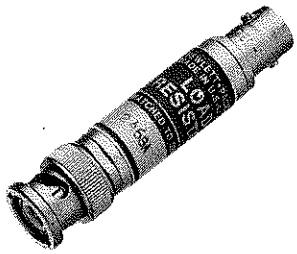
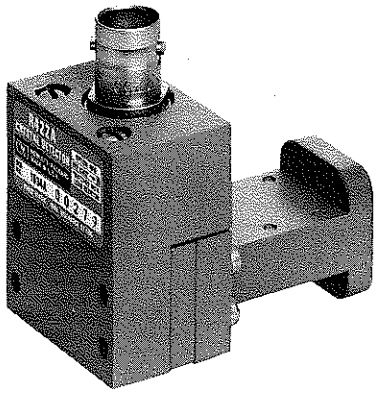
OPERATING AND SERVICE MANUAL

422A
CRYSTAL DETECTOR





Printed: AUGUST 1979

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SECTION I
GENERAL INFORMATION

1. The Model 422A Crystal Detector (Figure 1) is a broadband device which includes a crystal diode, a waveguide mount designed to match approximately the impedance of the crystal diode, and a resistor (Option 002 only) which loads the crystal for maximum square-law range. Lossy elements in the mount reduce the SWR of the device. Model 422A detectors are available for use in the K (18 to 26.5 GHz) and R (26.5 to 40 GHz) bands, and can be obtained in matched pairs.

2. For optimum square-law response, a separately contained Load Resistor is supplied with Model 422A Option 002 Crystal Detectors (see Figure 1). Each load resistance is factory-matched to a specific Model 422A, and permits conversion from optimum square-law response, with the load, to optimum sensitivity, without the load. Each Load Resistor is identified by a serial number marked on its name-plate which is identical to the serial number of the Model 422A to which it is matched. If you have more than one Load Resistor, always check that you are using the proper Load Resistor for the 422A in use.

3. Model 422A detectors are available in matched pairs for dual-channel applications such as reflectometer systems. Each detector of a pair meets the same specifications as single units, and the frequency-response difference between the detectors of a pair totals no more than ±1 dB for levels below approximately 0.05 mW. Each Model 422A of a matched pair is identified by an identical serial number marked on its name-plate.

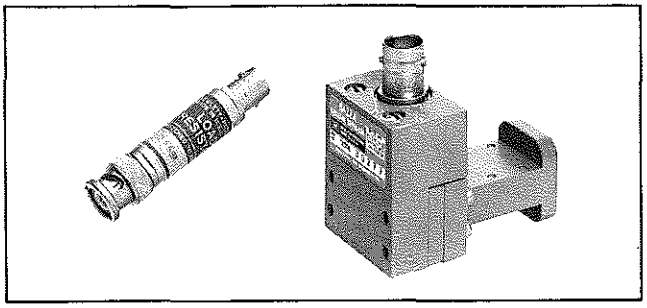


Figure 1. Model 422A Crystal Detector and Load Resistor

4. The rectified output appears at a BNC connector; the RF input is a waveguide cover flange. For use in systems using circular flanges, a contact flange adapter can be supplied on order with Model 422A (see Table 1). The detector in the Model 422A is a HP developed crystal diode; replacement crystals are supplied mounted in the required special waveguide holder.

Table 1. Specifications

SENSITIVITY: Typically 0.3 mV dc/μW CW

FREQUENCY RESPONSE: ±2 dB[1]

MAXIMUM SWR: Model K422A: 2.5
Model R422A: 3.0

MAXIMUM INPUT: 100 mW, peak or average

OUTPUT POLARITY: Negative

SQUARE-LAW RESPONSE: Furnished with matched load resistor for optimum square-law characteristics at 24°C (75°F),[2] less than ±0.5 dB variation from square law from low level up to 50 mV peak output working into an external load >75K.

LOAD RESISTOR: Load Resistor: value selected for optimum square-law response.

FLANGE: Cover type.

OPTION 001: Matched pair of units fitted with square-law load. Frequency response characteristics (exclusive of basic sensitivity) track within ±1 dB[2] for power levels less than approximately 0.05 mW.

