MICROWAVE NETWORK ANALYZER
0.11 to 12.4 GHz
Model 8410S

• ATTENUATION • PHASE • GAIN • IMPEDANCE • ADMITTANCE • COMPLEX REFLECTION COEFFICIENT

Choice of Three Complete Systems

All three systems measure transmission and reflection parameters of coaxial microwave components in the form of gain, attenuation, phase, reflection coefficient or impedance. The 8410S Option 100 System operates from 0.1 to 2 GHz. The 8410S Option 200 System operates from 2 to 12.4 GHz. The 8410S Option 300 System covers the complete frequency range from 0.1 to 12.4 GHz. All systems come complete with necessary accessories and interconnecting cables. Overall system accuracy is specified for easier error analysis. Individual instruments which make up the system can be ordered separately for updating existing Network Analyzer equipment or for specific applications only. Additional accessories for making transistor S-parameter measurements and waveguide measurements are also described.

Direct Readout with Choice of Display

Plug-in meter indicates magnitude and phase at spot frequencies. Wideband auxiliary outputs for swept displays on oscilloscope or X-Y recorder.

Plug-in CRT display for swept polar and Smith Chart readout. Auxiliary outputs for higher resolution X-Y plots.

Add display versatility with future plug-ins.

Fast Sweeps over Octave Bands

Swept displays for fast testing over full band. Rapid sweep for dynamic CRT display—make adjustments to devices while viewing overall effects.

Wide Dynamic Range—High Resolution

60 dB amplitude and 360° phase displays. Use precise offset controls to read amplitude and phase to 0.1 dB and 0.1 degree resolution. No phase ambiguity—meter indicates phase sense directly.

Easy Setup

All RF hardware is connected and pre-calibrated inside convenient modules. They provide:

—A calibrated variable measurement plane (line stretcher) to determine electrical and physical length of unknown devices in transmission tests, and to eliminate graphical Smith Chart transformations in reflection tests.

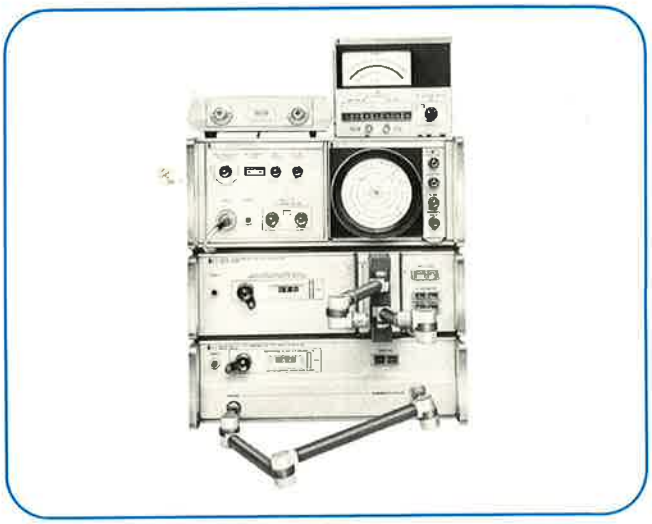
—Specified overall system accuracy for easier error analysis.

—Pushbutton selection of device parameters.

—Swivel joints and air lines for connection to any geometrical configuration.

System Description

The Hewlett-Packard Network Analyzer System includes the 8410A mainframe, 8411A Harmonic Frequency Converter, 8413A Phase-Gain Indicator and 8414A Polar Display Unit plug-in modules. The 8410A/8411A provide automatic RF tuning and IF conversion to 20 MHz over frequencies from 100 MHz through 12.4 GHz for swept or CW measurements. The phase and amplitude relationships of the RF are preserved in the IF. The 8410A/8411A include sampling and automatic tuning circuitry, IF amplifiers, precision IF gain control, amplitude and phase verniers, and frequency range selection.



