MEMS Gyroscope Metrics

1. Scale Factor: \( S \)
   \[ [S] = \text{mV/°/s} \]
   → evaluated as the slope of the least squares straight line fit to the input-output data

a. Scale Factor Errors
   1. Linearity Error - linear deviation from the least squares straight line fit
   2. Nonlinearity Error - nonlinear deviation from the least squares straight line fit

b. Scale Factor Temperature Sensitivity
   c. Scale Factor Acceleration Sensitivity
   d. Asymmetry Error - the difference in the scale factor between a +\( \Omega \) input and a -\( \Omega \) input
   e. Scale Factor Stability - how the scale factor varies over time of continuous gyro operation

2. Bias
   \[ \text{def: the average gyro output voltage with zero input} \]
   \[ \text{ex: } 2.5V \text{ is a common bias} \]
   \[ V_{\text{out}} > 2.5V \text{ for } \Omega > 0 \text{ °/s} \]
   \[ V_{\text{out}} < 2.5V \text{ for } \Omega < 0 \text{ °/s} \]
a. **Bias Error**: 

Typically expressed in °/hr

- Resulting angular error: \( \Theta_e(t) = \Theta f \) for zero input

b. **Noise on Bias**

The gyro's output is perturbed by zero-mean thermomechanical noise, which has an effect on the output signal

1. **Angle Random Walk**

   - The angular error buildup with time that is due to white noise in angular rate.

   Typically expressed in °/√hr or °/s/√hr

   * remember: \( \hat{\Theta}_{meas} \) is produced, while \( \Theta(t) \) is desired:

   \[ \Theta(t) = \int_0^t \hat{\Theta}_{meas} \, dt, \text{ and } \hat{\Theta}_{meas} \text{ is noisy} \]

2. **Bias Stability**

   - The random variation in bias as computed over a specified finite time, and averaging time intervals

   Typically expressed in °/hr

3. **Rate Random Walk**

   - The drift rate error buildup with time due to white noise in angular acceleration

   Typically expressed in °/hr/√hr

4. **Other Related Bias Error Metrics**

   i. Power Spectral Density (PSD): \((°/hr)^2/Hz\)

   ii. FFT Noise Density: \((°/hr)/\sqrt{Hz}\)

   iii. Noise Density (or rate noise density)

   \(°/s/\sqrt{Hz} \rightarrow \text{note: } \sqrt{Hz} = \sqrt{\text{BW}}\)
5. Bias Offset Calibration Error
   - If the bias has a fixed DC offset, then the measurement of \( R \) will be off a fixed amount at all times.
   - An easy error to measure and correct for.

6. Temperature-Induced Bias Offset
   - Temperature can be measured on-chip and used to null this error.

3. Operating Characteristics
   a. Resolution
      - The nominal minimum detectable change in input
   b. Bandwidth
      - The (typically 3dB) range in frequency of the angular rate input that can be detected
   c. Turn-On Time
      - Time from power on to useful output
   d. Linear and Angular Vibration Sensitivity
   e. Mechanical Shock Resistance
   f. Power Supply Sensitivity
      - \( \text{PSRR} \)
      - \( \text{PSRR} \)
      - \( \frac{\text{Effect of supply voltage on output:}}{\text{\%}} \)