



Ultra Series™ Crystal Oscillator

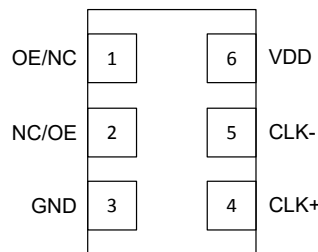
Si545 Data Sheet

Ultra Low Jitter Any-Frequency XO (80 fs), 0.2 to 1500 MHz

The Si545 Ultra Series™ oscillator utilizes Silicon Laboratories' advanced 4th generation DSPLL® technology to provide an ultra-low jitter, low phase noise clock at any output frequency. The device is factory-programmed to any frequency from 0.2 to 1500 MHz with <1 ppb resolution and maintains exceptionally low jitter for both integer and fractional frequencies across its operating range. The Si545 offers excellent reliability and frequency stability as well as guaranteed aging performance. On-chip power supply filtering provides industry-leading power supply noise rejection, simplifying the task of generating low jitter clocks in noisy systems that use switched-mode power supplies. Offered in industry-standard 3.2x5 mm and 5x7 mm footprints, the Si545 has a dramatically simplified supply chain that enables Silicon Labs to ship custom frequency samples 1-2 weeks after receipt of order. Unlike a traditional XO, where a different crystal is required for each output frequency, the Si545 uses one simple crystal and a DSPLL IC-based approach to provide the desired output frequency. This process also guarantees 100% electrical testing of every device. The Si545 is factory-configurable for a wide variety of user specifications, including frequency, output format, and OE pin location/polarity. Specific configurations are factory-programmed at time of shipment, eliminating the long lead times associated with custom oscillators.



Pin Assignments



(Top View)

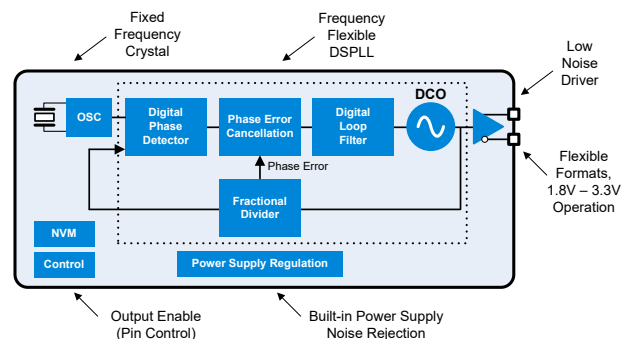
| Pin # | Descriptions |
|-------|---|
| 1, 2 | Selectable via ordering option OE = Output enable; NC = No connect |
| 3 | GND = Ground |
| 4 | CLK+ = Clock output |
| 5 | CLK- = Complementary clock output. Not used for CMOS. |
| 6 | VDD = Power supply |

KEY FEATURES

- Available with any frequency from 0.2 MHz to 1500 MHz
- Ultra low jitter: 80 fs Typ RMS (12 kHz – 20 MHz)
- Excellent PSRR and supply noise immunity: –80 dBc Typ
- 7 ppm stability option (–40 to 85 °C)
- 3.3 V, 2.5 V and 1.8 V V_{DD} supply operation from the same part number
- LVPECL, LVDS, CML, HCSL, CMOS, and Dual CMOS output options
- 3.2x5, 5x7 mm package footprints
- Samples available with 1-2 week lead times