8410S Opt 300 Measures all Network Parameters from 110 MHz to 12.4 GHz

The 8413A includes phase and amplitude circuitry, meter readout, log converter circuitry, and calibrated analog outputs at 50 mV/dB and 10 mV/deg. Expansion of the meter scale is accomplished with pushbutton ease in ranges of ±3, ±10, ±30 dB and ±6, ±18, ±60, ±180 degrees full scale. Phase offset in 10-degree steps allows higher resolution for phase readout. The 8414A includes polar conversion circuitry for direct polar readout of ratio coefficient and phase shift. Full scale ratio is dependent upon the gain setting on the 8410A mainframe.

The 8412A Phase-Magnitude Display which is described in the RF Microwave Network Analysis section (page 374) can also be used with the 8410S Network Analyzer systems. The 8412A combines the circuitry of the 8413A and a CRT to give direct phase and amplitude vs. frequency plots. The 8412A eliminates the need for an external oscilloscope when making swept frequency measurements.

The 8745A S-parameter Test Set and/or 8743A Transmission/Reflection Test Unit completes the systems. The 8745A and 8743A contain the necessary broadband directional couplers, line stretchers and RF switches necessary for separating the test signals for measurement. Both test units will make transmission and reflection measurements. The 8745A covers the frequency range of 0.1 to 2 GHz and the 8743A covers the range of 2 to 12.4 GHz. Other test units for measuring only transmission or reflection parameters are available and described in the individual instrument listing.

NETWORK ANALYZERS

MICROWAVE SYSTEMS
For swept frequency measurements
8410S Option 100, 200, 300 Systems

Specifications Common to 8410S Option 100, 200, 300 Systems

Function

All systems measure transmission and reflection parameters on a swept-frequency or CW basis in the form of attenuation, gain, phase shift, reflection coefficient, return loss, impedance, depending on readout display.

Display Units

8413A Phase-Gain Indicator:

Meter readout of amplitude in dB and phase in degrees.

Amplitude ranges: ±3, ±10, ±30 dB full scale.

Phase ranges: ±6, ±18, ±60, ±180 degrees full scale.

Resolution: 0.1 dB, 0.1 degree.

Swept-frequency readout with oscilloscope or X-Y recorder.

Amplitude: Front-panel analog output at 50 mV/dB, 10 kHz bandwidth. Also, rear output 0-1 volt linear, proportional to ratio of test and reference signals.

Phase: Front-panel analog output at 10 mV/degree, 10 kHz bandwidth.

8414A Polar Display:

Polar coordinate CRT with magnitude calibration divisions at 20, 40, 60, 80, and 100% of full scale. Outer range settable by IF Gain Control and amplitude vernier. Accepts marker signals from Hewlett-Packard sweep oscillators, —5 V peak, which appear as intensified dot on CRT face. Accepts blanking pulse, —4 V, from Hewlett-Packard sweep oscillators to blank retrace during swept operation.

Connectors:

RF Input, Type N female, stainless steel; Measurement Ports, APC-7 precision 7-mm connectors.

Transmission Measurement Accuracy:

Accuracy curves below show overall system uncertainty when measuring amplitude and phase. Sources of error included are IF gain control, meter accuracy, phase offset, system noise, and crosstalk. System frequency response is specified separately and is not included in accuracy curves.

Amplitude accuracy (using 8413A):

Range: full 60 dB dynamic range.

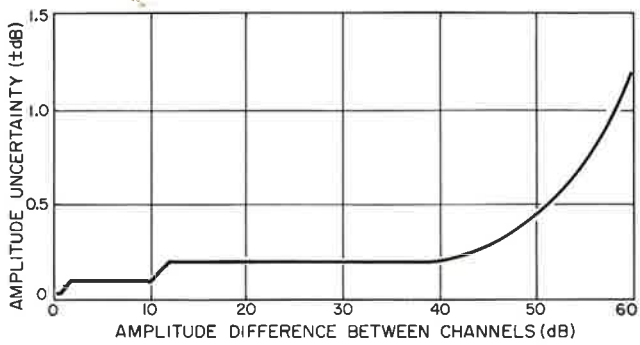
IF gain control:

60 dB in 10 dB and 1 dB steps.

