

Agilent 8644A-1

Phase noise test with the Agilent 8644A and 8665A Signal Generators

Product Note

This product note describes the unique characteristics of the FM scheme used in the Agilent Technologies 8644A and 8665A and explains how it affects phase noise measurements. Also included are typical performance, limitations, and specific operating instructions for using these generators as the tunable reference in a phase noise measurement.

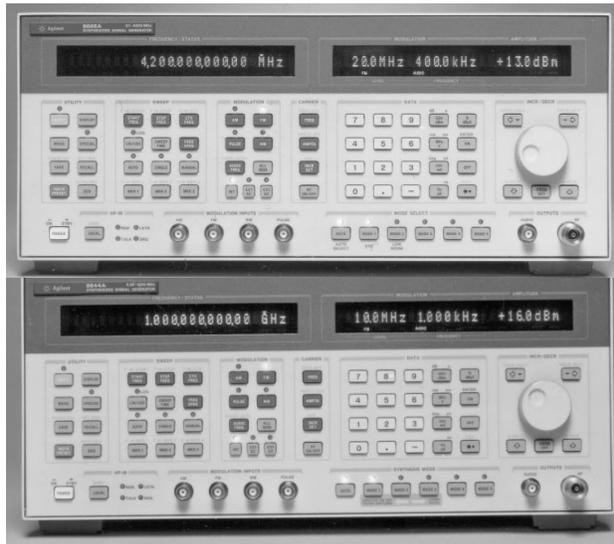
8644A and 8665A Theory of Operation

The 8644A and 8665A have a unique FM implementation that offers

benefits over the classical open loop dc coupled scheme but have inherent characteristics that are different from most other signal generators. The default FM is a digitized scheme that is used for most applications and has benefits such as center frequency accuracy and good close-in phase noise. A traditional open loop, non-digitized, linear FM is also available as a special function for applications that need true linear FM with low group delay. Both schemes have advantages and disadvantages that will be explained more thoroughly.

Digitized FM

This is the default FM scheme automatically selected on power-up or instrument preset. This scheme uses a single phase-lock-loop with a fractional N divider (Figure 1). The modulation signal is applied to the loop at two points, directly to the VCO and indirectly after digitization to the digital divider. Only low rate signals within the PLL bandwidth can cause modulation at the divider, the high rate signals must be applied directly to the VCO input. The benefits of this scheme are good dcFM stability since the loop remains locked to the reference and good close in phase noise because of the clean-up within the phase-lock-loop bandwidth. The drawback of this scheme in a phase noise measurement is the group delay and quantization error from the digitization. Group delay varies with modulation rate (Figure 2) and can cause phase shift and possible instability when the generator is used as an element in a phase-lock-loop. The quantization error is small but can show up when using small input signals <10 mV. For these very small signals, the generator appears to have a changing FM sensitivity which causes an incorrect phase noise measurement within the loop bandwidth. A true open loop, linear FM, is available for phase noise measurements that use small input signals and are sensitive to group delay.



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Linear FM

This FM scheme is true linear FM where the modulating signal is applied directly to the VCO and the feedback path for the phase locked loop is opened. This operation is selected with special function 120. The advantage of this scheme is true linear dcFM with group delay of < 1 msec. This eliminates the instability caused by large group delay and quantization error from digitization. The disadvantage of this scheme is poor center frequency accuracy and higher close-in phase noise because the loop is no longer locked to the reference and there is no clean up from the PLL.

Operation as a Phase Noise Measurement Reference

The most common technique for measuring the phase noise of a source is to use reference source and demodulate the phase instability using a phase detector. Commonly referred to as the Phase Detector method, this method requires a reference source with equal or better phase noise performance than the source being tested. It is also required that one of the sources have tuning capability, like dcFM, in order to maintain phase quadrature at the input of the phase detector. The need for good phase noise performance and dcFM capability often results in a

signal generator being used as the reference source of a phase noise measurement system. The remainder of this product note describes how to use and optimize the Agilent 8644A and 8665A as reference sources for phase noise measurements. More information on the measurement technique itself can be found in literature related to products such as the Agilent 11729C Carrier Noise Test Set (Literature #5954-7362) or Agilent 3048A Phase Noise Measurement System (#5953-8462).

