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(Revision of
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IEEE Standard for Inertial Sensor Terminology

IEEE Aerospace and Electronic Systems Society

Sponsored by the
Gyro and Accelerometer Panel

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Gyro and Accelerometer Panel
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IEEE Aerospace and Electronic SystemsSociety

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Abstract: Terms and definitions relating to inertial senors are presented in this standard. Usage as understood by the inertial sensor community is given preference over general technical usage of the terms herein. The criterion for inclusion of a term and its definition in this standard is usefulness as related to inertial sensor technology.
Keywords: inertial sensor technology, inertial sensor terminology

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Introduction

(This introduction is not a part of IEEE Std 528-2001, IEEE Standard for Inertial Sensor Terminology)

IEEE Std 528-2001 is a revision of IEEE Std 528-1994 and IEEE Std 528-1984. This standard is a listing of terms and definitions relating to inertial sensors. The criterion for inclusion of terms and definitions in this standard is their general usefulness as related to inertial sensor technology. This revision adds new terms associated with recent advancements in inertial sensor technology.

In this standard, the symbol g is used to denote a unit of acceleration equal in magnitude to the local value of gravity at a test site or the standard value 9.80665 m/s^2. The symbol g is thus distinguished from g, which is the standard symbol for gram.

Participants

This standard represents a consensus of manufacturers and users in industry, government agencies, and other interested groups. When necessary, the needs of the inertial sensor community have been given preference over general technical usage. For example, "degree-of-freedom," "rotor angular momentum," and "pendulosity" are defined in a specialized sense, as applied to inertial sensors. In general, definitions that might be found in a standard textbook have not been included; for example, "damping ratio" and "orthogonality."

This standard was prepared by the Gyro and Accelerometer Panel of the IEEE Aerospace Electronic Systems Society. This publication represents a group effort on a large scale. The major contributors to IEEE Std 528-1994 and to earlier versions were as follows:

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A total of 70 individuals attended 16 meetings of the Gyro and Accelerometer Panel during the preparation of this revised standard, IEEE Std 528-2001. The following individuals on the Gyro and Accelerometer Panel contributed to IEEE Std 528-2001:

Sid Bennett, *Chair*

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Michael E. Ash	Ken Homb	Rex B. Peters*
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The following members of the balloting group voted on this revised standard. Balloters may have voted for approval, disapproval, or abstention.

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Cleon H. Barker	Yoshiaki Hirobe	Rex B. Peters
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Yuri V. Filatov	Ralph B. Morrow, Jr.	Bruce R. Youmans
Thomas A. Fuhrman	Peter J. Palmer	

When the IEEE Standards Board approved this standard on 7 August 2001, it had the following membership:

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IEEE Standard for Inertial Sensor Terminology

1. Overview

This standard presents terms and definitions relating to inertial sensors. Usage as understood by the inertial sensor community is given preference over general technical usage of the terms herein. The criterion for inclusion of a term and its definition in this standard is usefulness as related to inertial sensor technology.

2. Definitions

2.1 acceleration-insensitive drift rate (gyro): The component of environmentally sensitive drift rate not correlated with acceleration.

NOTE—Acceleration-insensitive drift rate includes the effects of temperature, magnetic, and other external influences.

2.2 acceleration random walk (accelerometer): *See:* **random walk (acceleration random walk).**

2.3 acceleration-sensitive drift rate (gyro): The components of systematic drift rate correlated with the first power of a linear acceleration component, typically expressed in $(^\circ/\mathrm{h})/g$.

2.4 acceleration-squared-sensitive drift rate (gyro): The components of systematic drift rate correlated with either the second power of a linear acceleration component or the product of two linear acceleration components, typically expressed in $(^\circ/\mathrm{h})/g^2$.

2.5 accelerometer: An inertial sensor that measures linear or angular acceleration. Except where specifically stated, the term *accelerometer* refers to linear accelerometer. *See:* **angular accelerometer; linear accelerometer.**

2.6 activation time (gyro, accelerometer): *See:* **turn-on time.**

2.7 activity dip (vibrating beam accelerometer): The phenomenon where, at certain frequencies, the resonator vibration amplitude decreases due to parasitic resonances within itself or with the surrounding structure.

2.8 alignment (gyro, accelerometer): *See:* **input-axis misalignment.**

2.9 Allan variance: A characterization of the noise and other processes in a time series of data as a function of averaging time. It is one half the mean value of the square of the difference of adjacent time averages from a time series as a function of averaging time.

2.10 angle random walk (gyro): *See:* **random walk (angle random walk).**

2.11 angular acceleration sensitivity: (1) (accelerometer). The change of output (divided by the scale factor) of a linear accelerometer that is produced per unit of angular acceleration input about a specified axis, excluding the response that is due to linear acceleration.
(2) (gyro). The ratio of drift rate due to angular acceleration about a gyro axis to the angular acceleration causing it.

NOTE—In single-degree-of-freedom gyros, it is nominally equal to the effective moment of inertia of the gimbal assembly divided by the angular momentum.

2.12 angular accelerometer: An inertial sensor that measures the rate of change of inertial angular velocity about its input axis(es).

NOTE—An output signal is produced from the angular motion of a proof mass (rigid or fluid) relative to a case; or by differentiating the output of a strapdown gyroscope; or by differencing the outputs from an array of linear accelerometers.

2.13 angular-case-motion sensitivity (dynamically tuned gyro): The drift rate resulting from an oscillatory angular input about an axis normal to the spin axis at twice the rotor spin frequency. This effect is due to the single-degree-of-freedom of the gimbal relative to the support shaft and is proportional to the input amplitude and phase relative to the flexure axes. *See:* **two-N (2N) angular sensitivity.**

2.14 angular velocity sensitivity (accelerometer): The change of output (divided by the scale factor and the square of angular rate or product of two angular rates) of a linear accelerometer that is produced per unit of angular velocity squared, when spun about a specified axis, excluding the response that is due to acceleration. *See:* **effective center-of-mass for angular velocity; rate-squared sensitivity.**

2.15 angular vibration sensitivity (gyro): The ratio of the change in output due to angular vibration about a sensor axis to the amplitude of the angular vibration causing it.

2.16 anisoelasticity (mechanical gyro): The inequality of compliance of a structure in different directions. *See:* **acceleration-squared-sensitive drift rate; principal axis of compliance.**

2.17 anisoinertia: (1) (accelerometer). A relationship among the principal axis moments of inertia of an accelerometer pendulum in which the moment of inertia about the output axis differs from the difference of the moments of inertia about the other two principal axes. This inequality causes the effective centers of mass for angular velocity and for angular acceleration to be physically separated. In a system in which the accelerometer is modeled as though it were located at the effective center of mass for angular acceleration, there will be an offset in accelerometer output proportional to the product of the angular rates about the input and pendulous axes. Anisoinertia may be expressed as the magnitude of the actual separation in units of length, or as a compensation term in units of $\mu g/(\mathrm{rad/s})^2$. Anisoinertia, in this usage, differs from standard physical definitions, but it describes a real effect that is closely analogous to the effect of the same name in gyros. The effect is most easily described in a pendulous accelerometer, but it can also be seen in a nominally translational proof mass accelerometer that has sufficient angular elastic compliance to emulate a pendulous axis.
(2) (mechanical gyro). The inequality of the moments of inertia about the gimbal principal axes. When the gyro is subjected to angular rates about the input and spin axes, and the moments of inertia about these axes are unequal, a torque is developed about the output axis that is proportional to the difference of the inertias about the input and spin axes multiplied by the product of the rates about these two axes.

2.18 anti-lock means (laser gyro): Mitigation of lock-in effects by inducing a nonreciprocal phase (or frequency) shift between the counter-propagating beams.

NOTE—This can be accomplished by mechanical or magneto-optical means.

2.19 anti-lock residual (laser gyro): Output noise remaining after compensation for anti-lock means.