±0.1 dB/10 dB
±0.05 dB/1 dB } ±0.2 dB maximum cumulative

Amplitude vernier: 2 dB range.

Meter: ±3% of full scale, ±0.05 dB for readings between 0 and 0.5 dB only.



Amplitude uncertainty for transmission measurements as a function of amplitude measured.

Phase accuracy:

Phase offset:

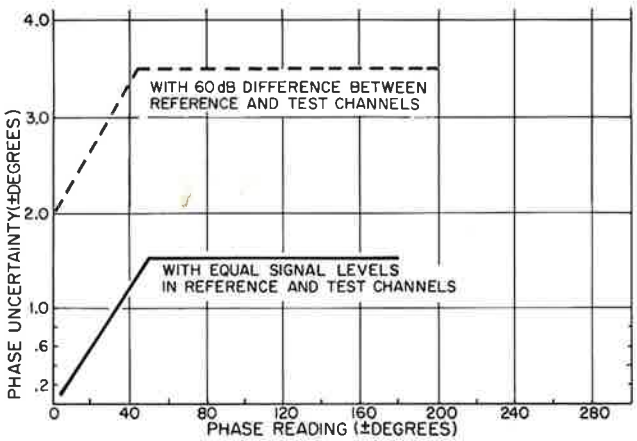
Range: ±180° in 10° steps.

Accuracy: ±0.3°/10° step, ±1.5° maximum cumulative for equal signal levels in reference and test channels. Add ±2° maximum to above for 60 dB difference between reference and test channels.

Meter: ±2% of full scale.

Phase vernier: 90° range.

Reference plane extension: 0 to 15 cm for reflection; 0 to 30 cm for transmission; calibrated by digital dial indicator. Indicator is adjustable for initial calibration.



Phase uncertainty for transmission measurements as a function of phase shift measured.

MICROWAVE SYSTEMS
Swept Measurements 0.11 to 2 GHz
8410S Option 100 System

NETWORK ANALYZERS

Specifications
8410S Option 100 System

8410A Network Analyzer
8411A Harmonic Frequency Converter
8413A Phase-Gain Indicator
8414A Polar Display Unit
8745A S-Parameter Test Set
11599A Quick Connect Adapter
11604A Universal Extension
1165A Accessory Kit
Cables for System Connection

Frequency range: 0.11 to 2.0 GHz.

Transmission-reflection selection: manual by front panel, lighted pushbuttons; remote by contact closure or saturated transistors through 36-pin connector contacts. Short circuit current, 12 mA; open circuit voltage, 12 V dc.

RF input: 20 dB range between −21 dBm and +7 dBm. 20 dB variation causes less than 1.5 dB and 4° change in amplitude and phase readings.

Source reflection coefficient:[1]
≤ 0.09 (≤ 1.2 SWR), 0.11 - 2.0 GHz.

Termination reflection coefficient:[2]
≤ 0.11 (< 1.25 SWR), 100 - 200 MHz.
≤ 0.09 (< 1.20 SWR), 200 - 2000 MHz.

Directivity:
> 36 dB (typically > 39 dB) 0.11 - 1.0 GHz.
> 32 dB (typically > 36 dB) 1.0 - 2.0 GHz.

Insertion loss, RF input to test port: 4 dB nominal.

Frequency response

Transmission: typically $< \pm 0.35$ dB amplitude and $< \pm 30$ phase.

