Automated Leveling Operation Manual

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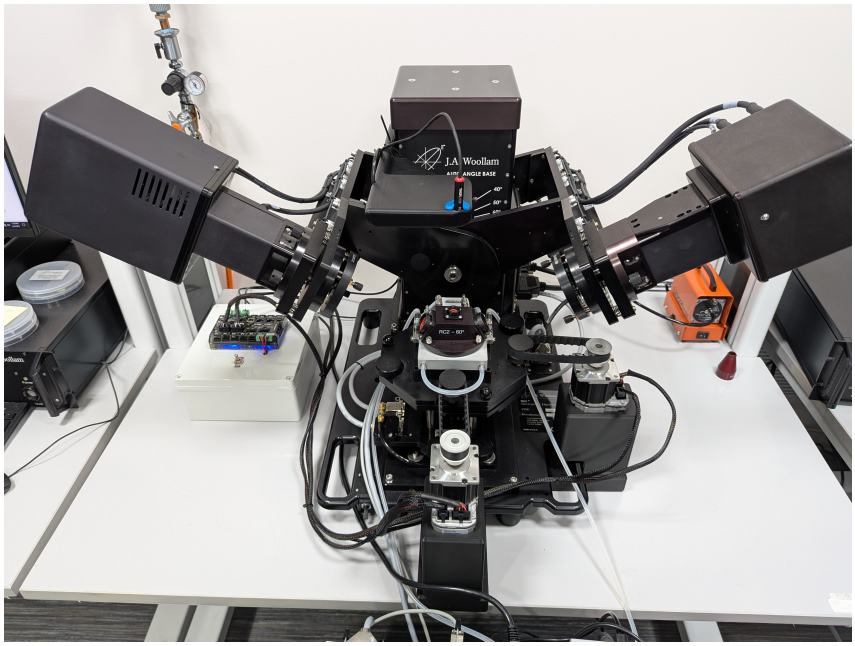


Introduction

The Ellipsometer Automated Leveling System is designed to enhance the precision and efficiency of sample alignment during ellipsometry measurements. By automating the leveling process, this system reduces user intervention and minimizes alignment errors, ensuring consistent and accurate results.

This manual provides an overview of the components of the system, setup instructions, operational guidelines, and troubleshooting procedures.

Contents

1 Overview of Ellipsometer Automated Leveling System

The system enclosure is shown in Figure 1. Its key components are listed below. More detailed descriptions and data sheets can be found in the technical design document.

Figure 1: System Enclosure

- **ThorLabs PDP90A - 2D Lateral Effect Position Sensor –** Measures sample tilt by detecting laser beam displacement. The beam wavelength range is 320 to 1100 nm.
- **ThorLabs PL204 Laser –** Provides a reference beam for tilt measurement. 635 nm wavelength.
- **ThorLabs NE506A –** 0.6 optical density neutral density filter. Reduces laser intensity to prevent the laser from saturating the lateral effect position sensor.
- **Teknic ClearCore I/O and Motion Controller –** Processes sensor data and controls motor adjustments.
- **2 Teknic CPM-SDSK-2310D-ELN Motors –** Adjust the leveling screws to maintain a stable sample position.
- **DPBW03F-05 & SPAN02B-05 DC-DC Converters –** Converts 24V from the power supplies to acceptable levels for PDP90A and PL204 respectively.

- **LM3900N Operational Amplifier –** Adjusts the X and Y measurements of the PDP90A up to 5V to conform to the ClearCore input ranges.
- **2 LRS-150 Power Supplies –** Deliver power to the system's electronics and motors.
- **Top Mount** - a 3D printed mount that houses the PDP90A and PL204 to the top of the ellipsometer.
- **3 M4 Screws With Washers** - used to mount the PDP90A to the top mount and the top mount to the ellipsometer.
- **Adjustment Knob Caps** - 3D printed caps that are placed over the ellipsometer knobs to interface with adjustment belt.
- **2 M3 Screws With Washers** - used to secure adjustment knob caps to adjustment knobs.
- **Motor Mounts** - 3D printed mounts that hold the X and Y motors in alignment with adjustment knobs.

