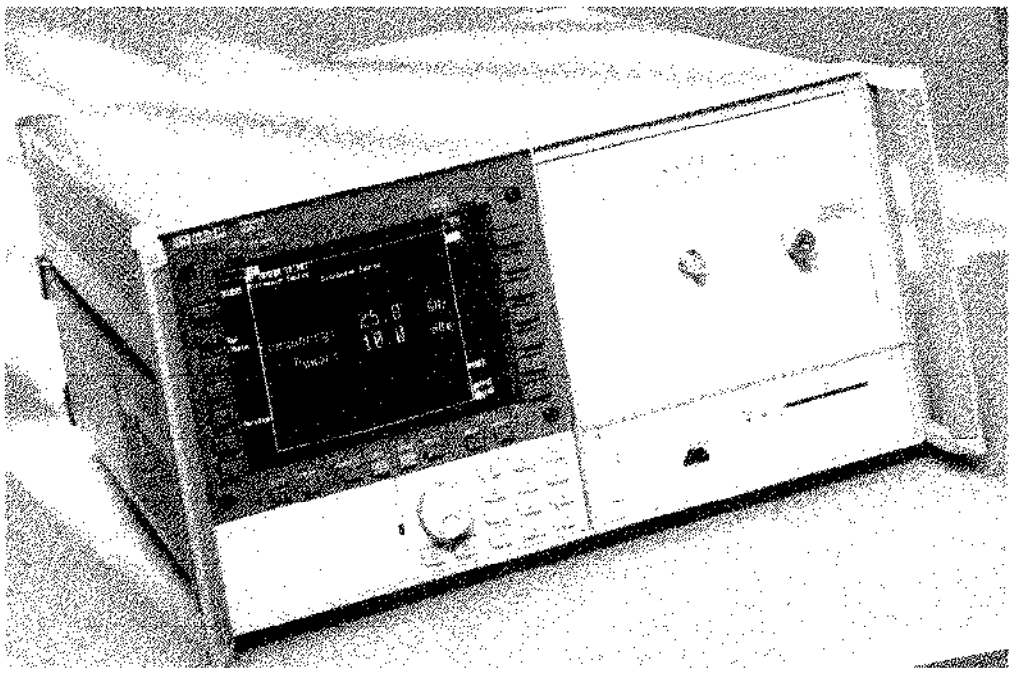
HEWLETT PACKARD

HP 71708A
Microwave Source

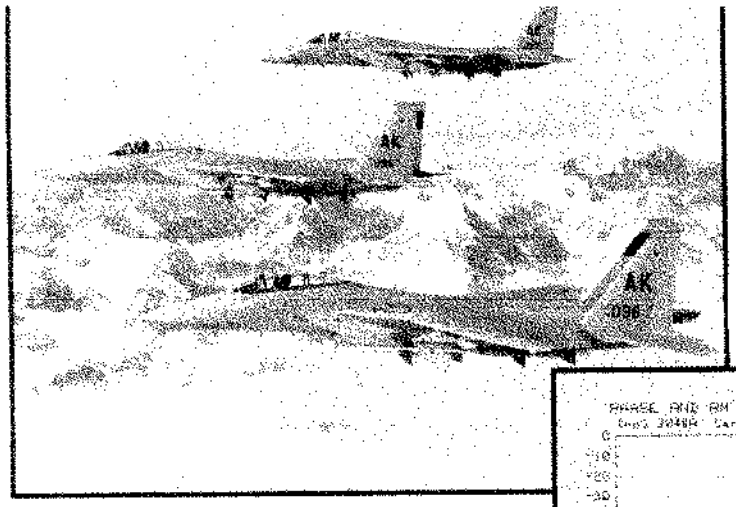
HP 70428A
Microwave Source Module

Technical Data

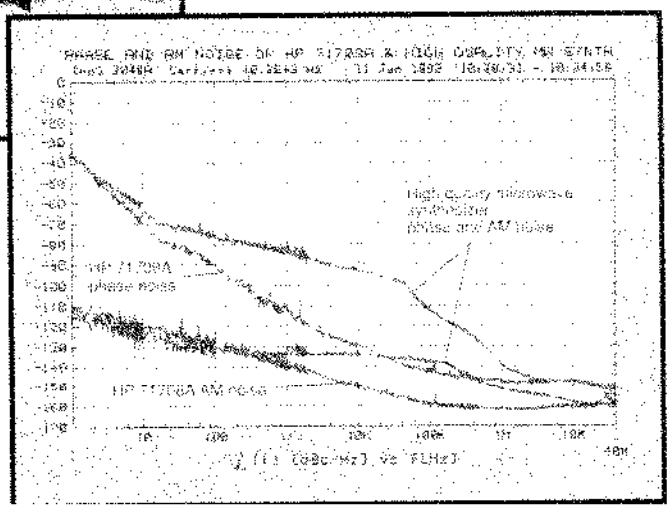


LOW NOISE

Variable frequency source with lowest phase noise



Courtesy of McDonnell Douglas



Typical phase and AM noise of HP 71708A microwave source and high quality microwave synthesizer

The HP 71708A microwave source provides signals with exceptionally low phase and AM noise performance from 2.4 to 26.4 GHz. Phase noise specifications are -113 dBc/Hz and -125 dBc/Hz at 1 kHz and 10 kHz offsets from a 10.2 GHz carrier. AM noise is as low as -150 dBc/Hz. Thus the HP 71708A is an ideal source for testing microwave receivers, verifying noise floors of phase noise measurement systems, or substituting for the local oscillator in radar systems.

