# CERTIFICATE OF CALIBRATION

This document certifies that the equipment referenced below meets published specifications.

Model Number: __FAS-G__

Calibration Date: __2/14/2003__

Calibration Technician: __DC__

Serial Number: __0001051__

Description: __Gyro-Enhanced Inclinometer__

## MicroStrain, Inc.

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# MicroStrain, Inc
# FAS-G Calibration Report

## Calibration Parameter Summary

Serial Number: 1051
Firmware Version Number: 2.0.00
Calibration Date: 2/14/2003

### Senor Calibration Parameters
These values constitute the sensor calibrations, and should not be changed by the user

| EEPROM Location | Description | Value |
|---|---|---|
| 2 | X Accelerometer Offset | 32764 |
| 6 | Z Accelerometer Offset | 32766 |
| 8 | Y Gyroscope Offset | 32755 |
| 14 | X Accelermeter Gain | 33939 |
| 18 | Z Accelerometer Gain | 33877 |
| 20 | Y Gyroscope Gain | 56162 |
| 48 | X Accelerometer DAC Offset | 471 |
| 50 | Z Accelerometer DAC Offset | 505 |
| 52 | Y Gyroscope DAC Offset | 217 |
| 74 | 1/Cos(Orthogonality Error) | 32768 |
| 76 | Sin(Orthogonality Error) | 32878 |

### Filter Parameters
These parameters govern the performance of the on-board filtering algorithms.
The user may alter these values to suit the application.

| EEPROM Location | Description | Value |
|---|---|---|
| 40 | Integral Gain | 66 |
| 46 | Proportional Gain | 655 |
| 36 | Vector Magnitude Factor | 5 |

### Analog Output Slopes
These values report the best-fit linear slope of the analog ouputs.
The units are (microvolts/degree)

| EEPROM Location | Description | Value |
|---|---|---|
| 70 | UnCompensated Analog Output Slope | 11430 |
| 72 | Gyro-Compensated Analog Output Slope | 11435 |

