



IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Laser Gyros

IEEE Aerospace and Electronic Systems Society

Sponsored by the
Gyro and Accelerometer Panel

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IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Laser Gyros

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**Gyro and Accelerometer Panel
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IEEE Aerospace and Electronic Systems Society**

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Abstract: Specification and test requirements for a single-axis ring laser gyro (RLG) for use as a sensor in attitude control systems, angular displacement measuring systems, and angular rate measuring systems are defined. A standard specification format guide for the preparation of a single-axis RLG is provided. A compilation of recommended procedures for testing an RLG, derived from those presently used in the industry, is also provided.

Keywords: dithered gyro, gyro, gyroscope, inertial instrument, inertial sensor, optical gyro, resonant cavity, ring laser gyro, RLG, Sagnac effect, Sagnac gyro.

The Institute of Electrical and Electronics Engineers, Inc.
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Introduction

This introduction is not part of IEEE Std 647-2006, IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Laser Gyros.

This standard is a minor revision of IEEE Std 647-1995 that corrects errors made in the publication process and adds minor technical improvements. It consists of two parts.

Part I is a specification format guide for the preparation of a laser gyro specification. It provides a common meeting ground of terminology and practice for manufacturers and users. The user is cautioned not to overspecify; only those parameters that are required to guarantee proper instrument performance in the specific application should be controlled. In general, the specification should contain only those requirements that can be verified by test or inspection. Parameters in addition to those given in this standard are not precluded.

Part II is a compilation of recommended procedures for testing a laser gyro. These procedures, including test conditions to be considered, are derived from those currently in use. For a specific application, the test procedure should reflect the requirements of the specification; therefore, not all tests outlined in this standard need be included, nor are additional tests precluded. In some cases, alternative methods for measuring performance characteristics have been included or indicated.

The intent is for the specification writer to extract the applicable test conditions and equipment requirements from Clause 11 for inclusion in the appropriate clauses listed under 6.5. Similarly, it is intended that the writer extract the applicable test procedures from Clause 12 for inclusion in the appropriate subclauses listed under 6.6. Part II can also be used as a guide in the preparation of a separate laser gyro test specification with appropriate clause numbering. In general, the intent is for the specification writer to ensure consistency and traceability between Part II test procedures and Part I requirements for performance, mechanical, electrical, environmental, reliability, and quality assurance. To that end, a test procedure should not be listed in Part II unless a related requirement exists in Part I.

Blank spaces in the text of this document permit the specification writer to insert specific information such as parameter values and their tolerances, clause numbers, etc. Brackets are used to enclose alternative choices of dimensional units, signs, axes, etc. Boxed statements are included for information only and are not part of the specification or test procedures. The following standards were used in the development of this standard.

ANSI/IEEE Std 260.1, IEEE Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).

ANSI/IEEE Std 268, American National Standard for Metric Practice.

ANSI/IEEE Std 280, IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

ANSI/IEEE Std 315, IEEE Graphic Symbols for Electrical and Electronics Diagrams.

IEEE Std 528, IEEE Standard for Inertial Sensor Terminology.

This standard defines the requirements and test procedures for a single-axis laser gyro in terms unique to the laser gyro. The requirements contained herein cover applications where the laser gyro is used as an angular motion sensor in navigation and control systems.

The term *laser gyro* is accepted to include the electronics necessary to operate the gyro and to condition the output signal. The laser gyro provides an output frequency proportional to inertial angular rate about its input axis.

Annex A lists various laser gyro design features for which this format is applicable. The list is not intended to make any suggestion regarding the selection of particular design features that might restrict the free choice of manufacturers.

Annex B is an overview of dynamic and stochastic modeling.

Annex C is an overview of noise process variance analysis as a method for determination of the drift rate coefficients and the quantization coefficient.

Annex D is a bibliography.

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Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

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Participants

This standard represents a large-scale group effort. A total of 143 individuals attended 46 meetings of the Gyro and Accelerometer Panel during preparation of this standard.

