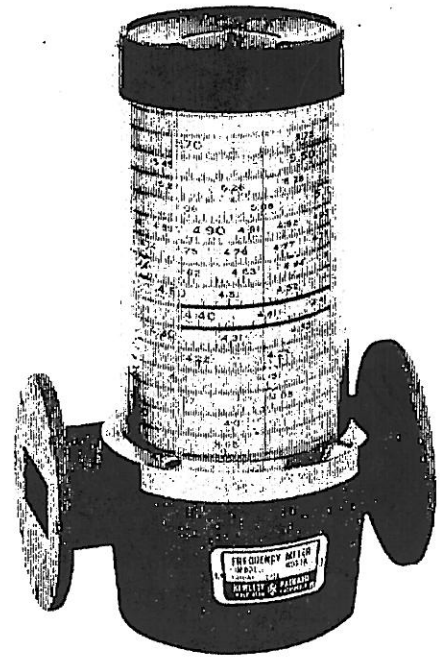


OPERATING AND SERVICE MANUAL

# 532A/B

## DIRECT-READING FREQUENCY METERS



OCTOBER 1980

 **HEWLETT  
PACKARD**

Table 1. Specifications

Model	G532A	J532A1	H532A	X532B	M532A	P532A	K532A5	R532A5
Frequency Range (GHz)	3.95-5.85	5.3-8.2	7.0-10	8.2-12.4	10-15	12.4-18	18-26.5	26.5-40
Overall Accuracy <sup>2</sup>	0.065%	0.065%	0.075%	0.08%	0.085%	0.10%	0.11%	0.12%
Calibration Increments	1 MHz	2 MHz	2 MHz	5 MHz	5 MHz	5 MHz	10 MHz	10 MHz
Scale Length in. (mm)	155 (3937)	140 (3556)	125 (3145)	77 (1956)	74 (1880)	75 (1905)	72 (1829)	75 (1905)
Dial Accuracy <sup>3</sup>	0.033%	0.033%	0.040%	0.050%	0.053%	0.068%	0.077%	0.083%
Fits Waveguide (in.) (EIA)	2 x 1 WR187	1-1/2 x 3/4 WR137	1-1/4 x 5/8 WR112	1 x 1/2 WR90	.850 x .475 WR75	.702 x .391 WR62	1/2 x 1/4 WR42	.360 x .220 WR28
Equip Flange	UG-407/U	UG-441/U	UG-138/U	UG-39/U	Cover	UG-419/U	UG-595/U	UG-599/U
Max Temp Coef %/°C	0.0012	0.0012	0.0015	0.0010	0.0012	0.0012	0.0013	0.0017
Size, in., (mm) Length Height Depth	6-1/4 (159) 9-1/2 (241) 5 (127)	6-1/4 (159) 9-1/8 (232) 5-1/2 (114)	6-1/4 (159) 8 (203) 4-3/8 (111)	4-1/2 (114) 6-1/8 (156) 2-7/8 (73)	4-1/2 (114) 6-1/4 (159) 2-3/4 (70)	4-1/2 (114) 6-1/4 (159) 2-3/4 (70)	4-1/2 (114) <sup>4</sup> 5-3/8 (137) 2-7/8 (73)	4-1/2 (114) <sup>4</sup> 5-1/2 (140) 2-3/4 (70)
Net Weight lb, (kg)	9-1/2 (4, 1)	7-1/2 (3, 4)	6 (2, 7)	3-1/2 (1, 6)	3-1/2 (1, 6)	3 (1, 4)	1-1/2 (0, 7)	1-1/2 (0, 7)

FOR ALL MODELS

DIP AT RESONANCE: 1 dB or more  
MINIMUM CALIBRATION SPACING: 1/32 inch

- <sup>1</sup> Because of the wide frequency range of the J532A, frequencies from 7.6 to 8.2 GHz can excite the TE<sub>112</sub> mode when the dial is set between 5.3 and 5.6 GHz.
- <sup>2</sup> Includes dial accuracy, 20 °C temperature variation (23 ° ±10 °C) and 0.02% for 0 to 100% relative humidity.
- <sup>3</sup> Includes mechanical tolerances and backlash.
- <sup>4</sup> With circular flange adapter, 5-5/16" (135 mm).
- <sup>5</sup> Circular flange adapters available: specify HP 11515A (UG-425/U) for "K" band; HP 11516A (UG-381/U) for "R" band.

## 1. DESCRIPTION.

2. The Model 532A/B direct-reading frequency meters offer good accuracy over an entire waveguide band. The meter consists of a TE<sub>111</sub> mode resonant cavity coupled to a waveguide section. When tuned to resonance, a fraction of the power is absorbed, and consequently there is a dip of about 1 dB in the transmitted power. The frequency at which this dip occurs may be read directly from the scale.

3. A long spiral scale, with small calibration increments and well-separated marks, provide the high resolution needed for measuring small frequency differences. Even at the high frequency end of each meter, minimum spacing of the calibration marks is 1/32 of an inch. The spiral scale is enclosed in a transparent cylinder so that the entire scale is always visible. The portion of the band that contains the frequency to which the meter is tuned is clearly marked by horizontal red cursor lines.

4. The high-Q resonant cavity is tuned by a choke plunger. Adjustment of the plunger is by means of a precision lead screw which is spring-loaded to prevent backlash. There are no sliding contacts. The base of the 532A/B will accommodate the shaft of a waveguide stand such as the HP Model 11540A.

