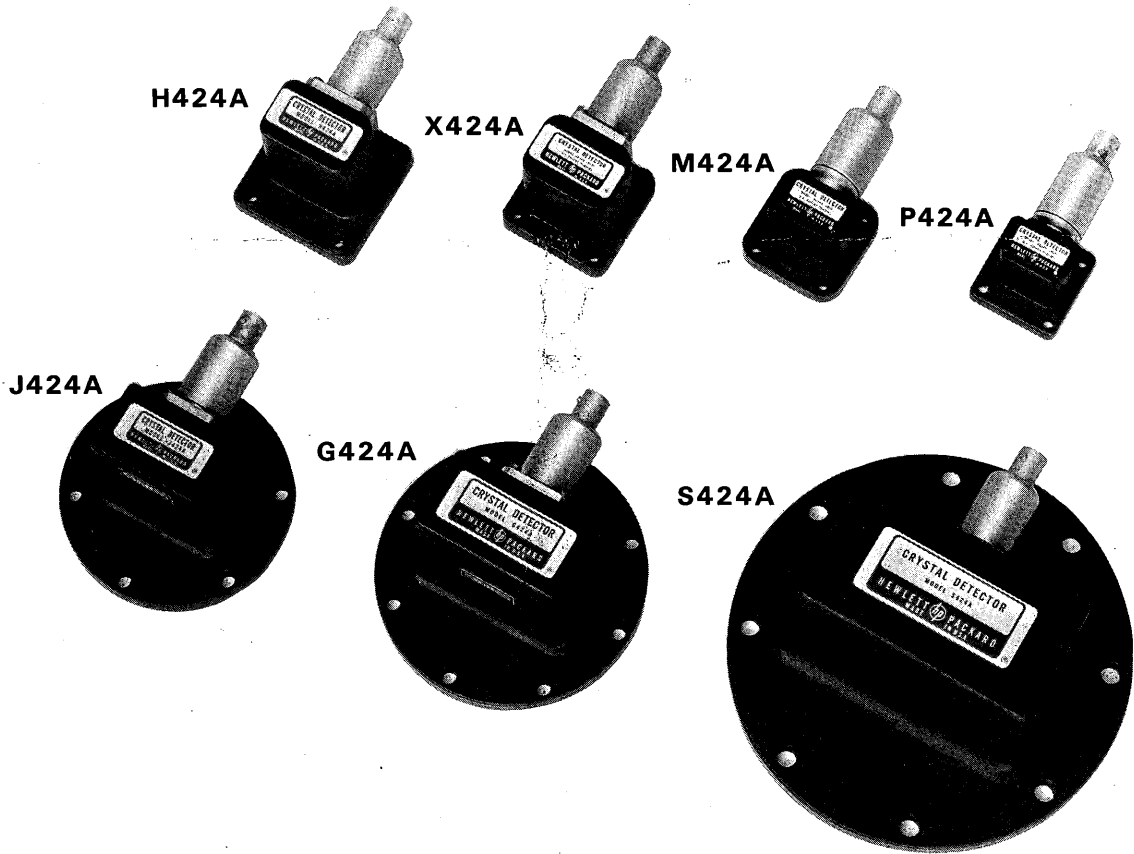



CRYSTAL DETECTORS

424A



HEWLETT  PACKARD

SIN 500 INTERGRA 
HP-424A

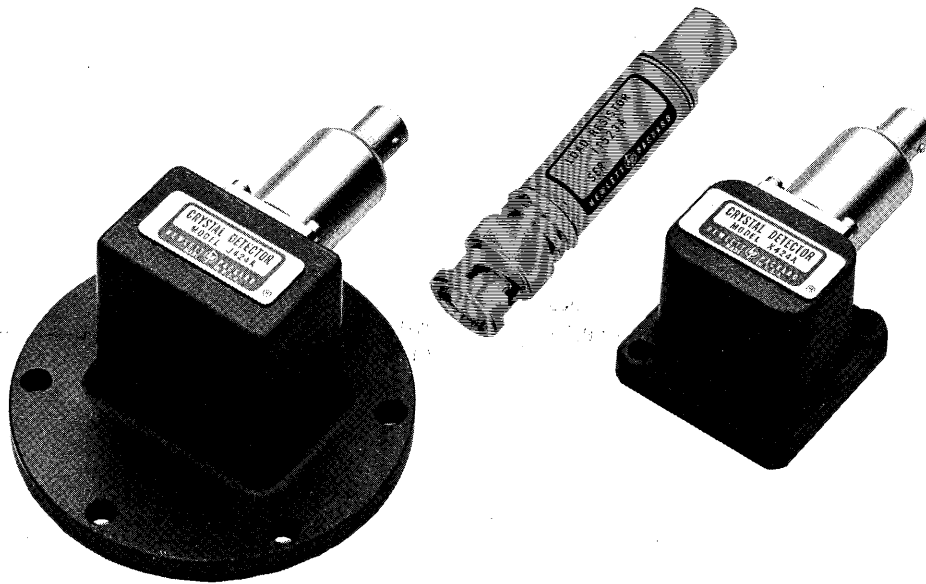


Figure 1. Models J424A and X424A Crystal Detectors with Model 11523A Load Resistor

Table 1. Specifications

Model	Frequency Range (GHz)	Frequency Response (dB)	Max SWR	Length		Equivalent Flange Type	Net Weight	
				(in.)	(mm)		(lb)	(g)
S424A	2.6 -3.95	±0.2	1.35	2-7/16	62	UG-53/U	1-1/4	560
G424A	3.95-5.85	±0.2	1.35	2-1/16	52	UG-149/U	1	450
J424 A	5.3 -8.2	±0.2	1.35	1-7/8	48	UG-344/U	1/2	225
H424A	7.05-10.0	±0.2	1.35	1-9/16	40	UG-51/U	1/2	225
X424A	8.2 -12.4	±0.3	1.35	1-3/8	35	UG-39/U	1/2	225
M424A	10.0-15.0	±0.5	1.5	1	25	Cover Flange	1/2	225
P424A	12.4-18.0	±0.5	1.5	15/16	24	UG-419/U	1/2	225

SENSITIVITY: (into >75K at 25°C): ***

High Level: * <0.35 mW (<0.5 mW; M424A, P424A).

Low Level: >0.4 mVdc/μW (>0.3 mV; M424A, P424A)

OUTPUT IMPEDANCE:

15k max, shunted by approx. 10 pF.

DETECTOR ELEMENT:

Supplied

MAXIMUM INPUT:

100 mW (Refer to Paragraph 15.)

OUTPUT POLARITY:

Negative

NOISE: <200 μV peak-to-peak with 100 mV output.

OUTPUT CONNECTOR: BNC female.

OPTIONS:

01. Matched pair. Freq. response characteristics (exclusive of basic sensitivity) track within ±.2 dB for S-, G-, J- and H-band units, ±.3 dB for X-band units, and ±.5 dB for M- and P-band units.

