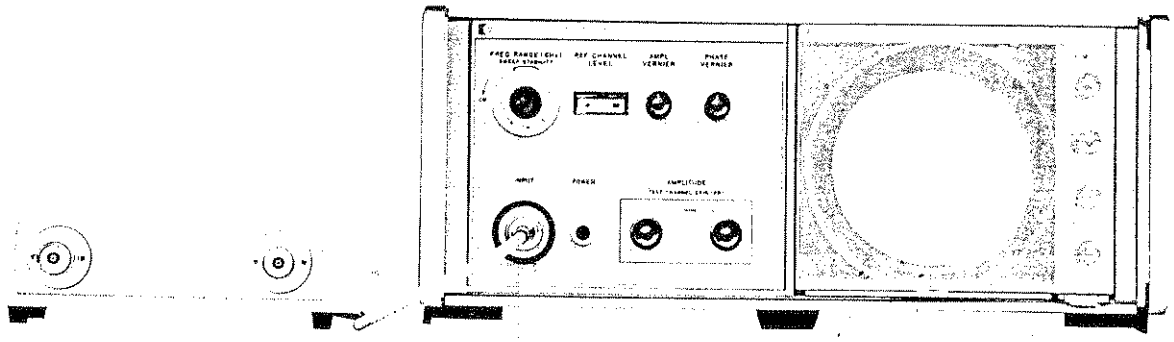
OPERATING MANUAL

NETWORK ANALYZER
8410A

HARMONIC FREQUENCY CONVERTER
8411A



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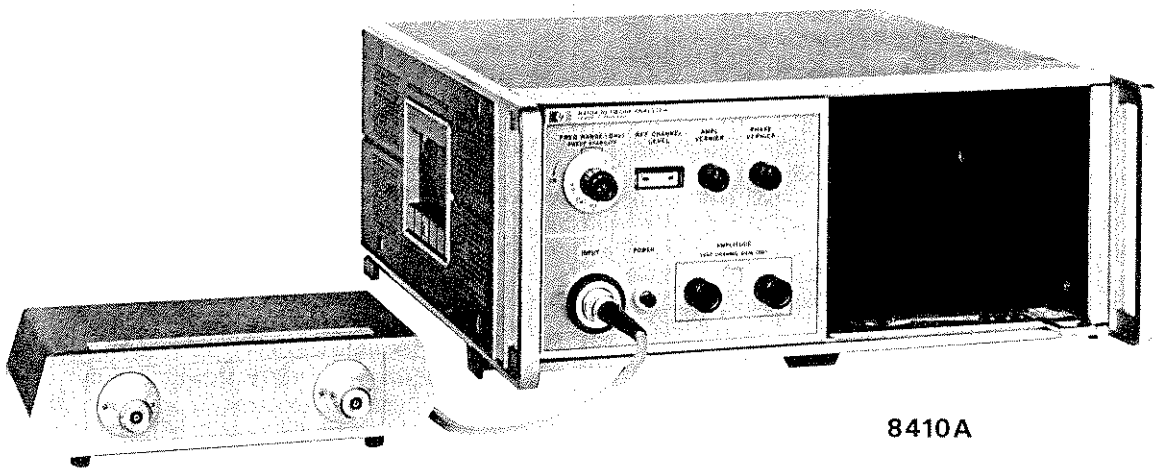
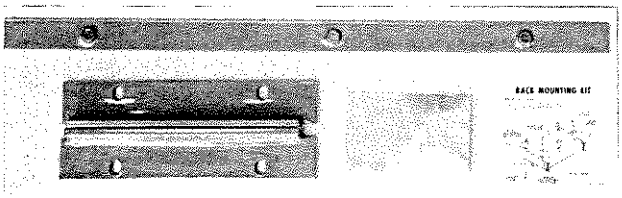
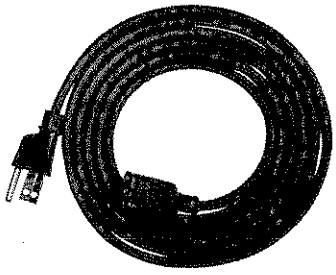


8411A

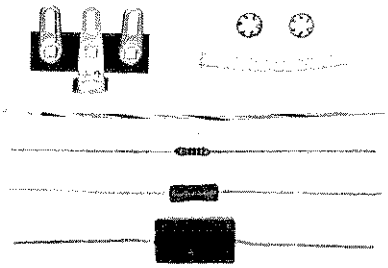
8410A



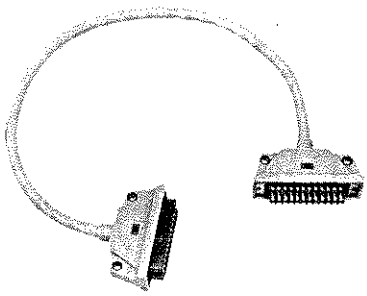
RACK MOUNTING KIT



POWER CABLE



SWEEP OSCILLATOR
HELIX MODIFICATION KIT



SERVICE CABLE

Figure 1-1. Models 8410A, 8411A, and Supplied Accessories

SECTION I

OPERATION

1-1. DESCRIPTION.

1-2. The combination of Model 8410A Network Analyzer, Model 8411A Frequency Converter, and a display unit for the Model 8410A, function as a phasemeter and a ratiometer for direct, continuous, simultaneous phase and amplitude ratio measurement on RF voltages. The complete instrument measures phase angles from 0 to 360° and amplitude ratios in decibels over a dynamic range of 60 dB. These measurements can be made on single frequencies and on swept frequencies in overlapping octave bands from 110 MHz to 12.4 GHz.

1-3. Measurements possible with the network analyzer include: direct determination of scattering (s) parameters; swept-frequency response measurements of phase sensitive systems; analysis of parameters relating to the use of solid state devices in wideband circuits; group delay measurements for communications systems; analysis of phase distortion in filters, amplifiers, and preamplifiers; antenna testing; and performance testing of components of sophisticated radars. Although the network analyzer is intended primarily for wideband coaxial measurements, it can also be used with waveguides within the limits imposed by waveguide bandwidths and the characteristics of waveguide-to-coax adapters.

1-4. The Models 8410A and 8411A convert the two RF signals being measured to two 278-kHz signals that have the same relative amplitudes and phase. The phase and amplitude information provided by the display unit used with the Model 8410A is derived from these 278-kHz signals. External monitoring points for the 278-kHz signals are provided on the Model 8410A. Operating power for the display unit and for the Model 8411A is furnished by the Model 8410A.

1-5. The Model 8411A automatically tracks the frequency of the signal applied to the reference input. This automatic tuning and tracking takes place over the octave frequency band preselected by a front panel control. In addition to the band selector, there is a control that permits the search and hold range of the automatic tuning to be adjusted for best performance with the selected band. For swept-frequency measurements at faster rates, a rear-panel input accepts a sweep reference voltage proportional to the frequency of the input signals. For a discussion of swept signal source requirements, see paragraph 1-55.

1-6. The signal applied to the reference input of he Model 8411A is used as the reference for both phase and amplitude measurements. Since it actuates the automatic tuning, its level is critical. A meter on the Model 8410A continuously monitors the reference channel signal level and indicates whether it is in the range required for making measurements.

1-7. Controls on the Model 8410A include phase and precision step-action amplitude offset controls. The vernier controls are for convenience in setting reference and calibration phase and amplitude indications. The amplitude offset controls allow large amplitude differences to be measured with greater resolution.

1-8. Complete specifications for the Model 8410A/8411A combination are given in Table 1-1. Specifications that include display unit performance are given in the Operating and Service Manuals for the display units.

OPERATING PRECAUTIONS

MAXIMUM RF POWER. Do not apply more than 50 milliwatts of RF power to the Model 8411A inputs. Power in excess of 50 milliwatts may damage the frequency converter units.

MAXIMUM DC ON RF LINE. Steady state (dc) voltage on the inner conductor of the transmission line carrying signals to the Model 8411A must not exceed ±3 volts. Greater dc voltage prevents normal operation of the Model 8411A, and may damage the converter units.

This dc voltage limitation also applies when input signals are obtained from the Model 8740A Transmission Test Unit. With the Model 8741A and 8742A Reflection Test Units, however, the limitation does not apply because there is dc isolation between the main and secondary lines of the internal directional couplers.