5. Complete specifications for each Model 532A/B are given in Table 1.

## 6. UNPACKING AND INSPECTION.

7. Inspect the frequency meter for mechanical damage incurred in transit, and test electrical performance. If there is damage or deficiency, notify the carrier and the nearest Hewlett-Packard office. In the event of mechanical damage, the packing materials and carton should be held for carrier's inspection.

## 8. REPACKAGING FOR SHIPMENT.

### 9. USING ORIGINAL PACKAGING.

10. The same type containers and materials used in factory packaging can be obtained through the Hewlett-Packard sales and service offices listed at the rear of this manual.

11. If the Model 532A/B is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number and full serial number. Also, mark the container FRAGILE to assure careful handling. In any correspondence refer to the instrument by model number and full serial number.

### 12. USING OTHER PACKAGING.

13. The following general instructions should be used for repackaging with commercially-available materials:

a. Wrap the frequency meter in heavy paper or plastic. (If shipping to a Hewlett-Packard service office or center, attach a tag indicating the type of service required, return address, model number, and full serial number.)

b. Use a strong shipping container. A double-wall carton made of 350 pound test material is adequate.

c. Use enough shock-absorbing material (3- to 4-inch layer) around all sides of the frequency meter to provide firm cushion and prevent movement inside the container. Protect the dial with cardboard.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

## 14. OPERATION.

### 15. OPERATING PRECAUTIONS.

16. When making initial equipment setup, align the flanges carefully with connecting equipment to reduce reflections due to flange mating. Scoring or burring of the mating surfaces may increase reflections; therefore, keep flange covers on when frequency meter is not in use to protect flanges from damage and to prevent foreign matter from entering the cavity.

17. Maximum power limitations are 0.7 of the power handling capability for equivalent waveguide.

### 18. OPERATING INSTRUCTIONS.

19. Insert the frequency meter in the equipment setup so that the RF energy passes through the meter. The frequency meter should be isolated from the signal source to prevent frequency pulling when the meter is tuned to resonance. The RF energy must be detected and the detected signal applied to an indicator. When the frequency meter is tuned to the RF input frequency, power is absorbed by the meter and a power dip of about 1 dB will occur in the detected signal.

20. For single frequency measurements the detector meter combination (shown in Figure 1) can be either a thermistor and power meter such as the HP Model 486 Thermistor Mount and 432 Power Meter or detector and high-gain voltmeter such as the HP Model 424 Detector and 415 VSWR Meter. Either a crystal or barretter can be used with the 415. The RF source must be modulated with 1000 Hz square-wave when the 415 is used as the indicator. Tune frequency meter for the point of maximum dip on the indicator, and read frequency meter dial by observing the indication under the black vertical line between the two horizontal red cursor lines.

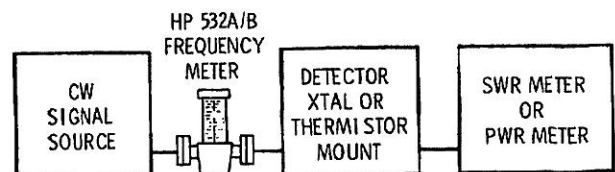


Figure 1. Typical Frequency-Measuring Setup

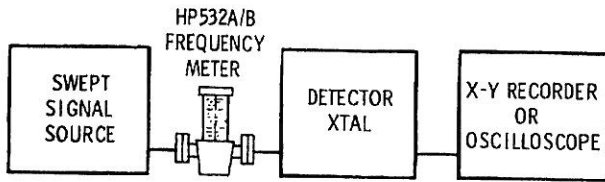


Figure 2. Simplified Swept-Frequency Setup

21. For swept-frequency measurements (see Figure 2) the detector is normally a crystal and the indicator an oscilloscope or X-Y recorder. When the frequency meter is tuned to a frequency included in the swept frequency band displayed on the oscilloscope or X-Y trace. To determine the frequency, adjust the frequency meter to place the dip at any point on the displayed trace. Then read the frequency meter dial by observing the indication under the black vertical line between the two horizontal red cursor lines. The frequency axis of the swept display can be calibrated by setting the frequency meter to a given frequency. A dip will then occur in the displayed trace corresponding to the frequency meter setting.

**22. MAINTENANCE.**

23. The Model 532A/B frequency meters require no maintenance. The frequency meters are not normally field repairable; therefore, if the meter is damaged or does not meet specifications return it to a Hewlett-Packard repair center or contact your nearest Hewlett-Packard office.

**24. PERFORMANCE TEST.**

**25. TEST EQUIPMENT REQUIRED.**

26. The test instruments and accessories required to make the performance checks are listed in Table 2. Test instruments other than the ones listed can be used provided their performance equals or exceeds the Critical Specifications listed.

**27. PROCEDURES.**

28. The procedures in Figure 3 check the Model 532A/B performance for incoming inspection and periodic evaluation. The specifications of Table 1 are the performance standards. Table 3 is a performance test record. This may be used during the test to record the test values obtained. This provides a permanent record of the test values for use at a later time during calibration or periodic evaluation.