The HP 71708A consists of a 4/8's width HP 70428A microwave source module and an HP 70004A color display/mainframe.

This system combines:

- Low phase noise
- Low AM noise
- Output frequency range from 2.4 to 26.4 GHz
- 600 MHz frequency resolution
- Optional 0.1 Hz frequency resolution
- Output power up to +16 dBm

Modular measurement system (MMS) building block

The user interface of the HP 71708A is built into the firmware of the HP 70428A microwave source module. This allows you to easily integrate the HP 70428A into existing MMS systems with multiple instruments. Through the MMS user interface, you have complete control of all its functions.

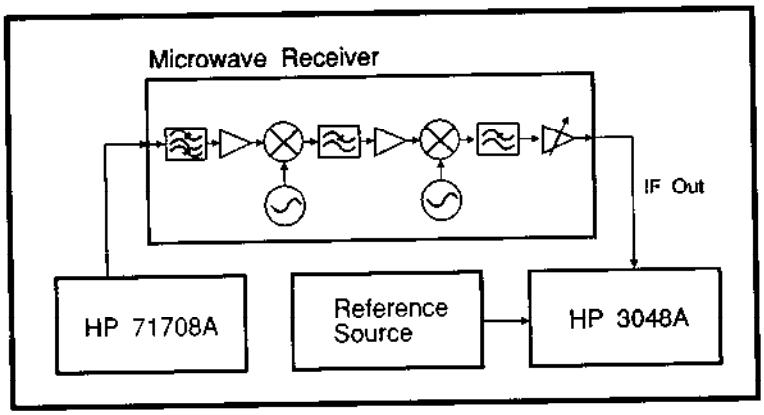
Some of these functions include:

- Output frequency
- Output power level
- Reference source configuration
- Calibration functions
- Tuning sensitivity

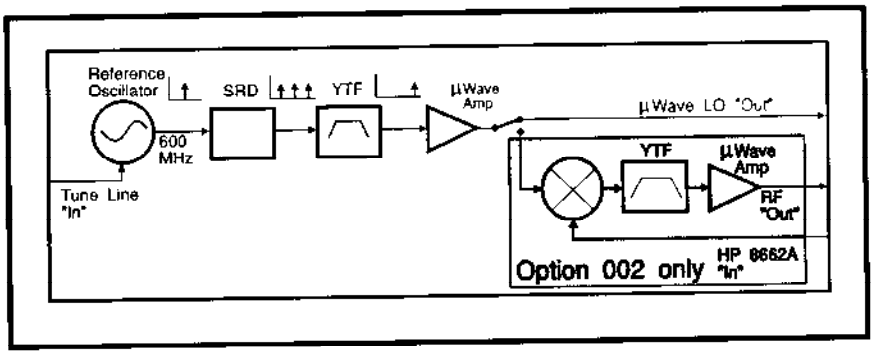
In addition to manual operation, all functions can be controlled over HP-IB by a computer.

0.1 Hz frequency resolution

For applications that demand frequency resolution finer than 600 MHz, add Option 002 and an HP 8662A/3A synthesized signal generator. This combination of instruments provides a signal from 2.4 GHz to 26.5 GHz with 0.1 Hz frequency resolution while preserving much of the low noise performance of the HP 71708A. With Option 002, simply enter the desired output frequency and the HP 71708A automatically sets the frequency of its internal microwave source and, over HP-IB, the frequency and power of the HP 8662A/3A.



Block diagram for microwave receiver noise measurements



HP 70428A microwave source block diagram

Selectable tuning and phase noise performance

Along with low phase noise, the HP 71708A provides a DC coupled tuning port with three sensitivity settings. This allows you to phase-lock the HP 71708A when using it as a reference source for phase noise measurements on synthesized sources. The three tuning sensitivity settings are directly coupled to noise performance and allow the HP 71708A flexibility to adapt to your measurement needs.

Built-in output power calibration

Periodic calibration of the output power of the HP 71708A can be quickly and easily performed using built-in calibration functions and an external power meter. Over HP-IB, the microwave source will automatically control an HP 437B, HP 438A, or HP 70100A power meter. Over MSIB, the HP 71708A will automatically control the HP 70100A.

Microwave receiver noise measurements

In the past, measuring the noise of microwave receivers required two receivers, driven by a common microwave source. This was due to the inadequate phase and AM noise performance of the available microwave sources. Using this method, the noise of the microwave source cancels out and the combined noise of the two receivers can be measured. However, it is difficult to accurately determine the noise of each of the individual receivers and two receivers are required.

With the low phase and AM noise of the HP 71708A and an HP 3048A phase noise measurement system, this measurement can be made directly. By driving the input of the microwave receiver with the low noise HP 71708A, the noise of the IF signal out of the receiver is dominated by the noise of its microwave conversion and IF processing components. The noise of the IF signal can then be measured using an RF reference source such as the HP 8662A, and the resulting absolute noise of the microwave receiver measured directly.