Several features of these signal generators make them good choices for use as a phase noise measurement source. These include wide carrier frequency range, high output power, good spectral purity, and dcFM. The phase noise of these signal generators is very low at offsets greater than 10 kHz from the carrier, as is commonly required for testing channelized communication devices or systems. Both signal generators have very low spurious on the output which simplifies the detection and interpretation of spurs from the test source. The typical phase noise and spurious performance is shown in the graph included in the "Phase Noise Performance" summary of this product note.

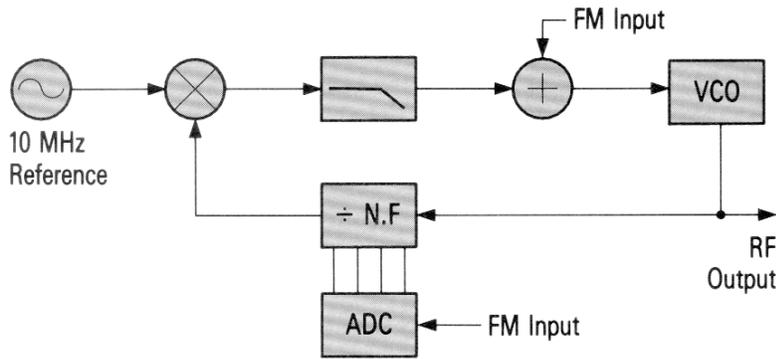


Figure 1. Simplified Agilent 8644A/65A block diagram

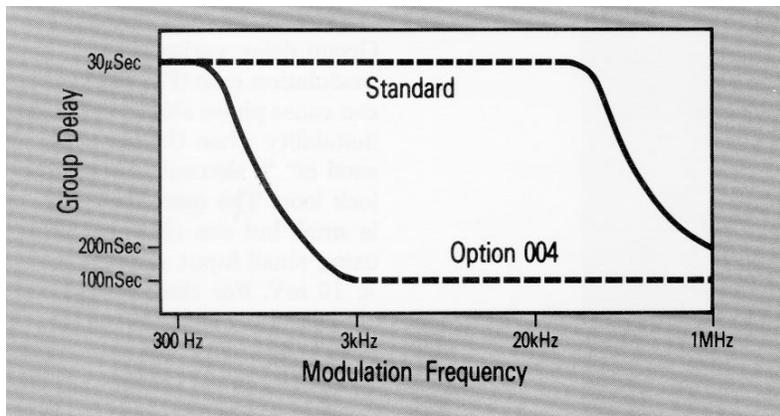


Figure 2. Group delay for digitized FM synthesis

When using these signal generators as non-tunable references, all modulation should be turned off. This provides good spectral purity and frequency stability. These generators can be used with or without the enhanced spectral purity Option 004.

Application Procedure

When using the 8644A or 8665A as the tunable reference in a phase noise measurement some special precautions must be taken to ensure the accuracy of the results. This section outlines the procedures and operating modes necessary to make a reliable measurement.

While these signal generators were not specifically designed as a reference for a phase noise measurement, they do have excellent spectral purity and may be useful for certain applications. As will be explained further, the digitized FM scheme must not be used for tuning the signal generator during a phase noise measurement. Currently these generators are not supported by the 3048A software and must be manually adjusted when connected to the system.

The first step that is necessary is to select Linear FM with special function 120 and DC coupled FM from the front panel. This dcFM mode eliminates the group delay, which can cause instability in the phase-lock-loop. This FM scheme also avoids the quantization error inherent in the default digitized FM, which would be significant because of the small signals presented to the FM input during a phase noise measurement.

Because it is necessary to use linear dcFM, the center frequency accuracy and resolution of these signal generators will be worse. To overcome these problems it is necessary to use at least the minimum amount of FM deviation specified in Tables 1 and 2. This is necessary to ensure that the signal generator and the DUT can be brought into phase quadrature with the feedback tuning control to the dcFM input. Also, on the 8665A, it is necessary to have the Option 004 installed and front panel Mode 2 selected. This minimizes the center frequency errors and gives the best possible phase noise performance. For 8644A with serial numbers < 150, Option 004 is also necessary to eliminate the tuning resolution problem and should only be used with the minimum amount of FM deviation specified in Table 1.