2.20 ARW: *See:* **angle random walk.**

2.21 attitude storage (mechanical gyro): The transient deviation of the output of a rate-integrating gyro from that of an ideal integrator when the gyro is subjected to an input rate. It is a function of the gyro characteristic time (see Figure 1). *See:* **float storage; torque-command storage.**

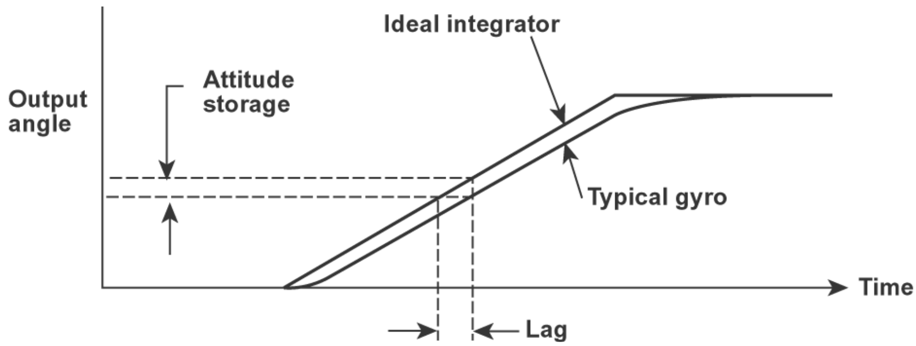


Figure 1—Attitude storage

2.22 autoerection (mechanical gyro): The process by which gimbal axis friction causes the spin axis of a free gyro to tend to align with the axis about which the case is rotated. The resulting drift rate is a function of the angular displacement between the spin axis and the rotation axis.

2.23 automatic bias nulling (gyro, accelerometer): A circuit or system technique for setting the mean value of sensor output, averaged over a defined time period, to zero, or to some defined value.

2.24 axis-of-freedom (gyro): A rotational axis that provides a degree-of-freedom. *See:* **degree-of-freedom.**

2.25 bias: (1) (accelerometer). The average over a specified time of accelerometer output measured at specified operating conditions that has no correlation with input acceleration or rotation. Bias is expressed in [m/s^2, g].
(2) (gyro). The average over a specified time of gyro output measured at specified operating conditions that has no correlation with input rotation or acceleration. Bias is typically expressed in degrees per hour ($^\circ$/h).

NOTE—Control of operating conditions may address sensitivities such as temperature, magnetic fields, and mechanical and electrical interfaces, as necessary.

2.26 bias asymmetry (gyro, accelerometer): The difference between the bias for positive and negative inputs, typically expressed in degrees per hour ($^\circ$/h) or [m/s^2, g].

2.27 biasing (laser gyro): The action of intentionally imposing a real or artificial rate into a laser gyro to avoid the region in which lock-in occurs.

2.28 bias instability (gyro, accelerometer): The random variation in bias as computed over specified finite sample time and averaging time intervals. This nonstationary (evolutionary) process is characterized by a $1/f$ power spectral density. It is typically expressed in degrees per hour ($^\circ$/h) or [m/s^2, g], respectively.

2.29 binary torquing (mechanical gyro, accelerometer): A torquing mechanization that uses only two torquer current levels that are usually positive and negative of the same magnitude; no sustained zero current or off condition exists. The positive and negative current periods can be either discrete pulses or duration-modulated pulses. In the case of zero input (acceleration or angular rate), a discrete pulse system will produce an equal number of positive and negative pulses. A pulse-duration-modulated system will produce positive and negative current periods of equal duration for zero input. Binary torquing delivers constant power to a sensor torquer (as compared to variable power ternary torquing) and results in stable thermal gradients for all inputs.

2.30 caging (mechanical gyro): The process of orienting and mechanically locking one or more gyro axes or gimbal axes to a reference position.

2.31 capturing (mechanical gyro, accelerometer): The use of a torquer (forcer) in a servo loop to restrain a gyro gimbal, rotor, or accelerometer proof mass to a specified reference position.

2.32 case (gyro, accelerometer): The housing or package that encloses the sensor, provides the mounting surface, and defines the reference axes.

2.33 characteristic time (mechanical gyro, accelerometer): The time required for the output to reach 63% of its final value for a step input.

NOTE—For a single-degree-of-freedom, rate-integrating gyro, characteristic time is numerically equal to the ratio of the float moment of inertia to the damping coefficient about the output axis. For certain fluid-filled sensors, the float moment of inertia may include other effects, such as that of transported fluid.

2.34 coast time (mechanical gyro): *See:* **run-down time.**

2.35 command rate (mechanical gyro): The input rate equivalent to a torquer command signal.

2.36 composite error (gyro, accelerometer): The maximum deviation of the output data from a specified output function. Composite error is due to the composite effects of hysteresis, resolution, nonlinearity, nonrepeatability, and other uncertainties in the output data. It is generally expressed as a percentage of half the output span. *See:* **input-output characteristics.**

2.37 coning effect (gyro): The apparent drift rate caused by motion of an input axis in a manner that generally describes a cone. This usually results from a combination of oscillatory motions about the gyro principal axes. The apparent drift rate is a function of the amplitudes and frequencies of oscillations present and the phase angles between them, and is equal to the net solid angle swept out by the input axis per unit time.

2.38 Coriolis acceleration: The acceleration of a particle in a coordinate frame rotating in inertial space, arising from its velocity with respect to that frame.

2.39 Coriolis vibratory gyro (CVG): A gyro based on the coupling of a structural, driven, vibrating mode into at least one other structural mode (pickoff) via Coriolis acceleration.

NOTE—CVGs may be designed to operate in open-loop, force-rebalance (i.e., closed-loop), and/or whole-angle modes.

2.40 coupler, optical (interferometric fiber optic gyro): *See:* **directional coupler, optical.**

2.41 cross acceleration (accelerometer): The acceleration applied in a plane normal to an accelerometer input reference axis.

2.42 cross-axis sensitivity (accelerometer): The proportionality constant that relates a variation of accelerometer output to cross acceleration. This sensitivity varies with the direction of cross acceleration and is primarily due to misalignment.

2.43 cross-coupling coefficient (accelerometer): The proportionality constant that relates a variation of accelerometer output to the product of acceleration applied normal and parallel to an input reference axis. This coefficient can vary depending on the direction of cross acceleration.

2.44 cross-coupling errors (gyro): The errors in the gyro output resulting from gyro sensitivity to inputs about axes normal to an input reference axis.

2.45 CVG: *See:* **Coriolis vibratory gyro.**

2.46 damping fluid (mechanical gyro, accelerometer): A fluid that provides viscous damping forces or torques to the inertial sensing element. *See:* **flotation fluid.**

2.47 dead band (gyro, accelerometer): A region between the input limits within which variations in the input produce output changes of less than 10% (or other small value) of those expected based on the nominal scale factor. *See:* **input-output characteristics.**

2.48 degree-of-freedom (DOF) (mechanical gyro): An allowable mode of angular motion of the spin axis with respect to the case. The number of degrees-of-freedom is the number of orthogonal axes about which the spin axis is free to rotate.

2.49 depolarizer, optical (interferometric fiber optic gyro): A component placed in an optical path that results in depolarization of the input light regardless of its state of polarization.

NOTE 1—Depolarizers are usually composed of two or more birefringent sections (optical fiber or crystal material such as quartz), each of which introduces a relatively large and different retardation. NOTE 2—Depolarization depends on the bandwidth of the light being more complete for wide bandwidth sources and not possible for purely monochromatic light.

2.50 directional coupler, optical (interferometric fiber optic gyro): A device that combines or splits the optical wave(s) from one or more waveguides to produce one or more optical waves.

2.51 directional gyro: A two-degree-of-freedom gyro with a provision for maintaining the spin axis approximately horizontal. In this gyro, an output signal is produced by gimbal angular displacement that corresponds to the angular displacement of the case about an axis that is nominally vertical.

2.52 discharge oscillations (laser gyro): Periodic variations in voltage and current at the terminals of a dc discharge tube that are supported by the negative resistance of the discharge tube itself.

2.53 dither spillover (laser gyro): *See:* **anti-lock residual.**

2.54 DOF: *See:* **degree-of-freedom.**

2.55 dormancy (gyro, accelerometer): The state wherein a sensor is connected to a system in the normal operational configuration and experiences below-normal often periodic, structural, mechanical, electrical, or environmental stresses for prolonged periods before being used in a mission. Dormancy consists of a long, predominantly inactive, period where material and component degradation effects due to age and/or storage environment dominate.

