

# LM111, LM211, LM311, LM311Y DIFFERENTIAL COMPARATORS WITH STROBES

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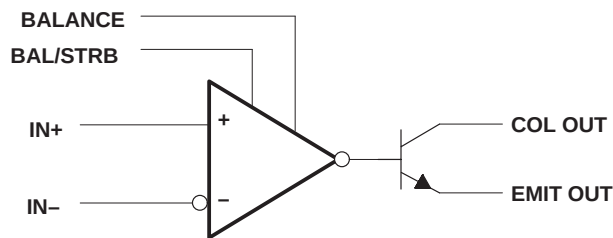
- **Fast Response Times**
- **Strobe Capability**
- **Maximum Input Bias Current . . . 300 nA**
- **Maximum Input Offset Current . . . 70 nA**
- **Can Operate From Single 5-V Supply**
- **Designed to Be Interchangeable With National Semiconductor LM111, LM211, and LM311**

## description

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  $\pm 15$ -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 will be in the off state regardless of the differential input.

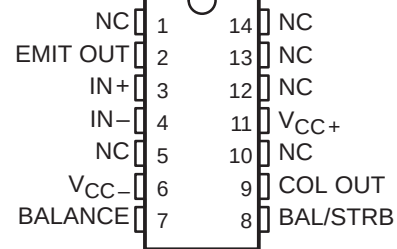
The LM111 is characterized for operation over the full military range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The LM211 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ , and the LM311 is characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ .

## functional block diagram



LM111 . . . J PACKAGE

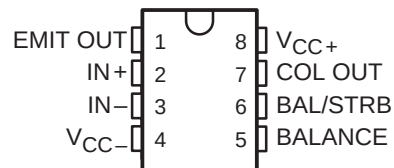
(TOP VIEW)



LM111 . . . JG PACKAGE

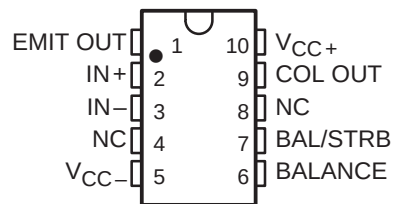
LM211, LM311 . . . D, DB, P, OR PW PACKAGE

(TOP VIEW)



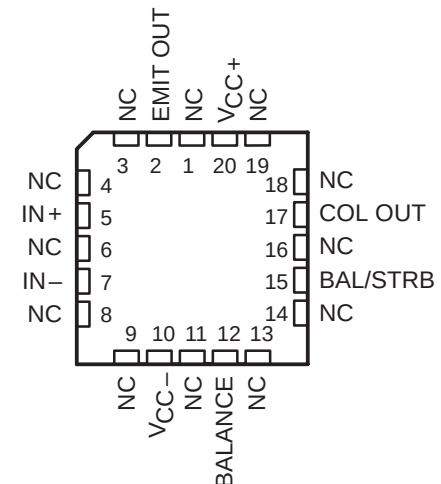
LM111 . . . U PACKAGE

(TOP VIEW)



LM111 . . . FK PACKAGE

(TOP VIEW)



# LM111, LM211, LM311, LM311Y

## DIFFERENTIAL COMPARATORS WITH STROBES

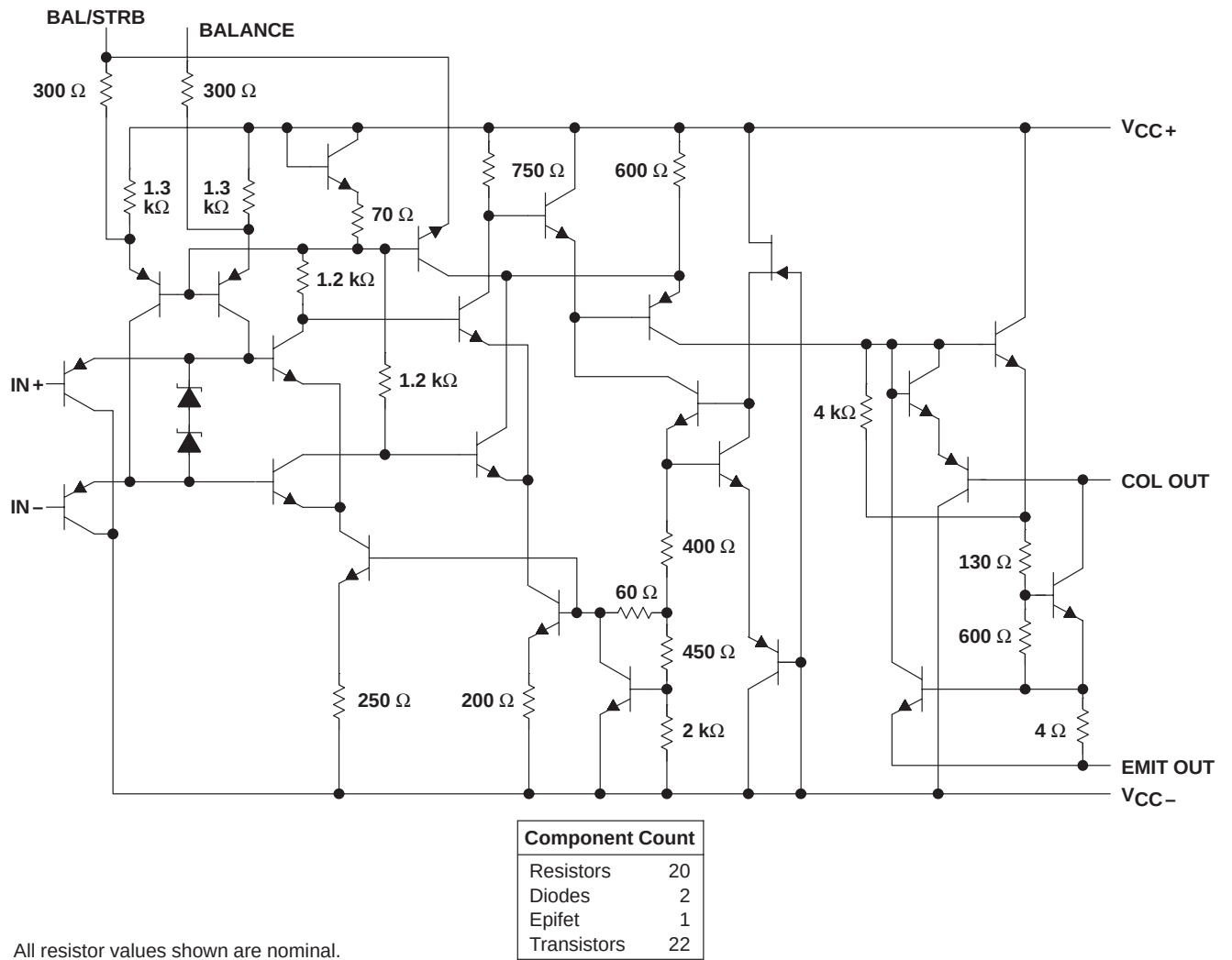
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AVAILABLE OPTIONS

| T <sub>A</sub>       | V <sub>IO</sub> max<br>at 25°C | PACKAGED DEVICES                     |              |                         |                       |                        |                       |               |                 | CHIP<br>FORM<br>(Y) |
|----------------------|--------------------------------|--------------------------------------|--------------|-------------------------|-----------------------|------------------------|-----------------------|---------------|-----------------|---------------------|
|                      |                                | SMALL<br>OUTLINE<br>(D) <sup>†</sup> | SSOP<br>(DB) | CHIP<br>CARRIER<br>(FK) | CERAMIC<br>DIP<br>(J) | CERAMIC<br>DIP<br>(JG) | PLASTIC<br>DIP<br>(P) | TSSOP<br>(PW) | FLATPACK<br>(U) |                     |
| 0°C<br>to<br>70°C    | 7.5 mV                         | LM311D                               | LM311DBLE    |                         |                       |                        | LM311P                | LM311PWLE     |                 | LM311Y              |
| –40°C<br>to<br>85°C  | 3 mV                           | LM211D                               |              |                         |                       |                        | LM211P                |               |                 |                     |
| –55°C<br>to<br>125°C | 3 mV                           |                                      |              | LM111FK                 | LM111J                | LM111JG                |                       |               | LM111U          |                     |

<sup>†</sup> The D package is available taped and reeled. Add the suffix R (e.g., LM311DR). The DB and PW packages are only available left-end taped and reeled.

