SiT1576

1.2mm^2 µPower, Low-Jitter, 1Hz – 2.5 MHz Super-TCXO

Features

- 1 Hz to 2.5 MHz ±5 ppm all-inclusive frequency stability
- Factory programmable output frequency
- 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
- Ultra-low power: 6 µA (100 kHz)
- 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

- Health and wellness monitors
- Smart pens
- ULP input devices
- Proprietary wireless
- Sensor interface

TempFlat MEMS™

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Electrical Specifications

Table 1. Electrical Characteristics

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

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Frequency and Stability						
Output Frequency	F_{OUT}	1		2.5 M	Hz	
Total Frequency Stability[1]	F_stab	-5		5	ppm	All inclusive, Stability code: E
		-20		20	ppm	All inclusive, Stability code: 1
Allan Deviation	AD		1e-8	4e-8		1 second averaging time
First Year Frequency Aging	F_aging		±1		ppm	T_A = 25°C, V_{DD} = 1.8V
Jitter Performance						
Integrated Phase Jitter	IPJ		2	3.5	ns_{RMS}	F_{OUT} > 1 kHz, Integration bandwidth = 100 Hz to F_{OUT} /2. Inclusive of 50 mV peak-to-peak sinusoidal noise on V_{DD}. Noise frequency 100 Hz to 20 MHz
Period Jitter	PJ		2.2	4.5	ns_{RMS}	Cycles = 10,000, f = 100kHz. Per JEDEC standard 65B, tested at 100kHz. See performance plot for other frequencies.
Peak-to-Peak Period Jitter	PJ_{p-p}		20	35	ns_{p-p}	
Supply Voltage and Current Consumption						
Operating Supply Voltage	V_{DD}	1.62		3.63	V	
No Load Supply Current	I_{DD}		3.65	5	µA	F_{OUT} = 1 Hz
			4.5	5.5		F_{OUT} = 33 kHz
			6	7		F_{OUT} = 100 kHz
			13	16		F_{OUT} = 1 MHz
			33	40		F_{OUT} = 2 MHz
Start-up Time at Power-up	t_start		150	300	ms	F_{OUT} > 200 Hz. Measured when supply reaches 90% of final V_{DD} to the first output pulse and within specified min/max frequency limit.
			300 + 2.0 cycles	300 + 2.5 cycles		10 Hz < F_{OUT} ≤ 200 Hz. Measured when supply reaches 90% of final V_{DD} to the first output pulse and within specified min/max frequency limit.
				500 + 2.5 Cycles		1 Hz ≤ F_{OUT} ≤ 10 Hz. Measured when supply reaches 90% of final V_{DD} to the first output pulse and within specified min/max frequency limit.
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	t_R, t_F		9	20	ns	20-80%, 15 pF load, V_{DD} = 1.8V +/-10%
Output Clock Duty Cycle	DC	45		55	%	
Output Voltage High	VOH	90%			V_{DD}	I_{OH} = -50 µA, 15 pF load
Output Voltage Low	VOL			10%	V_{DD}	I_{OL} = 50 µA, 15 pF load

Note:

1. Includes initial tolerance, over temp stability, 2x reflow, V_{DD} range, board-level under fill, and 20% load variation. 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	No Connect. Leave floating. Pin 1 is for internal testing and is designed to be left floating.
2	CLK Out	OUT	Oscillator clock output.
3	Vdd	Power Supply	Operates from nominal supply voltages between 1.8V and 3.3V. Under normal operating conditions, Vdd does not require external bypass/decoupling capacitor(s). SiT1576 includes on-chip Vdd filtering.
4	GND	Power Supply Ground	Connect to ground.

Top View

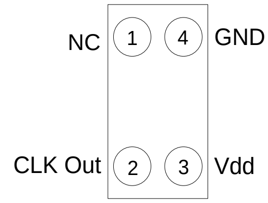


Figure 1. Pin Assignment

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	JESD22-A115	300	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

