release both red buttons on either side of the DFP module. The bolt will retract and the user can lower and close the oven lid as usual.

2.1.3 System Start-Up

1. Please see the relevant base TherMoiré system manual for its start-up procedures.
2. Run the DFP Surface Measurement program by clicking its icon on the Studio Manager bar on the left side of the screen. A start-up splash screen appears while the software initializes. For operation of this program, refer to the Surface Measurement User Manual.
3. Check if there is any dust or other kinds of contaminations on the oven lid glass along the light paths. If so, clean the window glass according to **Appendix A.3**.

2.2 Optical Alignment

This section is for reference only, as the system should already be aligned in most cases. However, if individual optical components, such as the projector or camera, have been moved, the optics should be realigned.

This procedure will be performed on an Akrometrix-supplied alignment target (**Figure 2.8, Figure 2.9**). This target is a six-inch square piece of glass with three rectangle outlines printed in the center. The outer rectangle (72 x 54 mm) is used to define the projected line area. The middle rectangle (64 x 48 mm) defines the maximum camera FOV. The inner most rectangle (60 x 45 mm) defines the maximum recommended sample size.

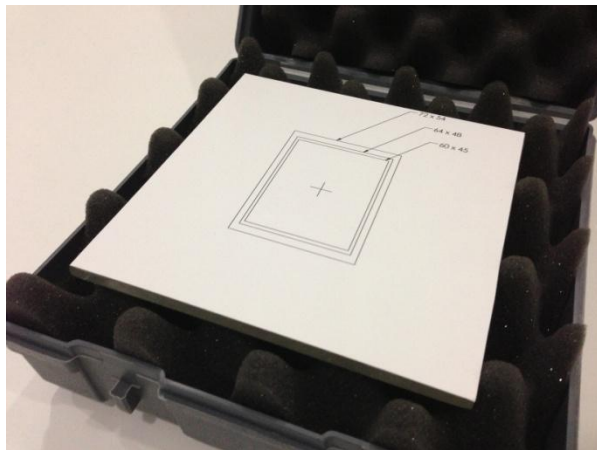


Figure 2.8 Alignment Target

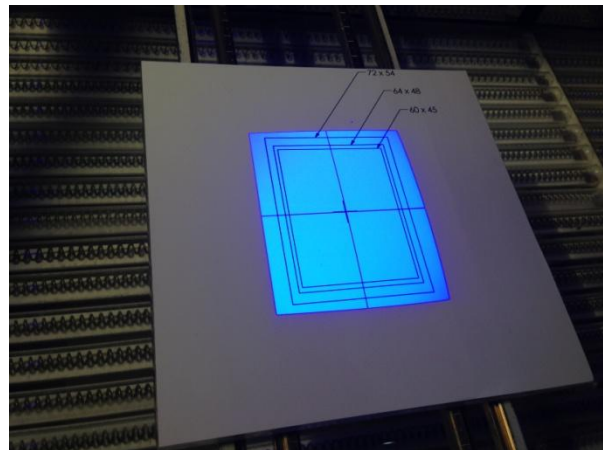


Figure 2.9 Alignment Target in System

1. Place the alignment target on the sample support in the camera's field of view. Then jog it vertically to the middle of the sample support travel range (one inch below the upper limit) using the DFP Surface Measurement program.

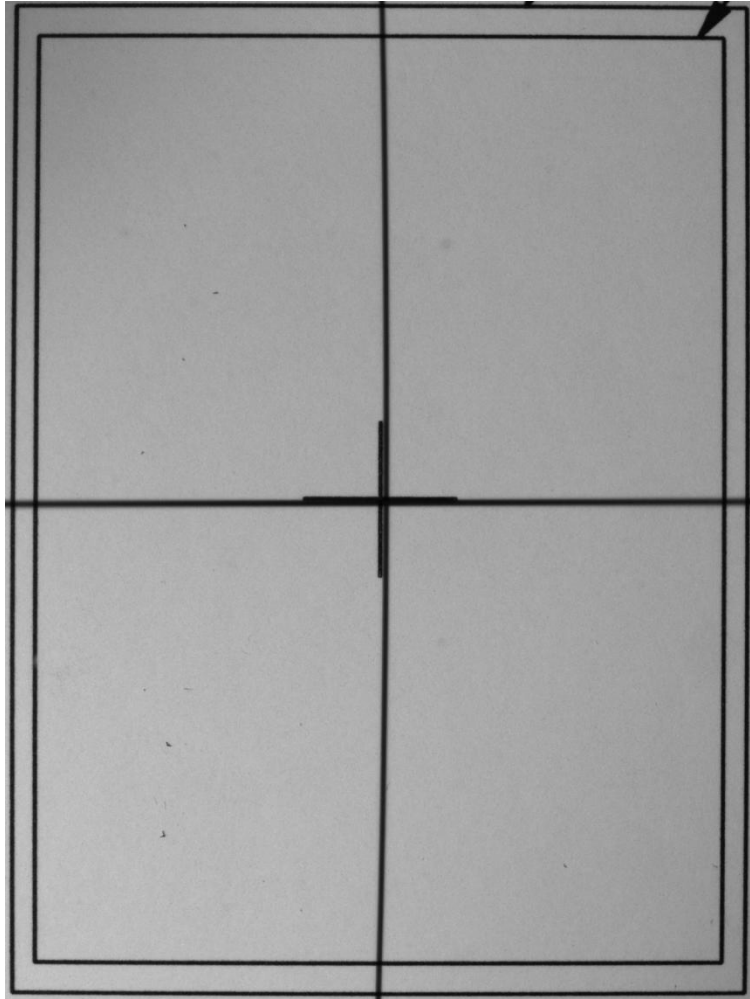


Figure 2.10 Alignment Target after Alignment

2. Adjust the camera iris such that the image is not too bright and not too dark. If the sample target image is not in focus, adjust the camera lens focus to get a sharp image. Now jog the sample stage up/down such that the middle rectangle is just inside the field of view as shown in **Figure 2.10**. The iris and focus may need to be adjusted again after this step. Lock them down using the set screws on the lens after they have been set.
3. Adjust the projector alignment such that the black crosshairs from the projector are aligned with the purple software crosshairs in the camera (**Figure 2.11**).