The following individuals on the Gyro and Accelerometer Panel were major contributors to IEEE Std 647-2006:

Sid Bennett, *Chair*

David Anderson
Michael Ash
Cleon Barker
Stephen Becka
Joseph Beri
Stephen Bongiovanni
Pierre Bouniol
Herbert Califano
Anthony Campbell*
Joseph D'Angelo
James Davies*
George Erickson
Julius Feldman
Joseph Ficalora
Scott Finken

Thomas Fuhrman
Frank Garcia
Kerry Green
Michael Hooser
Bert Katz
Menno Koning
Lalit Kumar
Kurt Lantz
Thomas Lear*
David Lynch
David Macy
R. D. (Sam) Marquess
Harold Morris
Gerald Morrison*
Ralph (Bart) Morrow

Jay Murphy
Gordon Murray*
Jay Neugroschl
Rex Peters*
Loren Richardson
Gerald Shaw
Philip Simpson
Norman Sinnott*
Timothy Stanley
Mohammad Tehrani
Leroy Thielman
Ludd Trozpek
Bud Wimber*
David Winkel
Bruce Youmans

*Past Chair

A total of 50 individuals attended 12 meetings of the Gyro and Accelerometer Panel during the preparation of this revision. The following individuals on the Gyro and Accelerometer Panel contributed to this standard:

Randall Curey, *Chair*

Michael Ash
Cleon Barker
Sid Bennett*
Timothy Buck
Herbert Califano

George Erickson
Kerry Green
Jean-François Kieffer
Robert Martinez
Ralph (Bart) Morrow

Reese Sturdevant
Daniel Tazartes
Leroy Thielman
Bruce Youmans

*Past Chair

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Michael Ash
Cleon Barker
Sid Bennett
Robert Correllus

Randall Curey
Robert Dahlgren
George Erickson
Jean-François Kieffer

Vladimir Skvortzov
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Jennie Steinhagen
IEEE Standards Program Manager, Document Development

Angela Ortiz
IEEE Standards Program Manager, Technical Program Development

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IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Laser Gyros

1. Overview

1.1 Scope

This standard defines the specification and test requirements for a single-axis laser gyro for use as a sensor in attitude control systems, angular displacement measuring systems, or angular rate measuring systems, including the electronics necessary to operate the gyro and to condition the output signals.

1.2 Purpose

This standard provided a common meeting ground of terminology and practice for manufacturers and users. The user is cautioned not to overspecify—only those parameters that are required to guarantee proper instrument performance in the specific application should be controlled. In general, the specification should contain only those requirements that can be verified by test or inspection. Part II of this standard can also be used as a guide in the preparation of a separate laser gyro test specification. In general, the intent is for the specification writer to ensure consistency and traceability between Part II test procedures and Part I requirements for performance, mechanical, electrical, environmental, and quality assurance.

1.3 Document structure

Part I (Clause 3 through Clause 8) of this standard is a specification format guide for the preparation of a laser gyro specification. Part II (Clause 9 through Clause 12) is a compilation of recommended procedures for testing a laser gyro.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

None

Part I—Specification format¹

3. Specification format overview

This specification defines the requirements for a single-axis laser gyro to be used as a sensor in [an inertial measure unit, ____]. This includes the electronics necessary to operate the gyro and to condition the output signal.

4. Applicable documents

The following documents form a part of the specification to the extent specified in this specification. In the event of any conflict between the requirements of this specification and the listed documents, the requirements of this specification shall govern.²

NOTE—Give identification number, title, date of issue, and revision letter of each listed document.

4.1 Standards

4.1.1 Government

NOTE—MIL-P-116H, Methods of Preservation

4.1.2 Industry/technical

4.1.3 Company

4.2 Standards

4.2.1 Government

NOTE—

MIL-STD-105	Sampling Procedure and Tables for Inspection by Attributes.
MIL-STD-461	Electromagnetic Interference Characteristics, Emission, and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-704C	Aircraft Electrical Power Characteristics.
MIL-STD-781C	Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution.
MIL-STD-785B	Reliability Program for Systems and Equipment Development and Production.
MIL-STD-810	Environmental Test Methods and Engineering Guidelines.

¹ The sample forms in Part I of this guide are included for information and example only. Users of this guide may freely reproduce and modify the forms in Part I so that they can be used for their intended purpose, so long as each page is reproduced in its entirety, including any and all copyright language.

² Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

4.2.2 Industry/technical

4.2.3 Company

4.3 Drawings

4.3.1 Government

4.3.2 Industry/technical

4.3.3 Company

4.4 Bulletins

4.4.1 Government

4.4.2 Industry/technical

4.4.3 Company

4.5 Other publications

NOTE—Other applicable documents should be listed under the appropriate paragraph.