### schematic

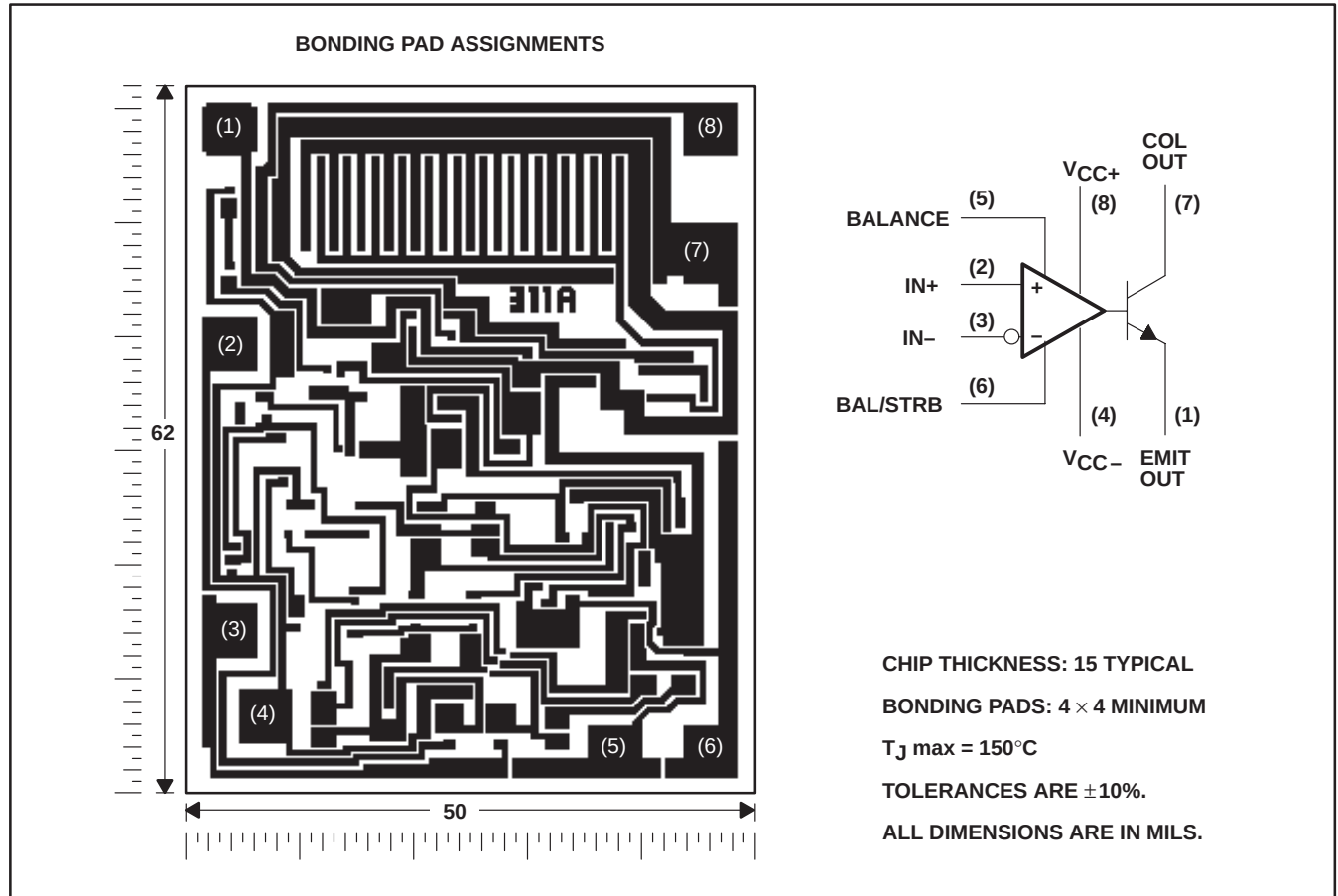


# LM111, LM211, LM311, LM311Y DIFFERENTIAL COMPARATORS WITH STROBES

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## LM311Y chip information

This chip, when properly assembled, displays characteristics similar to the LM311. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.



# LM111, LM211, LM311, LM311Y

## DIFFERENTIAL COMPARATORS WITH STROBES

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### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

|                                                                                       |                              |
|---------------------------------------------------------------------------------------|------------------------------|
| Supply voltage, $V_{CC+}$ (see Note 1)                                                | 18 V                         |
| Supply voltage, $V_{CC-}$ (see Note 1)                                                | –18 V                        |
| Supply voltage, $V_{CC+} - V_{CC-}$                                                   | 36 V                         |
| Differential input voltage, $V_{ID}$ (see Note 2)                                     | $\pm 30$ V                   |
| Input voltage, $V_I$ (either input, see Notes 1 and 3)                                | $\pm 15$ V                   |
| Voltage from emitter output to $V_{CC-}$                                              | 30 V                         |
| Voltage from collector output to $V_{CC-}$ : LM111                                    | 50 V                         |
| LM211                                                                                 | 50 V                         |
| LM311                                                                                 | 40 V                         |
| Duration of output short circuit (see Note 4)                                         | 10 s                         |
| Continuous total dissipation                                                          | See Dissipation Rating Table |
| Operating free-air temperature range, $T_A$ : LM111                                   | –55°C to 125°C               |
| LM211                                                                                 | –40°C to 85°C                |
| LM311                                                                                 | 0°C to 70°C                  |
| Storage temperature range                                                             | –65°C to 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, JG, or U package     | 300°C                        |
| Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: D, DB, P, or PW package | 260°C                        |

<sup>†</sup> 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: 1. All voltage values, unless otherwise noted, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .  
2. Differential voltages are at  $IN+$  with respect to  $IN-$ .  
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or  $\pm 15$  V, whichever is less.  
4. The output may be shorted to ground or either power supply.

DISSIPATION RATING TABLE

| PACKAGE  | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING<br>FACTOR | DERATE<br>ABOVE $T_A$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>POWER RATING |
|----------|---------------------------------------------|--------------------|-----------------------|------------------------------------------|------------------------------------------|-------------------------------------------|
| D        | 500 mW                                      | 5.8 mW/°C          | 64°C                  | 464 mW                                   | 377 mW                                   | –                                         |
| DB or PW | 500 mW                                      | 4.2 mW/°C          | 31°C                  | 336 mW                                   | –                                        | –                                         |
| FK       | 500 mW                                      | 11.0 mW/°C         | 105°C                 | 500 mW                                   | 500 mW                                   | 275 mW                                    |
| J        | 500 mW                                      | 11.0 mW/°C         | 105°C                 | 500 mW                                   | 500 mW                                   | 275 mW                                    |
| JG       | 500 mW                                      | 8.4 mW/°C          | 90°C                  | 500 mW                                   | 500 mW                                   | 210 mW                                    |
| P        | 500 mW                                      | 8.0 mW/°C          | 88°C                  | 500 mW                                   | 500 mW                                   | –                                         |
| U        | 500 mW                                      | 5.4 mW/°C          | 57°C                  | 432 mW                                   | 351 mW                                   | 135 mW                                    |

