

## CRYSTAL OSCILLATOR (XO) (10 MHz TO 1.4 GHz)

### Features

- Available with any-rate output frequencies from 10 MHz to 945 MHz and select frequencies to 1.4 GHz
- 3rd generation DSPLL<sup>®</sup> with superior jitter performance
- 3x better frequency stability than SAW-based oscillators
- Internal fixed crystal frequency ensures high reliability and low aging
- Available CMOS, LVPECL, LVDS, and CML outputs
- 3.3, 2.5, and 1.8 V supply options
- Industry-standard 5 x 7 mm package and pinout
- Pb-free/RoHS-compliant

### Applications

- SONET/SDH
- Networking
- SD/HD video
- Test and measurement
- Clock and data recovery
- FPGA/ASIC clock generation

### Description

The Si530/531 XO utilizes Silicon Laboratories' advanced DSPLL<sup>®</sup> circuitry to provide a low jitter clock at high frequencies. The Si530/531 is available with any-rate output frequency from 10 to 945 MHz and select frequencies to 1400 MHz. Unlike a traditional XO, where a different crystal is required for each output frequency, the Si530/531 uses one fixed crystal to provide a wide range of output frequencies. This IC based approach allows the crystal resonator to provide exceptional frequency stability and reliability. In addition, DSPLL clock synthesis provides superior supply noise rejection, simplifying the task of generating low jitter clocks in noisy environments typically found in communication systems. The Si530/531 IC based XO is factory configurable for a wide variety of user specifications including frequency, supply voltage, output format, and temperature stability. Specific configurations are factory programmed at time of shipment, thereby eliminating long lead times associated with custom oscillators.

### Functional Block Diagram



## 1. Electrical Specifications

**Table 1. Recommended Operating Conditions**

| Parameter                       | Symbol          | Test Condition                                  | Min                    | Typ | Max  | Unit |
|---------------------------------|-----------------|---|------------------------|-----|------|------|
| Supply Voltage <sup>1</sup>     | V <sub>DD</sub> | 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 <sub>DD</sub> | Output enabled<br>LVPECL<br>CML<br>LVDS<br>CMOS | —                      | 111 | 121  | mA   |
|                                 |                 |   | —                      | 99  | 108  |      |
|                                 |                 |   | —                      | 90  | 98   |      |
|                                 |                 |   | —                      | 81  | 88   |      |
|                                 |                 | Tristate mode                                   | —                      | 60  | 75   | mA   |
| Output Enable (OE) <sup>2</sup> |                 | V <sub>IH</sub>                                 | 0.75 x V <sub>DD</sub> | —   | —    | V    |
|                                 |                 | V <sub>IL</sub>                                 | —                      | —   | 0.5  | V    |
| Operating Temperature Range     | T <sub>A</sub>  |   | −40                    | —   | 85   | °C   |

**Notes:**

- Selectable parameter specified by part number. See Section 3. "Ordering Information" on page 7 for further details.
- OE pin includes a 17 kΩ pullup resistor to V<sub>DD</sub>.

**Table 2. CLK± Output Frequency Characteristics**

| Parameter                            | Symbol         | Test Condition                         | Min | Typ  | Max | Unit |
|--------------------------------------|----------------|--|-----|------|-----|------|
| Nominal Frequency <sup>1,2</sup>     | f <sub>O</sub> | LVPECL/LVDS/CML                        | 10  | —    | 945 | MHz  |
|                                      |                | CMOS                                   | 10  | —    | 160 | MHz  |
| Initial Accuracy                     | f <sub>i</sub> | Measured at +25 °C at time of shipping | —   | ±1.5 | —   | ppm  |
| Temperature Stability <sup>1,3</sup> |                |  | −7  | —    | +7  | ppm  |
|                                      |                |  | −20 | —    | +20 |      |
|                                      |                |  | −50 | —    | +50 |      |
| Aging                                | f <sub>a</sub> | Frequency drift over first year        | —   | —    | ±3  | ppm  |
|                                      |                | Frequency drift over 20 year life      | —   | —    | ±10 | ppm  |

**Notes:**

- See Section 3. "Ordering Information" on page 7 for further details.
- Specified at time of order by part number. Also available in frequencies from 970 to 1134 MHz and 1213 to 1417 MHz.
- Selectable parameter specified by part number.
- Time from powerup or tristate mode to f<sub>O</sub>.