1.1 System Functionality

The system operates by detecting the sample's tilt using the ThorLabs PDP90A sensor, which measures the displacement of a 625nm laser beam reflected from the sample surface. This data is processed by the Teknic ClearCore motion controller, which determines the necessary corrections. The controller then sends commands to the Teknic servo motors, adjusting the sample leveling screws in real time.

The system can operate in both automatic and manual modes, allowing users to either let the system self-correct the alignment or manually adjust the leveling.

2 Setup and Installation

2.1 Mounting the Components

1. Place the enclosure to the left side of the ellipsometer and plug the power cable into an outlet.
2. Insert the ThorLabs PDP90A Position-Sensing Detector into the cutout of the top mount and secure it with an M4 screw on the side. An additional 8-32 screw can be used at the bottom of the sensor for extra stability.

Figure 2: Sensor Placement

3. Insert the ThorLabs PL204 Laser into the circular hole at the end of the top mount. Secure the cables of both the laser and sensor using zip ties. The mount should appear as shown in Figure 3. Proper cable routing, as depicted in figure 3, is important to avoid interference with the ellipsometer.

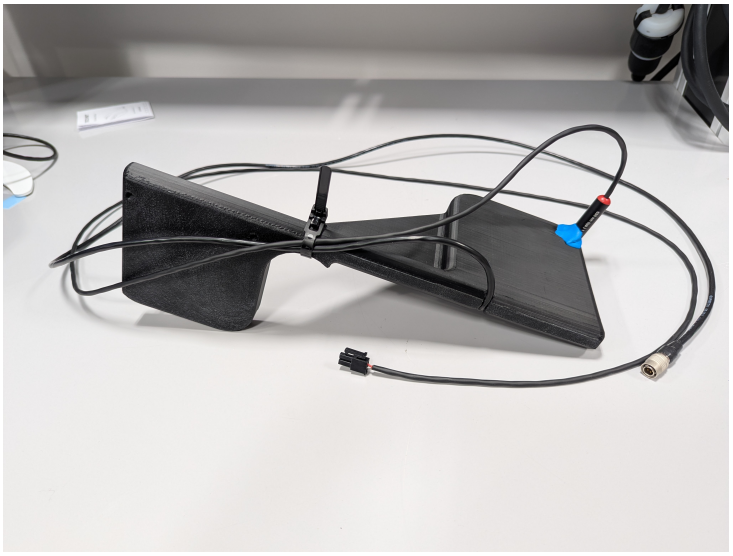


Figure 3: Cable Routing

4. Secure the 3D-printed top mount to the left side of the ellipsometer tower using two M4 screws, as seen in Figure 4.

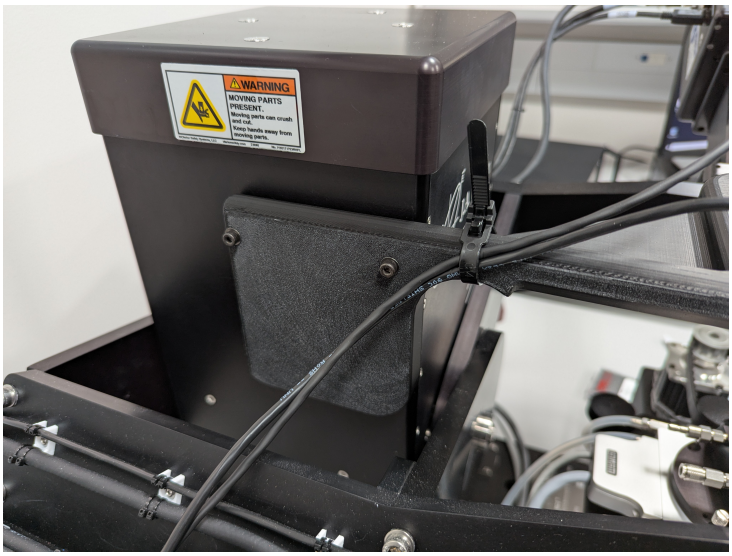


Figure 4: Top Mount Placement

5. Route the sensor and laser cables behind the ellipsometer and into the enclosure. The Hirose connector should be connected to the sensor port at the back of the enclosure. The laser module should be connected via the 2-pin quick connect on the rear of the enclosure labeled laser.
6. Position the motor mounts in their designated locations, as illustrated in Figure 5. The motorY mount should be on the right side while the motorX mount should be in front of the ellipsometer.

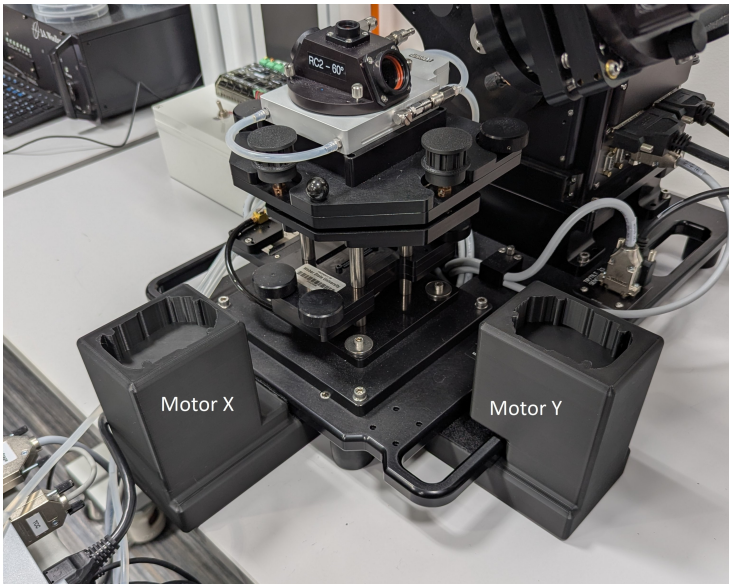


Figure 5: Motor Mount Placement

7. Place the adjustment knob caps over the adjustment knobs and secure them with an M3 screw. Ensure correct placement—the screws should align with the hole on the side of the adjustment knob. See Figure 6.