### recommended operating conditions

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



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

| PARAMETER                                                | TEST CONDITIONS                                          | $T_A^\dagger$     | LM111, LM211 |                  |     | LM311       |                  |     | UNIT    |
|----------------------------------------------------------|----------------------------------------------------------|-------------------|--------------|------------------|-----|-------------|------------------|-----|---------|
|                                                          |                                                          |                   | MIN          | TYP <sup>‡</sup> | MAX | MIN         | TYP <sup>‡</sup> | MAX |         |
| $V_{IO}$ Input offset voltage                            | See Note 5                                               | 25°C              |              | 0.7              | 3   |             | 2                | 7.5 | mV      |
|                                                          |                                                          | Full range        |              |                  | 4   |             |                  | 10  |         |
| $I_{IO}$ Input offset current                            | See Note 5                                               | 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 6)        | $V_{(strobe)} = 0.3$ 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 $\Omega$                | 25°C              | 40           | 200              |     | 40          | 200              |     | V/mV    |
| $I_{OH}$ High-level (collector) output current           | $I_{(strobe)} = -3$ mA, $V_{ID} = 5$ mV, $V_{OH} = 35$ V | 25°C              |              | 0.2              | 10  |             |                  |     | nA      |
|                                                          | $V_{ID} = 5$ mV, $V_{OH} = 35$ V                         | Full range        |              |                  | 0.5 |             |                  |     | $\mu$ A |
|                                                          | $V_{ID} = 5$ mV, $V_{OH} = 35$ V                         | 25°C              |              |                  |     | 0.2         |                  | 50  | nA      |
| $V_{OL}$ 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      |

<sup>†</sup> Unless otherwise noted, all characteristics are measured with BALANCE and BAL/STRB open and the emitter output grounded.

Full range for LM111 is -55°C to 125°C, for LM211 is -40°C to 85°C, and for LM311 is 0°C to 70°C.

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

NOTES: 5. 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 $\Omega$  to  $V_{CC+}$ . These parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.

6. 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, LM311 |     |     | UNIT |
|-----------------------------------------|-------------------------------------------------------|---------------------|-----|-----|------|
|                                         |                                                       | MIN                 | TYP | MAX |      |
| Response time, low-to-high-level output | $R_C = 500$ $\Omega$ to 5 V, $C_L = 5$ pF, See Note 7 |                     | 115 |     | ns   |
| Response time, high-to-low-level output |                                                       |                     | 165 |     | ns   |

NOTE 7: 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, LM311Y

## DIFFERENTIAL COMPARATORS WITH STROBES

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### electrical characteristics at $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

| PARAMETER                                                | TEST CONDITIONS†                                       | LM311Y      |               |     | UNIT |
|----------------------------------------------------------|--------------------------------------------------------|-------------|---------------|-----|------|
|                                                          |                                                        | MIN         | TYP           | MAX |      |
| $V_{IO}$ Input offset voltage                            | See Note 5                                             |             | 2             | 7.5 | mV   |
| $I_{IO}$ Input offset current                            | See Note 5                                             |             | 6             | 50  | nA   |
| $I_{IB}$ Input bias current                              | $V_O = 1$ V to 14 V                                    |             | 100           | 250 | nA   |
| $I_{IL(S)}$ Low-level strobe current (see Note 6)        | $V_{(strobe)} = 0.3$ V, $V_{ID} \leq -10$ mV           |             | –3            |     | mA   |
| $V_{ICR}$ Common-mode input voltage range                |                                                        | 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 $\Omega$              | 40          | 200           |     | V/mV |
| $I_{OH}$ High-level (collector) output current           | $I_{strobe} = -3$ mA, $V_{ID} = 5$ mV, $V_{OH} = 35$ V |             | 0.2           | 50  | nA   |
| $V_{OL}$ Low-level (collector-to-emitter) output voltage | $I_{OL} = 50$ mA, $V_{ID} = -10$ mV                    |             | 0.75          | 1.5 | V    |
| $I_{CC+}$ Supply current from $V_{CC+}$ , output low     | $V_{ID} = -10$ mV, No load                             |             | 5.1           | 7.5 | mA   |
| $I_{CC-}$ Supply current from $V_{CC-}$ , output low     | $V_{ID} = 10$ mV, No load                              |             | –4.1          | –5  | mA   |

† Unless otherwise noted, all characteristics are measured with BALANCE and BAL/STRB open and the emitter output grounded.

NOTES: 5. 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 $\Omega$  to  $V_{CC+}$ . These parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.

6. 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                                       | LM311Y |     |     | UNIT |
|-----------------------------------------|-------------------------------------------------------|--------|-----|-----|------|
|                                         |                                                       | MIN    | TYP | MAX |      |
| Response time, low-to-high-level output | $R_C = 500$ $\Omega$ to 5 V, $C_L = 5$ pF, See Note 7 |        | 115 |     | ns   |
| Response time, high-to-low-level output |                                                       |        | 165 |     | ns   |

NOTE 7: 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.

