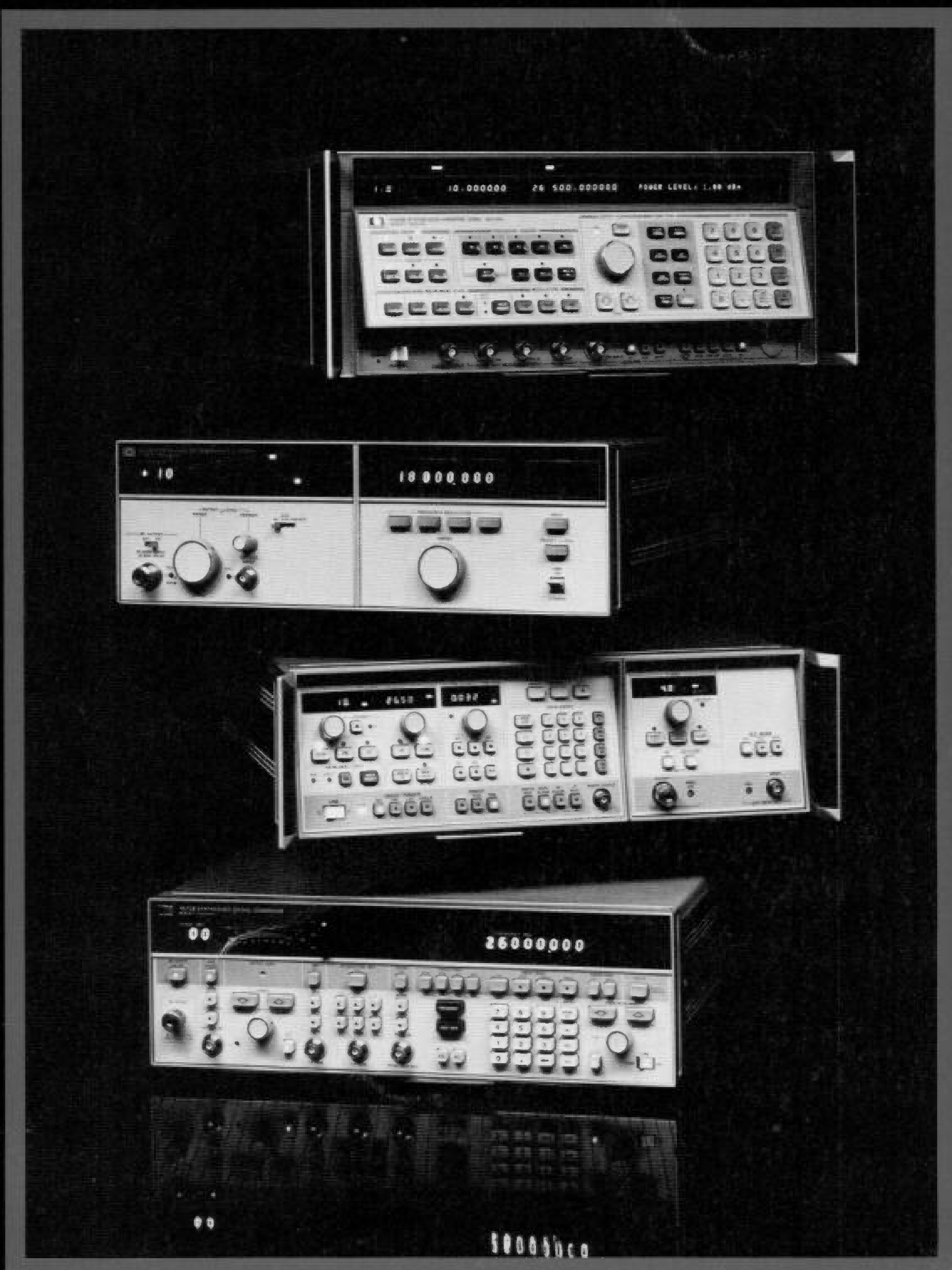
Application Note 329

HEWLETT PACKARD

Microwave signal sources

Spectral purity characteristics of HP microwave signal sources



Introduction

There are several types of microwave frequency sources available from Hewlett Packard. This application note focuses on the spectral purity of each source, as this specification can be a critical selection factor. In addition, the features, specifications and applications for the different types of microwave sources will also be covered.

Hewlett Packard offers microwave sources in four general categories: signal generators, sweep oscillators, synthesizers, and phase locked sweep oscillators. The representative Hewlett Packard instruments discussed are as follows:

Synthesized Sweepers:
HP 8340/41B

Synthesized Signal Generators:
HP 8672A, 8671B, 8673B/C/D/E

Signal Generator: HP 8683/8684

Sweep Oscillator:
HP 8350B/83595A

Sweep Oscillator with Microwave Source Synchronizer:
HP 5344S/8350B

Spectral Purity

The spectral purity of a frequency source describes how closely the output frequency spectrum represents that of an ideal signal. Spectral purity may be divided into three general components: phase noise, harmonically related spurious signals, and non-harmonically related spurious signals.

Phase noise is a measurement of short term frequency instability, describing the characteristic randomness of unwanted angular modulation on a carrier. Measurements of short term frequency instability include residual FM, fractional frequency deviation and single sideband (SSB) phase noise. All of these parameters are mathematically related to each other, however SSB phase noise is the most commonly referred to specification.

Since all sources are not specified by phase noise, a SSB phase noise measurement was made on a typical sample from each HP model mentioned above to show the relative shapes of the phase noise characteristics. These measurements were made on the HP 11740 Phase Noise Measurement System which is described in the Appendix. The SSB phase noise plots seen in each instrument section have carrier frequencies of 6 GHz and data normalized to dBc in a 1 Hz noise bandwidth. For frequencies greater than 6 GHz, an approximate phase noise level can be estimated by adding 6 dB for each doubling of the frequency.

In addition to phase noise measurements, AM noise data was taken on each HP model at a carrier frequency of 18 GHz by the HP 11740 Phase Noise Measurement System. The absolute noise of any device is set by both the residual noise of the active device and the bandwidth of the resonator. Most frequently, sources of this AM noise include ALC loops, modulation circuitry, AM flickers close to the carrier and power supply noise.

The most prevalent areas of concern for AM noise are in two-port device phase noise measurements and the AM to PM noise conversion that occurs in active or nonlinear devices. The need for minimizing the total phase noise present in these devices require an accurate characterization of the AM noise component alone. The measurements located in this application note are representative of each HP model, and should not be interpreted as specifications.

The phase noise and AM noise measurements in this application note include power line related spurious signals. These signals are visible only on the microwave synthesizers which have excellent close in phase noise characteristics. These signals are designated by separate specifications and are not included in the phase noise specifications of these sources. They have been included in this application note for completeness. Distinct power line related spurious signals will be visible on each plot in the approximate position indicated in Figure 1. These power line related spurious signals should only be compared with their individual power line related spurious specifications.

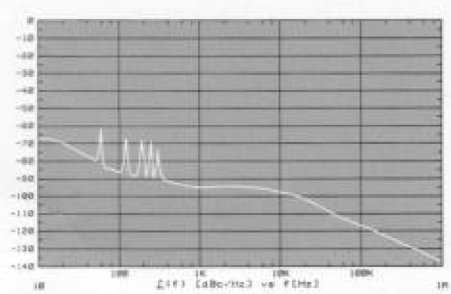


Figure 1

W1RG

Specifications and Applications

In addition to SSB phase noise there are many other performance areas which must be considered in determining which source is best suited for a particular application. These areas include frequency, power, modulation, and usability features, and will also be discussed in each source section. A complete summary is located in the Specification Summary Table at the conclusion of this document.

The main emphasis of this application note, however, is the spectral purity of the Hewlett Packard microwave sources. Specifically, SSB phase noise was measured for each source type, since it is often the limiting factor in the design and test of high performance microwave radar and communication systems. Some applications may have such stringent phase noise requirements that not even a synthesized microwave source can satisfy its requirements. Some examples of these applications include Doppler radar systems, reciprocal mixing receivers, and digital communication systems.

Doppler radars determine the velocity of a target by measuring the small Doppler shifts in frequency that the return echoes have undergone. In the case of an airborne radar, the return echo also includes a large "clutter" signal which is the unavoidable frequency shifted echo from the ground. This results in a situation where a small signal, the target echo, must be discerned in the presence of the much larger clutter signal that is very close in frequency (see Figure 2). The system performance than becomes limited by the phase noise of either the transmitter oscillator or the receiver local oscillator.

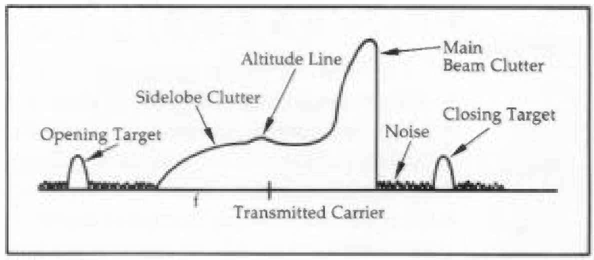


Figure 2

Reciprocal mixing causes a receiving system to lose sensitivity when there is a strong signal near the frequency to which the receiver is tuned. This effect is due to the phase noise of the local oscillator modulating the carrier of the strong signal. When the receiver is tuned to a frequency near the strong carrier, the power density in the strong carrier's noise sidebands may exceed the noise floor of the receiver, hence limiting the receiver sensitivity (see Figure 3).

Phase modulation is usually used to transmit digital signals. For digital signals, the phase of the carrier is shifted in integer multiples of a minimum phase step. Local oscillator phase noise will effect the bit error rate performance of a phase-shift keyed digital transmission system. A transmission error will occur any time the local oscillator phase, due to its noise, becomes sufficiently large so that the digital phase detection makes an incorrect decision as to the transmission phase.

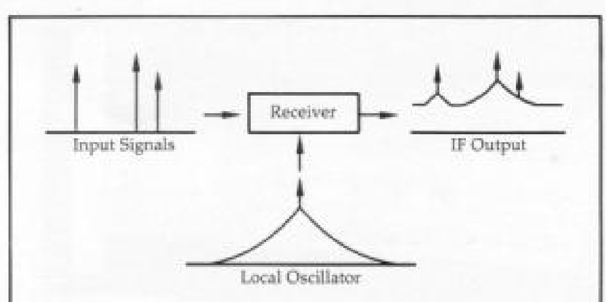


Figure 3

The predominant applications of microwave frequency sources are signal simulation for radar or communications receiver testing, component testing (including noise measurements), and satellite communications (as local oscillators). The source requirements for these applications are highly specialized, which precludes any one source from satisfying the needs of all applications or even all applications within a particular category. In order to determine the optimum source for a particular application it is necessary to make a comparison of the application requirements versus the complete set of source specifications.

Synthesized Sweepers: HP 8340B & 8341B

Synthesized sweepers combine the accuracy and precision of a synthesizer with the versatility of a broad band sweep oscillator in a single instrument. In CW operation the synthesized sweeper offers the low phase noise and high stability of a stand alone synthesizer. Modulation capability is also available to simulate signals required to test receiver systems. In swept operation a broad band, continuous, analog sweep is provided for rapid component characterization. For high Q devices a narrow-band, phase continuous synthesized sweep is available. Because it can perform as either a synthesizer or a sweeper, the synthesized sweeper is often found in large ATE system applications where it can replace several instruments. It is also well suited for EW/ECM system tests requiring broad frequency range, stability and pulse modulation. The following section will discuss the HP 8340B/8341B Synthesized Sweepers.

HP 8340B & 8341B Key Features

- Broad frequency range
- High frequency accuracy and resolution (1 Hz)
- Low phase noise
- Complete network analyzer compatibility
- DC coupled AM, FM and pulse modulation capability
- Full function analog sweep
- Calibrated output power/dynamic range

The HP 8340B/8341B Synthesized Sweepers are high performance sources with low phase noise CW and versatile swept performance. The frequency range is 10 MHz to 26.5 GHz for the HP 8340B and 10 MHz to 20.0 GHz for the HP 8341B. This range may be swept continuously or CW stepped with switching speeds as low as 20 msec and a resolution of 1 to 4 Hz. The output power is calibrated over a dynamic range spanning from +20 dBm to −110 dBm. Internal power leveling as well as external power leveling using a power meter or a diode detector, is provided for improving the level flatness and effective source match. The maximum leveled power varies over the frequency band as follows: + 10 dBm (0.01 to 2.3 GHz); +12 dBm (2.3 to 7.0 GHz); +10 dBm (7.0 to 13.5 GHz); +9 dBm (13.5 to 20.0 GHz); +3 dBm (20.0 to 23.0 GHz); +1 dBm (23.0 to 26.5 GHz).

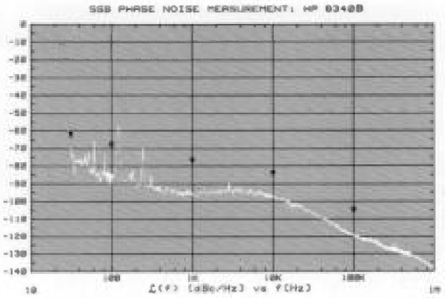
DC coupled AM and FM are available on both the HP 8340B and 8341B when an external modulation source is provided. AM modulation operates for rates ranging from DC to 100 kHz and depths from 0 to 90%. FM modulation is characterized by rates ranging from 50 kHz to 10 MHz with peak frequency deviations to 10 MHz (maximum).

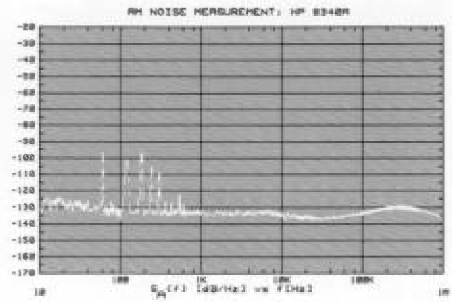
The HP 8340B/8341B contain an internal pulse modulator which when used with an external modulation source provides calibrated, leveled pulse modulation over the full frequency range. The HP 8340B/8341B excellent pulse performance features rise and fall times of <25 nsec, a >80 dB ON/OFF ratio, and a minimum leveled RF pulse width of <100 nsec. In addition the HP 8340B/8341B have extremely low video feedthrough: <5% (0.01 to 2.3 GHz) and <0.1% (2.3 to 26.5 GHz).

The analog sweep capability of the HP 8340B/8341B provides sweep widths from 100 Hz to the full frequency range of the instrument. Sweep rates are as fast as 600 MHz/msec or as slow as to accommodate a 200 sec sweep. The HP 8340B/8341B may be used in applications that require low RFI leakage levels as the conducted and radiated interference is within the requirements of CE03 and RE02 (relaxed by 10 dB) of MIL STD 461A. In addition to all the previous features, the HP 8340B/8341B are completely programmable. This capability makes them well suited for automatic test systems.

Spectral Purity

The outstanding phase noise of the HP 8340B/8341B reflect the phase noise of the internal reference oscillator as well as the spectrally clean phase lock loops. The spurious content of the HP 8340B/8341B contain harmonics of the output frequency <-35 dBc. Subharmonics (and multiples thereof) of the output frequency are <-25 dBc from 7.0 to 20.0 GHz and <-20 dBc from 20 to 26.5 GHz (HP 8340B only). For improved harmonic performance, Option 003 is available on the HP 8341B which provides harmonics and subharmonics of <-50 dBc from 1.4 to 20.0 GHz. The non-harmonically related spurious signal level varies with frequency range. Line related spurious signals are discernible due to the excellent phase noise characteristics of the HP 8340B/8341B. The specifications for these spurious signals are tabulated below.





Frequency (in GHz)	Non-Harmonic Spurious Signals	Line Related Spurious Signals		
		Offset from Carrier		
		<300 Hz	300 Hz to 1 kHz	>1 kHz
0.01 to 2.3	< −50 dBc	−50 dBc	−60 dBc	−65 dBc
2.3 to 7.0	< −70 dBc	−50 dBc	−60 dBc	−65 dBc
7.0 to 13.5	< −64 dBc	−44 dBc	−54 dBc	−59 dBc
13.5 to 20.0	< −60 dBc	−40 dBc	−50 dBc	−55 dBc
20.0 to 26.5	< −58 dbc	−38 dBc	−48 dBc	−53 dBc

Synthesized Signal Generators: HP 8673B/C/D/E, 8671A, 8671B

Synthesized signal generators are designed to perform the same functions as signal generators but with greatly improved phase noise and stability. As well as having improved spectral purity, synthesized signal generators are also programmable. In addition to the standard signal generator applications, such as low level signal measurements, and receiver testing, synthesized signal generators are also used in automatic test systems, noise figure measurements, metrology labs and as precision local oscillators. The following sections will discuss the HP 8671B Synthesized CW Generator and the 8672A and 8673 series Synthesized Signal Generators.

HP 8671B Key Features

- Low phase noise
- High frequency accuracy and fast frequency switching
- Calibrated output power from −120 to +8 dBm
- LO capabilities for downconversion
- +8 dBm across the entire frequency range

The HP 8671B is a high performance CW source, designed for demanding applications requiring high spectral purity, stability and frequency accuracy. The frequency range of the HP 8671B is 2.0 to 18.0 GHz. The broad frequency coverage in conjunction with fast switching speeds (less than 15 msec) and complete programmability combine to make this synthesizer a very efficient source.

The power output is calibrated over a dynamic range from +8 dBm to −120 dBm. Internal as well as external leveling using a power meter or a diode detector, is provided for improving the level flatness for effective source match.

The HP 8671B provides an economical alternative in both EW and communications testing. This high quality synthesized source produces low phase noise (<-60 dBc) and low spurious signals (<-40 dBc) by concentrating only on CW operation. The design is targeted for use as a downconvertor in local oscillator applications.