Table 2. Test Card

Hewlett-Packard Model 532A/B	Date _____
Frequency Meter	Tested by _____
<b>OVERALL ACCURACY</b>	
Maximum Dial Error _____ %	Specification _____ %
<b>POWER DIP AT RESONANCE</b>	
High End of Band _____ dB	Specifications $\geq 1$ dB
Center of Band _____ dB	Specifications $\geq 1$ dB
Low End of Band _____ dB	Specifications $\geq 1$ dB

Table 3. Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model
Equipment required for all frequency bands <sup>1</sup>		
Sweep Oscillator <sup>2</sup>	Frequency: To cover the range of 532A/B under test Power: $\geq 1$ mW into 50 ohms Sweep Out: dc voltage proportional to output frequency	HP 8620 Mainframe with HP 86290 Series plug-in
Transfer Oscillator	Fundamental Frequency: Variable from 195 to 205 MHz	HP 540B
Electronic Counter	Frequency Range: 195 to 205 MHz Accuracy: $\geq 0.0001\%$	HP 5245L/5253B
Oscilloscope	Vertical Input: Minimum Sensitivity: $200 \mu\text{V}/\text{cm}$ Bandwidth: 40 kHz <sup>3</sup> Horiz Input: Compatible with sweep oscillator sweep output	HP 1200B
Power Meter and Thermistor Mount	Frequency: To cover the range of 532A/B under test Instrument Accuracy: $\pm 3\%$ Power Range: 0 to -20 dBm	HP 432A (Meter) and HP 486A (Mount)
Low-Pass Filter	Passband: To cover the range of 532A/B under test	G-band Microphase <sup>5</sup> LTP 6000 J-band Microphase LTP 8200 H-band Microphase LTP 10500 X-band HP X362A P-band HP P362A K-band HP K362A R-band HP R362A
Isolator	Frequency: To cover the range of 532A/B under test Isolation: $\geq 20$ dB	G-band Ferrotec <sup>4</sup> I-152L J-band Ferrotec I-153L H-band Ferrotec I-154L X-band Ferrotec I-155L P-band Ferrotec I-156L K-band Ferrotec I-157L R-band Ferrotec I-158L
Attenuator	Frequency: To cover the range of 532A/B under test Attenuation: Continuously variable to 20 dB	HP G382A/J382A/H382A/ X375A/P375A/K382A/R382A
Directional Coupler	Frequency: To cover the range of 532A/B under test Coupling: 3 dB (10 dB for K and R bands)	HP 752A HP 752C (for K and R bands)
Crystal Detector	Minimum Sensitivity: $0.3 \text{ mV}/\mu\text{W}$	HP G424A/J424A/H424A X424A/P424A/K422A/R422A

<sup>1</sup>For M532A from 10 to 12.4 GHz, use equipment for X band plus (2) X to M adapters (HP MX272B) and from 12.4 to 15 GHz, use equipment for P band plus (2) P to M adapters (HP MP292B).

<sup>2</sup>Power Leveling may be used for a more convenient oscilloscope display; however, if the sweep oscillator does not have internal leveling, additional equipment is required to provide for external leveling.

<sup>3</sup>For oscilloscopes with greater bandwidth, connect a 40-kHz low pass filter to vertical input.

<sup>4</sup>Ferrotec Inc., 217 California St., Newton, Mass.

<sup>5</sup>Microphase 35 River Rd., Cos Cob, Conn.

Table 3. Recommended Test Equipment (Contd)

Instrument	Critical Specifications	Recommended Model
Additional equipment required for G, J, H, and X bands only		
Adapter Coax to Waveguide (2 required)	Frequency: To cover the range of 532A/B under test SWR: less than 1.25	HP 281A or 281B Option 13
Additional equipment required for P band only		
Mixer	Frequency Range: To cover the range of 532A/B under test Min. Video Output: 0.4 mV with 0 dBm input	HP P932A
Additional equipment required for K and R bands only		
Mixer	Frequency: To cover the range of 532A/B under test	HP 11517A
Adapter or Transition	Adapter from waveguide of direc- tional coupler to HP 11517A Mixer	HP 11519A HP 11520A
Adapter (UG-201 A/U)	BNC female to Type N male	UG-201 A/U HP Part No. 1250-0780
Microwave Amplifier	Frequency Range: 2-4 GHz Output Power: 50mW	HP 491C