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## TYPICAL CHARACTERISTICS†

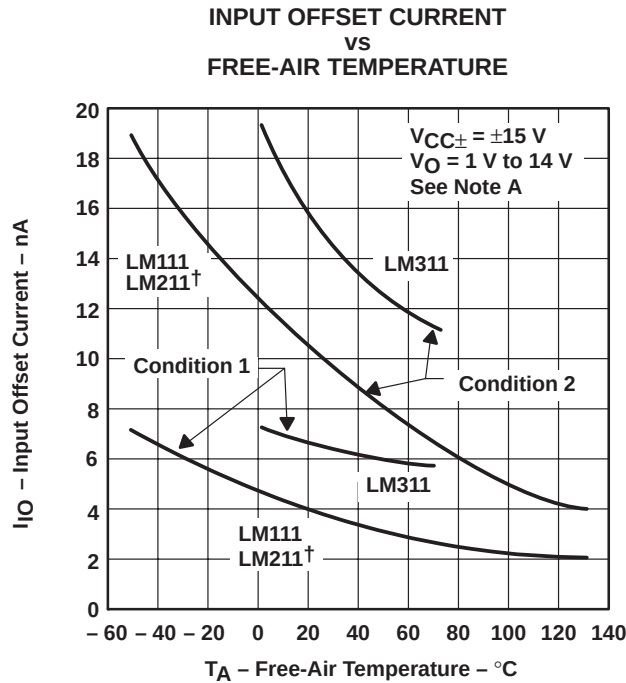


Figure 1

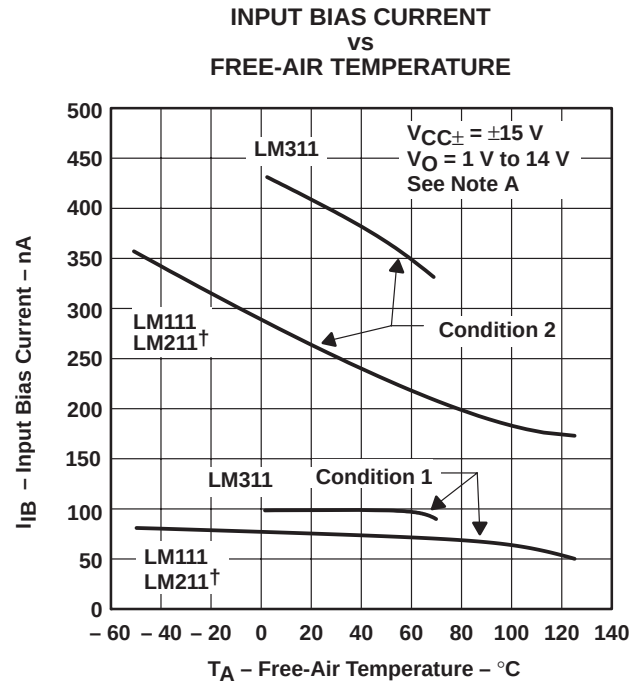


Figure 2

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

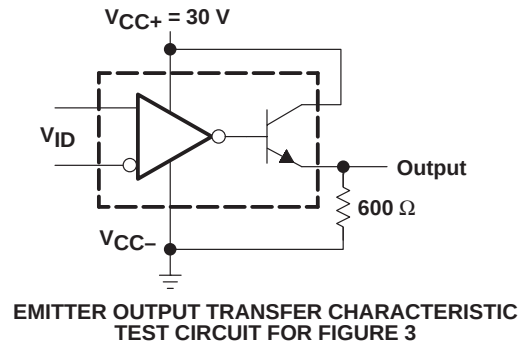
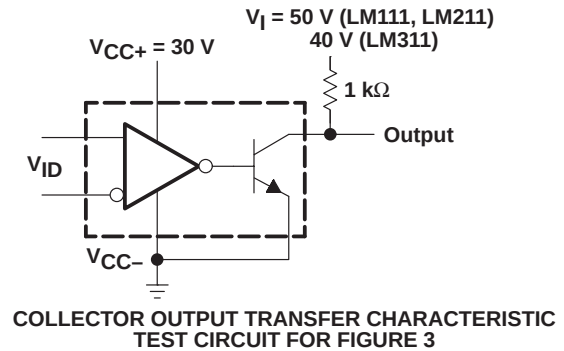
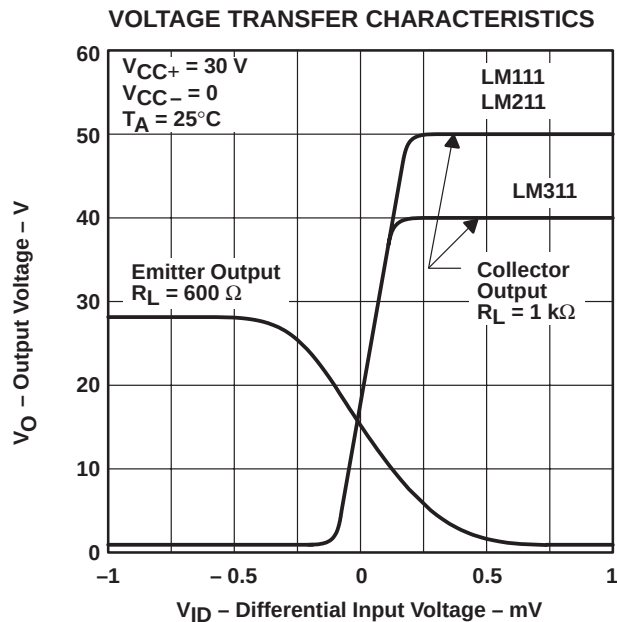


Figure 3

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

LM111, LM211, LM311, LM311Y  
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TYPICAL CHARACTERISTICS

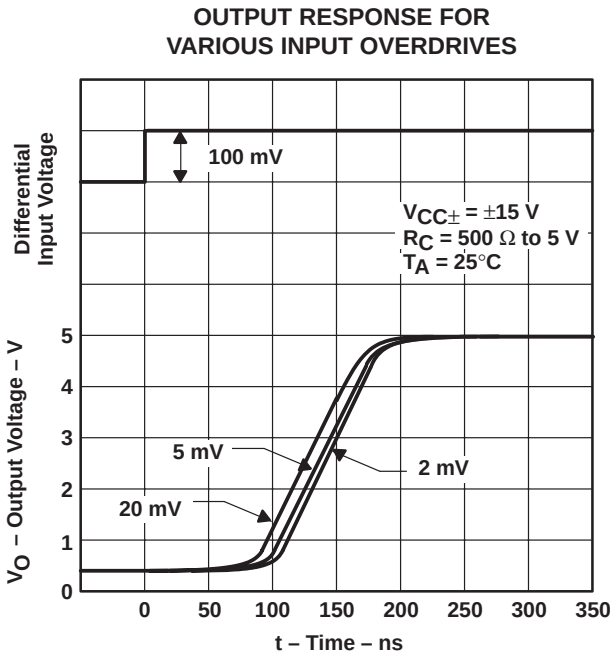


Figure 4

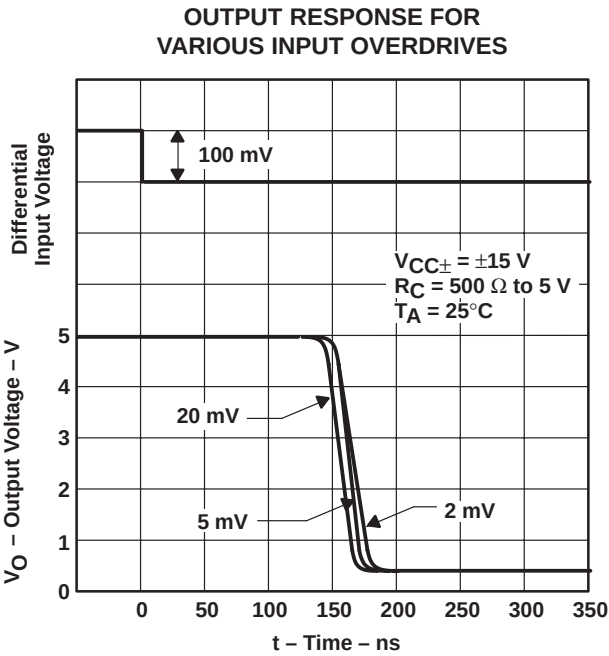
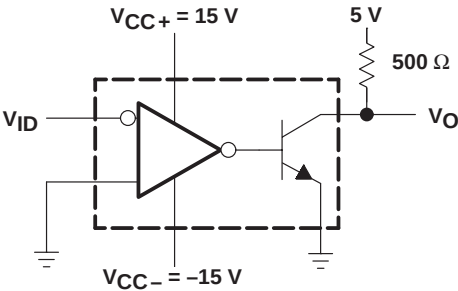