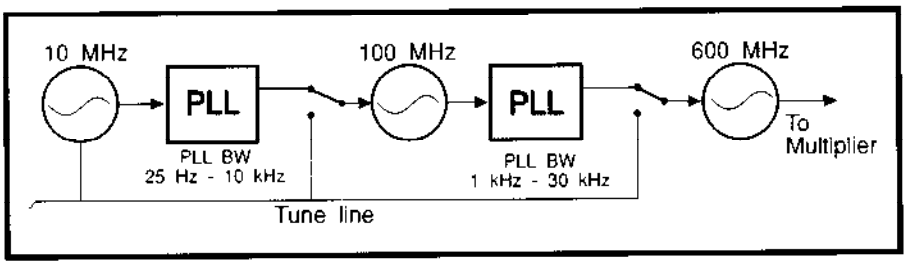
Low AM noise

Low AM noise allows the HP 71708A to be used as a source for AM noise measurements of signal processing components such as amplifiers and mixers. This low AM noise performance minimizes the degradation of residual PM measurements due to AM to PM conversion in the device under test or in the microwave phase detector.

Reference chain

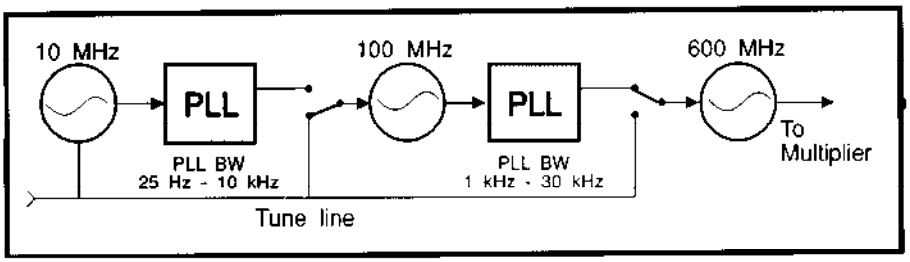
The heart of the HP 71708A microwave source is the reference chain which consists of a 10 MHz crystal oscillator, 100 MHz oscillator, and 600 MHz oscillator. Each of these oscillators can be the primary reference, providing three different tuning sensitivities with corresponding phase noise performance.

The 600 MHz signal from the reference chain is multiplied with a step recovery diode which generates harmonics from 2.4 to 26.4 GHz. To obtain a particular harmonic, this signal is filtered with a YIG tuned filter. A variable gain GaAs amplifier boosts the power of this signal.



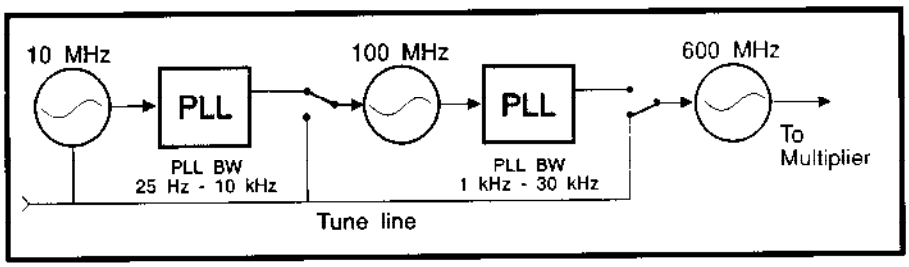
Configuration 1
All oscillators locked

- For those applications that demand the lowest possible noise at all offsets
- Tuning sensitivity of 0.05 ppm/volt
- Phase noise of -65 dBc/Hz at 10 Hz offset, -113 dBc/Hz at 1 kHz offset and 10 GHz carrier frequency



Configuration 2
100 MHz and 600 MHz oscillators locked

- For those applications that require the best phase noise >1 kHz and a moderate tuning range
- Tuning sensitivity of 1 ppm/volt
- Phase noise of -33 dBc/Hz at 10 Hz offset, -113 dBc/Hz at 1 kHz offset and 10 GHz carrier frequency