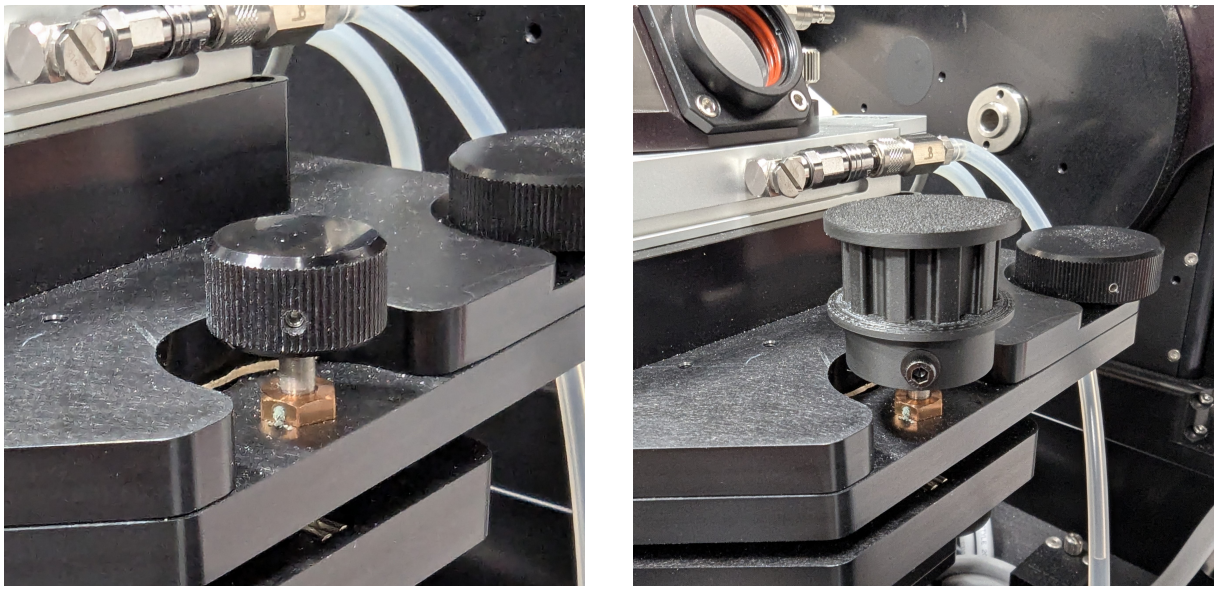


Figure 6: Adjustment Knob Installation

8. Attach the belt to the adjustment knobs first [1], then place the belt over the motor's drive shaft [2]. Gently ease the motor into the cutouts of the motor mounts. At this stage, the belts should be under tension, and the motors should be securely positioned. See Figure 7

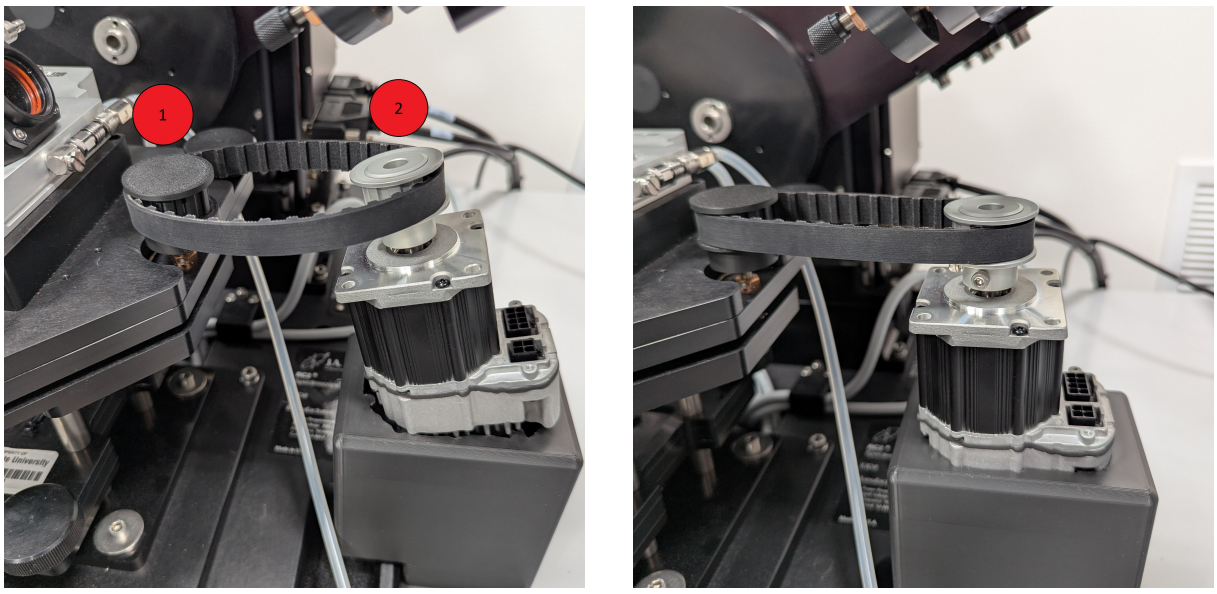


Figure 7: Belt Installation

2.2 Connecting Electronics

1. Connect the motors to the Teknic ClearCore Motion Controller using the 8-pin quick connectors:

   - M0 should be connected to the motor in front of the ellipsometer using the shorter cable. The end marked M0 should plug into the ClearCore M0 port and the end marked MotorX should plug into MotorX.

