TEGAM

IM-203
Rev. B

OPERATION & SERVICE MANUAL

Models 1107-7 and 1107-8 RF Power Transfer Standards

August 2009

Table of Contents

List of Illustrations

LIST OF TABLES

SECTION I GENERAL INFORMATION

SCOPE

This manual contains operation and maintenance information for the TEGAM Models 1107-7 and 1107-8 RF Power Transfer Standards. The information presented consists of descriptive data, installation and connection instructions, operating procedures, theory of operation and maintenance procedures.

PURPOSE AND USE OF MODELS 1107-7 AND 1107-8

PURPOSE

The Models 1107-7 and 1107-8 RF Power Transfer Standards, depicted in Figure 1-1, are designed for precise measurements of microwave power in the 18.0-26.5 GHz and 26.5-40.0 GHz ranges, respectively. Both units are highly accurate with time and temperature.

USE

Both Models 1107-7 and 1107-8 consist of a 3 dB coupler with a thermistor on the coupler's side arm, and a removable termination on the coupler's main arm. With the termination removed, the unit becomes a feedthrough transfer standard for the transfer of calibration factors to terminating power standards of power sensors. With the termination attached, the unit is used as a terminating transfer standard. Five calibration points transfer traceable to NIST are provided for "measure" calibration factor K_1. Five calibration points transfer traceable to NIST are also provided for "monitor" calibration factor K_2, when the unit is to be used as a terminating transfer standard.

The Models 1107-7 and 1107-8 are designed for use with a DC self-balancing bridge, such as the TEGAM Model 1806 Dual Type IV Power Meter.

SPECIFICATIONS

Tables 1-1 and 1-2 provide the operating specifications for the Models 1107-7 and 1107-8.

ITEMS SUPPLIED

The following items are supplied with the Models 1107-7 and 1107-8 RF Power Transfer Standards:

- Model 1107-7 and 1107-8 Operation and Service Manual (IM-203)
- Calibration Report

Table 1-1 Model 1107-7 Specifications

SPECIFICATION	DESCRIPTION
Frequency Range	18.0 to 26.5 GHz
Maximum Equivalent Source SWR	1.20 (1.10 typically)
Resistance when Biased	200 ohms
Temperature Coefficient or Resistance	Negative
DC Bias Power	11mW to 20mW
Power Measurement Range	Up to 10 mW
Calibration	Individual calibration traceable to NIST supplied at 18.0, 20.0, 22.0, 24.0 and 26.5 GHz
Accuracy	Within limits stated by NIST, 1.0 to 1.5% typically
Stability	>0.5%/year
Calibration Factor Power Level Dependence	<0.1% change from 1.0 to 10.0 mW, negligible to maximum useful limit.
Waveguide Connections	WR-42
Weight	Min. Net, 11 lbs. 3 oz (5.1 kg)
Dimensions	11.2 in (285 mm) high, 15.4 in (391 mm) long, 9.4 in (239 mm) wide

Table 2-2 Model 1107-8 Specifications

SPECIFICATION	DESCRIPTION
Frequency Range	26.5 to 40.0 GHz
Maximum Equivalent Source SWR	1.20 (1.10 typically)
Resistance when Biased	200 ohms
Temperature Coefficient or Resistance	Negative
DC Bias Power	11mW to 20mW
Power Measurement Range	Up to 10 mW
Calibration	Individual calibration traceable to NIST supplied at 26.5, 30.0, 33.0, 36.5 and 40.0 GHz
Accuracy	Within limits stated by NIST, 1.0 to 1.5% typically
Stability	>0.5%/year
Calibration Factor Power Level Dependence	<0.1% change from 1.0 to 10.0 mW, negligible to maximum useful limit.
Waveguide Connections	WR-28
Weight	Min. Net, 11 lbs. 3 oz (5.1 kg)
Dimensions	11.2 in (285 mm) high, 15.4 in (391 mm) long, 9.4 in (239 mm) wide

