

## LM111, LM211, LM311 Differential Comparators

### 1 Features

- Fast Response Time: 165 ns
- Strobe Capability
- Maximum Input Bias Current: 300 nA
- Maximum Input Offset Current: 70 nA
- Can Operate From Single 5-V Supply
- Available in Q-Temp Automotive
  - High-Reliability Automotive Applications
  - Configuration Control and Print Support
  - Qualification to Automotive Standards
- On Products Compliant to MIL-PRF-38535, All Parameters Are Tested Unless Otherwise Noted. On All Other Products, Production Processing Does Not Necessarily Include Testing of All Parameters.

### 2 Applications

- Desktop PCs
- Body Control Modules
- White Goods
- Building Automation
- Oscillators
- Peak Detectors

### 3 Description

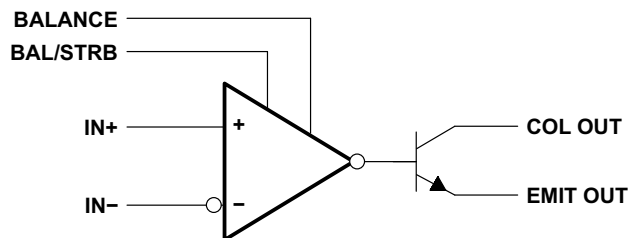
The LM111, LM211, and LM311 devices are single high-speed voltage comparators. These devices are designed to operate from a wide range of power-supply voltages, including  $\pm 15$ -V supplies for operational amplifiers and 5-V supplies for logic systems. The output levels are compatible with most TTL and MOS circuits. These comparators are capable of driving lamps or relays and switching voltages up to 50 V at 50 mA. All inputs and outputs can be isolated from system ground. The outputs can drive loads referenced to ground,  $V_{CC+}$  or  $V_{CC-}$ . Offset balancing and strobe capabilities are available, and the outputs can be wire-OR connected. If the strobe is low, the output is in the off state, regardless of the differential input.

**Device Information<sup>(1)</sup>**

| PART NUMBER | PACKAGE   | BODY SIZE         |
|-------------|-----------|-------------------|
| LM111FK     | LCCC (20) | 8.89 mm × 8.89 mm |
| LM111JG     | CDIP (8)  | 9.60 mm × 6.67 mm |
| LM311PS     | SO (8)    | 6.20 mm × 5.30 mm |
| LM211D      | SOIC (8)  | 4.90 mm × 3.91 mm |
| LM311D      |           |                   |
| LM211P      | PDIP (8)  | 9.81 mm × 6.35 mm |
| LM311P      |           |                   |
| LM211PW     | TSSOP (8) | 3.00 mm × 4.40 mm |
| LM311PW     |           |                   |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### Simplified Schematic



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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

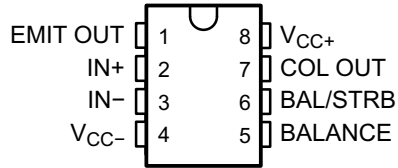
| Changes from Revision J (January 2017) to Revision K                                              | Page     |
|---------------------------------------------------------------------------------------------------|----------|
| • Changed Human body model (HBM) from: $\pm 1000$ to: $\pm 500$ in <i>ESD Ratings</i> table ..... | <b>4</b> |

| Changes from Revision I (June 2015) to Revision J                                                                                                                                                                       | Page      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| • Changed the data sheet title From: LMx11 Quad Differential Comparators To: LM111, LM211, LM311 Differential Comparators .....                                                                                         | <b>1</b>  |
| • Updated the <i>Applications</i> list .....                                                                                                                                                                            | <b>1</b>  |
| • Updated the <i>Thermal Information (8-Pin Packages)</i> table .....                                                                                                                                                   | <b>5</b>  |
| • Changed text From: "over a $-25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ temperature range..." To: ""over a $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ temperature range..." in the <i>Overview</i> section..... | <b>10</b> |
| • Added text "The LM311 has a temperature range of $-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ ." to the <i>Overview</i> section.....                                                                               | <b>10</b> |

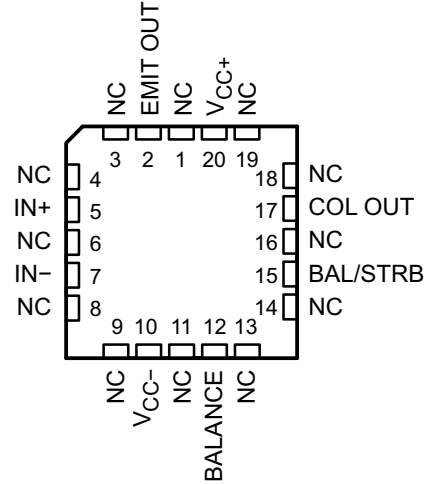
| Changes from Revision H (August 2003) to Revision I                                                                                                                                                                                                                                                                                                                                                                                                                                   | Page     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| • Updated <i>Features</i> with Military Disclaimer. ....                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>1</b> |
| • Added <i>Applications</i> , <i>Device Information</i> table, <i>Pin Configuration and Functions</i> section, <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section. No specification changes. .... | <b>1</b> |

## 5 Pin Configuration and Functions

**LMx11 D, JG, P, PS, or PW Package**  
**8-Pin SOIC, CDIP, PDIP, SO or TSSOP**  
**Top View**



**LM111 FK Package**  
**20-Pin LCCC<sup>(1)</sup>**  
**Top View**



(1) NC = No internal connection

### Pin Functions

| NAME             | PIN                                     |             |               |               | I/O <sup>(1)</sup> | DESCRIPTION                         |
|------------------|-----------------------------------------|-------------|---------------|---------------|--------------------|-------------------------------------|
|                  | LM211,<br>LM311<br>SOIC, PDIP,<br>TSSOP | LM311<br>SO | LM111<br>CDIP | LM111<br>LCCC |                    |                                     |
| IN+              | 2                                       | 2           | 2             | 5             | I                  | Noninverting comparator             |
| IN–              | 3                                       | 3           | 3             | 7             | I                  | Inverting input comparator          |
| BALANCE          | 5                                       | 5           | 5             | 12            | I                  | Balance                             |
| BAL/STRB         | 6                                       | 6           | 6             | 15            | I                  | Strobe                              |
| COL OUT          | 7                                       | 7           | 7             | 17            | O                  | Output collector comparator         |
| EMIT OUT         | 1                                       | 1           | 1             | 2             | O                  | Output emitter comparator           |
| V <sub>CC–</sub> | 4                                       | 4           | 4             | 10            | —                  | Negative supply                     |
| V <sub>CC+</sub> | 8                                       | 8           | 8             | 20            | —                  | Positive supply                     |
| NC               | —                                       | —           | —             | 1             | —                  | No connect (No internal connection) |
|                  |                                         |             |               | 3             |                    |                                     |
|                  |                                         |             |               | 4             |                    |                                     |
|                  |                                         |             |               | 6             |                    |                                     |
|                  |                                         |             |               | 8             |                    |                                     |
|                  |                                         |             |               | 9             |                    |                                     |
|                  |                                         |             |               | 11            |                    |                                     |
|                  |                                         |             |               | 13            |                    |                                     |
|                  |                                         |             |               | 14            |                    |                                     |
|                  |                                         |             |               | 16            |                    |                                     |
|                  |                                         |             |               | 18            |                    |                                     |
|                  |                                         |             |               | 19            |                    |                                     |

(1) I = Input, O = Output

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                                            |                                                     | MIN                     | MAX | UNIT |
|--------------------------------------------|-----------------------------------------------------|-------------------------|-----|------|
| Supply voltage                             | $V_{CC+}$ <sup>(2)</sup>                            |                         | 18  | V    |
|                                            | $V_{CC-}$ <sup>(2)</sup>                            |                         | –18 |      |
|                                            | $V_{CC+} - V_{CC-}$                                 |                         | 36  |      |
| $V_{ID}$                                   | Differential input voltage <sup>(3)</sup>           |                         | ±30 | V    |
| $V_I$                                      | Input voltage (either input) <sup>(2)(4)</sup>      |                         | ±15 | V    |
|                                            | Voltage from emitter output to $V_{CC-}$            |                         | 30  | V    |
| Voltage from collector output to $V_{CC-}$ | LM111                                               |                         | 50  | V    |
|                                            | LM211                                               |                         | 50  |      |
|                                            | LM211Q                                              |                         | 50  |      |
|                                            | LM311                                               |                         | 40  |      |
|                                            | Duration of output short circuit to ground          |                         | 10  | s    |
| $T_J$                                      | Operating virtual-junction temperature              |                         | 150 | °C   |
|                                            | Case temperature for 60 s                           | FK package              | 260 | °C   |
|                                            | Lead temperature 1,6 mm (1/16 inch) from case, 10 s | JG package              | 300 | °C   |
|                                            | Lead temperature 1,6 mm (1/16 inch) from case, 60 s | D, P, PS, or PW package | 260 | °C   |
| $T_{stg}$                                  | Storage temperature                                 | –65                     | 150 | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, unless otherwise noted, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
- (3) Differential voltages are at  $IN+$  with respect to  $IN-$ .
- (4) The magnitude of the input voltage must never exceed the magnitude of the supply voltage or ±15 V, whichever is less.

### 6.2 ESD Ratings

|             |                         | VALUE                                                                          | UNIT |
|-------------|-------------------------|--------------------------------------------------------------------------------|------|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±500 |
|             |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±750 |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

|                     |                                        | MIN             | MAX             | UNIT |
|---------------------|----------------------------------------|-----------------|-----------------|------|
| $V_{CC+} - V_{CC-}$ | Supply voltage                         | 3.5             | 30              | V    |
| $V_I$               | Input voltage ( $ V_{CC+}  \leq 15$ V) | $V_{CC-} + 0.5$ | $V_{CC+} - 1.5$ | V    |
| $T_A$               | Operating free-air temperature range   | LM111           | –55             | °C   |
|                     |                                        | LM211           | –40             |      |
|                     |                                        | LM211Q          | –40             |      |
|                     |                                        | LM311           | 0               |      |

## 6.4 Thermal Information (8-Pin Packages)

| THERMAL METRIC <sup>(1)</sup> |                                              | LM211, LM311 |          |            | LM311   | LM111     | UNIT |
|-------------------------------|----------------------------------------------|--------------|----------|------------|---------|-----------|------|
|                               |                                              | D (SOIC)     | P (PDIP) | PW (TSSOP) | PS (SO) | JG (CDIP) |      |
|                               |                                              | 8 PINS       | 8 PINS   | 8 PINS     | 8 PINS  | 8 PINS    |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 114.3        | 57.5     | 162        | 121.8   | —         | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 60.7         | 47.3     | 44.6       | 81.6    | 14.5      | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 54.5         | 34.6     | 93         | 66.5    | —         | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 17.4         | 24.9     | 2.6        | 31.4    | —         | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 54           | 34.5     | 90.8       | 65.8    | —         | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Thermal Information (20-Pin Package)

| THERMAL METRIC <sup>(1)</sup> |                                           | LM111     | UNIT |
|-------------------------------|-------------------------------------------|-----------|------|
|                               |                                           | FK (LCCC) |      |
|                               |                                           | 20 PINS   |      |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance | 5.61      | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## LM111, LM211, LM311

