SiT1566

1.2 mm^2 µPower, Low-Jitter, 3 & 5 ppm, 32.768 kHz Super-TCXO

Features

- 32.768 kHz ±3 and ±5 ppm all-inclusive frequency stability
- World's smallest TCXO Footprint: 1.2 mm^2
  - 1.5 x 0.8 mm CSP
  - No external bypass cap required
- Improved stability reduces system power with fewer network timekeeping updates
- Low integrated phase jitter (IPJ) suitable for multiplying up for portable audio: 2.5 ns_{RMS}
- Ultra-low power: 4.5 µA
- Operating supply voltage range: 1.62 V to 3.63 V
- Operating temperature ranges: -20°C to +70°C, -40°C to +85°C
- Pb-free, RoHS and REACH compliant

Applications

- Smart watches, health and wellness monitors
- Ultra-accurate RTC reference clock
- Smart utility meters, E-meters
- Internet-of-Things (IoT) with BLE

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TempFlat MEMS™

Electrical Specifications

Conditions: Min/Max limits are over temperature, Vdd = 1.8V ±10%, unless otherwise stated. Typicals are at 25°C and Vdd = 1.8V.

Table 1. Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Frequency and Stability						
Output Frequency	Fout		32.768		kHz	
Total Frequency Stability[1]	F_stab	-3		3	ppm	All inclusive, 1.62V to 3.63V
		-5		5		
Allan Deviation	AD		1e-8	4e-8		1 second averaging time
First Year Frequency Aging	F_aging		±1		ppm	T_A = 25°C, Vdd = 1.8V
Jitter and Frequency Response Performance						
Integrated Phase Jitter	IPJ		1.8	2.5	ns_{RMS}	Integration bandwidth = 100 Hz to 16.384 kHz. Inclusive of 50 mV peak-to-peak sinusoidal noise on Vdd. Noise frequency 100 Hz to 20 MHz.
RMS Period Jitter	PJ_{RMS}		2.5	4	ns_{RMS}	10,000 samples, per JEDEC standard 65B
Peak-to-Peak Period Jitter	PJ_{p-p}		20	35	ns_{p-p}	
Dynamic Temperature Frequency Response		-0.5		+0.5	ppm/sec	Under temp ramp up to 1.5°C/sec
Supply Voltage and Current Consumption						
Operating Supply Voltage	Vdd	1.62	1.8	1.98	V	
		1.62		3.63		
Supply Current	Idd		4.5	5.3	µA	No load
Start-up Time at Power-up	t_start			300	ms	Measured when supply reaches 90% of final Vdd to the first output pulse.
Operating Temperature Range						
Operating Temperature Range	Op_Temp	-20		70	°C	"C" ordering code
		-40		85	°C	"I" ordering code
LVCMOS Output						
Output Rise/Fall Time	tr, tf		9	20	ns	10 – 90% Vdd, 15pF load
Output Clock Duty Cycle	DC	45		55	%	
Output Voltage High	VOH	90%			Vdd	I_{OH} = -50 µA, 15 pF load
Output Voltage Low	VOL			10%	Vdd	I_{OL} = 50 µA, 15 pF load

Note:

1. Relative to 32.768 kHz, includes initial tolerance, over temp stability, Vdd, 20% load variation, hysteresis, board-level underfill (5 ppm only), 2x reflow. Tested with Agilent 53132A frequency counter. Measured with 100 ms gate time for accurate frequency measurement.

Table 2. Pin Configuration

Pin	Symbol	I/O	Functionality
1	NC	Internal Test	Leave Floating. Do not connect to GND.
2	CLK Out	OUT	Oscillator clock output. LVCMOS compatible logic.
3	Vdd	Power Supply	1.8V ±10% power supply. Under normal operating conditions, Vdd does not require external bypass/decoupling capacitor(s). SiT1566 includes on-chip filtering capacitors. Under extreme noise on the supply, a 10-100 nF low ESR ceramic bypass capacitor may be recommended close to the Vdd pin.
4	GND	Power Supply Ground	Connect to ground.