STATIC DISCHARGE. Static electrical charge on cables being connected to the Model 8411A inputs can damage the converter units. Before a cable is connected to the Model 8411A it should be discharged by momentarily touching its inner conductor to the outer parts of the Model 8411A input connector. Another way to prevent static discharge is to first connect the input end of the cable to a discharge path such as that provided by the output termination of a signal source. There is no risk of static discharge when connections are made directly to Model 8740A, 8741A, or 8742A Test Units because internal terminations provide discharge paths.

Table 1-1. Models 8410A and 8411A Specifications

BASIC NETWORK ANALYZER SYSTEM (8410A/8411A)

Instrument Type: Measures relative amplitude and phase of two RF input signals; choice of two plug-in display modules for meter readout (8413A) or for CRT polar display (8414A).

Frequency Range: 0.11 to 12.4 GHz.

Tuning: Automatic over octave band selected by front panel switch.

Swept Frequency Measurements: Automatically tunes to input frequency and tracks over octave bands. Sweep reference input accepts voltage proportional to input frequency for best tracking.*

Input Impedance: 50Ω SWR < 1.5, 0.11 to 8.0 GHz; < 2.0, 8.0 to 12.4 GHz; connectors precision 7 mm coax (APC-7).®

Channel Isolation: > 65 dB, 0.11 to 6.0 GHz; > 60 dB, 6.0 to 12.4 GHz.

Drift:
With 8413A
Amplitude:
Log: < ±0.05 dB/°C
Linear: < ±5 mV/°C
Phase: < ±0.1°/°C
With 8414A
CRT, < ±0.2 mm/°C; auxiliary outputs, < ±10 mV/°C

AMPLITUDE

Range:
Reference Channel: 20 dB range between -16 to -44 dBm (≈22 to 2.2 mV); meter indicates proper range. 20 dB variation causes less than 1.5 dB and 4° change in amplitude and phase readings.
Test Channel: -10 to -78 dBm (≅ 71 mV to 18 μV); not to exceed reference channel power by more than 20 dB.

Maximum RF Input to Either Channel: 50 mW (damage level).

Maximum dc on RF Line: ±3V (damage level).

Amplitude Control: Adjusts gain of test channel relative to reference channel.

Range: 69 dB total in 10- and 1-dB steps; vernier provides continuous adjustment over at least 2 dB.

Accuracy: ±0.1 dB per 10-dB step. ±0.05 dB per 1-dB step. Maximum cumulative ±0.2 dB.

Frequency Response: Reference and test channels track within ±0.5 dB, 6 to 8.0 GHz, ±0.7 dB (typical), 8.0 to 12.4 GHz.

Noise: Less than -78 dBm equivalent input noise (measured on 8413A Meter).

Drift: ±0.05 dB per degree C.

PHASE

Range: 0 to 360°.

Control: Vernier provides continuous phase reference adjustment over at least 90°.

Frequency Response: Reference and test channels track within ±3° (typical) to 8.0 GHz ±5° (typical); 8.0 to 12.4 GHz.

Drift: < ±0.1° phase per degree C.

GENERAL

Outputs: Two rear-panel auxiliary outputs provide 278-kHz IF signals; outputs may be used for signal analysis, special applications, and convenient test points; modulation bandwidth nominally 10 kHz.

Reference Channel IF: 2 volts peak-to-peak.

Test Channel IF: 10 volts peak-to-peak or less, depending on signal level and test channel gain setting.

Sweep Reference Input: Accepts dc voltage proportional to frequency for optimum swept-frequency operation; compatible with 0- to 40-volt per octave (nominal) sweep reference output of 8690-series Sweep Oscillators.*

Power: 115 or 230 volts ±10%, 50 to 60 Hz, 70 watts (includes 8411A).

Weight: 8410A, 34 lb. (15,2 kg); 8411A, 6-1/4 lb. (2,8 kg).

Dimensions: 8410A, 7 in. high, 8-3/8 in deep, 16-3/4 in. wide (17,8 x 21,3 x 42,5 cm); 8411A, 2-5/8 in. high, 5-5/8 in. deep, 9 in. wide (6,8 x 14,3 x 22,9 cm), exclusive of connectors; 5-ft. cable permanently attached for connection to 8410A.

*HP 690- and 8690-series Sweep Oscillators supply sweep reference voltage. 8690 voltage is useable directly, 690-series Oscillators require a simple resistive divider. See Paragraph 1-69.

® Registered trademark, Amphenol RF Div., Danbury, Connecticut.

1-9. INSTRUCTIONS FOR MAKING MEASUREMENTS.

1-10. Step-by-step instructions for making basic transmission and reflection measurements with display and test units are included in the Operating and Service Manuals for the Model 8413A Phase-Gain Indicator and the Model 8414A Polar Display.

1-11. NETWORK ANALYZER APPLICATIONS.

1-12. Use of the network analyzer system for various kinds of transmission and reflection measurements is described in Hewlett-Packard Application Note 92, Network Analyzis at Microwave Frequencies. Complimentary copies of this note are available at all Hewlett-Packard offices.

1-13. DESCRIPTIONS OF PANEL FEATURES.

1-14. Front and rear panel controls, connectors, and indicators are described in Figures 1-2 and 1-3. In these figures the numbers on the illustrations match the description numbers.

1-15. ACCESSORIES FURNISHED.

1-16. A detachable power cable, rack-mounting kit, servicing cable, and a sweep oscillator modification kit are supplied with Model 8410A. No accessories are furnished with the Model 8411A.

1-17. HELIX FILTER KIT.

1-18. Each modification kit contains parts and instructions for a simple component addition to HP 690- and 8690-series Sweep Oscillators. The modification improves network analyzer tracking stability for swept-frequency measurements and is intended for oscillators that operate in the 1-to 12.4-GHz range.

1-19. RACK-MOUNTING KIT.

1-20. The rack-mounting kit contains all the hardware needed for adapting the Model 8410A cabinet for installation in equipment racks having standard 19-inch spacing. Instructions for conversion to rack-mounting are included with the kit.

1-21. SERVICING CABLE.

1-22. The servicing cable permits all necessary interconnections to be made between the Model 8410A and a plug-in display unit with the unit outside the plug-in compartment.

1-23. ACCESSORIES AVAILABLE.

1-24. ACCESSORY KIT.

1-25. A kit containing an assortment of the line sections, adapters, shorts, and attenuators, together with special APC-7 connector tools and replacement inner conductor contacts, is available from Hewlett-Packard as Accessory No. 11587A. (See Figure 1-4.) The kit consists of the items listed in Table 1-2 and is housed in a sturdy plastic container that has storage space for additional accessories.

Table 1-2. Components of Accessory Kit No. 11587A

Quantity	Description	HP Part Number
1	10-cm Air Line	11566A
1	20-cm Air line	11567A
2	APC-7 to N Female Adapter	11524A
2	APC-7 to N Male Adapter	11525A
2	10-dB Fixed Coaxial Attenuators	8492A Option 10
1	30-dB Fixed Coaxial Attenuators	8492A Option 30
1	N Female Coaxial Short	11511A
1	N Male Coaxial Short	11512A
1	Open End Wrench 9/16" x 1/2"*	8710-0877
1	Contact Extractor Tool*	5060-0236
1	Spanner Wrench*	5060-0237
5	Replacement APC-7 Inner Conductor Contacts	1250-0907
*APC-7 Connector Tools		

1-26. APC-7 CONNECTOR TOOL KIT.

1-27. The APC-7 Connector Tool Kit No. 11591A contains all of the special tools needed to service APC-7 connectors. The kit is housed in a durable plastic container and consists of the items listed in Table 1-3.