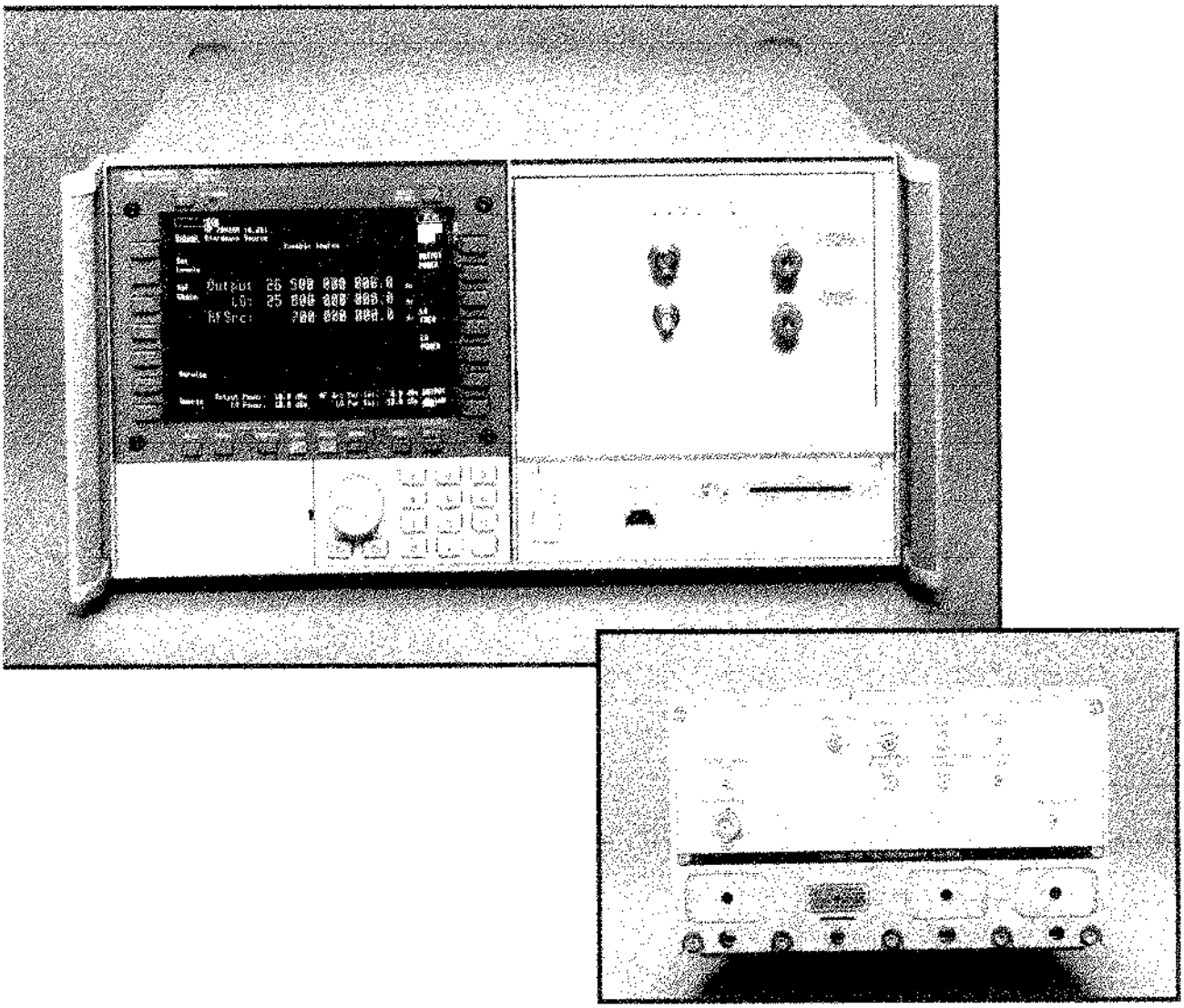


Configuration 3
600 MHz free-running oscillator

- For those applications that require a wide tuning range and a low broadband noise floor
- Tuning sensitivity of 20 ppm/volt
- Phase noise of -20 dBc/Hz at 10 Hz offset, -100 dBc/Hz at 1 kHz offset and 10 GHz carrier frequency

Option 002

Option 002 of the HP 71708A adds the capability to mix the internal microwave source with an external RF source. This option adds a microwave mixer, a second YIG tuned filter, a second GaAs amplifier, and associated signal switching. Once the first YIG tuned filter is tuned and the RF source frequency and power set, the second YIG tuned filter is tuned to the correct frequency. The variable gain GaAs amplifier provides output power control of this composite signal.



- **Output power up to +16 dBm provides sufficient drive level for your test applications**
- **Adding Option 002 and an HP 8662A/3A extends the superior noise performance with 0.1 Hz frequency resolution from 2.4 GHz to 26.5 GHz**
- **10 MHz crystal, 100 MHz and 600 MHz oscillator outputs on rear panel**
- **MMS user interface and modular functionality integrates easily into existing MMS systems**
- **Low phase noise yields state-of-the-art microwave receiver measurement capability**
- **Variable tuning sensitivity allows you to optimize the noise performance for your application**
- **Low AM noise is ideal for microwave residual measurements**

HP 71708A/HP 70428A Specifications

Specifications describe the instrument's warranted performance and apply after a 30 minute warm-up. These specifications are valid over its operating/environmental range unless otherwise noted.

Supplemental Characteristics (*shown in italics*) are intended to provide additional information, useful in applying the instrument by giving typical (expected), but not warranted performance parameters. These characteristics are shown in italics or labeled as "typical", "usable to", or "nominal".

Microwave source

RF output

Frequency range:

2.4 GHz to 25.8 GHz

Frequency resolution:

600 MHz

Output power:

2.4 to 6.6 GHz:

0 to +16 dBm

7.2 to 25.8 GHz:

0 to +10 dBm

Spectral purity:

The internal reference oscillators can be locked together in three configurations, each with different phase noise performance and tuning bandwidths. All noise levels are in units of dBc/Hz unless otherwise noted. Spurious and phase noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points given.

