SiT1552 Preliminary

Ultra-Low Power, Ultra-Small 32.768 kHz MEMS TCXO

The Smart Timing Choice™

Features

- 32.768 kHz ±5, ±10, ±20 ppm frequency stability options over temp
- Operating temperature ranges:
  - 0°C to +70°C
  - -40°C to +85°C
- Three package options: 2.0 x 1.2 mm (2012) SMD, SOT23-5[1], 1.5 x 0.8 mm CSP
- Ultra-low power: <1 μA
- Vdd supply range: 1.5V to 3.63V
- Improved stability reduces system power with fewer network timekeeping updates
- NanoDrive™ programmable output swing for lowest power and direct XTAL SoC input interface
- Internal filtering eliminates external Vdd bypass cap and saves space
- Pb-free, RoHS and REACH compliant

Applications

- Smart Meters (AMR)
- Health and Wellness Monitors
- Pulse-per-Second (pps) Timekeeping
- RTC Reference Clock

INSTANT SAMPLES GREEN SOLUTIONS LIFETIME WARRANTY

TempFlat MEMS™

Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Frequency and Stability						
Output Frequency	Fout		32.768		kHz	
Initial Tolerance	F_init	-5.0		5.0	ppm	T_A = 25°C, includes reflow. Tested with Agilent 53132A freq. counter, gate time ≥ 100ms.
Frequency Stability Over Temperature	F_stab	-5.0		5.0	ppm	Stability part number code = E, includes ±20% load variation
		-10		10		Stability part number code = F, includes ±20% load variation
		-20		20		Stability part number code = 1, includes ±20% load variation
Frequency Stability vs Voltage	F_vdd	-0.75		0.75	ppm	1.8V ±10%
		-1.5		1.5	ppm	1.5V – 3.63V
First Year Frequency Aging	F_aging	-1.0		1.0	ppm	T_A = 25°C, Vdd = 3.0V
Jitter Performance (T_A = over temp)						
Long Term Jitter				2.5	μs_{pp}	81920 cycles (2.5 sec), 100 samples
Period Jitter			35		ns_{RMS}	N = 10,000, T_A = 25°C, Vdd = 1.5V – 3.63V
Supply Voltage and Current Consumption						
Operating Supply Voltage	Vdd	1.5		3.63	V	T_A = -40°C to +85°C
Core Supply Current	Idd		0.99		μA	T_A = 25°C, Vdd = 1.8V, LVCMOS Output configuration, No Load
				1.52		T_A = -40°C to +85°C, Vdd = 1.5V – 3.63V, No Load
Power-Supply Ramp	t_Vdd_Ramp			100	ms	Vdd Ramp-Up 0 to 90% Vdd, T_A = -40°C to +85°C
Start-up Time at Power-up	t_start		200	300	ms	Valid Output with frequency stability specifications.

Notes:

1. Contact Factory for SOT23-5 availability.
2. Core operating current does not include output driver operating current or load current. To derive total operating current (no load), add core operating current + output driver operating current, which is a function of the output voltage swing. See the description titled, **Calculating Load Current.**

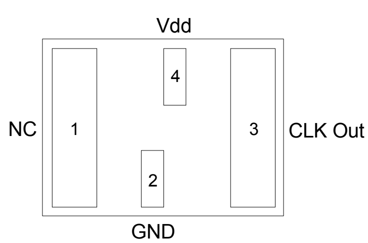
Electrical Characteristics (continued)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Operating Temperature Range						
Commercial Temperature	Op_Temp	0		70	°C	
Industrial Temperature		-40		85	°C	
Extended Industrial Temperature		-40		105	°C	Contact Factory for availability
LVCMOS Output						
Output Rise/Fall Time	tr, tf		100	200	ns	10-90%, 15 pF Load
Output Clock Duty Cycle	DC	48		52	%	
Output Voltage High	VOH	90%			V	Vdd: 1.5V – 3.63V. I_{OH} = -1 μA, 15 pF Load
Output Voltage Low	VOL			10%	V	Vdd: 1.5V – 3.63V. I_{OL} = 1 μA, 15 pF Load
NanoDrive™ Reduced Swing Output						
Output Rise/Fall Time	tf, tf			200	ns	10-90%, 15 pF Load
Output Clock Duty Cycle	DC	48		52	%	
AC-coupled Programmable Output Swing	V_sw		0.20 to 0.80		V	SiT1552 does not internally AC-couple. This output description is intended for a receiver that is AC-coupled. Vdd: 1.5V – 3.63V, 10 pF Load, I_{OH} / I_{OL} = ±0.2 μA
DC-Biased Programmable Output Voltage High Range	VOH		0.6 to 1.225		V	Vdd: 1.5V – 3.63V. I_{OH} = -0.2 μA, 10 pF Load
DC-Biased Programmable Output Voltage Low Range	VOL		0.35 to 0.80		V	Vdd: 1.5V – 3.63V. I_{OL} = 0.2 μA, 10 pF Load
Programmable Output Voltage Swing Tolerance		-0.055		0.055	V	T_A = -40°C to +85°C, Vdd = 1.5V to 3.63V. See Tables 1 and -2 for acceptable NanoDrive Settings.

