INCH-POUND

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MILITARY SPECIFICATION

SERVTORQ, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for integrated servomechanized synchro receiver-servomotors (acronym SERVTORQ). It is not complete in itself, but must be used in conjunction with MIL-S-81963 which forms an inherent part of this specification.

1.2 Classification.

1.2.1 Nomenclature. The nomenclature consists of the item name, Servtorq, followed by a type designation including a modification letter and a part identifying number. All units having the same nomenclature must be mechanically and electrically interchangeable for all military applications. The type designation is indicated by a combination of digits and letters. The type designation of a 26-volt unit should be preceded by "26V". The complete nomenclature of a size 23, 115-volt, 60- or 400-Hz Servtorq is illustrated in Table I. Nomenclature for new servtorq types will be assigned by the Naval Air Systems Command, Department of the Navy.

1.2.1.1 Size. The first two characters specify the maximum diameter in tenths of an inch. If the diameter is not a whole number of tenths, the next higher tenth should be used.

1.2.1.2 Function. The succeeding two characters, ST, indicate the function of the unit is that of a Servtorq.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to the Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department, Code 53, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC - N/A FSC 5990

1.2.1.3 Supply frequency. The succeeding digit or digits indicate the frequency of the input power and signal in Hertz (Hz) in accordance with the following:

Supply Frequency (Hz)	Code
60	6
400	4
60 or 400	64

1.2.1.4 Design modification. An upper-case letter "A" following the frequency code denotes the original or basic design of a standard servtorq. The first modification that affects the external mechanical dimensions or electrical characteristics of the basic unit will be indicated by the upper-case letter "B". Succeeding design modifications should be indicated by "C", "D", etc., except the use of "I", "L", "O", and "Q" is prohibited.

1.2.1.5 Part identifying number. The part identifying number (PIN) should consist of the letter "M", the basic specification sheet number (not including the revision letter), an assigned dash number, and a suffix letter designating the latest modification letter in the type designation, as shown in Table II.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS), and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

MIL-E-5400	Electronic Equipment, Aerospace, General Specification for
MIL-W-16768/4	Wire, Electrical, Polytetrafluoroethylene (PTFE) Insulated, 200°C, 600 Volts, Extruded Insulation
MIL-S-19500	Semiconductor Devices, General Specification for
MIL-S-20708	Synchros, General Specification for, and supplemental specification sheets

SPECIFICATIONS

MILITARY

MIL-S-81746/1	Servtorq, Type 15ST4A
MIL-S-81746/2	Servtorq, Type 23ST64A
MIL-S-81746/3	Servtorq, Type 23ST4A
MIL-S-81746/4	Servtorq, Type 37ST64C
MIL-S-81963	Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests: General Specification for

STANDARDS

MILITARY

MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-701	Lists of Standard Semiconductor Devices
MIL-STD-740	Airborne and Structureborne Noise Measurements and Acceptance Criteria of Shipboard Equipment
MS90406	Gage, Ring, Spline (Go-No Go)

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building #4, Section D, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 207.06	Tooth Proportions for Fine Pitch Involute Spur and Helical Gears
AGMA 2000-A	Gear Classification and Inspection Handbook Tolerances and Measuring Methods for Unassembled Spur and Helical Gears (Including Metric Equivalents)

(Application for copies should be addressed to the American Gear Manufacturers Association, 1330 Massachusetts Avenue, NW, Washington, DC 20005.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification takes precedence. Nothing in this specification, however, should supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein, in MIL-S-81963, and in accordance with the applicable specification sheets. In the event of any conflict between the requirements of this specification, MIL-S-81963, and the specification sheet, the specification sheet shall govern.

3.2 Qualification. Servtorqs furnished under this specification shall be products which have been listed or approved for listing on the applicable qualified products list (QPL) at the time set for opening of bids (see 4.4 and 6.4), if a QPL has been established.

3.3 First article. In the event that a QPL is not in existence, or when specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.5 and 6.3).

3.4 Quality conformance. The units furnished under this specification shall have been inspected and conform to the qualify conformance inspection specified herein (see 4.6).

3.5 Parts, materials, and processes. Servtorqs shall be constructed of parts and materials in accordance with MIL-S-81963 and the following criteria.

3.5.1 Material and process requirements. The requirements of MIL-STD-454 listed below are applicable to the materials and processes used in the manufacture of servtorqs described herein, in addition to the requirements of this specification and MIL-S-81963:

a. Requirement 13 - Structural welding

b. Requirement 17 - Printed wiring

c. Requirement 47 - Encapsulation and embedment (potting)

3.6 Design and construction.

3.6.1 Dimensions. The physical dimensions of the servtorq shall be identified by the letters shown on the outline drawings included as Figures 1, 2 and 3. The lettered dimensions are provided in Table III.

3.6.2 Termination identification. Screw and solder pin winding terminations shall be as specified in MIL-S-81963. Wire leads shall conform to MIL-W-16878/4 and shall be a minimum of 18 inches long. The identification of terminal screw, solder pin, or wire lead types shall be as specified in Table IV herein. Terminal hardware is listed in Table V.

3.6.2.1 Winding terminations. Windings shall be fabricated and assembled by processes which are not injurious to the wire or insulation. At the discretion of the qualifying activity, qualification samples may be sectioned and examined for wire deformation. Individual wire strands having a diameter reduced by 10 percent, or 10 percent of the wire strands in a group being deformed, shall be cause for withholding qualification approval.

3.6.3 Servtorq zero markings. The housing shall be permanently marked with an index line or arrow adjacent to the output shaft to coincide with a permanent mark on the shaft which positions the servtorq to within 10° of reference synchro zero, as defined in MIL-S-20708. Servtorq zero markings shall be inspected in accordance with 4.7.1.

3.6.4 Environmental temperature ranges. The servtorq shall be designed for use in Class 3 equipment as specified by MIL-E-5400. The environmental temperature ranges for operation and storage are:

a.	Storage	-57°C to +125°C
b.	Short time operation (10 minutes)	+150°C
c.	Intermittent operation (30 minutes)	+125°C
d.	Continuous operation	-54°C to +95°C

3.6.5 Input power requirements. A single-phase power source shall supply the voltage and frequency within the limits as specified in the applicable specification sheet.

3.6.5.1 Power factor. The input power factor shall be within 0.8 lagging and 0.95 leading.

3.6.5.2 Undervoltage protection. The servtorq shall not be damaged by voltages below the minimum specified herein and shall automatically resume normal operation when the voltage returns within limits.

3.6.6 Power supply. The servtorq shall incorporate an internal power supply. Power required within the amplifier shall be obtained from an internal source energized by this power supply. Transient protection shall be employed in the power supply design to prevent damage to the supply itself, as well as electronic assemblies powered by the supply (see 3.7.23 and 4.7.23).

3.6.7 Control transformer secondary load impedance. The secondary load on the servtorq control transformer shall be designed to provide the input impedance in accordance with 3.7.13 when power is supplied to the servtorq.

3.6.8 Signal input. The servtorq shall be designed to operate as specified herein from the signal output of a synchro transmitter, in accordance with MIL-S-20708, which is of compatible voltage and frequency and has an output impedance (Zss) equal to or less than the values listed in Table VI.

3.6.9 Electronic devices and components.

3.6.9.1 Discrete semiconductor devices. Discrete semiconductor devices, such as transistors and diodes, shall be selected in accordance with MIL-STD-701. The selection of these devices shall include the requirements of 3.6.9.4 in the design analysis.

3.6.9.2 Microcircuits. Microcircuits or integrated circuit devices shall be selected in accordance with requirement 64 of MIL-STD-454. The selection of these devices shall include the requirements of 3.6.9.4.

3.6.9.3 Passive components. Passive components shall be selected in accordance with the following requirements of MIL-STD-454. The selection of those components shall include the requirements of 3.6.9.4 in the design analysis.

a. Requirement 2 - Capacitors
b. Requirement 14 - Transformers, inductors, and coils
c. Requirement 33 - Resistors

3.6.9.4 Design requirements. All internal components selected shall meet the requirements of MIL-STD-454 and MIL-S-19500, as applicable.

3.6.10 Shaft data.

3.6.10.1 Splined. The end function of the spline is as a rotational positive fastener. It is not to be used as a gear. Splined shafts shall be inspected in accordance with MS90406. Tooth form shall be full depth involute.

3.6.10.2 Spur gear. Spur gears shall be designed in accordance with AGMA 207.06 and tested in accordance with AGMA 2000-A. Tooth form shall be full depth involute.

3.7 Performance.

3.7.1 Visual and mechanical inspection. Visual and mechanical inspection shall meet the requirements of MIL-S-81963 and this specification and shall be performed in accordance with 4.7.1.

3.7.2 Shaft radial and end play. Radial and end play shall be within the limits specified in the applicable specification sheet and shall be tested in accordance with 4.7.2.

3.7.3 Total shaft runout. When tested in accordance with 4.7.3, the total runout of the smooth portion of the shaft shall not exceed the value specified in the applicable specification sheet.

3.7.4 Dielectric withstanding. The servtorq shall meet the requirements of MIL-S-81963 and shall be tested in accordance with 4.7.4.

3.7.5 Insulation resistance. Insulation resistance of the servtorq shall be at least 50 megohms at 23°C ± 5°C and at -54°C ± 5°C, and at least 10 megohms at 95°C ±5°C when insulation resistance measurements are performed in accordance with 4.7.5.

3.7.6 Power and current.

3.7.6.1 Primary power and current. The values of the primary current and energizing power of the servtorq shall meet the requirements of the specification sheet and shall be tested in accordance with 4.7.6.1.

3.7.6.2 Power and current at stall. The values of input power and current consumption shall not exceed the values specified in the specification sheet and shall be tested in accordance with 4.7.6.2.

3.7.7 Direction of rotation. Shaft rotation of the servtorq shall be in the same direction as the shaft of the transmitter when both units are viewed from the shaft end while being tested in accordance with 4.7.7 and connected as shown in Figure 4.

3.7.8 Electrical error. The electrical error shall not exceed the value specified in the specification sheet when tested in accordance with 4.7.8.

3.7.9 Stall torque. The stall torque shall meet the requirement specified in the specification sheet when tested in accordance with 4.7.9.

3.7.10 Servtorq sensitivity. The change in electrical input to cause a perceptible movement in the servtorq output shaft shall not exceed the value specified in the specification sheet when the servtorq is tested in accordance with 4.7.10.

3.7.11 Dynamic error. The maximum error shall not exceed the value specified in the specification sheet when the servtorq is tested in accordance with 4.7.11.

3.7.12 Synchronizing time. The servtorq shall have a synchronizing time no greater than that specified in the specification sheet when tested in accordance with 4.7.12.

3.7.13 Impedance. The impedance values shall meet the requirements specified in the specification sheet when measured in accordance with 4.7.13.

3.7.14 Spinning. The output shaft of the servtorq shall synchronize or come to rest from any initial angular position without spinning when tested in accordance with 4.7.14.

3.7.15 Security of terminals or wire leads. The security of each screw type or solder pin type of terminal or of each wire lead, as applicable to the particular type of servtorq, shall meet the requirements of MIL-S-81963 when tested in accordance with 4.7.15.

3.7.16 Temperature rise.

3.7.16.1 Quiescent. The quiescent temperature rise measurements shall not exceed the values specified in the specification sheet when tested in accordance with 4.7.16.1.

3.7.16.2 Stall. The stall temperature rise measurements shall not exceed the values specified in the specification sheet when tested in accordance with 4.7.16.2.

3.7.17 Torque gradient. The torque gradient shall meet the requirements specified in the specification sheet when tested in accordance with 4.7.17.

3.7.18 No load slewing speed. The slewing speed shall meet the requirement specified in the specification sheet when tested in accordance with 4.7.18.

3.7.19 Velocity constant. The velocity constant shall meet the requirements specified in the specification sheet when tested in accordance with 4.7.19.

3.7.20 Variation of voltage and frequency. The servtorq shall be capable of operating satisfactorily from power sources subject to $\pm$ 10 percent voltage regulation in combination with $\pm$ 5 percent frequency variation. The power consumption shall not exceed that specified in the specification sheet when tested in accordance with 4.7.20.

3.7.21 Slewing speed under standard load. The servtorq shall synchronously drive the specified load at the slewing speed specified in the specification sheet when tested in accordance with 4.7.21.

3.7.22 Oscillation or hunting. No evidence of shaft oscillation or hunting shall be detected when the servtorq is tested in accordance with 4.7.22.

3.7.23 Transients. No damage shall occur to the servtorq, and it shall meet the requirements of 3.7.5, 3.7.12, and 3.7.13 when tested in accordance with 4.7.23.

3.7.24 Electromagnetic interference. When required by the applicable general specification, electromagnetic interference shall meet the requirements of MIL-S-81963 when tested in accordance with 4.7.24. The servtorq shall be connected as shown in Figure 5 during these tests.

