SiT1532 MEMS-based 32.768 kHz XO Frequency Stability

SiT1532 TempFlat™ MEMS technology and extremely low power CMOS analog circuit design provide a highly stable 32.768 kHz clock signal with <1µA of operating current.

The frequency stability of SiT1532 is specified in two key parameters: (1) Initial Stability and (2) Frequency Stability over Temperature.

Initial Stability is a room temperature specification of frequency offset in PPM (10^{-6}) with respect to nominal oscillation frequency 32.768 kHz. This includes solder-down shift and is measured over defined supply voltage range at room temperature.

Frequency Stability over Temperature specification in SiT1532 datasheets includes the frequency shift due to change in environmental temperature in addition to all the variable components accounted in the initial stability.

Figure 1 shows the frequency stability vs. temperature characteristic curves of SiT1532 MEMS-based 32.768 kHz oscillators. SiT1532 spec limits for industrial temperature (< 100 PPM p-p) are shown in blue dash lines. Typical spec limits of 32.768 kHz oscillators using Quartz-based, tuning fork type XTAL are also shown in red curves in Figure 1.

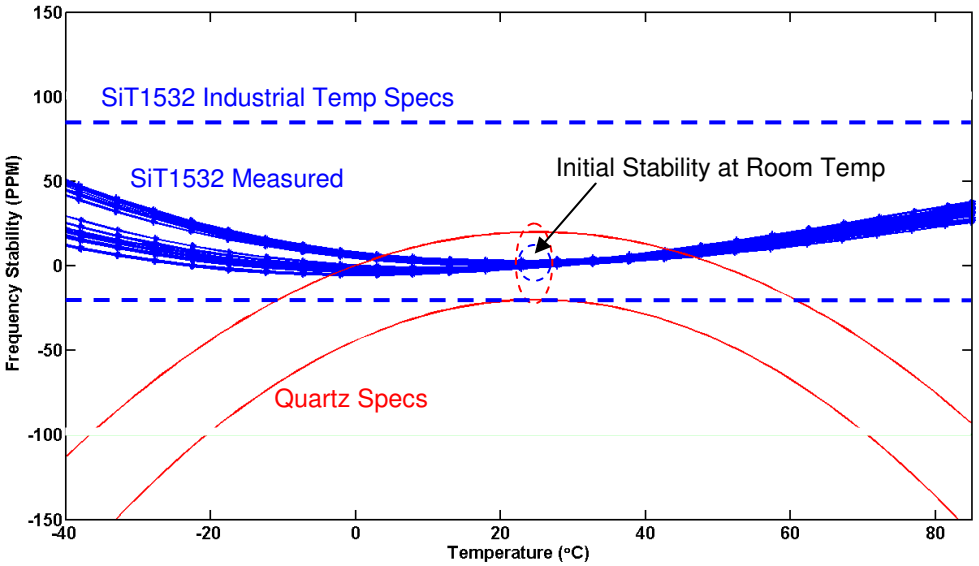

Figure 1: Frequency stability vs. temperature characteristic curves and spec limits for SiT1532 MEMS-based oscillators and Quartz-based, tuning fork type 32.768 kHz oscillators

The frequency stability of Quartz-based tuning fork type 32.768 kHz XTAL is generally specified in **Frequency Tolerance** at 25°C and two other parameters that define the parabolic behavior of its resonant frequency over temperature. The spec limits for actual frequency stability over temperature can then be calculated using the **Turning Point Temperature** and the second order **Temperature Coefficient** from vendor's datasheet.

Nominal frequency	32.768kHz
Operating temperature range	−40 to +85°C
Storage temperature range	−40 to +85°C
Level of drive	0.1μW (0.5μW Max.)
Frequency tolerance (25 ±3 °C)	±20 × 10^{-6}
Turning point	+25°C ± 5°C
Temperature coefficient	−0.04 × 10^{-6}/°C² Max.
Load capacitance	12.5pF
Equivalent series resistance	80kΩ Max.
Shunt capacitance	1.3pF typ./ 1.5pF Max.
Insulation resistance	500MΩ Min.