02. Furnished with HP Model 11523A Load Resistor selected for optimum square-law characteristics at 24°C (75°F) **, <±0.5 dB variation from square law over a range of at least 30 dB up to 50 mV peak output working into an external load >75k. Sensitivity typically >0.1 mV/μW when load resistor is used.

03. Positive polarity output.

*Input required to produce 100-mV output.

**As read on an HP Model 417 Ratio Meter or HP Model 415 SWR Meter calibrated for square-law detectors.

***Output decreases with increasing temperature. Typically 0.015 dB/°C from 0°C to +55.2°C.

1. INTRODUCTION.

2. The Model 424A Crystal Detectors are designed for use in waveguide systems in the measurement of relative microwave power upwards to 100 mW in the range from 2.6 to 18.0 Gc. Output polarity of the detected signal is normally negative but positive output polarity is available as Option 03. Complete specifications and listed options are given in Table 1. The J424A and the X424A are shown in Figure 1.

3. Separate housing of square-law load (Load Resistor, Option 02; see Figure 1) and detector permits easy conversion from optimum square-law response operation (with the Load Resistor) to maximum output sensitivity (without the Load Resistor). Each load is labeled with the serial number of the Model 424A detector to which it is matched. If you have more than one load (hp Model 11523A), always check that you are using the proper 11523A for the 424A in use.