3.7.25 Weight. The servtorq shall not exceed the maximum weight specified in the applicable specification sheet.

3.8 Environmental requirements.

3.8.1 Vibration. The servtorq shall meet the requirements of MIL-S-81963 and Table VII herein after vibration is conducted in accordance with 4.8.1.

3.8.2 Shock.

3.8.2.1 Shock, low impact. Servtorqs shall meet the requirements of MIL-S-81963 and Table VII herein after low shock is conducted in accordance with 4.8.2.1.

3.8.2.2 Shock, high impact. Servtorqs shall meet the requirements of MIL-S-81963 and Table VII herein after high shock is conducted in accordance with 4.8.2.2.

3.8.3 Altitude. During altitude testing, servtorqs shall be capable of operation from sea level to 100,000 feet in combination with any temperature from -54°C to 95°C. All servtorqs size 23 or smaller shall meet the requirements of Table VII herein.

3.8.3.1 Altitude, low temperature. When required by the specification sheet, the unit shall meet the requirements of Table VII during altitude, low temperature testing performed in accordance with 4.8.3.1.

3.8.3.2 Altitude, high temperature. When required by the specification sheet, the unit shall meet the requirements of Table VII during altitude, high temperature testing performed in accordance with 4.8.3.2.

3.8.4 Ambient temperature.

3.8.4.1 Ambient, low temperature. The servtorq shall meet the requirements of Table VII during ambient, low temperature testing performed in accordance with 4.8.4.1.

3.8.4.2 Ambient, high temperature. The servtorq shall meet the requirements of Table VII during ambient, high temperature testing performed in accordance with 4.8.4.2.

3.8.5 Endurance. The servtorq shall meet the requirements of Table VII after testing in accordance with 4.8.5. The servtorq shall be connected as shown in Figure 5 during the test.

3.8.6 Airborne noise. When required by the applicable specification sheet, servtorqs shall conform with the requirements of MIL-STD-740 for grade C equipment when tested in accordance with 4.8.6.

3.8.7 Audible noise, structureborne. When required by the applicable specification sheet, servtorqs shall meet the requirements of MIL-STD-740 when tested in accordance with 4.8.7.

3.8.8 Moisture resistance. Servtorqs shall meet the requirements of Table VII after testing in accordance with 4.8.8.

3.8.9 Salt atmosphere resistance. When required by the applicable specification sheet, servtorqs shall meet the requirements of MIL-S-81963 when tested in accordance with 4.8.9.

3.8.10 Explosion resistance. When required by the applicable specification sheet, servtorqs shall meet the requirements of MIL-S-81963 when tested in accordance with 4.8.10. The servtorq shall be connected as shown in Figure 5 during the test.

3.8.11 Internal examination. When required by the applicable specification sheet, servtorqs shall be subjected to an internal examination in accordance with 4.8.11 and shall meet the requirements of 3.5, 3.6.11 and 3.10.

3.9 Identification marking. Identification markings shall be as specified in MIL-S-81963.

3.10 Workmanship. Workmanship of the servtorq shall conform to the requirements of MIL-S-81963. The servtorq shall also conform with the applicable criteria of requirement 9 of MIL-STD-454.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Responsibility for inspection shall be as specified in MIL-S-81963.

4.1.1 Responsibility for compliance. The responsibility for compliance with all requirements of sections 3 and 5 shall be in accordance with MIL-S-81963.

4.1.2 Test equipment and inspection facilities. The accuracy of test equipment and inspection facilities shall conform to MIL-S-81963.

4.1.3 Alternate test methods. Alternate test methods shall conform to MIL-S-81963.

4.2 Test conditions.

4.2.1 Standard test conditions. Unless otherwise specified, the standard test conditions shall be as specified in MIL-S-81963, and each test shall be carried out with the servtorq in the applicable mounting fixture in accordance with MIL-S-81963.

4.2.2 Climatic conditions. Unless otherwise specified herein, all measurements shall be made within the following temperature, atmospheric pressure, and relative humidity limits.

Temperature - 23° ± 5°C
Pressure - 28 to 32 inches Hg
Humidity - No greater than 55 percent

4.2.3 Temperature, stabilized operating. The stabilized operating temperature is the temperature condition of the servtorq in a specified ambient environment, after the specified voltage of 4.2.5 has been applied to the R1-R2 terminals for a period sufficient for the servtorq to have attained a stable operating temperature. The stabilized operating temperature shall be determined by the periodic measurement of the DC resistance measured between S2 and terminals S1 and S3 strapped together. Stabilized operating temperature shall have been attained when the resistance, measured at five minute intervals, changes less than 0.5 percent from the preceding measurement. The servtorq shall be connected to a synchro transmitter, in accordance with 3.6.8 and Figure 6, between measurements and disconnected during the measurements.

4.2.4 Temperature, stabilized non-operating. The stabilized non-operating temperature of the servtorq shall be as specified in MIL-S-81963 using the applicable secondary windings S1-S2 for the periodic DC resistance measurement.

4.2.5 Standard test voltage and frequency. Unless otherwise specified, the test voltage and frequency of a true sine wave shall be as specified in Table VIII. The voltage and frequency shall be maintained within a tolerance of ± 1 percent. The total harmonic content shall be less than 1 percent.

4.2.6 Angular accuracy test stand. When specified, the angular accuracy test stand shall be an angular dividing device by which angular positions may be set with an error no greater than ± 15 seconds of arc. The means adopted to mount the synchro shall be such that accumulated tolerances do not introduce an error, due to lack of concentricity, greater than 30 seconds of arc.

4.2.7 Synchro signal simulator. A synchro simulator may be used wherever a signal input is specified. If used, the simulator electrical output shall conform with MIL-S-20708.

4.3 Classification of tests. The methods of sampling, inspection, and tests conducted on servtorqs shall be classified as follows:

a. Qualification (4.4)

b. First article (4.5)

c. Quality conformance (4.6)

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory approved by the Naval Air Systems Command and shall be performed in accordance with MIL-S-81963 and Table VII herein.

4.4.1 Qualification sample. The qualification sample shall be as specified in MIL-S-81963.

4.4.2 Qualification inspection routine. The qualification inspection routine shall be performed in accordance with MIL-S-81963 and Table VII herein.

4.4.3 Assessment of qualification approval test results.

4.4.3.1 Qualification sample failure. Qualification sample failure shall be as specified in MIL-S-81963.

4.4.3.2 Degradation of performance. The following relaxations may be permitted at the discretion of the qualifying activity in accordance with MIL-S-81963.

4.4.3.2.1 Quality conformance tests. All the specified performance characteristics must be attained.

4.4.3.2.2 Environmental tests. As appropriate during or following each of the environmental tests, the following minor relaxations in specified requirements may be permitted. It should be noted that the relaxations are not cumulative; for example, electrical error, if accepted at up to 1 minute of arc in addition to the specified maximum value following vibration, shall still not be more than 1 minute of arc in addition to the specified maximum value following low impact shock.

4.4.3.2.2.1 Shaft radial play. The maximum permissible radial play is 1.5 times the maximum value specified in the specification sheet. Following high impact shock, radial play not exceeding 2.25 times the maximum value specified in the specification sheet is permissible.

4.4.3.2.2.2 Shaft end play. Irrespective of the limits specified in the specification sheet, a minimum end play value of 0.0001 inch is required. The maximum permissible end play is 1.66 times the maximum value specified in the specification sheet. Following high impact shock, end play not exceeding 2.5 times the maximum value specified in the specification sheet is permissible.

4.4.3.2.2.3 Dielectric withstanding voltage. Following high impact shock, a winding leakage current increase to 1.5 milliamperes peak maximum is permissible.

4.4.3.2.2.4 Insulation resistance. Following high impact shock and having been immediately preceded by dielectric withstanding voltage, a reduction to 25 megohms insulation resistance is permissible.

4.4.3.2.2.5 Electrical error. An increase of 1 minute in addition to the maximum electrical error value specified in the specification sheet may be permitted. Following high impact shock, an increase to 1.5 times the maximum electrical error specified in the specification sheet is permissible.

4.4.3.2.2.6 Major failures during or following environmental tests. Allowances having been made for the relaxations quoted in 4.4.3.2.2, failures experienced during or following environmental tests shall be dealt with as provided for in MIL-S-81963.

4.4.3.3 Qualification sample isolated failure. In case of catastrophic failure, the procedures of MIL-S-81963 shall apply.

4.4.4 Disposition of qualification sample. Disposition of the qualification sample shall be as specified in MIL-S-81963.

4.4.5 Requalification. The frequency of qualification inspection in order to retain qualification approval shall be as specified in MIL-S-81963.

4.4.6 Changes to servtorq samples. After samples have been submitted for qualification, no change shall be made in the materials, design, or manufacturing processes without prior approval of the qualifying activity.

4.5 First article sample inspection. When required by the contracting activity, first article shall be as specified in MIL-S-81963.

4.5.1 First article sample failure. Action following first article sample failure shall be as specified in MIL-S-81963.

4.6 Quality conformance inspection. Quality conformance inspection shall be as specified in MIL-S-81963 and Table VII herein.

4.6.1 Burn-in period. The manufacturer shall subject all servtorqs to a burn-in period prior to quality conformance inspection. Burn-in shall be for a minimum period of 50 failure-free hours. Burn-in shall consist of mounting the servtorq in a chamber, maintained at 65°C, loading the shaft with the appropriate disc listed on Figure 7, applying standard voltage and frequency in accordance with 4.2.5 and signal input from a synchro transmitter in accordance with 3.6.8. The rotor shaft of the synchro transmitter shall be continuously driven at 60 rpm $\pm$ 1 rpm.

4.6.2 Quality conformance inspection sampling. Statistical sampling and inspection shall be as specified in MIL-S-81963. When MIL-STD-105 specifies an action by the Government, it shall, at the option of the Government, be performed either by the Government or by the contractor under the supervision of the Government.

4.6.3 Quality conformance inspection routine. The minimum of inspection to be verified by the Government Inspector shall be the requirements of MIL-S-81963 and Table VII herein. The Government Inspector may substitute 100 percent inspection for all or part of the sampling procedure.

4.6.4 Quality conformance sample failure. Action following quality conformance sample failure shall be as specified in MIL-S-81963.

4.7 Test methods and examinations.

4.7.1 Visual and mechanical inspection. The servtorq shall be examined in accordance with MIL-S-81963 and shall meet the requirements of 3.7.1.

4.7.2 Radial and end play. Shaft radial and end play shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.7.2.

4.7.3 Total shaft runout. Total shaft runout of the smooth portion of the shaft shall be conducted in accordance with MIL-S-81963 and shall not exceed the requirements of 3.7.3.

4.7.4 Dielectric withstanding. A test potential of 875 ± 15 volts rms, 60 Hz, for 115-volt units, or a 493.5 ± 7.5 volts rms, 60 Hz, for 26-volt units shall be applied between three stator leads, strapped together, and the housing. Terminals marked R1 and R2 shall not be tested for dielectric strength as they include electronic circuitry which incorporates low-voltage components, such as transistors and diodes. The test potential shall be raised slowly (minimum time 3 seconds) to the specified value and held at that value for one minute; then slowly reduced (minimum time 3 seconds) to zero. The peak value of the test potential throughout this test shall not exceed 1.5 times the specified rms test potential. The above test potential shall be used for quality conformance testing only. Any dielectric withstanding test that is repeated on the same unit, either during quality conformance or qualification testing, shall have a reduced test potential of 730 ± 20 volts rms, 60 Hz, applied to 115-volt units, or 394 ± 6 volts rms, 60 Hz, applied to 26-volt units. A failure shall be indicated by a winding leakage current in excess of one milliampere peak or the indication of internal arcing or discharge. The failure leakage current limit of one milliampere peak shall not include that current drawn by the equipment capacity or capacitance of the winding under tests. Test equipment that detects winding leakage current in the presence of a surge discharge current, or test equipment that produces equivalent results, shall be employed. Immediately after successfully conforming with the requirements of 3.7.4, the unit shall be subjected to the insulation resistance test as specified in 4.7.5.

4.7.5 Insulation resistance.

4.7.5.1 Stator terminals. The insulation of the control transformer stator shall be measured by means of a device that applies 500 VDC while indicating the insulation resistance. The measurement shall be made between the three stator windings, strapped together, and the housing. The servtorq shall meet the requirements of 3.7.5 herein.

4.7.5.2 R1 and R2 terminals. The insulation resistance of the electronics and torque motor circuits shall be measured by means of a device that applies 50 VDC while indicating insulation resistance. This measurement shall be made between the R1 and R2 terminals, strapped together, and the housing. The servtorq shall meet the requirements of 3.7.5.

4.7.6 Power and current.

4.7.6.1 Primary power and current. The primary power and current to the servtorq shall be measured with the unit energized and stabilized as specified in 4.2.5 and 4.2.3 with the shaft under a no-load condition. The measurements shall be made with the servtorq mounted in the applicable standard test fixture in accordance with MIL-S-81963. True rms meters and measurement techniques shall be used as required. The servtorq shall meet the requirements of 3.6.5.1 and 3.7.6.1.

4.7.6.2 Power and current at stall. The power and current to the servtorq shall be measured with the unit energized and stabilized as specified in 4.2.5 and 4.2.3. The shaft of the servtorq shall be rotated to produce the highest value of power and current. The measurements shall be made with the servtorq mounted in the applicable standard test fixture in accordance with MIL-S-81963. The servtorq shall meet the requirements of 3.7.6.2.

4.7.7 Direction of rotation. The servtorq shall be electrically connected to a synchro transmitter in accordance with 3.6.8 as shown in Figure 4, and energized in accordance with 4.2.5. The synchro transmitter shall be rotated, and the shaft rotation of the servtorq shall conform with the requirements of 3.7.7.

4.7.8 Electrical error. The servtorq shall be tested for electrical error by the proportional voltage nulling method, the synchro standard/angle position indicator method, or by a method of at least equal accuracy.

4.7.8.1 Proportional nulling method. The unit shall be connected in accordance with Figure 8.

4.7.8.1.1 Basic setup. With the synchro bridges set at zero, the control transmitter (CX1) shall be mounted in an angular index stand in accordance with 4.2.6. The fine adjustment control of the index stand shall be adjusted to obtain a minimum null reading on the phase-sensitive voltmeter (PSVM-1). The control transmitter (CX2) shaft shall then be mechanically coupled to the servtorq shaft and adjusted to obtain a minimum

null reading on PSVM-2. The mechanical coupling shall be such that there is no play or backlash between the servtorq and CX2 shafts. This is the reference position for this test.

4.7.8.1.2 Test procedure. The synchro bridges shall then be set at 5°, the CX1 positioned in the index stand to obtain a minimum null reading on PSVM-1, and the dial indicator of the index stand mechanically positioned to zero. After the dial indicator has been set at zero, the CX1 shaft shall be repositioned, using the fine adjustment control of the index stand to obtain a minimum null reading on PSVM-2. The reading appearing on the dial indicator of the index stand is the gross electrical error for the 5° rotor position. This procedure shall be repeated at 5° increments through 360°. The final reading, at the 0° position, shall not exceed ± 45 seconds, as specified in 4.2.6.

4.7.8.1.3 Control transmitter electrical error. The control transmitter (CX2) used for this test shall have had its electrical error determined in accordance with the MIL-S-20708 proportional voltage null method. These errors shall be algebraically subtracted from the gross electrical error at each position to obtain the electrical error of the servtorq. The servtorq electrical error shall conform with the requirements of 3.7.8.

4.7.8.2 Synchro standard/angle position indicator (API) method. The unit shall be connected in accordance with Figure 9. The standard shall be incremented in 5-degree increments. At each position, the API's reading shall be subtracted from the synchro standard's setting to obtain the electrical error. The largest difference is the electrical error. If the electrical error of the CX is more than 30 seconds, its error shall be algebraically subtracted from the corresponding total error to obtain the electrical error.

4.7.8.3 Alternate test methods. If an alternate method of testing is selected, the accuracy shall be demonstrated by analysis and calibration data or by subjecting at least 5 percent of the units under test to both methods and correlating the test data. Equal accuracy shall be defined as the test data corresponding within 1 minute at 0° rotor position (synchro zero) and 2 minutes at all other rotor positions.

4.7.9 Stall torque. The servtorq shall be mounted in an appropriate test fixture and the unit energized with the specified power of 4.2.5 and signal input of 3.6.8. After reaching the standard operating temperature specified in 4.2.3, torque shall be applied by weights suspended by a thread attached to the rim of a pulley that has been rigidly mounted on the servtorq shaft. The stall torque, in ounce-inches, shall be determined by measurement of the maximum torque, to an accuracy of ± 0.10 ounce-inch, that does not cause pullout of the shaft. If an alternate method of measurement is made, it shall be in a manner such that appreciable heating of the servtorq does not have time to occur. The servtorq shall meet the requirements of 3.7.9.

4.7.10 Servtorq sensitivity. The servtorq shall be connected to the basic circuit shown in Figure 8 and the reference position obtained as specified in 4.7.8.1. The CX1 shaft shall be repositioned in one direction, using the fine adjustment control of the index stand to obtain the minimum discernible change in the reading of PSVM-2. The reading of the dial indicator shall be recorded. The CX1 shaft shall then be repositioned in the opposite direction to again obtain the minimum discernible change in reading of PSVM-2. The difference between the two readings of the dial indicator shall be recorded. The sensitivity shall be the highest difference in reading of three successive tests performed in each direction. The servtorq sensitivity shall meet the requirements of 3.7.10.

4.7.11 Dynamic error. The dynamic error shall be the difference between the servtorq's input signal and the servtorq's shaft position while the servtorq is electrically driven at one rpm.

4.7.11.1 Proportional nulling method.

4.7.11.1.2 Basic setup. The unit shall be connected as shown in Figure 10. The reference transmitter CX1 selected shall be a frame size 23 (see MIL-S-20708) and have an electrical error of less than 2 minutes. The resolvers used in Figure 10 must have an error of 20 seconds or less. If the errors of the reference components exceed the above limits, the dynamic error must be adjusted to remove the errors.

4.7.11.1.2 Test procedure. The shaft of the servtorq shall be coupled to the shaft of the resolver transmitter in Figure 10. The output of the resolver transformer shall be connected to a phase-sensitive voltmeter (PSVM) and a recorder. The system shall be energized in accordance with 4.2.5 and allowed to reach stabilized operating temperature in accordance with 4.2.3. The control transmitter shall be de-energized and the shaft of the servtorq/resolver transmitter rotated until a maximum voltage reading is indicated on the PSVM. This voltage reading will be used to calculate the scale factor (SF) for the recorder using the following formula:

$$SF \text{ (arc minutes)} = \frac{(\text{max PSVM read}) \text{ Sine } 1^\circ}{60}$$

Example: max PSVM reading = 30 volts; Sine 1° = .01745

$$SF = \frac{30 \times .01745}{60} = .00873 \text{ volts/minute}$$

To calibrate the recorder for 30 minutes, rotate the servtorq/resolver transmitter shaft until the PSVM reads .262 volts (30 x .00873 = .262) and set the calibration on the recorder to 30 minutes. Re-energize the control transmitter and turn on the recorder and drive motor. Record for at least one revolution of the servtorq. Reverse direction of the drive motor and record for at least one revolution of the servtorq. The peak value shall meet the requirements of 3.7.11.

4.7.11.2 Synchro standard/angle position indicator (API) method.

4.7.11.2.1 Test setup. The test setup shall be in accordance with Figure 9.

4.7.11.2.2 Test procedure. The synchro standard shall be incremental with increments of 0.01 degrees or less. To increase the accuracy of the input synchro signal, an API(2) may be used to monitor the signal. The output synchro (CX) shall have an electrical error of 20 seconds or less. The synchro standard shall drive the servtorq to 0 degrees. The CX's shaft shall be coupled to the servtorq's shaft, and the CX adjusted to 0 degrees. The computer shall continuously increment the standard to simulate one rpm. At the same time, the computer shall compare the output API(1) to the input signal or API(2) to determine the dynamic accuracy.

4.7.12 Synchronizing time. The servtorq, mounted in the applicable test stand in accordance with MIL-S-81963, shall be connected to a synchro transmitter, locked at synchro zero, as shown in Figure 11. The applicable test dial shall be rigidly mounted on the shaft of the servtorq in accordance with MIL-S-81963. The system shall then be energized as specified in 4.2.5 and the servtorq allowed to reach stabilized operating temperature in accordance with 4.2.3. The unit shall be de-energized and the shaft of the servtorq displaced 30° ± 2°. The unit shall then be energized and the time required for the shaft to return to within one degree of synchro zero shall be measured on the oscilloscope. The synchronizing time shall be the average of three successive tests. This test shall be repeated at a displacement of 330° ± 2°, 177° ± 2°, and 183° ± 2°. The synchronizing time shall meet the requirements of 3.7.12.

4.7.13 Impedance. The servtorq, mounted in the applicable test stand in accordance with MIL-S-81963, shall be connected to a synchro transmitter in accordance with 3.6.8 as shown in Figure 6 and energized in accordance with 4.2.5. The servtorq shaft shall be allowed to seek its zero position. After the servtorq has been allowed to reach stabilized operating temperature in accordance with 4.2.3, the synchro transmitter shall be disconnected and the stator impedance immediately measured as shown in Figure 12. The method of impedance measurement shall be in accordance with the method described in MIL-S-81963. The impedance values shall meet the requirements of 3.7.13.

4.7.14 Spinning. The applicable test dial shall be rigidly mounted on the shaft of the servtorq in accordance with MIL-S-81963. A size 37 torque transmitter for 115-volt servtorqs, or a size 11 for 26-volt servtorqs, shall be locked at synchro zero and connected to the appropriate terminals of the servtorq. The rotor of the servtorq shall be displaced 177° ± 2° from synchro zero and the system energized with 120 percent of specified nominal test voltage at the specified frequency. This procedure shall be performed five times for a clockwise displacement and five times for a counterclockwise displacement. The servtorq shall conform with the requirements of 3.7.14.

4.7.15 Security of terminals or wire leads. The security of each screw type or solder pin type of terminal or of each wire lead, as applicable to the particular type of servtorq, shall be tested in accordance with MIL-S-81963 and shall meet the requirements of 3.7.15.

4.7.16 Temperature rise.

4.7.16.1 Quiescent temperature rise. Servtorqs shall be mounted in the applicable test fixture in accordance with MIL-S-81963 and placed in a suitable enclosure shielded from stray currents at the standard temperature (4.2.3). The enclosure shall have at least three cubic feet of space per unit. The units shall be connected in accordance with Figure 6 and energized until the servtorq shaft is synchronized with the CX. After synchronization, the units shall be de-energized and allowed to stabilize for a period of four hours. The CX shall be disconnected from the servtorq and the DC resistance of the servtorq's S1 to S2 shall be recorded as Rc. The units shall be reconnected in accordance with Figure 6 and energized in accordance with 4.2.5. After the unit has reached the stabilized operating temperature of 4.2.3, the temperature rise, in terms of the following formula, shall be determined.

$$\text{Temperature rise } (°C) = (T_h - T_c) = \frac{(R_h - R_c)\ (234.5 + T_c)}{R_c}$$

where:

R_h = Resistance of winding at the final stabilized temperature

R_c = Resistance of winding at the starting temperature T_c

T_c = Ambient temperature (°C) at start of test

T_h = Temperature at final stabilized point

234.5 = 1/0.00427 (0.00427 is the temperature coefficient of resistance of 100 percent conductivity of copper at 0°C per NBS Handbook 100.)

Any method of measuring the resistance of the windings without permitting significant cool-off is permissible. The servtorq shall meet the requirements of 3.7.16.1.

4.7.16.2 Temperature rise at stall. The servtorq shaft shall then be rotated to and locked at the position that produces maximum power consumption. The winding connection, power source, and signal input shall continue to be applied as specified in 4.7.16.1. After the servtorq has reached stabilized temperature, as measured in accordance with 4.2.3, the temperature rise shall be determined. Any method of measuring the resistance of the windings without permitting significant cool-off is permissible. The servtorq shall meet the requirements of 3.7.16.2.

4.7.17 Torque gradient. The servtorq shall be rigidly coupled to the shaft of a control transmitter, upon which a pulley of precisely known diameter has been mounted and connected to the circuit shown in Figure 13. The servtorq shall be energized in accordance with 4.2.5 and allowed to reach stabilized operating temperature in accordance with 4.2.3. A minimum of four readings utilizing weights in increments of approximately 25 percent, 50 percent, 75 percent, and 90 percent of the stall torque reading shall be taken by suspending the predetermined weight from a thread attached to the rim of the pulley. The servtorq shaft deflections shall be determined in both the clockwise and counterclockwise directions by this method. The torque-deflection curve plotted as the straight line best fitted to the observed points. The torque gradient shall be one-half the slope of this line expressed in ounce-inches per degree. The servtorq shall meet the requirements of 3.7.17.

4.7.18 No load slewing speed. The servtorq and applicable synchro transmitter shall be energized with the applicable power input of 4.2.5 and the servtorq allowed to reach standard operating temperature as specified in 4.2.3. The shaft of the synchro transmitter shall then be driven at that speed which is necessary to measure the no-load slewing speed of the servtorq. The slewing speed shall be measured by using a counter, strobotac, or other appropriate device which does not place a discernible load on the servtorq and has a tolerance no greater than 4 rpm. The slewing speed shall be measured within 5 minutes of beginning rotation of the synchro transmitter shaft. The no-load slewing speed shall meet the requirements of 3.7.18.

4.7.19 Velocity constant. Since the angular error input (control transformer error voltage into the amplifier) is not available for measurement, the velocity constant shall be obtained indirectly. The velocity constant is equal to the ratio of the torque gradient to the motor damping constant. The motor damping constant is the slope of the speed torque curve of the motor and is equal to the ratio of maximum output torque to the maximum speed:

$$\text{Velocity constant} = \frac{\text{Torque gradient (oz.-in./radian)}}{\frac{\text{Stall torque (oz.-in./radian}}{\text{Maximum speed (radians/sec.}}}$$

The test data obtained in performance of 4.7.9, 4.7.17 and 4.7.18, converted to the proper units, shall be used to determine the velocity constant. The velocity constant of the servtorq shall meet the requirements of 3.7.19.

