

# Keysight 8478B Thermistor Mount

Operating and  
Service Manual

# Notices

© Keysight Technologies  
1981–2018

No part of this manual may be reproduced in any form or by any means (including electronic storage and retrieval or translation into a foreign language) without prior agreement and written consent from Keysight Technologies, Inc. as governed by United States and international copyright laws.

## Manual Part Number

08478-90015

## Edition

Edition 3, March 2018

## Printed in:

Printed in Malaysia

## Published by:

Keysight Technologies  
Bayan Lepas Free Industrial Zone,  
11900 Penang, Malaysia.

## Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

## Declaration of Conformity

Declarations of Conformity for this product and for other Keysight products may be downloaded from the Web. Go to <http://www.keysight.com/go/conformity>. You can then search by product number to find the latest Declaration of Conformity.

## U.S. Government Rights

The Software is “commercial computer software,” as defined by Federal Acquisition Regulation (“FAR”) 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement (“DFARS”) 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to

the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at

<http://www.keysight.com/find/sweul>

a The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA.

Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFARS 227.7103-5 (c), as applicable in any technical data.

## Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED “AS IS,” AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED

HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

## Safety Notices

### CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

### WARNING

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

# Keysight 8478B Thermistor Mount

## Operating and Service Manual

### Certification

Keysight Technologies certifies that this product met its published specifications at the time of shipment. Keysight further certifies that its calibration measurements are traceable to the United States National Institute of Standard and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

### General Warranty

The material contained in this document is provided “as is,” and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, Keysight disclaims all warranties, either express or implied with regard to this manual and any information contained herein, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Keysight shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or any information contained herein. Should Keysight and the user have a separate written agreement with warranty terms covering the material in this document that conflict with these terms, the warranty terms in the separate agreement shall control. Duration and conditions of warranty for this product may be superseded when the product is integrated into (becomes a part of) other Keysight products. During the warranty period, Keysight will, at its option, either repair or replace products which prove to be defective. The warranty period begins on the date of delivery or on the date of installation if installed by Keysight.

### Warranty Service

For warranty service or repair, this product must be returned to a service facility designated by Keysight. For products returned to Keysight for warranty service, the Buyer shall prepay shipping charges to Keysight and Keysight shall pay shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Keysight from another country.

## Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer-supplied products or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

The design and implementation of any circuit on this product is the sole responsibility of the Buyer. Keysight does not warrant the Buyer's circuitry or malfunctions of Keysight products that result from the Buyer's circuitry. In addition, Keysight does not warrant any damage that occurs as a result of the Buyer's circuit or any defects that result from Buyer-supplied products.

To the extent allowed by local law, Keysight makes no other warranty, expressed or implied, whether written or oral with respect to this product and specifically disclaims any implied warranty or condition of merchantability, fitness for a particular purpose, or satisfactory quality.

## Exclusive Remedies

To the extent allowed by local law, the remedies provided herein are the Buyer's sole and exclusive remedies. Keysight shall not be liable for any direct, indirect, special, incidental, or consequential damages (including lost profit or data), whether based on warranty, contract, tort, or any other legal theory.

## Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

### Product category

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a “Monitoring and Control Instrument” product.

The affixed product label is as shown below.



Do not dispose in domestic household waste.

## Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

- [www.keysight.com/find/powersensors](http://www.keysight.com/find/powersensors)  
(product-specific information and support, software and documentation updates)
- [www.keysight.com/find/assist](http://www.keysight.com/find/assist)  
(worldwide contact information for repair and service)

Certification  
Sales and Technical Support

## Table of Contents

Certification .....	3
General Warranty .....	3
Warranty Service .....	3
Limitation of Warranty .....	4
Exclusive Remedies .....	4
Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC .....	5
Product category .....	5
Sales and Technical Support .....	5
<b>1. General Information</b>	
Introduction .....	10
Specifications .....	10
Instruments Covered By Manual .....	10
Incoming Inspection .....	11
<b>2. Operation</b>	
Precautions .....	14
Mechanical Shock .....	14
Biasing Thermistors .....	14
Specifications .....	15
Maximum Input .....	17
Average Power .....	17
Pulse Energy and Peak Power for 8478B/432 Combination .....	17
Pulse Energy and Peak Power for 8478B/431 Combination .....	17
Drift Precaution .....	19
Operation with 431A/B/C or 430 Power Meters .....	19
Zero Set .....	20
RF Power Turned Off for Zero-Set .....	20
Unbalanced Operation with Model 431A/B/C and 430 Power Meters .....	20
Balanced Operation with Model 431C Power Meter .....	20
8478B/432 .....	20
Mount Calibration .....	21
Calibration Factor .....	21
Effective Efficiency .....	21
Calibration Data Application .....	22
Thermoelectric Effect .....	23
Thermoelectric Effect Error Correction for 8478B/431 Combination .....	23
Thermoelectric Error for 8478B/432 Combination .....	24

## Contents

### 3. Operating Principles

General Operation .....	26
Operation with 432 Power Meter .....	26
Operation with 431 Power Meter .....	26
432 Power Detection .....	27
431 Power Meter Detector .....	28

### 4. Maintenance

Mechanical Shock .....	30
Performance Tests .....	32
SWR Measurement, 8GHz .....	32
SWR Measurement, 15 and 18GHz .....	34
Thermistor Resistive Match Test .....	35
Troubleshooting .....	37
Thermistor Compensation .....	38
Repair and Recalibration .....	42

### A. Manual Changes

CHANGE A .....	43
CHANGE B .....	46
CHANGE C .....	47



# 1 General Information

Introduction	10
Specifications	10
Instruments Covered By Manual	10
Incoming Inspection	11

This chapter contains information about initial inspection and overview of the Keysight 8478B Thermistor Mount.

## Introduction

The Keysight Model 8478B Coaxial Thermistor Mount is designed for use with Keysight Model 431 and 432 Power Meters to measure microwave power from 1 $\mu$ W to 10mW. Design of the mount minimizes adverse effects from environmental temperature changes during measurement. For increased measurement accuracy, Effective Efficiency and Calibration Factor are measured for each mount at selected frequencies across the operating range; the results are marked on the label of the instrument (see **“Mount Calibration” on page 21**). The Model 8478B can be used over the 10MHz to 18GHz frequency range. Throughout the range, the mount terminates the coaxial input in a 50-ohm impedance, and has a SWR of not more than 1.75 without external tuning.

Each mount contains two series pairs of thermistors, which are matched to cancel the effects of drift with ambient temperature change. Thermal stability is accomplished by mounting the leads of all four thermistors on a common thermal conductor to ensure a common thermal environment. This conductor is thermally insulated from the main body of the mount so the thermal noise or shocks applied externally to the mount, such as those from handling the mount manually, cannot significantly penetrate to disturb the thermistor. This thermal immunity enables the thermistors to be used in the measurement of microwave power down to the microwatt region.

The 8478B operates directly with 431C and 432 Power Meters. Model 11527A adapter is used for operation with 431A/B Power Meters. Model 11528A is used for operation with 430 Power Meters.

## Specifications

The specifications are listed in **“Specifications” on page 15**. These specifications are the performance standards against which the Thermistor Mount/Power Meter operation is compared.

For operation with the 431 Power Meter, add the following uncertainties to those indicated in **Table 2-1**: for 0.3mW range,  $\pm 0.3\%$ ; for 0.1mW range,  $\pm 0.7\%$ ; for 0.03mW range,  $\pm 1.5\%$ ; for 0.01mW range,  $\pm 2.8\%$ . The power range in which the 431/8478B operates is 1 $\mu$ W to 10mW.

## Instruments Covered By Manual

This manual applies directly to instruments with serial numbers prefixed 2106A. With the backdating found in **Appendix A**, the manual also applies to instruments with serial number prefixed 2030A and below.

## Incoming Inspection

Inspect the Model 8478B upon receipt for mechanical damage. Also check it electrically; if the mount was subjected to severe mechanical shock during shipment, the match between the thermistors may be affected. To check thermistor match, proceed as described in **“Performance Tests” on page 32.**

If any damage is found, inform the carrier and your nearest Keysight sales and Service office immediately.

General Information  
Incoming Inspection

## 2 Operation

Precautions	14
Specifications	15
Drift Precaution	19
Zero Set	20
Mount Calibration	21
Calibration Data Application	22
Thermoelectric Effect	23

This chapter contains information about specifications and operation of the Keysight 8478B Thermistor Mount.

## Precautions

### Mechanical Shock

**CAUTION**

**DO NOT SUBJECT THE MOUNT TO MECHANICAL SHOCK.** Shock may destroy the match between thermistors and increase susceptibility to drift.

---

### Biasing Thermistors

**CAUTION**

Before connecting the 8478B to a 431C or 432-series Power Meter, set the MOUNT RES switch to the 200 $\Omega$  position. For Mounts with serial numbers prefixed below 1833A, set the MOUNT RES switch to 200 $\Omega$  BAL (431) or 200 $\Omega$  (432).

