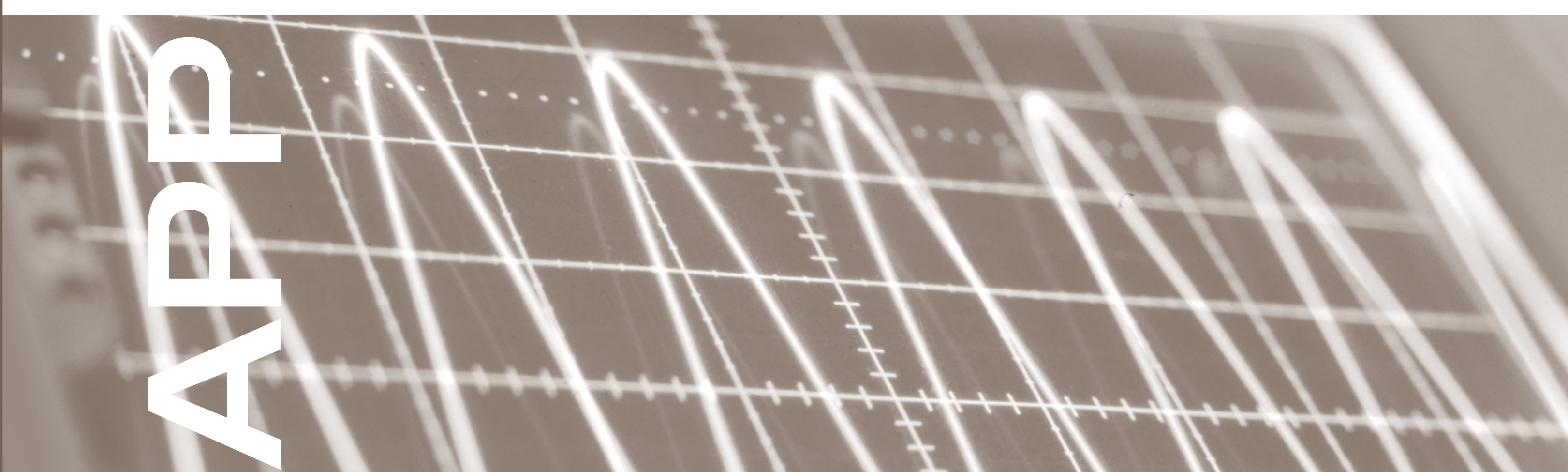
Quartz Crystal Based Oscillators
Low Phase Noise Characteristics

APP NOTE



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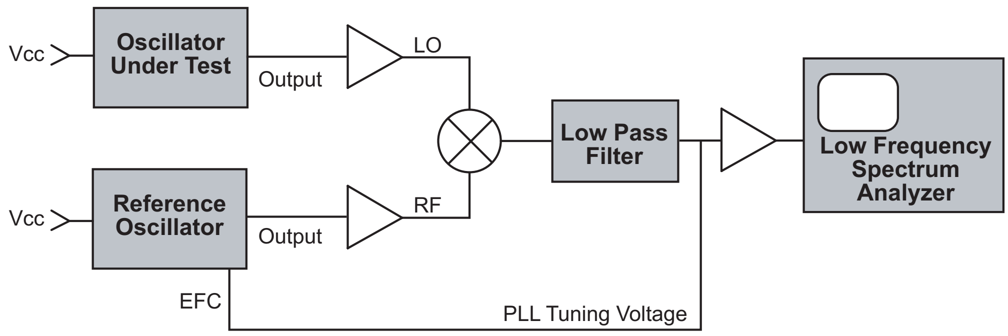
Frequency generation is an essential function in practically all present-day commercial, industrial and military technologies. All oscillator signals contain some level of noise. Although simple oscillators such as those constructed with resistor-capacitor (RC) or inductor-capacitor (LC) resonators are adequate for some circuits, many applications require the additional stability and lower noise provided by quartz crystal oscillators.