4.7.20 Variation of voltage and frequency. The servtorq shall be mounted in the applicable test stand in accordance with MIL-S-81963, energized and stabilized in accordance with 4.2.5 and 4.2.3. The voltage shall be adjusted to 110 percent and the frequency adjusted to 95 percent of the values specified in 4.2.5. The power drawn from the energizing source shall meet the requirements of 3.7.20.

4.7.21 Slewing speed under standard load. The standard loading disk shown in Figure 7 shall be rigidly mounted on the servtorq shaft. The servtorq shall be connected to a synchro transmitter in accordance with 3.6.8 and energized with the applicable power input of 4.2.5. After the servtorq has been allowed to reach standard operating temperature as specified in 4.2.3, the shaft of the synchro transmitter shall be driven at that speed which is necessary to measure the slewing speed under standard load. The slewing speed shall be measured using a counter, strobotac, or other appropriate device, which does not place an additional load on the servtorq and has a tolerance no greater than 4 rpm. The slewing speed under standard load shall meet the requirements of 3.7.21.

4.7.22 Oscillation and hunting. The servtorq shall be connected to the basic circuit shown in Figure 11, energized in accordance with 4.2.5, and the servtorq shaft allowed to seek its quiescent position. The input current waveform shall then be monitored on the oscilloscope for evidence of hunting or oscillation. The servtorq shall conform to the requirements of 3.7.22.

4.7.23 Transients. The servtorq shall be electrically connected to a synchro transmitter in accordance with 3.6.8. The system shall be energized in accordance with 4.2.5 and the synchro transmitter shaft rotated continuously at a rate of 1 rpm. A 600-volt, 10-microsecond pulse shall be superimposed on the supply voltage at the servtorq rotor input terminals. Following the pulse discharge, the servtorq shall meet the requirements of 3.7.23.

4.7.24 Electromagnetic interference. When required by the applicable general specification, the servtorq shall be tested in accordance with MIL-S-81963 and conform with the requirements of 3.7.24. During this testing, the servtorq shall be connected to a synchro transmitter in accordance with 3.6.8 (as shown in Figure 5) energized in accordance with 4.2.5, and the synchro transmitter rotated continuously at a rate as specified in the applicable specification sheet.

4.8 Environmental tests.

4.8.1 Vibration. Servtorqs shall be tested in accordance with MIL-S-81963, with terminals R1 and R2 energized as specified in 4.2.5. After vibration, servtorqs shall meet the requirements of 3.8.1 herein.

4.8.2 Shock.

4.8.2.1 Shock, low impact. Servtorqs shall be tested in accordance with MIL-S-81963 and energized in accordance with 4.2.5. After testing, servtorqs shall meet the requirements of 3.8.2.1.

4.8.2.2 Shock, high impact. Servtorqs shall be tested in accordance with MIL-S-81963 and energized in accordance with 4.2.5. After testing, servtorqs shall meet the requirements of 3.8.2.2.

4.8.3. Altitude.

4.8.3.1 Altitude, low temperature. Servtorqs shall be tested in accordance with MIL-S-81963, energized in accordance with 4.2.5, and shall meet the requirements of 3.8.3.1.

4.8.3.2 Altitude, high temperature. Servtorqs shall be tested in accordance with MIL-S-81963, energized in accordance with 4.2.5, and shall meet the requirements of 3.8.3.2.

4.8.4 Ambient temperature test. The temperature extremes of -57°C and 125°C required in accordance with 4.8.4.1 and 4.8.4.2 are tests for storage extremes and are required to be accomplished once only on each servtorq tested. The unit shall be conditioned at the operational temperatures as often as necessary to perform the required tests. Upon completion of the applicable temperature test, the unit shall be removed from the test chamber and maintained at the standard test conditions specified by 4.2.2 for a minimum period of four hours before being subjected to subsequent tests.

4.8.4.1 Ambient low temperature. The servtorq, mounted in the applicable text fixture, shall be placed in a test chamber and the temperature reduced to -57°C ± 2°C. This temperature shall be maintained for at least 24 hours. The test chamber temperature shall then be raised to and controlled at -54°C ± 2°C. After the temperature of the unit, energized in accordance with 4.2.5 and supplied with an input signal from a source in accordance with 3.6.8, has stabilized as specified by 4.3.2, the servtorq shall be tested to determine conformance with the requirements of 3.8.4.1. The conditioning provisions of 4.8.4 shall apply.

4.8.4.2 Ambient high temperature. The servtorq, mounted in the applicable test fixture, shall be placed in a test chamber and the temperature raised to 125°C ± 2°C. This temperature shall be maintained for at least 24 hours. The chamber temperature shall then be reduced to 95°C ± 2°C. After the temperature of the unit, energized in accordance with 4.2.5 and supplied with an input signal in accordance with 3.6.8, has stabilized as specified by 4.3.2, the servtorq shall meet the requirements of 3.8.4.2. The conditioning provisions of 4.8.4 shall apply.

4.8.5 Endurance. Servtorqs shall be subjected to an endurance test of 2000 ± 10 hours while energized as specified in 4.2.5 and with the shaft electrically driven by a signal source in accordance with 3.6.8 (as shown in Figure 5). The rate of shaft rotation shall be as listed on the specification sheet. The 2000-hour test period shall be divided according to Table IX. The servtorq shall be electrically driven in the clockwise direction of rotation for 50 percent of each time period and in the counterclockwise direction for the remaining 50 percent. Following the 2000 hours, the servtorq shall be stabilized at standard conditions (see 4.2.2) and shall then meet the requirements of 3.8.5.

4.8.6 Airborne noise. When required by the applicable specification sheet, servtorqs shall be tested in accordance with MIL-STD-740 for grade C equipment, and shall meet the requirements of 3.8.6.

4.8.7 Audible noise, structureborne. When required by the applicable specification sheet, servtorqs shall be tested in accordance with MIL-S-81963, energized in accordance with 4.2.5, and shall meet the requirements of 3.8.7.

4.8.8 Moisture resistance. Servtorqs shall be subjected to the moisture resistance test in accordance with MIL-S-81963, energized in accordance with 4.2.5, and shall meet the requirements of 3.8.8.

4.8.9 Salt atmosphere resistance. When required by the applicable specification sheet, servtorqs shall be tested in accordance with MIL-S-81963. After completion of the test, servtorqs shall meet the requirements of 3.8.9.

4.8.10 Explosion resistance. When required by the applicable specification sheet, servtorqs shall be tested in accordance with MIL-STD-202, Method 109, except there shall be no vibration requirement. The servtorq shall be connected and driven in accordance with Figure 5 while energized with 105 percent of the specified voltage at the specified frequency of 4.2.5. While the servtorq is being driven, the signal input shall be open-circuited a minimum of five times. The servtorq shall conform to the requirements of 3.8.10.

4.8.11 Internal examination. When required by the applicable specification sheet, the servtorq shall be disassembled and examined for conformance to the requirements of 3.5, 3.6.10, and 3.10. There shall be no evidence of damage resulting from the tests specified herein, loose parts, corrosion, or deterioration.

4.9 Inspection of packaging. The sampling and inspection of the preservation-packaging, packing, and container marking shall be in accordance with the requirements of MIL-S-81963.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-81963.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The intended use for servtorqs covered by this specification must be in accordance with MIL-S-81963.

6.2 Acquisition requirements. Acquisition documents should contain the information specified in MIL-S-81963.

6.3 First article inspection. Information pertaining to first article inspection of servtorqs should be obtained as specified in MIL-S-81963.

6.4 Qualification. With respect to products requiring qualification, awards will be made in accordance with MIL-S-81963. The activity responsible for the Qualified Products List is the Naval Air Systems Command (AIR-5163), Department of the Navy, Washington, DC 20361-5160; however, information pertaining to qualification of products may be obtained from Commanding Officer, Naval Weapons Support Center (Code 7025), Crane, IN 47522-5070.

6.5 Definitions.

6.5.1 Servtorq. The servtorq is a self-contained, remote angular positioning device for converting synchro electrical input data into an accurate high-torque shaft position. The integrated assembly will consist of a synchro control transformer (CT), a power supply, a demodulator, an amplifier, and a direct-current torque drive motor.

6.5.1.2 Functional design. A functional block diagram of the servtorq is provided in Figure 14. The servtorq is commanded by a three-wire electrical input from a synchro transmitter (CDX, TDX, CX, or TX). The synchro transmitter converts angular position into electrical voltage, and excites the stator windings of the servtorq control transformer (CT), which has its rotor directly coupled to the servtorq output shaft. An error voltage, proportional to the difference in the synchro transmitter shaft position and the servtorq shaft position, is obtained from the rotor electrical output of the CT. The error voltage is injected into a phase-sensitive demodulator which converts the in-phase alternating current error signal to a proportional direct current voltage. This voltage is amplified and drives a direct current torque motor, which is mounted on the same shaft as the CT rotor. Phasing in the loop is such that the error voltage produces a torque on the CT rotor, which drives it to a null voltage position. At this point, the error signal is nulled, and rotation of the CT rotor and output shaft stops. Thus, a 1:1 correspondence between the input synchro transmitter shaft position and the servtorq output shaft position is established.

6.5.2 Direction of rotation. Clockwise or counterclockwise rotation is determined when facing the shaft extension end of the unit. Standard positive direction of rotation is counterclockwise.

6.5.3 Rotor position. The rotor position of any unit is an angular mechanical rotor displacement from the unit zero position, measured in a counterclockwise direction.

6.5.4 Rotor angle. The rotor angle of a unit is the angular mechanical rotor displacement from the unit zero position, measured in a counter-clockwise direction, at which the unit input voltages exactly correspond to the output voltages of an ideal unit set at any specific rotor position.

6.5.5 Dynamic error. Dynamic error is the instantaneous difference in the shaft displacement of the unit under test to the corresponding shaft position of a transmitter.

6.5.6 Synchronizing time. Synchronizing time is the time required for the rotor to reach the quiescent rotor position when energized.

6.5.7 Stall torque. The stall torque of a servtorq is the torque developed at zero speed of the shaft when rated voltages and frequencies are applied to the input of the servtorq. Maximum stall torque is developed when the input signal applied to the servtorq stator windings produces maximum torque at the output shaft.

6.5.8 Slewing speed. The slewing speed of a servtorq is the maximum speed at which the output shaft synchronously follows the shaft of the transmitter when coupled to a specified load.

6.5.9 Spinning. Spinning is defined as the action of the servtorq rotor when it fails to synchronize or come to a stop from any angular position.

6.5.10 Electrical error. The electrical error at a given rotor position is the difference between the electrical angle and the rotor position.

6.5.11 Radial play and end play. The radial play of a unit is the shaft displacement perpendicular to the shaft axis due to the reversal of force applied perpendicular to the shaft axis. The end play of a unit is the axial displacement due to the reversal of an axial force.

6.5.12 Temperature rise. Temperature rise is the increase of the internal temperature of a unit above the ambient temperature due to the dissipation of the energizing power.

6.5.13 Torque gradient. Torque gradient is the initial rate of change of torque with angular displacement of the rotor from a position where the torque is zero, when the servtorq is energized from a standard transmitter of the same frame size and rating. The torque gradient is normally given as the mean value obtained in a range of less than 1 degree from the zero torque position.

6.5.14 Time phase. The time phase at a point in a servtorq is the phase of the voltage at that point with respect to the phase of the energizing voltage of the unit.

6.5.15 Units of measurement. Unless otherwise specified, units of measurement are as follows:

a.	Angles	- degrees
b.	Potential	- volts, rms
c.	Impedance	- ohms
d.	Current	- amperes, rms
e.	Temperature	- degrees, Centigrade

f. Time phase - degrees
g. Torque - ounce-inches
h. Time - seconds

6.6 Subject term (key word) listing.

Burn-in
Dynamic error
Electrical error
Environmental tests
First article
Microcircuits
No-load slewing speed
Oscillation (hunting)
Part identifying number (PIN)
Passive components
Qualification
Qualified products list (QPL)
Quality conformance
Rotating components
Semiconductor devices
Servocomponent
Signal input
Slewing speed
Stall torque
Synchro control transformers
Synchro transmitters (control)
Synchro transmitters (torque)
Synchronizing time
Torque gradient
Torque motors, DC
Variation of voltage and frequency
Velocity constant

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

6.8 International standardization agreements. Certain provisions of this specification are the subject of international standardization agreements reached by the NATO Ad Hoc Group on Analogue and Digital Servocomponents (AC/301(SG/A)(WG/5)(AHG)). When amendment, revision, or cancellation of this specification is proposed which affects or violates the international agrement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental standardization offices, if required.