4. Uses of the detector include peak RF power measurement, reflectometer measurements, closed loop leveling, and observation of RF envelope variation.

5. PRECAUTIONS.

6. HANDLING DETECTOR ELEMENT.

7. DO NOT HANDLE DETECTOR ELEMENT USED IN CRYSTAL NEEDLESSLY. A static charge which builds up on a person, especially on a cold, dry day, must never be allowed to discharge through the element. Refer to Paragraph 38 for proper handling precautions.

8. FORWARD AND REVERSE DIODE RESISTANCE.

CAUTION: A SMALL STATIC CHARGE BETWEEN OPERATOR AND OHMMETER LEADS CAN DESTROY DETECTOR ELEMENT.

9. EQUIPMENT CONNECTION.

10. DISCHARGES OF STORED ENERGY CAN EASILY DAMAGE THE CRYSTAL DETECTOR. Input capacitors of ac-coupled equipment must be discharged before connecting Crystal Detector. Make connections to other equipment and discharge then connect detector.

11. GENERAL.

12. The Model 424A Crystal Detector can be used as a demodulator for oscilloscope observation.

13. When the crystal detector is used with an oscilloscope to observe waveshapes of rise times less than 5 usec, the cable connecting detector output and oscilloscopes should be as short as possible and shunted with a resistor. This resistor should be 50 ohms to terminate the coaxial cable in its characteristic impedance. However, with 50 ohms resistance, the video pulse may have insufficient amplitude to drive some oscilloscopes. Hence, the cable should be shunted by the smallest resistance which will produce a satisfactory presentation. Typically, the value is between 50 and 2000 ohms. The larger the resistance, the more the degradation of rise time.

14. Power applied to the detector can be either modulated or continuous wave (CW). If modulated at a 1000-Hz $\pm 5\%$ rate, the sensitive, hp Model 415 E (tuned

voltmeter) can be used. For CW detection, a dc milliammeter or millivoltmeter such as the hp Model 425A Microvolt-Ammeter can be used.

15. SENSITIVITY.

16. For low level RF inputs up to 0.01 mW, the ratio of detected voltage to input power in $\mu\text{volt}/\mu\text{watt}$ is > 400 to 1. For high level RF inputs between 0.1 and 0.7 mW the sensitivity ratio in millivolts per milliwatts is ≥ 286 to 1. For RF inputs between 0.01 mW and 0.1 mW, the sensitivity ratio changes gradually from 400 to 1 to a ratio of 286 to 1. For RF inputs greater than 0.7 mW, the detected output to RF input ratio begins to decrease. Depending on the element, the ratio decreases to the point where additional input power will not produce an output in excess of 300 to 500 millivolts.

17. SQUARE-LAW LOADING.

18. The square-law load (hp Model 11523A) is selected for optimum response (minimum deviation from square law) at 24°C (75°F). Typically, detector output varies ± 0.3 dB from exact square law for output voltages between 5 and 50 mV. At higher temperatures there is less positive and more negative deviation in the curve of output voltage vs input power. At lower temperatures there is more positive and less negative deviation. The change with temperature is approximately 0.04 dB/°C. For example, a detected output which varies +0.3 to -0.3 dB from exact square law at 24°C normally varies about +0.1 to -0.5 dB at 29°C.

