



Standard Specification for Tachometers, Various¹

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1. Scope

1.1 This specification covers various tachometers capable of measuring rotational shaft speed.

1.2 Special requirements for tachometer types used in naval shipboard applications are included in Supplement S1.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

- 2.1 *ASTM Standards*:
D 3951 Practice for Commercial Packaging²

3. Terminology

3.1 Definitions:

3.1.1 *SI (Le Systeme International d'Unites) Units*—units of measurement recognized by the Comite' International des Poids et Mesures (CIPM).

3.1.2 *tachometer*—an instrument capable of generating, transmitting, and indicating information or signal that can be converted into a function of rotational speed.

4. Classification

4.1 *Design Types*—The following are among the types of tachometers available:

- (a) Centrifugal;
- (b) Centrifugal, flexible drive;
- (c) Chronometric;
- (d) Electrical, alternating current (ac) voltage responsive, direct drive;
- (e) Electrical reactance;
- (f) Electrical, magnetovoltmeter, direct drive;
- (g) Electrical, magnetovoltmeter;
- (h) Frequency responsive, electrical control box and voltmeter, direct drive;

(i) Frequency sensitive, electrical, nonrotating magnetic pickup, direct drive, consists of a magnetic pickup, transducer, and indicator;

(j) Photoelectric;

(k) Digital contact;

(l) Centrifugal, flexible drive; and

(m) Vibrating resonant reed.

5. Ordering Information

5.1 The buyer shall provide the manufacturer with all of the pertinent application data in accordance with the acquisition requirements, 5.2.

5.2 *Acquisition Requirements*—Acquisition documents shall specify the following:

(a) Title, number, and date of this specification;

(b) Quantity of tachometers required;

(c) Range;

(d) Manufacturer's part number;

(e) When qualification inspection is required;

(f) Final disposition of qualification test samples;

(g) Type of electrical connection;

(h) Mounting method;

(i) Environmental requirements;

(j) Materials;

(k) Size and weight restrictions;

(l) Critical service life requirements;

(m) Performance requirements;

(n) Surface finish requirements;

(o) Cleaning requirements;

(p) When certification is required;

(q) Marking requirements;

(r) Packaging requirements; and

(s) Preservation requirements.

6. Materials and Manufacture

6.1 *Material Selection*—The materials for all parts shall be selected for long-term compatibility with the environment in which the tachometer will be installed or used.

6.2 *Material Inspection*—The manufacturer shall be responsible for ensuring that materials used are manufactured, examined, and tested in accordance with the specifications and standards as applicable.

¹ This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.10 on Electrical and Electronics.

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² *Annual Book of ASTM Standards*, Vol 15.09.

7. Physical Properties

7.1 *Size and Weight*—The buyer may have intended applications where size and weight are limited. Size and weight limitations shall be specified in the acquisition requirements.

8. Performance Requirements

8.1 *Service Life*—The buyer may have a minimum specified service life requirement. Critical service life requirements shall be specified in the acquisition requirements.

8.2 *Tachometer Performance*—Performance tolerances are usually specified in percentage of range span. The following performance characteristics and environmental exposures may or may not be important to each buyer's intended application.

- (a) Accuracy,
- (b) Repeatability,
- (c) Damping,
- (d) Temperature,
- (e) Humidity,
- (f) Salt spray,
- (g) Vibration,
- (h) Shock, and
- (i) Electromagnetic interference (EMI).

9. Workmanship, Finish, and Appearance

9.1 *Cleaning, Finish, and Appearance*—Any special cleaning, surface finish, and appearance requirements shall be specified in the acquisition requirements.

10. Inspection

10.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

- (a) Qualification testing and
- (b) Quality conformance testing.

10.2 *Qualification Testing*—Qualification test requirements shall be specified, where applicable. Test methods should be identified for each design and performance characteristic specified. Test report documentation requirements should also be specified.

10.3 *Quality Conformance Testing*—Quality conformance inspection is accomplished when acceptance and qualification testing is satisfied by a previous acquisition or when the product has demonstrated reliability in similar applications. Quality conformance inspection is usually less intensive than acceptance and qualification, often verifying that samples of a production lot meet a few critical performance requirements.