Figure 5



TEST CIRCUIT FOR FIGURES 4 AND 5



TYPICAL CHARACTERISTICS

OUTPUT RESPONSE FOR  
VARIOUS INPUT OVERDRIVES

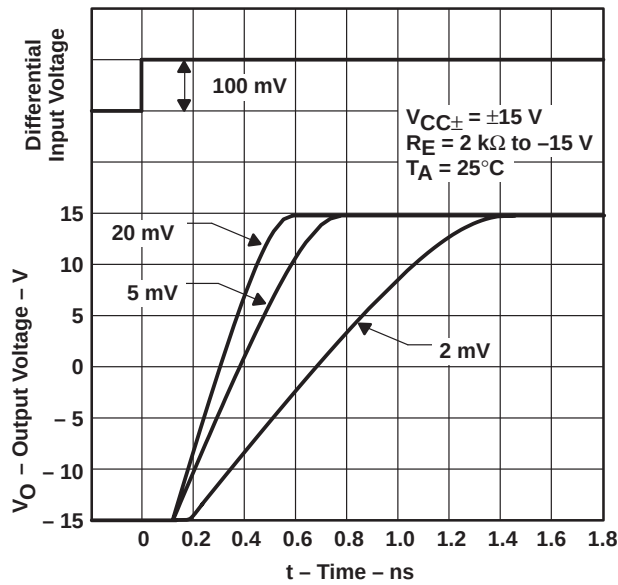


Figure 6

OUTPUT RESPONSE FOR  
VARIOUS INPUT OVERDRIVES

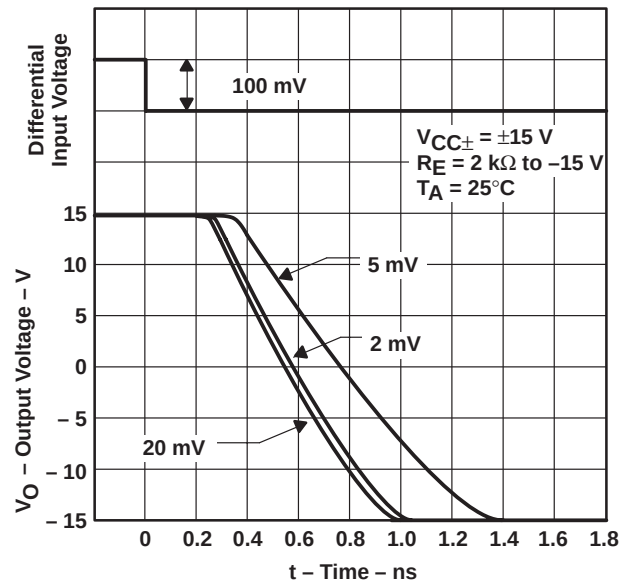
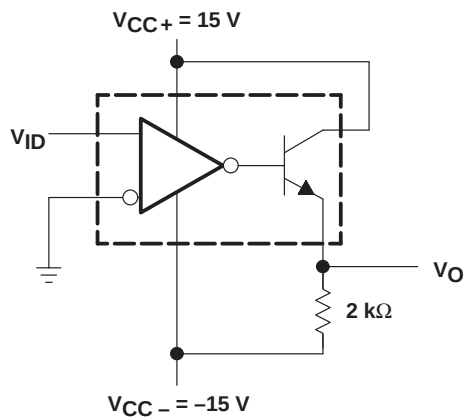


