



**IM-199
Rev. A**

**OPERATION & SERVICE
MANUAL**

**Model 1807A
RF TRANSFER STANDARD**

November 1999

SAFETY SUMMARY

DEFINITIONS

The following definitions apply to WARNINGS, CAUTIONS, and NOTES found throughout this manual.

WARNING

An operating or maintenance procedure, practice, statement, condition, etc., which, if not strictly observed, could result in injury and/or death of personnel. Do not proceed beyond a WARNING symbol until all the indicated conditions have been fully understood and/or met.

CAUTION

An operating or maintenance procedure, practice, statement, condition, etc., which, if not strictly observed, could result in damage or destruction of the equipment or long-term health hazards to personnel. Do not proceed beyond a CAUTION symbol until all the indicated conditions have been fully understood and/or met.

NOTE

An essential operating or maintenance procedure, condition, or statement that must be highlighted.

GENERAL PRECAUTIONS

The following are general precautions that are not related to any specific procedure and, therefore, do not appear elsewhere in this publication. These are precautions that personnel must understand and apply during various phases of instrument operation or service.

WARNING

Potentially lethal voltages are present in this instrument. Serious shock hazards from voltages above 70 volts may exist in any connector, chassis, or circuit board. Observe the following precautions:

Use the buddy system any time work involving active high voltage components is required. Turn OFF the power before making/breaking any electrical connection. Regard any exposed connector, terminal board, or circuit board as a possible shock hazard. DO NOT replace any component or module with power applied.

If test conditions to live equipment are required, ground the test equipment before probing the voltage or signal to be tested.

Personnel working with or near high voltage should be familiar with modern methods of resuscitation.

DO NOT wear jewelry (rings, bracelets, metal watches, and/or neck chains) while working on exposed equipment. Be very cautious about using hand tools near exposed backplanes, bus bars, and/or power supply terminals. Use properly insulated tools. When making test connections to the power supply terminals and bus bars; use only insulated probe tips.

Verify that the instrument is set to match the available line voltage and the correct fuse is installed.

DO NOT install substitute parts or perform any unauthorized modification to this instrument. Contact TEGAM to acquire any information on replacement parts or returning the instrument for repair. Unauthorized modification can cause injury to

personnel and/or destruction of the instrument.


Operating personnel must not remove instrument covers. Component replacement or adjustments **MUST BE** performed by qualified service personnel.

DO NOT operate the instrument near or in the presence of flammable gases or fumes.

DETAILED PRECAUTIONS

The following **WARNINGS**, **CAUTIONS** and **NOTES** appear throughout the text of this manual and are repeated here for emphasis.

CAUTION

All procedures and/or steps identified as  must be followed exactly as written and according to ESDS device handling procedures in IM-211 or other accepted ESDS procedures. Failure to comply **WILL RESULT** in ESDS damage.

DO NOT use a nylon bristle brush in the solvent as the bristles may dissolve and cause damage to the circuit card or component.

DO NOT use ultrasonic cleaning on parts or assemblies containing electrical or electronic components.

DO NOT bend pins of electrical connectors when using fiber-bristle brush.

Compressed air used for cleaning and/or drying can create airborne particles that may enter the eye. Goggles/faceshields should be worn. **DO NOT** direct air stream towards self or other personnel. Pressure should be restricted to a maximum of 15 psi to avoid personal injury.

Under no circumstances use a wire brush, steel wool, or abrasive compound. Using these items will cause extensive damage to the instrument surface.

NOTE

DO NOT return any instrument or component to TEGAM without receiving prior factory authorization.

SAFETY SYMBOLS

The following symbols are used to identify safety hazards found throughout this publication and/or located on the instrument.

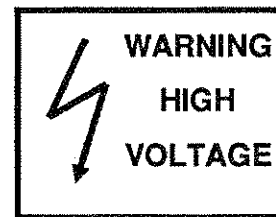
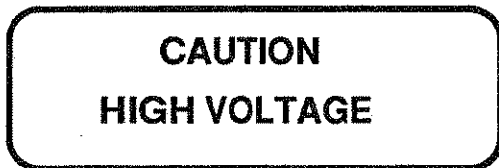


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SECTION I INTRODUCTION AND GENERAL DESCRIPTION

INTRODUCTION

PURPOSE

This manual provides Operation and Service instructions necessary to install, service, test, troubleshoot, and operate the TEGAM Model 1807A RF Transfer Standard. The manual also provides component location, reference designators, part numbers, and nomenclature to identify all the assemblies and sub-assemblies of the RF Transfer Standard (Figure 1-1).

SCOPE

This manual is to be used in conjunction with the operation and maintenance of the RF Transfer Standard. The manual provides a description of each assembly; testing of the instrument; maintenance procedures to maintain the instrument; and troubleshooting to a module assembly.

ARRANGEMENT

The information contained in this manual is tabulated in the Table of Contents, List of Illustrations, and List of Tables. The manual is divided into eight sections, listed as follows:

SECTION I	Introduction and General Description
SECTION II	Installation and Shipment
SECTION III	Operating Instructions & Theory of Operation
SECTION IV	Maintenance
SECTION V	Testing, Calibration and Troubleshooting

RELATED MANUALS

The following manuals contain information that may be used in conjunction with this manual to operate, service, or calibrate the RF Transfer Standard.


<u>Manual</u>	<u>Title</u>
H4-1 and H4-2	Federal Supply Code for Manufacturer's Cataloging Handbook
IM-198	Operation and Service Manual, System IIA, Automatic Power Meter Calibration System


CONTACTING TEGAM



In the event of an instrument malfunction, contact TEGAM. An apparent malfunction of an instrument or component may be corrected over the phone by contacting TEGAM. **DO NOT** send the instrument or component back to the factory without prior authorization. When it is necessary to return an item, state the symptoms or problems, catalog and type number of the instrument or component, serial number of the item, and date of original purchase. Also write the company name, your name, and phone number on an index card. Then attach the card to the instrument or component to be returned. Or contact TEGAM using the following:

TEGAM, INC.	800-666-1010 toll-free
TEN TEGAM WAY	440-466-6100 phone
GENEVA, OH 44041 USA	440-466-6110 fax

ELECTROSTATIC DISCHARGE SENSITIVE

The equipment documented in this manual contains certain Electrostatic Discharge Sensitive (ESDS) components or parts. Therefore, certain procedures/steps are identified by the use of the symbol . This symbol is used in two ways:

All procedures and/or steps identified as  must be followed exactly as written and according to ESDS device handling procedures in IM-211 or other accepted ESDS procedures. Failure to comply **WILL RESULT** in ESDS damage.

- a. When the ESDS symbol  is placed between a paragraph number and title, all of that paragraph, including all subparagraphs, is considered an ESDS device handling procedure.
- b. When the ESDS symbol  is placed between a procedure/step number and the text, all of that procedure is considered an ESDS device handling procedure.

ABBREVIATIONS AND ACRONYMS

The following list contains all abbreviations used throughout this manual. Abbreviations and acronyms that are not listed conform with MIL-STD-12D.

DUT	Device Under Test
ESDS	Electrostatic Discharge Sensitive

SAFETY CONSIDERATIONS

The RF Transfer Standard and all related documentation must be reviewed for familiarization with safety markings and procedures before performing any operation and/or service. Refer to the SAFETY SUMMARY located at the beginning of this manual for a summary of safety information and procedures. Following these simple safety precautions will ensure safe operation and service of the RF Transfer Standard.

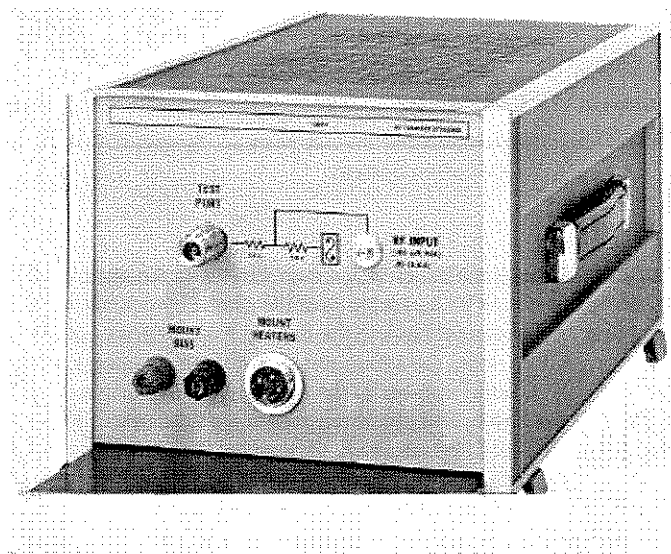


Figure 1-1 Model 1807A RF Transfer Standard

GENERAL DESCRIPTION

DESCRIPTION OF EQUIPMENT

The following paragraphs provide a general description of the RF Transfer Standard (shown in Figure 1-1).

Functional Description

This RF Transfer Standard is designed for the precise measurement of microwave power in the 0.01 to 18 GHz range. The unit is highly accurate, stable with time and temperature, and is designed for use as a standard for the transfer of calibration factors to other standards and power meters. Each unit is supplied with calibration points traceable to National Institute of Standards and Technology (NIST). The RF Transfer Standard is a thermistor mount power splitter combination employed as a feedthrough standard for the calibration of terminating power sensors such as bolometer mounts and power meters. This RF Transfer Standard was designed for use in the TEGAM System IIA Automatic Power Meter Calibration System (Figure 1-2).

