

NOISE FIGURE METER

Automatic Noise Figure Meter, Noise Sources

Models 8970A, 346A/B/C

- Accurate and simple, swept or CW measurements.
- Automatic operation, 10 MHz—26.5 GHz.
- Second stage correction.
- Display of both noise figure and gain.
- Calibrated display on oscilloscope or recorder.
- Powerful special function enhancements.



8970A

8970A Noise Figure Meter

With the 8970A Automatic Noise Figure Meter, accurate and repeatable noise figure measurements are now easy. RF and microwave (with an external local oscillator) measurements from 10 MHz to at least 26.5 GHz are equally simple; any IF between 10 and 1500 MHz may be used. The ENR (Excess Noise Ratio) calibration table of the noise source may be stored in the 8970A, and a properly interpolated value is automatically used at each frequency. Automatic second stage correction makes accurate noise figure readings possible even for low gain devices. The 8970A's dynamic range allows it to measure either gain up to at least 40 dB (higher in some cases) or loss to -20 dB, with no external attenuation or amplification required.

Microprocessor and Controller Functions

The 8970A takes the mystery out of noise figure measurement. It uses a microprocessor to make the myriad calculations and corrections necessary for truly accurate, convenient and flexible noise figure measurement. The 8970A also acts as a controller to external HP-IB local oscillators (such as the 8672A Synthesized Signal Generator or 8350A Sweep Oscillator) so that swept, broad-band microwave measurements of amplifiers, mixers, and transistors are essentially as simple as RF measurements.

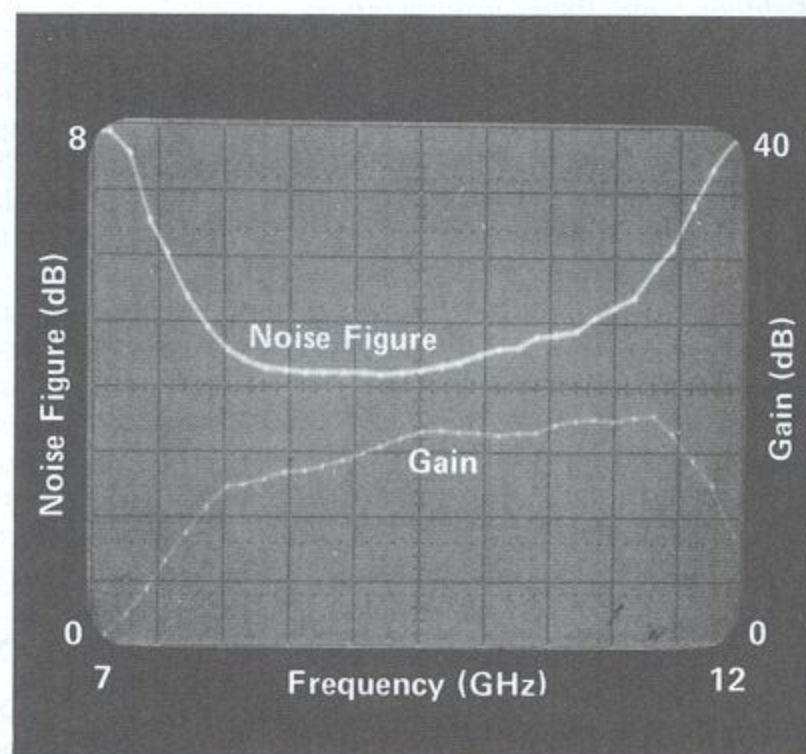
In addition to acting as controller for an HP-IB local oscillator at microwave frequencies, the 8970A is fully programmable. Virtually all front panel buttons and functions are accessible over HP-IB, which is Hewlett-Packard's enhanced implementation of IEEE-488.

Simple Calibration and Second Stage Correction

Accuracy is greatly enhanced because the 8970A measures its own noise figure (and that of the rest of the measurement system) at up to 81 points. It stores this information, interpolates if necessary, and corrects for it to remove second stage (measurement system) effects. The 8970A also measures the gain of the device under test (DUT).

Display

The 8970A has an LED digital front panel display. For swept display of noise figure and gain on an oscilloscope, or x-y recorder, rear panel BNC Connectors are available. Either display mode is easily and accurately scaled from the 8970A from the front panel to any resolution desired. The swept oscilloscope display allows the design engineer to optimize his DUT in real time for both corrected noise figure and gain. The noise figure display is easily changed from noise figure to effective noise temperature (T_e) if desired, or Y factor.



Typical oscilloscope display of amplifier.