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### 6.6 Electrical Characteristics

at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)

| PARAMETER                                                | TEST CONDITIONS                                                                  | $T_A^{(1)}$              | LM111<br>LM211<br>LM211Q |                    |       | LM311 |                    |       | UNIT |
|----------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------|-------|-------|--------------------|-------|------|
|                                                          |                                                                                  |                          | MIN                      | TYP <sup>(2)</sup> | MAX   | MIN   | TYP <sup>(2)</sup> | MAX   |      |
| $V_{IO}$ Input offset voltage                            | See <sup>(3)</sup>                                                               | 25°C                     |                          | 0.7                | 3     |       | 2                  | 7.5   | mV   |
|                                                          |                                                                                  | Full range               |                          |                    | 4     |       |                    | 10    |      |
| $I_{IO}$ Input offset current                            | See <sup>(3)</sup>                                                               | 25°C                     |                          | 4                  | 10    |       | 6                  | 50    | nA   |
|                                                          |                                                                                  | Full range               |                          |                    | 20    |       |                    | 70    |      |
| $I_{IB}$ Input bias current                              | $1\text{ V} \leq V_O \leq 14\text{ V}$                                           | 25°C                     |                          | 75                 | 100   |       | 100                | 250   | nA   |
|                                                          |                                                                                  | Full range               |                          |                    | 150   |       |                    | 300   |      |
| $I_{IL(S)}$ Low-level strobe current <sup>(4)</sup>      | $V_{(strobe)} = 0.3\text{ V}$ ,<br>$V_{ID} \leq -10\text{ mV}$                   | 25°C                     |                          | –3                 |       |       | –3                 |       | mA   |
| $V_{ICR}$ Common-mode input-voltage range <sup>(3)</sup> | Lower range                                                                      | Full range               |                          | –14.7              | –14.5 |       | –14.7              | –14.5 | V    |
|                                                          | Upper range                                                                      |                          |                          | 13                 | 13.8  |       | 13                 | 13.8  |      |
| $A_{VD}$ Large-signal differential-voltage amplification | $5\text{ V} \leq V_O \leq 35\text{ V}$ , $R_L = 1\text{ k}\Omega$                | 25°C                     |                          | 40                 | 200   |       | 40                 | 200   | V/mV |
| $I_{OH}$ High-level (collector) output leakage current   | $I_{(strobe)} = -3\text{ mA}$ ,<br>$V_{ID} = 5\text{ mV}$                        | 25°C                     |                          | 0.2                | 10    |       |                    |       | nA   |
|                                                          |                                                                                  | Full range               |                          |                    | 0.5   |       |                    |       | μA   |
|                                                          | $V_{ID} = 5\text{ mV}$ , $V_{OH} = 35\text{ V}$                                  | 25°C                     |                          |                    |       |       | 0.2                | 50    | nA   |
| $V_{OL}$ Low-level (collector-to-emitter) output voltage | $I_{OL} = 50\text{ mA}$                                                          | $V_{ID} = -5\text{ mV}$  |                          | 0.75               | 1.5   |       |                    |       | V    |
|                                                          |                                                                                  | $V_{ID} = -10\text{ mV}$ |                          |                    |       |       | 0.75               | 1.5   |      |
|                                                          | $V_{CC+} = 4.5\text{ V}$ ,<br>$V_{CC-} = 0\text{ V}$ ,<br>$I_{OL} = 8\text{ mA}$ | $V_{ID} = -6\text{ mV}$  |                          | 0.23               | 0.4   |       |                    |       |      |
|                                                          |                                                                                  | $V_{ID} = -10\text{ mV}$ |                          |                    |       |       | 0.23               | 0.4   |      |
| $I_{CC+}$ Supply current from $V_{CC+}$ output low       | $V_{ID} = -10\text{ mV}$ ,<br>No load                                            | 25°C                     |                          | 5.1                | 6     |       | 5.1                | 7.5   | mA   |
| $I_{CC-}$ Supply current from $V_{CC-}$ output high      | $V_{ID} = 10\text{ mV}$ ,<br>No load                                             | 25°C                     |                          | –4.1               | –5    |       | –4.1               | –5    | mA   |

- (1) Unless otherwise noted, all characteristics are measured with BALANCE and BAL/STRB open and EMIT OUT grounded. Full range for LM111 is –55°C to 125°C, for LM211 is –40°C to 85°C, for LM211Q is –40°C to 125°C, and for LM311 is 0°C to 70°C.
- (2) All typical values are at  $T_A = 25^\circ\text{C}$ .
- (3) The offset voltages and offset currents given are the maximum values required to drive the collector output up to 14 V or down to 1 V with a pullup resistor of 7.5 kΩ to  $V_{CC+}$ . These parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.
- (4) The strobe must not be shorted to ground; it must be current driven at –3 mA to –5 mA (see Figure 18 and Figure 31).

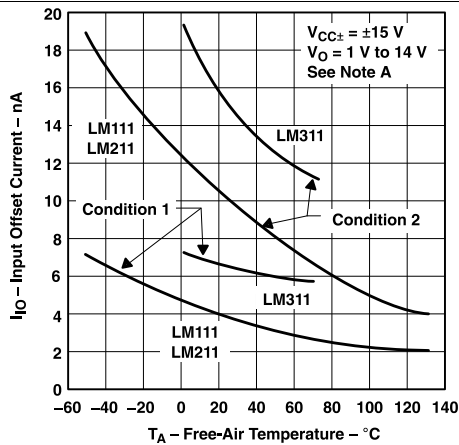
### 6.7 Switching Characteristics

$V_{CC\pm} = \pm 15$  V,  $T_A = 25^\circ\text{C}$

| PARAMETER                                                 | TEST CONDITIONS                                                            | LM111<br>LM211<br>LM211Q<br>LM311 | UNIT |
|-----------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------|------|
|                                                           |                                                                            | TYP                               |      |
| Response time, low-to-high-level outputSee <sup>(1)</sup> | $R_C = 500\text{ }\Omega$ to 5 V, $C_L = 5\text{ pF}$ , see <sup>(2)</sup> | 115                               | ns   |
| Response time, high-to-low-level outputSee <sup>(1)</sup> |                                                                            | 165                               | ns   |

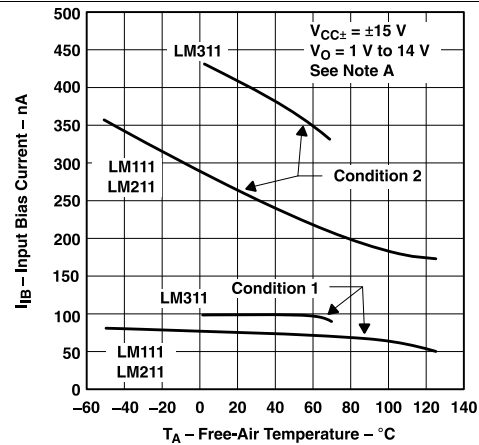
- (1) The response time specified is for a 100-mV input step with 5-mV overdrive and is the interval between the input step function and the instant when the output crosses 1.4 V.
- (2) The package thermal impedance is calculated in accordance with MIL-STD-883.

## 6.8 Typical Characteristics



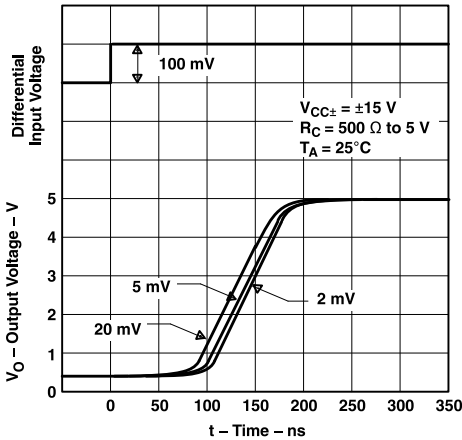
Condition 1 is with BALANCE and BAL/STRB open.  
Condition 2 is with BALANCE and BAL/STRB connected to  $V_{CC+}$ .

**Figure 1. Input Offset Current vs Free-Air Temperature**

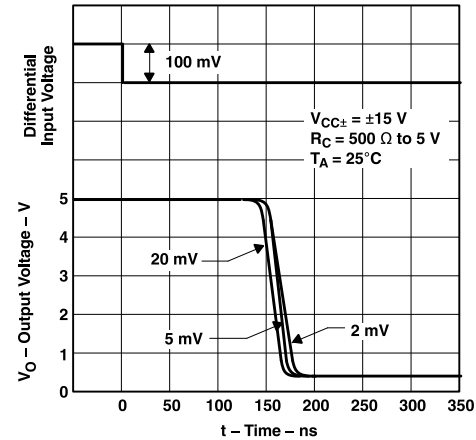


Condition 1 is with BALANCE and BAL/STRB open.  
Condition 2 is with BALANCE and BAL/STRB connected to  $V_{CC+}$ .

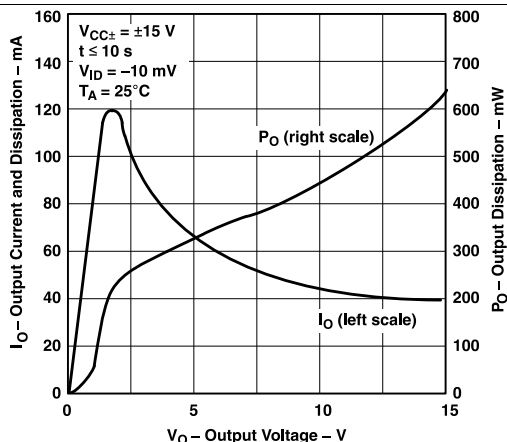
**Figure 2. Input Bias Current vs Free-Air Temperature**



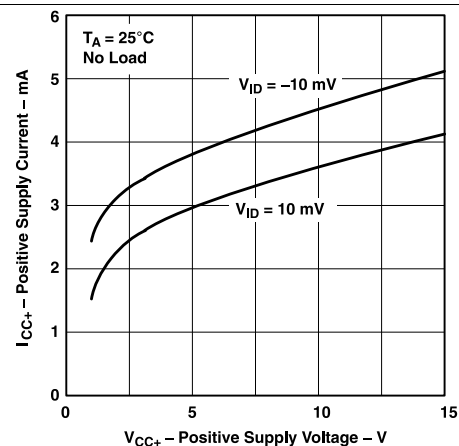
**Figure 3. Output Response for Various Input Overdrives**



**Figure 4. Output Response for Various Input Overdrives**

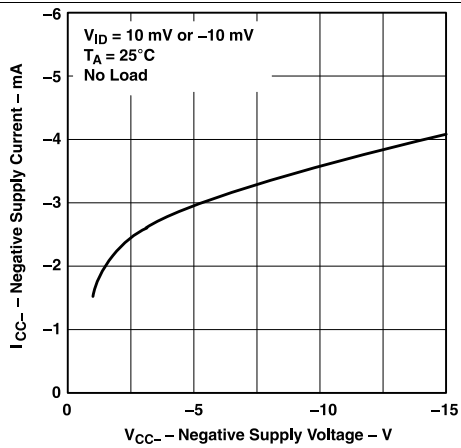


**Figure 5. Output Current and Dissipation vs Output Voltage**

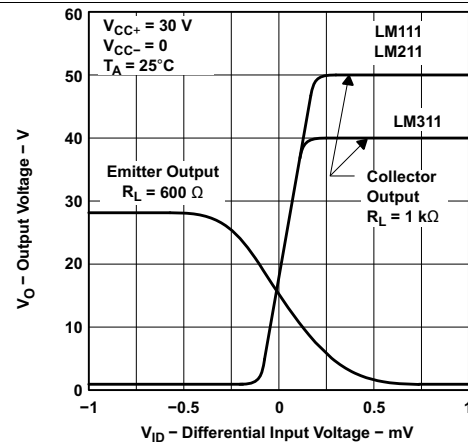


**Figure 6. Positive Supply Current vs Positive Supply Voltage**

## Typical Characteristics (continued)

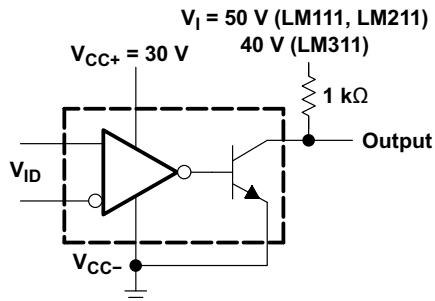


**Figure 7. Negative Supply Current vs Negative Supply Voltage**



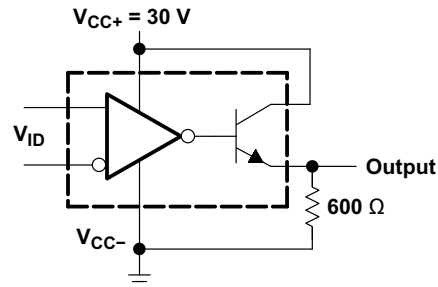
**Figure 8. Voltage Transfer Characteristics and Test Circuits**