**FIGURE 3. PERFORMANCE TEST**

**1. Overall Accuracy**

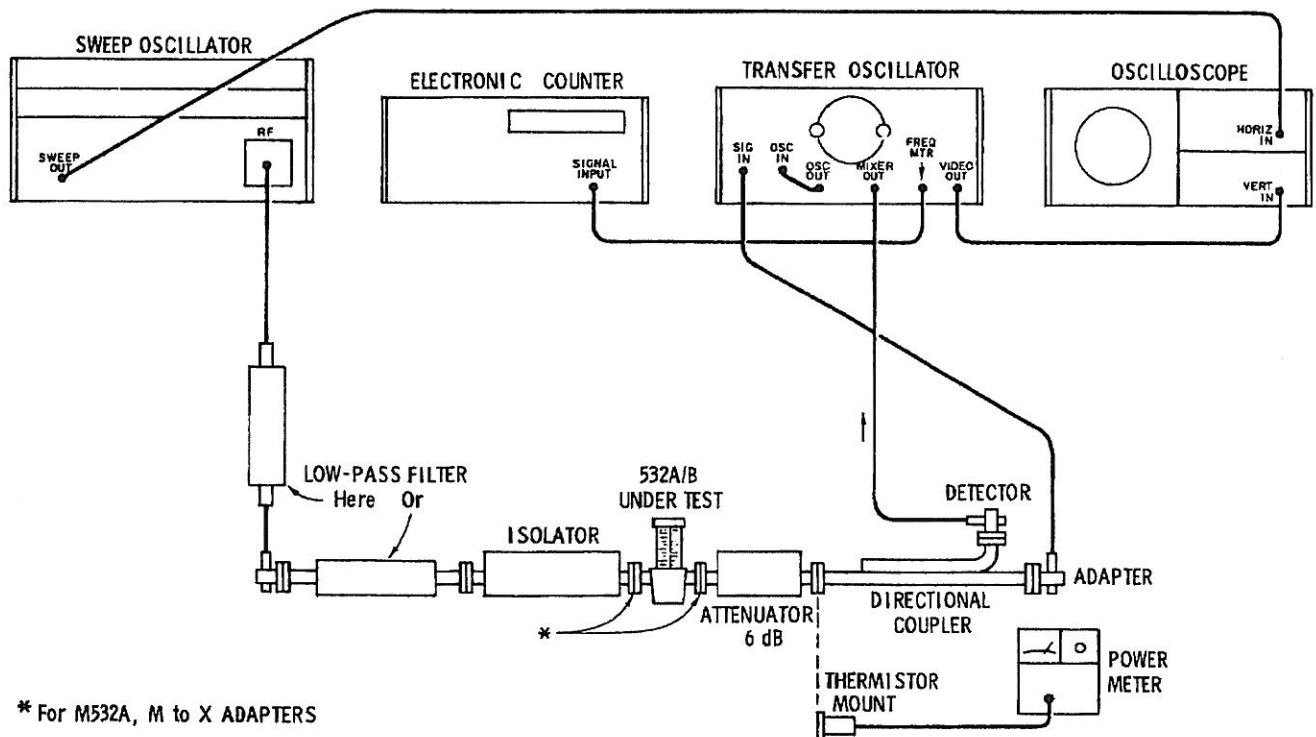
**SPECIFICATION:**

G532A, 0.065%	M532A, 0.085%
J532A, 0.065%	P532A, 0.10%
H532A, 0.075%	K532A, 0.11%
X532B, 0.08%	R532A, 0.12%

**DESCRIPTION:**

The 532A/B frequency meter dial is set to a multiple of 200 MHz. The sweep oscillator is set to sweep across the frequency setting of the 532A/B. With the transfer oscillator frequency set to approximately 200 MHz, the sweep oscillator signal and transfer oscillator signal mix and a beat note marker or birdie occurs at each harmonic of the transfer oscillator frequency. The detected output signal displayed on an oscilloscope shows the frequency meter's absorption dip and the marker birdies. A marker birdie is placed at the center of the absorption dip. Because the transfer oscillator frequency is related to the frequency of the absorption dip by some harmonic number, percent of error is determined from the difference between the transfer oscillator frequency with zero error (200 MHz) and the actual transfer oscillator frequency.

**TEST SETUP:**

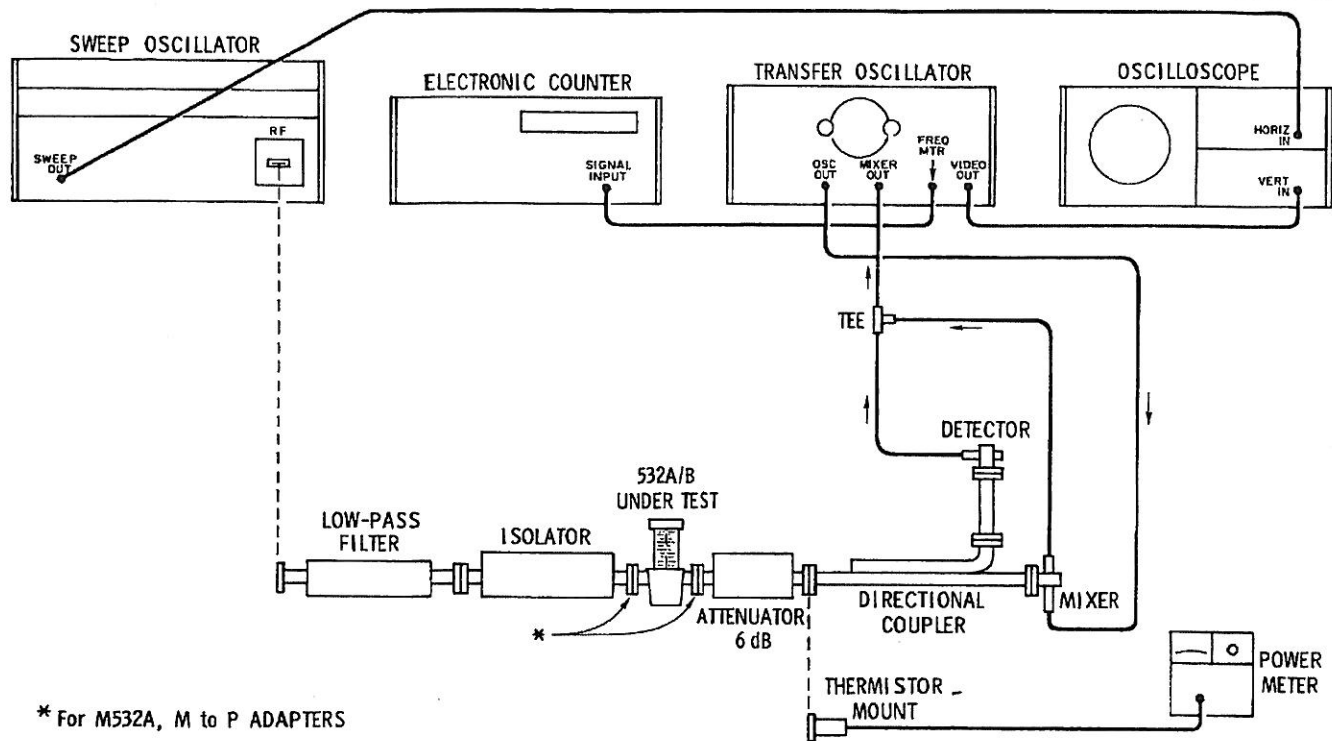


\* For M532A, M to X ADAPTERS

3.95 to 12.4 GHz (G, J, H, X, and M band 10 to 12.4 GHz)

