

## DUAL FREQUENCY CRYSTAL OSCILLATOR (XO) 100 kHz TO 250 MHz

### Features

- Supports any frequency from 100 kHz to 250 MHz
- Two selectable output frequencies
- Low-jitter operation
- 2 to 4 week lead times
- Total stability includes 10-year aging
- Comprehensive production test coverage includes crystal ESR and DLD
- On-chip LDO regulator for power supply noise filtering
- 3.3, 2.5, or 1.8 V operation
- Differential (LVPECL, LVDS, HCSL) or CMOS output options
- Optional integrated 1:2 CMOS fanout buffer
- Runt suppression on OE and power on
- Industry standard 5x7, 3.2x5, and 2.5x3.2 mm packages
- Pb-free, RoHS compliant
- -40 to 85 °C operation

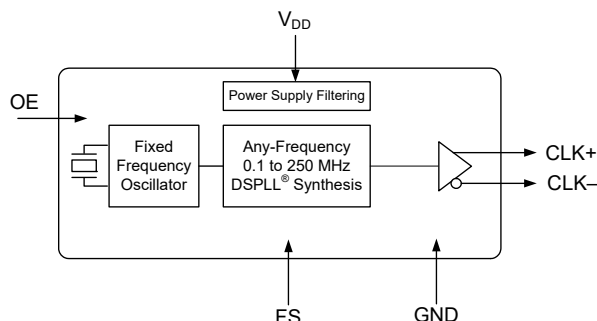
### Applications

- SONET/SDH/OTN
- Gigabit Ethernet
- Fibre Channel/SAS/SATA
- PCI Express
- Broadcast video
- Switches/routers
- Telecom
- FPGA/ASIC clock generation

### Description

The Si512/513 dual frequency XO utilizes Silicon Laboratories' advanced PLL technology to provide any frequency from 100 kHz to 250 MHz. Unlike a traditional XO where a different crystal is required for each output frequency, the Si512/513 uses one fixed crystal and Silicon Labs' proprietary any-frequency synthesizer to generate any frequency across this range. This IC-based approach allows the crystal resonator to provide enhanced reliability, improved mechanical robustness, and excellent stability. In addition, this solution provides superior supply noise rejection, simplifying low jitter clock generation in noisy environments. The Si512/513 is factory-configurable for a wide variety of user specifications, including frequency, supply voltage, output format, output enable polarity, and stability. Specific configurations are factory-programmed at time of shipment, eliminating long lead times and non-recurring engineering charges associated with custom frequency oscillators.

### Functional Block Diagram

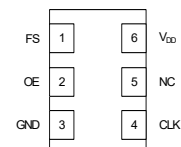


### Ordering Information:

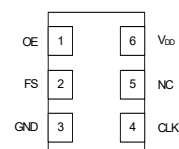
See page 13.

### Pin Assignments:

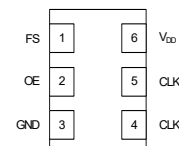
See page 12.



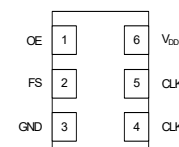
**Si512 CMOS Dual XO**



**Si513 CMOS Dual XO**



**Si512 LVDS/LVPECL/HCSL/CMOS Dual XO**



**Si513 LVDS/LVPECL/HCSL/CMOS Dual XO**

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## 1. Electrical Specifications

**Table 1. Operating Specifications**

$V_{DD} = 1.8\text{ V} \pm 5\%$ ,  $2.5\text{ or }3.3\text{ V} \pm 10\%$ ,  $T_A = -40\text{ to }+85\text{ }^{\circ}\text{C}$

| Parameter                                                                                                                                                                          | Symbol   | Test Condition              | Min                  | Typ | Max                  | Units              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------|----------------------|-----|----------------------|--------------------|
| Supply Voltage                                                                                                                                                                     | $V_{DD}$ | 3.3 V option                | 2.97                 | 3.3 | 3.63                 | V                  |
|                                                                                                                                                                                    |          | 2.5 V option                | 2.25                 | 2.5 | 2.75                 | V                  |
|                                                                                                                                                                                    |          | 1.8 V option                | 1.71                 | 1.8 | 1.89                 | V                  |
| Supply Current                                                                                                                                                                     | $I_{DD}$ | CMOS, 100 MHz, single-ended | —                    | 21  | 26                   | mA                 |
|                                                                                                                                                                                    |          | LVDS (output enabled)       | —                    | 19  | 23                   | mA                 |
|                                                                                                                                                                                    |          | LVPECL (output enabled)     | —                    | 39  | 43                   | mA                 |
|                                                                                                                                                                                    |          | HCSL (output enabled)       | —                    | 41  | 44                   | mA                 |
|                                                                                                                                                                                    |          | Tristate (output disabled)  | —                    | —   | 18                   | mA                 |
| FS, OE "1" Setting                                                                                                                                                                 | $V_{IH}$ | See Note                    | $0.80 \times V_{DD}$ | —   | —                    | V                  |
| FS, OE "0" Setting                                                                                                                                                                 | $V_{IL}$ | See Note                    | —                    | —   | $0.20 \times V_{DD}$ | V                  |
| FS, OE Internal Pull-Up/Pull-Down Resistor*                                                                                                                                        | $R_I$    |                             | —                    | 45  | —                    | $k\Omega$          |
| Operating Temperature                                                                                                                                                              | $T_A$    |                             | -40                  | —   | 85                   | $^{\circ}\text{C}$ |
| <b>Note:</b> Active high and active low polarity OE options available. Active high uses internal pull-up. Active low uses internal pull-down. See ordering information on page 12. |          |                             |                      |     |                      |                    |

**Table 2. Output Clock Frequency Characteristics**

$V_{DD} = 1.8\text{ V} \pm 5\%$ ,  $2.5\text{ V} \pm 10\%$ ,  $T_A = -40\text{ to }+85\text{ }^\circ\text{C}$

| Parameter                                                                                                                                                                                                         | Symbol    | Test Condition                                                      | Min  | Typ | Max   | Units         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------------------------------------------------------------|------|-----|-------|---------------|
| Nominal Frequency                                                                                                                                                                                                 | $F_O$     | CMOS, Dual CMOS                                                     | 0.1  | —   | 212.5 | MHz           |
|                                                                                                                                                                                                                   | $F_O$     | LVDS/LVPECL/HCSL                                                    | 0.1  | —   | 250   | MHz           |
| Total Stability*                                                                                                                                                                                                  |           | Frequency Stability Grade C                                         | -30  |     | +30   | ppm           |
|                                                                                                                                                                                                                   |           | Frequency Stability Grade B                                         | -50  |     | +50   | ppm           |
|                                                                                                                                                                                                                   |           | Frequency Stability Grade A                                         | -100 |     | +100  | ppm           |
| Temperature Stability                                                                                                                                                                                             |           | Frequency Stability Grade C                                         | -20  |     | +20   | ppm           |
|                                                                                                                                                                                                                   |           | Frequency Stability Grade B                                         | -25  |     | +25   | ppm           |
|                                                                                                                                                                                                                   |           | Frequency Stability Grade A                                         | -50  |     | +50   | ppm           |
| Startup Time                                                                                                                                                                                                      | $T_{SU}$  | Minimum $V_{DD}$ to output frequency ( $F_O$ ) within specification | —    | —   | 10    | ms            |
| Disable Time                                                                                                                                                                                                      | $T_D$     | $F_O \geq 10\text{ MHz}$                                            | —    | —   | 5     | $\mu\text{s}$ |
|                                                                                                                                                                                                                   |           | $F_O < 10\text{ MHz}$                                               | —    | —   | 40    | $\mu\text{s}$ |
| Enable Time                                                                                                                                                                                                       | $T_E$     | $F_O \geq 10\text{ MHz}$                                            | —    | —   | 20    | $\mu\text{s}$ |
|                                                                                                                                                                                                                   |           | $F_O < 10\text{ MHz}$                                               | —    | —   | 60    | $\mu\text{s}$ |
| Settling Time after FS Change                                                                                                                                                                                     | $t_{FRQ}$ |                                                                     | —    | —   | 10    | ms            |
| <b>*Note:</b> Total stability includes initial accuracy, operating temperature, supply voltage change, load change, shock and vibration (not under operation), and 10 years aging at $40\text{ }^\circ\text{C}$ . |           |                                                                     |      |     |       |               |