## 7 Parameter Measurement Information



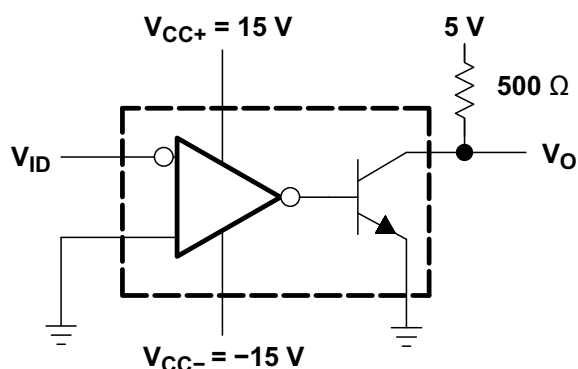
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**Figure 9. Collector Output Transfer Characteristic Test Circuit**



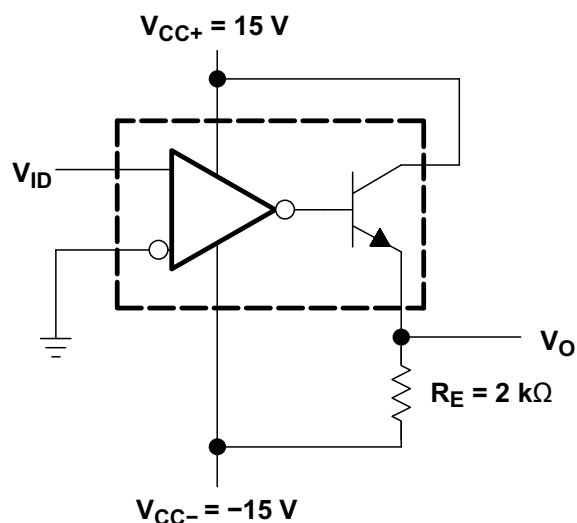
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**Figure 10. Emitter Output Transfer Characteristic Test Circuit**



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**Figure 11. Test Circuit for [Figure 3](#) and [Figure 4](#)**



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**Figure 12. Test Circuit for [Figure 14](#) and [Figure 15](#)**

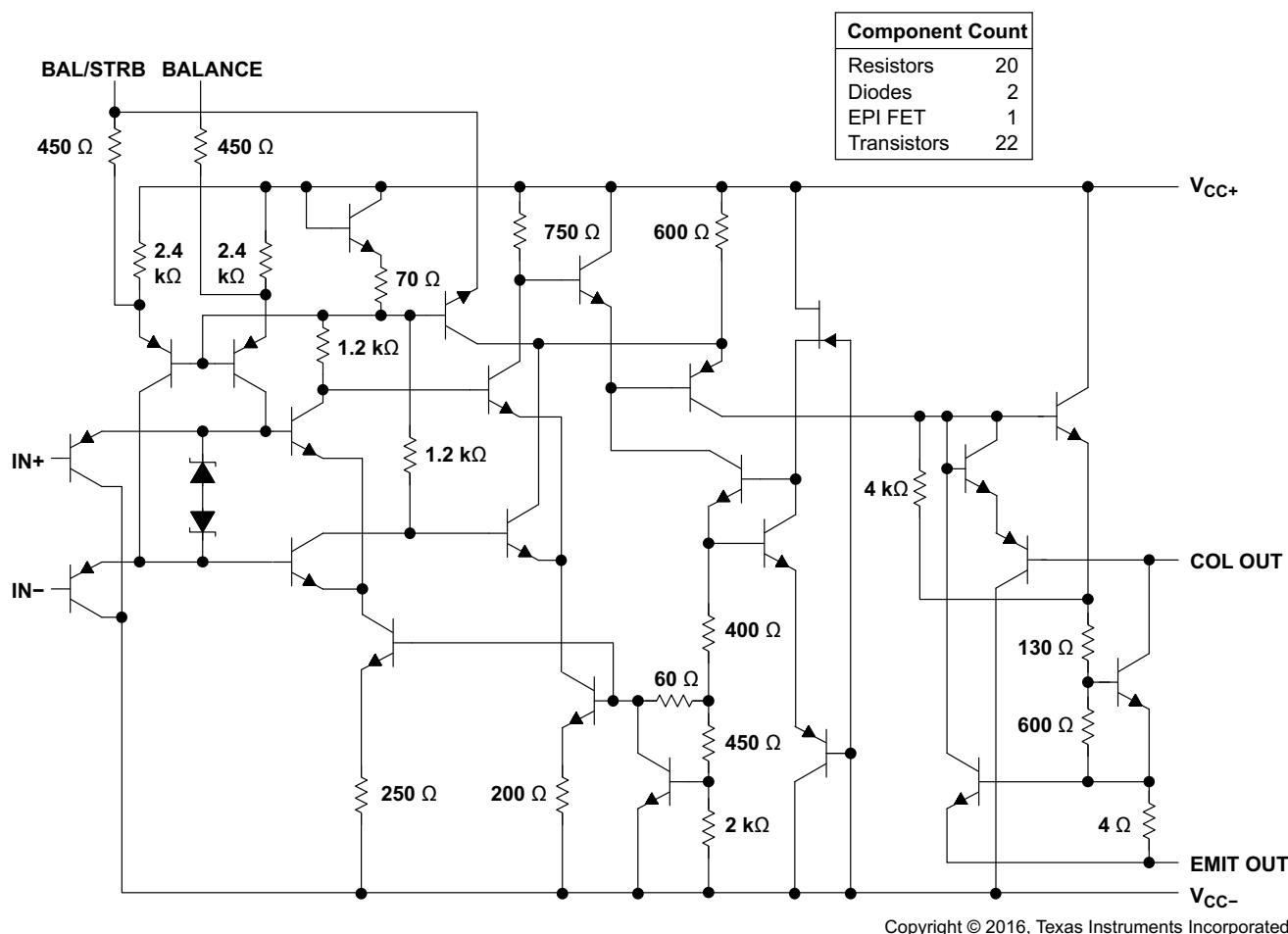
## 8 Detailed Description

### 8.1 Overview

The LM111, LM211 and LM311 are voltage comparators that have input currents nearly a thousand times lower than legacy standard devices. They are also designed to operate over a wider range of supply voltages: from standard  $\pm 15\text{V}$  op amp supplies down to the single 5-V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, they can drive lamps or relays, switching voltages up to 50 V at currents as high as 50 mA.

Both the inputs and the outputs of the LM111, LM211 or the LM311 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire ORed. The LM211 is identical to the LM111, except that its performance is specified over a  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range instead of  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . The LM311 has a temperature range of  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . The LM211Q has a temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### 8.2 Functional Block Diagram



### 8.3 Feature Description

LMx11 consists of a PNP input stage to sense voltages near  $V_{CC-}$ . It also contains balance and strobe pins for external offset adjustment or trimming.

The input stage is followed by a very high gain stage for very fast response after a voltage difference on the input pins have been sensed.

This is then followed by the output stage that consists of an open collector NPN (pulldown or low-side) transistor. Unlike most open drain comparators, this NPN output stage has an isolated emitter from  $V_{CC-}$ , allowing this device to set the  $V_{OL}$  output value for collector output.

### 8.4 Device Functional Modes

#### 8.4.1 Voltage Comparison

The LMx11 operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pullup) based on the input differential polarity.

## 9 Application and Implementation

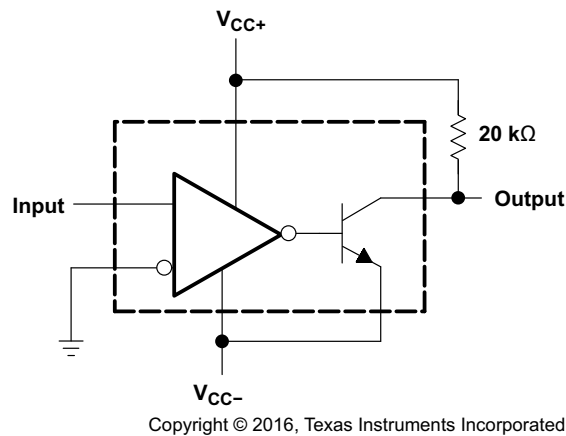
### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Validate and test the design implementation to confirm system functionality.

### 9.1 Application Information

A typical LMx11 application compares a single signal to a reference or two signals against each other. Many users take advantage of the open-drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes LMx11 optimal for level shifting to a higher or lower voltage.

### 9.2 Typical Application



**Figure 13. Zero-Crossing Detector**

#### 9.2.1 Design Requirements

For this design example, use the parameters listed in [Table 1](#) as the input parameters.

**Table 1. Design Parameters**

| PARAMETER |                         | MIN | TYP | MAX | UNIT |
|-----------|-------------------------|-----|-----|-----|------|
| $V_{IN}$  | Input voltage range     | -15 |     | 13  | V    |
| $V_{CC+}$ | Positive supply voltage |     |     | 15  | V    |
| $V_{CC-}$ | Negative supply voltage | -15 |     |     |      |
| $I_{OUT}$ | Output current          |     |     | 20  | mA   |

#### 9.2.2 Detailed Design Procedure

When using LMx11 in a general comparator application, determine the following:

- Input voltage range
- Minimum overdrive voltage
- Output and drive current
- Response time

### 9.2.2.1 Input Voltage Range

When choosing the input voltage range, consider the input common mode voltage range ( $V_{ICR}$ ). Operation outside of this range can yield incorrect comparisons.

The following list describes the outcomes of some input voltage situations.

- When both  $IN-$  and  $IN+$  are both within the common-mode range:
  - If  $IN-$  is higher than  $IN+$  and the offset voltage, the output is low and the output transistor is sinking current
  - If  $IN-$  is lower than  $IN+$  and the offset voltage, the output is high impedance and the output transistor is not conducting
- When  $IN-$  is higher than common mode and  $IN+$  is within common mode, the output is low and the output transistor is sinking current
- When  $IN+$  is higher than common mode and  $IN-$  is within common mode, the output is high impedance and the output transistor is not conducting
- When  $IN-$  and  $IN+$  are both higher than common mode, the output is undefined

### 9.2.2.2 Minimum Overdrive Voltage

Overdrive voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage ( $V_{IO}$ ). To make an accurate comparison the Overdrive voltage ( $V_{OD}$ ) must be higher than the input offset voltage ( $V_{IO}$ ). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. [Figure 14](#) and [Figure 15](#) show positive and negative response times with respect to overdrive voltage.

### 9.2.2.3 Output and Drive Current

Output current is determined by the pullup resistance and pullup voltage. The output current produces a output low voltage ( $V_{OL}$ ) from the comparator, in which  $V_{OL}$  is proportional to the output current. Use [Figure 5](#) to determine  $V_{OL}$  based on the output current.

The output current can also effect the transient response.