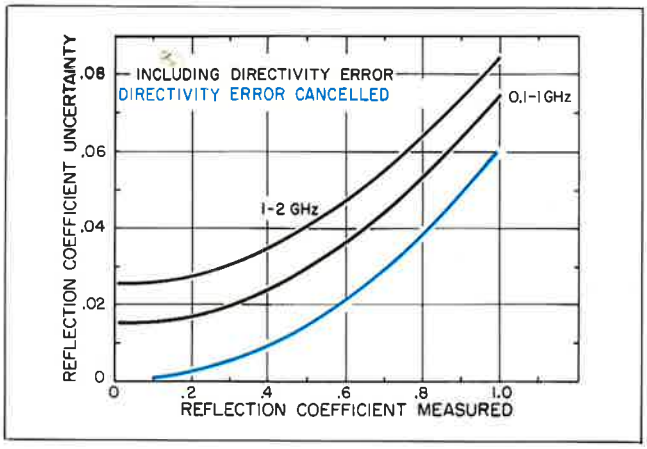
Reflection: typically $< \pm 0.06$ magnitude and $\pm 5°$ phase as read on the 8414A polar display with a short on the test port.

Transmission measurement accuracy
(see common specifications).

Reflection measurement accuracy
Accuracy curves show overall system uncertainty when measuring reflection coefficient. Sources of error included are directivity, source match, and polar display accuracy. System frequency response is specified separately and is not included in the accuracy curves.

Magnitude accuracy:

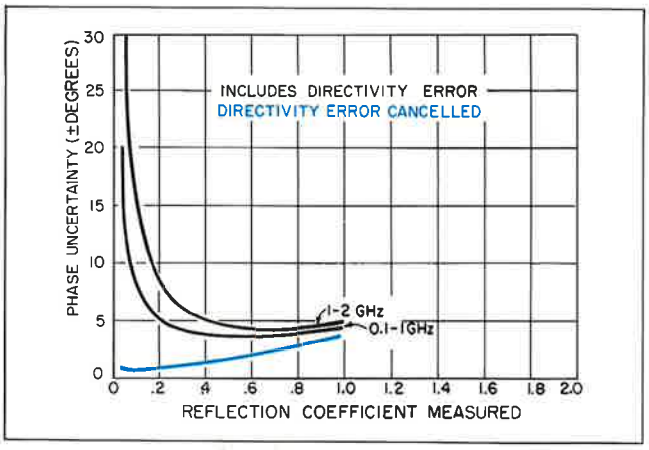
$\rho_u = \pm(0.015 + 0.06\ \rho_L^2)$ 0.11 - 1.0 GHz
$\rho_u = \pm(0.025 + 0.06\ \rho_L^2)$ 1.0 - 2.0 GHz
ρ_u = magnitude uncertainty
ρ_L = measured reflection coefficient magnitude



Reflection coefficient magnitude uncertainty including coupler directivity and when directivity is cancelled using a low VSWR load.

Phase accuracy:

$\phi_u = \sin^{-1}\frac{\rho_u}{\rho_L}$ for $\phi_u < 90°$
ϕ_u = phase uncertainty
(See Magnitude above for ρ_u, ρ_L terms)



Phase uncertainty including coupler directivity and when directivity is cancelled using a low VSWR load.

Weight and dimensions: instruments shipped separately. (See individual instrument listing.)

Price: Model 8410S Option 100, $11,470.

[1]Source Reflection Coefficient: Reflection coefficient of the port used to supply incident signal to the device under test.
[2]Termination Reflection Coefficient: Reflection coefficient of port connected to output of test device when transmission or reflection measurement is being made.

NETWORK ANALYZERS

MICROWAVE SYSTEMS
Swept Measurements 2 to 12.4 GHz
8410S Option 200 System

Specifications
8410S Option 200 System

8410A Network Analyzer
8411A Harmonic Frequency Converter
8413A Phase-Gain Indicator
8414A Polar Display Unit
8743A Reflection-Transmission Test Unit
11605A Flexible Arm
11650A Accessory Kit
Cables for System Connection

Frequency range: 2.0 to 12.4 GHz.

Transmission-reflection selection: manual, by front-panel, lighted pushbuttons; remote, by contact closure or saturated transistors through 36-pin connector contacts. Short circuit current, 12 mA; open circuit voltage, 12 V dc.

RF input: 20-dB range between −14 dBm and +14 dBm. 20-dB variation causes less than 1.5 dB and 4° change in amplitude and phase readings.

