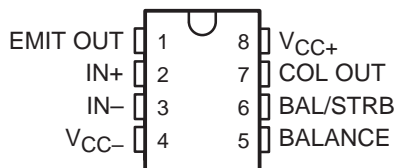


LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

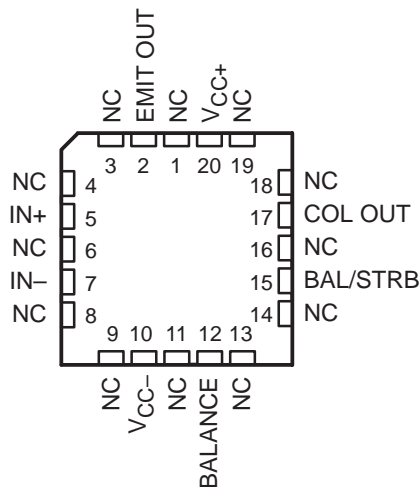
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- **Fast Response Times**
- **Strobe Capability**
- **Maximum Input Bias Current . . . 300 nA**
- **Maximum Input Offset Current . . . 70 nA**
- **Can Operate From Single 5-V Supply**
- **Available in Q-Temp Automotive**
 - **High-Reliability Automotive Applications**
 - **Configuration Control/Print Support**
 - **Qualification to Automotive Standards**

LM111 . . . JG PACKAGE
LM211 . . . D, P, OR PW PACKAGE
LM311 . . . D, P, PS, OR PW PACKAGE
(TOP VIEW)



LM111 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

description/ordering information

The LM111, LM211, and LM311 are single high-speed voltage comparators. These devices are designed to operate from a wide range of power-supply voltages, including ± 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.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

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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.

LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

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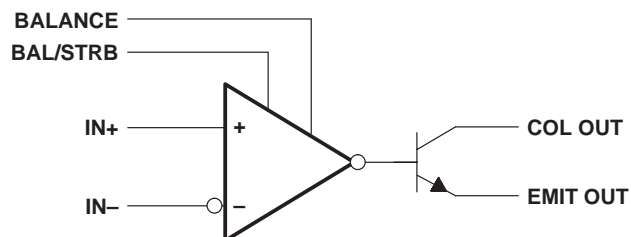
description/ordering information

ORDERING INFORMATION

| TA | V _{IO} max AT 25°C | PACKAGE† | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|-----------------------------|------------|--------------|-----------------------|------------------|
| -0°C to 70°C | 7.5 mV | PDIP (P) | Tube of 50 | LM311P | LM311P |
| | | SOIC (D) | Tube of 75 | LM311D | LM311 |
| | | | Reel of 2500 | LM311DR | |
| | | SOP (PS) | Reel of 2000 | LM311PSR | L311 |
| | | TSSOP (PW) | Reel of 150 | LM311PW | L311 |
| Tube of 2000 | LM311PWR | | | | |
| -40°C to 85°C | 3 mV | PDIP (P) | Tube of 50 | LM211P | LM211P |
| | | SOIC (D) | Tube of 75 | LM211D | LM211 |
| | | | Reel of 2500 | LM211DR | |
| | | TSSOP (PW) | Reel of 150 | LM211PW | L211 |
| | | | Reel of 2000 | LM211PWR | |
| -40°C to 125°C | 3 mV | SOIC (D) | Tube of 75 | LM211QD | LM211Q |
| | | | Reel of 2500 | LM211QDR | |
| -55°C to 125°C | 3 mV | CDIP (JG) | Tube of 50 | LM111JG | LM111JG |
| | | LCCC (FK) | Tube of 55 | LM111FK | LM111FK |

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

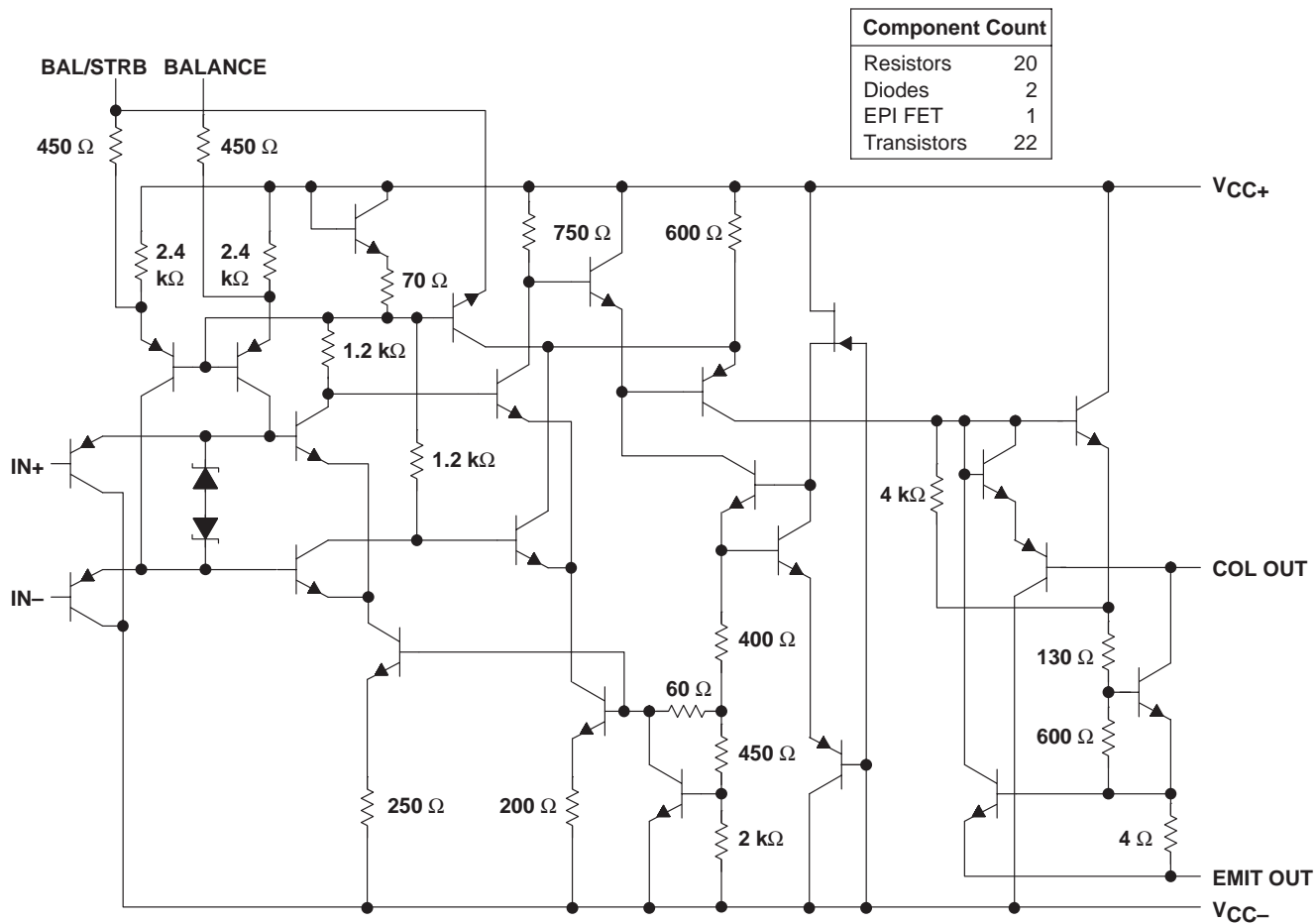
functional block diagram



LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

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schematic



All resistor values shown are nominal.

LM111, LM211, LM311

DIFFERENTIAL COMPARATORS WITH STROBES

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|---|----------------|
| Supply voltage: V_{CC+} (see Note 1) | 18 V |
| V_{CC-} (see Note 1) | -18 V |
| $V_{CC+} - V_{CC-}$ | 36 V |
| Differential input voltage, V_{ID} (see Note 2) | ± 30 V |
| Input voltage, V_I (either input, see Notes 1 and 3) | ± 15 V |
| Voltage from emitter output to V_{CC-} | 30 V |
| Voltage from collector output to V_{CC-} : | |
| LM111 | 50 V |
| LM211 | 50 V |
| LM211Q | 50 V |
| LM311 | 40 V |
| Duration of output short circuit (see Note 4) | 10 s |
| Package thermal impedance, θ_{JA} (see Notes 5 and 6): | |
| D package | 97°C/W |
| P package | 85°C/W |
| PS package | 95°C/W |
| PW package | 149°C/W |
| Package thermal impedance, θ_{JC} (see Notes 7 and 8): | |
| FK package | 5.61°C/W |
| JG package | 14.5°C/W |
| Operating virtual junction temperature, T_J | 150°C |
| Case temperature for 60 seconds: FK package | 260°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J or JG package | 300°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: D, P, PS, or PW package | 260°C |
| Storage temperature range, T_{stg} | -65°C to 150°C |

† 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.