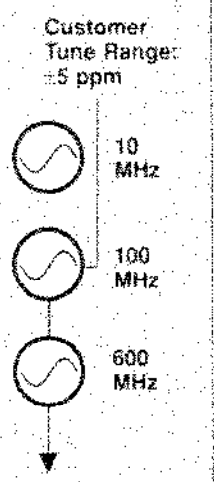
Configuration 1 - All oscillators locked

Best phase noise <100 Hz frequency offsets, narrow tuning sensitivity

Output frequency		Offset from carrier (Hz)									Spurious (dBc)	
		1'	10	100	1k	10k	100k	1M	10M	40M	10 to 100	1k
2.4 to 3.0 GHz	Typ.	-50	-80	-100	-128	-138	-148	-152	-152	-152	-60	-80
	Spec.	-45	-75	-95	-123	-133	-143	-147	-147	-147	-50	-70
3.0 to 4.2 GHz	Typ.	-47	-77	-97	-125	-136	-146	-150	-150	-150	-54	-80
	Spec.	-42	-72	-92	-120	-131	-141	-145	-145	-145	-44	-70
4.2 to 6.0 GHz	Typ.	-44	-74	-94	-122	-134	-144	-148	-148	-148	-54	-80
	Spec.	-39	-69	-89	-117	-129	-139	-143	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	-42	-72	-92	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	-37	-67	-87	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	-40	-70	-90	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	-35	-65	-85	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	-38	-68	-88	-116	-128	-140	-143	-143	-143	-50	-80
	Spec.	-33	-63	-83	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	-35	-65	-85	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	-30	-60	-80	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 25.8 GHz	Typ.	-32	-62	-82	-110	-122	-134	-136	-136	-136	-44	-70
	Spec.	-27	-57	-77	-105	-117	-129	-131	-131	-131	-34	-60

Configuration 2 - 100 and 600 MHz oscillators locked

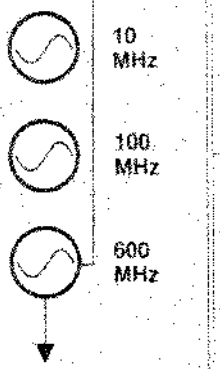
Better phase noise <10 kHz frequency offsets, moderate tuning sensitivity



Output frequency		Offset from carrier (Hz)									Spurious (dBc)	
		1[1]	10[2]	100	1k	10k	100k	1M	10M	40M	10 to 100	≥1k
2.4 to 3.0 GHz	Typ.	-2	-46	-98	-128	-138	-148	-152	-152	-152	-60	-80
	Spec.	+7	-40	-83	-122	-133	-143	-147	-147	-147	-50	-70
3.0 to 4.2 GHz	Typ.	+5	-45	-95	-125	-136	-146	-150	-150	-150	-54	-80
	Spec.	+10	-40	-90	-120	-131	-141	-145	-145	-145	-44	-70
4.2 to 6.0 GHz	Typ.	+8	-42	-92	-122	-134	-144	-148	-148	-148	-54	-80
	Spec.	+13	-37	-87	-117	-129	-139	-143	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	+10	-40	-90	-120	-132	-143	-147	-147	-147	-54	-80
	Spec.	+16	-35	-85	-115	-127	-138	-142	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	+12	-38	-88	-118	-130	-141	-145	-145	-145	-50	-80
	Spec.	+17	-33	-83	-113	-125	-136	-140	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	+14	-36	-86	-116	-128	-140	-153	-153	-153	-50	-80
	Spec.	+19	-31	-81	-111	-123	-135	-138	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	+17	-33	-83	-113	-125	-137	-140	-140	-140	-47	-70
	Spec.	+22	-28	-78	-108	-120	-132	-135	-135	-135	-37	-60
18.0 to 25.8 GHz	Typ.	+20	-30	-80	-110	-122	-134	-136	-136	-136	-44	-70
	Spec.	+25	-25	-75	-105	-117	-129	-131	-131	-131	-34	-60

Configuration 3 - 600 MHz free-running oscillator

Good phase noise <10 kHz frequency offsets, wide tuning sensitivity



Output frequency		Offset from carrier (Hz)									Spurious (dBc)		
		1[1]	10[2]	100	1k	10k	100k	1M	10M	40M	100	1k	≥10k
2.4 to 3.0 GHz	Typ.	-15	-35	-75	-113	-138	-148	-152	-152	-152	-40	-80	-80
	Spec.	+20	-30	-70	-108	-133	-143	-147	-147	-147	-30	-70	-70
3.0 to 4.2 GHz	Typ.	+18	-32	-72	-111	-136	-146	-150	-150	-150	-34	-74	-80
	Spec.	+23	-27	-67	-106	-131	-141	-145	-145	-145	-24	-64	-70
4.2 to 6.0 GHz	Typ.	-21	-29	-69	-109	-134	-144	-148	-148	-148	-34	-74	-80
	Spec.	+26	-24	-64	-104	-129	-139	-143	-143	-143	-24	-64	-70
6.0 to 7.8 GHz	Typ.	+23	-27	-67	-107	-132	-143	-147	-147	-147	-34	-74	-80
	Spec.	+28	-22	-62	-102	-127	-138	-142	-142	-142	-24	-64	-70
7.8 to 10.2 GHz	Typ.	+25	-25	-65	-105	-130	-141	-145	-145	-145	-30	-70	-80
	Spec.	+30	-20	-60	-100	-125	-136	-140	-140	-140	-20	-60	-70
10.2 to 12.6 GHz	Typ.	+27	-23	-63	-103	-128	-140	-143	-143	-143	-30	-70	-80
	Spec.	+32	-18	-58	-98	-123	-135	-138	-138	-138	-20	-60	-70
12.6 to 18.0 GHz	Typ.	+30	-20	-60	-100	-125	-137	-140	-140	-140	-27	-67	-70
	Spec.	+35	-15	-55	-95	-120	-132	-135	-135	-135	-17	-57	-60
18.0 to 25.8 GHz	Typ.	+33	-17	-57	-97	-122	-134	-136	-136	-136	-24	-64	-70
	Spec.	+38	-12	-52	-92	-117	-129	-131	-131	-131	-14	-54	-60