Table 2. CLK± Output Frequency Characteristics (Continued)

| Parameter                 | Symbol    | Test Condition                | Min | Typ | Max        | Unit |
|---------------------------|-----------|-------------------------------|-----|-----|------------|------|
| Total Stability           |           | Temp stability = $\pm 7$ ppm  | —   | —   | $\pm 20$   | ppm  |
|                           |           | Temp stability = $\pm 20$ ppm | —   | —   | $\pm 31.5$ | ppm  |
|                           |           | Temp stability = $\pm 50$ ppm | —   | —   | $\pm 61.5$ | ppm  |
| Powerup Time <sup>4</sup> | $t_{OSC}$ |                               | —   | —   | 10         | ms   |

**Notes:**

- See Section 3. "Ordering Information" on page 7 for further details.
- Specified at time of order by part number. Also available in frequencies from 970 to 1134 MHz and 1213 to 1417 MHz.
- Selectable parameter specified by part number.
- Time from powerup or tristate mode to  $f_O$ .

Table 3. CLK± Output Levels and Symmetry

| Parameter                         | Symbol     | Test Condition   | Min                 | Typ             | Max             | Unit     |
|-----------------------------------|------------|--|---------------------|-----------------|-----------------|----------|
| LVPECL Output Option <sup>1</sup> | $V_O$      | mid-level  | $V_{DD} - 1.42$     | —               | $V_{DD} - 1.25$ | V        |
|                                   | $V_{OD}$   | swing (diff)   | 1.1                 | —               | 1.9             | $V_{PP}$ |
|                                   | $V_{SE}$   | swing (single-ended)   | 0.55                | —               | 0.95            | $V_{PP}$ |
| LVDS Output Option <sup>2</sup>   | $V_O$      | mid-level  | 1.125               | 1.20            | 1.275           | V        |
|                                   | $V_{OD}$   | swing (diff)   | 0.5                 | 0.7             | 0.9             | $V_{PP}$ |
| CML Output Option <sup>2</sup>    | $V_O$      | 2.5/3.3 V option mid-level   | —                   | $V_{DD} - 1.30$ | —               | V        |
|                                   |            | 1.8 V option mid-level   | —                   | $V_{DD} - 0.36$ | —               | V        |
|                                   | $V_{OD}$   | 2.5/3.3 V option swing (diff)  | 1.10                | 1.50            | 1.90            | $V_{PP}$ |
|                                   |            | 1.8 V option swing (diff)  | 0.35                | 0.425           | 0.50            | $V_{PP}$ |
| CMOS Output Option <sup>3</sup>   | $V_{OH}$   | $I_{OH} = 32$ mA   | $0.8 \times V_{DD}$ | —               | $V_{DD}$        | V        |
|                                   | $V_{OL}$   | $I_{OL} = 32$ mA   | —                   | —               | 0.4             | V        |
| Rise/Fall time (20/80%)           | $t_R, t_F$ | LVPECL/LVDS/CML  | —                   | —               | 350             | ps       |
|                                   |            | CMOS with $C_L = 15$ pF  | —                   | 1               | —               | ns       |
| Symmetry (duty cycle)             | SYM        | LVPECL: $V_{DD} - 1.3$ V (diff)<br>LVDS: 1.25 V (diff)<br>CMOS: $V_{DD}/2$ | 45                  | —               | 55              | %        |

**Notes:**

- $50 \Omega$  to  $V_{DD} - 2.0$  V.
- $R_{term} = 100 \Omega$  (differential).
- $C_L = 15$  pF

**Table 4. CLK± Output Phase Jitter**

| Parameter   | Symbol         | Test Condition                         | Min | Typ  | Max  | Unit |
|---|----------------|--|-----|------|------|------|
| Phase Jitter (RMS) <sup>1</sup><br>for F <sub>OUT</sub> ≥ 500 MHz               | ϕ <sub>J</sub> | 12 kHz to 20 MHz (OC-48)               | —   | 0.25 | 0.40 | ps   |
|   |                | 50 kHz to 80 MHz (OC-192)              | —   | 0.26 | 0.37 | ps   |
| Phase Jitter (RMS) <sup>1</sup><br>for F <sub>OUT</sub> of 125 to 500 MHz       | ϕ <sub>J</sub> | 12 kHz to 20 MHz (OC-48)               | —   | 0.36 | 0.50 | ps   |
|   |                | 50 kHz to 80 MHz (OC-192) <sup>2</sup> | —   | 0.34 | 0.42 | ps   |
| Phase Jitter (RMS)<br>for F <sub>OUT</sub> of 10 to 160 MHz<br>CMOS Output Only | ϕ <sub>J</sub> | 12 kHz to 20 MHz (OC-48) <sup>2</sup>  | —   | 0.62 | —    | ps   |
|   |                | 50 kHz to 20 MHz <sup>2</sup>          | —   | 0.61 | —    | ps   |

**Notes:**

1. Refer to AN256 for further information.
2. Max offset frequencies: 80 MHz for F<sub>OUT</sub> ≥ 250 MHz, 20 MHz for 50 MHz ≤ F<sub>OUT</sub> < 250 MHz, 2 MHz for 10 MHz ≤ F<sub>OUT</sub> < 50 MHz.