When using the 8478B with 431A/B or 430 Power Meter, use Model 11527A or 11528A Adapter respectively and set MOUNT RES switch to 200 $\Omega$  position. Connecting a 200-ohm mount to a power meter set for a 100-ohm mount can result in thermistor damage.

---

## Specifications

**Frequency Range:** 10MHz to 18GHz

Table 2-1

Uncertainty of Calibration Factor Data

Frequency (GHz)	Sum of Uncertainty <sup>1</sup>	Probable Uncertainty <sup>2</sup>
2.0	±2.60%	±1.60%
3.0	±2.60%	±1.60%
4.0	±2.70%	±1.60%
5.0	±2.70%	±1.60%
6.0	±2.70%	±1.60%
7.0	±2.70%	±1.60%
8.0	±3.10%	±1.80%
9.0	±3.30%	±1.80%
10.0	±3.40%	±2.00%
11.0	±3.60%	±2.00%
12.4	±3.70%	±2.20%
13.0	±3.70%	±2.20%
14.0	±4.00%	±2.20%
15.0	±4.00%	±2.50%
16.0	±4.40%	±2.50%
17.0	±5.20%	±3.20%
18.0	±5.10%	±3.20%

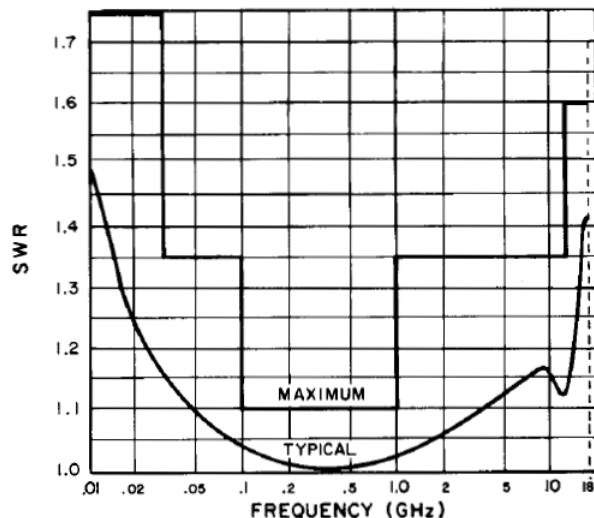
1. Includes uncertainty of reference standard and transfer uncertainties. Directly traceable to NBS.

2. Square root of the sum of the squares of the individual uncertainties (RSS).

<b>Input Impedance:</b>	50 ohms
<b>Operating Resistance:</b>	200 ohms, unbalanced
<b>Power Range with Model 432:</b>	1μW to 10mW
<b>Maximum Peak Power:</b>	200W
<b>Maximum Average Power:</b>	30mW
<b>Maximum Energy per Pulse:</b>	10W-μs for a PRF ≥1kHz; 5W-μs for a PRF <1kHz

Figure 2-1

SWR Limits



**Maximum Reflection Coefficient:**

10 to 30MHz: 0.273(1.75SWR, 11.3 dB return loss)  
 30MHz to 100MHz: 0.15 (1.35 SWR, 16.5 dB return loss)  
 100MHz to 1GHz: 0.048 (1.1 SWR, 26.4 dB return loss)  
 1 to 12.4GHz: 0.15 (1.35 SWR, 16.5 dB return loss)  
 12.4 to 18GHz: 0.230 (1.6 SWR, 12.8 dB return loss)

**Elements:**

Thermally balanced thermistor assembly. Thermistor assembly is field adjustable so that full zero-set capability can be restored in the event of inadvertent overload.

**RF Connector:**

Stainless steel type N male (APC-7 also available- see Option 11 below).

**Output Connector:**

Mates with power meter cable (operates directly with 432).

**Weight:**

Net 140g (5 oz).

**Option 11:**

8478B Thermistor Mount supplied with APC-7 RF connector.



## Maximum Input

### CAUTION

The Model 8478B/431 and 8478B/432 combinations respond to the average RF power applied. The maximum signal applied to the thermistor mount should not exceed the limitations for 1) average power, 2) pulse energy, and 3) peak pulse power. Excessive input can permanently damage the Model 8478B by altering the match between the RF and compensation thermistors (resulting in excessive drift or zero shift) or cause error in indicated power.

---

## Average Power

### CAUTION

**UNDER NO CIRCUMSTANCES APPLY MORE THAN 30mW AVERAGE POWER TO THE MOUNT.** The 8478B/431 and 8478B/432 combinations can measure average power up to 10mW (ranges 1 $\mu$  W to 10mW). To measure power in excess of 10mW, insert a calibrated directional coupler such as one of the Model 790 series or one of the 8491 series coaxial attenuators between the mount and the source.

---

## Pulse Energy and Peak Power for 8478B/432 Combination

### CAUTION

For pulses shorter than 250 $\mu$ s, energy per pulse must not exceed 10 W- $\mu$ s and peak power should never exceed 200 watts. (For example, a 40mW, 250 $\mu$ s pulse contains 10 W- $\mu$ s of energy.) Pulses longer than 250 $\mu$ s are allowed to contain more energy but peak power must not exceed 200 watts. [Figure 2-2](#) and [Figure 2-3](#) interpret these limits in graphical form. (For lack of space, the mount nameplate lists only a 5 W- $\mu$ s limit, a rating which applies to the 8478B/432A combination.)

---

## Pulse Energy and Peak Power for 8478B/431 Combination

The limitations of this combination are basically the same as the 8478B/432 with the exception that at pulse repetition rates less than 1kHz, energy per pulse must not exceed 5 W- $\mu$  and peak power must not exceed 10mW. These limits are also interpreted in [Figure 2-2](#) and [Figure 2-3](#).

Figure 2-2 Maximum Power Meter Reading vs PRF for Pulses Shorter than 250 $\mu$ s

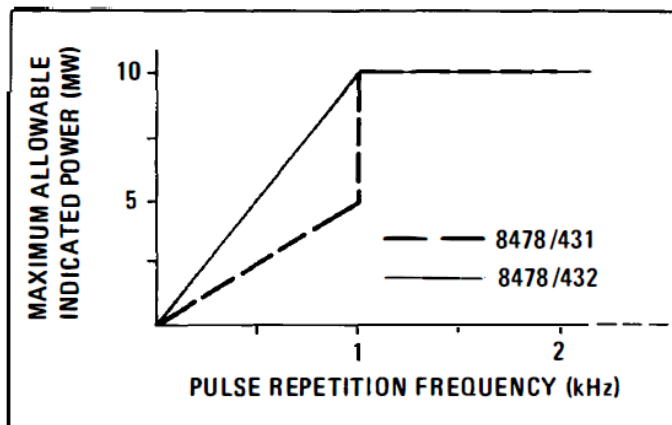
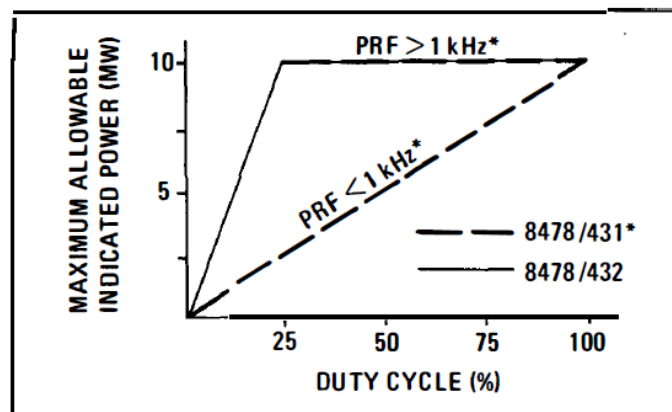
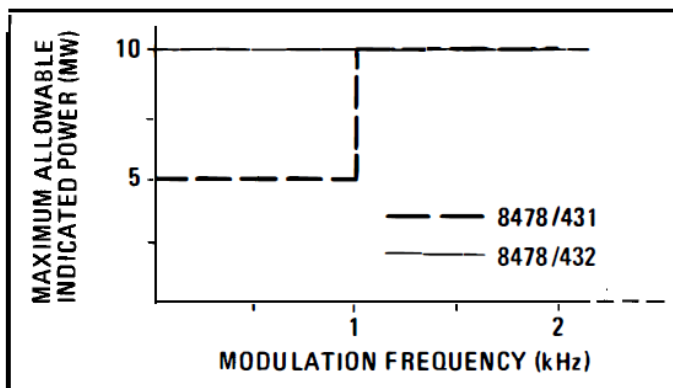


Figure 2-3 Maximum Power Meter Reading vs Duty Cycle for Pulses Longer than 250 $\mu$ s



Square-wave modulation is a special case of pulse modulation, and maximum power meter reading versus square-wave frequency is illustrated in [Figure 2-4](#). This figure also holds for sinewave modulation.

