



MILLIMETER-WAVE  
PRODUCTS

**HUGHES**

MICROWAVE PRODUCTS DIVISION

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# **TECHNICAL MANUAL FOR**

**MILLIMETER-WAVE TEMPERATURE COMPENSATED  
THERMISTOR MOUNT  
MODEL NUMBER 4577xH**

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**TECHNICAL MANUAL  
FOR**

**MILLIMETER-WAVE TEMPERATURE COMPENSATED  
THERMISTOR MOUNT**

**MODEL NUMBER 4577xH**

**MANUAL PART NUMBER PM-MMW-1801**

**NOVEMBER 1988**

**HUGHES AIRCRAFT COMPANY  
MICROWAVE PRODUCTS DIVISION  
3100 FUJITA STREET  
TORRANCE, CA 90509  
(213) 517-6400 TWX 910-347-7321**

## WARRANTY FOR SOLID STATE MICROWAVE PRODUCTS

1. The millimeter-wave products identified in your order and sold by Hughes Aircraft Company, Microwave Products Division, are warranted to the original Buyer to meet the published specifications, drawing and/or such modifications thereof as Buyer and Seller have agreed to in writing and to be free from defects in workmanship and materials. Seller's entire warranty obligation is limited to making adjustments by repairing, replacing or refunding the purchase price of any product which fails to meet this warranty and which is returned to Seller, as provided below, within one (1) year from date of first shipment by Seller. Replacement, repairs, or adjustments under this warranty shall not reinstate the warranty set forth herein. Under all circumstances, except as provided for in Paragraph 2 and 8 below, the warranty will expire not later than one (1) year after such first shipment.
2. **EXTENDED WARRANTY.** IMPATT oscillators, when used as components in Hughes MPD sweep generators, sweep sources and synthesizers, will have an extended warranty period of three (3) years from date of first shipment by Seller.
3. Adjustment will not be allowed for products which have been subjected to abuse, improper application or installation, alteration, accidental or negligent damage in use, storage, transportation or handling. Alteration or removal of serial number or identification markings voids the warranty.
4. Seller shall have the right of final determination as to the existence and cause of a defect, and whether to make adjustment by repair, replacement or refund. When adjustment is not allowed, a reasonable charge will be made to Buyer to cover Seller's cost of inspection and handling.
5. In the event Seller determines that any product claimed to be defective is not subject to adjustment set forth herein, Buyer will be notified that product is not subject to adjustment. Unless the Buyer furnishes disposition instructions for the product within thirty (30) days after such notification, Seller may return the product "as is" to Buyer, transportation collect.
6. In returning products under this warranty, Buyer in all cases will obtain and comply with Seller's packaging and shipping instructions. Buyer will pay for all packing and transportation costs for returned product. Credit for transportation charges within the United States will be issued by Seller if adjustment is allowed. Where adjustment is not allowed, products will be returned to Buyer transportation collect.
7. **THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE OF THIS CONTRACT.** Seller shall not be liable for consequential damages. No change in this warranty shall be binding upon Seller unless it shall be in writing signed by a duly authorized representative of the Seller.
8. **EXCLUSION OF CERTAIN DIODES.** a) Field replacement diodes – if the unit contains a Hughes diode clearly indicated on the unit's specification sheet as Field Replacement, there is no warranty on that diode. b) If the unit contains a Schottky diode and the diode fails within the one (1) year warranty period, upon the initial return of the product to Hughes, Hughes will replace the failed diode free of charge and return the product as provided in this warranty. If the product fails a second time during the initial one (1) year period, then Hughes, upon return of that product, will replace the failed diode at its usual charge for such replacement; and for an additional period of one (1) year from the date of the second replacement, Hughes will warrant the product containing the replacement diode (exactly as though it were a new unit).
9. To return products for repair under this warranty, write to Hughes Aircraft Company, Microwave Products Division, Customer Service, 3100 Fujita Street, Torrance, California 90505, or telephone (213) 517-6400.