CSP Package (Top View)

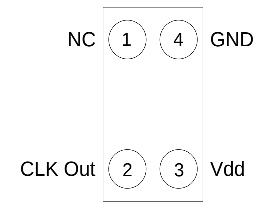


Figure 1. Pin Assignment

Table 3. Absolute Maximum Ratings

Attempted operation outside the absolute maximum ratings may cause permanent damage to the part.
Actual performance of the IC is only guaranteed within the operational specifications, not at absolute maximum ratings.

Parameters	Test Conditions	Value	Unit
Continuous Power Supply Voltage Range (Vdd)		-0.5 to 4.0	V
Continuous Maximum Operating Temperature Range		105	°C
Short Duration Maximum Operating Temperature Range	≤ 30 minutes	125	°C
Human Body Model (HBM) ESD Protection	JESD22-A114	2000	V
Charge-Device Model (CDM) ESD Protection	JESD22-C101	750	V
Machine Model (MM) ESD Protection	T_A = 25°C	200	V
Latch-up Tolerance	JESD78 Compliant		
Mechanical Shock Resistance	Mil 883, Method 2002	20,000	*g*
Mechanical Vibration Resistance	Mil 883, Method 2007	70	*g*
1508 CSP Junction Temperature		150	°C
Storage Temperature		-65 to 150	°C

System Block Diagram

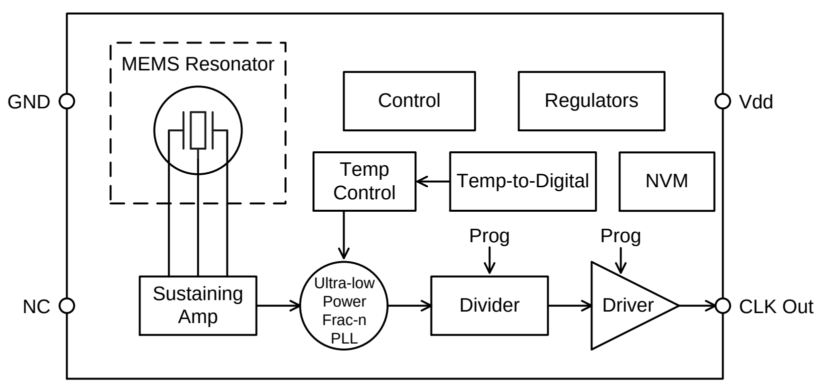


Figure 2. SiT1566 Block Diagram

Description

SiT1566 is an ultra-small, micro-power 32.768 kHz TCXO optimized for battery-powered applications. SiTime's silicon MEMS technology enables the first 32 kHz TCXO in the world's smallest footprint and chip-scale packaging (CSP). Typical supply current is 4.5 µA under no load condition.

SiTime's MEMS oscillator consists of a MEMS resonator and a programmable analog circuit. SiT1566 MEMS resonator is built with SiTime's unique MEMS First™ process. A key manufacturing step is EpiSeal™ during which the MEMS resonator is annealed with temperatures over 1000°C. EpiSeal creates an extremely strong, clean, vacuum chamber that encapsulates the MEMS resonator and ensures the best performance and reliability. During EpiSeal, a poly silicon cap is grown on top of the resonator cavity, which eliminates the need for additional cap wafers or other exotic packaging. As a result, SiTime's MEMS resonator die can be used like any other semiconductor die. One unique result of SiTime's MEMS First and EpiSeal manufacturing processes is the capability to integrate SiTime's MEMS die with a SOC, ASIC, microprocessor or analog die within a package to eliminate external timing components and provide a highly integrated, smaller, cheaper solution to the customer.

TCXO Frequency Stability

SiT1566 is factory calibrated (trimmed) over multiple temperature points to guarantee extremely tight stability over temperature. Unlike quartz crystals that have a classic tuning fork parabola temperature curve with a 25°C turnover point with a 0.04 ppm/C^2 temperature coefficient, the SiT1566 temperature coefficient is calibrated and corrected over temperature with an active temperature correction circuit. The result is a 32 kHz TCXO with extremely tight frequency variation over the -40°C to +85°C temperature range.