Spectral Purity

The low phase noise of this synthesizer reflects the phase noise of the reference oscillator as well as the internal phase lock loops. The spurious content of this synthesizer contains harmonics <-25 dBc. The non-harmonically related spurious content varies with frequency range; and line related spurious signals are also discernible. Refer to the table for specifications.

HP 8672A Key Features

- Low phase noise
- High frequency accuracy and fast frequency switching
- Metered AM/FM capability
- Calibrated output power/dynamic range

Additional HP 8673E Key Features

- Digital display (0.1 dB resolution)
- Pulse modulation
- 128 dB dynamic range

HP 8673B Key Features

- 2.0 to 26.0 frequency coverage
- Digital sweep modes
- AM, FM and pulse modulation

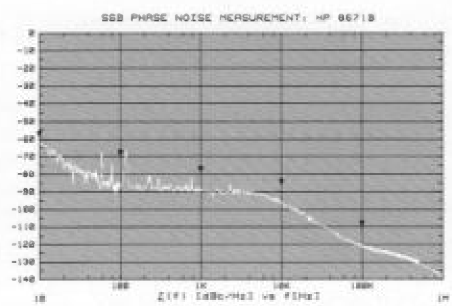
HP 8673C/D Key Features

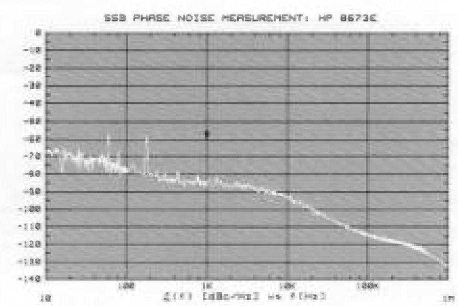
- 0.05 to 2.0 GHz extended frequency range
- +6 dBm output power at 26.0 GHz (HP 8673D only)
- Internal tracking YIG-filter

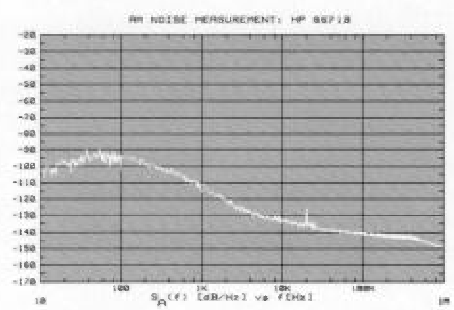
The HP 8672A and 8673 series of high performance CW synthesizers provides a combination of excellent spectral purity and stability. Frequency coverage consists of 0.05 to 18.6 GHz for the HP 8673C (26.5 GHz for the HP 8673D) and 2.0 to 18.0 GHz for the HP 8672A and HP 8673E (26.5 GHz for the HP 8673B). The combination of this broad frequency range and switching times of <20 msec (<50 msec on the HP 8673C/D) provide the versatility demanded in modern communications and radar/EW applications.

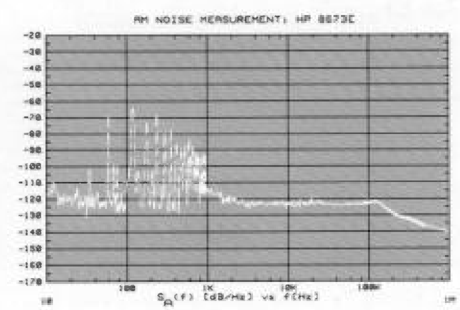
AM and FM modulation are available on the HP 8672A while the full HP 8673 series adds pulse modulation to the list. AM modulation rates operate from 20 Hz to 100 kHz (10 Hz to 50 kHz for the HP 8673E). FM modulation operates for rates between 50 Hz to 10 MHz on the HP 8672A and rates between 100 Hz to 10 MHz for the HP 8673 series (50 Hz to 2 MHz for the HP 8673E), with deviations up to 10 MHz peak. Phase lock is maintained in all modes, and simultaneous modulation operation is also available.

The HP 8673 series has a calibrated and leveled internal pulse modulator, which when used with a modulation source produces an ON/OFF ratio >80 dB (>70 dB for the HP 8673E). Rise/Fall times are typically <40 nsec (<50 nsec on the HP 8673E). The resultant pulse can be leveled and has a minimum pulse width of 100 nsec.









Spectral Purity

The synthesizer's low phase noise is a direct result of the phase noise of the reference oscillator. The harmonic content of the spurious signals is <-25 dBc on the HP 8672A (up to 18 GHz). For the HP 8673 series these signals are <-40 dBc up to 1.2 GHz and <-60 dBc for above 1.2 GHz. The non-harmonically related content varies with frequency range, the specifications for line related spurious signals are also low.

Frequency[1] (in GHz)	Non-Harmonic Spurious Signals[2]	Line Related Spurious Signals		
		Offset from Carrier		
		<300 Hz	300 Hz to 1 kHz	>1 kHz
0.05 to 2.0	< −60 dBc	−50 dBc	−60 dBc	−65 dBc
2.0 to 6.6	< −70 dBc	−50 dBc	−60 dBc	−65 dBc
6.6 to 12.3	< −64 dBc	−44 dBc	−54 dBc	−59 dBc
12.3 to 18.6	< −60 dBc	−40 dBc	−50 dBc	−55 dBc
18.6 to 26.0	< −58 dbc	−38 dBc	−48 dBc	−53 dBc

1 The HP 8671B and 8672A frequency range limits require replacement of 6.6 GHz with 6.2 GHz, and 12.3 GHz with 12.4 GHz.
2 The HP 8673E is typically < −40 dBc for all frequency ranges.

Signal Generators: HP 8683 & 8684

The term signal generator refers to a source which is tunable over a calibrated range of frequency, has calibrated output power with a wide dynamic range and provides one or more forms of calibrated modulation. Most often, signal generators are used for applications which require a simulated signal, an example being receiver calibration and performance verification. Additionally, since these measurements must often be accomplished at low signal levels, signal generators have low RFI leakage levels. The following section will discuss the HP 8683/8684 Signal Generators.

HP 8683 & 8684 Key Features

- Less than 5 kHz residual FM
- Extensive modulation capabilities with internal pulse rate generator (HP 8683/8684B and D only)
- Frequency ranges matched to microwave applications
- Good phase noise far from the carrier (>1 MHz offset)
- Calibrated power (up to +10 dBm)/dynamic range
- EMI performance
- Rugged/portable
- Calibrated AM/FM capabilities

The HP 8680 family of signal generators is optimized for radar/EW and communication applications. These applications require modulation capability over a broad frequency range, a low noise floor and low RFI leakage levels. These sources provide CW signals with frequency ranges of 2.3 to 6.5 GHz for the HP 8683A/B (13 GHz for the HP 8683D), and 5.4 to 12.5 GHz for the HP 8684A/B (18 GHz for the HP 8684D). The 8680 family is based on a mechanically tuned cavity oscillator which provides a very low noise floor of typically −150 dBc (HP 8683) and −145 dBc (HP 8684) at maximum specified power. As a result of the mechanically tuned cavity the HP 8680 signal generators are not programmable; however, internal leveling is provided for source match and power level flatness. The generators meet the radiated and conducted limits of MIL STD 461A, while their size, weight and rugged construction make these instruments ideal for portable applications.

HP 8683A & 8684A

The 8683A and the 8684A Signal Generators are optimized for communication applications, providing both AM and FM modulation. These signal generators have calibrated, low distortion FM modulation with the FM rate ranging from DC to 10 MHz (DC coupled) and 50 Hz to 10 MHz (AC coupled), and deviations to +5 MHz. The modulation capability also includes calibrated and metered AM. In addition to external modulation these sources have internal AM (1 kHz square wave) and internal FM (1 kHz sawtooth) modulation.

Dynamic range is often an important criteria in applications such as low level signal simulation. The HP 8683A/8684A provide 130 dB (optional 140 dB) of dynamic range. This range spans from 0 dBm (+10 dBm optional) to −130 dBm.

HP 8683B & 8684B

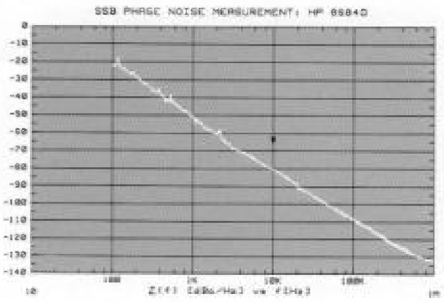
By adding pulse modulation to the AM and FM modulation offered by the HP 8683A/8684A, the HP 8683B/8684B have the capabilities required for many radar/EW applications. The high performance internal pulse modulation capability of the HP 8683B/8684B offers an ON/OFF ratio of >80 dB and a rise/fall time <10 nsec. The internal pulse generator has pulse widths from <100 nsec to 100 msec, rates from 10 Hz to 1 MHz and delays from <50 nsec to 100 msec.

