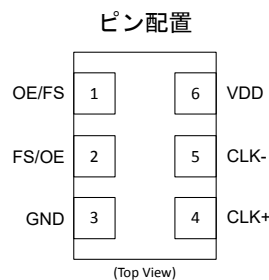


Ultra Series™ 水晶発振器

Si541 データ・シート

超低ジッタ・デュアル任意周波数 X0 (125 fs)、0.2 ~ 1500 MHz

Si541 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選択可能な 2 つの周波数で実現します。デバイスは、0.2 ~ 1500 MHz の選択可能な任意の 2 つ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。Si541 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。Si541 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 X0 とは違い、Si541 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。Si541 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。



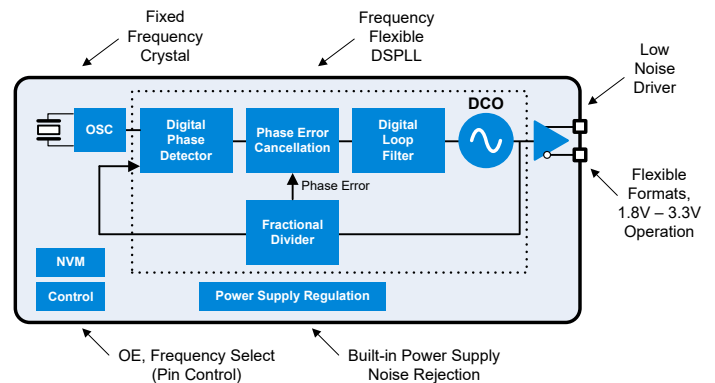
ピン番号	説明
1, 2	発注オプションにより選択可能 OE = 出力イネーブル、FS = 周波数選択
3	GND = グランド
4	CLK+ = クロック出力
5	CLK- = 相補クロック出力。CMOS には未使用。
6	VDD = 電源

主な機能

- 0.2 MHz ~ 1500 MHz の選択可能な任意の 2 つの周波数で利用可能
- 超低ジッタ : 125 fs (標準値) RMS (12 kHz ~ 20 MHz)
- 優れた PSRR および電源ノイズ耐性 : -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_{DD} 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・タイムで任意のカスタム周波数を提供