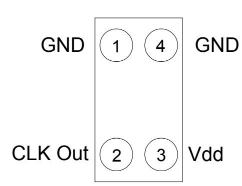
Pin Configuration

SMD Pin	CSP Pin	SOT23-5 Pin	Symbol	I/O	Functionality
1	n/a	2	NC	No Connect	No Connect. Will not respond to any input signal. When interfacing to an MCU's XTAL input pins, this pin is typically connected to the receiving IC's X Out pin. In this case, the SiT1552 will not be affected by the signal on this pin. If not interfacing to an XTAL oscillator, leave pin 1 floating (no connect).
2	1, 4	1, 5	GND	Power Supply Ground	Connect to ground. All GND pins must be connected to power supply ground. The GND pins on the SOT23 and CSP packages can be connected together, as long as both GND pins are connected ground.
3	2	4	CLK Out	OUT	Oscillator clock output. When interfacing to an MCU's XTAL, the CLK Out is typically connected to the receiving IC's X IN pin. The SiT1552 oscillator output includes an internal driver. As a result, the output swing and operation is not dependent on capacitive loading. This makes the output much more flexible, layout independent, and robust under changing environmental and manufacturing conditions.
4	3	3	Vdd	Power Supply	Connect to power supply 1.5V ≤ Vdd ≤ 3.63V. Under normal operating conditions, Vdd does not require external bypass/decoupling capacitor(s). Internal power supply filtering will reject more than 500 mV_{pp} with frequency components through 10 MHz. Contact factory for applications that require a wider operating supply voltage range.

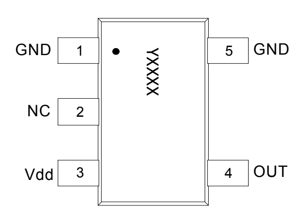
SMD Package (Top View)



CSP Package (Top View)



SOT23-5 Package (Top View)



System Block Diagram

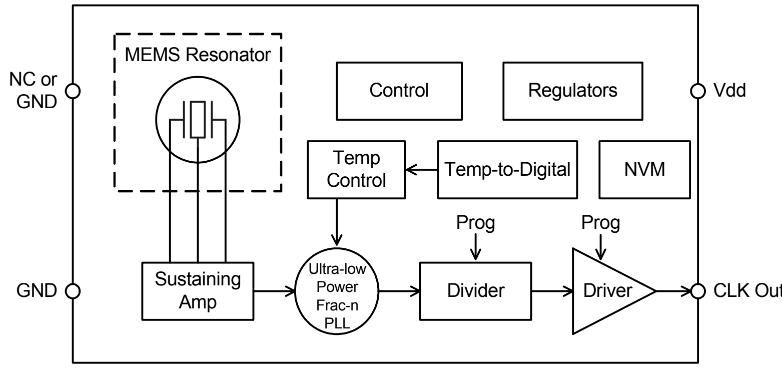


Figure 1.