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## SECTION 1

### GENERAL INFORMATION

#### 1.1 SCOPE AND ORGANIZATION OF THE MANUAL

This manual contains information to install, operate and service the Hughes 4577xH series of Millimeter-Wave (MMW) Thermistor Mounts. The manual is divided into the following five sections:

- Section 1: General Information
- Section 2: Installation
- Section 3: Operation Procedure
- Section 4: Theory of Operation
- Section 5: Repair and Maintenance.

#### 1.2 INTRODUCTION

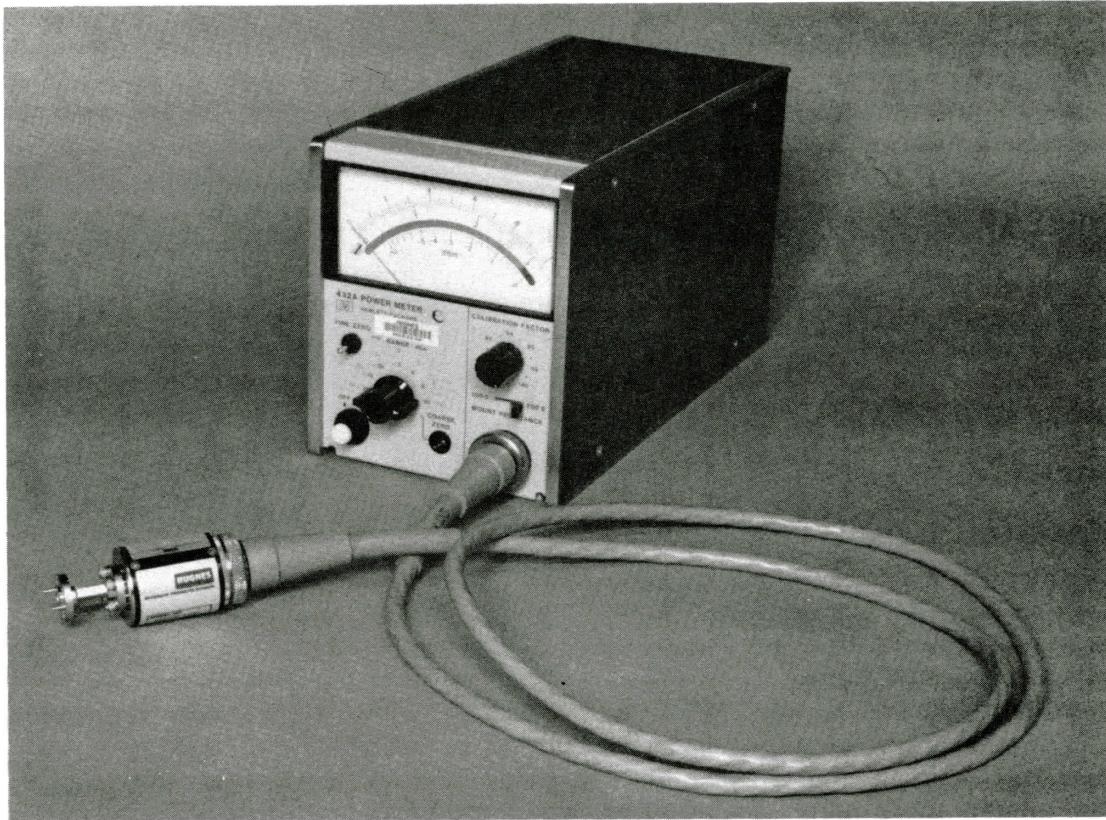
This section of the manual contains a general description of the Hughes 4577xH Thermistor Mount including a functional description of the instrument, specifications and available options.

#### 1.3 GENERAL DESCRIPTION

The Hughes 4577xH MMW Thermistor Mount is designed for use with the Hewlett-Packard Model 432 series of power meters as shown in Figure 1-1. These Temperature Compensated Thermistor Mounts are used in the power ranges from 10  $\mu$ W (-20 dBm) to 10 mW (+10 dBm) in the frequency range of 26.5 to 166 GHz in eight waveguide bands. The temperature compensated feature of these mounts provides relatively drift-free operation in a changing ambient environment.