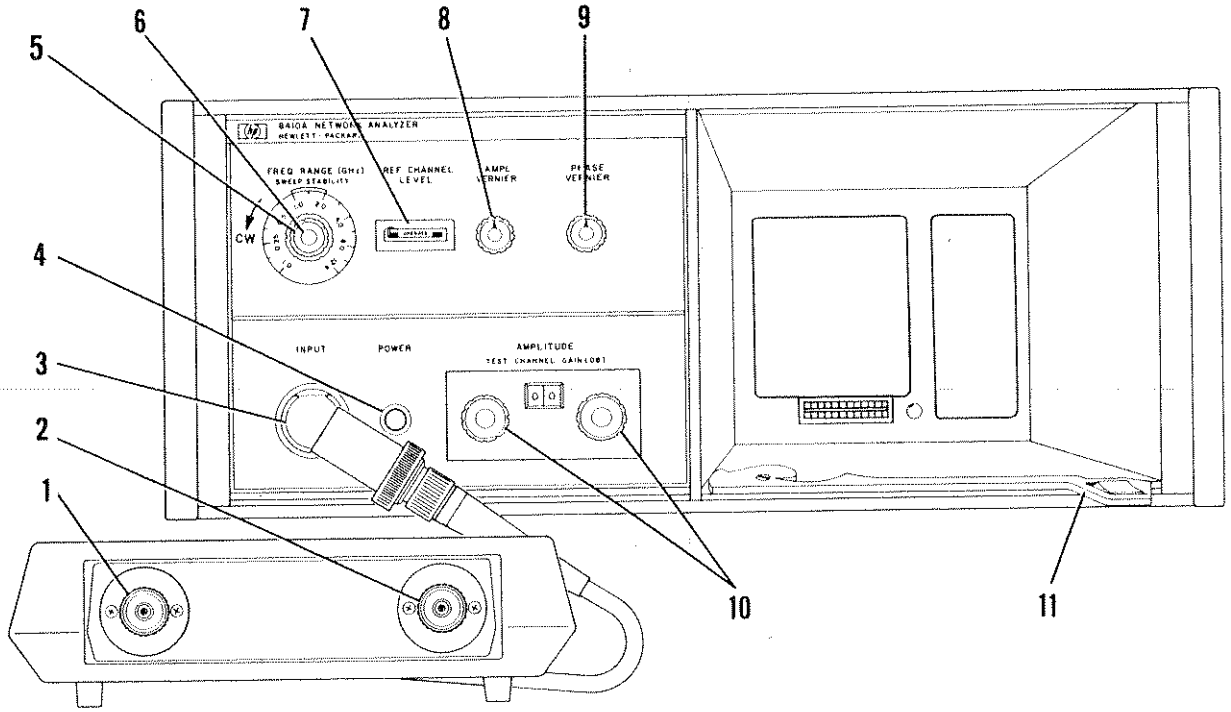
1-28. ADAPTERS.

1-29. Table 1-4 lists adapters available to accommodate some of the most common connector types.

Table 1-3. Components of APC-7 Connector Tool Kit No. 11591A

Quantity	Description	HP Part Number
1	Contact Extractor	5060-0236
1	Spanner Wrench	5060-0237
2	1/2" x 9/16" Open End Wrench	8710-0877
2	Pin Vise	8710-0932
5	Inner Conductor Contact	1250-0907

FRONT PANEL CONTROLS



1. TEST. Test channel input. Impedance 50 ohms. Frequency range: 0.11-12.4 GHz. Input power: -10 dBm maximum, not to exceed reference channel power by more than 20 dB. Dynamic range: at least 60 dB. Admits frequency to which reference channel is tuned. Connector is Amphenol precision APC-7. [1,2]

2. REFERENCE. Reference channel input. Impedance: 50 ohms. Frequency range: 0.11-12.4 GHz. Internal auto-tuning tunes and tracks REFERENCE and TEST channel inputs to the frequency of the REFERENCE input over octave bands. Required input levels lie in a 20 dB range between -16 and -44 dBm. Input power is in this range when the REF CHANNEL LEVEL meter indicates in the OPERATE region. Range of OPERATE region is between 12 and 20 dB. Connector is Amphenol precision APC-7[1,2].

INPUT PRECAUTIONS

- Maximum input power: 50 mW (damage level).
- Maximum dc on RF line: ±3 volts (damage level).
- Static Discharge: Static charge on cables being connected to the input can damage the Model 8411A.
- Do not twist the inner conductor.

Figure 1-2. Front Panel Features (Sheet 1 of 2)

3. INPUT. 8410A connector mates with 8411A Harmonic Frequency Converter cable.

4. POWER. Combination line power switch and power indicator. Pushbutton glows when instrument is on. Pushbutton retainer unscrews for lamp replacement (Paragraph 1-117).

5. FREQ RANGE (GHz). Coarse tuning control. Sets range of the automatic tuning to the frequency range selected. Selected range must include the frequency (or frequencies) at which measurements are to be made.

6. SWEEP STABILITY. Fine tuning control. Adjusts for best automatic tuning. A CW detent at the fully counterclockwise position gives best auto-tuning for single frequency CW-mode operation.

7. REF CHANNEL LEVEL. Meter indicates amplitude of signal applied to Model 8411A reference channel input. Pointer should be in OPERATE region for all phase and amplitude measurements.

8. AMPLITUDE VERNIER. Uncalibrated test channel gain vernier with at least 2 dB continuous range. Gain increases with clockwise rotation.

9. PHASE VERNIER. Continuous control for changing relative phase of reference and test channel signals. Range is at least 90°, uncalibrated.

10. AMPLITUDE. Precision 69 dB test channel gain control. Left hand control has 0 to 60 dB range in 10-dB steps. Right hand control has 0 to 9 dB range in 1-dB steps.

11. Pivoting lever installs, retains, and extracts plug-in display units.

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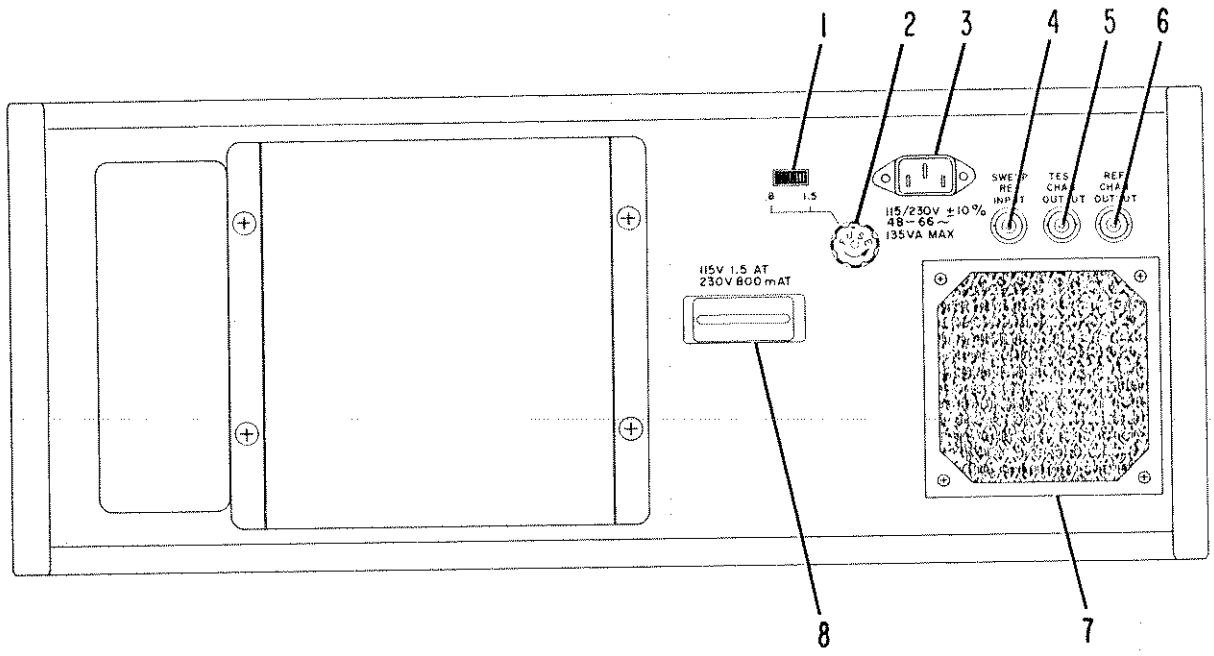
[1] See Paragraph 1-105 for important instructions and information on the use and care of APC-7 connectors.

[2] Protect critical contacting surfaces by leaving the coupling sleeve extended when connectors are not in use.

Figure 1-2. Front Panel Features (Sheet 2 of 2)

REAR PANEL FEATURES



1. Line Voltage Selector. Permits operation from 115 or 230 Vac. Number showing on slider is selected operating voltage. Adjacent number on panel is correct line fuse rating.

2. Power line fuseholder. Fuse should have rating shown adjacent to number on line voltage selector.

3. Power Cable Connector. NEMA type with offset pin connected to 8410A cabinet. Power requirements: 115 or 230 Vac ±10%, 50 to 60 Hz, approximately 85 watts with HP 8413A, 105 watts with HP 8414A.