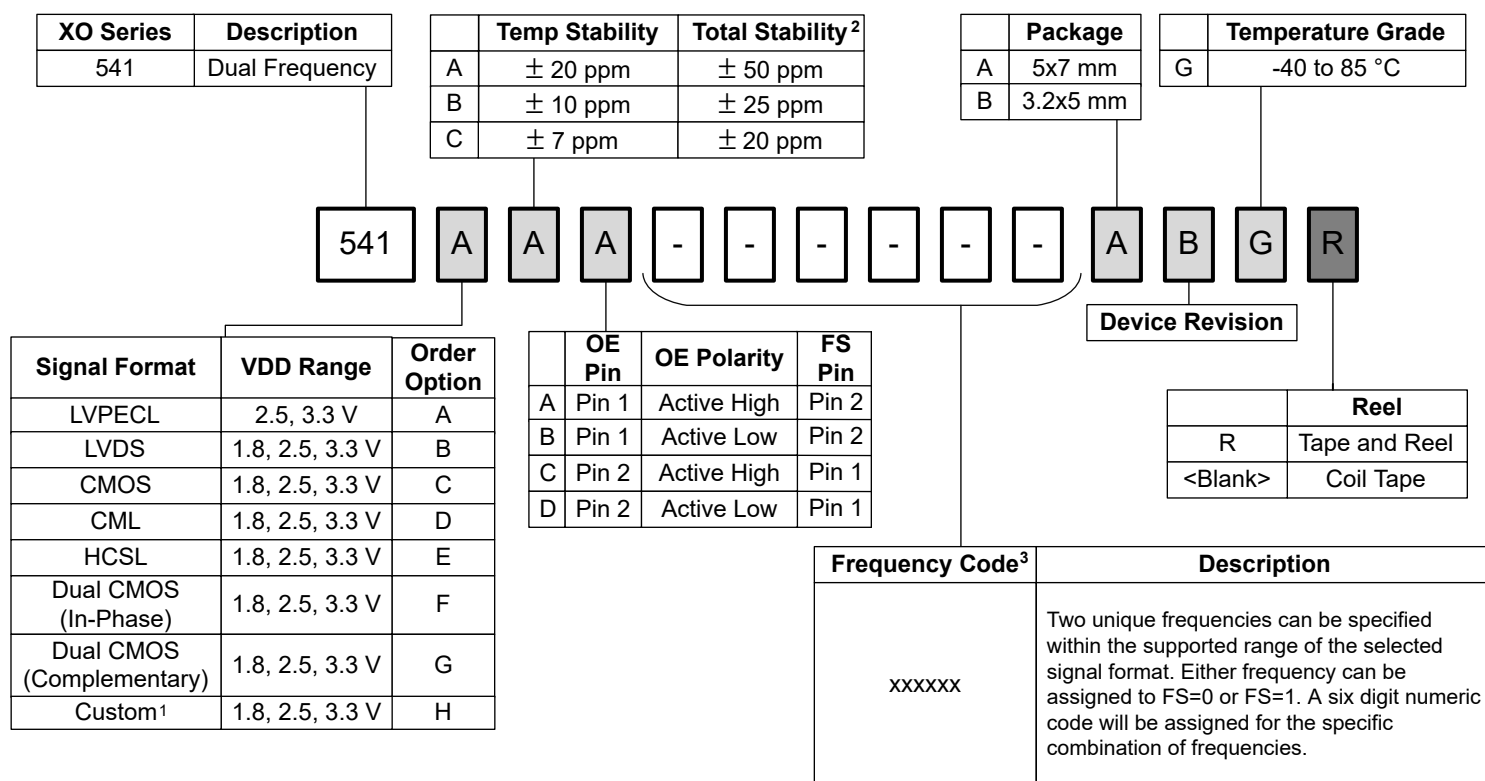
アプリケーション

- 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
- サーバ、スイッチ、ストレージ、NIC、検索の高速化
- 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 Si541 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 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.
- Create custom part numbers at www.silabs.com/oscillators.

1.1 Technical Support

Frequently Asked Questions (FAQ)	www.silabs.com/Si541-FAQ
Oscillator Phase Noise Lookup Utility	www.silabs.com/oscillator-phase-noise-lookup
Quality and Reliability	www.silabs.com/quality
Development Kits	www.silabs.com/oscillator-tools

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)	—	100	132	mA
		LVDS/CML (output enabled)	—	75	111	mA
		HCSL (output enabled)	—	80	125	mA
		CMOS (output enabled)	—	74	108	mA
		Dual CMOS (output enabled)	—	80	125	mA
		Tristate Hi-Z (output disabled)	—	64	100	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 ¹	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) Frequency Select (FS) ²	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	μs
	T_E	Output Enable Time, $F_{CLK} > 10\text{ MHz}$	—	—	20	μs
	T_{FS}	Settling Time after FS Change	—	—	10	ms
Powerup Time	t_{OSC}	Time from $0.9 \times V_{DD}$ until output frequency (F_{CLK}) within spec	—	—	10	ms
LVPECL Output Option ³	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 ⁴	V _{OC}	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 _O	Swing (diff)	0.5	0.7	0.9	V _{PP}
HCSL Output Option ⁵	V _{OH}	Output voltage high	660	750	850	mV
	V _{OL}	Output voltage low	-150	0	150	mV
	V _C	Crossing voltage	250	350	550	mV
CML Output Option (AC-Coupled)	V _O	Swing (diff)	0.6	0.8	1.0	V _{PP}
CMOS Output Option	V _{OH}	I _{OH} = 8/6/4 mA for 3.3/2.5/1.8 V VDD	0.85 × V _{DD}	—	—	V
	V _{OL}	I _{OL} = 8/6/4 mA for 3.3/2.5/1.8 V VDD	—	—	0.15 × V _{DD}	V

Notes:

1. Total Stability includes temperature stability, initial accuracy, load pulling, VDD variation, and aging for 20 yrs at 70 °C.
2. 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. FS includes a 50 kΩ pull-up to VDD.
3. 50 Ω to V_{DD} - 2.0 V.
4. R_{term} = 100 Ω (differential).
5. 50 Ω to GND.