Table 1: Frequency stability specs of quartz-based 32.768 kHz XTAL

Table 1 shows an example of frequency stability specifications of standard 32.768 kHz quartz XTAL. With a Turning Point Temperature of 25°C and maximum Temperature Coefficient of -0.04 PPM/°C^2, the frequency stability over temperature calculated is ~ -169 PPM for -40 to 85 °C. Note that this frequency tolerance is only from the quartz XTAL. Variations due to drive level of oscillator sustaining circuit and matching capacitors on pc board are not included. Figure 2 is an example of frequency stability vs. temperature curve of another quartz-based tuning fork XTAL with similar specs.

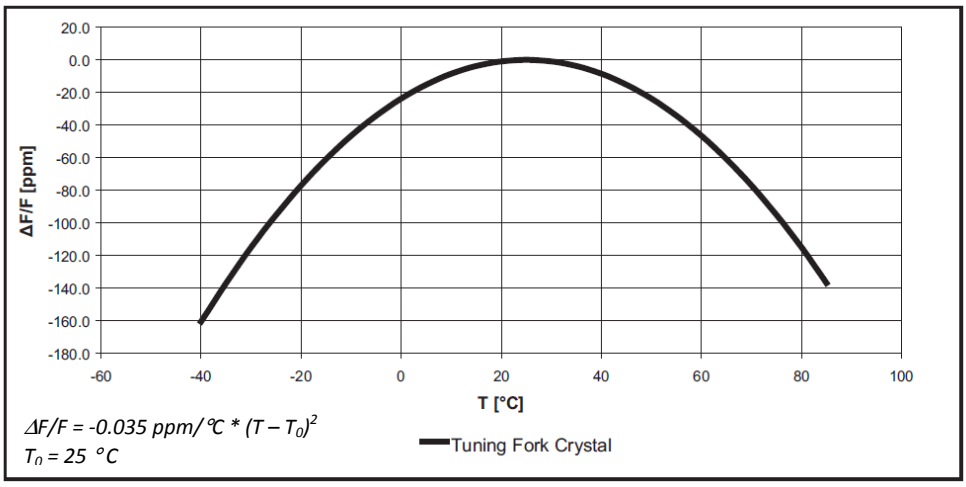

Figure 2: Example of frequency stability vs. temperature curve of a quartz-based-tuning fork 32.768 kHz XTAL

SiT1532 is factory calibrated (trimmed) to guarantee frequency stability to be less than 10 PPM at room temperature and less than 100 PPM over the full -40°C to +85°C temperature range. Table 2 highlights the frequency stability parameters of SiT1532 32.768 kHz oscillator. Unlike quartz crystals that have a classic tuning fork parabola temperature curve with a 25°C turnover point, the SiT1532 temperature coefficient is extremely flat across temperature. The device

maintains less than 100 PPM frequency stability over the full operating temperature range when the operating voltage is between 1.5 and 3.63V. When measuring the SiT15xx output frequency with a frequency counter, it is important to make sure the counter's gate time is >100ms.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Frequency and Stability						
Fixed Output Frequency	Fout		32.768		kHz	
Frequency Stability						
Frequency Stability [2]	F_stab			10	ppm	T_A = 25°C, post reflow, includes underfill, Vdd: 1.5V – 3.63V. Tested with Agilent 53132A freq. counter, gate time ≥ 100ms.
				75		T_A = -10°C to +70°C, Vdd: 1.5V – 3.63V. Stability includes initial, power supply, and temperature stability components.
				100		T_A = -40°C to +85°C, Vdd: 1.5V – 3.63V. Stability includes initial, power supply, and temperature stability components.
				250		T_A = -10°C to +70°C, Vdd: 1.2V – 1.5V. Stability includes initial, power supply, and temperature stability components.
25°C Aging		-3		3	ppm	1st Year

Table 2: Frequency stability specs of SiT1532 32.768 kHz oscillator

In conclusion, SiT1532 initial stability of 10 PPM represents a 2x improvement with respect to Quartz's 20 PPM. SiT1532 also achieves better overall frequency stability over temperature consuming <1µA of operating current and is available in industry leading, smallest oscillator package (1.55 x 0.85 mm CSP) in the world.

SiTime Corporation
990 Almanor Avenue
Sunnyvale, CA 94085
USA
Phone: 408-328-4400
http://www.sitime.com