Selecting the FM deviation requires two considerations. First, the deviation must be within that specified in Tables 1 and 2. Secondly, only use the minimum amount of deviation necessary to keep the signal generator locked to the DUT. As a general rule, start with the minimum deviation shown in the table and increase it if the system loses lock during the measurement. Choosing the least amount of deviation necessary gives the signal generator the best possible spectral purity.

One other unique characteristic of these generators is that several circuits internally are calibrated whenever the center frequency setting is changed. The output is decreased by more than 60 dB during these resets so that the unspecified output during the transition will not affect the user's device. This transition period typically lasts 200 msec. This operational characteristic will be apparent when the center frequency of the signal generator is tuned, causing the beat-note to disappear momentarily with each change. Activating special function 105 Amplitude Muting disables this amplitude blanking and is recommended when manual tuning.

Phase Noise Performance Summary

Agilent 8644A

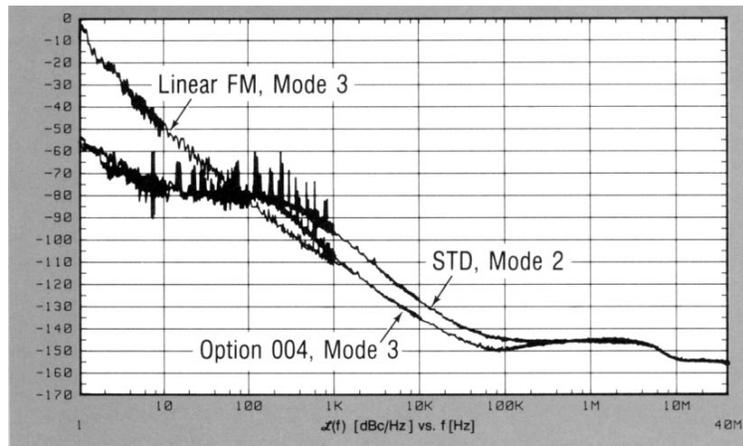
Necessary conditions:

- 1) Linear FM special 120.
- 2) FM deviation selected according to Table 1.
- 3) When using Option 004 the minimum amount of FM deviation should be used. If larger amounts of deviation are selected, the signal generator will automatically select standard performance with less spectral purity. This standard performance is shown in the graph below.

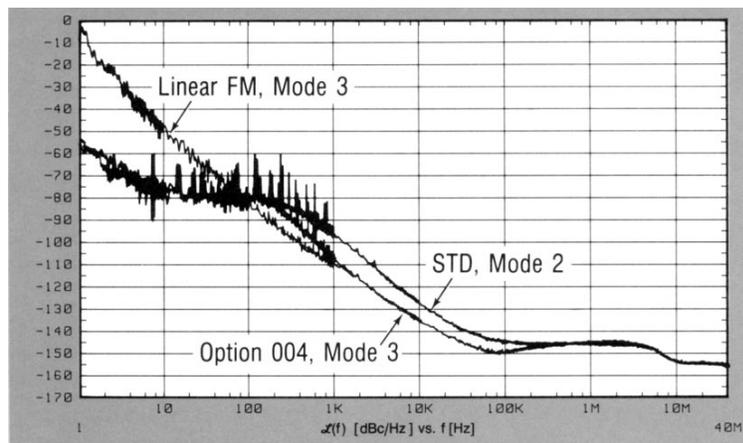
Table 1. 8644A frequency/FM deviation settings

Carrier Frequency (MHz)	Recommended FM Deviation	Tuning Resolution in Linear FM (kHz)
1030 - 2060	200 kHz - 2 MHz	4 - 10
515 - 1029.9999999	100 kHz - 1 MHz	2 - 5
257.5 - 514.9999999	50 kHz - 500 kHz	1 - 2.5
128.75 - 257.4999999	25 kHz - 250 kHz	.5 - 1.25
64.375 - 128.7499999	12.5 kHz - 125 kHz	.25 - .62
32.1875 - 64.3749999	6.25 kHz - 62.5 kHz	.12 - .31
16.09375 - 32.1874999	3.12 kHz - 31.2 kHz	.06 - .15
8.046875 - 16.0937499	1.56 kHz - 15.6 kHz	.03 - .078
4.0234375 - 8.0468749	.781 kHz - 7.81 kHz	.015 - .039
2.01171875 - 4.02343749	.39 kHz - 3.9 kHz	.008 - .019
1.00585937 - 2.01171874	.19 kHz - 1.9 kHz	.004 - .009
0.50292968 - 1.00585937	.097 kHz - .97 kHz	.002 - .004
0.25146485 - 0.50292968	.048 kHz - .48 kHz	.001 - .002