Figure 2-4 Maximum Power Meter Reading vs Square and Sine-Wave Frequency



## Operation Drift Precaution

In the discussions above, the primary consideration is maximum power or energy. However; for modulation frequencies less than 100 Hz, the low repetition frequency itself causes errors in indicated power. These errors may be as large as two percent regardless of range or reading.

When RF is switched by pulse-gating (coaxial solid state switches), consideration must be given to the RF energy contained in the switching pulse itself. This energy must be added to actual RF pulse power when estimating the RF power dissipated in the thermistor mount. PIN diode modulators of Model 8741A/8716A Modulators and 8614A/8616A Signal Generators, however, are not subject to this consideration because output filtering prevents transmission of modulating signals.

## Drift Precaution

Thermistors are inherently temperature sensitive devices. A cold thermistor mount connected to a warm piece of equipment, or vice versa, produces 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.

Let the power sensor warm up at least 30 min before perform COARSE and FINE ZERO.

## Operation with 431A/B/C or 430 Power Meters

If the 8478B is used with a 430 Power Meter, a Model 11528A Adapter is required.

Because the mount is unbalanced, a large amount of 10kHz audio bias signal may be coupled from the power meter to the RF source output. The RF source 10kHz output impedance forms a parallel circuit shunt across one of the detection thermistor elements. If the RF source presents a 10kHz impedance of 15k ohms or greater, the audio bias voltage appearing at the RF input connection is typically 1.3 Vrms. For an RF source 10kHz impedance of 50 ohms, the audio bias voltage is greatly reduced to typically 5 mVrms: The presence of a large 10 kHz audio bias voltage at the RF source output may affect solid state RF sources and RF voltmeter measurements. To minimize or eliminate these effects, use a high-pass filter at the RF source output.

A variation in 10kHz impedance at the RF input connection affects the power meter RF detection bridge circuit. This causes a shift in the power meter zero setting. Refer to the following section for the proper power meter zero procedure.

## Zero Set

It is necessary to electrically zero-set the Power Meter before making a power measurement. To preserve the same zero reference through the measurement, maintain the same thermal environment when RF power is applied. Recommended setups for 430 and 431 zero-settings are presented in **“Unbalanced Operation with Model 431A/B/C and 430 Power Meters”** and **“Balanced Operation with Model 431C Power Meter”**. The recommended setup for zero-set in the 432 is shown in **“8478B/432”**.

### RF Power Turned Off for Zero-Set

There is minimum zero drift when the zero is set with the RF system connected to the thermistor mount and the RF power switch off or greatly attenuated by the generator attenuator. After allowing time for the mount to stabilize thoroughly, follow zero-set procedures in the Power Meter manual.

### Unbalanced Operation with Model 431A/B/C and 430 Power Meters

When the RF source presents a high 10kHz output impedance of 100k ohms or greater, the power meter may be zeroed with the 8478B disconnected from the RF source and unterminated as explained in the previous section. If the RF source presents a low 10kHz impedance of 1k ohm or less, a zero setting made with the 8478B disconnected from the RF source and unterminated will not be the proper zero setting for power measurement. This error can be eliminated by terminating the 8478B in an impedance that approximates the RF source impedance at 10kHz while zeroing the power meter. For example, if the RF source 10kHz impedance is 50 ohms, terminate the RF input connection to the 8478B with a 50 ohm resistor.

### Balanced Operation with Model 431C Power Meter

When using a balanced mount, if it is inconvenient to turn off RF power in the RF source, connect the 8478B to the RF source and set 431C Power Meter RANGE switch to obtain an approximate midscale reading. When the reading does not drift, disconnect the 8478B from the source, zero the power meter, and immediately reconnect the mount to the RF source for the power measurement.

### 8478B/432

When it is inconvenient to turn the RF power off while using the 8478B/ 432 combination simply remove the mount from the source, and using the COARSE and FINE ZERO, zero the 432.

## Mount Calibration

The calibration points imprinted on the label of each 8478B allow power measurements to be made with increased accuracy. Values of Calibration Factor and Effective Efficiency are given at seven frequencies between 10MHz and 18GHz. The mounts are tested on a swept-frequency basis to assure accurate interpolation between calibration points. Calibration Factor and Effective Efficiency values are traceable to the National Bureau of Standards to the extent allowed by the Bureau's calibration facilities.

### Calibration Factor

Calibration Factor is the ratio of substituted audio or dc power in a thermistor mount to the microwave RF power incident upon the mount.

$$\text{Calibration Factor} = \frac{P_{\text{dc}} \text{Substituted}}{P_{\mu\text{wave}} \text{Incident}}$$

Calibration Factor is a figure of merit assigned to a thermistor mount to correct for the following sources of error:

1. RF reflected by the mount due to mismatch.
2. RF loss caused by absorption within the mount but not in the detection thermistor elements.
3. dc-to-microwave power substitution error.

Calibration Factor is applied as a correction factor to all measurements made without a tuner. When these factors and thermoelectric effect (refer to **“Thermoelectric Effect Error Correction for 8478B/431 Combination” on page 23**) are taken into consideration, the power indicated is the power that would be delivered by the RF source to the characteristic impedance of the transmission line. The total SWR in the transmission line determines a region of uncertainty about the measured power. This subject is discussed in Application Note 64-1, available from any Keysight Sales and Service office.

### Effective Efficiency

Effective Efficiency is the ratio of substituted audio or dc power in a thermistor mount to the microwave RF power dissipated within the mount.

$$\text{Effective Efficiency} = \frac{P_{\text{dc}} \text{Substituted}}{P_{\mu\text{wave}} \text{Dissipated}}$$

Effective Efficiency corrects for power absorbed in parts of the mount other than the detection thermistor elements and dc-to-microwave power substitution error in the thermistor mount. Effective Efficiency is applied as a

## Operation Calibration Data Application

correction factor when a tuner is used to match the thermistor mount to the transmission line or RF source. In this case, all of the RF power incident upon the mount is absorbed in the mount. Since all power is absorbed in the mount, measurement uncertainty due to mount SWR is eliminated; however, losses in the tuner must be considered.

## Calibration Data Application

When the 8478B is used with the Model 431 or 432 Power Meters, Calibration Factor or Effective Efficiency corrections can be made by setting a front panel switch. With the proper setting, the 431 or 432 compensates for the Calibration Factor or Effective Efficiency in the 8478B. If the 8478B is used with a power meter other than the 431 or 432, Calibration Factor or Effective Efficiency corrections can be made by dividing the measured power by the Calibration Factor or Effective Efficiency value respectively.

## Thermoelectric Effect

When using 431 Power Meters, thermoelectric errors must be taken into consideration. Mount calibration uncertainties given in [Table 2-1 on page 15](#) include inaccuracies caused by thermoelectric effect error. Calibration Factor uncertainty of  $\pm 1.5\%$  and Effective Efficiency uncertainty of  $\pm 2.5\%$  can be maintained on the three lowest power ranges of the Model 431 series Power Meters by correcting for the measurement error introduced by thermoelectric effect. An error correction procedure is given in [“Thermoelectric Effect Error Correction for 8478B/431 Combination”](#).

A mild thermocouple exists at each point of contact where the connecting wires join to the thermistor elements. Each thermocouple creates a dc voltage. Thus, two thermocouple voltages of opposite relative polarity are formed, one at each junction to each thermistor element.

Ideally, each thermocouple voltage would be equal in magnitude so that they cancel with no resultant effect on the accuracy of power measurement. In practice, however, each point of contact does not have identical thermocouple characteristics, and in addition, the temperatures at each junction may not be the same. These differences cause an incomplete cancellation of the thermoelectric voltages, resulting in a voltage that causes a thermoelectric effect error. The magnitude of the error is important when making dc substitution measurements on the 0.1mW, 0.03mW, and 0.01mW ranges with one of the Model 431 series Power Meters. On other ranges, the effect is negligible. Maximum error introduced by thermoelectric effect is about  $0.3\mu\text{W}$  and is typically  $0.1\mu\text{W}$  on the 0.01mW range. Refer to [“Specifications” on page 15](#).

### Thermoelectric Effect Error Correction for 8478B/431 Combination

Use the following technique to correct for thermoelectric effect error.

1. Measure power.
2. Connect a HP Model 8402B Power Meter Calibrator to the power meter DC CALIBRATION AND SUBSTITUTION connector.
3. Zero and null power meter.
4. By dc substitution (refer to procedure in 431 Manual), duplicate power measurement made in step 1. Calculate and record substituted power as  $P_1$ .
5. Reverse connection polarity between the calibrator and power meter.
6. Re-zero and re-null power meter, if necessary.
7. By dc substitution, duplicate lower measurement made in step 1. Calculate and record substituted power as  $P_2$ .

