

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

### Features

- Supports any frequency from 100 kHz to 250 MHz
- Two selectable output frequencies
- 1 ps phase jitter (rms, max)
- 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 and 3.2x5 mm packages
- Pb-free, RoHS compliant
- -40 to 85 °C operation

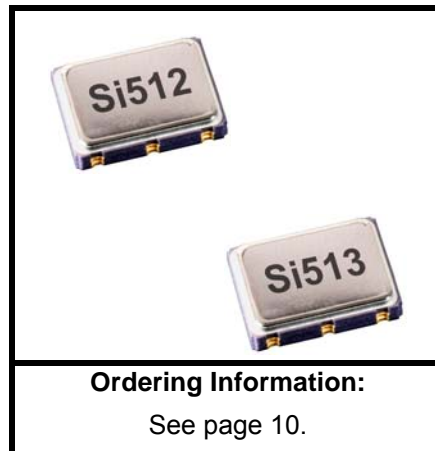
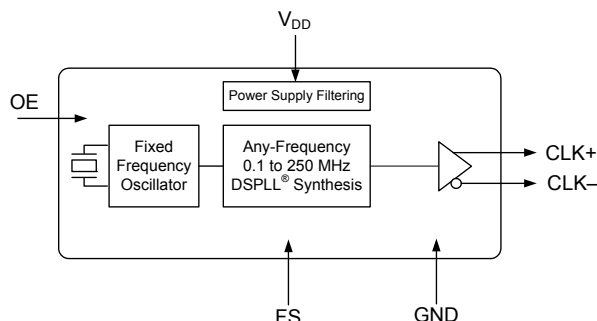
### Applications

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

### Description

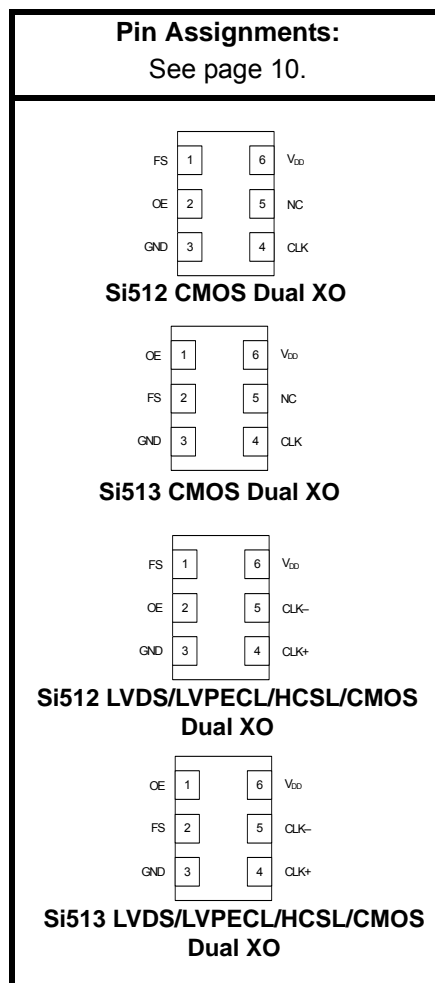
The Si512/513 dual frequency XO utilizes Silicon Laboratories' advanced PLL technology to provide any frequency from 100 kHz to 250 MHz. Unlike a traditional XO where a different crystal is required for each output frequency, the Si512/513 uses one fixed crystal and Silicon Labs' proprietary any-frequency 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 10.





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# Si512/513

## 1. Electrical Specifications

**Table 1. Operating Specifications**

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

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 kHz, single-ended	—	17	27	mA
		LVDS (output enabled)	—	21	26	mA
		LVPECL (output enabled)	—	37	42	mA
		HCSL (output enabled)	—	32	35	mA
		Tristate (output disabled)	—	—	18	mA
FS, OE "1" Setting	$V_{IH}$	See Note	$0.75 \times V_{DD}$	—	—	V
FS, OE "0" Setting	$V_{IL}$	See Note	—	—	$0.25 \times V_{DD}$	V
FS, OE Internal Pull-Up/Pull-Down Resistor*	$R_I$		—	45	—	k $\Omega$
Operating Temperature	$T_A$		-40	—	85	$^\circ\text{C}$