OPTION 02. Furnished with matched load resistor for optimum square-law characteristics at 24°C (75°F),[2] <±0.5-dB variation from square law from low level up to 50-mV peak output working into an external load >75K. Sensitivity typically 0.1 mV/μW.

CONNECTORS:
Model 422A: BNC female
Load Resistor: BNC (one male, one female).

Model	Frequency Range	Mates with Waveguide Size	Length	Equiv. Flange JAN Type	Net Weight
K422A[3]	18 - 26.5 GHz	0.500 x 0.250 in. (12 x 64 mm)	2 in. (51 mm)	UG595/U	9 oz (252 gm)
R422A[3]	26.5 - 40.0 GHz	0.360 x 0.220 in. (9 x 6 mm)	2 in. (51 mm)	UG599/U	7.5 oz (2.1 kg)

[1] As read on a meter which is calibrated for use with square-law detectors.

[2] Read on a meter such as one of the HP 415 or 416 series, which is calibrated for square-law detectors.

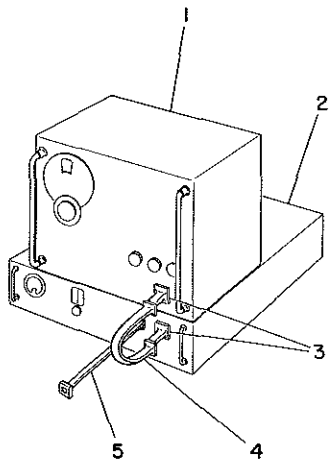
[3] Circular flange adapters: K-band (UG425/U), HP 11515A, R-band (UG318/U), HP 11516A.

SECTION II
OPERATING INSTRUCTIONS

5. REFLECTOMETER MEASUREMENTS.

6. PROCEDURES. Improved techniques make it possible to use non-matched crystal detectors in reflectometer setups. The new techniques are described in the Hewlett-Packard Journal, Vol. 12, No. 4, a copy of which may be obtained from the Hewlett-Packard Company on request. Use of matched crystal detectors in a reflectometer system is described in the HP Journal, Vol. 6, No. 1-2.

7. SIGNAL SOURCE. For reflectometer measurement systems, the RF signal must be square-wave modulated with 1 kHz. An economical source of modulated signals in K or R band is obtained by using a broadband frequency doubler driven by a RF source with built-in provision for 1 kHz square-wave modulation. Figure 2 shows such a combination for K band, and Table 2 lists equipment required to obtain K- or R-band signals with HP Models 938A and 940A Frequency Doubler Sets.*



1. HP Model 626A SHF Signal Generator (or Model 8690/8694 Sweep Oscillator)
2. HP Model 938A Frequency Doubler Set
3. HP Model MX292B M-to-X Adapter
4. HP 11504A Flexguide
5. K-band Waveguide

Figure 2. Using HP Model 938A Frequency Doubler Set to Obtain Modulated K-Band Signals

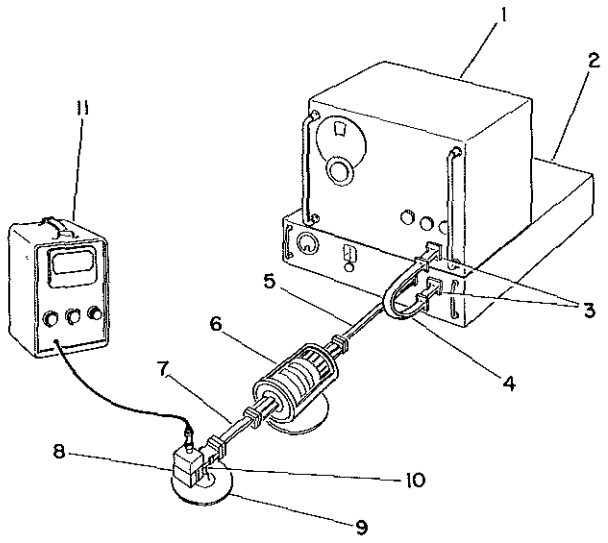
* The filter in the Models 938A, 940A passes the second harmonic of the input frequency, rejects the fourth harmonic and most of the third.

