WHITE PAPER

STABILIZED PAN AND TILT POSITIONERS

MECHANICAL STABILIZATION'S ROLE IN OVERCOMING ENVIRONMENTAL FACTORS

INTRODUCTION

Advanced technologies that ensure a secure physical environment are increasingly common standard features of surveillance and security systems. One long-standing issue in the surveillance and security industry is losing sight of a target due to environmental factors. While rain, snow, ice, heat, and a myriad of other forces can render a sensor or group of sensors ineffective, thereby compromising the security of the location, the focus of stabilization technologies is to mitigate the effects of undesired platform motion. Whether the disturbance is expected (such as waves in the ocean) or not (such as a gust of wind), stabilization enables users to maintain target location and identification even when conditions are less than ideal.

There are several technologies in use today to provide image stabilization ranging from mechanical stabilization to digital image processing. Each has a set of strengths and weaknesses, so choosing the correct technology for a given application is critical. Some key factors to keep in mind when selecting the correct stabilization solution include frequency and amplitude of the disturbance motion, slew rate (which relates to frequency and amplitude) and data retention/cropping.

This paper specifically focuses on the use of gyroscopic feedback to an electronic positioning system to stabilize an electromechanical positioner, also referred to as a pan and tilt. In addition to providing brief details regarding the system design, we present sample performance data.

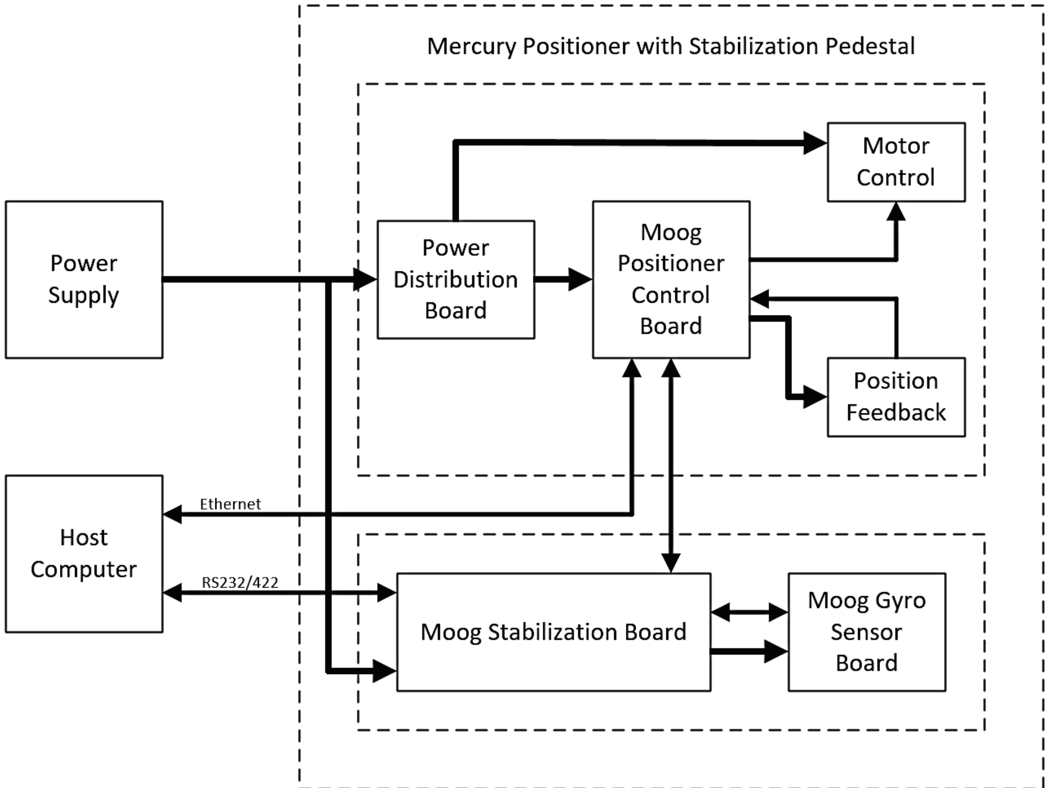
SYSTEM ARCHITECTURE

Over the years, Moog has designed and fielded a number of systems that were configured with gyroscopic stabilization. The system featured in this paper is based on our current Mercury positioner. The architecture described below was designed such that it could be applied to a platform of products currently offered in Moog's portfolio.

A classic Proportional Integral Derivative (PID) control loop implemented on a microcontroller lies at the heart of this stabilization system. In this specific system, a microelectromechanical system (MEMs) based sensor is used, however the architecture allows for the use of other gyroscopic sensors by simply updating the sensor's communication driver.