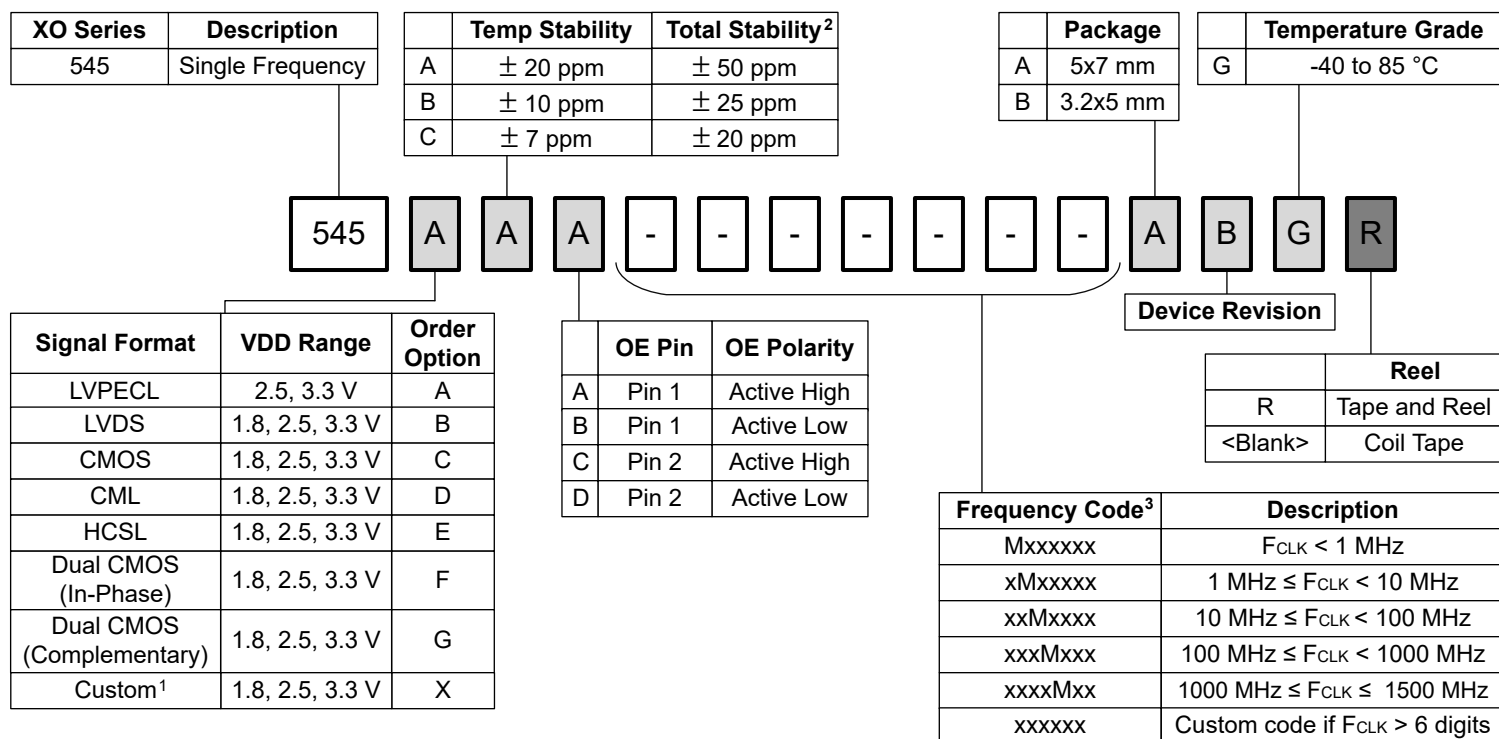
APPLICATIONS

- 100G/200G/400G OTN, coherent optics
- 10G/40G/100G optical ethernet
- 3G-SDI/12G-SDI/24G-SDI broadcast video
- Datacenter
- Test and measurement
- Clock and data recovery
- FPGA/ASIC clocking



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 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.

1.1 Technical Support

| | |
|---------------------------------------|--|
| Frequently Asked Questions (FAQ) | www.silabs.com/Si545-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) | — | 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 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) 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 |
| 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:

- 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_{DD} - 2.0 V.
- R_{term} = 100 Ω (differential).
- 50 Ω to GND.