Absolute Maximum

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

Parameter	Test Condition	Value	Unit
Continuous Power Supply Voltage Range (Vdd)		-0.5 to 3.63	V
Short Duration Maximum Power Supply Voltage (Vdd)	≤30 minutes	4.0	V
Continuous Maximum Operating Temperature Range	Vdd = 1.5V - 3.63V	105	°C
Short Duration Maximum Operating Temperature Range	Vdd = 1.5V - 3.63V, ≤30 mins	125	°C
Human Body Model (HBM) ESD Protection	JESD22-A114	3000	V
Charge-Device Model (CDM) ESD Protection	JESD22-A115	750	V
Machine Model (MM) ESD Protection	JESD22-C101	300	V
Latch-up Tolerance	JESD78 Compliant		
Mechanical Shock Resistance	Mil 883, Method 2002	10,000	g
Mechanical Vibration Resistance	Mil 883, Method 2007	70	g
2012 SMD Junction Temperature		150	°C
1508 CSP Junction Temperature		150	°C
SOT23-5 Junction Temperature		150	°C
Storage Temperature		-65°C to 150°C	

Thermal Consideration

Package	θJA, 4 Layer Board (°C/W)	θJA, 2 Layer Board (°C/W)	θJC, Bottom (°C/W)
2012 SMD	TBD		
1508 CSP	TBD		
SOT23-5	TBD		

Description

The SiT1552 is an ultra-small and ultra-low 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 core supply current is only 1 µA. And unlike standard oscillators, the SiT1552 features NanoDrive™, a factory programmable output that reduces the voltage swing to minimize power.

SiTime's MEMS oscillators consist of MEMS resonators and a programmable analog circuit. Our MEMS resonators are 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

The SiT1552 is factory calibrated (trimmed) over multiple frequency 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 SiT1552 temperature coefficient is calibrated and corrected over temperature with an active temperature correction circuit. The result is 32 kHz TCXO with extremely tight frequency variation over the -40°C to +85°C temperature range. Contact SiTime for applications that require a wider supply voltage range >3.63V, or lower operating frequency below 32 kHz.

When measuring the SiT1552 output frequency with a frequency counter, it is important to make sure the counter's gate time is ≥100ms. The slow frequency of a 32kHz clock will give false readings with faster gate times.

Power Supply Noise Immunity

In addition to eliminating external output load capacitors common with standard XTALs, this device includes special power supply filtering and thus, eliminates the need for an external Vdd bypass-decoupling capacitor to keep the footprint as small as possible. Internal power supply filtering is designed to reject more than 500 mV noise and frequency components from low frequency to more than 10 MHz.

Start-up and Steady-State Supply Current

The SiT1552 TCXO starts-up to a valid output frequency within 300 ms (150ms typ). To ensure proper start-up, Vdd power-supply ramp, from a power-down state to 90% of final Vdd, must be less than 100ms.

During initial power-up, the SiT1552 power-cycles internal blocks, as shown in the power-supply start-up and steady state plot in the *Typical Operating Curves* section. Power-up and initialization is typically 200 ms, and during that time, the peak supply current reaches 28 µA as the internal capacitors are charged, then sequentially drops to its 990 nA steady-state current. During steady-state operation, the internal temperature compensation circuit turns on every 350 ms for a duration of approximately 10 ms.

Output Voltage

The SiT1552 has two output voltage options. One option is a standard LVCMOS output swing. The second option is the NanoDrive reduced swing output. Output swing is customer specific and Factory programmed between 200 mV and 800 mV. For DC-coupled applications, output V_{OH} and V_{OL} are individually factory programmed to the customers' requirement. V_{OH} programming range is between 600 mV and 1.225V in 100 mV increments. Similarly, V_{OL} programming range is between 350 mV and 800 mV. For example; a PMIC or MCU is internally 1.8V logic compatible, and requires a 1.2V V_{IH} and a 0.6V V_{IL}. Simply select SiT1552 NanoDrive factory programming code to be "D14" and the correct output thresholds will match the downstream PMIC or MCU input requirements. Interface logic will vary by manufacturer and we recommend that you review the input voltage requirements for the input interface.

For DC-biased NanoDrive output configuration, the minimum V_{OL} is limited to 350mV and the maximum allowable swing (V_{OH} - V_{OL}) is 750mV. For example, 1.1V V_{OH} and 400mV V_{OL} is acceptable, but 1.2V V_{OH} and 400 mV V_{OL} is not acceptable.