5. Requirements

5.1 Description

The major components of the laser gyro herein specified are: a _____ gain medium, a closed path optical resonator utilizing _____, a _____ path length control, and a combining optics readout device (including pulse forming electronics) consisting of _____.

The particular laser gyro specified may have additional major components as follows: a _____ anti-lock means, temperature control or temperature compensation, power supplies for _____, and an excitation control.

NOTE—To fill in the blanks, refer to Annex A for examples. For gyros that do not include built-in anti-lock mechanisms, the test equipment and test procedures must provide the necessary anti-lock motion as a part of the test environment. Failure to provide anti-lock motion may result in damage to the gyro.

5.2 General requirements

5.2.1 Precedence

In the event of conflict among the purchase agreement, this specification, and other documents referred to in this standard, the order of precedence shall be as follows:

- a) Purchase agreement
- b) This standard and its applicable drawings (see 5.4.2 and 5.5.1)
- c) Other applicable documents (see Clause 4)

5.3 Performance

Performance characteristics shall be as specified in this subclause.

The tolerances include a summation of manufacturing and test errors, and environmental effects. Any exception due to environmental effects will be listed in 5.6.3.1.

NOTE—When required by the application, the sensitivity of a gyro characteristic to variations in voltage, frequency, temperature, or other variables should be included in the subclause specifying that characteristic.

5.3.1 Input rates

5.3.1.1 Maximum input rate

The maximum input rate about the gyro input axis (IA) shall be $\pm$ _____ [$^{\circ}/s$, _____].

NOTE—The positive and negative input rate limits need not be equal. Multiple rate limits may be specified.

5.3.1.2 Minimum input rate

The minimum rate of rotation about the IA for which the performance is of the specified quality shall be $\pm$ _____ [$^{\circ}/s$, _____].

NOTE—This characteristic is important for laser gyros without built-in anti-lock devices. The minimum input rate at which the gyro can be operated without damage should be specified.

5.3.2 Gyro scale factor, S

The gyro scale factor shall be between _____ $^{\circ}/p$ and _____ $^{\circ}/p$.

NOTE 1—The scale factor is the angular input in arc seconds ($^{\circ}$) equivalent to a digital pulse (p) output. The scale factor is directly proportional to the total pathlength and operating wavelength, and inversely proportional to the enclosed ring area.

NOTE 2—This scale factor range includes the manufacturing tolerance. The test procedure will result in a nominal scale factor that is defined in the model equation of 8.3.

5.3.2.1 Gyro scale factor errors

- a) Asymmetry: _____ ppm.

NOTE—The specific input rotational rate(s) at which the scale factor asymmetry is to be determined may be specified. The asymmetry is the ratio of the difference in magnitudes of scale factor measured for clockwise and counterclockwise inputs to one-half the sum of the same magnitudes.

- b) Nonlinearity: _____ ppm deviation [maximum spread, 1σ _____] from the nominal scale factor.

NOTE—The rates over which the specification is valid should be specified. For some gyros it may be appropriate to include a specification and test for linearity error.

- c) Repeatability: _____ ppm [maximum spread, 1σ _____].

NOTE—Thermal cycles and other environmental exposures, shutdowns, time between runs, remounting, and additional factors pertinent to the particular application should be specified.

- d) Stability: _____ ppm, [maximum spread, 1σ , _____] for _____ [h, _____].

5.3.2.2 Gyro scale factor sensitivities

- a) Temperature: the gyro scale factor temperature sensitivity resulting from a change in steady-state operating temperature shall not exceed _____ ppm/°C from the nominal scale factor.
- b) Temperature gradient: the change in gyro scale factor resulting from a change in steady-state temperature difference measured across the gyro case in the _____ [IA, other] direction shall be _____ $\pm$ _____ ppm/Δ°C.

NOTE—The specific points on the case where the temperatures are measured, the temperature difference, and the specific temperature should be specified.

- c) Other sensitivities

NOTE—Additional sensitivities may be specified such as those due to variations in supply voltage, rate of temperature change, orientation, acceleration, vibration, magnetic field, radiation, and other environments pertinent to the particular application.