Operation  
Thermoelectric Effect

8. Calculate arithmetic mean of the two substitution powers  $P_1$  and  $P_2$ . This mean power includes a correction for thermoelectric effect error.

$$\text{Power} = \frac{P_1 + P_2}{2}$$

Thermoelectric Error for 8478B/432 Combination

The thermoelectric errors present in the 431 are minimized in the 432 since the thermoelectric voltage is negligible compared with the dc voltage used to bias the thermistor bridges.



# 3 Operating Principles

General Operation **26**

This chapter contains information about operating principles and general operation of the Keysight 8478B Thermistor Mount.

## General Operation

Two matched pairs of thermistor elements are used in the 84 78B. Each pair is connected in series and the two pairs are mounted in a common thermal conducting block. The thermistor pairs are used in the bridges of the power meter. One pair, the detection thermistors, is used as an arm of the RF detection bridge. The other pair, the compensation thermistors, is used as an arm of the compensation and metering bridge.

### Operation with 432 Power Meter

With the 8478B attached to the 432 Power Meter the detection thermistors are part of the RF bridge and the compensation thermistors are part of the compensation bridge. Since the two pairs of thermistors show the same thermal environment, any change in temperature which affects the RF bridge simultaneously affects the metering bridge; this allows the power meter circuit to compensate for changes in temperature and thus minimize drift.

During operation sufficient amounts of dc current are supplied from 432 Power Meter to heat the thermistors until their resistances are reduced to approximately 2000 per series pair. Capacitor C1 is practically a short to RF. This causes “D” to appear series connected to the dc bridge, parallel connected to RF. In this manner, “D” appears to the dc bridge in the 432 Power Meter as a 2000 resistance that terminates the coaxial cable into 50 $\Omega$ . Capacitor C1 blocks any dc and audio power that may be present in the incoming signal and passes only RF power.

### Operation with 431 Power Meter

The RF detection bridge balance is affected by RF power input to the 8478B, and the bridge is balanced by the application of 10kHz audio bias power. The compensation and metering bridge is indirectly, but equally affected, by the application of RF power. Deviation from a near-balance condition is caused by an equal change in the 10kHz audio bias power to the compensation thermistor pair, as initiated by the RF detection bridge. The compensation and metering bridge is returned to near-balance by the application of dc power.

During 8478B/431 operation, sufficient amounts of dc and 10kHz bias currents are supplied from the 431 Power Meter to heat the thermistors until their resistances are reduced to approximately 2000 per series pair. Capacitor C3 offers high impedance to 10kHz, but is practically a short to RF. This causes “D” to appear series connected to 10kHz, but parallel connected to RF. In this manner, “D” appears to the audio bridge of the 431 Power Meter as a 2000 resistance, but terminates the coaxial cable in 50 $\Omega$ . Capacitor C1 blocks any dc and audio power that may be present in the incoming signal, and passes only RF power.

### 432 Power Detection

Under normal operation, the total power applied to heat thermistor pair “D” (see **Figure 3-1**) consists of:

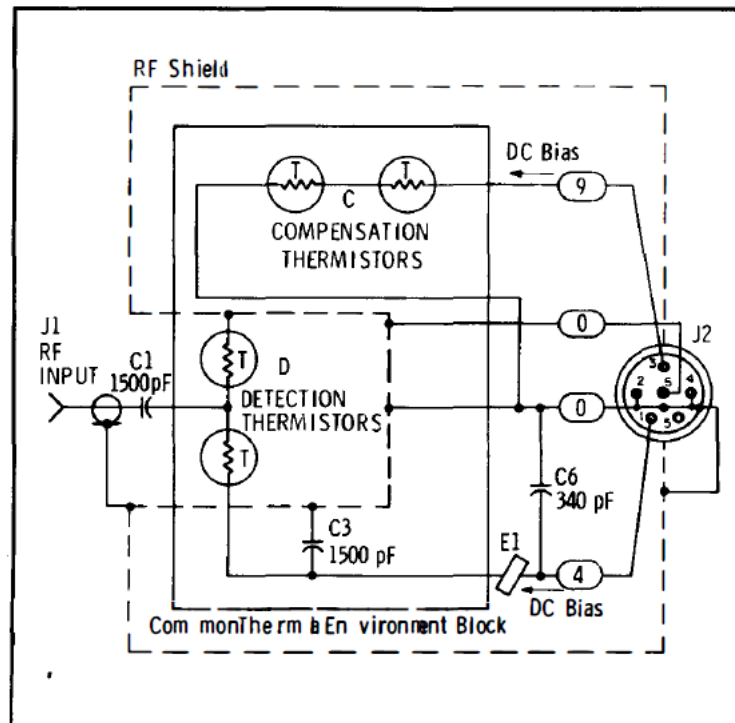
1. RF signal
2. heat from the environment
3. dc bias

The total power supplied to heat thermistor “C” consists of:

1. dc bias
2. heat from the same environment

As “D” and “C” are matched thermally, the total amounts of heat applied to reduce their series resistance equally must be equal.

Figure 3-1 8478B Connected to a 432A Power Meter



### 431 Power Meter Detector

Under normal operation, the total power supplied to heat thermistor pair “D” (see **Figure 3-2**) consists of:

1. RF signal
2. 10 kHz bias
3. heat from the environment

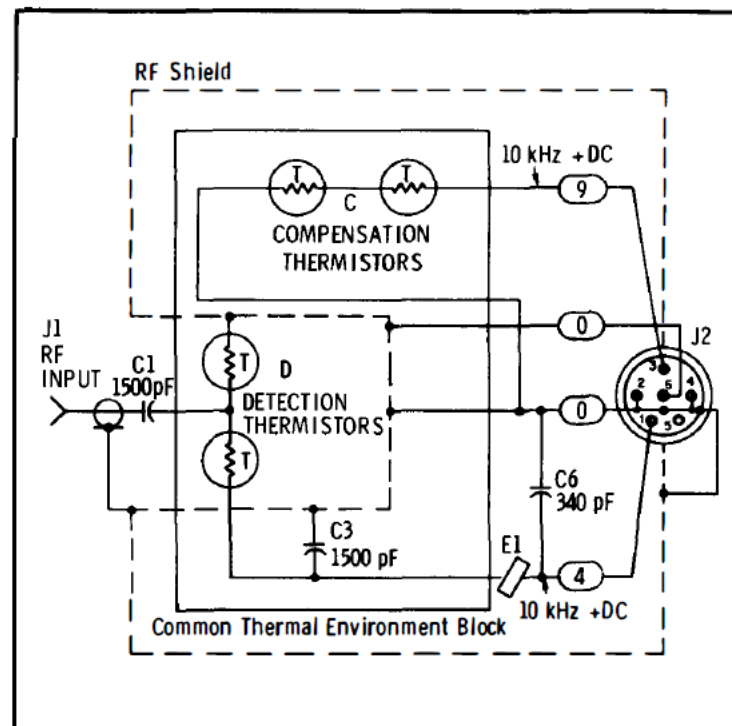
The total power supplied to heat thermistor pair “C” consists of:

1. dc bias
2. an equal amount of 10kHz bias
3. heat from the same environment

As “D” and “C” are matched thermally, the total amounts of heat applied to reduce their series resistance equally must be equal.

Figure 3-2

8478B Connected to a 431C Power Meter



## 4 Maintenance

Mechanical Shock	30
Performance Tests	32
Troubleshooting	37
Thermistor Compensation	38
Repair and Recalibration	42

This chapter contains information about maintenance and troubleshooting of the Keysight 8478B Thermistor Mount.

## Mechanical Shock

The Model 8478B is a precision instrument. A void dropping or other mechanical shocks. Such shocks destroy the resistive match between thermistor elements, or otherwise degrade performance.

Test equipment and accessories required to perform maintenance are listed in **Table 4-1**. Equipment other than recommended models can be used provided the critical specifications are satisfied.

### NOTE

The following procedures apply to the 8478B/ 432 combination. The same procedures can be used for the 431 except that the COARSE ZERO and FINE ZERO controls are replaced by the ZERO/VERNIER control.