6.9 Applicable international documentation. NATO documents applicable to this specification are Allied Standard Publication (AStanP)-3, Volume 5990 Chapter 5, NATO Electronic/Electrical Preferred Parts List, Servtorqs; AStanP-4, Volume 5990 Chapter 7, NATO Electronic/Electrical Technical Recommendation, Servtorqs; and AStanP-5, Volume 5990 Chapter 7, NATO Quality Assessment Recommendation for Electronic/Electrical Parts, Servtorqs.

TABLE I. Nomenclature.

SERVTORQ	23	ST	64	A	MS1746/1-1
Item name (1.2.1)	Size (1.2.1.1)	Function (1.2.1.2)	Supply Frequency (1.2.1.3)	Modification (1.2.1.4)	Part Number (1.2.1.5)

TABLE II. Example of part identifying number.

M	81746/1	-01	D
Military Designation	Specification Sheet No.	Dash No.	Latest Modification Letter

TABLE III. Standard dimensions for servtorqs.

For location of lettered dimensions, see:

FIGURE	1	2	3
SERVTORQ SIZE	15	23	37

(Unless otherwise specified, dimensions are in inches)

DIMENSIONS	A	B 1/	C	D	E
SERVTORQ SIZE	AS LISTED ON SPECIFICATION SHEET TABLE II		+0.000 −0.005	+0.0000 −0.0010	+0.000 −0.005
15			1.437	1.3120 4/	0.875
23			2.250 2/	1.9995	1.990
37			3.625 3/	3.3750	1.625

DIMENSIONS	SPUR GEAR DATA F			OUTSIDE DIAMETER	G
SERVTORQ SIZE	NO. OF TEETH	DIAMETRAL PITCH	PRESSURE ANGLE	+0.0000 −0.0003	AS LISTED ON SPECIFICATION SHEET TABLE II
15	21	120	20°	0.1872 5/	
23	22	96	20°	0.2405	
37	22	96	20°	0.2405	

NOTES: 1/ B is full length of tooth.

2/ Tolerance is +0.000/−0.001.

3/ Tolerance is +0.000/−0.002.

4/ Tolerance is +0.0000/−0.0005.

5/ Tolerance is +0.0000/−0.0002.

TABLE III. Standard dimensions for servtorqs - (Continued).

DIMENSIONS	H	I	J	K	L	M	M'
SERVTORQ SIZE	±0.005	±0.005	±0.005	±0.005	±0.005	Min	Min
15	0.040	0.132	0.093	0.078	1.312	0.308	0.190
23	0.252 6/	0.170 6/	0.250 7/	0.200	——	0.310	0.326
37	0.160	0.257	0.250	——	3.375	0.310	0.326

DIMENSIONS	N	N'	O	P	Q	S
SERVTORQ SIZE	Min	Min	±0.003	±0.003	±0.003	Maximum
15	0.166	0.253	1.100	0.062	0.125	0.060
23	——	——	1.250	0.062	0.125	——
37	——	——	1.500	——	——	——

DIMENSIONS	T	U	V	W	X	Z
SERVTORQ SIZE	±0.010	AS LISTED ON SPECIFICATION SHEET TABLE II	Minimum	+.000 −0.10	±0.010	Maximum
15	0.665		0.450	——	0.117	1.437
23	0.064		——	.600	0.463 8/	1.990
37	——		——	——	——	3.339

NOTES:

6/ Tolerance is +0.000/−0.010.

7/ Tolerance is +0.000/−0.002.

8/ Tolerance is ±0.005.

TABLE IV. Identification for terminals and lead wires.

Terminal	Winding	Lead Wire Color
R1	Rotor 1	Red, white tracer
R2	Rotor 2	Black, white tracer
S1	Stator 1	Blue
S2	Stator 2	Black
S3	Stator 3	Yellow

TABLE V. Terminal hardware.

Military Hardware	Number Required	Military Standard	Size
Machine Screw	5 EA	MS-35276-203	15
		MS-35275-226	23,37
Lock Washer	5 EA	MS-35338-134	15
		MS-35338-136	23,37
Drive Washer	1 EA	MS-17186-6	15
		MS-17186-8	23,37
Nut	1 EA	MS-17187-2	15
		MS-17187-3	23,37

TABLE VI. Signal input impedance.

Supply Frequency Code	Frequency	Synchro Transmitter Impedance
6 and 64	60 Hz	1389 + j436 ohms
4 and 64	400 Hz	525 + j310 ohms
Type 26V - 4 and 64	400 Hz	200 + j365 ohms

TABLE VI. Qualification and quality conformance inspection tests.

Test No.	Requirement	Test	Test method for examination	Inspection	
				Qualification Sample Number	Quality Conformance
1	3.7.1	4.7.1	Visual and mechanical inspection	1, 2, 3, 4	X
2	3.7.2	4.7.2	Shaft radial and end play	1, 2, 3, 4	X
3	3.7.3	4.7.3	Total shaft runout	1, 2, 3, 4	X
4	3.7.4	4.7.4	Dielectric withstanding voltage	1, 2, 3, 4	X
5	3.7.5	4.7.5	Insulation resistance	1, 2, 3, 4	X
6	3.7.6.1	4.7.6.1	Primary power and current	1, 2, 3, 4	X
7	3.7.6.2	4.7.6.2	Power and current at stall	1, 2, 3, 4	X
8	3.7.7	4.7.7	Direction of rotation	1, 2, 3, 4	X
9	3.7.8	4.7.8	Electrical error	1, 2, 3, 4	X
10	3.7.9	4.7.9	Stall torque	1, 2, 3, 4	X
11	3.7.21	4.7.21	Slewing speed under standard load	1, 2, 3, 4	X
12	3.7.10	4.7.10	Servtorq sensitivity	1, 2, 3, 4	X
13	3.7.11	4.7.11	Dynamic error	1, 2, 3, 4	X
14	3.7.12	4.7.12	Synchronizing time	1, 2, 3, 4	X
15	3.7.13	4.7.13	Impedance	1, 2, 3, 4	X

TABLE VI. Qualification and quality conformance inspection tests - (Continued).

Test No.	Requirement	Test	Test method for examination	Inspection	
				Qualification Sample Number	Quality Conformance
16	3.7.14	4.7.14	Spinning	1, 2, 3, 4	X
17	3.7.15	4.7.15	Security of terminals or wire leads	1, 2, 3, 4	X
18	3.7.16.1	4.7.16.1	Temperature rise, quiescent	1, 2, 3, 4	-
19	3.7.16.2	4.7.16.2	Temperature rise, at stall	1, 2, 3, 4	-
20	3.7.17	4.7.17	Torque gradient	1, 2, 3, 4	-
21	3.7.18	4.7.18	No-load slewing speed	1, 2, 3, 4	-
22	3.7.19	4.7.19	Velocity constant	1, 2, 3, 4	-
23	3.7.20	4.7.20	Variation of voltage and frequency	1, 2, 3, 4	-
24	3.7.22	4.7.22	Oscillation or hunting	1, 2, 3, 4	-
25	3.8.1	4.8.1	Vibration, followed by test nos. 2, 4, 5, 9, 11, 12, 13, 14, 16 and 24	1, 2, 3, 4	-
26	3.8.2.1	4.8.2.1	Shock, low impact followed by test nos. 2, 4, 5, 9, 11, 12, 13, 14, 16 and 24	1, 2, 3, 4	-
27	3.8.3.1	4.8.3.1	Altitude, low temperature, followed by test nos. 5 and 19	1, 2	-

TABLE VI. Qualification and quality conformance inspection tests - (Continued).

Test No.	Requirement	Test	Test method for examination	Inspection	
				Qualification Sample Number	Quality Conformance
28	3.8.3.2	4.8.3.2	Altitude, high temperature, followed by test nos. 5 and 19	1, 2	-
29	3.8.5	4.8.5	Endurance, followed by test nos. 2, 4, 5, 9, 10, 11, 12, 13, 14, 16, and 24	1, 2	-
30	3.8.2.2	4.8.2.2	Shock, high impact followed by test nos. 2, 4, 5, 9, 11, 12, 13, 14, 16 and 24	1, 2, 3, 4	-
31	3.8.11	4.8.11	Internal examination 1/	1, 2	-
32	3.7.23	4.7.23	Transients, followed by test nos. 5, 12 and 13	3, 4	-
33	3.7.24	4.7.24	Electromagnetic interference 1/	3, 4	-
34	3.8.6	4.8.6	Airborne noise 1/	3, 4	-
35	3.8.7	4.8.7	Audible noise structureborne 1/	3, 4	-
36	3.8.4.1	4.8.4.1	Ambient low temperature, followed by test nos. 4, 5, 9, 12, 13, 14, 16, 21 and 24	3, 4	-

TABLE VI. Qualification and quality conformance inspection tests - (Continued).

Test No.	Requirement	Test	Test method for examination	Inspection	
				Qualification Sample Number	Quality Conformance
37	3.8.4.2	4.8.4.2	Ambient high temperature, followed by test nos. 4, 5, 9, 12, 13, 14, 16, 19 and 24	3, 4	-
38	3.8.8	4.8.8	Moisture resistance, followed by test nos. 4, 5, 9, 10, 12, 13, 14, 16 and 24	3, 4	-
39	3.8.9	4.8.9	Salt atmosphere, followed by test nos. 12, 24 and 31 1/	3, 4	-
40	3.8.10	4.8.10	Explosion resistance 1/	3, 4	-

1/Test Nos. 31, Internal examination; 33, Electromagnetic interference; 34, Airborne noise; 35, Audible noise structureborne; 39, Salt atmosphere; and 40, Explosion resistance shall be performed only when required by the specification sheet.

TABLE VIII. Test voltage (rms).

Type Designation	Volts	Terminals 1/
26V Prefix	26	R1 - R2
	11.8	2/
	10.2	S2-S1S3 3/
No Prefix	115	R1 - R2
	90	2/
	78	S2-S1S3 3/

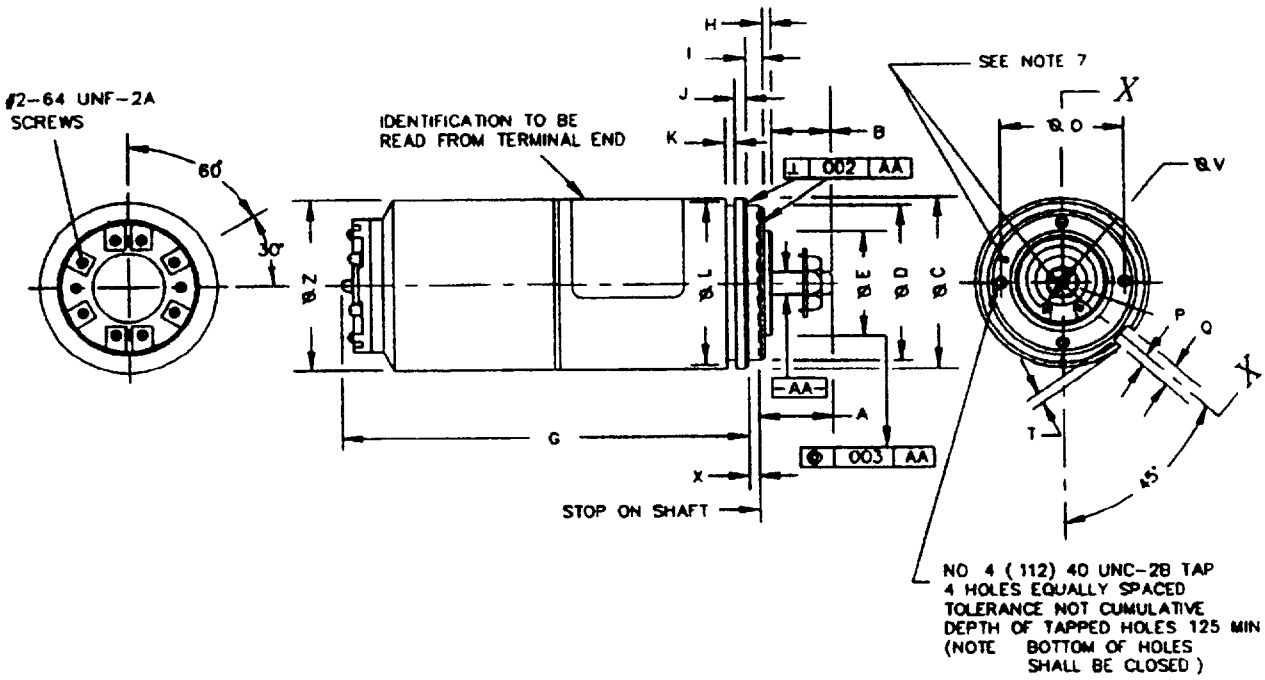
1/Terminals R1 and R2 are the reference voltage terminals and S1, S2, and S3 are the servtorq stator terminals.

