SiT1543 Preliminary

Ultra-Low Power 32.768 kHz XTAL SMD Replacement for Single-Cell Li+ Unregulated Battery Powered Applications

SiTime™
The Smart Timing Choice™

Features

- Supply voltage optimized for Li+ battery voltage: 2.7V to 4.3V
- Pin-compatible to 2.0 x 1.2 mm (2012) XTAL SMD package(1)
- Ultra-low power: 750 nA (typ)
- Oscillator output eliminates external load caps
- NanoDrive™ programmable output swing for lowest power
- Internal filtering eliminates external Vdd bypass cap
- Fixed 32.768 kHz output frequency
- <20 PPM initial stability
- <100 PPM stability over -40°C to +85°C
- Pb-free, RoHS and REACH compliant

Note: 1. For the smallest 32 kHz XO in CSP (1.2mm^2), consider the SiT1542

Applications

- Wireless Mouse or Trackball
- Wireless Keypads
- Pulse-per-Second (pps) Timekeeping
- RTC Reference Clock
- Battery Management Timekeeping

Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Frequency and Stability						
Fixed Output Frequency	Fout		32.768		kHz	
Frequency Stability						
Frequency Stability (2)	F_stab			20	PPM	T_A = 25°C, Vdd: 3.0V – 4.3V
				75		T_A = -10°C to +70°C, Vdd: 3.0V – 4.3V. Stability includes initial, power supply, and temperature stability components.
				100		T_A = -40°C to +85°C, Vdd: 3.0V – 4.3V. Stability includes initial, power supply, and temperature stability components.
				TBD		T_A = -40°C to +85°C, Vdd: 2.7V – 3.0V. Stability includes initial, power supply, and temperature stability components.
25°C Aging		-3		3	PPM	1st Year
Supply Voltage and Current Consumption						
Operating Supply Voltage	Vdd	2.7		4.3	V	T_A = -40°C to +85°C
		2.7		4.5	V	T_A = -10°C to +70°C
Power Supply Reset Voltage	Reset		1.8		V	
Core Operating Current (3, 4)	Idd		0.75		µA	T_A = 25°C, Vdd: 2.7V – 4.3V. No Load
				TBD		T_A = -10°C to +70°C, Vdd max: 4.3V. No Load
				TBD		T_A = -40°C to +85°C, Vdd max: 4.3V. No Load
Output Stage Operating Current (3)	Idd_out		0.165		µA/Vpp	T_A = 25°C, Vdd: 2.7V – 4.3V No Load
$T_{START-UP}$ at Power-up	T_start		150	TBD	ms	T_A = 25°C
Operating Temperature Range						
Commercial Temperature	T_use	-10		70	°C	
Industrial Temperature		-40		85	°C	
Rail-to-Rail Output Option						
Output Rise/Fall Time	tr, tf			200	ns	20-80%, 15 pF Load.
Output Clock Duty Cycle	DC	45		55	%	LVCMOS Output
Output Voltage High	VOH	Vdd - 1.54			V	Vdd: 2.7V – 4.3V. I_{OH} = -0.2µA, 15 pF
Output Voltage Low	VOL			50	mV	Vdd: 2.7V – 4.3V. I_{OL} = 0.2µA, 15 pF
NanoDrive™ Programmable, Reduced Swing Output						
Reduced Swing Output	V_sw	0.25		0.80	V	Vdd: 2.7V – 4.3V. For AC-coupled receiver
Output Voltage High Range	VOH	0.50		1.20	V	15 pF, I_{OH} = -0.2µA
Output Voltage Low Range	VOL	0.25		0.80	V	15 pF, I_{OL} = 0.2µA
Output Rise/Fall Time	tr, tf		80	TBD	ns	
Output Clock Duty Cycle	DC	45		55	%	
Jitter Performance (T_A = 25°C, Vdd = 3.0V to 4.3V, unless otherwise stated)						
Period Jitter	T_djitt		45		ns_{RMS}	N = 10,000

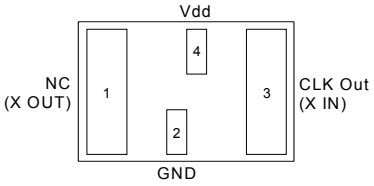
Notes:

2. Stability is specified for two operating voltage ranges. Stability progressively degrades with supply voltage below 3.0V.
3. Core operating current does not include output driver operating current or load current.
4. To derive total operating current (no load), add core operating current + (0.165 µA/V) * (peak-to-peak output Voltage swing).

