

## 250MHz Video Buffer

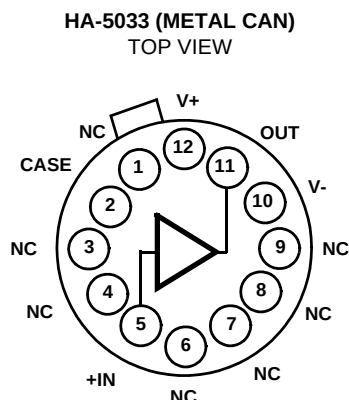
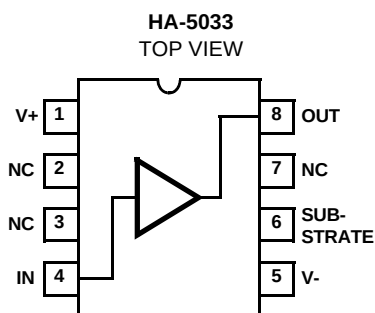
The HA-5033 is a unity gain monolithic IC designed for any application requiring a fast, wideband buffer. Featuring a bandwidth of 250MHz and outstanding differential phase/gain characteristics, this high performance voltage follower is an excellent choice for video circuit design. Other features, which include a minimum slew rate of 1000V/μs and high output drive capability, make the HA-5033 applicable for line driver and high speed data conversion circuits.

The high performance of this product is a result of the Intersil Dielectric Isolation process. A major feature of this process is that it produces both PNP and NPN high frequency transistors which makes wide bandwidth designs, such as the HA-5033, practical. Alternative process methods typically produce a lower AC performance.

## Ordering Information

| PART NUMBER<br>(BRAND) | TEMP.<br>RANGE (°C) | PACKAGE          | PKG.<br>DWG. # |
|------------------------|---------------------|------------------|----------------|
| HA2-5033-2             | -55 to 125          | 12 Pin Metal Can | T12.C          |
| HA3-5033-5             | 0 to 75             | 8 Ld PDIP        | E8.3           |

## Pinouts



## Features

- Differential Phase Error . . . . . 0.02 Degrees
- Differential Gain Error . . . . . 0.03%
- High Slew Rate . . . . . 1100V/μs
- Wide Bandwidth (Small Signal) . . . . . 250MHz
- Wide Power Bandwidth . . . . . DC to 17.5MHz
- Fast Rise Time . . . . . 3ns
- High Output Drive. . . . . ±10V With 100Ω Load
- Wide Power Supply Range . . . . . ±5V to ±16V
- Replace Costly Hybrids

## Applications

- Video Buffer
- High Frequency Buffer
- Isolation Buffer
- High Speed Line Driver
- Impedance Matching
- Current Boosters
- High Speed A/D Input Buffers
- Related Literature
  - AN548, Designer's Guide for HA-5033

**Absolute Maximum Ratings**

Voltage Between V+ and V- Pins. . . . . 40V  
 DC Input Voltage . . . . . V+ to V-  
 Output Current (Peak) (50ms On/1 Second Off) . . . . .  $\pm 200\text{mA}$   
 ESD Rating  
 Human Body Model (Per MIL-STD-883 Method 3015.7) . . . . . 2000V

**Operating Conditions**

Temperature Ranges  
 HA-5033-2 . . . . .  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$   
 HA-5033-5 (Note 3) . . . . .  $0^{\circ}\text{C}$  to  $75^{\circ}\text{C}$

**Thermal Information**

Thermal Resistance (Typical, Note 2)  $\theta_{JA}$  ( $^{\circ}\text{C/W}$ )  $\theta_{JC}$  ( $^{\circ}\text{C/W}$ )  
 Metal Can Package . . . . . 65 34  
 PDIP Package . . . . . 120 N/A  
 Maximum Junction Temperature (Note 1) . . . . .  $175^{\circ}\text{C}$   
 Maximum Junction Temperature (Plastic Packages) . . . . .  $150^{\circ}\text{C}$   
 Maximum Storage Temperature Range . . . . .  $-65^{\circ}\text{C}$  to  $150^{\circ}\text{C}$   
 Maximum Lead Temperature (Soldering 10s) . . . . .  $300^{\circ}\text{C}$

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

**NOTES:**

1. Maximum power dissipation, including load conditions, must be designed to maintain the maximum junction temperature below  $175^{\circ}\text{C}$  for the metal can package, and below  $150^{\circ}\text{C}$  for the plastic packages (See Figure 5.).
2.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.
3. The maximum operating temperature may have to be derated depending on the output load condition. See Figure 5 for more information.