Calibration is provided every 5 GHz, with additional calibration points available upon request, over any waveguide band through WR-10 (75 to 110 GHz). For waveguide bands above 110 GHz, calibration is provided at three frequencies: The two band edges and midband. At each calibration frequency, a correction factor in +dB is shown on the label of the Thermistor Mount. This calibration factor takes into account all losses within the Thermistor Mount including mismatch and efficiency. The correction factor is added to the power meter reading to yield the value of true power.

A certificate of calibration is supplied with each unit. The thermistor is supplied and calibrated with an input waveguide section and standard flange for ease of connection and use. Each Model 4577xH Thermistor Mount is designed to provide a low VSWR over its full frequency band without external tuning.



**Figure 1-1.** MODEL 4577xH THERMISTOR MOUNT WITH HP 432 POWER METER.

#### 1.4 INSTRUMENT IDENTIFICATION

Each Hughes Model 4577xH Thermistor Mount is identified by a label which includes its model number. Table 1-1 lists the model number structure for the Thermistor Mount. As this table shows, to order a W-band Thermistor Mount at 94 GHz, specify 45776H-1400, center frequency 94 GHz for a 20 GHz bandwidth unit or a 45776H-1100 for a 75 to 110 GHz full bandwidth.

#### 1.5 SPECIFICATIONS

Table 1-2 lists the specifications for the Model 4577xH Thermistor Mount.

**TABLE 1-1**  
**MODEL 4577xH TEMPERATURE COMPENSATED THERMISTOR MOUNT**  
**MODEL NUMBER STRUCTURE**

4577xH-xx00	Feature	No.	Description
4577x	Frequency Band	1	Ka-band
		2	Q-band
		3	U-band
		4	V-band
		5	E-band
		6	W-band
		7	F-band
		8	D-band
4577xH-x	Flange Type	1	Round
		2	Square (Ka-band only)
		8	Maury Precision Flange (Ka- through W-band)
4577xH-xx	Bandwidth	1	Full band (Ka- through W-bands)
		4	20 GHz bandwidth (W-band only: Specify center frequency)
		5	10 GHz bandwidth (F- and D-bands only: Specify center frequency)

TABLE 1-2  
HUGHES MODEL 4577xH THERMISTOR MOUNT SPECIFICATIONS

Bandwidth (GHz)	Frequency Band <sup>6</sup> (GHz)							
	Ka (26.5-40) Full	Q (33-50) Full	U (40-60) Full	V (50-75) Full	E (60-90) Full	W (75-110) Full or 20	F (90-140) 10	D (110-166) 10
Power Range:								
CW: Low (dBm)	-20	-20	-20	-20	-20	-20	-20	-20
CW: High (dBm) <sup>4</sup>	+10	+10	+10	+10	+10	+10	+10	+10
Pulse:								
Peak (dBm) <sup>4,5</sup>	+27	+27	+27	+27	+22	+22	+22	+22
Operating Resistance (ohms)	200	200	200	200	200	200	200	200
VSWR (max)	2:1	2:1	2:1	2:1	2.3:1	2.3:1	2.5:1	2.5:1
Number of Calibration Points (minimum)	6	5	5	6	7	9/5 <sup>7</sup>	3	3
Basic Accuracy Worst Case (±dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.8
Waveguide Size	WR-28	WR-22	WR-19	WR-15	WR-12	WR-10	WR-8	WR-6
Waveguide Flange UG-	599/U <sup>3</sup> 381/U <sup>2</sup>	383/U	383/U (mod)	385/U	387/U	387/U (mod)	387/U (mod)	387/U (mod)
Dimensions.....1.8 inches long by 1.3 inches diameter (4.6 by 3.3 cm)								
Weight.....0.25 pounds (115 grams)								

<sup>1</sup> The Maury precision waveguide flange also is available.