**Table 3. Output Clock Levels and Symmetry** $V_{DD} = 1.8\text{ V} \pm 5\%$ , 2.5 or 3.3 V  $\pm 10\%$ ,  $T_A = -40$  to  $+85\text{ }^{\circ}\text{C}$ 

| Parameter                                                  | Symbol    | Test Condition                                          | Min                  | Typ                     | Max                  | Units      |
|------------------------------------------------------------|-----------|---------------------------------------------------------|----------------------|-------------------------|----------------------|------------|
| CMOS Output Logic High                                     | $V_{OH}$  |                                                         | $0.85 \times V_{DD}$ | —                       | —                    | V          |
| CMOS Output Logic Low                                      | $V_{OL}$  |                                                         | —                    | —                       | $0.15 \times V_{DD}$ | V          |
| CMOS Output Logic High Drive                               | $I_{OH}$  | 3.3 V                                                   | –8                   | —                       | —                    | mA         |
|                                                            |           | 2.5 V                                                   | –6                   | —                       | —                    | mA         |
|                                                            |           | 1.8 V                                                   | –4                   | —                       | —                    | mA         |
| CMOS Output Logic Low Drive                                | $I_{OL}$  | 3.3 V                                                   | 8                    | —                       | —                    | mA         |
|                                                            |           | 2.5 V                                                   | 6                    | —                       | —                    | mA         |
|                                                            |           | 1.8 V                                                   | 4                    | —                       | —                    | mA         |
| CMOS Output Rise/Fall Time<br>(20 to 80% $V_{DD}$ )        | $T_R/T_F$ | 0.1 to 125 MHz,<br>$C_L = 15\text{ pF}$                 | —                    | 0.8                     | 1.2                  | ns         |
|                                                            |           | 0.1 to 212.5 MHz,<br>$C_L = \text{no load}$             | —                    | 0.6                     | 0.9                  | ns         |
| LVPECL/HCSL Output Rise/Fall Time<br>(20 to 80% $V_{DD}$ ) | $T_R/T_F$ |                                                         | —                    | —                       | 565                  | ps         |
| LVDS Output Rise/Fall Time<br>(20 to 80% $V_{DD}$ )        | $T_R/T_F$ |                                                         | —                    | —                       | 800                  | ps         |
| LVPECL Output Common Mode                                  | $V_{OC}$  | $50\ \Omega$ to $V_{DD} - 2\text{ V}$ ,<br>single-ended | —                    | $V_{DD} - 1.4\text{ V}$ | —                    | V          |
| LVPECL Output Swing                                        | $V_O$     | $50\ \Omega$ to $V_{DD} - 2\text{ V}$ ,<br>single-ended | 0.55                 | 0.8                     | 0.90                 | $V_{PPSE}$ |
| LVDS Output Common Mode                                    | $V_{OC}$  | 100 $\Omega$ line-line, $V_{DD} = 3.3/2.5\text{ V}$     | 1.13                 | 1.23                    | 1.33                 | V          |
|                                                            |           | 100 $\Omega$ line-line, $V_{DD} = 1.8\text{ V}$         | 0.83                 | 0.92                    | 1.00                 | V          |
| LVDS Output Swing                                          | $V_O$     | Single-ended, 100 $\Omega$ differential<br>termination  | 0.25                 | 0.35                    | 0.45                 | $V_{PPSE}$ |
| HCSL Output Common Mode                                    | $V_{OC}$  | $50\ \Omega$ to ground                                  | 0.35                 | 0.38                    | 0.42                 | V          |
| HCSL Output Swing                                          | $V_O$     | Single-ended                                            | 0.58                 | 0.73                    | 0.85                 | $V_{PPSE}$ |
| Duty Cycle                                                 | DC        | All Output Formats                                      | 48                   | 50                      | 52                   | %          |

**Table 4. Output Clock Jitter and Phase Noise (LVPECL)**

$V_{DD} = 2.5$  or  $3.3$  V  $\pm 10\%$ ,  $T_A = -40$  to  $+85$  °C; Output Format = LVPECL

| Parameter                                                           | Symbol   | Test Condition                                                     | Min | Typ  | Max | Units  |
|---------------------------------------------------------------------|----------|--------------------------------------------------------------------|-----|------|-----|--------|
| Period Jitter (RMS)                                                 | JPRMS    | 10k samples <sup>1</sup>                                           | —   | —    | 1.3 | ps     |
| Period Jitter (Pk-Pk)                                               | JPPKPK   | 10k samples <sup>1</sup>                                           | —   | —    | 11  | ps     |
| Phase Jitter (RMS)                                                  | $\phi J$ | 1.875 MHz to 20 MHz integration bandwidth <sup>2</sup> (brickwall) | —   | 0.31 | 0.5 | ps     |
|                                                                     |          | 12 kHz to 20 MHz integration bandwidth (brickwall) <sup>2</sup>    | —   | 0.8  | 1.0 | ps     |
| Phase Noise, 156.25 MHz                                             | $\phi N$ | 100 Hz                                                             | —   | –86  | —   | dBc/Hz |
|                                                                     |          | 1 kHz                                                              | —   | –109 | —   | dBc/Hz |
|                                                                     |          | 10 kHz                                                             | —   | –116 | —   | dBc/Hz |
|                                                                     |          | 100 kHz                                                            | —   | –123 | —   | dBc/Hz |
|                                                                     |          | 1 MHz                                                              | —   | –136 | —   | dBc/Hz |
| Additive RMS Jitter Due to External Power Supply Noise <sup>3</sup> | JPSR     | 10 kHz sinusoidal noise                                            | —   | 3.0  | —   | ps     |
|                                                                     |          | 100 kHz sinusoidal noise                                           | —   | 3.5  | —   | ps     |
|                                                                     |          | 500 kHz sinusoidal noise                                           | —   | 3.5  | —   | ps     |
|                                                                     |          | 1 MHz sinusoidal noise                                             | —   | 3.5  | —   | ps     |
| Spurious                                                            | SPR      | LVPECL output, 156.25 MHz, offset > 10 kHz                         | —   | –75  | —   | dBc    |

**Notes:**

1. Applies to output frequencies: 74.17582, 74.25, 75, 77.76, 100, 106.25, 125, 148.35165, 148.5, 150, 155.52, 156.25, 212.5, 250 MHz.
2. Applies to output frequencies: 100, 106.25, 125, 148.35165, 148.5, 150, 155.52, 156.25, 212.5 and 250 MHz.
3. 156.25 MHz. Increase in jitter on output clock due to sinewave noise added to VDD (2.5/3.3 V = 100 mVPP).