**Note:** 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 10.

**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	0.1	—	212.5	MHz
	$F_O$	LVDS/LVPECL/HCSL	0.1	—	250	MHz
Total Stability		Frequency Stability Grade C <sup>1</sup>	-30		+30	ppm
		Frequency Stability Grade B <sup>2</sup>	-50		+50	ppm
		Frequency Stability Grade A <sup>2</sup>	-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	$T_D$	$F_O \geq 10\text{ MHz}$	—	—	25	$\mu\text{s}$
		$F_O < 10\text{ MHz}$	—	—	60	$\mu\text{s}$
Settling Time after FS Change	$t_{FRQ}$		—	—	10	ms
<b>Notes:</b>						
1. Total stability includes initial accuracy, operating temperature, supply voltage change, load change, and shock and vibration (not under operation), and 1 year aging at 25 °C.						
2. Total stability includes initial accuracy, operating temperature, supply voltage change, load change, shock and vibration (not under operation), and 10 years aging at 40 °C.						

**Table 3. Output Clock Levels and Symmetry**

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

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
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 (20 to 80% $V_{DD}$ )	$T_R/T_F$	0.1 to 125 MHz, $C_L = 15\text{ pF}$	—	—	1.9	ns
		0.1 to 212.5 MHz, $C_L = \text{no load}$	—	1	—	ns
LVPECL/HCSL Output Rise/Fall Time	$T_R/T_F$		—	—	520	ps
LVDS Output Rise/Fall Time	$T_R/T_F$		—	—	800	ps
LVPECL Output Common Mode	$V_{OC}$	$50\ \Omega$ to $V_{DD} - 2\text{ V}$ , single-ended	—	$V_{DD} - 1.4\text{ V}$	—	V
LVPECL Output Swing	$V_O$	$50\ \Omega$ to $V_{DD} - 2\text{ V}$ , single-ended	0.55	0.8	0.95	$V_{PPSE}$
LVDS Output Common Mode	$V_{OC}$	100 $\Omega$ line-line, $V_{DD} = 3.3/2.5\text{ V}$	1.13	1.20	1.28	V
		100 $\Omega$ line-line, $V_{DD} = 1.8\text{ V}$	0.83	0.90	0.97	V
LVDS Output Swing	$V_O$	Single-ended, 100 $\Omega$ differential termination	0.25	0.35	0.45	$V_{PPSE}$
HCSL Output Common Mode	$V_{OC}$	$50\ \Omega$ to ground	0.35	0.38	0.40	V
HCSL Output Swing	$V_O$	Single-ended	0.58	0.73	0.85	$V_{PPSE}$
Duty Cycle	DC	All Output Formats	45	50	55	%

**Table 4. Output Clock Jitter and Phase Noise**

$V_{DD} = 2.5$  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>	—	—	1.2	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	0.55	ps
		12 kHz to 20 MHz integration bandwidth <sup>2</sup>	—	0.8	1.0	ps
Phase Noise, 156.25 MHz	$\phi N$	100 Hz	—	-85	—	dBc/Hz
		1 kHz	—	-110	—	dBc/Hz
		10 kHz	—	-115	—	dBc/Hz
		100 kHz	—	-120	—	dBc/Hz
		1 MHz	—	-135	—	dBc/Hz
Additive RMS Jitter Due to External Power Supply Noise <sup>3</sup>	JPSR	10 kHz sinusoidal noise	—	<0.5	—	ps
		100 kHz sinusoidal noise	—	1	—	ps
		500 kHz sinusoidal noise	—	1	—	ps
		1 MHz sinusoidal noise	—	1	—	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, 1.8 V = 50 mVPP).

**Table 5. 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:**

- 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.
- The device is compliant with JEDEC J-STD-020C.