<sup>2</sup> Round flange.

<sup>3</sup> Square flange.

<sup>4</sup> Safe operation.

<sup>5</sup> 100 nanosecond pulses, 1% duty cycle.

<sup>6</sup> Standards traceable to NBS exist only in WR-28, WR-22, WR-15 and WR-10.

<sup>7</sup> Full-Band/Partial Band

## SECTION 2

### INSTALLATION

#### 2.1 INTRODUCTION

This section provides instructions on how to set up and prepare the Hughes 4577xH Millimeter-Wave Thermistor Mount for use, as well as information about initial inspection, damage claims, repacking and shipping.

#### 2.2 UNPACKING AND INITIAL INSPECTION

The Hughes Millimeter-wave Thermistor Mount is packed in a special shipping container to meet normal shipping requirements. Before opening the container, check for damage. If damage to the shipping container is evident, request that a representative of the freight carrier be present when the container is opened.

Unpack and verify the contents of the container against the Packing Sheet. Retain the container and the packing material until the equipment has been checked mechanically and electronically, and performance verification tests have been performed.

#### 2.3 CLAIM FOR DAMAGE

If physical damage is evident or if the instrument does not meet specifications when received, notify the freight carrier and Hughes Aircraft Company, Microwave Products Division, to arrange for repair or replacement. Refer to Paragraphs 2.4, Packaging for Shipment, and 2.5, Communicating With The Factory.

#### 2.4 PACKAGING FOR SHIPMENT

**Disassembly of Equipment:** Make sure that the various components are disconnected from each other to avoid damage during packaging and shipment:

**Packaging of Equipment:** When using original packaging materials or other packing materials, make sure that all items are individually wrapped in protective wrapping before they are packed in the shipping carton.

- a. Enclose copy of Packing List, listing Model Number and Serial Number of each item being shipped. If an item does not have a model number (i.e., cable assembly), list item by description.
- b. To assist problem diagnosis and repair, enclose a brief description of problem or malfunction encountered.
- c. Enclose equipment Return-to address and Bill-to address.
- d. Reference original Purchase Order number for repair under warranty.
- e. Mark or label outside of shipping carton "FRAGILE".

**Original Packaging:** Cartons and packaging materials identical to that in which the instrument was originally shipped are available upon request.

**Other Packaging:** The following general instructions should be used for packing the instrument with commercial packaging materials:

- a. Use a double-wall carton made of at least 350-pound test material.
- b. Use enough shock absorbing packing materials on all sides to provide a firm cushion and to prevent the instrument from sliding. Protect control panel and exposed parts and connectors with cardboard.

## **2.5 COMMUNICATING WITH THE FACTORY**

Telephone numbers for Marketing and Engineering Inquiries:

Telephone: (213) 517-6400  
TWX: 910-321-3145  
FAX: (213) 517-7665

Shipping Hardware to Factory:

Hughes Aircraft Company  
Microwave Products Division  
3100 Fujita Street  
Torrance, California 90505

Mailing Address for Marketing and Engineering Inquiries:

Hughes Aircraft Company  
Microwave Products Division  
PO Box 2940  
Torrance, California 90509-2940

## **2.6 STORAGE AND SHIPPING ENVIRONMENT**

Keep Instrument as free from dampness as possible, both in storage and during shipment.

## SECTION 3

## OPERATING PROCEDURE

## 3.1 INTRODUCTION

This section provides information for using the Hughes 4577xH Thermistor Mount, including information on initial setup, maximum input, drift, zero-set, power measurement, mount calibration data and correction factor application.

## 3.2 INITIAL SETUP

Connect the Thermistor Mount to the cable furnished with the HP 432A Power Meter. Set the Power Meter calibration factor control at 100 percent and the resistance switch at 200 ohms. Operate the Power Meter as described in the Hewlett-Packard 432A Power Meter Manual.

