Description

The SiT1532 is the world’s smallest, lowest power 32 kHz oscillator optimized for mobile and other battery-powered applications. SiTime’s silicon MEMS technology enables the smallest footprint and chip-scale packaging. This device reduces the 32 kHz footprint by as much as 85% compared to existing 2.0 x 1.2 mm SMD XTAL packages. Unlike XTALs, the SiT1532 oscillator output enables greater component placement flexibility and eliminates external load capacitors, thus saving additional component count and board space. And unlike standard oscillators, the SiT1532 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.

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.

Frequency Stability

The SiT1532 is factory calibrated (trimmed) to guarantee frequency stability to be less than 10 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 SiT1532 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 as shown in Figure 3.

Functionality is guaranteed over the 1.2V – 3.63V operating supply voltage range. However, frequency stability degrades below 1.5V and steadily degrades as it approaches the 1.2V minimum supply due to the internal regulator limitations. Between 1.2V and 1.5V, the frequency stability is 250 ppm max over temperature.

When measuring the SiT1532 output frequency with a frequency counter, it is important to make sure the counter's gate time is $\geq$100ms. The slow frequency of a 32kHz clock will give false readings with faster gate times.

Contact SiTime for applications that require a wider supply voltage range >3.63V or lower frequency options as low as 1Hz.

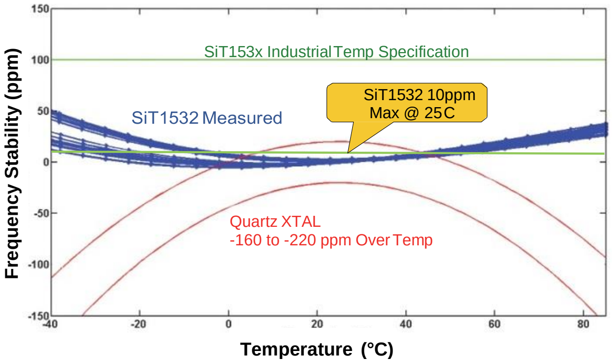


Figure 3. SiTime vs. Quartz

Power Supply Noise Immunity

In addition to eliminating external output load capacitors common with standard XTALs, The SiT1532 includes special internal 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 greater than ±150 mVpp magnitude and frequency components through 10 MHz.

Output Voltage

The SiT1532 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 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 SiT1532 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 750 mV. For example, 1.1V V_{OH} and 400 mV 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 SiT1532 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 800 mV swing, then simply choose the SiT1532 NanoDrive programming code “AA8” in the part number. It is important to note that the SiT1532 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.

Power-up

The SiT1532 starts-up to a valid output frequency within 300 ms (180 ms typ). To ensure the device starts-up within the specified limit, make sure the power-supply ramps-up in approximately 10 – 20 ms (to within 90% of Vdd). Start-up time is measured from the time Vdd reaches 1.5V. For applications that operate between 1.2V and 1.5V, the start-up time will be typically 50 ms longer over temperature.

SiT1532 NanoDrive™

Figure 4 shows a typical output waveform of the SiT1532 (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: SiT1532AI-J4-<u>D14</u>-32.768
- V_{OH} = 1.1V, V_{OL} = 0.4V ($V_{\_sw}$ = 0.70V)

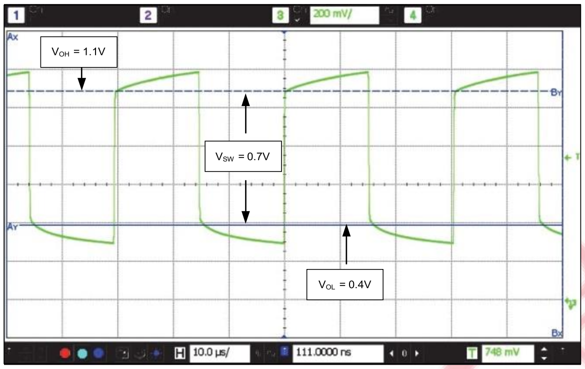


Figure 4. SiT1532AI-J4-<u>D14</u>-32.768 Output Waveform (10 pF load)

Table 4 shows the supported NanoDrive™ V_{OH}, V_{OL} factory programming options.