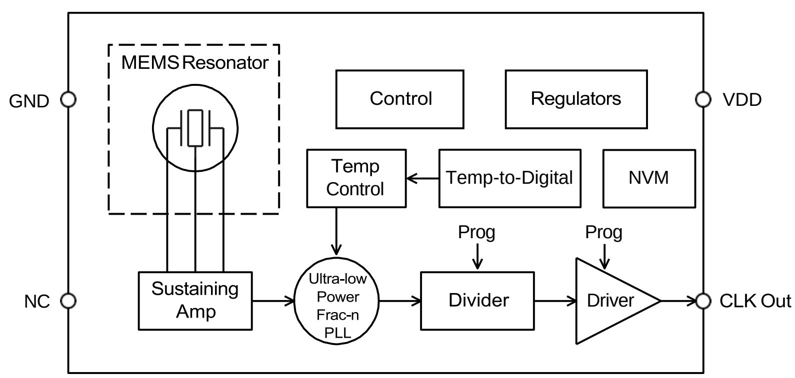


Figure 2. SiT1576 Block Diagram

Description

SiT1576 is an ultra-small and ultra-low power Factory programmable TCXO with an output frequency range between 1 Hz to 2.5 MHz. SiTime's silicon MEMS technology enables the first 1 Hz – 2.5 MHz TCXO in the world's smallest footprint and chip-scale packaging (CSP). Typical supply current is only 6 µA (100 kHz).

SiTime's MEMS oscillator consists of a MEMS resonator and a programmable analog circuit. SiT1576 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

SiT1576 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 to 0.06 ppm/°C^2 temperature coefficient, the SiT1576 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 SiT1576 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 Similarly, the gate time will need to increase for frequencies in the 1Hz to 500Hz frequency range.

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 3 Hz update rate. This device family supports faster update rates for further reducing dynamic frequency error at the expense of slightly increased current consumption.

Typical Operating Curves

(T_A = 25°C, Vdd = 1.8V, supply current plots are no load, unless otherwise stated)