Table 2.2. Clock Output Phase Jitter and PSRR

V_{DD} = 1.8 V, 2.5 or 3.3 V ± 5%, T_A = -40 to 85 °C

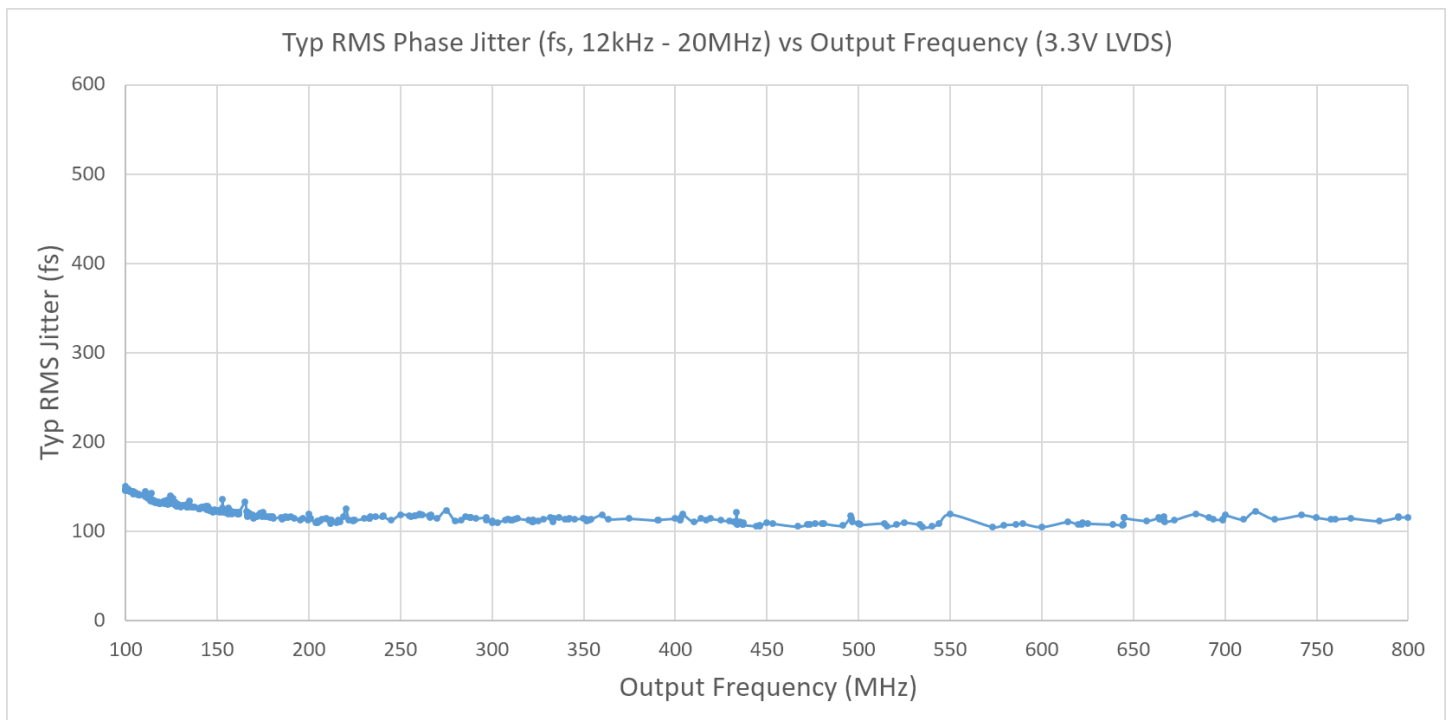
Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Phase Jitter (RMS, 12kHz - 20MHz) ¹ 3.2 x 5 mm, F _{CLK} ≥ 100 MHz	ϕ _J	Differential Formats	—	125	200	fs
		CMOS, Dual CMOS	—	200	—	fs
Phase Jitter (RMS, 12kHz - 20MHz) ¹ 5 x 7 mm, F _{CLK} ≥ 100 MHz		Differential Formats	—	150	200	fs
		CMOS, Dual CMOS	—	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:

1. 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	-110	-107	-99	dBc/Hz
1 kHz	-121	-120	-109	
10 kHz	-132	-130	-121	
100 kHz	-139	-137	-127	
1 MHz	-151	-149	-138	
10 MHz	-160	-161	-155	
20 MHz	-161	-162	-157	
Offset Frequency (f)	156.25 MHz LVPECL	200 MHz LVPECL	644.53125 MHz LVPECL	Unit
100 Hz	-113	-110	-100	dBc/Hz
1 kHz	-123	-120	-110	
10 kHz	-133	-130	-119	
100 kHz	-139	-137	-127	
1 MHz	-151	-149	-138	
10 MHz	-162	-166	-156	
20 MHz	-163	-167	-157	



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.

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.

Table 2.5. Thermal Conditions

Package	Parameter	Symbol	Test Condition	Value	Unit
3.2×5 mm 6-pin CLCC	Thermal Resistance Junction to Ambient	Θ_{JA}	Still Air, 85 °C	80.3	°C/W
	Thermal Resistance Junction to Board	Θ_{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	Θ_{JA}	Still Air, 85 °C	68.4	°C/W
	Thermal Resistance Junction to Board	Θ_{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 Ratings¹

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 ²	T_{PEAK}	260	°C
Solder Time at T_{PEAK} ²	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 Si541 device.

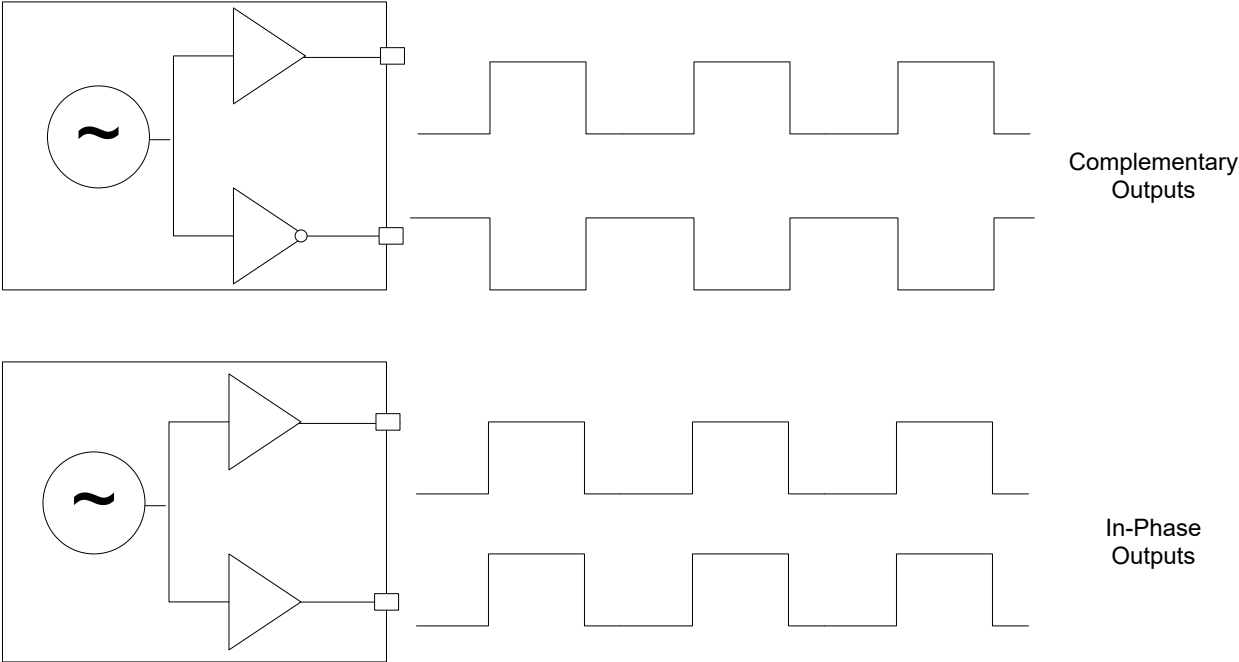


Figure 3.1. Integrated 1:2 CMOS Buffer Supports Complementary or In-Phase Outputs

