SiT1533
Ultra-Low Power 32.768 kHz XTAL Replacement in 2.0 x 1.2 mm SMD

Features
- Small SMD package: 2.0 x 1.2 mm (2012)[1]
- Pin-compatible to 2012 XTAL SMD package
- Ultra-low power: <1μA
- Supports coin-cell or super-cap battery backup voltages
- Vdd supply range: 1.5V to 3.63V over -40°C to +85°C
- 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

Applications
- Mobile Phones
- Tablets
- Health and Wellness Monitors
- Fitness Watches
- Sport Video Cams
- Wireless Keypads
- Ultra-Small Notebook PC
- Pulse-per-Second (pps) Timekeeping
- RTC Reference Clock
- Battery Management Timekeeping

Notes:
1. For the smallest 32 kHz XO in CSP (1.2mm²), consider the SiT1532

Electrical Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency and Stability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Output Frequency</td>
<td>Fout</td>
<td>32.768 kHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
<td>PPM</td>
<td>TA = -10°C to +70°C, Vdd: 1.5V – 3.63V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>250</td>
<td></td>
<td>PPM</td>
<td>TA = -40°C to +85°C, Vdd: 1.5V – 3.63V</td>
</tr>
<tr>
<td>25°C Aging</td>
<td></td>
<td>-3</td>
<td></td>
<td>3</td>
<td>PPM</td>
<td>1st Year</td>
</tr>
<tr>
<td>Supply Voltage and Current Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Supply Voltage</td>
<td>Vdd</td>
<td>1.2</td>
<td>3.63</td>
<td>V</td>
<td></td>
<td>TA = 10°C to +70°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5</td>
<td>3.63</td>
<td>V</td>
<td></td>
<td>TA = -40°C to +85°C</td>
</tr>
<tr>
<td>Power Supply Reset Voltage</td>
<td>Reset</td>
<td>0.3</td>
<td></td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core Operating Current [3, 4]</td>
<td>Idd</td>
<td>0.9</td>
<td>1.3</td>
<td>μA</td>
<td></td>
<td>TA = 25°C, Vdd: 1.5V – 3.63V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No load</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TA = -10°C to +70°C, Vdd max: 3.63V, No load</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TA = -40°C to +85°C, Vdd max: 3.63V, No load</td>
</tr>
<tr>
<td>Output Stage Operating Current [3]</td>
<td>Idd_out</td>
<td>0.065</td>
<td>0.125</td>
<td>μA/Vpp</td>
<td></td>
<td>TA = -40°C to +85°C, Vdd: 1.5V – 3.63V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No load</td>
</tr>
<tr>
<td>Power-Supply Ramp</td>
<td>tVdd_Ramp</td>
<td>100</td>
<td>300</td>
<td>ms</td>
<td></td>
<td>TA = -40°C to +85°C, 0 to 100% Vdd</td>
</tr>
<tr>
<td>T_{START-UP} at Power-up</td>
<td>T_start</td>
<td>150</td>
<td>300</td>
<td>ms</td>
<td></td>
<td>TA = -40°C to +85°C</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Temperature</td>
<td>T_use</td>
<td>-10</td>
<td>70</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Temperature</td>
<td></td>
<td>-40</td>
<td>85</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LVCMOS Output Option, TA = -40°C to +85°C, typical value is TA = 25°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Rise/Fall Time</td>
<td>t_r, t_f</td>
<td>100</td>
<td>200</td>
<td>ns</td>
<td>10-90%, 15 pF load, Vdd = 1.5V to 3.63V</td>
<td></td>
</tr>
<tr>
<td>Output Clock Duty Cycle</td>
<td>DC</td>
<td>48</td>
<td>52</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage High</td>
<td>VOH</td>
<td>90%</td>
<td></td>
<td>V</td>
<td></td>
<td>Vdd: 1.5V – 3.63V, IOH = -10μA, 15 pF</td>
</tr>
<tr>
<td>Output Voltage Low</td>
<td>VOL</td>
<td>10%</td>
<td></td>
<td>V</td>
<td></td>
<td>Vdd: 1.5V – 3.63V, IOL = 10μA, 15 pF</td>
</tr>
</tbody>
</table>

NanoDrive™ Programmable, Reduced Swing Output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Rise/Fall Time</td>
<td>t_r, t_f</td>
<td>200</td>
<td>52</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Clock Duty Cycle</td>
<td>DC</td>
<td>48</td>
<td>52</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-coupled Programmable Output Swing</td>
<td>V_sw</td>
<td>0.25</td>
<td>0.80</td>
<td>V</td>
<td></td>
<td>Vdd: 1.2V – 3.63V, 15 pF Load, 10 pF, IOH / IOL = ±0.2μA</td>
</tr>
<tr>
<td>DC-Biased Programmable Output Voltage High Range</td>
<td>VOH</td>
<td>0.5</td>
<td>1.20</td>
<td>80</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>DC-Biased Programmable Output Voltage Range</td>
<td>VOL</td>
<td>0.35</td>
<td>0.80</td>
<td>V</td>
<td></td>
<td>Vdd: 1.2V – 3.63V, IOL = 0.2μA, 10 pF Load</td>
</tr>
</tbody>
</table>