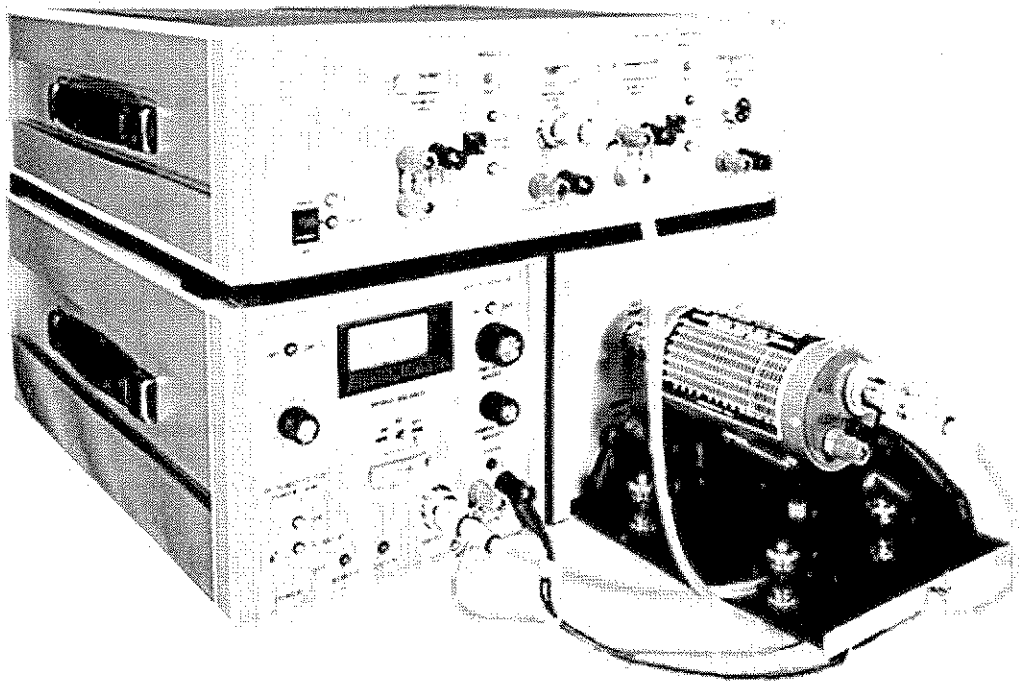


Figure 1-2 TEGAM System IIA

Physical Description

Refer to Table 1-1 for all the physical dimensions for the RF Transfer Standard. The RF Transfer Standard features TEST PORT, RF INPUT, MOUNT BIAS and MOUNT HEATERS connectors mounted on the front panel. The RF Transfer Standard can be easily stacked with other TEGAM instruments or mounted in any cabinet or rack designed according to EIA RS-310 and MIL-STD-189 using the appropriate hardware. The following items are supplied with the TEGAM RF Transfer Standard:

- Model 1807A RF Transfer Standard Operation & Service Manual (IM-199)
- Individual unit calibration report
- Floppy disc set containing calibration data files

APPLICATIONS

Figure 1-3 shows a calibration setup using a System IIA Precision Power Source and the RF Transfer Standard to perform calibrations at 1 mW in the 0.01 to 18 GHz frequency range.

Figure 1-4 shows an example of how the RF Transfer Standard used within System IIA Precision Power Source can be configured with the Weinschel Model 8300-2 Programmable Attenuator to perform reference verification and calibration of spectrum analyzers.

Figure 1-5 shows a measurement setup using the RF Transfer Standard and a Weinschel Model 8300-2 Programmable Attenuator that can be used to verify the linearity of microwave receivers.

For further information configuring this or other similar RF microwave or millimeter wave systems, contact TEGAM.

SPECIFICATIONS

Table 1-1 lists specifications to be considered when using the RF Transfer Standard.

RECOMMENDED MATERIALS

Table 1-2 provides a list of recommended consumables to be used when cleaning or servicing the RF Transfer Standard.

SPECIAL TOOLS AND TEST EQUIPMENT

All recommended special tools and test equipment to be used with the RF Transfer Standard are listed in Table 1-3.

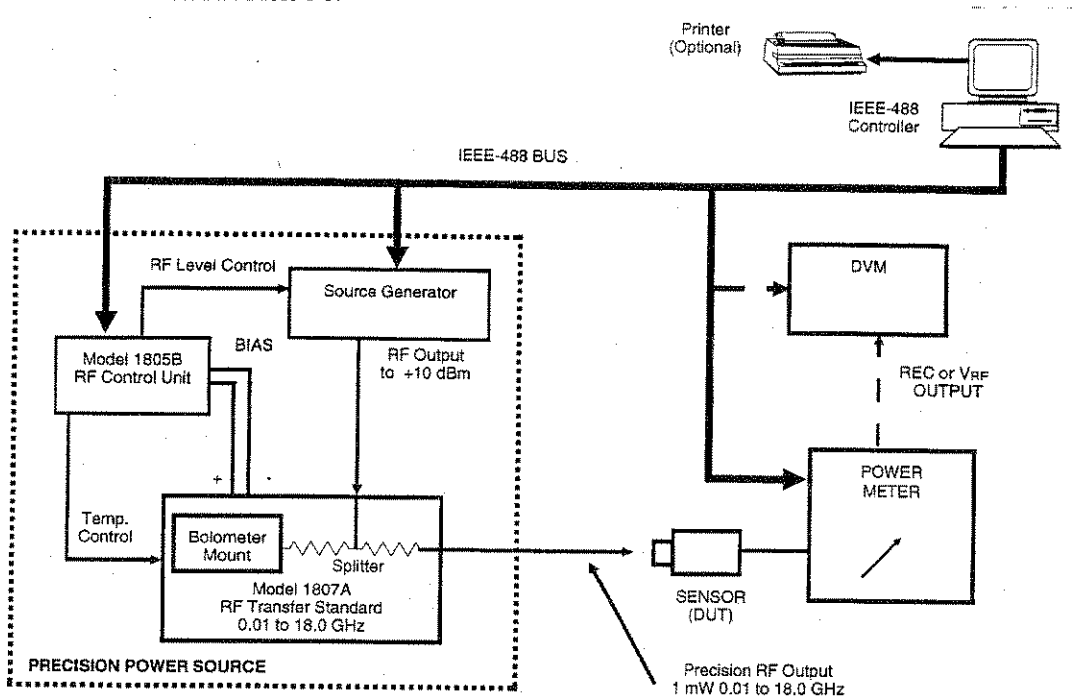


Figure 1-3 Power Meter Calibration Setup

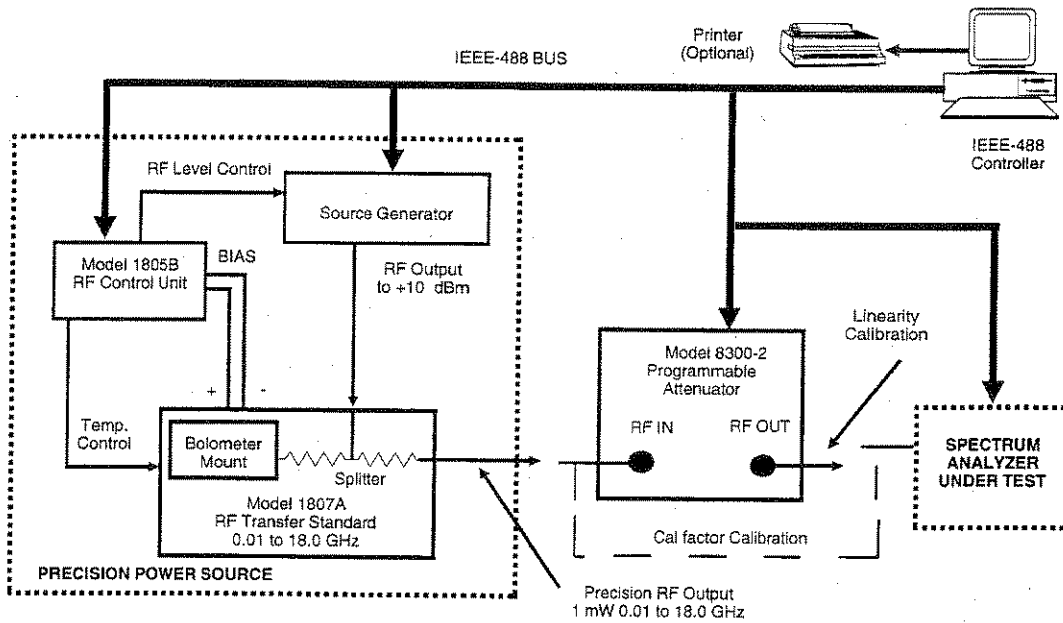


Figure 1-4 Spectrum Analyzer Calibration Setup

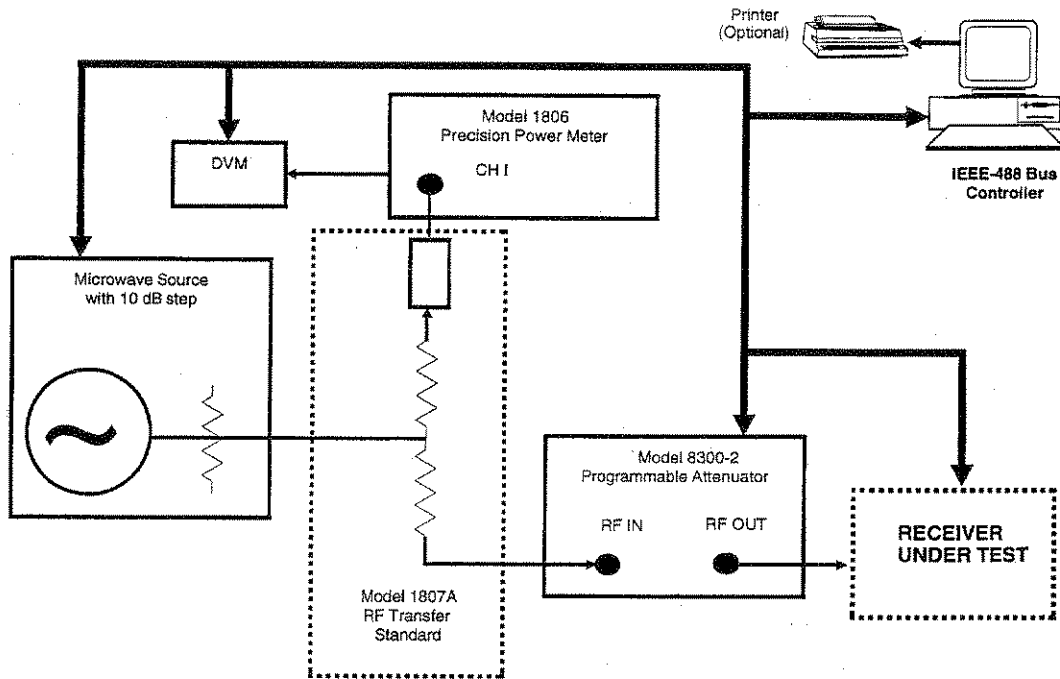


Figure 1-5 Receiver Linearity Verification Setup

Table 1-1 RF Transfer Standard Specifications

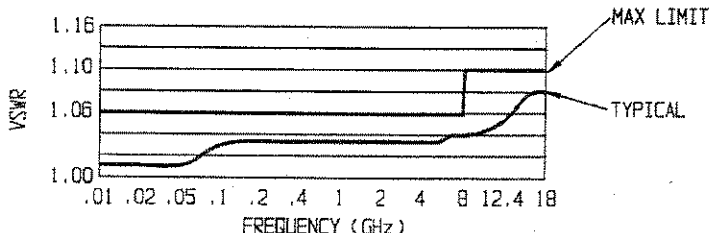
Specification	Description
FREQUENCY RANGE	0.01 to 18.0 GHz
RF IMPEDANCE	50 Ohms nominal
THERMISTOR BIAS POWER	30 ±0.7 mW with temperature control
CONNECTORS	
Model 1807A	RF OUTPUT: Type N female RF INPUT: Precision 3.5mm female Mount Bias: Binding Post standard 0.75" spacing for Banana plugs Temperature Control: 4 conductor Amphenol
CALIBRATION	Individual calibration traceable to NIST supplied at the following frequencies (137 total): 0.01 to 0.100 GHz in 0.01 GHz increments 0.150 to 2.000 GHz in 0.05 GHz increments 2.100 to 4.000 GHz in 0.1 GHz increments 4.200 to 12.400 GHz in 0.2 GHz increments 12.750 to 18.000 GHz in 0.25 GHz increments
RESISTANCE @ BIAS	200 Ohms
CALIBRATION FACTOR STABILITY	Changes less than 0.5% per year
POWER DEPENDENCE OF CALIBRATION FACTOR	Less than 0.1% from 1 to 10 mW
TEMPERATURE COEFFICIENT OF RESISTANCE	Negative
POWER SENSITIVITY OF RESISTANCE	Approximately 13 ohms/mW
SWR (Sg)	Individual calibration of magnitude and phase of reflection coefficient supplied for all calibration frequencies. This data is supplied on floppy disc with hardcopy backup: 