**Table 5. Output Clock Jitter and Phase Noise (LVDS)**

$V_{DD} = 1.8 \text{ V} \pm 5\%$ ,  $2.5 \text{ or } 3.3 \text{ V} \pm 10\%$ ,  $T_A = -40 \text{ to } +85 \text{ }^\circ\text{C}$ ; Output Format = LVDS

| Parameter               | Symbol   | Test Condition                                                     | Min | Typ  | Max  | Unit   |
|-------------------------|----------|--------------------------------------------------------------------|-----|------|------|--------|
| Period Jitter (RMS)     | JPRMS    | 10k samples <sup>1</sup>                                           | —   | —    | 2.1  | ps     |
| Period Jitter (Pk-Pk)   | JPPKPK   | 10k samples <sup>1</sup>                                           | —   | —    | 18   | ps     |
| Phase Jitter (RMS)      | $\phi J$ | 1.875 MHz to 20 MHz integration bandwidth <sup>2</sup> (brickwall) | —   | 0.25 | 0.55 | ps     |
|                         |          | 12 kHz to 20 MHz integration bandwidth <sup>2</sup> (brickwall)    | —   | 0.8  | 1.0  | ps     |
| Phase Noise, 156.25 MHz | $\phi N$ | 100 Hz                                                             | —   | −86  | —    | dBc/Hz |
|                         |          | 1 kHz                                                              | —   | −109 | —    | dBc/Hz |
|                         |          | 10 kHz                                                             | —   | −116 | —    | dBc/Hz |
|                         |          | 100 kHz                                                            | —   | −123 | —    | dBc/Hz |
|                         |          | 1 MHz                                                              | —   | −136 | —    | dBc/Hz |
| Spurious                | SPR      | LVPECL output, 156.25 MHz, offset > 10 kHz                         | —   | −75  | —    | dBc    |

**Notes:**

1. Applies to output frequencies: 74.17582, 74.25, 75, 77.76, 100, 106.25, 125, 148.35165, 148.5, 150, 155.52, 156.25, 212.5, 250 MHz.
2. Applies to output frequencies: 100, 106.25, 125, 148.35165, 148.5, 150, 155.52, 156.25, 212.5 and 250 MHz.

**Table 6. Output Clock Jitter and Phase Noise (HCSL)**

$V_{DD} = 1.8 \text{ V} \pm 5\%$ ,  $2.5 \text{ or } 3.3 \text{ V} \pm 10\%$ ,  $T_A = -40 \text{ to } +85 \text{ }^\circ\text{C}$ ; Output Format = HCSL

| Parameter               | Symbol   | Test Condition                                         | Min | Typ  | Max  | Unit   |
|-------------------------|----------|--------------------------------------------------------|-----|------|------|--------|
| Period Jitter (RMS)     | JPRMS    | 10k samples*                                           | —   | —    | 1.2  | ps     |
| Period Jitter (Pk-Pk)   | JPPKPK   | 10k samples*                                           | —   | —    | 11   | ps     |
| Phase Jitter (RMS)      | $\phi J$ | 1.875 MHz to 20 MHz integration bandwidth* (brickwall) | —   | 0.25 | 0.30 | ps     |
|                         |          | 12 kHz to 20 MHz integration bandwidth* (brickwall)    | —   | 0.8  | 1.0  | ps     |
| Phase Noise, 156.25 MHz | $\phi N$ | 100 Hz                                                 | —   | −90  | —    | dBc/Hz |
|                         |          | 1 kHz                                                  | —   | −112 | —    | dBc/Hz |
|                         |          | 10 kHz                                                 | —   | −120 | —    | dBc/Hz |
|                         |          | 100 kHz                                                | —   | −127 | —    | dBc/Hz |
|                         |          | 1 MHz                                                  | —   | −140 | —    | dBc/Hz |
| Spurious                | SPR      | LVPECL output, 156.25 MHz, offset>10 kHz               | —   | −75  | —    | dBc    |

**\*Note:** Applies to an output frequency of 100 MHz.

**Table 7. Output Clock Jitter and Phase Noise (CMOS, Dual CMOS)**

$V_{DD} = 1.8 \text{ V} \pm 5\%$ ,  $2.5 \text{ or } 3.3 \text{ V} \pm 10\%$ ,  $T_A = -40 \text{ to } +85 \text{ }^\circ\text{C}$ ; Output Format = CMOS, Dual CMOS

| Parameter               | Symbol   | Test Condition                                                     | Min | Typ  | Max  | Unit   |
|-------------------------|----------|--------------------------------------------------------------------|-----|------|------|--------|
| Phase Jitter (RMS)      | $\phi J$ | 1.875 MHz to 20 MHz integration bandwidth <sup>2</sup> (brickwall) | —   | 0.25 | 0.35 | ps     |
|                         |          | 12 kHz to 20 MHz integration bandwidth <sup>2</sup> (brickwall)    | —   | 0.8  | 1.0  | ps     |
| Phase Noise, 156.25 MHz | $\phi N$ | 100 Hz                                                             | —   | −86  | —    | dBc/Hz |
|                         |          | 1 kHz                                                              | —   | −108 | —    | dBc/Hz |
|                         |          | 10 kHz                                                             | —   | −115 | —    | dBc/Hz |
|                         |          | 100 kHz                                                            | —   | −123 | —    | dBc/Hz |
|                         |          | 1 MHz                                                              | —   | −136 | —    | dBc/Hz |
| Spurious                | SPR      | LVPECL output, 156.25 MHz, offset>10 kHz                           | —   | −75  | —    | dBc    |

**Notes:**

1. Applies to output frequencies: 74.17582, 74.25, 75, 77.76, 100, 106.25, 125, 148.35165, 148.5, 150, 155.52, 156.25, 212.5 MHz.
2. Applies to output frequencies: 100, 106.25, 125, 148.35165, 148.5, 150, 155.52, 156.25, 212.5 MHz.