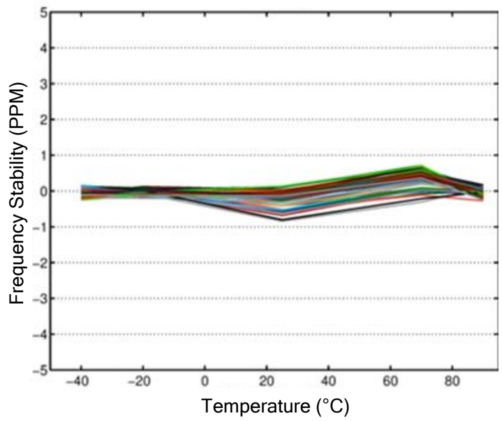


Figure 3. Frequency Stability over Temperature

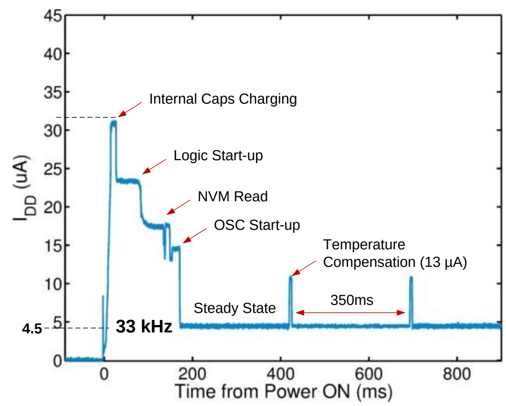


Figure 4. Start-up and Steady-State Current Profile

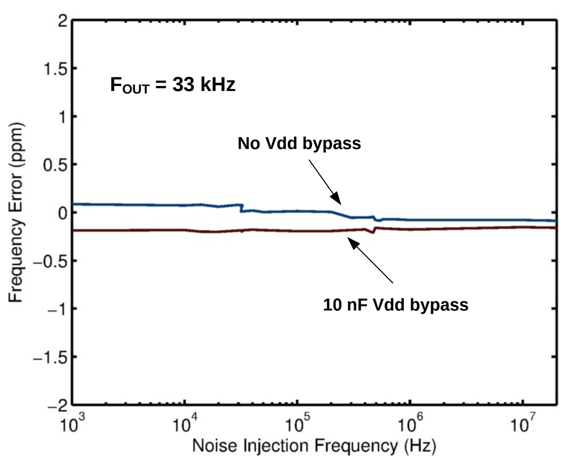


Figure 5. Power Supply Noise Rejection

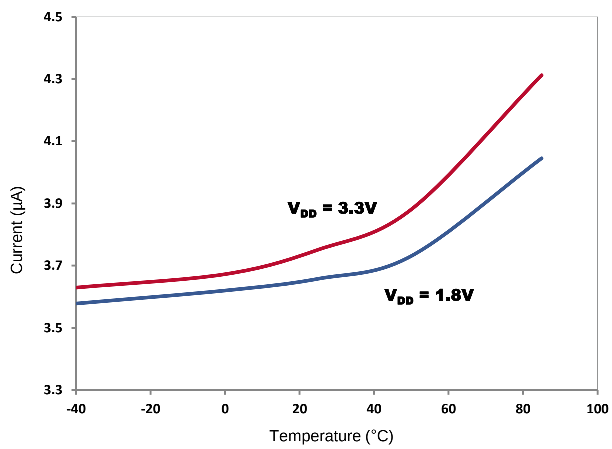


Figure 6. Supply Current vs Temperature (F_{OUT} = 1 Hz)

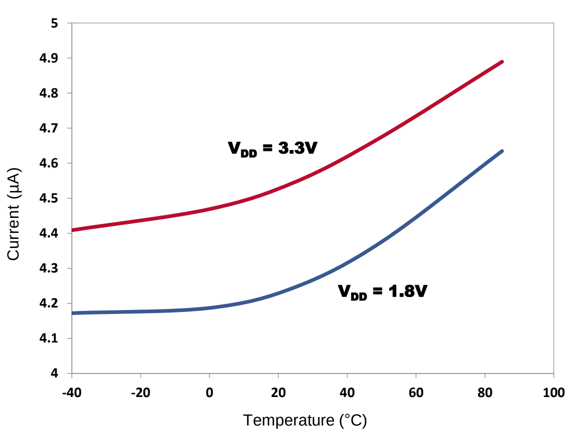


Figure 7. Supply Current vs Temperature (F_{OUT} = 100 Hz)

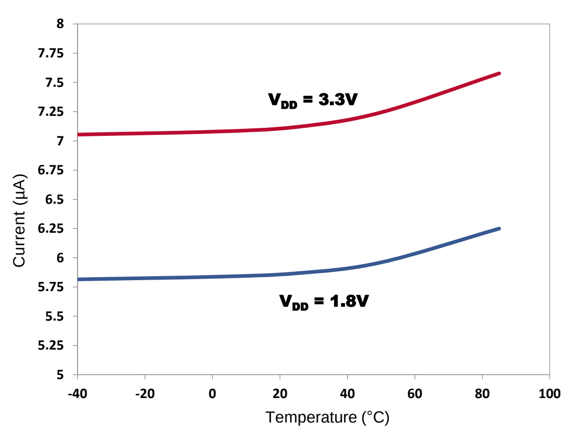


Figure 8. Supply Current vs Temperature (F_{OUT} = 100 kHz)

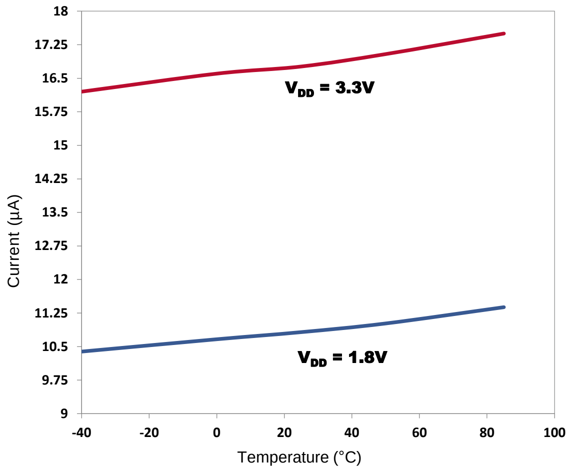


Figure 9. Supply Current vs Temperature (F_{OUT} = 500 kHz)

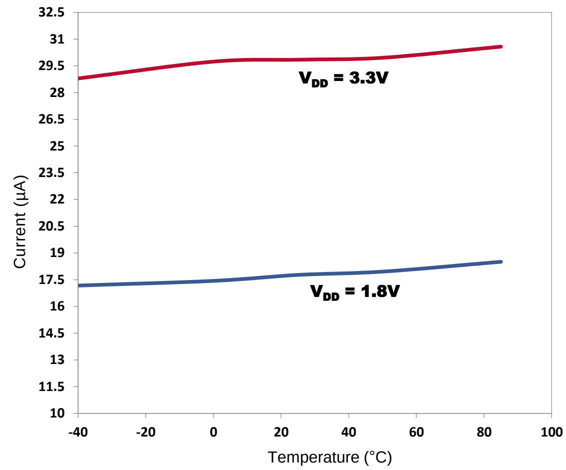


Figure 10. Supply Current vs Temperature (F_{OUT} = 1 MHz)