5.3.3 Drift rate, D , E

5.3.3.1 Bias and random, D

5.3.3.1.1 Bias, D_F

_____ $\pm$ _____ $^{\circ}/h$.

- a) Repeatability: _____ $^{\circ}/h$ [maximum spread, 1σ , _____].

NOTE—Thermal cycles and other environmental exposures, shutdowns, time between runs, remounting, and additional factors pertinent to the particular application should be specified.

- b) Warm-up, $D_F(t)$: _____ $\pm$ _____ $^{\circ}/h$ from _____ [s, _____] to _____ [s, _____] after turn-on.

NOTE—The drift rate limits of the gyro, during a certain time interval after turn-on, should be specified for certain applications. The limits may be specified as a function of time after turn-on. More than one function may be specified for different temperatures at the time of turn-on.

5.3.3.1.2 Random, D_R

NOTE—Random drift rate is usually defined in terms of the Allan variance components. These components should be specified. See D_R terms in 8.3 and Annex C.

- a) Angle random walk (rate white noise) coefficient, N . _____ $^{\circ}/h^{1/2}$ maximum.
b) Bias instability coefficient, B . _____ $^{\circ}/h$ maximum.
c) Rate random walk coefficient, K . _____ $(^{\circ}/h)/h^{1/2}$ maximum.
d) Ramp coefficient, R . _____ $(^{\circ}/h)/h$ maximum.

NOTE—For some applications it may be sufficient to define random drift as the standard deviation of the output. The time interval and integration time should be specified.

5.3.3.1.3 Measurement noise, D_Q

Combined quantization and anti-lock residual noise coefficient, Q _____ " maximum.

NOTE—Measurement noise is usually defined as the Allan variance component Q . See 8.3 and Annex C.

5.3.3.2 Environmentally sensitive, E

5.3.3.2.1 Temperature, D_T

The change in bias drift due to a change in the steady-state operating temperature shall not exceed _____ $(^{\circ}/h)/^{\circ}C$.

NOTE—The specific point or points where the temperature is measured and the temperature range should be specified.

5.3.3.2.2 Temperature gradient, $D_{\nabla T}$

The change in the bias drift resulting from a change in steady-state temperature difference measured across the gyro case in the _____ [IA, other} direction shall not exceed _____ ($^{\circ}/h$)/ $\nabla^{\circ}C$.

NOTE—The specific points on the case where the temperature is measured, the temperature gradient(s), and the test temperature(s) should be specified.

5.3.3.2.3 Magnetic

The change in gyro bias resulting from a change in steady-state flux density shall not exceed $\pm$ _____ $^{\circ}/h$ over the range _____ to _____ [mT, G].

NOTE—Gyro axis and characteristics of the field should be defined. If exposure to a varying field is required, the nature of the variation should be described. Demagnetization may be necessary following exposure.

5.3.3.2.4 Other sensitivities

5.3.4 IA alignment characteristics

5.3.4.1 IA misalignment

_____ [mrad, ", _____], maximum with respect to the input reference axis (IRA).

NOTE—The specific direction of IA misalignment may be important in some applications and should be specified with respect to L reference axis (LRA) and N reference axis (NRA) defined in 5.4.3.

5.3.4.2 IA misalignment repeatability

_____ [mrad, ", _____], [1σ , peak-to-peak, _____].

NOTE—Thermal cycles and other environmental exposures, shutdowns, time between runs, remounting, and additional factors pertinent to the particular application should be specified.

5.3.4.3 IA misalignment sensitivities

NOTE—Sensitivities, such as those due to temperature, thermal gradients, rate of temperature change, acceleration, vibration, and additional environments pertinent to the particular application may be specified.

5.3.5 Operating temperature

_____ $\pm$ _____ $^{\circ}\text{C}$.

NOTE—The preceding operating temperature applies only to temperature controlled gyros. Typically, laser gyros are not designed with internal temperature controls. Temperature sensors may be built into the gyro for use in characterizing its temperature sensitivity. For gyros intended to operate without temperature control, see 5.6.4.

5.3.6 Turn-on time

The gyro output rate shall be within _____ [$^{\circ}/\text{h}$, _____] of the input rate within _____ [s, _____] after the application of power.

5.3.7 Warm-up time

_____ [s, _____], maximum.

5.3.8 Polarities

5.3.8.1 Input axis

The positive IA shall conform to [drawing number _____, Figure _____].