**Table 6. Environmental Compliance and Package Information**

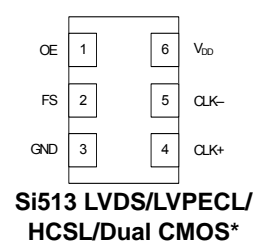
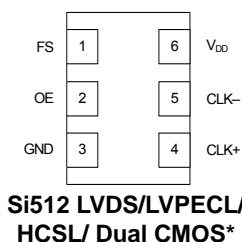
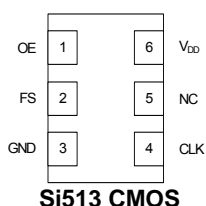
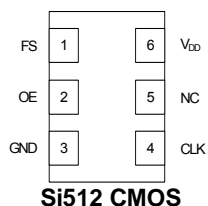
Parameter	Conditions/Test Method
Mechanical Shock	MIL-STD-883, Method 2002
Mechanical Vibration	MIL-STD-883, Method 2007
Solderability	MIL-STD-883, Method 2003
Gross and Fine Leak	MIL-STD-883, Method 1014
Resistance to Solder Heat	MIL-STD-883, Method 2036
Moisture Sensitivity Level	MSL 1
Contact Pads	Gold over Nickel

**Table 7. Thermal Characteristics**

Parameter	Symbol	Test Condition	Value	Units
Thermal Resistance Junction to Ambient	$\theta_{JA}$	Still air	110	°C/W



## 2. Pin Descriptions



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

**Table 8. Si512 Pin Descriptions (CMOS, OE Pin 2)**

Pin	Name	CMOS Function
1	FS	Frequency Selected. 0 = First frequency selected. 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 9. 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. 0 = First frequency selected. 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 10. Si512 Pin Descriptions (OE Pin 2)**

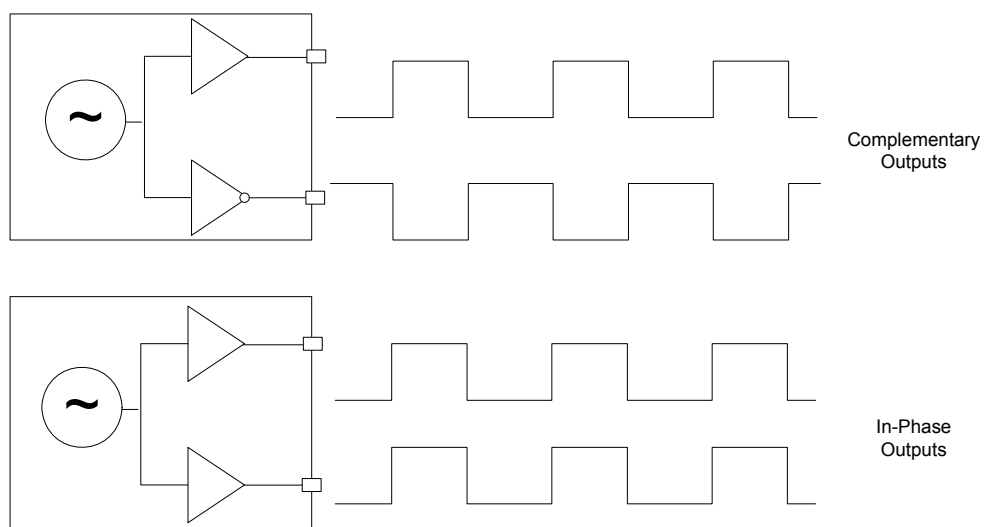
Pin	Name	LVPECL/LVDS/HCSL/Dual CMOS Function
1	FS	Frequency Selected. 0 = First frequency selected. 1 = Second frequency selected.
2	OE	Output Enable. Internal pull-up for OE active high. Pull-down for OE active low. See ordering information.
3	GND	Electrical and Case Ground.
4	CLK+	Clock Output.
5	CLK-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

**Table 11. 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. 0 = First frequency selected. 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.

## 2.1. 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**

### 3. 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. Refer to [www.silabs.com/VCXOPartNumber](http://www.silabs.com/VCXOPartNumber) to access this tool and for further ordering instructions. The Si512/513 XO series is supplied in industry-standard, RoHS compliant, lead-free, 3.2 x 5.0 mm and 5 x 7 mm packages. Tape and reel packaging is an ordering option.