The stop band in the Model 938A is from 31 to 80 GHz; when using the low end of the band, 18 to 20.6 GHz (input to 938A of 9-10.3 GHz) the presence of third harmonics may make it necessary to use a filter with a 27- to 30.9-GHz stop band.

The stop band in the Model 940A is from 46 to 120 GHz; when using the low end of the band, 26.5 to 30.6 GHz (input to 940A of 13.25 to 15.3 GHz) the presence of third harmonics may make it necessary to use a filter with a 39.75 to 45.9 GHz stop band.

Table 2. K- and R-Band Signal Sources

Frequency Required	Signal Source with Mod Capabilities		Adapter Required		Waveguide Link	Frequency Doubler Set	
	Model	Freq. (GHz)	Model	Qty.		Model	Output Freq. (GHz)
K band	626A	10 - 13.25	MX292B	2	11504A Flexguide	938A	20 - 26.5
	8694B	9 - 12.4	MX292B	1	11504A		18 - 24.8
	8695A	12.4 - 15	MP292B	1	11503A		24.8 - 30
R band	626A	13.25 - 15.5	MP292B NP292A	1 1	11503A Flexguide	940A	26.5 - 31
	628A	15.0 - 20	NP292A	2	11503A		30 - 40
	8695A	13.25 - 18	NP292A	1	11503A		26.5 - 36



1. HP Model 626A SHF Signal Generator (or Model 8690/8695 Sweep Oscillator)
2. HP Model 938A Frequency Doubler Set
3. HP Model MX292B M-to-X Adapter
4. HP 11504A Flexguide
5. K-Band Waveguide
6. HP K382A Variable Attenuator
7. Waveguide filter under test
8. HP Model 422A Crystal Detector and Load Resistor
9. HP Model 24 Waveguide Stand
10. HP Model X25 Waveguide Clamp
11. HP Model 415B/E Standing Wave Indicator

Figure 3. Typical K-Band Setup for Measuring Insertion Loss

8. MEASUREMENT OF RELATIVE POWER LEVELS.

9. GENERAL.

10. When sensitivity is important, the Model 422A is also useful for relative power measurements such as measuring insertion loss or monitoring power level where the power is sampled with a directional coupler. A typical K-band setup for measuring insertion loss is shown in Figure 3. Device under measurement is a waveguide filter. The reference reading is made with the filter out of the line and the Model K382A Variable Attenuator set for at least 10 dB; the setting of the attenuator as well as the reading of the Model 415B/E are noted. Then the filter is inserted in the line and the attenuator adjusted to again obtain the reference reading on the Model 415B/E. Difference between the first and second settings of the attenuator is the insertion loss of the filter. Characteristics required of equipment used in a setup like that shown in Figure 3 are discussed below.

11. EQUIPMENT CONSIDERATIONS.

12. INDICATOR. For applications where signal level is low it is convenient to use an indicator such as the HP Model 415B/E Standing Wave Indicator which is a high-gain voltmeter with square-law calibration. Maximum sensitivity is obtained from the Model 422A by setting the Model 415B/E input selector switch at the XTAL 200K Ω position.

13. SIGNAL SOURCE. Since the Model 415B/E is an audio device, the RF must be modulated at the rate of the frequency to which the Model 415B/E input filter is tuned; generally this is 1 kHz. Thus the signal source must have either an internal source of modulating voltage or an input for modulating voltage. Signal sources such as those discussed in Paragraph 7 are suitable.

14. For most measurements, level of the signal into the Model 422A should be low enough that crystal response is in the square-law range (see Figure 4). With RF input signals of −18 dBm (peak) or less, error due to deviation from square-law typically will be less than a half dB when the Model 422A is operated with its selected Load Resistor. With RF input signals of about −18 dBm to −3 dBm, and loading resistor attached, error due to deviation from square-law will be no higher than ±1 dB.

(1) As a precaution against operating the crystal outside the square-law region, use only the 30, 40, 50, or 60 ranges of the Model 415B/E.

(2) The level of the RF into the Model 422A can be determined approximately from reading the Model 415B/E. With the input selector at XTAL 200K Ω, 3 mV into the Model 415B/E will give a reading of at least 0 on the 30 range.