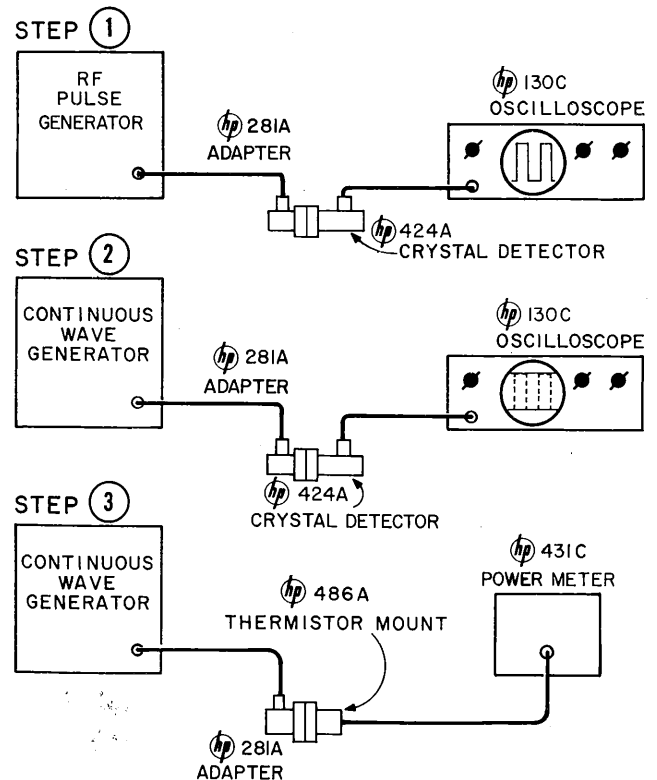


Figure 2. Peak Power Measurement

19. PEAK POWER MEASUREMENT.

20. An arrangement for peak power measurement is shown in Figure 2. The procedure involves calibration of an oscilloscope using the envelope of the pulse under measurement. The oscilloscope calibration is then used to set the output amplitude of a CW source. Output power of the CW source is thus equal to the peak power and is measured by a power meter. The measurement procedure is as follows:

- a. Connect equipment as shown in Figure 2, step 1.
- b. Display pulse on a dc-coupled oscilloscope. Using a marking pencil, mark base and peak of pulse on oscilloscope graticule.
- c. Replace pulse source with CW generator (step 2). Using graticule marks as reference, adjust output level of CW generator until amplitude of oscilloscope display equals amplitude of pulse envelope previously observed.
- d. Without changing the output level of the CW generator, replace detector and oscilloscope with a thermistor mount and power meter (step 3). The power output as measured on the power meter is equal to the peak power of the pulse under measurement.

21. REFLECTOMETER MEASUREMENTS.

22. The reflectometer principle of measurement can be adapted to broadband evaluation of such microwave transmission properties as SWR, attenuation, and insertion loss.

23. The usual reflectometer used in broadband testing consists of a sweep frequency oscillator (modulated at 1 kHz) connected to a transmission system which contains the device under test and a directional coupler, or couplers, arranged to sample incident and reflected signal. Two detectors demodulate the incident and reflected signals and apply the modulation voltages to a ratio meter that displays the reflection coefficient of the device under test. Versions of the arrangement can be used to measure attenuation, insertion

loss and other properties that can be determined from ratio.

24. Information about reflectometer systems and measurements is contained in *hp* Application Note 65 and Hewlett-Packard Journal Vol. 12, No. 4, copies of which are available upon request.

25. MEASUREMENT OF RELATIVE POWER LEVELS.

26. GENERAL.

27. When sensitivity is important, the Model 424A is also useful for relative power measurements such as measuring insertion loss or monitoring power level where the power is sampled by a directional coupler. A typical S band setup for measuring insertion loss is shown in Figure 3. The device under test is a microwave filter. A reference reading is made with the filter out of the line and the variable attenuator set for any convenient reference greater than 10 dB. The setting of the attenuator and the reading (in dB) of the standing wave indicator are noted. The filter is then inserted in the line and the variable attenuator adjusted to obtain the reference reading on the Standing wave indicator. The difference between the first and second settings of the attenuator is the insertion loss of the device under test.

28. HARMONIC-FREQUENCY COMPARISON MEASUREMENTS.

29. The Model 424A can be used as a mixer in harmonic-frequency comparison measurements. See *hp* Application Note 2.

30. CLOSED LOOP LEVELING.

31. A typical setup for controlling output level variations of swept frequency oscillators is shown in Figure 4. The sweep frequency output is sampled by a directional coupler and rectified by the crystal detector. The variations in the detected output of the crystal detector are proportional to the sweep frequency output level variations and are amplified within