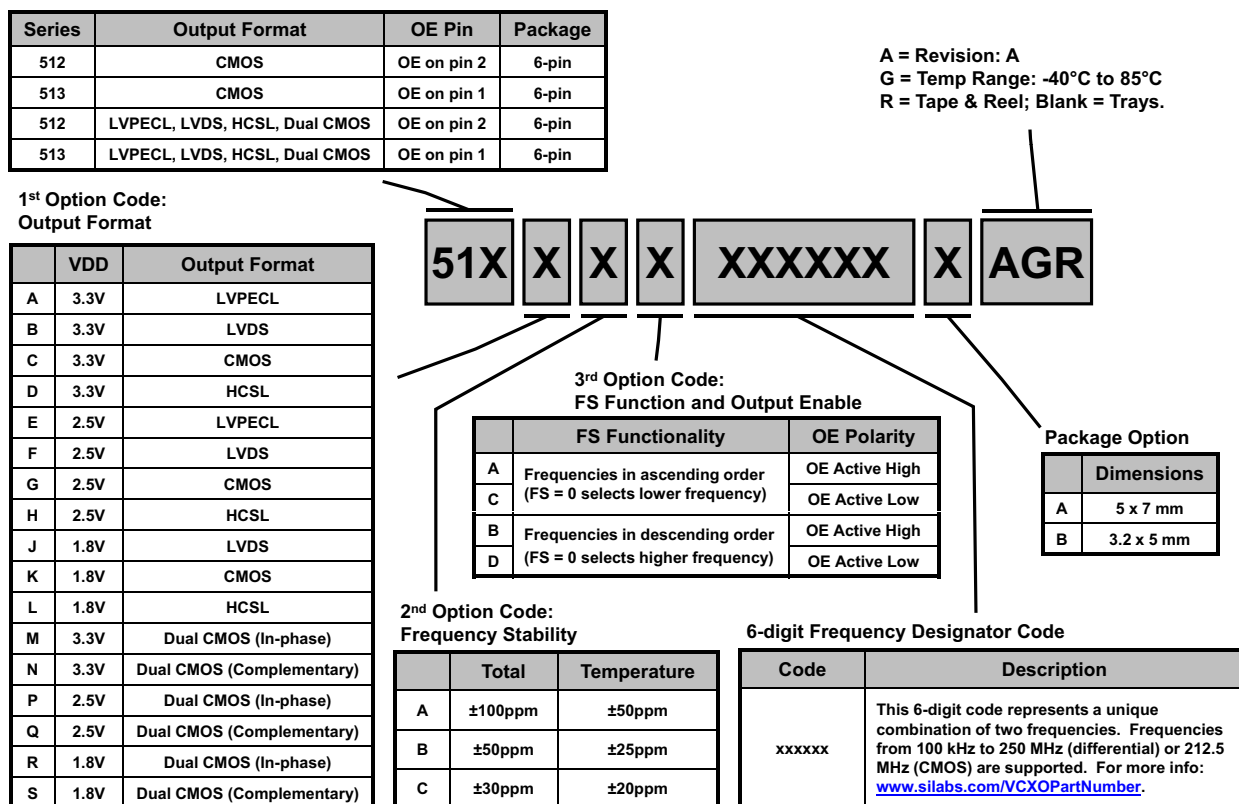


Figure 2. Part Number Convention

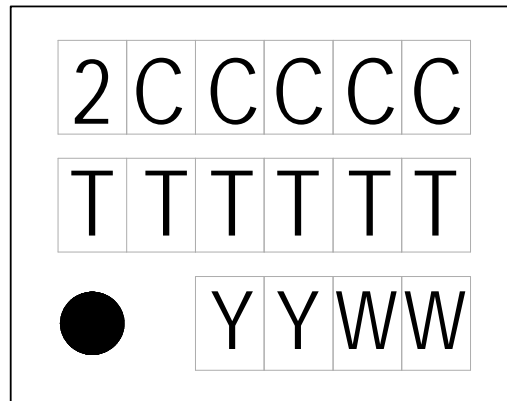
Example part number: 512PCA000104BAGR:

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.

## 4. Si512/513 Mark Specification

Figure 3 illustrates the mark specification for the Si512/13. 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.



2 = Si512, 3 = Si513  
CCCCC = mark code  
TTTTTT = assembly manufacturing code  
YY = year  
WW = work week

**Figure 3. Top Mark**

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

Figure 4 illustrates the package details for the 5 x 7 mm Si512/513. Table 12 lists the values for the dimensions shown in the illustration.