11. Number of Tests and Retests

11.1 *Test Specimens*—The number of test specimens to be subjected to qualification testing shall depend on the tachometer design. If each range is covered by a separate and distinct

design, a test specimen for each range will require testing. In instances in which a singular design series may cover multiple ranges and types, it is recommended that three test specimens be tested provided the electrical and mechanical similarities are approved by the buyer. In no case, however, should less than three units, one unit each representing low, medium, and high ranges, be tested, regardless of design similarity.

12. Test Methods

12.1 *Tests*—All tests shall be performed in accordance with ASTM, ASME, or industry standards as specified.

12.2 *Test Data*—All test data shall remain on file at the manufacturer's facility for review by the buyer upon request. It is recommended that test data be retained in the manufacturer's files for at least three years or a period of time acceptable to the buyer and manufacturer.

13. Quality Assurance Provisions

13.1 *Warranty*:

13.1.1 *Responsibility for Warranty*—Unless otherwise specified, the manufacturer is responsible for the following:

- (a) All materials used to produce a unit and
- (b) Manufacturer will warrant his product to be free from defect of workmanship to produce the unit.

14. Certification

14.1 When specified in the purchase order or contract, the buyer shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification, and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Product Marking

15.1 User-specified product marking shall be listed in the acquisition requirements. The minimum data to be clearly marked on each tachometer shall include the following:

- (a) Manufacturer's name,
- (b) Manufacturer's part number,
- (c) Serial number or lot number,
- (d) Date of manufacture, and
- (e) Range.

16. Packaging and Package Marking

16.1 *Packaging of Product for Delivery*—Product shall be packaged for shipment in accordance with Practice D 3951.

16.2 Any special preservation, packaging, or package marking requirements for shipment or storage shall be identified in the acquisition requirements.

17. Keywords

17.1 tachometer

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements established for U.S. Naval shipboard application shall apply when specified in the contract or purchase order. When there is conflict between the standard (Specification F 2046) and this supplement, the requirements of this supplement shall take precedence for equipment acquired by this supplement. This document supersedes MIL-T-16049C, Tachometers: Electrical; Self-Generating; Mechanical, Fixed Mounting, and Hand Held; and Vibrating Reed, for new ship construction. This document also supersedes MIL-T-24797, Tachometers, Fiber Optic, (Naval Shipboard Use), (Metric) General Specification for, for new ship construction.

TACHOMETERS: ELECTRIC AND FIBER OPTIC, FIXED MOUNTING
S1. Scope

S1.1 This supplement covers single-range noncontact electric and fiber-optic tachometers capable of generating, transmitting, and indicating information or signal that can be converted into a function of rotational speed. The subject tachometers may be used in shipboard systems, such as gas generators, power turbines, propulsion shafts, and gas steam turbine generators.

S1.2 Vibrating reed resonant-type tachometers are not covered in this specification.

S1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

S2. Referenced Documents
S2.1 Commercial Documents:
S2.1.1 ASTM Standards:

B 117 Practice for Operating Salt Spray (Fog) Apparatus³

D 3951 Practice for Commercial Packaging⁴

S2.1.2 ANSI/ISA Standards:

ANSI/ISA S37.1 (R-1982) Electrical Transducer Nomenclature and Terminology⁵

ANSI/ASQC Q9001-1994 Quality Systems—Model for Quality Assurance in Design, Development, Production, Installation, Inspection, Testing, and Servicing⁵

S2.1.3 Electronic Industries Association (EIA):

RS-422 Electrical Characteristics of Balanced Voltage Digital Interface Circuit⁶

455-22 FOTP-22 Ambient Light Susceptibility of Fiber Optic Components⁶

455-34 FOTP-34 Interconnection Device Insertion Loss Test⁶

S2.2 Government Documents:
S2.2.1 Military Standards:

MIL-STD-461 Electromagnetic Interference Characteristics of Subsystems and Equipment, Requirements for the Control of⁷

MIL-STD-167-1 Mechanical Vibrations of Shipboard Equipment (Type I—Environmental and Type II—Internally Excited)⁷