## 3.3 MAXIMUM INPUT

The Model 4577xH Thermistor Mount and the HP 432A Power Meter combination responds to the average RF power applied. The maximum signal applied to the Thermistor Mount should not exceed the limitations of average power or peak pulse power listed in Table 1-2. Excessive input can cause permanent damage to the Model 4577xH by altering the match between the RF and compensation thermistors, resulting in drift or error in indicated power.

The Thermistor/Power Meter combination can measure average power up to 10 mW. To measure power in excess of 10 mW, a directional coupler or calibrated attenuator can be inserted between the power source and the thermistor mount.

**WARNING**

**Application of more than 15 mW average power to the mount may result in permanent damage to the RF thermistor.**

## 3.4 DRIFT

Thermistors are inherently temperature sensitive devices. A cold Thermistor Mount connected to a warm piece of equipment or vice versa will produce rapid drift. For minimum drift on sensitive ranges, make sure that the mount and the equipment connected to it are at nearly the same temperature before making a measurement.

## 3.5 ZERO-SET

It is necessary to electrically zero the power meter before making a power measurement. To preserve the same zero reference throughout a series of measurements, especially when

operating on the more sensitive ranges, periodically reset zero. Three recommended setups for zero-set are presented in the paragraphs below.

### **3.5.1 RF Power Turned Off**

There is minimum zero drift when zero is set with the RF system connected to the Thermistor Mount and RF power turned off at the generator or turned off by a waveguide switch. After allowing time for the mount to stabilize thermally, follow the steps for zero-set described in the Power Meter manual, using COARSE and FINE ZERO, and then turn on the RF power for measurement.

### **3.5.2 Use of High Attenuation with RF Source On**

When it is inconvenient to turn off the RF source for zero-set, connect a variable attenuator between the RF system and the Thermistor Mount. Attenuate the RF power at least 30 dB for zero-set, and reduce attenuation to zero during the measurement.

### **3.5.3 Disconnecting the Mount**

When it is inconvenient to turn off or attenuate RF power, simply remove the mount from the source and zero the power meter.

## **3.6 POWER MEASUREMENT**

The Thermistor Mount has a long thermal time constant, which causes it to respond to average microwave power, whether CW or modulated (pulse, sine wave or square wave).

In pulse modulation, response is proportional to the amplitude and the duty cycle of the pulse. The power level of an individual pulse can be determined by dividing the average power reading by the duty cycle of the pulse. Accurate measurements can be made with pulse repetition rates as low as 50 Hz.

To measure millimeter-wave power in excess of 10 mW, use a calibrated attenuator such as the Hughes 4574xH series of fixed attenuators or the 4572xH series of precision variable attenuators between the source and the thermistor. A broadband directional coupler from the Hughes 4532xH series may also be used.

## **3.7 MOUNT CALIBRATION DATA**

The calibration points imprinted on the label of each Thermistor Mount allow power measurements to be made with increased accuracy. Values of Correction Factor are given at specific frequencies. Correction Factor values are traceable to the National Bureau of Standards to the extent indicated in Table 1-2.

Correction Factor is the ratio of power indicated on the Power Meter to actual power incident on the Thermistor Mount waveguide flange. It accounts for reflection loss at the RF input, waveguide and mount losses, and dc-to-microwave substitution errors.

### 3.8 CORRECTION FACTOR APPLICATION

The Correction Factor is added to the Power Meter reading to yield the value of true power. This is illustrated in the example below. The example supposes that a 1 mW (0 dBm) deflection is indicated on the Power Meter. The true power, based on the correction factor, would be the figures shown. The HP 432A Power Meter's calibration factor control should be set at 100 percent and mount resistance switch set at 200 ohms.