4. SWEEP REF INPUT. Accepts a voltage proportional to reference channel input frequency. Voltage enables auto-tuning to track fast sweeping input frequencies. Nominal 0 to +40 volts per octave[1] from 20K ohms ±20% source impedance required. The lower voltage must coincide with the lowest input frequency. HP 690 and 8690 Sweep Oscillators furnish suitable reference voltages.[2] SWEEP REF INPUT voltage must be provided when sweep mode selected is from high frequency to low frequency at any sweep speed.

5. TEST CHAN OUTPUT. 278 kHz sine wave. Amplitude depends upon the amplitude of the test channel RF input and the settings of the front-panel TEST CHANNEL GAIN (dB) and AMPL VERNIER controls. Amplitude range is 0 to about 10 volts p-p.

6. REF CHAN OUTPUT. 278 kHz sine wave with amplitude fixed at about 2 volts p-p nominal when REF CHANNEL LEVEL meter reads in the OPERATE region.

7. Air Intake Filter. Clean regularly. Do not obstruct air flow.

8. Serial Number Plate. Eight-eigit serial number should be included in any correspondence concerning the Model 8410A.

[1] Swept frequency measurements can be made over somewhat wider frequency ranges than indicated by the FREQ RANGE (GHz) selector provided the sweep reference voltages cover the required ranges. See Tables 1-6 and 1-7 for details.

[2] 690-series Oscillators need dividers for sweep reference output, and internal dividers of 8690 Oscillators should be checked. See Tables 1-6 and 1-7.

Figure 1-3. Model 8410A Rear Panel Features

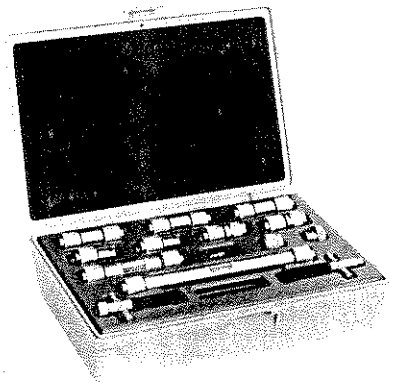


Figure 1-4. Accessory Kit No. 11587A

Table 1-4. Adapters

Adapter	Manufacturer	Model Number
APC-7 to N female	1	11524A
APC-7 to N male	1	11525A
APC-7 to OSM male	1	11533A
APC-7 to OSM female	1	11534A
APC-7 to BNC	2	
APC-7 to TNC	2	
APC-7 to GR900	2	
APC-7 to GR874	2	
APC-7 to NPM	3	

1. Hewlett-Packard
2. Amphenol RF Division, Danbury, Connecticut
3. Narda Microwave Corp., Long Island, N.Y.

1-30. FIXED COAXIAL ATTENUATORS.

1-31. Fixed coaxial attenuators are useful for reducing mismatch ambiguities, reducing power to safe levels for power-sensitive devices, and improving signal-to-noise ratio for wide range attenuation measurements.

1-32. 8492A Series. These attenuators have APC-7 connectors, and can be used from dc to 18 GHz. Their nominal attenuation values are listed in Table 1-5.

1-33. 8491A Series. These attenuators have one male and one female type N connector, and can be used from dc to 12.4 GHz. Their nominal attenuation values are the same as listed in Table 1-5 for the 8492A series.

Table 1-5. HP 8492A Series Attenuators

Option Number	Attenuation	SWR (up to 12.4 GHz)
003	3 dB	1.3:1
006	6 dB	1.3:1
010	10 dB	1.25:1
020	20 dB	1.25:1
030	30 dB	1.25:1

1-34. LINE LENGTHS.

1-35. Rigid, air dielectric, coaxial line sections of 10 and 20 centimeters are available for making transmission measurements on devices physically longer than the 10-cm extension of the Model 8740A. These line sections, designated 11566A for the 10-cm length and 11567A for the 20-cm length, have APC-7 connectors.

1-36. LOADS.

1-37. Fixed Load. The Model 909A is a 50-ohm coaxial termination with APC-7 connector for use with the Models 8741A and 8742A Reflection Test Units.

1-38. Sliding Load. The Model 905A or 907A is a movable load in a 50-ohm coaxial line that has an APC-7 connector. The load is useful for improving the accuracy of reflection measurements above 1.8 GHz.

1-39. SHORTS.

1-40. The 11511A Type N Shorting Jack, the 11512A Type N Shorting Plug, and 11565A APC-7 short can be used with the reflection test units for calibrating reflectometer measurements.

1-41. DISPLAY UNITS.

1-42. All plug-in display units designated for use with the Model 8410A are completely interchangeable. These units are powered by the Model 8410A with all necessary interconnections made automatically when the unit is properly installed.

1-43. Model 8412A Phase-Magnitude Display. Intended for fixed- and swept-frequency transmission or reflection measurement, the Model 8412A provides phase and amplitude information on an oscilloscope. Phase can be displayed at 1, 10, 45, and 90 DEG/Division. A phase offset switch offsets the display in 20 degree steps from -180 degrees to +180 degrees. Magnitude can be displayed at 0.25, 1, 0, 2.5, and 10 dB/Division. Analog voltages for both phase and magnitude are available at rear output jacks. The analog voltages can be used to obtain calibrated plots of phase angle and amplitude ratio against frequency on graphic recorders.

1-44. Model 8413A Phase-Gain Indicator. Intended for fixed- and swept-frequency transmission or re-

flection measurements, the Model 8413A provides phase and amplitude information in two forms: meter indication and analog voltage. The meter indicates phase or amplitude according to the function selected, while the analog voltages continuously monitor both phase and amplitude. The meter has center-zero scales with phase ranges of ±6°, ±18°, ±60°, and ±180° and amplitude ranges of ±3, ±10, and ±30 dB. Calibrated phase offsets in 10 degree steps allow any phase angle to be read on the best-resolution range of ±6°. The analog voltages can be used to obtain calibrated plots of phase angle and amplitude ratio against frequency on conventional two-trace oscilloscopes or graphic recorders.

1-45. Model 8414A Polar Display. The Model 8414A is used for transmission (gain, attenuation) and for reflection measurements (impedance, admittance, reflection coefficient, return loss). It displays amplitude and phase in polar form on a built-in cathode ray tube, and provides simultaneous voltages proportional to the amplitude and phase components of the display. Frequency marker and blanking signals from HP 8690- and 690-series Sweep Oscillators can be applied to the Model 8414A. Marker signals spot-intensify the trace for frequency reference, while blanking signals eliminate the trace in-between sweep intervals when there is no RF power. Supplied Smith Chart graticule overlays permit impedance and admittance to be read directly from the display.

1-46. A ground modification has been made on the Model 8414A plug-in that affects interchangeability between the units. Table 1-5A shows the units that will work together. As shown in the table, modification kit no. HP 08414-6022 may be added to the 8414A with serial numbers 749-00215 and below to make it compatible with any 8410A.

Table 1-5A. Models 8410A and 8414A Compatibility by Serial Number

8414A	Mates with 8410A
802-00216 and above	All
749-00215 and below	804-00380 and below only
749-00215 and below with HP Part No. 8414-6022 Modification Kit installed.	All

1-47. AUXILIARY EQUIPMENT.

1-48. TRANSMISSION AND REFLECTION TEST UNITS.

1-49. For added convenience in making transmission and reflection measurements, auxiliary signal-separating units are available. These compact, portable modules contain the passive devices required to divide a test signal into two signals for amplitude and phase comparison.

1-50. Model 8740A Transmission Test Unit. The transmission test unit divides a test signal into the two channels required for transmission measurements. It includes a calibrated line stretcher and a calibrated extension line with separate digital counters for measuring the mechanical and electrical lengths of the network being tested. APC-7 output connectors on the measuring channels are spaced to match the inputs of the Model 8411A Harmonic Frequency Converter. The test unit covers the entire frequency range of the network analyzer.

1-51. Models 8741A and 8742A Reflection Test Units. Two reflection test units cover the frequency range of the network analyzer; Model 8741A spans 0.11 to 2 GHz, and the Model 8742A covers 2 to 12.4 GHz. They contain broadband directional couplers and a calibrated line stretcher. The line stretcher is for equalizing the electrical distance from the test signal input to the incident and reflected signal outputs. It can also be used to move the plane of measurement as much as 14 cm for the Model 8741A and 16.5 cm for the Model 8742A. A digital counter registers line length with 0.1 mm resolution. APC-7 connectors are used on the test unit output ports, compatible type N on the input port. An HP Stock No. 11565A APC-7 short is a furnished accessory with each 8741A and 8742A.