2.56 drift rate (gyro): The component of gyro output that is functionally independent of input rotation. It is expressed as an angular rate. See Figure 2.

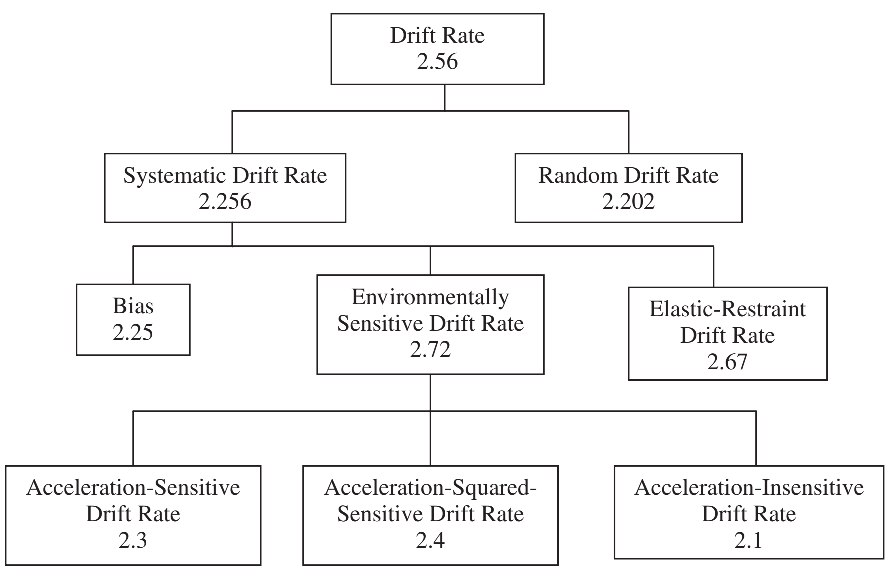


Figure 2—Components of gyro drift rate

2.57 DTG: *See:* **dynamically tuned gyro.**

2.58 dynamically tuned gyro (DTG): A two-degree-of-freedom gyro in which a dynamically tuned flexure and gimbal mechanism both support the rotor and provide angular freedom about axes perpendicular to the spin axis. *See:* **dynamic tuning.**

2.59 dynamic range (gyro, accelerometer): The ratio of the input range to the resolution. *See:* **input-output characteristics.**

2.60 dynamic time constant: (1) (accelerometer). The delay time between an input ramp and the output after steady state is reached. For a second-order system, it has a value of twice the damping ratio divided by the natural frequency in radians/second.
(2) (dynamically tuned gyro). The time required for the rotor to move through an angle equal to 63% of its final value following a step change in case angular position about an axis normal to the spin axis with the gyro operating open loop. The value depends on the gimbal and rotor damping and drag forces, and is inversely proportional to quadrature spring rate.

2.61 dynamic tuning (dynamically tuned gyro): The adjustment of the gimbal inertia, flexure spring rate, or the spin rate of a rotor suspension system to achieve a condition in which the dynamically induced (negative) spring rate cancels the spring rate of the flexure suspension.

2.62 earth rate: The angular velocity of the earth with respect to inertial space. Its magnitude is $7.292\,115 \times 10^{-5}$ rad/s ($15.041\,06°$/h). This vector quantity is usually expressed as two components in local level coordinates, north (or horizontal) and up (or vertical).

2.63 earth's rate correction (gyro): A command rate applied to a gyro to compensate for the rotation of the earth with respect to the gyro input axis.

2.64 effective center-of-mass for angular acceleration (accelerometer): That point defined by the intersection of the pendulous axis and an axis parallel to the output axis, about which angular acceleration results in a minimum accelerometer output.

2.65 effective center-of-mass for angular velocity (accelerometer): That point defined by the intersection of the pendulous axis and an axis of constant angular rate approximately parallel to the input axis, for which the offset due to spin becomes independent of orientation. *See:* **spin-offset coefficient.**

2.66 elastic-restraint coefficient (mechanical gyro): The ratio of gimbal restraining torque about an output axis to the output angle.

2.67 elastic-restraint drift rate (mechanical gyro): The component of systematic drift rate that is proportional to the angular displacement of a gyro gimbal about an output axis. The relationship of this component of drift rate to the gimbal angle can be stated by means of a coefficient having dimensions of angular displacement per unit time per unit angle. This coefficient is equal to the elastic-restraint coefficient divided by angular momentum.

2.68 electrical null (gyro, accelerometer): The minimum electrical output. It may be specified in terms of root-mean-square (rms), peak-to-peak, quadrature component, or other electrical parameters.

2.69 electrical null position (mechanical gyro, accelerometer): The angular or linear position of a pickoff corresponding to electrical null.

2.70 electrical zero: Deprecated. *See:* **electrical null position.**

2.71 electrostatically suspended gyro (ESG): A free gyro in which the main rotating element—the inertial member—is suspended by an electrostatic field within an evacuated enclosure.

2.72 environmentally sensitive drift rate (gyro): The component of systematic drift rate that includes acceleration-sensitive, acceleration-squared-sensitive, and acceleration-insensitive drift rates.

2.73 erection (mechanical gyro): The process of aligning, by precession, a reference axis with respect to the vertical.

2.74 erection cut-out (mechanical gyro): The feature wherein the signal supplying the erection torque is disconnected in order to minimize vehicle maneuver effects.

2.75 erection or slaving rate (mechanical gyro): The angular rate at which the spin axis is precessed to a reference position. It is expressed as angular displacement per unit time.

2.76 error band (gyro, accelerometer): A specified band about the specified output function that contains the output data. The error band contains the composite effects of nonlinearity, resolution, nonrepeatability, hysteresis, and other uncertainties in the output data. *See:* **input-output characteristics.**

2.77 ESG: *See:* **electrostatically suspended gyro.**

2.78 Faraday cell (laser gyro): A biasing device consisting of an optical material with a Verdet constant, such as quartz, that is placed between two quarter-wave plates and surrounded by a magnetic field in such a fashion that a differential phase change is produced for oppositely directed plane-polarized waves.

2.79 figure of merit (FOM) (dynamically tuned gyro): A design constant that relates the rotor polar moment of inertia and the principal moments of inertia of the gimbal(s). A simplified expression for the figure of merit is

$$\mathrm{FOM} = \frac{C}{\sum_{n=1}^{N} (A_n + B_n - C_n)}$$

where

C	is the rotor polar moment of inertia,
A_n, B_n	are the transverse moments of inertia of the nth gimbal,
C_n	is the polar moment of inertia of the nth gimbal.

2.80 flexure (gyro, accelerometer): Mechanical restraint element that is elastic in the desired degree(s)-of-freedom and rigid in others.

2.81 float (mechanical gyro, accelerometer): An enclosed gimbal assembly immersed in a fluid that is usually at the condition of neutral buoyancy.

2.82 float-displacement hysteresis (mechanical gyro, accelerometer): The difference in rebalance torque or equivalent input after displacing the float about the output axis from its null position in successive clockwise and counterclockwise directions by equal amounts (up to its full range of angular freedom, unless otherwise specified). The float may be displaced by applying torques to the float through a torquer or through gyroscopic or acceleration torques in either open- or closed-loop mode. The amount of float-displacement hysteresis may depend on the methods of applying torques, on the mode of operation (open- or closed-loop), and on the amount and duration of float displacement.

2.83 float storage (mechanical gyro): The sum of attitude storage and torque-command storage in a rate-integrating gyro. *See:* **attitude storage; torque-command storage.**

2.84 flotation fluid (mechanical gyro, accelerometer): The fluid that suspends the float inside the instrument case. The float may be fully or partially floated within the fluid. The degree of flotation varies with temperature because the specific gravity of the fluid varies with temperature. In addition, the fluid provides damping. *See:* **damping fluid.**

2.85 FOM: *See:* **figure of merit.**

2.86 forcer: *See:* **torquer.**

2.87 force-rebalance mode (Coriolis vibratory gyro): A mode in which the vibration amplitude of the pickoff is nulled by a signal whose amplitude is proportional to the rotation rate about the input axis(es).