- NOTES:
- All voltage values, unless otherwise noted, are with respect to the midpoint between V_{CC+} and V_{CC-} .
 - Differential voltages are at $IN+$ with respect to $IN-$.
 - The magnitude of the input voltage must never exceed the magnitude of the supply voltage or ± 15 V, whichever is less.
 - The output may be shorted to ground or either power supply.
 - Maximum power dissipation is a function of $T_J(max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 - The package thermal impedance is calculated in accordance with JESD 51-7.
 - Maximum power dissipation is a function of $T_J(max)$, θ_{JC} , and T_C . The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(max) - T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 - The package thermal impedance is calculated in accordance with MIL-STD-883.

recommended operating conditions

| | | MIN | MAX | UNIT | |
|---------------------|--|-----------------|-----------------|------|----|
| $V_{CC+} - V_{CC-}$ | Supply voltage | 3.5 | 30 | V | |
| V_I | Input voltage ($ V_{CC\pm} \leq 15$ V) | $V_{CC-} + 0.5$ | $V_{CC+} - 1.5$ | V | |
| T_A | Operating free-air temperature range | LM111 | -55 | 125 | °C |
| | | LM211 | -40 | 85 | |
| | | LM211Q | -40 | 125 | |
| | | LM311 | 0 | 70 | |



LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

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

| PARAMETER | TEST CONDITIONS | T_A † | LM111 LM211 LM211Q | | | LM311 | | | UNIT | |
|--|--|--|--------------------------|---------------|------|-------------|---------------|-----|---------|--|
| | | | MIN | TYP‡ | MAX | MIN | TYP‡ | MAX | | |
| V_{IO} Input offset voltage | See Note 6 | 25°C | 0.7 | | 3 | 2 | | 7.5 | mV | |
| | | Full range | | | 4 | | | 10 | | |
| I_{IO} Input offset current | See Note 6 | 25°C | 4 | | 10 | 6 | | 50 | nA | |
| | | Full range | | | 20 | | | 70 | | |
| I_{IB} Input bias current | $V_O = 1$ V to 14 V | 25°C | 75 | | 100 | 100 | | 250 | nA | |
| | | Full range | | | 150 | | | 300 | | |
| $I_{IL(S)}$ Low-level strobe current (see Note 7) | $V_{(strobe)} = 0.3$ V, $V_{ID} \leq -10$ mV | 25°C | -3 | | | -3 | | | mA | |
| V_{ICR} Common-mode input voltage range | | Full range | 13 to -14.5 | 13.8 to -14.7 | | 13 to -14.5 | 13.8 to -14.7 | | V | |
| A_{VD} Large-signal differential voltage amplification | $V_O = 5$ V to 35 V, $R_L = 1$ k Ω | 25°C | 40 | | 200 | 40 | | 200 | V/mV | |
| I_{OH} High-level (collector) output leakage current | $I_{(strobe)} = -3$ mA, $V_{OH} = 35$ V, $V_{ID} = 5$ mV | 25°C | 0.2 | | 10 | | | | nA | |
| | | Full range | | | 0.5 | | | | μ A | |
| V_{OL} Low-level (collector-to-emitter) output voltage | $I_{OL} = 50$ mA | $V_{ID} = -5$ mV | 25°C | | 0.75 | 1.5 | | | V | |
| | | $V_{ID} = -10$ mV | 25°C | | | | 0.75 | 1.5 | | |
| | | $V_{CC+} = 4.5$ V, $V_{CC-} = 0$, $I_{OL} = 8$ mA | $V_{ID} = -6$ mV | Full range | | 0.23 | 0.4 | | | |
| | | $V_{ID} = -10$ mV | Full range | | | | 0.23 | 0.4 | | |
| I_{CC+} Supply current from V_{CC+} , output low | $V_{ID} = -10$ mV, No load | 25°C | 5.1 | | 6 | 5.1 | | 7.5 | mA | |
| I_{CC-} Supply current from V_{CC-} , output high | $V_{ID} = 10$ mV, No load | 25°C | -4.1 | | -5 | -4.1 | | -5 | mA | |

† 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.

‡ All typical values are at $T_A = 25^\circ\text{C}$.

NOTES: 9. 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 k Ω to V_{CC+} . These parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.

10. The strobe should not be shorted to ground; it should be current driven at -3 mA to -5 mA (see Figures 13 and 27).

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

| PARAMETER | TEST CONDITIONS | LM111 LM211 LM211Q LM311 | UNIT |
|---|---|-----------------------------------|------|
| | | TYP | |
| Response time, low-to-high-level output | $R_C = 500$ Ω to 5 V, $C_L = 5$ pF, See Note 8 | 115 | ns |
| Response time, high-to-low-level output | | 165 | ns |

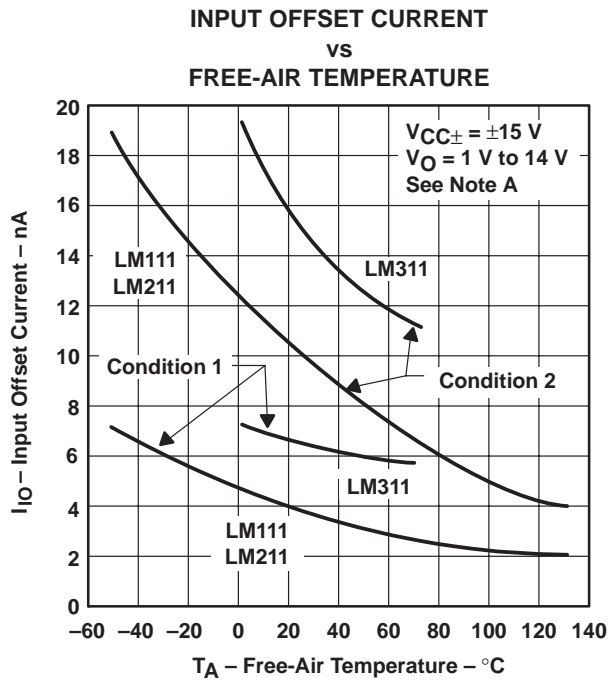
NOTE 11: The response time specified is for a 100-mV input step with 5-mV overdrive and is the interval between the input step function and the instant when the output crosses 1.4 V.



LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

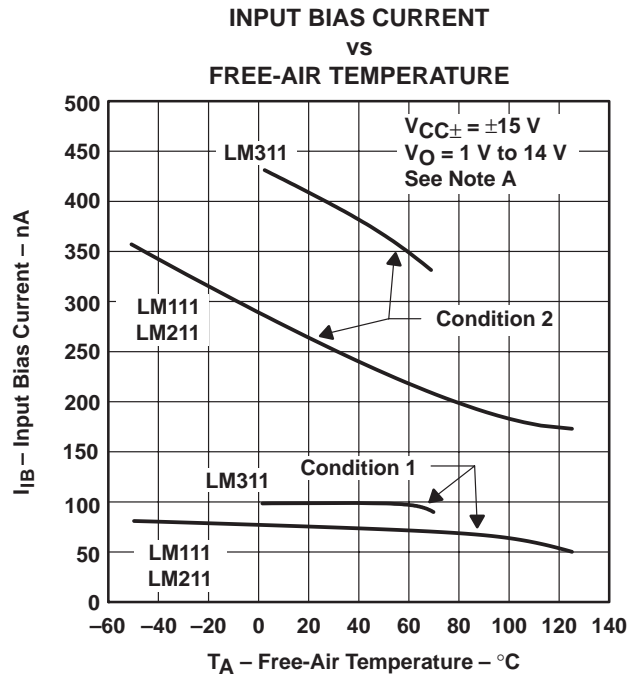
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TYPICAL CHARACTERISTICS†



