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What are the 8 Most Important Oscillator Specs?

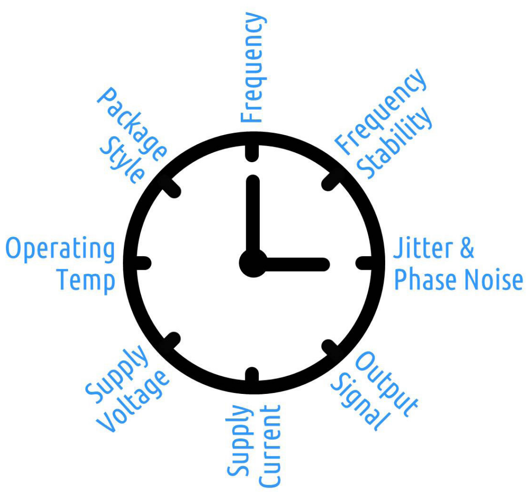
Choosing the right oscillator typically involves weighing multiple factors. Here are eight parameters that should be at the top of the list.

What's the first thing you think of when selecting electronic components? Chances are it's the processor or something else central to the system. The timing component may be the last thing on your mind, even though the clock provides the heartbeat that all signals in the system depend on.

Selecting these essential timing components may appear to be a straightforward process, but one must consider a number of factors that affect system performance. So, what are the most important specifications and considerations? Here's a short rundown of the top oscillator parameters and why they're important. Of course, there are more details to consider, so we've created an in-depth glossary that covers a broader range of oscillator characteristics (*Fig. 1*).

1. Frequency

The most basic parameter for any oscillator is the frequency, which is the repetition rate (cycle) of the signal output from the oscillator. Frequency is measured in hertz (Hz), i.e., cycles per second. SiTime's (www.sitime.com) oscillators are currently available in frequencies as low as 1 Hz for low-power devices and as high as 725 MHz. The frequency of SiTime's oscillators is programmable within this range to six decimals of accuracy.



1. Engineers should consider these eight parameters when selecting an oscillator.

Using custom frequencies can optimize system performance. Frequency can be factory-programmed by SiTime, programmed by key distributors, or programmed for lower volumes in the customer's lab using an oscillator programmer.

2. Frequency Stability

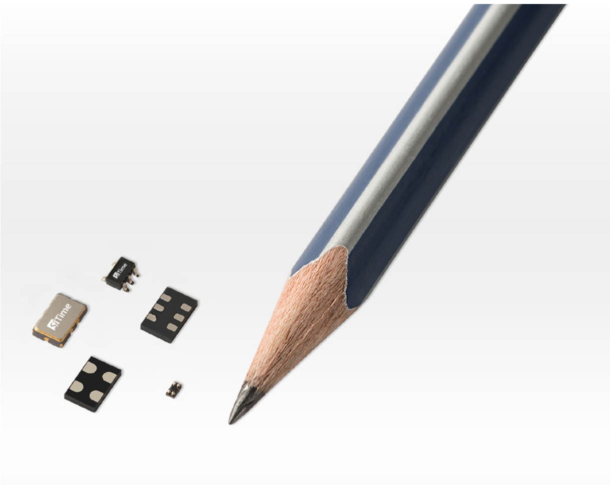
Frequency stability is a fundamental performance specification for oscillators. It's typically expressed in parts per million (ppm) or parts per billion (ppb) referenced to the nominal output frequency. It represents the deviation of output frequency from its ideal value due to external conditions. Therefore, a smaller stability number means better performance.

The definition of external conditions can vary for different oscillator categories, but it usually includes temperature variation and initial offset at 25°C. It may also include frequency aging over time, solder-down frequency shift, and electrical conditions like supply voltage variation and output load variation.

3. Jitter and Phase Noise

Phase noise and its time-domain counterpart, jitter, are often considered the most important characteristics of an oscillator after frequency stability. Phase noise and jitter have a direct impact on system performance, affecting such parameters as bit-error-ratio (BER) in serial data systems. Phase noise and jitter are two methods for quantifying noise on a clock signal. Phase noise measures clock noise in the frequency domain; jitter measures the noise impact on the clock in the time domain.

Because jitter and phase noise are the main contributors to system timing errors, it's critical to account for this clock noise when evaluating the total timing budget. This is not necessarily a simple matter. Not all oscillator manufacturers specify jitter in the same way. Jitter requirements vary by application, and there are various types of jitter and different integration ranges for integrated phase jitter measured in the frequency



2. Oscillators are available in a variety of package types.

domain.