Table 2.2. Clock Output Phase Jitter and PSRRV_{DD} = 1.8 V, 2.5 or 3.3 V ± 5%, T_A = -40 to 85 °C

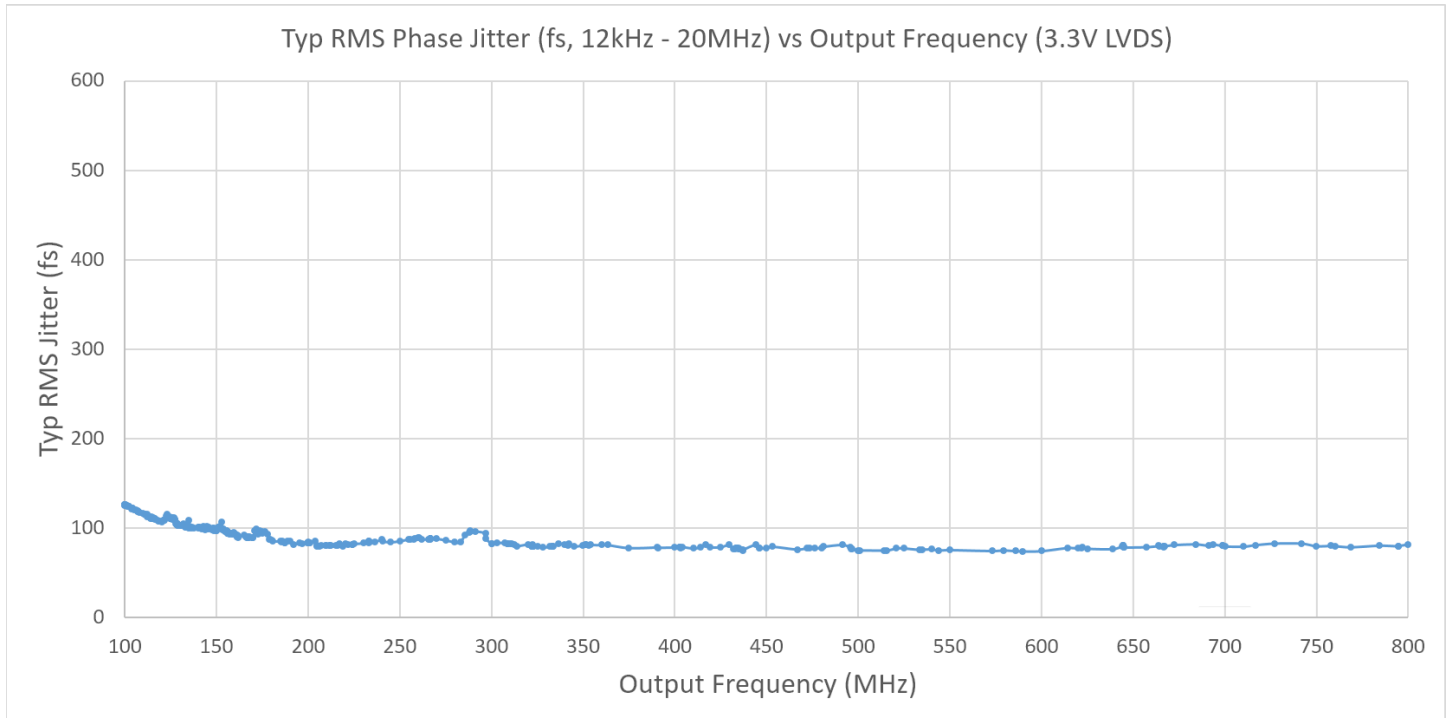
| Parameter | Symbol | Test Condition/Comment | Min | Typ | Max | Unit |
|--|----------------|--------------------------------------|-----|-----|-----|------|
| Phase Jitter (RMS, 12kHz - 20MHz) ¹ 3.2 x 5 mm, All Differential Formats | ϕ _J | F _{CLK} ≥ 200 MHz | — | 80 | 110 | fs |
| | | 100 MHz ≤ F _{CLK} < 200 MHz | — | 100 | 150 | fs |
| | | LVPECL @ 156.25 MHz | — | 90 | 125 | fs |
| Phase Jitter (RMS, 12kHz - 20MHz) ¹ 5 x 7 mm, All Differential Formats | | F _{CLK} ≥ 200 MHz | — | 80 | 130 | fs |
| | | 100 MHz ≤ F _{CLK} < 200 MHz | — | 100 | 150 | fs |
| | | LVPECL @ 156.25 MHz | — | 90 | 125 | fs |
| Phase Jitter (RMS, 12kHz - 20MHz) ¹ CMOS / Dual CMOS Formats | ϕ _J | 10 MHz ≤ F _{CLK} ≤ 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.

