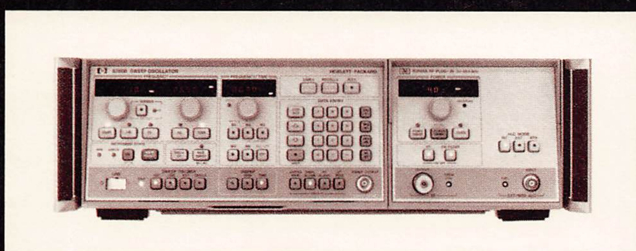
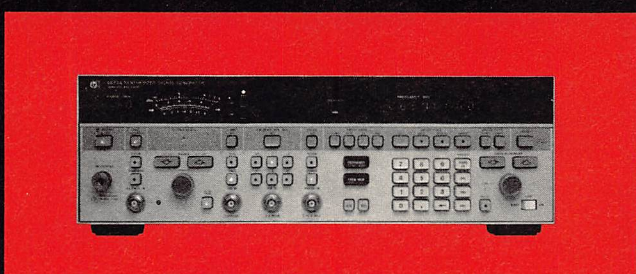
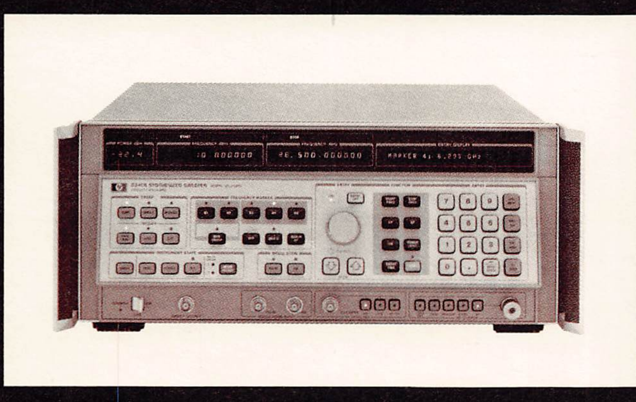
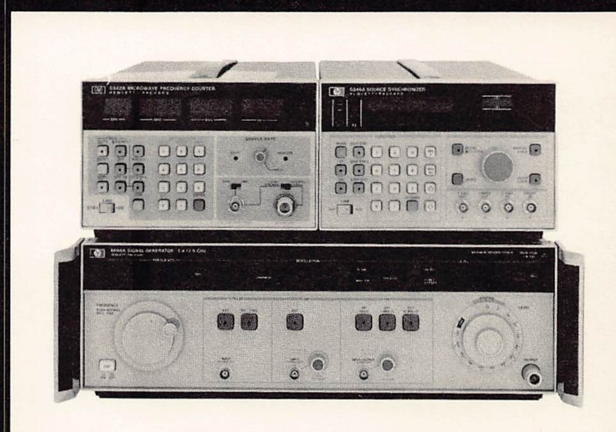
APPLICATION NOTE 329

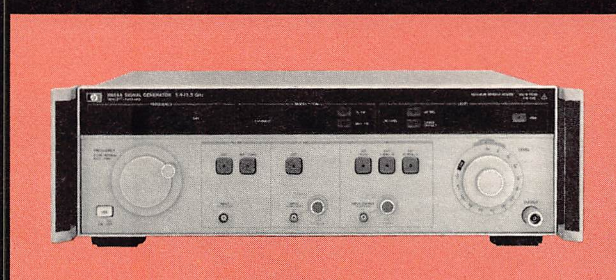
PERFORMANCE CHARACTERISTICS OF HP MICROWAVE SIGNAL SOURCES











HEWLETT PACKARD

— A COMPARISON

INTRODUCTION

There are many different types of microwave frequency sources available from Hewlett-Packard, with each type of source possessing different qualities. This paper will discuss the spectral purity of each source, as this is often a critical yet subtle specification. In addition the features, specifications and applications for the various types of microwave sources will be covered.

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

Signal Generator: HP 8683/8684

Sweep Oscillator: HP 8350B/83595A

Synthesizers: HP 8672A, 8672S, 8673B, 8340A

Sweep Oscillator/Signal Generator with Microwave Source Synchronizer: HP 5344S/8350B or 5344S/8683/8684

Sweep Oscillator with Synchronizer: HP 8709A/8350B/8656A

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 which describes the characteristic randomness of unwanted angular modulation on a carrier. Measurements of short term frequency instability include residual FM, fractional frequency deviation and single side-band (SSB) phase noise. All of these parameters may be 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 3047 Spectrum Analyzer System which is described in Appendix A. The SSB phase noise plots seen in each instrument section have data normalized to dBc in a 1 Hz noise bandwidth.

SPECIFICATIONS AND APPLICATIONS

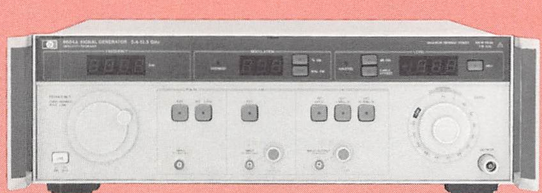
In addition to SSB phase noise there are many other performance areas which must be considered in determining which source is best suited for a particular application. These areas include frequency, power, modulation, and usability features, and will be discussed in each source section. A complete specification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

Among the predominant applications are signal simulation for radar or communications receiver testing, component testing (including noise measurements), and satellite communication (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 source specifications.

SIGNAL GENERATORS: HP 8683 / 8684

OVERVIEW

The term signal generator refers to a source which is tuneable 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 (like those produced by a transmitter), 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 8684 SIGNAL GENERATOR

HP 8683 / 8684 KEY FEATURES

- Less than 5 kHz residual FM
- Extensive modulation capability with internal modulation source
- Applications-oriented frequency ranges
- Good far out phase noise (>1 MHz offset)
- EMI Performance
- Rugged/Portable

GENERAL DESCRIPTION

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. The generators meet the radiated and conducted limits of MIL STD 461A. These sources provide CW signals with a frequency range of 2.3 to 6.5 GHz (HP 8683) and 5.4 to 12.5 GHz (HP 8684). The HP 8680 family is based on a mechanically tuned cavity oscillator which provides a very low noise floor of −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, their size, weight and rugged construction make these instruments ideal for portable applications. Internal leveling is provided for source match and power level flatness.

HP 8683A / 8684A

The HP 8683A and the HP 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 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.

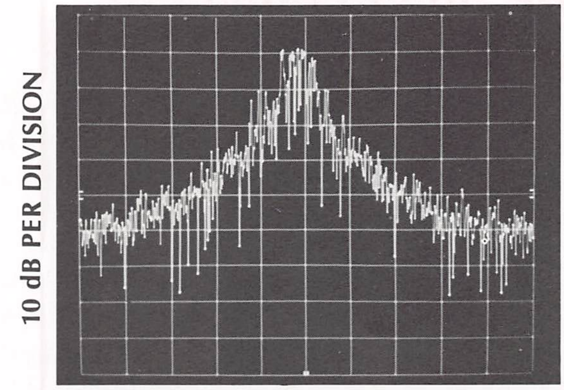
The dynamic range of the HP 8683B/8684B is extended to 140 dB by providing +10 dBm standard and maintaining the minimum power level at −130 dBm.

SPECTRAL PURITY

The phase noise characteristics of a cavity tuned oscillator result in excellent phase noise far away from the carrier with close in phase noise representative of a free running oscillator. This can be seen by observing the steep, straight slope of the phase noise plot. The spectral purity characteristics of signal generators are specified by residual FM instead of phase noise.

The spurious content of the signal contains very small non-harmonically related signals, <−80 dBc, and harmonically related signals <−25 dBc.

HP 8684A SIGNAL GENERATOR



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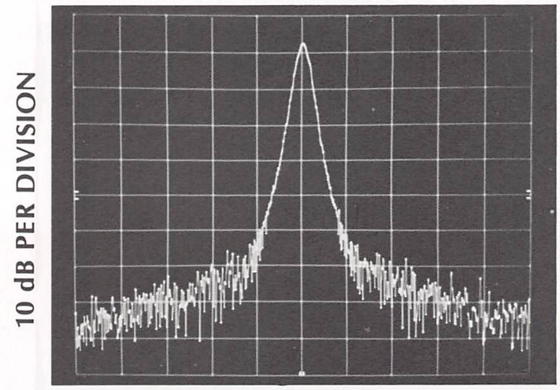

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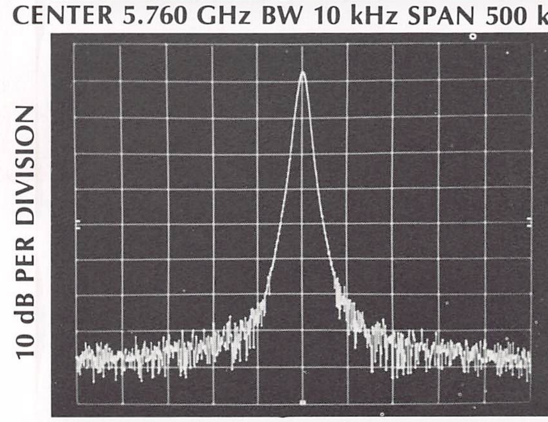

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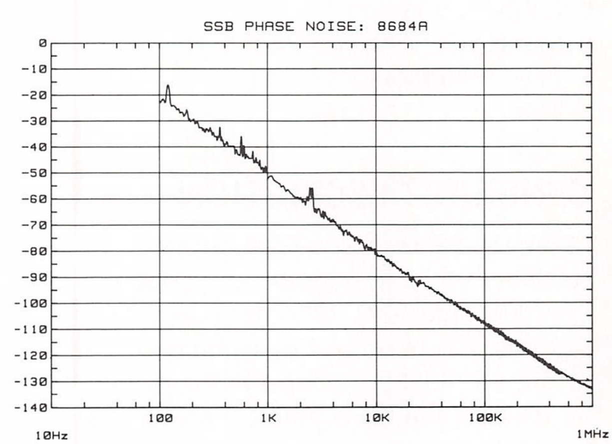
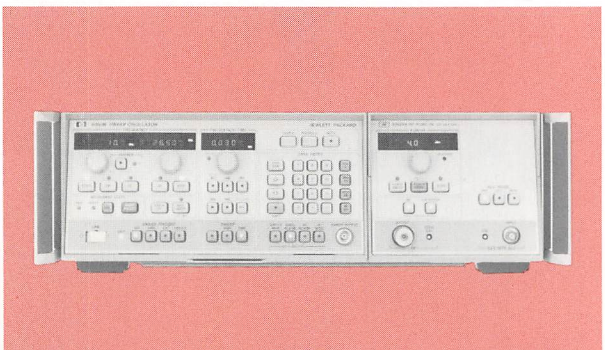


SWEEP OSCILLATORS: HP 8350B / 83595A

OVERVIEW

Sweep oscillators are designed to provide a calibrated, swept frequency output with high power. In addition, external and/or 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 mamy automatic test systems and general purpose applications such as signal simulation. The following section discusses the HP 8350B/83595A Sweep Oscillator.