**Table 8. Environmental Compliance and Package Information**

| Parameter                 | Conditions/Test Method   |
|---------------------------|--------------------------|
| Mechanical Shock          | MIL-STD-883, Method 2002 |
| Mechanical Vibration      | MIL-STD-883, Method 2007 |
| Solderability             | MIL-STD-883, Method 2003 |
| Gross and Fine Leak       | MIL-STD-883, Method 1014 |
| Resistance to Solder Heat | MIL-STD-883, Method 2036 |
| Contact Pads              | Gold over Nickel         |

**Table 9. Thermal Characteristics**

| Parameter                                         | Symbol        | Test Condition | Value | Unit |
|---------------------------------------------------|---------------|----------------|-------|------|
| CLCC, Thermal Resistance Junction to Ambient      | $\theta_{JA}$ | Still air      | 110   | °C/W |
| 2.5x3.2mm, Thermal Resistance Junction to Ambient | $\theta_{JA}$ | Still air      | 164   | °C/W |

**Table 10. Absolute Maximum Ratings<sup>1</sup>**

| Parameter                                                               | Symbol     | Rating                 | Units |
|-------------------------------------------------------------------------|------------|------------------------|-------|
| Maximum Operating Temperature                                           | $T_{AMAX}$ | 85                     | °C    |
| Storage Temperature                                                     | $T_S$      | –55 to +125            | °C    |
| Supply Voltage                                                          | $V_{DD}$   | –0.5 to +3.8           | V     |
| Input Voltage (any input pin)                                           | $V_I$      | –0.5 to $V_{DD} + 0.3$ | V     |
| ESD Sensitivity (HBM, per JESD22-A114)                                  | HBM        | 2                      | kV    |
| Soldering Temperature (Pb-free profile) <sup>2</sup>                    | $T_{PEAK}$ | 260                    | °C    |
| Soldering Temperature Time at $T_{PEAK}$ (Pb-free profile) <sup>2</sup> | $T_P$      | 20–40                  | sec   |

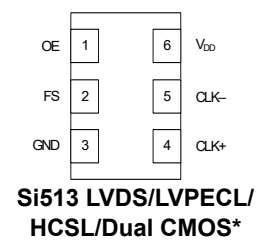
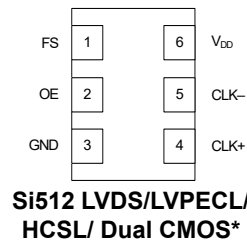
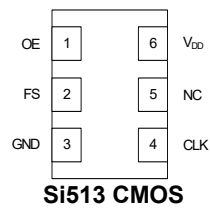
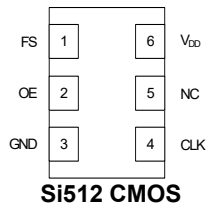
**Notes:**

1. Stresses beyond those listed in this table may cause permanent damage to the device. Functional operation or specification compliance is not implied at these conditions. Exposure to maximum rating conditions for extended periods may affect device reliability.
2. The device is compliant with JEDEC J-STD-020E.

## 2. Solder Reflow and Rework Requirements for 2.5x3.2 mm Packages

Reflow of Silicon Labs' components should be done in a manner consistent with the IPC/JEDEC J-STD-20E standard. The temperature of the package is not to exceed the classification Temperature provided in the standard. The part should not be within -5°C of the classification or peak reflow temperature ( $T_{PEAK}$ ) for longer than 30 seconds. Key to maintaining the integrity of the component is providing uniform heating and cooling of the part during reflow and rework. Uniform heating is achieved through having a preheat soak and controlling the temperature ramps in the process. J-STD-20E provides minimum and maximum temperatures and times for the preheat/Soak step that need to be followed, even for rework. The entire assembly area should be heated during rework. Hot air should be flowed from both the bottom of the board and the top of the component. Heating from the top only will cause un-even heating of component and can lead to part integrity issues. Temperature Ramp-up rate are not to exceed 3°C/second. Temperature ramp-down rates from peak to final temperature are not to exceed 6°C/second. Time from 25°C to peak temperature is not to exceed 8 min for Pb-free solders.

### 3. Pin Descriptions



**\*Note:** Supports integrated 1:2 CMOS buffer. See section 2.1 “3.1. Dual CMOS Buffer” and section 3 “4. Ordering Information”.

**Table 11. Si512 Pin Descriptions (CMOS, OE Pin 2)**

| Pin | Name            | CMOS Function                                                                                              |
|-----|-----------------|------------------------------------------------------------------------------------------------------------|
| 1   | FS              | Frequency Selected.<br>0 = First frequency selected.<br>1 = Second frequency selected.                     |
| 2   | OE              | Output Enable. Internal pull-up for OE active high. Pull-down for OE active low. See ordering information. |
| 3   | GND             | Electrical and Case Ground.                                                                                |
| 4   | CLK             | Clock Output.                                                                                              |
| 5   | NC              | No connect. Make no external connection to this pin.                                                       |
| 6   | V <sub>DD</sub> | Power Supply Voltage.                                                                                      |

**Table 12. Si513 Pin Descriptions (CMOS, OE Pin 1)**

| Pin | Name            | CMOS Function                                                                                              |
|-----|-----------------|------------------------------------------------------------------------------------------------------------|
| 1   | OE              | Output Enable. Internal pull-up for OE active high. Pull-down for OE active low. See ordering information. |
| 2   | FS              | Frequency Selected.<br>0 = First frequency selected.<br>1 = Second frequency selected.                     |
| 3   | GND             | Electrical and Case Ground.                                                                                |
| 4   | CLK             | Clock Output.                                                                                              |
| 5   | NC              | No connect. Make no external connection to this pin.                                                       |
| 6   | V <sub>DD</sub> | Power Supply Voltage.                                                                                      |

**Table 13. Si512 Pin Descriptions (OE Pin 2)**

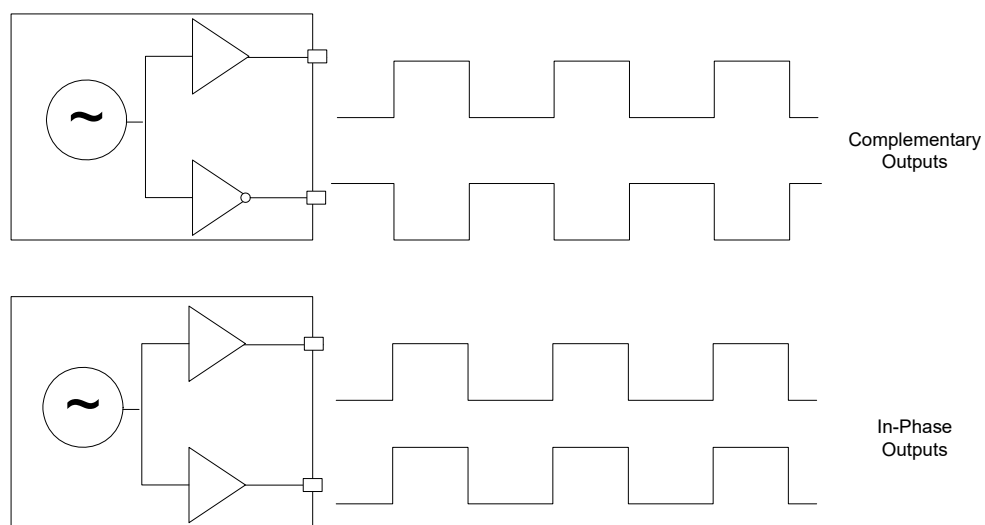
| Pin | Name            | LVPECL/LVDS/HCSL/Dual CMOS Function                                                                        |
|-----|-----------------|------------------------------------------------------------------------------------------------------------|
| 1   | FS              | Frequency Selected.<br>0 = First frequency selected.<br>1 = Second frequency selected.                     |
| 2   | OE              | Output Enable. Internal pull-up for OE active high. Pull-down for OE active low. See ordering information. |
| 3   | GND             | Electrical and Case Ground.                                                                                |
| 4   | CLK+            | Clock Output.                                                                                              |
| 5   | CLK-            | Complementary Clock Output.                                                                                |
| 6   | V <sub>DD</sub> | Power Supply Voltage.                                                                                      |

**Table 14. Si513 Pin Descriptions (OE Pin 1)**

| Pin | Name            | LVPECL/LVDS/HCSL/Dual CMOS Function                                                                        |
|-----|-----------------|------------------------------------------------------------------------------------------------------------|
| 1   | OE              | Output Enable. Internal pull-up for OE active high. Pull-down for OE active low. See ordering information. |
| 2   | FS              | Frequency Selected.<br>0 = First frequency selected.<br>1 = Second frequency selected.                     |
| 3   | GND             | Electrical and Case Ground.                                                                                |
| 4   | CLK+            | Clock Output.                                                                                              |
| 5   | CLK–            | Complementary Clock Output.                                                                                |
| 6   | V <sub>DD</sub> | Power Supply Voltage.                                                                                      |

## 3.1. Dual CMOS Buffer

Dual CMOS output format ordering options support either complementary or in-phase output signals. This feature enables replacement of multiple XOs with a single Si512/13 device.