An ideal oscillator would produce a perfectly repetitive signal at a single frequency. However, noise processes in the electronic components and the frequency determining resonant circuit cause the instantaneous frequency to vary or dither about its center value. This causes uncertainty about the exact frequency at any given time and the spectrum produced by the oscillator is spread across a narrow frequency band – with most of the energy concentrated near the center frequency.

There are many ways of measuring or expressing this oscillator noise phenomenon, but the most common way for precision oscillators is as phase noise. Phase noise is measured in the frequency domain, plotted as signal amplitude vs. frequency. This is the representation that is displayed on a spectrum analyzer. For relatively noisy signals, the phase noise may be observed directly on a spectrum analyzer if the measurement bandwidth is set properly. However, for clean signals such as those produced by most crystal oscillators, the noise of the analyzer's wideband local oscillator is higher than the noise from the source to be measured so that the noise from the unit being tested can not be observed directly. Some means of increasing the sensitivity of the measurement system must therefore be employed.

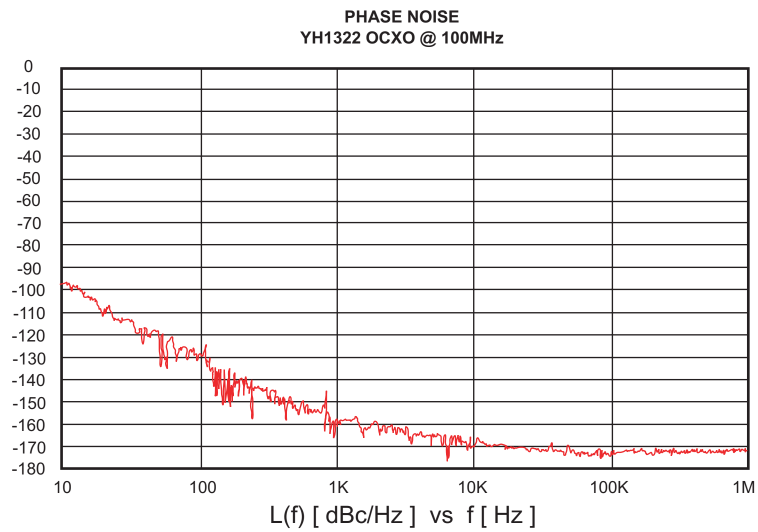
Phase Noise Measurement Block Diagram

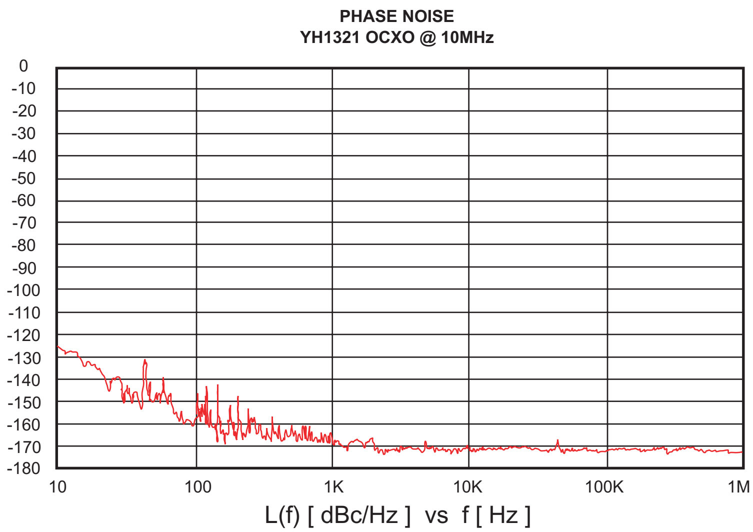


The most common method of achieving this sensitivity improvement is to compare one oscillator to another. This is how most commercial phase noise measurement systems operate. A very low noise reference oscillator is adjusted to be at exactly the same frequency as the unit being tested. When these two signals are fed into a phase detector with their relative phase adjusted and locked at a 90 degree offset, the carrier frequencies are cancelled in the mixer. After filtering of the high frequency components, only the residual noise modulation that has been mixed down to the base-band frequency remains. This noise signal is then amplified to increase the sensitivity. Since the high frequency signals have been removed by the mixing and filtering process, the residual noise signal can then be examined with a very low bandwidth analyzer.