4. Recommended Output Terminations

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

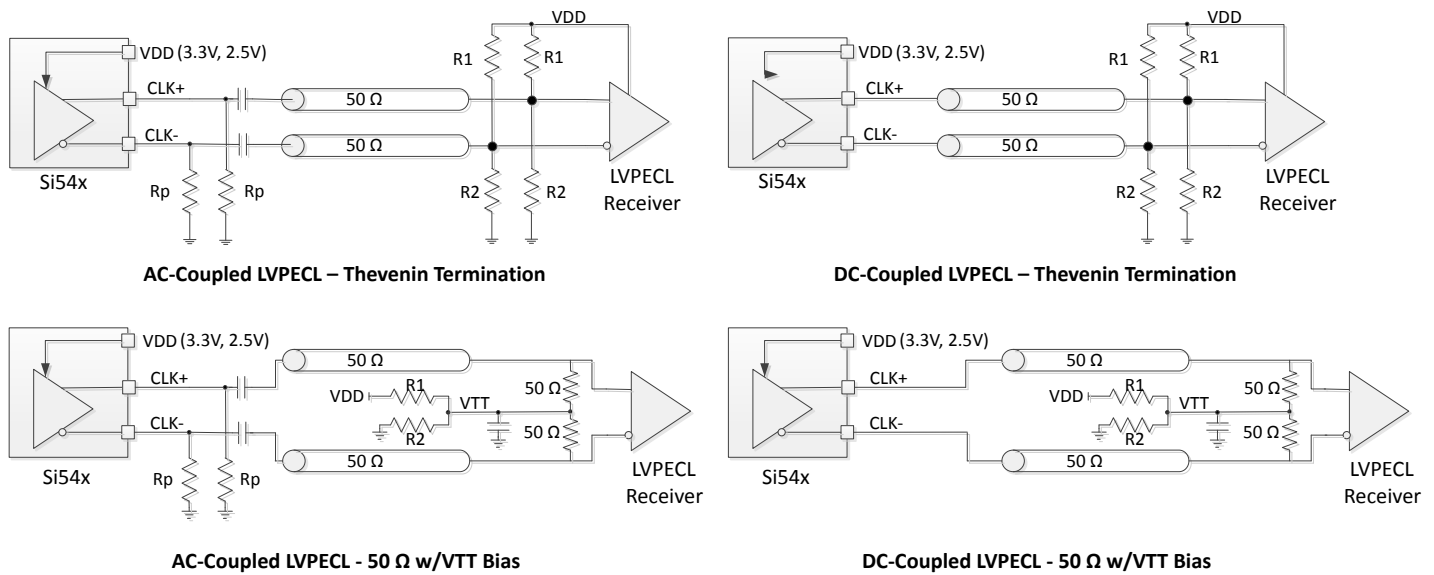


Figure 4.1. LVPECL Output Terminations

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

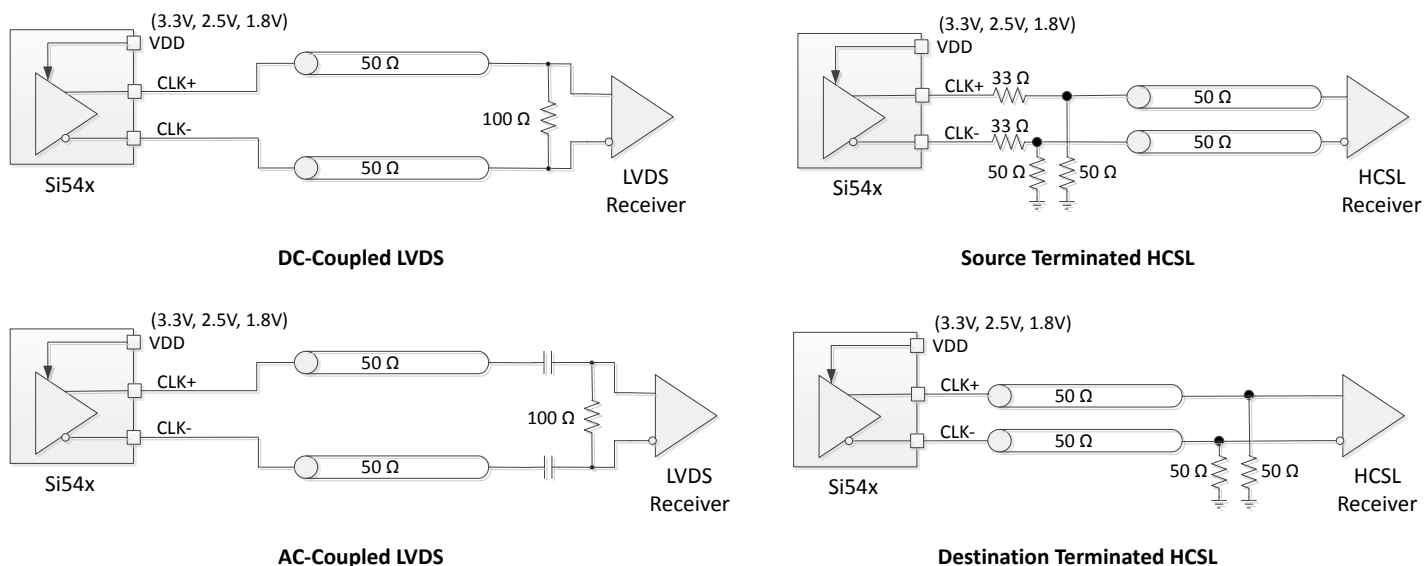


Figure 4.2. LVDS and HCSL Output Terminations