Table 4-1

Recommended Test Equipment

Instrument Type	Critical Specifications	Recommended HP Model
Sweep Oscillator	Accuracy: $\pm 1\%$ full scale for all RF Units Leveling Capabilities Frequency Range: 8GHz to 18GHz	8690A, 8694A, 8695A
SWR Meter	Sensitivity: $0.15\mu\text{V}$ for full scale deflection Accuracy: $\pm 0.05$ dB/10 dB step Range: 70 dB in 10 dB steps	415E
Directional Detector	Frequency Range: 8.0 to 12.4GHz Maximum SWR: 1.25:1	789C
Directional Coupler	Frequency Range: 12.4 to 18GHz 10 dB Coupler SWR: $< 1.05:1$	P752C
Carriage	Accepts HP 816A Slotted Line	809C
Slotted Line	Frequency Range: 8 to 18GHz Impedance: 50 ohms $\pm 0.2$ ohms SWR: $< 1.06:1$ , 8 to 18GHz	816A
Probe	Frequency Range: 8 to 18GHz	447B
Passband Filter	Passband Frequency: 12.4 to 18GHz	P362A
Crystal Detector	Frequency Range: 12.4 to 18GHz	P424A

Table 4-1

Recommended Test Equipment

Instrument Type	Critical Specifications	Recommended HP Model
Waveguide to Coax Adapter	Frequency Range: 12.4 to 18GHz Connector - Type N	P281B
Power Meter	Power Range: 10mW Accuracy: $\pm 1\%$ of full scale	432A
Digital Voltmeter	Input Impedance: 10 Megohm Resolution: 4 significant digits Accuracy: $\pm 0.05\%$	3466A
Power Supply	Output Voltage: 29 Vdc	6217A
Cables	1.Coax-Type N connectors 2. BNC-BNC - male connectors	11500A 10502A
Battery	Voltage +2.0 to 3.1 Vdc	See <b>“Thermistor Resistive Match Test”</b>
Resistor	2.2K ohm 5%	0698-4262

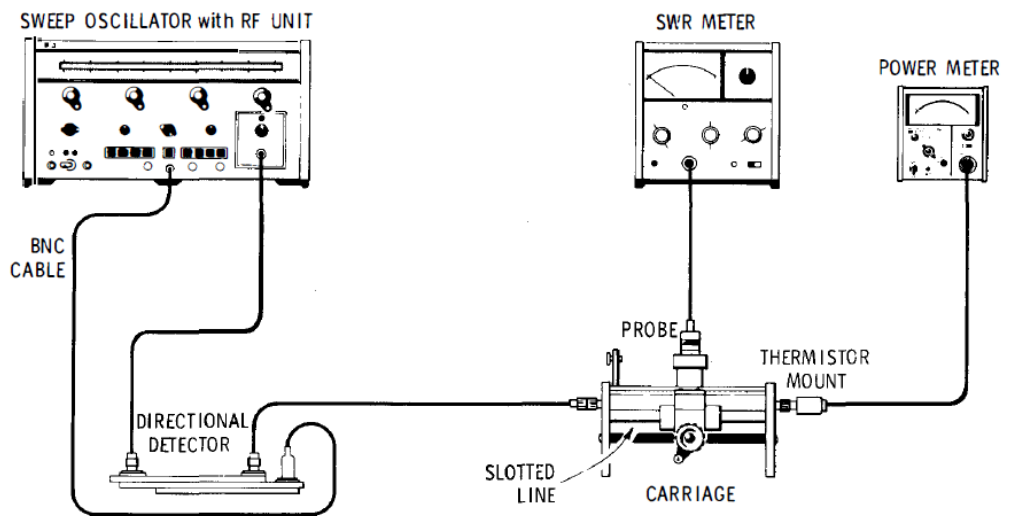
## Performance Tests

### SWR Measurement, 8GHz

SPECIFICATION: SWR at 8GHz = <1.35:1

DESCRIPTION: SWR measurement using standard SWR measurement techniques.

Figure 4-1 SWR Measurement Test, 8GHz



#### Procedure:

1. Connect the test equipment as shown in **Figure 4-1**. Make sure all connections are secured tightly.
2. Set the instrument controls as follows:

8690B/8692A

SWEEP SELECTOR:	CW
FUNCTION:	START/STOP
ALC:	IN
AMPLITUDE MOD:	INT SQ WAVE
START/CW:	8GHz
POWER LEVEL:	Adjust to maximum with the UNLEVELED light off



Maintenance  
Performance Tests

415E

INPUT: XTAL IMPED - HIGH  
RANGE-DB/EXPAND: 30/NORM  
GAIN /VERNIER: Centered

432

MOUNT RESISTANCE: 200 ohms  
RANGE: 10mW

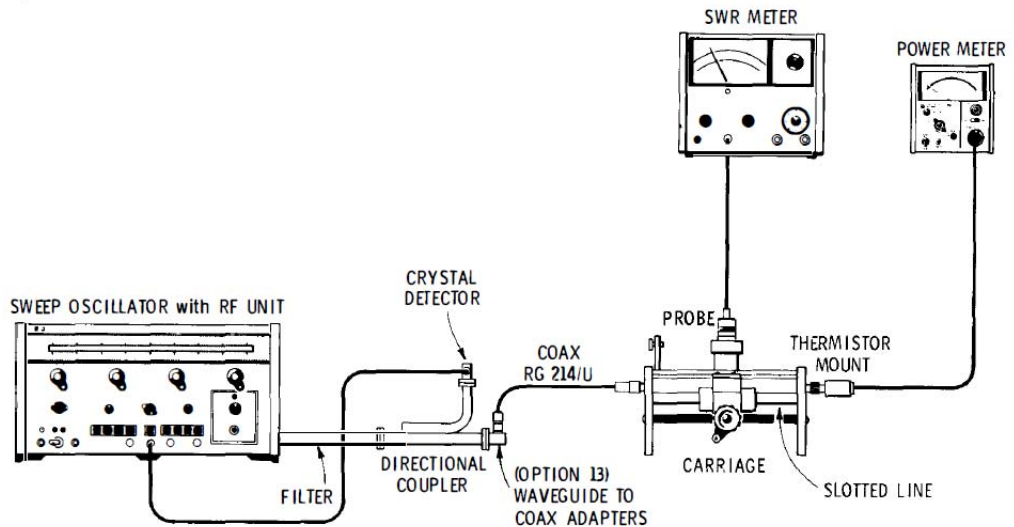
3. Adjust the HP 8690B Sweep Oscillator INT SQ WAVE FREQ for a maximum reading on the HP 415E SWR meter.
4. Adjust the HP 447B Probe penetration for a half scale reading on the SWR meter.
5. Move the HP 809C Carriage adjustment for a maximum reading on the SWR meter.
6. Use the 415E GAIN/VERNIER controls to set the SWR meter reading to 1.0 SWR on the 415E meter.
7. Move the 415E RANGE-DB/EXPAND switch to 0. Adjust the GAIN/VERNIER controls for a 1.0 SWR reading.
8. Move the 809C carriage adjustment for a minimum SWR reading on the 415E. The SWR at 8GHz should be less than 1.35:1.  
HP 415E (8GHz) \_\_\_\_\_ <1.35:1
9. Repeat steps 1 through 8 to determine the SWR at 12.4GHz. The SWR at 12.4GHz should be less than 1.35:1.  
HP 415E (12.4 GHz) \_\_\_\_\_ <1.35:1

## SWR Measurement, 15 and 18GHz

SPECIFICATION: SWR at 15 and 18GHz = 1.6:1 maximum

DESCRIPTION: SWR measurement using standard SWR measurement techniques.

Figure 4-2 SWR Measurement, 15 and 18GHz



### Procedure:

1. Replace the RF unit, filter and directional detector in the 12GHz test setup with the instruments shown in **Figure 4-2**.
2. Repeat steps 1 through 8 to determine the SWR at 15GHz. The SWR at 15GHz should be 1.6:1 maximum.

HP 415E (15GHz)\_\_\_\_\_1.6:1 maximum

3. Move the 8690B START/CW control to 18GHz. Repeat steps 1 through 8 to determine the SWR at 18GHz. The SWR should be 1.6:1 maximum.

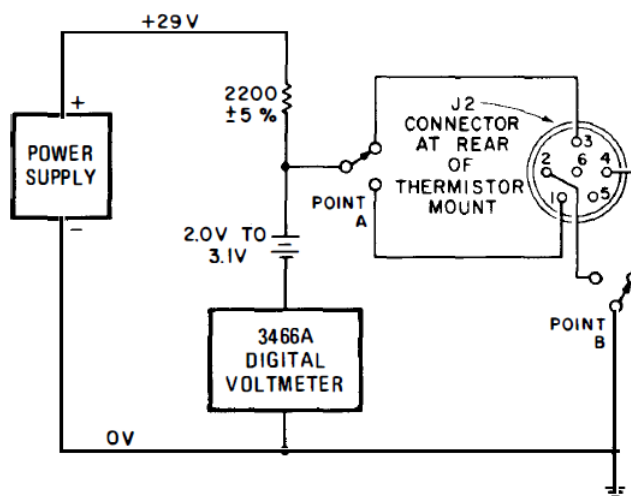
HP 415E (18GHz)\_\_\_\_\_1.6:1 maximum.

### Thermistor Resistive Match Test

SPECIFICATION: Thermistor match  $\pm 0.5$  ohm.

DESCRIPTION: The voltage drop across each thermistor is measured to check thermistor match.