**Figure 1. Integrated 1:2 CMOS Buffer Supports Complementary or In-Phase Outputs**

## 4. Ordering Information

The Si512/513 supports a wide variety of options including frequency, stability, output format, and  $V_{DD}$ . Specific device configurations are programmed into the Si512/513 at time of shipment. Configurations can be specified using the Part Number Configuration chart below. Silicon Labs provides a web browser-based part number configuration utility to simplify this process. To access this tool refer to [www.silabs.com/oscillators](http://www.silabs.com/oscillators) and click "Customize" in the product table. The Si512/513 XO series is supplied in industry-standard, RoHS compliant, lead-free, 2.5 x 3.2 mm, 3.2 x 5.0 mm, and 5 x 7 mm packages. Tape and reel packaging is an ordering option.

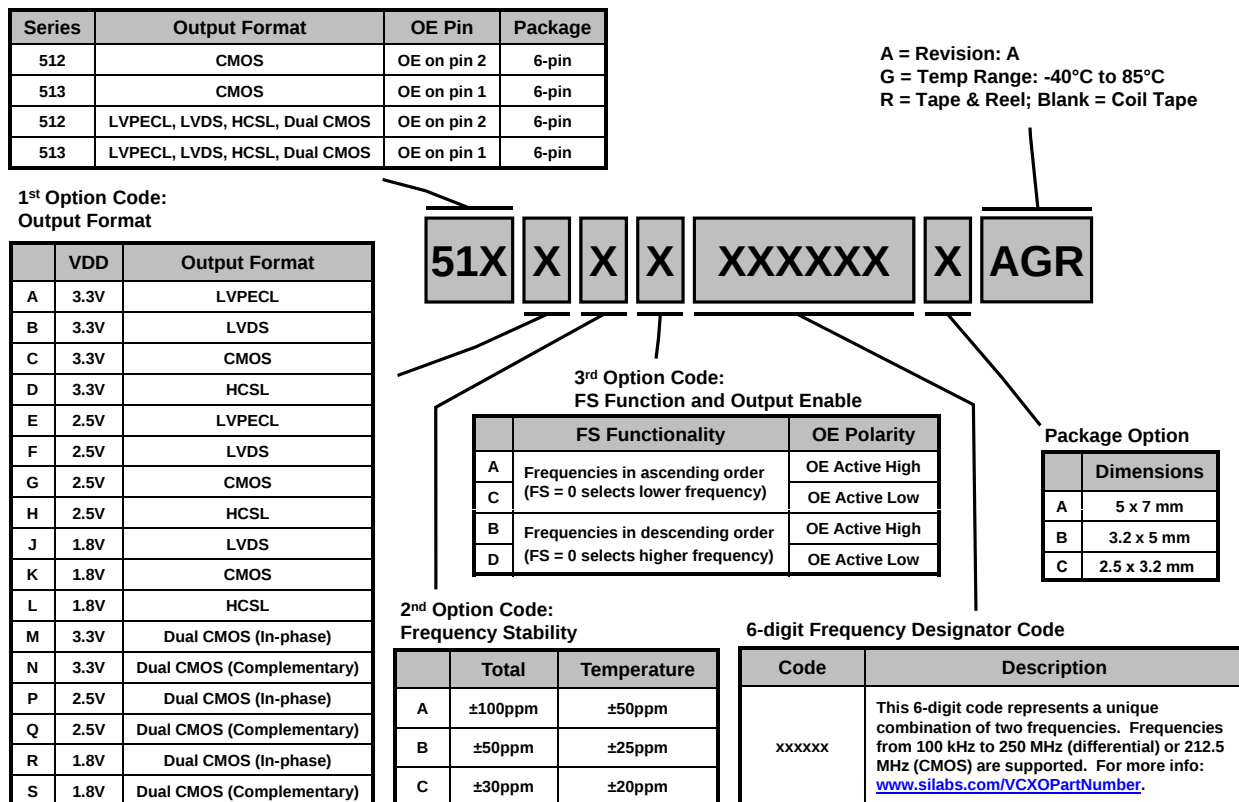


Figure 2. Part Number Convention

Example part number: 512PCA000104BAGR:

The series prefix, 512, indicates the device is a Dual CMOS XO with the OE function on pin 2. The output format code P specifies the outputs are dual in-phase CMOS with a 2.5 V supply. The frequency stability code C indicates a total stability of ± 30 ppm. The frequency select and output enable code A specifies that the two frequencies are listed in ascending order, with the output frequency  $f_0$  (the lower frequency) selected when FS=0, and  $f_1$  (the higher frequency) selected when FS = 1. The device's output enable polarity is active High.

The six-digit code is 000104. As specified by the part number lookup utility at [www.silabs.com/VCXOPartNumber](http://www.silabs.com/VCXOPartNumber),  $f_0$  is 155.52 MHz (the lower frequency) and  $f_1$  is 156.25 MHz (the higher frequency). The package code B refers to the 3.2 x 5 mm footprint with six pins. The last A refers to the product revision, G indicates the temperature range (-40 to +85°C), and R means the device ships in tape and reel format.

**Note:** CMOS and Dual CMOS maximum frequency is 212.5 MHz.

## 5. Package Outline Diagram, 5 x 7 mm, 6-pin

Figure 3 illustrates the package details for the 5 x 7 mm Si512/513. Table 15 lists the values for the dimensions shown in the illustration.

