Clock-source jitter: A clear understanding aids oscillator selection

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Continuous advances in high-speed communication and measurement systems require higher levels of performance from system equipment. One of the most important and least understood measures of clock performance is jitter. The International Frequency Synthesis Association (IFSA) presents this figure:

**Figure 1**

A plot of the equation for the noise floor of the system, in other words, the minimum level of jitter that the system can resolve at various jitter frequencies. The equation is:

\[ J(t) = \frac{2 \cdot \pi \cdot f \cdot J_0}{\ln(10)} \]

where:
- \( J(t) \) is the peak-to-peak jitter in pico-seconds (psec)
- \( f \) is the frequency in MHz
- \( J_0 \) is the noise floor of the system in nsec/√Hz

The graph shows a logarithmic relationship between frequency and jitter, with the noise floor increasing as the frequency increases. This is critical to understand the advantages and limitations of different jitter measurement techniques.

**Table 3—Application Jitter Performance Requirements**

<table>
<thead>
<tr>
<th>Application</th>
<th>Close-in Jitter</th>
<th>High-frequency Jitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound/MRI</td>
<td>0.01 psec</td>
<td>100 psec</td>
</tr>
<tr>
<td>Digital Transmission</td>
<td>0.1 psec</td>
<td>1000 psec</td>
</tr>
<tr>
<td>Transmission Systems</td>
<td>0.05 psec</td>
<td>500 psec</td>
</tr>
<tr>
<td>Low-Distortion Oscillators</td>
<td>0.02 psec</td>
<td>200 psec</td>
</tr>
</tbody>
</table>

**References**


**Discussion**

Jitter is a crucial parameter in the design and operation of high-speed systems. It is defined as the variation in time of a signal from its ideal value. There are two types of jitter: close-in and high-frequency.

- **Close-in Jitter** refers to jitter with a frequency content less than 10 kHz. It is typically measured as the peak-to-peak jitter.
- **High-frequency Jitter** refers to jitter with a frequency content greater than 10 kHz. It is typically measured as the root-mean-square (RMS) jitter.

Jitter can be quantitatively expressed in various ways, including:
- Peak-to-peak jitter (psec)
- RMS jitter (μsec)
- Phase noise level (dBc/Hz)
- Spectral density (dBHz)

The choice of measurement technique depends on the application and the system requirements.

**Examples**

- **Peak-to-peak Jitter**: Measured directly using an oscilloscope to display the waveform. The reading is typically given in psec.
- **RMS Jitter**: Calculated from the power spectral density (PSD) of the jitter using the following formula:
  \[ \text{RMS Jitter} = \sqrt{\frac{1}{T} \int_{-f}^{f} P(f) \, df} \]

where:
- \( T \) is the integration period
- \( P(f) \) is the PSD of the jitter

**Conclusion**

Jitter is a complex parameter that affects the performance of high-speed systems. Understanding and managing jitter is crucial for ensuring reliable and efficient system operation. Techniques such as phase-locked loops (PLLs), digital downconversion, and synchronization are commonly used to reduce jitter and improve system performance.
Author's biography

Joseph Adler is senior project engineer for R&D at Vectron International (Norwalk, CT), where he has worked for 11 years. His role focuses on developing innovative technologies and core competencies for sensor technology, testing, and propulsion systems. In his free time, Adler enjoys camping; fishing; and spending time with his wife, daughter, and son.