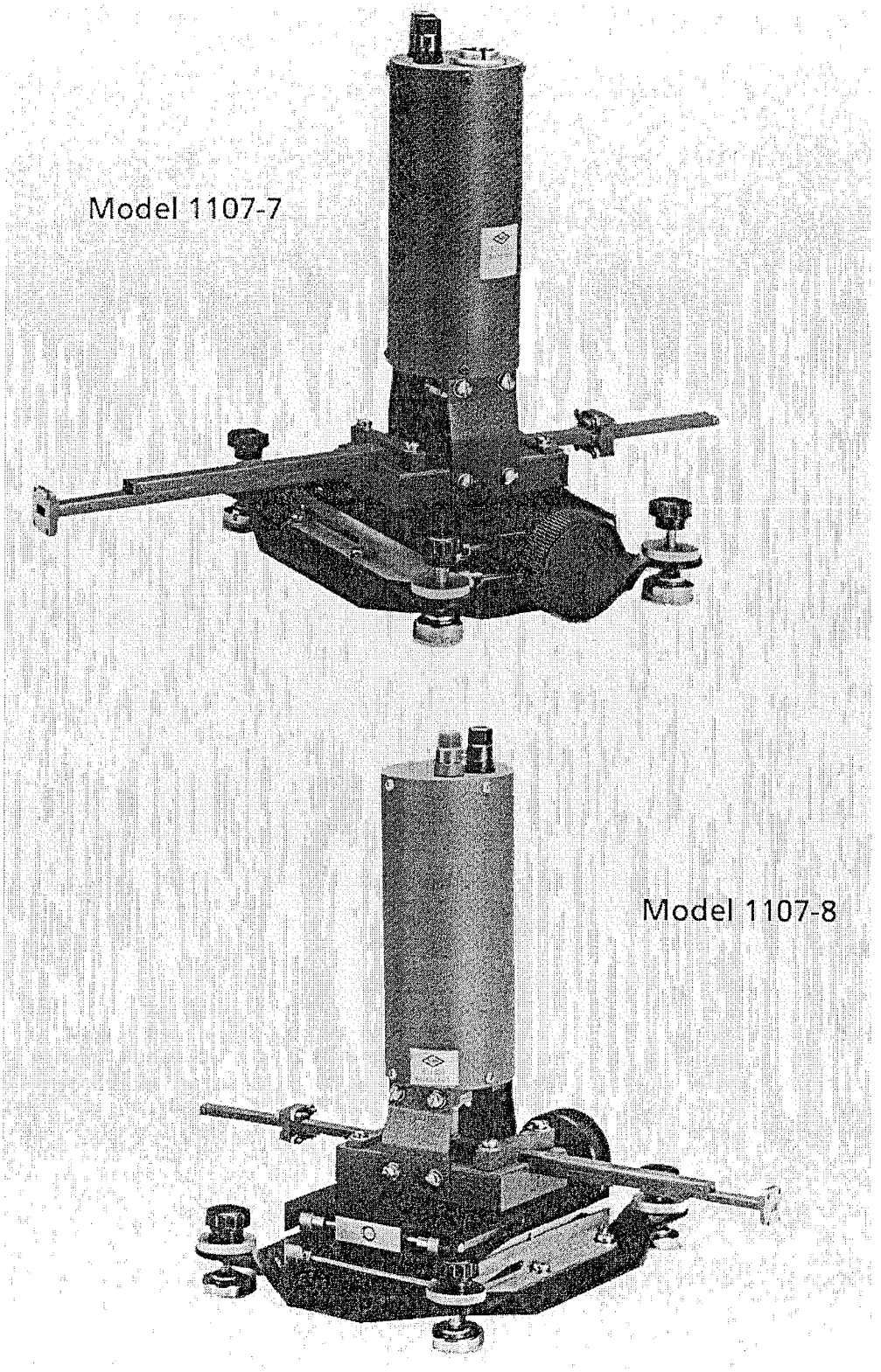


Figure 1-1 TEGAM Models 1107-7 and 1107-8 RF Power Transfer Standards

SECTION II INSTALLATION

UNPACKING AND INSPECTION

TEGAM ships the Models 1107-7 and 1107-8 cushioned between molded-in-place, expanded plastic pads in a cardboard shipping carton. This carton is then packed in another carton with "peanut" type packing material to reduce the potential for damage during shipment. After unpacking the equipment, retain the shipping containers and packing material for future reshipment for calibration. Perform the following initial inspections:

A. Carefully inspect the outside of the shipping container for discoloration, stains, charring, or other signs of exposure to excessive heat, moisture, or liquid chemicals. Check for any physical damage to the shipping container such as dents, snags, rips, crushed areas, or similar signs of excessive shock or careless handling.