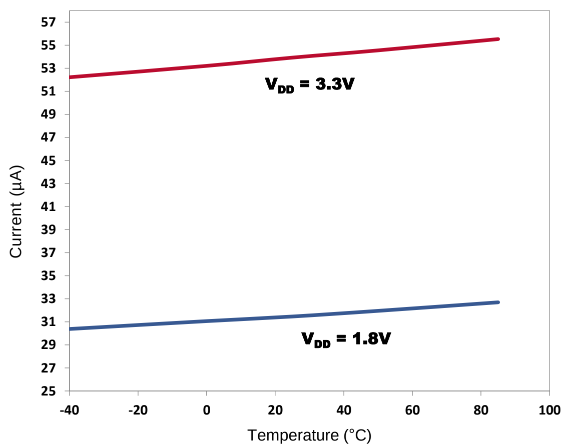


Figure 11. Supply Current vs Temperature (F_{OUT} = 1.85 MHz)

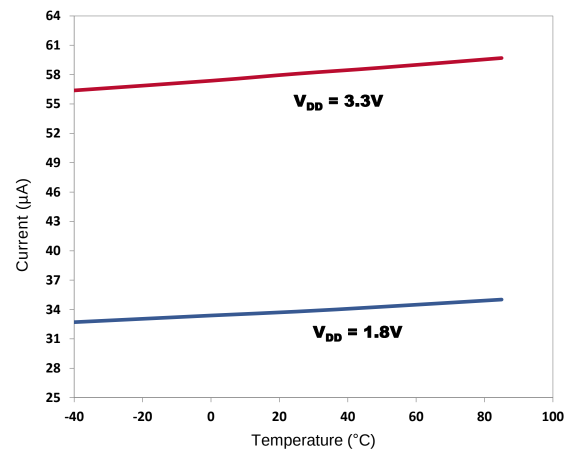
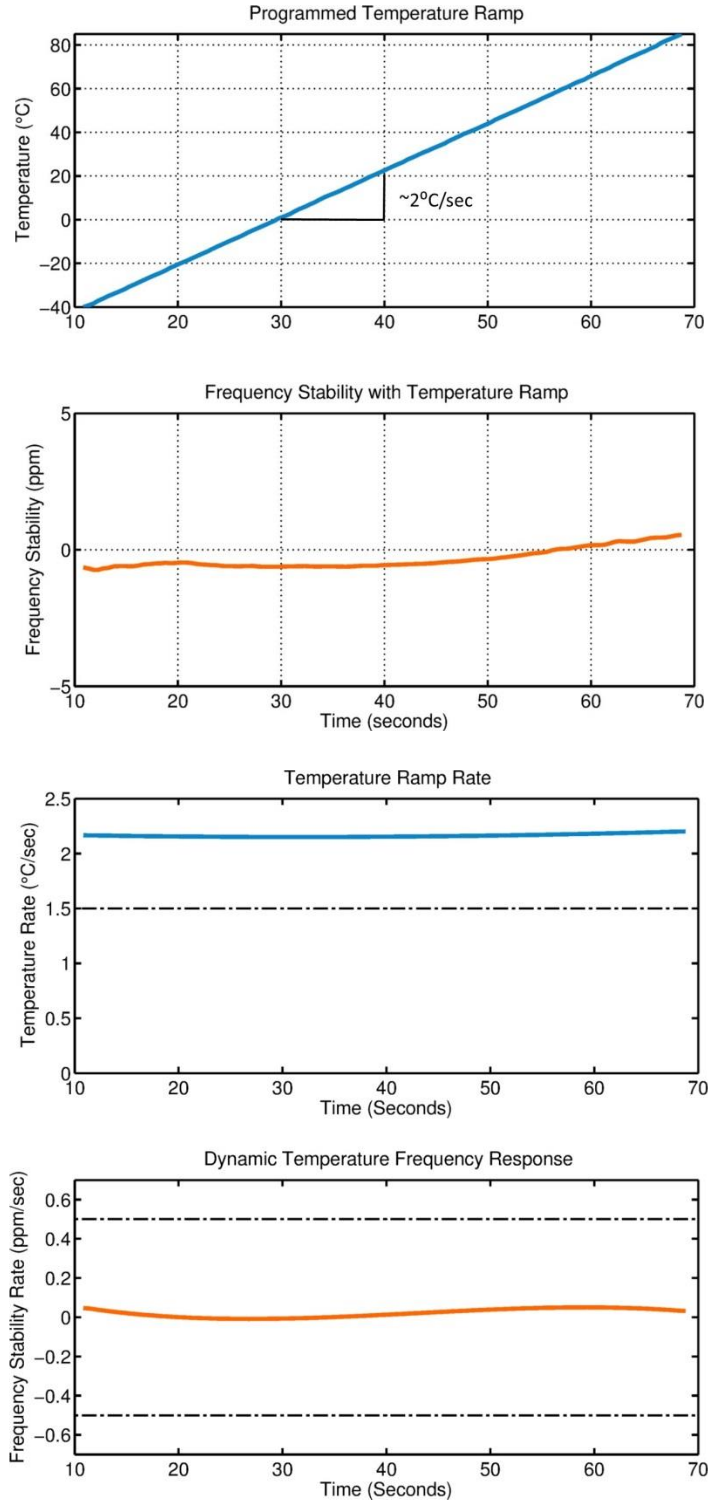