S2.2.1 Military Specifications:

MS3452 Connector, Receptacle, Electric, Box Mounting, Rear Release, Crimp Contact, AN Type⁷

MS3456 Connector, Plug, Electrical, Rear Release, Crimp Contact, AN Type⁷

MIL-C-5015 Connectors, Electrical, Circular Threaded, AN Type General Specification for⁷

MIL-M-24794 Material, Index Matching, Fiber Optics⁷

MIL-F-49291 Fiber, Optical, (Metric), General Specifications for⁷

MIL-C-83522 Connectors, Fiber Optic, Single Terminus, General Specification for⁷

MIL-C-83522/16 Connector, Fiber Optic, Single Terminus, Plug, Adapter Style, 2.5 mm Bayonet Coupling, Epoxy⁷

MIL-C-83522/17 Connector, Fiber Optic, Single Terminus, Adapter, 2.5 mm Bayonet Coupling, Bulkhead Panel Mount⁷

MIL-C-83522/18 Connector Fiber Optic, Single Terminus, Adapter, 2.5 mm Bayonet Coupling, PC Mount⁷

MIL-C-85045 Cables, Fiber Optic, (Metric), General Specification for⁷

MIL-S-901 Shock Tests, H.I. (High Impact), Shipboard Machinery, Equipment, and Systems, Requirements for⁷

S3. Terminology

S3.1 *Definitions*—Terms marked with (ANSI/ISA S37.1) are taken directly from ANSI/ISA S37.1 (R-1982) and are included for the convenience of the reader.

S3.1.1 *ambient conditions*—conditions, such as pressure and temperature, of the medium surrounding the case of a sensor (ANSI/ISA S37.1).

S3.1.2 *calibration*—test during which known values of measurands are applied to the sensor and corresponding output readings are recorded under specific conditions (ANSI/ISA S37.1).

³ Annual Book of ASTM Standards, Vol 03.02.

⁴ Annual Book of ASTM Standards, Vol 15.09.

⁵ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

⁶ Available from Electronics Industries Association, 2500 Wilson Blvd., Arlington, VA 22201.

⁷ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

S3.1.3 *environmental conditions*—specified external conditions, such as shock, vibration, and temperature, to which a sensor may be exposed during shipping, storage, handling, and operation (ANSI/ISA S37.1).

S3.1.4 *error*—the error for a given value of the input variable (measurand) is the difference between the measured value of the output signal and the expected value of the output signal. The expected value of the output signal for any value of the measurand shall be represented by a straight line whose end points are given by:

S3.1.4.1 The specified value of the output signal at the minimum input value of the measurand (for example, 4 mA at the minimum specified rotational speed).

S3.1.4.2 The specified value of the output signal at the maximum input value of the measurand (for example, 20 mA at the maximum specified rotational speed).

S3.1.5 *noncontact tachometer*—any type of tachometer that senses or responds to rotational speed without physical contact or mechanical connection to the shaft being measured.

S3.1.6 *operating environmental conditions*—environmental conditions during exposure to which a sensor must perform in some specified manner (ANSI/ISA S37.1).

S3.1.7 *optical*—involving the use of light-sensitive devices to acquire information.

S3.1.8 *optical fiber*—a very thin filament or fiber, made of dielectric materials, that is enclosed by material of lower index of refraction and transmits light throughout its length by internal reflections.

S3.1.9 *optoelectronics module*—a component of the fiber optic tachometer that contains the optical source and detector, and signal conditioner devices necessary to convert the sensed rotational speed to a specified output signal.

S3.1.10 *output*—electrical or numerical quantity, produced by a sensor or measurement system, that is a function of the applied measurand.

S3.1.11 *range*—measurand values, over which a sensor is intended to measure, specified by their upper and lower limits (ANSI/ISA S37.1).

S3.1.12 *repeatability*—ability of a sensor to reproduce output readings when the same measurand value is applied to it consecutively, under the same conditions, and in the same direction (ANSI/ISA S37.1).

S3.1.13 *sensor element*—that part of the sensor that responds directly to the measurand (ANSI/ISA S37.1).