#### Correction Factor Example

	Frequency (GHz)					
	50	55	60	66	70	75
Correction Factor (+ dB)	0.65	1.15	0.70	0.80	1.25	1.00
Meter Reading (dBm/mW)	0/1	0/1	0/1	0/1	0/1	0/1
True Power (dBm/mW)	0.65/ 1.16	1.15/ 1.30	0.70/ 1.175	0.80/ 1.202	1.25/ 1.333	1.0/ 1.259

SECTION 4

THEORY OF OPERATION

4.1 INTRODUCTION

This section describes the principles of operation for the Hughes 4577xH Thermistor Mount. Figure 4-1 shows a schematic of the thermistor mount. Figures 4-2 and 4-3 shows its front and rear views.

4.2 THE THERMISTORS

Thermistors have a negative temperature coefficient; that is, when a thermistor's temperature increases, its resistance decreases. The 4577xH Thermistor Mount uses two thermistors: A detection thermistor that samples RF power and a compensation thermistor that compensates for ambient temperature changes. When the Thermistor Mount is attached to a 432 Power Meter, the RF thermistor shown in Figure 4-1 is part of the RF bridge in the Power Meter; the compensation thermistor is part of the compensation bridge, and the bridges supply sufficient dc bias to drive the thermistors to their operating resistances (200 ohms).

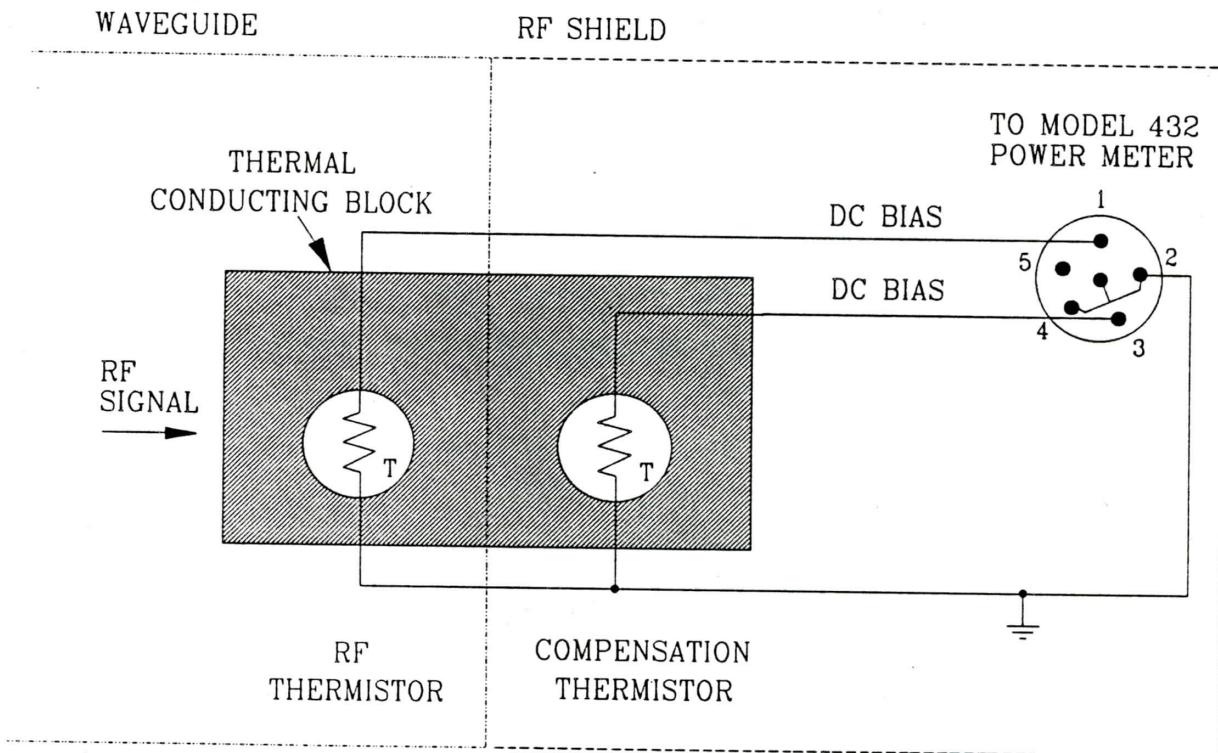


Figure 4-1. THERMISTOR MOUNT SCHEMATIC DIAGRAM.