2.88 free gyro (mechanical gyro): A two-degree-of-freedom gyro in which the spin axis may be oriented in any specified attitude. In this gyro, output signals are produced by an angular displacement of the case about an axis other than the spin axis.

2.89 frequency lock (vibrating beam accelerometer): The phenomenon where, in a certain band of acceleration around the cross-over point of the dual resonator frequencies, the resonator frequencies lock together and do not normally respond to changes in acceleration.

2.90 full range (gyro, accelerometer): The algebraic difference between the upper and lower values of the input range. *See:* **input-output characteristics.**

2.91 full-scale input (gyro, accelerometer): The maximum magnitude of the two input limits. *See:* **input-output characteristics.**

2.92 *g*: The magnitude of the local plumb bob gravity that is used as a reference value of acceleration.

NOTE 1—g is a convenient reference used in inertial sensor calibration and testing. NOTE 2—In some applications, the standard value of g ($g_n = 9.806\ 65\,\mathrm{m/s^2}$) may be specified. NOTE 3—The symbol g is printed in italic type to differentiate it from the symbol g, representing gram, which is printed in roman (non-italic) type.

2.93 gain medium (laser gyro): A medium that, when energized, provides amplification of coherent light waves to maintain lasing within a closed optical path.

2.94 gas flow error (laser gyro): The error resulting from the flow of gas in dc discharge tubes.

2.95 gimbal (mechanical gyro): A device that permits the spin axis to have an angular degree of freedom.

NOTE—A gyro may have more than one gimbal.

2.96 gimbal error (mechanical gyro): The error resulting from angular displacements of gimbals from their reference positions such that gimbal pickoffs do not measure the true angular motion of the case about the input reference axis.

2.97 gimbal freedom (mechanical gyro): The maximum angular displacement of a gimbal about its axis.

2.98 gimbal lock (mechanical gyro): A condition of a two-degree-of-freedom gyro wherein the alignment of the spin axis with an axis-of-freedom deprives the gyro of a degree-of-freedom and, therefore, of its useful properties.

2.99 gimbal retardation (mechanical gyro): A measure of output-axis friction torque when the gimbal is rotated about the output axis. It is expressed as an equivalent input.

2.100 gimbal-unbalance torque (dynamically tuned gyro): The acceleration-sensitive torque caused by gimbal unbalance along the spin axis due to nonintersection of the flexure axes. Under constant acceleration, it appears as a second harmonic of the rotor spin frequency because of the single-degree-of-freedom of the gimbal relative to the support shaft. When the gyro is subjected to vibratory acceleration applied normal to the spin axis at twice the rotor spin frequency, this torque results in a rectified unbalance drift rate. *See:* **synchronous-vibration sensitivity; two-N (2N) translational sensitivity.**

2.101 gravimeter: A device for measuring the acceleration due to gravity at a fixed point on the earth or other celestial body.

2.102 gravity gradiometer: A device for measuring the components of the gravity gradient tensor.

2.103 gyro (gyroscope): An inertial sensor that measures angular rotation with respect to inertial space about its input axis(es).

NOTE 1—The sensing of such motion could utilize the angular momentum of a spinning rotor, the Coriolis effect on a vibrating mass, or the Sagnac effect on counter-propagating light beams in a ring laser or an optical fiber coil. NOTE 2—This definition does not include more complex systems, such as stable platforms, that use gyros as components.

2.104 gyrocompass: A device or technique for determining the horizontal north direction using one or more gyroscope(s) to sense the earth rotation and a vertical sensor.

2.105 gyro gain (mechanical gyro): The ratio of the output angle of the gimbal to the input angle of a rate-integrating gyro at zero frequency. It is numerically equal to the ratio of the rotor angular momentum to the damping coefficient.

2.106 gyro operating null (dynamically tuned gyro): The condition where minimum change in drift rate occurs due to changes in wheel speed.

2.107 hang-off (mechanical gyro, accelerometer): The displacement of an inertial sensing element from its null position that occurs when an input is applied, and which is due to the finite compliance of a capture loop or a restoring spring.

2.108 hinge axis (accelerometer): *See:* **output axis.**

2.109 hysteresis error (gyro, accelerometer): The maximum separation due to hysteresis between up-scale-going and down-scale-going indications of the measured variable (during a full-range traverse, unless otherwise specified) after transients have decayed. It is generally expressed as an equivalent input. *See:* **input-output characteristics.**

2.110 IA: *See:* **input axis.**

2.111 IFOG: *See:* **interferometric fiber optic gyro.**

2.112 inertial instrument: *See:* **inertial sensor.**

2.113 inertial sensor: A position, attitude, or motion sensor whose references are completely internal, except possibly for initialization.

2.114 initial erection (mechanical gyro): The mode of operation of a vertical gyro, in which the gyro is being erected or slaved initially.

2.115 in-phase spring rate (dynamically tuned gyro): The residual difference in a dynamically tuned gyro between the dynamically induced spring rate and the flexure spring rate.

2.116 input angle (gyro): The angular displacement of the case about an input axis.

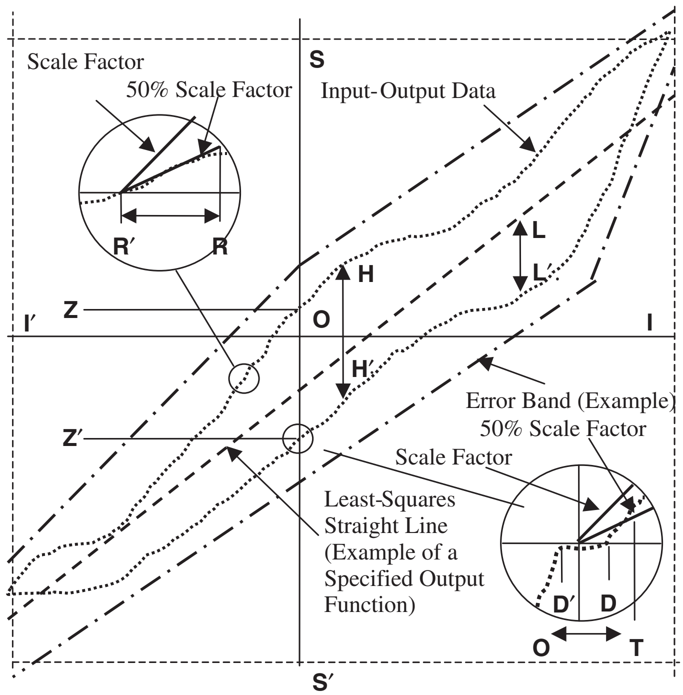
2.117 input axis (IA): (1) (accelerometer). The axis(es) along or about which a linear or angular acceleration input causes a maximum output.
(2) (gyro). The axis(es) about which a rotation of the case causes a maximum output.

NOTE 1—For a multi-input axis device, an orthogonal set of input axes is defined by the placement of the pickoffs. NOTE 2—For mechanical gyros, the input axis(es) is (are) perpendicular to the spin or vibration axis. NOTE 3—For planar laser gyros, the input axis is a vector perpendicular to the plane in which photons circulate; or for nonplanar laser gyros, the input axis is the resultant of same-handed vectors perpendicular to the planes in which the closed optical path lies. NOTE 4—For fiber optic gyros, the input axis is along the axis about which the optical fiber coil is wound.

2.118 input-axis misalignment (gyro, accelerometer): The angle between an input axis and its associated input reference axis when the device is at a null condition.

NOTE—The magnitude of this angle is unambiguous but, when components are reported, the convention should always be identified. IEEE standards use both direction cosines and right-handed Euler angles, depending on the principal field of application. Other conventions, differing both in signs and in designation of axes, are sometimes used.