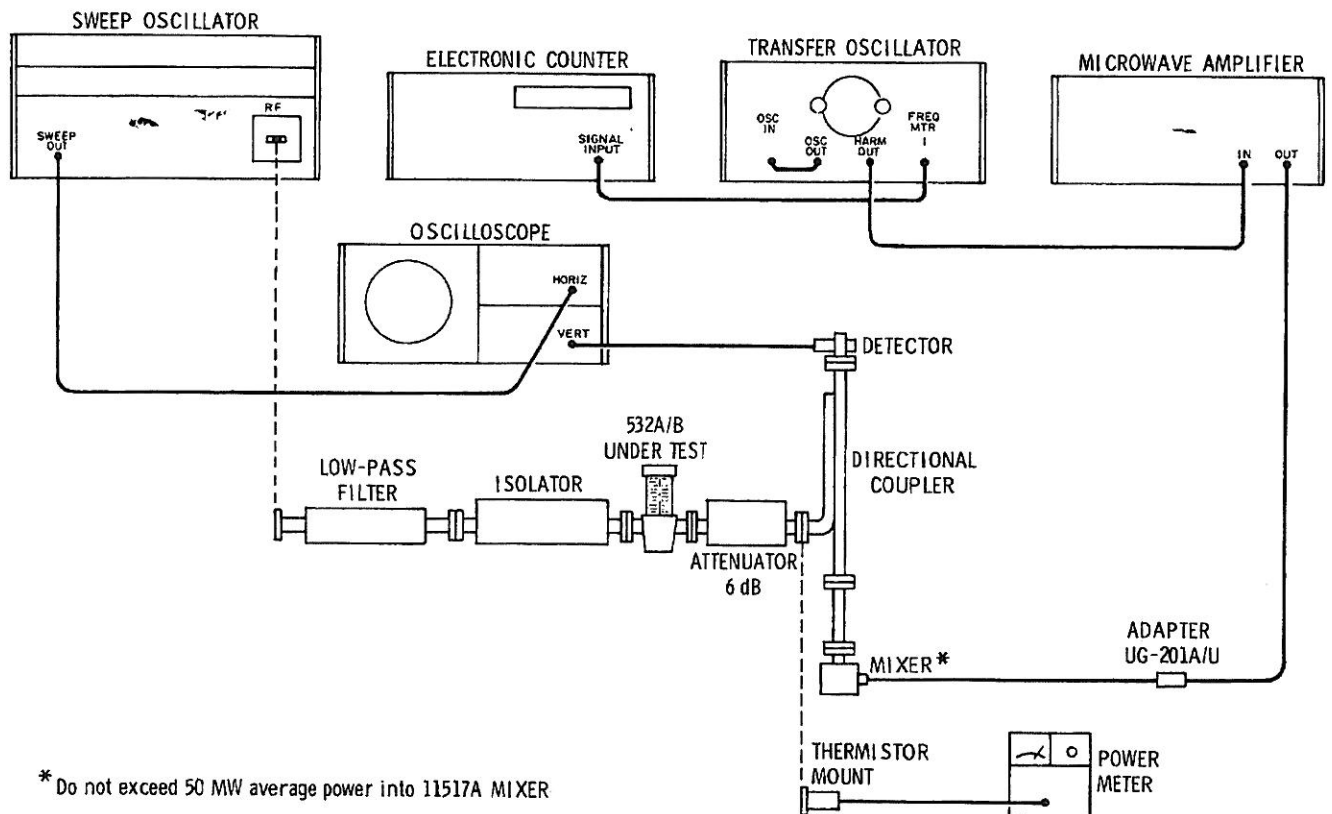
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FIGURE 3. PERFORMANCE TEST



\* For M532A, M to P ADAPTERS

12.4 to 18 GHz (P-band and M-band 12.4 to 15 GHz)



\* Do not exceed 50 MW average power into 11517A MIXER

18 to 40 GHz (K and R band)

(Continued)



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**FIGURE 3. PERFORMANCE TEST**


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**PROCEDURE:**

- a. Select test setup for appropriate frequency range, and connect equipment as shown.

**CAUTION**

Before connecting the microwave amplifier output to the 11517A Mixer, measure the microwave amplifier average output power and adjust for 50 mW (+17 dBm).