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

Figure 1



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

Figure 2

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

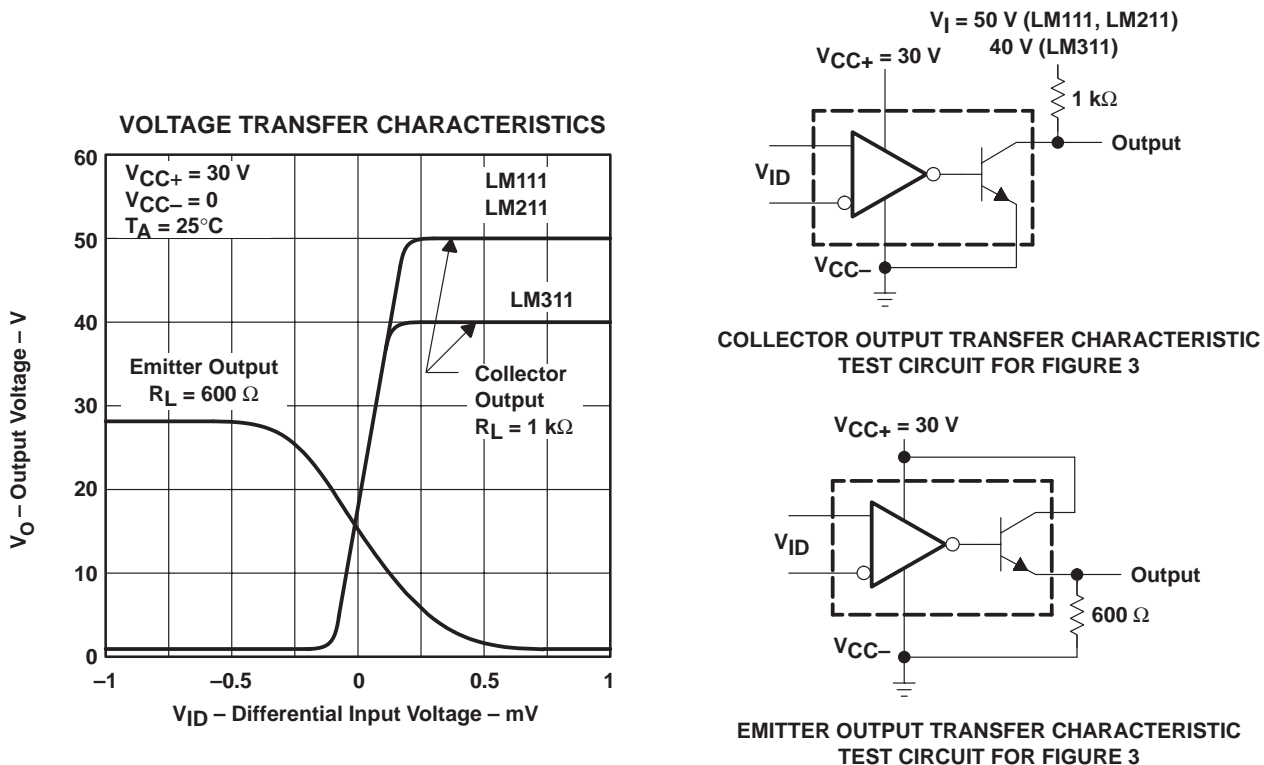


Figure 3

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

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TYPICAL CHARACTERISTICS

OUTPUT RESPONSE FOR
VARIOUS INPUT OVERDRIVES

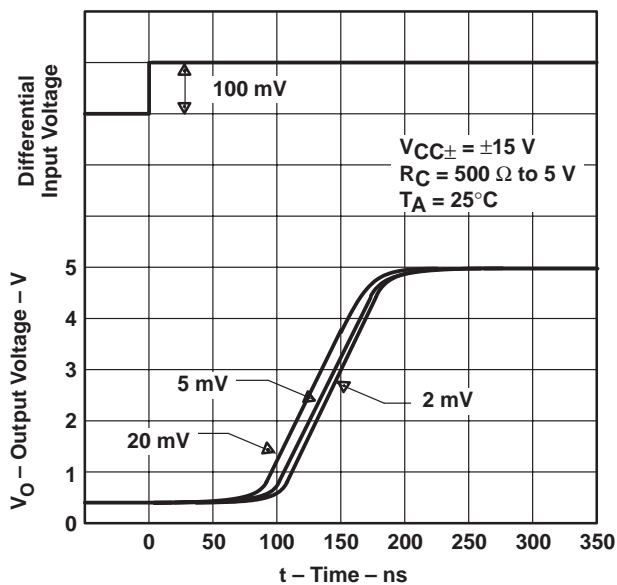


Figure 4

OUTPUT RESPONSE FOR
VARIOUS INPUT OVERDRIVES

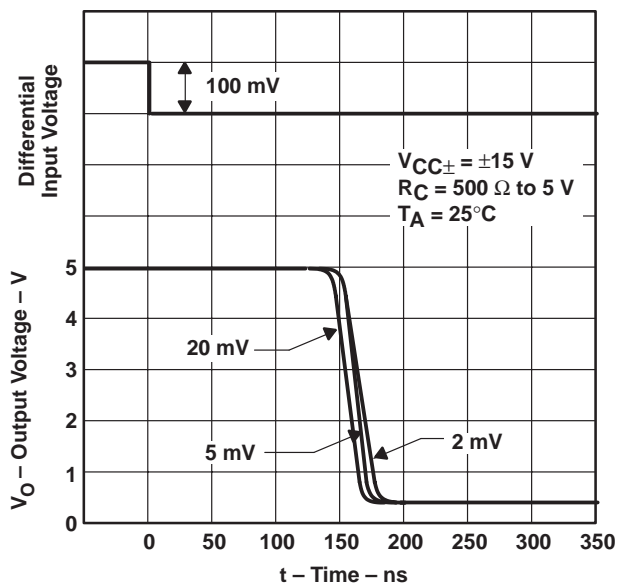
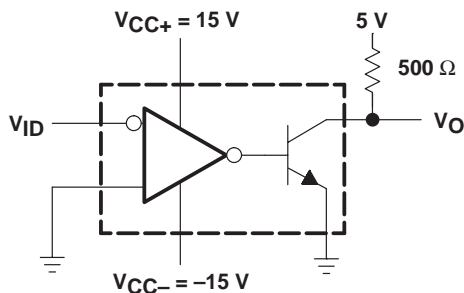


Figure 5



TEST CIRCUIT FOR FIGURES 4 AND 5

TYPICAL CHARACTERISTICS

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

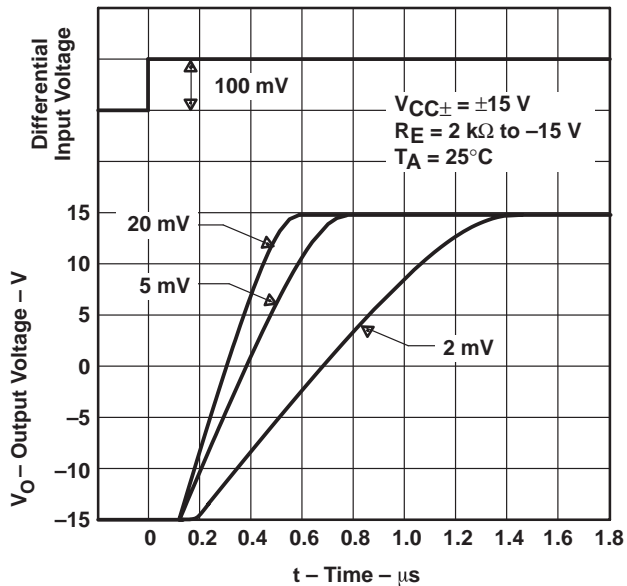


Figure 6

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

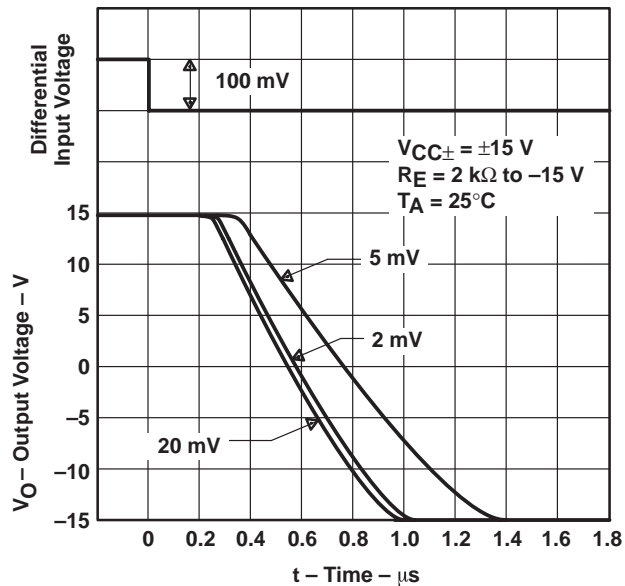
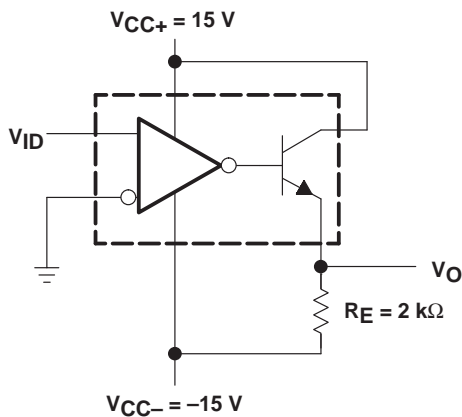