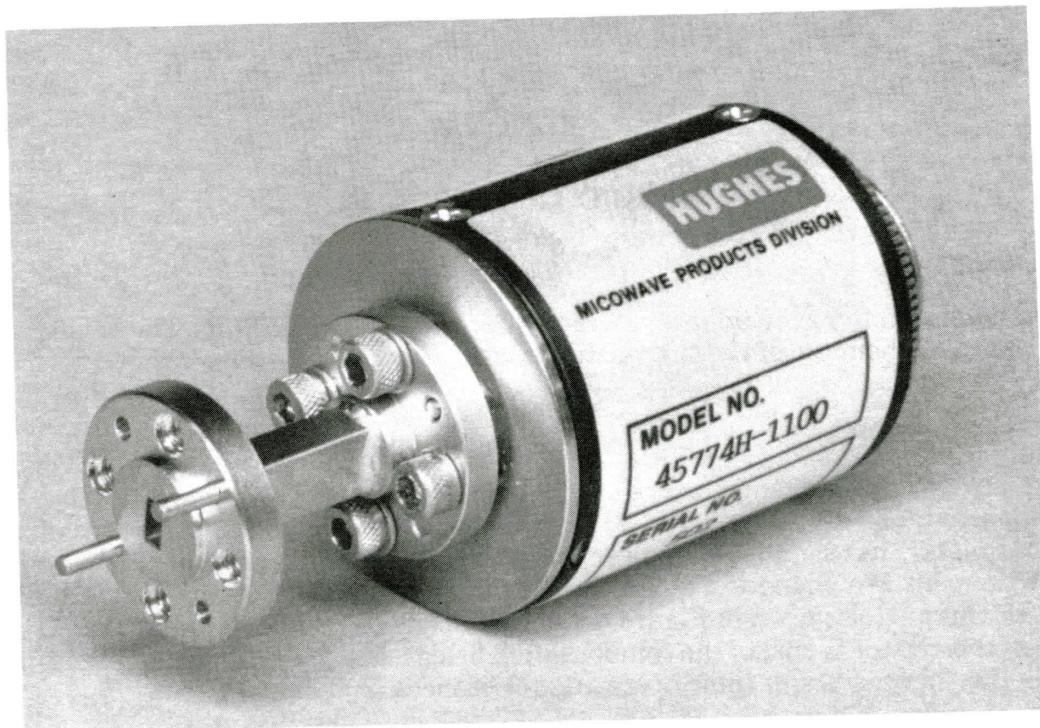


Figure 4-2. THERMISTOR MOUNT, FRONT VIEW

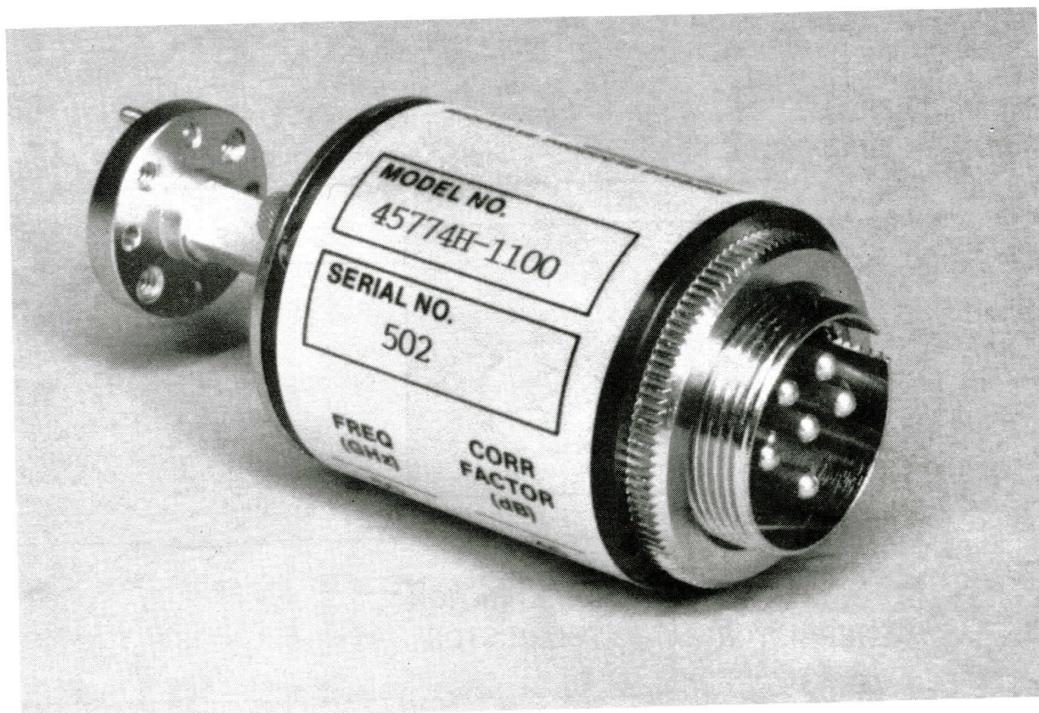


Figure 4-3. THERMISTOR MOUNT, REAR VIEW

#### 4.2.1 RF Thermistor

The RF thermistor is mounted within the mount's shorted waveguide section and is located so that it samples the E-field and provides an optimum match across the band. As it absorbs RF power, its temperature (and therefore its resistance) attempts to change. However, the RF bridge circuit is self-balancing and reduces thermistor bias current to maintain the thermistor's proper operating resistance. Since the amount of bias change is proportional to incoming RF power, it is measured and used to indicate the RF power absorbed by the mount.

#### 4.2.2 Compensation Thermistor

To prevent ambient temperature changes from affecting power readings, a compensation thermistor is mounted so that it shares the detection thermistor's thermal environment. Any change in ambient temperature causes a bias change in both thermistor bridges. This means that the total bias change in the detection thermistor is caused by incoming RF power plus ambient temperature. But the bias change in the compensation thermistor is caused only by ambient temperature. The power meter subtracts compensation bias from detection bias to get stable, error-free power readings.

**SECTION 5****REPAIR AND MAINTENANCE****5.1 INTRODUCTION**

This section of the manual contains information to repair and troubleshoot the Hughes 4577xH Thermistor Mount.