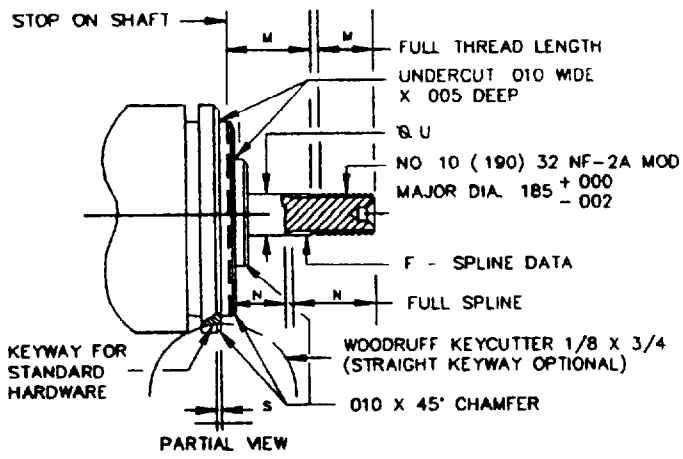
2/Terminal-to-terminal voltage of S1-S3 with the synchro transmitter rotor at 90°, S1-S2 at 210°, and S2-S3 at 330° from synchro zero as defined by MIL-S-20708. Servtorq and synchro transmitter shall be connected as shown in Figure 4.

3/Voltage between terminal S2 and terminals S1 and S3 strapped together. Servtorq and synchro transmitter shall be connected as shown in Figure 6.

TABLE IX. Endurance test time schedule.

Time (hours)	Temperature (°C)	Position
1680 ± 4	23 ± 5	Shaft horizontal
128 ± 2	-54 ± 2	Shaft horizontal
48 ± 1	95 ± 2	Shaft up
48 ± 1	95 ± 2	Shaft 45° up
48 ± 1	95 ± 2	Shaft 45° down
48 ± 1	95 ± 2	Shaft down





NOTES

1 PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED

2 RUNOUT OF THE SMOOTH PORTION OF SHAFT "AA" SHALL NOT EXCEED .0008 FIM

3 END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS

END PLAY - 1 POUND RADIAL PLAY - 1/2 POUND

4 THE TERMINAL BLOCK SHALL BE SECURED BY SCREWS OTHER THAN THE TERMINAL SCREWS RECESSES SHALL ALLOW TERMINAL LUGS, MS-17182-1, TO BE INSTALLED WITH BARRELS INBOARD OR OUTBOARD, AND PREVENT THE LUGS FROM TURNING

5 MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL

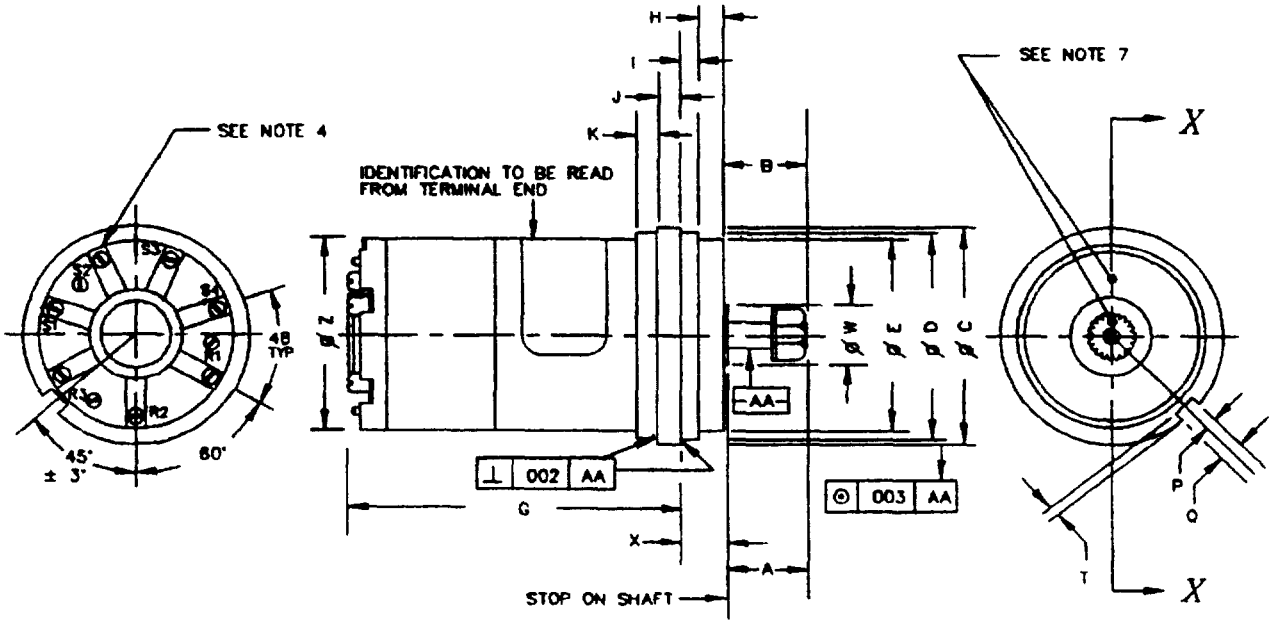
6 UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64 ON DECIMALS XX = ± .01, XXX = ± .005 AND ON ANGLES ± 1/2°

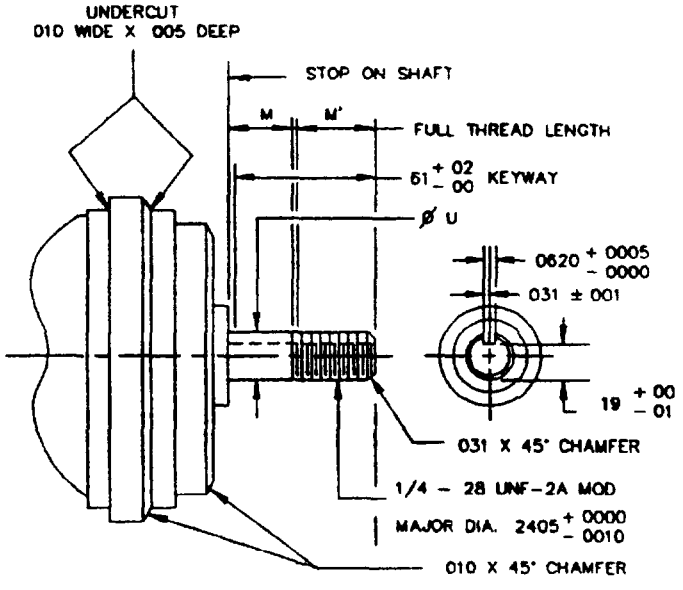
7 MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10° WHEN ROTOR IS SET AT APPROXIMATELY ELECTRICAL ZERO AND WILL BEAR NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING

8 FOR TESTING INSULATION RESISTANCE AT ALTITUDE, TEST VOLTAGE SHALL BE 300 VDC FOR ALL UNITS OVER 50 VOLTS RMS

9 LETTERED DIMENSIONS ARE SHOWN IN TABLE III OF MIL-S-81746

FIGURE 1 Outline drawing for size 15 Servtorgs





PARTIAL SECTION

X - X

NOTES

1 PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED

2 RUNOUT OF THE SMOOTH PORTION OF SHAFT "AA" SHALL NOT EXCEED 0008 FIM

3 END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS

END PLAY - 1 POUND RADIAL PLAY - 1/2 POUND

4 THE TERMINAL BLOCK SHALL BE SECURED BY SCREWS OTHER THAN THE TERMINAL SCREWS RECESSES SHALL ALLOW TERMINAL LUGS, MS-17182-1, TO BE INSTALLED WITH BARRELS INBOARD OR OUTBOARD, AND PREVENT THE LUGS FROM TURNING

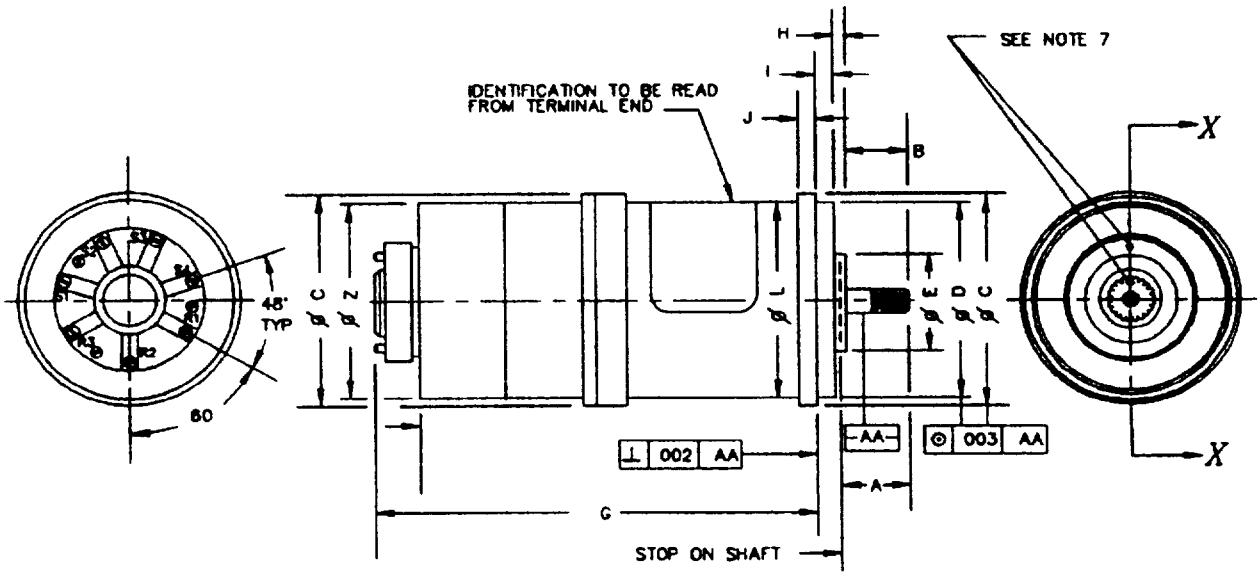
5 MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL

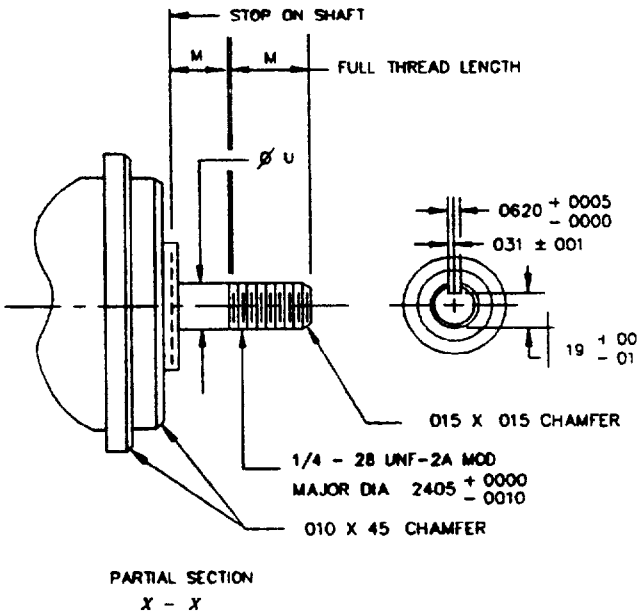
6 UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64, ON DECIMALS XX = ±.01, XXX = ± 005, AND ON ANGLES ± 1/2°

7 MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10° WHEN ROTOR IS SET AT APPROXIMATELY ELECTRICAL ZERO AND WILL BEAR NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING

8 LETTERED DIMENSIONS ARE SHOWN IN TABLE III OF MIL-S-81746

FIGURE 7 Outline drawing for size 23 Servtorgs





PARTIAL SECTION
X - X

NOTES

1. PERPENDICULARITY AND CONCENTRICITY SHALL BE MEASURED WITH THE UNIT IN A VERTICAL POSITION SUPPORTED BY THE SHAFT, THEN THE HOUSING ROTATED
2. RUNOUT OF THE SMOOTH PORTION OF SHAFT "AA" SHALL NOT EXCEED 0010 FIM
3. END PLAY AND RADIAL PLAY SHALL BE MEASURED DURING REVERSAL OF THE FOLLOWING LOADS

   END PLAY - 1 POUND RADIAL PLAY - 1 POUND
4. THE TERMINAL BLOCK SHALL BE SECURED BY SCREWS OTHER THAN THE TERMINAL SCREWS RECESSES SHALL ALLOW TERMINAL LUGS, MS-25036-6, TO BE INSTALLED WITH BARRELS INBOARD OR OUTBOARD AND PREVENT THE LUGS FROM TURNING
5. MINOR VARIATIONS OF UNIT CONFIGURATION ARE PERMITTED FOR UNDIMENSIONED DESIGN DETAIL
6. UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS ± 1/64, ON DECIMALS XX = ± 01, XXX = ± 005, AND ON ANGLES ± 1/2
7. MARK ON HOUSING IS TO MATCH SHAFT MARK WITHIN 10° WHEN ROTOR IS SET AT APPROXIMATELY ELECTRICAL ZERO AND WILL BEAR NO RELATION TO THE CENTER LINES SHOWN ON THIS DRAWING
8. LETTERED DIMENSIONS ARE SHOWN IN TABLE III OF MIL-S-81746