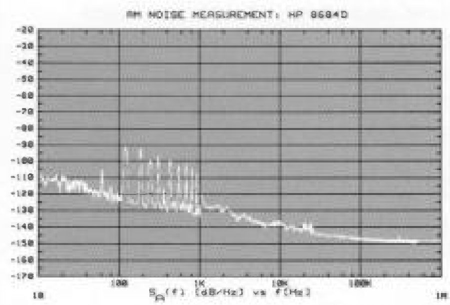
The dynamic range of the HP 8683B/8684B is extended to 140 dB by providing +10 dBm standard and maintaining the minimum power level at −130 dBm.

HP 8683D & 8684D

The HP 8683D and 8684D Signal Generators are designed for communications and radar/EW applications, providing AM, FM and pulse modulation. The increased frequency range due to the internal passive doubler, (2.3 to 13.0 GHz for the HP 8683D, and 5.4 to 18.0 GHz for the HP 8684D), enables one-box testing of the S, C, X and Ku bands.

The extended dynamic range (140 dBm) satisfies high output power applications. The high performance internal pulse modulation capability provides a rise/fall time <10 nsec, an ON/OFF ratio of >80 dB, and a pulse width of <100 nsec. Complex signals can also be generated with the use of simultaneous modulation types: chirping with FM and pulse, or antenna scan patterns with AM and pulse.





Spectral Purity

The phase noise characteristics of a cavity tuned oscillator result in excellent phase noise far away from the carrier with phase noise representative of a free running oscillator close to the carrier. This can be seen by observing the steep, straight slope of the phase noise plot. The spurious content of the signal contains harmonically related signals <-25 dBc, and very small non-harmonically related signals, <-80 dBc. These non-harmonic signals are ideal for image and spurious rejection testing.

Sweep Oscillators: HP 8350B/83595A

Sweep oscillators are designed to provide a calibrated, swept frequency output with high power capability. In addition, external and internal leveling is provided for improved source match and power level flatness. Sweep oscillators have traditionally been used for component testing because of the speed and convenience that is provided by a swept signal. However, their broad frequency range, high calibrated output power and programmability have made them suitable for many automatic test systems and general purpose applications such as signal generation and simulation. The following section discusses the HP 8350B/83595A Sweep Oscillator which is representative of the HP 8350B/83500 series.

HP 8350B/83595A Key Features

- Analog sweep capability
- Broad frequency range (extensive plug-in flexibility)
- Calibrated output power
- Frequency markers (up to 5)
- Low harmonics
- Compatibility with HP scalar and vector network analyzers and noise figure meter

The HP 8350B Sweep Oscillator family is very versatile, utilizing plug-ins for variable broad-band frequency coverage and offering a wide variety of mainframe features. A discussion of the 8350B Sweep Oscillator family may be divided into two areas, the main frame and the RF plug-ins.

Mainframe (HP 8350B)

The 8350B mainframe operates with 33 different plug-ins to cover the broad frequency range of 10 MHz to 40 GHz. It is microprocessor-based, which allows for many usability features such as digital data entry and SAVE/RECALL of the front panel settings. The HP 8350B also provides five independent frequency markers with such functions as marker sweep, marker difference, and marker to center frequency. For improved accuracy while sweeping the HP 5343A Microwave Counter can be used (with a simple 2-wire interface) to measure marker, start and stop frequencies. Additional accuracy and stability can be acquired by utilizing the HP 5344S Source Synchronizer to phase lock the RF output.

Network analyzer compatibility is a key feature when making many swept measurements. The HP 8350B is compatible with the HP 8756A and 8757A Scalar Network Analyzers (providing the required 27.8 kHz modulation) and the HP 8410C and 8510A Microwave Network Analyzers. Noise figure measurements from 1.5 to 26.5 GHz are also easily made using the HP 8970A Noise Figure Meter and the HP 8350B Sweep Oscillator as an external local oscillator. In addition, the HP 8350B driving the HP 8349B Microwave Amplifier provides up to +20 dBm of output power across a 2 to 20 GHz frequency range.

RF and Microwave Plug-ins

HP 83500 series RF Plug-ins: The HP 83500 series provide broad-band frequency coverage, as demonstrated by the HP 83595A which covers 10 MHz to 26.5 GHz in a single sweep, with frequency accuracy better than 12 MHz at 26 GHz. This plug-in series provides calibrated, internally leveled output power over a 15 dB range (typically) with 0.1 dB resolution that can be extended to 80 dB with an internal attenuator (Option 002). The output power may also be swept over a 10 dB range (minimum) allowing for real time power response measurements, and can be externally leveled with diode detectors or power meters. Additional standard features include internal leveling, power sweep and slope control. All functions on the HP 83500 series RF Plug-ins are completely programmable.

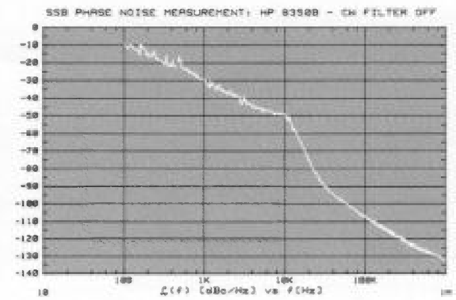
HP 86200 series Plug-ins: The HP 86200 series plug-ins provide economical alternatives to the HP 83500 series plug-ins via the HP 11869A adapter, as well as offering specialized singleband frequency coverage. Internal leveling and external leveling with crystal detectors and power meters are available with calibrated power (not programmable) and optional attenuators are available on selected plug-ins. This series also provides upconvertor simulation options for use in microwave link analysis to measure communications distortions.

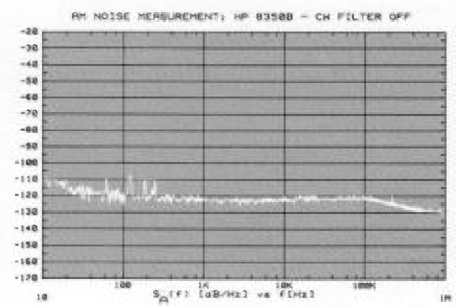
Spectral Purity

Because they are designed for swept frequency applications, sweep oscillators have not generally been optimized for spectral purity. Consequently sweep oscillators are not specified by phase noise but by residual FM. The signal characteristics come directly from the YIG oscillator and the CW filter (when engaged). The CW filter is a large capacitor that filters the tuning voltage to the YIG oscillator. This filter serves to improve the phase noise between 100 Hz and 50 kHz offset from the carrier but does not alter the close-in phase noise of the free running oscillator. This filter also slows down the frequency settling time. The noise floor of the sweeper is below −130 dBc.

The phase noise level of the HP 8350B/83595A with the CW filter off is degraded from the performance with the CW filter on. The sweep oscillator is often used with the CW filter off because the frequency settling time is as much as a hundred times faster than with the CW filter on. In addition the majority of phase lock systems require that the CW filter be off to achieve phase lock. As a result the phase noise improvement of the phase locked sweeper as compared with the unlocked sweeper should be made using the phase noise plot of the HP 8350B/83595A with the CW filter off.

The spurious content of the HP 83595A RF Plug-in consists of: harmonics and subharmonics <-25 dBc (typically <-35 dBc) between 10 MHz and 20.0 GHz and <-20 dBc (typically <-25 dBc) between 20.0 and 26.5 GHz; and non-harmonically related spurs <-25 dBc between 10 MHz and 2.4 GHz and <-50 dBc between 2.4 and 26.5 GHz. (Improved harmonically related spurious performance is available on the 10 MHz to 20 GHz HP 83592C where they are specified at −50 dBc from 1.4 to 20 GHz).





Phase Locked Sweep Oscillators: HP 5344S/8350B

Phase locked sweep oscillators exhibit improved long term stability, frequency accuracy and resolution from that of a stand alone instrument. The enhanced performance obtained by phase locking a signal generator makes this source more suitable for applications such as narrow-band channel testing. The improved sweeper performance increases its ability to accurately measure frequency selective devices, in addition to enhancing its capability in signal simulation applications. The HP 5344S Microwave Source Synchronizer is used for the purpose of phase locking a source and will be discussed in the following sections.

Source Synchronizer: HP 5344S

The HP 5344S Microwave Source Synchronizer is capable of phase locking a signal source (which has a DC coupled FM input of 1-50 MHz/Volt sensitivity) with 1 Hz resolution to any frequency between 500 MHz and 18 GHz (26.5 GHz with Option 043). The HP 5344S system uses both a microwave counter (HP 5342A or HP 5343A) and a source synchronizer (HP 5344A) to phase lock the source. The system utilizes the microprocessor located in the HP 5342A (or HP 5343A) Microwave Counter to perform the calculation and communication functions.

