

## 5071A-02

# S E R V I C E N O T E

SUPERSEDES: None

### HP 5071A Primary Frequency Standard

**Serial Numbers:** 0000A00000 / 9999A99999

#### HP 5071A Performance Tests

Before performing the following tests, the HP 5071A under test must have been in operation for at least 30 minutes. If you are initially starting the HP 5071A, follow the instructions in the HP 5071A Operating and Programming Manual.

#### Recommended Test Equipment

| Instrument              | Required Characteristics                                                                                                                                | Use              | Model             |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------|
| Spectrum Analyzer       | Frequency Range Span: 0 Hz to 40 MHz<br>Measurement Range (50 ohm): -90 to 0 dBm<br>Frequency Resolution Bandwidth: 300 Hz to 1 kHz                     | Performance Test | HP 3585B          |
| Linear Phase Comparator | Input Frequency Range: 5 to 10 MHz<br>Input Level (50 ohm): 1 Vrms<br>Output: 0 to +1 Vdc<br>Output Linearity: Proportional from 0 to 360 degrees phase | Performance Test | K34-59991A        |
| Strip Chart Recorder    | Paper Movement: 1 inch/hour<br>Input Range: 0 to +1 Vdc<br>Full Scale Range: +1 Vdc<br>Full Scale Resolution: 50 minor divisions                        | Performance Test | No Recommendation |

*Continued*

DATE: 07 April 1993

#### ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:

### INFORMATION ONLY

AUTHOR:

ENTITY:

ADDITIONAL INFORMATION:

DC

0200

**Supplemental Hardware**

- N-to-BNC Adapter
- 50 ohm coaxial cable with BNC connectors

**I. Verifying Operation**

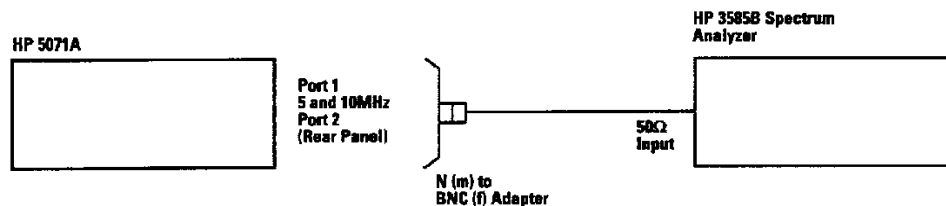
Perform the Verifying Operation procedure (see section titled "Verifying Operation" in the *HP 5071A Operating and Programming Manual*). The equipment recommended for this procedure is also listed in this manual.

**II. Output Signals: Harmonic Distortion and Spurious Signals Check****A. Harmonic Distortion Check for the 5 and 10 MHz Outputs**

Harmonics on the 10 MHz and 5 MHz output signals must be more than 40 dBc below the fundamental. To perform this check, a spectrum analyzer is tuned to the fundamental frequency and an amplitude reference is established. The output frequency spectrum is then examined to determine fundamental-to-sideband amplitude relationship at harmonic points of the fundamental.

**Equipment**

HP 3585B Spectrum Analyzer

**Setup :****Specifications:**

Verify all harmonics are  $< -40$  dBc with respect to the fundamental frequency.

**Procedure:**

If you are using the HP 3585B Spectrum Analyzer, follow the steps below to test for harmonic signals on the 5 and 10 MHz outputs. If you are using a different spectrum analyzer, use these steps as a guide for operation of that analyzer.

1. Connect the HP 5071A Port 1 to the HP 3585B analyzer as shown above. Set the HP 3585B for 50 ohm input impedance.

2. On the HP 5071A, set output ports 1 and 2 to 10 MHz using the front panel controls. See section titled "Setting the Output Port Frequency" in the *HP 5071A Operating and Programming Manual* for instructions on how to do this.
3. On the HP 3585B, perform the following steps:
  - a. Press the green "INSTR PRESET" button and allow the analyzer to go through its auto range algorithm (this takes about 5 seconds).
  - b. Press the "DISP LINE" (display line) button in the marker menu and adjust the line to -40.0 dBc.
  - c. Press the "PEAK SEARCH" button and then the "MKR->REF LVL" button (both are in the marker menu area).
  - d. Set both the resolution bandwidth (RES BW) and the video bandwidth (VIDEO BW) to 1 kHz. Enter the 1 kHz values using the numeric and unit keys. The RES BW and VIDEO BW values are displayed at the bottom of the screen.

**Note:** The sweep time is 125 seconds. DO NOT adjust the sweep time manually.
  - e. Press the "CONT" button in the sweep menu area to begin a new sweep.
  - f. When the new sweep has passed through the fundamental frequency, press the "PEAK SEARCH" button again. Then press the "OFFSET" and the "ENTER OFFSET" buttons in the marker menu area. Verify that both the offset frequency (Hz) and the offset level (dB) go to zero (0 Hz and 0 dB should be displayed at the top of the screen). If necessary, press and hold the "ENTER OFFSET" button to zero-out the marker offsets.
  - g. When at least one sweep has completed, verify that there are no signals on or above the -40 dBc display line. Use the knob in the marker area to move the offset marker to any spurious signal that you want to measure or record..

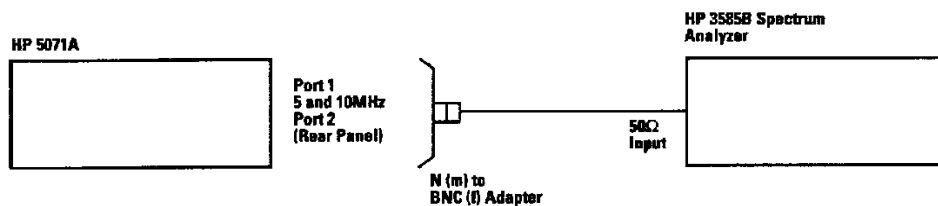
The marker shows the offset frequency and level in dBc from the output signal at 5 or 10 MHz. Verify that there are no harmonically related signals on or above -40dBc within 5 harmonics of the fundamental.
4. On the HP 5071A, set output ports 1 and 2 to 5 MHz using the front panel controls.
5. Repeat step 3.
6. Connect HP 5071A Port 2 to the HP 3585B Spectrum Analyzer and repeat steps 2 through 5 to test Port 2.

**B. Non-harmonic (Spurious) Signal Check for the 5 and 10 MHz Outputs**

Non-harmonically related (spurious) signals on the 5 and 10 MHz outputs must be more than 80 dBc below the output signal levels. To perform this test, a spectrum analyzer is tuned to the 5 or 10 MHz signal and an amplitude reference is established. The output frequency spectrum is then examined at 1 MHz on either side of the center frequency to determine the fundamental-to-sideband amplitude relationship for any signals occurring within this range.

**Equipment:**

HP 3585B Spectrum Analyzer

**Setup:****Specifications:**

All spurious signals must be  $< -80$  dBc with respect to the fundamental frequency.

**Procedure:**

If you are using the HP 3585B Spectrum Analyzer, follow the steps below to test for spurious signals on the 5 and 10 MHz outputs. If you are using a different spectrum analyzer, use these steps as a guide for operation of that analyzer.

1. Connect the HP 5071A Port 1 to the HP 3585B analyzer as shown above. Set the HP 3585B for 50 ohm input impedance.
2. On the HP 5071A, set output ports 1 and 2 to 10 MHz using front panel controls. See section titled "Setting the Output Port Frequency" in the *HP 5071A Operating and Programming Manual* for instructions on how to do this.
3. On the HP 3585B, perform the following steps:
  - (a) Press the green "INSTR PRESET" button and allow the analyzer to go through its auto range algorithm (this will take about 5 seconds).
  - (b) Press the "DISP LINE" (display line) button in the marker menu and adjust the line to  $-80.0$  dBc.