FIGURE 3 Outline drawing for size 37 Servtorgs

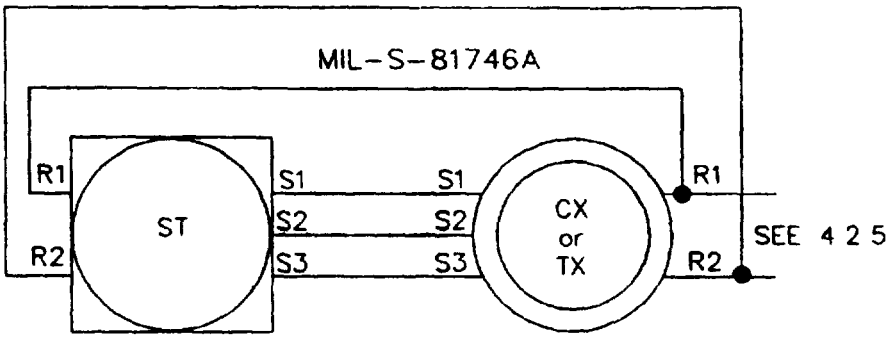
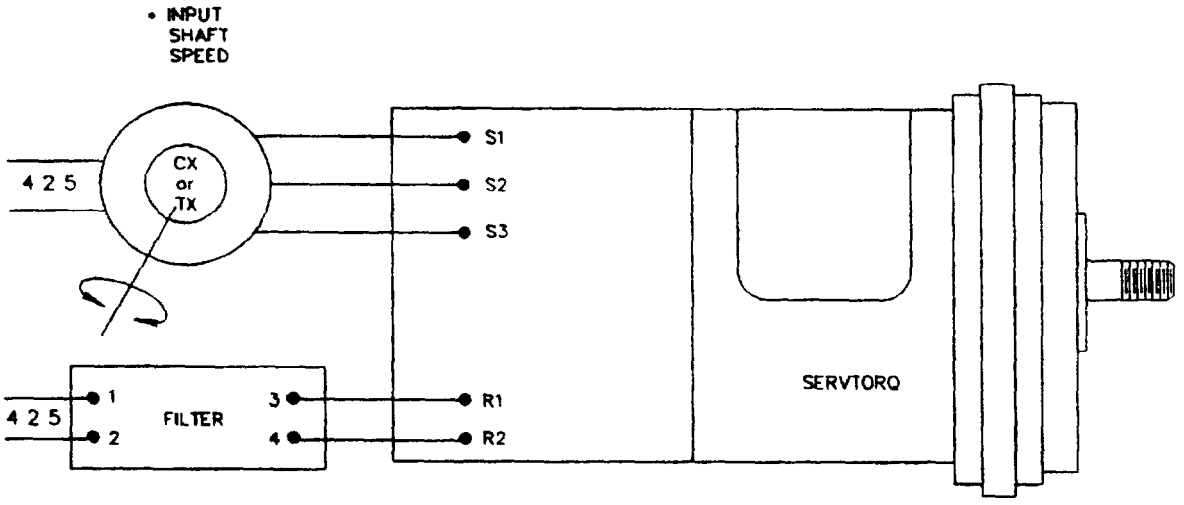


FIGURE 4 Standard test connection



* INPUT SHAFT SPEED AS LISTED ON SPECIFICATION SHEET

FIGURE 5 Test setup for electromagnetic interference, explosion resistance, and endurance

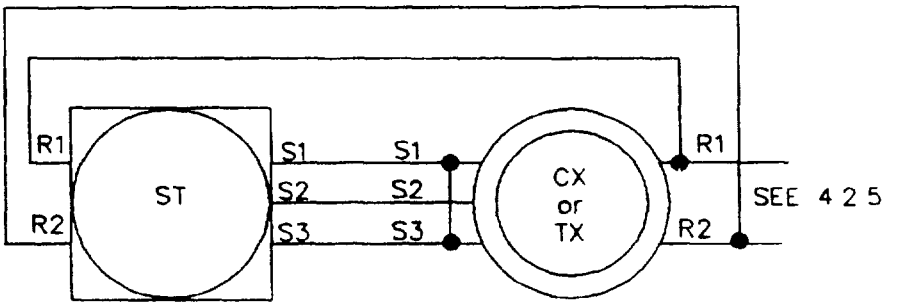
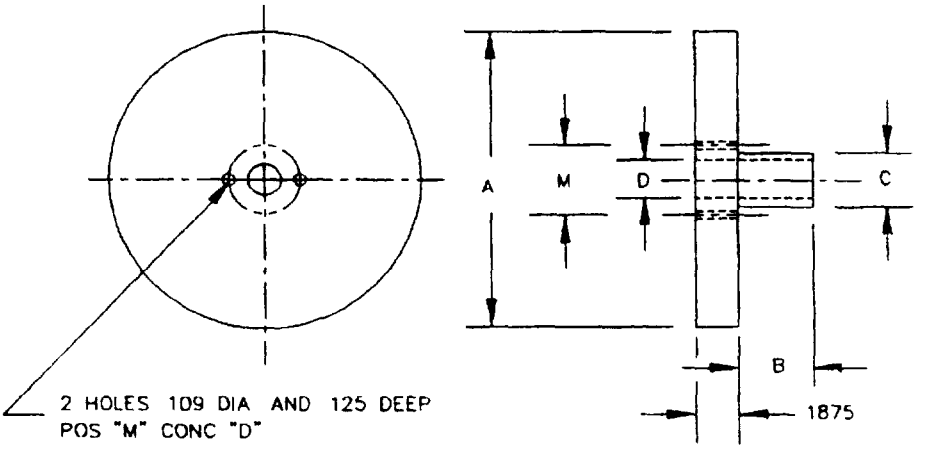


FIGURE 6 Standard connection with S1 and S3 strapped together



SERVO-COMPONENT SIZE	DIMENSIONS				
	A	B	C	D	M
	INCH	INCH	INCH	INCH	INCH
11, 15 18 23 31, 37	2 00 2 90 SPIGOT DIA	1875 3125 3125	26 60 60	1875 2410 2410	375 437 437

NOTES

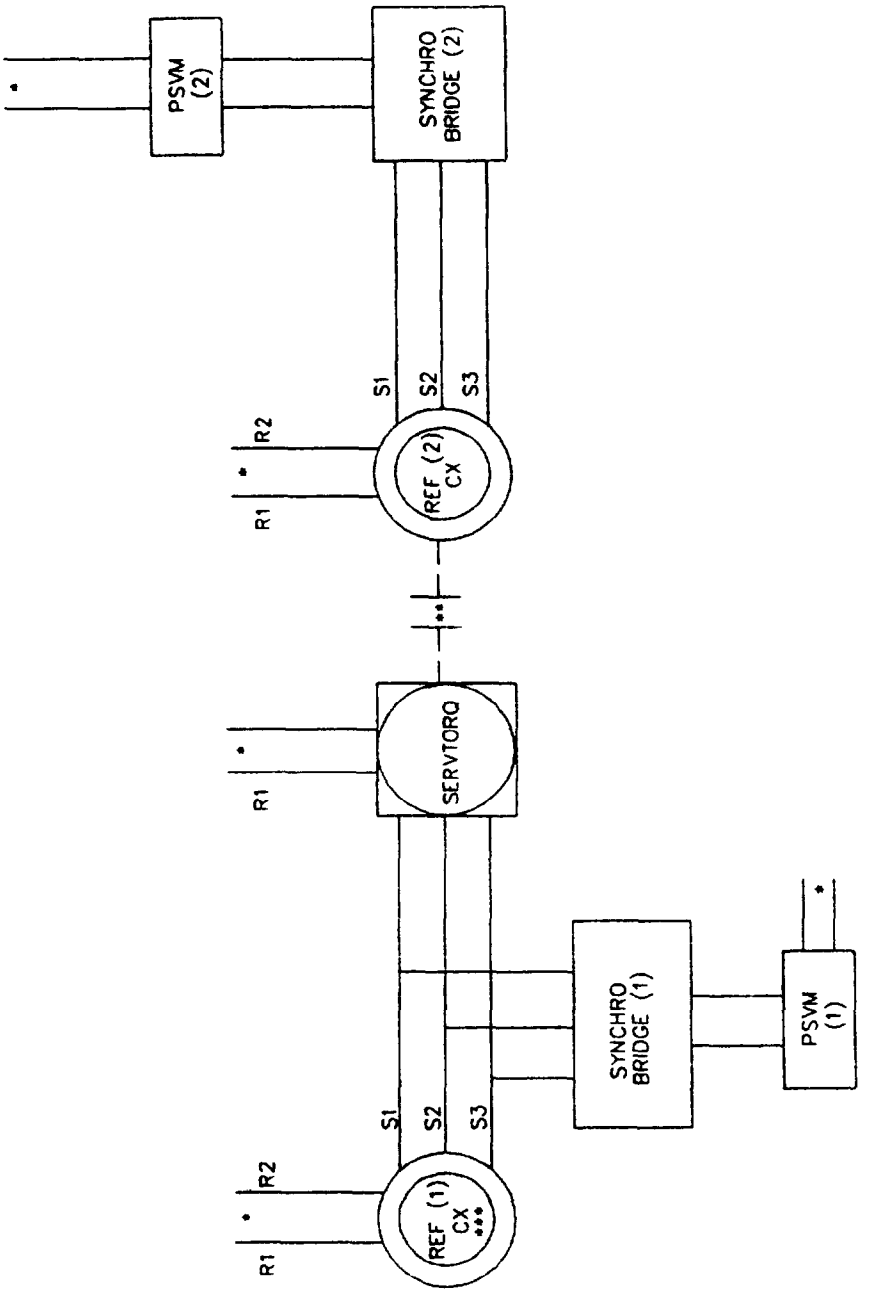
1 THF TWO HOLES ON DIAMETER "M" ARE FOR MOUNTING WITH STANDARD DRIVE WASHERS

2 MATERIAL ALUMINUM ALLOY, QQ-A-250/4

3 UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES

4 TOLERANCES ON DIMENSIONS ARE 3 PLACES ± 005
2 PLACES ± 02

FIGURE 7 Standard disc for loading servtorq shaft

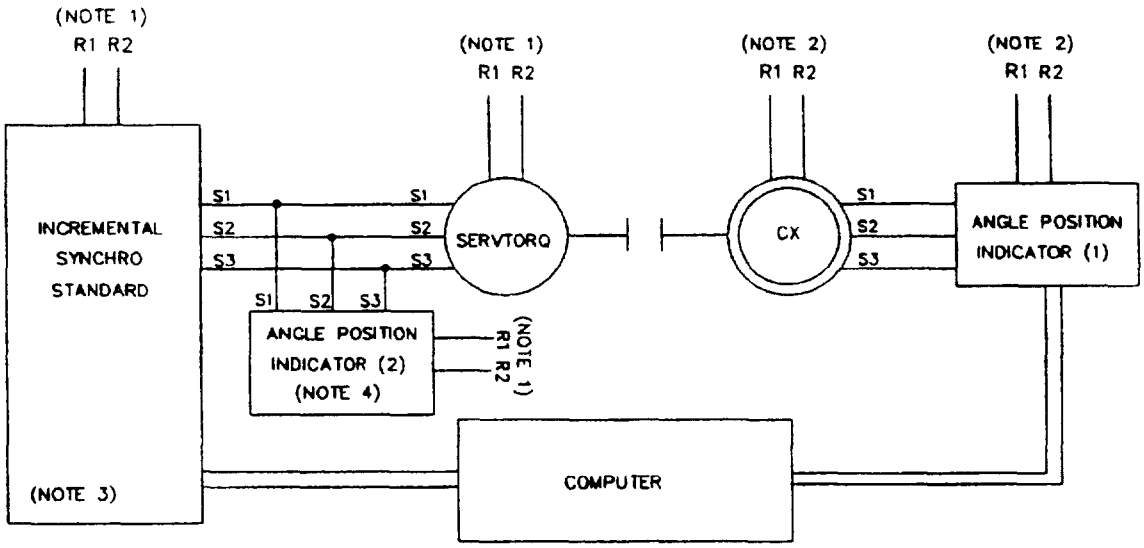


* TO POWER SOURCE (SEE 4.2.5)

** SHAFTS MECHANICALLY COUPLED

*** CX FRAME SIZE 23

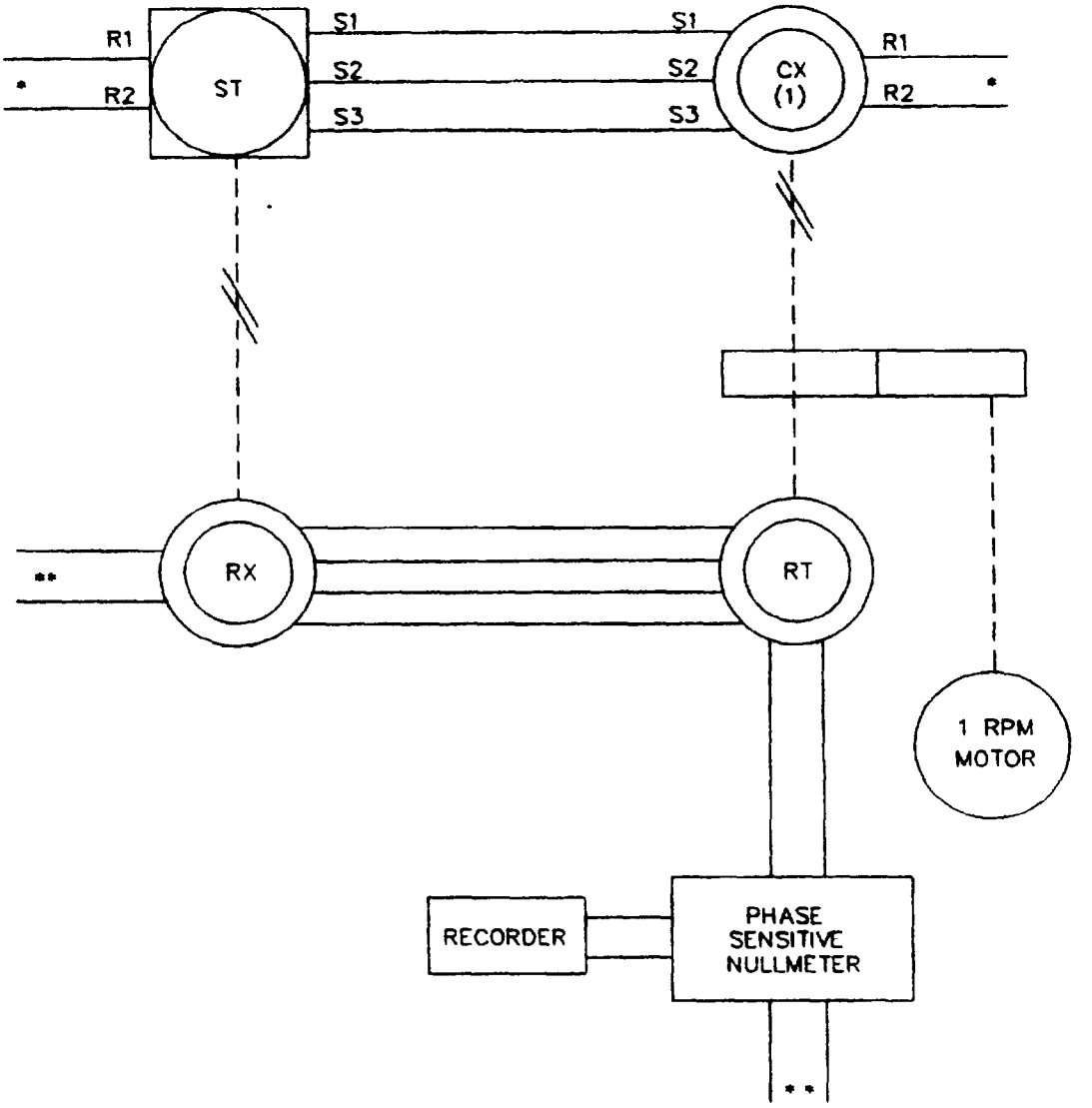
FIGURE 8 Electrical error test circuit



NOTES

1. TO SERVTORQ'S INPUT POWER SOURCE
2. TO CX'S POWER SOURCE
3. FOR DYNAMIC ACCURACY, THE SYNCHRO STANDARD SHALL BE INCREMENTAL AND HAVE A MAXIMUM RESOLUTION OF 0 01 DEGREE WITH A DIGITAL INPUT CONTROLLED BY THE COMPUTER
4. AN OPTIONAL ANGLE POSITION INDICATOR (2) MAY BE USED TO INCREASE THE ACCURACY OF THE INPUT ANGLE DATA

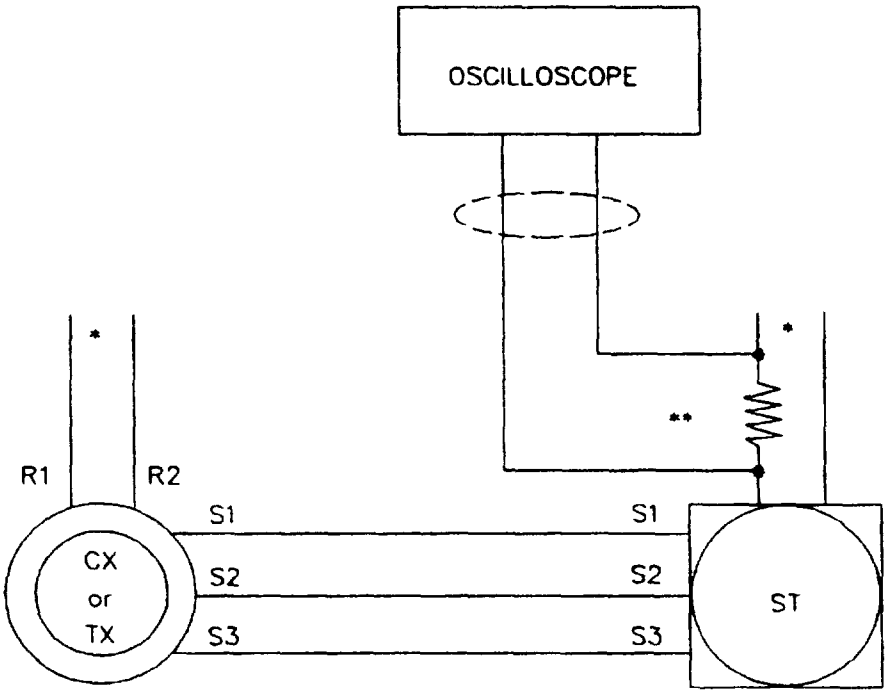
FIGURE 9 Electrical and dynamic error using a synchro standard, angle position indicator, and a computer



* TO POWER SOURCE (SEE 4 2 5)

** TO POWER COMPATIBLE WITH RESOLVERS

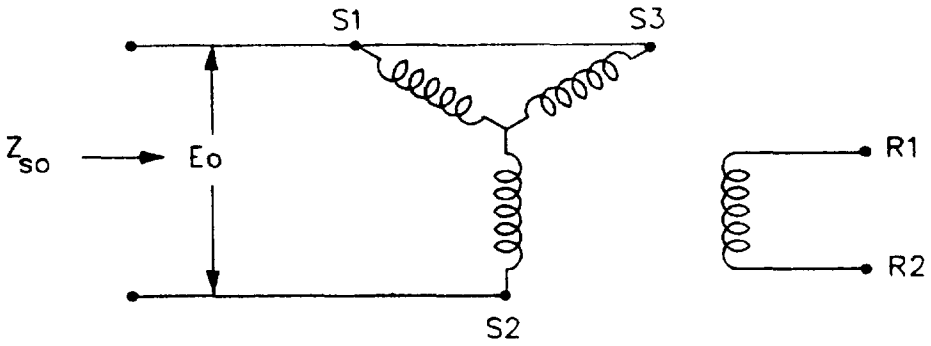
FIGURE 10 Dynamic error test circuit



* SEE 4 2 5

** 1 OHM NOMINAL RESISTANCE

FIGURE 11 Oscillation and synchronization



Eo – 78 volts for 115-volt units and 10 2 volts for 26-volt units as specified in 4 2 5

FIGURE 12 Circuit for determining stator impedance of servtorq

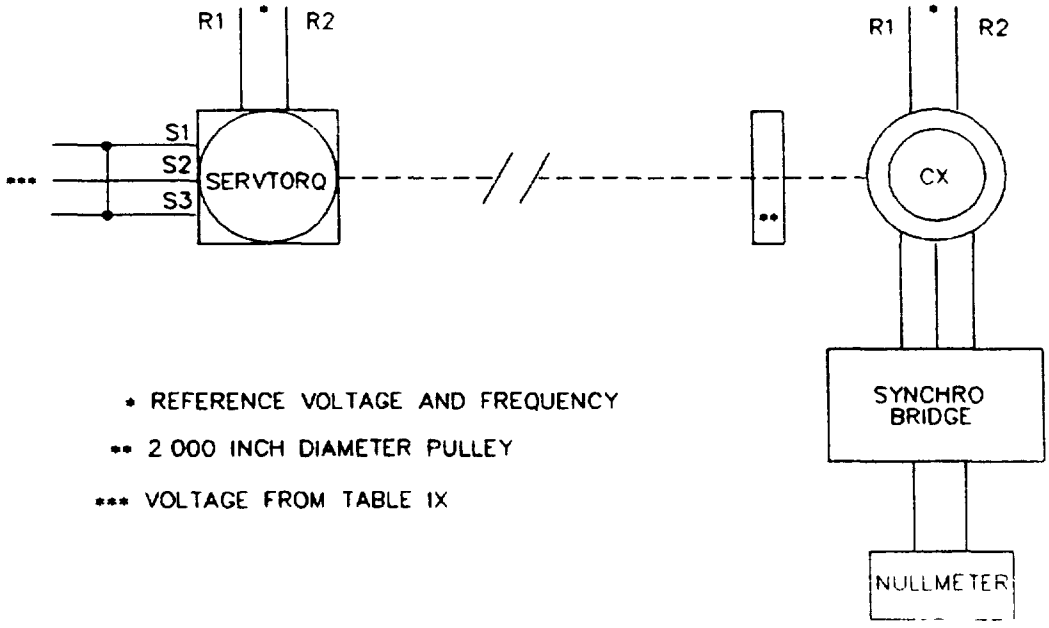


FIGURE 13 Torque gradient

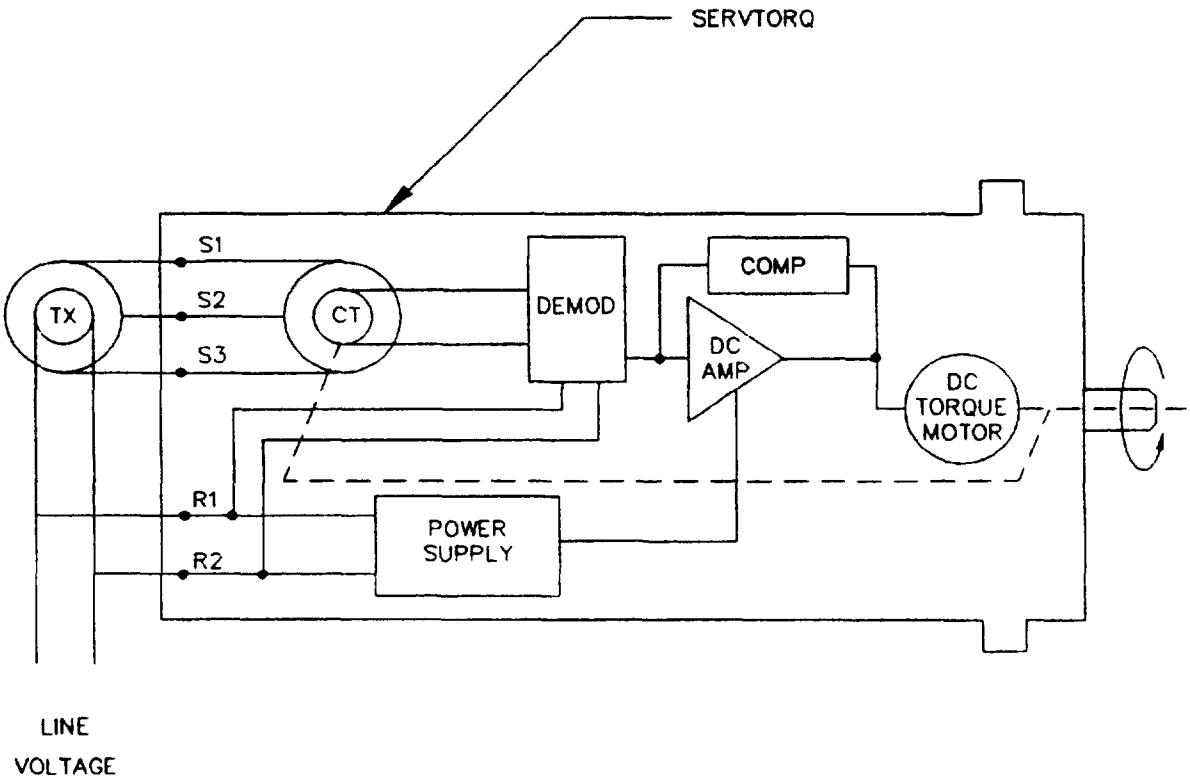


FIGURE 14 Servtorq functional block diagram

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Navy - SH
DLA - EC

Preparing Activity:
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(Project 5990-0396)

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	MIL-S-81746A	5 APRIL 1991

3 DOCUMENT TITLE

SERVTORQ, GENERAL SPECIFICATION FOR

4 NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible Attach extra sheets as needed)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

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