Ejercicio Entregable Nro 1 – Modelo de un giróscopo

A) Implementar en Matlab/Simulink el modelo de un giróscopo que incluya, al menos, los siguientes efectos:

- Quantization noise
- Angle Random Walk (ARW)
- Bias instability
- Rate Random Walk
- Constant Bias / Drift Rate Ramp
- Scale factor

La medición de un giróscopo, en un eje, se puede modelar según la siguiente ecuación:

$$\omega_{Out} = S\ \omega_{In} + B_0 + B_{ARW} + B_{RRW} + B_{BI} + B_{QN}$$

Donde:

ω_{Out} Velocidad angular medida por el giróscopo
ω_{In} Velocdiad angular real
S Factor de escala
B_0 Bias constante
B_{ARW} Variable aleatoria debido al Angle Random Walk (ruido blanco)
B_{RRW} Variable aleatoria debido al Rate Random Walk (ruido blanco integrado)
B_{BI} Variable aleatoria debido a la inestabilidad del bias (ruido 1/f o flicker noise)
B_{QN} Variable aleatoria debido a la cuantización de la medición

Usando valores típicos para los parámetros del modelo, generar una serie de datos temporales, sampleados a una dada frecuencia fs. Luego, sobre estos datos, calcular la Allan Variance de la señal, identificar las distintas componentes de ruido aleatorio y comparar con los valores esperados.

B) Utilizar el simulador de giróscopo desarrollado para comparar dos tecnologías distintas de sensores: MEMS y Ring Laser Gyro, con las especificaciones que se muestran en el apéndice. Generar los gráficos de Allan Variance para ambos sensores simulados.

C) Calcular los parámetros del modelo de giróscopo tipo MEMS I3DM-GX3-35 en base a mediciones relevadas con este equipo. Comparar con los valores esperados según el manual.

Referencias:

1. "IEEE Standard SpeciÞcation Format Guide and Test Procedure for Single-Axis Interferometric Fiber Optic Gyros" IEEE std 952-1997, 2003
2. "Investigation of a Navigation-Grade RLG SIMU type iNAV-RQHR", Dorobantu, C. Gerlach, 2004
3. "Modeling Inertial Sensors Errors Using Allan Variance", Haiying Hou,m 2004
4. "Analysis and Modeling of Inertial Sensors Using Allan Variance" Naser El-Sheimy, Haiying Hou, Xiaoji Niu, 2008
5. "Low-Cost Inertial Sensors Modeling Using Allan Variance" A. A. Hussen, I. N. Jleta, 2015
6. "Discrete Simulation of Colored Noise and Stochastic Processes and 1/f^a Power Law Noise Generation," J. Kasdin, 1995
7. “LORD DATASHEET 3DM-GX3-35, Attitude Heading Reference System (AHRS) with GPS”

Apéndice: Características de sensores MEMS y RLG:

Sensor MEMS (I3DM-GX3-35 / Lord MicroStrain)

Inertial Measurement Unit (IMU) Sensor Outputs			
	Accelerometer	**Gyroscope**	**Magnetometer**
Measurement range	±5 *g* (standard) ±1.7±16, and ±50 *g* (option)	300°/sec (standard) ±50, ±600, ±1200 °/sec (options)	±2.5 Gauss
Non-linearity	±0.1 % fs	±0.03 % fs	±0.4 % fs
Bias instability	±0.04 m*g*	18°/hr	--
Initial bias error	±0.002 *g*	±0.25°/sec	±0.003 Gauss
Scale factor stability	±0.05 %	±0.05 %	±0.1 %
Noise density	80 µg/√Hz	0.03°/sec/√Hz	100 µGauss/√Hz
Alignment error	±0.05°	±0.05°	±0.05°
Adjustable bandwidth	225 Hz (max)	440 Hz (max)	230 Hz (max)
IMU filtering	Digitally filtered (user adjustable) and scaled to physical input; coning and sculling integrals computed at 1 kHz		
Sampling rate	30 kHz	30 kHz	7.5 kHz
IMU data output rate	1 Hz to 1000 Hz		

Sensor Ring Laser Gyro:

Scale factor repeatability over 1 month shall not exceed 5 ppm (1 sigma).

Scale factor stability over 1 year shall not exceed 5 ppm (1 sigma)

Scale factor stability over 1 month shall not exceed 1.5 ppm (1 sigma)

Scale factor modeling error (across temperature) shall not exceed 2 ppm (1 sigma)

Scale factor asymmetry shall not exceed 37 ppm (1 sigma)

Bias repeatability over 1 month shall not exceed 0.015 deg/hr (1 sigma)

Bias stability over 1 year shall not exceed 0.04 deg/hr (1 sigma)

Bias stability over 8 hours shall not exceed 0.015 deg/hr peak (1 sigma)

Bias modeling error (across temperature) shall not exceed 0.009 deg/hr (1 sigma)

Bias magnetic field induced drift, for a magnetic field of 0 to 10 gauss applied outside the chassis in any direction, shall not exceed 0.03 deg/hr/gauss.

Repositioning gradient sensitivity (in a 1g field only, with magnetic shield) shall not exceed the following: Steady state deviation from mean: 0.033 deg/hr (1sigma), ansient response (to changes of ±1g): 0.25 deg/hr (1 sigma)

Angle Random Walk shall not exceed 0.015 deg/sq.rt hr (1 sigma).

Unfiltered readout noise, exclusive of dither cross coupling and third harmonic effects, shall not exceed 6 µrad (1 sigma). Contributions from gyro quantization and output channel scaling is included in the filtered and unfiltered readout noise budgets.

Filtered readout noise: The gyro channel output data shall have a 3 dB bandwidth of 5 Hz with a maximum filtered readout noise of 0.9 µradians, 1 sigma.

Gyro pulse weight (quantization) is 5.6 µrad. This is equivalent to a contribution of 5.6/(sqrt 12) = 1.62 µrad (1 sigma) in readout noise.

Rate detection threshold noise: There shall be no dead zone between ±0.002 degrees per hour and the full performance rate limit.