Source reflection coefficient:[1]

≤0.09 (1.2 SWR), 2-8 GHz
≤0.13 (1.3 SWR), 8-12.4 GHz

Termination Reflection Coefficient:[2]

≤0.09 (1.2 SWR), 2 - 8 GHz
≤0.13 (1.3 SWR), 8 - 12.4 GHz

Directivity: ≥30 dB, 2-12.4 GHz.

Insertion loss, RF input to test port: 20 dB nominal.

Frequency response

Transmission: typically <±0.5 dB amplitude <±5° phase.

Reflection: typically <±0.06 magnitude and <±7° phase, as read on the 8414A with a short on the unknown port.

Transmission measurement accuracy

(See common performance specifications.)

Reflection measurement accuracy

Accuracy curves show overall system uncertainty when measuring reflection coefficient. Sources of error included are directivity, source match, and polar display accuracy. System frequency response is specified separately and is not included in the accuracy curves.

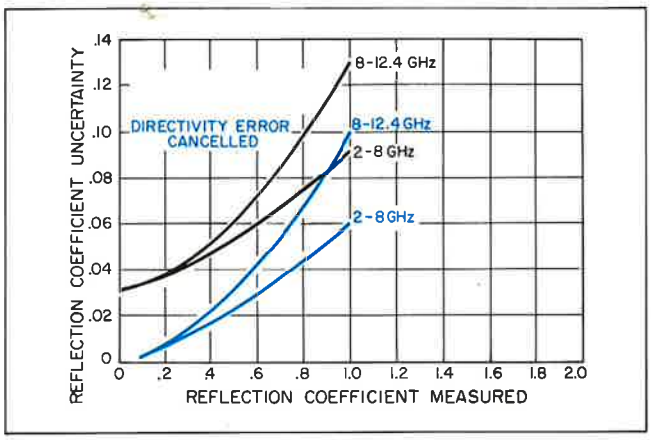
Magnitude accuracy:

$\rho_u = \pm(0.032 + 0.03\,\rho_L + 0.03\,\rho^2_L)$ 2-8 GHz

$\rho_u = \pm(0.032 + 0.04\,\rho_L + 0.04\,\rho^2_L)$ 8-12.4 GHz

ρ_L = magnitude uncertainty

ρ_L = measured reflection coefficient magnitude



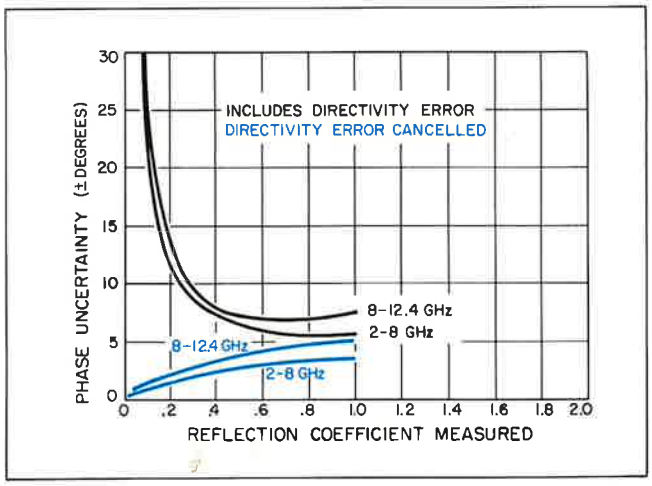
Reflection coefficient uncertainty including coupler directivity and when directivity is cancelled using a sliding load.

Phase accuracy:

$\phi_u = \sin^{-1}\frac{\rho_u}{\rho_L}$ for $\phi_u < \pm 90°$

ϕ_u = phase uncertainty

(See magnitude above for ρ_u, ρ_L terms)



Phase uncertainty including coupler directivity and when directivity is cancelled using a sliding load.

Weight and dimensions: instruments shipped separately. See individual instrument listing.)

Price: Model 8410S Option 200, $10,595.