Figure 12. Supply Current vs Temperature (F_{OUT} = 2 MHz)

Dynamic Frequency Response for Moderate Temperature Ramps

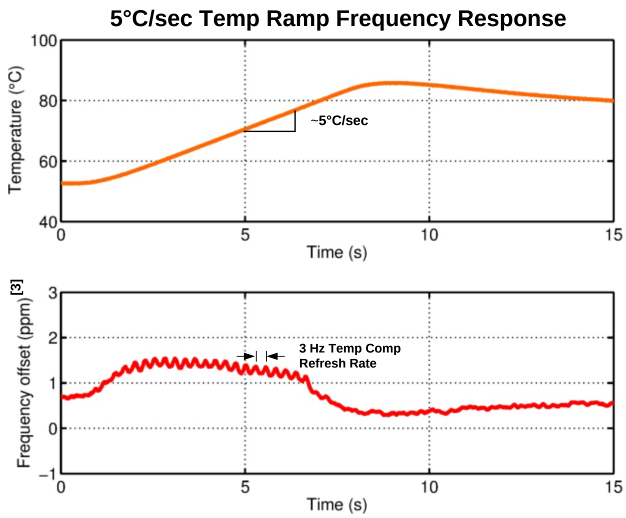


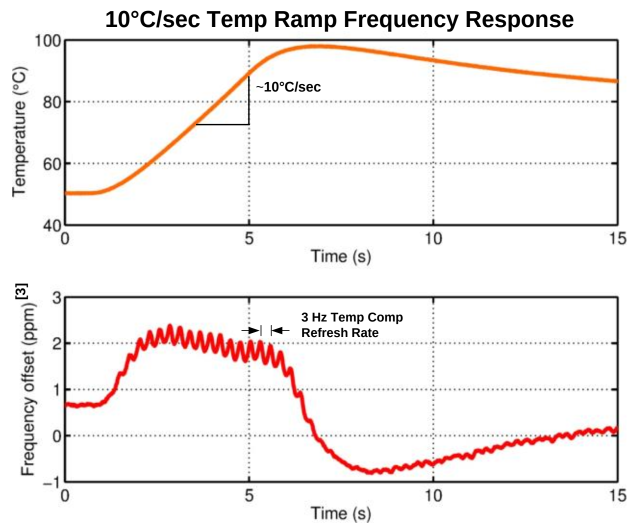
Frequency accuracy under a moderate temperature ramp up to 2°C/sec is limited by the TCXO's trimmed accuracy of the frequency stability over-temperature.

Note:

2. Measured relative to 32.768 kHz.

Dynamic Frequency Response for Fast Temperature Ramps





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).