Notes:
2. Stability is specified for two operating voltage ranges. Stability progressively degrades with supply voltage below 1.5V.
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 + (0.065 μA/V) * (peak-to-peak output Voltage swing).
Electrical Characteristics (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitter Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(TA = 25°C, Vdd = 1.5V to 2.0V, unless otherwise stated)</td>
</tr>
<tr>
<td>Period Jitter</td>
<td>T_djitt</td>
<td>45</td>
<td></td>
<td></td>
<td>nsRMS</td>
<td>N = 10,000</td>
</tr>
</tbody>
</table>

Pin Configuration

<table>
<thead>
<tr>
<th>Pin</th>
<th>Symbol</th>
<th>I/O</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NC</td>
<td>No Connect, don't care</td>
<td>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 SiT1533 will not be affected by the signal on this pin.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Power Supply Ground</td>
<td>Connect to ground.</td>
</tr>
<tr>
<td>3</td>
<td>CLK Out</td>
<td>OUT</td>
<td>Oscillator clock output. The CLK Out is typically connected to the receiving IC's X IN pin. The SiT1533 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.</td>
</tr>
<tr>
<td>4</td>
<td>Vdd</td>
<td>Power Supply</td>
<td>Connect to power supply 1.5V ≤ Vdd ≤ 3.63V for operation over -40°C to +85°C temperature range. Under normal operating conditions, Vdd does not require external bypass/decoupling capacitor(s). Contact factory for applications that require a wider operating supply voltage range.</td>
</tr>
</tbody>
</table>

System Block Diagram

![System Block Diagram](image)

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage Range (Vdd)</td>
<td>Vdd</td>
<td></td>
<td>-0.5</td>
<td>to 4</td>
</tr>
<tr>
<td>ESD Protection</td>
<td></td>
<td>HBM 100pF, 1.5kΩ</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>ESD Protection</td>
<td></td>
<td>CDM, 25°C</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td>ESD Protection</td>
<td></td>
<td>MM, 25°C</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Power Supply Voltage Range (Vdd)</td>
<td>Vdd</td>
<td></td>
<td>-0.5</td>
<td>to 4</td>
</tr>
<tr>
<td>Latch-up Tolerance</td>
<td></td>
<td>JESD78 Compliant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Shock Resistance</td>
<td>△F/F</td>
<td>Mil 883, Method 2002</td>
<td>TBD</td>
<td>g</td>
</tr>
<tr>
<td>Mechanical Vibration Resistance</td>
<td>△F/F</td>
<td>Mil 883, Method 2005</td>
<td>TBD</td>
<td>g</td>
</tr>
<tr>
<td>2012 SMD Junction Temperature</td>
<td></td>
<td></td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td></td>
<td></td>
<td>-65°C to 150°C</td>
<td></td>
</tr>
</tbody>
</table>

Thermal Consideration

<table>
<thead>
<tr>
<th>Package</th>
<th>(LA, 4 Layer Board (°C/W))</th>
<th>(LA, 2 Layer Board (°C/W))</th>
<th>(JC, Bottom (°C/W))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 SMD</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Description

The SiT1533 is an ultra-small and ultra-low power 32.768 kHz oscillator optimized for mobile and other battery-powered applications. The SiT1533 is pin-compatible and footprint compatible to existing 2012 XTALs when using the SiTime solder-pad layout (SPL). And unlike standard oscillators, the SiT1533 features NanoDrive™, a factory programmable output that reduces the voltage swing to minimize power.

The 1.2V to 3.63V operating supply voltage range makes it an ideal solution for mobile applications that incorporate a low-voltage, battery-back-up source such as a coin-cell or super-cap.

XTAL Footprint Compatibility (SMD Package)

The SiT1533 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 SiT1533 footprint is compatible with existing 32 kHz XTALs in the 2012 SMD package. Figure 2 shows the comparison between the quartz XTAL footprint and the SiTime footprint. For applications that require the smallest footprint solution, consider the SiT1532 XO available in a 1.2mm² CSP.

Frequency Stability

The SiT1533 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 SiT1533 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. Contact SiTime for applications that require a wider supply voltage range >3.63V, or lower operating frequency below 32 kHz.

Power Supply Noise Immunity

The SiT1533 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 AC-noise greater than ±150 mVpp magnitude and beyond 10 MHz frequency component.