When the output is interfacing to an XTAL input that is internally AC-coupled, the SiT1552 output can be Factory programmed to match the input swing requirements. For example, if a PMIC or MCU input is internally AC-coupled and requires an 800mV swing, then simply choose the SiT1552 NanoDrive programming code "AA8" in the part number. It is important to note that the SiT1552 does not include internal AC-coupling capacitors. Please see the *Part Number Ordering* section at the end of the datasheet for more information about the part number ordering scheme.

SiT1552 NanoDrive™

Figure 3 shows a typical output waveform of the SiT1552 (into a 10 pF load) when factory programmed for a 0.70V swing and DC bias (V_{OH}/V_{OL}) for 1.8V logic:

***Example*:**

- NanoDrive part number coding: D14. Example part number: SiT1552AI-J4-D14-32.768
- V_{OH} = 1.1V, V_{OL} = 0.4V (V_{sw} = 0.70V)

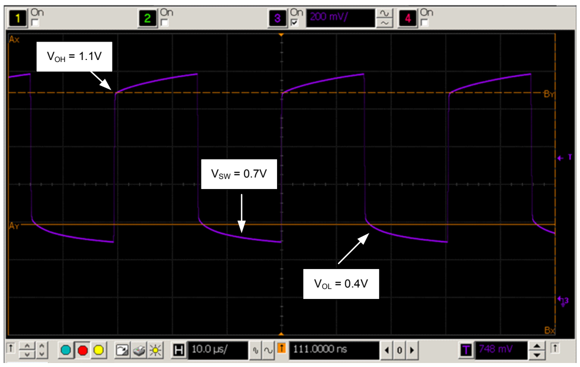


Figure 2. SiT1552AI-J4-D14-32.768
Output Waveform (10 pF load)

Table 1 shows the supported NanoDrive V_{OH}, V_{OL} factory programming options.

Table 1. Acceptable V_{OH}/V_{OL} NanoDrive Levels

V_{OL}/V_{OH}	1.225	1.100	1.000	0.900	0.800	0.700	0.600
0.800	D28	D18	D08				
0.700	D27	D17	D07	D97			
0.525	D26	D16	D06	D96	D86		
0.500	D25	D15	D05	D95	D85	D75	
0.400		D14	D04	D94	D84	D74	D64
0.350		D13	D03	D93	D83	D73	D63

Table 2 shows the supported AC coupled Swing levels. The "AC-coupled" terminology refers to the programming description for applications where the downstream chipsets includes an internal AC-coupling capacitor, and therefore, only the output swing is important and V_{OH}/V_{OL} is not relevant. For these applications, refer to Table 2 for the acceptable voltage swing options.

Table 2. Acceptable NanoDrive Voltage Swing Options (for downstream AC-coupled receivers)

Swing	0.800	0.700	0.600	0.500	0.400	0.300	0.250	0.200
Output Code	AA8	AA7	AA6	AA5	AA4	AA3	AA2	AA1

***Example*:**

- NanoDrive part number coding: AA2. Example part number: SiT1552AI-J4-**AA2**-32.768
- Output voltage swing: 0.250V

The values listed in Tables 1 and -2 are nominal values at 25°C and will exhibit a tolerance of ±55 mV across Vdd and -40°C to 85°C operating temperature range.