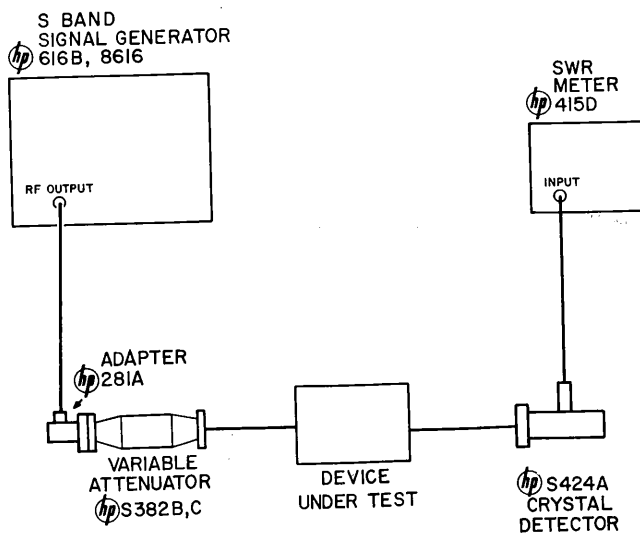


Figure 3. Insertion Loss Measurement

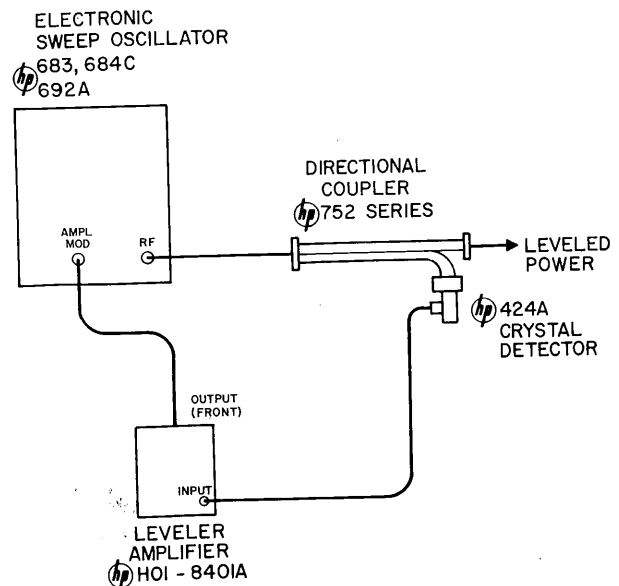


Figure 4. Closed Loop Leveling

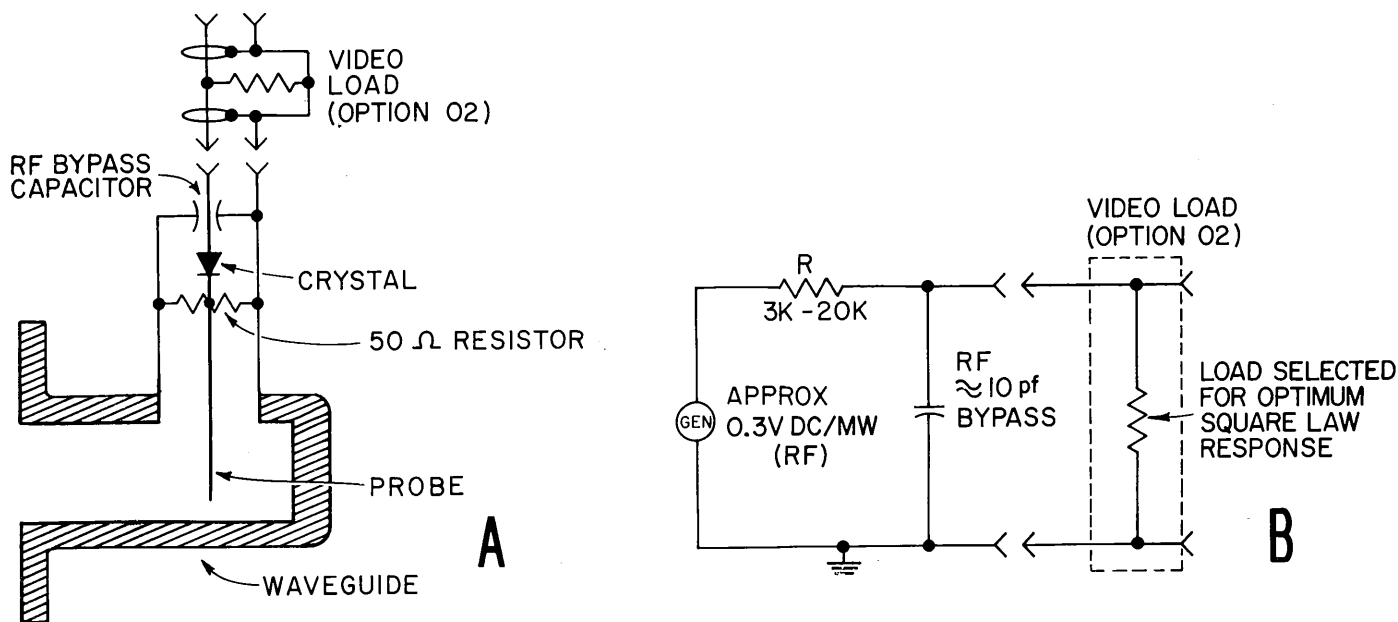


Figure 5. Arrangement of Model 424A and Equivalent Circuit

the leveler amplifier to produce a negative control voltage that is applied to the amplitude modulation input of the sweep oscillator. With the Model 692A, the external leveler amplifier shown is not needed since it is built into the instrument. With such a system leveling occurs at the sampling point (the directional coupler) with the advantage that RF level stability can be maintained at a point remote from the RF source.

32. The leveling capability of the leveler amplifier/crystal detector combination is limited mainly by the coupling variation of the directional coupler and the frequency response of the crystal detector.

33. CIRCUIT.

34. Arrangement of the Model 424A and equivalent circuit is shown in Figure 5. The crystal may be considered as a voltage generator with an internal resistance of about 3k to 20k ohms and a shunt capacitance of approximately 10 pF. The video load (option 02) is selected to obtain optimum square-law performance for outputs up to 50 mV.

35. PREVENTIVE MAINTENANCE.

36. Protect the machined surface of the waveguide coupling flange from damage. Scoring, burring, and distortion of the flange surface causes coupling discontinuity and increased SWR.

37. REPLACEMENT OF PARTS.

38. Succeeding paragraphs give instructions for repair of the Model 424A, and the Option 02 Load Resistor, Model 11523A. Additional maintenance information can be obtained from your local Hewlett-Packard field office. Stock numbers for replaceable parts are given in Table 2.

39. Detector elements as replacement parts are listed in Table 2. This assembly is available with or without a Load Resistor replacement resistor that must be installed if the detector has a matching load.

40. DETECTOR ELEMENT REPLACEMENT.

WARNING

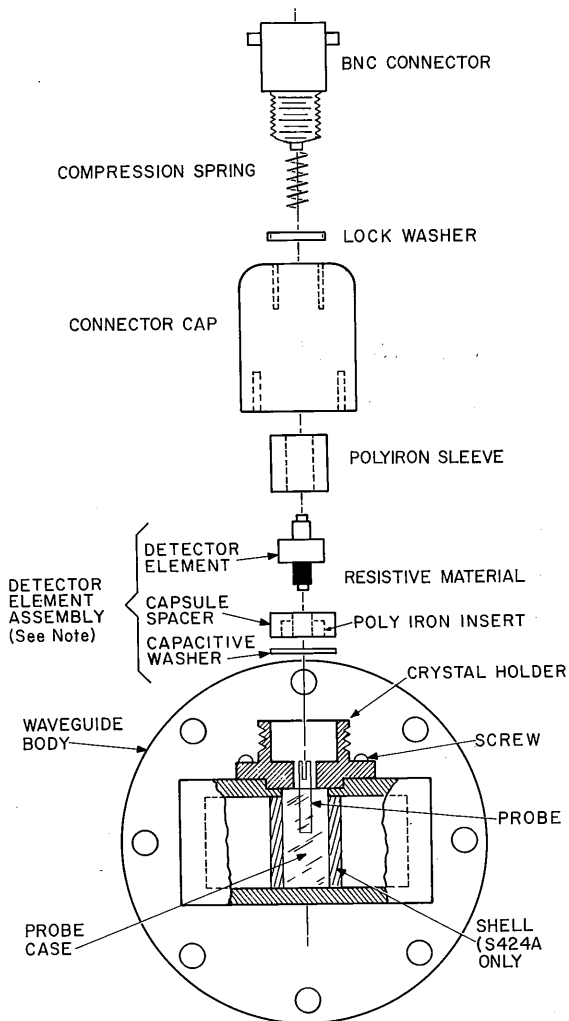
The special detector element (see Figure 6) contained in the Model 424A can be damaged in handling, removal, or installation if certain precautions are not taken. The handling precautions which follow should be read before performance of any operation with the detector element when it is out of either the Model 424A or the detector element shipping container.