The system operates as a closed loop, meaning that the MEMs device measures error and the PID loop corrects for this error. More specifically, the gyroscopic data and position coordinates of the pan and tilt are merged to create the error signal that drives the control loop. The feedback control is user-adjustable to provide optimal functionality of the stabilization algorithm for different system designs (e.g. sensor payloads, pan and tilts) and target variation such as small watercraft, humans on foot, or unmanned aerial systems. The latency between the gyroscope's sample acquisition and positioner's drive electronics is minimized in order to create a high-performance system. The bandwidth of the control loop has been optimized to provide response at higher frequencies while weighing the effects of in-band noise. Drift compensation capabilities are included within the sensor board and a phase compensation filter is also available when required. All of these features and capabilities are included to create a modular and adjustable stabilization driver that has applicability across Moog's pan and tilt offering.

BLOCK DIAGRAM – STABILIZED MERCURY SYSTEM



PERFORMANCE CRITERIA

Evaluating the performance of the stabilized Mercury system requires a special fixture that simulates the external motion inputs. This fixture creates a sinusoidal motion profile in both the azimuth and elevation axes. The amplitude and frequency of the sinusoidal motion are adjustable over a range covering many real-world mounting configurations.

In order to facilitate meaningful discussions, a straightforward calculation is used to characterize the impact of adding stabilization feedback to a standard Moog positioner.

The term rejection ratio is defined as:

$$Rejection\ Ratio = \frac{\Delta\phi_{PLATFORM}}{\Delta\phi_{LOS}}$$

$$LOS = Line\ Of\ Sight$$

For reference, a rejection ratio of 7.5 simply means that for a platform disturbance of 7.5°, the system will maintain the line of sight to within 1° of the target. In order to evaluate the appropriate rejection ratio for a specific application, the expected disturbance amplitude and sensor angle of view are required. For the case of a camera/lens combination, the angle of view is typically available from the manufacturer's datasheet. If we assume a camera/lens that has an angle of view of 2.0°, then with a rejection ratio of 3.75 we should be able to maintain sight of a target with a platform disturbance of up to 7.5°. Adjustments can be made to this calculation to better serve specific system requirements.

Keep in mind that the rejection ratio varies with the frequency of the platform disturbance. For this reason, we provide performance at various frequencies to ensure that customers know what to expect from our product. The table below provides an idea of the relevant disturbance frequencies and amplitudes for some typical mounting scenarios.

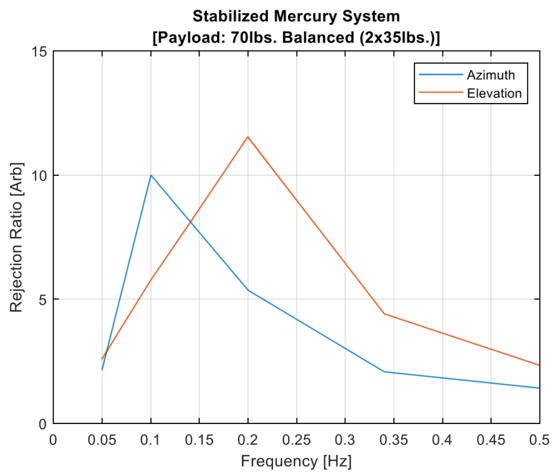
TYPICAL SYSTEM MOUNT PARAMETERS

Mount Style	Disturbance Frequency [Hz]	Disturbance Amplitude [°]
Surveillance Pole	0.1	10
Surveillance Pole, Boat	0.2	10
Boat, Ground Vehicle	0.5	10
Ground Vehicle	1.0	2

TEST RESULTS

The following rejection ratios were measured using a stabilized Mercury system with two 35 lb. payloads.

MERCURY SYSTEM – STABILIZATION PERFORMANCE



Disturbance Frequency [Hz]	Platform Disturbance [°]	Rejection Ratio	
		Azimuth	Elevation
0.05	7.5	2.14	2.59
0.10	7.5	10.00	5.77
0.20	7.5	5.36	11.54
0.34	7.5	2.08	4.41
0.50	7.5	1.42	2.34

The performance for all stabilized positioners will depend on payload weight/balance, payload configuration, desired slew speed and disturbance input profile. Installations in the real world will see additional inputs and disturbances that are not easily replicated in lab environments, but this testing and evaluation shows the applicability of MEMs-based stabilization for systems used in shipboard, mast and tower applications. The addition of other stabilization technologies, such as electronic image stabilization in camera sensors, can further contribute to the overall performance of the system.

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