Table 1-1 RF Transfer Standard Specifications (continued)

Specification	Description	
CALIBRATION FACTOR		
ACCURACY OF CAL FACTOR	<u>Frequency (GHz)</u>	<u>RSS%</u>
	0.01-10	±1.00
	10-18	±1.10
TEMPERATURE RANGE	Operating:	+12° to +40° C
	Non-Operating:	-55° to +75° C
WEIGHT	Net:	12 lbs. 8.5 oz. (5.69 kg)
	Shipping:	16 lbs. 4.5 oz. (7.39 kg)
PHYSICAL (Figures 1-6 & 1-7)	Height:	7.00 inches/177.00 mm
	Width:	8.50 inches/215.90 mm
	Depth:	17.62 inches/447.50 mm

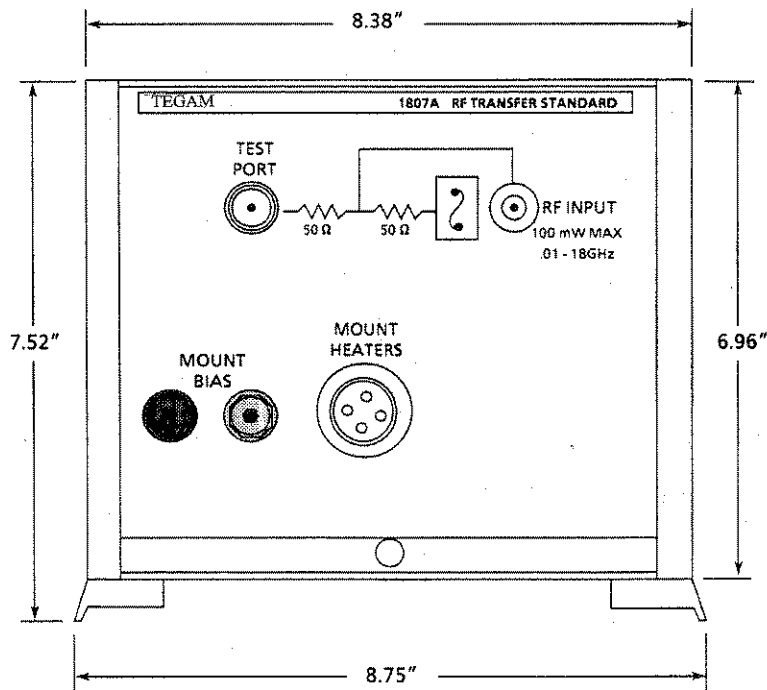


Figure 1-6 Model 1807A Physical Dimensions (Front)

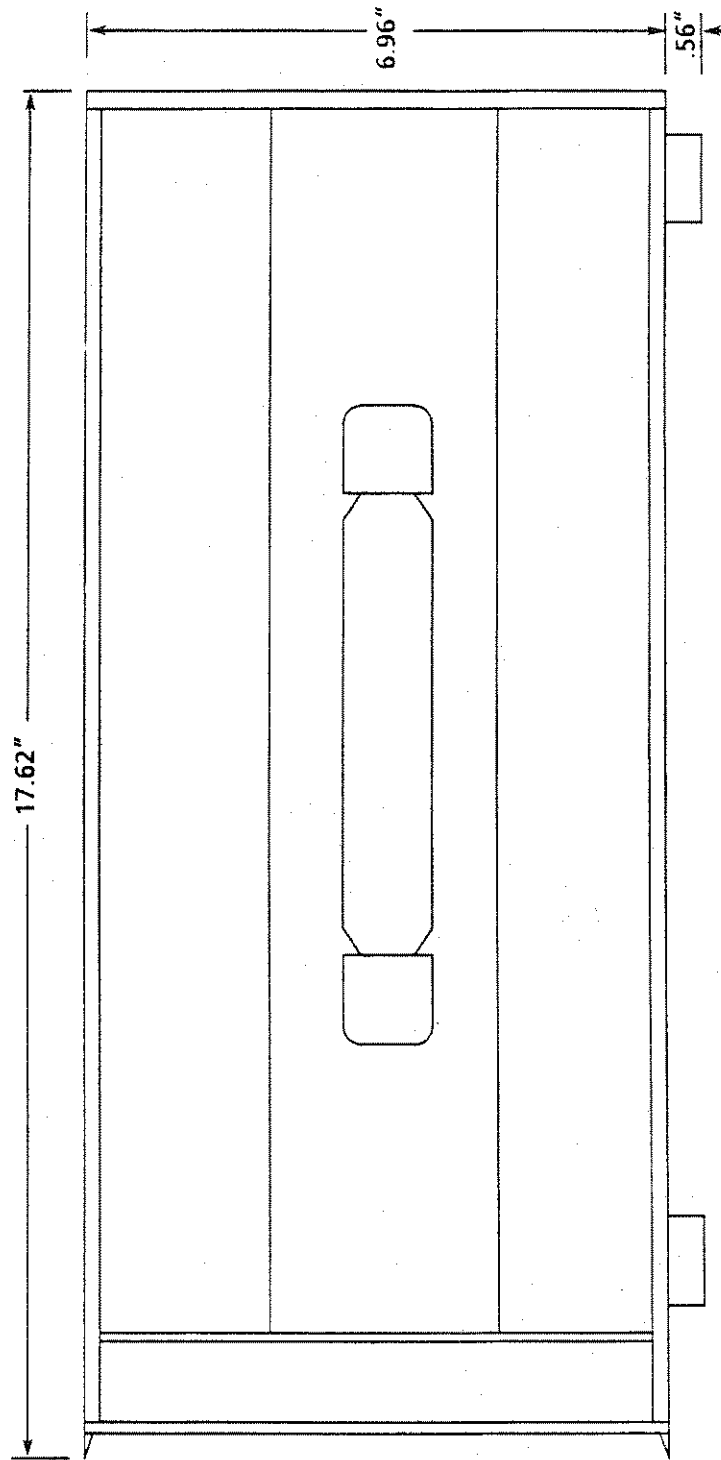


Figure 1-7 Model 1807A Physical Dimensions (Side)

Table 1-2 Recommended Consumable Materials

Item Number	Nomenclature	Material	Specification Number	MGR Part Number
1	Acid Brush (Fiber Bristle)	Isopropyl Alcohol	H-B-643 Type II, Class I	411 (Pump Spray) or 418 (Aerosol) Research Products Corp. 021-22-4
2	Aluminum Wool		MIL-A-4864A	
3	Brush, Soft Bristle		H-B-420 Type II	
4	Cleaner/Solvent		TT-1-735A (3)	
5	Cloth, Lint Free		MIL-C-85043	
6	Filter Coat Adhesive		Type IIA	
7	Filter Media		IPC-SM-840, Class III	
8	Permanent Polymer Coating (Solder Mask)			
9	Thermal Joint Compound			
				250 (Tube) Thermalloy Inc. or 074-678

Table 1-3 Special Tools and Test Equipment

Tool/Equipment/Model Number	Nomenclature	Use and Application
HP 83620B	Synthesized Signal Generator 0.01-18 GHz +10 dBm	Operational Checkout/Calibration
1806	Dual Type IV Power Meter	Operational Checkout/Calibration
MI1110	Terminating Coaxial Power Standard	Operational Checkout/Calibration 0.01 to 18 GHz
HP 3458A	Digital Voltmeter, 8-1/2 digits	Operational Checkout/Calibration
189-15	System IIA Software	Operational Checkout/Calibration
Any	PC Based Controller with National Instruments GPIB interface card as specified in System II Manual	Operational Checkout/Calibration
Any	Printer compatible with PC above	Operational Checkout/Calibration

SECTION II INSTALLATION AND SHIPMENT

GENERAL

This section contains all necessary instructions and information to install and interface the Model 1807A RF Transfer Standard. Included in this section is initial inspection; power requirements; preparation for use; and shipping instructions.

INITIAL INSPECTION

The RF Transfer Standard is carefully inspected both mechanically and electrically before shipment. This instrument should be free of marks or scratches and in perfect electrical order upon receipt. After unpacking the instrument, do not discard the shipping and packing material until the instrument has been visually inspected and it is determined that reshipment is not necessary. Perform initial inspection in accordance with the following paragraphs.

INSPECTION

Perform the following procedures before removing any item from the shipping container.

- a. Visually inspect the shipping container for any discoloration, stains, charring, or any other signs of exposure to heat, moisture, or liquid chemicals.
- b. Check for any physical damage to the shipping container such as dents, large snags or rips, crushed sections or areas, and/or similar signs of excessive shock caused by careless handling.
- c. Carefully remove the instrument and all other items from the shipping container.
- d. Inventory all items against the packing list.
- e. Inspect the instrument for any dents, cracks, deep scratches, damaged or loose switches and/or knobs, and any other signs of careless handling.

Damage

If it has been determined that shipping damage has occurred, immediately contact the delivering carrier to perform an inspection and prepare a concealed damage report. Do not destroy any shipping or packing material until it has been examined by an agent of the carrier. Also notify TEGAM to report the nature and extent of damage to the instrument. When contacting TEGAM, please provide model and serial number of instruments received, so that the necessary actions can be taken. DO NOT return the instrument until a claim for the damages has been established. If there is mechanical damage (not from shipping), the contents are incomplete, and/or the instrument does not function properly, refer to Section I and notify TEGAM.

POWER REQUIREMENTS

There are no external power requirements for the Model 1807A RF Transfer Standard.

ENVIRONMENTAL REQUIREMENTS

The RF Transfer Standard operates best within its specifications at an ambient temperature of -10° to $+40^{\circ}\text{C}$. Operating beyond these limits can affect the accuracy of the instrument and damage internal circuitry.

RECOMMENDED OPERATING ENVIRONMENT

Normal Calibration Laboratory best practice dictates that the environment should be closely controlled. This will minimize errors introduced by temperature and humidity changes. A nominal temperature of $+22^{\circ}\text{C}$ ($+73.4^{\circ}\text{F}$) provides a good working condition. A tolerance of $\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$) gives allowable temperature spread. Controlled temperatures also stabilize the

aging process of the standards.

It is also recommended that the other equipment be supplied with power from stabilized power supplies.