HP 8350B/83595A SWEEP OSCILLATOR

HP 8350B / 83595A KEY FEATURES

- Analog Sweep Capability
- Frequency Range (10 MHz – 26.5 GHz)
- High Power
- Calibrated Power
- Markers
- Plug-in Flexibility
- Size

GENERAL DESCRIPTION

The HP 8350B Sweep Oscillator family is very versatile, utilizing plug-ins for variable frequency coverage and offering many mainframe features which expand its usability. A discussion of the HP 8350B Sweep Oscillator family may be divided into two areas, the mainframe and the RF Plug-ins.

MAINFRAME (HP 8350B)

The HP 8350B mainframe is completely programmable and operates with 33 different plug-ins to cover the broad frequency range of 10 MHz to 40 GHz. The mainframe is microprocessor-based, which allows for many usability features such as digital data entry and SAVE/RECALL of front panel settings. The mainframe also provides five independent frequency markers with such functions as marker sweep, marker delta, and marker to center frequency. Counted marker, start and stop frequencies can be easily obtained while sweeping using the HP 5343A Microwave Counter.

Network Analyzer compatibility is key when making many swept measurements. The HP 8350B is compatible with the HP 8755C and 8756A Scalar Network Analyzers (providing the required 27.8 kHz modulation) and the HP 8410B/C and 8510 Microwave Network Analyzers. For automatic network measurements the HP 8350B provides the source for systems such as the HP 8756S Automatic Scalar Network Analyzer, the HP 8408B Automatic Network Analyzer and the HP 8409C Automatic Network Analyzer. Noise figure measurements above 1.5 GHz are easily made using the HP 8970A Noise Figure Meter and the HP 8350B Sweep Oscillator as an external local oscillator.

RF AND MICROWAVE PLUG-INS

HP 83500 Series Plug-ins: The HP 83500 series provide broadband 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 (0.1 dB resolution) that can be extended to 80 dB with an optional internal attenuator. The output power may also be swept over a 10 dB range, allowing for real time power response measurements, and can be externally leveled with diode detectors or power meters. All functions on the HP 83500 series plug-ins are completely programmable.

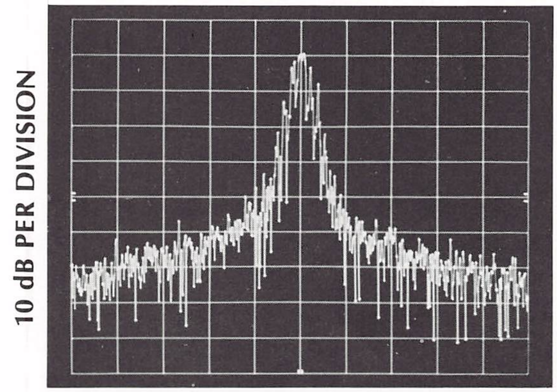
HP 86200 Series Plug-ins: The HP 86200 series plug-ins provide economical alternatives to the HP 83500 series plug-ins as well as offering specialized singleband frequency coverage. Internal leveling and external leveling with crystal detectors and power meters are available with calibrated power (not programmable) and optional attenuators also available on selected plug-ins. This series provides the optional capability to function as Microwave Link Analyzer upconverters for important communication band plug-ins.

SPECTRAL PURITY

Because they are designed for swept frequency applications, sweep oscillators have not been generally optimized for spectral purity. Due to this sweep oscillators are not specified by phase noise but by residual FM. The signal characteristics come directly from the YIG oscillator that generates the signal 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 (see Appendix B for a phase noise plot with the CW filter off) but does not alter the close-in phase noise of the free running oscillator. This filter (when engaged) slows down the frequency settling time. The noise floor of the sweeper is below 130 dBc.

The spurious content of the HP 83595A plug-in is: sub-harmonics <– 25 dBc (typ <– 35 dBc) between 10 MHz and 20.0 GHz and <– 20 dBc (typ <– 25 dBc) between 20.0 and 26.5 GHz; harmonics <– 40 dBc; and non-harmonically related spurs <– 30 dBc between 10 MHz and 2.4 GHz and <– 50 dBc between 2.4 and 26.5 GHz.

HP 8350B/83595A SWEEP OSCILLATOR (CW FILTER ON)



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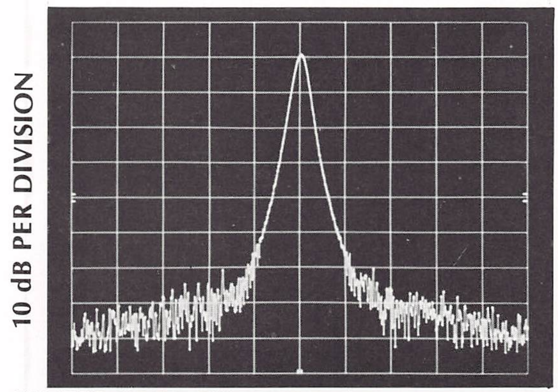

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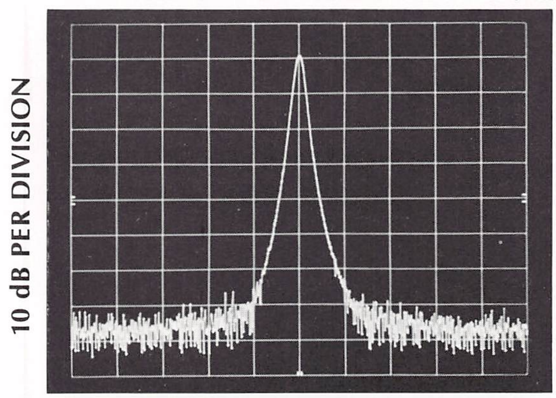

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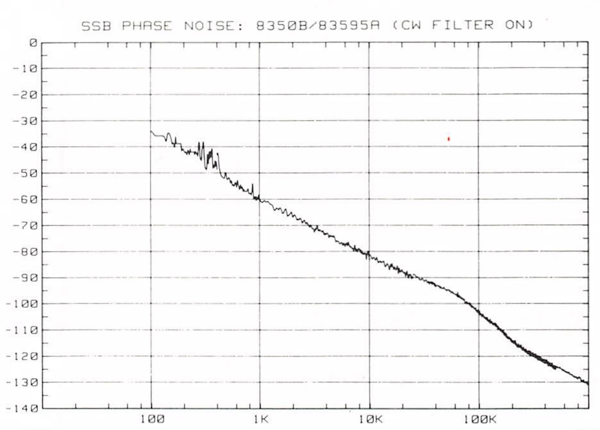
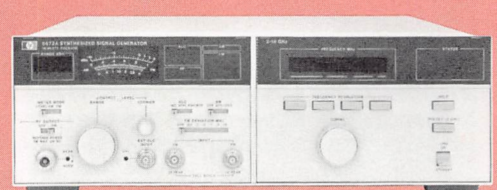


SYNTHESIZED SIGNAL GENERATORS: HP 8673B, 8672A and 8672S

OVERVIEW

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, metrology labs, and as precision local oscillators. The following section will discuss the HP 8673B, 8672A, and 8672S synthesized signal generators.



HP 8672A SYNTHESIZED SIGNAL GENERATOR

HP 8672A KEY FEATURES

- Low Phase Noise
- High Frequency Accuracy
- Metered AM/FM Capability
- Frequency Switching Time
- EMI Performance
- Calibrated Output Power/Dynamic Range

ADDITIONAL HP 8672S FEATURES

- 10 MHz to 2 GHz Frequency Coverage
- Internal Pulse Modulator

ADDITIONAL HP 8673B FEATURES

- 18 to 26 GHz Frequency Coverage
- +8 dBm Output Power to 20 GHz
- Internal Pulse Modulator
- Digital Sweep

GENERAL DESCRIPTION

These synthesizers are high performance CW sources, designed for demanding applications requiring high spectral purity, stability and frequency accuracy. The frequency range of the HP 8672A covers 2 to 18 GHz, the HP 8672S covers 10 MHz to 18 GHz, and the HP 8673B covers 2 to 26 GHz. The broad frequency coverage in conjunction with fast switching speeds (less than 15 msec) and complete programmability combine to make these synthesizers very agile sources. The power output is calibrated over a dynamic range spanning from +8 dBm (to 20 GHz and +4 dBm 20 to 26 GHz) to −100 dBm on the HP 8673B; +3 dBm (+8 dBm with Opt. 008) to −120 dBm on the HP 8672A; and +2 dBm (+7 dBm with Opt 008) to −120 dBm on the HP 8672S. Internal power leveling as well as external power leveling (with either positive or negative inputs) using a power meter or a diode detector, is provided for improving the level flatness or effective source match. These sources are well suited for applications requiring low RFI leakage levels as the HP 8673B meets the radiated and conducted limits of MIL STD 461A and the HP 8672A/8672S meets the radiated and conducted limits of MIL-I-6181S.

Both AM and FM modulation are available on these synthesizers (the HP 8672S only has AM modulation above 2 GHz) when an external modulation source is provided. AM modulation operates for rates up to 100 kHz (set using the front panel meter). FM modulation operates for rates between 50 Hz to 10 MHz (HP 8672A and 8672S) and 100 Hz to 10 MHz (HP 8673B) with deviations up to 10 MHz peak, which can be monitored over six ranges using the front panel meter. Simultaneous AM and FM is possible. Phase-lock is maintained in both the AM and FM modes.

The HP 8673B has a calibrated and leveled internal pulse modulator which, when used with a modulation source, has a ON/OFF ratio >80 dB and rise/fall times <35 nsec. The resultant pulse can be leveled and has a minimum pulse width of 100 nsec. The HP 8672S also provides an internal pulse modulator with an ON/OFF ratio >80 dB, rise/fall time <10 nsec and a minimum pulse width <50 nsec.

The HP 8672A may be used with the HP 11720A Pulse Modulator and a modulation source, to provide pulse modulation over the full frequency range. The HP 11720A features short rise and fall times (less than 10 nsec) and a high ON/OFF ratio (greater than 80 dB).