When measuring the output frequency of SiT1566 with a frequency counter, it is important to make sure the counter's gate time is >100 ms. Shorter gate times may lead to inaccurate measurements.

Dynamic Temperature Frequency Response

Dynamic Temperature Frequency Response is the rate of frequency change during temperature ramps. This is an important performance metric when the oscillator is mounted near a high power component (e.g. SoC or power management) that may rapidly change the temperature of surrounding components.

For moderate temperature ramp rates (<2°C/sec), the dynamic response is primarily determined by the steady-state frequency vs. temperature of the device. The best dynamic response is obtained from parts which have been trimmed to be flat in frequency over temperature.

For high temperature ramp rates (>5°C/sec), the latency in the temperature compensation loop contributes a larger frequency error, which is dependent on the temperature compensation update rate. This part achieves excellent performance at the default 3 Hz refresh update rate. This device family supports faster update rates for further reducing dynamic frequency error at the expense of slightly increased current consumption. Other compensation refresh rate options include 6 Hz, 12 Hz, and 24 Hz. Contact SiTime for other options.

Typical Operating Curves

(T_A = 25°C, Vdd = 1.8V, unless otherwise stated)

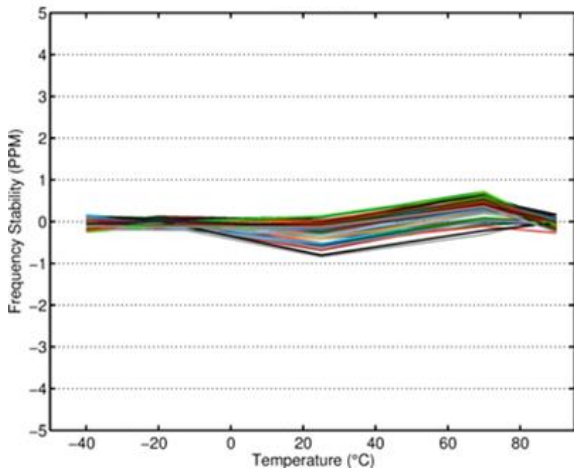


Figure 3. Frequency Stability over Temperature

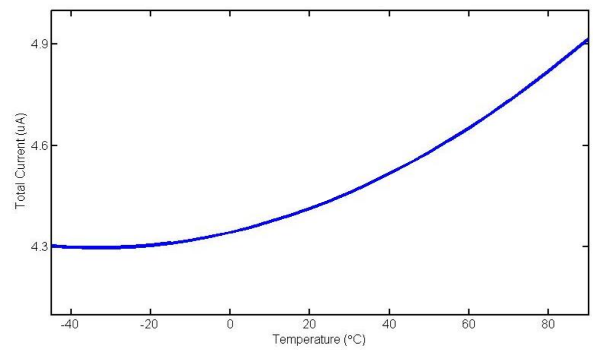


Figure 4. Supply Current over Temperature (No Load)