1-52. Model 8743A Reflection-Transmission Test Unit. This reflection-transmission test unit divides a signal into two channels for amplitude and phase comparison. Pushbuttons select either transmission or reflection measurement. It includes a line stretcher with a digital counter. This unit covers the frequency range from 2.0 to 12.4 GHz.

1-53. Models X8747A/P8747A Transmission and Reflection Test Unit. This waveguide transmission and reflection test unit divides a test signal into two channels for amplitude and phase comparison. This unit permits testing waveguide components with the coaxial network analyzer. It includes a calibrated line stretcher. The X8747A covers from 8.2 to 12.4 GHz, while the P8747A covers from 12.4 to 18.0 GHz. A special option 8410A is necessary to operate in P-band.

1-54. Model 8745A S-Parameter Test Set. The most convenient way to measure s-parameters in the 0.1 to 2 GHz frequency range is with the HP Model 8745A S-Parameter Test Set. This test set combines in one unit all the coaxial switches, directional couplers, bias networks, and signal-path-length compensators (line stretchers) that are required for s-parameter measurements. Initially, the device being tested, an RF source, and a detector such as the network analyzer must be connected to the test set. After a simple calibration, all four s-parameters can be measured without disconnecting and reconnecting the device under test. Measurement circuits are automatically connected and powered by pressing the appropriate front-panel pushbutton or by applying the appropriate digital remote control signal. This remote control capability makes the test set completely programmable for automatic testing.

1-55. Accessories are available which suit various kinds of two-port devices. The 11604A Universal Extension, with its pivoting air-line extensions and swivelling connectors, allows many kinds of non-axial connector devices to be connected to the test set. The 11600B and 11602B Transistor Fixtures adapt the test set ports for measurements of transistors. The 11600B is for TO-18/TO-72 base patterns, and the 11602B is for TO-5/TO-12 base patterns. The fixtures mount on the front of the test set. Measurements can be made on both bipolar and FET transistors in all of their common operating configurations, using the snap-on dials furnished with the fixture to accomodate the various lead orientations. Terminals are provided on the test set to apply and sense dc bias. The fixtures and their dials can also be used to make measurements on components such as capacitors, inductors, and diodes.

1-56. SIGNAL SOURCE REQUIREMENTS.

1-57. OUTPUT POWER.

1-58. RANGE. About -6 to +15 dBm (0.1 to 50 mW) is adequate for both wide range attenuation measurements and reflection measurements.

1-59. STABILITY. Output power must be constant enough across the frequency range being swept to hold an OPERATE indication on the REF CHANNEL LEVEL meter. The REF CHANNEL LEVEL meter gives an OPERATE indication over a range of 12 to 20 dB, depending on the 8410A. The power limits of this range vary from analyzer to analyzer but lie between -16 and -44 dBm.

1-60. SIGNAL PURITY.

1-61. To prevent the analyzer from mistuning, spurious signal output should be at least 20 dB below the desired frequency.

1-62. FREQUENCY STABILITY.

1-63. Of chief importance to the tuning and tracking of the network analyzer are the influences on frequency stability and rate of change of frequency. Among these are residual FM and susceptibility to radiated interference, power line conducted interference, and power line transients.

1-64. SWEEP CHARACTERISTICS.

1-65. Swept signal sources should have uniform tuning rate and sweeping time that is variable between about 15 and 150 MHz per millisecond. RF blanking should not be used in order to keep the network analyzer in phase lock during retrace. An additional important requirement is a pause between sweeps. There should be at least a 3 millisecond pause at the start frequency prior to each sweep in order to allow the network analyzer to lock initially.

1-66. FREQUENCY-RELATED VOLTAGE OUTPUT.

1-67. For fastest swept-frequency measurements, the signal source should furnish a voltage proportional to output frequency. This voltage enables the network analyzer to track at its highest rate, and is particularly important for down sweeping and for sweeping wider frequency ranges than those marked on the FREQ RANGE (GHz) selector. Requirements for the voltage are positive polarity and range of 40 volts per frequency octave with the lowest voltage corresponding to the lowest frequency. Hewlett-Packard 690- and 8690- series Sweep Oscillators furnish frequency-related voltage that is adaptable for use with the network analyzer. See Paragraph 1-69 for details.

1-68. ADAPTING HEWLETT-PACKARD SWEEP OSCILLATORS FOR USE WITH THE NETWORK ANALYZER.

1-69. SWEEP REFERENCE OUTPUT DIVIDERS.

1-70. Hewlett-Packard 690- and 8690-series Sweep Oscillators furnish a voltage proportional to output frequency that is required by the Model 8410A for fast swept-frequency measurements. With 690-series Oscillators, a simple resistive divider is required to reduce the voltage range to that required by the Model 8410A. This divider can be permanently installed in the oscillator or used externally. HP8690-series Oscillators have built-in dividers, but the values of resistance should be checked. This check is especially important for oscillators that do not cover standard frequency ranges. The details of wiring and resistance values for internal and external dividers to be used with 690-series oscillators and correct values for the internal resistors in 8690-series Oscillators are given in Tables 1-6 and 1-7.

1-71. EXTERNAL LOW-PASS FILTER.

1-72. Low-pass or bandpass filters should be connected to the RF output of 690- and 8690-series Sweep Oscillators to eliminate the possibility of harmonics interfering with measurements.

1-73. HELIX FILTER.

1-74. A simple, easily installed filter for the BWO tube helix circuit of all 690- and 8690-series Sweep Oscillators improves tracking stability for swept-frequency measurements. One filter kit, HP Stock Number 08690-6029, is shipped with each 8410A instrument.

1-75. POWER LINE FILTER.

1-76. An external plug-in filter for connecting in series with the ac power cable is recommended for all 690- and 8690-series Oscillators. This filter

Table 1-6. Sweep Reference Output Voltage Requirements from HP 8690-series Sweep Oscillators

To ensure proper sweep reference output, the HP 8690-series Sweep Oscillators should be disconnected from 8410A and checked at the high-frequency end for the open circuit voltage listed. If the voltage is incorrect, change A1R36 and A1R37 to the values listed.

Model	Frequency Range (GHz)	Voltage Divider Values	Open Circuit Voltage Required at High-Frequency End
8691A 8691B	1 - 2	A1R36: 42.2K A1R37: 56.2K	+40V
8692A 8692B 8692C	2 - 4 2 - 4	A1R36: 42.2K A1R37: 56.2K A1R32: 51.1K A1R34: 42.2K	+40V +41 to +42V
8699B	2 - 4 (no sweep ref. 1-2)	A1R32: 51.1K A1R34: 42.2K	+41 to +42V
8692B Opt. 100	1.7 - 4.2	A1R36: 34.8K A1R37: 90.0K	+50V
8693A 8693B	4 - 8	A1R36: 42.2K A1R37: 56.2K	+40V
H01-8693B	3.7 - 8.3	A1R36: 38.3K A1R37: 75.0K	+46V
8694A 8694B	8 - 12.4	A1R36: 82.5K A1R37: 38.3K	+22V
8694A Opt. 100 8694B Opt. 100	7 - 12.4	A1R36: 56.2K A1R37: 46.4K	+31V
8694A Opt. 200 8694B Opt. 200	7 - 11	A1R36: 75.0K A1R37: 38.3K	+23V

(Hewlett-Packard Stock Number 9100-2484) reduces susceptibility to power line conducted interference that can cause frequency modulation of the RF output.

1-77. INITIAL MECHANICAL INSPECTION.

1-78. If external damage to the shipping carton is evident, ask the carrier's agent to be present when the instrument is unpacked. Check the instrument for external damage such as broken controls or connectors, and dents or scratches on the panel surface. If damage is evident, refer to Paragraph 1-81 for recommended claim procedure and repackaging information. If the shipping carton is not damaged, check the cushioning material and note any signs of severe stress as an indication of rough handling in transit. If the instrument appears undamaged, check for all supplied accessories, then perform the electrical check (paragraph 1-79).

1-79. INITIAL ELECTRICAL INSPECTION.