2.119 input limits (gyro, accelerometer): The extreme values of the input, generally plus or minus, within which performance is of the specified accuracy. *See:* **input-output characteristics.**



Composite error $= \dfrac{100(L-L')}{S-O}$ or $\dfrac{100(L-L')}{O-S'}$

Dead band $= D - D'$

Dynamic range $= \dfrac{I-I'}{R-R'}$

Hysteresis error $= (H-H') \times \dfrac{I-I'}{S-S'}$

Input limits $= I, I'$

Input range $= I'$ to I

Full range $= I - I'$

Output range $= S'$ to S

Output span $= S - S'$

Resolution $= R - R'$

Scale factor $= \dfrac{S-S'}{I-I'}$

Threshold $= T - O$

Zero offset $= \dfrac{Z+Z'}{2} \times \dfrac{I-I'}{S-S'}$

Figure 3—Input-output characteristics

2.120 input-output characteristics (gyro, accelerometer): Figure 3 shows the relationship between the input-output characteristics of an accelerometer or gyro.

2.121 input range (gyro, accelerometer): The region between the input limits within which a quantity is measured, expressed by stating the lower- and upper-range value. For example, an angular displacement input range of -5° to $+6^\circ$. *See:* **input-output characteristics.**

2.122 input rate (gyro): The angular displacement per unit time of the case about an input axis.

2.123 input reference axis (IRA) (gyro, accelerometer): The direction of an axis (nominally parallel to an input axis) as defined by the case mounting surfaces, or external case markings, or both.

2.124 input span (gyro, accelerometer): *See:* **full range.**

2.125 integrating accelerometer: An accelerometer that produces an output proportional to the time integral of the sensed acceleration.

2.126 interferometric fiber optic gyro (IFOG): A single-axis gyro based on the Sagnac effect, using the interference pattern between counter-propagating optical beams in an optical fiber coil.

NOTE 1—For increased sensitivity, a nonreciprocal phase shift is imposed between the counter-propagating beams. NOTE 2—The dynamic range is increased and scale factor linearity is improved by operating in a closed-loop mode.

2.127 IRA: *See:* **input reference axis.**

2.128 isolator, optical (interferometric fiber optic gyro): A device intended to suppress return reflections along a transmission path.

NOTE—The Faraday isolator uses the magneto-optic effect.

2.129 jerk: A vector that specifies the time rate of change of the acceleration; the third derivative of displacement with respect to time.

2.130 laser gyro: A single-axis gyro based on the Sagnac effect, using optical heterodyning of internally generated counter-propagating optical beams.

NOTE—Typical implementations include three- or four-mirror planar devices using mechanical anti-lock means, and four-mirror nonplanar devices using magneto-optical anti-lock means.

2.131 lasing threshold (laser gyro): The discharge current at which the gain of the laser just equals the losses.

2.132 LED: *See:* **light-emitting diode.**

2.133 light-emitting diode (LED) (interferometric fiber optic gyro): A p-n junction semiconductor device that emits low-coherence optical radiation by spontaneous emission when biased in the forward direction.

2.134 linear accelerometer: An inertial sensor that measures the component of translational acceleration minus the component of gravitational acceleration along its input axis(es).

NOTE 1—An output signal is produced from the motion of a proof mass relative to the case, or from the force or torque required to restore the proof mass to a null position relative to the case. NOTE 2—When transforming to an inertial frame for navigation computations, a linear accelerometer's output must be compensated for the effects of centripetal and angular acceleration and gravity. *See:* **nongravitational acceleration.**

2.135 linearity error (gyro, accelerometer): The deviation of the output from a least-squares linear fit of the input-output data. It is generally expressed as a percentage of full scale, or percent of output, or both. *See:* **composite error; input-output characteristics.**

2.136 lock-in (laser gyro): The phenomenon exhibited by laser gyros that is characterized by frequency locking of the clockwise and counterclockwise beams at low input rates. It is caused by the coupling of energy between the laser beams, and it results in a threshold error near zero input angular rate unless a corrective means, such as biasing, is used.

2.137 lock-in rate (laser gyro): One half of the absolute value of the algebraic difference between the two rates defining the region over which lock-in occurs.

2.138 mass unbalance (mechanical gyro): The characteristic of a gyro resulting from lack of coincidence of the center of supporting forces and the center of mass. It gives rise to torques caused by linear accelerations that lead to acceleration-sensitive drift rates.

2.139 mechanical freedom (accelerometer): The maximum linear or angular displacement of the accelerometer's proof mass, relative to its case.

2.140 mechanical gyro: Gyro based on the angular momentum of a spinning rotor or the Coriolis effect on a vibrating mass.

2.141 microsyn (mechanical gyro, accelerometer): An electromagnetic device often used as a pickoff in single-degree-of-freedom gyros and accelerometers. It has a stator fastened to the sensor case containing primary and secondary sets of windings, and a rotor without windings that is attached to the float.

2.142 misalignment (gyro, accelerometer): *See:* **input-axis misalignment.**

2.143 multimode fiber (interferometric fiber optic gyro): An optical fiber waveguide that will allow more than one bound mode to propagate.

2.144 multisensor: A device that measures more than one type of inertial input, such as linear acceleration and angular motion.

2.145 natural frequency (gyro, accelerometer): The frequency at which the output lags the input by 90°. It generally applies only to inertial sensors with approximate second-order response.

2.146 nongravitational acceleration (accelerometer): The component of the acceleration of a body that is caused by externally applied forces (excluding gravity) divided by the mass.

NOTE 1—In vector notation:

$$\vec{A} = \vec{G} + \vec{N}$$

where

$\vec{A}$ is the translational (kinematic) acceleration (i.e., the second derivative of position in inertial space with respect to time),

$\vec{G}$ is the acceleration due to gravity, the acceleration of an object that is allowed to fall freely in the local gravitational field,

$\vec{N}$ is the nongravitational acceleration.

NOTE 2—For an accelerometer, it is the indicated acceleration, $\vec{A}_{\text{ind}} = \vec{N} = \vec{A} - \vec{G}$. A freely falling accelerometer ($\vec{A} = \vec{G}$) has zero output, and an earth-fixed accelerometer ($\vec{A} = 0$) indicates $1\,g$ upward due to the upward reaction of the support to gravity pulling downward. NOTE 3—Nongravitational acceleration is sometimes referred to as specific force. *See:* **linear accelerometer.**

2.147 nonlinearity (gyro, accelerometer): The systematic deviation from the straight line that defines the nominal input-output relationship.

2.148 null (gyro, accelerometer): *See:* **electrical null.**

2.149 null offsetting (gyro, accelerometer): A calibration or test technique by which the electrical null position is intentionally shifted, resulting in a rotation of the input axis relative to the input reference axis.

2.150 nutation (mechanical gyro): The oscillation of the spin axis of a gyro about two orthogonal axes normal to the mean position of the spin axis.

2.151 nutation frequency (mechanical gyro): The frequency of the coning or periodic wobbling motion of the rotor spin axis that results from a transient input. For an undamped rotor, the nutation frequency equals the product of the rotor spin frequency and the ratio of the rotor polar moment of inertia to the effective rotor transverse moment of inertia.

2.152 OA: *See:* **output axis.**

2.153 one-N (1N) modulation (dynamically tuned gyro): The modulation of the pickoff output at spin frequency.

2.154 one-N (1N) translational sensitivity (dynamically tuned gyro): *See:* **radial-unbalance torque.**

2.155 open-loop mode (Coriolis vibratory gyro): A mode in which the vibration amplitude of the pickoff is proportional to the rotation rate about the input axis(es).

2.156 operating life (gyro, accelerometer): The accumulated time of operation throughout which a gyro or accelerometer exhibits specified performance when maintained and calibrated in accordance with a specified schedule.

2.157 operating temperature (gyro, accelerometer): The temperature at one or more gyro or accelerometer elements when the device is in the specified operating environment.

2.158 optical gyro: Gyro based on the Sagnac effect.

2.159 optical path length (laser gyro, interferometric fiber optic gyro): The optical length of the path traversed in a single pass by an optical beam, taking into account the index of refraction of each medium supporting propagation.

2.160 ORA: *See:* **output reference axis.**

2.161 output angle (mechanical gyro): The angular displacement of a gimbal about its output axis with respect to its support.

2.162 output axis (OA) (mechanical gyro, accelerometer): An axis-of-freedom about which the output of the sensor is measured. A pickoff generates an output signal as a function of the output angle. In an accelerometer, it is sometimes referred to as the hinge or flexure axis.