SiT1552 Full Swing LVCMOS Output

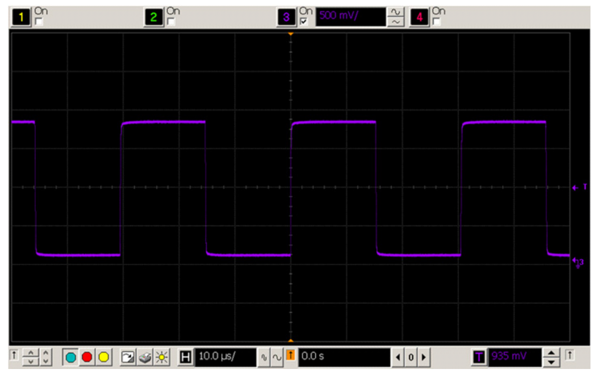


Figure 3. LVCMOS Waveform
(Vdd = 1.8V) into 15 pF Load

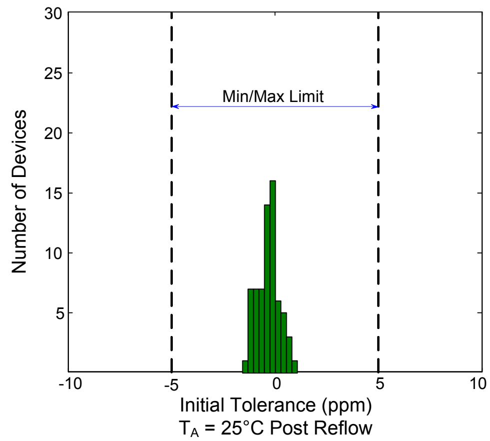
***Example*:**

- LVCMOS output part number coding is always **DCC**
- Example part number: SiT1552AI-J4-DCC-32.768

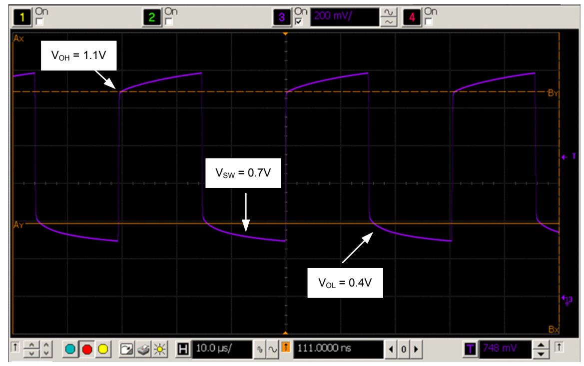
Typical Operating Curves

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

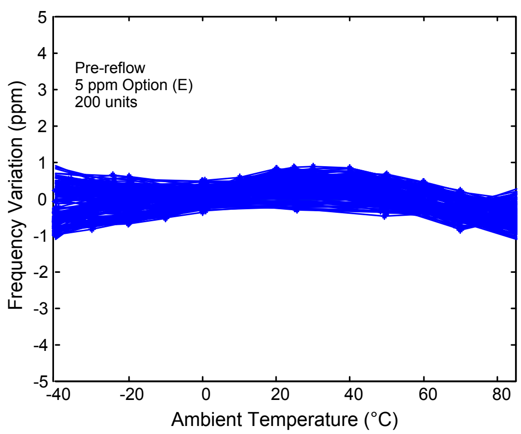
Initial Tolerance Histogram



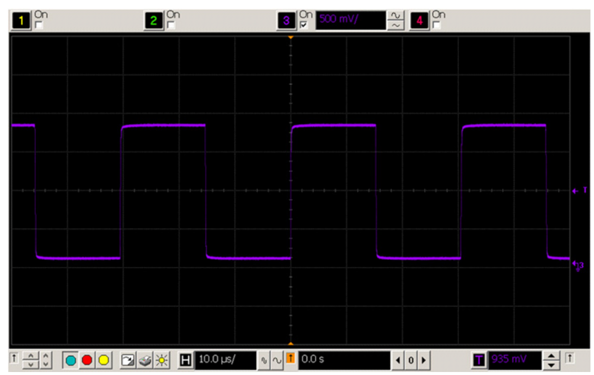
NanoDrive™ Output Waveform
(V_{OH} = 1.2V, V_{OL} = 0.4V, 10 pF Load; SiT1552AI-AI-D14-32.768)



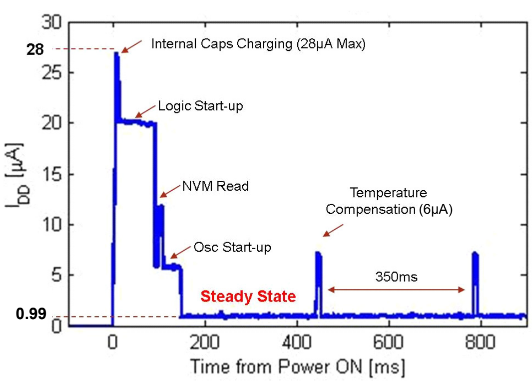
Frequency Stability Over Temperature



LVCMOS Output Waveform
(SiT1552AI-JE-DCC-32.768, 10 pF Load)