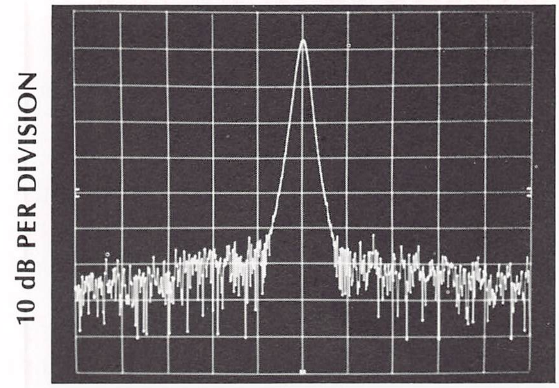
SPECTRAL PURITY

The low phase noise of these synthesizers reflects the phase noise of the reference oscillator as well as the spectrally clean phase-lock loops that internally phase-lock the YIG oscillator. Farther away from the carrier, a noise floor of −135 dBm is maintained.

The spurious content of these synthesizers contains harmonics <−25 dBc (<−20 dBc subharmonics from 18.6 to 26 GHz on the HP 8673B). The non-harmonically related spurious content varies with frequency range; between 2 and 6.2 GHz non-harmonic spurs are <−70 dBc, between 6.2 and 12.4 GHz they are <−64 dBc, between 12.4 and 18 GHz (18.6 GHz) they are <−60 dBc, and between 18.6 and 26 GHz they are <−58 dBc (HP 8673B only). Because of the excellent phase noise characteristics, line related spurious signals are discernable. The specifications for these signals are as follows:

Freq. (in GHz)	Offset from carrier		
	<300 Hz	300 Hz – 1 kHz	>1 kHz
2-6.2	−50 dBc	−60 dBc	−65 dBc
6.2-12.4	−44 dBc	−54 dBc	−59 dBc
12.4-18	−40 dBc	−50 dBc	−55 dBc
18.6-26	−38 dBc	−48 dBc	−53 dBc

HP 8672A SYNTHESIZED SIGNAL GENERATOR



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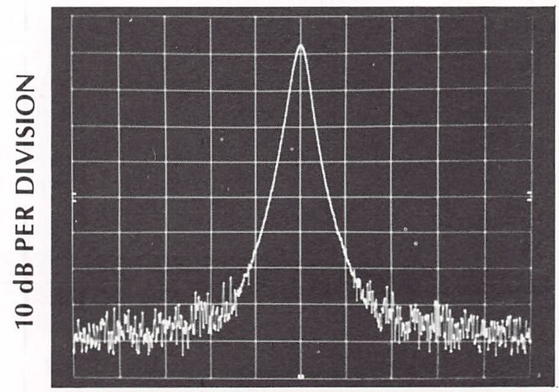

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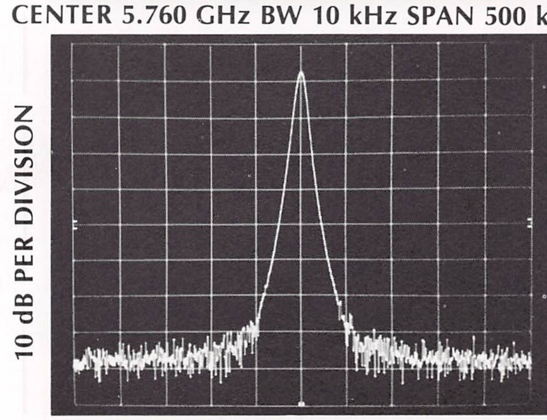

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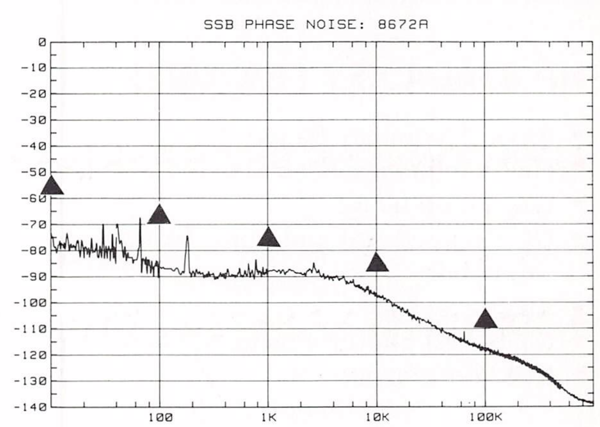
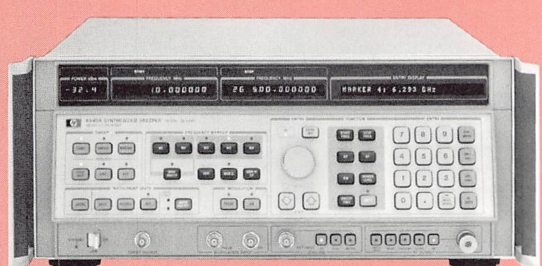


▲ = SPECIFIED SSB PHASE NOISE

SYNTHESIZED SWEEPERS: HP 8340A

OVERVIEW

Synthesized sweepers combine the accuracy and precision of a synthesizer with the versatility of a broadband 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 broadband, continuous, analog sweep is provided for rapid component characterization. For high Q devices a narrowband, 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 8340A Synthesized Sweeper.



HP 8340A SYNTHESIZED SWEEPER

HP 8340A KEY FEATURES

- Broad Frequency Range
- High Frequency Accuracy and Resolution
- Low Phase Noise
- DC Coupled AM and Pulse Modulation Capability
- Analog Sweep
- Calibrated Output Power/Dynamic Range
- EMI Performance

GENERAL DESCRIPTION

The HP 8340A Synthesized Sweeper is a high performance source with low phase noise CW and versatile swept performance. The frequency range of the HP 8340A is 10 MHz to 26.5 GHz. This range may be swept continuously or CW stepped with switching speeds typically less than 35 msec and a resolution of 1 to 4 Hz. (Additionally, a "fast phase lock" mode can be accessed to permit switching speeds typically less than 20 ms.) The output power is calibrated over a dynamic range spanning from +18 dBm to −110 dBm. Internal power leveling as well as external power leveling (with either positive or negative inputs) 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 to 13.5 GHz); +9 dBm (13.5 to 20 GHz); +3 dBm (20 to 23 GHz); +1 dBm (23 to 26.5 GHz). The analog sweep capability of the HP 8340A provides sweep widths from 100 Hz to 26.49 GHz and sweep times ranging from 45 msec full span to as long as 200 sec full span. The HP 8340A 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.

DC coupled AM modulation is available on the HP 8340A when an external modulation source is provided. AM modulation operates for rates ranging from DC to 100 kHz and depths for 0 to 90%.

The HP 8340A has an internal pulse modulator; when used with an external modulation source it provides calibrated, leveled pulse modulation over the full frequency range. The HP 8340A pulse performance features rise and fall times <25 nsec, a high 80 dB ON/OFF ratio, and a minimum leveled RF pulse width <100 nsec. In addition the pulse performance has extremely low video feedthrough; <5% (0.4 to 2.3 GHz) and <0.2% (2.3 to 26.5 GHz).

In addition to all the previous features, the HP 8340A is completely programmable. This capability makes it well suited for automatic test systems.

SPECTRAL PURITY

The outstanding phase noise of the HP 8340A reflects the phase noise of the reference oscillator as well as the spectrally clean phase-lock loops that internally phase-lock the YIG oscillator. Farther away from the carrier a noise floor of −135 dBm is maintained.

The spurious content of the HP 8340A contains harmonics (up to 26.5 GHz) of the output frequency <−40 dBc. Subharmonics (and multiplies therof) of the output frequency are <−25 dBc from 0.01 to 20 GHz and <−20 dBc from 20 to 26.5 GHz. The nonharmonically related spurious signal level varies with frequency range as follows:

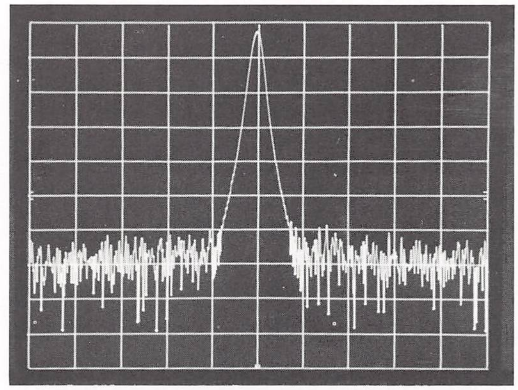
−55 dBc 0.01 to 2.3 GHz
−70 dBc 2.3 to 7.0 GHz
−64 dBc 7.0 to 13.5 GHz
−60 dBc 13.5 to 20 GHz
−58 dBc 20 to 26.5 GHz

Because of the excellent phase noise characteristics, line related spurious signals are discernable. The specifications for these signals are tabulated below:

Frequency Range (GHz)	Offset from Carrier <300 Hz	300Hz-1kHz	>1 kHz
0.01-2.3	−50 dBc	−60 dBc	−65 dBc
2.3-7.0	−50 dBc	−60 dBc	−65 dBc
7.0-13.5	−44 dBc	−54 dBc	−59 dBc
13.5-20.0	−40 dBc	−50 dBc	−55 dBc
20.0-26.5	−38 dBc	−48 dBc	−53 dBc

HP 8340A SYNTHESIZED SWEEPER

10 dB PER DIVISION



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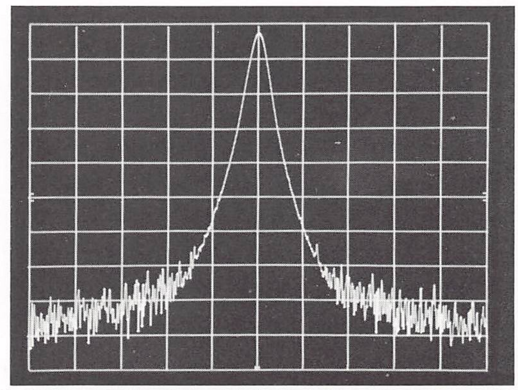
10 dB PER DIVISION



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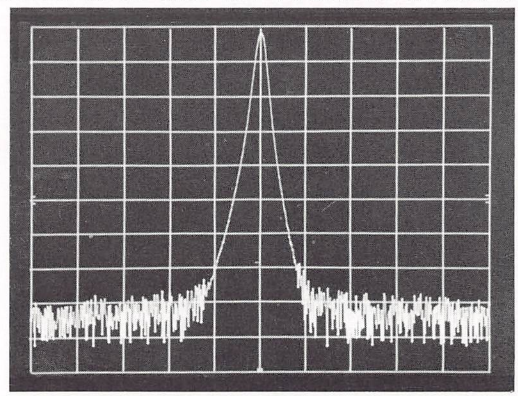
10 dB PER DIVISION