PREPARATION FOR USE

The following paragraphs provide mounting instructions, input/output options and initial setup for the System IIA Automatic Power Meter Calibration System.

MOUNTING INSTRUCTIONS

The RF Transfer Standard is shipped with four plastic feet mounted to the bottom cover. This allows the user to place the instrument on any bench or to stack the Model 1807A with other TEGAM instruments. When the instrument is placed on a bench or table, these feet provide a level support. Model 1807A can be connected to the TEGAM Model 1805B or other half-rack instruments to create a 19-inch stackable bench instrument (Figure 2-1) or can be mounted in any cabinet or rack according to EIA RS-310 or MIL-STD-189 using Model 1919 Rack Adapter Kit.



Figure 2-1 Model 1805B/1807A Bench Configuration

INITIAL SETUP

The initial setup procedure for operating and servicing the RF Transfer Standard is as follows:

- a. Perform inspection prior to connecting any instrument to the RF Transfer Standard.
- b. Set up equipment as desired. Figure 2-4 is provided as a guideline for connecting the RF Transfer Standard to the System IIA Precision Power Source. Refer to Section III for RF Transfer Standard operation.
- c. If desired, perform the operational checkout procedures (located in Section V) to ensure proper operation of the RF Transfer Standard.

INPUT/OUTPUT OPTIONS

The following paragraphs provide a description of the connections that can be made to the RF Transfer Standard. Figure 2-3 shows the location of these connectors.

MOUNT BIAS Input Terminals

These terminals are spade-lug connecting posts which are located on the front panel of the RF Transfer Standard. These terminals provide a connection point for the dc bias voltage supplied by the Model 1805B or 1806. The red connector is for positive (+) dc power and the black connector is for negative (-) dc power.

Temperature Control (MOUNT HEATERS) Connector

This connector is located on the front panel of the RF Transfer Standard. This connector is a four (4) pin threaded connector which is used to apply the current supplied by the Model 1806 or 1805B to control the internal temperature thermistor mount.

TEST Port Connector

This connector is located in the upper left corner of the RF Transfer Standard front panel and is a Precision Type N female connector. This connector provides the precision output to the device under test or other thermistor mounts to be calibrated.

RF INPUT Port Connector

This Precision 3.5mm female connector is located on the upper right corner of the RF Transfer Standard front panel and is used to pass the RF signal from the signal source directly to the internal power splitter. This RF Input connector can handle a maximum of 100 mW of RF power within the 0.01 to 18 GHz frequency range.

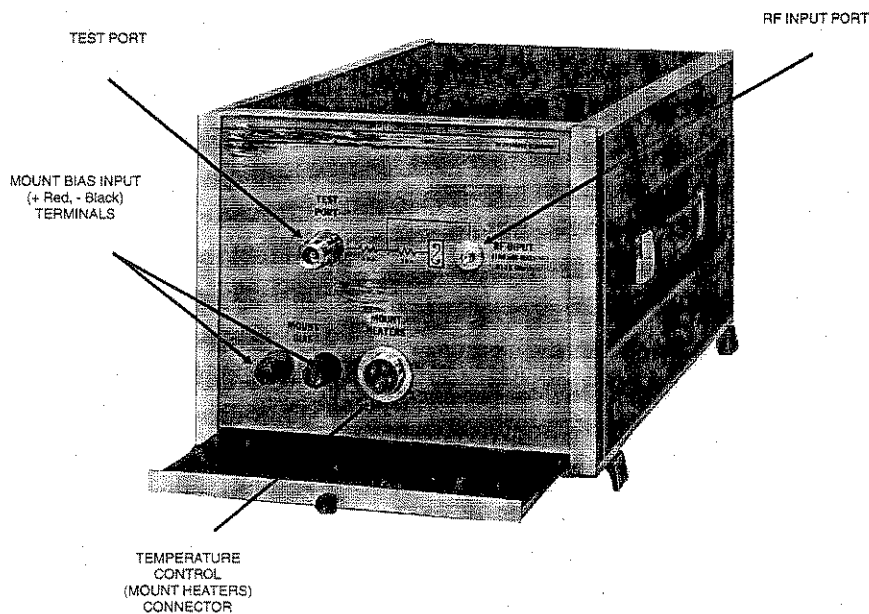


Figure 2-2 INPUT/OUTPUT Options (Front)

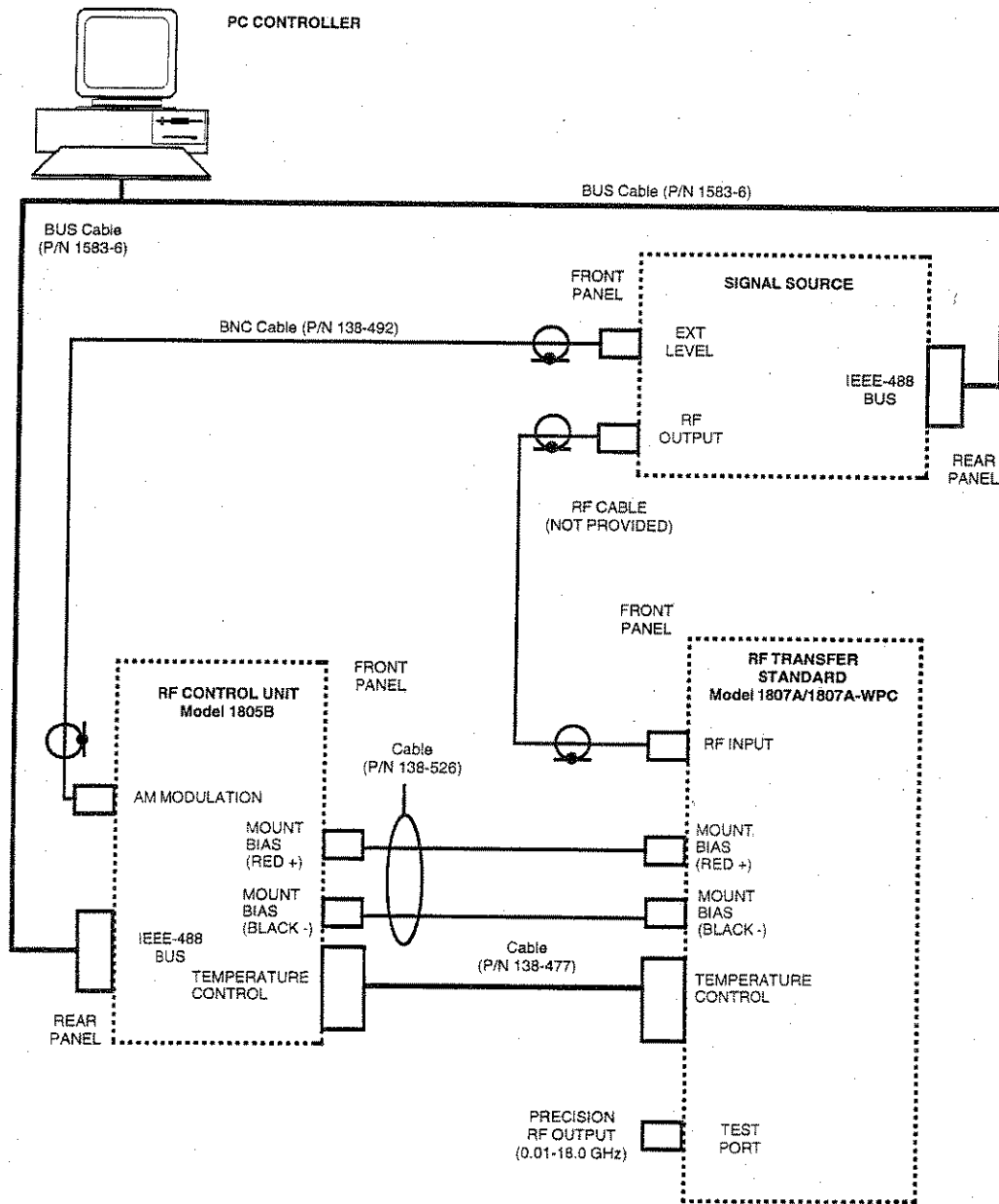


Figure 2-3 Precision Power Source Setup

PREPARATION FOR RESHIPMENT OR STORAGE

RESHIPMENT

Perform the following procedure when reshipping an instrument or component to TEGAM.

NOTE

- DO NOT return any instrument or component to TEGAM without receiving prior factory authorization.
- Use the best available packing materials to protect the instrument during reshipment. When possible, use original shipping container and packing materials.
- a. Cover the front and rear panel connectors with plastic connector covers.
- b. Wrap instrument with sturdy paper or plastic.
- c. Place all accessories, cables and loose hardware into a plastic bag.
- d. Place the wrapped instrument into a strong container with a layer of shock absorbing material (3/4 inch thickness) to wrap around all sides of the instrument to provide a firm cushion and to prevent movement inside the container.
- e. Place bag of accessories and hardware into container.
- f. If shipping the instrument for service, attach a tag to indicate the following:
 - Model and serial number
 - Service required
 - Description of malfunction
 - Return address
 - Authorization to conduct repairs
 - Instrument repair authorization
- g. Thoroughly seal shipping container and mark it FRAGILE.
- h. Ship to an authorized sales representative or:

TEGAM, Inc.
Ten TEGAM Way
Geneva, OH 44041
USA

STORAGE

When the RF Transfer Standard is to be stored for extended periods, pack instrument into a container per preceding paragraph. Place container into a clean, dry, temperature-controlled location. If instrument is to be stored in excess of 90 days, place desiccant with items before sealing container. The safe environmental limits for storage are as follows:

Temperature:	-40° to +167°F (-40° to +167°C)
Humidity:	less than 95%
Altitude:	less than 40,000' (12,192 m)

SECTION III THEORY & OPERATION

GENERAL

This section contains all the theory and operating instructions necessary to perform power measurements and calibrations using the Model 1807A RF Transfer Standard.

GENERAL OPERATING CONSIDERATIONS

The TEGAM Model 1807A RF Transfer Standard is normally employed as the fourth arm of a bridge configuration. This unit is designed as the sensing element in complete calibration and measurement systems. These systems employ other electronic elements to effect control of the measurement routines. An example of this type of system is the TEGAM System IIA Automatic Power Meter Calibration System. Proper use of the thermistor mounts in the TEGAM System IIA is further documented in TEGAM System IIA Automatic Power Meter Calibration System Operation and Service Manual (IM-198). A feedthrough mount-splitter combination like the RF Transfer Standard is normally used with the TEGAM Model 1805B RF Control Unit. The Model 1805B precisely controls the level of dc substituted power from .5 mW and 1-10 mW in 1 mW steps. Complete calibration procedures utilizing the Model 1805B are presented in TEGAM System IIA Automatic Power Meter Calibration System Operation and Service Manual (IM-198).

All equipment should be operated from either a regulated 115 VAC or 230 VAC supply. Allow at least one hour for electronic equipment to warm up before any measurements are made. When operated from a cold start, the RF Transfer Standard will require at least two hours to reach temperature stability under control of a temperature controller.