Start-up and Steady-State Current Profile



Calculating Load Current

No Load Supply Current

When calculating no-load power for the SiT1552, the core and output driver components need to be added. Since the output voltage swing can be programmed to minimize load current, the output driver current is variable. Therefore, no-load operating supply current is broken into two sections; core and output driver. The equation is as follows:

Total Supply Current (no load) = Idd Core + Idd Output Driver

***Example 1**: Full-swing LVCMOS*

- Vdd = 1.8V
- Idd Core = 990nA (typ)
- $Vout_{pp}$ = 1.8V
- Idd Output Driver: (Cdriver)(Vout)(Fout) = (3.5pF)(1.8V)(32768Hz) = 206nA

Supply Current = 990nA + 206nA = 1.2µA

***Example 2**: NanoDrive Reduced Swing*

- Vdd = 1.8V
- Idd Core = 990nA (typ)
- $Vout_{pp}$ (Programmable) = $V_{OH} – V_{OL}$ = 1.1V - 0.6V = 500mV
- Idd Output Driver: (Cdriver)(Vout)(Fout) = (3.5pF)(0.50V)(32768Hz) = 57nA

Supply Current = 990nA + 57nA = 1.05µA

Total Supply Current with Load

To calculate the total supply current, including the load, follow the equation listed below. Note the 30% reduction in power with NanoDrive.

Total Current = Idd Core + Idd Output Driver + Load Current

***Example 1**: Full-swing LVCMOS*

- Vdd = 1.8V
- Idd Core = 990nA
- Load Capacitance = 10pF
- Idd Output Driver: (Cdriver)(Vout)(Fout) = (3.5pF)(1.8V)(32768Hz) = 206nA
- Load Current: (10pF)(1.8V)(32768Hz) = 590nA
- Total Current = 990nA + 206nA + 590nA = 1.79µA

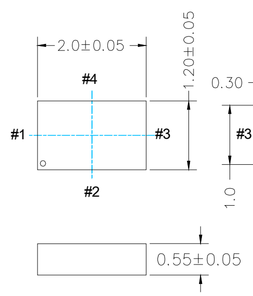
***Example 2**: NanoDrive Reduced Swing*

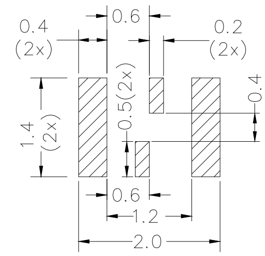
- Vdd = 1.8V
- Idd Core = 990nA
- Load Capacitance = 10pF
- $Vout_{pp}$ (Programmable): $V_{OH} – V_{OL}$ = 1.1V - 0.6V = 500mV
- Idd Output Driver: (Cdriver)(Vout)(Fout) = (3.5pF)(0.5V)(32768Hz) = 57nA
- Load Current: (10pF)(0.5V)(32768Hz) = 164nA
- Total Current = 990nA + 57nA + 164nA = 1.2µA

Dimensions and Patterns

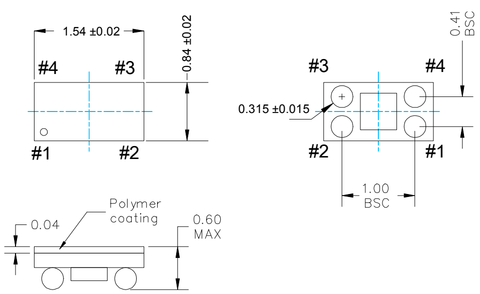
Package Size – Dimensions (Unit: mm)[3] | **Recommended Land Pattern (Unit: mm)**