Pin Configuration

Pin	Symbol	I/O	Functionality
1	NC (X OUT)	No Connect, don't care	No Connect. Will not respond to any input signal. This pin is typically connected to the receiving IC's X Out pin. In this case, the SiT1543 will not be affected by the signal on this pin.
2	GND	Power Supply Ground	Connect to ground.
3	CLK Out (X IN)	OUT	Oscillator clock output. The CLK Out is typically connected to the receiving IC's X IN pin. The SiT1543 oscillator output includes an internal driver. As a result, the output swing is not dependent on capacitive loading. This makes the output much more flexible, layout independent, and robust under changing environmental and manufacturing conditions.
4	Vdd	Power Supply	Connect to power supply 2.7V ≤ Vdd ≤ 4.5V. Under normal operating conditions, Vdd does not require external bypass/decoupling capacitor(s).

SMD Package (Top View)



System Block Diagram

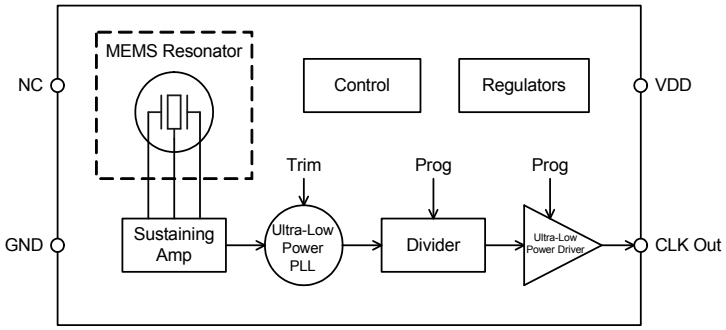


Figure 1.

Absolute Maximum

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

Parameter	Symbol	Test Condition	Value	Unit
Power Supply Voltage Range (Vdd)	Vdd		-0.5 to 4.7	V
ESD Protection		HBM 100pF, 1.5kΩ	2000	V
ESD Protection		CDM, 25°C	750	V
ESD Protection		MM, 25°C	200	V
Latch-up Tolerance			JESD78 Compliant	
Mechanical Shock Resistance	ΔF/F	Mil 883, Method 2002	50,000	g
Mechanical Vibration Resistance	ΔF/F	Mil 883, Method 2005	70	g
2012 SMD Junction Temperature			TBD	
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		

Description

The SiT1543 is an XTAL compatible, ultra-low power 32.768 kHz oscillator optimized for unregulated Li+ battery powered applications where the supply voltage must track the Li+ battery voltage from 4.3V down to 2.7V. The SiT1543 is pin-compatible and footprint compatible to existing 2012 XTALs when using the SiTime solder-pad layout (SPL). And unlike standard oscillators, the SiT1543 features NanoDrive™, a factory programmable output that reduces the voltage swing to minimize power.

For applications that require the smallest footprint, consider the SiT1542 offered in a 1.5 x 0.8 mm CSP. Or, for lower operating voltage, consider the SiT1532/3 which operate down to 1.2V

XTAL Footprint Compatibility (SMD Package)

The SiT1543 is a replacement to the 32 kHz XTAL in the 2.0 x 1.2 mm (2012) package. Unlike XTAL resonators, SiTime's silicon MEMS oscillators require a power supply (Vdd) and ground (GND) pin. Vdd and GND pins are conveniently placed between the two large XTAL pins. When using the SiTime Solder Pad Layout (SPL), the SiT1543 footprint is compatible with existing 32 kHz XTALs in the 2012 SMD package. Figure 1 shows the comparison between the quartz XTAL footprint and the SiTime footprint.