5.3.8.2 Output signals

The output signals representing gyro rotation shall conform to [drawing number _____, Figure _____].

5.3.9 Reference constants

NOTE—These constants are for reference only. They are not specified independently, because they may vary within the framework of the specification, or because they are difficult or impossible to measure independently in a complete gyro. Nominal values are listed.

5.3.9.1 Laser beam wavelength

_____ [μm , _____].

5.3.9.2 Beam path length

_____ cm.

5.3.9.3 Dithered element IA moment of inertia

_____ gm-cm^2 .

5.3.10 Anti-lock residual

NOTE 1—Anti-lock means introduce extraneous output, which should be considered in the data processing.

NOTE 2—Signal processing techniques to mitigate the effect and the residual error after compensation should be specified.

NOTE 3—Note that oscillatory motion of the gyro base caused by mechanical interaction of the dithered gyro with the sensor mounting assembly in a real system is actual rate and not anti-lock residual.

5.4 Mechanical requirements

Mechanical characteristics shall be as specified in this subclause.

5.4.1 Exterior surface

All exterior surfaces shall withstand the environment specified herein and the handling expected in the normal course of operation, testing, and maintenance without deterioration that causes nonconformance to this specification.

NOTE—Additional requirements controlling surface finish, workmanship, processing, etc., may be specified.

5.4.2 Outline and mounting dimensions

Shall conform to [drawing number _____, Figure _____].

NOTE—Specify center of gravity, if required.

5.4.3 Gyro axes

The IRA, LRA, and NRA are mutually orthogonal right-handed reference axes defined with respect to the mounting provisions. The IRA is nominally parallel to the true gyro IA and shall conform to [drawing number _____, Figure _____] (see Figure 1).

NOTE—The IRA is typically perpendicular to the mounting surface. LA and NA are nominally parallel to the LRA and NRA. Misalignment angles θ_L and θ_N represent rotations of IA about LRA and NRA, respectively.

5.4.4 Weight

_____ $\pm$ _____ [g, _____]

NOTE—Specify those components such as cables, connectors, and electronics that are to be included in the weight.

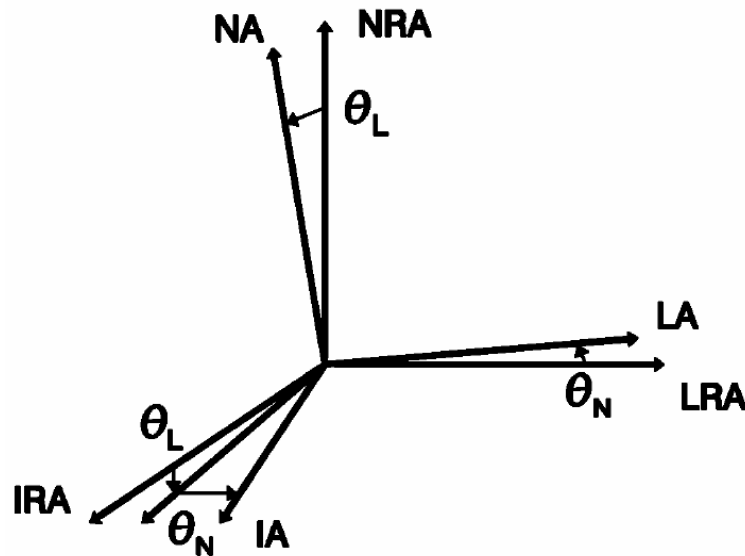


Figure 1—Gyro axes and misalignment angles

5.4.5 Seal

The gyro housing shall be sealed such that the leak rate is less than _____ [cm³/s, _____] when subjected to pressure of _____ ± _____ Pa and gyro temperature of _____ ± _____ °C for a minimum of _____ min.

5.4.6 Mount reaction torque

NOTE—Mechanically dithered gyros generate oscillatory torques at the mounting interface that should be considered in testing and usage.

5.4.7 Identification of product

The gyro shall be identified on the surface and in the manner indicated in drawing number _____. Identification shall include the following:

- a) Laser gyro
- b) Specification number
- c) Unit serial number
- d) Axis identification marking as shown in [drawing number _____, Figure _____]
- e) Manufacturer's name or symbol
- f) Safety warnings

NOTE—The purchase agreement may require additional identification, such as date of manufacture.