Figure 7



TEST CIRCUIT FOR FIGURES 6 AND 7

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TYPICAL CHARACTERISTICS

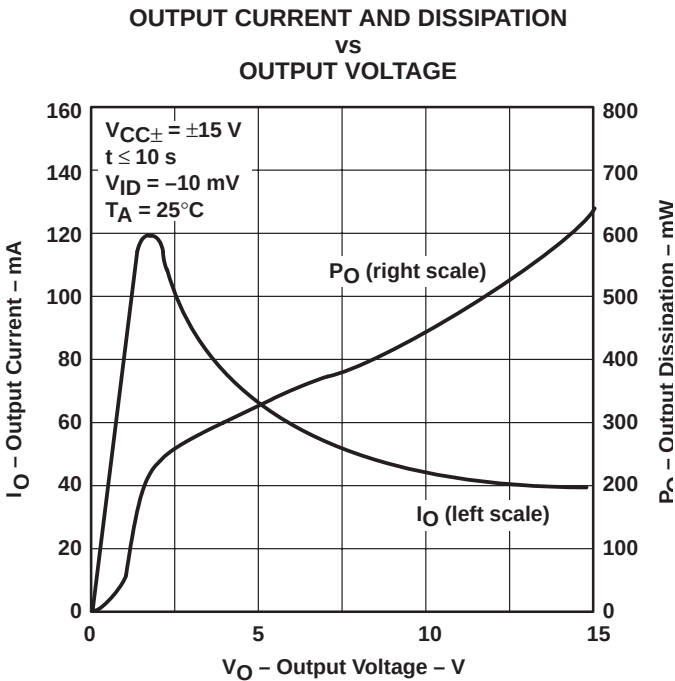


Figure 8

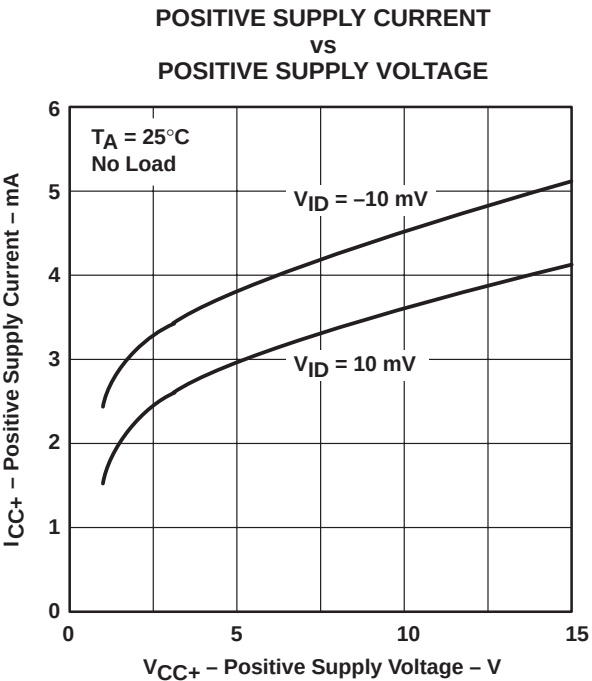


Figure 9

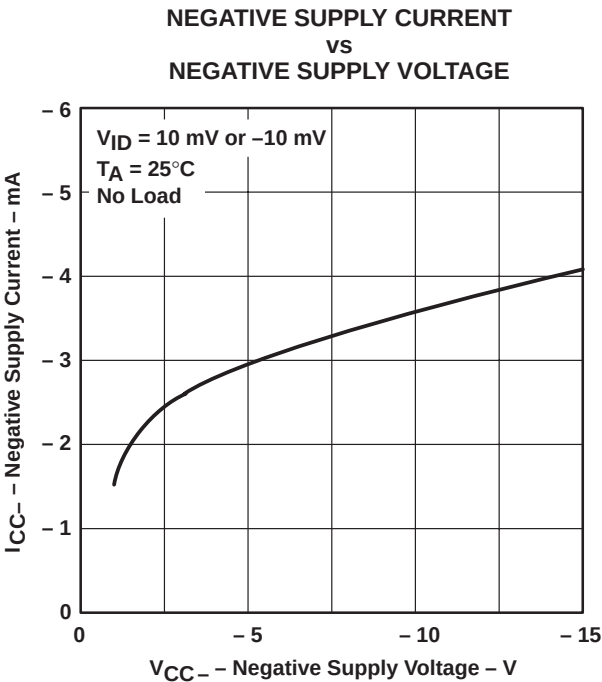


Figure 10



## APPLICATION INFORMATION

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

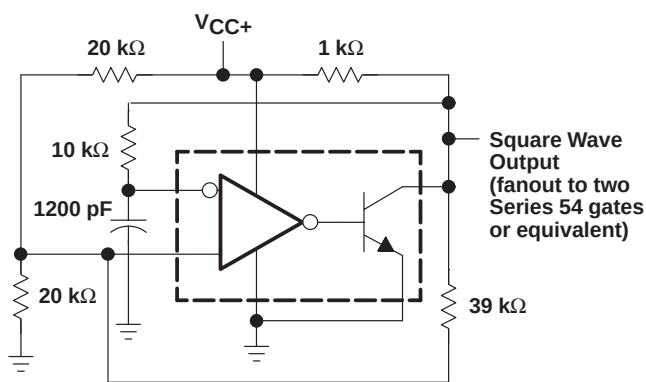


Figure 11. 100-kHz Free-Running Multivibrator

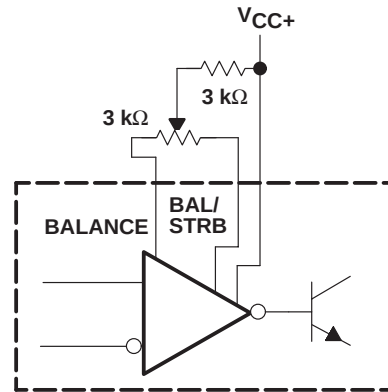


Figure 12. Offset Balancing

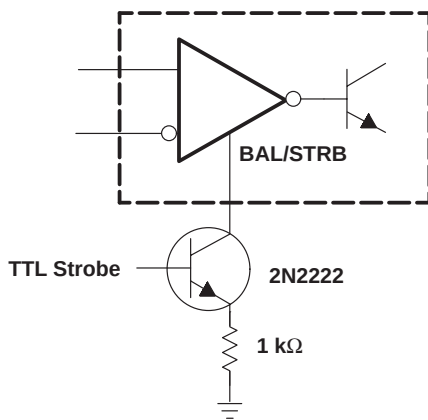


Figure 13. Strobing

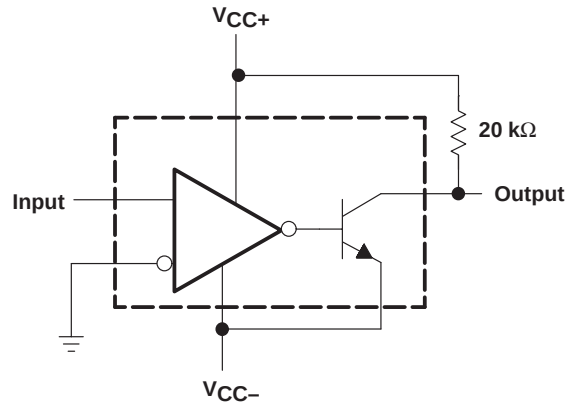
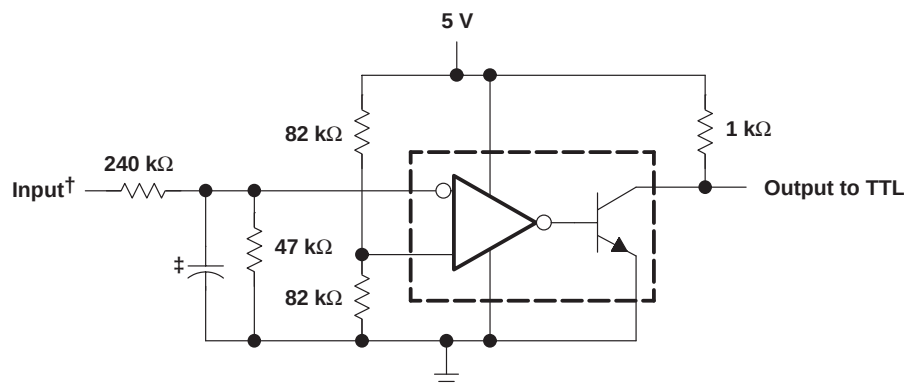


Figure 14. Zero-Crossing Detector



† 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

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## DIFFERENTIAL COMPARATORS WITH STROBES

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### APPLICATION INFORMATION

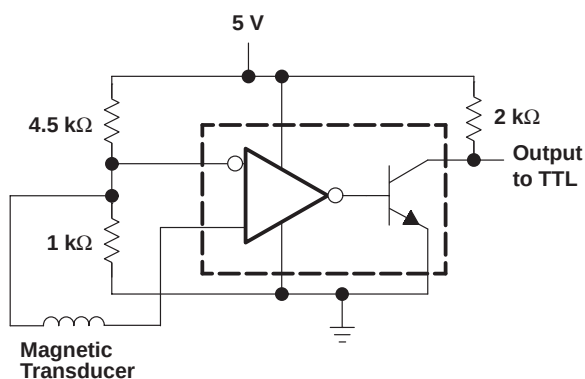


Figure 16. Detector for Magnetic Transducer

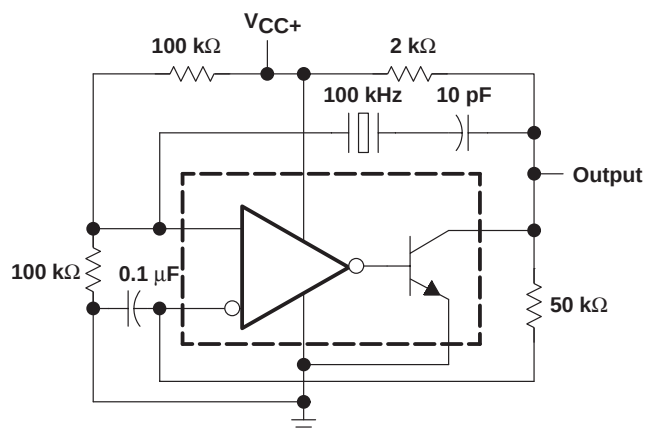


Figure 17. 100-kHz Crystal Oscillator

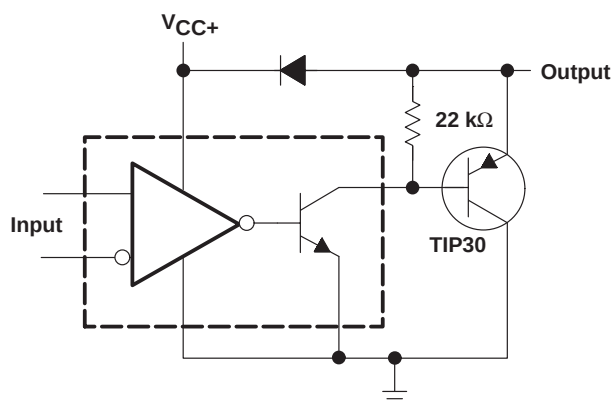
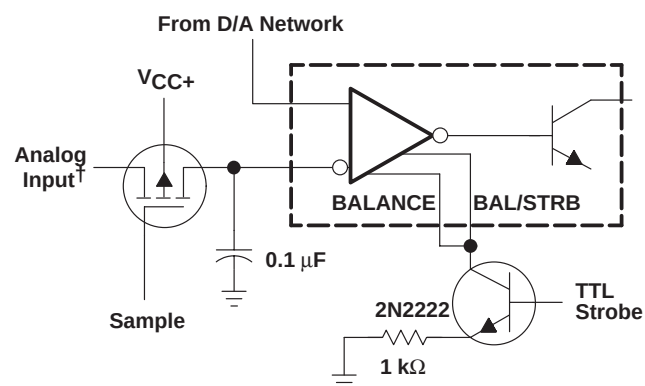