S3.1.14 *sensor head*—the transduction element of a fiber optic tachometer that detects rotational speed by means of changes in optical properties.

S3.1.15 *sheath*—the protective covering of a sensor element.

S3.1.16 *signal conditioner*—an electronic device that makes the output signal from a transduction element compatible with a readout system.

S3.1.17 *span*—the algebraic difference between the limits of the measurement range.

S3.1.18 *static error band*—the maximum deviation from a straight line drawn through the coordinates of the lower range limit at specified sensor output, and the upper range limit at specified output expressed in percentage of sensor span.

S3.1.19 *supporting surface*—surface on which the equipment is placed.

S3.1.20 *target*—description including items such as material, size, multiple reflectors, and surface features shall be as specified in the acquisition requirements.

S3.1.21 *tachometer*—an instrument capable of generating, transmitting, and indicating information or signal that can be converted into a function of rotational speed.

S3.1.22 *warm-up time*—the time required for a sensor to operate within specified accuracy, repeatability, and other critical parameters after being energized from a cold (ambient) state.

S4. Design Classification

S4.1 *Electric Types:*

S4.1.1 *Designation*—Tachometers shall be classified by a series of designations which shall be assigned and listed in the format following.

Example: F 2046-20M-BK-A

F 2046	20M	BK	A
Specification	Range (see S4.1.2)	Mounting (see S4.1.3)	Indicator (see S4.1.4)

S4.1.2 *Range*—Electric tachometer ranges shall be selected from the standard ranges listed in Table S4.1.

S4.1.3 *Mounting*—Tachometer indicators shall be either bulkhead mounted (designator—BK) or panel (designator—PL) mounted.

S4.1.4 *Indicator*—Tachometer indicators shall be either analog (designator—A) or digital (designator—D).

TABLE S4.1 Standard Ranges for Electric Tachometers

Range, RPM	Designation
0–100	10A
0–200	20A
0–500	50A
50–500	50M
0–1000	10B
100–1000	10M
0–2000	20B
200–2000	20M
0–3000	30B
300–3000	30M
0–4000	40B
0–5000	50B
500–5000	50N
0–10 000	10C
1000–10 000	10N
0–20 000	20C
1000–20 000	20N
0–30 000	30C
0–50 000	50C
5000–50 000	50P
0–100 000	10D
500–100 000	10P
1000–100 000	10R
5000–100 000	10T

S4.2 *Fiber-Optic Type:*

S4.2.1 *Designation*—The sensor classification shall consist of a series of designations which shall be assigned and listed in the form following.

Example: F 2046-DC-A-1

F 2046	dc	A	1
Specification	Input power S4.2.2	Optoelectronics module type S4.2.3	Sensor mounting configuration S4.2.4

S4.2.2 *Input Power*—The input power required to operate the optoelectronics module shall be designated as follows:

dc—28-V direct current (Vdc)
ac—115-V alternating current (Vac)

S4.2.3 *Optoelectronics Module*—The mounting of the tachometer’s optoelectronics module type shall be designated as follows:

Type A—Bulkhead mounted (see S7.3.1)
Type B—Console mounted (see S7.3.2)

S4.2.4 *Sensor Mounting Configuration*—The tachometer’s sensor shall be mounted according to the following mount requirement type. The mass per unit length of the sensor mount configuration shall be no greater than 0.02 kg/mm. The dimensions of the tachometer’s sensor head shall be in accordance with Fig. S4.1.

S4.2.4.1 *Mass*—Unless otherwise specified, the mass of the optoelectronics module shall be not greater than 5 kg.

S4.2.4.2 *Target*—The target description including items such as material, size, multiple reflectors, and surface features shall be as specified in the acquisition requirements.

S4.2.5 *Range*—The fiber-optic tachometer range is an internal selection within the optoelectronics module with the following ranges:

- 0—1000 RPM
- 0—5000 RPM
- 0—10 000 RPM
- 0—20 000 RPM

S5. Ordering Information

S5.1 The buyer shall provide the manufacturer with all of the pertinent application data shown in S5.2. If special application operating conditions exist that are not shown in the acquisition requirements, they shall also be described.