- (c) Press the "PEAK SEARCH" button and then the "MKR->REF LVL" button (both are in the marker menu area).
- (d) Set both the resolution bandwidth (RES BW) and the video bandwidth (VIDEO BW) to 1 kHz. Enter the 1 kHz values using the numeric and unit keys. The RES BW and VIDEO BW values are displayed at the bottom of the screen.

**Note:** The sweep time is 125 seconds. DO NOT adjust the sweep time manually.

- (e) Press the "CONT" button in the sweep menu area to begin a new sweep.
- (f) When the new sweep has passed through the fundamental frequency, press the "PEAK SEARCH" button again. Then press the "OFFSET" and the "ENTER OFFSET" buttons in the marker menu area. Verify that both the offset frequency (Hz) and the offset level (dB) go to zero (0 Hz and 0 dB should be displayed at the top of the screen). If necessary, press and hold the "ENTER OFFSET" button to zero-out the marker offsets.
- (g) When at least one sweep has completed, verify that there are no signals on or above the -80 dBc display line. Use the knob in the marker area to move the offset marker to any spurious signal that you want to measure or record..

The marker shows the offset frequency and level in dBc from the output signal at 5 or 10 MHz.

- (h) Verify one of the following conditions is true:
  - (1) No signals are on or above the -80 dBc display line between 4 MHz and 6 MHz for the 5 MHz output, or
  - (2) No signals are on or above the -80 dBc display line between 9 MHz and 11 MHz for the 10 MHz output.

4. On the HP 5071A, set output ports 1 and 2 to 5 MHz using the front panel controls.

5. Repeat step 3. 5. Connect HP 5071A Port 2 to the HP 3585B Spectrum Analyzer and repeat steps 2 through 5 to test Port 2.

### C. Harmonic Distortion Check for the 1 MHz Output

Harmonics on the 1 MHz output signal must be more than 40 dBc below the fundamental. To perform this check, a spectrum analyzer is tuned to the fundamental frequency and an amplitude reference is established. The output frequency spectrum is then examined to determine the fundamental-to-sideband amplitude relationship at harmonic points of the fundamental.

#### Equipment:

HP 3585B Spectrum Analyzer

## Setup



### Specifications:

All harmonics must be  $< -40$  dBc with respect to the fundamental frequency.

### Procedure:

If you are using the HP 3585B Spectrum Analyzer, follow the steps below to test for harmonic signals on the 1 MHz output. If you are using a different spectrum analyzer, use these steps as a guide for operation of that analyzer.

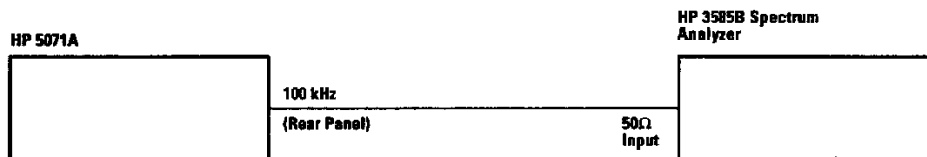
1. Connect the HP 5071A 1 MHz output to the HP 3585B Spectrum Analyzer as shown above. Set the HP 3585B for 50 ohm input impedance.
2. On the HP 3585B, perform the following steps:
  - (a) Press the green "INSTR PRESET" button and allow the analyzer to go through its auto range algorithm (this will take about 5 seconds).
  - (b) Press the "STOP FREQ" button. Then set the stop frequency to 20 MHz using the numeric and unit keys in the entry menu.
  - (c) Press the "DSP LINE" button and move the display line to  $-40.0$  dBc.
  - (d) Press the "PEAK SEARCH" button, then the "MKR-REF LVL" button.
  - (e) When the new sweep has passed through the fundamental frequency, press the "OFFSET" and the "ENTER OFFSET" buttons in the marker menu area. Verify that both the offset frequency (Hz) and the offset level (dB) go to zero (0 Hz and 0 dB should be displayed at the top of the screen). If necessary, press and hold the "ENTER OFFSET" button to zero-out the marker offsets.
  - (f) When at least one sweep has completed, verify that there are no signals on or above the  $-40$  dBc display line at multiples of 1 MHz up to 4 MHz. Use the knob in the marker area to move the offset marker to any signals within this range if you want to measure or record these signals. The marker shows the offset frequency and level in dBc from the 1 MHz signal.