Table 4. Acceptable V_{OH}/V_{OL} NanoDrive™ Levels

NanoDrive	V_{OH} (V)	V_{OL} (V)	Swing (mV)	Comments
D26	1.2	0.6	600 ±55	1.8V logic compatible
D14	1.1	0.4	700 ±55	1.8V logic compatible
D74	0.7	0.4	300 ±55	XTAL compatible
AA3	n/a	n/a	300 ±55	XTAL compatible

The values listed in Table 4 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.

SiT1532 Full Swing LVCMOS Output

The SiT1532 can be factory programmed to generate full-swing LVCMOS levels. Figure 5 shows the typical waveform (Vdd = 1.8V) at room temperature into a 15 pF load.

Example:

- LVCMOS output part number coding is always **DCC**
- Example part number: SiT1532AI-J4-**<u>DCC</u>**-32.768

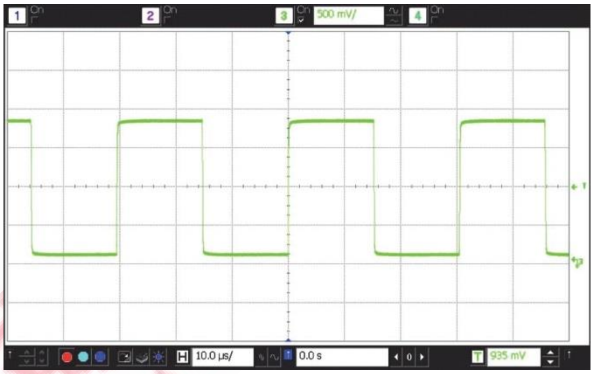


Figure 5. LVCMOS Waveform (Vdd = 1.8V) into 15 pF Load

Calculating Load Current

No Load Supply Current

When calculating no-load power for the SiT1532, 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} Core + (65nA/V)($Vout_{pp}$)

Example 1: Full-swing LVCMOS

- Vdd = 1.8V
- Idd Core = 900nA (typ)
- $Vout_{pp}$ = 1.8V

Supply Current = 900nA + (65nA/V)(1.8V) = 1017nA

Example 2: NanoDrive™ Reduced Swing

- Vdd = 1.8V
- Idd Core = 900nA (typ)
- $Vout_{pp}$ (D14) = $V_{OH} - V_{OL}$ = 1.1V - 0.4V = 700mV

Supply Current = 900nA + (65nA/V)(0.7V) = 946nA

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 (65nA/V*$Vout_{pp}$) + Load Current (C*V*F)

Example 1: Full-swing LVCMOS

- Vdd = 1.8V
- Idd Core = 900nA
- Load Capacitance = 10pF
- Idd Output Driver: (65nA/V)(1.8V) = 117nA
- Load Current: (10pF)(1.8V)(32.768kHz) = 590nA
- Total Current = 900nA + 117nA + 590nA = 1.6µA

Example 2: NanoDrive™ Reduced Swing

- Vdd = 1.8V
- Idd Core = 900nA
- Load Capacitance = 10pF
- $Vout_{pp}$ (D14): $V_{OH} - V_{OL}$ = 1.1V - 0.4V = 700mV
- Idd Output Driver: (65nA/V)(0.7V) = 46nA
- Load Current: (10pF)(0.7V)(32.768kHz) = 229nA
- Total Current = 900nA + 46nA + 229nA = 1.175µA