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 Si545 device.

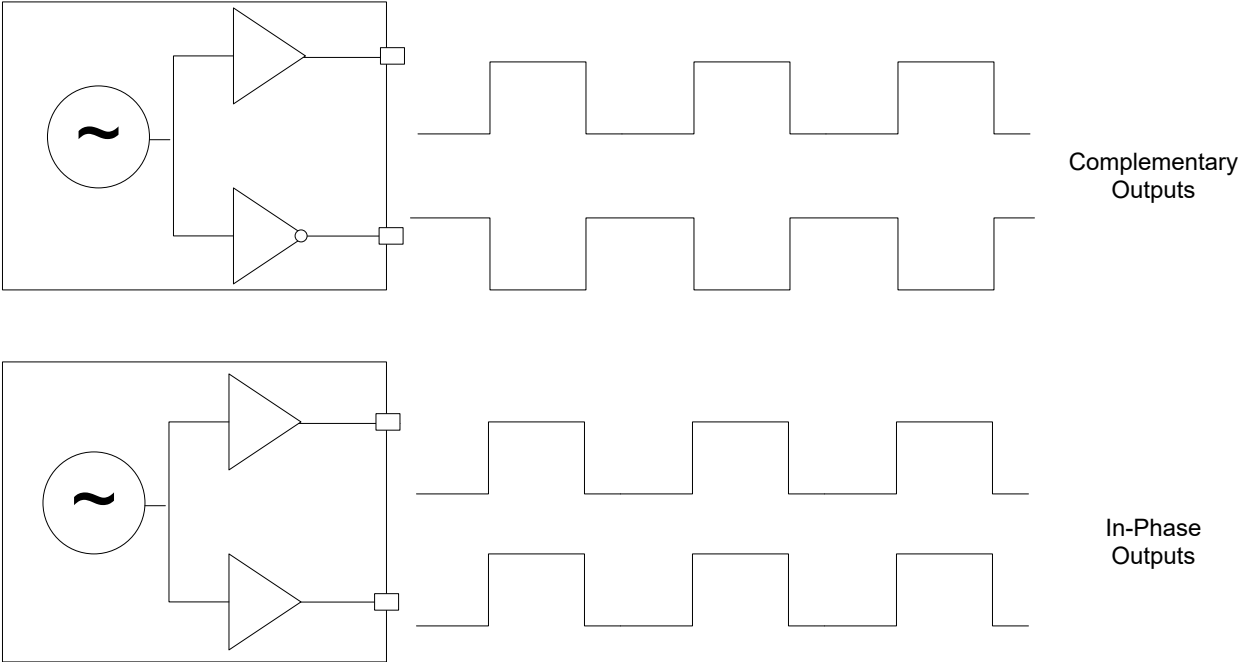


Figure 3.1. Integrated 1:2 CMOS Buffer Supports Complementary or In-Phase Outputs