1-80. Check the electrical performance of the network analyzer as soon as possible after receipt by performing the Calibration Test (Figure 2-1). The Calibration Test procedure compares the electrical performance to the specifications of Table 1-1. This test is also suitable for incoming quality control inspection. If the network analyzer does not perform within the specifications when received, refer to Paragraph 1-81 for recommended claim procedure and Paragraph 1-83 for repackaging information.

1-81. CLAIMS.

1-82. If physical damage is evident, or if the instrument does not meet specifications when received, notify the carrier and the nearest Hewlett-Packard Sales and Service Office. (See list at rear of manual.) The Sales and Service Office will arrange for repair or replacement without waiting for settlement of a claim with the carrier.

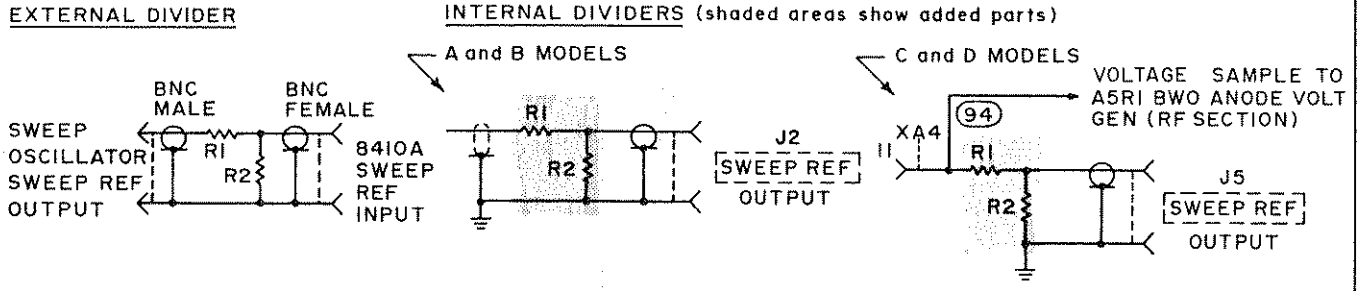
Table 1-7. Sweep Reference Output Voltage Requirements from HP 690-series Sweep Oscillators

Sweep Reference output voltage from the HP 690-series Sweep Oscillators should be disconnected from 8410A and checked at the high-frequency end for the open circuit voltage listed. If the voltage is incorrect, add either the external or internal voltage divider shown in the note.

Model	Frequency Range (GHz)	Voltage Divider Values (see note)	Open Circuit Voltage Required at High-Frequency End
691A 691B 691C 691D	1 - 2	R1: 42.2K R2: 46.2K	+40V
692A 692B 692C 692D	2 - 4	R1: 42.2K R2: 56.2K	+40V
H01-692A H01-692B H01-692D	1.7 - 4.2	R1: 34.8K R2: 90.9K	+50V
693A 693B 693C 693D	4 - 8	R1: 42.2K R2: 56.2K	+40V
H01-693A H01-693B H01-693D	3.7 - 8.3	R1: 38.3K R2: 75.0K	+46V
694A 694B 694C 694D	8 - 12.4	R1: 82.5K R2: 38.3K	+22V
H01-694A H01-694B H01-694C H01-694D	7 - 12.4	R1: 56.2K R2: 46.4K	+31V

NOTE

Details of Sweep Reference Output Dividers for 690 series Sweep Oscillators. Resistor designators are for correlation with above table only. Resistors are 1/8W 1% metal film.



1-83. REPACKAGING FOR SHIPMENT.

1-84. USING ORIGINAL PACKAGING.

1-85. The same containers and materials used in factory packaging can be obtained through the Hewlett-Packard offices listed at the rear of this manual. If the Model 8410A or Model 8411A 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.

1-86. USING OTHER PACKAGING.

1-87. The following general instructions should be used when repackaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard service office or center, attach a tag indicating the type of service required, the 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 instrument to provide firm cushion and prevent movement inside the container. Protect the control panel with cardboard.

d. Seal the shipping container securely, and mark it FRAGILE to assure careful handling.

e. In any correspondence refer to the instrument by model number and full serial number.

1-88. PREPARATION FOR USE.

1-89. POWER REQUIREMENTS.

1-90. The Model 8410A - 8411A combination requires a power source of 115 or 230 volts ac ±10%, 50 to 60 Hz, single phase, that can supply approximately 85 watts when the Model 8413A Phase-Gain Indicator plug-in is installed, approximately 105 watts when the Model 8414A Polar Display plug-in is installed.

1-91. SELECTING 115- OR 230-VOLT OPERATION.

1-92. A two-position slide switch on the rear panel of the Model 8410A permits operation from either a 115- or 230-volt power source. The number showing on the switch slider indicates the voltage for which the instrument is connected. The correct line fuse rating for each line voltage is marked next to the switch.

1-93. To prepare the Model 8410A for operation, position the 115-230 volt switch so that the number showing on the slider corresponds to the available line voltage, and install a line fuse of correct rating. "Slo-blo" fuses should be used. Hewlett-Packard stock numbers for these fuses are given under F1 in the Table of Replaceable Parts.

CAUTION

To avoid damage to the instrument, set the 115-230 switch to the line voltage to be used before connecting the power cable.

1-94. POWER CABLE.

1-95. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recomends that instrument panels and cabinets be grounded. Accordingly, the Model 8410A is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds panel and cabinet. The offset pin of the three-prong connector is the grounding pin.

1-96. When operating the Model 8410A from a two-contact outlet, the protecting feature may be preserved by using a three-prong to two-prong adapter (HP Stock No. 1251-0048) and connecting the green wire of the adapter to ground.

1-97. BENCH OPERATION.

1-98. The Model 8410A cabinet has plastic feet and a foldaway tilt stand for convenience in bench operation. The stand inclines the instrument enough to make the panel features easy to see. The plastic feet provide clearance for air circulation and make the Model 8410A self-aligning when stacked on other Hewlett-Packard full rack-width modular instruments.

1-99. RACK MOUNTING.

1-100. Preparation for rack-mounting is illustrated in Figure 1-5. All necessary hardware is contained in the supplied rack-mounting kit (HP Stock No. 5060-0776).

1-101. CONNECTING THE MODEL 8411A.

1-102. To connect the Model 8411A to the Model 8410A:

a. Set the Model 8410A LINE to off (push-button not lighted).

b. Hold the Model 8411A cable connector so that the head of the screw in the connector body enters the slot in the top of the Model 8410A INPUT connector and push the connectors firmly together.

c. Tighten the coupling ring securely.

NOTE

* PART OF RACK-MOUNTING KIT hp 5060-0776

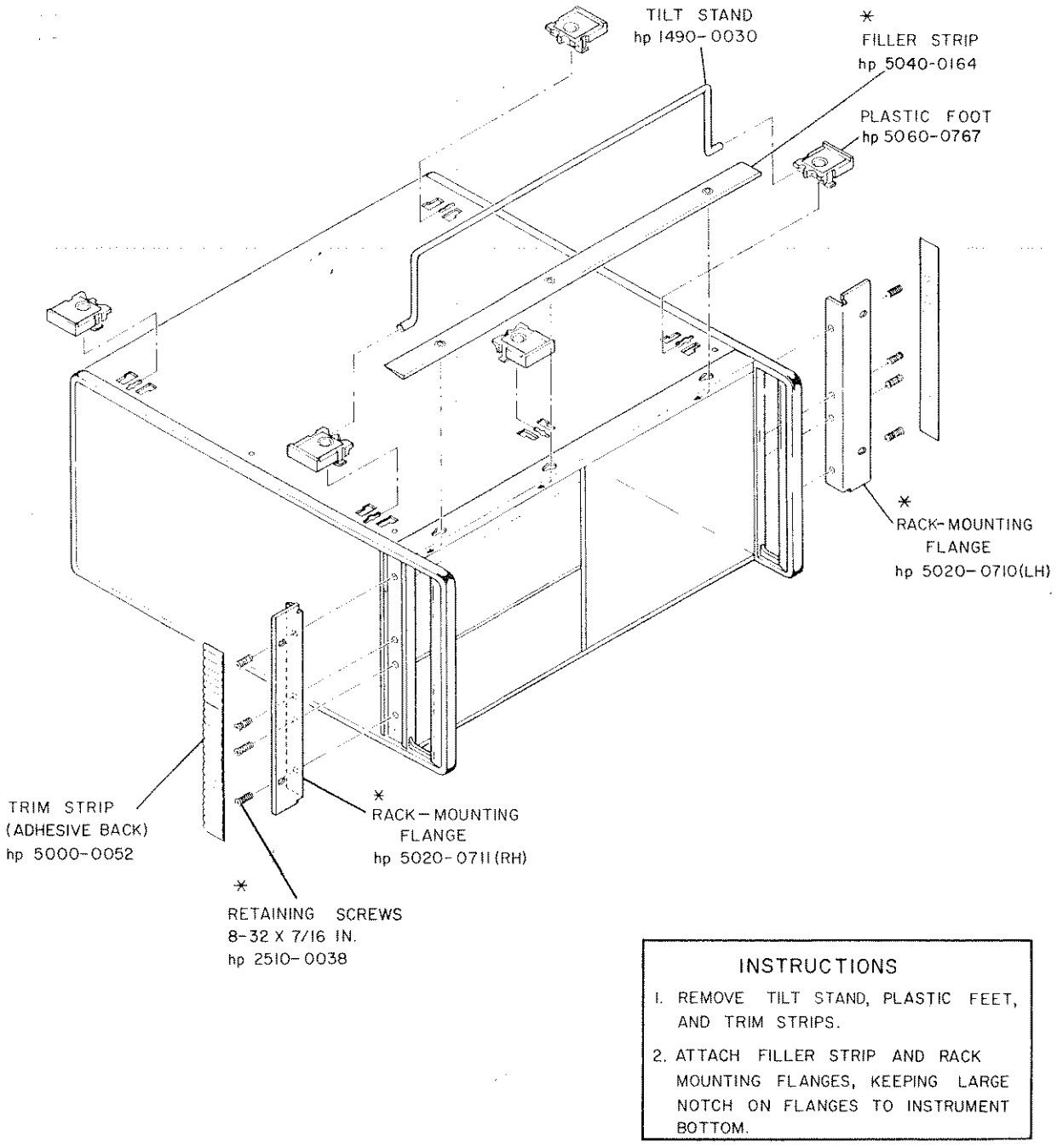


Figure 1-5. Rack-Mounting Kit Installation

1-103. INSTALLING A DISPLAY UNIT.

1-104. To install a plug-in display unit:

a. Set Model 8410A LINE switch to off (push-button not lighted).

b. Press down on the extractor-retainer lever latch and swing the lever outward to its mechanical stop.

c. Rest the rear feet of the display unit on the buttom of the plug-in compartment, then slide the plug-in toward the back of the compartment until the extractor-retainer lever starts to move.

d. Pivot the extractor-retainer lever back to its closed and latched position. All necessary electrical connections between the display unit and Model 8410A are made automatically.

1-105. CARE OF INPUT CONNECTORS.

1-106. RF signals are coupled into the Model 8411A through 50-ohm, 7-mm Amphenol APC-7 coaxial connectors. These connectors should be handled with particular care for two main reasons: (1) continuity through APC-7 connectors is obtained by end-to-end contact of the inner and outer conductors, consequently, the electrical performance of the connector is largely dependent upon the condition of these exposed surfaces, and (2) the critical contacting surfaces are directly attached to the vital frequency converter units inside the Model 8411A and are not separately replaceable.

1-107. Important recommendations for the handling and care of the input connectors are given in Figure 1-6. The part of an input connector that is most likely to be damaged is the inner conductor contact. Since it protrudes slightly beyond the plane of electrical contact, any wiping action of one connector across the other can damage the contact enough to cause a discontinuity. The risk of this kind of damage can be minimized by always having the coupling sleeves on the Model 8411A connectors fully extended.

1-108. CONTACT REPLACEMENT.

1-109. Replacement inner conductor contacts are available from Hewlett-Packard (Stock Number 1250-0907), and from Amphenol RF Division, Danbury, Connecticut (Part Number 131-129).

1-110. The following important precautions apply to the replacement of inner conductor contacts:

a. Do not apply more than slight inward pressure to the inner conductor.

b. Do not apply ANY twisting force to the inner conductor.

c. Do not attempt to repair contacts.

d. Do not re-use contacts.

CAUTION

Inward pressure or twisting force applied to the inner conductor can render the Model 8411A inoperative.

1-111. Because of the above considerations, contact removal should not be attempted with ordinary hand tools. Only the Hewlett-Packard self-positioning, hypodermic-action contact extractor tool (Stock No. 5060-0236) should be used. This tool exerts no appreciable inward pressure and no twisting force on the inner conductor. Instructions for removing contacts are supplied with the tool.

1-112. No tool is required for installing a replacement contact. Insert the contact gently by hand, applying only enough inward pressure to snap it into place. Then check for proper installation by inspecting the contact for even spacing of its four segments. Also, test for normal spring action by applying light inward pressure against the end of the contact with a pencil eraser. As the pressure is released the spring action of the contact should cause it to move outward. If not, the contact is defective and should be replaced.

1-113. COUPLING MECHANISMS.

1-114. The coupling mechanism includes the coupling nut and the two-piece coupling sleeve assembly shown in Figure 1-6. Both of these parts can be replaced without access to the inside of the Model 8411A, and without disturbing either of the conductors. A special spanner wrench, HP Stock Number 5060-0237, is required. This wrench is included in Accessory Kit 11587A and APC-7 Connector Tool Kit 11591A.

1-115. To remove a coupling mechanism:

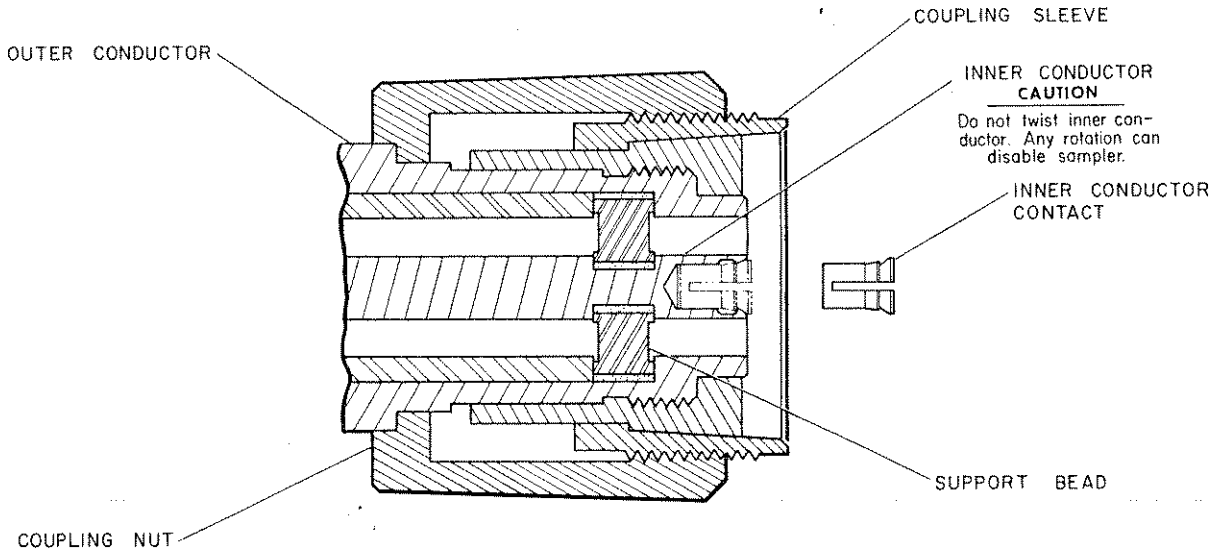
a. Fully extend the coupling sleeve to provide a guide for the spanner wrench.

b. Align the wrench so both pegs engage the holes in the end of the coupling sleeve assembly.

c. Pressing the wrench firmly against the connector, unscrew the sleeve assembly by turning the wrench counterclockwise.

1-116. When installing a coupling mechanism, set the coupling nut in place on the connector first, then thread on the coupling sleeve assembly and tighten it firmly with the spanner wrench. (Extending the coupling sleeve helps to keep the spanner in position during the final tightening.)