Temperature variations within the laboratory should be held to a minimum to avoid excessive temperature fluctuations within the sensor or instrument under test.

All equipment should be operated on a laboratory work bench as firm and solid as possible. The thermistor mounts should be used on a smooth surface, such as a 1/8" sheet of nylon plastic, to improve ease of positioning. Components should be supported at proper intervals to avoid misalignment.

Connectors must be properly aligned. Center lines must be coaxial; connector faces must be parallel and must meet neatly and firmly. When the coupling nuts are engaged and the connector starts to seat, the mount should be wiggled slightly as the connector is tightened to ensure accurate seating. The recommended torque applied to the coupling nut is 7-10 inch/pounds.

OPERATING INSTRUCTIONS

This TEGAM RF Transfer Standard is an element of a system and is not a "stand-alone" instrument. Once cabling has been correctly installed, there are no further operator adjustments to be made on either model. Control of the units is accomplished by other elements of the system. For use of the units in a typical operating system, refer to TEGAM System IIA Automatic Power Meter Calibration System Operation and Service Manual (IM-198). Figure 3-1 illustrates the RF Transfer Standard used as part of TEGAM System IIA Precision Power Source to calibrate Power Meters and Sensors.

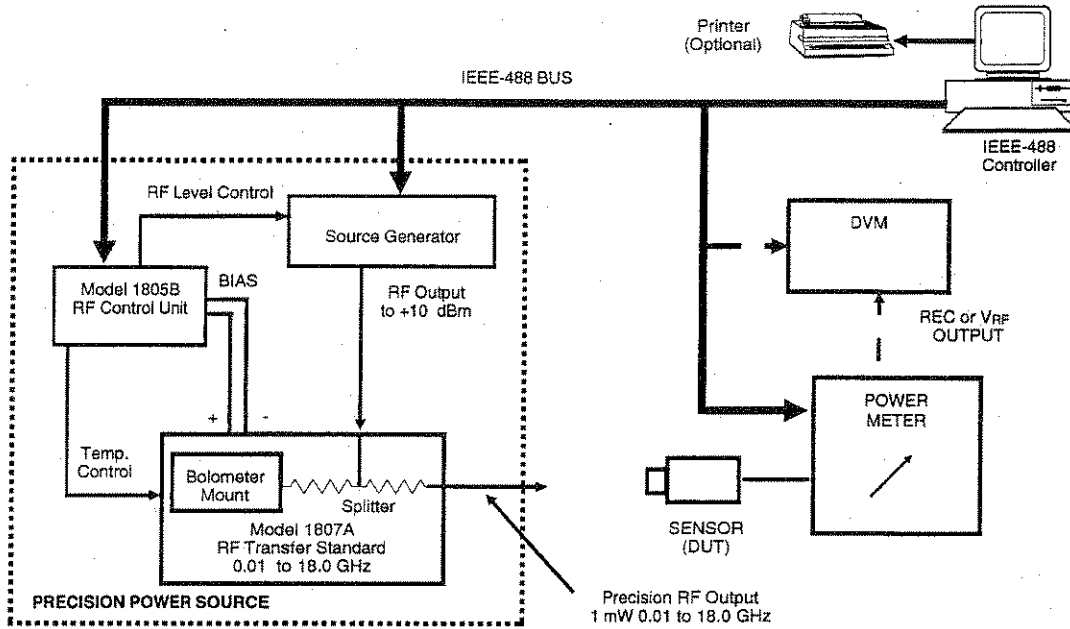


Figure 3-1 Power Meter Calibration Setup

THEORY OF OPERATION

The TEGAM Model 1807A RF Transfer Standard is configured to provide a path for RF energy via a coaxial line. DC Bias is introduced from the Bias terminals to the thermistors via a filter network. The following paragraphs provide a description of the internal components of the RF Transfer Standard.

TEMPERATURE VARIABLE RESISTANCE

The RF Transfer Standard contains a pair of thermistor beads whose resistance changes as a function of temperature. Thermistor bead temperature is a function of the combined dc and RF power applied to the beads and the ambient temperature surrounding the beads. The level of power applied to the beads is controlled externally. A heating element, controlled by an external controller, provides ambient temperature stability.

THERMISTOR ASSEMBLY

Figure 3-2 depicts the thermistor assembly electrical configuration. DC biasing of the dual thermistor beads to 100 ohms each provides a nominal 50 ohm parallel RF resistance and a 200 ohm series dc resistance. Blocking capacitors complete the RF path and provide dc isolation. The low frequency RC network provides low VSWR in the lower end of the frequency range.

THERMISTOR BEAD VARIABLE RESISTANCE

Application of approximately 30 mW of power to the thermistor beads produces a 200 ohm dc resistance. As the power applied to the thermistor beads increases, their effective resistance values decrease (refer to Figure 3-2). This is due to the negative temperature coefficient of the beads. Initially, the beads are dc biased to 200 ohms. Application of RF power increases the power level present at the beads and causes the effective resistance value of the beads to drop. DC power is then reduced until the initial effective resistance value is restored (200 ohms).

The total amount of dc power removed is proportional to the amount of RF power that was introduced. Quantitatively, the total power applied equals the sum of the two types of power.

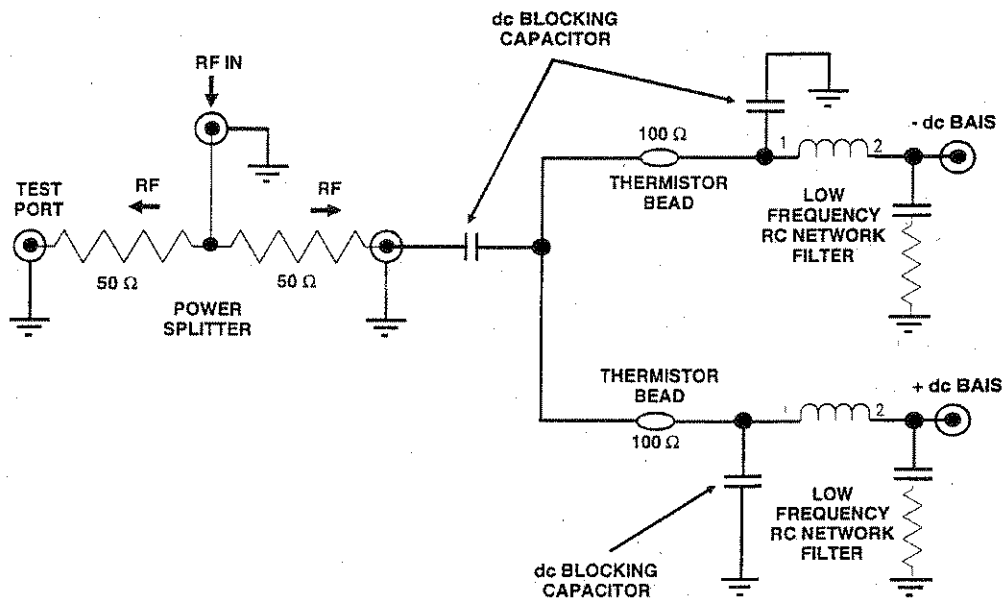


Figure 3-2 Thermistor Assembly Schematic

POWER SPLITTER

The RF Transfer Standard contains a two-element resistive power splitter. The T-shaped divider contains a series 50 ohm resistor in each of the two legs (refer to Figure 3-2). Use of the splitter in a closed loop configuration which applies constant power, causes the common point to become a virtual constant voltage point and results in the circuitry determining the impedance to power flow from the common point outward. From Figure 3-2, it is apparent that the impedance will be nominally equal in either direction of power flow from the common point outward: thus, the configuration divides the power approximately in half.

HEATER ELEMENT CONFIGURATION

The heater element electrical assembly, illustrated in Figure 3-3, is a Wheatstone bridge configuration composed of wiring wound around a thermal mass. The wiring heats the mass to a temperature above the ambient temperature. The thermistor beads are mounted on this thermal mass and insulation surrounds the assembly to improve temperature stability. Two windings, represented as R1 and R2, of zero temperature coefficient wire (manganin) make up two legs of the bridge. The remaining two bridge windings, R3 and R4, have a positive temperature coefficient wire (nickel). An external controller drives the heater.

THERMISTOR MOUNT INTERNAL TEMPERATURE CONTROL

Since thermistor mounts are temperature sensitive devices, it is necessary to eliminate or to minimize the effects of changes in the ambient temperature. This is accomplished by thermally isolating the mount, raising its temperature with a heater element to a level higher than the ambient temperature, and maintaining that level by means of an external temperature controller.

The heater bridge shown in Figure 3-3 balances when the heater windings provide equal resistance. The 2K-ohm potentiometer forces a balanced condition at the proper temperature. This compensates for any thermistor imbalance which creates an improper bias current requirement (30 ± 0.7 mW). In an unbalanced condition, the bridge output controls the output of a temperature controller. Hence, the bridge configuration accomplishes both a temperature sensing and heating function.

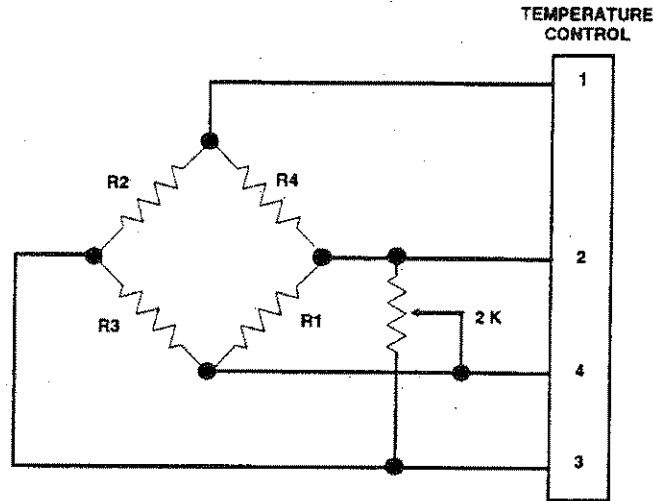


Figure 3-3 Heater Assembly Schematic

DC SUBSTITUTION

A calibration system, such as the TEGAM System IIA, utilizes the principle of dc substitution. This method involves substituting a precise amount of dc power for some amount of RF power where the two powers are proportional. Thus, the calibration factor, K, is determined by the formula:

$$K = \frac{P_{dc}}{P_{RF}}$$

Where:

- K = the calibration factor of the mount
- P_{dc} = the substituted dc power that is precisely derived and measured, and
- P_{RF} = RF power into a matched load.

CALIBRATION FACTORS

For a terminating mount, K is denoted as the measure calibration factor (K_1), and P_{RF} is the RF power from a match-terminated source incident upon the mount. If the mount is connected to the side arm of a coupler or a port of a power splitter (for a feedthrough mount), K is denoted as the monitor calibration factor (K_2), and P_{RF} is the RF power emerging from the mount into a match-terminated load.