[1] All noise levels above -30 dBc/Hz are 3 dB below $S_\phi(f)$ expressed in dB with respect to 1 rad²/Hz.
[2] All noise levels above -40 dBc/Hz are 3 dB below $S_\phi(f)$ expressed in dB with respect to 1 rad²/Hz.

AM noise:

Specifications apply for +10 dBm output power. All noise levels in dBc/Hz. AM noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points given.

Output frequency		Offset from carrier (Hz)									Spurious (dBc)	
		1	10	100	1k	10k	100k	1M	10M	40M	10	1k to 40M
2.4 to 25.8 GHz	Typ.	-100	-110	-117	-133	-143	-153	-155	-155	-155	-60	-80
	Spec.	-95	-105	-112	-128	-138	-148	-150	-150	-150	-50	-70

Supplemental characteristics

Frequency overrange:

26.4 GHz with degraded output power

Output level entry resolution:

0.1 dB

Absolute power accuracy:

±3 dB

Harmonics:

-10 dBc

Frequency switching transients:

Output power can peak at +22 dBm during frequency switching

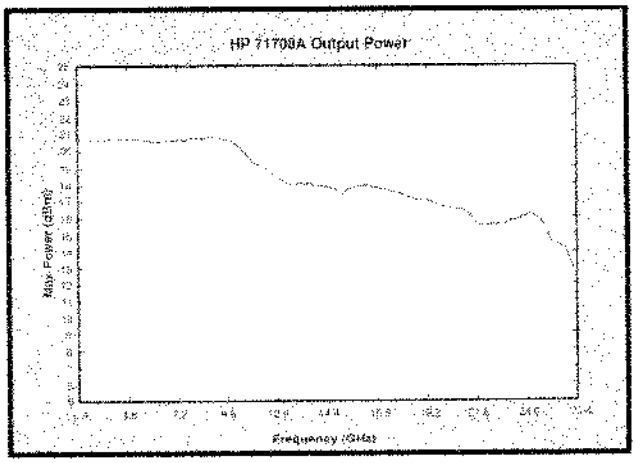
Output power drift:

<1 dB after warm-up

Output power settling time:

<100 ms

Maximum output power vs frequency:



Frequency switching speed:

3 seconds, standard; 6 seconds, Option 002

Reference tuning:

Voltage control of the internal reference oscillators is available through a port on the front panel.

Tuning range (sensitivity):

Configuration 1:

±0.25 ppm (0.05 ppm/volt)

Configuration 2:

±5 ppm (1 ppm/volt)

Configuration 3:

±100 ppm (20 ppm/volt)

Tuning port voltage range:

±5 volts (overrange to ±10 volts)

Tuning port input impedance:

2 kΩ

Option 002 specifications

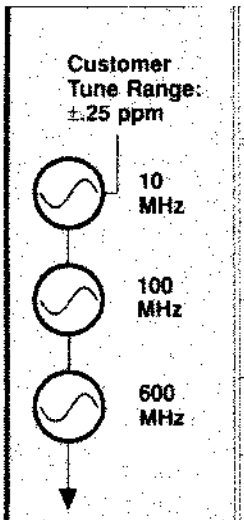
Requires HP 8662A or HP 8663A as an RF source.
Adds capability to the HP 71708A such that an RF source can be mixed with the microwave source. The front panel frequency of the RF source is automatically controlled by the HP 71708A over HP-IB.

Option 002 spectral purity:

The following spectral purity table combines the effects of the HP 71708A Option 002, configuration 1, and HP 8662A/3A when used together as a microwave source. All noise levels are in units of dBc/Hz unless otherwise noted. Spurious and phase noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points given. To combine the HP 8662A/3A phase noise with configuration 2 and 3 tables, use the phase noise numbers from this table for offsets ≥1 kHz and configuration 2 and 3 tables for offsets ≤100 Hz.