Figure 4-3 Thermistor Resistive Match Test



EQUIPMENT REQUIRED:

- |                             |                            |
|-----------------------------|----------------------------|
| POWER SUPPLY:               | HP 6217 A Power Supply     |
| DIGITAL VOLTMETER:          | HP 3466A Digital Voltmeter |
| BATTERY:                    | See Note                   |
| RESISTOR (2.2K $\pm 5\%$ ): | HP 0698-4262               |

**NOTE**

The small battery connected in series with the DVM is in opposition to the power supply. The value of this reverse voltage should be selected to provide voltmeter resolution of 0.001 volt.

Maintenance  
Performance Tests

1. Connect the equipment as shown in **Figure 4-3**. Set instrument controls as follows:

6217A

METER RANGE: 30 VDC

VOLTAGE ADJUST: 29VDC

3466A

RANGE: AUTO

2. Connect point A to pin 3 of the thermistor mount jack and point B to pin 4 of the thermistor mount jack.
3. Record the DVM Reading.  
3466A\_\_\_\_\_
4. Connect point A to pin 1 of the thermistor mount jack and point B to pin 2 of the thermistor mount jack.
5. Record the DVM Reading.  
3466A\_\_\_\_\_
6. Thermistor match ( $\pm 0.5\Omega$ ) is satisfactory if the two readings do not differ by more than 0.03 volt.  
Difference \_\_\_\_\_ < 0.03 volt

## Troubleshooting

Exceeding the CW or pulse power limits of the Model 84 78B Thermistor Mount may result in damage such that the mount will no longer zero on the power meter.

Before adjusting the mount in any way, make sure that the mount is the cause of the problem. An open or short indication, using the performance test or the check in below means that the mount is not repairable by the procedure outlined in the following paragraphs. However, the mount may be nonoperative, but still repairable. Test for this by using the thermistor resistive match test procedure, or by connecting the mount to a power meter and cable which are known to be good. A faulty cable will not have continuity through the respective connector pins, or may have poor contact at the mount connector. Poor contact will show up as intermittence or a great deal of noise (visible on the power meter) when the cable is gently flexed near the connector end.

To troubleshoot a damaged mount, proceed as follows:

1. Connect mount to Model 432.
2. Set:

MOUNT RES:	200 $\Omega$
RANGE:	COARSE ZERO
POWER:	ON

3. Rotate COARSE ZERO from one limit to the other.

If meter remains pegged upscale, the thermistor elements have been damaged. However, it may be possible to re-compensate the thermistors and return the mount to operation; otherwise they must be replaced. In either case, the Effective Efficiency and Calibration Factor data on the nameplate are no longer valid (refer to **“Repair and Recalibration”**).

If meter remains pegged downscale, measure resistance between pins 1 and 2, and pins 3 and 4. The resistance should measure between 1000 and 5000 ohms. An open or shorted reading indicates the need for replacement of the thermistors.

### CAUTION

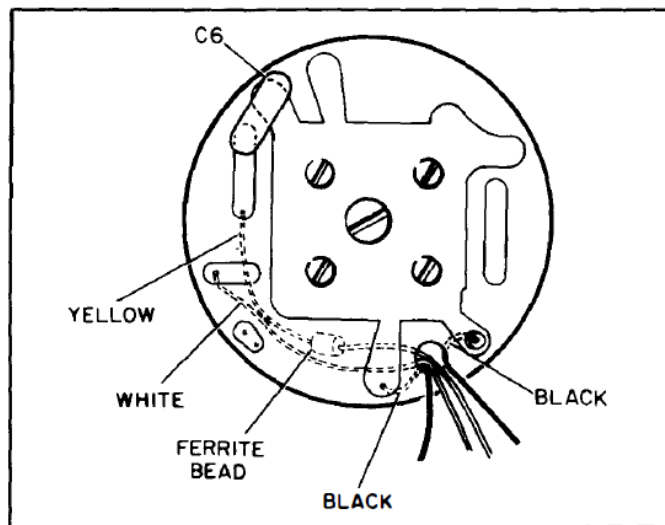
**Under no conditions should the mount be required to carry a current higher than 14mA.**

---

## Thermistor Compensation

If the resistance reading is satisfactory, it may be possible to re-compensate the mount, and return it to service. The drift with temperature changes will be higher because of the damage to the thermistors, but it will be possible to zero the meter and to make accurate measurements. The Effective Efficiency and Calibration Factor imprinted on the label will no longer be valid (refer to **“Repair and Recalibration”**). There are two adjusting screws which permit re-compensation within limits.

Figure 4-4 Printed Circuit Board



Refer to **Figure 4-5** and proceed as follows:

1. Remove the three screws (A).
2. Slide terminal shield away from instrument.
3. Plug connector J2 into Model 432A.
4. Connect mount to 50 $\Omega$  load.
5. Set:

MOUNT RES:        200 $\Omega$

POWER:            ON

If meter is pegged downscale:

1. Set RANGE to COARSE ZERO.
2. Set COARSE ZERO and adjustment to mid range.

3. Turn screws (B) clockwise, 1/8 turn alternately.

**CAUTION**

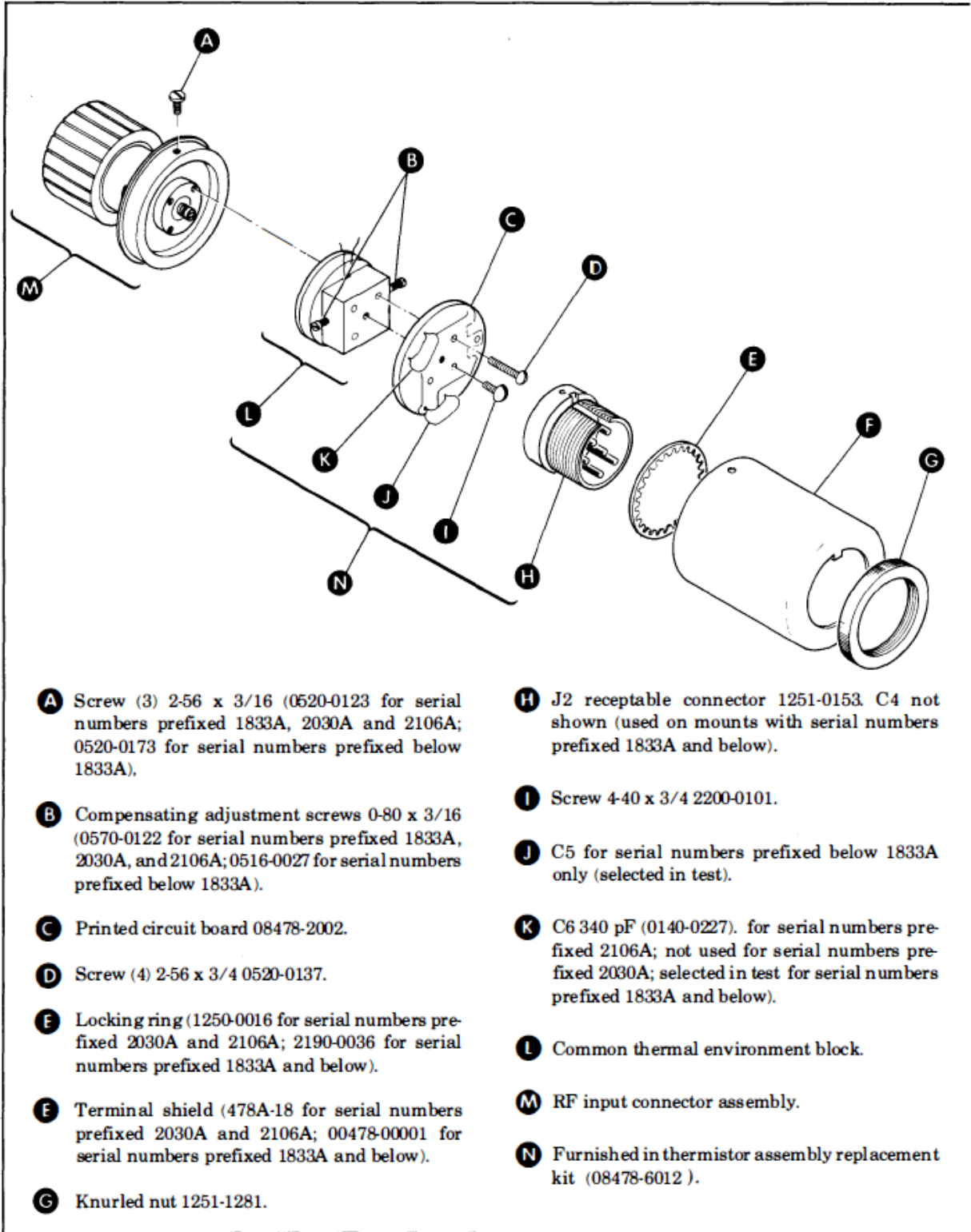
The compensating screws are in very close proximity to the thermistors themselves. Thermistor damage can easily occur if the screws are forced in any way.