Typical Operating Curves

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

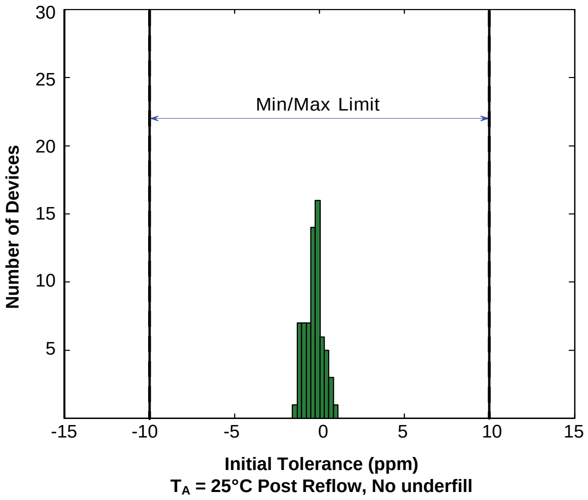


Figure 6. Initial Tolerance Histogram

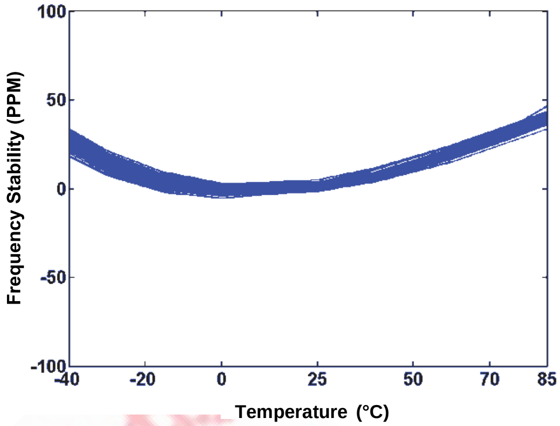


Figure 7. Frequency Stability Over Temperature

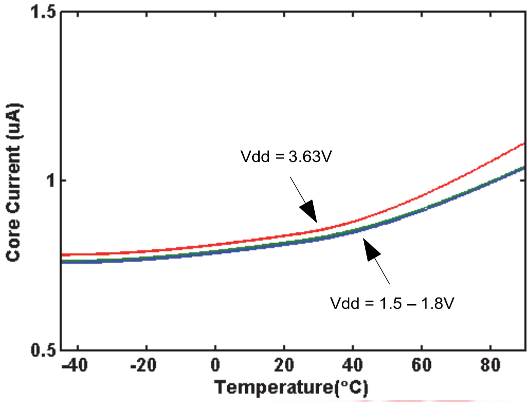


Figure 8. Core Current Over Temperature

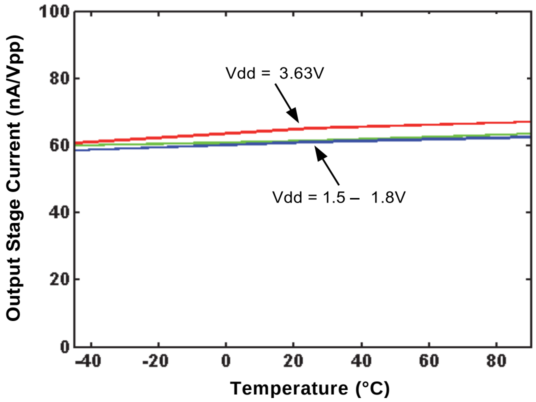


Figure 9. Output Stage Current Over Temperature

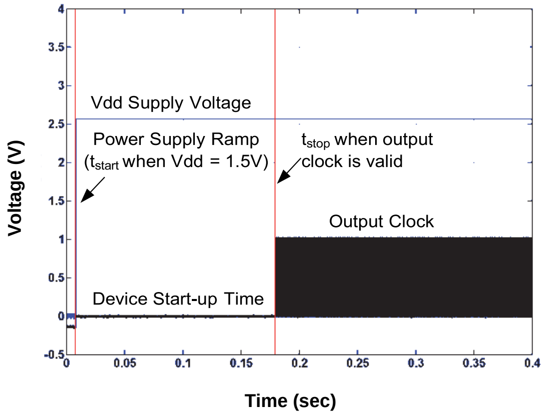


Figure 10. Start-up Time

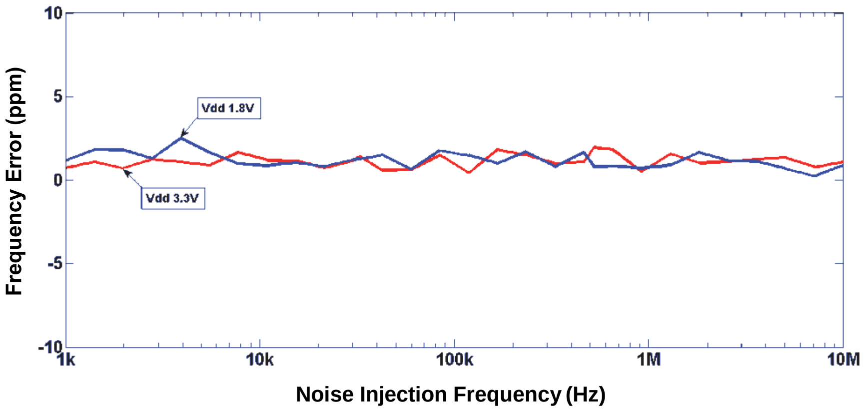


Figure 11. Power Supply Noise Rejection
(±150mV Noise)

