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MMT Observatory

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Dynamic Measurements of the MMT f/9

Secondary Pneumatic Support System

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Multiple Mirror Telescope (MMT) Project
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Abstract

This document summarizes results of dynamic measurements of the MMT f/9 Secondary Pneumatic Support using a Hewlett Packard 35670A dynamic signal analyzer (DSA) with swept sine, arbitrary waveform generation and synthesis options. The synthesis option allows for curving fitting data in order to obtain a transfer function. The measurements compare a Bellofram transducer to a ControlAir transducer. Included in the tech memo are bode plot results, curve fit transfer functions for the Bellofram transducer and details of the measurement and setup.

Distribution

- **SO** — S. DeRigne, B. Cuerden
- **MMT** — C Foltz, D. Clark
- **LBT** — J. Hill

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1 Introduction

I was tasked to perform dynamic measurements of the MMT f/9 load cell in order to determine whether it was possible to close a load control loop with a 1 Hz bandwidth. Rather than rely on performing Lissajous patterns in order to determine dynamic response, I decided to use a dynamic signal analyzer (DSA). This allowed for a better determination of the frequency response. Also, the Curve Fit option of the DSA allows me to determine a transfer function. I was able to borrow an HP35670A dynamic signal analyzer for the tests.

2 Required Bandwidth

Reference the memo from B. Cuerden to S. West dated 24 May, 1997 titled *Wind Disturbance for the MMT Primary & f/9 Secondary Mirrors.*

In this memo, a 3 Hz bandwidth was shown to be adequate to meet full performance in a 22 m/sec wind (performance is required only in a 6.7 m/sec wind). Loads would be 50% higher if a 1 Hz bandwidth was used, but this distortion would still be less than the budget allocation even in 22 m/sec winds.

3 Conclusion

Both the Bellofram and ControlAir transducer will achieve the 1 Hz closed loop bandwidth with the Bellofram allowing for a wider bandwidth but suffering from noise problems at the lower signal to noise ratios.

4 Test Cases

I was asked to determine dynamic response under the following 4 test cases.

	Pressure (psi)	
Case #	*Mean (DC)*	*Sinusoidal Peak*
1	1.0	0.05
2	1.0	0.75
3	3.0	0.05
4	3.0	0.75

The DC voltage of 1 and 3 volts corresponds to elevation angles of 10 and 30 degrees above the horizon respectively. The 0.05 volt sinusoid level duplicates the amplitude response expected over all frequencies fora 6.7 m/sec wind. The 0.75 volt amplitude corresponds to a 22 m/sec wind.

5 Setup

Since I do not have the capability or embedding a postscript of encapsulated postscript graphic into LATEXso please see me for measurement test setup details.

6 Results

6.1 Bode Plots

Bode plot measurements were taken of the system with both the Bellofram transducer and the ControlAir transducers. The Bode plots were of the open loop from the transducer input to the load cell output. The transducer was driven with a swept sine from 0.1 Hz to 10 Hz and the load cell response was measured. The DSA was used to drive the transducer and measure the response. The

The Bellofram bode plots obtained with the DSA can be found at ftp://valiant.as.arizona.edu in the subfolder MMT F9 Plots/Bellofram. The plots correlated to the cases as follows for the Bellofram transducer:

Case #	*Plot*
1	Plot 2
2	Plots 3 and 4
3	Plot 5
4	Plots 6 and 7

The results of the Bode plots indicate that the Bellofram transducer has poor performance at low mean pressures as indicated by the noise-like response.

The plots for the ControlAir transducer can be found at ftp://valiant.as/arizona.edu in the subfolder MMT F9 Plots/ControlAir. The plots correlated to the cases as follows for the Bellofram transducer:

Case #	*Plot*
1	Plot 1
2	Plot 2
3	Plot 4
4	Plot 5

The Bode plots for the ControlAir transducer shows good low mean pressure performance as evident by lower noise compared with the Bellofram transducer, but suffers from a reduced bandwidth compared with the Bellofram transducer. Still, the ControlAir crosses over the 0 dB point on the Bode plot past 1 Hz in all plots.

6.2 Transfer Function

Transfer functions were determined for Cases 2 and 4 for the Bellofram transducer. An assumption made was that there were no more than two poles and one zero in the transfer function. The DSA was used to determine the poles and zeros for the best fit in these two cases using the Curve Fit option of the DSA. The resulting poles and zeros were calculated by the analyzer in Hertz and converted by me to rad/sec. The results are as follows.

Case 2

$$G_p(s) = \frac{-4.908864(s+138.6322)}{s^2 + 8.590496615s + 158.427349}$$

Case 4

$$G_p(s) = \frac{-9.708778(s+114.774946)}{s^2 + 8.37963292s + 264.689614073}$$

where $G_p(s)$ is the plant transfer function.

These transfer functions can be used for control design to achieve objectives.

Since only one transducer from each manufacturer was available, I was not able to make measurements to determine repeatability of the responses over a number of transducers.