Figure 7



TEST CIRCUIT FOR FIGURES 6 AND 7

TYPICAL CHARACTERISTICS

OUTPUT CURRENT AND DISSIPATION
vs
OUTPUT VOLTAGE

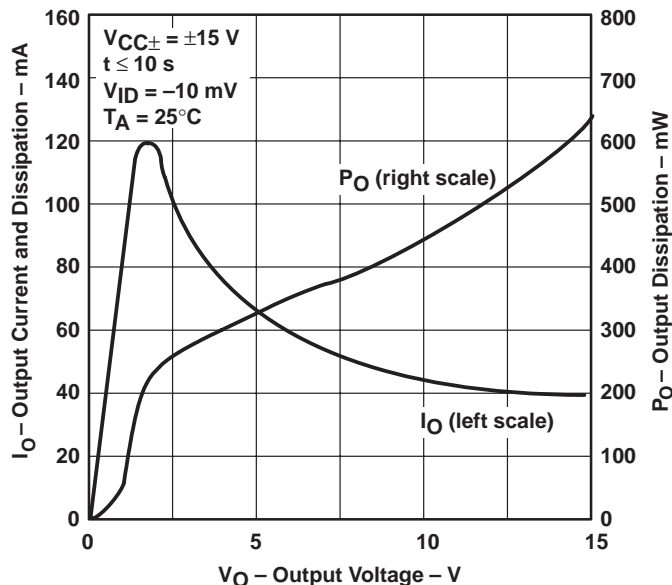


Figure 8

POSITIVE SUPPLY CURRENT
vs
POSITIVE SUPPLY VOLTAGE

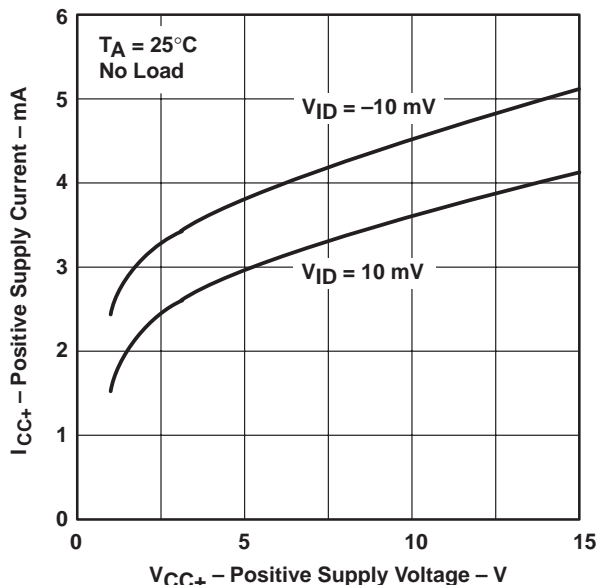


Figure 9

NEGATIVE SUPPLY CURRENT
vs
NEGATIVE SUPPLY VOLTAGE

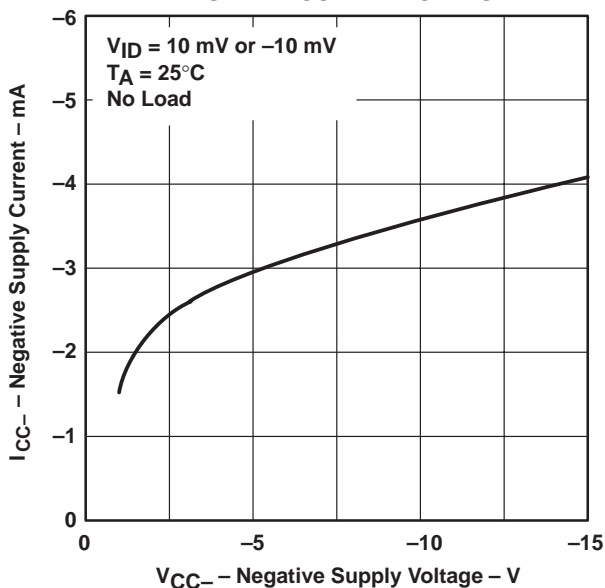


Figure 10



APPLICATION INFORMATION

Figure 11 through Figure 29 show various applications for the LM111, LM211, and LM311 comparators.

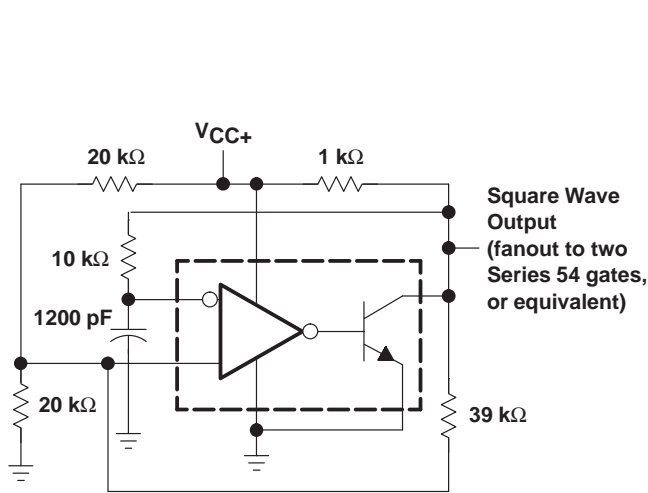
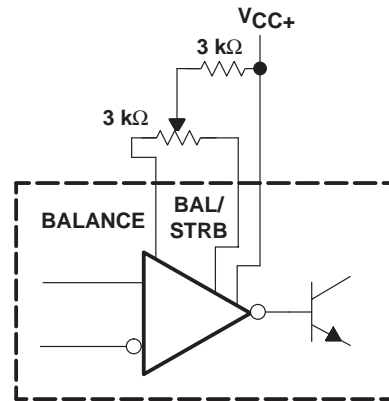


Figure 11. 100-kHz Free-Running Multivibrator



NOTE: If offset balancing is not used, the BALANCE and BAL/STRB pins should be shorted together.

Figure 12. Offset Balancing

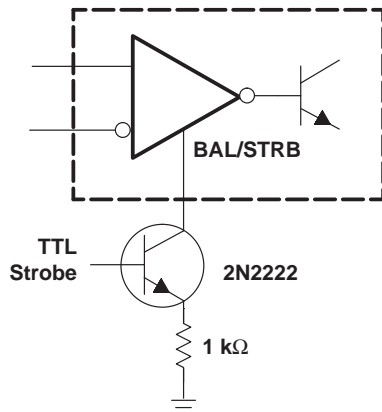


Figure 13. Strobbing

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

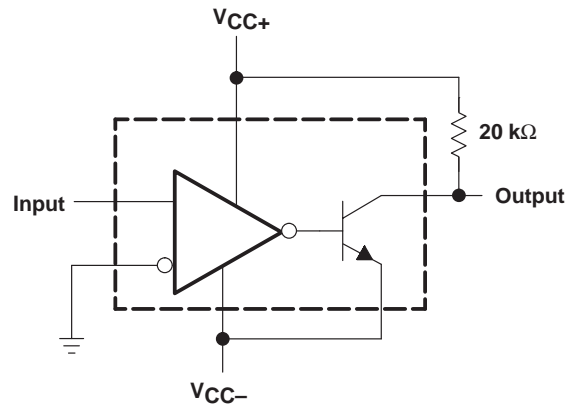
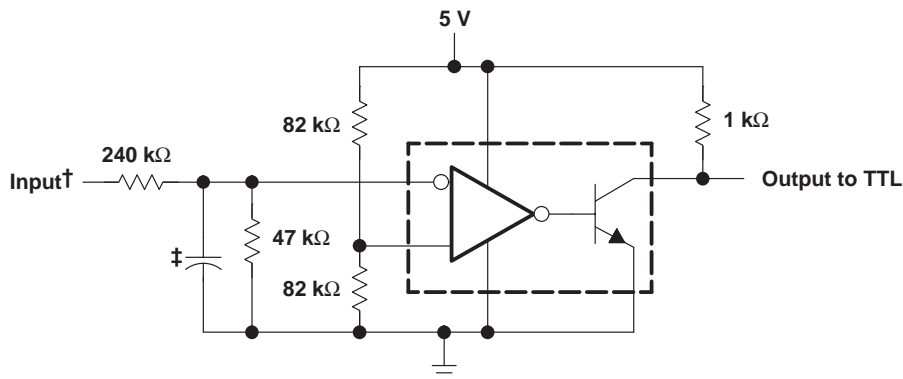


Figure 14. Zero-Crossing Detector

LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

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APPLICATION INFORMATION



† 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

Figure 15. TTL Interface With High-Level Logic

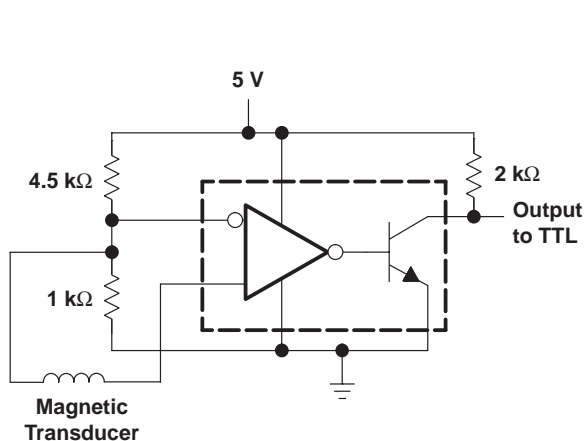


Figure 16. Detector for Magnetic Transducer

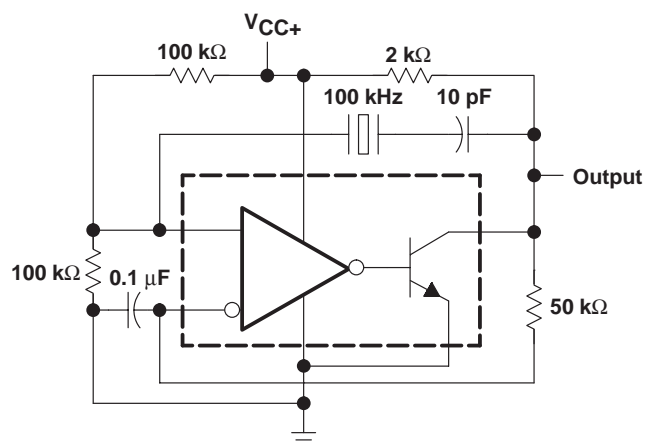


Figure 17. 100-kHz Crystal Oscillator

APPLICATION INFORMATION

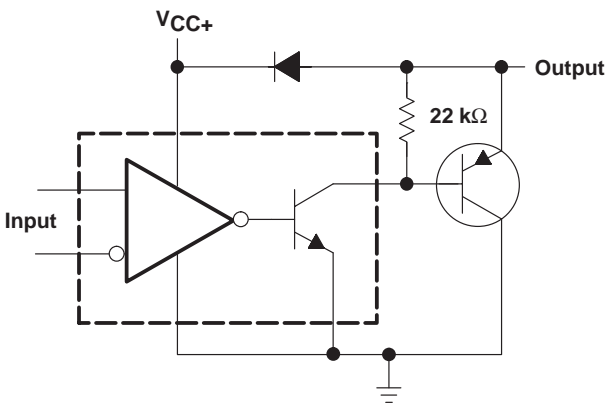
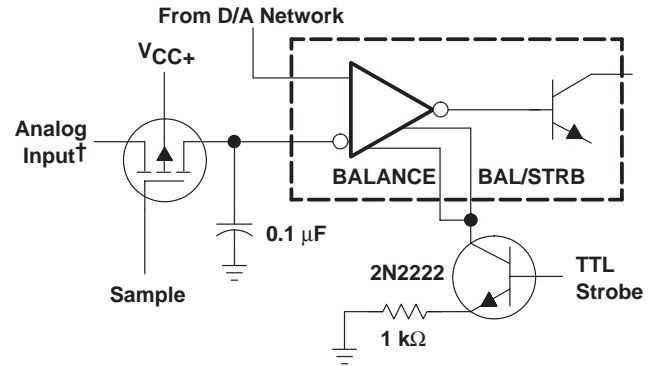