4. Recommended Output Terminations

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

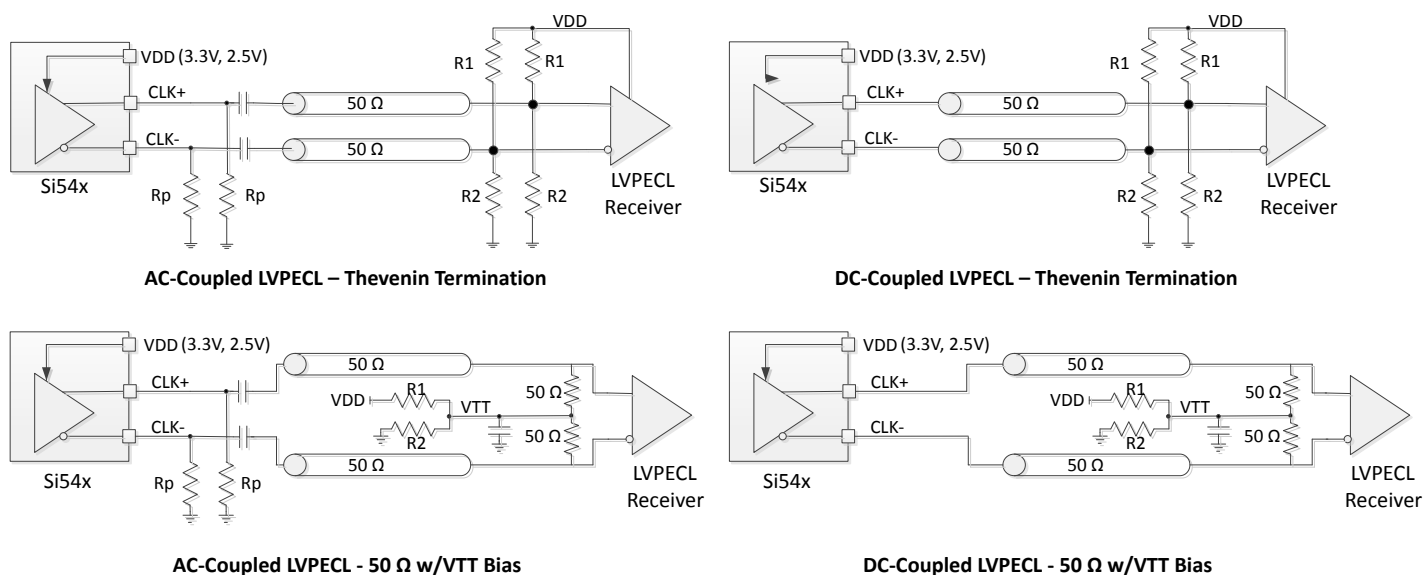


Figure 4.1. LVPECL Output Terminations

| 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 |