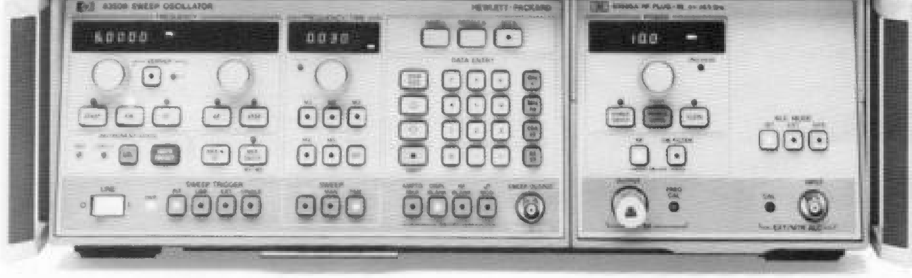
The HP 5344S has many capabilities beyond CW phase locking. For example, the counter in the HP 5344S system may be used as a stand alone counter. In addition, the HP 5344S has two sweep modes: a narrow-band, phase continuous sweep mode and a wideband Lock and Roll sweep mode, which phase locks the start frequency of a swept source thereby improving the swept accuracy to the sweep linearity ($\pm$10 MHz on the HP 83595A).

HP 5344S/8350B Key Features

- Improved frequency accuracy and extended frequency range
- Improved close-in phase noise and stability
- High resolution (1 Hz)
- Locked sweeps (up to 40 MHz) with markers (up to 4)
- Lock and Roll sweeps with markers
- Auto-lock via HP-IB
- Auxiliary output (on multiband plug-ins) for RF power conservation

The HP 5344S Source Synchronizer can phase lock the HP 8350B Sweep Oscillator or HP 8620C (Option 011) Sweep Oscillator in either CW or swept modes. This system improves the frequency stability to 5×10^{-10} per day and the frequency resolution to 1 Hz. To achieve phase lock, the HP 5344S operates in either Manual Lock or Auto Lock mode. In the Manual Lock mode, phase lock may be achieved within a capture range of $\pm$25 MHz. The lock time in the Manual Lock mode is typically 900 msec when using the HP 5342A Microwave Counter, or 500 msec when using the HP 5343A Microwave Counter. The Auto Lock mode is capable of phase locking the HP 8350B over an unlimited capture range. In this mode, the HP 5344S operates as a controller and programs the HP 8350B to the desired frequency via HP-IB. The lock time for Auto Lock is typically 1.5 sec when using the HP 5342A or 1.1 sec when using the HP 5343A.

There are two swept modes on the HP 5344S: narrow-band locked sweep, and wideband Lock and Roll sweep. A narrow-band sweep is a continuous phase sweep (phase locked) with widths up to 40 MHz wide and linearity of $\pm$0.05%. Up to



four markers are available from the HP 5344S during a narrow-band sweep. Lock and Roll sweeps are attained by phase locking the start frequency and transferring control to the sweeper for the remainder of the sweep. The swept accuracy using Lock and Roll is improved to that of the sweep linearity (there is no longer any error in the sweep due to start frequency inaccuracy). While in the Lock and Roll mode, counted markers and counted stop frequencies are available when using the HP 5344S Option 043.

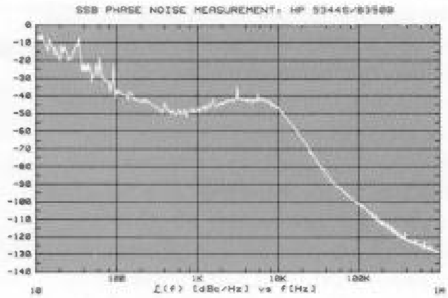
The loop bandwidth of the HP 5344A is selectable to either narrow-band (10 kHz) or wideband (100 kHz). The wide bandwidth is used to capture sources that are known to be noisy. The narrow bandwidth phase locks most HP 8350 sweeper plug-ins.

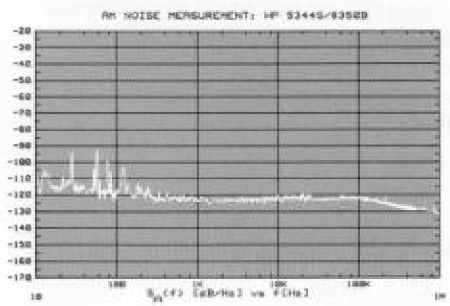
Two additional features of the HP 5344S are its offset locking and subharmonic locking modes. The offset locking mode may be used when the auxiliary output of the source is offset from the main output by the frequency of the cavity oscillator used in the heterodyne band (this technique is used in the HP 83592A/B/C and HP 83595A plug-ins when covering 10 MHz to 2.4 GHz). When using this offset mode, the main output accuracy is limited by the residual stability of the cavity. In subharmonic locking, the HP 5344S phase locks the fundamental YIG oscillator frequency available from the auxiliary output on broadband, multiplier based plug-ins (the HP 8359X and HP 86290 series). Using the auxiliary output eliminates the need to couple off a reference signal from the main output for phase locking, allowing maximum RF power at the main output. In addition, the HP 5344S Source Synchronizer with the HP 8350B Sweep Oscillator is a fully HP-IB programmable system.

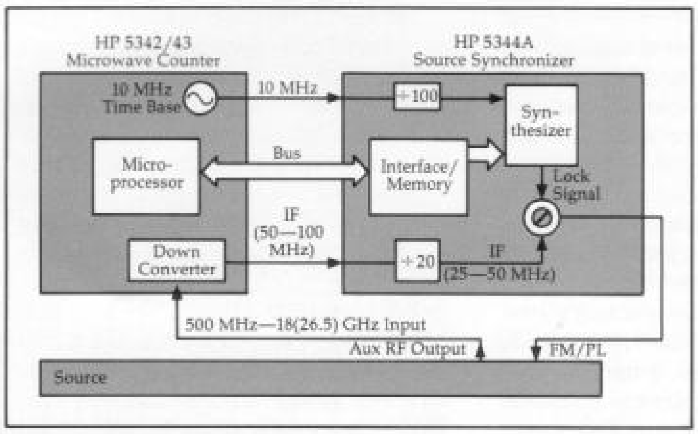
Spectral Purity

Phase locking the HP 8350B Sweep Oscillator with the HP 5344S Source Synchronizer improves the close-in (less than 200 Hz) phase noise. The phase noise between 200 Hz and 100 kHz is increased from that of the stand-alone sweep oscillator due to the phase lock loop performance. The phase noise at offsets greater than 100 kHz resembles that of the stand-alone sweeper with the CW filter on.

The phase locked sweep oscillator contains spurious signals that have been added by the loop characteristics, although the magnitude of these signals falls within the sweep oscillator's non-harmonic specification of <-50 dBc (2.4 to 26.5 GHz). The harmonically related spurious signals are the same as for the stand alone sweeper (<-25 dBc between 10 MHz and 20 GHz, <-20 dBc between 20 GHz and 26.5 GHz).







HP 5344S Block Diagram

Conclusion

The figures below provide a summary of the characteristic SSB phase noise shapes of the source types discussed in this application note. The phase noise characteristics of the sweep oscillators (Figure 1) are representative of a free running YIG oscillator. Adding the HP 5344S Microwave Source Synchronizer improves the accuracy and long term stability . However, the phase lock loop response increases the noise in the offset region between 1 kHz and 100 kHz. For stringent close-in phase noise requirements, the performance of a synthesizer, such as the HP 8340B, provides the best solution.

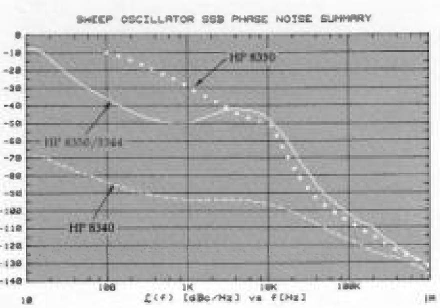


Figure 1

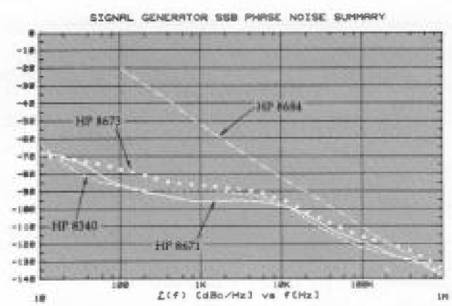


Figure 2

The phase noise characteristics of the signal generators (Figure 2) are representative of the free running cavity tuned oscillator. While they are superior to a free running YIG oscillator, they are still higher than a synthesizer. Not shown are the characteristics at >1 MHz offsets. This is where the HP 8683/84 series offers superior performance, even when compared to a microwave synthesizer.

The AM noise measurement plots shown below present a summary of the sources on the basis of residual AM. Comparing the measurements of the sweep oscillators (Figure 3), it can be seen that the responses are approximately flat for carriers up to 100 kHz. For applications where low residual AM is necessary, the HP 8350 provides the best response.

The residual AM plots for signal generators are summarized in Figure 4. A comparison of these measurements shows that the HP 8671B provides the lowest residual AM for offsets greater than 100 Hz. Applications requiring low AM noise close-in however, are best served by the HP 8684D.