APC-7 CONNECTORS



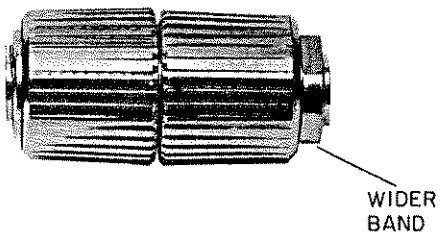
USE

To Connect:

1. On one connector, retract the coupling sleeve by turning the coupling nut counterclockwise until the sleeve and nut disengage.
2. On the other connector, fully extend the coupling sleeve by turning the coupling nut clockwise. To engage coupling sleeve and coupling nut when the sleeve is fully retracted, press back lightly on the nut while turning it clockwise.
3. Push the connectors firmly together, and thread the coupling nut of the connector with retracted sleeve over the extended sleeve. Leave the other coupling nut in the original position; closing the gap between coupling nuts tends to loosen the electrical connection.

To Disconnect:

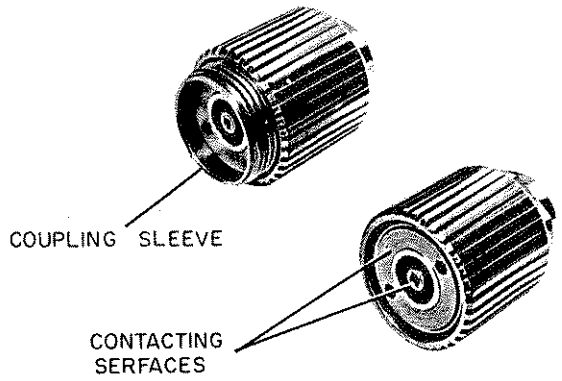
1. Loosen the coupling nut of the connector showing the wider gold band.



2. IMPORTANT: Part the connectors carefully to prevent striking the inner conductor contact.

CARE

1. Keep contacting surfaces smooth and clean. Irregularities and foreign particles can degrade electrical performance.



2. Protect the contacting surfaces when the connector is not in use by leaving the coupling sleeve extended.
3. Use lintless material and/or firm-bristled brush such as tooth brush for cleaning. If a cleaning fluid is needed use isopropyl alcohol. IMPORTANT: Do not use aromatic or chlorinated hydrocarbons, esters, ethers, terpenes, higher alcohols, ketones, or ether-alcohols such as benzene, toluene, turpentine, dioxanne, gasoline, cellosolve acetate, or carbon tetrachloride. Keep exposure of the connectors parts to both the cleaning fluid and its vapors as brief as possible.

Figure 1-6. APC-7 Connectors

1-117. POWER SWITCH LAMP REPLACEMENT.

1-118. The lamp housed in the POWER switch pushbutton indicates that line power is applied to the Model 8410A. To replace the lamp, unscrew the retaining ring near the front panel, pull out the pushbutton, and remove the lamp. The HP Stock Number for a replacement lamp is listed under DS1 in the Table of Replaceable Parts.

1-119. INSTRUMENTS COVERED BY MANUAL.

1-120. Each Model 8410A and Model 8411A carries a two-section, eight-digit serial number (000-00000). The first three digits of the number are a prefix. The contents of this manual apply directly to the Models 8410A and 8411A which have the same serial number prefix(es) as listed after SERIALS PREFIXED on the title page.

1-121. Revisions required to adapt this manual to other serial number prefixes are given in a yellow Manual Changes insert supplied with the manual. For information concerning serial number prefixes not listed on the title page or in an insert, contact the nearest Hewlett-Packard office listed at the rear of this manual.

1-122. WARRANTY.

1-123. Terms of the warranty on the 8410A and all supplied accessories are described in the warranty on the front cover of this manual. For any additional information concerning warranty, contact the nearest Hewlett-Packard field office listed at the rear of this manual.

1-124. OPERATORS QUICK-CHECK PROCEDURE.

1-125. The following procedure checks the overall functional operation of the 8410A and 8411A system, but does not check calibration.

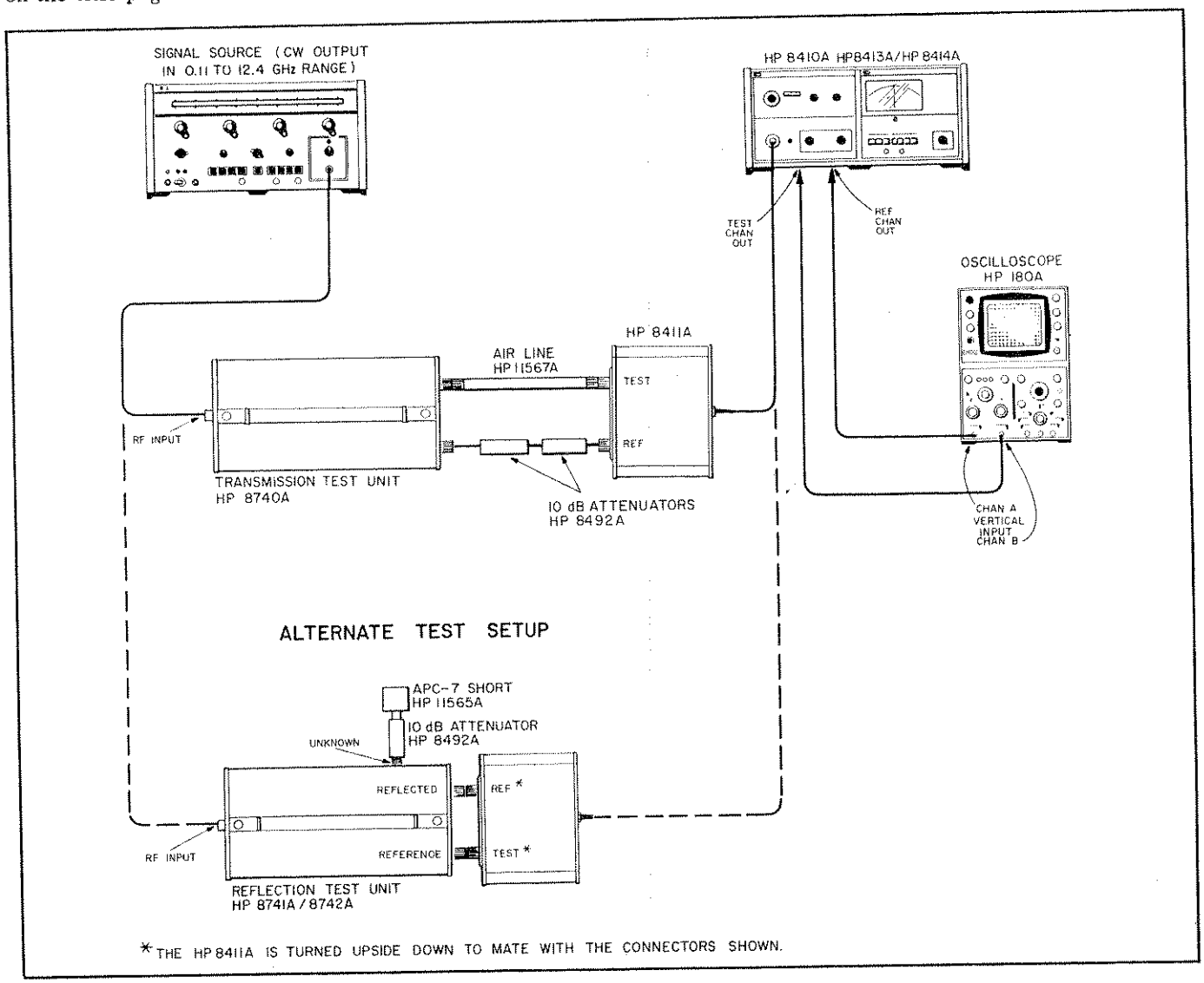


Figure 1-7. Test Setup For Operators Quick Check

a. Connect equipment as shown in Figure 1-7.

b. Set signal source for single-frequency CW operation, any frequency from 110 MHz to 12.4 GHz.

c. Set the 8410A FREQ RANGE switch to a position that includes the signal source frequency.

d. Set 8410A SWEEP STABILITY control to CW detent position.

e. Slowly increase signal source power until the 8410A REF CHANNEL LEVEL meter indicates in the OPERATE range.

f. Set TEST CHANNEL GAIN for a convenient TEST CHAN indication on the oscilloscope.

g. With the dual trace oscilloscope set for chopped mode, display channel A on the top of the screen and channel B at the bottom. Adjust 8410A PHASE VERNIER control through it's range. One of the waveforms should move smoothly in a horizontal direction on the screen. (This indicates that the 8410A is phase locked to the input signal.)