**Table 5. CLK± Output Period Jitter**

| Parameter      | Symbol           | Test Condition | Min | Typ | Max | Unit |
|----------------|------------------|----------------|-----|-----|-----|------|
| Period Jitter* | J <sub>PER</sub> | RMS            | —   | 2   | —   | ps   |
|                |                  | Peak-to-Peak   | —   | 14  | —   | ps   |

**\*Note:** Any output mode, including CMOS, LVPECL, LVDS, CML. N = 1000 cycles. Refer to AN279 for further information.

**Table 6. CLK± Output Phase Noise (Typical)**

| Offset Frequency (f) | 120.00 MHz<br>LVDS | 156.25 MHz<br>LVPECL | 622.08 MHz<br>LVPECL | Unit   |
|----------------------|--------------------|----------------------|----------------------|--------|
| 100 Hz               | -112               | -105                 | -97                  | dBc/Hz |
| 1 kHz                | -122               | -122                 | -107                 |        |
| 10 kHz               | -132               | -128                 | -116                 |        |
| 100 kHz              | -137               | -135                 | -121                 |        |
| 1 MHz                | -144               | -144                 | -134                 |        |
| 10 MHz               | -150               | -147                 | -146                 |        |
| 100 MHz              | n/a                | n/a                  | -148                 |        |

**Table 7. Environmental Compliance**

The Si530/531 meets the following qualification test requirements.

| 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 & Fine Leak          | MIL-STD-883, Method 1014 |
| Resistance to Solder Heat  | MIL-STD-883, Method 2036 |
| Moisture Sensitivity Level | J-STD-020, MSL1          |
| Contact Pads               | Gold over Nickel         |

**Table 8. Thermal Characteristics**

(Typical values  $T_A = 25\text{ }^\circ\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ )

| Parameter                              | Symbol        | Test Condition | Min | Typ  | Max | Unit               |
|--|---------------|----------------|-----|------|-----|--------------------|
| Thermal Resistance Junction to Ambient | $\theta_{JA}$ | Still Air      | —   | 84.6 | —   | $^\circ\text{C/W}$ |
| Thermal Resistance Junction to Case    | $\theta_{JC}$ | Still Air      | —   | 38.8 | —   | $^\circ\text{C/W}$ |
| Ambient Temperature                    | $T_A$         |                | -40 | —    | 85  | $^\circ\text{C}$   |
| Junction Temperature                   | $T_J$         |                | —   | —    | 125 | $^\circ\text{C}$   |

**Table 9. Absolute Maximum Ratings<sup>1</sup>**

| Parameter  | Symbol     | Rating                 | Unit             |
|--|------------|------------------------|------------------|
| Maximum Operating Temperature  | $T_{AMAX}$ | 85                     | $^\circ\text{C}$ |
| Supply Voltage, 1.8 V Option   | $V_{DD}$   | -0.5 to +1.9           | V                |
| Supply Voltage, 2.5/3.3 V Option                                       | $V_{DD}$   | -0.5 to +3.8           | V                |
| Input Voltage (any input pin)  | $V_I$      | -0.5 to $V_{DD} + 0.3$ | V                |
| Storage Temperature  | $T_S$      | -55 to +125            | $^\circ\text{C}$ |
| ESD Sensitivity (HBM, per JESD22-A114)                                 | ESD        | 2500                   | V                |
| Soldering Temperature (Pb-free profile) <sup>2</sup>                   | $T_{PEAK}$ | 260                    | $^\circ\text{C}$ |
| Soldering Temperature Time @ $T_{PEAK}$ (Pb-free profile) <sup>2</sup> | $t_p$      | 20–40                  | seconds          |

**Notes:**

1. Stresses beyond those listed in Absolute Maximum Ratings 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-020C. Refer to Si5xx Packaging FAQ available for download at [www.silabs.com/VCXO](http://www.silabs.com/VCXO) for further information, including soldering profiles.