If there is a sudden jump in meter indication when advancing either screw, back off 1/8 turn, and do not advance that screw further. Check resistance as in “If meter remains pegged downscale, measure resistance between pins 1 and 2, and pins 3 and 4. The resistance should measure between 1000 and 5000 ohms. An open or shorted reading indicates the need for replacement of the thermistors.” on page 37. If either screw bottoms, do not apply force. Thermistor replacement is indicated.

---

4. When meter pointer rises, trim to zero with each adjusting screw.
5. Replace terminal shield and three screws (A). The instrument is now operative.

Figure 4-5 Thermistor Mount Assembly





If meter is pegged upscale:

1. Set RANGE to highest position which will not peg the meter. If meter pegs on all ranges, set RANGE to 10mW.
2. Turn one of the screws (B) counterclockwise to obtain a meter reading half that observed in step 2.
3. Turn the other screw (B) counterclockwise to zero the meter. If it is impossible to zero the meter, replace the thermistors.
4. Set RANGE to COARSE ZERO; set COARSE ZERO adjustment to mid-range. If necessary, readjust compensation serials to zero the meter.

**CAUTION**

The compensating screws are in very close proximity to the thermistors themselves. Thermistor damage can easily occur if the screws are forced in any way. If there is a sudden jump in meter indication when advancing either screw, back off 1/8 turn, and do not advance that screw further. Check resistance as in **“If meter remains pegged downscale, measure resistance between pins 1 and 2, and pins 3 and 4. The resistance should measure between 1000 and 5000 ohms. An open or shorted reading indicates the need for replacement of the thermistors.” on page 37.** If either screw bottoms, do not apply force. Thermistor replacement is indicated.

---

5. Replace cover and three screws (A). The instrument is now operative.

**NOTE**

The three cover screws must be tight (use lock washers) for proper operation with 432A. If these screws are not tight noisy operation will occur.

---

Maintenance  
Repair and Recalibration

## Repair and Recalibration

If repair or recalibration of the mount is desired, the instrument may be returned to Keysight for repair and recalibration, or for recalibration only. Arrangements can be made with any Keysight Sales and Service office.

## A Manual Changes

To adapt this manual to your instrument, refer to **Table A-1** and make all of the manual changes listed opposite your instrument serial number. Perform these changes in the sequence listed.

If your instrument serial number is not listed on page 2 of this manual or in **Table A-1** below, it may be documented in a yellow MANUAL CHANGES supplement.

**Table A-1 Manual Changes by Serial Number**

Serial Number or Prefix	Make Manual Changes
Below 1833A	C,B,A
1833A	C,B
2030A	C

### CHANGE A

1. Change **“Operating Resistance:”** on page 15 to **“200 ohms Balanced”**.
2. Replace the section title **“Operation with 431A/B/C or 430 Power Meters”** on page 19 to **“Unbalanced Operation with 431A/B or 430 Power Meters”** and its first paragraph with following:  

If the 8478B is used with a Model 431 Power Meter, a Model 11527 A Adapter is required. If the 8478B is used with a 430 Power Meter, a Model 11528A Adapter is required. The use of an adapter breaks the balanced circuit and an unbalanced circuit results. In this unbalanced condition, a large amount of 10 kHz audio bias signal may be coupled from the power meter to the RF source output.
3. Delete first sentence of **“Because the mount is unbalanced, a large amount of 10kHz audio bias signal may be coupled from the power meter to the RF source output. The RF source 10kHz output impedance forms a parallel circuit shunt across one of the detection thermistor elements. If the RF source presents a 10kHz impedance of 15k ohms or greater, the audio bias voltage appearing at the RF input connection is typically 1.3 Vrms. For an RF source 10kHz impedance of 50 ohms, the audio bias voltage is greatly reduced to typically 5 mVrms: The presence of a large 10 kHz audio bias**

voltage at the RF source output may affect solid state RF sources and RF voltmeter measurements. To minimize or eliminate these effects, use a high-pass filter at the RF source output.” on page 19.

4. Change the section title of “Unbalanced Operation with Model 431A/B/C and 430 Power Meters” on page 20 to “8478B with Model 431A/B and 430 PowerMeters”.  
And add the following to the next paragraph, “The Model 11527A or 11528A Adapter is required when operating the 8478B with 431A/B or 430 Power Meters respectively.”
5. Replace Figure 3-1 and Figure 3-2 with Figure A-2 and Figure A-2 respectively.

Figure A-2

84788 Connected to a 432A Power Meter (P /0 Change A)

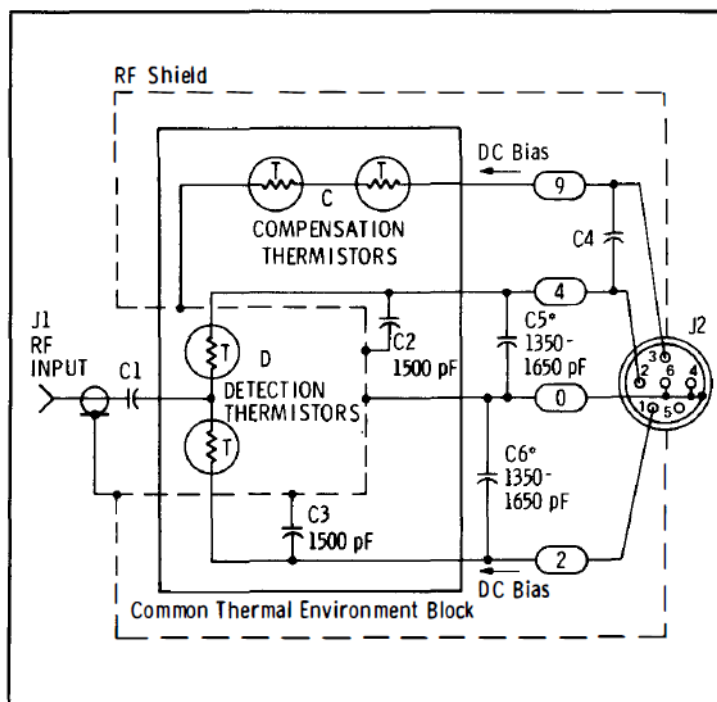
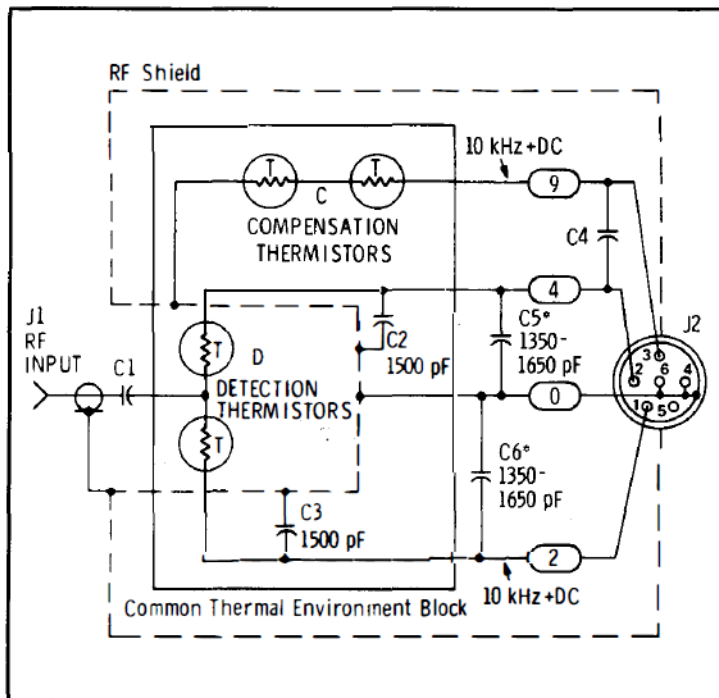


Figure A-2

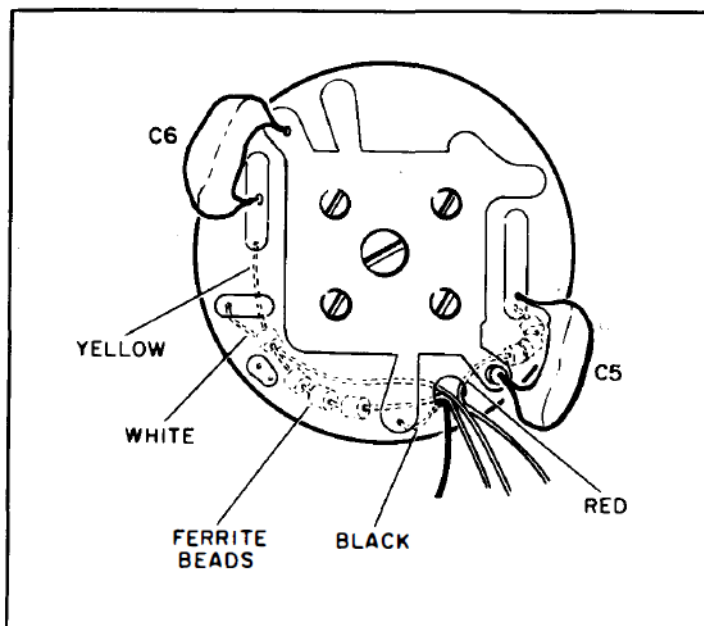
84788 Connected to a 431 C Power Meter (P /0 Change A)