Figure 18. Comparator and Solenoid Driver



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

Figure 19. Strobing Both Input and Output Stages Simultaneously

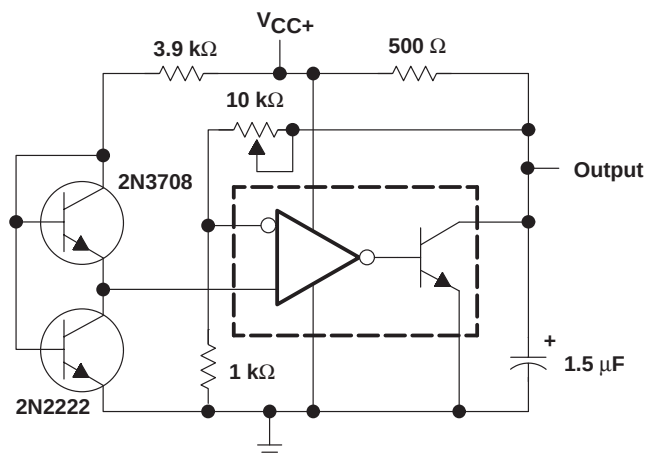


Figure 20. Low-Voltage Adjustable Reference Supply

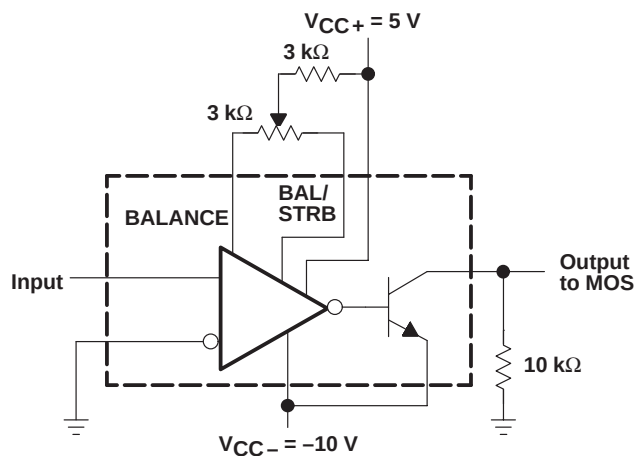


Figure 21. Zero-Crossing Detector Driving MOS Logic

## APPLICATION INFORMATION

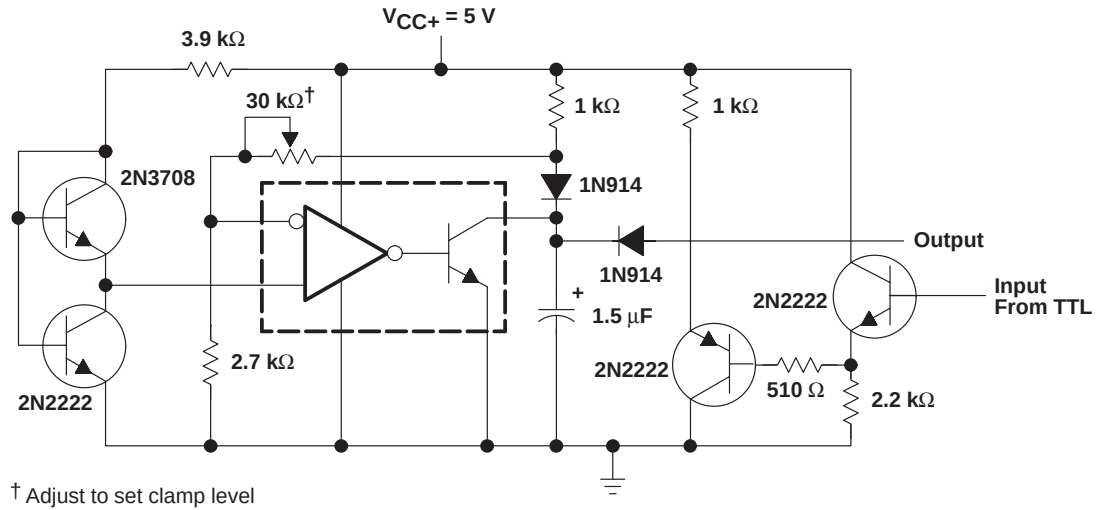


Figure 22. Precision Squarer

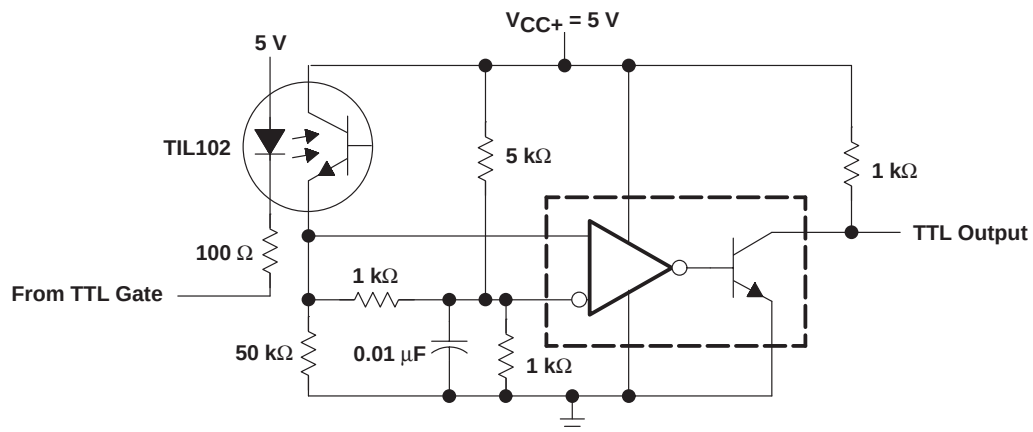


Figure 23. Digital Transmission Isolator

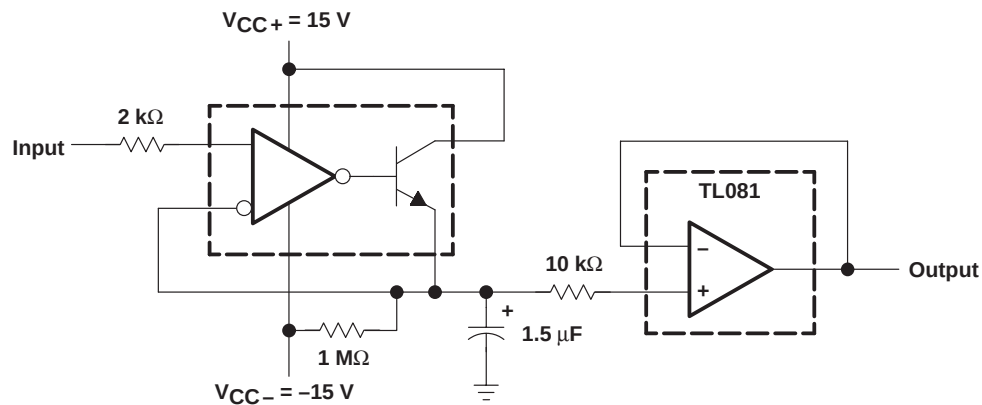


Figure 24. Positive-Peak Detector

# LM111, LM211, LM311, LM311Y DIFFERENTIAL COMPARATORS WITH STROBES

SLCS007A – SEPTEMBER 1973 – REVISED FEBRUARY 1992

## APPLICATION INFORMATION

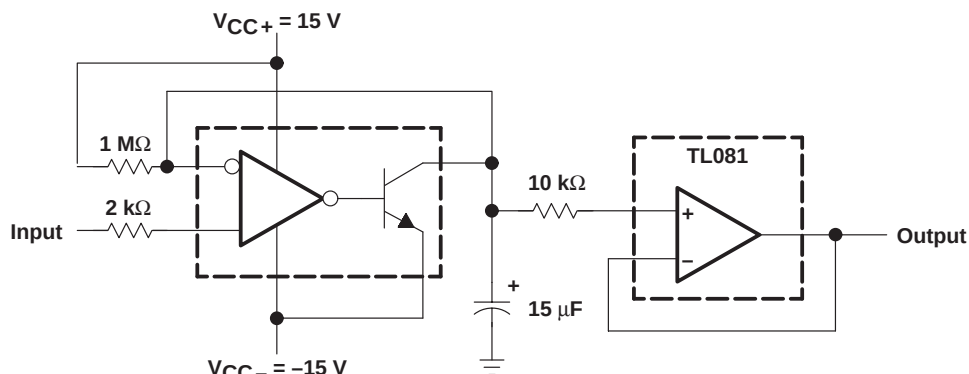
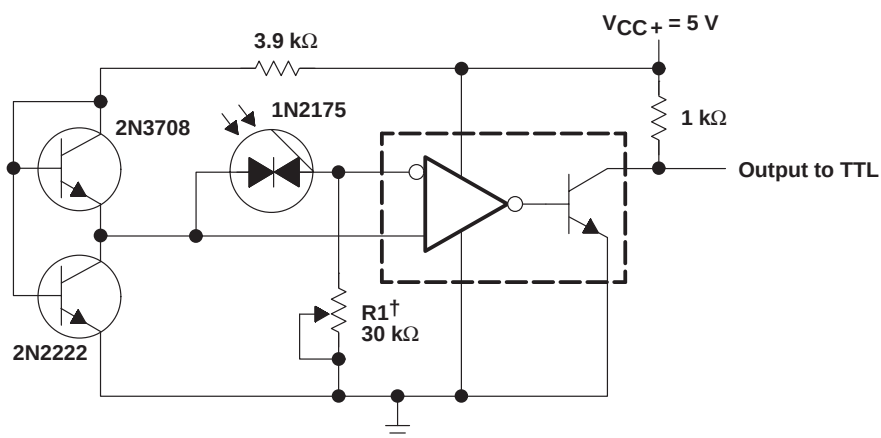
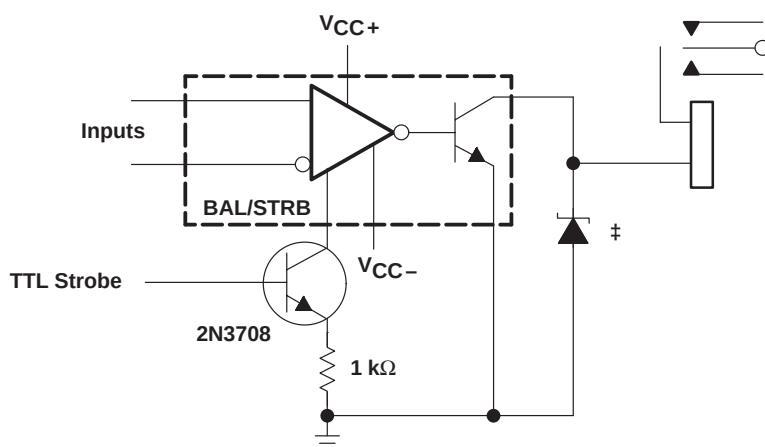