- b. Turn ON the sweep oscillator, transfer oscillator, electronic counter, and oscilloscope. Allow 30 minutes for warmup.
- c. Set the sweep oscillator for automatic sweep, leveled RF output,  $\Delta F$  operation, and sweep width of 100 to 200 MHz. Adjust  $\Delta F$  center frequency so that sweep width brackets the lowest frequency in the frequency meter's band.
- d. Set the transfer oscillator frequency to 200 MHz. Beat note markers or birdies will occur at multiples of the transfer oscillator frequency<sup>1</sup> (see Waveform A).
- e. Adjust the sweep oscillator  $\Delta F$  center frequency to display the lowest frequency birdie at the center of the oscilloscope CRT.
- f. Set the 532A/B under test to the lowest frequency which is a multiple of 200 MHz. Reduce the Sweep Oscillator  $\Delta F$  sweep width to approximately 10 MHz (see Waveform B).
- g. Adjust the transfer oscillator frequency to place a marker birdie at the center of the test 532A/B absorption dip (see Waveforms C, D, and E).
- h. Determine the 532A/B accuracy as follows:
- (1) Measure the transfer oscillator frequency (counter converter frequency of 190 MHz + counter indication).
- $$\text{Percent error} = \frac{\text{Difference between 200 MHz and transfer oscillator frequency}}{2}$$
- EXAMPLE: Transfer oscillator frequency = 200.13 MHz. Percent error is 0.13 divided by 2, or 0.065%.
- (2) The percent error must not exceed the overall accuracy specification.
- i. Increase the 532A/B frequency setting by 200 MHz.
- j. Adjust the sweep oscillator  $\Delta F$  center frequency to place the absorption dip at the center of the oscilloscope CRT.
- k. Adjust the transfer oscillator frequency to place a marker birdie at the center of the absorption dip.
- m. Determine percent error as in step h.
- n. Repeat steps h through m every 200 MHz.

<sup>1</sup>If birdie amplitude is insufficient, check detector sensitivity.

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**FIGURE 3. PERFORMANCE TEST**

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**2. Dip of Resonance**

## SPECIFICATION.

> 1 dB

## DESCRIPTION:

A power meter is connect to the output of the frequency meter. A reference power level is established with the frequency meter tuned off resonance. The frequency meter is tuned for the maximum power dip. The difference in power between the reference level and the level at maximum dip must be 1 dB or greater.

## PROCEDURE:

- a. Switch the sweep oscillator to standby (RF off) and connect power meter thermistor mount as shown in Test 1 equipment setup.
- b. Set the sweep oscillator for single frequency operation at the highest frequency in the band.
- c. Establish a power meter reference level with the frequency meter tuned close to, but not at, the sweep oscillator frequency. Note this reference level.
- d. Tune the frequency meter for the maximum power dip. The difference between the reference level and the level at maximum dip must be 1 dB or greater.
- e. Repeat steps c and d at a sweep oscillator frequency in the center of the band and again at the lowest frequency.

## NOTE

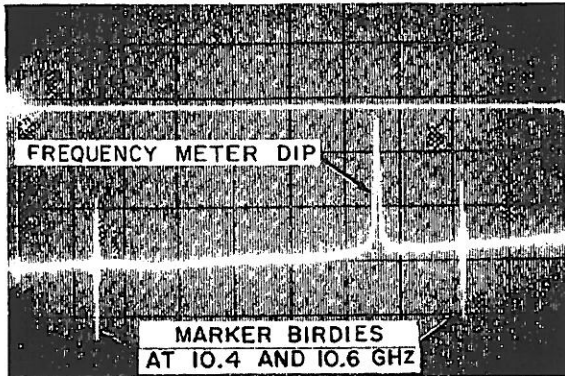
For K532A or R532A repeat steps c and d at 1 GHz intervals across the band.

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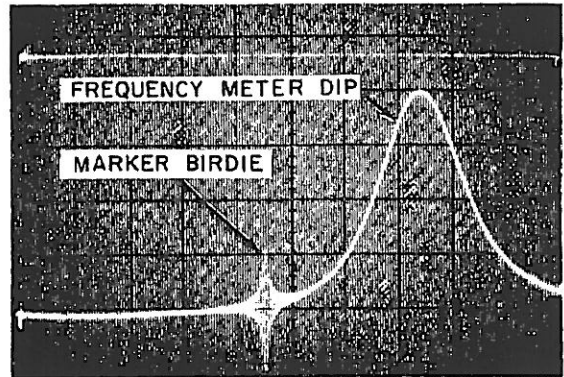
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**FIGURE 3. PERFORMANCE TEST**

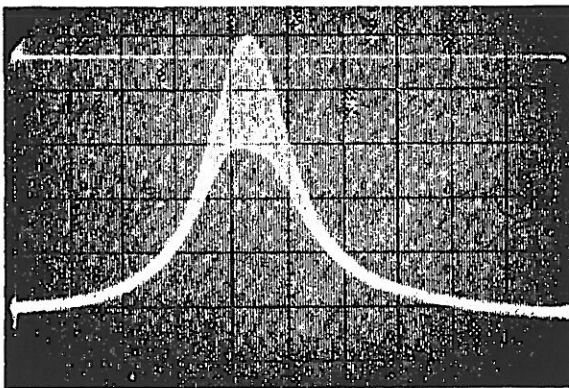
Typical Oscilloscope Waveforms Showing Frequency Meter Power Dip and Marker Birdies.