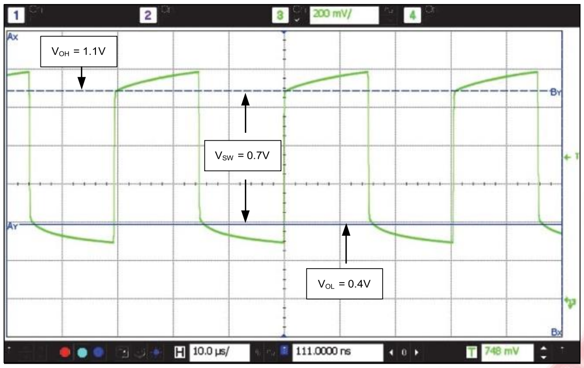


Figure 12. NanoDrive™ Output Waveform
(V_{OH} = 1.1V, V_{OL} = 0.4V; SiT1532AI-J4-D14-32.768)

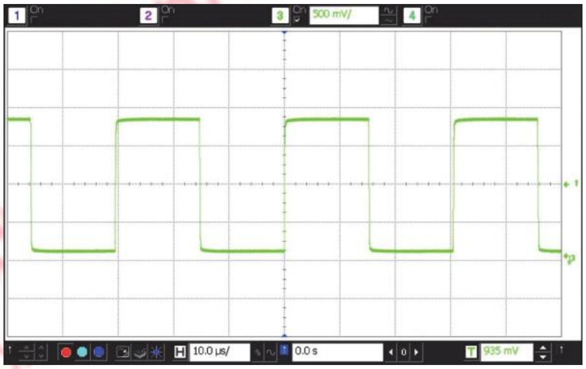
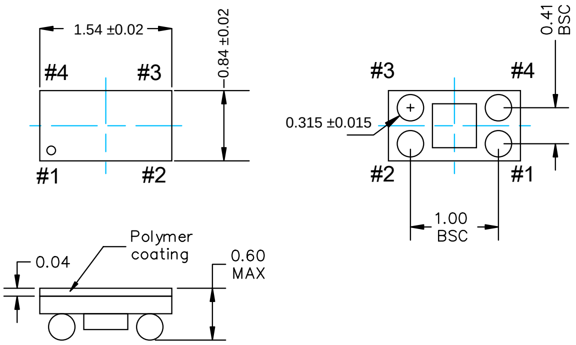
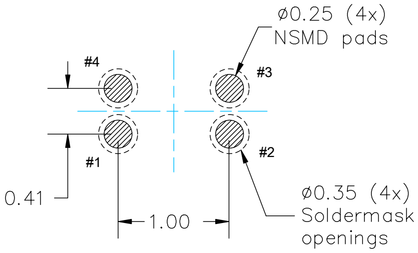


Figure 13. LVCMOS Output Waveform
(V_{swing} = 1.8V, SiT1532AI-J4-DCC-32.768)