The system determines the calibration factor of the tested mount in terms of the known calibration factor of the previously calibrated thermistor mount and the precision measurement of the substituted dc power.

CALIBRATION FACTOR CALCULATION FOR DEVICE UNDER TEST

The calibration factor, K_1 , for the sensor or terminating mount under test is determined by the following formulas:

First, calculate P_{RF} by:

$$P_{RF} = \frac{P_{dc\ 1}}{K_2}$$

Next, calculate the calibration factor for the device under test by:

$$K_1 = \frac{P_{dc\ 2}}{P_{RF}}$$

Where:

P_{RF} = the RF power incident upon the device under test

$P_{dc\ 1}$ = the dc substituted power as set at the Model 1805B

$P_{dc\ 2}$ = the dc substituted power as measured at the Model 1806 or power meter as configured

K_2 = the established calibration factor for the feedthrough mount, and

K_1 = the calibration factor for the power meter or terminating mount.

SOURCES OF CALIBRATION ERROR

The thermistor mount/power splitter combination is calibrated for K_2 . Since the mount calibration factor is traceable to NIST, and the precise level of dc substituted power is known, mis-match error accounts for the largest portion of measurement uncertainty. The equation:

$$K_1 = \frac{P_{dc}}{P_{RF}}$$

Where:

K_1 = the calibration factor for the device under test.

P_{dc} = the dc substituted power as measured at the 1806 or other device under test instrumentation as configured, and

P_{RF} = the RF power available for calibration

Is defined when the equivalent source impedance is an exact 50 ohms.

For an imperfect source, the measured incident power is defined by the formula:

$$P_{inc} = \frac{P_{RF}}{|1 - \Gamma_g \Gamma_L|^2}$$

Where:

P_{inc} = actual effective power incident upon the device under test

P_{RF} = measured power available to the device under test

Γ_g = the reflection coefficient of the source, and

Γ_L = the reflection coefficient of the load

The full formula for calibration factor becomes:

$$K_1 = \frac{K_2 \times P_{dc 2} \times |1 - \Gamma_g \Gamma_L|^2}{P_{dc 1}}$$

CALIBRATION FACTOR IN dB

When transferring calibration to an active device, it is also alternative practice to define the device calibration factor in dB rather than in %. In this case, the basic equation becomes:

$$K_{1dB} = 10 \log \left(\frac{P_m}{PRF} \right)$$

Where:

- K_{1dB} = the calibration factor of device under test in dB
- P_m = the power level as registered by the device or system under test, and
- PRF = RF power into a matched load

Note that with an active device such as a spectrum analyzer, no absolute accuracy device or technique is used, e.g. dc substitution, thermistors, etc., so that uncalibrated power measurement values can be quite arbitrary. The calibration factor can be up to several dB and have either sign. A negative sign indicates a system that is reading a level lower than actual. A positive sign indicates that a system is reading a level higher than actual. The true level is given by:

$$PA = P_m - K_{1dB}$$

Where PA is the actual power, and P_m is the power level as registered by the device or system under test, and both are in dBm.

SECTION IV MAINTENANCE

GENERAL

This section provides general maintenance practices for daily operation of the Model 1807A.

MAINTENANCE

The following paragraphs contain procedures outlining operational checkouts, inspection, preventive maintenance, and special cleaning instructions for the RF Transfer Standard.

OPERATIONAL CHECKOUT

Accomplish the operational checkout and calibration of the RF Transfer Standard by performing all procedures located in Section V of this manual (Testing, Calibration, and Troubleshooting). If a fault or problem occurs during these tests, perform the fault isolation procedures located in Section V of this manual.

INSPECTION

Perform a visual inspection (Table 4-1) in conjunction with the maintenance activities schedule when a malfunction is suspected, or whenever an assembly is removed or replaced.

PREVENTIVE MAINTENANCE

While the RF Transfer Standard requires very little preventive maintenance, it should not be subjected to physical abuse, severe mechanical shock, high humidity, or operating temperatures outside the specification range. The instrument should be kept free of excessive dirt and dust, since these can interfere with connector functions and with normal heat dissipation. For cleaning instructions, refer to Special Cleaning Instructions (below). The following paragraphs provide the preventive maintenance that is to be performed on the RF Transfer Standard.

Connectors

Care should be taken to prevent strain on the interconnecting cables, since damage here may not always be apparent. Occasionally check the external cables and connectors for signs of cracked insulation and/or bent or worn pins. Tests show that connectors must be clean for accuracy and stability. This requires an inspection and cleaning of each connector immediately before use. When cleaning precautions are observed regularly, connectors can maintain their stability for over several thousand connection cycles. Refer to Appendix A for more information about cables and connectors.

Calibration

Since the stability of the calibration factor of a thermistor mount depends upon the extent of use, degree of temperature stability and care in handling, TEGAM recommends recalibration of the standard every year. To recalibrate the unit, use one of the following methods.

1. Return the RF Transfer Standard to TEGAM indicating that recalibration or repair is necessary. TEGAM provides NIST traceable calibration of K2.
2. Transfer the known calibration factor of another mount to the mount requiring calibration in accordance with procedures outlined in Section V.

SPECIAL CLEANING INSTRUCTIONS

The cleaning procedures for RF Transfer Standard are divided into five general groups: microwave coaxial cable assemblies, machined surfaces and hardware, chassis cleaning, and

connector cleaning. Table 1-3 provides a list of consumables recommended to perform these procedures.

Microwave Coaxial Cable Assemblies

Appendix A (located at the end of this manual) provides all the necessary procedures for care, cleaning, and handling of microwave coaxial cable assemblies.

Machined Surfaces and Hardware

To remove light dirt and dust from mechanical parts such as castings, covers and other hardware, proceed as follows:

WARNING

Compressed air used for cleaning and/or drying can create airborne particles that may enter the eye. Goggles/faceshields should be worn. DO NOT direct air stream towards self or other personnel. Pressure should be restricted to a maximum 15 psi to avoid personal injury.

CAUTION

- Under no circumstances use a wire brush, steel wool, or abrasive compound. Using these items will cause extensive damage to the instrument's surface.
 - DO NOT use a nylon bristle brush in solvent as the bristles may dissolve and cause damage to the circuit card or component.
- a. Use 5 psi of clean, moisture-free compressed air or preferably dry nitrogen to blow loose dirt and dust from surface of item.
 - b. Briskly brush isopropyl alcohol (Table 1-2) onto area to be cleaned with a fiber-bristle brush.
 - c. Remove residue with lint-free cloth and repeat step "b" as a rinse.
 - d. When parts are thoroughly clean, dry parts using 5 psi of clean, moisture-free compressed air or preferably dry nitrogen.
 - e. Clean smaller mechanical parts or hardware by dipping into a container of isopropyl alcohol. Remove dirt by brushing with fiber-bristle brush after parts have been immersed for several hours.
 - f. Remove parts from isopropyl alcohol and rinse by immersing into a different container of isopropyl alcohol.
 - g. When parts are thoroughly cleaned, dry parts using 5 psi of clean, moisture-free compressed air or preferably dry nitrogen.

Chassis Cleaning

Clean chassis using a lint-free cloth (Table 1-3) moistened with water and mild detergent. For harder-to-clean areas, such as inside corners of chassis, use a vacuum cleaner.

Connector Cleaning

Where small amounts of rust, corrosion, and/or oxide deposits are present on connectors, clean externally with a soft-bristle brush (Table 1-2), aluminum wool, or internally with an acid brush; then wash with a noncorrosive solvent. MIL-C 83102 is recommended. Exercise care to ensure no metal filing or residue remains inside the connector and the connector is thoroughly dry. Where rust, corrosion, and/or oxide deposits are present in large quantities, replace the connector.

CONTACTING TEGAM

DO NOT return any instrument or component to the factory without prior authorization. When an instrument or component has to be returned to the factory, Section I provides the necessary

information to contact and return the instrument or component to TEGAM.

REPAIR AND REPLACEMENT

Due to the calibration sensitivity of this instrument, it is not recommended to remove or replace any RF components within the RF Transfer Standard. In the event that damage or a malfunction has occurred, return the unit to TEGAM for repair and calibration. If the user chooses to replace an item within the RF Transfer Standard such as a connector or defective cable, the instrument must be recalibrated.

Table 4-1 Inspection

ITEM	INSPECTION
Top, Bottom, Side Panels	Dents, cracks, scratches, or other damage; loose or missing handles, brackets, or mounting hardware; damaged mounts; corrosion or excessive dirt.
Connectors	Bent, broken or corroded pins; cracked or broken inserts; cracked or broken shell; loose or missing mounting nuts, washers, or screws.
Hardware	Stripped threads, missing washers, corrosion, or other signs of damage.
External Wiring	Frayed, broken, or abraded insulation; improperly dressed or tied cables; broken, corroded, or poorly soldered conductors at the terminals; missing or damaged sleeving at connector terminals.
Painted Surfaces	Scratches, chips, or peeling.
Preformed Packing	Nicks, burrs, or foreign materials present.

SECTION V TESTING, CALIBRATION & TROUBLESHOOTING

GENERAL

This section contains the calibration and troubleshooting procedures to ensure that the Model 1807A RF Transfer Standard is operational and performing within its design specifications. The calibration procedures located in this section should be performed after any repair or replacement of an assembly, module, or component located within the Model 1807A and as regular maintenance procedures as described below. Troubleshooting is also provided to isolate a problem to a faulty component.

OPERATIONAL CHECKOUT

The following paragraphs provide procedures to perform an Operational Checkout of the RF Transfer Standard, Model 1805B, and the Signal Source that comprise the precision power source of the System IIA. The individual instruments that make up the system can be independently tested according to procedures in their respective manuals.

Performing the following procedure will verify that the system is able to transfer a calibration from a standard to the RF Transfer Standard and back with adequate stability and accuracy. Listed below is the recommended equipment to perform the test.

<u>MODEL</u>	<u>NOMENCLATURE</u>
TEGAM 1806	Dual Type IV Power Meter
TEGAM 1805B	RF Power Level Control Unit 0.5 to 10 mW dc substitution
TEGAM M1110	Terminating Coaxial Power Standard, 0.01 to 18 GHz, Type N Male
HP 3458A	Digital Voltmeter, 8-1/2 digits
Any	PC Based Controller with GPIB Interface Card and HT Basic Software
Any	Printer

- a. Connect the equipment as in Figure 5-1.
- b. Allow several hours for system warm-up before making measurements.
- c. Using the terminating mount as a standard, perform a calibration of the feedthrough mount selecting 10 runs, and covering all 132 NIST calibration frequencies. Use 1 mW.
- d. Check that upon completion the standard deviation in the printout is in the fourth decimal place of the calibration factor. Check that the calibration factors are all greater than 0.80.
- e. If the system shows variability check all connections and/or allow more time to stabilize.
- f. Now, using the feedthrough mount as the standard, calibrate the terminating mount. Run 10 calibrations.
- g. Check that the standard deviation in the printout is in the fourth decimal place of the calibration.
- h. Check that the calibration factors so produced are the same as the original calibration factors of the terminating mount to within ± 0.002 .