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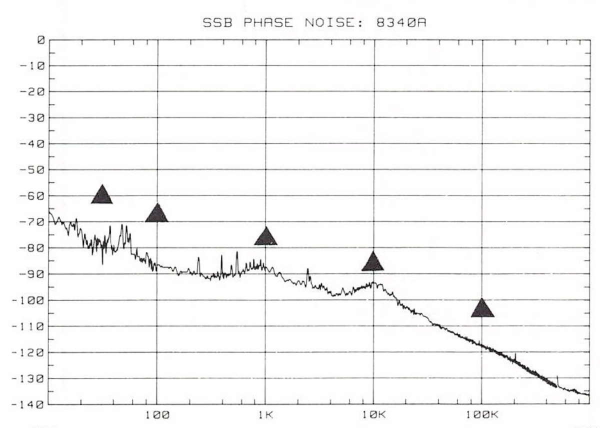


▲ = SPECIFIED SSB PHASE NOISE

PHASE-LOCKED SIGNAL GENERATORS / SWEEP OSCILLATORS

OVERVIEW

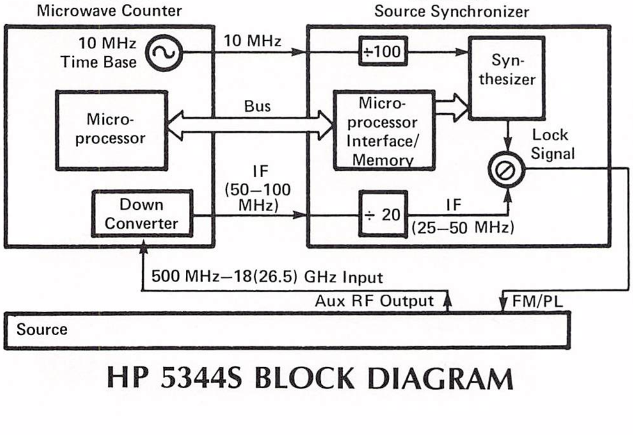
Phase-locked signal generators and sweep oscillators exhibit improved long term stability, frequency accuracy and resolution from that of the stand-alone instrument. The enhanced performance obtained by phase-locking a signal generator makes this source more suitable for many applications such as narrowband channel testing. The improved sweeper performance due to phase-locking increases its ability to accurately measure frequency selective devices, in addition to enhancing its capability in signal simulation applications.

There are two Hewlett-Packard instruments that may be used for the purpose of phase-locking sources: the HP 5344S Microwave Source Synchronizer and the HP 8709A Synchronizer. Phase-lock systems involving these instruments will be discussed in the following sections.

SOURCE SYNCHRONIZER: HP 5344S

GENERAL OVERVIEW

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 Opt. 043). In addition to performing the basic CW phase-lock function, the HP 5344S has two swept modes: a narrowband, phase continuous sweep and a broadband sweep. The HP 5344S system uses both a microwave counter (HP 5342A or HP 5343A) and a source synchronizer (HP 5344A) to phase-lock a source. The system utilizes the microprocessor located in the HP 5342A (or HP 5343A) Microwave Counter to perform the calculations and communication.

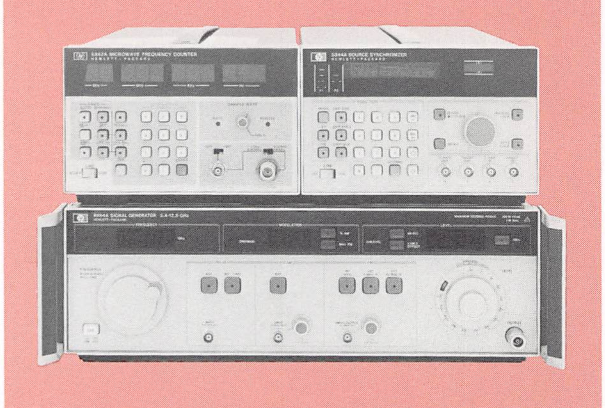


HP 5344S BLOCK DIAGRAM

The phase-lock loop begins with a signal from the source being input into the high frequency counter input. This signal is downconverted by the counter to a 50-100 MHz IF signal. The IF signal is routed to a rear-panel IF Out BNC on the counter where it is subsequently input to a rear panel, IF Input BNC on the source synchronizer. Once inside the source synchronizer, the IF signal is phase compared with a reference signal which produces a lock signal that is input to the source (via FM input) to phase-lock the RF output. The reference signal is synthesized within the source synchronizer using the 10 MHz time base from the counter as the reference.

The HP 5344S has many capabilities beyond CW phase locking. The counter in the HP 5344S system may be used as a stand-alone counter. The HP 5344S has two sweep modes; a narrowband, phase continuous sweep mode which adds narrowband sweeps to CW sources with FM capability (HP 8683/84); and a wideband Lock and Roll sweep mode which phase-locks the start frequency of a swept source, improving the swept accuracy to the sweep linearity (±10 MHz on the HP 83595A); (only on the HP 8350B).

PHASE-LOCKED SIGNAL GENERATORS: HP 5344S / 8683 / 8684



HP 5344S/8684A PHASE-LOCKED SIGNAL GENERATOR

HP 5344S / 8683 / 8684 KEY FEATURES

- Improved Frequency Accuracy
- Improved Close-in Phase Noise / Stability
- High Resolution (1 Hz)
- Locked Sweeps with Markers (up to 5 MHz)
- Auxiliary Output for Phase Locking

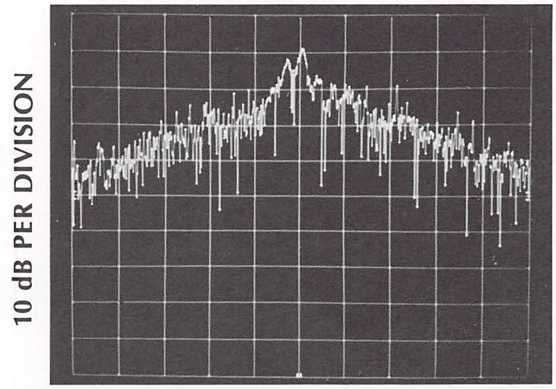
GENERAL DESCRIPTION

The HP 5344S provides CW phase-lock capability using the phase-lock input available on the HP 8683 / 8684 and the RF auxiliary output which does not reduce the power level of the front panel RF output. This system improves the frequency stability to 5 x 10^{-10} / day and improves the frequency resolution to 1 Hz. The lock time for the system is typically 900 msec using the HP 5342A Microwave Counter and 500 msec using the HP 5343A Microwave Counter (manual lock mode only). The system is capable of achieving phase-lock within a $\pm$25 MHz capture range using either a narrowband (10 kHz) or a wideband (100 kHz) loop bandwidth. However, when the signal generator is phase-locked, it is not possible to use the FM modulation capability. The narrowband sweep mode may be used with the HP 8683 / 8684 for sweeps up to 10 MHz wide (this range is determined by the maximum FM deviation of the HP 8683/8684).

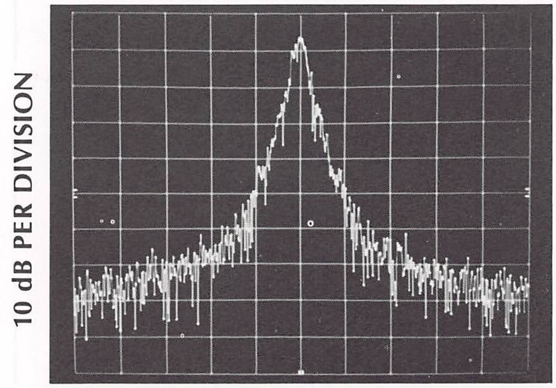
SPECTRAL PURITY

Close in phase noise (<1 kHz offset from carrier) is improved using the HP 5344S. However, the loop response adds some phase noise outside of 1 kHz offset, as well as some spurious signals. The phase noise farther away from the carrier tracks that of the unlocked cavity oscillator. The harmonically related spurious signals are the same as for the stand-alone signal generator (<– 25 dBc).

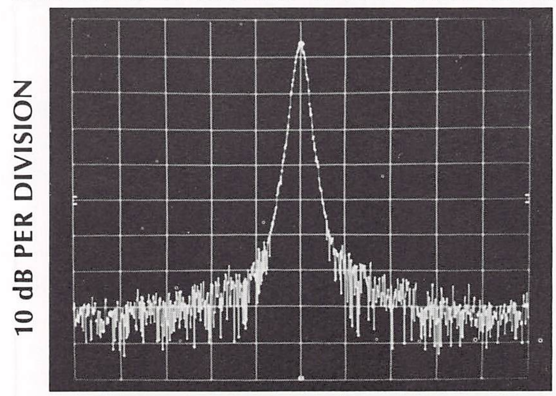
HP 5344S/8684A PHASE-LOCKED SIGNAL GENERATOR



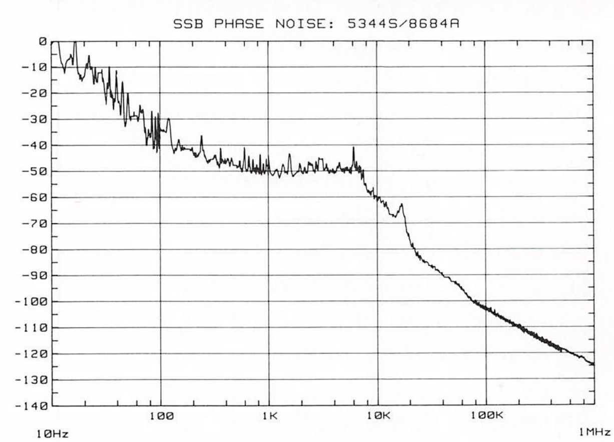
CENTER 5.760 GHz BW 300 Hz SPAN 20.0 kHz