To help sort this out, the SiTime glossary includes definitions for cycle-to-cycle (C2C) jitter, integrated phase jitter (IPJ), long-term jitter, period jitter, and phase noise. And the SiTime application note, "Clock Jitter Definitions and Measurement Methods," provides even more information. SiTime also offers an online *Phase Noise and Jitter Calculator* that generates phase-noise plots of families at specific frequencies. The integrated phase jitter (IPJ) can also be calculated for standard integration ranges as well as user-specified integration ranges.

4. Output Signal Format

Chipset vendors may specify the required output signal mode for timing chips, or the system designer may have some leeway. Output types fall into two categories: single-ended or differential. Single-ended oscillators are lower cost and easier to implement, but have limitations. They are somewhat sensitive to board noise and therefore are typically better suited for frequencies below 166 MHz.

Low-voltage CMOS (LVCMOS) is the most common single-ended output type that swings rail-to-rail. SiTime also offers NanoDrive output, which is similar to LVCMOS, but has programmable output swing down to 200 mV to match the input requirements of the downstream chip as well as minimize power consumption.

Differential signaling is a more expensive option, but it enables better performance and is preferred for higher-frequency applications. Since any noise common to both differential traces will be zeroed out, this mode is less sensitive to external noise and generates lower levels of jitter and EMI. The most commonly used differential signal types are LVPECL, LVDS, and HCSL.

5. Supply Voltage

Supply voltage, specified in volts (V), is the input power required to operate the oscillator. Supply voltage powers the oscillator through the VDD pin and hence is sometimes referred to as VDD. Standard voltages for single-ended oscillators include 1.8, 2.5, and 3.3 V. Voltages for modern differential oscillators typically range between 2.5 and 3.3 V.

SiTime offers oscillators that operate as low as 1.2 V for regulated supply applications such as coin-cell or supercap battery backup. The supply voltage of most of the company's oscillator families is programmable, which reduces the need for external components like level translators or voltage regulators.

6. Supply Current

Supply current is the maximum operating current of an oscillator. It's measured in microamps (µA) or milliamps (mA) at the maximum and sometimes nominal supply voltage. Typical supply current is measured without load.

7. Operating Temperature

The operating temperature range specifies the ambient temperature under which the device is expected to operate and meet the datasheet specifications. Common temperature ranges are:

- Commercial, Automotive Grade 4: 0 to +70°C
- Extended Commercial: −20 to +70°C
- Industrial, Automotive Grade 3: −40 to +85°C
- Extended Industrial, Automotive Grade 2: −40 to +105°C
- Automotive Grade 1: −40 to +125°C
- Military: −55 to 125°C
- Automotive Grade 0: −40 to 150°C

8. Packages

Oscillators are usually housed in metal, ceramic, or plastic packages. They come in a variety of industry-standard package dimensions. The pad (pin) arrangements may vary among vendors, but the overall x-y dimensions are standardized. Common oscillator package sizes for single-ended oscillators, which usually have four pins, include.

- 2016: 2.0 × 1.6 mm
- 2520: 2.5 × 2.0 mm
- 3225: 3.2 × 2.5 mm
- 5032: 5.0 × 3.2 mm
- 7050: 7.0 × 5.0 mm

Differential oscillators, which have six pins, are typically available in the larger 3225, 5032, and 7050 package sizes.

Some specialized oscillators, such as oven-controlled crystal oscillators (OCXOs), are housed in significantly larger packages. They often measure 25.4 × 25.4 mm and can range from 9.7 × 7.5 mm to 135 × 72 mm (*Fig. 2*).

In addition to these standard package sizes, SiTime offers a few unique packages to solve difficult design challenges. One is a tiny 1508 (1.5 × 0.8 mm) chip-scale package (CSP), which is the smallest oscillator package available. Another option is a leaded SOT23-5 package for applications that require higher board-level reliability and easier visual inspection during board assembly.

Other Parameters

The eight parameters listed are the most common specifications that designers inspect when selecting an oscillator. But depending on the application, it's possible that many other characteristics and features should be considered. These include EMI reduction features, pull range options for fine-tuning frequency, startup time, and quality/reliability (Q, DPPM, MTBF, FIT rate).

For high-performance applications, a number of additional stability-related specifications should be considered beyond basic frequency stability. These include aging, frequency versus temperature slope (ΔF/ΔT), thermal hysteresis, Allan deviation, Hadamard variance, holdover, and retrace.

To learn about these parameters and more, see the SiTime glossary—one of the most extensive oscillator definition guides available.

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