41. DETECTOR ELEMENT HANDLING PRECAUTIONS.

a. Before installing detector into mount, touch exposed metal on mount with your hand to discharge static electricity. Then insert detector into mount.

b. When handing crystal to another person, touch hands first to ensure there is no difference in static electrical potential between you.

c. Power line-operated ohmmeters should NOT be used to measure forward and reverse resistance since it is rather easy to damage these diodes with such ohmmeters. (The difficulty arises because of the substantial voltage difference which often exists between the operator and the ohmmeter leads. Unless connections are very carefully made, it is easy for this voltage difference to appear across the diode and damage it.)



NOTE: Silver Capacitive Washer is used in J424A,
Gold Capacitive Washer is used in H424A, & X424A

Figure 7. Model 424A Assembly

42. **REPLACING DETECTOR ELEMENT.** Parts mentioned in the following procedure are identified in Figure 7.

- a. Loosen connector cap and remove from body (protect connector cap with heavy paper or tape and use gas pliers).
- b. Remove old detector element, capsule spacer and capacitive washer.
- c. Install new capacitive washer, capsule spacer and detector element. The capsule spacer should be placed in the body with the polyiron insert towards the capacitive washer. The resistive end of the diode element goes into the body.

CAUTION

When inserting the detector element, do not force the tip (resistive end) into the center conductor in the body as the fingers of the center conductor might be damaged.

d. Replace connector cap and tighten firmly.

NOTE

The detector element assembly includes a detector element, resistor (if its an Option 02), capacitive washer and a capsule spacer. The resistor is to load the diode for square-law operation, the capacitive washer is to match the diode for VSWR while the capsule spacer is mainly for flatness of sensitivity. All should be replaced as a unit when a diode is replaced.

NOTE

For J424A use silver capacitive washer (discard gold washer). For H424A or X424A use gold capacitive washer (discard silver washer).

43. **REPLACING 424A BNC CONNECTOR.**

44. **TOOLS REQUIRED.**

- a. Needle-point soldering iron
- b. Wire cutters (11523A only)
- c. Flat file, #4 (11523A only)
- d. Tweezers

45. **PROCEDURE.** Parts mentioned in the following procedure are identified in Figure 7.

- a. Remove BNC connector and lockwasher.
- b. Unsolder spring soldered to center conductor lead.
- c. Slip spring over center conductor lead and solder.
- d. Let spring cool, and then replace lockwasher and connector in connector cap.

46. **REPLACEMENT OF 11523A PARTS.**

47. Parts mentioned in the following procedure are identified in Figures 8 and 9. Tools required are listed in Paragraph 42.

48. **REPLACING MALE BNC CONNECTOR.**

- a. Remove male BNC connector and lockwasher from housing. To remove BNC, use a 3/8-inch open-end wrench and hold housing either in a vise or with gas pliers. Before putting pliers on, protect housing of the 11523A with material such as heavy papers.
- b. Unsolder resistor.
- c. Solder resistor to new BNC.
- d. Let resistor cool and then check resistance from male BNC pin through resistor; resistance measured should be $\pm 10\%$ that indicated by the coding.
- e. Replace lockwasher and male BNC.