Typical SSB phase noise and spurs at 1 GHz in digitized FM or FM off



Typical SSB phase noise and spurs at 640 MHz in linear FM



Agilent 8665A

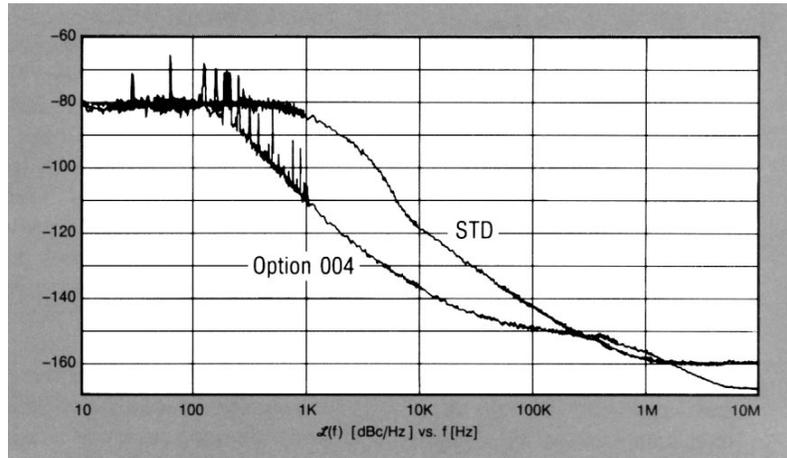
Necessary conditions:

- 1) Option 004 installed, front panel Mode 2 selected.
- 2) Linear FM special 120 selected.
- 3) FM deviation selected according to Table 2.

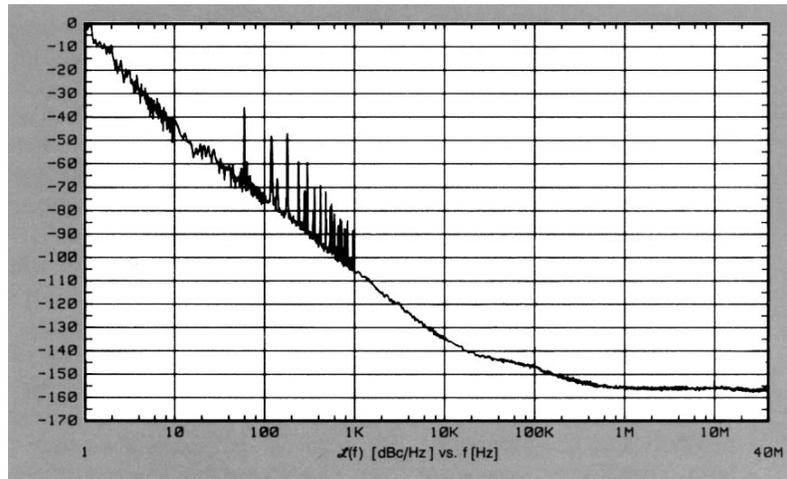
Table 2. 8665A frequency/FM deviation settings

Carrier Frequency (MHz)	FM Deviation	Tuning Step Size in Linear FM (kHz)
4120 - 4200	800 kHz	16
2060 - 4119.99999999	400 kHz	8
1030 - 2059.99999999	200 kHz	4
515 - 1029.99999999	100 kHz	2
257.5 - 514.99999999	50 kHz	1
187.5 - 257.49999999	25 kHz	.5
30 - 187.49999999	200 kHz	4
.1 - 29.99999999	100 kHz	2

Typical SSB phase noise and spurs at 1 GHz in digitized FM



Typical SSB phase noise and spurs at 640 MHz in linear FM



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