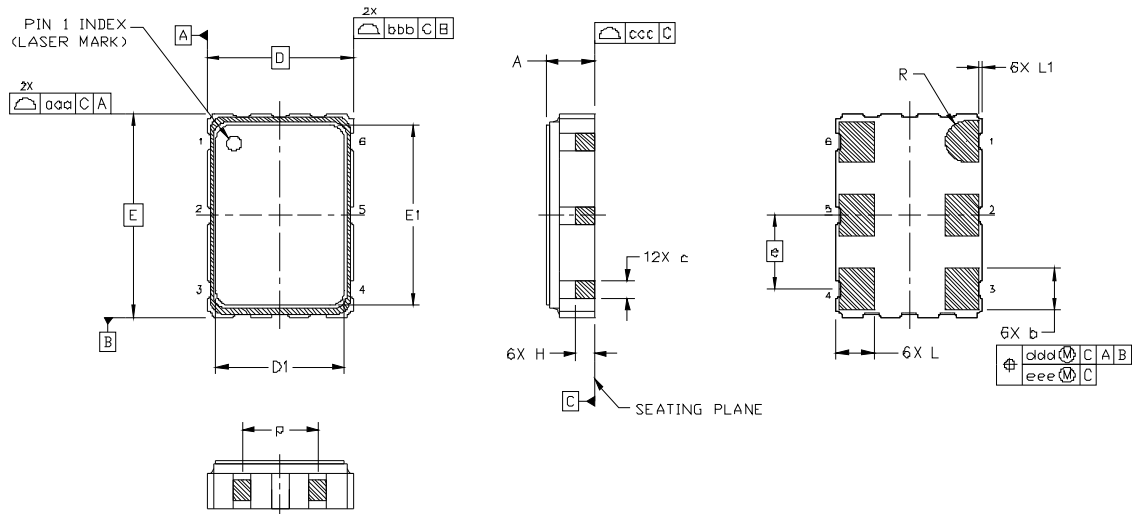


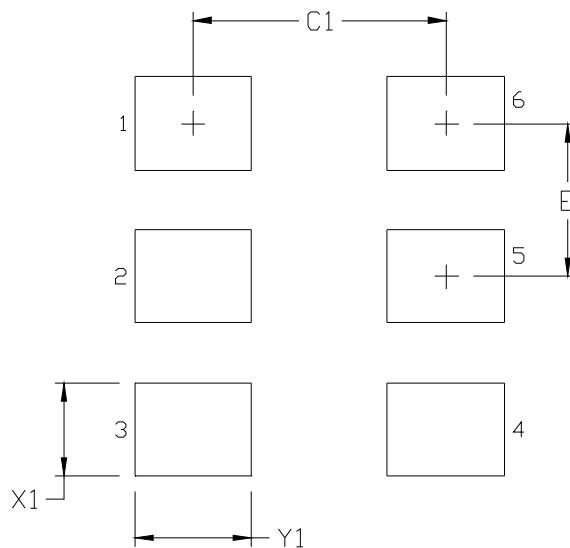
Figure 4. Si512/513 Outline Diagram

Table 12. 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 5 illustrates the 5 x 7 mm PCB land pattern for the Si512/513. Table 13 lists the values for the dimensions shown in the illustration.



**Figure 5. Si512/513 PCB Land Pattern**

**Table 13. PCB Land Pattern Dimensions (mm)**

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

**Notes:**

**General**

- All dimensions shown are in millimeters (mm) unless otherwise noted.
- Dimensioning and Tolerancing is per the ANSI Y14.5M-1994 specification.
- This Land Pattern Design is based on the IPC-7351 guidelines.
- 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**

- All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60  $\mu\text{m}$  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.

**Card Assembly**

- A No-Clean, Type-3 solder paste is recommended.
- 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 6 illustrates the package details for the 3.2 x 5.0 mm Si512/513. Table 14 lists the values for the dimensions shown in the illustration.