CALIBRATION

When supplied, TEGAM feedthrough and terminating standards have valid calibrations that are directly traceable to NIST. Subsequent calibrations of the terminating mounts can be effected by TEGAM, NIST in Boulder, Colorado, or by some other calibration and standards laboratories throughout the world. Feedthrough mounts can either be calibrated by the user, or can be returned to TEGAM.

CALIBRATION CYCLE

Within the first few years, it is recommended that all standards be calibrated at least once per year. Once a standard has proved to be stable long-term, calibration can be spaced out. The following is a quote from NIST Calibration Services Users Guide, 1989, NIST Special

Publication 250:

"Thermistor-type bolometer units have shown adequate stability over long periods of time (approximately 10 years) and warrant long recalibration intervals. Two- or three-year recalibration intervals are recommended once the stability of a bolometer unit has been verified."

RF Transfer Standards that are used regularly for a heavy workload should be compared to the standard on a regular basis, as wear of the connector interface could affect performance.

CALIBRATION DATA RECORD

Keeping a record of all the instrument and mount calibration data can provide a reference for periodic calibration, troubleshooting of the RF Transfer Standard, after repair testing, and to obtain maximum factory assistance.

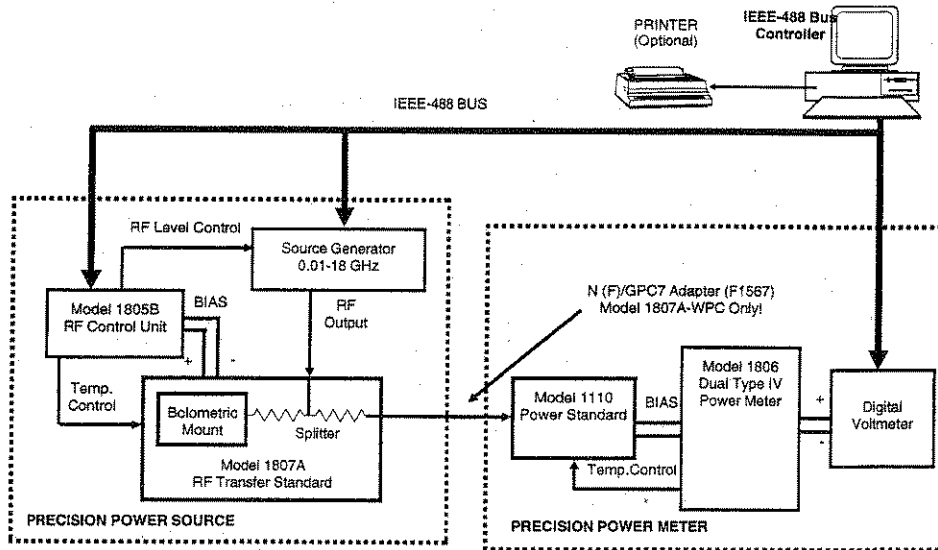


Figure 5-1 0.01 to 18 GHz Calibration Setup

CALIBRATION OF RF TRANSFER STANDARD

The following procedures and information are provided as a guideline when calibrating this TEGAM RF Transfer Standard. Listed below is the necessary equipment to perform the calibration.

<u>Model</u>	<u>Nomenclature</u>
HP 83620B	Synthesized Signal Generator 0.01-18 GHz + 10 dBm
TEGAM 1805B	RF Power Level Control Unit 0.5 to 10 mW dc substitution
TEGAM 1806	Dual Type IV Power Meter
TEGAM M1110	Terminating Coaxial Power Standard, 0.01 to 18 GHz, Calibrated
HP 3458A	Digital Voltmeter, 8-1/2 digits
Any	PC Based Controller with National Instruments GPIB Interface Card and HT Basic Software
Any	Printer

TROUBLESHOOTING

Despite their sensitivity, thermistor beads are sturdy elements requiring up to 0.2 Watts for burnout. However, a burnout condition is eventually possible. An "open" reading at the dc bias binding post indicates a burnout condition. High SWR or incorrect calibration factors could indicate a defective power splitter or broken RF connector.

APPENDIX A CARE AND HANDLING OF MICROWAVE COAXIAL CABLE ASSEMBLIES

CARE AND HANDLING OF ASSEMBLIES

To ensure accurate measurements and optimal performance of TEGAM products, the microwave coaxial cable assemblies used in system and test setups must be properly used and maintained. Proper connections, routine inspection of all cables, and cleaning of the connectors are extremely important procedures which can prolong the longevity and accuracy of equipment.

CABLE INSPECTION

Routinely check external cables for signs of cracked insulation, dents, twists, flattening, signs of jacket abrasion, or other signs of abuse. Wrinkles in the jacket indicate that the minimum bend radius has been exceeded. Most often, this occurs near the marker tubes and connectors.

Also inspect the connector interfaces for the following:

- Bent pins (male)
- Bent or missing tines (female)
- Worn or chipped plating
- Damaged or displaced dielectric inserts
- Thread damage
- Folded or mushroomed outer interface rims
- Mushroomed pin shoulders (male) or tine ends (female)
- Score lines on pins and outer interface rims visible to the unaided eye
- Recessed or protruding pins

It is advisable to clean the connectors prior to inspection to make subtle damage more apparent. If any of the above is noted, replace the assembly before its further use results in equipment damage. Also inspect the mating connectors for similar damage.

Table A-1 provides both TEGAM specifications and MIL-C39012C data for the pin height of the various types of connectors. Pin height is defined as the vectorial distance along a horizontal axis of the pin shoulder from the electrical/mechanical reference plane.

Table A-1 Pin Height Specifications

CONNECTOR TYPE	MALE	FEMALE	SEXLESS	MIL-C-39012C
7mm	NA	NA	0.000 + .000 - .002 ²	See Fig. A-1
N type	0.208 min	0.207 max	NA	See Fig. A-2
SMA	0.000 + .000 - .010	0.000 + .000 - .030	NA	See Fig. A-3
WPM	0.000 + .000 - .010	0.000 + .000 - .010	NA	See Fig. A-3
WPM-3	0.000 + .000 - .005	0.000 + .000 - .005	NA	See Fig. A-3
WPM-4	0.000 + .000 - .005	0.000 + .000 - .005	NA	See Fig. A-3
BNC	+ .210 + .230	+ .186 + .206	NA	See Fig. A-4
TNC	+ .210 + .230	+ .186 + .206	NA	See Fig. A-5

Inspect the connector interface for signs of debris. Debris may be in the form of:

- Plating chips or other metal particles
- Dust or dirt

- Oily films
- Other miscellaneous foreign particles

If signs of debris are present, clean the connector interface as directed below in Cleaning Connector Interfaces.

MAKING INITIAL CONNECTIONS

Exercise caution when mating cables. Poor connections lead to poor system performance. They can also damage not only the cable assembly, but more significantly, front or rear panel connectors on the equipment itself which may be more difficult to repair.

Aligning Connectors

Align the center lines of two connectors before actual mating. Male retaining nuts contain a small amount of necessary play which may make it possible to mate the threads without the pins being properly aligned. Pin misalignment can damage pins and dielectric inserts.

NOTE 1 ALL DIMENSIONS IN MILLIMETERS
(PARENTHEICAL DIMENSIONS IN INCHES).

ELECTRICAL MATING PLANE

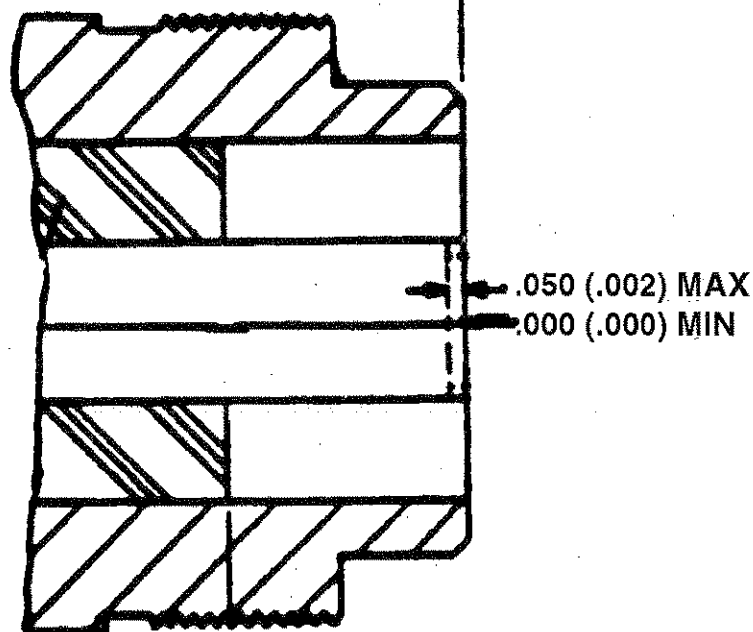


Figure A-1 Important Interface Dimensions for Type 7 MM, Precision Connectors (IEEE Std 287)

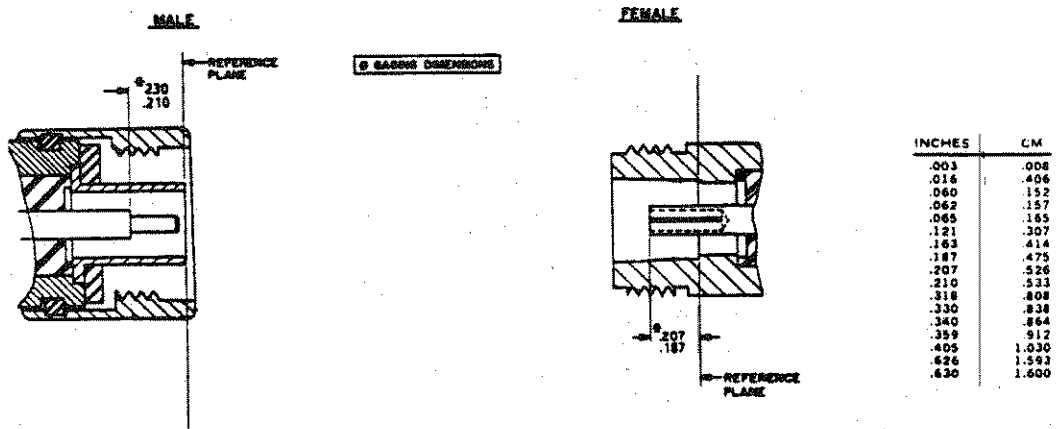


Figure A-2 Important Interface Dimensions for Type 7 MM, Precision Connectors (IEEE Std 287)