### 9.2.2.4 Response Time

The load capacitance ( $C_L$ ), pullup resistance ( $R_{PULLUP}$ ), and equivalent collector-emitter resistance ( $R_{CE}$ ) levels determine the transient response. [Equation 1](#) approximates the positive response time. [Equation 2](#) approximates the negative response time.  $R_{CE}$  can be determine by taking the slope of [Figure 5](#) in the linear region at the desired temperature, or by [Equation 3](#).

$$\tau_P \cong R_{PULLUP} \times C_L \quad (1)$$

$$\tau_N \cong R_{CE} \times C_L \quad (2)$$

$$R_{CE} = \frac{V_{OL}}{I_{OUT}}$$

where

- $V_{OL}$  is the low-level output voltage
  - $I_{OUT}$  is the output current
- (3)

## 9.2.3 Application Curves

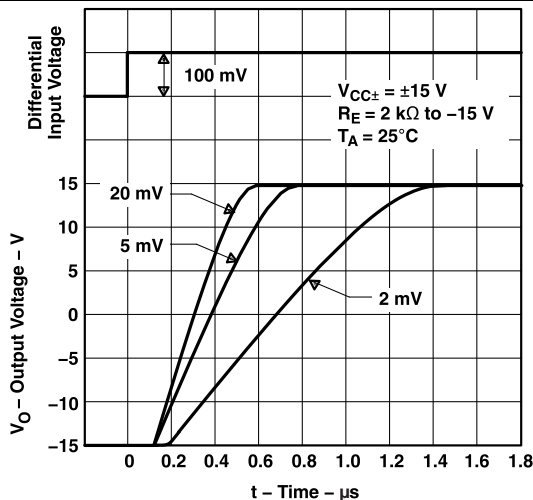


Figure 14. Output Response for Various Input Overdrives

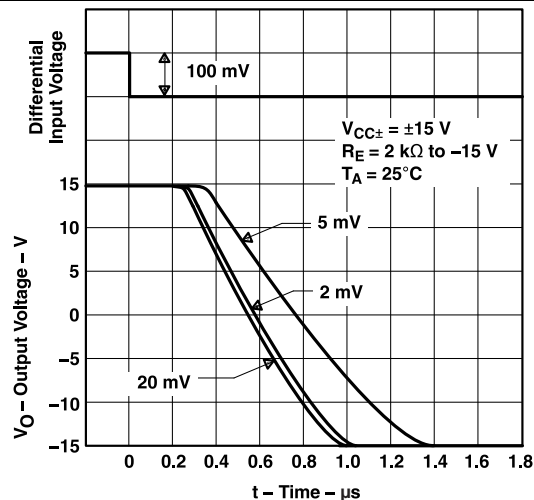
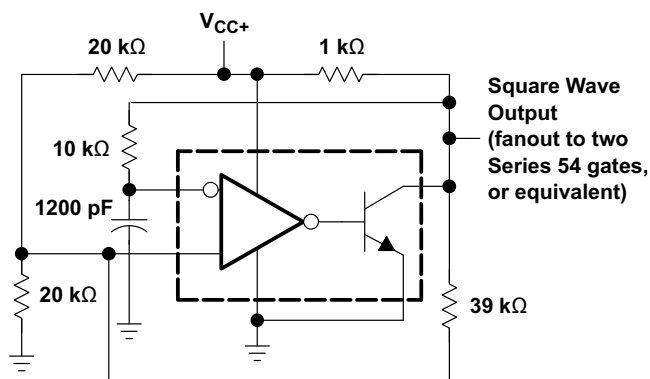


Figure 15. Output Response for Various Input Overdrives

## 9.3 System Examples

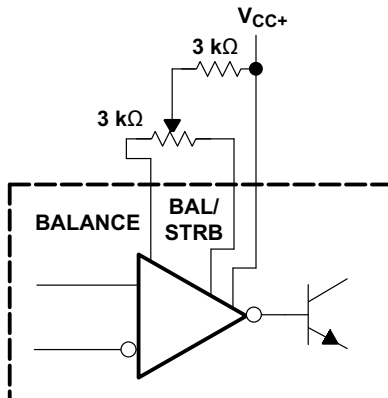
Figure 16 through Figure 33 show various applications for the LM111, LM211, and LM311 comparators.



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Figure 16. 100-kHz Free-Running Multivibrator

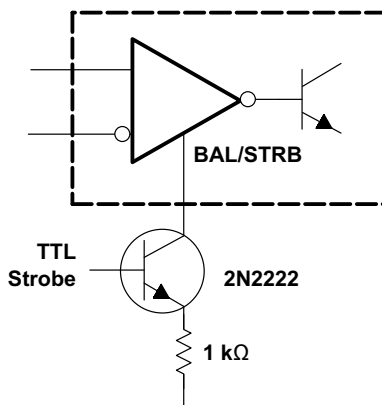
## System Examples (continued)



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If offset balancing is not used, the BALANCE and BAL/STRB pins must be unconnected. It is also acceptable to short pins together.

**Figure 17. Offset Balancing**

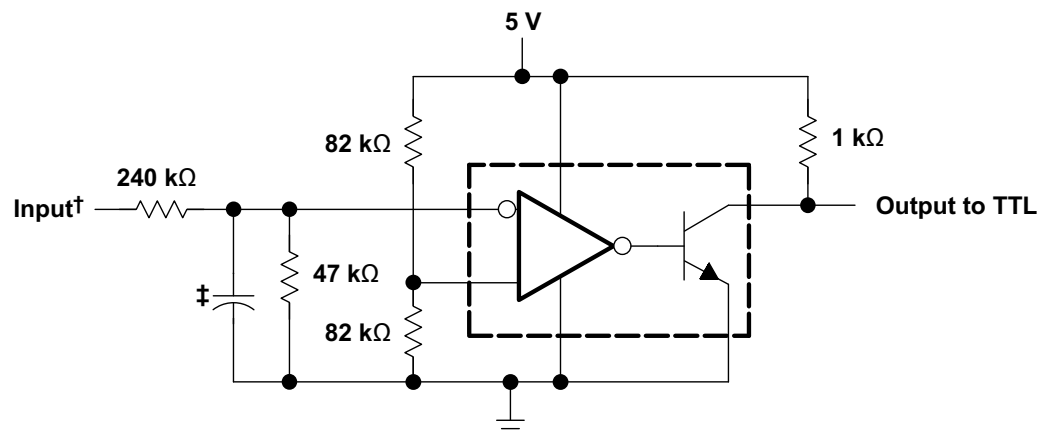


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Do not connect strobe pin directly to ground, because the output is turned off whenever current is pulled from the strobe pin.

**Figure 18. Strobing**

## System Examples (continued)

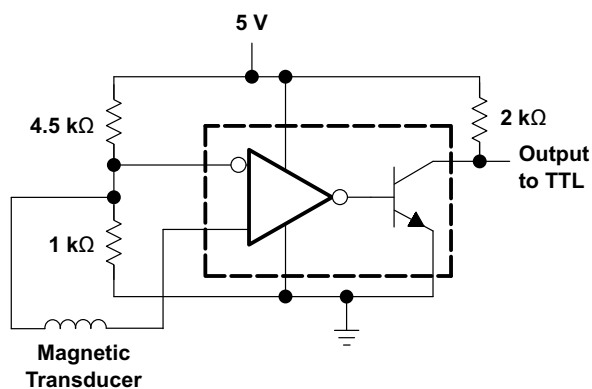


† Resistor values shown are for a 0- to 30-V logic swing and a 15-V threshold.

‡ May be added to control speed and reduce susceptibility to noise spikes

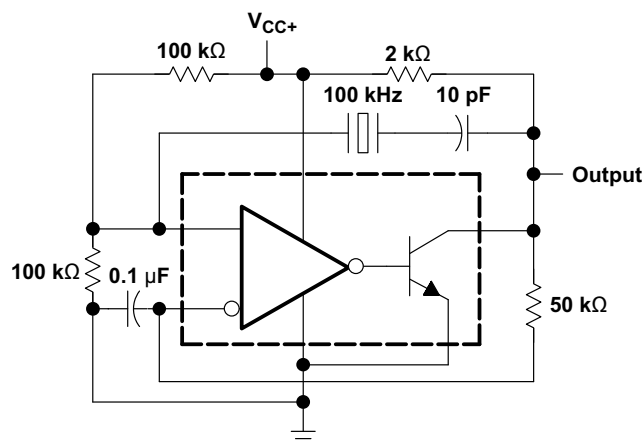
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**Figure 19. TTL Interface With High-Level Logic**



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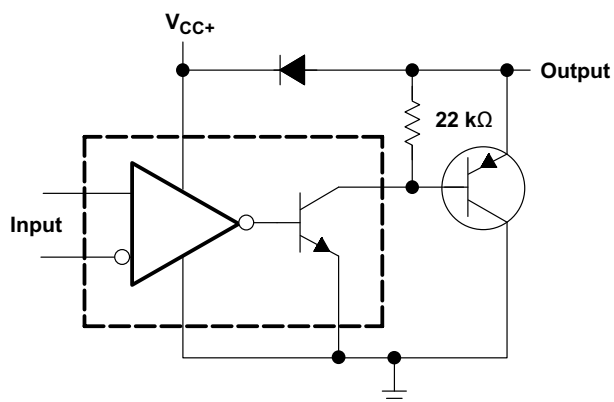
**Figure 20. Detector for Magnetic Transducer**



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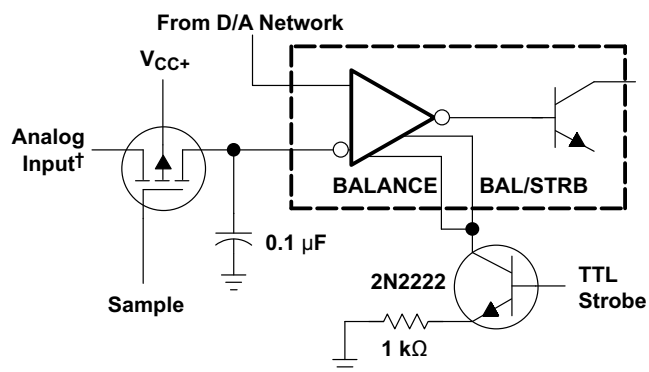
**Figure 21. 100-kHz Crystal Oscillator**

## System Examples (continued)



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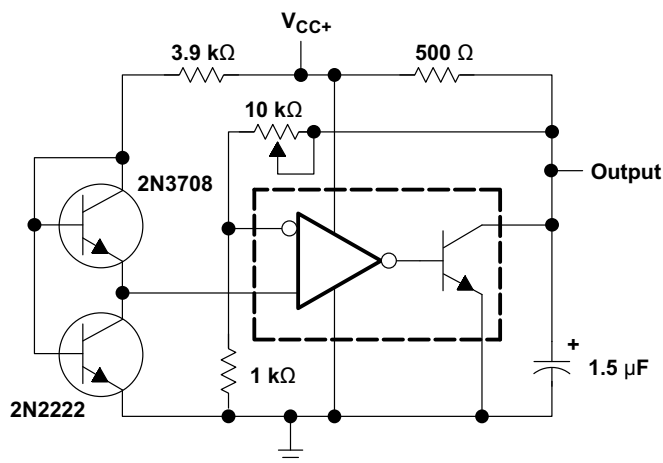
**Figure 22. Comparator and Solenoid Driver**



† Typical input current is 50 pA with inputs strobed off.

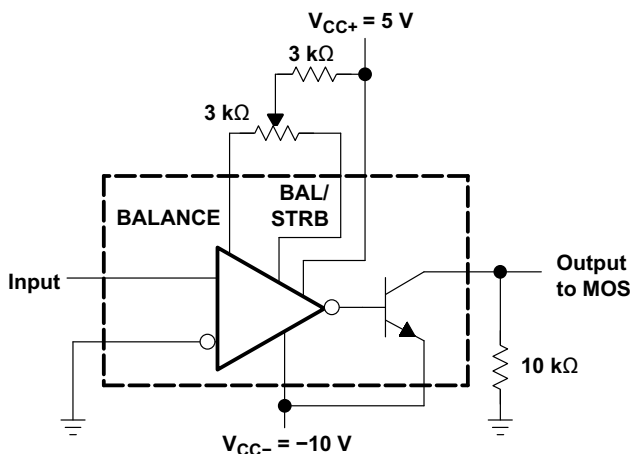
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**Figure 23. Strobing Both Input and Output Stages Simultaneously**



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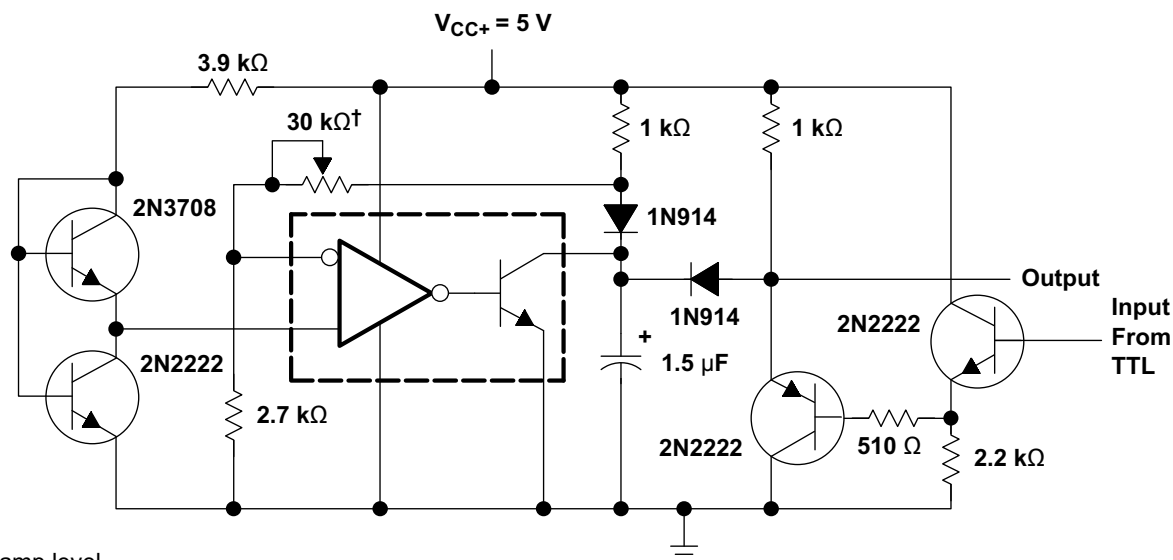
**Figure 24. Low-Voltage Adjustable Reference Supply**