Figure 25. Negative-Peak Detector



† 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

# APPLICATION INFORMATION

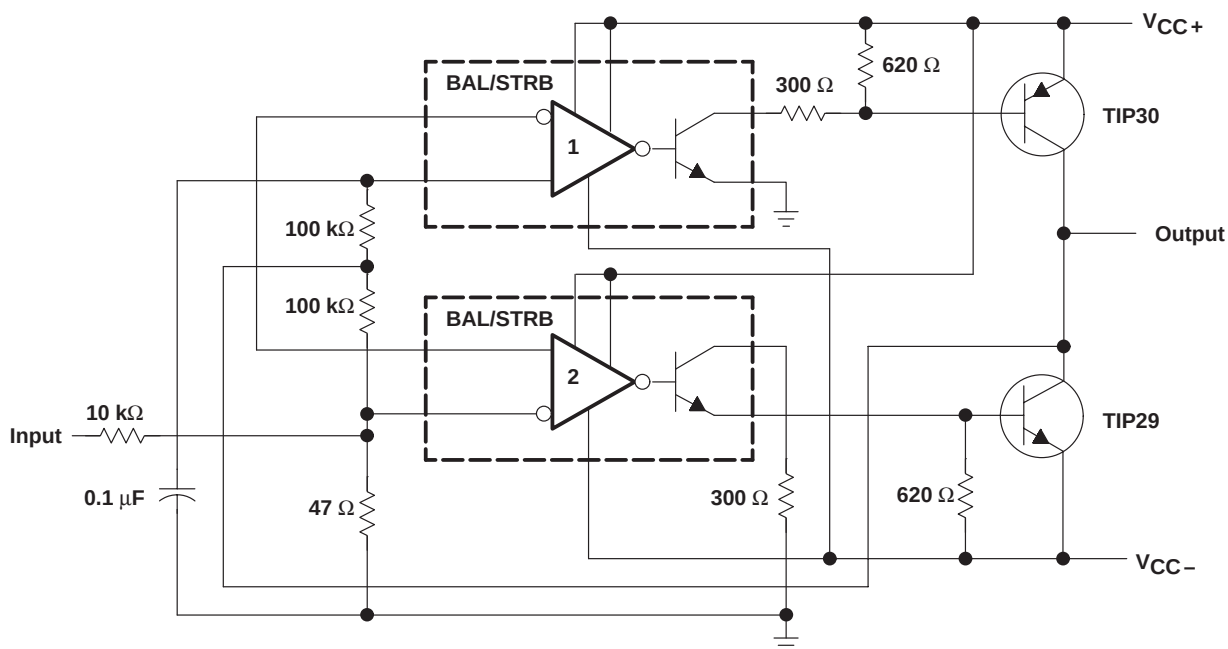


Figure 28. Switching Power Amplifier

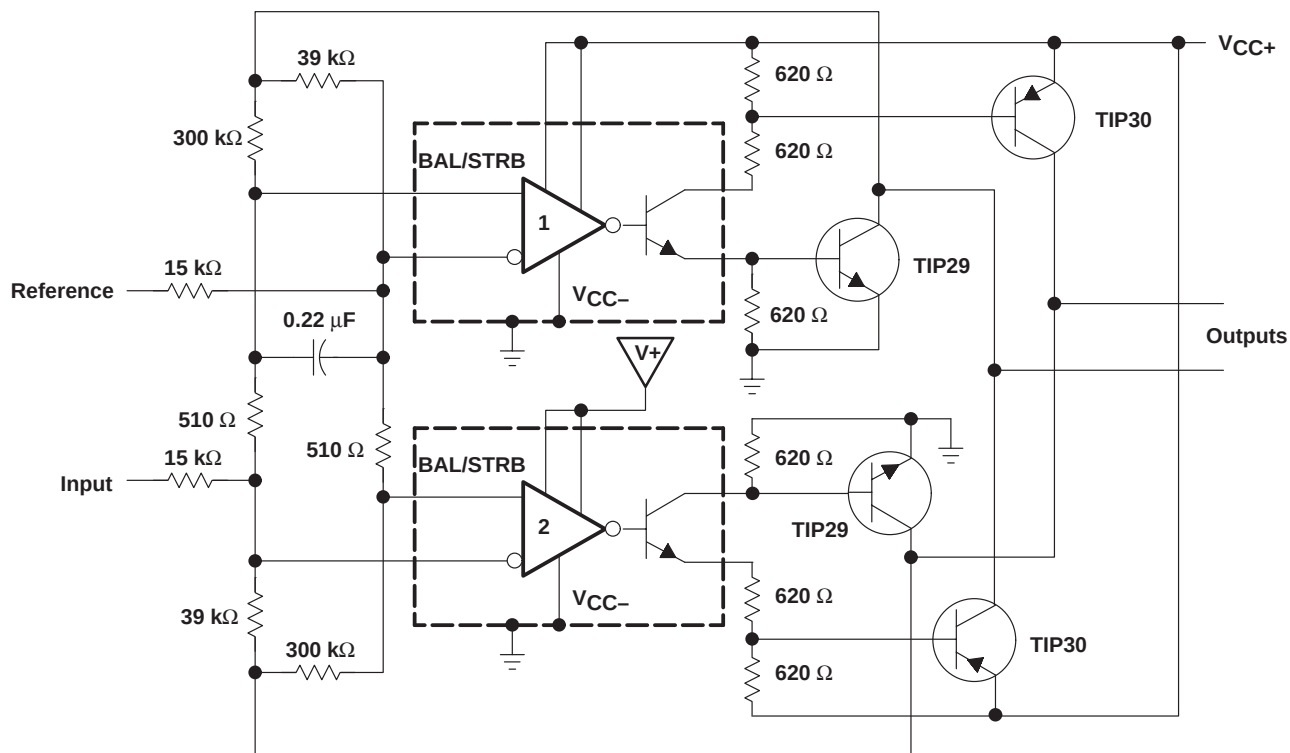


Figure 29. Switching Power Amplifiers

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