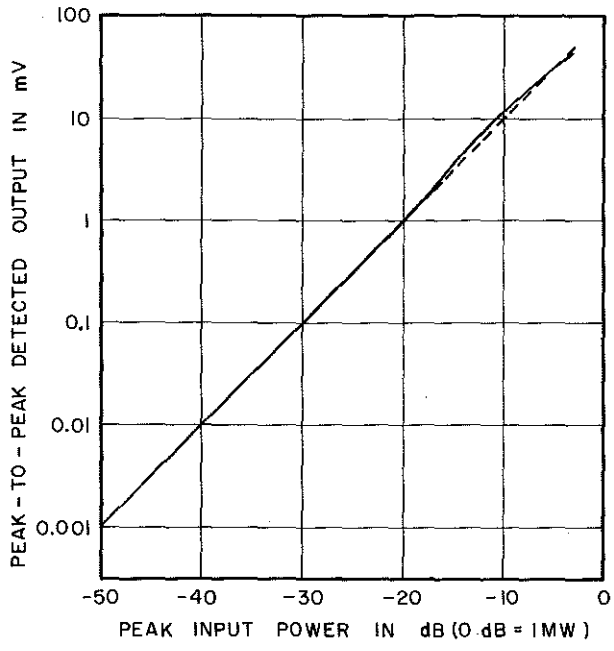


Figure 4. Square-Law Characteristics at 20°C of Typical 422A Crystal

(3) The following typical Model 415B reading can be used as a rough guide to determine whether the signal into the Model 422A is low enough to operate the crystal within its square-law range. The reading was made with the Load Resistor installed in the Model 422A, the Model 415B/E GAIN control set at maximum (full clockwise), and the input selector at XTAL 200K Ω. With a RF signal of −23 dBm into the Model 422A, the Model 415B/E indicated approximately 2 on the 40 range.

15. ATTENUATOR. A variable precision attenuator, such as the Model 382A attenuator, is required for the measurement method briefly described in Paragraph 10. To reduce error due to source mismatch, connect the attenuator between source and system and set the attenuator for at least 10 dB.

16. HARMONIC FREQUENCY-COMPARISON MEASUREMENTS.

17. The Model 422A is suitable for use as a mixer in harmonic frequency-comparison measurements. (See HP Application Note 2.)

SECTION III
CIRCUIT

18. Arrangement of the Model 422A and equivalent circuit is indicated in Figure 5. The crystal may be considered as a voltage generator with an internal resistance of from approximately 3K to 20K ohms and a shunt capacitance of approximately 3 pF. The Load Resistor is selected to obtain the maximum range of square-law operation with inputs of up to half a milliwatt average.

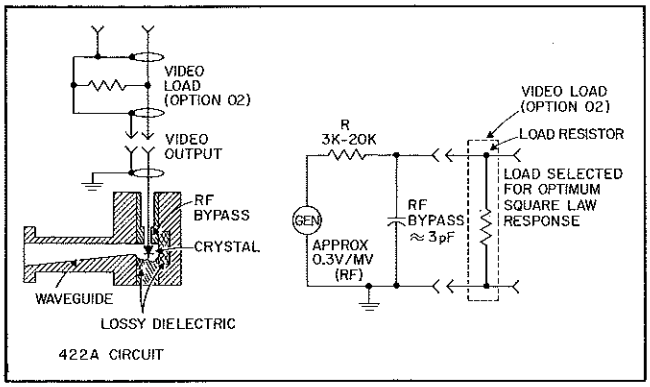


Figure 5. Arrangement of 422A and Equivalent Circuit

SECTION IV
MAINTENANCE

19. PREVENTIVE MAINTENANCE.

20. Protect the face of the coupling flange from damage. Any scoring or burring of the mating surfaces causes discontinuity. The resulting increase in SWR degrades performance.