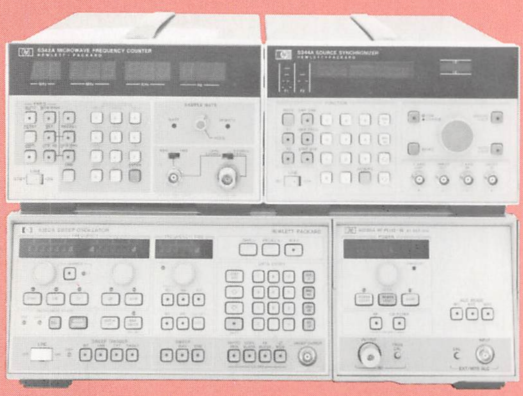
CENTER 5.760 GHz BW 10 kHz SPAN 500 kHz



CENTER 5.760 GHz BW 30 kHz SPAN 2.00 MHz



PHASE-LOCKED SWEEP OSCILLATOR: HP 5344S / 8350B / 83595A



HP 5344S/8350B/83595A
PHASE-LOCKED SWEEP OSCILLATOR

HP 5344S / 8350B / 83595A KEY FEATURES

- Improved Frequency Accuracy
- Improved Close-in Phase Noise/Stability
- High Resolution (1Hz)
- Locked Sweeps (up to 40 MHz) with Markers
- Lock and Roll Sweeps with Markers
- Auto-Lock via HP-IB
- Auxiliary Output (on multiband plug-ins) for simplified Phase-Locking

GENERAL DESCRIPTION

The HP 5344S Source Synchronizer can phase-lock the HP 8350B Sweep Oscillator or HP 8620C Sweep Oscillator in either CW or swept modes. This system improves the frequency stability to 5 x 10^{-10}/day and improves the frequency resolution to 1 Hz. To achieve phase-lock, the HP 5344S operates in either Manual Lock mode or Auto Lock mode. In the Manual Lock mode, phase-lock may be achieved within a capture range of ± 25 MHz. The lock time in the Manual Lock mode is typically 900 msec when using 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 within the capture range via the 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: narrowband sweep, and wideband Lock and Roll. A narrowband sweep is a phase-continuous sweep (phase-locked) with a sweep width up to 40 MHz wide and a sweep linearity of 0.05%. Four markers are available from the HP 5344S during a narrowband sweep. Lock and Roll sweeps are attained by phase-locking the start frequency and then letting the sweeper control the remainder of the sweep. The swept accuracy using Lock and Roll is improved to that of the sweep linearity (i.e. there is no longer any error in the sweep due to start frequency inaccuracy; the linearity is ± 10 MHz on the HP 83595A). While in the Lock and Roll mode, counted markers and a counted stop frequency are available when using the HP 5344S Opt. 043.

The loop bandwidth of the HP 5344A is selectable to either narrowband (10 kHz) or wideband (100 kHz). The wide bandwidth is used to capture noisy sources. 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 the 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 (i.e. HP 83590, 86290 series). This locks the multiplied (or harmonically related) main output frequency. Using the auxiliary output eliminates the need to couple off a reference signal from the main output for phase-locking, allowing maximum power at the main output.

The HP 5344S Source Synchronizer with the HP 8350B Sweep Oscillator is a fully HP-IB programmable system.

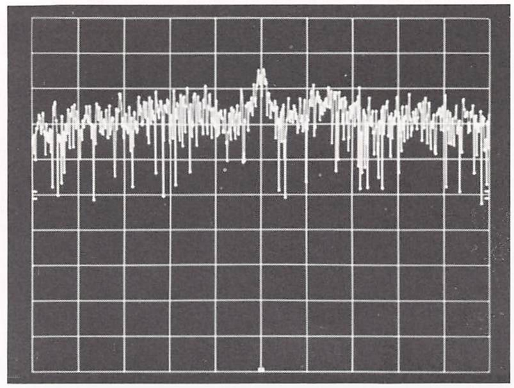
SPECTRAL PURITY

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 offsets from the carrier 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).

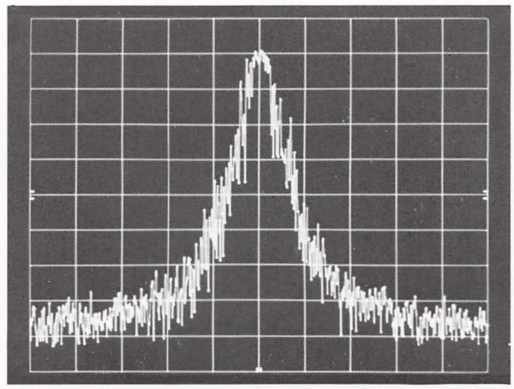
HP 5344S/8350B/83595A
PHASE-LOCKED SWEEP OSCILLATOR

10 dB PER DIVISION



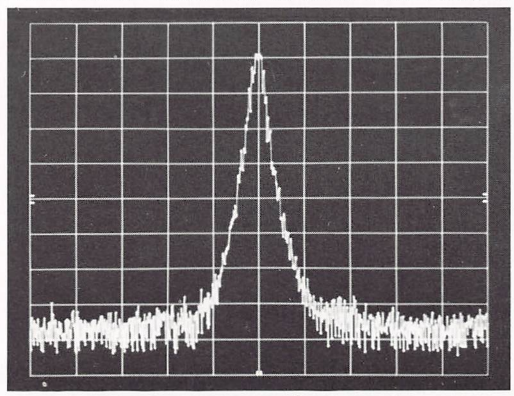
CENTER 5.760 GHz BW 300 Hz SPAN 20.0 kHz

10 dB PER DIVISION

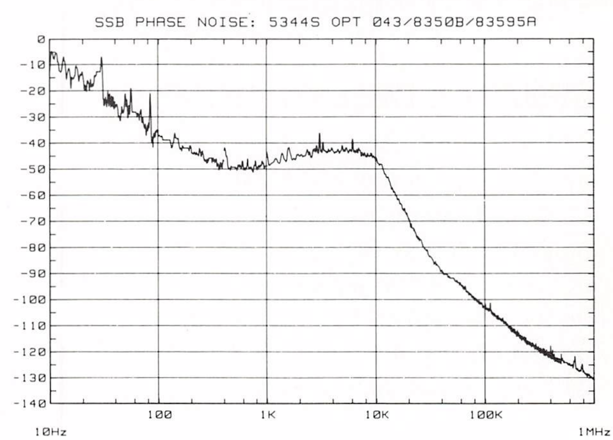


CENTER 5.760 GHz BW 10 kHz SPAN 500 kHz

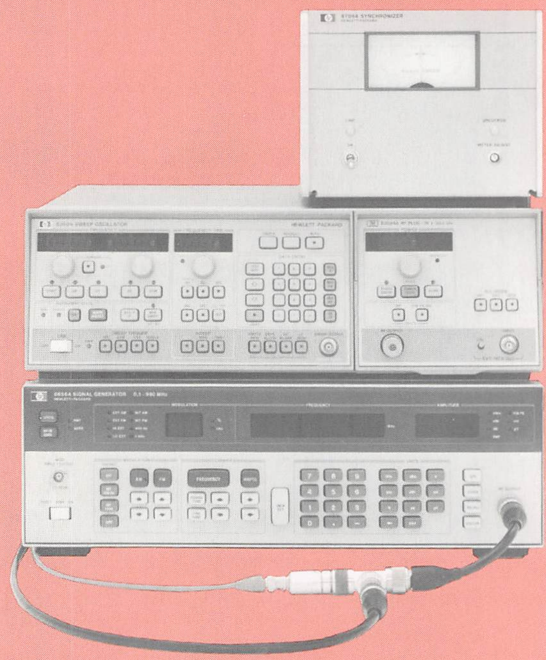
10 dB PER DIVISION



CENTER 5.760 GHz BW 30 kHz SPAN 2.00 MHz



SYNCHRONIZER: HP 8709A / 8350B / 83595A / 8656A OPT 001



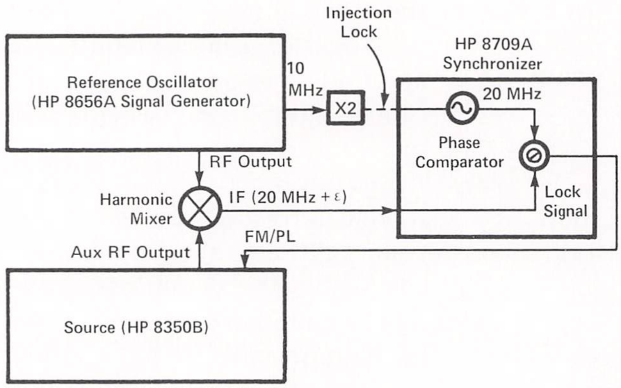
HP 8709A / 8350B / 8656A
PHASE-LOCKED SWEEP OSCILLATOR

HP 8709A / 8350B / 8656A KEY FEATURES

- Improved Frequency Accuracy
- Improved Close in Phase Noise / Stability
- Flexibility in Choosing Reference Oscillator

GENERAL DESCRIPTION

The HP 8709A phase-lock system uses a harmonic of a reference oscillator (HP 8656A used in the following examples) to mix with the RF output of the sweep oscillator. The mixing product of these two signals is 20 MHz plus the frequency deviations (ε) of the sweeper. This mixing product is input to the HP 8709A Synchronizer where it is compared with a 20 MHz standard. Any phase deviation from the standard is converted to a voltage and used to phase-lock the sweeper via its FM input.



HP 8709A SYSTEM BLOCK DIAGRAM

This phase-lock system is flexible in that it uses a programmable low-frequency, general-purpose signal generator which is selected by the user. In addition, this system utilizes the auxiliary output of the plug-in (when available), so the main output does not experience a power loss due to couplers or splitters.

The HP 8709A Synchronizer performs the phase-lock loop functions. The synchronizer has a selectable FM sensitivity setting to accommodate various sources. An injection lock input is available to improve the 20 MHz reference crystal stability which results in improved stability of the phase-locked signal. The HP 8709A Synchronizer has approximately ±30 MHz of capture range, and a system lock time of approximately 2.1 sec when using the HP 8656A. Faster lock times may be achieved with faster reference oscillators. The configuration of this system is described in detail in Application Note 187-2.