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 SiT1533 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 350 mV and 800 mV. For DC-biased NanoDrive™ output configuration, the minimum $V_{OL}$ is limited to 350mV. For example, 1.1V $V_{OH}$ and 400mV $V_{OL}$ is acceptable, but 1.0V $V_{OH}$ and 350mV $V_{OL}$ is not acceptable. 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 SiT1533, 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:

Total Supply Current (no load) = \( I_{dd \, \text{Core}} + (65\, \text{nA/V})(V_{out\,pp}) \)

**Example 1: Full-swing LVCMOS**
- \( V_{dd} = 1.8\, \text{V} \)
- \( I_{dd \, \text{Core}} = 900\, \text{nA} \, (\text{typ}) \)
- \( V_{out\,pp} = 1.8\, \text{V} \)
Supply Current = 900nA + (65nA/V)(1.8V) = 1047nA

**Example 2: NanoDrive™ Reduced Swing**
- \( V_{dd} = 1.8\, \text{V} \)
- \( I_{dd \, \text{Core}} = 900\, \text{nA} \, (\text{typ}) \)
- \( V_{out\,pp} \, (\text{Programmable}) = V_{OH} - V_{OL} = 1.1\, \text{V} - 0.6\, \text{V} = 500\, \text{mV} \)
Supply Current = 900nA + (65nA/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 30% reduction in power with NanoDrive™.

Total Current = \( I_{dd \, \text{Core}} + I_{dd \, \text{Output Driver}} (65\, \text{nA/V}\times V_{out\,pp}) + \text{Load Current (C*V*F)} \)

**Example 1: Full-swing LVCMOS**
- \( V_{dd} = 1.8\, \text{V} \)
- \( I_{dd \, \text{Core}} = 900\, \text{nA} \)
- \( \text{Load Capacitance} = 10\, \text{pF} \)
- \( I_{dd \, \text{Output Driver}}: (65\, \text{nA/V})(1.8\, \text{V}) = 117\, \text{nA} \)
- \( \text{Load Current: (10\, \text{pF})(1.8\, \text{V})(32.768kHz)} = 590\, \text{nA} \)
- Total Current = 900nA + 117nA + 590nA = 1.6\, \mu\text{A} \)

**Example 2: NanoDrive™ Reduced Swing**
- \( V_{dd} = 1.8\, \text{V} \)
- \( I_{dd \, \text{Core}} = 900\, \text{nA} \)
- \( \text{Load Capacitance} = 10\, \text{pF} \)
- \( V_{out\,pp} \, (\text{Programmable}) = V_{OH} - V_{OL} = 1.1\, \text{V} - 0.6\, \text{V} = 500\, \text{mV} \)
- \( I_{dd \, \text{Output Driver}}: (65\, \text{nA/V})(0.5\, \text{V}) = 33\, \text{nA} \)
- \( \text{Load Current: (10\, \text{pF})(0.5\, \text{V})(32.768kHz)} = 164\, \text{nA} \)
- Total Current = 900nA + 33nA + 164nA = 1.1\, \mu\text{A} \)
## Dimensions and Patterns

<table>
<thead>
<tr>
<th>Package Size – Dimensions (Unit: mm)</th>
<th>Recommended Land Pattern (Unit: mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 x 1.2 mm SMD</td>
<td>SiTime Only SPL</td>
</tr>
<tr>
<td></td>
<td>XTAL Compatible SPL</td>
</tr>
</tbody>
</table>

### SiTime Only SPL

- Dimensions:
  - 2.0 ± 0.05
  - 1.30 ± 0.1
  - 0.65 ± 0.05
  - 1.0 ± 0.05
  - 0.30 ± 0.05

- SPL Pattern:
  - 0.4 (2x)
  - 0.6
  - 0.2 (2x)

### XTAL Compatible SPL

- Dimensions:
  - 0.7 ± 0.1
  - 0.4 ± 0.05
  - 0.8 ± 0.05
  - 1.4 ± 0.1

- SPL Pattern:
  - 0.4 (2x)
  - 0.2 (2x)
Ordering Information

Part number characters in blue represent the customer specific options. The other characters in the part number are fixed. Here are guidelines to select the correct output voltage.

1) For XTAL replacement applications that will keep the chipset oscillator enabled, configure the NanoDrive™ output for a swing similar to the XTAL, approximately 250mV.
   \[ \text{SiT1533AI-H4-AA2-32.768} \]

2) For XTAL replacement applications that will disable the chipset oscillator, configure the output with one of the following:
   - For \( VDD = 1.8V \): \[ \text{SiT1533AI-H4-D14-32.768} \]
   - For \( VDD > 1.8V \): \[ \text{SiT1533AI-H4-DCC-32.768} \]

The following examples illustrate how to select the appropriate temp range and output voltage requirements:

**Example 1: SiT1533AI-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:
  - \( "D" = \) DC-coupled receiver
  - \( "1" = V_{OH} = 1.1V \)
  - \( "4" = V_{OL} = 0.4V \)

**Example 2: SiT1533AC-H5-AA2-32.768**
- 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:
  - \( "A" = \) AC-coupled receiver
  - \( "A" = \) AC-coupled receiver
  - \( "2" = 250mV swing \)