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**Figure 25. Zero-Crossing Detector Driving MOS Logic**

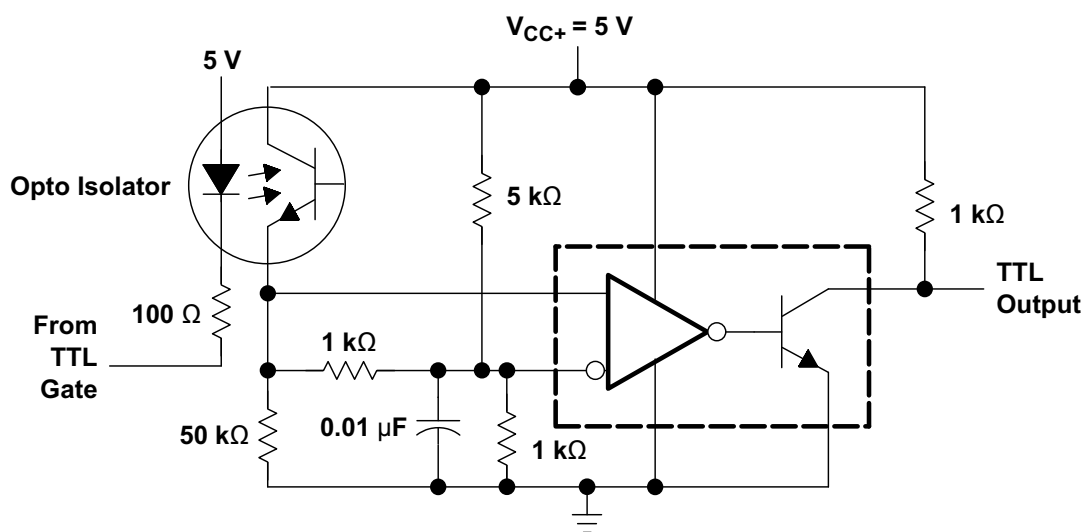
## System Examples (continued)



† Adjust to set clamp level

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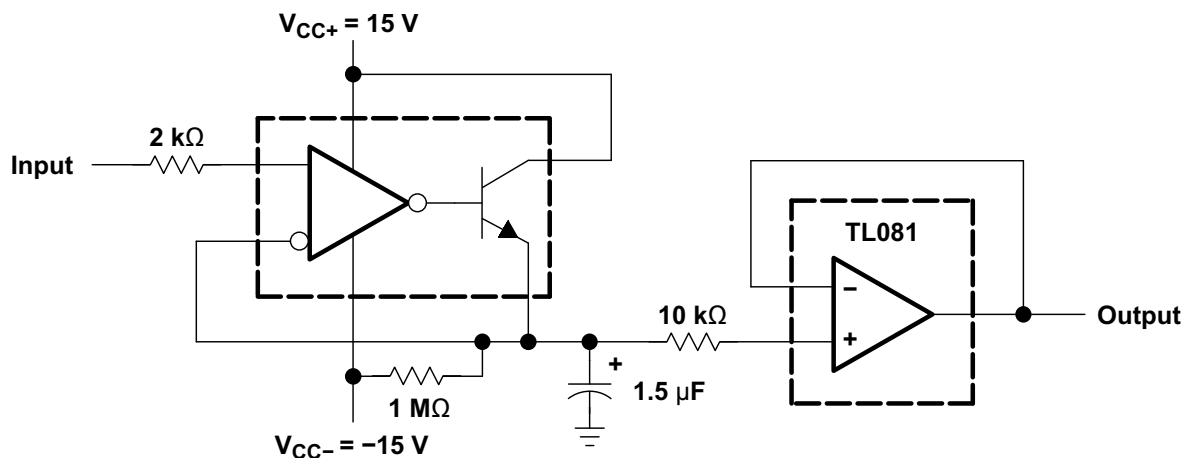
**Figure 26. Precision Squarer**



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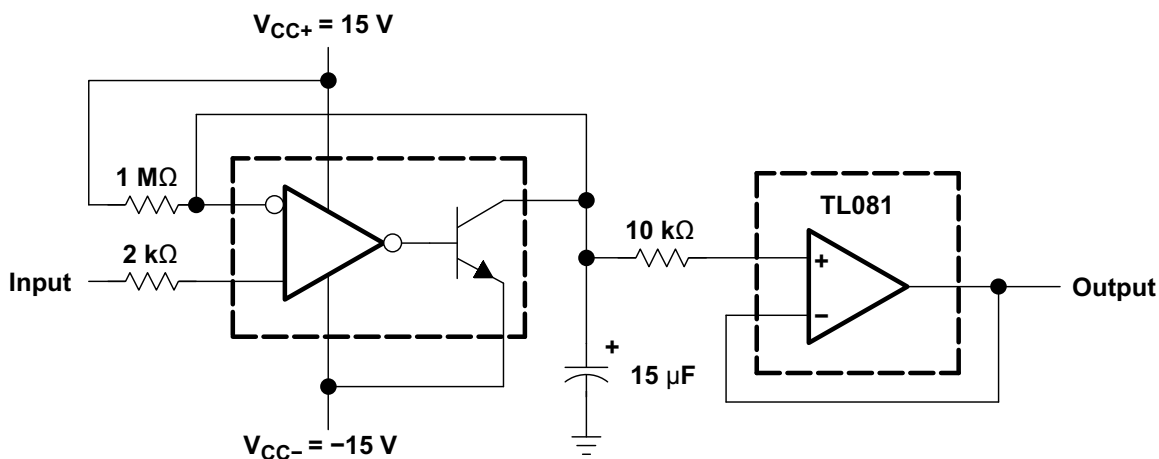
**Figure 27. Digital Transmission Isolator**

## System Examples (continued)



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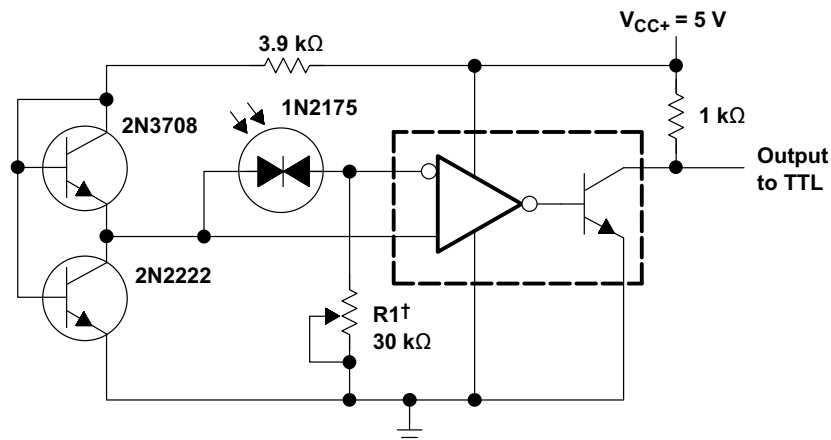
**Figure 28. Positive-Peak Detector**



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**Figure 29. Negative-Peak Detector**

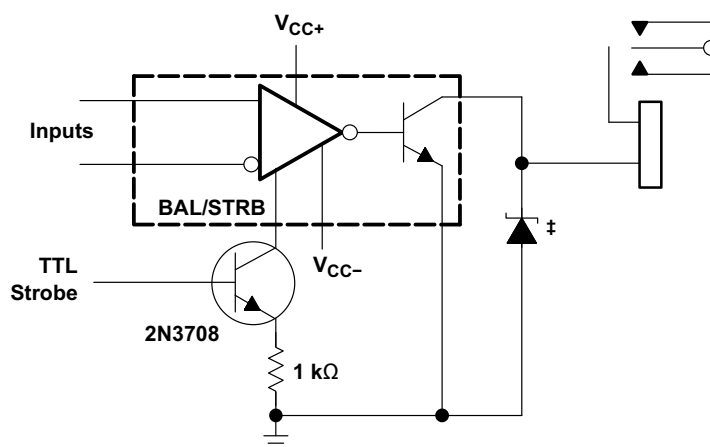
## System Examples (continued)



† R1 sets the comparison level. At comparison, the photodiode has less than 5 mV across it, decreasing dark current by an order of magnitude.

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**Figure 30. Precision Photodiode Comparator**