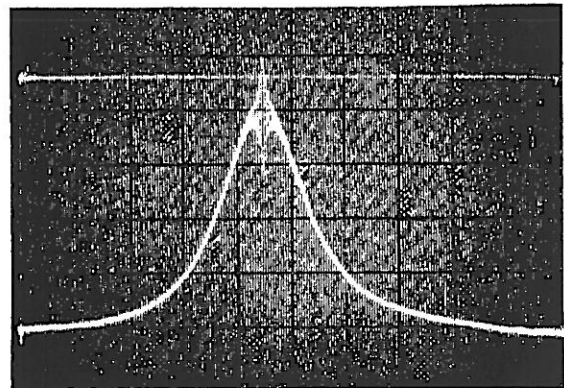
A. Frequency meter dip between two beat note markers or birdies.  $\Delta F$  sweep width = 300 MHz, Vert. Sens. = 1 mV/cm



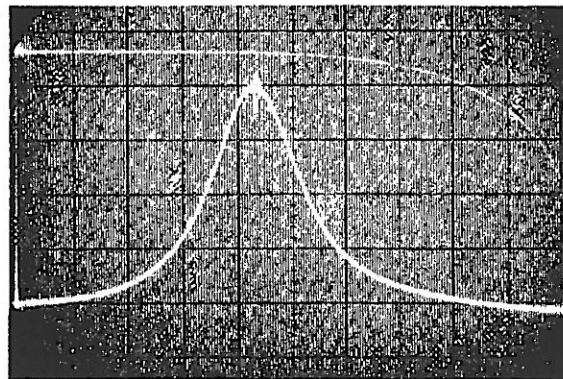
B.  $\Delta F$  sweep width = 10 MHz Reducing the  $\Delta F$  sweep width expands the Frequency Meter's dip for greater resolution



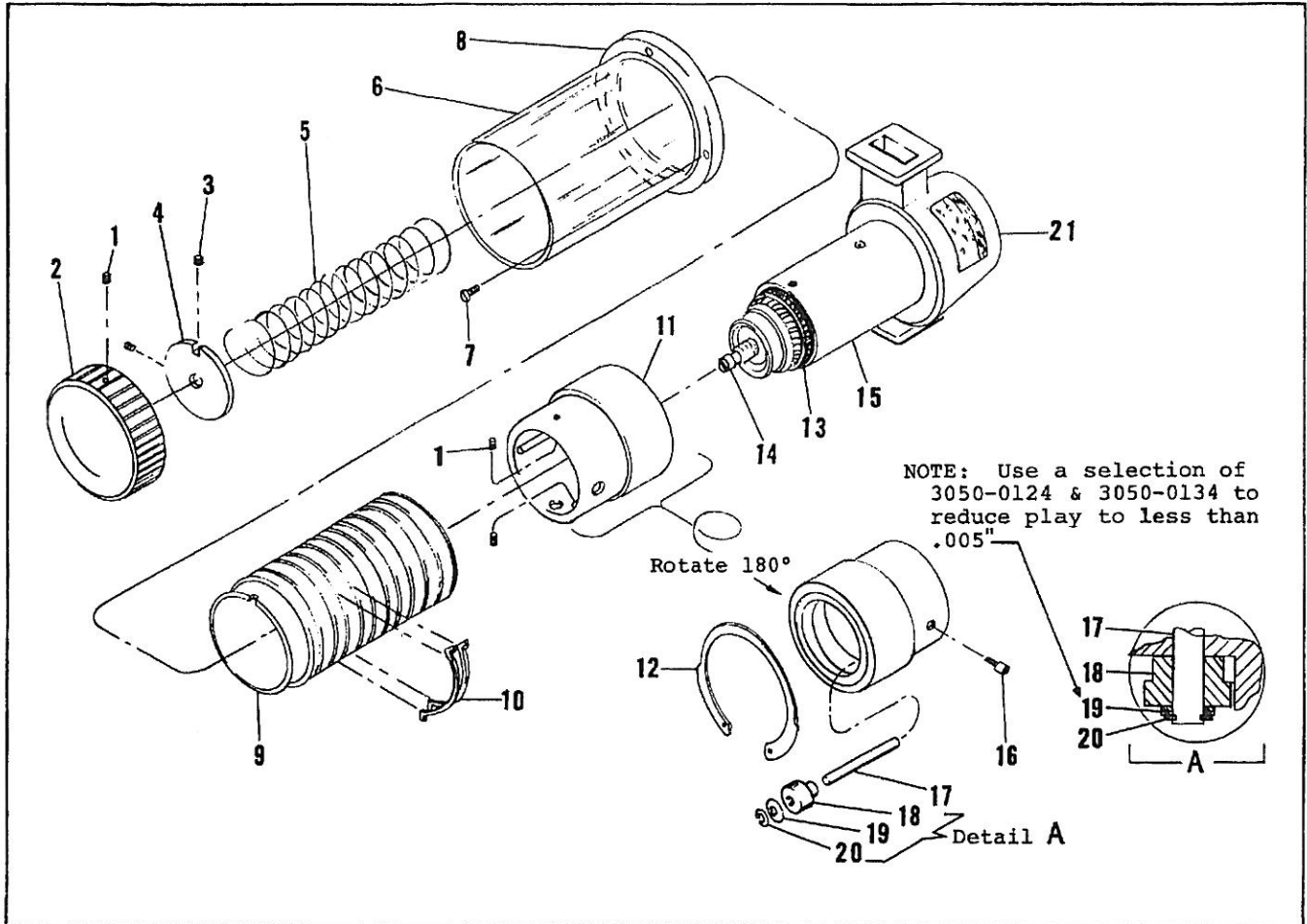
C. Oscilloscope vertical amplifier bandwidth of 400 kHz. Poor resolution



D. Oscilloscope vertical amplifier bandwidth of 40 kHz. Good resolution



E. Oscilloscope vertical amplifier bandwidth reduced to 4 kHz. Note the narrower marker birdie, which results in better resolution