5.5 Electrical requirements

Electrical characteristics shall be as specified in this subclause.

5.5.1 Schematic

The electrical circuits shall be connected as shown in [drawing number _____, Figure _____].

NOTE—The schematic may include circuits for monitoring laser discharge current, laser intensity, path length control, etc.

5.5.2 Impedances

The gyro impedances shall be _____.

NOTE—Load impedances and impedances of excitation, monitoring, temperature sensing, and test circuits should be specified.

5.5.3 Input power and circuit excitations

The input power (current) shall not exceed _____ W (A) with a circuit excitation of _____ $\pm$ _____ V.

NOTE—Requirements such as power factor, frequency, voltage, ripple, and starting and running currents for each excitation should be specified. Transient conditions may need to be specified.

5.5.4 Test points

NOTE—Test points required for monitoring and testing of the laser gyro should be specified. These may include excitation voltages, other control signals, or temperature sensor(s). Any special buffering or scaling requirements should be specified.

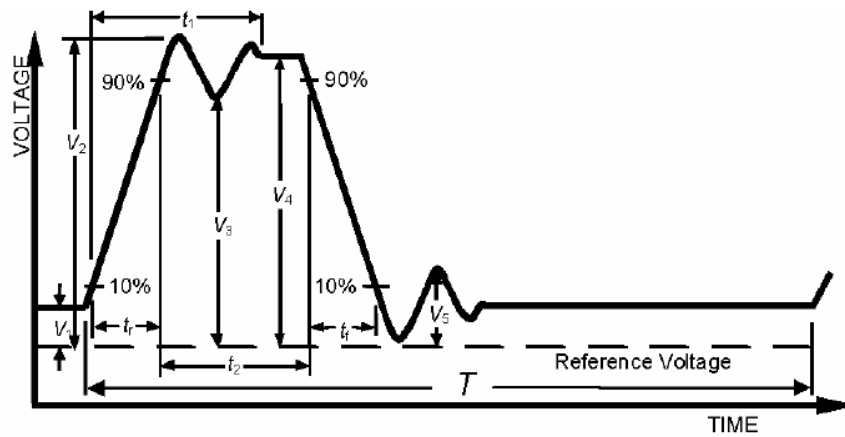
5.5.5 Grounding

NOTE—Electrical grounding design requirements (e.g., requirements for isolation between input, output, and power returns and the grounding requirements for shields, chassis, and critical components) should be specified.

5.5.6 Output signals

NOTE—Specify the type and characteristics of output signals required. For example:

- a) Type: pulses indicating positive angular increments on one signal line and pulses indicating negative angular increments on a second line
- b) Characteristics:
 - 1) Source impedance
 - 2) Load impedance
 - 3) Wave shape (see Figure 2)
 - 4) Maximum pulse rate



	UNITS	MAXIMUM	MINIMUM	REMARKS
V_1	volts	_____	_____	steady state low voltage
V_2	volts	_____	N/A	overshoot voltage
V_3	volts	N/A	_____	undershoot voltage
V_4	volts	_____	_____	steady state high voltage
V_5	volts	_____	N/A	maximum low voltage transient
t_r	seconds	_____	_____	rise time
t_f	seconds	_____	_____	fall time
t_1	seconds	_____	_____	turn-on transient time
t_2	seconds	_____	_____	high voltage on time
t_1/t_2	_____	_____	N/A	ratio of turn-on transient to high voltage on time
T	seconds	_____	_____	waveform period
t_2/T	_____	_____	_____	duty cycle

Figure 2—Wave shape requirements for direct coupled pulse-type signals

5.5.7 Temperature sensors

The output of the temperature sensor(s) shall be _____ $\pm$ _____ [V, _____] within the temperature range specified in 5.3.5 or 5.6.4.4. The temperature rise of the sensor due to self-heating shall not exceed _____ $^{\circ}\text{C}$ at _____ mA. The scale factor of the temperature sensor(s) shall be [+ , -] _____ $\pm$ _____ [V/ $^{\circ}\text{C}$, _____] at operating temperature.

NOTE—Thermistors, thermocouples, or other temperature sensors may be specified. Typically, laser gyros are not designed with internal temperature controls. Temperature sensors may be built into the gyro for use in characterizing its temperature sensitivity. If sensors are required, specify quantity, locations, and characteristics.