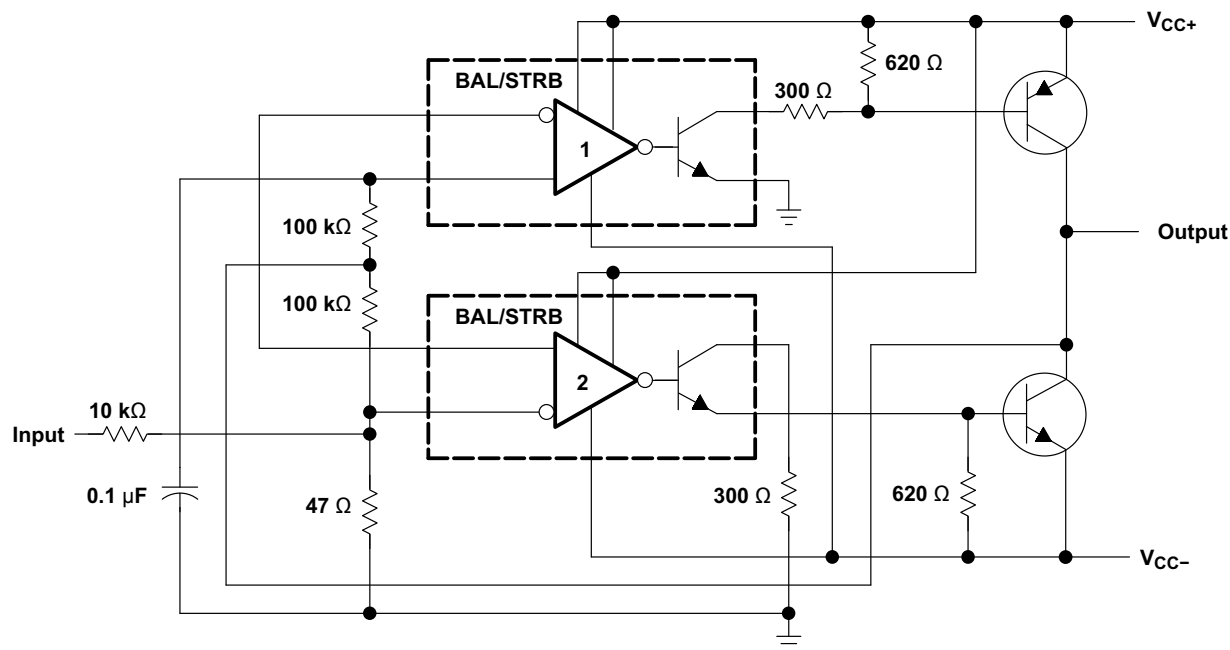


† Transient voltage and inductive kickback protection

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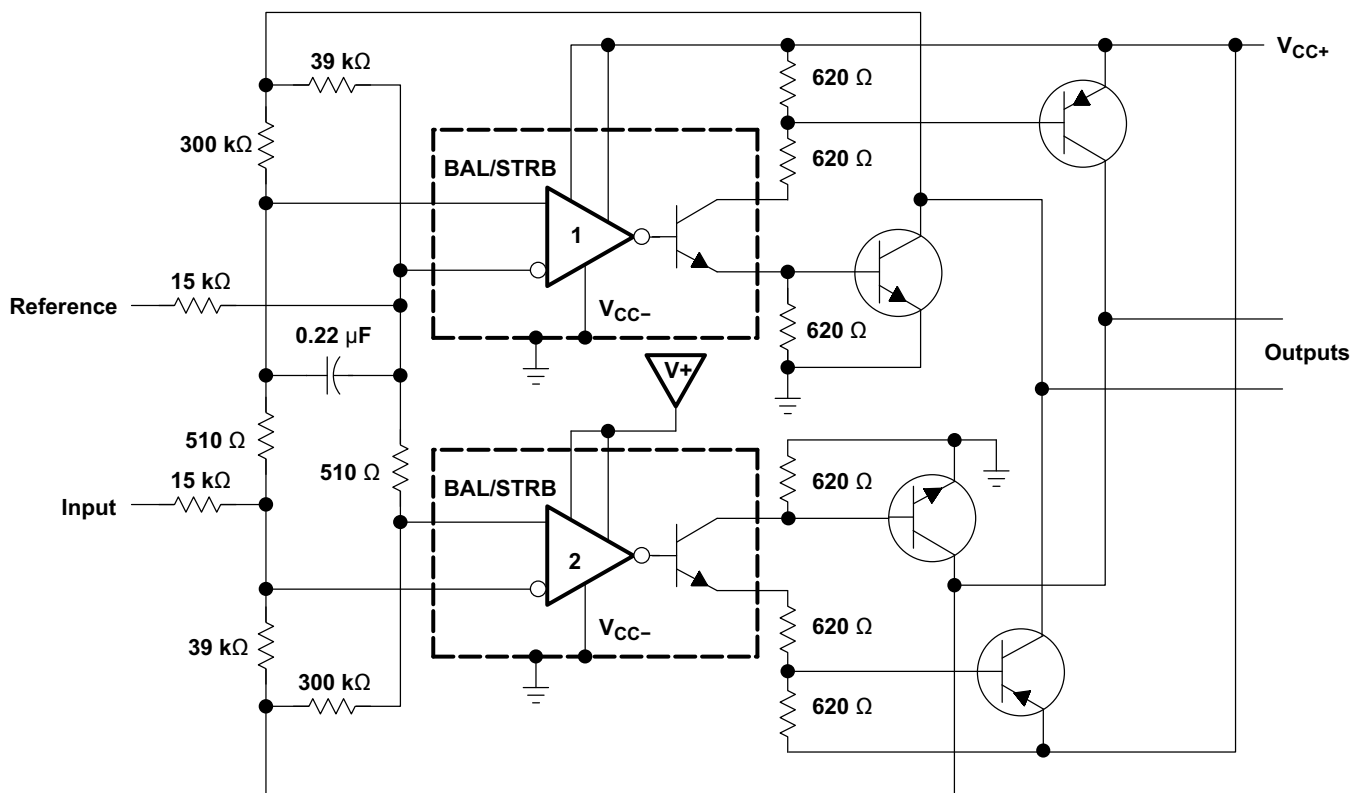
**Figure 31. Relay Driver With Strobe**

## System Examples (continued)



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Figure 32. Switching Power Amplifier



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Figure 33. Switching Power Amplifiers

## 10 Power Supply Recommendations

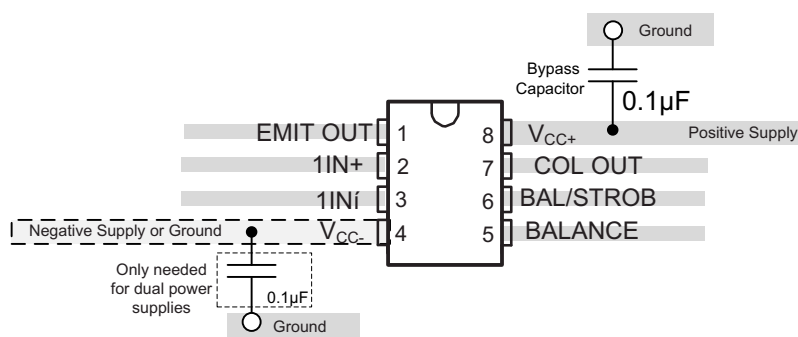
For fast response and comparison applications with noisy or AC inputs, use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can affect the common-mode range of the comparator input and create an inaccurate comparison.

## 11 Layout

### 11.1 Layout Guidelines

To create an accurate comparator application without hysteresis, maintain a stable power supply with minimized noise and glitches, which can affect the high level input common-mode voltage range. To achieve this accuracy, add a bypass capacitor between the supply voltage and ground. Place a bypass capacitor on the positive power supply and negative supply (if available).

### 11.2 Layout Example



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**Figure 34. LMx11 Layout Example**

## 12 Device and Documentation Support

### 12.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

**Table 2. Related Links**

| PARTS | PRODUCT FOLDER             | ORDER NOW                  | TECHNICAL DOCUMENTS        | TOOLS & SOFTWARE           | SUPPORT & COMMUNITY        |
|-------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| LM111 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| LM211 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| LM311 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |

### 12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 12.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 12.4 Trademarks

E2E is a trademark of Texas Instruments.  
All other trademarks are the property of their respective owners.

### 12.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 12.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser based versions of this data sheet, refer to the left hand navigation.

## PACKAGING INFORMATION

| Orderable part number            | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6)  |
|----------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|----------------------|
| <a href="#">JM38510/10304BPA</a> | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | JM38510<br>/10304BPA |
| JM38510/10304BPA.A               | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | JM38510<br>/10304BPA |
| <a href="#">LM111FKB</a>         | Active        | Production           | LCCC (FK)   20 | 55   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | LM111FKB             |
| LM111FKB.A                       | Active        | Production           | LCCC (FK)   20 | 55   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | LM111FKB             |
| <a href="#">LM111JG</a>          | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | LM111JG              |
| LM111JG.A                        | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | LM111JG              |
| <a href="#">LM111JGB</a>         | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | LM111JGB             |
| LM111JGB.A                       | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | LM111JGB             |
| <a href="#">LM211D</a>           | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | LM211                |
| LM211D.A                         | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | LM211                |
| <a href="#">LM211DR</a>          | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | LM211                |
| LM211DR.A                        | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | LM211                |
| <a href="#">LM211DRG4</a>        | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | LM211                |
| LM211DRG4.A                      | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | LM211                |
| <a href="#">LM211P</a>           | Active        | Production           | PDIP (P)   8   | 50   TUBE             | Yes         | NIPDAU                               | N/A for Pkg Type                  | -40 to 85    | LM211P               |
| LM211P.A                         | Active        | Production           | PDIP (P)   8   | 50   TUBE             | Yes         | NIPDAU                               | N/A for Pkg Type                  | -40 to 85    | LM211P               |
| LM211PE4                         | Active        | Production           | PDIP (P)   8   | 50   TUBE             | -           | Call TI                              | Call TI                           | -40 to 85    |                      |
| <a href="#">LM211PW</a>          | Active        | Production           | TSSOP (PW)   8 | 150   TUBE            | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | L211                 |
| LM211PW.A                        | Active        | Production           | TSSOP (PW)   8 | 150   TUBE            | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | L211                 |
| <a href="#">LM211PWR</a>         | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | L211                 |
| LM211PWR.A                       | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | L211                 |
| LM211PWRE4                       | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | -           | Call TI                              | Call TI                           | -40 to 85    |                      |
| <a href="#">LM211QD</a>          | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | LM211Q               |
| LM211QD.A                        | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | LM211Q               |
| <a href="#">LM211QDG4</a>        | Obsolete      | Production           | SOIC (D)   8   | -                     | -           | Call TI                              | Call TI                           | -40 to 125   | LM211Q               |
| <a href="#">LM211QDR</a>         | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | LM211Q               |
| LM211QDR.A                       | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | LM211Q               |
| <a href="#">LM211QDRG4</a>       | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | LM211Q               |

| Orderable part number           | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6)  |
|---------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|----------------------|
| LM211QDRG4.A                    | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 125   | LM211Q               |
| <a href="#">LM311D</a>          | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | LM311                |
| LM311D.A                        | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | LM311                |
| <a href="#">LM311DR</a>         | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | LM311                |
| LM311DR.A                       | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | LM311                |
| <a href="#">LM311DRG4</a>       | Obsolete      | Production           | SOIC (D)   8   | -                     | -           | Call TI                              | Call TI                           | 0 to 70      | LM311                |
| <a href="#">LM311P</a>          | Active        | Production           | PDIP (P)   8   | 50   TUBE             | Yes         | NIPDAU                               | N/A for Pkg Type                  | 0 to 70      | LM311P               |
| LM311P.A                        | Active        | Production           | PDIP (P)   8   | 50   TUBE             | Yes         | NIPDAU                               | N/A for Pkg Type                  | 0 to 70      | LM311P               |
| LM311PE4                        | Active        | Production           | PDIP (P)   8   | 50   TUBE             | -           | Call TI                              | Call TI                           | 0 to 70      |                      |
| <a href="#">LM311PSR</a>        | Active        | Production           | SO (PS)   8    | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | L311                 |
| LM311PSR.A                      | Active        | Production           | SO (PS)   8    | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | L311                 |
| <a href="#">LM311PW</a>         | Active        | Production           | TSSOP (PW)   8 | 150   TUBE            | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | L311                 |
| LM311PW.A                       | Active        | Production           | TSSOP (PW)   8 | 150   TUBE            | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | L311                 |
| LM311PWG4                       | Active        | Production           | TSSOP (PW)   8 | 150   TUBE            | -           | Call TI                              | Call TI                           | 0 to 70      |                      |
| <a href="#">LM311PWR</a>        | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | L311                 |
| LM311PWR.A                      | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70      | L311                 |
| LM311PWRG4                      | Active        | Production           | TSSOP (PW)   8 | 2000   LARGE T&R      | -           | Call TI                              | Call TI                           | 0 to 70      |                      |
| <a href="#">M38510/10304BPA</a> | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125   | JM38510<br>/10304BPA |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

**(6) Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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**OTHER QUALIFIED VERSIONS OF LM211 :**

- Automotive : [LM211-Q1](#)
- Enhanced Product : [LM211-EP](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device    | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-----------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM211DR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM211DRG4 | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM211DRG4 | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM211PWR  | TSSOP        | PW              | 8    | 2000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |
| LM211QDR  | SOIC         | D               | 8    | 2500 | 330.0              | 12.5               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM311DR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM311DR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| LM311PSR  | SO           | PS              | 8    | 2000 | 330.0              | 16.4               | 8.35    | 6.6     | 2.4     | 12.0    | 16.0   | Q1            |
| LM311PWR  | TSSOP        | PW              | 8    | 2000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device    | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM211DR   | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM211DRG4 | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM211DRG4 | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| LM211PWR  | TSSOP        | PW              | 8    | 2000 | 353.0       | 353.0      | 32.0        |
| LM211QDR  | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM311DR   | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM311DR   | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |
| LM311PSR  | SO           | PS              | 8    | 2000 | 353.0       | 353.0      | 32.0        |
| LM311PWR  | TSSOP        | PW              | 8    | 2000 | 353.0       | 353.0      | 32.0        |