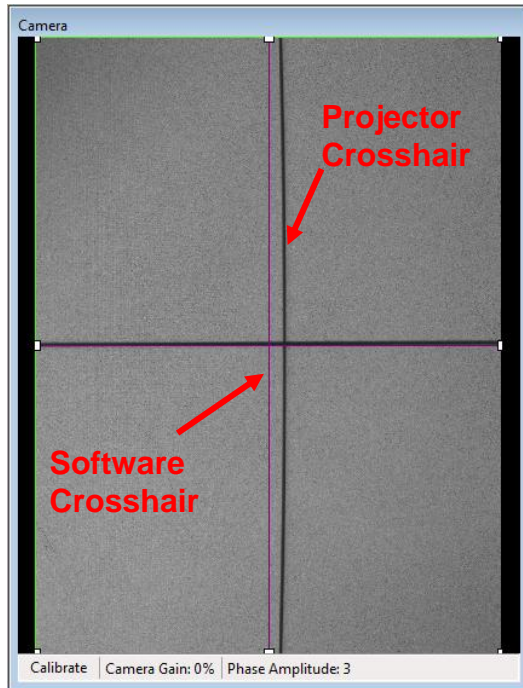


Figure 2.11 Projector and Camera Crosshairs



Figure 2.12 Projector Mounting Bracket

Adjustment is achieved through the projector mounting bracket (**Figure 2.12**). The projector vertical crosshair line may appear somewhat curved; this is a normal consequence of lens distortion and is accounted for in the system calibration.



Note: For illustration purposes, the crosshairs are not lined up in **Figure 2.11**. The projector would need to be rotated clockwise on its mount slightly in order to achieve good alignment.

4. Focus the black projector crosshair using the focus ring on the projector. The lines should be as sharp as possible though some blurring towards the edges of the camera window is normal.

2.3 Calibration

Once the Camera Lens and Projector are properly aligned, a calibration needs to be performed before measurement. Please see the Surface Measurement User Manual for instructions on how to calibrate DFP system.



Note: After the optical alignment and calibration are done, the camera iris and focus should not be touched. Doing so will require re-calibration of the DFP system. To focus the image for varying samples, move the sample support stage using the Surface Measurement program.

2.4 System Removal and Shutdown

1. Close the DFP Surface Measurement application.

2. Press the Lid Release button, open the oven, and remove the sample from the oven chamber.



Warning: The temperature control chamber cools much more slowly than it heats. The sample supports, sample and other components inside may retain significant heat long after the thermal cycle is complete. Use extreme caution in unloading the sample or other components. The Process Temperatures for each loop of the temperature controller display the sample temperature, which may not be an accurate indicator of the temperature of other oven components.

3. Close the oven lid.
4. Turn on both light sources if they are off.
5. Disconnect all 4 cables from the camera, trigger box, and lid latch control box. Carefully place them to the back or right side of the oven. Keep them a safe distance from the oven body or any moving components.



Warning: The DFP Instrument Package Assembly is heavy. Accidentally dropping the whole assembly or components from it could damage the components themselves or the glass lid.

6. Prep the DFP module for lifting by sliding the inspection assembly all the way back and locking it in position using the Y position locking handle on the far right side of the module (**Figure 2.2**).
7. Remove the 6 aluminum thumbscrews (marked by red circles in **Figure 2.7**). Slide the module forward and lift it by the aluminum braces located on either side of the inspection assembly as shown circled in red in **Figure 2.1**.
8. Place the DFP system somewhere safe and out of the way.
9. Install the grating in the oven lid if the system needs to be operated in TherMoiré mode.
10. For full shutdown procedures, please see the main User Manual for the TherMoiré model in use.

3 Troubleshooting

3.1 Failure to Initialize the Camera

Symptom:

When opening DFP Surface Measurement program, the program hangs at the splash screen.

Cause:

- The camera cable or trigger box are not connected properly.

Solution:

Press Ctrl+Shift+Esc to access the Windows Task Manager. Under the Processes tab, highlight SurfaceMeasurement.exe and hit End Process to close the Surface Measurement process. Press End Process in the confirmation dialog that pops up.

Double check that all cables are correctly and firmly attached to the camera and trigger box. If DFP Surface Measurement still fails to load, completely turn off the computer and TherMoiré system, wait 30 seconds, and turn everything back on again.

Appendix A- Miscellaneous Information

A.1 Equipment Ratings

Electrical*	
Supply Voltage	220VAC, 50/60 Hz, 1 Φ
Amp Rating	2.3 A
*All electrical requirements supplied by host AXP system, no additional facilities setup needed	
Mechanical	
Footprint	700(w) \times 490(h) \times 655(d) mm
Weight	13 kg

A.2 Transport

When transporting the DFP system to a new location, Akrometrix recommends that certain components be removed from the system and packed and moved separately. These include:

- Camera lens (place lens cap on lens, both ends, and a cap over the exposed camera element)

A.3 Maintenance

A.3.1 Optical Lenses

Dust or dirt on the camera or projector lens will not be imaged onto the sample surface but may darken the images. Clean the lenses with a soft lint free cloth and lens cleaner if excessive dirt or dust is present. A lens cap should be placed on the camera lens to protect it from contamination when it is not in use.