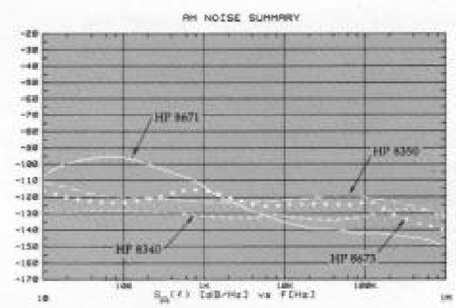


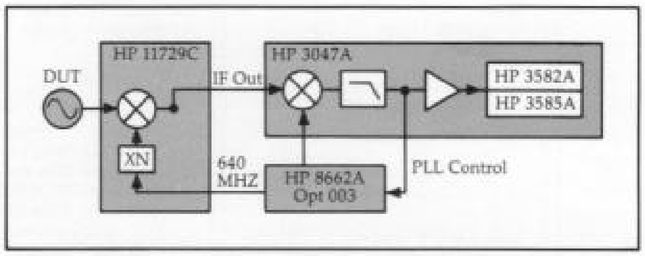
Figure 3

Appendix: HP 11740S Phase Noise Measurement System

The HP 11740S Phase Noise Measurement System consists of a HP 3047A Spectrum Analyzer System (HP 3585A Spectrum Analyzer, 3582A Spectrum Analyzer, 35601A Spectrum Analyzer Interface and HP 9836 Desktop Computer), an HP 11729C Carrier Noise Test Set, an HP 8662A Synthesized Signal Generator and the 11740S system software. The system defines phase noise as all forms of frequency and phase instabilities.

The complexity of phase noise measurements increases with increasing source performance. For relatively noisy sources, the noise can be measured directly on a spectrum analyzer. However, for many sources this measurement is not sensitive enough. If the spectrum analyzer is preceded by a frequency discriminator or phase detector, the system sensitivity can be increased. The HP 11740S is designed to reduce the difficulty of making accurate phase noise measurements with quadrature phase detector techniques.

When the above technique is used, phase noise measurements are always made with respect to a 1 Hz bandwidth. To measure the entire spectrum in a 1 Hz bandwidth would take an excessive amount of time so the HP 11740S measures the phase noise in wider bandwidths as the frequencies are further removed from the carrier. (Close to the carrier, bandwidths much less than 1 Hz must be used.) From these measurements, the system normalizes the noise to a 1 Hz bandwidth and plots this result.



HP 11740S Block Diagram

This phase detector method uses a double balanced mixer as a phase detector. If two signals of the same frequency and 90 degrees out of phase are applied to the mixer, the output will contain a low frequency signal whose amplitude represents the phase noise of the sources. The phase detector system depends on the 90 degrees phase relation between the two sources. Unless the sources are extremely stable, they will not stay 90 degrees out of phase for any length of time. The solution to this problem is to lock one of the sources to the other with a phase lock loop. The loop provides a tuning voltage to one of the sources to maintain the two sources at the same frequency and, on the average, 90 degrees out of phase. For frequencies that are far from the carrier, the phase lock loop does not affect the signal to the analyzer. For lower frequencies, the phase lock loop causes the controlled source to follow the phase variations of the reference source. This causes the voltage to the analyzer to represent the frequency noise at low frequencies and the phase noise at higher frequencies.

With the HP 11740S, the capabilities of the HP 3047A Phase Noise Measurement System are combined with the specified low noise floor of the HP 11729C/8662A. The integrated HP 11729C/8662A is used as a low noise reference and downconvertor, translating the input signal to an intermediate frequency. This IF signal is phase detected against the tunable HP 8662A signal using the HP 3047A hardware. Since the phase noise measured by the quadrature phase detector method is the sum of the noise of the reference and the source-under-test, it requires that the reference source be of at least equal phase noise performance. The measurements made used a high quality frequency synthesizer (the HP 8662A-Option 003) as a reference source. The detected baseband signal is then measured automatically by the spectrum analyzers resident in the HP 3047A.

The HP 11740S Phase Noise Measurement System was also used for the AM noise measurements. The incident microwave signal was rectified by an external HP 8470B diode detector, thereby producing a DC output voltage proportional to the input power. Any amplitude modulation from the source caused this low frequency output to vary at the same rate as the modulation itself. An external high pass filter then blocked the output DC voltage and bled the DC current to ground, allowing the pure AC signal to pass through. The spectrum analyzers resident in the HP 11740S System were then able to measure the AM noise present in the signal.

Specification Summary

Specifications	HP 8683/8684	HP 8350B/83595A	HP 8671B/8672A
Frequency Range	2.3 to 6.50 GHz: 8683A/B 2.3 to 13.0 GHz: 8683D 5.4 to 12.5 GHz: 8684A/B 5.4 to 18.0 GHz: 8684D	10 MHz to 26.5 GHz	2.0 to 18.0 GHz
Resolution	Displayed: <5 MHz: 8683 10 MHz: 8684	CW: <1.65 MHz Vernier: <26.2 kHz	1 kHz: 2.0 to 6.2 GHz 2 kHz: 6.2 to 12.4 GHz 3 kHz: 12.4 to 18.0 GHz
Accuracy (CW)	Calibration Accuracy: 8683: ±1.25%<4 GHz ±0.75%>4 GHz 8684: ±1.25%<9 GHz ±0.75%>9 GHz	±5 MHz: 0.01 to 7.0 GHz ±10 MHz: 7.0 to 20.0 GHz ±12 MHz: 20.0 to 26.5 GHz	See time base stability
Stability (with time)	Typ: <100 kHz/hour after 1 hour	Typ: after 1 hour: <±100 kHz: 0.01 to 7.0 GHz <±200 kHz: 7.0 to 13.5 GHz <±300 kHz: 13.5 to 20.0 GHz <±400 kHz: 20.0 to 26.5 GHz	See time base stability
Time Base Stability	Temp: 0 to 55°C: <15 MHz: 8683 <30 MHz: 8684 Line Variation: <20 ppm for +5% to −10% change from normal	Typ: Temp (kHz/°C): ±200: 0.01 to 7.0 GHz ±400: 7.0 to 13.5 GHz ±600: 13.5 to 20.0 GHz ±800: 20.0 to 26.5 GHz Line Variation for ±10% change from normal: ±50 kHz: 0.01 to 7.0 GHz ±100 kHz: 7.0 to 13.5 GHz ±150 kHz: 13.5 to 20.0 GHz ±200 kHz: 20.0 to 26.5 GHz	Aging Rate: <$5x10^{-10}$/day Temp: <$1x10^{-10}$/°C Line Variation: <$5x10^{-10}$ for +5% to −10% change from normal
Lock Time/Frequency Switching Time	N/A	N/A	<15 msec to be within frequency resolution
Spectral Purity Harmonics	<-25 dBc	<-25 dBc: 0.01 to 20.0 GHz (<-35 dBc: typ) <-20 dBc: 20.0 to 26.5 GHz (<-35 dBc: typ)	<-25 dBc
Subharmonics and Multiples thereof	None	Same as harmonics	Same as harmonics
Non-harmonics	<-80 dBc	<-25 dBc: 0.01 to 2.4 GHz <-50 dBc: 2.4 to 26.5 GHz	<-70 dBc: 2.0 to 6.2 GHz <-64 dBc: 6.2 to 12.4 GHz <-60 dBc: 12.4 to 18.0 GHz
SSB Phase Noise	Typ: averaged rms at 10 kHz offset: <-72 dBc: 8683 <-65 dBc: 8684	N/A	2.0 to 6.2 GHz range: −58 dBc/Hz: 10 Hz offset −70 dBc/Hz: 100 Hz offset −78 dBc/Hz: 1 kHz offset −86 dBc/Hz: 10 kHz offset −110 dBc/Hz: 100 kHz offset
RF Output Maximum Power Out	0 dBm: 8683A/8684A +10dBm: 8683B/D and 8684B/D	+10 dBm: 0.01 to 20.0 GHz +4 dBm: 20.0 to 26.5 GHz	+3 dBm: 8672A +8 dBm: 8671B and 8672A (Option 008)
Minimum Power Out	−130 dBm	−5 dBm −60 dBm (Option 002)	−120 dBm
Power Level Accuracy	±2.5 dB, down to −110 dBm ±3.5 dB, −110 to −120 dBm	<±1.5 dB: 0.01 to 2.4 GHz <±1.3 dB: 2.4 to 13.5 GHz <±1.4 dB: 13.5 to 20.0 GHz <±1.7 dB: 20.0 to 26.5 GHz	−20 dBm output level: <±1.70 dB: 2.0 to 6.2 GHz <±2.00 dB: 6.2 to 12.4 GHz <±2.30 dB: 12.4 to 18.0 GHz
Flatness	±1 dB for levels >-10 dBm	±0.9 dB: 0.01 to 2.4 GHz ±0.7 dB: 2.4 to 1.35 GHz ±0.8 dB: 13.5 to 20.0 GHz ±0.9 dB: 20.0 to 26.5 GHz	±0.75 dB: 2.0 to 6.2 GHz ±1.00 dB: 6.2 to 12.4 GHz ±1.25 dB: 12.4 to 18.0 GHz