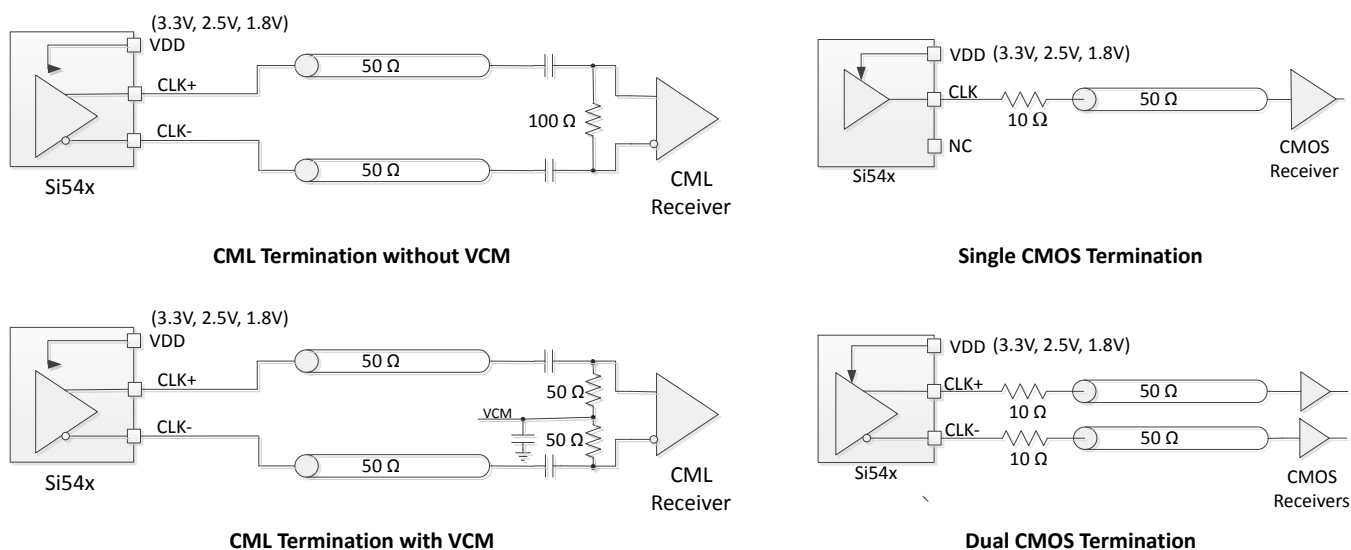


Figure 4.3. CML and CMOS Output Terminations

5. Package Outline

5.1 Package Outline (5×7 mm)

The figure below illustrates the package details for the 5×7 mm Si541. The table below lists the values for the dimensions shown in the illustration.