## 2. Pin Descriptions



**Table 10. Pinout for Si530 Series**

| Pin | Symbol                        | LVDS/LVPECL/CML Function   | CMOS Function  |
|-----|-------------------------------|--|--|
| 1   | OE (CMOS only)*               | No connection  | Output enable<br>0 = clock output disabled (outputs tristated)<br>1 = clock output enabled |
| 2   | OE<br>(LVPECL, LVDS,<br>CML)* | Output enable<br>0 = clock output disabled (outputs tristated)<br>1 = clock output enabled | No connection  |
| 3   | GND                           | Electrical and Case Ground   | Electrical and Case Ground   |
| 4   | CLK+                          | Oscillator Output  | Oscillator Output  |
| 5   | CLK-                          | Complementary Output   | No connection  |
| 6   | V <sub>DD</sub>               | Power Supply Voltage   | Power Supply Voltage   |

**\*Note:** OE includes a 17 kΩ pullup resistor to V<sub>DD</sub>.

**Table 11. Pinout for Si531 Series**

| Pin | Symbol                  | LVDS/LVPECL/CML Function   |
|-----|-------------------------|--|
| 1   | OE (LVPECL, LVDS, CML)* | Output enable<br>0 = clock output disabled (outputs tristated)<br>1 = clock output enabled |
| 2   | No connection           | No connection  |
| 3   | GND                     | Electrical and Case Ground   |
| 4   | CLK+                    | Oscillator Output  |
| 5   | CLK-                    | Complementary output   |
| 6   | V <sub>DD</sub>         | Power Supply Voltage   |

**\*Note:** OE includes a 17 kΩ pullup resistor to V<sub>DD</sub>.

### 3. Ordering Information

The Si530/531 XO supports a variety of options including frequency, temperature stability, output format, and  $V_{DD}$ . Specific device configurations are programmed into the Si530/531 at time of shipment. Configurations can be specified using the Part Number Configuration chart below. Silicon Laboratories 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 Si530 and Si531 XO series are supplied in an industry-standard, RoHS compliant, 6-pad, 5 x 7 mm package. The Si531 Series supports an alternate OE pinout (pin #1) for the LVPECL, LVDS, and CML output formats. See Tables 10 and 11 for the pinout differences between the Si530 and Si531 series.



Example P/N: 530AB622M080DGR is a 5 x 7 XO in a 6 pad package. The frequency is 622.080 MHz, with a 3.3 V supply, LVPECL output and Output Enable active high polarity Temperature stability is specified as  $\pm 20$  ppm. The part is specified for  $-40$  to  $+85$  °C ambient temperature range operation and is shipped in tape and reel format

**Figure 1. Part Number Convention**

## 4. Outline Diagram and Suggested Pad Layout

Figure 2 illustrates the package details for the Si530/531. Table 12 lists the values for the dimensions shown in the illustration.



Figure 2. Si530/531 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.                   |          |      |      |



## 5. Si530/Si531 Mark Specification

Figure 3 illustrates the mark specification for the Si530/Si531. Table 13 lists the line information.