5.5.8 Temperature sensors

The output of the temperature sensor(s) shall be _____ $\pm$ _____ [V, _____] within the temperature range specified in 5.3.5 or 5.6.4.4. The temperature rise of the sensor due to self-heating shall not exceed _____ $^{\circ}\text{C}$ at _____ mA. The scale factor of the temperature sensor(s) shall be [+ , -] _____ $\pm$ _____ [V/ $^{\circ}\text{C}$, _____] at operating temperature.

NOTE—Thermistors, thermocouples, or other temperature sensors may be specified. Typically, laser gyros are not designed with internal temperature controls. Temperature sensors may be built into the gyro for use in characterizing its temperature sensitivity. If sensors are required, specify quantity, locations, and characteristics.

5.5.9 Dielectric strength

The leakage current shall not exceed _____ nA when a voltage of _____ $\pm$ _____ V rms, at _____ Hz, is applied between isolated interface circuits, and between the case(s) and circuits isolated from the case(s), for _____ $\pm$ _____ s.

NOTE—Different voltages may be specified for different circuits. In some instances, lower voltages may be specified for subsequent tests.

5.5.10 Insulation resistance

The insulation resistance between isolated interface circuits and between the case(s) and circuits isolated from the case(s) shall not be less than _____ M Ω measured at _____ $\pm$ _____ V dc, applied for _____ $\pm$ _____ s.

NOTE—Different voltages may be specified for different circuits.

5.5.11 Electromagnetic interference

The electromagnetic emissions and susceptibilities shall conform to _____.

NOTE—Describe the requirements. In the United States, a common standard is MIL-STD-461.

5.5.12 Magnetic leakage

The magnetic leakage shall not exceed _____ [mT, G] at a distance of _____ $\pm$ _____ [m, _____] from the gyro in any direction.

5.5.13 Electromagnetic compatibility

NOTE—Describe the requirements. In the United States, a common standard is MIL-STD-461.

5.6 Environmental requirements

NOTE—This subclause contains environmental requirements only. Test procedures that are to be used, including required combinations of environments, are covered in 6.6.

5.6.1 Storage

The gyro shall conform to all requirements of this specification after exposure to the following environments or specified combinations thereof, while packaged as specified in Clause 7.

NOTE—The procuring organization should list the applicable environments from 5.6.4 and specify the limits for each based on the expected storage conditions.

5.6.2 Transport

The gyro shall conform to all requirements of this specification after exposure to the following environments or specified combinations thereof, while packaged as specified in Clause 7.

NOTE—The procuring organization should list the applicable environments from 5.6.4 and specify the limits for each based on the expected transportation conditions.

5.6.3 Operation

NOTE—In order to properly specify the environmental requirements for a gyro, three different sets of environments or environmental limits, or both, as defined in 5.6.3.1, 5.6.3.2, and 5.6.3.3 may need to be described.

5.6.3.1 Operating environment

The gyro shall conform to all requirements of this specification during exposure to the following environments or specified combinations thereof (except during exposure to _____ where the deviations from this specification are given in the following clauses).

NOTE—Where degraded performance is to be allowed, include the parenthetical phrase in 5.6.3.1 and list in the blank space those environments for which degraded performance is allowed. The procuring organization should list the applicable environments from 5.6.4 and specify the limits for each based on the conditions expected when the gyro is in use. For those environments where degraded performance is allowed, specify the performance deviation in the clause that specifies the environment.

5.6.3.2 Survival environment—Operating

The gyro shall conform to all requirements of this specification after the operating gyro has been exposed to the following environments or specified combinations thereof.

NOTE—The procuring organization should list the applicable environments from 5.6.4 and specify the limits for each based on the conditions expected when the gyro is operating but not in use.

5.6.3.3 Survival environment—Nonoperating

The gyro shall conform to all requirements of this specification after the nonoperating gyro has been exposed to the following environments or specified combinations thereof.

NOTE—The procuring organization should list the applicable environments from 5.6.4 and specify the limits for each based on the conditions expected when the gyro is not operating. Such conditions are expected to occur when the gyro is mounted in the system and the system is stored or transported in severe environments.

Environmental characteristics shall be as specified in this subclause.