- M1 should be connected to the motor on the right side of the ellipsometer using the longer cable. The end marked M1 should plug into the ClearCore M1 port and the end marked MotorY should plug into MotorY.

2. Plug the power connectors into the motors using the 4-pin quick connects:
   - The quick connect marked MotorX with four wires should be plugged into MotorX.
   - The end of the quick connect marked MotorY should be plugged into MotorY.
   - The quick connect marked MotorPWR should plug into the corresponding port on the back of the enclosure.
3. Flip the switch labeled power on the back of the enclosure to the on position to power the system.

2.3 Performing Measurements

1. For best results, a sample size of 12 mm × 10 mm is recommended, as this is the maximum size that will fit in the test bed. The minimum sample size is 12 mm × 6 mm.
2. Ensure the laser is aligned correctly so that the reflected beam is centered on the Thor-Labs PDP90A Position-Sensing Detector. It is encouraged that beam placement on the sample avoids interference with the test beam produced by the ellipsometer.
3. Remove ThorLabs PDP90A sensor cap.
4. Power on the ellipsometer and perform an initial manual leveling of the sample using the adjustment knobs.
5. Flip the leveling switch to the on position to enable automatic leveling. The servo motors will begin adjusting the leveling screws in real time based on sensor feedback.
6. To pause automatic leveling at any time, flip the leveling switch to the off position. The motors will disengage, allowing for manual repositioning or termination of the test.

2.4 Teardown

When measurements are complete and the system needs to be stored, follow the steps below:

1. Place the cap back on the ThorLabs PDP90A sensor.
2. Turn both the leveling and power switch to the off position.
3. Remove motor connectors from the ClearCore and ClearPath motors.
4. Remove power connectors from the rear of the enclosure and from the supply ports of the ClearPath motors.
5. Remove motors from platforms and store them in their supplied boxes.
6. Remove motor platforms from the ellipsometer.
7. Remove adjustment knob caps if desired.

8. Disconnect the laser and sensor from the rear of the enclosure.
9. Unplug the power cable from the enclosure.
10. Place cables and enclosure in a cool, dry location.
11. The top mount, sensor, and laser can be left installed on the ellipsometer as they will not interfere with normal operation.

2.5 Error Check

If the PDP90A sees a drastic decrease in the signal strength on the sensor, a red LED will begin flashing at the center of the board and the motors will abort leveling. This typically indicates that alignment is too far off and the beam has fallen outside the sensing area. This could also indicate the laser wasn't properly aligned to the center of the PDP90A. Turn off the leveling switch, realign the sample in the CompleteEase software, and then realign the laser and verify the beam is making contact with the sensor.

A Getting Started with the Software

A.1 Installing Microchip Studio and ClearCore Library

To program the ClearCore Motion Controller, install Microchip Studio (formerly Atmel Studio) and the ClearCore Motion and I/O Library. Follow the steps below for installation and setup:

1. Download and run the ClearCore Microchip Installer from the following link:

   `https://teknic.com/files/downloads/ClearCore_Microchip_Installer.zip`

2. If the installer cannot be run or if a manual installation is preferred, follow the manual install instructions provided by Teknic:

   `https://teknic.com/files/downloads/ClearCore_Microchip_Installer.zip`

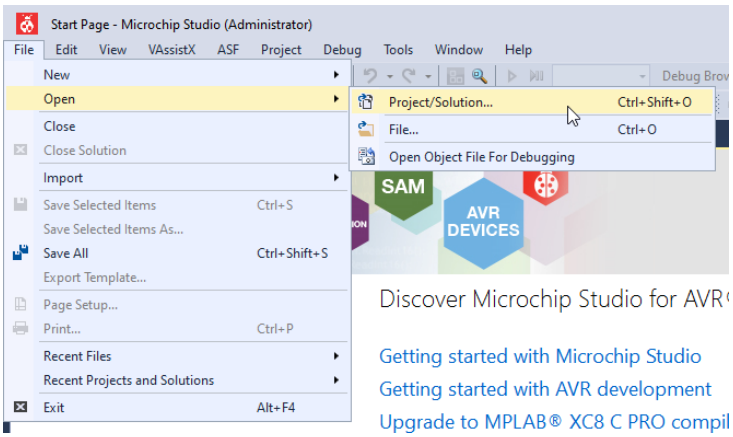
3. Open Microchip Studio (for best performance, run as Administrator).

A.2 Opening and Running Example Code

Several C++ ClearCore examples are installed alongside the ClearCore Motion and I/O Library. To open and run an example project:

1. In Microchip Studio, navigate to:

   File > Open > Project/Solution

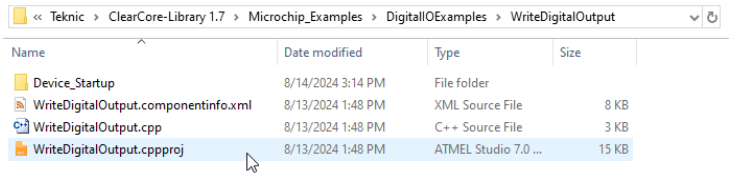


2. Open the WriteDigitalOutput project, located in:

   C:\Program Files (x86)\Teknic\ClearCore-Library 1.X\Microchip_Examples\DigitalIOExamples

3. In the Solution Explorer, right-click on the WriteDigitalOutput project heading and select Set as StartUp Project.

4. Double-click on WriteDigitalOutput.cpp to view the example code.

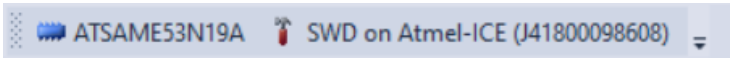


5. Read through the comments, descriptions, and requirements in the example file.

A.3 Uploading Code to ClearCore

The example project can be uploaded to the ClearCore controller over USB or through an Atmel ICE debugger.

1. To upload over USB:
   - Each example includes a custom programming tool to facilitate uploading.
   - The project is already configured for ClearCore's processor.
   - Click the Start Without Debugging button to begin uploading.
2. To upload using an Atmel ICE debugger:
   - Change the debugger/programmer settings in Microchip Studio.



3. The project will compile, upload, and start running on the ClearCore. The six I/O LEDs should toggle on and off every second.

A.4 Creating a New Project

To develop custom code for the system, use the ProjectTemplate provided in the ClearCore installation.

1. Navigate to:

   C:\Program Files (x86)\Teknic\ClearCore-Library 1.X\ProjectTemplate

2. Copy and paste the entire ProjectTemplate solution folder to create a new project.
3. Avoid pasting the template into a different directory, as this may cause broken references and build errors.

Note: If running Windows 11 24H2 or later and encountering upload issues, ensure that WMIC is enabled using the appropriate system configuration steps.

A.5 Debugging

An onboard JTAG connector is provided for developers who wish to connect a third-party debugging tool during development. The ClearCore cover must be removed to access the JTAG connector.

- Recommended debugger: Atmel part number ATATMEL-ICE (for use with Atmel Studio 7 IDE).
- Required debugging cable: TAG-Connect part number TC2030-CTX-LEMTA.
- This cable features a six-pin "plug of nails" connector that connects directly to the ClearCore board.
- The opposite end of the cable connects to the ICE debugger's "SAM" port.
- The LEMTA option must be selected for compatibility with the Atmel-ICE debugger.

References

[1] `https://teknic.com/products/io-motion-controller/clcr-4-13/#system-components_accordion`

[2] `https://teknic-inc.github.io/ClearCore-library/_microchip_install.html`