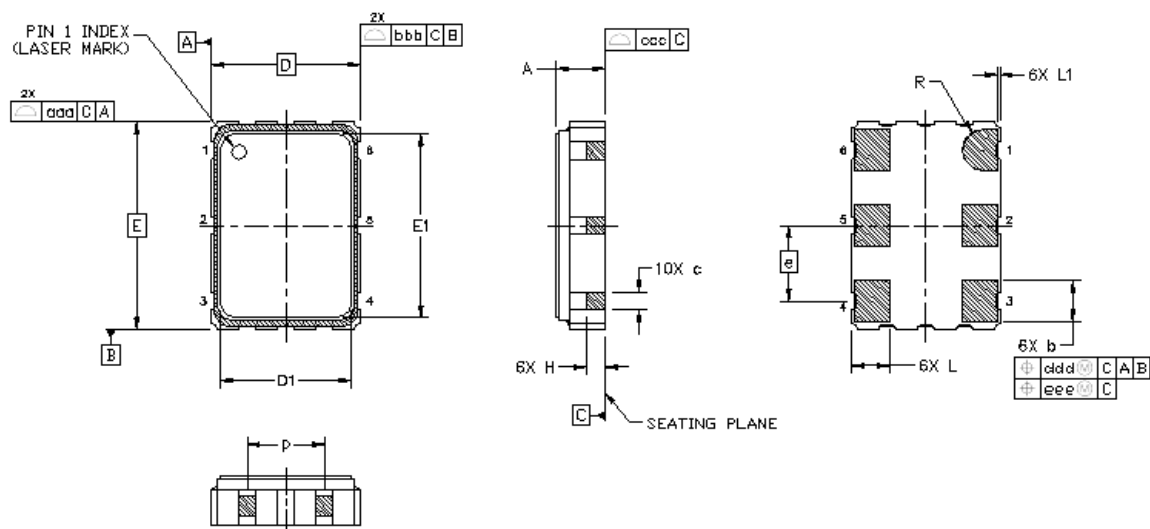


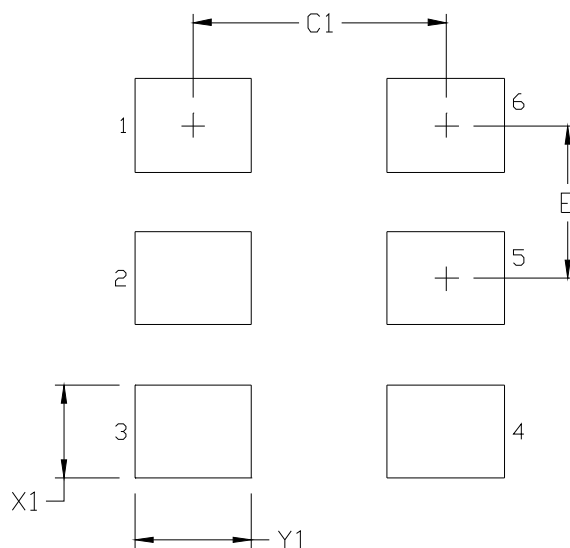
Figure 3. Si512/513 Outline Diagram

Table 15. Package Diagram Dimensions (mm)

| Dimension                                                               | Min       | Nom  | Max  |
|-------------------------------------------------------------------------|-----------|------|------|
| A                                                                       | 1.50      | 1.65 | 1.80 |
| b                                                                       | 1.30      | 1.40 | 1.50 |
| c                                                                       | 0.50      | 0.60 | 0.70 |
| D                                                                       | 5.00 BSC. |      |      |
| D1                                                                      | 4.30      | 4.40 | 4.50 |
| e                                                                       | 2.54 BSC. |      |      |
| E                                                                       | 7.00 BSC. |      |      |
| E1                                                                      | 6.10      | 6.20 | 6.30 |
| H                                                                       | 0.55      | 0.65 | 0.75 |
| L                                                                       | 1.17      | 1.27 | 1.37 |
| L1                                                                      | 0.05      | 0.10 | 0.15 |
| p                                                                       | 1.80      | —    | 2.60 |
| R                                                                       | 0.70 REF. |      |      |
| aaa                                                                     | 0.15      |      |      |
| bbb                                                                     | 0.15      |      |      |
| ccc                                                                     | 0.10      |      |      |
| ddd                                                                     | 0.10      |      |      |
| eee                                                                     | 0.05      |      |      |
| <b>Notes:</b>                                                           |           |      |      |
| 1. All dimensions shown are in millimeters (mm) unless otherwise noted. |           |      |      |
| 2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.                   |           |      |      |

## 6. PCB Land Pattern: 5 x 7 mm, 6-pin

Figure 4 illustrates the 5 x 7 mm PCB land pattern for the Si512/513. Table 16 lists the values for the dimensions shown in the illustration.



**Figure 4. Si512/513 PCB Land Pattern**

**Table 16. PCB Land Pattern Dimensions (mm)**

| Dimension | (mm) |
|-----------|------|
| C1        | 4.20 |
| E         | 2.54 |
| X1        | 1.55 |
| Y1        | 1.95 |

**Notes:**

**General**

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Dimensioning and Tolerancing is per the ANSI Y14.5M-1994 specification.
3. This Land Pattern Design is based on the IPC-7351 guidelines.
4. All dimensions shown are at Maximum Material Condition (MMC). Least Material Condition (LMC) is calculated based on a Fabrication Allowance of 0.05 mm.

**Solder Mask Design**

5. All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60  $\mu$ m minimum, all the way around the pad.

**Stencil Design**

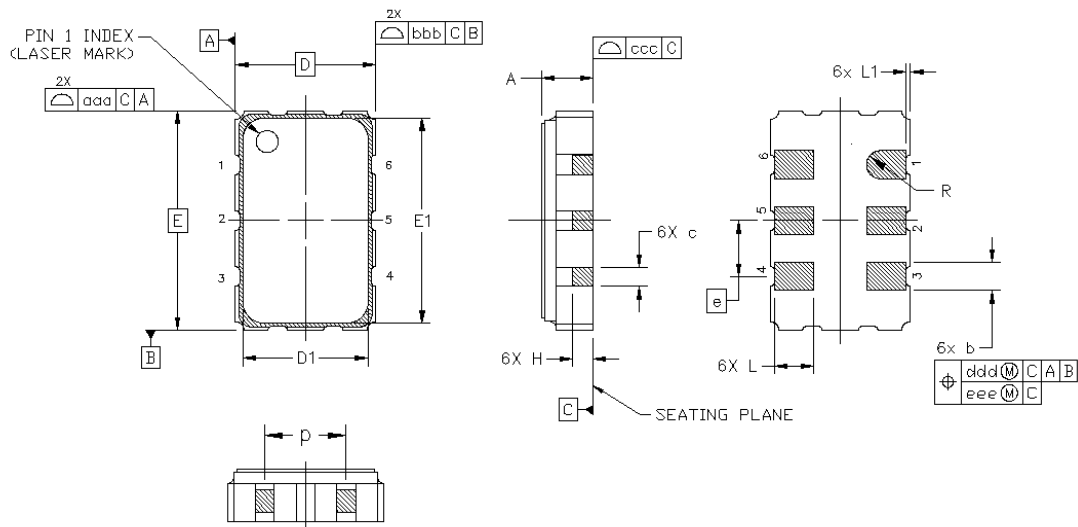
6. A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
7. The stencil thickness should be 0.125 mm (5 mils).
8. The ratio of stencil aperture to land pad size should be 1:1.

**Card Assembly**

9. A No-Clean, Type-3 solder paste is recommended.
10. The recommended card reflow profile is per the JEDEC/IPC J-STD-020C specification for Small Body Components.

## 7. Package Outline Diagram: 3.2 x 5.0 mm, 6-pin

Figure 5 illustrates the package details for the 3.2 x 5.0 mm Si512/513. Table 17 lists the values for the dimensions shown in the illustration.