Figure 18. Comparator and Solenoid Driver



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

Figure 19. Strobing Both Input and Output Stages Simultaneously

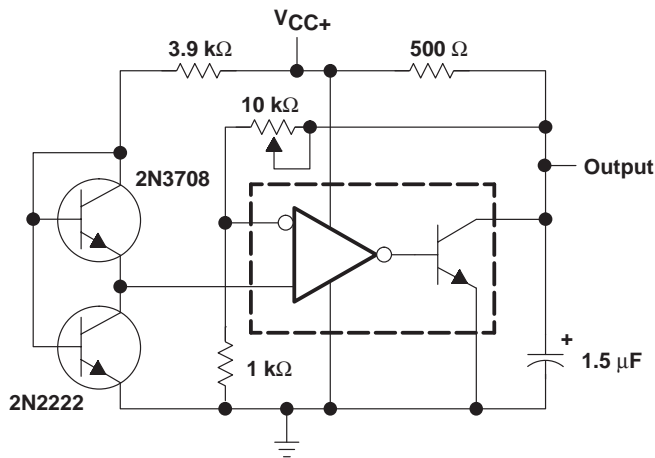


Figure 20. Low-Voltage Adjustable Reference Supply

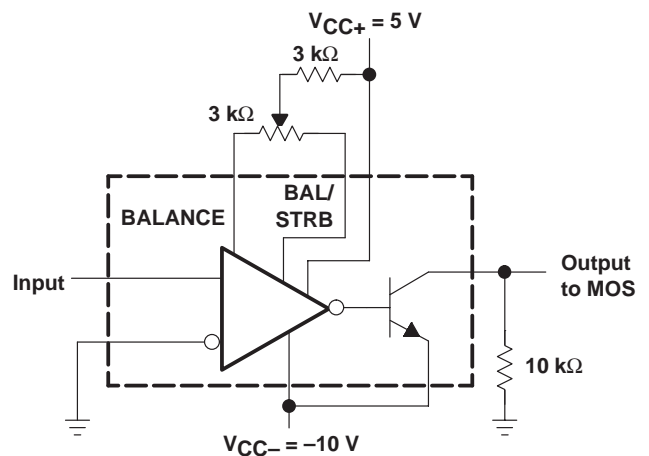
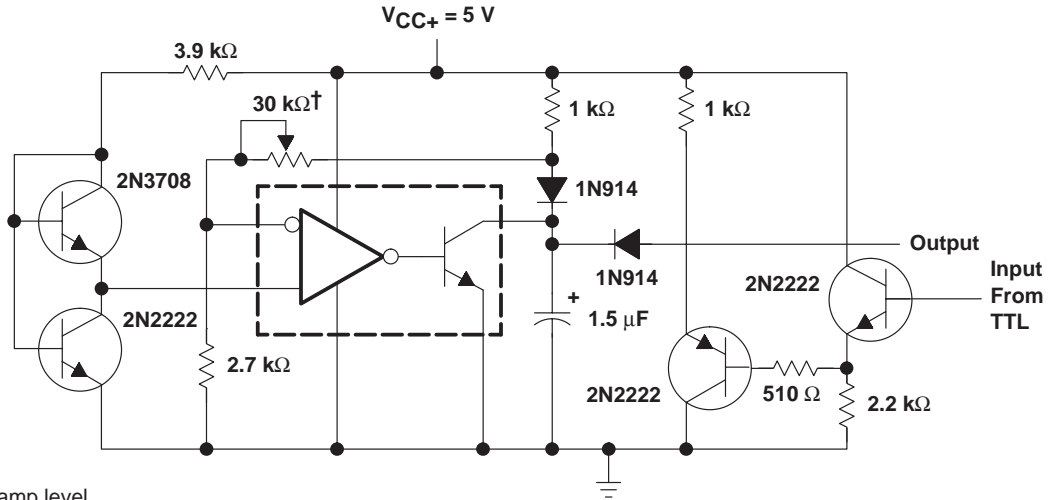


Figure 21. Zero-Crossing Detector Driving MOS Logic

APPLICATION INFORMATION



† Adjust to set clamp level

Figure 22. Precision Squarer

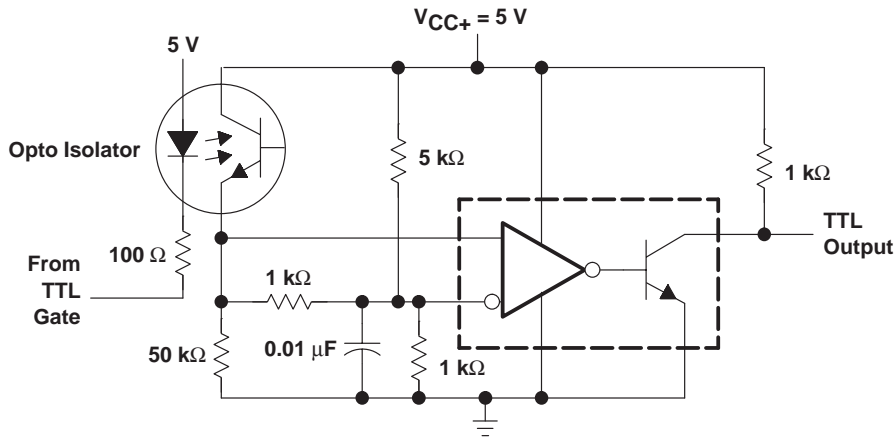


Figure 23. Digital Transmission Isolator

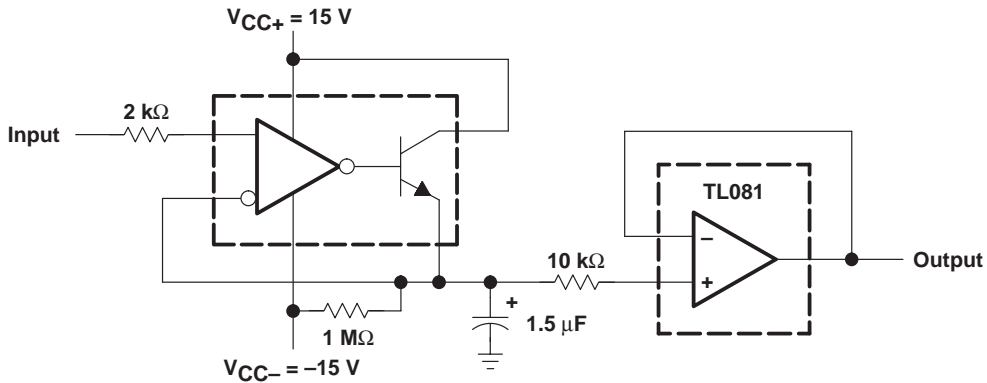


Figure 24. Positive-Peak Detector

APPLICATION INFORMATION

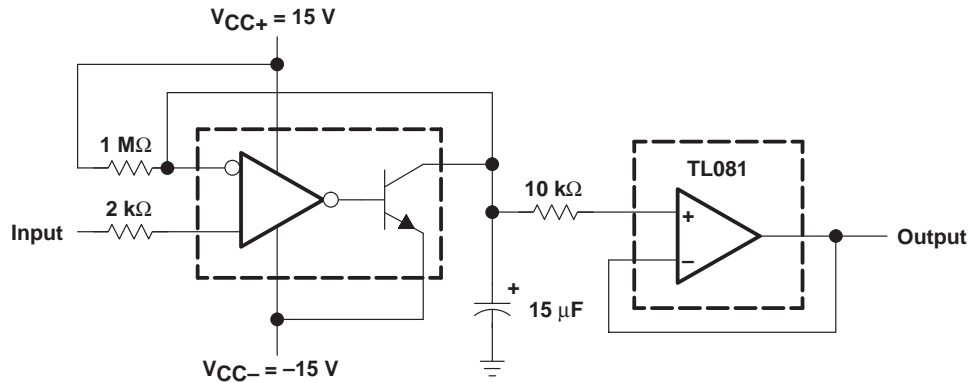
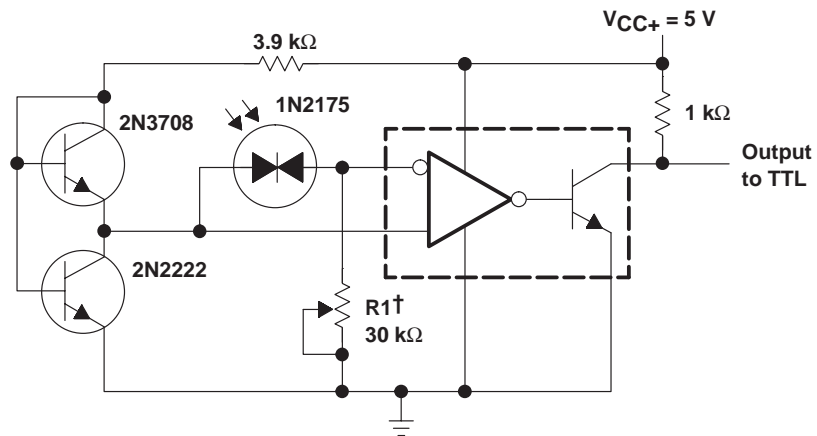
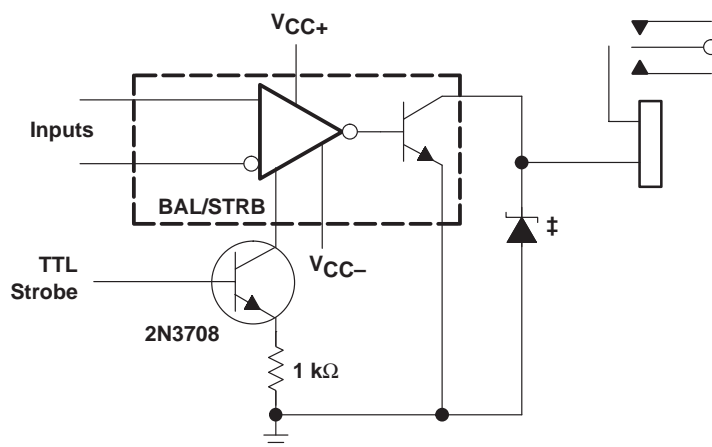