SPECTRAL PURITY

The close-in phase-noise of this system is improved over the stand-alone sweeper and mirrors the phase noise of the reference oscillator (the HP 8656A was used in the phase noise graph) but is proportional to the logarithm of the harmonic number used. The net system phase noise (PN) equation is typically as follows:

Offset From Carrier: 0 to 2 kHz

PN = HP 8656A PN + 20log(N1xN2)

Offset From Carrier: 2 kHz to 15 kHz

PN = HP 8656A PN + 20log(N1xN2) + 10 dB

Offset From Carrier: >15 kHz

PN = HP 8656A PN + 20log(N1xN2) + 5 dB

Note: N1 = Multiplier of plug-in (if multiplier type plug-in)

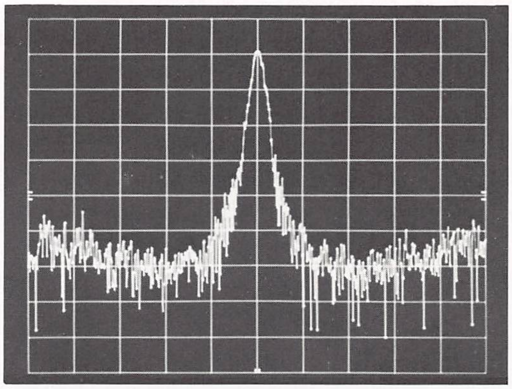
N2 = Multiplier of reference oscillator such that N2xFreq = (F/N1) – 20 MHz and Freq within reference oscillator frequency range

PN = phase noise

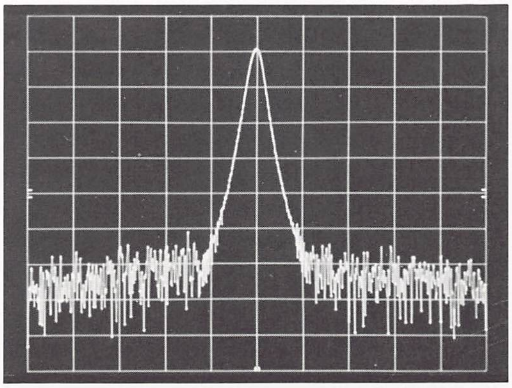
Freq = frequency of reference (HP 8656A)

The additional phase noise, compared to that of the stand alone sweep oscillator, that occurs at offsets greater than 2 kHz results from the loop response.

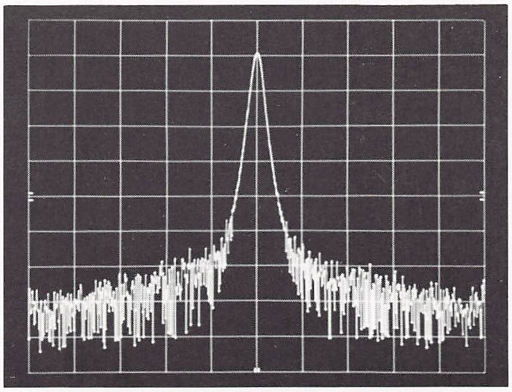
HP 8709A/8350B/8656A PHASE-LOCKED SWEEP OSCILLATOR



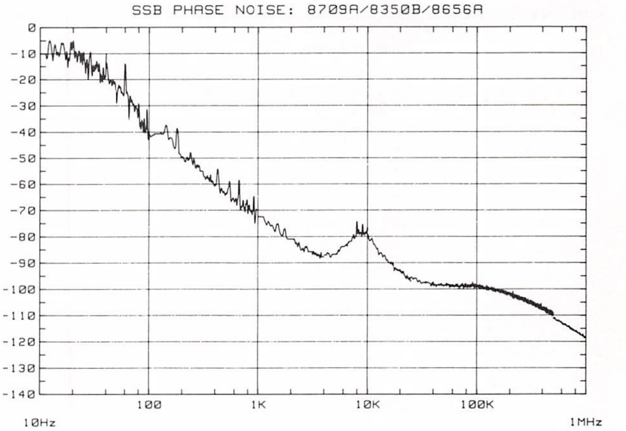
CENTER 5.760 GHz BW 300 Hz SPAN 20.0 kHz



CENTER 5.760 GHz BW 10 kHz SPAN 500 kHz



CENTER 5.760 GHz BW 30 kHz SPAN 2.00 MHz



CONCLUSION

The main emphasis of this paper is the spectral purity of different types of Hewlett-Packard Microwave Sources. In particular, 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. A summary of these results is provided below. This summary may aid in determining which type of microwave source can be used in a particular application. Some applications may have such stringent phase noise requirements that not even a synthesized microwave source can satisfy its requirements. Some examples of applications in which phase noise performance is important 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 1). The system performance then becomes limited by the phase noise of either the transmitter oscillator or the receiver local oscillator.

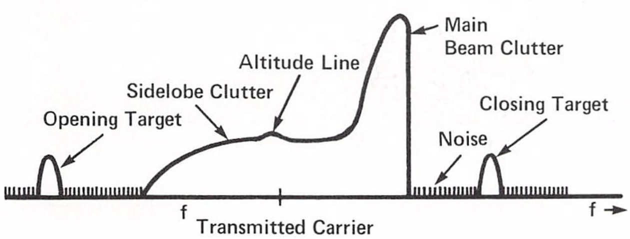


Figure 1

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 2).

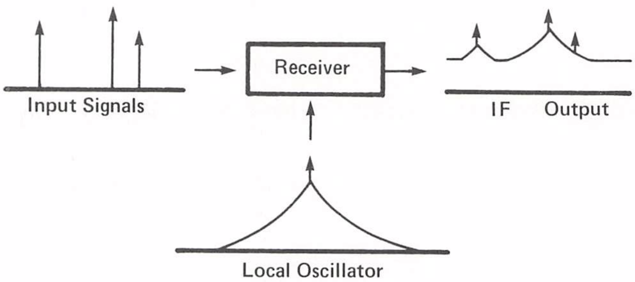
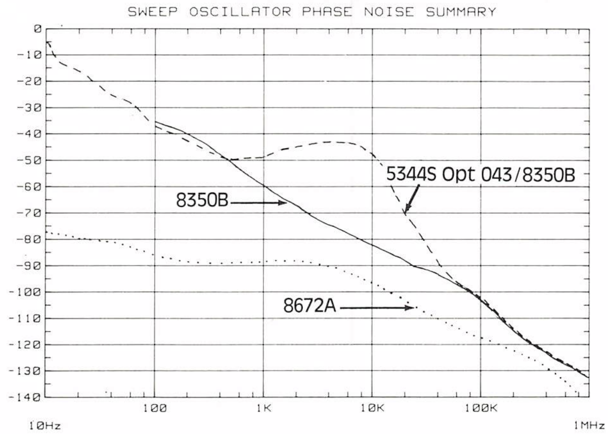


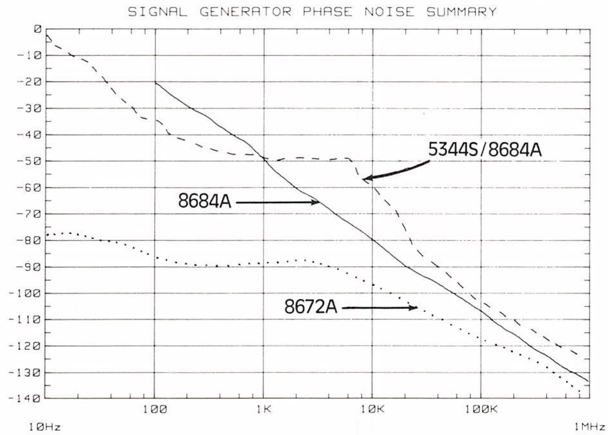
Figure 2

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 that the digital phase detection makes an incorrect decision as to the transmission phase.

The plots below provide a summary of the characteristic phase noise shapes of the source types discussed throughout this paper. The phase noise characteristics of the sweep oscillator are representative of a free running YIG oscillator. Adding the HP 5344S Microwave Source Synchronizer (or HP 8709A not shown) improves the accuracy and long term stability (note the noise improvement at offsets less than 1 kHz from the carrier). 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 8673B or the 8340A, provides the best solution.



The phase noise characteristics of the signal generator are representative of the free running cavity tuned oscillator. As seen with the sweep oscillator, adding the HP 5344S Microwave Source Synchronizer improves the accuracy and long term stability with the corresponding increase in phase noise for offsets between 1 kHz and 100 kHz. Comparing these phase noise characteristics with the phase noise characteristics of a synthesizer, it can be seen that applications requiring excellent close-in phase noise are best served by the HP 8672A, 8673B or 8340A.



SPECIFICATION SUMMARY

Specifications	HP 8350B / 83595A	HP 8709A/8656A Opt 001/8350B	HP 5344S / 8350B
Frequency			
Range	10 MHz to 26.5 GHz	10 MHz to 26.5 GHz	500 MHz to 26.5 GHz
Resolution	CW: 1.5 MHz; Vernier: 25 kHz	250 Hz x N1 x N2 (See p. 17 for definition of N1, N2)	1 Hz
Accuracy (CW)	±5 MHz to ±15 MHz depending on freq. range	See time base stability	See time base stability
Stability (with time)	±100 kHz to ±400 kHz/10 min. after 1 hr.depending on freq. range	See time base stability	See time base stability
Time Base Stability	N/A	8656A: Aging Rate: 1 x 10^{-9}/day Temperature: <7 x 10^{-9} over 0 to 50°C Line Variation: <2 x 10^{-9} for ±10% change from normal	5343A Opt 001: Aging Rate: <5 x 10^{-10}/day Temperature: <7 x 10^{-9} over 0 to 50°C Line Variation: <1 x 10^{-10} for ±10% change from normal
Spectral Purity			
Harmonics	0.01 – 20.0 GHz: < –25 dBc typ: < –35 dBc 20.0 – 26.5 GHz: < –20 dBc typ: < –25 dBc	0.01 – 20.0 GHz: < –25 dBc typ: < –35 dBc 20.0 – 26.5 GHz: < –20 dBc typ: < –25 dBc	0.01 – 20.0 GHz: < –25 dBc typ: < –35 dBc 20.0 – 26.5 GHz: < –20 dBc typ: < –25 dBc
Subharmonics and Multiples thereof	Same as harmonics	Same as harmonics	Same as harmonics
Non-harmonics	0.01 – 2.4 GHz: < –25 dBc 2.4 – 26.5 GHz: < –50 dBc	0.01 – 2.4 GHz: < –25 dBc 2.4 – 26.5 GHz: < –50 dBc	0.01 – 2.4 GHz: < –25 dBc 2.4 – 26.5 GHz: < –50 dBc
SSB Phase Noise	N/A	N/A	N/A
RF Output			
Max. Power Out	0.01 – 20.0 GHz: +10 dBm 20.0 – 26.5 GHz: +4 dBm	0.01 – 20.0 GHz: +10 dBm 20.0 – 26.5 GHz: +4 dBm	0.01 – 20.0 GHz: +10 dBm 20.0 – 26.5 GHz: +4 dBm
Min. Power Out	–5 dBm –60 dBm (Opt. 002)	–5 dBm –60 dBm (Opt. 002)	–5 dBm –60 dBm (Opt. 002)
Power Level Acc.	±1.3 to ±1.8 dB depending on freq. range	±1.3 to ±1.8 dB depending on freq. range	±1.3 to ±1.8 dB depending on freq. range
Flatness	±0.7 to ±1.0 dB depending on freq. range	±0.7 to ±1.0 dB depending on freq. range	±0.7 to ±1.0 dB depending on freq. range
General			
Lock Time / Freq. Switching Time	N/A	3.1 sec. (2.1 sec typ)	5342A: Manual Lock 900 ms Auto Lock 1.5 s 5343A: Manual Lock 500 ms Auto Lock 1.1 s
Capture Range	N/A	35 MHz (typ)	±25 MHz (Manual Mode)
Loop Bandwidth	N/A	N/A	Wideband: 100 kHz Narrowband: 10 kHz
Programmable	YES	YES	YES
Size: Weight	Mainframe: 16.5 kg (36.4 lb) Plug-in: 6.0 kg (13.2 lb)	8350/83595: 32.5 kg (50 lb) 8709A: 4.5 kg (10 lb) 8656A: 18.1 kg (40 lb)	8350/83595: 32.5 kg (50 lb) 5344S: 18.7 kg (41 lb)
Dimensions	133H x 425W x 422 mmD	8350: 133H x 425W x 422 mmD 8709: 190H x 155W x 279 mmD 8656: 133H x 425W x 520 mmD	8350: 133H x 425W x 422 mmD 5344S: 133H x 426W x 498 mmD