### D. Harmonic Distortion Check for the 100 kHz Output

Harmonics on the 100 kHz output signal must be more than 40 dBc below the fundamental. To perform this check, a spectrum analyzer is tuned to the fundamental frequency and an amplitude reference is established. The output frequency spectrum is then examined to determine fundamental-to-sideband amplitude relationship at harmonic points of the fundamental.

**Equipment:**

HP 3585B Spectrum Analyzer

**Setup****Specifications:**

All harmonics must be  $< -40$  dBc with respect to the fundamental frequency.

**Procedure:**

If you are using the HP 3585B Spectrum Analyzer, follow the steps below to test for harmonic signals on the 100 kHz output. If you are using a different spectrum analyzer, use these steps as a guide for operation of that analyzer.

1. Connect the HP 5071A 100 kHz output to the HP 3585B Spectrum Analyzer as shown above. Set the HP 3585B for 50 ohm input impedance.
2. On the HP 3585B, perform the following steps:
  - (a) Press the green "INSTR PRESET" button and allow the analyzer to go through its auto range algorithm (this will take about 5 seconds).
  - (b) Press the "STOP FREQ" button. Then set the stop frequency to 3 MHz using the numeric and unit keys in the entry menu.
  - (c) Press the "DSP LINE" button and move the display line to  $-40.0$  dBc.
  - (d) Press the "PEAK SEARCH" button, then the "MKR-REF LVL" button.
  - (e) Set the resolution bandwidth (RES BW) to 300 Hz and the video bandwidth (VIDEO BW) to 1 kHz.

*Note: The sweep time is 66.8 seconds. DO NOT adjust the sweep time manually.*

  - (f) Press the "CONT" button in the sweep menu area to begin a new sweep.
  - (g) When the new sweep has passed through the fundamental frequency, press the "OFFSET" and the "ENTER OFFSET" buttons in the marker menu area. Verify that both the offset frequency (Hz) and the offset level (dB) go to zero (0 Hz and 0 dB should be displayed at the top of the screen). If necessary, press and hold the "ENTER OFFSET" button to zero-out the marker offsets.
  - (h) When at least one sweep has completed, look for any signals that appear on or above the  $-40$  dBc display line at multiples of 100 kHz up to 500 kHz. Use the knob in the marker area to move the offset marker to any signals within this range if you want to measure or record these signals. The marker shows the offset frequency and level in dBc from the 100 kHz signal.

### III. Frequency Accuracy

The following accuracy check measures the changing phase relationship between the HP 5071A 10 MHz output and another primary frequency standard (HP 5071A Primary Frequency Standard or better). An HP K34-59991A Linear Phase Comparator is used to measure the phase between the HP 5071A under test and the reference standard.

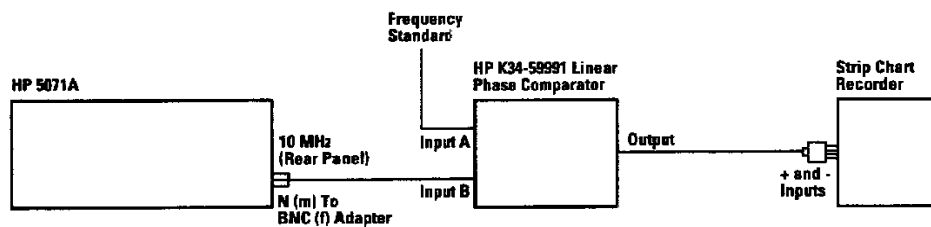
#### Note

*In this test, the reference standard must be of known accuracy. The measurement time must be of sufficient length so the accuracy of the measurement is not impaired by the stability of either the reference standard or the unit under test. If the reference standard is an HP 5071A with Option 001, the accuracy measurement must be made for 24 hours if the unit under test is a standard unit. Or, the test can be made in 2 1/2 hours if the unit under test has Option 001 (High Performance Cesium Beam Tube).*