Configuration 1 - All oscillators locked

Best phase noise <100 Hz frequency offsets, narrow tuning sensitivity



Output frequency		Offset from carrier (Hz)											Spurious[2] (dBc)	
		1[1]	10	100	1k	3k	5k	10k	100k	1M	10M	40M	10 to 100	≥1k
2.4 to 3.0 GHz	Typ.	-50	-80	-100	-119	-121	-124	-130	-130	-135	-147	-147	-60	-80
	Spec.	-43	-73	-92	-112	-112	-114	-124	-124	-130	-142	-142	-50	-70
3.0 to 4.2 GHz	Typ.	-47	-77	-97	-122	-129	-130	-133	-136	-141	-149	-149	-54	-80
	Spec.	-42	-72	-92	-115	-117	-120	-128	-131	-136	-144	-144	-44	-70
4.2 to 6.0 GHz	Typ.	-44	-74	-94	-120	-124	-127	-131	-136	-141	-148	-148	-54	-80
	Spec.	-39	-69	-89	-114	-117	-119	-126	-131	-136	-143	-143	-44	-70
6.0 to 7.8 GHz	Typ.	-42	-72	-92	-119	-123	-125	-130	-136	-140	-147	-147	-54	-80
	Spec.	-37	-67	-87	-113	-116	-118	-125	-131	-135	-142	-142	-44	-70
7.8 to 10.2 GHz	Typ.	-40	-70	-90	-118	-121	-124	-129	-135	-139	-145	-145	-50	-80
	Spec.	-35	-65	-85	-112	-115	-117	-124	-130	-134	-140	-140	-40	-70
10.2 to 12.6 GHz	Typ.	-38	-68	-88	-116	-121	-123	-128	-134	-138	-143	-143	-50	-80
	Spec.	-33	-63	-83	-111	-114	-116	-123	-129	-133	-138	-138	-40	-70
12.6 to 18.0 GHz	Typ.	-35	-65	-85	-113	-119	-121	-125	-133	-137	-140	-140	-47	-70
	Spec.	-30	-60	-80	-108	-112	-114	-120	-128	-132	-135	-135	-37	-60
18.0 to 26.5 GHz	Typ.	-32	-62	-82	-110	-115	-117	-122	-128	-133	-136	-136	-44	-70
	Spec.	-27	-57	-77	-105	-108	-110	-117	-123	-127	-131	-131	-34	-60

[1] All noise levels above -30 dBc/Hz are 3 dB below $S_\phi(f)$ expressed in dB with respect to 1 rad²/Hz.
[2] Mixing an RF source with the microwave LO in the HP 71708A Option 002 may result in some mixing spurious exceeding spurious specifications, see mixing spurious table on page 10.

AM noise of Option 002[1]:

Specifications apply for +10 dBm output power. All noise levels in dBc/Hz. AM noise specifications at any offset can be determined by drawing a line, on a log-log plot, between specification points given.

Output frequency		Offset from carrier (Hz)									Spurious (dBc)	
		1	10	100	1k	10k	100k	1M	10M	40M	10	1k to 40M
2.4 to 26.5 GHz	Typ	-97	-107	-114	-130	-140	-150	-152	-152	-152	-60	-80
	Spec	-92	-102	-109	-125	-135	-145	-147	-147	-147	-50	-70

Supplemental characteristics

Mixing spurious:

Carrier frequency range (GHz) where a mixing spur will occur ≤40 MHz from the carrier	*Typical spurious level (dBc)*
2.990 - 3.010	*-40*
2.392 - 2.408, 2.737 - 2.749, 2.793 - 2.807 2.995 - 3.005, 3.592 - 3.608	*-60*
2.493 - 2.507, 2.929 - 2.938 3.493 - 3.507, 4.109 - 4.120	*-70*

LO feedthrough 430-480 MHz offset below carrier:

<-50 dBc typical

General specifications

HP 71708A system components:

HP 70004A Color Display/Mainframe
HP 70428A Microwave Source Module

Internal reference oscillator:

Internal 10 MHz reference oscillator:

10 MHz Quartz oscillator

Aging rate:

$<1\times10^{-9}$/day after 10 day warm-up

Temperature stability:

$<\pm2\times10^{-8}$ over 0 to 55°C

[1]AM noise specifications apply when an HP 8662A or HP 8663A is used as the RF source.

Rear panel connections:

- 10 MHz IN (+7 dBm required)
- BUFFERED 10 MHz OUT (Typical +7 dBm)
- 10 MHz OVEN OUT (Typical +10 dBm)
- 100 MHz OUT (Typical -2 dBm)
- 100 MHz OUT (Typical +8 dBm)
- 600 MHz OUT (Typical +20 dBm)
- 600 MHz OUT (Typical 0 dBm)
- TUNE SPAN OUT (not specified)
- MULTIPLEXER OUT (not specified)
- TUNE OUTPUT (not specified)

Environmental temperature:

Operational, 0 to +55°C; storage, -40 to +75°C

Humidity:

Operational, 0 to 95% relative humidity at 45°C

Warm-up time:

30 minutes recommended

EMC:

Meets MIL-STD 461B

Power requirements:

HP 71708A - See requirements for HP 70004A. All power supplied by the mainframe (HP 70004A).

HP 70428A - Requires as much as 80 watts of regulated power from mainframe.