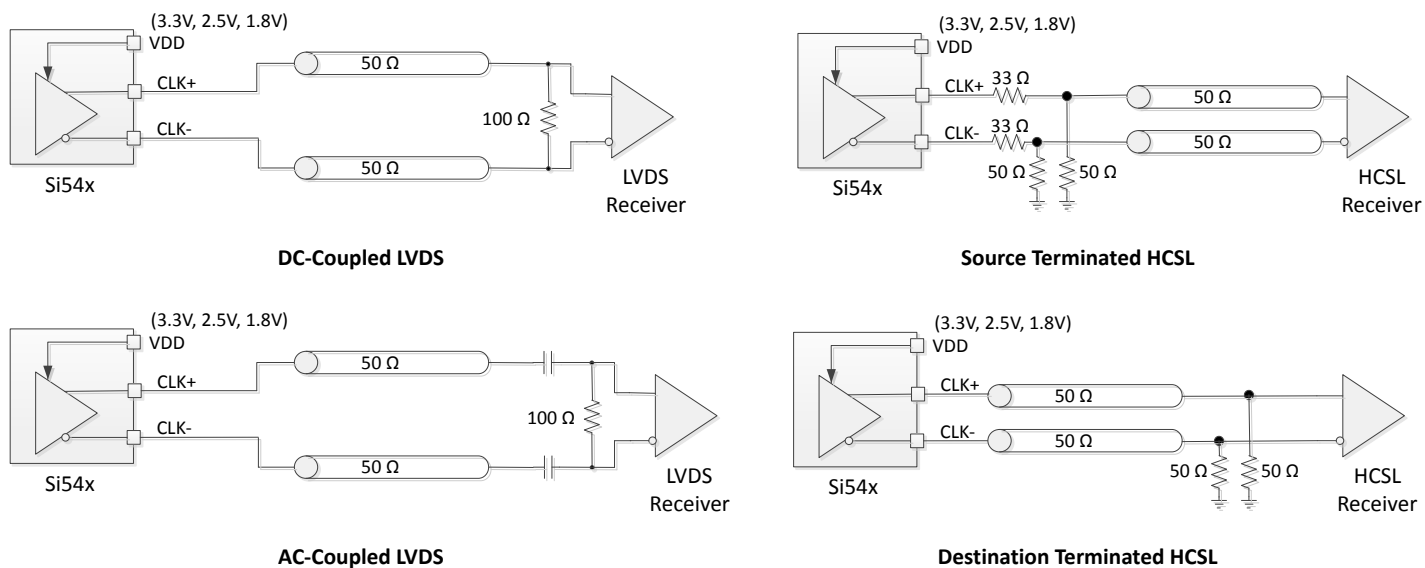


Figure 4.2. LVDS and HCSL Output Terminations

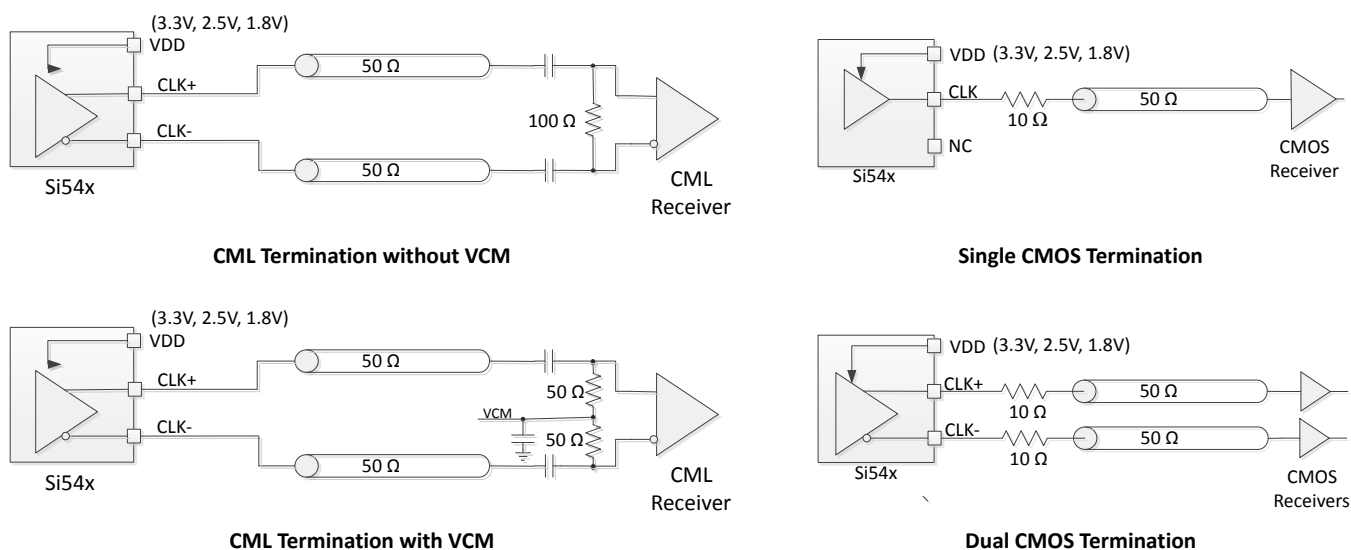


Figure 4.3. CML and CMOS Output Terminations

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.