#### Equipment:

HP K34-59991A      Linear Phase Comparator  
Strip Chart Recorder

#### Setup:



#### Specifications

Standard Unit:  $\pm 2 \times 10^{-12}$

Option 001:  $\pm 1 \times 10^{-12}$



**Note**

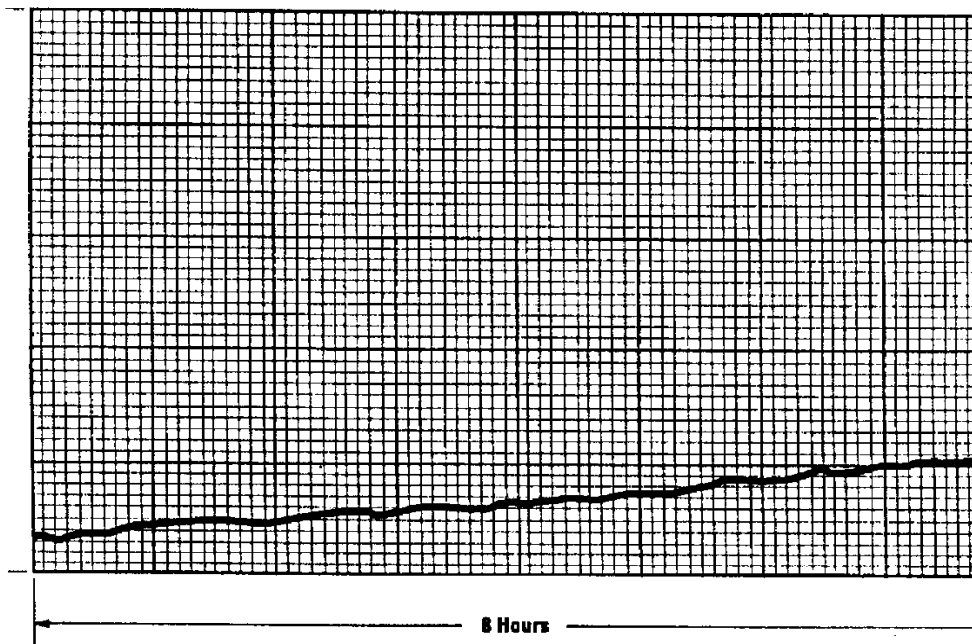
*The accuracy of the HP 5071A is better than  $1 \times 10^{-12}$  (Option 001) or  $2 \times 10^{-12}$  (standard unit). Be sure the accuracy of the reference standard is known with sufficient precision to accurately make this measurement.*

**Procedure**

1. The HP 5071A must be on for at least 30 minutes and the green continuous operation LED must be on.
2. Connect the HP K34-59991A Phase Comparator OUTPUT terminals to the strip chart recorder. Set the recorder for 1 V full scale and 1 inch/hour. Turn on the recorder.
3. Turn on the K34-59991A power.
4. Connect the 10 MHz reference to INPUT A and the HP 5071A (unit under test) 10 MHz to INPUT B.
5. Set K34-59991A "ZERO-OPER-FULL" front panel mounted toggle switch to "ZERO." Adjust the "ZERO SCALE" control for a zero reading on the meter. Then adjust the recorder for a zero indication.
6. Set K34-59991A switch to "FULL" and adjust "FULL SCALE" control for a full scale reading in the meter. Then adjust the recorder for a full scale indication.
7. Check both "ZERO" and "FULL SCALE" outputs and readjust if necessary.
8. Set K34-59991A switch to "OPER" for normal operation.
9. The recorder now provides a continuous record of the phase difference between the reference standard and the HP 5071A unit under test. When its output reaches full scale (360 degrees), the HP K34-59991A will automatically reset to 0 (0 degrees).
10. With the recorder set as described in step 2 for 1 Volt full scale, the phase record is 100 ns full scale (with 10 MHz inputs). The figure below shows an example of a frequency difference measurement under these conditions.
11. The frequency difference between the unit under test and the reference is given by the following equation:

$(\Delta f)/F = (\Delta t)/T$  Where:  $(\Delta f)/F$  is the desired frequency difference, and  $(\Delta t)$  is the phase change (in seconds) over the measurement time,  $T$

The following figure shows a typical plot using the strip chart recorder:



In the example, the frequency difference,  $(\Delta f)/F$ , is computed as follows:

$$\begin{aligned}
 (\Delta f)/F &= (\Delta t)/T \\
 &= (7 \text{ minor divisions} \times 2 \times 10^{-9} \text{ second/division}) / (8 \text{ hours}) \\
 &= 14 \times 10^{-9} \text{ seconds} / 8 \text{ hours} = 14 \times 10^{-9} / 2.88 \times 10^4 \text{ (seconds)} \\
 &= 4.86 \times 10^{-13}
 \end{aligned}$$

This calculation shows that the frequency difference between the unit under test and the reference is 4.86 parts in ten to the 13th. This is only an example. The measured frequency accuracy of an HP 5071A must be  $2 \times 10^{-12}$  or better for a standard unit, or  $1 \times 10^{-12}$  or better for a high performance unit (Option 001).

#### IV. Stability

##### Note

High accuracy precision measurements of both time and frequency domain stability are available through the National Institute of Standards and Technology (NIST) in the USA. NIST can completely characterize and verify all major specifications of the HP 5071A. For information regarding the various tests available, contact:

**M.C. 847.4**  
**National Institute of Standards and Technology**  
**325 Broadway**  
**Boulder CO 80303-3328**  
**USA**  
**Telephone: (303) 497-3753**

**A. Time Domain**

This is an engineering-level measurement requiring a special test setup. The test setup must be carefully designed to eliminate all sources of noise. For more information on how to make this measurement, see HP Application Note 358-12. Also, see NIST Technical Note 1337 (available from US Government Printing Office, Washington DC., USA). This is an excellent theoretical as well as technical reference for this measurement.

**B. Frequency Domain**

This measurement requires the HP 3048A Phase Noise Measurement System, a highly specialized test system. In order to perform properly, this system must contain a reference oscillator whose phase noise characteristics are equal to or better than the HP 5071A. Instructions for performing frequency domain stability tests can be found in the HP 3048A system documentation.

| Description                                                                                                                                                                                                                                                                                                                | Actual Reading                                              | Limits                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------------------|
| 1. Verifying Operation                                                                                                                                                                                                                                                                                                     | _____                                                       | Passed                                                                        |
| 2. Output Signals: Harmonic Distortion and Spurious Signals Check<br>A. Harmonic Distortion Check for the 5 and 10 MHz Outputs<br><br>B. Non-harmonic (Spurious) Signal Check for the 5 and 10 MHz Outputs<br><br>C. Harmonic Distortion Check for the 1 MHz Output<br>D. Harmonic Distortion Check for the 100 kHz Output | _____<br>_____<br>_____<br>_____<br>_____<br>_____<br>_____ | < -40 dBc<br><br>< -80 dBc<br><br>< -40 dBc<br>< -40 dBc                      |
| 3. Frequency Accuracy                                                                                                                                                                                                                                                                                                      | _____                                                       | Standard Unit: $\pm 2 \times 10^{-12}$<br>Option 001: $\pm 1 \times 10^{-12}$ |
| 4. Stability<br>A. Time Domain<br>B. Frequency Domain                                                                                                                                                                                                                                                                      | _____<br>_____                                              | See procedures                                                                |