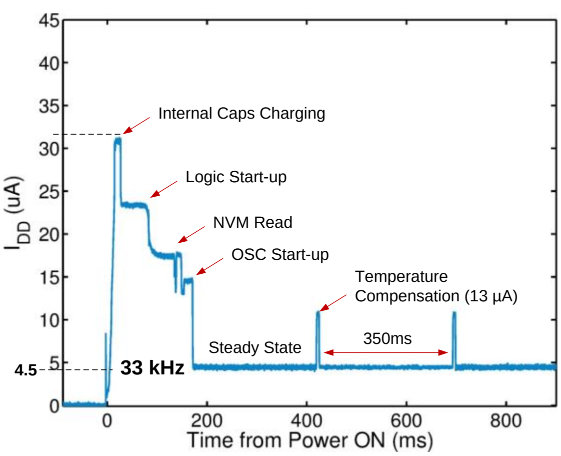


Figure 5. Start-up and Steady-State Current Profile

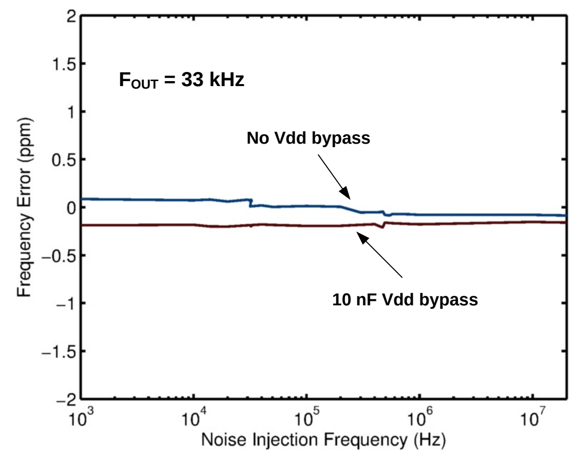
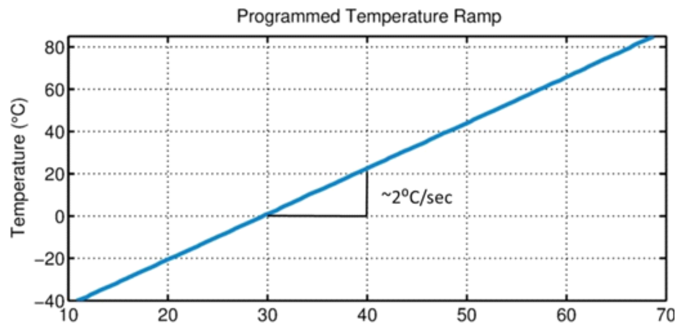
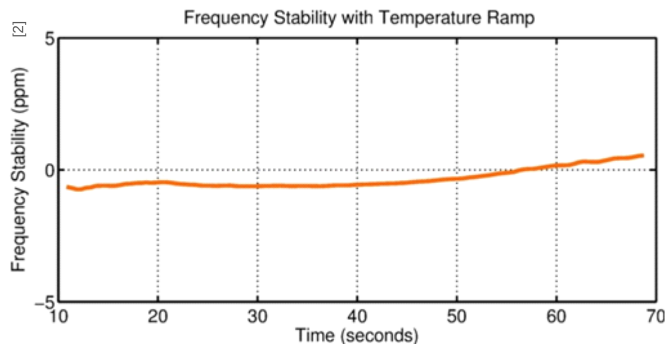


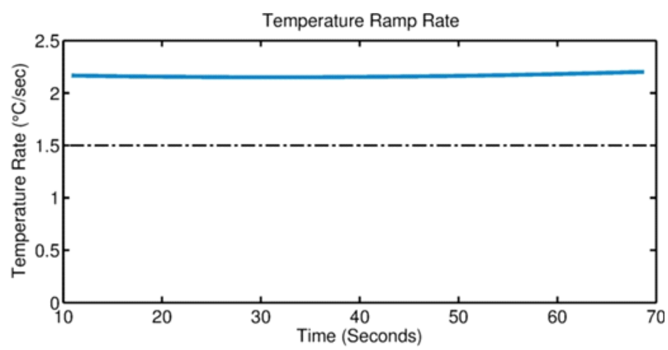
Figure 6. Power Supply Noise Rejection (PSNR)