S5.2 *Acquisition Requirements*—Acquisition documents shall specify the following:

- (a) Title, number, and date of this specification;
- (b) Type and quantity required;

- (c) Whether panel or bulkhead mounting is required;
- (d) Range required;
- (e) National Stock Numbers (NSNs) if available;
- (f) When self-contained red illumination is required;
- (g) Whether tachometer, control box, and indicator should be other than drip-proof construction;
- (h) Number of additional indicators, if required;
- (i) When qualification testing is required;
- (j) Disposition of qualification test samples;
- (k) Analog or digital indicator requirement;
- (l) Special levels of preservation-packaging and packing required; and
- (m) Product marking and labeling required.

S5.2.1 *Fiber-Optic Requirements*—In addition to the requirements outlined in S5.2, acquisition documents for fiber-optic tachometers should specify the following:

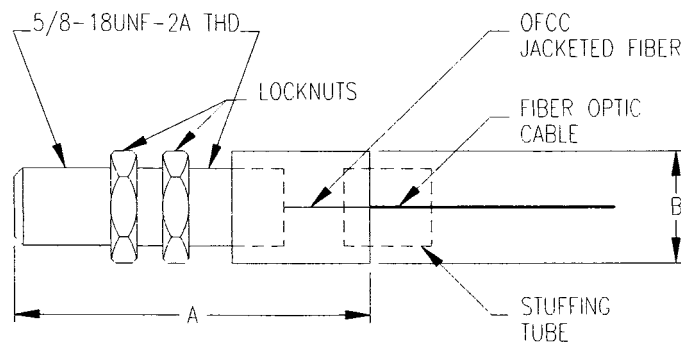
- (a) Classification (see S4.2.1):
 - (1) Input power,
 - (2) Optoelectronics module,
 - (3) Signal output, and
 - (4) Range.
- (b) Whether bulkhead or console mounting is required.
- (c) Type and quantity of indicator(s) required.
- (d) Whether junction box should be other than drip-proof construction.

S6. Materials and Manufacture

S6.1 *Metals*—Unless otherwise specified herein, all metals used in the construction of the tachometer shall be corrosion resistant. Dissimilar metals shall not be used in close physical contact with each other unless suitably finished to prevent electrolytic corrosion.

S6.2 *Flammable Materials*—Materials used in the construction of the tachometer shall, in the end configuration, be noncombustible or retardant in the most hazardous conditions of atmosphere, pressure, and temperature to be expected in the application.

S6.3 *Fungus-Resistant Materials*—Materials used in the construction of the tachometer shall be fungus-inert materials.



SENSOR HEAD DIMENSIONS (mm)	
A	200.0 MAX
B	50.0 MAX

FIG. S4.1 Sensor Head Construction

S6.4 *Solvents, Adhesives, and Cleaning Agents*—If any chemicals or cements are used in bonding of internal tachometer components, no degradation of these components shall result during in-service use.

S6.5 *Refractive Index Matching Gels, Fluids, or Compounds*—Refractive index matching gels, fluids, or compounds for fiber-optic tachometers shall be in accordance with MIL-M-24794.

S7. Physical Properties

S7.1 *Electric Tachometers*—Electric tachometers shall be a noncontact design and shall provide an output proportional to the continuous instantaneous shaft speed. Tachometers shall be for fixed mounted type of installations in which ranges from 100 to 100 000 RPM are encountered. Unless otherwise specified, the sensor, control box, and indicator shall be of drip-proof construction.

S7.1.1 *Sensor*—The sensor shall produce a signal by magnetic pulse, light pulse, or other noncontact method for input to the control box. The method of mounting or adapting the sensor may be varied to suit the machinery details.

S7.1.2 *Control Box*—The control box shall include the necessary electronics to process the sensor signal for driving the indicator. The sensor and control box may be combined in a single unit.

S7.1.3 *Indicator*—The indicator shall be capable of panel or bulkhead mounting. The indicator shall be analog or digital, as specified in the acquisition requirements. The analog indicator shall be a nominal 4½- or 6-in. round scale with a 250° minimum arc. The digital indicator may be a round or rectangular liquid crystal or light-emitting diode display with readout numerals a minimum of 1 cm in height. A stop shall be provided in analog indicators to prevent the indicating pointer from going past full-scale reading. Analog indicators shall have self-contained red illumination.