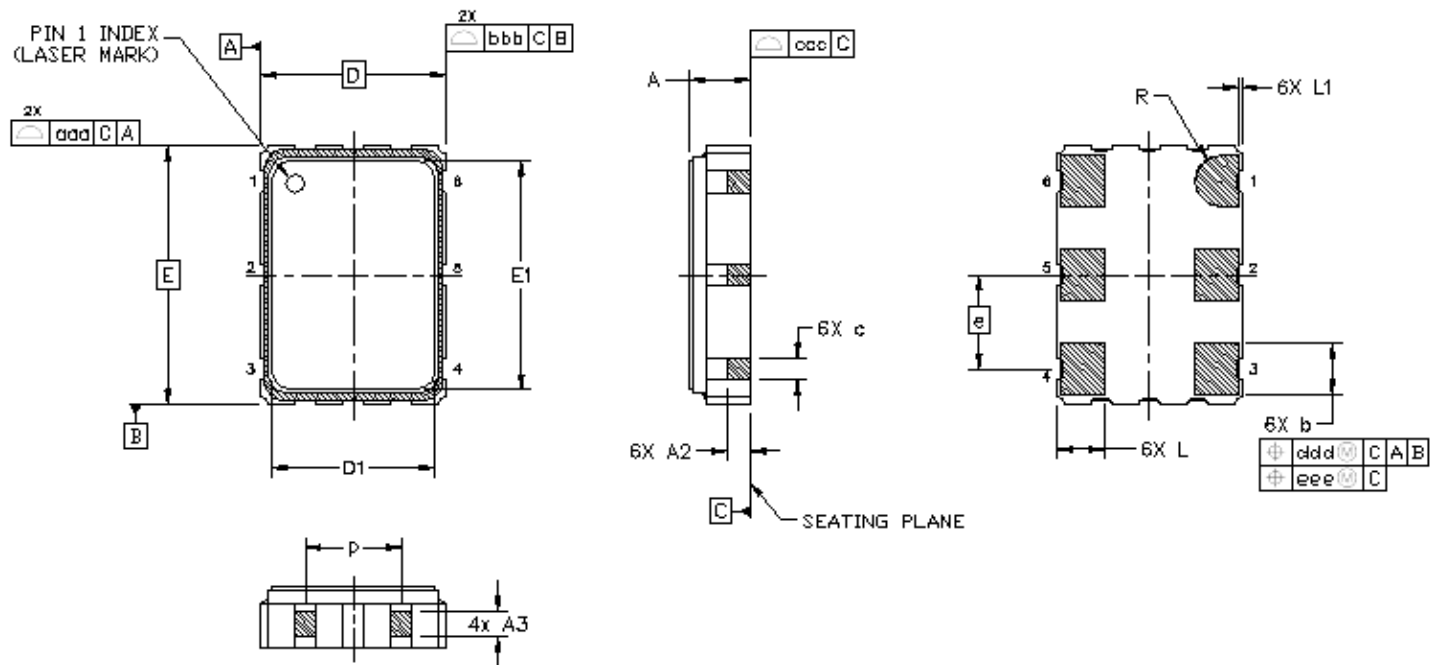


Figure 5.1. Si541 (5×7 mm) Outline Diagram

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 Si541. The table below lists the values for the dimensions shown in the illustration.

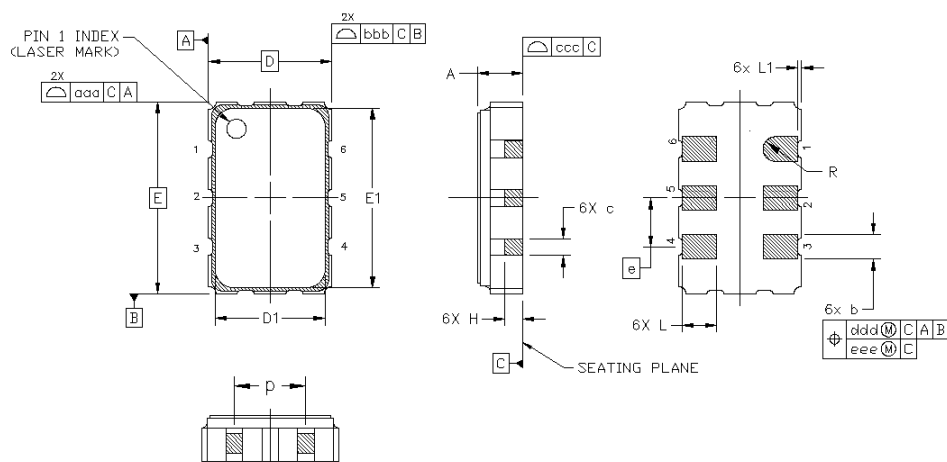


Figure 5.2. Si541 (3.2×5 mm) Outline Diagram

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 Si541. The table below lists the values for the dimensions shown in the illustration.