6. Replace Figure 4-4 on page 38 to Figure A-3.

Figure A-3

Printed Circuit Board (P/O CHANGE A)



## CHANGE B

1. Replace **Figure 3-1** and **Figure 3-2** with **Figure A-4** and **Figure A-5** respectively.

Figure A-4

84788 Connected to a 432A Power Meter (P/O Change B)

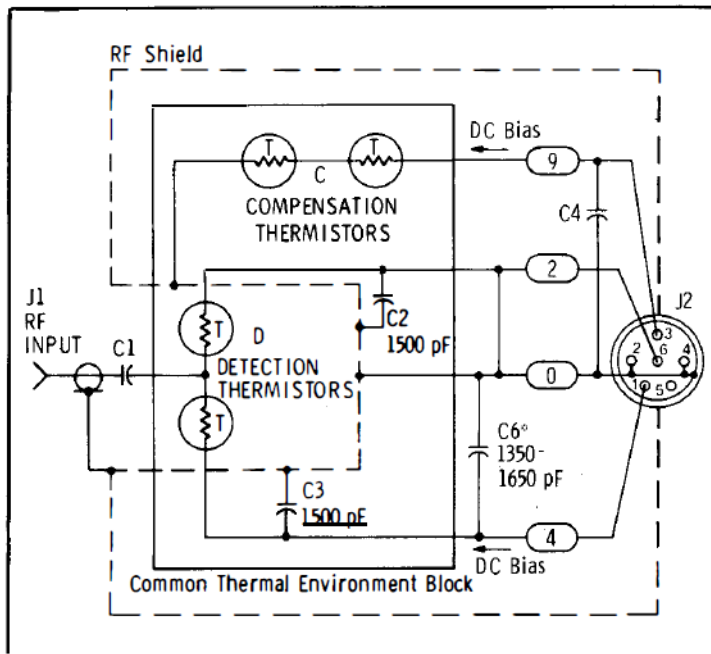
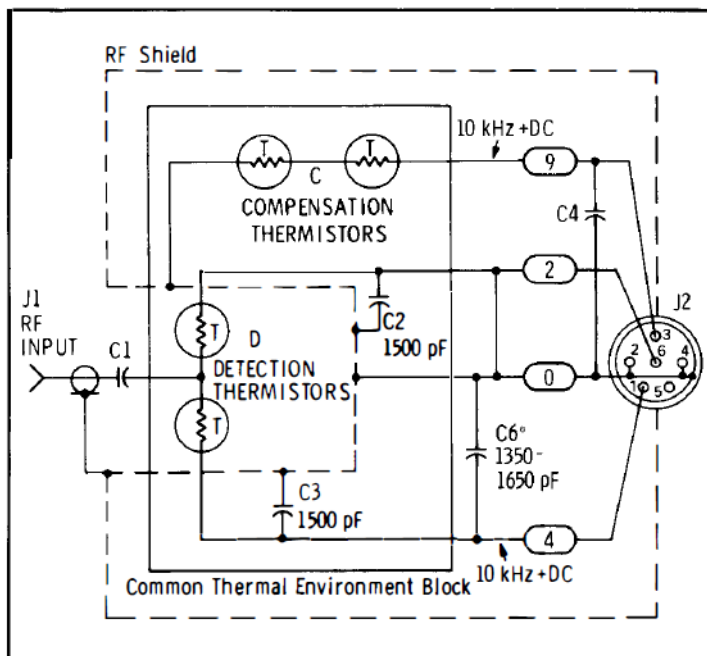


Figure A-5

84788 Connected to a 431 C Power Meter (P/O Change B)



Manual Changes  
CHANGE C

6. For **Figure 4-4 on page 38**, Return C6 as it is shown in the manual (it was deleted by “CHANGE C”).

## CHANGE C

1. Replace **Figure 3-1** and **Figure 3-2** with **Figure A-6** and **Figure A-7** respectively.

Figure A-6

8478B Connected to a 432A Power Meter (P /0 Change C)

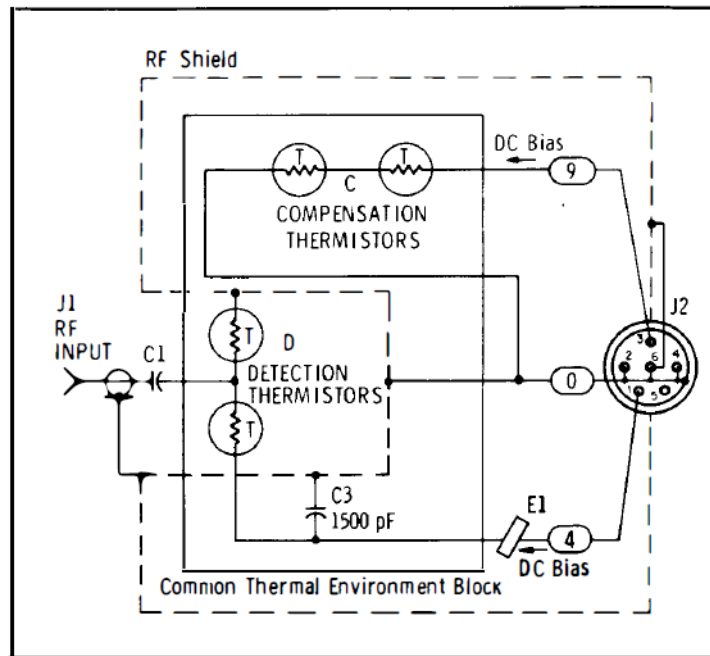
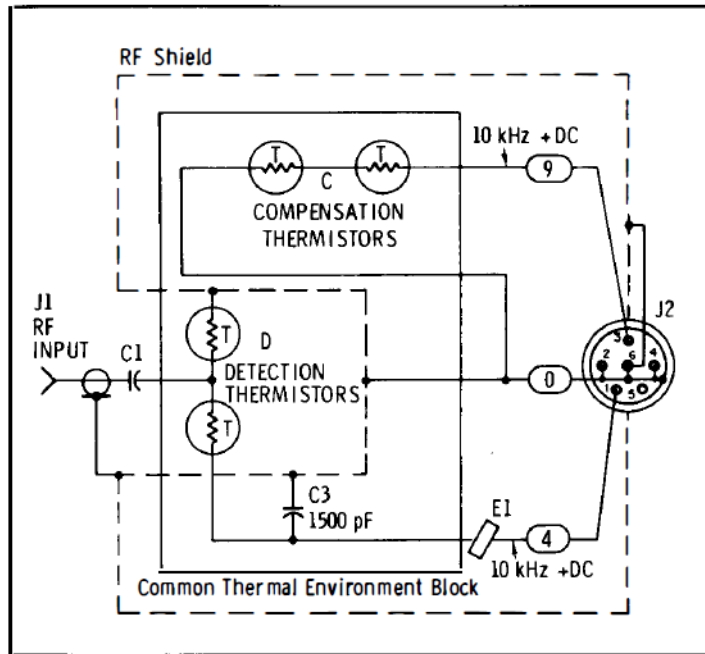


Figure A-7

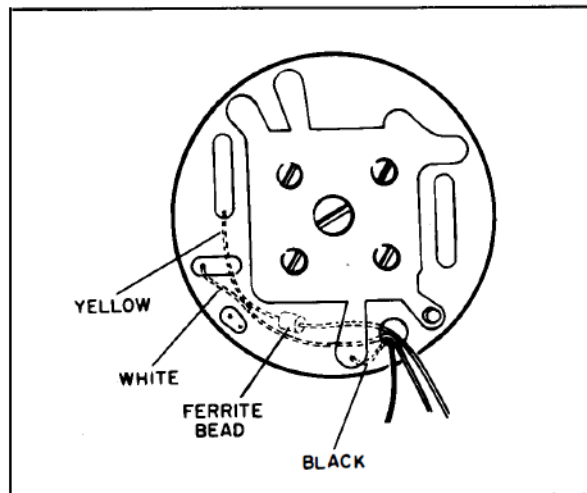
84788 Connected to a 431 C Power Meter (P /0 Change C)



2. Replace **Figure 4-4 on page 38** to **Figure A-8**.

Figure A-8

Printed Circuit Board (P/O Change C)





This information is subject to change without notice.  
© Keysight Technologies 1981-2018  
Edition 3, March 2018



08478-90015  
[www.keysight.com](http://www.keysight.com)