B. Remove all the equipment and any accessory packages from the shipping container. Check each item against the packing list. If any items are missing, contact either TEGAM or a local manufacturer's representative.

C. Carefully inspect the equipment, looking for dents, deep scratches, damaged or loose connectors or waveguides, or any other signs of physical abuse or careless handling.

If damage is found, forward an immediate request to the delivering carrier to perform an inspection and prepare a concealed damage report. Do not destroy any packing material until it has been examined by an agent of the carrier. Concurrently, report the nature and extent of damage to TEGAM, giving equipment, model and serial numbers, so that necessary action can be taken. Under U.S. shipping regulations, damage claims must be collected by the consignee; DO NOT return the equipment to TEGAM until a claim for damages has been established.

PREPARATION FOR RESHIPMENT OR STORAGE

Use the best packaging materials available to protect the unit during storage or reshipment. When possible, use the original packing containers and cushioning material. If the original packing materials are not available, use the following procedure:

A. Wrap the instrument in sturdy paper or plastic.

B. Place the wrapped instrument in a strong shipping container and place a layer of shock-absorbing material (2-inch minimum thickness) around all sides of the unit to provide a firm cushion and to prevent movement inside the container. DO NOT place any unnecessary strain on waveguides.

C. If shipping the unit to TEGAM for service or recalibration, attach a tag to indicate:
   1. Model and serial numbers.
   2. Service required.
   3. Description of malfunction.
   4. Return address.
   5. Authorization to conduct repairs or to recalibrate.
   6. Instrument return authorization.

D. Thoroughly seal the shipping container and mark it FRAGILE.

E. Ship to:

TEGAM, INC.
TEN TEGAM WAY
GENEVA, OH 44041
USA

When storing the 1107-7 and 1107-8 for extended periods, follow the instructions above to prevent damage to internal circuitry. The safe limits for storage environment are:

Temperature:	-67° to +167° F (-55° to +75° C)
Humidity:	less than 95%
Altitude:	40,000 feet (12,192 m)

POWER, ENVIRONMENTAL AND MOUNTING REQUIREMENTS

The Models 1107-7 and 1107-8 are externally powered by a dc self-balancing bridge such as the TEGAM Model 1806 Dual Type IV Power Meter. The temperature control cable provided with the model 1806 connects directly to the 1107-7 or 1107-8, as do the mount bias leads. No external power is required.

The Models 1107-7 and 1107-8 are designed to operate within their specifications at an ambient temperature of +12° to +40° C. Operating in ambient temperatures beyond these limits could affect the accuracy of the units and possibly damage internal circuitry.

To ensure NIST traceability while transferring calibration factors, the units should be operated in an area with an ambient temperature of +20 ±1° C.

The units are shipped ready for bench use and are equipped with an adjustable jack stand to provide four-way adjustment of mount height and attitude.

INSTALLATION

Installation of the Models 1107-7 and 1107-8 consist of connecting cabling to the unit and making proper waveguide connections. The following paragraphs discuss cabling procedures and guidelines for making waveguide connections.

TEMPERATURE CONTROL CONNECTOR (J1)

Connector J1 is a four contact, screw-on type connector designed for mating with a temperature control cable such as those supplied with the TEGAM Model 1806 Dual Type IV Power Meter. To install this cable to the 1107-7 or 1107-8, carefully align the four contacts on the cable connector with the contact in J1. Insert the connector into J1 and secure the connector by tightening down the threaded retainer ring. The opposite end of the cable connects to the connector on the Model 1806 marked TEMPERATURE CONTROL.