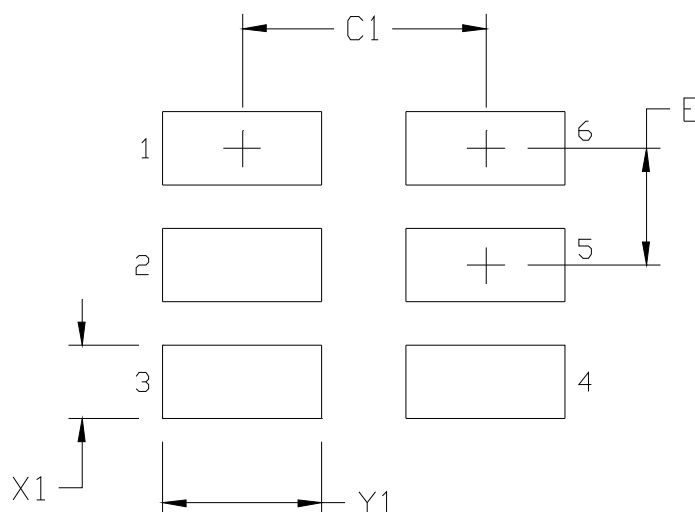
**Figure 5. Si512/513 Outline Diagram**

**Table 17. Package Diagram Dimensions (mm)**

| Dimension                                                               | Min      | Nom  | Max  |
|-------------------------------------------------------------------------|----------|------|------|
| A                                                                       | 1.06     | 1.17 | 1.33 |
| b                                                                       | 0.54     | 0.64 | 0.74 |
| c                                                                       | 0.35     | 0.45 | 0.55 |
| D                                                                       | 3.20 BSC |      |      |
| D1                                                                      | 2.55     | 2.60 | 2.65 |
| e                                                                       | 1.27 BSC |      |      |
| E                                                                       | 5.00 BSC |      |      |
| E1                                                                      | 4.35     | 4.40 | 4.45 |
| H                                                                       | 0.45     | 0.55 | 0.65 |
| L                                                                       | 0.80     | 0.90 | 1.00 |
| L1                                                                      | 0.05     | 0.10 | 0.15 |
| p                                                                       | 1.17     | 1.27 | 1.37 |
| R                                                                       | 0.32 REF |      |      |
| aaa                                                                     | 0.15     |      |      |
| bbb                                                                     | 0.15     |      |      |
| ccc                                                                     | 0.10     |      |      |
| ddd                                                                     | 0.10     |      |      |
| eee                                                                     | 0.05     |      |      |
| Notes:                                                                  |          |      |      |
| 1. All dimensions shown are in millimeters (mm) unless otherwise noted. |          |      |      |
| 2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.                   |          |      |      |

## 8. PCB Land Pattern: 3.2 x 5.0 mm

Figure 6 illustrates the 3.2 x 5.0 mm PCB land pattern for the Si512/513. Table 18 lists the values for the dimensions shown in the illustration.



**Figure 6. Si512/513 Recommended PCB Land Pattern**

**Table 18. PCB Land Pattern Dimensions (mm)**

| Dimension | (mm) |
|-----------|------|
| C1        | 2.60 |
| E         | 1.27 |
| X1        | 0.80 |
| Y1        | 1.70 |

**Notes:**

**General**

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Dimensioning and Tolerancing is per the ANSI Y14.5M-1994 specification.
3. This Land Pattern Design is based on the IPC-7351 guidelines.
4. All dimensions shown are at Maximum Material Condition (MMC). Least Material Condition (LMC) is calculated based on a Fabrication Allowance of 0.05 mm.

**Solder Mask Design**

5. All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60 µm minimum, all the way around the pad.

**Stencil Design**

6. A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
7. The stencil thickness should be 0.125 mm (5 mils).
8. The ratio of stencil aperture to land pad size should be 1:1.

**Card Assembly**

9. A No-Clean, Type-3 solder paste is recommended.
10. The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

## 9. Package Outline Diagram: 2.5 x 3.2 mm, 6-pin

Figure 7 illustrates the package details for the 2.5 x 3.2 mm Si512/513. Table 19 lists the values for the dimensions shown in the illustration.