In order to standardize phase noise measurements, the results are usually expressed as the ratio of the sideband noise power measured in a 1Hz bandwidth at a given offset distance from the center carrier frequency to the carrier signal power. Plots suc h as those shown here are then produced.

These graphs show the performance of precision low noise crystal oscillators at 10 MHz and 100 MHz. Both of these units achieve a noise floor of better than -170 dBc/Hz at greater than 10kHz offsets from the carrier. This approaches state-of-the-art performance for commercial product.





At lower offset frequencies approaching the carrier, the phase noise is determined by the quality of the crystal resonator. A 100 MHz crystal has a considerably lower “Q” than a 10 MHz crystal, so the noise is higher at the low offsets.

Precision quartz crystal based oscillators have been shown to provide the best phase noise performance available from any commercially available device. Even simple crystal clock oscillators can give very good phase noise performance due to the inherent frequency stability of the quartz.

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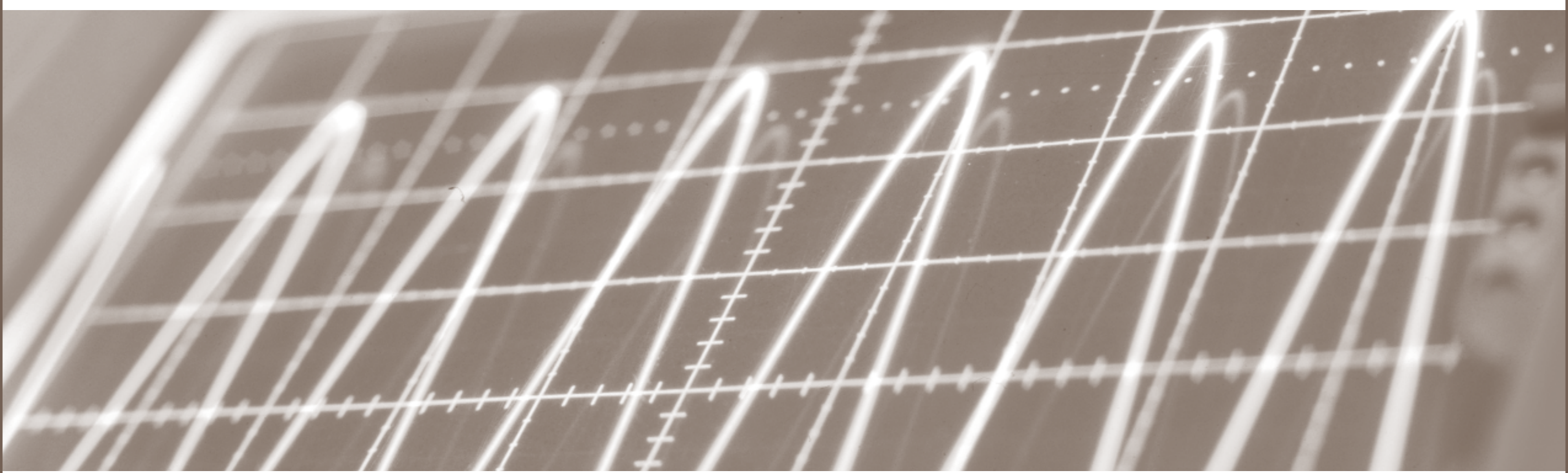

Precision quartz-based oscillators for the wireless, wired telephony, aerospace, military, satellite, and other communications markets.

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