HP 8673B/E	HP 8673C/D	HP 8340B/8341B	HP 5344S/8350B/83595A
2.0 to 26.0 GHz: 8673B 2.0 to 18.0 GHz: 8673E	0.05 to 18.6 GHz: 8673C 0.05 to 26.0 GHz: 8673D	10 MHz to 26.5 GHz: 8340B 10 MHz to 20.0 GHz: 8341B	0.05 to 26.5 GHz
1 kHz: 2.0 to 6.6 GHz 2 kHz: 6.6 to 12.3 GHz 3 kHz: 12.3 to 18.6 GHz 4 kHz: 18.6 to 26.0 GHz	1 kHz: 0.05 to 6.6 GHz 2 kHz: 6.6 to 12.3 GHz 3 kHz: 12.3 to 18.6 GHz 4 kHz: 18.6 to 26.0 GHz	1 Hz: 0.01 to 7.0 GHz 2 Hz: 7.0 to 13.5 GHz 3 Hz: 13.5 to 20.0 GHz 4 Hz: 20.0 to 26.5 GHz	1 Hz
See time base stability	See time base stability	See time base stability	See time base stability
See time base stability	See time base stability	See time base stability	See time base stability
Aging Rate: per day: <5x10^{-10}: 8673B <1.5x10^{-9}: 8673E Typ: Temp: <1x10^{-10}/°C: 8673B <1x10^{-7}/°C: 8673E Typ: Line Variation: <5x10^{-10} for +5% to −10% change from normal	Aging Rate: <5x10^{-10}/day Typ: Temp: <1x10^{-10}/°C Line Variation: <5x10^{-10} for +5% to −10% change from normal	Aging Rate: <1x10^{-9}/day Typ: Temp: <1x10^{-10}/°C Typ: Line Variation: <1x10^{-11} for ±10% change from normal	5343A (Option 001): Aging Rate: <5x10^{-10}/day Temp: <7x10^{-9} over 0 to 50°C Line Variation: <1x10^{-10} for ±10% change from normal
<20 msec to be within frequency resolution (N/A: 8673E)	<50 msec to be within frequency resolution	<50 msec: Fast Phase Lock mode provides typical time of <20 msec	5342A: Manual Lock 900 msec, Auto Lock 1.5 sec 5343A: Manual Lock 500 msec, Auto Lock 1.1 sec
<-40 dBc	<-40 dBc: <1.2 GHz <-60 dBc: >1.2 GHz	<-35 dBc <-50 dBc: 1.4 to 20 GHz (8341B Opt. 003)	<-25 dBc: 0.01 to 20.0 GHz (<-35 dBc: typ) <-20 dBc: 20.0 to 26.5 GHz (<-25 dBc: typ)
<-35 dBc: 8673E only <-25 dBc: 2.0 to 18.6 GHz <-20 dBc: 18.6 to 26.0 GHz	<-60 dBc	<-25 dBc: 7.0 to 20.0 GHz <-20 dBc: 20.0 to 26.5 GHz <-50 dBc: 1.4 to 20 GHz (8341B Opt. 003)	Same as harmonics
<-60 dBc: 8673E only <-70 dBc: 2.0 to 6.6 GHz <-64 dBc: 6.6 to 12.3 GHz <-60 dBc: 12.3 to 18.6 GHz <-58 dBc: 18.6 to 26.0 GHz	<-60 dBc: 0.05 to 2.0 GHz <-70 dBc: 2.0 to 6.6 GHz <-64 dBc: 6.6 to 12.3 GHz <-60 dBc: 12.3 to 18.6 GHz <-58 dBc: 18.6 to 26.0 GHz	<-50 dBc: 0.01 to 2.3 GHz <-70 dBc: 2.3 to 7.0 GHz <-64 dBc: 7.0 to 13.5 GHz <-60 dBc: 13.5 to 20.0 GHz <-58 dBc: 20.0 to 26.5 GHz	<-25 dBc: 0.01 to 2.4 GHz <-50 dBc: 2.4 to 26.5 GHz
8673E: −60 dBc/Hz: 1 kHz offset 8673B: 2 to 6.6 GHz range: −58 dBc/Hz: 10 Hz offset −70 dBc/Hz: 100 Hz offset −78 dBc/Hz: 1 kHz offset −86 dBc/Hz: 10 kHz offset −110 dBc/Hz: 100 kHz offset	0.05 to 6.6 GHz range: −64 dBc/Hz: 30 Hz offset −70 dBc/Hz: 100 Hz offset −78 dBc/Hz: 1 kHz offset −86 dBc/Hz: 10 kHz offset −110 dBc/Hz: 100 kHz offset	0.01 to 7.0 GHz range: −64 dBc/Hz: 30 Hz offset −70 dBc/Hz: 100 Hz offset −78 dBc/Hz: 1 kHz offset −86 dBc/Hz: 10 kHz offset −107 dBc/Hz: 100 kHz offset	N/A
+8 dBm: 8673E only +8 dBm: 2.0 to 18.0 GHz +4 dBm: 18.0 to 22.0 GHz 0 dBm: 22.0 to 26.0 GHz	+11 dBm: 0.05 to 2.0 GHz +5 dBm: 2.0 to 16.0 GHz +2 dBm: >16.0 GHz: 8673C +6 dBm: >16.0 GHz: 8673D	+10 dBm: 0.01 to 2.3 GHz +12 dBm: 2.3 to 7.0 GHz +10 dBm: 7.0 to 13.5 GHz +9 dBm: 13.5 to 20.0 GHz +3 dBm: 20.0 to 23.0 GHz +1 dBm: 23.0 to 26.5 GHz	+10 dBm: 0.01 to 20.0 GHz +4 dBm: 20.0 to 26.5 GHz
−100 dBm: 8673B −120 dBm: 8673E	−100 dBm	−110 dBm: 8340B −20 dBm: 8341B	−5 dBm −60 dBm (Option 002)
8673B: 0 dBm output level: ±1.00 dB: 2.0 to 6.6 GHz ±1.25 dB: 6.6 to 12.3 GHz ±1.50 dB: 12.3 to 18.6 GHz ±2.00 dB: 18.6 to 26.0 GHz 8673E: 0 dBm output level: ±4.0 dB: 2.0 to 12.0 GHz ±5.0 dB: 12.0 to 18.0 GHz	+10 dBm output level: ±1.75 dB: 0.05 to 2.0 GHz ±1.25 dB: 2.0 to 6.6 GHz ±1.50 dB: 6.6 to 12.3 GHz ±1.75 dB: 12.3 to 18.6 GHz ±2.00 dB: 18.6 to 26.0 GHz	+10 to −9.95 dBm: ±0.9 dB: 0.01 to 2.3 GHz ±1.5 dB: 2.3 to 20.0 GHz ±2.0 dB: 20.0 to 26.5 GHz	±1.3 to ±1.8 dB depending on frequency range
0 dBm range: ±0.75 dB: 2.0 to 6.6 GHz ±1.00 dB: 6.6 to 12.3 GHz ±1.25 dB: 12.3 to 18.6 GHz ±1.75 dB: 18.6 to 26.0 GHz (±2.0 dB: 8673E)	0 dBm range: ±0.50 dB: 0.05 to 2.0 GHz ±0.75 dB: 0.05 to 6.6 GHz ±1.00 dB: 0.05 to 12.3 GHz ±1.25 dB: 0.05 to 18.6 GHz ±1.75 dB: 0.05 to 26.0 GHz	+10 to −9.95 dBm: ±0.6 dB: 0.01 to 2.3 GHz ±1.1 dB: 2.3 to 20.0 GHz ±1.6 dB: 20.0 to 26.5 GHz	±0.7 to ±1.0 dB depending on frequency range