NOTE—In a translational proof mass accelerometer, there is no output axis perpendicular to the input axis; the pickoff senses motion along the input axis.

2.163 output-axis-angular-acceleration drift rate (mechanical gyro): Drift rate that is proportional to angular acceleration of the gyro case about the output axis with respect to inertial space. The relationship of this component of drift rate to angular acceleration can be stated by means of a coefficient having dimensions of angular displacement per unit time divided by angular displacement per unit time squared.

2.164 output pulse (gyro, accelerometer): A pulse that represents the minimum unit of angle increment [$^\circ$, $''$, rad] or velocity increment [m/s, $g \cdot$ s], respectively.

2.165 output range (gyro, accelerometer): The product of input range and scale factor. *See:* **input-output characteristics.**

2.166 output reference axis (ORA) (gyro, accelerometer): The direction of an axis defined by the case mounting surfaces, or external case markings, or both. It is nominally parallel to the output axis.

2.167 output span (gyro, accelerometer): The algebraic difference between the upper and lower values of the output range. *See:* **input-output characteristics.**

2.168 overload capacity (accelerometer): The maximum acceleration to which an accelerometer may be subjected beyond the normal operating range without causing a permanent change in the specified performance characteristics.

2.169 PA: *See:* **pendulous axis.**

2.170 path length (laser gyro, interferometer fiber optic gyro): The geometrical length of the path traversed in a single pass by an optical beam. *See:* **optical path length.**

2.171 pendulosity (mechanical gyro, accelerometer): The product of the inertial-sensing mass and the distance from the center of mass to the center of support measured along the pendulous axis.

2.172 pendulous accelerometer. An accelerometer that employs a proof mass that is suspended to permit rotation about an axis perpendicular to its input axis.

2.173 pendulous axis (PA) (accelerometer): In pendulous devices, an axis through the mass center of the proof mass, perpendicular to and intersecting the output axis. The positive direction is defined from the output axis to the proof mass.

2.174 pendulous integrating gyroscopic accelerometer (PIGA): A linear accelerometer using a single-degree-of-freedom gyro having a pendulosity along the spin axis that is servo-driven about the input axis at a rate that balances the torque induced by sensed acceleration along the input axis. The angle through which the servoed axis rotates is proportional to the integral of the sensed acceleration.

2.175 pendulous reference axis (PRA) (accelerometer): The direction of an axis, as defined by the case mounting surfaces or external case markings, or both. It is nominally parallel to the pendulous axis.

2.176 phase modulator, optical (interferometric fiber optic gyro): A device that modulates the phase of a light wave as a function of an electrical control signal.

NOTE—Commonly used phase modulators vary the optical path length by means of electro-optic or elasto-optic effects.

2.177 pickoff (mechanical gyro, accelerometer): A device that produces an output signal as a function of the relative linear or angular displacement between two elements.

2.178 pickoff axis (dynamically tuned gyro): The axis of angular displacement between the rotor and the case that results in the maximum signal per unit of rotation from the pickoff.

2.179 pickoff offset (dynamically tuned gyro): The difference in angular rotor position between operation at pickoff electrical null and at gyro operating null.

2.180 piezoelectric accelerometer: A device that employs a piezoelectric material as the principal restraint and pickoff. It is generally used as a vibration or shock sensor.

2.181 PIGA: *See:* **pendulous integrating gyroscopic accelerometer.**

2.182 plumb bob gravity: The force per unit mass acting on a mass at rest at a point on the earth, not including any reaction force of the suspension. The plumb bob gravity includes the gravitational attraction of the earth, the effect of the centripetal acceleration due to the earth rotation, and tidal effects. The direction of the plumb bob gravity acceleration defines the local vertical down direction, and its magnitude defines a reference value of acceleration (g).

2.183 polarization controller, optical (interferometric fiber optic gyro): A component, placed in the optical path, that can be adjusted to change the light from any state of polarization at the input to any desired polarization at the output.

NOTE—In fiber optics, polarization controllers usually consist of two or three sections of birefringent fiber that can be rotated with respect to each other.

2.184 polarization-maintaining fiber (interferometric fiber optic gyro): A single-mode fiber that preserves the plane of polarization of light coupled into it as the beam propagates through its length.

2.185 polarizer, optical (interferometric fiber optic gyro): A device that selects a single, linear polarization state by suppressing the orthogonal state.

2.186 polarizing fiber (interferometric fiber optic gyro): A single-mode fiber that maintains one, and only one, polarization state as the beam propagates through its length by suppressing its orthogonal state.

2.187 power spectral density (PSD): A characterization of the noise and other processes in a time series of data as a function of frequency. It is the mean squared amplitude per unit frequency of the time series. It is usually expressed in $(°/h)^2/Hz$ for gyroscope rate data or in $(m/s^2)^2/Hz$ or g^2/Hz for accelerometer acceleration data.

2.188 PRA: *See:* **pendulous reference axis.**

2.189 precession (mechanical gyro): A rotation of the spin axis produced by a torque, T, applied about an axis mutually perpendicular to the spin axis and the axis of the resulting rotation. A constant precession rate, ω, is related to rotor angular momentum, H, and applied torque, T, by the equation $T = H\omega$.

2.190 principal axis of compliance (gyro, accelerometer): An axis along which an applied force results in a displacement along that axis only.

NOTE—The acceleration-squared error due to anisoelasticity is zero when acceleration is along a principal axis of compliance.

2.191 proof mass (accelerometer): The effective mass whose inertia transforms an acceleration along, or about, an input axis into a force or torque. The effective mass takes into consideration flotation and contributing parts of the suspension.

2.192 PSD: *See:* **power spectral density.**

2.193 pulse capture (mechanical gyro, accelerometer): A technique that uses discrete quanta of torque-time (force-time) for capturing.

2.194 pulse-duration-modulation torquing (gyro, accelerometer): A torquing mechanization that provides current to a sensor torquer of fixed amplitude but variable pulse duration proportional to input. The duration may be quantized to enable digital interpretation and readout. *See:* **binary torquing; ternary torquing.**

2.195 pulse rebalance: *See:* **pulse capture.**

2.196 pulse-width-modulation torquing (mechanical gyro, accelerometer): *See:* **pulse-duration-modulation torquing.**

2.197 quadrature-acceleration drift rate (dynamically tuned gyro): A drift rate about an axis normal to both the spin axis and the axis along which an acceleration is applied. This drift rate results from a torque about the axis of applied acceleration, and it is in quadrature with that due to mass unbalance.

2.198 quadrature spring rate (dynamically tuned gyro): When the case of a dynamically tuned gyro is displaced with respect to the gyro rotor through an angle about an axis perpendicular to the spin axis, a torque proportional to and 90° away from the displacement acts in a direction to reduce this angle and to align the rotor with the case. The torque is usually due to windage, a squeeze-film force, or flexure hysteresis. This spring rate results in a drift rate coefficient having dimensions of angular displacement per unit time per unit angle of displacement about an input axis.

2.199 quantization (gyro, accelerometer): The analog-to-digital conversion of a gyro or accelerometer output signal that gives an output that changes in discrete steps, as the input varies continuously.

2.200 quantization noise (gyro, accelerometer): The random variation in the digitized output signal due to sampling and quantizing a continuous signal with a finite word length conversion. The resulting incremental error sequence is a uniformly distributed random variable over the interval $\pm 1/2$ least significant bit (LSB).

NOTE—It has the same statistical properties as a random binary transmission process. Sometimes referred to as "discrete-time white noise," it is characteristically different from digitized continuous "white noise."

2.201 radial-unbalance torque (dynamically tuned gyro): The acceleration-sensitive torque caused by radial unbalance due to noncoincidence of the flexure axis and the center of mass of the rotor. Under constant acceleration, it appears as a rotating torque at the rotor spin frequency. When the gyro is subjected to vibratory acceleration along the spin axis at the spin frequency, this torque results in a rectified drift rate.

2.202 random drift rate (gyro): The random time-varying component of drift rate.

2.203 random walk: A zero-mean Gaussian stochastic process with stationary independent increments and with standard deviation that grows as the square root of time.