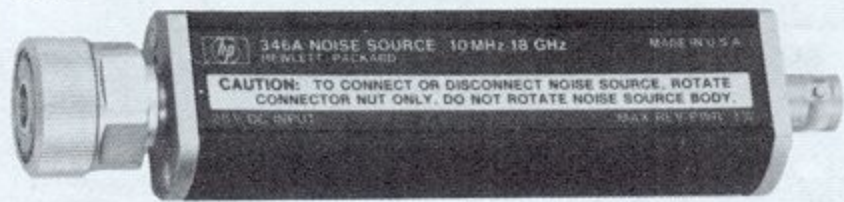
Front Panel and Special Functions

The 8970A front panel buttons control the number entry, calibration, and measurement functions. STORE, RECALL, and SEQ buttons allow up to 9 front panel settings to be stored and sequenced automatically or manually to save set-up time. Smoothing INCREASE and DECREASE buttons are used to average up to 512 readings before display, to eliminate flicker and increase accuracy.

The simple front panel control of the 8970A satisfies many noise figure measurement needs. In addition, for those who may need even greater measurement power, there are more than 150 special functions that are easily selected via a numerical code and the SP button. Two examples are hot-cold measurements and automatic compensation for losses at the input of the DUT. One special function is a catalog that quickly indicates the current special function status. Three pull-out cards serve as a mini-reference manual to the instrument, including most of the special functions, the HP-IB formats and codes, and typical measurement setups. A complete set of service-oriented special functions can also be accessed.



346C



346A (option 002)



346B (option 001)



346B (option 004)

Noise Figure Measurement Repeatability and Accuracy

A very troublesome noise figure measurement problem is repeatability. For example, a vendor's system may not measure the same noise figure as his customer's. This is much less of a problem with the 8970A. Using randomly selected 8970A's, 346B's, mixers, and local oscillators, superimposed plots of a single DUT are routinely within 0.1 dB of each other.

The 8970A internal circuitry is so accurate and linear that instrumentation uncertainty is less than ± 0.1 dB. With the ± 0.1 dB ENR uncertainty of the 346B at most frequencies, and the uncertainties due to mismatch, total root-sum-square measurement uncertainties of less than ± 0.25 are easily attainable.

346A/B/C Broadband Noise Sources

The ideal companion to the 8970A is the 346 family of noise sources. These noise sources, covering the microwave frequency range up to 26.5 GHz as well as the UHF and IF ranges, make it unnecessary to maintain a different noise source for each frequency band. Each source has individually calibrated values of ENR at cardinal frequencies printed on its label (see illustration) for easy loading into the 8970A. The low SWR of each noise source reduces a major source of measurement uncertainty—re-reflections of test signals. The variety of connectors available reduces the need for degrading accuracy with connector adapters.

The 346 family of noise sources are designed for a broad range of measurement applications. The 346C covers the broadest frequency range, 10 MHz to 26.5 GHz. The 346B has a high excess noise ratio, low SWR, and a variety of connectors to make it a general purpose noise source. The 346A is especially designed for accurately characterizing the noise figure of DUT's which do not include an isolator at the input, such as GaAsFET's and many UHF amplifiers. Without an isolator such devices can change gain during the noise figure measurement and thereby cause large errors in measuring noise figure. The 346A has a very small change in reflection coefficient (< 0.01) from ON to OFF to minimize the gain changes. The ENR is large enough (~ 5.2 dB) to accurately measure noise figures of low noise GaAsFET's and UHF amplifiers.

FREQ GHz	ENR dB	FREQ GHz	ENR dB	FREQ GHz	ENR dB
0.01	5.31	0.01	15.18	0.01	13.35
0.10	5.57	0.10	15.49	0.01	13.43
1.0	5.36	1.0	15.26	1.0	13.49
2.0	5.17	2.0	15.17	2.0	13.52
3.0	5.02	3.0	14.93	3.0	13.35
4.0	4.98	4.0	14.86	4.0	13.58
5.0	4.97	5.0	14.91	5.0	13.67
6.0	4.94	6.0	14.83	6.0	13.80
7.0	4.99	7.0	14.90	7.0	14.04
8.0	5.09	8.0	15.05	8.0	14.33
9.0	5.26	9.0	15.26	9.0	14.55
10.0	5.36	10.0	15.39	10.0	14.77
11.0	5.28	11.0	15.43	11.0	15.04
12.0	5.21	12.0	15.50	12.0	15.16
13.0	5.02	13.0	15.41	13.0	15.37
14.0	4.93	14.0	14.93	14.0	15.42
15.0	4.96	15.0	15.51	15.0	15.66
16.0	4.99	16.0	15.55	16.0	15.46
17.0	5.04	17.0	15.62	17.0	15.56
18.0	5.05	18.0	15.66	18.0	15.60
				19.0	15.62
				20.0	15.91
				21.0	15.90
				22.0	16.13
				23.0	16.28
				24.0	16.22
				25.0	16.17
				26.0	16.16
				26.5	15.60

346A

346B

346C

Example labels of 346 Noise Sources

346 Partial Specifications

(See technical data sheet for complete specifications.)

Frequency range: 10 MHz to 18 GHz for 346A/B; 10 MHz to 26.5 GHz for 346C.