# MicroStrain, Inc.
# FAS-G Calibration Report

Serial Number: 0001051
Firmware Version: 2.0.00
Calibration Date: 2/14/2003

## Accelerometer Output vs. Orientation



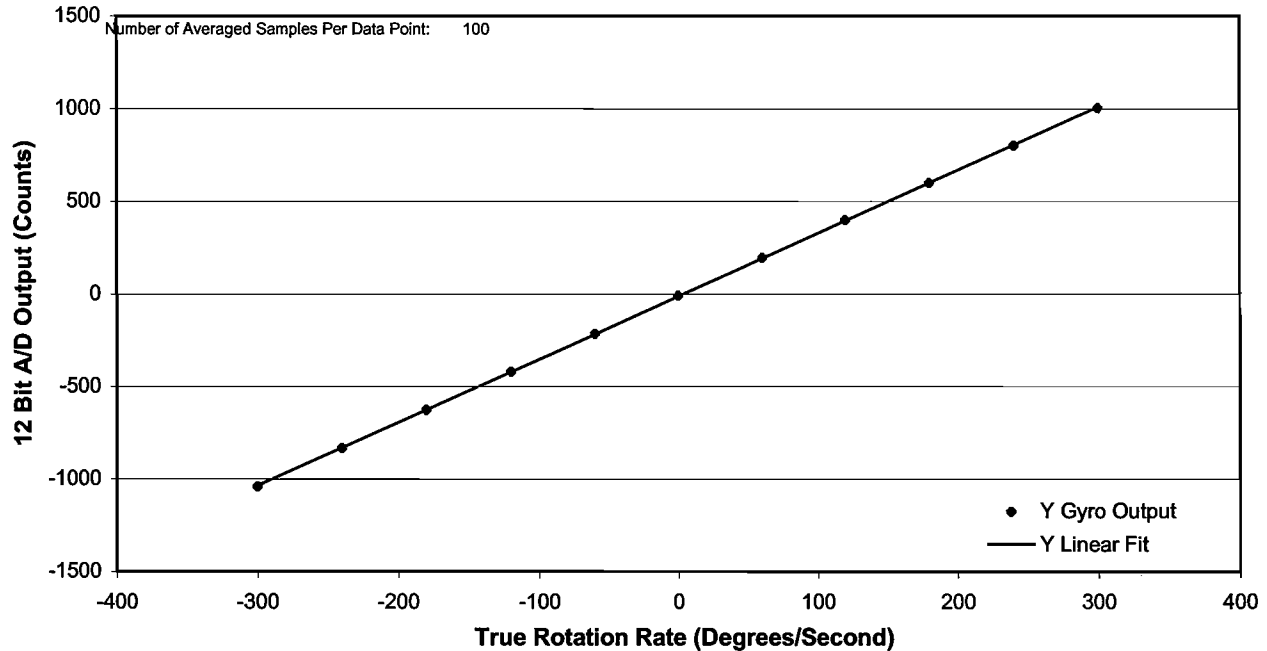## Accelerometer Error vs. Orientation
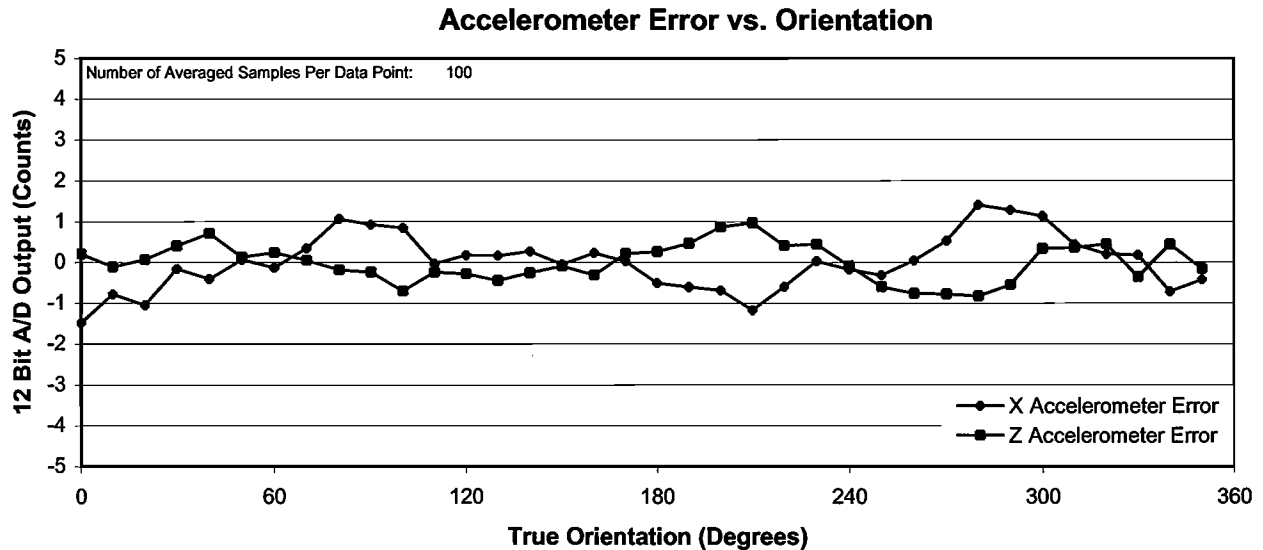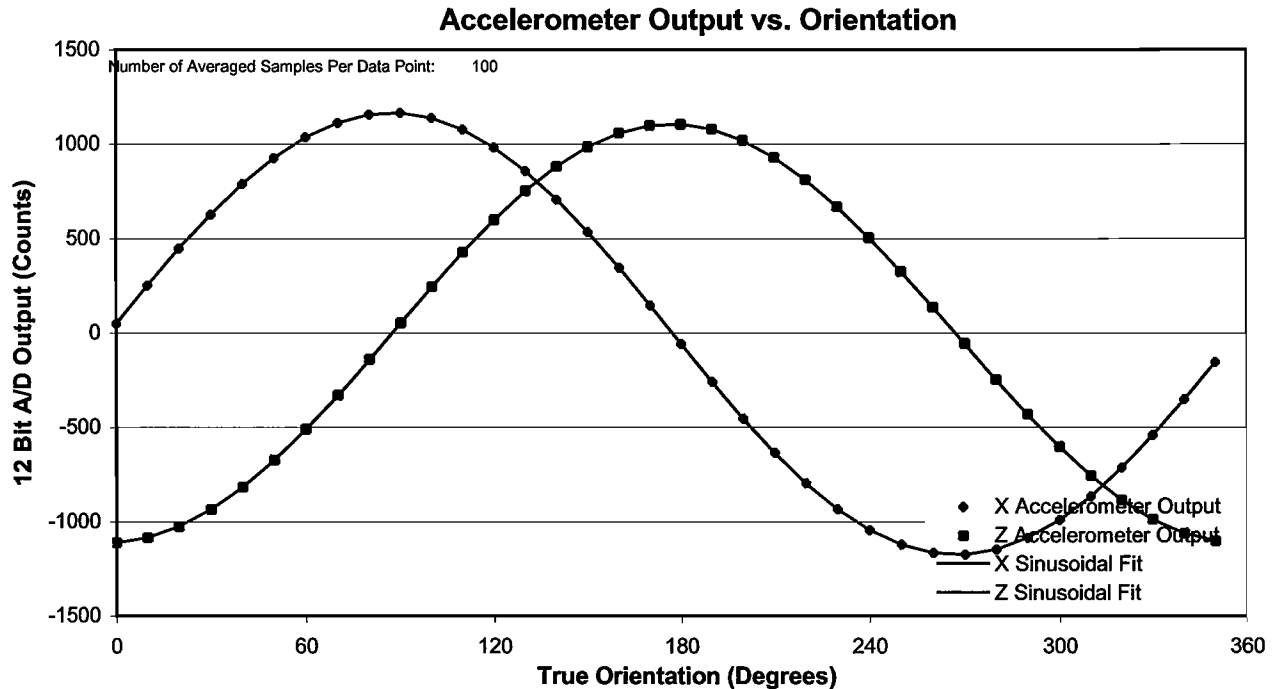