HP 8683 / 8684	HP 5344S / 8684A	HP 8672A / 8672S	HP 8673B	HP 8340A
8683A / B: 2.3 – 6.5 GHz 8684A / B: 5.4 – 12.5 GHz	8683A / B: 2.3 – 6.5 GHz 8684A / B: 5.4 – 12.5 GHz	2 to 18 GHz (8672A) 0.01 to 18 GHz (8672S)	2 to 26 GHz	10 MHz to 26.5 GHz
Displayed: 8683: ≤5 MHz 8684: ≤10 MHz	1 Hz	0.01 – 6.2 GHz: 1 kHz 6.2 – 12.4 GHz: 2 kHz 12.4 – 18 GHz: 3 kHz	2.0 - 6.6 GHz: 1 kHz 6.6 - 12.3 GHz: 2 kHz 12.3 - 18.6 GHz: 3 kHz 18.6 - 26 GHz: 4 kHz	0.01 - 7.0 GHz: 1 Hz 7.0 - 13.5 GHz: 2 Hz 13.5 - 20.0 GHz: 3 Hz 20.0 - 26.5 GHz: 4 Hz
Calibration Accuracy 8683 / 84: ±1.25%<4/9 GHz ±0.75%>4/9 GHz	See time base stability	See time base stability	See time base stability	See time base stability
<100 kHz/hr after 1 hour	See time base stability	See time base stability	See time base stability	See time base stability
N/A	5343A Opt 001: Aging Rate: <5 x 10^{-10}/day Temp: <7 x 10^{-9} over 0 to 50°C Line Variation: <1 x 10^{-10} for ±10% change from normal	Aging Rate: <5 x 10^{-10}/day Temp: <1 x 10^{-10}/°C Line Variation: <5 x 10^{-10} for ±10% change from normal	Aging Rate: <5 x 10^{-10}/day Temp: <1 x 10^{-10}/°C (typ) Line Variation: <5 x 10^{-10} for +5% to −10% change from normal	Aging Rate: <1 x 10^{-9}/day Temp: <1 x 10^{-10}/°C (typ) Line Variation: <1 x 10^{-11} for ±10% change from normal (typ)
<−25 dBc	<−25 dBc	<−25 dBc	<−40 dBc	<−35 dBc
None	None	Same as harmonics	<−25 dBc 2- 18.6 GHz <−20 dBc 18.6 - 26 GHz	<−25 dBc 0.01 - 20 GHz <−20 dBc 20 - 26.5 GHz
<−80 dBc	<−80 dBc	0.01–2 GHz: <−60 dBc 2.0 - 6.2 GHz: <−70 dBc 6.2 - 12.4 GHz: <−64 dBc 12.4 - 18 GHz: <−60 dBc	2.0 - 6.6 GHz: <−70 dBc 6.6 - 12.3 GHz: <−64 dBc 12.3-18.6 GHz: <−60 dBc 18.6 - 26 GHz: <−58 dBc	0.01 - 2.3 GHz: <−55 dBc 2.3 - 7.0 GHz: <−70 dBc 7.0 - 13.5 GHz: <−64 dBc 13.5-20 GHz: <−60 dBc 20 - 26.5 GHz: <−58 dBc
N/A	N/A	Offset 10 Hz: −58 dB/Hz 100 Hz: −70 dB/Hz 1 kHz: −78 dB/Hz 10 kHz: −86 dB/Hz 100 kHz: −110 dB/Hz (0.01 - 6.2 GHz)	Offset 10 Hz: −58 dB/Hz 100 Hz: −70 dB/Hz 1 kHz: −78 dB/Hz 10 kHz: −86 dB/Hz 100 kHz: −110 dB/Hz (2.0 - 6.6 GHz)	Offset 30 Hz: −64 dB/Hz 100 Hz: −70 dB/Hz 1 kHz: −78 dB/Hz 10 kHz: −86 dB/Hz 100 kHz: −107 dB/Hz (0.01 - 7.0 GHz)
8683A / 8684A: 0 dBm 8683B / 8684B: +10 dBm	8683A / 8684A: 0 dBm 8683B / 8684B: +10 dBm	+3 dBm (+2 dBm 8672S) +8 dBm (Opt 008; +7 dBm 8672S)	+8 dBm 2 - 18 GHz +4 dBm 18 - 22 GHz 0 dBm 22 - 26 GHz	+9 dBm 0.01 - 20 GHz +3 dBm 20 - 23 GHz +1 dBm 23 - 26.5 GHz
−130 dBm	−130 dBm	−120 dBm	−100 dBm	−110 dBm
±2.5 dB to −110 dBm ±3.5 dB, −110 to −120 dBm	±2.5 dB to −110 dBm ±3.5 dB, −110 to −120 dBm	2.0 – 6.2 GHz: <±1.75 dB 6.2 - 12.4 GHz: <±2.0 dB 12.4 - 18.0 GHz: <±2.25 dB	2.0 - 6.6 GHz: ±1.25 dB 6.6 - 12.3 GHz: ±1.50 dB 12.3-18.6 GHz: ±1.75 dB 18.6-26.0 GHz: ±2.00 dB	0.01 - 2.3 GHz: <±0.9 dB 2.3 - 20 GHz: <±1.5 dB 20 - 26.5 GHz: <±2.0 dB
±1 dB	±1 dB	2.0 - 6.2 GHz: ±0.75 dB 6.2 - 12.4 GHz: ±1.0 dB 12.4 - 18.0 GHz: ±1.25 dB	±0.75 to ±1.75 dB depending on freq. range	±0.6 to 1.6 dB depending on freq. range
N/A	5342A: Manual Lock 900 ms 5343A: Manual Lock 500 ms	<15 msec to be within freq. resolution	<20 ms to be within freq. resolution	<50 ms; "Fast Phase Lock" mode provides typ. time of <20 ms
N/A	±25 MHz (manual mode)	N/A	N/A	N/A
N/A	Narrowband: 10 kHz	N/A	N/A	N/A
NO	NO	YES	YES	YES
8683A: 16.8 kg (37 lb) 8683B: 17.4 kg (38 lb) 8684A: 15.6 kg (34 lb) 8684B: 16.0 kg (35 lb)	5344S: 18.7 kg (41 lb) 8683 / 8684: see previous column	27.8 kg (60 lb)	29 kg (64 lb)	34 kg (75 lb)
145H x 425W x 441 mmD	8683/84: 145H x 425W x 441 mmD 5344S: 133H x 426W x 498 mmD	146H x 425W x 613 mmD	146H x 425W x 620 mmD	188H x 425W x 609 mmD

SPECIFICATION SUMMARY

Specifications	HP 8350B / 83595A	HP 8709A / 8350B / 8656A	HP 5344S / 8350B
Amplitude Modulation			
AM Depth	15 dB (typ)	15 dB (typ)	15 dB (typ)
AM Rates	DC to 100 kHz (typ)	DC to 100 kHz (typ)	DC to 100 kHz (typ)
AM Distortion	N/A	N/A	N/A
Incidental FM	N/A	N/A	N/A
Internal AM	Selectable to 1 kHz or 27.8 kHz sq. wave mod. ON/OFF ratio: ⩾30 dB. Symmetry 50% ± 10%	Selectable to 1 kHz or 27.8 kHz sq. wave mod. ON/OFF ratio: ⩾30 dB. Symmetry 50% ± 10%	Selectable to 1 kHz or 27.8 kHz sq. wave mod. ON/OFF ratio: ⩾30 dB. Symmetry 50% ± 10%
AM Freq. Response	N/A	N/A	N/A
Ext. AM Sensitivity	1 dB/V into 10 kΩ	1 dB/V into 10 kΩ	1 dB/V into 10 kΩ
Frequency Modulation			
Max. Peak Deviation	DC to 100 Hz: ±75 MHz 100 Hz to 1 MHz: ±7 MHz 1 MHz to 2 MHz: ±5 MHz 2 MHz to 10 MHz: ±1 MHz	N/A	N/A
FM Rates	DC to 10 MHz	N/A	N/A
Distortion %	N/A	N/A	N/A
Incidental AM	N/A	N/A	N/A
External FM Sens.	Switch selectable: FM mode: −20 MHz/V (typ) Phase-lock: −6 MHz/V (typ)	N/A	N/A
Internal FM	N/A	N/A	N/A
Pulse Modulation			
Width	Leveled: 5 μsec (typ) Unleveled: 100 nsec (typ)	Leveled: 5 μsec (typ) Unleveled: 100 nsec (typ)	Leveled: 5 μsec (typ) Unleveled: 100 nsec (typ)
ON/OFF Ratio	N/A	N/A	N/A
Rise/Fall Time	50 ns (typ)	50 ns (typ)	50 ns (typ)