MOUNT BIAS CONNECTORS (J2, J3)

Connectors J2 and J3 are red and black binding posts located on the top end of the thermistor mounts of the 1107-7 and 1107-8. These connectors accept the red and black spade lug terminated cables supplied with the Model 1806. To install these cables, unscrew the end of each binding post sufficiently enough to insert the cable spade lugs. Insert the cable spade lug (red to red, black to black) firmly and tighten down the end of the binding post. Ensure the connections are secure by lightly pulling on the cable. The opposite end of these cables connect to the binding posts on the Model 1806 marked MOUNT BIAS.

MAKING WAVEGUIDE CONNECTIONS

When making waveguide connections to the Models 1107-7 or 1107-8, align the waveguide port(s) and screw holes of the 3 dB coupler of the 1107-7 and 1107-8 with the mating waveguide(s) by making adjustments to the jack stand. Ensure the waveguide planes are well aligned, and install waveguide mounting screws and nuts. Use socket head screws (P/N MS16995-11 and hex nuts (P/N MS35649-244) or equivalent. DO NOT cause any unnecessary stress to waveguides.

SECTION III OPERATION

INTRODUCTION

This section contains information for the use of the Models 1107-7 and 1107-8 in their different operating applications with the TEGAM Model 1806 Dual Type IV Power Meter.

TRANSFERRING THE KNOWN CALIBRATION OF A MOUNT TO A SECOND MOUNT

Figure 3-1 illustrates the equipment setup required to transfer the calibration factor of a known mount to a second mount. These procedures are identical for both the Models 1107-7 and 1107-8 with the exception of the equipment required. Table 3-1 lists the equipment required when performing these procedures using the Model 1107-7 (18.0 to 26.5 GHz range) and Table 3-2 lists the equipment required when using the Model 1107-8 (26.5 to 40.0 GHz range).

The following paragraphs provides the procedure for transferring the *monitor* calibration factor (K_2) of a feedthrough mount to the *measure* calibration factor (K_1) of a terminating mount, and for transferring the *measure* calibration factor (K_1) of a terminating mount to the *monitor* calibration factor (K_2) of a feedthrough mount.