Accelerometer Calibration was performed by mounting the FAS-G to a precision rotary stage. The stage's rotation axis was horizontal. The FAS-G's sensitive axis was aligned parallel to the stage's rotatary axis. The stage was indexed through a number of known orientations in both the positive and negative directions, and the FAS-G accelerometer outputs recorded. Least-squared sinusoids were fit to each accelerometer's dataset. "Accelerometer Error" represents the deviation between the measured accelerometer output and the sinusoidal fit.
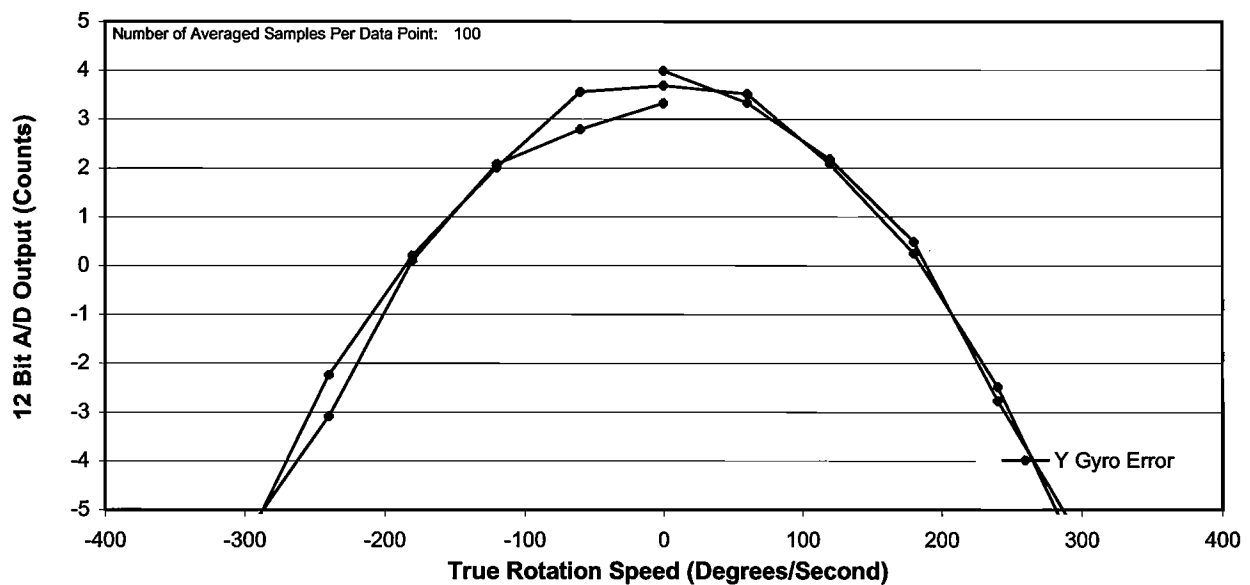
# MicroStrain, Inc.
# FAS-G Calibration Report