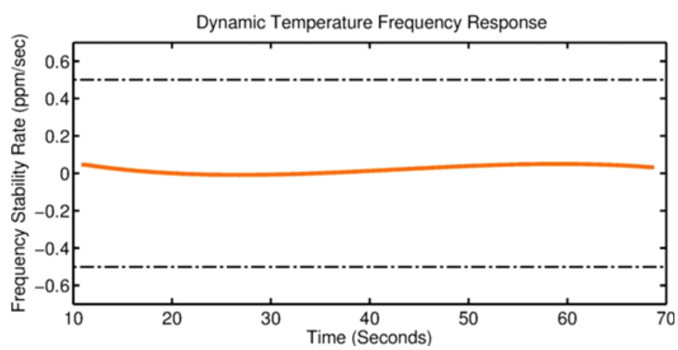
Figure 7. LVCMOS Output Sing

Dynamic Frequency Response for Moderate Temperature Ramps







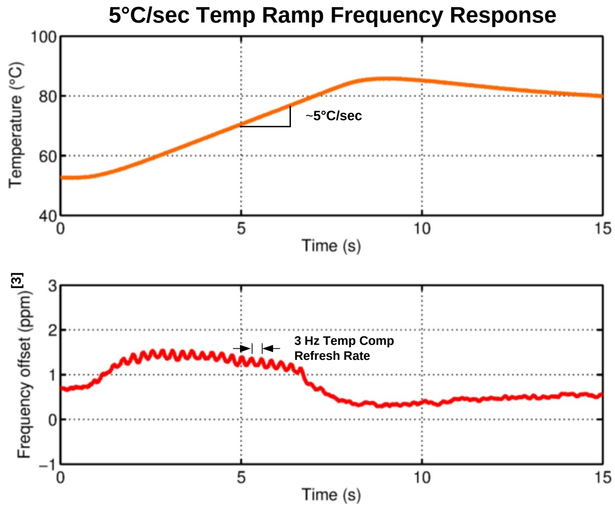


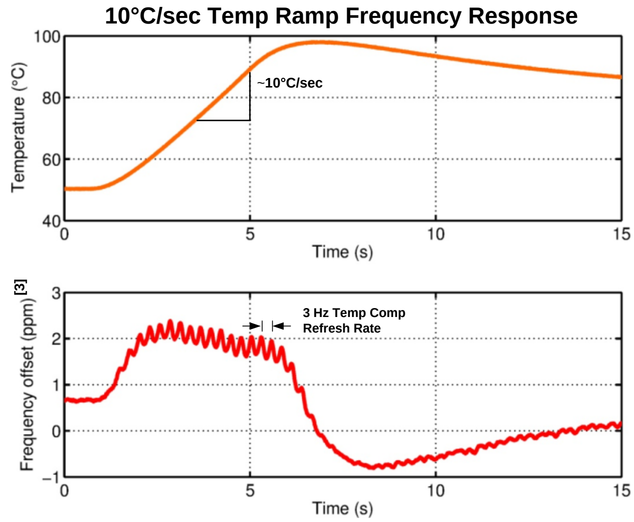
Note:

2. Measured relative to 32.768 kHz.

Frequency accuracy under a moderate temperature ramp up to 2°C/sec is limited by the TCXO's trimmed accuracy of the frequency stability over-temperature.

Dynamic Frequency Response for Fast Temperature Ramps





Note:

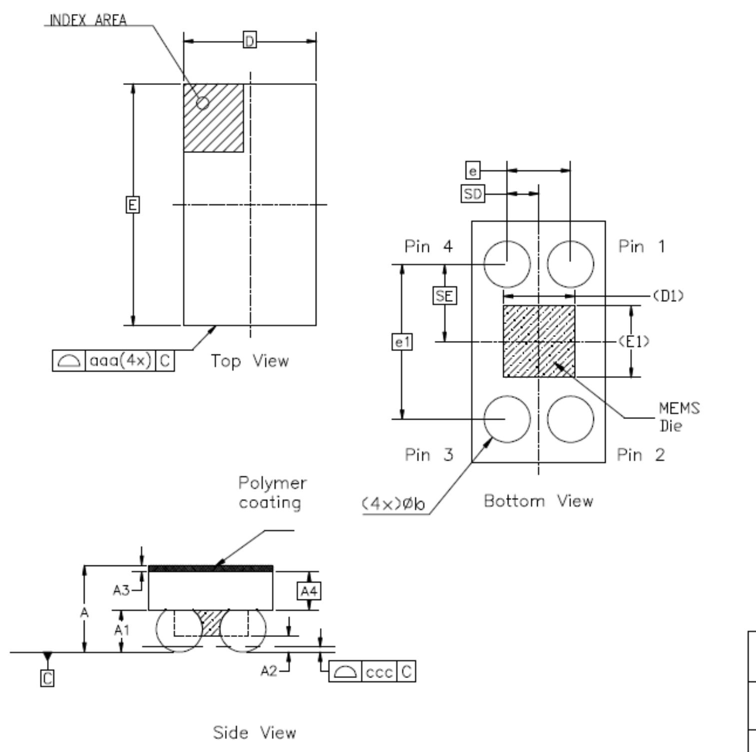
3. Measured relative to 32.768 kHz.