NOTE—This list is intended as an aid to the selection of the applicable environments under 5.6.1, 5.6.2, and 5.6.3. In this form, 5.6.4 would not be included in a final specification.

5.6.4.1 Vibration

NOTE 1—Axes should be defined.

NOTE 2—When available, the specific vibration characteristics including dwell frequencies, frequency spectrum, time duration, etc., should be supplied.

NOTE 3—If exposure to random vibration is required, PSD, bandwidth, peak acceleration level, and duration should be specified.

NOTE 4—The linear or angular vibration amplitude should be below levels that may cause permanent performance degradation or damage to the gyro.

5.6.4.1.1 Linear

Sinusoidal: _____ [cm, in] DA (double amplitude) _____ to _____ Hz; _____ [m/s², g] peak, _____ to _____ Hz. Sweep rate: _____ min/octave (continuous). Exposure time: _____ [min, _____] per axis.

5.6.4.1.2 Angular

Sinusoidal: _____ rad/s² _____ to _____ Hz. Sweep rate shall be _____ min/octave (continuous). Exposure time: _____ [min, _____] per axis.

5.6.4.2 Mechanical shock

_____ [m/s², g] peak, _____ wave shape, _____ ms, _____ shock(s) per axis.

NOTE—Gyro axes and direction of shock should be defined. A figure may be included to describe more complex waveforms. A shock spectrum may be specified.

5.6.4.3 Linear acceleration

_____ [m/s², g], exposure time _____ [min, _____].

NOTE—Gyro axes and direction of acceleration should be defined.

5.6.4.4 Temperature

_____ °C to _____ °C.

5.6.4.5 Thermal shock

_____ °C to _____ °C within _____ [s, _____].

NOTE—If exposure to cyclic conditions is required, temperature limits for each level, dwell times, and sequence should be specified. A figure may be included to describe the complex profiles.

5.6.4.6 Thermal radiation

_____ W/cm² of radiation of wavelength from _____ to _____ m; exposure time: _____ [min, _____].

5.6.4.7 Ambient air pressure

_____ to _____ [Pa, _____].

5.6.4.8 Acoustic noise

_____ dB referenced to 2×10^{-5} Pa, _____ to _____ Hz; exposure time: _____ [min, _____].

NOTE—When available, the specific decibel versus frequency for the application should be supplied. Sweep rate may be specified as _____ min/octave (continuous), if applying sinusoidal acoustic noise.

5.6.4.9 Humidity

_____ % relative humidity for _____ h obtained from steam or distilled water having a pH value of _____
± _____.

5.6.4.10 Air currents

_____ [m/s, _____].

NOTE—Gyro axes and direction of air flow should be defined.

5.6.4.11 Fungus

NOTE—Specify fungi organisms, length of exposure, and temperature and humidity conditions during exposure.

5.6.4.12 Salt spray

_____ % salt solution; exposure time: _____ [min, _____].

5.6.4.13 Nuclear radiation

_____ [J/kg, rad(Si)] with an exposure of _____ [(J/kg)/s, rad(Si)/s] or combinations, of _____ particles at a fluence of _____/cm²

5.6.4.14 Magnetic fields

_____ [mT, G]; exposure time: _____ [min, _____].

NOTE—Gyro axes and direction of field should be defined. If exposure to varying fields is required, the nature of the variation should be described.

5.6.4.15 Electromagnetic fields

Electromagnetic fields shall conform with _____.

NOTE—In the United States, a common standard is MIL-STD-461.

5.6.4.16 Sand and dust

_____ [g/m³, _____] at a velocity of _____ ± _____ [m/s, _____]; exposure time: _____ [min, _____].
Relative humidity not to exceed _____ %.

NOTE—Particle size, shape, and chemical composition should be specified.

5.6.4.17 Solar radiation

_____ ± _____ [W/m², _____] of wavelength _____ to _____ m; exposure time: _____ [min, _____].

NOTE—Distribution of power density versus wavelength should be specified.

5.6.4.18 Rain

_____ ± _____ [mm/h, _____] consisting of droplets having a minimum diameter of _____ mm; exposure time: _____ [min, _____].

5.6.4.19 Excitation variation

The excitation voltage and frequency required shall conform with _____.

NOTE—In the United States, a common standard is MIL-STD-704C.