Serial Number: 0001051
Firmware Version: 2.0.00
Calibration Date: 2/14/2003

## Gyroscope Output vs. Rotation Rate



Number of Averaged Samples Per Data Point: 100

- Y Gyro Output
— Y Linear Fit

12 Bit A/D Output (Counts)

True Rotation Rate (Degrees/Second)

## Gyroscope Error vs. Rotation Rate



Number of Averaged Samples Per Data Point: 100

— Y Gyro Error

12 Bit A/D Output (Counts)
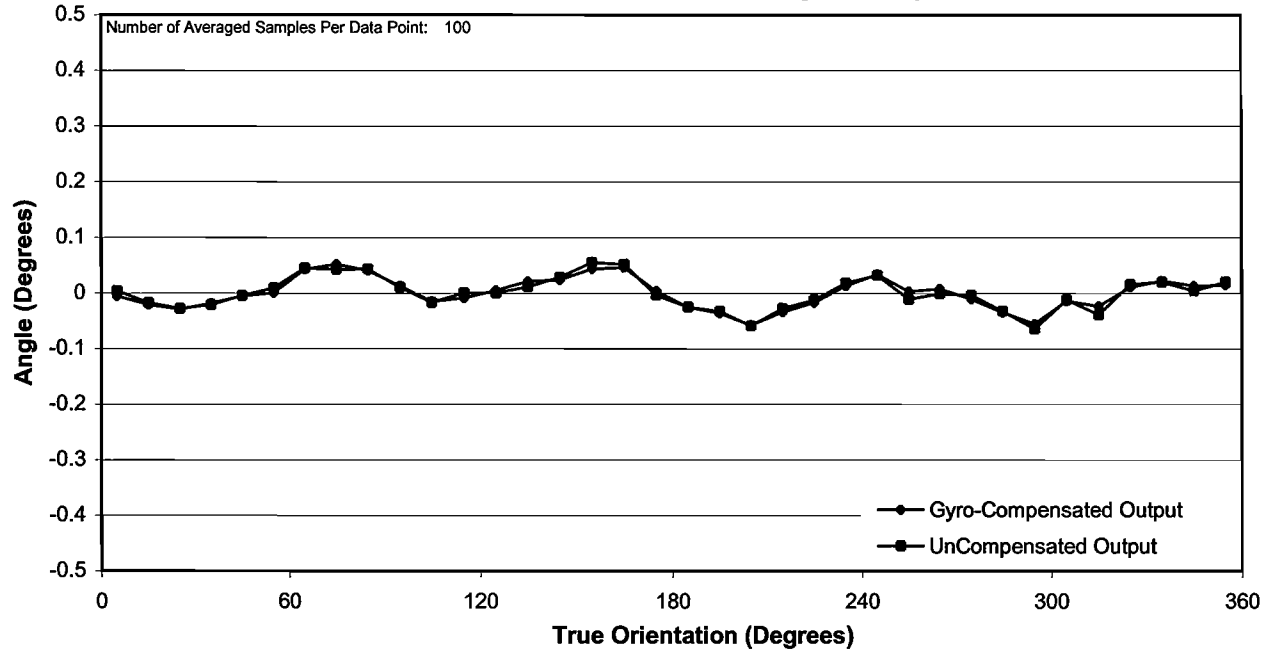
True Rotation Speed (Degrees/Second)

Gyroscope Calibration was performed by mounting the FAS-G to a precision rotary stage. The stage's rotation axis was horizontal. The FAS-G's sensitive axis was aligned parallel to the stage's rotary axis. The stage was rotated at a number of known constant rated in both the positive and negative directions, and the FAS-G gyroscope output recorded. A least-squared line was fit to the dataset. "Gyroscope Error" represents the deviation between the measured gyroscope output and the linear fit.
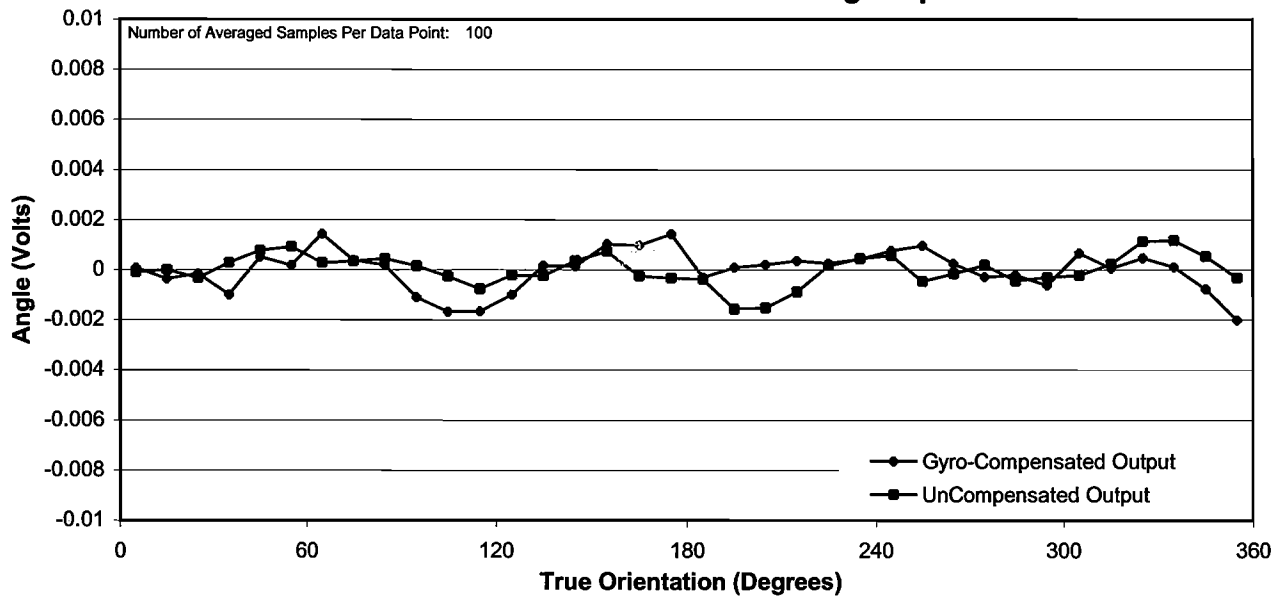
# MicroStrain, Inc.
# FAS-G Calibration Report