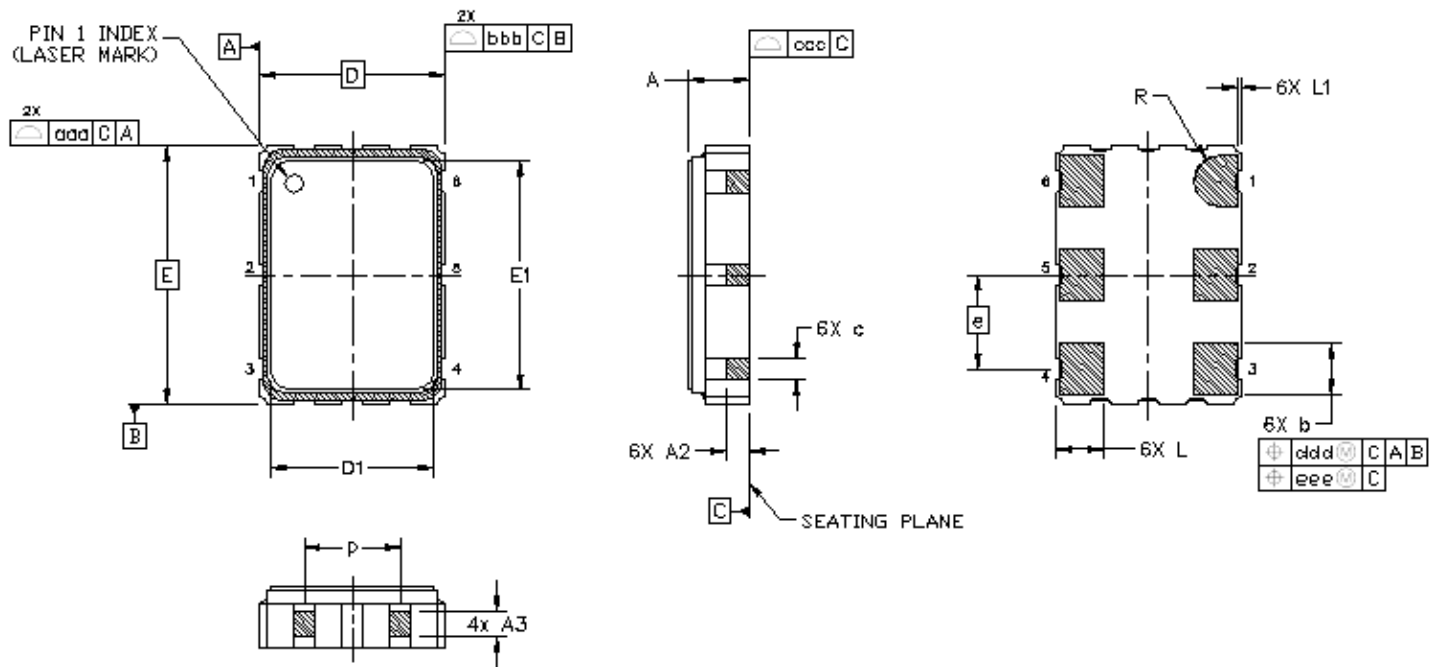


Figure 5.1. Si545 (5×7 mm) Outline Diagram

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.

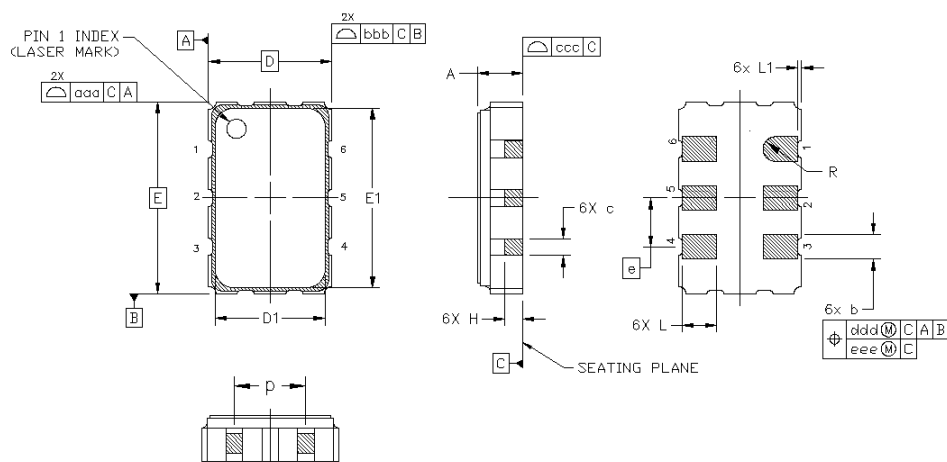


Figure 5.2. Si545 (3.2×5 mm) Outline Diagram

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:

- All dimensions shown are in millimeters (mm) unless otherwise noted.
- 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.