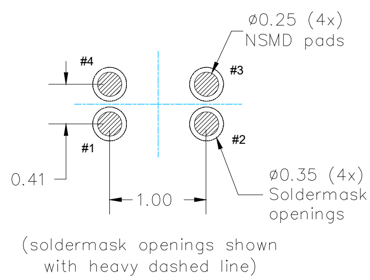
2.0 x 1.2 mm SMD



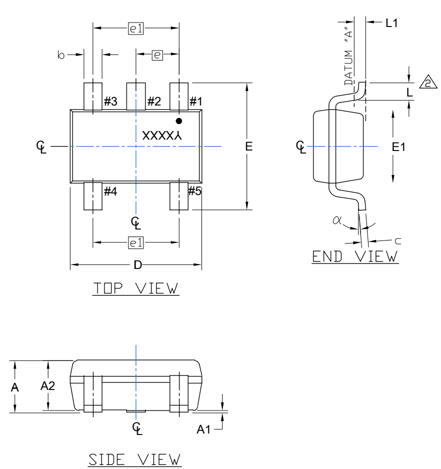


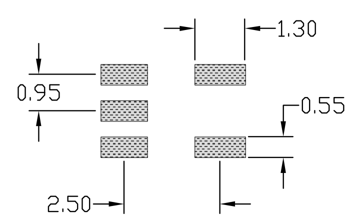
1.55 x 0.85 mm CSP





2.90 x 2.80 mm SOT23-5





Note:

3. Top marking: Y denotes manufacturing origin and XXXX denotes manufacturing lot number. The value of "Y" will depend on the assembly location of the device.

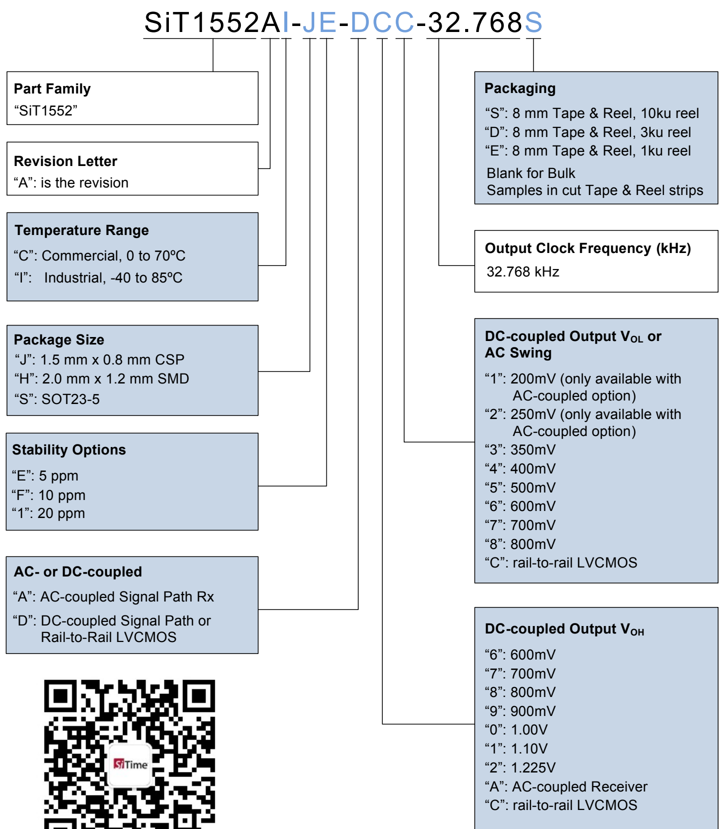
SOT23-5 Dimension Table

Symbol	Min.	Nom.	Max.
A	0.90	1.27	1.45
A1	0.00	0.07	0.15
A2	0.90	1.2	1.30
b	0.30	0.35	0.50
c	0.14	0.153	0.20
D		2.90	

Symbol	Min.	Nom.	Max.
E		2.80	
E1		1.60	
e		0.95	
e1		1.90	
L	0.30	0.38	0.55
L1		0.25	
a	0°	–	8°

Ordering Information

Part number characters in blue represent the customer specific options. The other characters in the part number are fixed.



The following examples illustrate how to select the appropriate part number scheme:

Example 1: ***SiT1552AI-JE-DCC-32.768***

- Industrial temperature range
- CSP package
- 5 ppm frequency stability
- Output requirements:
  a) Output frequency = 32.768 kHz
  b) "D" = DC-coupled receiver
  c) "C" = LVCMOS output swing
  d) "C" = LVCMOS output swing

Example 2: ***SiT1552AI-SF-AA5-32.768***

- Industrial temperature range
- SOT23-5 package
- 10 ppm frequency stability
- Output requirements:
  a) Output frequency = 32.768 kHz
  b) "A" = AC-coupled receiver
  c) "A" = AC-coupled receiver
  d) "5" = 500mV swing