Figure 25. Negative-Peak Detector



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

Figure 26. Precision Photodiode Comparator



‡ Transient voltage and inductive kickback protection

Figure 27. Relay Driver With Strobe

LM111, LM211, LM311 DIFFERENTIAL COMPARATORS WITH STROBES

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APPLICATION INFORMATION

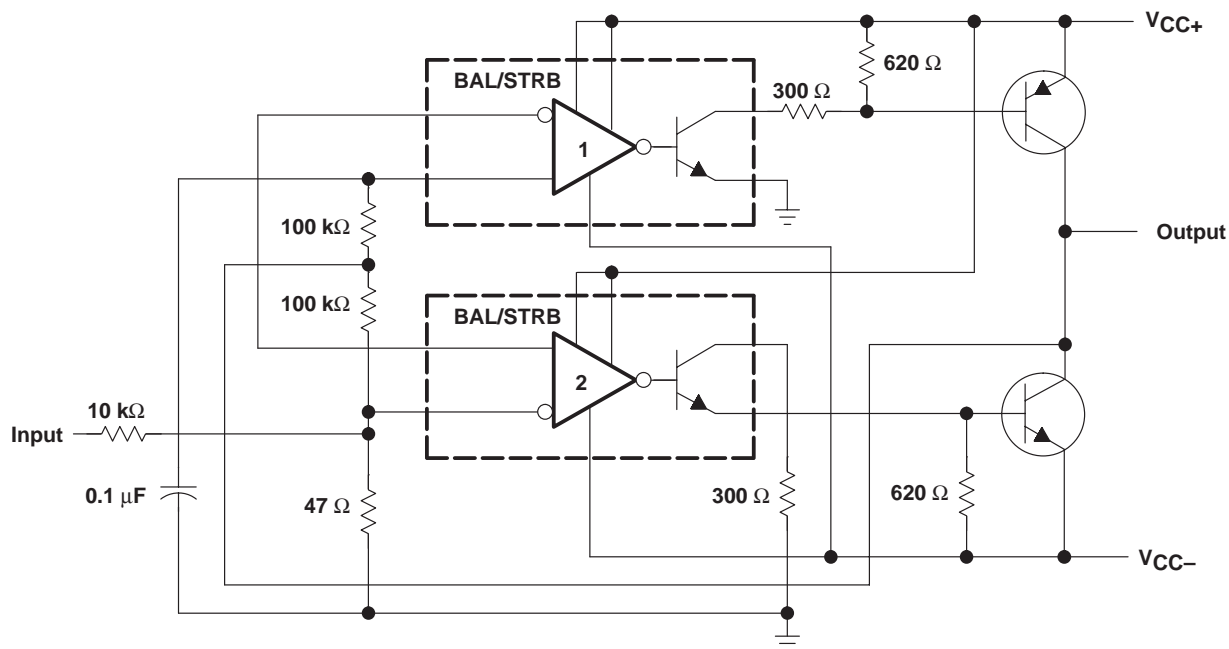


Figure 28. Switching Power Amplifier

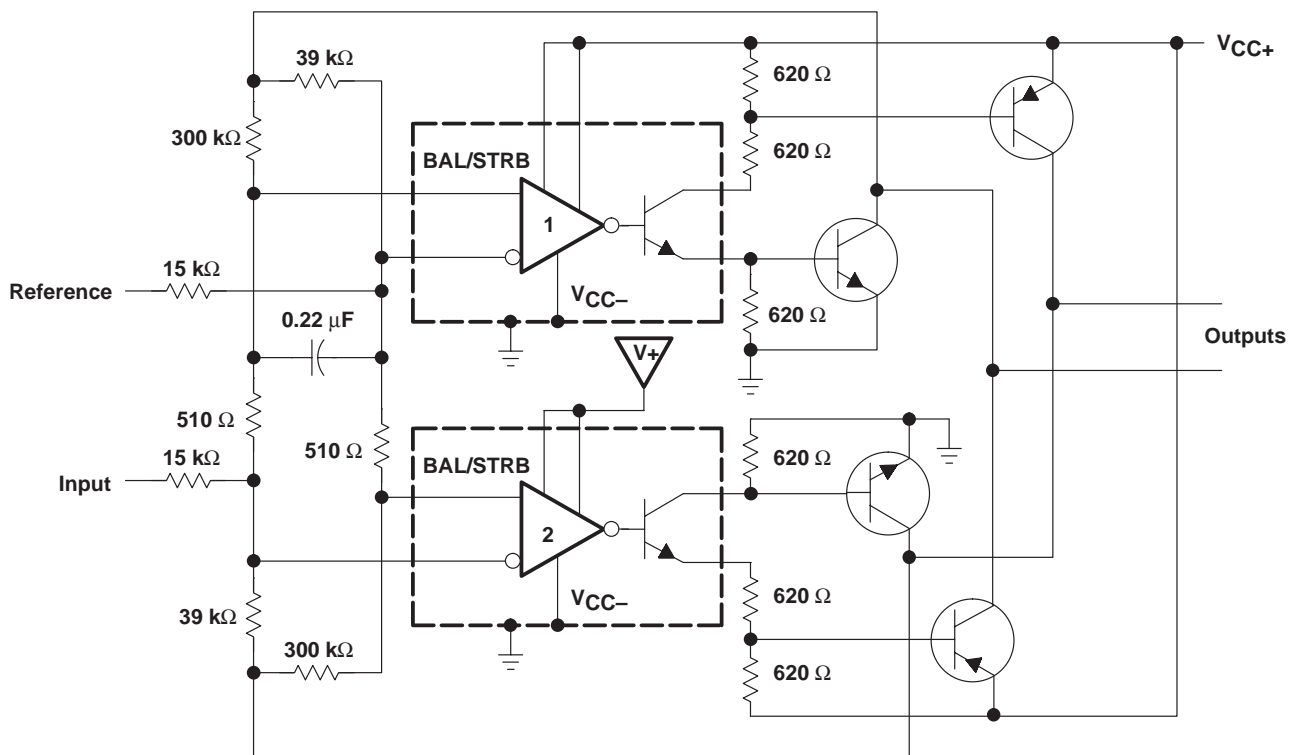


Figure 29. Switching Power Amplifiers

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|--|
| JM38510/10304BPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 SNPB | Level-NC-NC-NC |
| LM111FKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | Level-NC-NC-NC |
| LM111JG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 SNPB | Level-NC-NC-NC |
| LM111JGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 SNPB | Level-NC-NC-NC |
| LM211D | ACTIVE | SOIC | D | 8 | 75 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| LM211DR | ACTIVE | SOIC | D | 8 | 2500 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| LM211P | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | Level-NC-NC-NC |
| LM211PW | ACTIVE | TSSOP | PW | 8 | 150 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM211PWE4 | ACTIVE | TSSOP | PW | 8 | 150 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM211PWR | ACTIVE | TSSOP | PW | 8 | 2000 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM211PWRE4 | ACTIVE | TSSOP | PW | 8 | 2000 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM211QD | ACTIVE | SOIC | D | 8 | 75 | Pb-Free (RoHS) | CU NIPDAU | Level-2-250C-1 YEAR/ Level-1-235C-UNLIM |
| LM211QDR | ACTIVE | SOIC | D | 8 | 2500 | Pb-Free (RoHS) | CU NIPDAU | Level-2-250C-1 YEAR/ Level-1-235C-UNLIM |
| LM311D | ACTIVE | SOIC | D | 8 | 75 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| LM311DR | ACTIVE | SOIC | D | 8 | 2500 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| LM311P | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | Level-NC-NC-NC |
| LM311PSR | ACTIVE | SO | PS | 8 | 2000 | Pb-Free (RoHS) | CU NIPDAU | Level-2-260C-1 YEAR/ Level-1-235C-UNLIM |
| LM311PW | ACTIVE | TSSOP | PW | 8 | 150 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM311PWE4 | ACTIVE | TSSOP | PW | 8 | 150 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM311PWLE | OBSOLETE | TSSOP | PW | 8 | | TBD | Call TI | Call TI |
| LM311PWR | ACTIVE | TSSOP | PW | 8 | 2000 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM311PWRE4 | ACTIVE | TSSOP | PW | 8 | 2000 | Pb-Free (RoHS) | CU NIPDAU | Level-1-250C-UNLIM |
| LM311Y | OBSOLETE | XCEPT | Y | 0 | | TBD | Call TI | Call TI |