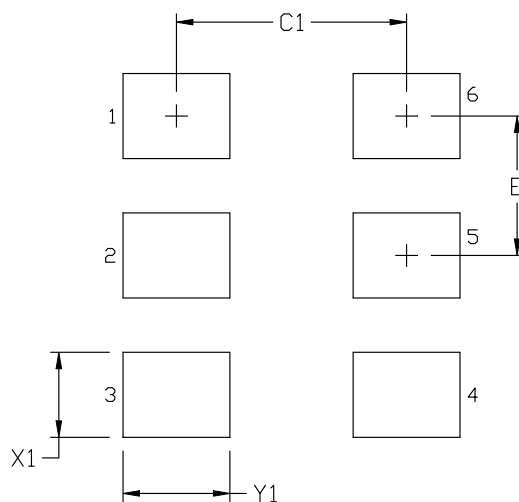


Figure 6.1. Si545 (5×7 mm) PCB Land Pattern

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 μm 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.

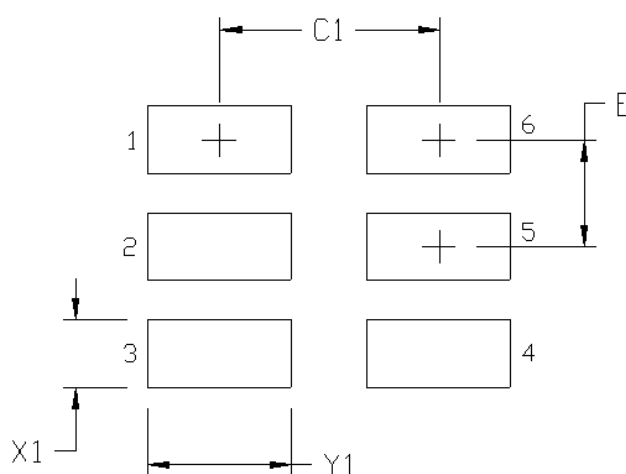


Figure 6.2. Si545 (3.2×5 mm) PCB Land Pattern

Table 6.2. PCB Land Pattern Dimensions (mm)

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

Notes:

General

- 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 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.

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. Top Marking

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

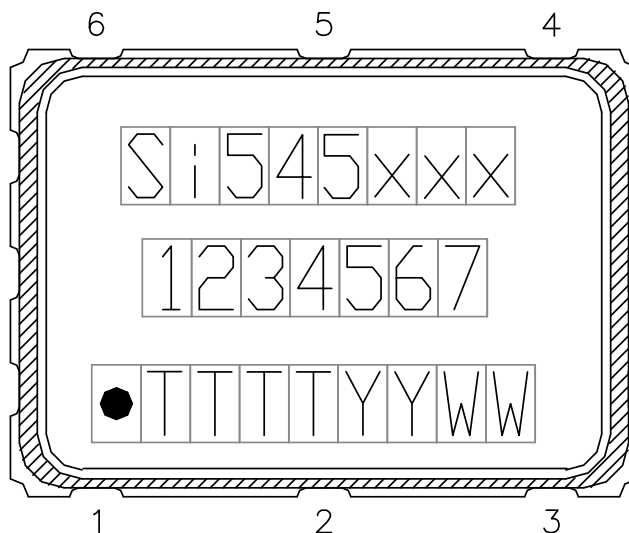


Figure 7.1. Mark Specification

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 | 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.



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