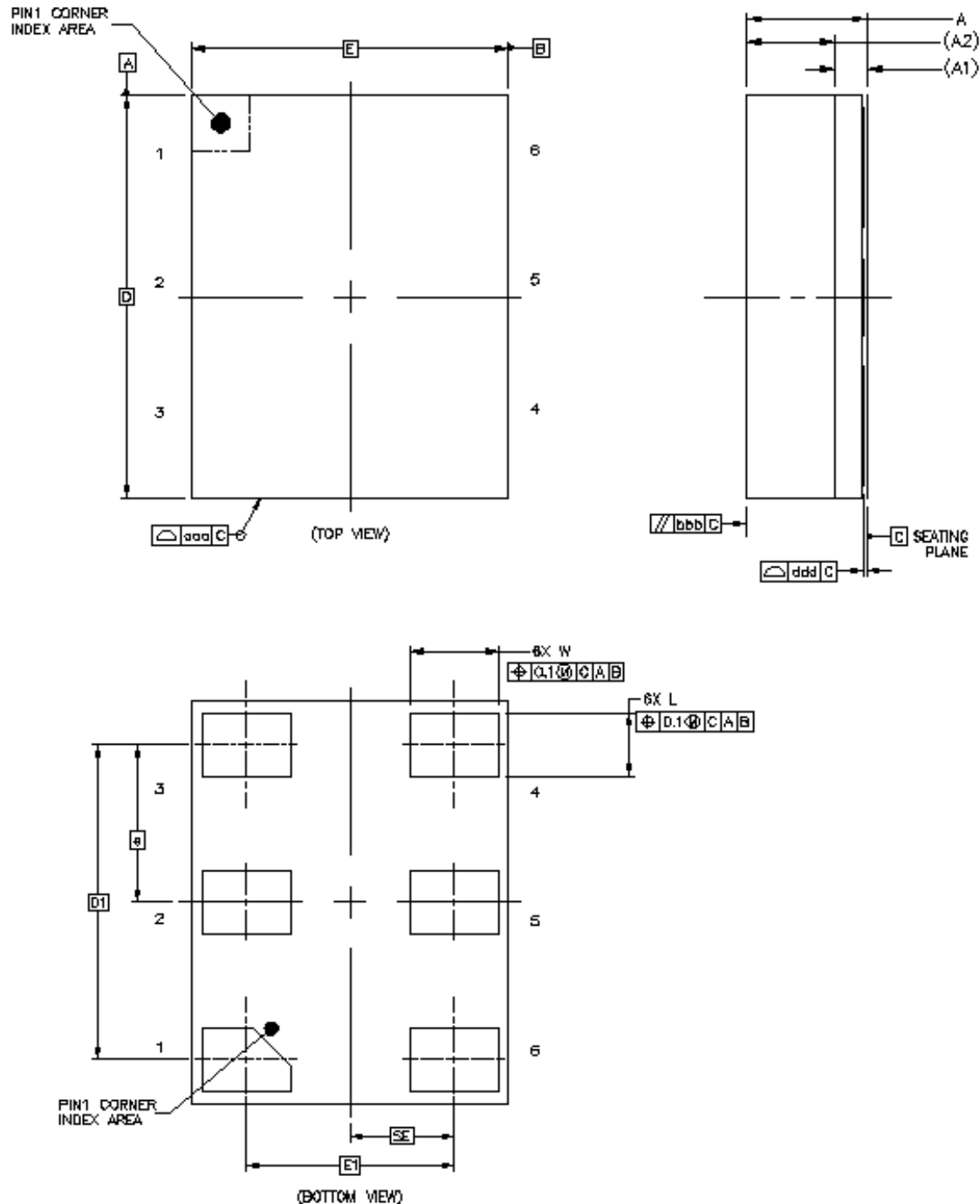


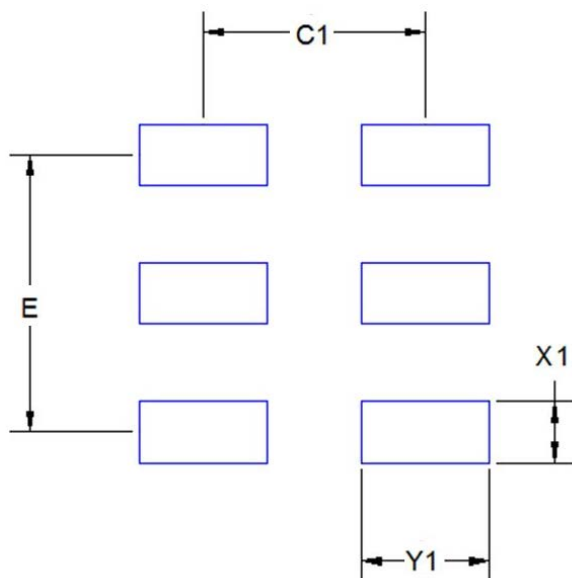
Figure 7. Si512/513 Outline Diagram

**Table 19. Package Diagram Dimensions (mm)**

| Dimension                                                               | Min       | Nom | Max  |
|-------------------------------------------------------------------------|-----------|-----|------|
| A                                                                       | —         | —   | 1.1  |
| A1                                                                      | 0.26 REF  |     |      |
| A2                                                                      | 0.7 REF   |     |      |
| W                                                                       | 0.65      | 0.7 | 0.75 |
| D                                                                       | 3.20 BSC  |     |      |
| e                                                                       | 1.25 BSC  |     |      |
| E                                                                       | 2.50 BSC  |     |      |
| M                                                                       | 0.30 BSC  |     |      |
| L                                                                       | 0.45      | 0.5 | 0.55 |
| D1                                                                      | 2.5 BSC   |     |      |
| E1                                                                      | 1.65 BSC  |     |      |
| SE                                                                      | 0.825 BSC |     |      |
| aaa                                                                     | 0.1       |     |      |
| bbb                                                                     | 0.2       |     |      |
| ddd                                                                     | 0.08      |     |      |
| Notes:                                                                  |           |     |      |
| 1. All dimensions shown are in millimeters (mm) unless otherwise noted. |           |     |      |
| 2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.                   |           |     |      |

## 10. PCB Land Pattern: 2.5 x 3.2 mm, 6-pin

Figure 8 illustrates the 2.5 x 3.2 mm PCB land pattern for the Si512/513. Table 20 lists the values for the dimensions shown in the illustration.



**Figure 8. Si512/513 Recommended PCB Land Pattern**

**Table 20. PCB Land Pattern Dimensions (mm)**

| Dimension | (mm) |
|-----------|------|
| C1        | 1.9  |
| E         | 2.50 |
| X1        | 0.70 |
| Y1        | 1.05 |

**Notes:**

**General**

- All dimensions shown are at Maximum Material Condition (MMC). Least Material Condition (LMC) is calculated based on a Fabrication Allowance of 0.05 mm.
- This Land Pattern Design is based on the IPC-7351 guidelines.

**Solder Mask Design**

- All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60 µm minimum, all the way around the pad.

**Stencil Design**

- A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.
- The stencil thickness should be 0.125 mm (5 mils).
- The ratio of stencil aperture to land pad size should be 1:1 for all perimeter pins.

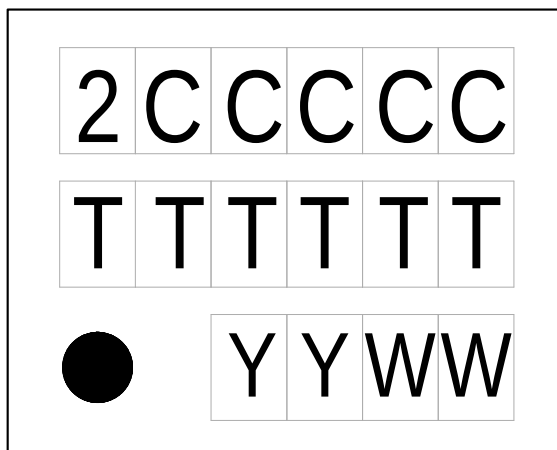
**Card Assembly**

- A No-Clean, Type-3 solder paste is recommended.
- The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

## 11. Top Marking

Use the part number configuration utility located at: [www.silabs.com/VCXOpartnumber](http://www.silabs.com/VCXOpartnumber) to cross-reference the mark code to a specific device configuration.

### 11.1. Si512/513 Top Marking



### 11.2. Top Marking Explanation

|                        |                                                                                                          |                                                |
|------------------------|----------------------------------------------------------------------------------------------------------|------------------------------------------------|
| <b>Mark Method:</b>    | Laser                                                                                                    |                                                |
| <b>Line 1 Marking:</b> | 2 = Si512<br>3 = Si513<br>CCCCC = Mark Code                                                              | 2CCCCC                                         |
| <b>Line 2 Marking:</b> | TTTTTT = Assembly Manufacturing Code                                                                     | TTTTTT                                         |
| <b>Line 3 Marking:</b> | Pin 1 indicator.                                                                                         | Circle with 0.5 mm diameter;<br>left-justified |
|                        | YY = Year.<br>WW = Work week.<br>Characters correspond to the year and<br>work week of package assembly. | YYWW                                           |

## REVISION HISTORY

### Revision 1.2

June, 2018

- Changed “Trays” to “Coil Tape” in Ordering Guide.

### Revision 1.1

December, 2017

- Add 2.5 x 3.2 mm package.

### Revision 1.0

- Updated Table 1 on page 3.
  - Updates to supply current typical and maximum values for CMOS, LVDS, LVPECL and HCSL.
  - CMOS frequency test condition corrected to 100 MHz.
  - Updates to OE VIH minimum and VIL maximum values.
- Updated Table 2 on page 4.
  - Dual CMOS nominal frequency maximum added.
  - Total stability footnotes clarified for 10 year aging at 40 °C.
  - Disable time maximum values updated.
  - Enable time parameter added.
- Updated Table 3 on page 5.
  - CMOS output rise / fall time typical and maximum values updated.
  - LVPECL/HCSL output rise / fall time maximum value updated.
  - LVPECL output swing maximum value updated.
  - LVDS output common mode typical and maximum values updated.
  - HCSL output swing maximum value updated.
  - Duty cycle minimum and maximum values tightened to 48/52%.
- Updated Table 4 on page 6.
  - Phase jitter test condition and maximum value updated.
  - Phase noise typical values updated.
  - Additive RMS jitter due to external power supply noise typical values updated.
  - Footnote 3 updated limiting the VDD to 2.5/3.3V
- Added Tables 5, 6, 7 for LVDS, HCSL, CMOS, and Dual CMOS operations.
- Moved Absolute Maximum Ratings table.
- Added note to Figure 2 clarifying CMOS and Dual CMOS maximum frequency.
- Updated Figure 5 outline diagram to correct pinout.
- Updated Table 17 on page 16.
- Updated “11. Top Marking” section and moved to page 21.

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