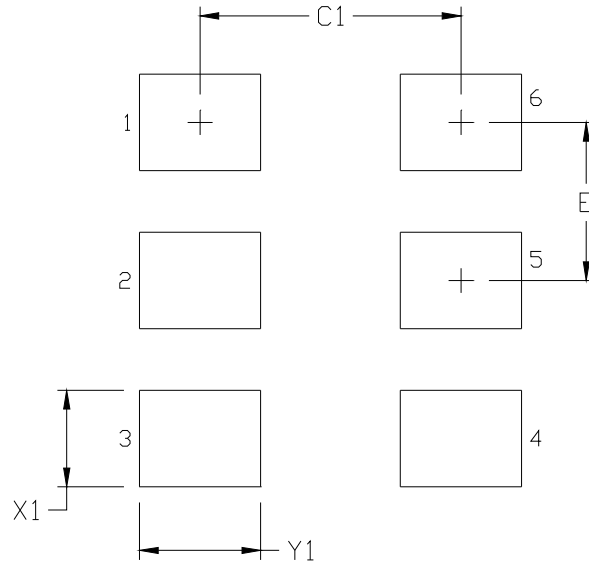
**Figure 3. Mark Specification**

**Table 13. Si53x Top Mark Description**

| Line | Position          | Description  |
|------|-------------------|--|
| 1    | 1–10              | “SiLabs”+ Part Family Number, 53x (First 3 characters in part number where x = 0 indicates a 530 device and x = 1 indicates a 531 device).             |
| 2    | 1–10              | Si530, Si531: Option1 + Option2 + Freq(7) + Temp<br>Si532, Si533, Si534, Si530/Si531 w/ 8-digit resolution:<br>Option1 + Option2 + ConfigNum(6) + Temp |
| 3    | <b>Trace Code</b> |  |
|      | Position 1        | Pin 1 orientation mark (dot)   |
|      | Position 2        | Product Revision (D)   |
|      | Position 3–6      | Tiny Trace Code (4 alphanumeric characters per assembly release instructions)  |
|      | Position 7        | Year (least significant year digit), to be assigned by assembly site (ex: 2007 = 7)  |
|      | Position 8–9      | Calendar Work Week number (1–53), to be assigned by assembly site  |
|      | Position 10       | “+” to indicate Pb-Free and RoHS-compliant   |

## 6. 6-Pin PCB Land Pattern

Figure 4 illustrates the 6-pin PCB land pattern for the Si530/531. Table 14 lists the values for the dimensions shown in the illustration.



**Figure 4. Si530/531 PCB Land Pattern**

**Table 14. 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-020 specification for Small Body Components.

## DOCUMENT CHANGE LIST

### Revision 0.4 to Revision 0.5

- Updated Table 1, “Recommended Operating Conditions,” on page 2.
  - Added maximum supply current specifications.
  - Specified relationship between temperature at startup and operation temperature.
- Updated Table 4, “CLK± Output Phase Jitter,” on page 4 to include maximum rms jitter generation specifications and updated typical rms jitter specifications.
- Added Table 6, “CLK± Output Phase Noise (Typical),” on page 4.
- Added Output Enable active polarity as an option in Figure 1, “Part Number Convention,” on page 7.

### Revision 0.5 to Revision 1.0

- Updated Note 3 in Table 1, “Recommended Operating Conditions,” on page 2.
- Updated Figure 1, “Part Number Convention,” on page 7.

### Revision 1.0 to Revision 1.1

- Updated Table 1, “Recommended Operating Conditions,” on page 2.
  - Device maintains stable operation over –40 to +85 °C operating temperature range.
  - Supply current specifications updated for revision D.
- Updated Table 2, “CLK± Output Frequency Characteristics,” on page 2.
  - Added specification for ±20 ppm lifetime stability (±7 ppm temperature stability) XO.
- Updated Table 3, “CLK± Output Levels and Symmetry,” on page 3.
  - Updated LVDS differential peak-peak swing specifications.
- Updated Table 4, “CLK± Output Phase Jitter,” on page 4.
- Updated Table 5, “CLK± Output Period Jitter,” on page 4.
  - Revised period jitter specifications.
- Updated Table 9, “Absolute Maximum Ratings<sup>1</sup>,” on page 5 to reflect the soldering temperature time at 260 °C is 20–40 sec per JEDEC J-STD-020C.
- Updated 3. “Ordering Information” on page 7.
  - Changed ordering instructions to revision D.
- Added 5. “Si530/Si531 Mark Specification” on page 9.

### Revision 1.1 to Revision 1.2

- Updated 2.5 V/3.3 V and 1.8 V CML output level specifications for Table 3 on page 3.
- Added footnotes clarifying max offset frequency test conditions for Table 4 on page 4.
- Added CMOS phase jitter specs to Table 4 on page 4.
- Removed the words “Differential Modes: LVPECL/LVDS/CML” in the footnote referring to AN256 in Table 4 on page 4.
- Separated 1.8 V, 2.5 V/3.3 V supply voltage specifications in Table 9 on page 5.
- Updated and clarified Table 9 on page 5 to include the “Moisture Sensitivity Level” and “Contact Pads” rows.
- Updated Figure 3 on page 9 and Table 13 on page 9 to reflect specific marking information. Previously, Figure 3 was generic.

### Revision 1.2 to Revision 1.3

- Added Table 8, “Thermal Characteristics,” on page 5.

### Revision 1.3 to Revision 1.4

- Revised Figure 2 and Table 12 on page 8 to reflect current package outline diagram.
- Revised Figure 4 and Table 14 on page 10 to reflect the recommended PCB land pattern.

### Revision 1.4 to Revision 1.5

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



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

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- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



Тел: +7 (812) 336 43 04 (многоканальный)

Email: [org@lifeelectronics.ru](mailto:org@lifeelectronics.ru)