[1]Source Reflection Coefficient: Reflection coefficient of the port used to supply incident signal to the device under test.
[2]Termination Reflection Coefficient: Reflection coefficient of port connected to output of test device when transmission or reflection measurement is being made.

MICROWAVE SYSTEMS
Swept measurements 0.11 to 12.4 GHz
8410S Option 300; 8410A, 8411A, 8413A, 8414A, 8740A-8742A

Specifications
8410S Option 300 System

8410A Network Analyzer
8411A Harmonic Frequency Converter
8413A Phase-Gain Indicator
8414A Polar Display Unit
8743A Reflection-Transmission Test Unit
8745A S-Parameter Test Set
11599A Quick Connect Adapter
11604A Universal Extension
11605A Flexible Arm
11650A Accessory Kit
Cables for System Connection

Frequency range: 0.11 to 12.4 GHz.

Specifications for Model 8410S-300 are a combination of Models 8410S-100 and 8410S-200. All specifications for those models pertain directly to the 8410S-300 at the frequencies of interest.

Weight and dimensions: instruments shipped separately. (See individual instrument listing.)

Price: Model 8410S Option 300, $14,470.

INDIVIDUAL INSTRUMENT LIST

NETWORK ANALYZER

8410A Network Analyzer, 8411A Frequency Converter Function: 8411A Harmonic Frequency Converter converts RF signals to IF signals for processing in 8410A Mainframe. 8410A is the mainframe for display plug-in units. Mainframe includes tuning circuits. IF amplifiers and precision IF attenuator.

Dimensions

8410A: 7″ high, 8⅜″ deep, 16¾″ wide (17,8 x 21,3 x 42,5 cm).

8411A: 2⅝″ high, 5⅝″ deep, 9″ wide (6,8 x 14,3 x 22,9 cm), exclusive of connectors. 5-ft cable permanently attached for connection to 8410A.

Price

Model 8410A, $2000.
Option 005: (compatible with 8418A), add $100.
Model 8411A, $2500.

DISPLAY UNITS
8414A Polar Display

Function: plug-in CRT display unit for 8410A or 8407A. Displays amplitude and phase data in polar coordinates on 5″ cathode ray tube.

Weight: net, 13 lb (5,8 kg); shipping, 17½ lb (7,8 kg).

Dimensions: 6″ high, 15-9/16″ deep, 7-9/32″ wide (15,2 x 39,5 x 18,6 cm), excluding front panel knobs.

Price: Model 8414A, $1250.

8413A Phase-Gain Indicator

Function: plug-in meter display unit for 8410A or 8407A. Displays relative amplitude in dB between reference and test channel inputs or relative phase in degrees. Pushbutton selection of meter function and range.

Weight: net, 11 lb (4,9 kg); shipping, 15 lb (6,7 kg).

Dimensions: 6″ high, 15-9/16″ deep, 7-9/32″ wide (15,2 x 39 x 18,6 cm), excluding front panel knobs.

Price: Model 8413A, $1050.

TEST UNITS
8740A Transmission Test Unit

Function: RF power splitter and calibrated line stretcher for transmission measurement with Network Analyzer.

Frequency range: dc-12.4 GHz.

Weight: net, 16 lb (7,1 kg); shipping, 21 lb (9,4 kg).

Dimensions: 6″ high, 16-3/16″ deep, 7-9/32″ wide (15,2 x 41 x 18,6 cm), excluding knobs and connectors.

Price: Model 8740A, $1300.

8741A & 8742A Reflection Test Units

Function: wideband reflectometer, phase-balanced for swept or single frequency impedance tests with 8410A. Calibrated adjustable reference plane.

Frequency range: 0.11-2.0 GHz (8741A); 2.0-12.4 GHz (8742A).

Weight: net, 15 lb (6,7 kg); shipping, 20 lb (8,9 kg).

Dimensions: 6″ high, 16-3/16″ deep, 7-9/32″ wide (15,2 x 41 x 18,6 cm), excluding connectors and knobs.

Price

Model 8741A, $1500.
Model 8742A, $1500.