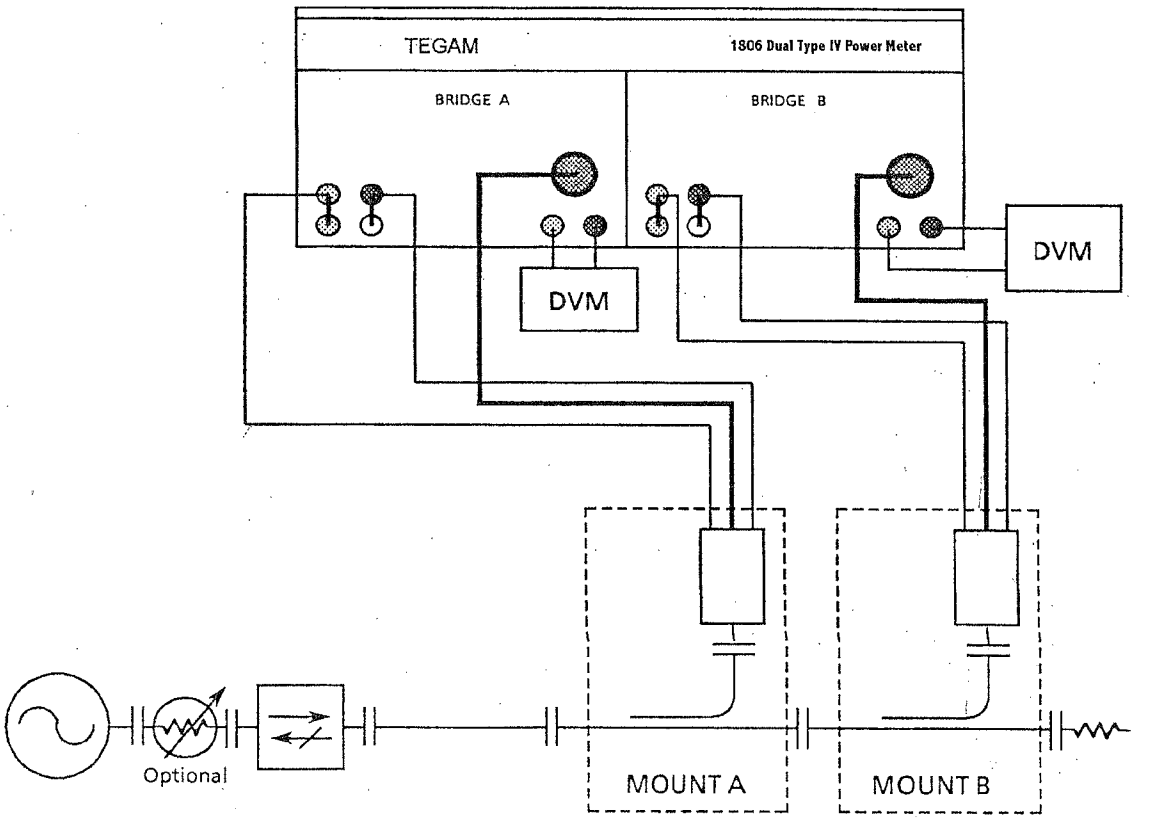


Figure 3-1 Equipment Setup for Transferring a Known Calibration Factor to Another Mount

Table 3-1 Equipment Required When Using The Model 1107-7

DESCRIPTION	RECOMMENDED MODEL NO.
1 18 to 26.5 GHz Synthesizer (with output of 2 mW minimum)	HP Model 83640B
2 Type IV RF Bridges with operating resistance of 200 ohms	TEGAM Model 1806
2 18 to 26.5 GHz Thermistor Mounts	TEGAM Model 1107-7
1 WR-42 Waveguide Isolator	Trak Microwave Model 2561-1810
2 Digital Voltmeters (with 7 1/2 digits)	HP 3458A

Table 3-2 Equipment Required When Using The Model 1107-8

DESCRIPTION	RECOMMENDED MODEL NO.
1 26.5 to 40.0 GHz Synthesizer (with output of 2 mW minimum)	HP Model 83640B
2 Type IV RF Bridges with operating resistance of 200 ohms	TEGAM Model 1806
2 26.5 to 40.0 GHz Thermistor Mounts	TEGAM Model 1107-8
1 WR-28 Waveguide Isolator	Trak Microwave Model 2571-1810
2 Digital Voltmeters (with 7 1/2 digits)	HP 3458A

TRANSFERRING THE CALIBRATION OF A FEEDTHROUGH MOUNT TO A TERMINATING MOUNT

In the following procedure, it is assumed that the monitor calibration factor (K_2) of feedthrough Mount A is known and the transfer of this calibration factor to obtain a tertiary measure calibration factor (K_1) of Mount B is desired. Proceed as follows:

A. On the Model 1806, set both bridges for a 200 ohm operating resistance and place the rear panel FLOAT/GROUND switch to the FLOAT position.

B. With all power removed, construct the setup illustrated in Figure 3-1. Use the shorting jacks supplied with the Model 1806 to short its BOLOMETER and SENSE connectors.

C. On the Model 1806, set the POWER switch to the STANDBY position. Wait until the Temperature Control Meter on each bridge is in the green region (preferably overnight) before proceeding.

D. With both Temperature Control Meters in the green region, set the POWER switch to the ON position. Wait for the voltages to be well settled before proceeding.

E. With no power applied to the mounts ($V_{RF\ OFF}$), record the voltages indicated by the DVMs connected to Bridge A and Bridge B.

F. Tune the millimeterwave source to one of the frequencies for which a calibration is provided or to a frequency point for which a calibration factor has been interpolated from two known calibration factors.