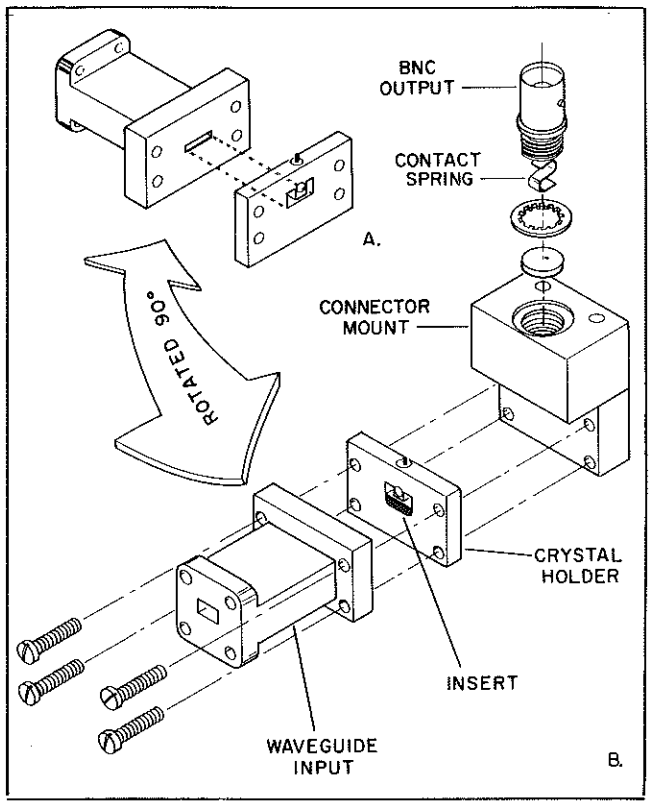


Figure 6. Exploded View of Model 422A Crystal Detector

21. REPLACEMENT OF PARTS.

22. Procedure for replacing the BNC connector on the detector mount is covered in Paragraph 24, and replacing those on the Load Resistor in Paragraph 27. For additional maintenance information contact the Hewlett-Packard Company of your local HP field office.

23. Stock numbers for replaceable parts are given in Table 3, Section V.

24. REPLACING BNC CONNECTOR.

25. TOOLS REQUIRED.

a. Needle-point soldering iron

b. Wire cutters

c. Flat file, #4

d. Tweezers.

26. PROCEDURE. Parts mentioned in the following procedure are identified in Figures 6 and 7.

a. Remove BNC connector; type UG-88/U mating male connector may be used to loosen the female.

b. Unsolder contact spring soldered to center conductor lead.

c. Prepare replacement BNC connector:
(1) Cut center conductor lead to approximately 1/32 inch (see Figure 7.)

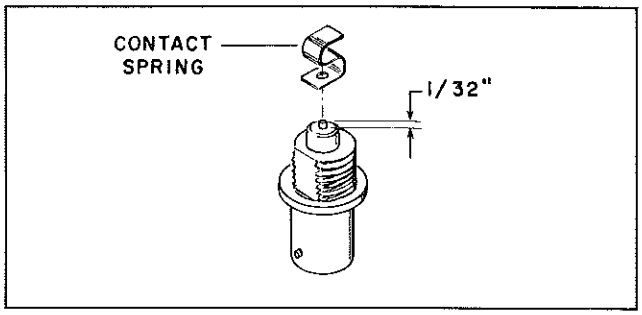


Figure 7. Cutting BNC Connector Center Conductor Lead to Accommodate Contact Spring

(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. CAUTION: Use solder sparingly or it will creep back on spring. Solder on spring destroys its usefulness, and solder is diffucult to remove from spring.

e. Let spring cool, and then screw the connector into the mount.

f. CHECKING. After the new BNC is installed, check for alignment of the leaf spring and crystal lead by measuring the resistance across the BNC connector.

CAUTION

Use a low-current ohmmeter such as the HP Model 410B.

(1) Set the ohmmeter for the RX100 or higher range. Connect one ohmmeter lead to the BNC center conductor and the other to the BNC shell.

(2) Take a reading. Reverse the leads and take another reading.

(a) Normal. There will be a reading of a few hundred ohms in one direction and tens of thousands of ohms in the other.

(b) No reading. The leaf spring is not making contact with the crystal lead. Remove the BNC connector (a mating male connector may be used to loosen the female), stretch the leaf spring, reinstall the BNC, and again measure the resistance.