2.203.1 angle random walk (gyro). The angular error buildup with time that is due to white noise in angular rate. This error is typically expressed in degrees per square root of hour [$^\circ/\sqrt{h}$].

2.203.2 rate random walk (gyro). The drift rate error buildup with time that is due to white noise in angular acceleration. This error is typically expressed in degrees per hour per square root of hour [$(^\circ/\mathrm{h})/\sqrt{h}$].

2.203.3 velocity random walk (accelerometer). The velocity error build-up with time that is due to white noise in acceleration. This error is typically expressed in meters per second per square root of hour [$(\mathrm{m/s})/\sqrt{h}$].

2.203.4 acceleration random walk (accelerometer). The acceleration error buildup with time that is due to white noise in jerk. This error is typically expressed meters per second squared per square root of hour [$(\mathrm{m/s^2})/\sqrt{h}$].

2.204 rate biasing (laser gyro): The action of intentionally rotating the laser gyro about the input axis to avoid the region in which lock-in occurs. *See:* **anti-lock means.**

2.205 rate gyro: A gyro whose output is proportional to its angular velocity with respect to inertial space.

NOTE—Historically, the term derives from a single-degree-of-freedom gyro having a primarily elastic restraint of the spin axis about the output axis. In this gyro, an output signal is produced by precession of the gimbal, the precession angle being proportional to the angular rate of the case about the input axis.

2.206 rate-integrating gyro: A gyro whose output is proportional to its integrated angular velocity relative to inertial space.

NOTE—Historically, the term derives from a single-degree-of-freedom gyro having a primarily viscous restraint of the spin axis about the output axis. In this gyro, an output signal is produced by precession of the gimbal, the precession angle being proportional to the integral of the angular rate of the case about the input axis.

2.207 rate ramp (gyro): A gyro behavior characterized by quadratic growth with averaging time of the rate Allan variance.

NOTE—When estimated by a linear least-squares fit to the data time series, this behavior is usually called trend.

2.208 rate random walk (gyro). *See:* **random walk (rate random walk) (gyro).**

2.209 rate-squared sensitivity (angular accelerometer, linear accelerometer): An error torque about the input axis proportional to the product of input rates on the other two axes. This is analogous to anisoinertia torque.

2.210 ratiometric output: An output method where the representation of the measured output quantity (e.g., voltage, current, pulse rate, pulse width) varies in proportion to a reference quantity.

2.211 reaction torque (or force) (mechanical gyro, accelerometer): A torque (or force) exerted on a gimbal, gyro rotor, or accelerometer proof mass, which is usually as a result of applied electrical excitations exclusive of torquer (or forcer) command signals.

2.212 rectification error (accelerometer): A steady-state error in the output while vibratory disturbances are acting on an accelerometer. Anisoelasticity, for example, is one source of rectification error.

2.213 rectified unbalance (dynamically tuned gyro): *See:* **gimbal-unbalance torque.**

2.214 repeatability (gyro, accelerometer): The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or nonoperating periods occur between measurements.

2.215 resolution (gyro, accelerometer): The largest value of the minimum change in input, for inputs greater than the noise level, that produces a change in output equal to some specified percentage (at least 50%) of the change in output expected using the nominal scale factor. *See:* **input-output characteristics.**

2.216 RLG: Ring laser gyro. *See:* **laser gyro.**

2.217 rotor angular momentum (mechanical gyro): The product of spin angular velocity and rotor moment of inertia about its spin axis.

2.218 rotor moment-of-inertia (mechanical gyro): The moment of inertia of a gyro rotor about its spin axis.

2.219 rotor rotation detector (mechanical gyro): A device that produces a signal output as a function of the speed of the rotor.

2.220 rotor-speed sensitivity (dynamically tuned gyro): The change in in-phase spring rate due to a change in gyro rotor speed.

2.221 run-down time (mechanical gyro): The time interval after removal of excitation during which either (1) the gyro maintains specified performance or (2) the sensing element motion decays to a specified characteristic.

2.222 run-up time (mechanical gyro): The time interval after application of excitation required for the gyro sensing element to reach a specified rotation speed or vibration amplitude.

2.223 SA: *See:* **spin axis.**

2.224 Sagnac effect (laser gyro, interferometric fiber optic gyro): A relativistic rotation-induced optical path length difference between electromagnetic waves that counter-propagate around a closed path.

2.225 scale factor (gyro, accelerometer): The ratio of a change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data.

NOTE—For some sensors, the scale factor may be expressed as a reciprocal.

2.226 scale factor asymmetry (gyro, accelerometer): The difference between the scale factor measured with positive input and that measured with negative input, specified as a fraction of the scale factor measured over the input range. Scale factor asymmetry implies that the slope of the input-output function is discontinuous at zero input. It must be distinguished from other nonlinearities.

2.227 sculling effect (accelerometer): The apparent acceleration resulting from the combined inputs of linear vibration along one axis, and angular oscillation at the same frequency around a perpendicular axis. The magnitude of the effect depends on the amplitudes and relative phase of these inputs, and appears on the axis perpendicular to both inputs.

2.228 SDOF, SDF: Single-degree-of-freedom. *See:* **degree-of-freedom.**

2.229 second-order nonlinearity coefficient (accelerometer): The proportionality constant that relates a variation of the output to the square of the input, applied parallel to the input reference axis.

2.230 sensing coil (interferometric fiber optic gyro): A coil of optical fiber in which counter-propagating light waves differ in phase as a consequence of the Sagnac effect, when the coil is rotated about an axis normal to the plane of the coil.

2.231 sensitivity (gyro, accelerometer): The ratio of a change in output to a change in an undesirable or secondary input. For example: a scale factor temperature sensitivity of a gyro or accelerometer is the ratio of change in scale factor to a change in temperature.

2.232 Shupe effect (interferometric fiber optic gyro): A time-variant nonreciprocity due to temperature changes along the length of the fiber.

2.233 signal generator: *See:* **pickoff.**

2.234 single-mode fiber (interferometric fiber optic gyro): An optical fiber waveguide in which only the lowest-order bound mode (which may consist of a pair of orthogonally polarized fields) can propagate at the wavelength of interest.

2.235 slaving (mechanical gyro): The use of a torquer to maintain the orientation of the spin axis relative to an external reference, such as a pendulum or magnetic compass.

2.236 SLED, SLD: *See:* **superluminescent light-emitting diode.**

2.237 slewing (mechanical gyro): The rotation of the spin axis about an axis parallel to that of the applied torque causing the rotation.

2.238 specific force: *See:* **nongravitational acceleration.**

NOTE—The sign convention is not consistent in the literature.

2.239 spin axis (SA) (mechanical gyro): The axis of rotation of the rotor.

2.240 spin-axis-acceleration detuning error (dynamically tuned gyro): The error in a dynamically tuned gyro whereby deflection of the flexure, resulting from acceleration along the spin axis, can cause a shift in the tuning frequency. This will result in a change in the gyro output when there also exists a pickoff or capture-loop offset.

2.241 spin-input-rectification drift rate (mechanical gyro): The drift rate in a single-degree-of-freedom gyro resulting from coherent oscillatory rates about the spin reference axis (SRA) and input reference axis (IRA). It occurs only when gyro and loop dynamics allow the gimbal to move away from null in response to the rate about the input reference axis, resulting in a cross coupling of the spin reference axis rate. This drift rate is a function of the input rate amplitudes and the phase angle between them.

2.242 spin-offset coefficient (accelerometer): The constant of proportionality between bias change and the square of angular rate for an accelerometer that is spun about an axis parallel to its input reference axis and that passes through its effective center of mass for angular velocity.

2.243 spin-output-rectification drift rate (mechanical gyro): The drift rate in a single-degree-of-freedom gyro resulting from coherent oscillatory rates about the spin reference axis (SRA) and output reference axis (ORA). It occurs only when gyro and loop dynamics allow the float motion to lag case motion when subjected to a rate about the output reference axis, resulting in a cross coupling of the spin reference axis rate. This drift rate is a function of the input rate amplitudes and the phase angle between them.

2.244 spin reference axis (SRA) (mechanical gyro): An axis normal to the input reference axis (IRA) and nominally parallel to the spin axis when the gyro output has a specified value, usually null.