## TUBE



\*All dimensions are nominal

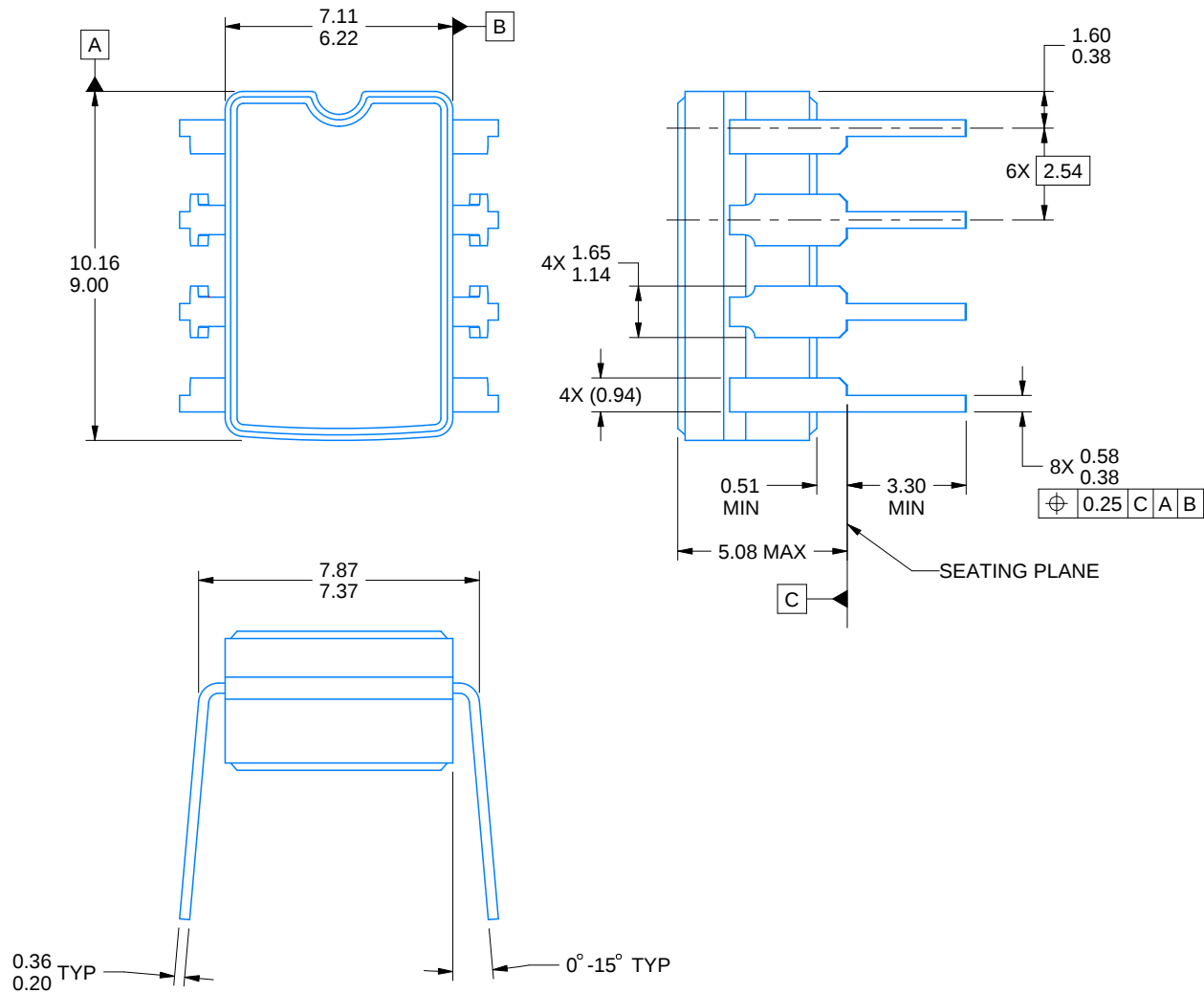
| Device     | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LM111FKB   | FK           | LCCC         | 20   | 55  | 506.98 | 12.06  | 2030   | NA     |
| LM111FKB.A | FK           | LCCC         | 20   | 55  | 506.98 | 12.06  | 2030   | NA     |
| LM211D     | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| LM211D     | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| LM211D.A   | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| LM211D.A   | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| LM211P     | P            | PDIP         | 8    | 50  | 506    | 13.97  | 11230  | 4.32   |
| LM211P.A   | P            | PDIP         | 8    | 50  | 506    | 13.97  | 11230  | 4.32   |
| LM211PW    | PW           | TSSOP        | 8    | 150 | 530    | 10.2   | 3600   | 3.5    |
| LM211PW.A  | PW           | TSSOP        | 8    | 150 | 530    | 10.2   | 3600   | 3.5    |
| LM211QD    | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| LM211QD.A  | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| LM311D     | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| LM311D     | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| LM311D.A   | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| LM311D.A   | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| LM311P     | P            | PDIP         | 8    | 50  | 506    | 13.97  | 11230  | 4.32   |
| LM311P.A   | P            | PDIP         | 8    | 50  | 506    | 13.97  | 11230  | 4.32   |
| LM311PW    | PW           | TSSOP        | 8    | 150 | 530    | 10.2   | 3600   | 3.5    |
| LM311PW.A  | PW           | TSSOP        | 8    | 150 | 530    | 10.2   | 3600   | 3.5    |

JG0008A

## PACKAGE OUTLINE

CDIP - 5.08 mm max height

CERAMIC DUAL IN-LINE PACKAGE



4230036/A 09/2023

### NOTES:

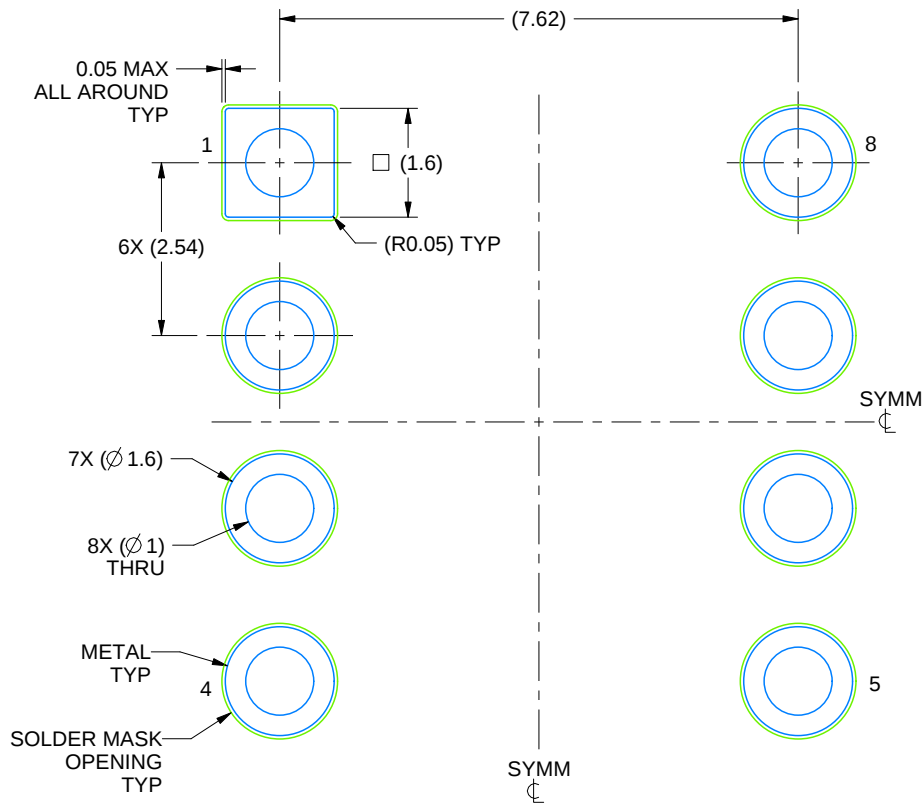
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package can be hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification.
5. Falls within MIL STD 1835 GDIP1-T8