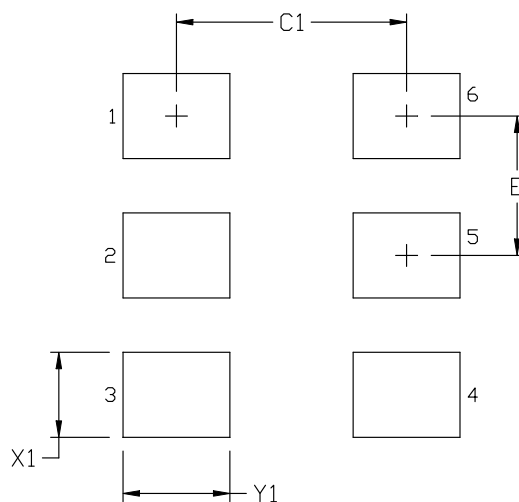


Figure 6.1. Si541 (5×7 mm) PCB Land Pattern

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 μ 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 Si541. The table below lists the values for the dimensions shown in the illustration.

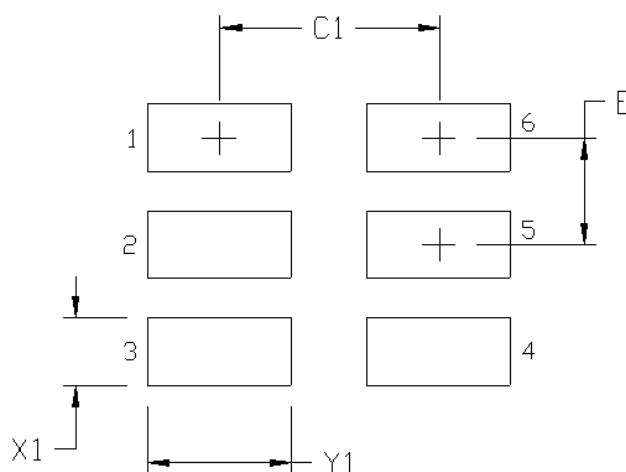


Figure 6.2. Si541 (3.2×5 mm) PCB Land Pattern

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.

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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 Si541. The table below lists the line information.

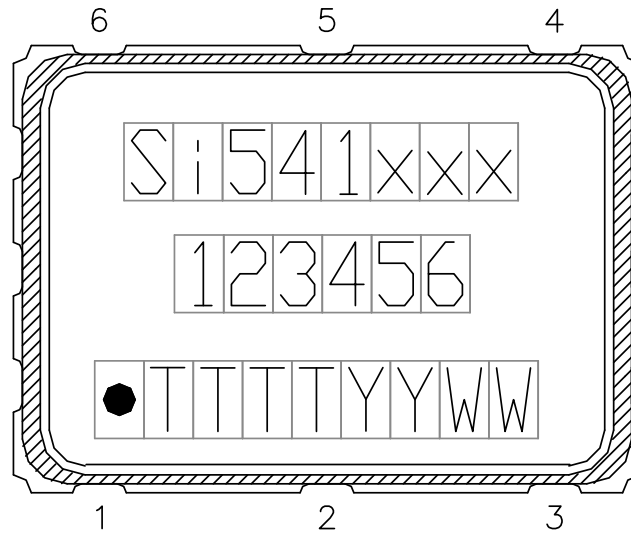


Figure 7.1. Mark Specification

Table 7.1. Si541 Top Mark Description

Line	Position	Description
1	1–8	"Si541", xxx = Ordering Option 1, Option 2, Option 3 (e.g. Si541AAA)
2	1–6	Frequency Code (6-digit custom code as described in the Ordering Guide)
3	Trace Code	
	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

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