Weight:

HP 71708A:
26.8 kg (58.9 lb) nominal

HP 71708A Option 002:
29.3 kg (64.5 lb) nominal

HP 70428A:
7.4 kg (16.1 lb) nominal

HP 70428A Option 002:
9.9 kg (21.7 lb) nominal

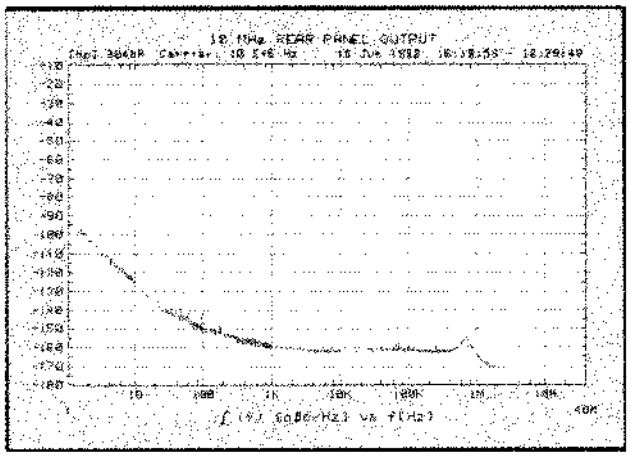
Warranty:
One year (extendible with options)

Calibration cycle:
One year recommended

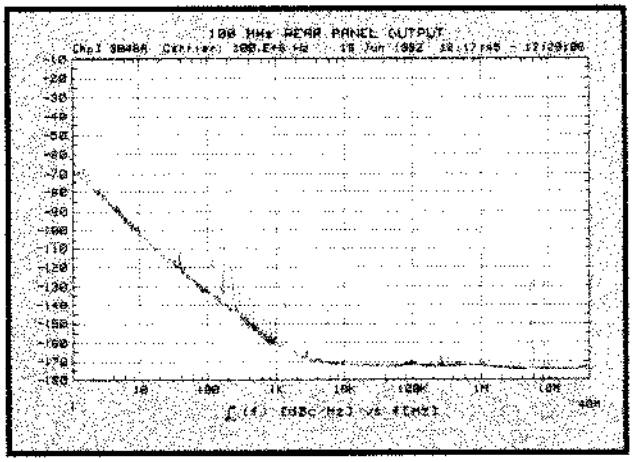
Supported power meters for output power calibration:
HP 70100A Power Meter
HP 437B Power Meter
HP 438A Power Meter

Supported displays and mainframes:
HP 70004A Color Display/Mainframe
HP 70206A Display with HP 70001A Mainframe

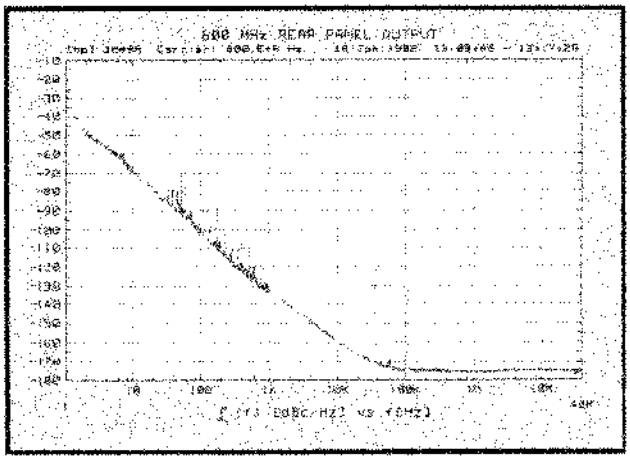
Supplemental characteristics



10 MHz rear panel output:
Typical Phase Noise Performance



100 MHz rear panel output:
Typical Phase Noise Performance



600 MHz rear panel output:
Typical Phase Noise Performance

HEWLETT PACKARD

Ordering information

HP 71708A Microwave Source $60,700
Options:
002
0.1 Hz frequency resolution capability.....$25,000
(requires an HP 8662A/3A Option 003)
003
Add HP 8662A Option 003
Synthesized Signal Generator.....$42,500
004
Add HP 8663A Option 003
Synthesized Signal Generator.....$58,400
+W30
Extended service and repair (std) $1,485
with Option 002 .....$2,110
908
Rack flange kit without handles
(p/n 5062-3979) $40
910
Provides a total of two sets of
user guides (p/n 70427-90002),
component level information
packets (p/n 70427-90004), and service
documentation disks (p/n 70428-90007
and 70428-90008) $1,400
913
Rack flange kit with handles
(p/n 5062-4073) $45
0BW[1]
Service documentation on a disk
(p/n 70428-90007 and 70428-90008) $400

HP 70428A Microwave Source Module.....$50,000
Options:
002
0.1 Hz frequency resolution capability.....$25,000
(requires an HP 8662A/3A Option 003)
+W30
Extended service and repair (std) $1,250
with Option 002 .....$1,875
910
Provides a total of two sets of
user guides (p/n 70427-90002),
component level information
packets (p/n 70427-90004), and service
documentation disks (p/n 70428-90007
and 70428-90008) $1,400
0BW[1]
Service documentation on a disk
(p/n 70428-90007 and 70428-90008) $400

[1] Requires a PC, Windows 3.0/3.1, 3½-inch 1.44 Mbyte floppy drive, 4 Mbyte RAM, VGA monitor, and 7 Mbyte available hard disk space.

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