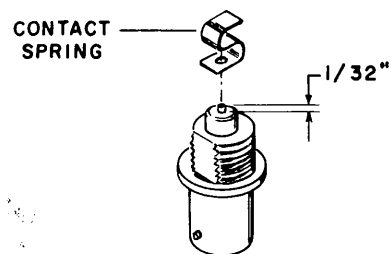


Figure 8. Cutting Center Conductor Lead to Accommodate Contact Spring

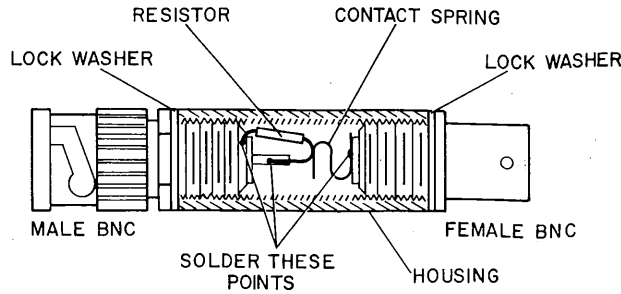


Figure 9. Model 11523A Load Resistor, Cutaway View

49. REPLACING FEMALE CONNECTOR.

- a. Remove BNC connector. To remove or install BNC, use a BNC wrench or use a male BNC connector
- b. Unsolder contact spring.
- c. Prepare replacement BNC connector:
 - (1) Cut center conductor lead to approximately 1/32 inch.

- (2) With flat file, smooth end of lead; wipe off burr with tweezers or similar metal instrument.
- d. Slip contact spring over center conductor lead, and solder.
- e. Let contact spring cool and then screw into mount.

NOTE

Use solder sparingly or it will creep back on spring. Solder on spring destroys its usefulness and is difficult to remove.

50. REPLACEABLE PARTS.

- 51. This section contains information pertaining to replaceable parts (see Table 2).
- 52. To order a replacement part, address order or inquiry to your local Hewlett-Packard field office (see lists at rear of this Note).
- 53. Specify the following information for each part.
 - a. Model number
 - b. Hewlett-Packard stock number
 - c. Description of part

Table 2. Replaceable Parts, All Models 424A and 11523A

Description	Stock Number						
	424A	11523A					
Connector, male BNC, includes lockwasher	---	1250-0045					
Connector, female BNC, includes lockwasher (except Option 02)	1250-0254	1250-0251					
Connector, female BNC, includes lockwasher (Option 02 only)	1250-0251	---					
Cap, connector	5020-0210	---					
Sleeve, polyiron	00424-221	---					
Spring	1460-0012	5000-0234					
Housing	---	5020-3215					
Screw, crystal holder, retaining, RHMS, SS, 4-40 x 1/4 in.	2200-0003	---					
Load Resistor Assembly, includes: Model 11523A housing, BNC connectors (female and male), spring, and 2 nameplates with identical serial numbers.	---	11523-600					
Detector Element Replacement Assemblies (includes diode element, capacitive washer and capsule spacer)							
<u>Unloaded</u>							
Type	Neg. output	Neg. output pairs Option 01	Pos. output Option 03	Pos. output pairs Options 01, 03			
SG	00423-802	00423-605	00423-803	00423-606			
JHX	00424-802	00424-806	00424-803	00424-807			
MP	00424-810	00424-814	00424-811	00424-815			
<u>Loaded (includes matched load resistor)</u>							
	Option 02	Options 01,02	Options 02,03	Options 01, 02, 03			
SG	00423-800	00423-603	00423-801	00423-604			
JHX	00424-800	00424-804	00424-801	00424-805			
MP	00424-808	00424-812	00424-809	00424-813			
	S424A	G424A	J424A	X424A	H424A	P424A	M424A
Body, waveguide	S281-5	G281-4	J281-4	X281-4	H281-6	00424-210	00424-207
Probe	00424-215	00424-200	004240205	00424-218	00424-203	00424-212	00424-208
Probe, case	00424-216	00424-201	J281-3	00424-219	00424-204	00424-213	00424-209
Shell	00424-217	---	---	---	---	---	---
Holder, crystal	00424-202	00424-202	00424-222	00424-222	00424-202	00424-211	00424-211
Ramp, polyiron	---	---	---	---	---	00424-214	00424-214
Epoxy Package	---	---	---	---	---	0470-0249	0470-0249

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Printed in U.S.A. 30M-11/68