Quantic Wenzel

Dynamic Phase Noise Calculator

Description and uses:
Quartz crystal oscillators change frequency slightly when accelerated. Crystals exhibit an acceleration sensitivity and, if the designer is careless, so will the circuitry.

The sensitivity to acceleration means that the random and periodic mechanical vibrations found in many equipment bays and instruments can induce significant phase noise in high-performance crystal oscillators.

Portable units are exposed to significant vibration in trucks, tanks, ships, helicopters, jets, and even back-packs. Stationary units may be near vibrating machinery or simply shaken by a nearby cooling fan.

Crystal holders, circuit boards, and cases can exhibit mechanical resonance giving the oscillator substantially increased sensitivity at particular frequencies of vibration, but careful design and crystal mount selection can move this resonance to high frequencies where mechanical damping is more effective.

This calculator application allows you to easily perform dynamic phase noise calculations, as well as see the performance of the oscillator when damping is added using vibration isolators.

This calculator can assist you in selecting the most useful of one of our world class Quantic Wenzel Devices!

See also: https://www.quanticwenzel.com/library/time-frequency-articles/vibration-induced-phase-noise/

Equations:

The calculator uses the following equations to perform the calculations.

For dynamic phase noise calculations:

$$L_{dynamic}(f) = L_{static}(f) + \left(\frac{\Gamma(10^3)T(f)\sqrt{ASD}(F_O)}{\sqrt{2}f}\right)$$

$L_{dynamic}(f)$	The Dynamic Phase Noise (dbc/Hz) at frequency f
$L_{static}(f)$	The Static Phase Noise (dbc/Hz) at frequency f
Γ	The g-sensitivity (ppb/g)
$T(f)$	The Transmissibility value at frequency f
ASD	Acceleration Spectral Density (g^2/hz)
F_O	Oscillator Frequency (MHz)
f	Frequency (Hz)

1: https://www.microwavejournal.com/articles/37979-improving-oscillator-dynamic-phase-noise-with-passive-vibration-isolation-and-accelerometer-based-vibration-compensation

For Transmissibility calculations:

$$T(f) = \sqrt{\frac{1 + (2\zeta\frac{f}{f_n})^2}{(1 - (\frac{f}{f_n})^2)^2 + (2\zeta\frac{f}{f_n})^2}}$$

$T(f)$	The transmissibility at frequency f
ζ	The damping factor
f_n	The Natural Frequency (Hz)
f	The frequency (Hz)

1: https://www.fabreeka.com/wp-content/uploads/2017/02/vibration-and-shock-isolation-theory.pdf

For RMS Phase Jitter:

$$\text{jitter}_{(\text{radians})} = \text{jitter}_{(\text{secs})} \cdot 2\pi F_O$$

$$\text{jitter}_{(\text{degrees})} = \text{jitter}_{(\text{radians})} \cdot \frac{180}{\pi}$$

$$\text{jitter}_{(\text{secs})} = \sqrt{\sum_{i=1}^{n-1} (\text{jitter}_{(\text{secs})}[i-1])^2}$$

$$\text{jitter}_{(\text{secs})}[i-1] = \sqrt{2 \cdot \text{jitter}_{\text{component}}} \cdot \frac{1}{2 \cdot \pi \cdot F_O}$$

If a = 1:

$$\text{jitter}_{\text{component}} = b \cdot \log\left(\frac{f[i]}{f[i-1]}\right)$$

If a != 1:

$$\text{jitter}_{\text{component}} = \frac{b}{1-a}\left(f[i]^{1-a} - f[i-1]^{1-a}\right)$$

$$b = f[i-1]^a \cdot 10^{(L(f[i-1])/10)}$$

$$a = \frac{L(f[i-1]) - L(f[i])}{10 \cdot (\ln(f[i]/f[i-1]))}$$

$L(f[i])$	The Phase Noise value (dbc/Hz) at the i-th frequency value
F_O	Oscillator Frequency (Hz)
$f[i]$	The i-th frequency value (Hz)

1: https://www.analog.com/media/en/training-seminars/tutorials/MT-008.pdf

For Allan Deviation/Variance: