

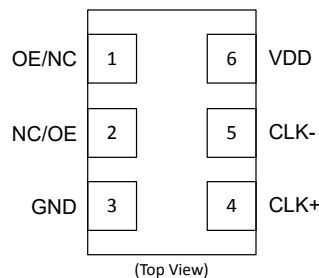
# Ultra Series™ 水晶発振器

## Si545 データ・シート

### 超低ジッタ任意周波数 XO (80 fs)、0.2 ~ 1500 MHz

Si545 Ultra Series™ 発振器は Silicon Labs の高度な第 4 世代 DSPLL® テクノロジーを使用し、超低ジッタ、低位相ノイズのクロックを任意の出力周波数で実現します。デバイスは、0.2 ~ 1500 MHz の任意の周波数に対応するよう、1 ppb 未満の分解能で工場出荷時にプログラムされ、動作範囲全体の整数周波数と分数周波数両方で非常に低いジッタを維持します。Si545 は優れた信頼性と周波数の安定性を提供し、経年的な性能も保証されています。オンチップの電源フィルタリングにより、業界最先端の電源ノイズ除去性能を実現しており、スイッチング方式の電源を使用するノイズの多いシステムで、低ジッタ・クロックの生成タスクを簡素化します。Si545 は業界標準の 3.2×5 mm および 5×7 mm フットプリントで提供され、サプライ・チェーンが非常に簡素化されているため、Silicon Labs はカスタム周波数のサンプルを受注後 1 ~ 2 週間で出荷できます。出力周波数ごとに異なる水晶が必要な従来の XO とは違い、Si545 は 1 つの簡単な水晶と DSPLL IC ベースのアプローチで必要な出力周波数を生成します。このプロセスでは、各デバイスの 100% 電気的試験も保証しています。Si545 は、周波数、出力形式、OE ピン配列/極性など、幅広いユーザ仕様に合わせて工場出荷時に構成できます。カスタム発振器に伴う長いリード・タイムを排除するために、固有の構成は工場出荷時にプログラムされています。

ピン配置



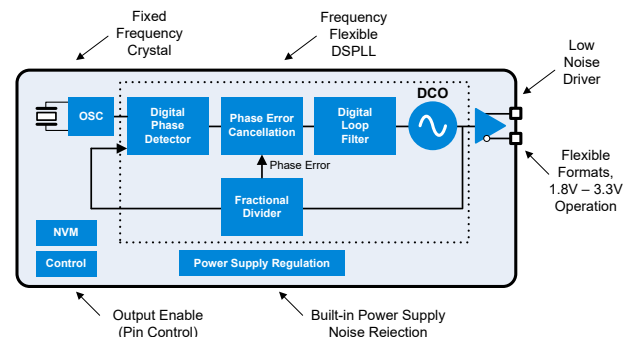
ピン番号	説明
1, 2	発注オプションにより選択可能 OE = 出力イネーブル、NC = 接続なし
3	GND = グランド
4	CLK+ = クロック出力
5	CLK- = 相補クロック出力。CMOS には未使用。
6	VDD = 電源

#### 主な機能

- ・ 0.2 MHz ~ 1500 MHz の任意の周波数で利用可能
- ・ 超低ジッタ : 80 fs (標準値) RMS (12 kHz ~ 20 MHz)
- ・ 優れた PSRR および電源ノイズ耐久性 : -80 dBc (標準値)
- ・ 7 ppm 安定性オプション (-40 ~ 85 °C)
- ・ 同じ部品番号から、3.3 V、2.5 V および 1.8 V V<sub>DD</sub> の電源動作
- ・ LVPECL、LVDS、CML、HCSL、CMOS、およびデュアル CMOS 出力オプション
- ・ 3.2×5、5×7 mm パッケージ・フットプリント
- ・ 1 ~ 2 週間のリード・タイムでサンプルを提供

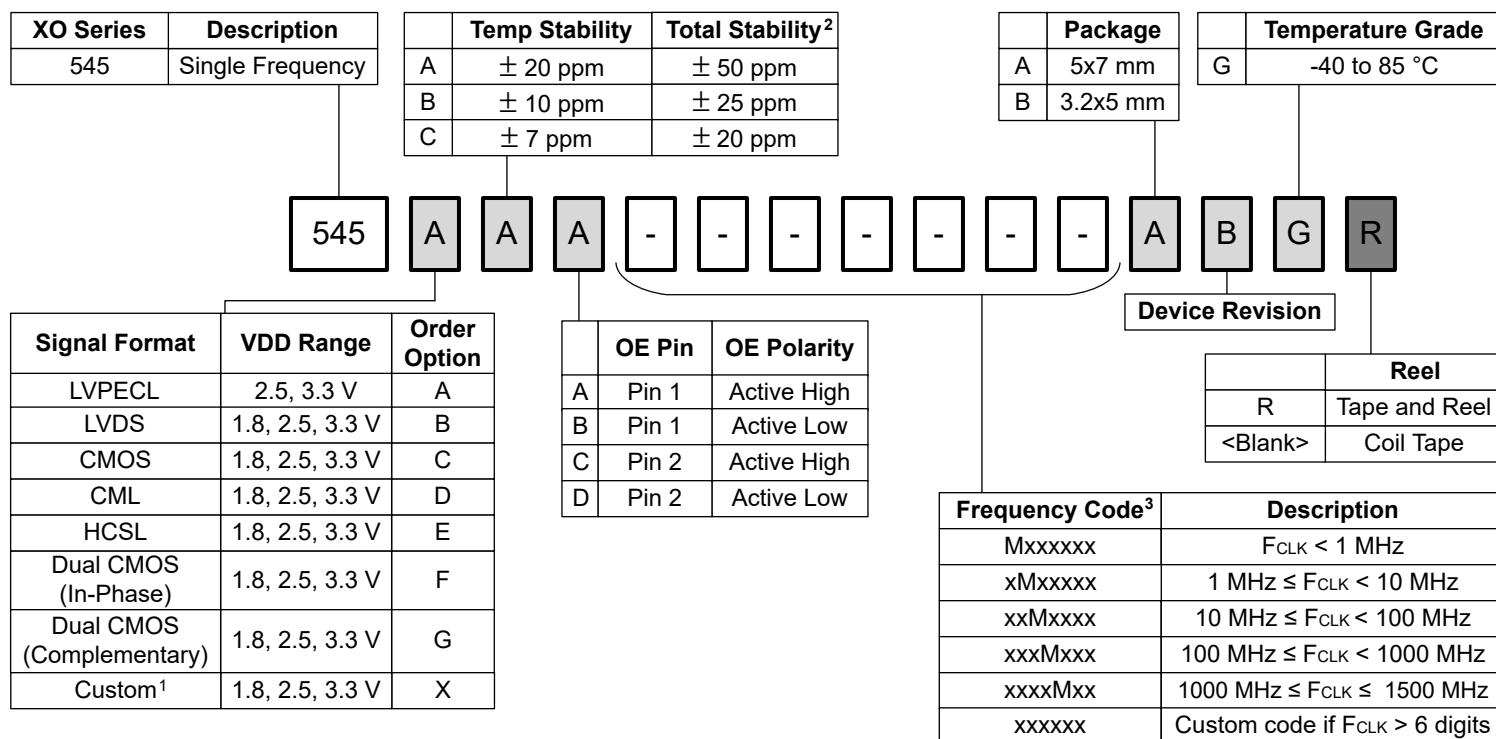
#### アプリケーション

- ・ 100G/200G/400G OTN、コヒーレント光学
- ・ 10G/40G/100G 光イーサネット
- ・ 3G-SDI/12G-SDI/24G-SDI 放送ビデオ
- ・ データセンター
- ・ テストおよび測定
- ・ クロックおよびデータ・リカバリ
- ・ FPGA/ASIC クロッキング



## 1. Ordering Guide

The Si545 XO supports a variety of options including frequency, output format, and OE pin location/polarity, as shown in the chart below. Specific device configurations are programmed into the part at time of shipment, and samples are available in 1-2 weeks. Silicon Laboratories provides an online part number configuration utility to simplify this process. Refer to [www.silabs.com/oscillators](http://www.silabs.com/oscillators) to access this tool and for further ordering instructions.



### Notes:

- Contact Silicon Labs for non-standard configurations.
- Total stability includes temp stability, initial accuracy, load pulling, VDD variation, and 20 year aging at 70 °C.
- For example: 156.25 MHz = 156M250; 25 MHz = 25M0000. Create custom part numbers at [www.silabs.com/oscillators](http://www.silabs.com/oscillators).

### 1.1 Technical Support

Frequently Asked Questions (FAQ)	<a href="http://www.silabs.com/Si545-FAQ">www.silabs.com/Si545-FAQ</a>
Oscillator Phase Noise Lookup Utility	<a href="http://www.silabs.com/oscillator-phase-noise-lookup">www.silabs.com/oscillator-phase-noise-lookup</a>
Quality and Reliability	<a href="http://www.silabs.com/quality">www.silabs.com/quality</a>
Development Kits	<a href="http://www.silabs.com/oscillator-tools">www.silabs.com/oscillator-tools</a>

## 2. Electrical Specifications

**Table 2.1. Electrical Specifications**

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

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Temperature Range	$T_A$		-40	—	85	$^\circ\text{C}$
Frequency Range	$F_{CLK}$	LVPECL, LVDS, CML	0.2	—	1500	MHz
		HCSL	0.2	—	400	MHz
		CMOS, Dual CMOS	0.2	—	250	MHz
Supply Voltage	$V_{DD}$	3.3 V	3.135	3.3	3.465	V
		2.5 V	2.375	2.5	2.625	V
		1.8 V	1.71	1.8	1.89	V
Supply Current	$I_{DD}$	LVPECL (output enabled)	—	107	153	mA
		LVDS/CML (output enabled)	—	83	121	mA
		HCSL (output enabled)	—	86	126	mA
		CMOS (output enabled)	—	87	127	mA
		Dual CMOS (output enabled)	—	92	141	mA
		Tristate Hi-Z (output disabled)	—	73	112	mA
Temperature Stability		Frequency stability Grade A	-20	—	20	ppm
		Frequency stability Grade B	-10	—	10	ppm
		Frequency stability Grade C	-7	—	7	ppm
Total Stability <sup>1</sup>	$F_{STAB}$	Frequency stability Grade A	-50	—	50	ppm
		Frequency stability Grade B	-25	—	25	ppm
		Frequency stability Grade C	-20	—	20	ppm
Rise/Fall Time (20% to 80% $V_{PP}$ )	$T_R/T_F$	LVPECL/LVDS/CML	—	—	350	ps
		CMOS / Dual CMOS, ( $C_L = 5\text{ pF}$ )	—	0.5	1.5	ns
		HCSL, $F_{CLK} > 50\text{ MHz}$	—	—	550	ps
Duty Cycle	$D_C$	All formats	45	—	55	%
Output Enable (OE) <sup>2</sup>	$V_{IH}$		$0.7 \times V_{DD}$	—	—	V
	$V_{IL}$		—	—	$0.3 \times V_{DD}$	V
	$T_D$	Output Disable Time, $F_{CLK} > 10\text{ MHz}$	—	—	3	$\mu\text{s}$
	$T_E$	Output Enable Time, $F_{CLK} > 10\text{ MHz}$	—	—	20	$\mu\text{s}$
Powerup Time	$t_{OSC}$	Time from $0.9 \times V_{DD}$ until output frequency ( $F_{CLK}$ ) within spec	—	—	10	ms
LVPECL Output Option <sup>3</sup>	$V_{OC}$	Mid-level	$V_{DD} - 1.42$	—	$V_{DD} - 1.25$	V
	$V_O$	Swing (diff)	1.1	—	1.9	$V_{PP}$

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
LVDS Output Option <sup>4</sup>	V <sub>OC</sub>	Mid-level (2.5 V, 3.3 V VDD)	1.125	1.20	1.275	V
		Mid-level (1.8 V VDD)	0.8	0.9	1.0	V
	V <sub>O</sub>	Swing (diff)	0.5	0.7	0.9	V <sub>PP</sub>
HCSL Output Option <sup>5</sup>	V <sub>OH</sub>	Output voltage high	660	750	850	mV
	V <sub>OL</sub>	Output voltage low	-150	0	150	mV
	V <sub>C</sub>	Crossing voltage	250	350	550	mV
CML Output Option (AC-Coupled)	V <sub>O</sub>	Swing (diff)	0.6	0.8	1.0	V <sub>PP</sub>
CMOS Output Option	V <sub>OH</sub>	I <sub>OH</sub> = 8/6/4 mA for 3.3/2.5/1.8 V VDD	0.85 × V <sub>DD</sub>	—	—	V
	V <sub>OL</sub>	I <sub>OL</sub> = 8/6/4 mA for 3.3/2.5/1.8 V VDD	—	—	0.15 × V <sub>DD</sub>	V

**Notes:**

- Total Stability includes temperature stability, initial accuracy, load pulling, VDD variation, and aging for 20 yrs at 70 °C.
- OE includes a 50 kΩ pull-up to VDD for OE active high. Includes a 50 kΩ pull-down to GND for OE active low.
- 50 Ω to V<sub>DD</sub> - 2.0 V.
- R<sub>term</sub> = 100 Ω (differential).
- 50 Ω to GND.

Table 2.2. Clock Output Phase Jitter and PSRR

V<sub>DD</sub> = 1.8 V, 2.5 or 3.3 V ± 5%, T<sub>A</sub> = -40 to 85 °C

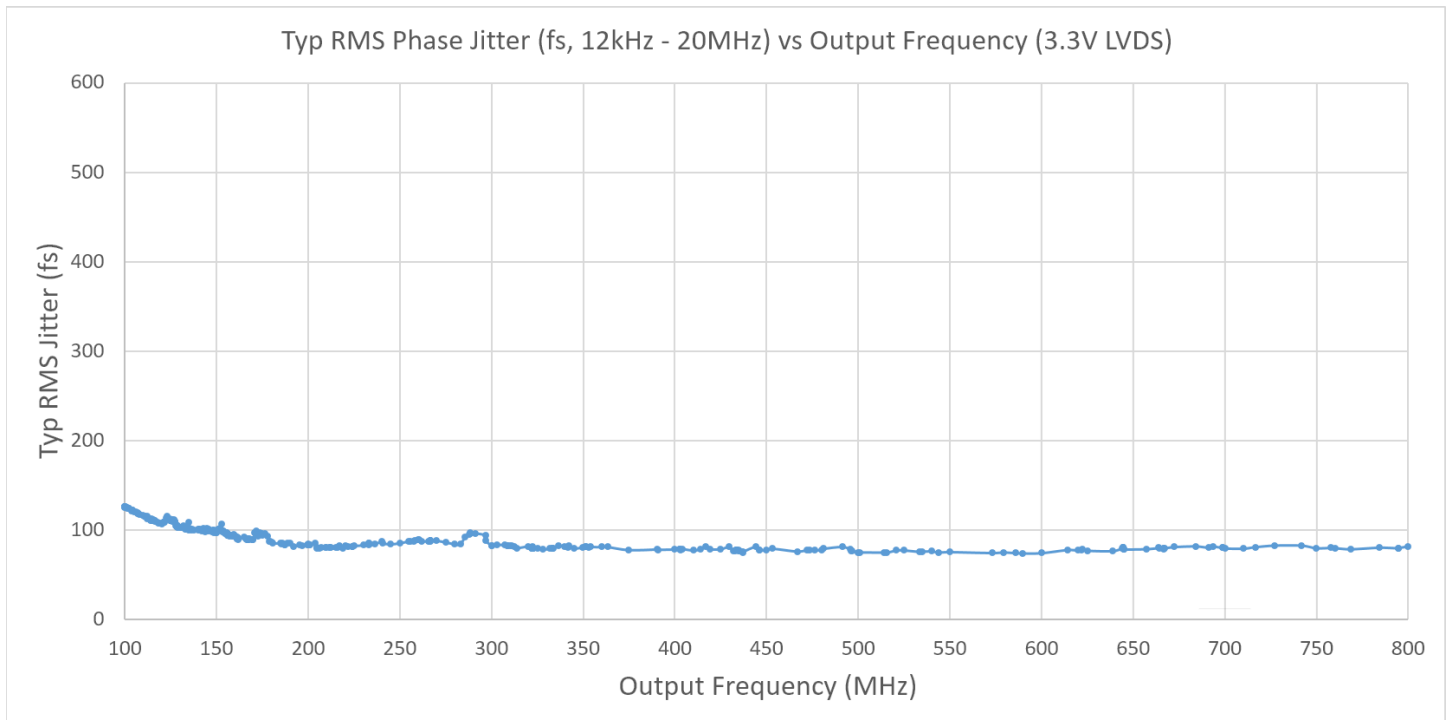
Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Phase Jitter (RMS, 12kHz - 20MHz) <sup>1</sup> 3.2 x 5 mm, All Differential Formats	ϕ <sub>J</sub>	F <sub>CLK</sub> ≥ 200 MHz	—	80	110	fs
		100 MHz ≤ F <sub>CLK</sub> < 200 MHz	—	100	150	fs
		LVPECL @ 156.25 MHz	—	90	125	fs
Phase Jitter (RMS, 12kHz - 20MHz) <sup>1</sup> 5 x 7 mm, All Differential Formats		F <sub>CLK</sub> ≥ 200 MHz	—	80	130	fs
		100 MHz ≤ F <sub>CLK</sub> < 200 MHz	—	100	150	fs
		LVPECL @ 156.25 MHz	—	90	125	fs
Phase Jitter (RMS, 12kHz - 20MHz) <sup>1</sup> CMOS / Dual CMOS Formats	ϕ <sub>J</sub>	10 MHz ≤ F <sub>CLK</sub> ≤ 250 MHz	—	200	—	fs
Spurs Induced by External Power Supply Noise, 50 mVpp Ripple. LVDS 156.25 MHz Output	PSRR	100 kHz sine wave	—	-83	—	dBc
		200 kHz sine wave	—	-83	—	
		500 kHz sine wave	—	-82	—	
		1 MHz sine wave	—	-85	—	

**Note:**

- Guaranteed by characterization. Jitter inclusive of any spurs.

**Table 2.3. 3.2 x 5 mm Clock Output Phase Noise (Typical)**

Offset Frequency (f)	156.25 MHz LVDS	200 MHz LVDS	644.53125 MHz LVDS	Unit
100 Hz	-106	-102	-92	dBc/Hz
1 kHz	-133	-129	-119	
10 kHz	-140	-138	-127	
100 kHz	-145	-142	-132	
1 MHz	-152	-150	-139	
10 MHz	-160	-160	-154	
20 MHz	-161	-161	-155	
Offset Frequency (f)	156.25 MHz LVPECL	200 MHz LVPECL	644.53125 MHz LVPECL	Unit
100 Hz	-103	-104	-91	dBc/Hz
1 kHz	-130	-128	-118	
10 kHz	-140	-138	-127	
100 kHz	-145	-142	-132	
1 MHz	-152	-150	-140	
10 MHz	-162	-162	-155	
20 MHz	-163	-163	-156	



Phase jitter measured with Agilent E5052 using a differential-to-single ended converter (balun or buffer). Measurements collected for >700 commonly used frequencies. Phase noise plots for specific frequencies are available using our free, online Oscillator Phase Noise Lookup Tool at [www.silabs.com/oscillators](http://www.silabs.com/oscillators).

**Figure 2.1. Phase Jitter vs. Output Frequency**

Table 2.4. Environmental Compliance and Package Information

Parameter	Test Condition
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

**Note:**

- For additional product information not listed in the data sheet (e.g. RoHS Certifications, MDDS data, qualification data, REACH Declarations, ECCN codes, etc.), refer to our "Corporate Request For Information" portal found here: [www.silabs.com/support/quality/Pages/RoHSInformation.aspx](http://www.silabs.com/support/quality/Pages/RoHSInformation.aspx).

Table 2.5. Thermal Conditions

Package	Parameter	Symbol	Test Condition	Value	Unit
3.2 × 5 mm 6-pin CLCC	Thermal Resistance Junction to Ambient	$\Theta_{JA}$	Still Air, 85 °C	80.3	°C/W
	Thermal Resistance Junction to Board	$\Theta_{JB}$	Still Air, 85 °C	50.8	°C/W
	Max Junction Temperature	$T_J$	Still Air, 85 °C	125	°C
5 × 7 mm 6-pin CLCC	Thermal Resistance Junction to Ambient	$\Theta_{JA}$	Still Air, 85 °C	68.4	°C/W
	Thermal Resistance Junction to Board	$\Theta_{JB}$	Still Air, 85 °C	52.9	°C/W
	Max Junction Temperature	$T_J$	Still Air, 85 °C	125	°C

Table 2.6. Absolute Maximum Ratings<sup>1</sup>

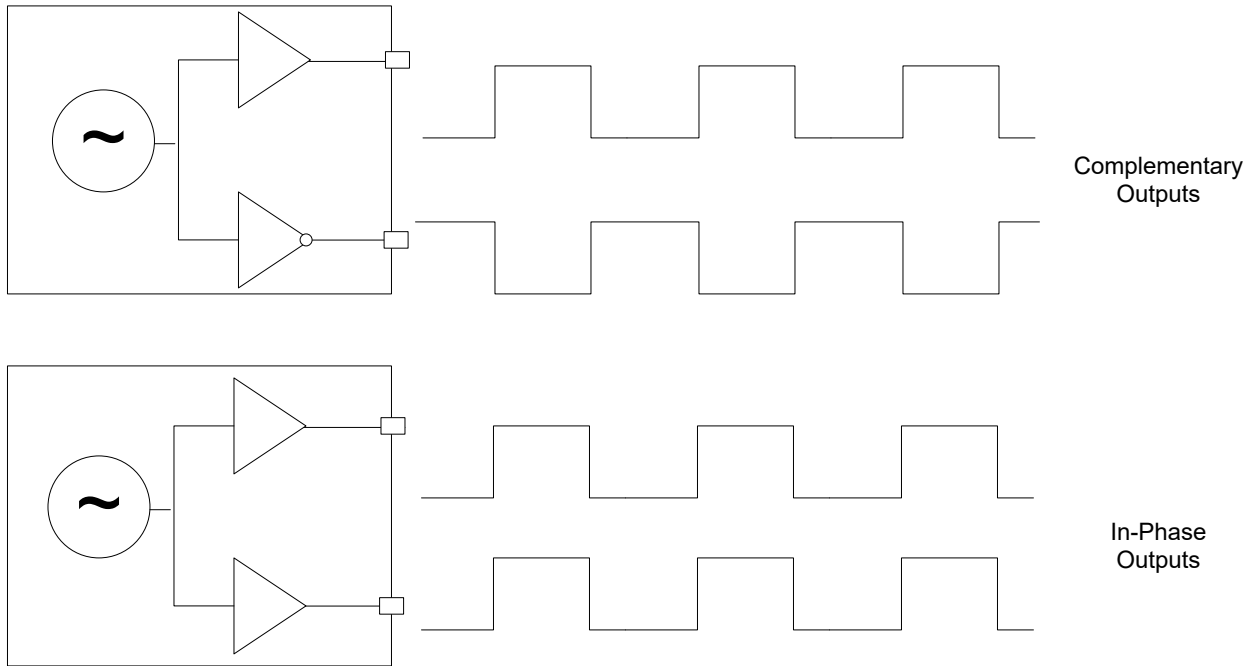
Parameter	Symbol	Rating	Unit
Maximum Operating Temp.	$T_{AMAX}$	95	°C
Storage Temperature	$T_S$	-55 to 125	°C
Supply Voltage	$V_{DD}$	-0.5 to 3.8	°C
Input Voltage	$V_{IN}$	-0.5 to $V_{DD} + 0.3$	V
ESD HBM (JESD22-A114)	HBM	2.0	kV
Solder Temperature <sup>2</sup>	$T_{PEAK}$	260	°C
Solder Time at $T_{PEAK}$ <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 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-020.

### 3. Dual CMOS Buffer

Dual CMOS output format ordering options support either complementary or in-phase signals for two identical frequency outputs. This feature enables replacement of multiple XOs with a single Si545 device.



**Figure 3.1. Integrated 1:2 CMOS Buffer Supports Complementary or In-Phase Outputs**

## 4. Recommended Output Terminations

The output drivers support both AC-coupled and DC-coupled terminations as shown in figures below.

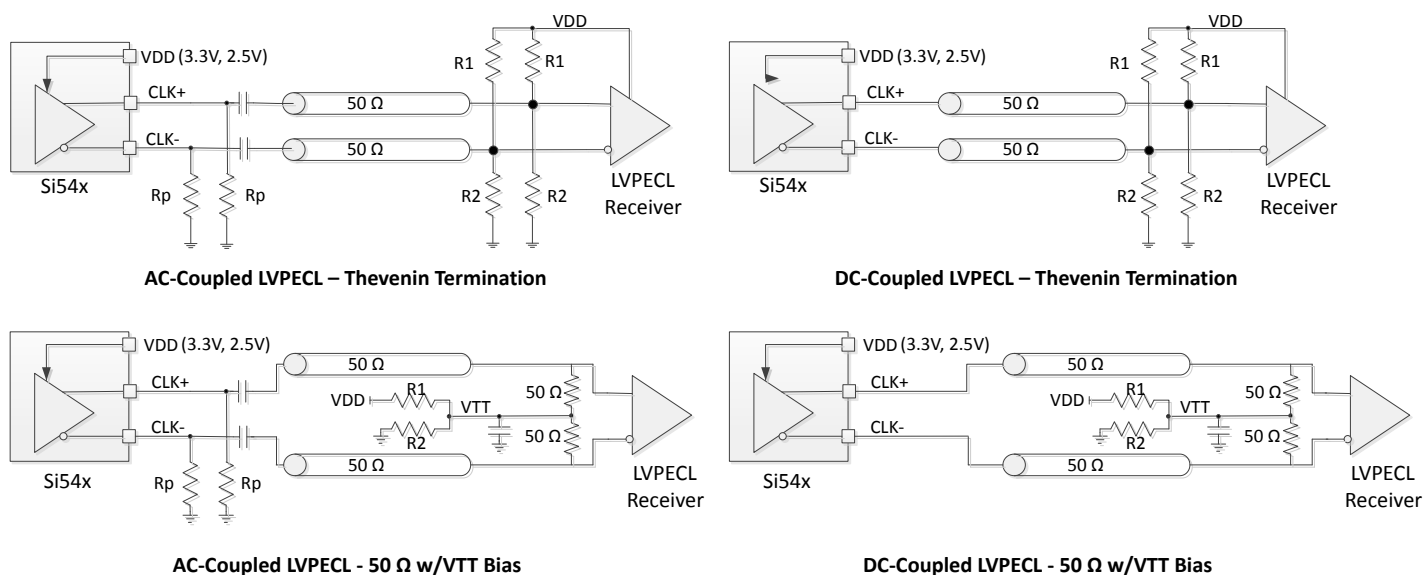
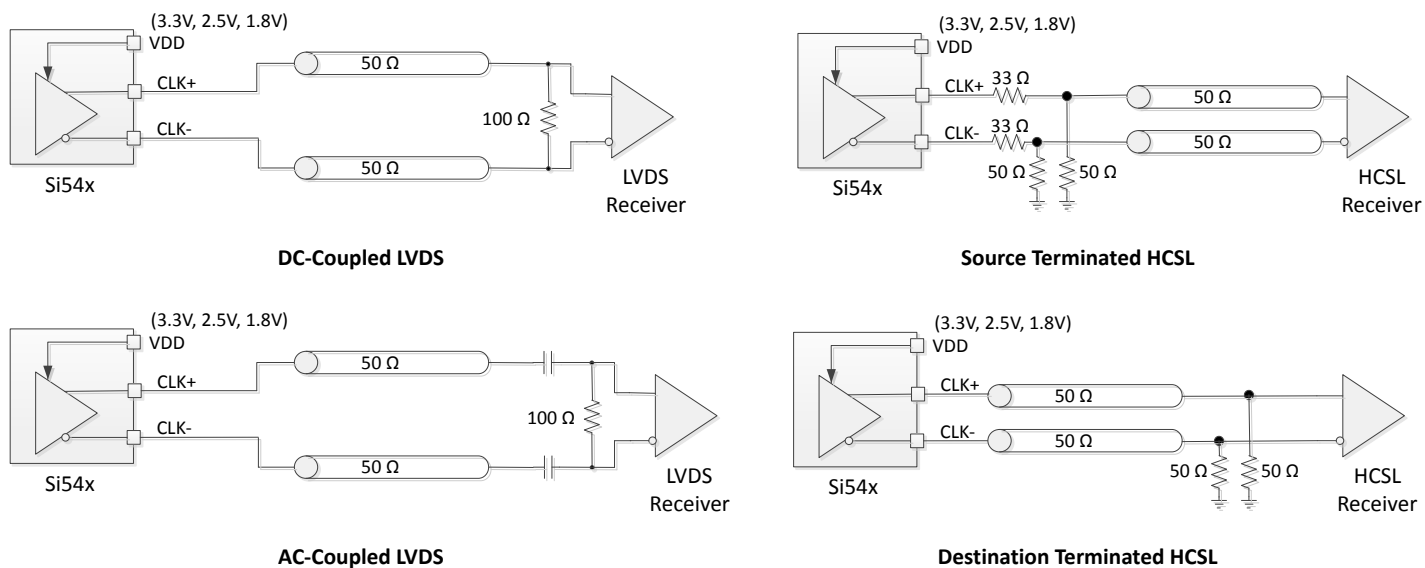


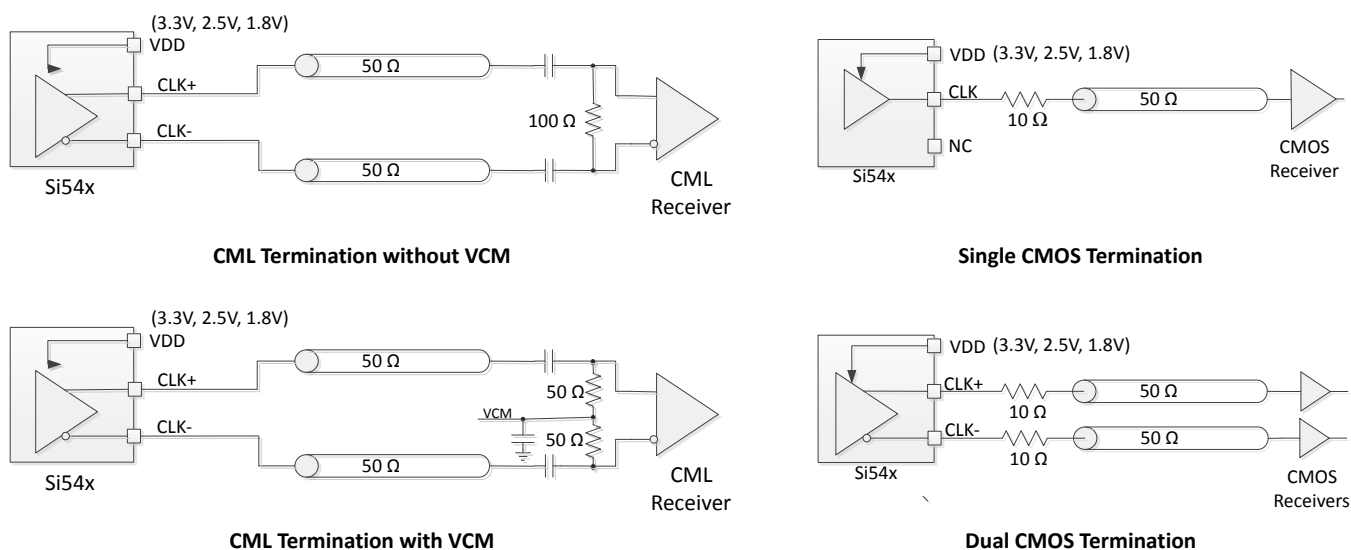
Figure 4.1. LVPECL Output Terminations

AC Coupled LVPECL Termination Resistor Values				DC Coupled LVPECL Termination Resistor Values		
VDD	R1	R2	Rp	VDD	R1	R2
3.3 V	127 Ω	82.5 Ω	130 Ω	3.3 V	127 Ω	82.5 Ω
2.5 V	250 Ω	62.5 Ω	90 Ω	2.5 V	250 Ω	62.5 Ω





**Figure 4.2. LVDS and HCSL Output Terminations**



**Figure 4.3. CML and CMOS Output Terminations**

## 5. Package Outline

### 5.1 Package Outline (5×7 mm)

The figure below illustrates the package details for the 5×7 mm Si545. The table below lists the values for the dimensions shown in the illustration.

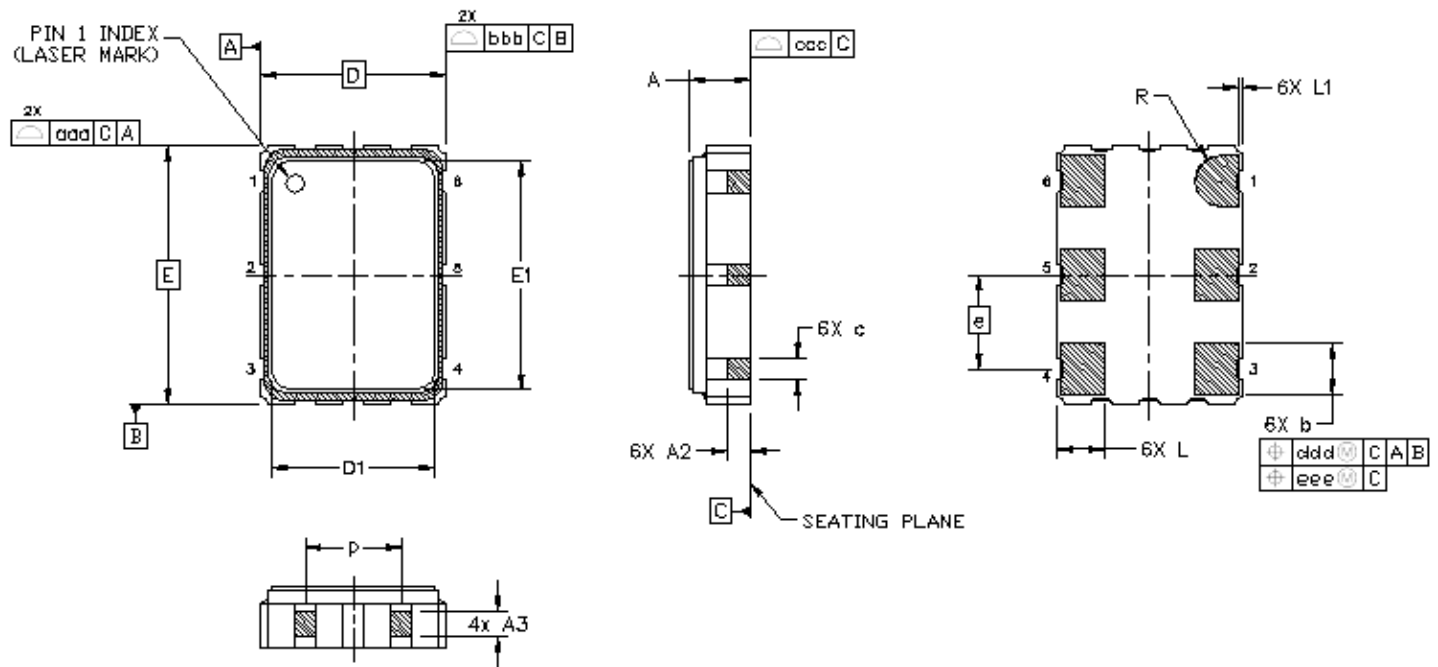


Figure 5.1. Si545 (5×7 mm) Outline Diagram

Table 5.1. Package Diagram Dimensions (mm)

Dimension	Min	Nom	Max	Dimension	Min	Nom	Max
A	1.13	1.28	1.43	L	1.17	1.27	1.37
A2	0.50	0.55	0.60	L1	0.05	0.10	0.15
A3	0.50	0.55	0.60	p	1.70	—	1.90
b	1.30	1.40	1.50	R	0.70 REF		
c	0.50	0.60	0.70	aaa	0.15		
D	5.00 BSC			bbb	0.15		
D1	4.30	4.40	4.50	ccc	0.08		
e	2.54 BSC			ddd	0.10		
E	7.00 BSC			eee	0.05		
E1	6.10	6.20	6.30				

**Notes:**

1. All dimensions shown are in millimeters (mm) unless otherwise noted.
2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.

## 5.2 Package Outline (3.2×5 mm)

The figure below illustrates the package details for the 3.2×5 mm Si545. The table below lists the values for the dimensions shown in the illustration.

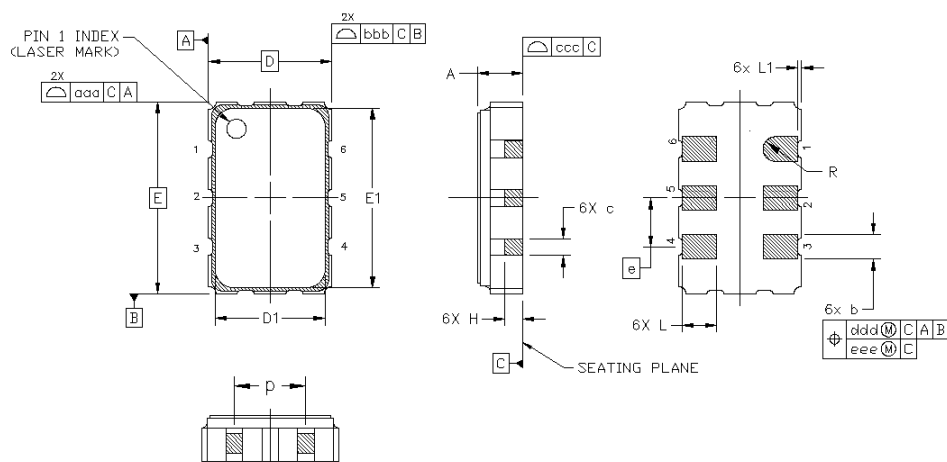


Figure 5.2. Si545 (3.2×5 mm) Outline Diagram

Table 5.2. 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	1.36	1.46	1.56
R	0.32 REF		
aaa	0.15		
bbb	0.15		
ccc	0.08		
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.

## 6. PCB Land Pattern

### 6.1 PCB Land Pattern (5×7 mm)

The figure below illustrates the 5×7 mm PCB land pattern for the Si545. The table below lists the values for the dimensions shown in the illustration.

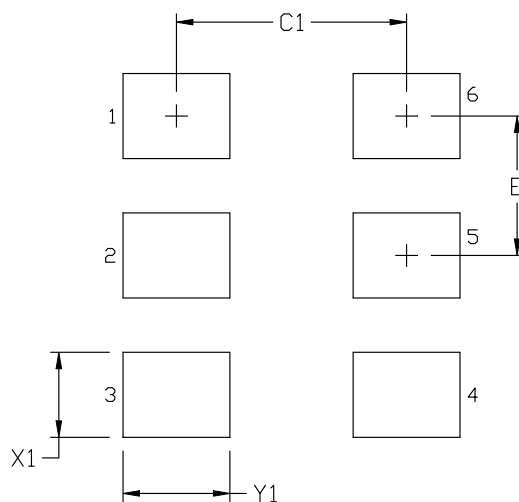


Figure 6.1. Si545 (5×7 mm) PCB Land Pattern

Table 6.1. 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

1. 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

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

##### Card Assembly

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

## 6.2 PCB Land Pattern (3.2×5 mm)

The figure below illustrates the 3.2×5.0 mm PCB land pattern for the Si545. The table below lists the values for the dimensions shown in the illustration.

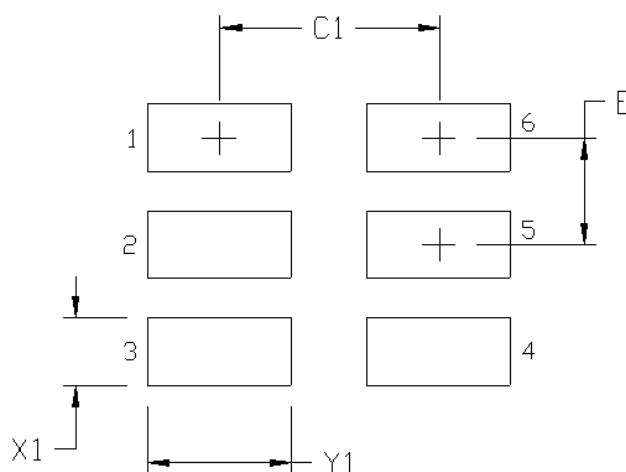


Figure 6.2. Si545 (3.2×5 mm) PCB Land Pattern

Table 6.2. 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

1. 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

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

#### Card Assembly

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

## 7. Top Marking

The figure below illustrates the mark specification for the Si545. The table below lists the line information.

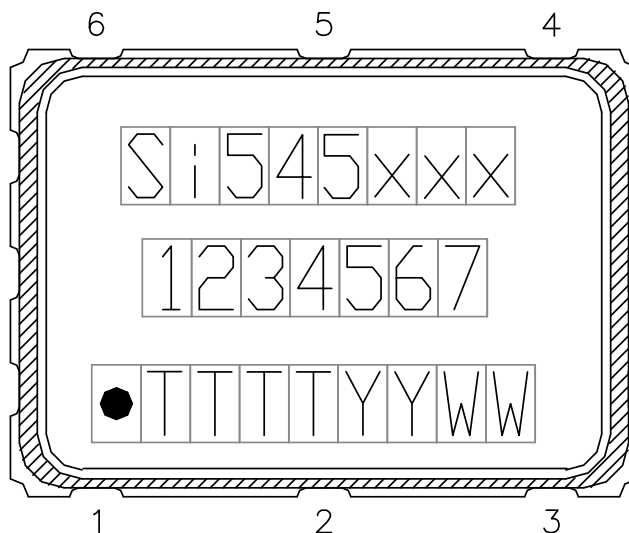


Figure 7.1. Mark Specification

Table 7.1. Si545 Top Mark Description

Line	Position	Description
1	1–8	"Si545", xxx = Ordering Option 1, Option 2, Option 3 (e.g. Si545AAA)
2	1–7	Frequency Code (e.g. 100M000 or 6-digit custom code as described in the Ordering Guide)
3	<b>Trace Code</b>	
	Position 1	Pin 1 orientation mark (dot)
	Position 2	Product Revision (B)
	Position 3–5	Tiny Trace Code (3 alphanumeric characters per assembly release instructions)
	Position 6–7	Year (last two digits of the year), to be assigned by assembly site (ex: 2017 = 17)
	Position 8–9	Calendar Work Week number (1–53), to be assigned by assembly site

## 8. Revision History

### Revision 1.0

July, 2018

- Added 20 ppm total stability option.

### Revision 0.75

March, 2018

- Added 25 ppm total stability option.

### Revision 0.71

December 11, 2017

- Added 5x7 package and land pattern.

### Revision 0.7

June 27, 2017

- Initial release.



## ClockBuilder Pro

One-click access to Timing tools, documentation, software, source code libraries & more. Available for Windows and iOS (CBGo only).

[www.silabs.com/CBPro](http://www.silabs.com/CBPro)



**Timing Portfolio**  
[www.silabs.com/timing](http://www.silabs.com/timing)



**SW/HW**  
[www.silabs.com/CBPro](http://www.silabs.com/CBPro)



**Quality**  
[www.silabs.com/quality](http://www.silabs.com/quality)



**Support and Community**  
[community.silabs.com](http://community.silabs.com)

### Disclaimer

Silicon Labs intends to provide customers with the latest, accurate, and in-depth documentation of all peripherals and modules available for system and software implementers using or intending to use the Silicon Labs products. Characterization data, available modules and peripherals, memory sizes and memory addresses refer to each specific device, and "Typical" parameters provided can and do vary in different applications. Application examples described herein are for illustrative purposes only. Silicon Labs reserves the right to make changes without further notice and limitation to product information, specifications, and descriptions herein, and does not give warranties as to the accuracy or completeness of the included information. Silicon Labs shall have no liability for the consequences of use of the information supplied herein. This document does not imply or express copyright licenses granted hereunder to design or fabricate any integrated circuits. The products are not designed or authorized to be used within any Life Support System without the specific written consent of Silicon Labs. A "Life Support System" is any product or system intended to support or sustain life and/or health, which, if it fails, can be reasonably expected to result in significant personal injury or death. Silicon Labs products are not designed or authorized for military applications. Silicon Labs products shall under no circumstances be used in weapons of mass destruction including (but not limited to) nuclear, biological or chemical weapons, or missiles capable of delivering such weapons.

### Trademark Information

Silicon Laboratories Inc.®, Silicon Laboratories®, Silicon Labs®, SiLabs® and the Silicon Labs logo®, Bluegiga®, Bluegiga Logo®, Clockbuilder®, CMEMS®, DSPLL®, EFM®, EFM32®, EFR, Ember®, Energy Micro, Energy Micro logo and combinations thereof, "the world's most energy friendly microcontrollers", Ember®, EZLink®, EZRadio®, EZRadioPRO®, Gecko®, ISOModem®, Micrium, Precision32®, ProSLIC®, Simplicity Studio®, SiPHY®, Telegesis, the Telegesis Logo®, USBXpress®, Zentri, Z-Wave, and others are trademarks or registered trademarks of Silicon Labs. ARM, CORTEX, Cortex-M3 and THUMB are trademarks or registered trademarks of ARM Holdings. Keil is a registered trademark of ARM Limited. All other products or brand names mentioned herein are trademarks of their respective holders.



Silicon Laboratories Inc.  
400 West Cesar Chavez  
Austin, TX 78701  
USA

<http://www.silabs.com>