G. Adjust the power output for an approximately 2mW input to Mount A.

H. Record the voltages indicated by the DVMs connected to Mount A and Mount B ($V_{RF\ ON}$).

I. Calculate the dc power substituted by the bridge for each mount using the following equation:

$$\frac{(V_{RF\ ON}^2 - V_{RF\ OFF}^2)}{200\ (ohms)} = DC\ Power\ Substituted\ by\ Bridge$$

J. Calculate the tertiary measure calibration of Mount B using the following equation:

$$K_1\ of\ Mount\ B = \frac{DC\ Power\ Substituted\ by\ Bridge\ A}{DC\ Power\ Substituted\ by\ Bridge\ B} \times K_2\ of\ Mount\ A$$

TRANSFERRING THE CALIBRATION OF A TERMINATING MOUNT TO A FEEDTHROUGH MOUNT

To transfer the calibration of a terminating mount to a feedthrough mount, perform steps A through I (above), swapping Mount A with Mount B. Calculate the tertiary measure calibration of Mount A using the following equation:

$$K_2 \textit{ of Mount } A = \frac{\textit{DC Power Substituted by Bridge } A}{\textit{DC Power Substituted by Bridge } B} \times K_1 \textit{ of Mount } B$$

USING A FEEDTHROUGH MOUNT TO CALIBRATE A POWER SENSOR

This procedure is identical for both the Models 1107-7 and 1107-8 with the exception of the equipment required. Figure 3-2 illustrates the test setup required to calibrate a power sensor using the known *monitor* calibration factor (K_2) of a feedthrough mount. Table 3-1 lists the equipment required when performing these procedures using the 1107-7 (18 to 26.5 GHz range) and Table 3-2 lists the equipment required when using the 1107-8 (26.5 to 40.0 GHz range).

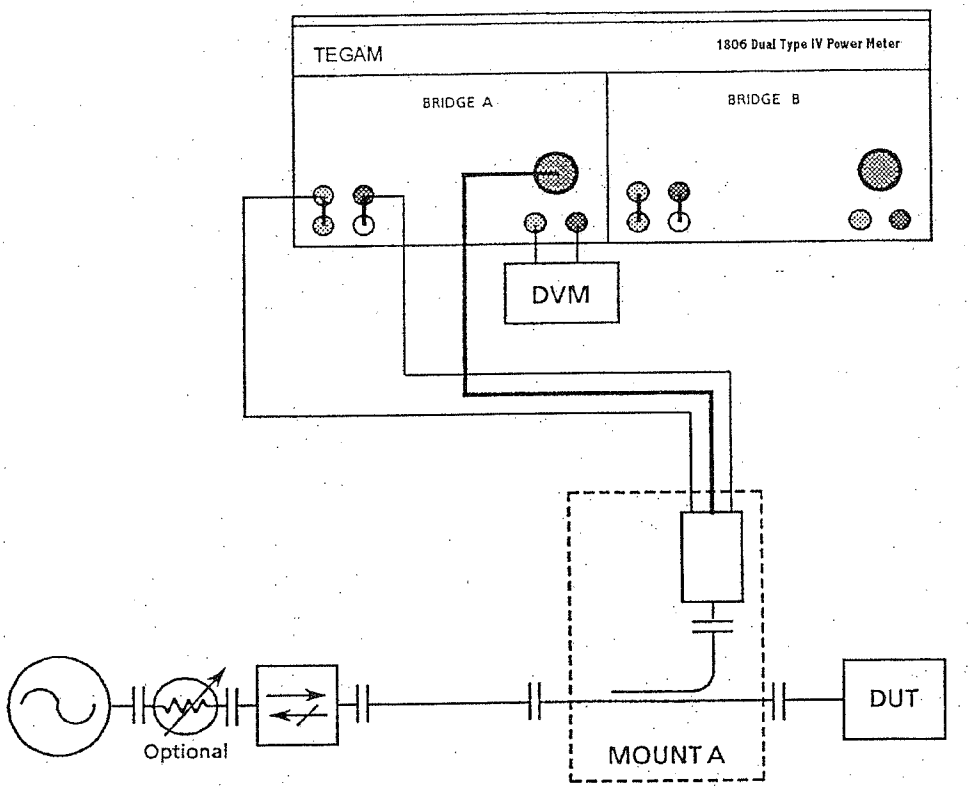
A. On the Model 1806, set both bridges for a 200 ohm operating resistance and place the rear panel FLOAT/GROUND switch to the FLOAT position.
B. With all power removed, construct the setup illustrated in Figure 3-2. Use the shorting jacks supplied with the Model 1806 to short its BOLOMETER and SENSE connectors.
C. On the Model 1806, set the POWER switch to the STANDBY position. Wait until the Temperature Control Meter on Bridge A is in the green region before proceeding (preferably overnight).
D. With the Temperature Control Meter in the green region, set the POWER switch to the ON position. Wait for the voltages to be well settled before proceeding (approx. 20 minutes).
E. With no RF power applied to the mount ($V_{RF\ OFF}$), record the voltage indicated by the DVM.
F. Tune the millimeterwave source to one of the frequencies for which a calibration is provided or to a frequency point for which a calibration factor has been interpolated from two known calibration factors.
G. Adjust the generator power output to obtain a reading of approximately 1 mW on the power meter and record the reading.
H. Calculate the dc power substituted by bridge using the following equation:

$$\frac{(V_{RF\ OFF}^2 - V_{RF\ ON}^2)}{200\ \textit{(ohms)}} = \textit{DC Power Substituted by Bridge}$$

I. Calculate the calibration factor of the power sensor using the following equation:

$$\textit{Cal Factor of } K_1 \textit{ of Power Sensor} = \frac{\textit{Power Read at Power Meter}}{\textit{DC Power Substituted by Bridge } A} \times K_2$$

J. Repeat steps C through I for the remaining frequencies.


TEGAM
1806 Dual Type IV Power Meter
BRIDGE A
BRIDGE B
DVM
Optional
MOUNT A
DUT

SECTION IV THEORY OF OPERATION

INTRODUCTION

The TEGAM Models 1107-7 and 1107-8 RF Power Transfer Standards are configured to provide a path for RF energy via a waveguide line. DC bias is introduced from the Bias terminals to the thermistors via a filter network.

The following paragraphs provide a more detailed description of the operating theory of the Models 1107-7 and 1107-8.

TEMPERATURE-VARIABLE RESISTANCE

The Models 1107-7 and 1107-8 each contain a thermistor bead whose resistance changes as a function of temperature. Thermistor bead temperature is a function of the combined dc and RF power applied to the bead and the ambient temperature surrounding the bead. The level of power applied to the bead is controlled externally. A heating element provides ambient temperature stabitlity.

THERMISTOR BEAD VARIABLE RESISTANCE

Application of approximately 30 mW of power to the thermistor bead produces a 200 ohm dc resistance. As the power applied to the thermistor bead increases, the effective resistance value decreases. This is due to the negative temperature coefficient of the bead. Initially, the bead is dc biased to 200 ohms. Application of RF power increases the power level present at the bead and causes the effective resistance value of the bead 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.

HEATER ELEMENT ELECTRICAL CONFIGURATION

The heater element electrical assembly, illustrated in Figure 4-1, 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 bead is 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.