(c) Low reading. If the reading is very low, the leaf spring probably is touching the side of the mount. Remove the BNC, adjust the spring so it will center in the opening, reinstall the BNC, and again measure the resistance.

27. REPLACEMENT OF BNC CONNECTORS.

28. Parts referred to in the following procedures are identified in Figures 7 and 8.

29. REPLACING MALE BNC CONNECTOR.

a. Remove male BNC connector from housing. To remove BNC use a 3/8-inch open-end wrench and hold the housing either in a vise or with gas pliers. Before putting pliers on protect the housing of the Load Resistor with material such as heavy paper.

b. Unsolder resistor.

c. Solder resistor to new BNC.

d. Let resistor cool and then check resistance from male BNC pin through resistor.

e. Replace lockwasher and male BNC.

30. REPLACING FEMALE BNC CONNECTOR. To remove and install a BNC connector use a BNC wrench or use a male BNC connector as a wrench.

a. Remove 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.

CAUTION

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

e. Let contact spring cool, and then screw the connector into the mount.

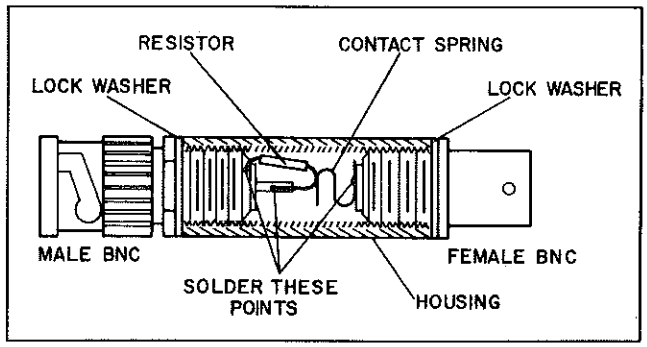


Figure 8. Load Resistor, Cutaway View

31. REPLACEMENT OF CRYSTAL HOLDER

32. Parts referred to in the following procedure are identified in Figure 6. To replace the crystal holder, proceed as follows:

a. Remove the four screws from the waveguide input section.

b. Remove waveguide input section.

c. Remove the crystal holder.

d. Check that the contact to the BNC connector center conductor is bright and clean. If not, burnish with fine sandpaper and wipe clean with cloth.

e. Install the new crystal holder with the polyiron insert facing toward the waveguide input.

f. Replace waveguide input section and secure with the four screws.

SECTION V
REPLACEABLE PARTS

33. INTRODUCTION

34. This section contains information on ordering replacement parts for the Model 422A and Load Resistor. In addition to identifying the part, Table 3 lists the manufacturer's name and the total quantity (TQ) used in the instrument.

35. ORDERING INFORMATION

36. To order a replacement part, address order or inquiry either to your nearest Hewlett-Packard field office (see lists on following page) or to

CUSTOMER SERVICE CENTER
Hewlett-Packard Company
333 Logue Ave.
Mt. View, California 94040

or, in Western Europe, to

HP GmbH
Technisches Buero Boblingen
Herrenbergerstrasse 110
D-7030 Boblingen, Wurttemberg

37. Specify the following for each part:

a. Model and serial number of the device.

b. HP Part number, and Check Digit (CD).

c. Description.

38. To order a part not listed in Table 3, give a complete description of the part.

Table 3. Replaceable Parts, Model 422A and Load Resistor

Description	HP Part Number					
	K422A	CD	R422A	CD	Load Resistor	CD
Crystal Kit (Loaded)	00422-60005	7	00422-60007	9		
Crystal Kit (Matched pair with square-law load)	00422-60006	8	00422-60008	0		
Polyiron Disk	00422-20004	2	00422-20004	2		
Connector, male BNC, includes rubber ring					1250-0045	5
Connector, female, BNC, includes lockwasher	1250-0083	1	1250-0083	1	1250-0251	5
Spring, contact	5000-0234	9	5000-0234	1	5000-0234	9
Screw, 4-40 x 5/8 fillister, stainless steel	4 (TQ)		4 (TQ)			

TQ = Total quantity used in instrument

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

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

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

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

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MANUAL PART NO. 00422-90009
Microfiche Part No. 00422-90011

Printed in U.S.A.