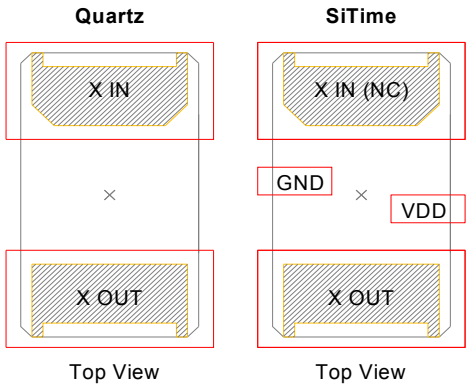


Figure 1. SiT1543 Footprint Compatibility with Quartz XTAL Footprint (5)

Frequency Stability

The SiT1543 is factory calibrated (trimmed) to guarantee frequency stability to be less than 20 PPM at room temperature and less than 100 PPM over the full -40°C to +85°C temperature range. Unlike quartz crystals that have a classic tuning fork parabola temperature curve with a 25°C turnover point, the SiT1543 temperature coefficient is extremely flat across temperature. The devices maintain less than 100 PPM frequency stability over the full operating temperature range.

Power Supply Noise Immunity

The SiT1543 is an ultra-small 32 kHz oscillator. 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. This feature further simplifies the design and keeps the footprint as small as possible. Internal power supply filtering is designed to reject noise up to ±50 mVpp magnitude 5 MHz frequency.

Output Voltage

For low-power applications that drive directly into a chip-set's XTAL input, the reduced swing output is ideal. SiTime's unique NanoDrive™, factory-programmable output stage is optimized for low voltage swing to minimize power and maintain compatibility with the downstream oscillator input (X IN pin). The SiT1543 output swing is customer specific and factory programmed between 250 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 500 mV and 1.2V in 100 mV increments. Similarly, V_{OL} programming range is between 250 mV and 800 mV. Contact SiTime for programming support.

Note:

5. On the Sitime device, X IN is not internally connected and will not respond to any signal. It is acceptable to connect to chipset X OUT.

Calculating Load Current

No Load Supply Current

When calculating no-load power for the SiT1543, the core and output driver components need to be added. Since the output voltage swing can be programmed for reduced swing between 250 mV and 800 mV for ultra-low power applications, 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:

Supply Current (no load) = I_{dd} Core + (165nA/V)($Vout_{pp}$)

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

- Vdd = 3.3V
- Idd Core = 750nA
- $Vout_{pp}$ = 2.1V (max output of device)

Supply Current = 750nA + (165nA/V)(2.1V) = 1047nA

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

- Vdd = 3.3V
- Idd Core = 750nA
- $Vout_{pp}$ (Programmable) = V_{OH} – V_{OL} = 1.1V - 0.6V = 0.5V

Supply Current = 750nA + (165nA/V)(0.5V) = 832nA

Total Supply Current with Load

To calculate the total supply current, including the load, follow the equation listed below. Note the greater than 40% reduction in power with NanoDrive™.

* Total Current = Idd Core + Idd Output Driver (165nA/V*$Vout_{pp}$) + Load Current (C*V*F)

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

- Vdd = 3.3V
- $Vout_{pp}$ = 2.1V (max output of device)
- Idd Core = 750nA
- Load Capacitance = 10pF
- Idd Output Driver: (165nA/V)(2.1V) = 347nA
- Load Current: (10pF)(2.1V)(32.768kHz) = 688nA

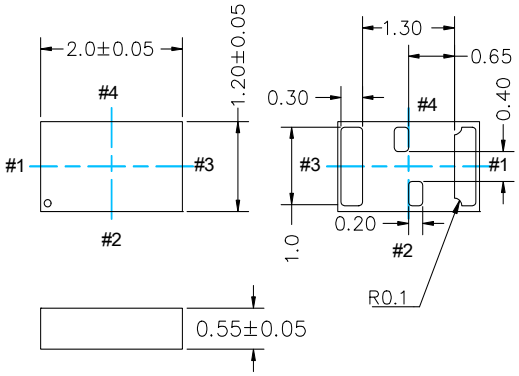
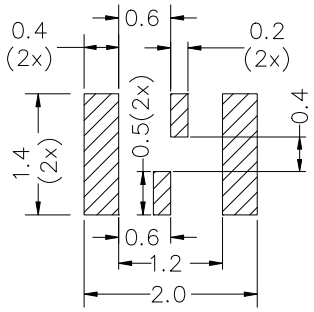
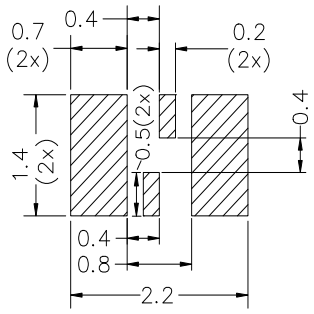
Total Current = 750nA + 347nA + 688nA = 1785nA