Specification Summary

Specifications	HP 8683/8684	HP 8350B/83595A	HP 8671B/8672A
General			
Capture Range	N/A	N/A	N/A
Loop Bandwidth	N/A	N/A	N/A
Programmable	No	Yes	Yes
Size:			
Weight (net)	16.8 kg (37 lb): 8683A 17.4 kg (38 lb): 8683B 17.9 kg (39 lb): 8683D 15.6 kg (34 lb): 8684A 16.0 kg (35 lb): 8684B 16.5 kg (36 lb): 8684D	16.5 kg (36.4 lb): 8350B 6.0 kg (13.2 lb): 83595A	27.2 kg (60 lb)
Dimensions	145H x 425W x 441mmD	133.3H x 425W x 422mmD	146H x 435W x 620mmD
Amplitude Modulation			
AM Depth	0 to 70%	Typ: 15 dB	0 to 75%: 2.0 to 6.2 GHz 0 to 60%: 6.2 to 12.4 GHz 0 to 50%: 12.4 to 18.0 GHz (N/A: 8671B)
AM Rates	3 dB BW at 50% depth: DC to 10 kHz (DC coupled) 20 Hz to 10 kHz (AC coupled)	Typ: DC to 100 kHz	3 dB BW at 50% depth: 10 Hz to 100 kHz (N/A: 8671B)
AM Distortion	<10% at 40% depth and 10 kHz rate	N/A	<3% at 30% depth <4% at 50% depth <5% at 75% depth (N/A: 8671B)
Incidental FM	At 30% AM depth: <10 kHz peak-to-peak: 8683 <15 kHz peak-to-peak: 8684	N/A	$<0.7 \times f_{mod}$: 2.0 to 6.2 GHz $<1.8 \times f_{mod}$: 6.2 to 12.4 GHz $<1.2 \times f_{mod}$: 12.4 to 18.0 GHz (N/A: 8671B)
Internal AM	1 kHz square wave with 50% ±5% duty cycle	Selectable to 1 kHz or 27.8 kHz square wave modulation. ON/OFF ratio >30 dB. Symmetry 50% ± 10%.	N/A
AM Frequency Response	N/A	N/A	± 0.25 dB: 100 Hz to 10 kHz (N/A: 8671B)
External AM Sensitivity	Typ: 100%/V into 600Ω, continuously variable	Typ: 1 dB/V into 10 kΩ	30%/V & 100%/V into 600Ω (N/A: 8671B)
Frequency Modulation			
Maximum Peak Deviation	±5 MHz	±75 MHz: DC to 100 Hz ±7 MHz: 100 Hz to 1 MHz ±5 MHz: 1 MHz to 2 MHz ±1 MHz: 2 MHz to 10 MHz	The smaller of 10 MHz or: $f_{mod} \times 5$: 2.0 to 6.2 GHz $f_{mod} \times 10$: 6.2 to 12.4 GHz $f_{mod} \times 15$: 12.4 to 18.0 GHz (N/A: 8671B)
FM Rates	3 dB BW: DC to 10 MHz (DC coupled) 100 Hz to 10 MHz (AC coupled)	DC to 10 MHz	Typ: 50 Hz or 1 kHz to 10 MHz depending on range (N/A: 8671B)
Distortion %	<5% at 100 kHz rate and <1 MHz peak deviation	N/A	<12% for <20 kHz rate <5% for >20 kHz rate (N/A: 8671B)
Incidental AM	<6% at 100 kHz rate and <1 MHz peak deviation	N/A	<10% (N/A: 8671B)
External FM Sensitivity	Typ: variable in 1 MHz and 10 MHz ranges	Typ: Switch Selectable: −20 MHz/V: FM mode −6 MHz/V: Phase-lock mode	30, 100, 300 kHz/V and 1, 3, 10 MHz/V ranges; max input 1V peak into 50Ω (N/A: 8671B)
Internal FM	FM sawtooth with fixed sweep rate of 1 kHz and variable deviation up to ±5 MHz. 1V peak sawtooth available at FM in/out.	N/A	N/A
Pulse Modulation			
Width	Leveled: >10 μsec: 8683A/8684A >100 nsec: 8683B/D and 8684B/D	Typ: 0.01 to 2.5 GHz: 5 μsec: leveled 200 nsec: unleveled Typ: 2.5 to 26.5 GHz: 1 μsec: leveled 100 nsec: unleveled	With 11720A: 50 nsec (unleveled) (N/A: 8671B)
ON/OFF Ratio	>30 dB: 8683A/8684A >80 dB: 8683B/D and 8684B/D	N/A	With 11720A: 80 dB (N/A: 8671B)
Rise/Fall Time	<5 μsec: 8683A/8684A <10 nsec: 8683B/D and 8684B/D	Typ: unleveled: 50 nsec: 0.01 to 2.5 GHz 10 nsec: 2.5 to 26.5 GHz	With 11720A: 10 nsec (N/A: 8671B)

HP 8673B/E	HP 8673C/D	HP 8340B/8341B	HP 5344S/8350B/83595A
N/A	N/A	N/A	±25 MHz (Manual Mode)
N/A	N/A	N/A	100 kHz: Wideband 10 kHz: Narrowband
Yes	Yes	Yes	Yes
29 kg (64 lb)	42.3 kg (94 lb)	34 kg (75 lb)	8350/83595: 32.5 kg (50 lb) 5344S: 18.7 kg (41 lb)
146H x 425W x 620mmD	234H x 425W x 620mmD	188H x 425.5W x 609.6mmD	8350: 133H x 425W x 422mmD 5344S: 133H x 426W x 498mmD
0 to 75%: 2.0 to 24.0 GHz 0 to 50%: 24.0 to 26.0 GHz 0 to 75%: 8673E only	0 to 90%	0 to 90%	Typ: 15 dB
3 dB BW at 30% depth: 20 Hz to 100 kHz: 8673B 10 Hz to 50 kHz: 8673E	3 dB BW at 30% depth: 20 Hz to 100 kHz	3 dB BW at 30% depth: DC to 100 kHz (DC coupled)	Typ: DC to 100 kHz
2% to 5% depending on AM rate and modulation depth: 8673B <8% at 50% modulation depth and 1 kHz AM rate: 8673E	2% to 5% depending on AM rate and modulation depth	0.2% to 5% depending on AM rate and modulation depth	N/A
$<0.4 \times f_{mod}$: 2.0 to 6.6 GHz $<0.8 \times f_{mod}$: 6.6 to 12.3 GHz $<1.2 \times f_{mod}$: 12.3 to 18.6 GHz $<1.6 \times f_{mod}$: 18.6 to 24.0 GHz $<2.0 \times f_{mod}$: 24.0 to 26.0 GHz $<1.2xf_{mod}$: 8673E only: Typ	$<0.4 \times f_{mod}$: 0.05 to 6.6 GHz $<0.8 \times f_{mod}$: 6.6 to 12.3 GHz $<1.2 \times f_{mod}$: 12.3 to 18.6 GHz $<1.6 \times f_{mod}$: 18.6 to 24.0 GHz $<2.0 \times f_{mod}$: 24.0 to 26.0 GHz	Typ: $<0.4 \times f_{mod}$	N/A
N/A	N/A	N/A	Selectable to 1 kHz or 27.8 kHz square wave modulation. ON/OFF ratio: >30 dB. Symmetry 50% ±10%.
Typ: Relative to 1 kHz rate: ±0.25 dB (100 Hz to 10 kHz) (N/A: 8673E)	Typ: Relative to 1 kHz rate: ±0.25 dB (100 Hz to 10 kHz)	Relative to 1 kHz rate at 30% depth: ±0.2 dB (DC to 10 kHz)	N/A
30% & 100%/V into 600Ω	30% & 100%/V into 600Ω	Relative to 1 kHz rate at 30% depth: 100%/V ±5% into 600Ω	Typ: 1 dB/V into 10kΩ
The smaller of 10 MHz (3 MHz: 8673E) or: f_{mod} x 5: 2.0 to 6.6 GHz f_{mod} x 10: 6.6 to 12.3 GHz f_{mod} x 15: 12.3 to 18.6 GHz f_{mod} x 20: 18.6 to 26.0 GHz	The smaller of 10 MHz or: f_{mod} x 5: 0.05 to 6.6 GHz f_{mod} x 10: 6.6 to 12.3 GHz f_{mod} x 15: 12.3 to 18.6 GHz f_{mod} x 20: 18.6 to 26.0 GHz	The smaller of 10 MHz or: f_{mod} x 5: 0.01 to 7.0 GHz f_{mod} x 10: 7.0 to 13.5 GHz f_{mod} x 15: 13.5 to 20.0 GHz f_{mod} x 20: 20.0 to 26.5 GHz	N/A
100 Hz or 1 kHz to 10 MHz depending on range: 8673B 100 Hz or 3 kHz to 2 MHz depending on range: 8673E	Typ: 100 Hz or 1 kHz to 10 MHz depending on range	50 kHz to 10 MHz	N/A
Typ: <12% for <20 kHz rate <5% for >20 kHz rate	Typ: <12% for <20 kHz rate <5% for >20 kHz rate	N/A	N/A
<5%	<5%	N/A	N/A
30, 100, 300 kHz/V and 1, 3, 10 MHz/V ranges; max input 1V peak into 50Ω	30, 100, 300 kHz/V and 1, 3, 10 MHz/V ranges; max input 1V peak into 50Ω	1, 10 MHz/V ranges; max input 1V peak into 50Ω	N/A
N/A	N/A	N/A	N/A
>100 nsec, leveled	>100 nsec, leveled	>100 nsec leveled	Typ: 5 μsec: leveled Typ: 100 nsec: unleveled
>80 dB: 8673B >70 dB: 8673E	>80 dB	>80 dB	N/A
<35 nsec: 8673B Typ: <50 nsec: 8673E	<15 nsec: 0.05 to 2.0 GHz <40 nsec: 2.0 to 26.0 GHz	<25 nsec	Typ: 50 nsec

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