Dimensions and Patterns

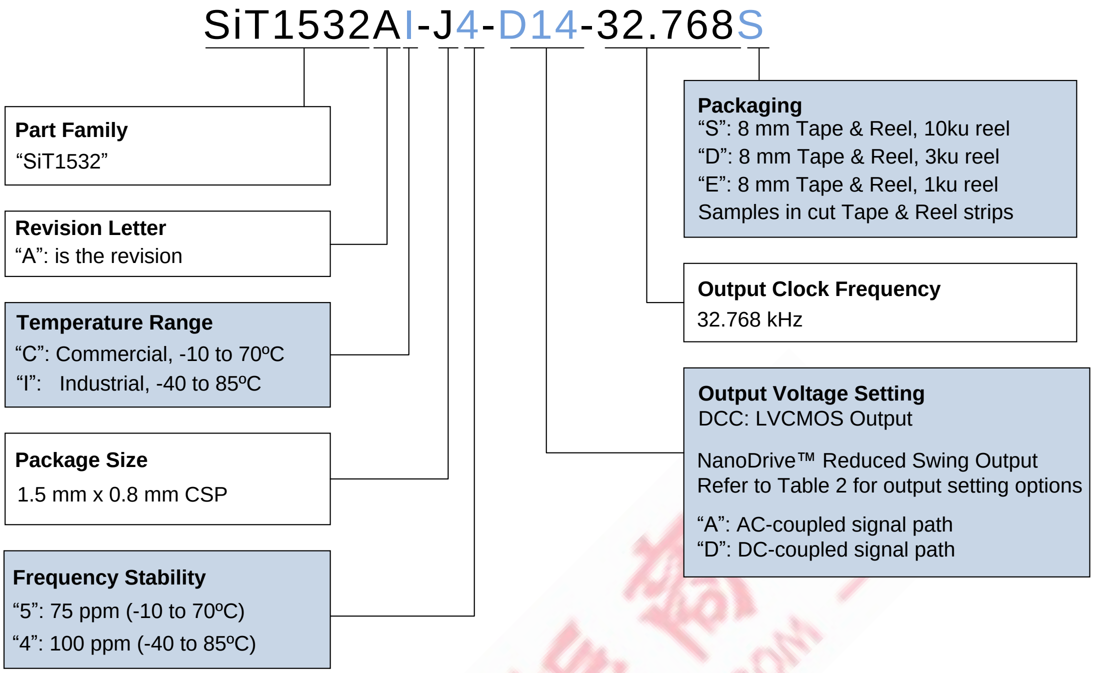
Package Size – Dimensions (Unit: mm)	Recommended Land Pattern (Unit: mm)
1.55 x 0.85 mm CSP  	 (soldermask openings shown with dashed line around NSMD pad) **Recommend 4-mil (0.1mm) stencil thickness**

Manufacturing Guidelines

1) No Ultrasonic Cleaning: Do not subject the SiT1532 to an ultrasonic cleaning environment. Permanent damage or long term reliability issues to the MEMS structure may occur.
2) Applying board-level underfill (BLUF) to the device is acceptable, but will cause a shift in the frequency tolerance, as specified in the datasheet electrical table. Tested with UF3810, UF3808, and FP4530 underfill.
3) Reflow profile, per JESD22-A113D.
4) For additional manufacturing guidelines and marking/tape-reel instructions, refer to SiTime Manufacturing Notes.

Ordering Information

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



SiT1532AI-J4-D14-32.768S

Part Family
"SiT1532"

Revision Letter
"A": is the revision

Temperature Range
"C": Commercial, -10 to 70ºC
"I": Industrial, -40 to 85ºC

Package Size
1.5 mm x 0.8 mm CSP

Frequency Stability
"5": 75 ppm (-10 to 70ºC)
"4": 100 ppm (-40 to 85ºC)

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 & Reel strips

Output Clock Frequency
32.768 kHz

Output Voltage Setting
DCC: LVCMOS Output

NanoDrive™ Reduced Swing Output
Refer to Table 2 for output setting options

"A": AC-coupled signal path
"D": DC-coupled signal path

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

Example 1: SiT1532AI-J4-D14-32.768

1) 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.
2) Output swing requirements:
    a) "D" = DC-coupled receiver
    b) "1" = V_{OH} = 1.1V
    c) "4" = V_{OL} = 400mV

Example 2: SiT1532AC-J5-AA3-32.768

1) 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.
2) Output swing requirements:
    a) "A" = AC-coupled receiver
    b) "A" = AC-coupled receiver
    c) "3" = 300mV swing

Table 5. Acceptable V_{OH}/V_{OL} NanoDrive™ Levels[5]

NanoDrive	V_{OH} (V)	V_{OL} (V)	Swing (mV)	Comments
D26	1.2	0.6	600 ±55	1.8V logic compatible
D14	1.1	0.4	700 ±55	1.8V logic compatible
D74	0.7	0.4	300 ±55	XTAL compatible
AA3	n/a	n/a	300 ±55	XTAL compatible

Note:

5. If these available options do not accommodate your application, contact Factory for other NanoDrive options.

Table 6. Revision History

Version	Release Date	Change Summary
1.0	09/02/2014	Rev 0.9 Preliminary to Rev 1.0 Production Release Updated start-up time specification Added typical operating plots Separated initial tolerance spec for condition with and without underfill Added Manufacturing Guidelines section
1.1	10/14/2014	Improved Start-up Time at Power-up spec Added 5pF LVCMOS rise/fall time spec
1.2	11/07/2014	Updated 5pF LVCMOS rise/fall time spec
1.25	06/03/2016	Updated NanoDrive section Updated test conditions in the absolute maximum table
1.26	01/16/2018	Updated SPL, page layout changes

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