Excess noise ratio (ENR) limits: 346A: 5 to 7 dB
 346B: 14 to 16 dB
 346C: 12 to 16 dB (10 MHz - 12 GHz)

14 to 17 dB (12.0-26.5 GHz)
Maximum SWR (reflection coefficient) on and off: for 346A/B; 10 to 30 MHz — 1.3 (0.13), 30 MHz to 5 GHz — 1.15 (0.07), 5 to 18 GHz — 1.25 (0.11). For 346C; 10 MHz to 18 GHz — 1.25 (0.11), 18 to 26.5 GHz — 1.35 (0.15).

Power required: 28 ± 1 Vdc

Dimensions: 140 H x 21 W x 30 mm D (5.5" x 0.8 x 1.2").

Weight: Net, 0.108 kg (3.5 oz). Shipping, 0.5 kg (1 lb).

8970A Partial Specifications

(See technical data sheet for complete specifications.)

Noise figure measurement range: 0 to 30 dB.

Noise figure instrumentation uncertainty: ± 0.1 dB for 0 to 55°C.

Noise figure resolution: 0.01 dB (0.001 dB over HP-IB)

Gain measurement range: -20 to at least 40 dB.

Gain instrumentation uncertainty: ± 0.2 dB.

Gain resolution: 0.01 dB (0.001 dB over HP-IB)

Frequency range: tunable from 10 to 1500 MHz.

Tuning accuracy: (from 10 to 40°C) $\pm (1 \text{ MHz} + 0.01 \times \text{freq.})$, 6 MHz maximum.

Frequency resolution: 1 MHz.

Noise figure: (for input power levels below -60 dBm) $< 7 \text{ dB} + 0.003 \text{ dB/MHz}$.

Maximum operating input power: -10 dBm.

Maximum net external gain: 80 dB between noise source and 8970A RF input.

Noise source drive: 28.0 ± 0.1 volt

HP-IB capability: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT1, C1, C3, C28, E1.

Operating temperature: 0°C to 55°C.

Storage temperature: -55°C to 75°C.

Power: 100, 120, 220, or 240 V (+5, -10%); 48-66 Hz; 150 VA maximum.

Dimensions: 146 H x 425 W x 476 mm D (5.75" x 16.8" x 18.8").

Weight: net, 15.5 kg (34 lb). Shipping, 18.5 kg (40 lb).

Ordering Information

Item	Price
8970A Noise Figure Meter	\$10,300
Option 907: Front panel handle kit	add \$43
Option 908: Rack mounting flange kit	add \$25
Option 909: Both options 907 and 908	add \$65
Option 910: Extra operating and service manual	add \$25
346A Noise Source (Available Nov., 1983)	
346B Noise Source	\$1,400
346C Noise Source (Available Nov., 1983)	
Option 001 (346A/B only): Type N (male) connector	N/C
Option 002 (346A/B only): APC-7 connector	Add \$25
Option 004 (346A/B only): Type N (female) connector	N/C

HP 8970B NOISE FIGURE METER

Before operating the Noise Figure Meter, read the following information:

- **Recording IF Cal Data** - Refer to paragraph 2-14, "Recording IF Cal Data", in Section II of the HP 8970B Operating Manual. The IF attenuator data is needed to return the Noise Figure Meter to specified operation should a non-volatile memory failure occur (Error E-80).
- **For those familiar with the HP 8970A Noise Figure Meter, please note:** The procedure for calibrating the IF attenuators has changed. If E-26 or E-13 should occur, refer to the "Calibrate, IF Attenuator" detailed operating instruction in Section III of the HP 8970B Operating Manual.
- **Maximum Input Power** - The maximum average power level for a CW signal at the RF INPUT connector of the HP 8970B must not exceed +20 dBm (100mW). The maximum power for a pulsed signal is also +20 dBm (100mW). The HP 8970B may be damaged by voltages exceeding +/- 20 Vdc at the RF INPUT connector.
- **Using the HP 346A Noise Source with the HP 8970S/T** - A preamplifier is required when using the HP 346A Noise Source to calibrate the HP 8970S/T system. Typically, a preamplifier with > 15 dB of gain and < 6 dB noise figure will work. Without a preamplifier, error E-19 will result when trying to perform a YIG-tuned filter fine peak calibration (36.3 SPECIAL FUNCTION or 36.4 SPECIAL FUNCTION) and error E-27 will result when trying to calibrate the noise figure meter with 36.1 SPECIAL FUNCTION active (Disable YIG Tune in Cal). This applies to the HP 346A Noise Source only.
- **Using the HP 346A Noise Source with the HP 8970A/B** - A preamplifier may be required when using the HP 346A Noise source to calibrate the HP 8970A/B Noise Figure Meter. If error E-27 occurs after pressing the CALIBRATE key on the noise figure meter, use a preamplifier to correct the situation. Typically, a preamplifier with > 10 dB of gain and < 6 dB noise figure will work.