2.245 splitter, optical (interferometric fiber optic gyro): *See:* **directional coupler, optical.**

2.246 SRA: *See:* **spin reference axis.**

2.247 stability (gyro, accelerometer): A measure of the ability of a specific mechanism or performance coefficient to remain invariant when continuously exposed to a fixed operating condition. (This definition does not refer to dynamic or servo stability.)

2.248 storage life (gyro, accelerometer): The nonoperating time interval under specified conditions, after which a device will still exhibit a specified operating life and performance.

2.249 strapdown (gyro, accelerometer): Direct-mounting of inertial sensors (without gimbals) to a vehicle to sense the linear and angular motion of the vehicle.

2.250 superfluorescent source (interferometric fiber optic gyro): A wide-bandwidth light source using an externally pumped rare-earth-doped optical fiber.

2.251 superluminescent light-emitting diode (SLED, SLD) (interferometric fiber optic gyro): A p-n junction semiconductor emitter based on stimulated emission with amplification, but insufficient for feedback oscillation to build up.

2.252 suspension (mechanical gyro, accelerometer): A means of supporting and positioning a float (floated gyro), rotor (dynamically tuned gyro, electrically suspended gyro), or proof mass (accelerometer, Coriolis vibratory gyro) with respect to the case.

2.253 switch, optical (interferometric fiber optic gyro): A device in an optical path that can pass, stop, or redirect light, depending on control input.

2.254 synchronization time (mechanical gyro): The time interval required for the gyro rotor to reach synchronous speed from standstill.

2.255 synchronous-vibration sensitivity (dynamically tuned gyro): The functions that relate drift rates to linear or angular vibrations that are phase coherent with spin frequency or its harmonics. *See:* **one-N (1N) translational sensitivity; two-N (2N) angular sensitivity; two-N (2N) translational sensitivity.**

2.256 systematic drift rate (gyro): The component of drift rate comprising bias, environmentally sensitive drift rate, and elastic-restraint drift rate (see Figure 2).

2.257 ternary torquing (mechanical gyro, accelerometer): A torquing mechanization that utilizes three levels of torquer current, usually positive and negative of the same magnitude, and a zero current or off condition. The positive and negative torque conditions can be either discrete pulses or pulse-duration-modulated current periods. In both implementations, the case of zero input (acceleration or angular rate) will result in zero torquer current. Ternary torquer power is proportional to the input (acceleration or angular rate), resulting in minimum power as compared to binary torquing.

2.258 third-order nonlinearity coefficient (accelerometer): The proportionality constant that relates a variation of the output to the cube of the input, applied parallel to the input reference axis.

2.259 threshold (gyro, accelerometer): The largest absolute value of the minimum input that produces an output equal to at least 50% of the output expected using the nominal scale factor. *See:* **input-output characteristics.**

2.260 tidal acceleration: The tidal acceleration is due to the difference between the lunar and solar attractions at a site and at the center of the earth, the variation in earth attraction caused by the variation in the distance of the site from the center of the earth due to tidal deformation and ocean tide loading, and the gravitational attraction of the solid earth and ocean tide deformations. The tidal variations in the magnitude and direction of the instantaneous plumb bob gravity acceleration about their averages are approximately $\pm 0.15\,\mu g$ and $\pm 0.15\,\mu\text{rad}$, respectively, with a 12.4-h period.

2.261 torque-command storage (mechanical gyro): The transient deviation of the output of a rate-integrating gyro from that of an ideal integrator when the gyro is subjected to a torquer command signal. It is a function of the gyro's characteristic time and the torquer time constant. *See:* **attitude storage; float storage.**

2.262 torque-generator reaction torque (mechanical gyro, accelerometer): *See:* **torquer reaction torque.**

2.263 torquer (or forcer) (mechanical gyro, accelerometer): A device that exerts a torque (or force) on a gimbal, a gyro rotor, or a proof mass, in response to a command signal.

2.264 torquer axis (mechanical gyro, accelerometer): The axis about which a force couple is produced by a torquer.

2.265 torquer-current rectification (mechanical gyro, accelerometer): An apparent drift rate (or bias) in an inertial sensor resulting from effects such as torquer nonlinearity or capture-loop asymmetry.

2.266 torque (force) rebalance accelerometer: A closed-loop device that measures acceleration by applying a torque (force) to restore the proof mass to a null position.

2.267 torquer reaction torque (mechanical gyro, accelerometer): The usually undesired reaction torque that is a function of the frequency and amplitude of the command torque signal.

2.268 torquing (mechanical gyro, accelerometer): The application of torque to a gimbal or a gyro rotor about an axis-of-freedom for the purpose of precessing, capturing, slaving, or slewing.

2.269 tumbling (mechanical gyro): The loss of reference in a two-degree-of-freedom gyro due to gimbal lock or contact between a gimbal and a mechanical stop. This is not to be confused with "tumble testing," which is a method of evaluating gyro performance.

2.270 tuned rotor gyro: *See:* **dynamically tuned gyro.**

2.271 tuned speed (dynamically tuned gyro): The rotor spin velocity at which the dynamically induced spring rate is equal in magnitude, and of opposite sign, to the physical spring rate of the rotor suspension.

2.272 turn error (gyro): An error in gyro output due to cross coupling and acceleration encountered during vehicle turns.

2.273 turn-on time (gyro, accelerometer): The time from the initial application of power until a sensor produces a specified useful output, though not necessarily at the accuracy of full specification performance.

2.274 two-N (2N) angular sensitivity (dynamically tuned gyro): The coefficient that relates drift rate to angular vibration at twice spin frequency applied about an axis perpendicular to the spin axis. It has the dimensions of angular displacement per unit time, per unit of angle of the input vibration. *See:* **angular-case-motion sensitivity.**

2.275 two-N (2N) translational sensitivity (dynamically tuned gyro): The coefficient that relates drift rate to linear vibrations at twice spin frequency applied perpendicularly to the spin axis. It has the dimensions of angular displacement per unit time, per unit of acceleration of the input vibration.

2.276 VBA: *See:* **vibrating beam accelerometer.**

2.277 velocity random walk (accelerometer): *See:* **random walk (velocity random walk).**

2.278 velocity storage (accelerometer): The velocity information that is stored in the accelerometer as a result of its dynamics.

2.279 velocity storage, normal (accelerometer): The velocity information that is stored in the accelerometer during the application of an acceleration within its input range.

2.280 velocity storage, overrange (accelerometer): The velocity information that can be stored in the accelerometer during the application of an acceleration exceeding its input range.

2.281 vertical gyro (mechanical gyro): A two-degree-of-freedom gyro with provision for maintaining the spin axis vertical. In this gyro, output signals are produced by gimbal angular displacements that correspond to angular displacements of the case surrounding two nominally orthogonal, horizontal axes.

2.282 vibrating beam accelerometer (VBA): A linear accelerometer with one or more proof masses constrained by one or more force-sensitive beam resonators. The resultant change in oscillation frequency is a function of input acceleration. The resonators are often configured as differential pairs for common mode error rejection.

2.283 vibrating string accelerometer (VSA): A device that employs one or more vibrating strings whose natural frequencies are affected as a result of acceleration acting on one or more proof masses.

2.284 vibropendulous error (accelerometer): A cross-coupling rectification error caused by angular motion of the pendulum in a pendulous accelerometer in response to a linear vibratory input. The error varies with frequency and is maximum when the vibratory acceleration is applied in a plane normal to the output axis and at 45° to the input axis.

2.285 VSA: *See:* **vibrating string accelerometer.**

2.286 warm-up time (gyro, accelerometer): The time from the initial application of power for a sensor to reach specified performance under specified operating conditions.

2.287 wheel-speed sensitivity (dynamically tuned gyro): *See:* **rotor-speed sensitivity.**

2.288 whole-angle mode (Coriolis vibratory gyro): A mode of single-axis operation in which the pickoff output is a measure of the net angle of rotation since initialization.

2.289 zero offset (restricted to rate gyros): The gyro output when the input rate is zero, generally expressed as an equivalent input rate. It excludes outputs due to hysteresis and acceleration. *See:* **input-output characteristics.**