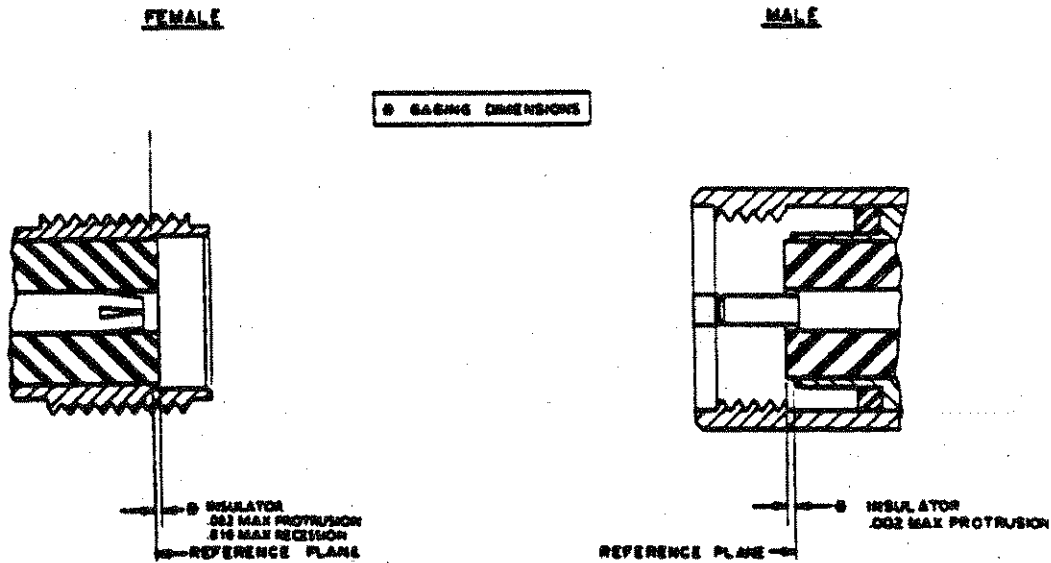


Figure A-3 Important Interface Dimensions for Type SMA, Class II Connectors (MIL-C-39012/55&57)

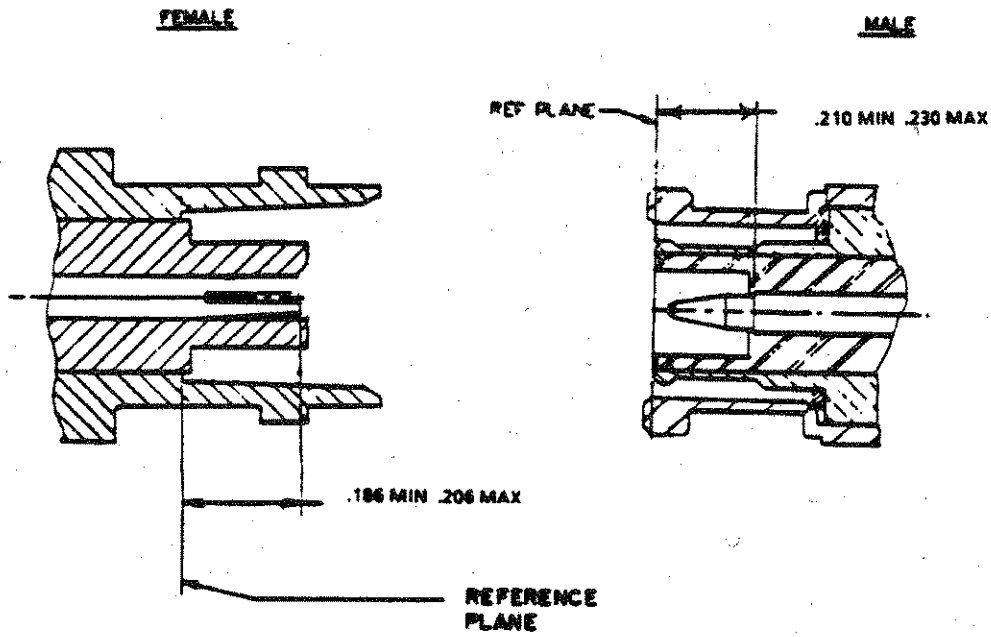


Figure A-4 Important Interface Dimensions for Type BNC, Class II Connectors (MIL-C-39012/16&17)

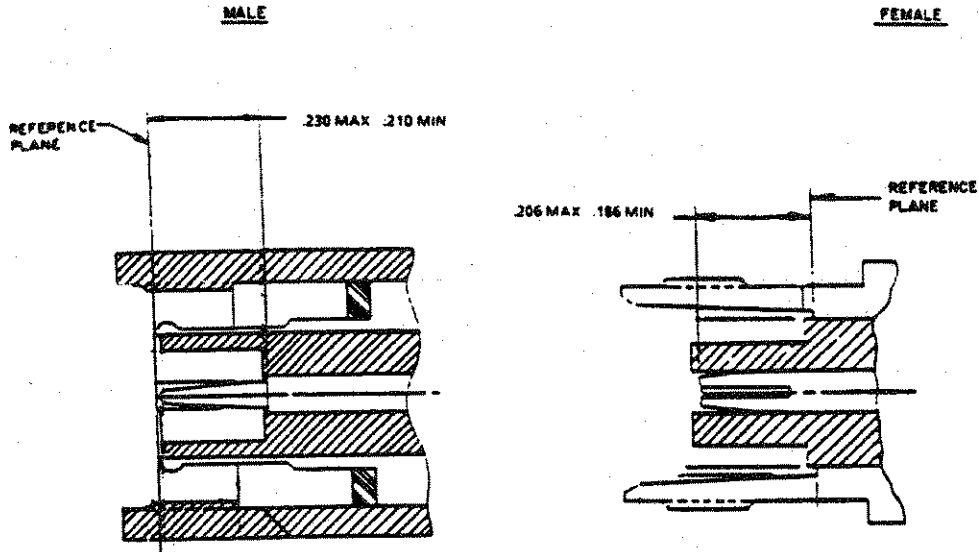


Figure A-5 Important Interface Dimensions for Type TNC, Class II Connectors (MIL-C-39012/26&27)

MATING CONNECTORS

Gently mate the connectors by hand, taking care not to force the coupling nut at the slightest resistance. It is often possible to feel whether or not the pins are mated. If the coupling nut is difficult to turn, either the pins are not mated, the coupling nut is cross-threaded, or one of the connectors has

been damaged by excess torque.

Never hold a male connector coupling nut stationary while screwing a female connector into it. This rotation can erode the plating and damage both the outer interface rim as well as the pin. If the pins become locked, serious damage can result to both the equipment and the cable assembly.

ENSURING PROPER CONNECTOR TORQUE

OVERTORQUING

Once connectors have been properly mated, apply only the proper amount of torque. Overtorquing damages both connectors involved. Also, a connector which has been damaged by overtorquing, in turn, damages every connector to which it is subsequently mates. It usually leads to poor system performance as well. Overtorque can cause:

- Bent pins
- Recessed or protruding pins
- Recessed or protruding dielectrics
- Chipped plating
- Damaged coupling threads
- Coupling nut retaining ring damage
- Mushroomed outer interface shells
- Mushroomed pin shoulders

HEX-NUT TYPES

To mate a connector of the hex-nut type, always use a torque wrench set to the correct torque value. Tighten the connector slowly until the wrench snaps. Tightening too quickly can cause the wrench to exceed its set limit. Do not snap the wrench more than once as this also causes overtorque.

KNURLED NUTS

Tighten connectors with knurled nuts by hand. If this does not provide sufficient tightness use a hex-nut connector and torque wrench instead. Never use pliers to tighten a connector. Table A-2 recommends torque specifications for the various types of connectors.

Table A-2 Connector Torque Recommendations

CONNECTOR TYPE	RECOMMENDED TORQUE
7 mm connector with hex nuts	14.0 in/lbs \pm 1 in/lbs
Type N connector with hex nut	14.0 in/lbs \pm 1 in/lbs
SMA connector	7.5 in/lbs \pm 0.5 in/lbs
WPM	7.5 in/lbs \pm 0.5 in/lbs
WPM-3	7.5 in/lbs \pm 0.5 in/lbs
WPM-4	7.5 in/lbs \pm 0.5 in/lbs
Type N connector (knurled)	hand-tight
TNC connector (knurled)	hand-tight
BNC	hand-tight

PROPER CABLE HANDLING

Never exceed the minimum bend radius specified for a cable. Guard against tight bends at the end of connector strain relief tubing, or at the ends of marker tubing where they may be less noticeable. Although cable bend may seem slight, the actual radius of the bend at the point of angular departure may be far smaller than the acceptable radius.

Never pinch, crush or drop objects on cable assemblies. Also, do not drag a cable over sharp edges as this will pinch it and cause it to exceed the minimum bend radius.

Never use a cable assembly to pull a piece of equipment. Cables and connectors are not designed to support or move equipment.

SECURING CABLES

Use toothed, rubber-lined "P-clamps" to hold cables in place. If it is necessary to use tie-wraps, use the widest possible wrap and the lowest setting on the gun to ensure the minimum pressure on the cable.

STORING CABLES

When storing cables, minimize cable "set" by coiling them in large diameters (1 or 2 feet). Unroll the cable properly when it is ready to be used; do not pull the loops out hastily. Similarly, re-roll them when storing them away again.

CLEANING CONNECTOR INTERFACES

Use the following guidelines in cleaning connector interfaces:

- A. Do not use chlorinated solvents including common tap water. These solvents are extremely penetrating and sometimes ruin otherwise good devices and assemblies.
- B. Moisten a cotton swab with isopropyl alcohol. Roll the swab on a paper towel to remove excess.
- C. Use the moistened cotton swab to wipe away debris. Do not try to dissolve the debris by overwetting the swab.
- D. Repeat the cleaning process using additional swabs as necessary. If metallic particles are embedded in the dielectric, use an eyeglass and a sharp pick in an attempt to dislodge them. Swab again.
- E. When satisfied that the interfaces are clean, blow them dry with dry compressed air, or preferably dry nitrogen (pressurized spray cans work well). Do not use breath.
- F. Clean the mating connectors. These may be the source of debris.

Warranty

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of one year from date of shipment. During the warranty period, we will at our option, either repair or replace any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of one year from date of shipment. During this period we will recalibrate any product that does not conform to the published accuracy specification.

To exercise the warranty, contact TEGAM, Inc., 10 TEGAM Way, Geneva, Ohio 44041, phone 440-466-6100, fax 440-466-6110, M-F, 8 a.m.-5 p.m. ET. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty, or at least 90 days, whichever is longer.

Limitation of Warranty

TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of any product or part. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular use. TEGAM, Inc shall not be liable for any indirect, special or consequential damages.

Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by TEGAM, Inc.

The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment that is calibrated at planned intervals by comparison to certified standards maintained in the Laboratories of TEGAM, Inc.

How to Contact TEGAM

TEGAM, Inc.
10 TEGAM Way
Geneva, OH 44041

Phone: 440-466-6100
Fax: 440-466-6110
e-mail: sales@tegam.com

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