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

- Vdd = 3.3V
- Idd Core = 750nA
- Load Capacitance = 10pF
- $Vout_{pp}$ (Programmable): V_{OH} – V_{OL} = 1.1V - 0.6V = 0.5V
- Idd Output Driver: (165nA/V)(0.5V) = 83nA
- Load Current: (10pF)(0.5V)(32.768kHz) = 164nA

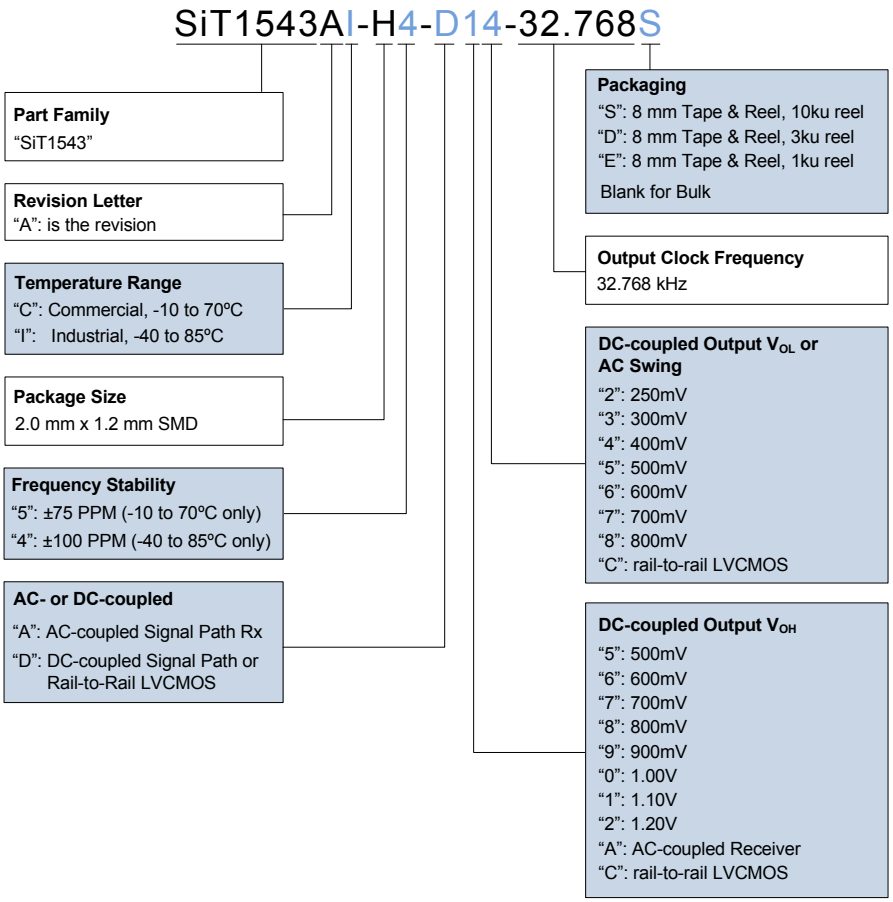
Total Current = 750nA + 83nA + 164nA = 997nA

Dimensions and Patterns

Package Size – Dimensions (Unit: mm)	Recommended Land Pattern (Unit: mm)
2.0 x 1.2 mm SMD 	**SiTime Only SPL** 
	XTAL Compatible SPL 

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 temp range and output voltage requirements:

Example 1: ***SiT1543AI-H4-D14-32.768***

- Industrial temp & corresponding 100 PPM frequency stability. Note, 100 PPM is only available for the industrial temp range, and 75 PPM is only available for the commercial temp range.
- Output swing requirements:
  a) "D" = DC-coupled receiver
  b) "1" = V_{OH} = 1.1V
  c) "4" = V_{OL} = 0.4V

Example 2: ***SiT1543AC-H5-AA5-32.768***

- Commercial temp & corresponding 75 PPM frequency stability. Note, 100 PPM is only available for the industrial temp range, and 75 PPM is only available for the commercial temp range.
- Output swing requirements:
  a) "A" = AC-coupled receiver
  b) "A" = AC-coupled receiver
  c) "5" = 500mV swing