ITEM	QTY.	DESCRIPTION	HP PART NUMBER		
			G532	H532	J532
1		8-32 SCREW SET HEX	3030-0001	-	-
2		KNOB	0370-0082	-	-
3		6-32 x 3/16 SET SCREW	3030-0033	-	-
4		CAP	H532A-16	-	-
5		SPRING	1460-0055	-	-
6		WINDOW	J532A-7	H532A-18	J532A-7
7		4-40 x 1/4 FLAT HD SCREW	2210-0002	-	-
8		RETAINING RING	H532A-20	-	-
9		DIAL	G532A-4	H532A-9	J532A-7
10		CURSOR	H532A-21	-	-
11		DIAL HOLDER	H532A-4	-	-
12		RETAINING RING	0510-0072	-	-
13		BALL BEARING	1410-0026	-	-
14		CHOKE ASSY	G532A-5	H532A-12	J532A-5
15		CAVITY ASSY	G532A-2	H532A-3	J532A-2
16		2-56 x 1/4 FILL HD SCREW	0520-0012	-	-
17		SHAFT	H532A-5	-	-
18		STOP GEAR	P532A-19	-	-
19		WASHER	3050-0134	-	-
20		RETAINING RING	0510-0070	-	-
21		BASE CASTING	G532A-1	H532A-1	J532A-1

Figure 4. Stop Gear Replacement for HP Model G, H, and J532A (Sheet 1 of 3)

The following special tools are required for this procedure. An INDUSTRIAL PLIER #105 modified by bending one inch of tip end 45° and a WALDES TRUARC PLIER #5 modified by bending tips 90°.

Upon completion of the stop gear replacement it will be necessary to check the frequency calibration of the instrument.

#### PROCEDURE:

1. Remove knob (2).
  2. Scribe dial position to give approximate location of dial on dial holder. (Do not use pencil as this may inadvertently erase.)
  3. Unscrew four flat head screws (7) holding window retaining ring (8).
  4. Remove ring and window.
  5. Loosen two #8 Allen set screws (1) holding dial. (These are located inside of dial holder (11).)
  6. Turn dial holder until cap (4) is approximately flush with top of dial holder (near high frequency stop position).
  7. Scribe a line from lead screw on plunger to cap for later alignment.
  8. Loosen both #6 Allen set screws (3) holding cap in place on lead screw. These screws are spaced about 90° apart and access to them is through two inspection holes in the dial holder (11).
  9. While holding cap in place back out both screws sufficiently to allow removal of cap (approximately three full turns of the Allen screw). Dial holder cap is spring loaded; therefore, release tension slowly and remove cap and spring.
- CAUTION**
- DO NOT TURN OR REMOVE PLUNGER.**
10. Turn the 532 upside down and remove the tru Arc retaining ring (12) holding dial holder (11). (This requires special tru-Arc pliers or Industrial #105 pliers.
  11. Lift 532 off dial holder and place base assembly upright again. Examine both sections for pieces of broken stop gear.
  12. Inspect bearing and gear rack to make sure that these haven't been damaged by portions of the broken stop gear. If any of the internal workings other than stop gear have been damaged, return the meter to a Hewlett-Packard repair center.
  13. If gear and bearings look satisfactory, replace small stop gear using the following procedure:
    - a. Remove small C ring (20) holding stop gear. Long nose pliers held at a fixed opening may be used to push the C ring out of the shaft groove.
    - b. Remove washer (19) and broken stop gear (18).
    - c. Replace with new stop gear and position washers as shown in exploded view.
    - d. Replace C ring so that it properly engages the groove of shaft.
    - e. Take excess grease from old gear and shaft (17): use to moderately lubricate new gear.
  14. Replace dial holder taking care not to damage gears when engaging stop gear with gear rack.
  15. Check rotation of the dial holder. There should be approximately 15 turns for G & J band and 12 for H band. If the dial makes less, disengage and try again with a new gear position.
  16. When the stop gear is positioned to give the correct number of turns from stop to stop, secure dial holder with the tru Arc retaining ring. Make sure ring is seated properly on inside groove of dial holder.
  17. Turn dial holder to stop at high frequency end of dial.
  18. Insert spring into dial holder; large diameter end first.
  19. Replace cap by compressing spring. Note alignment of cap and lead screw. See step 6 and 7.
  20. Tighten both #6 Allen set screws holding cap to lead screw.
  21. Turn dial holder counterclockwise (towards lower frequency) to expose dial retaining set screws.
  22. Place dial on dial holder and check alignment with scribe mark of step 2.
  23. Tighten both #8 Allen set screws to hold dial in place.
- CAUTION**
- Do not tighten excessively as knob may not slip into place in the dial/dial holder.

24. Turn dial clockwise near the stop at the high frequency end (high frequency mark should be  $1/3$  turn from stop for G & J band and  $1/5$  turn for H band) and place both cursors into dial grooves to indicate approximately 5.85 for G, 10.0 for H and 8.2 for J band.
25. Carefully replace window and window retaining ring making sure that cursors ride in the window grooves.
26. Align window with base. Window key must be in the base groove.
27. Replace the four screws holding window retaining ring.
28. Turn from stop to stop. Check for binding or other erratic behavior. It may be necessary to make slight adjustments in screw tightness or dial position so that no binding occurs during dial rotation.
29. When assured of smooth operation, check calibration. Calibration should be reasonably close if care was taken in alignment of the cap, lead screw and dial. Replace knob.

## 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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