EE 296 Project Report

Spring Loaded Pins as a Voltage Supply Interface to the Deformable Mirror Contacts

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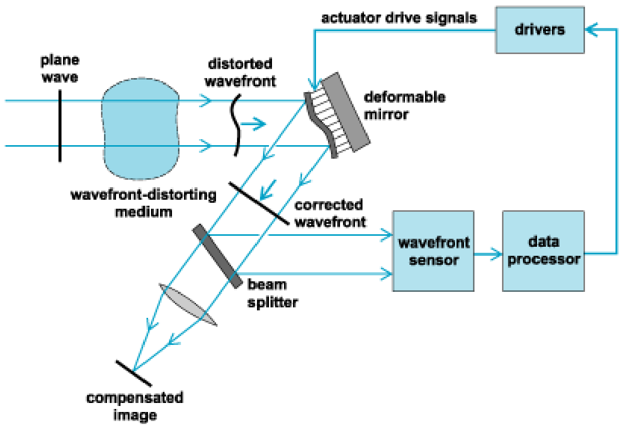
I. Introduction

Adaptive optics (AO) is a technology used in many ground-based telescopes today to reduce the effect of wavefront distortions. When starlight passes through the Earth turbulent atmosphere, images are moved and distorted in various ways causing a blurred image. Adaptive optics measures the distortions of once a planar wavefront and is compensated with a device called a deformable mirror (DM). A deformable mirror is a tool for a wavefront sensor made out of two wafers of piezoelectric ceramic material (PZT) called unimorph DMs, containing laminated electrode actuators on the back, and a reflective surface on the front.



In a closed-loop AO system, shown on the left, the wavefront sensor behaves as a sense and correct system for the DM. It continually measures how the DM has changed the wavefront, applying iterative corrections to the DM's shape by applying voltages to its electrode actuators; thus produces a near planar wavefront.

II. Problem

With the nature of adaptive optics, it is necessary to perform tests and analyze a DM's behavior due to certain voltage applications. By using spring loaded pins as an interface for a voltage supply to the DM's contacts, we can create a test bench for data collection and analysis. This data can be compared to the results of a traditional DM and can further be characterized. With this interface, we can also apply different types of signals to the DM's electrodes without the need of soldering wires to the DM. This allows an easy replacement of worn out spring loaded pins, creating a low maintenance interface.

Since the DM's curvature varies depending on the voltage applied to it, the behavior of these spring loaded pins must be considered: how they perform at high frequencies of motion and high voltage applications, and how it might affect the operation of a DM.

III. Experiment

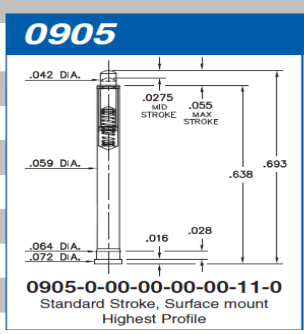
The spring loaded pins should be able to supply the required voltage to the DM, while 100% contact time and minimal effect on the performance of the DM itself. We must evaluate different pin options that should be most beneficial to the DM's performance whiles assuring that these pins never interfere with the movement of the DM itself, cause an undesirable motion of the DM, or behave in a destructive manner.

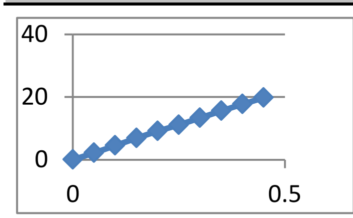
IV. Results and Data

Behavior and Characteristics of a Spring:

A simple harmonic motion of a spring exhibits a characteristic feature when displaced from equilibrium position of restoring force proportional to the displacement called Hooke's law (F = -kx). Using a stage micrometer, and a digital scale, we were able to determine the force in grams for every ten millimeter of displacement for different pins. Also, by measuring the mass of the spring and its cap, we were able to determine the angular frequency ($w = \sqrt{\frac{k}{m}}$) of the spring, needed to determine the pins ability to track the DM's contacts.

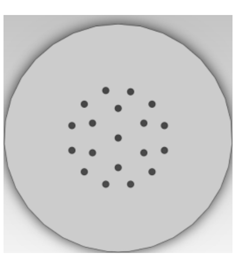
Since we need 100% contact time without interfering with the DM's movement, we chose the pin with the greatest angular frequency, range, and length. The data of the best spring loaded pin is shown below.

Spring 1 [P/N: 575-900511]	**Distance(mm)**	**Mass (g)**	**Spring Constant (N/m)**	**Angular Frequency ω^2 (Hz) =k/m**
	0	0		Mass of Spring: 0.004g
	0.05	2.175	426.735	Mass of Spring Cap: 0.027g
	0.1	4.508	457.7346	Total Mass: 0.031g
	0.15	6.869	463.2282	
	0.2	9.1	437.7221999	
	0.25	11.113	394.9506	
	0.3	13.333	435.564	
	0.35	15.542	433.4058	
	0.4	17.705	424.3806	
	0.45	19.744	400.0518	
			430.4192	**3726.189786 Hz**



The distance to force plot on the left is linear which makes the spring constant data valid. It was also compared to similar spring constants of pins obtain from various websites and datasheets, all having a range between 400 N/m to 600 N/m.

Mounting Options



After analyzing the spring behaviors and its characteristics, we needed an easy way to mount the pins to the DM's contacts. Using a digital caliper, we measured the distance among each contacts of the DM, and reproduced the DM's layout using Solidworks. The design was sent to Randy Chung of IFA and will be made of a non-conductive circular material with pin holes, shown on the left. The disk will fit in a two inch circular mount held by two lock rings. The circular mount will then be placed on a stage with the ability to move back and forth to connect the pins to the DM's contacts.

5V USB Voltage Supply using Measurement Computing USB-3100

Using Matlab's Data Acquisition Toolbox, we were able to communicate with Measurement Computing USB-3100, 16 channel voltage output device. We created different square wave and sinusoidal signals that can be applied to the pins for testing. As we tested these signals with an oscilloscope, we realized that the device has a maximum output frequency of 100 Hz. With such low frequencies, we do not have a way of characterizing how the DM performs with traditional interface, in comparison to how the DM performs with pins. Nonetheless, we still can collect necessary data for our test bench.

V. Conclusion

Clearly, such test bench is suitable for minor data collection and should be able to perform within expectations. However, since the circular disk pin mount was not created on time, we were not able test and analyze the behavior of the DM using spring loaded pins as a voltage supply interface. Once completed, a simulation of spring loaded pins can be evaluated to whether they can perform as expected without interfering with the movement of the DM itself.

Since, the USB voltage supply could provide a voltage of at most five volts, arcing through the pins were highly unlikely. Once we begin to administer higher voltages, these pins must be further examined to determine arcing distance, its ability to deliver higher voltages, and other electrical characteristics. The damping factor must also be considered with higher input frequencies. By measuring the viscous damping coefficient of these springs, we can determine their behavior at the DM's maximum frequencies relative to traditional interface of the DM.

Overall, dealing adaptive optics was a great experience. It provided an understanding of how they are used in today's technologies and its importance, especially here in Hawaii. Without adaptive optics, images from astronomical telescopes will look nothing but that of shimmering blobs.