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check

<http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

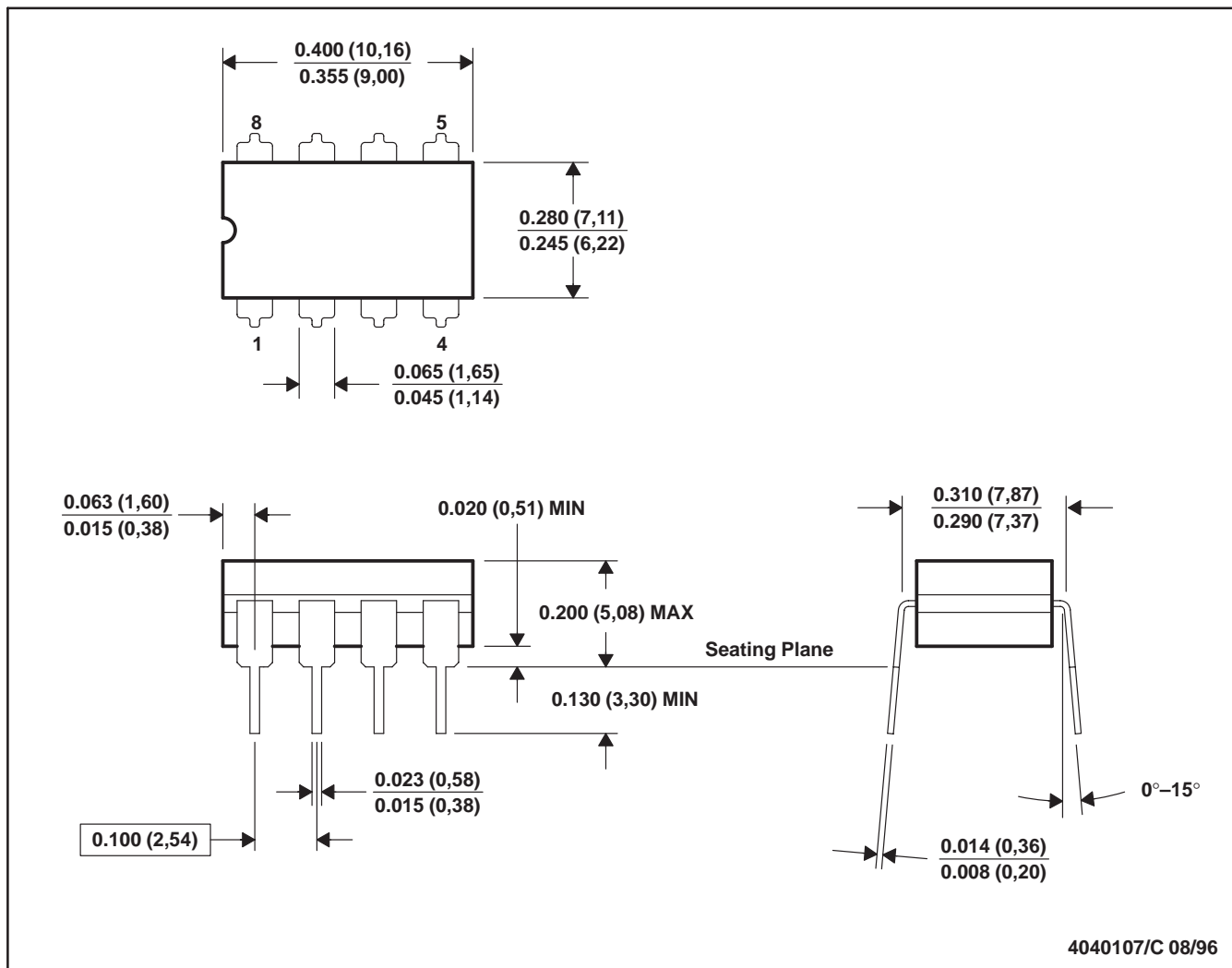
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE

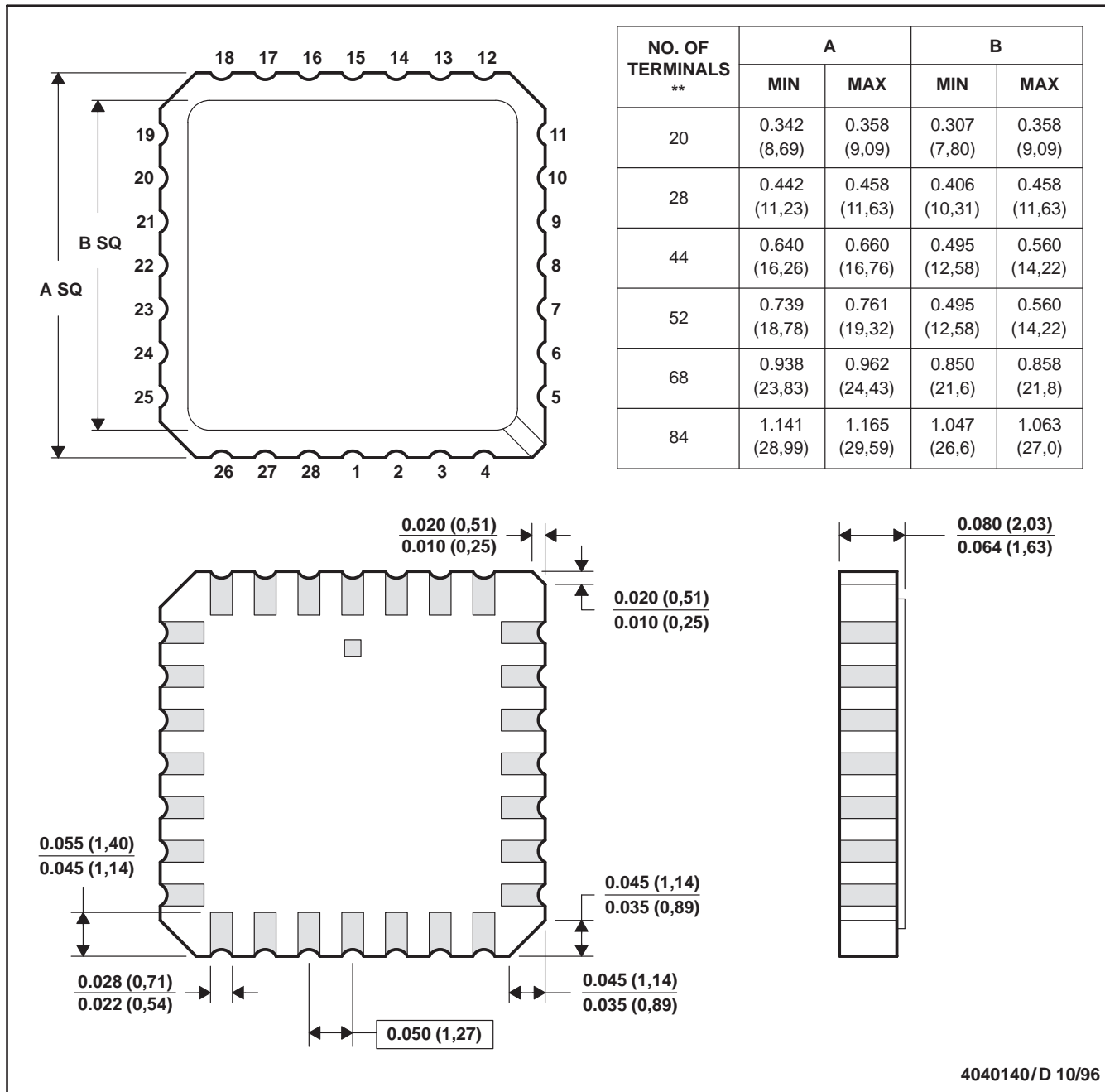


- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a ceramic lid using glass frit.
 D. Index point is provided on cap for terminal identification.
 E. Falls within MIL STD 1835 GDIP1-T8