# EXAMPLE BOARD LAYOUT

JG0008A

CDIP - 5.08 mm max height

CERAMIC DUAL IN-LINE PACKAGE



LAND PATTERN EXAMPLE  
NON SOLDER MASK DEFINED  
SCALE: 9X

4230036/A 09/2023

## GENERIC PACKAGE VIEW

**FK 20**

**LCCC - 2.03 mm max height**

8.89 x 8.89, 1.27 mm pitch

LEADLESS CERAMIC CHIP CARRIER

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4229370VA\

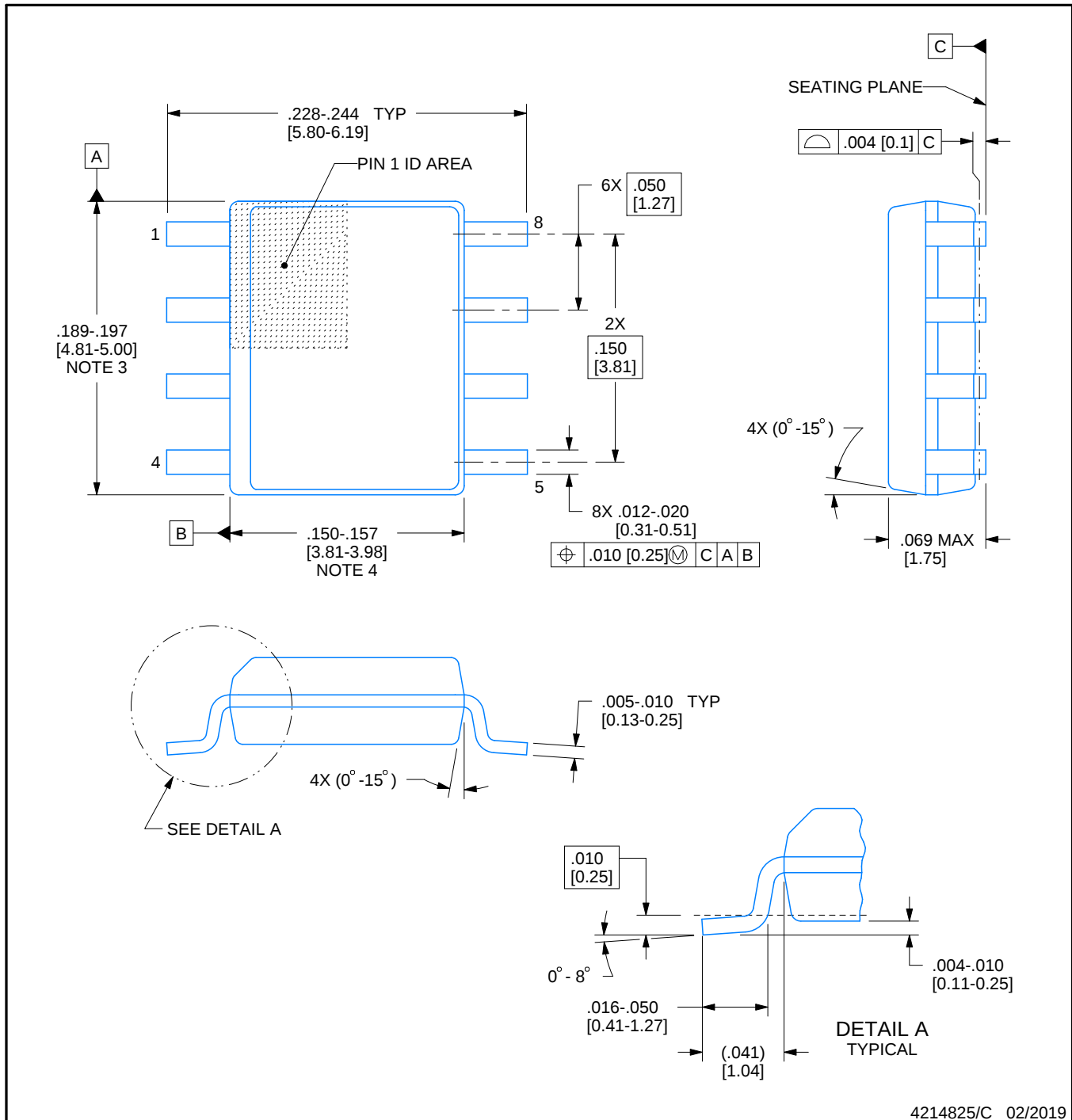


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

## NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

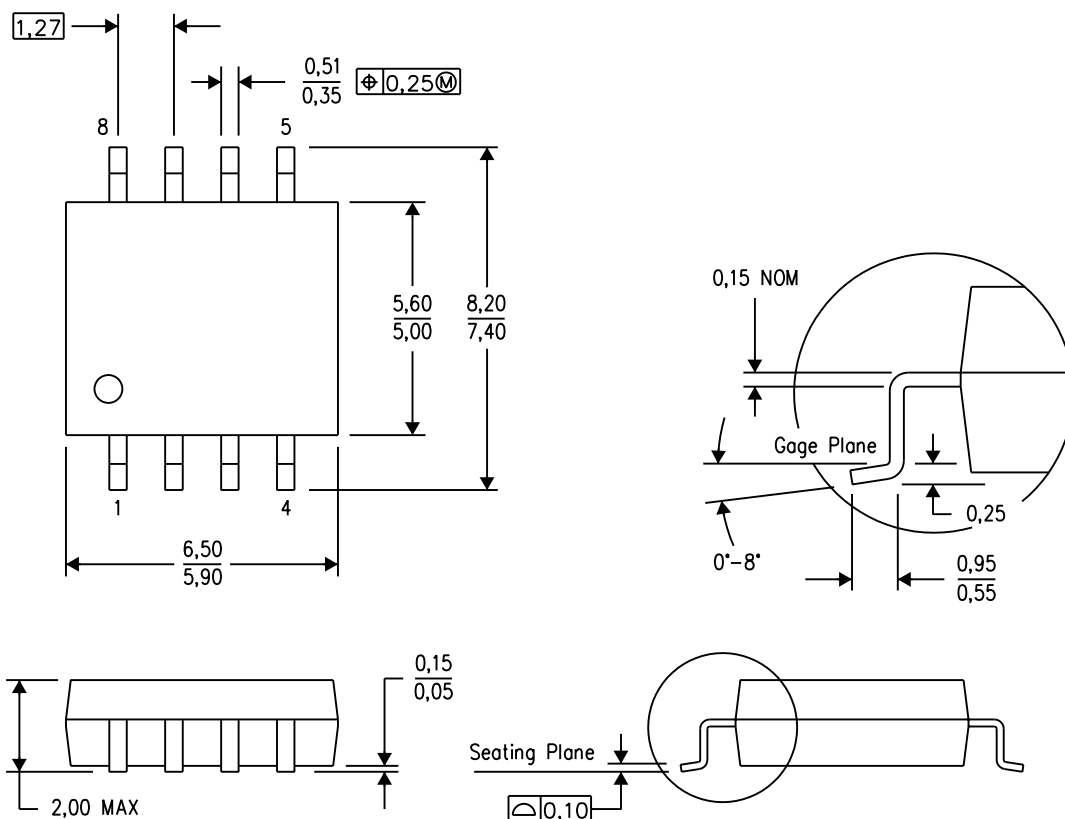
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

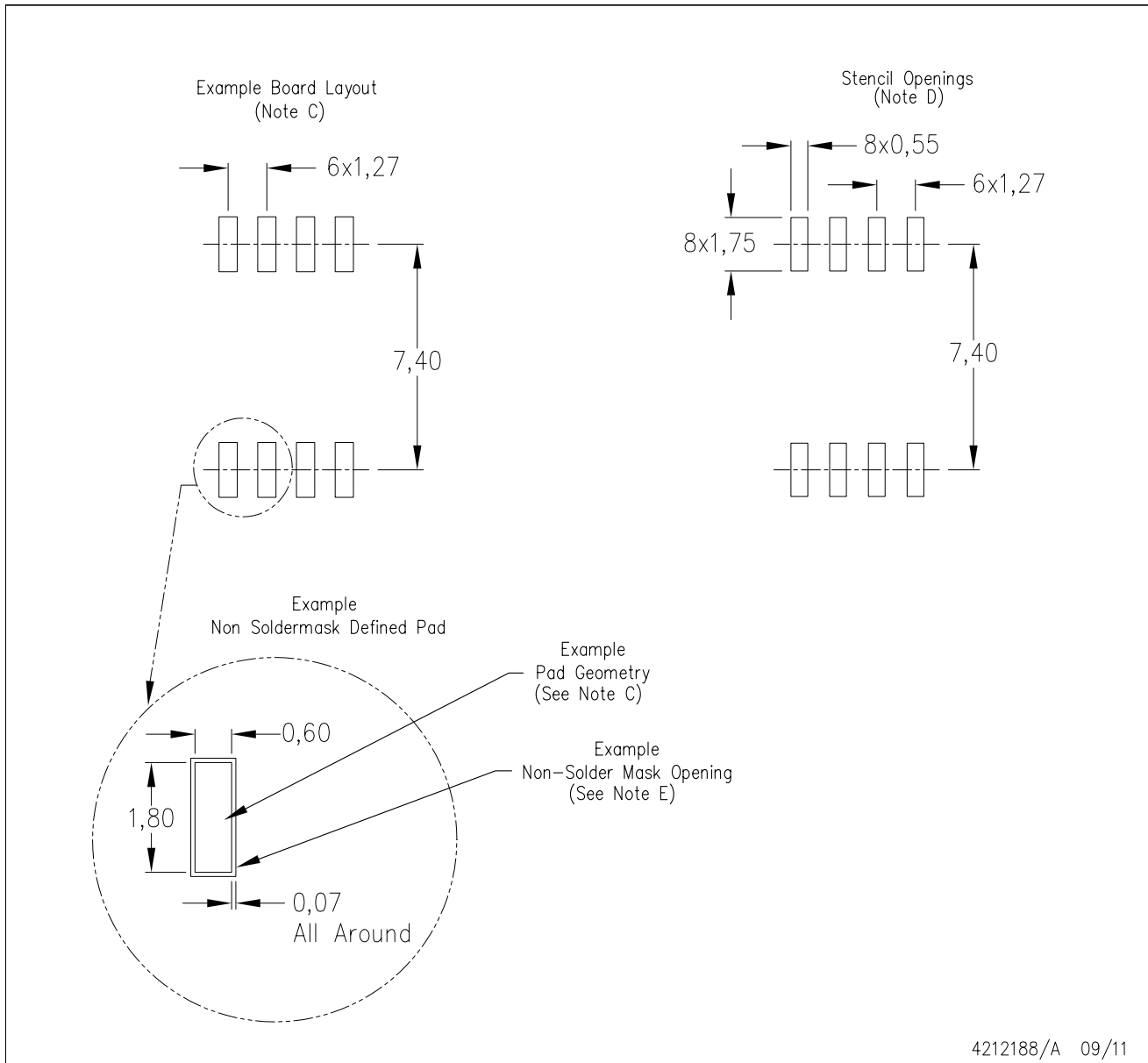


4040063/C 03/03

- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

## PS (R-PDSO-G8)

## PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

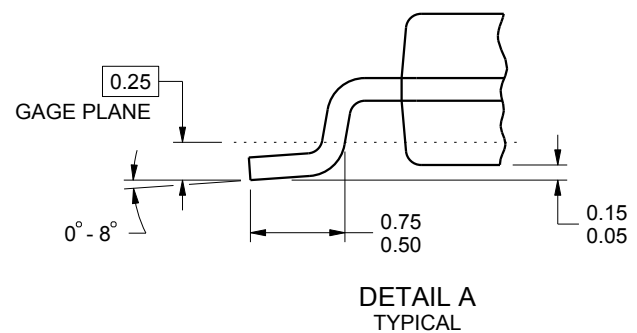
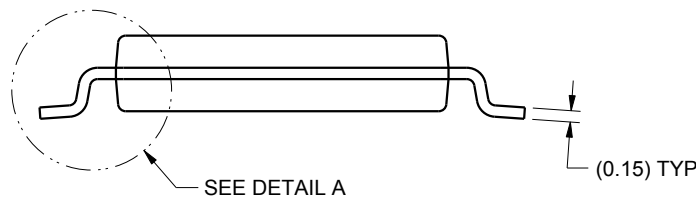
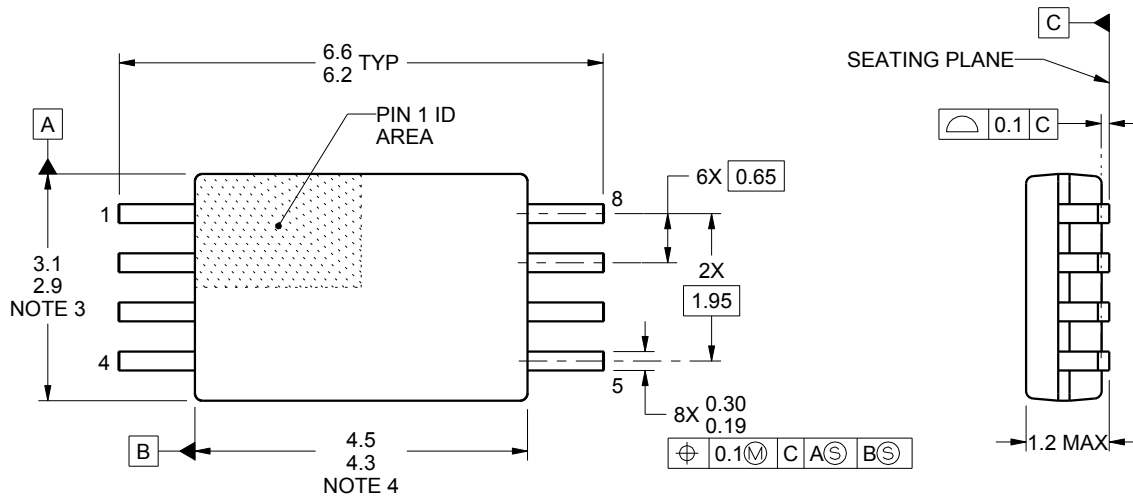
PW0008A



# PACKAGE OUTLINE

## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4221848/A 02/2015

### NOTES:

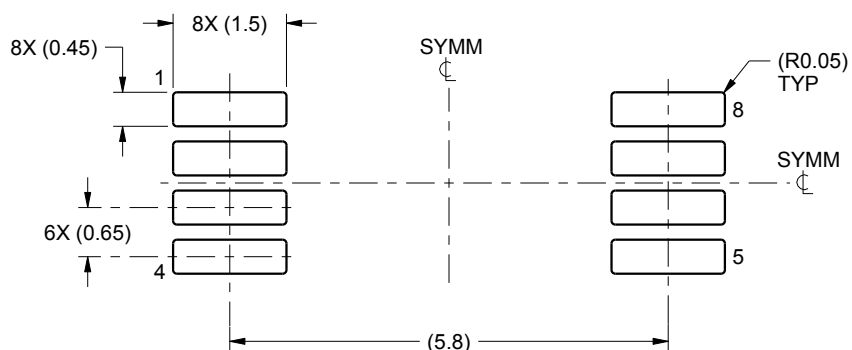
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.

# EXAMPLE BOARD LAYOUT

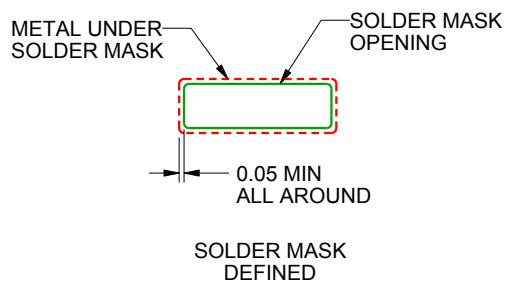
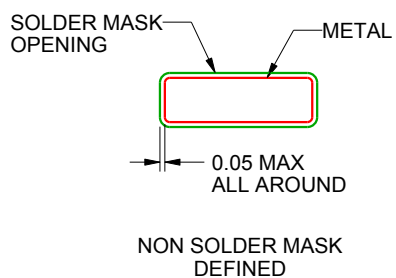
PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:10X



SOLDER MASK DETAILS  
NOT TO SCALE

4221848/A 02/2015

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

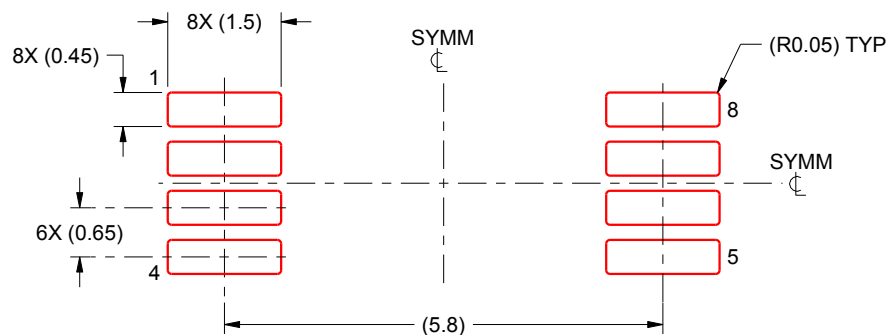
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:10X

4221848/A 02/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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