**5.2 MAINTENANCE**

The RF thermistor in the Ka-, Q-, and U-Band mounts is protected against air currents and debris by dielectric foam plug inserted in the input waveguide. Keep the plastic cap on the waveguide flange when the mount is not in use, especially with the V- through W-Band mounts which do not have this foam plug.

**5.3 REPAIR**

The 4577xH Thermistor Mount contains no field replaceable parts.

In the event that the Power Meter will no longer zero with the Thermistor Mount connected, determine whether the problem is located in the Thermistor Mount or in the Power Meter.

The simplest method of locating the problem is to substitute another Power Meter which is known to be operable along with its cable. If the substitute meter cannot be zeroed, then the mount should be returned to the factory for repair.



MICROWAVE PRODUCTS DIVISION  
Industrial Electronics Group

# Certificate of Calibration

Customer: TRW Electronic Products, Inc.  
Customer PO No: 9100539 Hughes SO No: W-53008  
Hughes Model: 45776H-1100 Serial No: 507 508 + 509

*This certifies that the above item has been calibrated in accordance with applicable Hughes procedures on the indicated date. At the time of calibration the item met its published operating specifications. Hughes calibration measurements are traceable to NIST calibration facilities.*

M. Mc Kennis 5-9-91  
Hughes - Microwave Products Date

P.O. Box 2940, Torrance, CA 90509-2940  
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