S7.1.3.1 *Dial and Pointer for Analog Indicators*—The dial shall be of a corrosion-resistant material that will not warp at 90°C. The dial shall have a dull white finish with scale markings, numerals, and pointer a dull black. Dial and pointer assembly shall be of commercial design.

S7.1.3.2 *Display or Indicator Windows*—The display shall be protected by a window of high-quality plastic, free from flaws and defects, that does not cause parallax error.

S7.1.4 *Dimensions and Weights (Maximum)*—Dimensions and weights of the indicator shall be as shown in Table S7.1.

TABLE S7.1 Dimensions and Weight (Indicators)

Nominal Scale Length Min, in.	Height Max, in.	Width Max, in.	Depth Max, in.	Weight Max, lbs
4½	5½	5½	5	5
6	7½	7½	6	6

S7.1.5 *Mounting*—The indicator shall be designed for panel or bulkhead mounting.

S7.1.6 *Operating Characteristics*—The tachometers shall instantaneously and continuously indicate information or a signal that can be converted into a function of the speed of rotation in RPM of the rotating part being measured. The

tachometers shall indicate, without change or adjustment, regardless of the direction of rotation of the driving part on the same scale.

S7.2 *Fiber-Optic Tachometers*—The fiber-optic tachometer shall be a noncontact device capable of converting a rotational speed to a continuous output signal throughout a specified measurement range. A fiber-optic tachometer shall consist of a sensor head, optoelectronics module, and fiber-optic cable connector at both ends. The optoelectronics module translates the optical input from the sensor head to a continuous linear proportional analog electrical signal or other output signal such as optical and digital.

S7.2.1 *Sensor Head*—The sensor head(s) shall be passive and detect shaft rotation through change in optical properties. The beam interruption sensing mechanism shall consist of two sensor heads. One sensor head shall be used to transmit, and one sensor head shall be used to receive an optical signal (generated from the optoelectronics module) across an air gap. Neither electrical nor electronic components shall be used in the construction of the sensor head. The configuration and physical dimensions of the sensor head(s) shall be as specified.

S7.2.2 *Optoelectronics Module Mounting*—The optoelectronics module mounting shall be either bulkhead or console mounted as specified.

S7.2.2.1 *Bulkhead Mounted (Type A)*—The optoelectronics module shall be housed in a junction box.

S7.2.2.2 *Console Mounted (Type B)*—The optoelectronics module shall be packaged in a circuit card that is a modular subassembly of a control console. Design and test requirements for the optoelectronics module shall be as specified.

S7.2.3 *Fiber-Optic Cable*—For integrity, the cable shall have an outer diameter of a four-fiber cable in accordance with MIL-C-85045. In the cable, there shall be no less than two times the number of fibers needed for operation of the sensor. The cable shall be supplied with a stuffing tube, packing assembly, and an O-ring, installed on each end of the cable to accomplish watertight penetration into the sensor head and optoelectronics module. Exposed single-fiber OFCC shall not be used over distances greater than 1 m. The length of cable shall be as specified.

S7.2.3.1 *Optical Fiber*—Optical fiber used to transmit light between the optoelectronics unit and the sensor head shall be in accordance with MIL-F-49291.

S7.2.3.2 *Fiber-Optic Connectors, Receptacles, and Bulkhead Adapters*—Fiber-optic connectors, receptacles, or bulkhead adapters used shall be in accordance with MIL-C-83522 and MIL-C-83522/16,17,18, respectively. Connectors shall be assembled at both ends of the fiber-optic cable between the sensor head and the optoelectronics module. The connectors and receptacles shall be mounted inside the sensor head or optoelectronics module.

S7.2.4 *Electrical Input Power Requirements*—Nominal steady-state power supply requirements for ac shall be 115 ± 8 V, 60 ± 2 Hz, single phase. Nominal steady-state power supply requirements for dc shall be 28 ± 4.5 V. The tachometer shall meet all performance requirements specified herein while operating with specified power supply voltages and their tolerances.