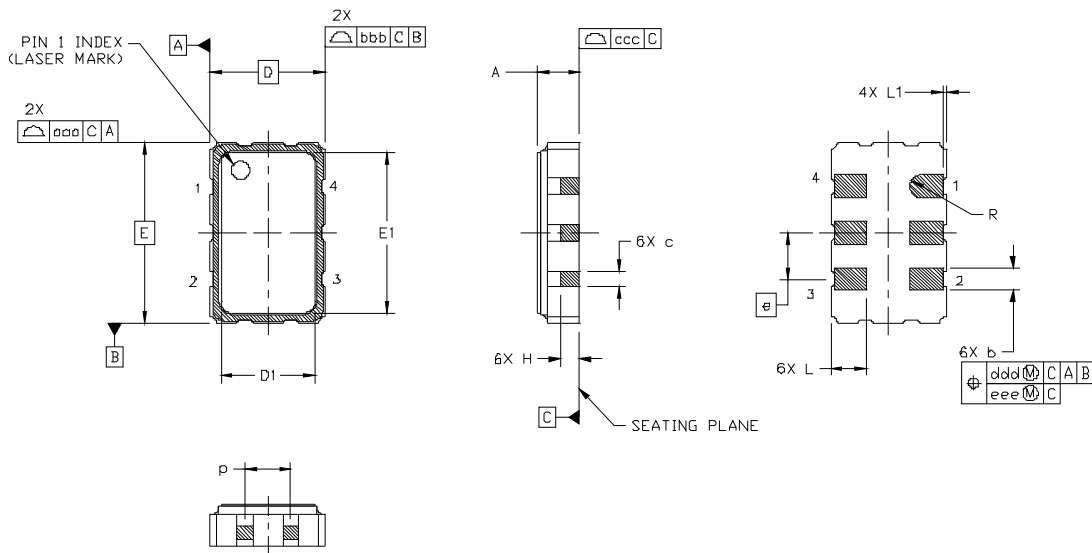


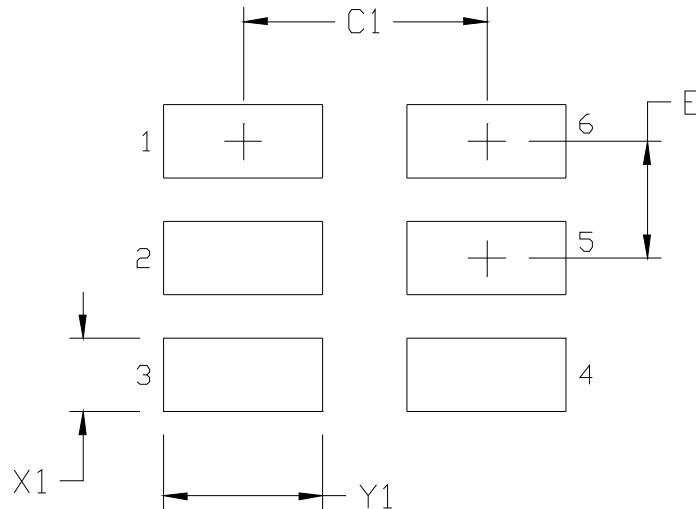
Figure 6. Si512/513 Outline Diagram

Table 14. Package Diagram Dimensions (mm)

Dimension	Min	Nom	Max
A	1.06	1.17	1.28
b	1.10	1.20	1.30
c	0.70	0.80	0.90
D	3.20 BSC		
D1	2.55	2.60	2.65
e	2.54 BSC		
f	0.40 TYP		
E	5.00 BSC		
E1	4.35	4.40	4.45
H	0.40	0.50	0.60
L	0.90	1.00	1.10
L1	0.05	0.10	0.15
p	1.17	1.27	1.37
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.			

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

Figure 7 illustrates the 3.2 x 5.0 mm PCB land pattern for the Si512/513. Table 15 lists the values for the dimensions shown in the illustration.



**Figure 7. Si512/513 Recommended PCB Land Pattern**

**Table 15. PCB Land Pattern Dimensions (mm)**

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

**Notes:**

**General**

- All dimensions shown are in millimeters (mm) unless otherwise noted.
- Dimensioning and Tolerancing is per the ANSI Y14.5M-1994 specification.
- This Land Pattern Design is based on the IPC-7351 guidelines.
- 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**

- All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60  $\mu\text{m}$  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.

**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.



**NOTES:**

## CONTACT INFORMATION

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