For temperature ramps >5°C/sec, the frequency accuracy is limited by the update rate of the temperature compensation path (see the 5°C/sec and 10°C/sec plots above).

Contact SiTime for applications that require improved dynamic performance.

Dimensions and Patterns

Package Size – Dimensions (Unit: mm)



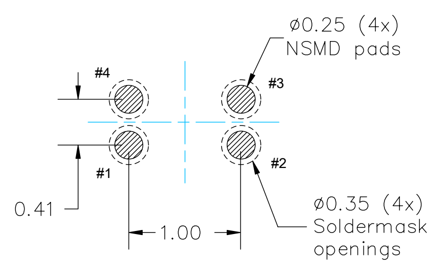
Dimension Table (mm)					
Item		SYMBOL	MINIMUM	NOMINAL	MAXIMUM
Total Thickness		A	0.48	0.54	0.60
Stand Off		A1	0.22		0.28
MEMS Clearance		A2	0.027		0.113
Film Thickness		A3	0.036	0.040	0.044
Wafer Thickness		A4	0.225	0.250	0.275
Ball Diameter		b	0.30	0.315	0.33
Ball Pitch	X	e		0.41 BSC	
	Y	e1		1.00 BSC	
MEMS	X	D1		0.46 REF	
	Y	E1		0.46 REF	
Body Size	X	D		0.84 BSC	
	Y	E		1.54 BSC	
Ball To Center	X	SD		0.205 BSC	
	Y	SE		0.500 BSC	
Package Edge Tolerance		aaa		0.040	
Coplanarity		ccc		0.075	

4 LD – 1.5 x 0.8 x 0.55 mm

Package Outline

POD-35 Rev A

Recommended Land Pattern (Unit: mm)



(soldermask openings shown with dashed line around NSMD pad)

Recommended 4-mil (0.1mm) stencil thickness

Manufacturing Guidelines

1. No Ultrasonic or Megasonic cleaning: Do not subject SiT1566 to an ultrasonic or megasonic cleaning environment. Permanent damage or long term reliability issues may occur.
2. Applying board-level underfill and overmold is acceptable and will not impact the reliability of the device.
3. Reflow profile, per JESD22-A113D.
4. The SiT1566 CSP includes a protective, opaque polymer top-coat. If the SiT1566 will see intense light, especially in the 1.0-1.2µm IR spectrum, we recommend a protective "glob-top" epoxy or other cover to keep the light from negatively impacting the frequency stability.
5. For additional manufacturing guidelines and marking/tape-reel instructions, refer to SiTime Manufacturing Notes.

Ordering Information

SiT1566AI-JE-18E-32.768S

Part Family
"SiT1566"

Revision Letter
"A": is the revision

Temperature Range
"C": Extended Commercial, -20 to 70ºC
"I": Industrial, -40 to 85ºC

Package Size
"J": 1.5 mm x 0.8 mm CSP

All-Inclusive Over Temp Stability
"V": ±3 ppm
"E": ±5 ppm

Packaging
"S": 8 mm Tape & Reel, 10ku reel
"D": 8 mm Tape & Reel, 3ku reel
"E": 8 mm Tape & Reel, 1ku reel

Samples in cut Tape

Output Clock Frequency (kHz)
32.768 kHz

Supply Voltage
XX = 1.8V – 3.3V
1.8V = 18
2.0V = 20
2.5V = 25
3.0V = 30
3.3V = 33

Table 4. Revision History

Version	Release Date	Change Summary
0.1	06/30/2015	Advanced datasheet initial release
0.7	03/11/2016	Preliminary datasheet initial release
1.0	03/15/2018	Production Datasheet Release, added ±3ppm option Updated logo and company address, other page layout changes
1.01	01/16/2019	Updated the frequency stability specification in Table 1, Electrical Characteristics, to be valid for 1.62V to 3.63V.

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