HP 8683 / 8684	HP 5344S / 8684A	HP 8672A / 8672S	HP 8673B	HP 8340A
0 to 70%	0 to 70%	2.0 - 6.2 GHz: 0 to 75% 6.2 - 12.4 GHz: 0 to 60% 12.4-18.0 GHz: 0 to 50%	2.0 - 24 GHz: 0 to 75% 24 - 26 GHz: 0 to 50%	0 to 90%
3 dB BW at 50% depth: DC to 10 kHz (DC coupled) 50 Hz to 10 kHz (AC coupled)	3 dB BW at 50% depth: DC to 10 kHz (DC coupled) 50 Hz to 10 kHz (AC coupled)	3 dB BW at 50% depth: 10 Hz to 100 kHz	3 dB BW at 30% depth: 20 Hz - 100 kHz	3 dB BW at 30% depth: DC-100 kHz (DC coupled)
<5% at 40% depth and 1 kHz rate	<10% at 40% depth and 10 kHz rate	<3% at 30% depth <4% at 50% depth <5% at 75% depth	2% to 5% depending on AM rate and modulation depth	2% to 5% depending on AM rate and modulation depth
<10 kHz peak to peak (30% AM depth)	<10 kHz peak to peak (30% AM depth)	2.0-6.2 GHz: $<0.7 \times f_{mod}$ 6.2-12.4 GHz: $<1.8 \times f_{mod}$ 12.4-18.0 GHz: $<1.2 \times f_{mod}$	2.0-6.6 GHz: $<0.4 \times f_{mod}$ 6.6-12.3 GHz: $<0.8 \times f_{mod}$ 12.3-18.6 GHz: $<1.2 \times f_{mod}$ 18.6 - 24.0 GHz: $<1.6 \times f_{mod}$ 24.0 - 26.0 GHz: $<2.0 \times f_{mod}$	$<0.4 \times f_{mod}$ (typ)
1 kHz square wave with 50% ±5% duty cycle	1 kHz square wave with 50% ±5%	N/A	N/A	N/A
N/A	N/A	Relative to 1 kHz rate: ±0.25 dB (100 Hz - 10 kHz)	Relative to 1 kHz rate: ±0.25 dB (100 Hz - 10 kHz)(typ)	Relative to 1 kHz rate: ±0.2 dB (DC to 10 kHz)
100%/V into 600 Ω continuously variable	100%/V into 600 Ω continuously variable	30%/V & 100%/V into 600 Ω Note: The 8672S only has AM modulation above 2 GHz.	30% & 100%/V into 600 Ω	100%/V into 600 Ω
±5 MHz	N/A	The smaller of 10 MHz or: 2.0 - 6.2 GHz: $f_{mod} \times 5$ 6.2-12.4 GHz: $f_{mod} \times 10$ 12.4-18.0 GHz: $f_{mod} \times 15$	The smaller of 10 MHz or: 2.0 - 6.6 GHz: $f_{mod} \times 5$ 6.6-12.3 GHz: $f_{mod} \times 10$ 12.3-18.6 GHz: $f_{mod} \times 15$ 18.6-26 GHz: $f_{mod} \times 20$	N/A
DC to 10 MHz (DC coupled) 100 Hz to 10 MHz (AC coupled)	N/A	typ 50 Hz to 10 MHz	typ 100 Hz to 10 MHz	N/A
<5% at 100 kHz rate and <1 MHz peak deviation	N/A	<5% to 12% depending on range	<5% to 12% depending on range	N/A
<6% at 100 kHz rate and <1 MHz peak deviation	N/A	<10%	<5%	N/A
Variable in 1 MHz and 10 MHz ranges	N/A	30, 100, 300 kHz/V and 1, 3, 10 MHz/V ranges; max input 1V peak into 50 Ω	30, 100, 300 kHz/V and 1, 3, 10 MHz/V ranges; max input 1 V peak into 50Ω	N/A
FM sawtooth with fixed swp rate of 1 kHz and variable deviation up to ±5 MHz. 1V p sawtooth available at FM in/out	N/A	N/A	N/A	N/A
8683A/8684A: 10 μsec leveled 8683B/8684B: 100 nsec leveled	8683A/8684A: 10 μsec leveled 8683B/8684B: 100 nsec leveled	With 11720A Pulse Modulator: 50 nsec (unleveled)	100 nsec leveled	100 nsec leveled
8683A/8684A: 30 dB 8683B/8684B: 80 dB	8683A/8684A: 30 dB 8683B/8684B: 80 dB	80 dB	>80 dB	>80 dB
8683A/8684A: 5 μsec 8683B/8684B: 10 nsec	8683A/8684A: 5 μsec 8683B/8684B: 10 nsec	10 nsec	<35 nsec	<25 nsec

APPENDIX A: HP 3047A SPECTRUM ANALYZER SYSTEM

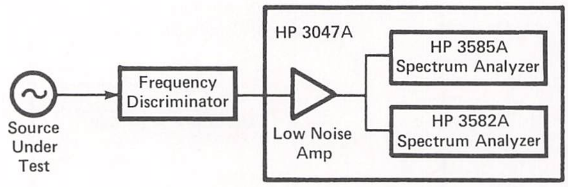
The HP 3047A Spectrum Analyzer system comprises a HP 3585A Spectrum Analyzer, a HP 3582A Spectrum Analyzer, a HP 35601A Spectrum Analyzer Interface and HP 9845B Desktop Computer. The software that comes with the HP 3047A includes a phase noise measurement program. When used with the HP 3047A, the term phase noise includes all forms of frequency and phase instabilities. Frequency and phase noise are included in the term and can be measured by the HP 3047A Spectrum Analyzer system.

The complexity of phase noise measurement 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 descriminator or phase detector, the system sensitivity can be increased. The Phase Noise Measurement Mode of the HP 3047A is designed to reduce the difficulty of making accurate phase noise measurements with either the frequency discriminator or quadrature phase detector techniques.

No matter which of the above techniques are used, phase noise measurements are always made with repsect to a 1 Hertz bandwidth. To measure the entire spectrum in a 1 Hertz bandwidth would take an excessive amount of time so, as is common practice, the HP 3047A 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 Hertz must be used.) From these measurements, the system normalizes the noise to a 1 Hertz bandwidth and plots this result.

DISCRIMINATOR METHOD

Any variations in the carrier frequency or phase are changed into voltage variations by the discriminator. The voltage variations are then analyzed by the HP 3047 system. Used with sources having high close-in phase noise; i.e., HP 8350, 8709/8350, 5344/8350, 5344/8684.

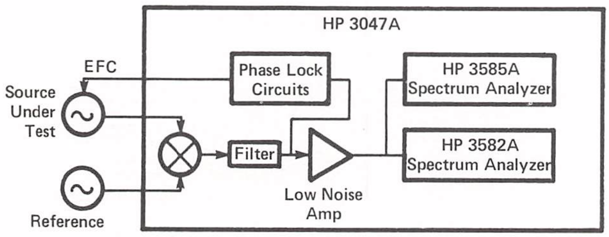


FREQUENCY DISCRIMINATOR METHOD

PHASE DETECTOR METHOD

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 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. At frequencies 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 phase noise at higher frequencies. With the HP 3047, the system software measures the transfer function of the phase-lock loop before the phase noise measurement and uses this information to correct for the effects of the phase-lock loop on the voltage to the analyzer.

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) as a reference.

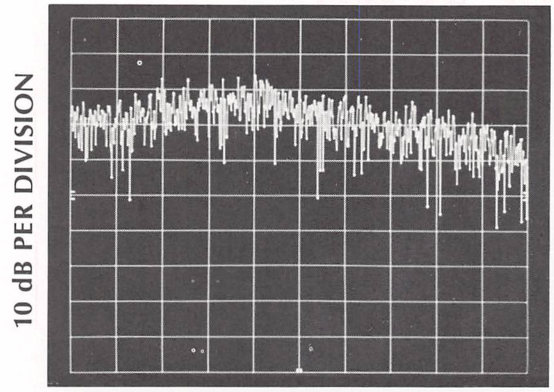


PHASE DETECTOR METHOD

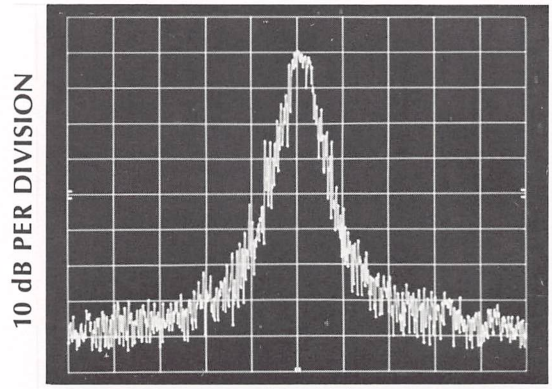
APPENDIX B

The spectrum analyzer photographs and SSB phase noise plot in the adjacent column reflect the performance of the HP 8350B/83595A Sweep Oscillator with the CW filter off. The spectral purity of this configuration is degraded from the performance with the CW filter on (as seen on page 7). The sweep oscillator is often used with the 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 is 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.

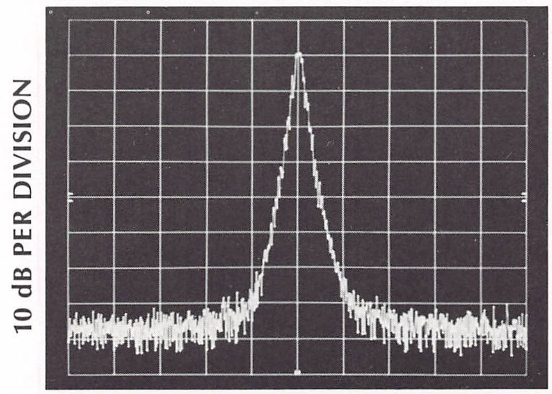
HP 8350B/83595A SWEEP OSCILLATOR (CW FILTER OFF)



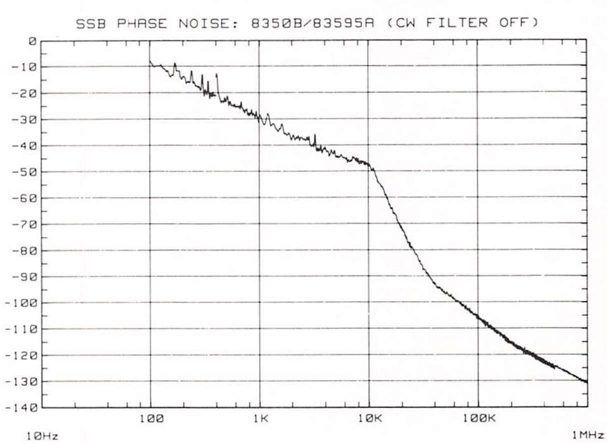
CENTER 5.760 GHz BW 300 Hz SPAN 20.0 kHz



CENTER 5.760 GHz BW 10 kHz SPAN 500 kHz



CENTER 5.760 GHz BW 30 kHz SPAN 2.00 MHz



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