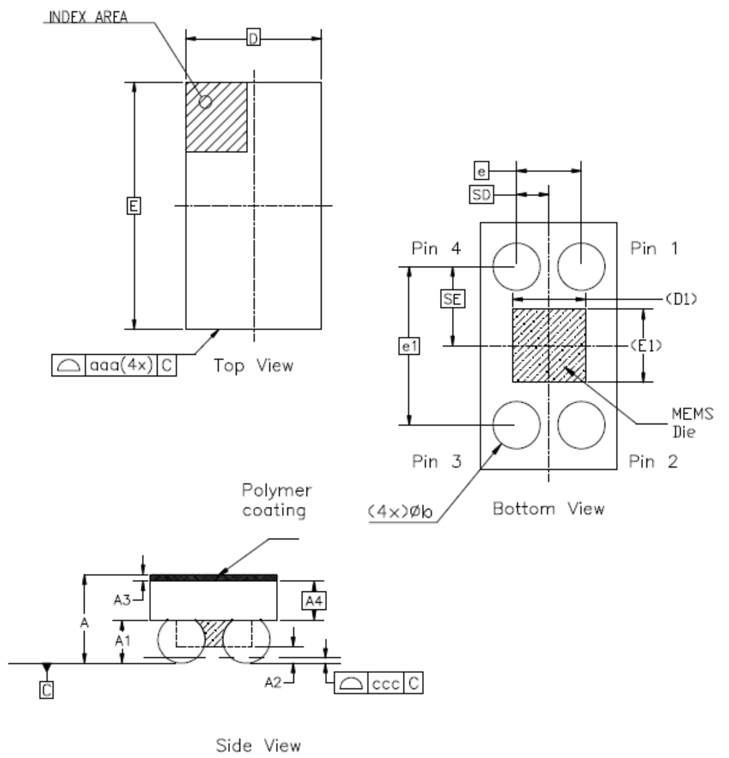
Contact SiTime for applications that require improved dynamic performance.

Note:

3. Referenced to 32.768 kHz.

Dimensions and Patterns

Package Size – Dimensions (Unit: mm)



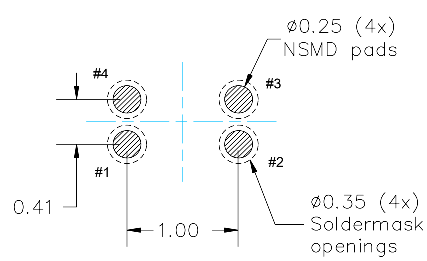
Dimension Table (mm)					
Item		SYMBOL	MINIMUM	NOMINAL	MAXIMUM
Total Thickness		A	0.48	0.54	0.60
Stand Off		A1	0.22		0.28
MEMS Clearance		A2	0.027		0.113
Film Thickness		A3	0.036	0.040	0.044
Wafer Thickness		A4	0.225	0.250	0.275
Ball Diameter		b	0.30	0.315	0.33
Ball Pitch	X	e	0.41 BSC		
	Y	e1	1.00 BSC		
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 SiT1576 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 SiT1576 CSP includes a protective, opaque polymer top-coat. If the SiT1576 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

SiT1576AI-JE-XXE-XXXX.XXXXXXQ

Part Family
"SiT1576"

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
"E": ±5 ppm
"1": ±20 ppm

Packaging
"S": 8 mm Tape & Reel, 10ku reel
"Q": 8 mm Tape & Reel, 5ku reel
"E": 8 mm Tape & Reel, 1ku reel

Samples in cut Tape

Output Frequency
Continuous frequency options from 1Hz to 2.5 MHz

Enter your desired frequency as shown below:

2500.000000 = 2.5 MHz
1850.000000 = 1.85 MHz
0512.288000 = 512.288 kHz
0010.000000 = 10.0 kHz
0004.096000 = 4.0960 kHz
0000.100256 = 100.256 Hz
0000.010000 = 10.0 Hz
0000.001000 = 1.0 Hz
0000.001100 = 1.10 Hz
0000.005123 = 5.123 Hz

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
0.25	01/13/2016	Initial Release of Advanced datasheet
0.5	03/10/2016	Preliminary datasheet initial release
0.9	02/15/2017	Updated Package Outline Drawing (POD) Updated part number ordering information Updated max programmable frequency Updated logo and company address, other page layout changes
1.0	05/09/2017	Final Release Updated supply current vs frequency Updated start-up time
1.1	06/12/2017	Updated max operating frequency to 2.0 MHz
1.2	08/03/2017	Added additional typical operating curves Updated typical No Load Supply Current (Table 1)
1.3	03/15/2018	Updated max operating frequency from 2.0MHz to 2.5MHz

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