Serial Number: 0001051
Firmware Version: 2.0.00
Calibration Date: 2/14/2003
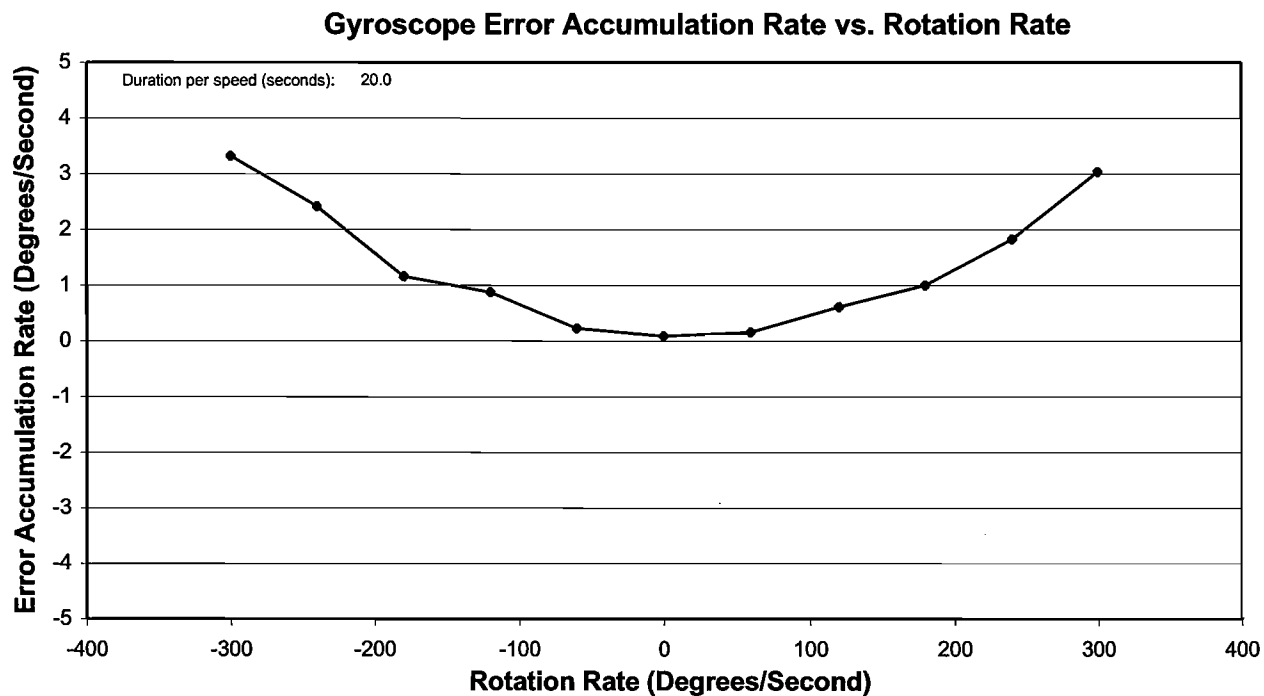
## Static Reference Error:  Digital Output



Number of Averaged Samples Per Data Point:  100

Angle (Degrees)

True Orientation (Degrees)

- Gyro-Compensated Output
- UnCompensated Output

## Static Reference Error:  Analog Outputs



Number of Averaged Samples Per Data Point:  100

Angle (Volts)

True Orientation (Degrees)

- Gyro-Compensated Output
- UnCompensated Output

The static reference accuracy quantifies the ability of the FAS-G to correctly report its orientation under static conditions.  The FAS-G was mounted to a precision rotary stage.  The stage's rotation axis was horizontal. The FAS-G's sensitive axis was aligned parallel to the stage's rotatary axis.  The stage was indexed to a number of known orientations, and the FAS-G's digital and analog outputs recorded.  "Static Reference Error" is the difference between the reported orientation and the true orientation.

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## FAS-G Calibration Report

Serial Number: 0001051
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## Gyroscope Error Accumulation Rate vs. Rotation Rate



Duration per speed (seconds): 20.0

X-axis: Rotation Rate (Degrees/Second)
Y-axis: Error Accumulation Rate (Degrees/Second)

The "Error Accumulation Rate" quantifies the ability of the time integral of the gyroscope to correctly measure orientation. To evaluate the error accumulation rate, the FAS-G was fixed to a precision rotary stage. The stage was rotated at a constant speed for a fixed time interval and then stopped. The reported orientation as determined by the time integral of the gyroscope output was then calculated and compared to the actual orientation. This error divided by the duration of rotation is the error accumulation rate.