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN

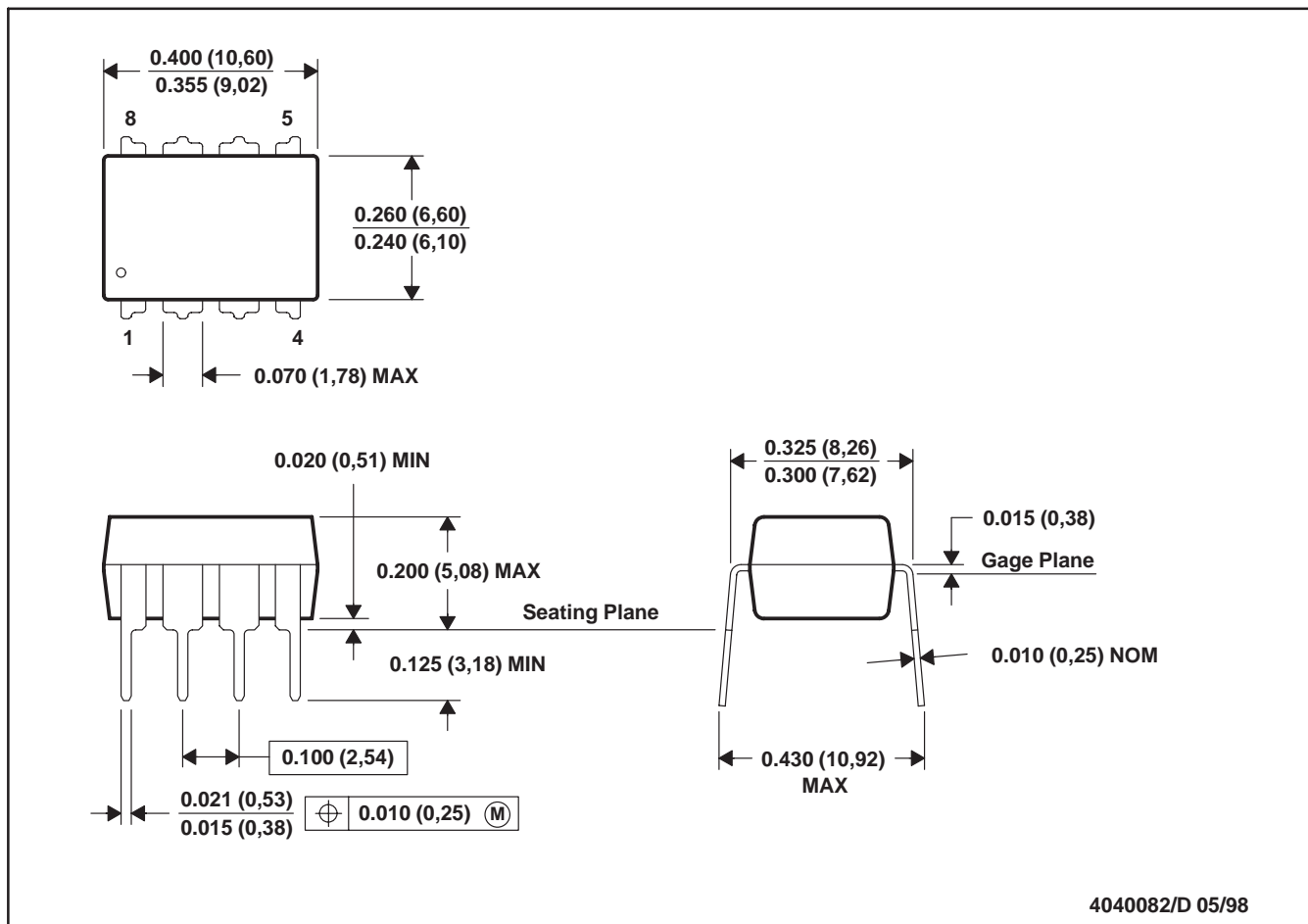


4040140/D 10/96

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a metal lid.
 - D. The terminals are gold plated.
 - E. Falls within JEDEC MS-004

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE

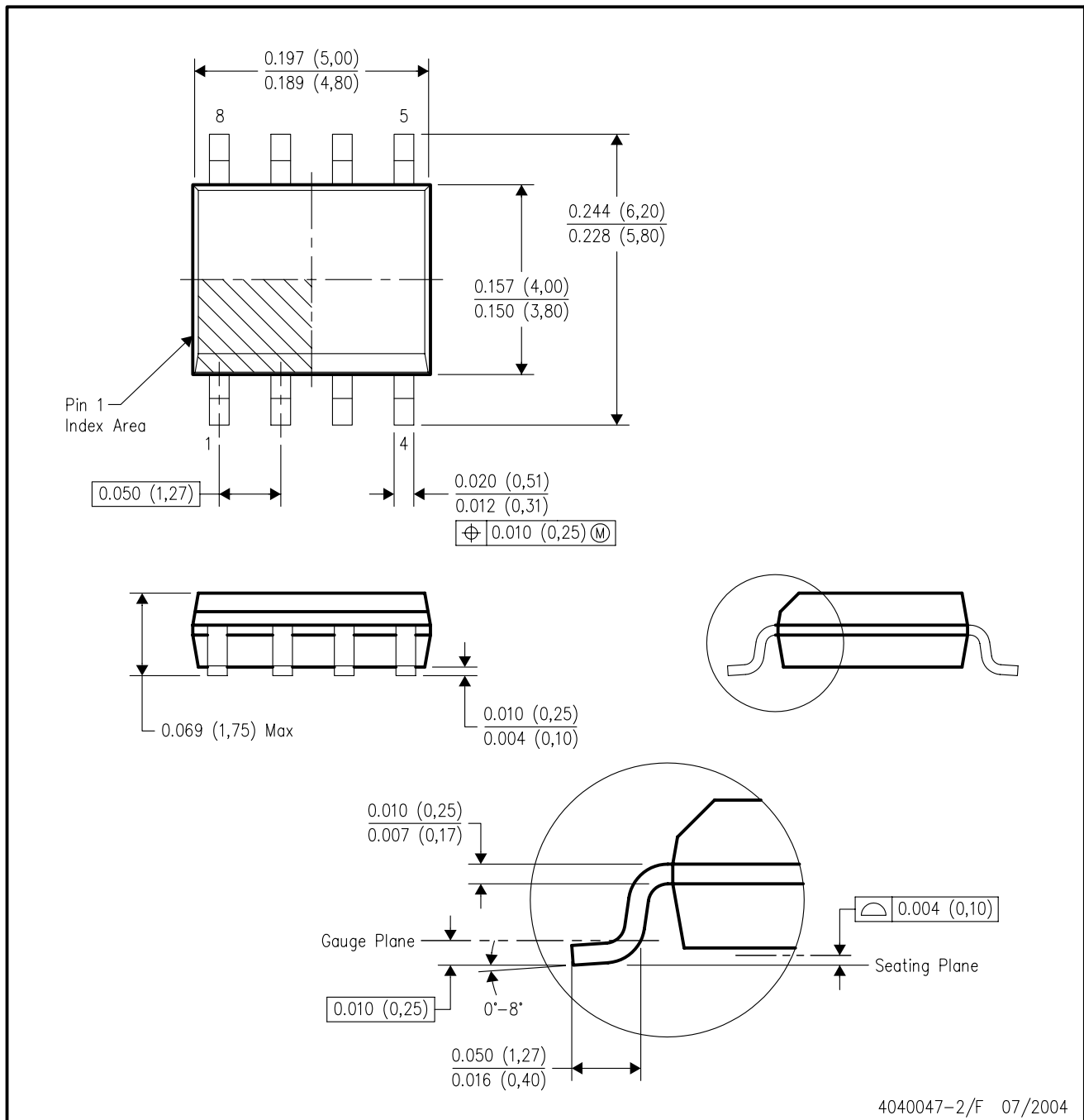


- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

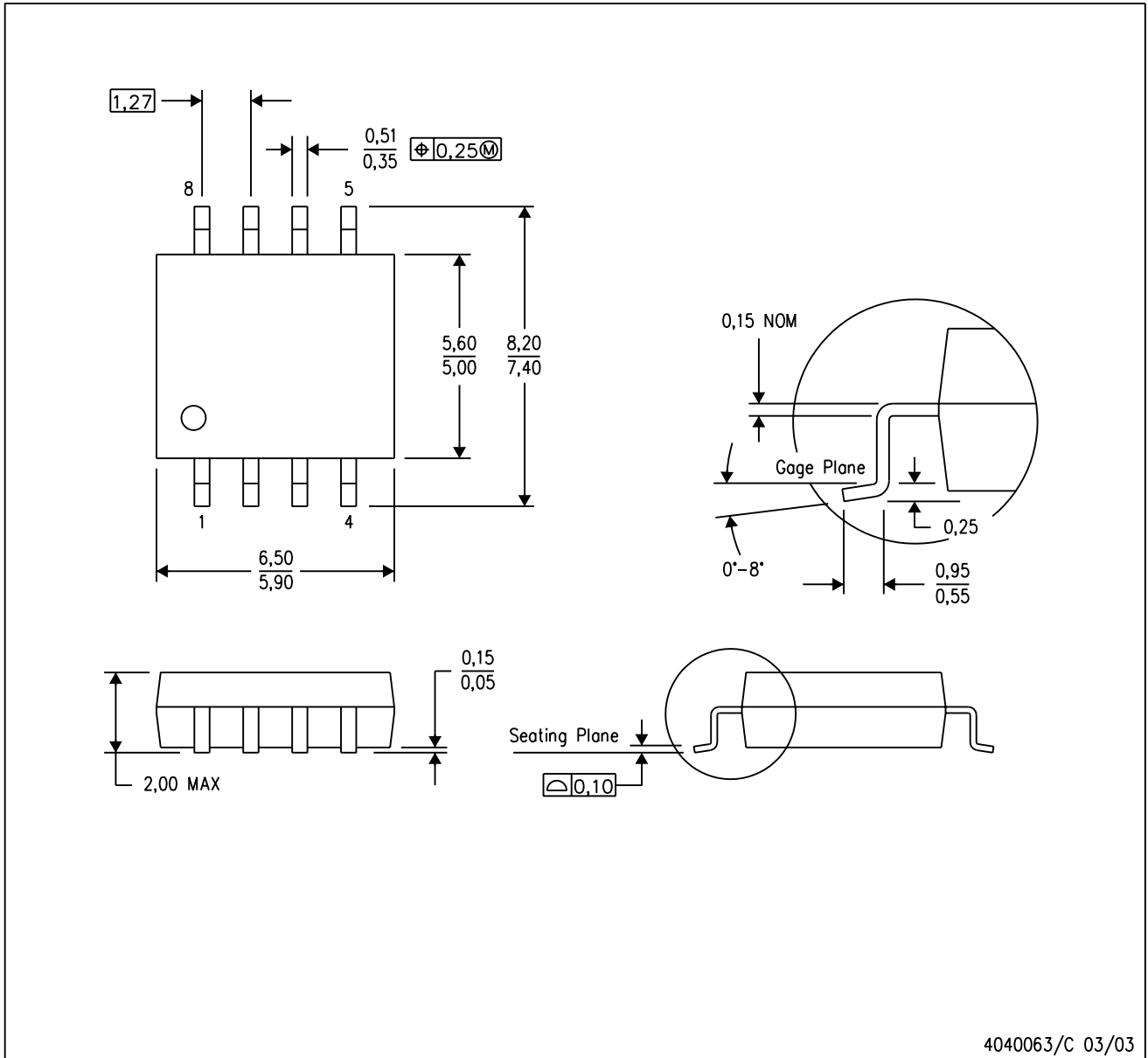


- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - D. Falls within JEDEC MS-012 variation AA.

MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- 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.

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- 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.
 D. Falls within JEDEC MO-153

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