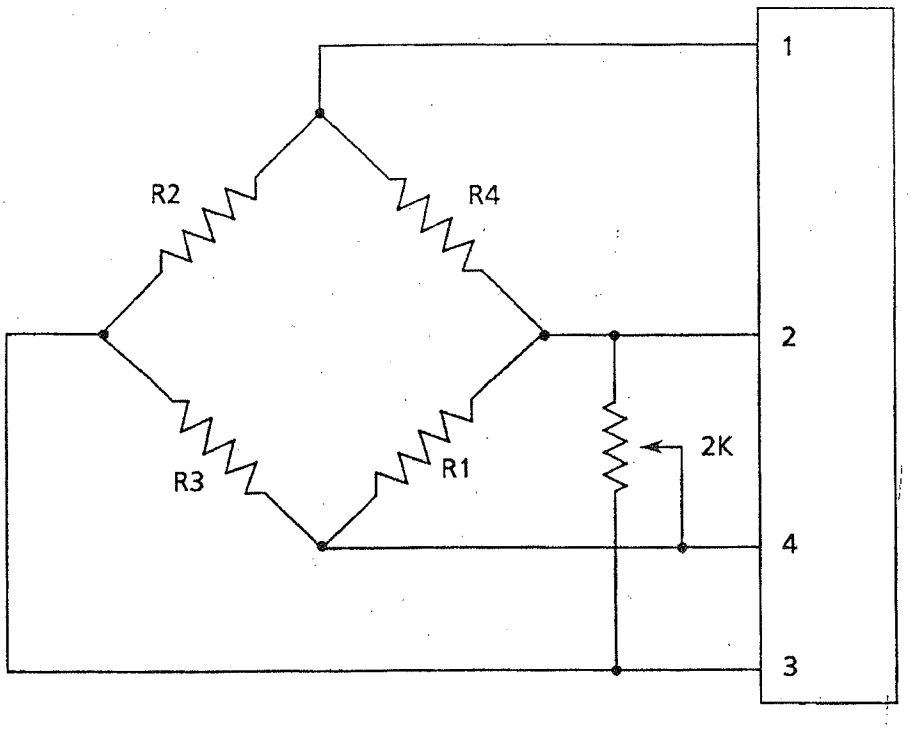


Figure 4-3 Mount Heater Assembly Electrical Configuration

The heater bridge, shown in Figure 4-1, balances when the heater windings provide equal resistance. The 2K-ohm potentiometer forces a balanced condition at the proper temperature and ensures the proper thermistor bias (30 mW ±0.7 mW). Hence, the bridge configuration accomplishes both a temperature sensing and heating function.

SECTION V MAINTENANCE

INTRODUCTION

The Models 1107-7 and 1107-8 require no preventive maintenance other than the normal handling and cleaning procedures explained below. Troubleshooting and repair information is also provided below.

PREVENTIVE MAINTENANCE

Tests show that connectors must be clean for accuracy and stability. This requires inspection and cleaning of each connector immediately before use, and periodic inspection during use. If cleaning is necessary, use currents of compressed air and a lint-free tissue. Where more drastic measures are required, use tissue that is moistened (not saturated) with methanol. When such cleaning precautions are observed regularly, connectors can maintain their stability for several thousand connection cycles.

TROUBLESHOOTING AND REPAIR

Despite their sensitivity, thermistor beads are sturdy elements requiring up to 0.2 watts for electrical burnout. However, a burnout condition is a possible eventuality. An "open" resistance reading at the dc bias binding posts indicates a burnout condition.

Due to their calibration sensitivity, there are no field replaceable parts on the Model 1107-7 and 1107-8. In the event that damage or a malfunction has occurred, return the unit to TEGAM for repair and calibration.

RECALIBRATION

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 one to two years according to use and handling.

Disassembly of the mount or replacement of the thermistor assembly voids the calibration factor of the Models 1107-7 and 1107-8. This is due to the delicate physical relationships within the mount and the equally sensitive characteristics of the thermistor bead. To recalibrate the unit, use one of the following methods:

1. Return the Model 1107-7 or 1107-8 to TEGAM indicating that recalibration or thermistor assembly replacement (or both) is necessary.
2. Transfer the known calibration factor of a mount to the affected mount using the procedures outlined in Section III.
3. For NIST traceable calibration of K_1, send unit to TEGAM.

CONTACTING TEGAM

In the event of an instrument malfunction, contact TEGAM. An apparent malfunction of an instrument or component may be diagnosed over the phone by first contacting the Customer Service Department at 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, catalog and type number of the instrument or component, and date of original purchase. Also write the Company name and your name and phone number on a card and tape the card to the item being returned.

Contact TEGAM at:

TEGAM, INC.
TEN TEGAM WAY
GENEVA, OH 44041 U.S.A

800-666-1010 (toll free)
440-466-6100 (ph)
440-466-6110 (fx)
sales@tegam.com (e-mail)

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