**Electrical Specifications**  $V_{\text{SUPPLY}} = \pm 12\text{V}$ ,  $R_S = 50\Omega$ ,  $R_L = 100\Omega$ ,  $C_L = 10\text{pF}$ , Unless Otherwise Specified

| PARAMETER                     | TEST<br>CONDITIONS                                          | TEMP.<br>(°C) | HA-5033-2 |      |     | HA-5033-5 |      |     | UNITS             |
|-------------------------------|-------------------------------------------------------------|---------------|-----------|------|-----|-----------|------|-----|-------------------|
|                               |                                                             |               | MIN       | TYP  | MAX | MIN       | TYP  | MAX |                   |
| INPUT CHARACTERISTICS         |                                                             |               |           |      |     |           |      |     |                   |
| Offset Voltage                |                                                             | 25            | -         | 5    | 15  | -         | 5    | 15  | mV                |
|                               |                                                             | Full          | -         | 6    | 25  | -         | 6    | 25  | mV                |
| Average Offset Voltage Drift  |                                                             | Full          | -         | 33   | -   | -         | 33   | -   | μV/°C             |
| Bias Current                  |                                                             | 25            | -         | 20   | 35  | -         | 20   | 35  | μA                |
|                               |                                                             | Full          | -         | 30   | 50  | -         | 30   | 50  | μA                |
| Input Resistance              |                                                             | 25            | -         | 3    | -   | -         | 3    | -   | MΩ                |
| Input Capacitance             |                                                             | 25            | -         | 1.6  | -   | -         | 1.6  | -   | pF                |
| Input Noise Voltage           | 10Hz to 100MHz                                              | 25            | -         | 20   | -   | -         | 20   | -   | μV <sub>P-P</sub> |
| TRANSFER CHARACTERISTICS      |                                                             |               |           |      |     |           |      |     |                   |
| Voltage Gain                  | R <sub>L</sub> = 100Ω                                       | 25            | 0.93      | -    | -   | 0.93      | -    | -   | V/V               |
|                               | R <sub>L</sub> = 1kΩ                                        | 25            | 0.93      | 0.99 | -   | 0.93      | 0.99 | -   | V/V               |
|                               | R <sub>L</sub> = 100Ω                                       | Full          | 0.92      | -    | -   | 0.92      | -    | -   | V/V               |
| -3dB Bandwidth                |                                                             | 25            | -         | 250  | -   | -         | 250  | -   | MHz               |
| OUTPUT CHARACTERISTICS        |                                                             |               |           |      |     |           |      |     |                   |
| Output Voltage Swing          | R <sub>L</sub> = 100Ω                                       | Full          | ±8        | ±10  | -   | ±8        | ±10  | -   | V                 |
|                               | R <sub>L</sub> = 1kΩ, V <sub>S</sub> = ±15V                 | Full          | ±11       | ±12  | -   | ±11       | ±12  | -   | V                 |
| Output Current                |                                                             | 25            | ±80       | ±100 | -   | ±80       | ±100 | -   | mA                |
| Output Resistance             |                                                             | 25            | -         | 8    | -   | -         | 8    | -   | Ω                 |
| Full Power Bandwidth          | V <sub>OUT</sub> = 1V <sub>RMS</sub> , R <sub>L</sub> = 1kΩ | 25            | -         | 146  | -   | -         | 146  | -   | MHz               |
| Full Power Bandwidth (Note 4) |                                                             | 25            | 15.9      | 17.5 | -   | 15.9      | 17.5 | -   | MHz               |
| TRANSIENT RESPONSE            |                                                             |               |           |      |     |           |      |     |                   |
| Rise Time                     | V <sub>OUT</sub> = 500mV                                    | 25            | -         | 4.6  | -   | -         | 4.6  | -   | ns                |
| Propagation Delay             |                                                             | 25            | -         | 1    | -   | -         | 1    | -   | ns                |

**Electrical Specifications**  $V_{\text{SUPPLY}} = \pm 12\text{V}$ ,  $R_S = 50\Omega$ ,  $R_L = 100\Omega$ ,  $C_L = 10\text{pF}$ , Unless Otherwise Specified **(Continued)**

| PARAMETER                           | TEST CONDITIONS                             | TEMP. (°C) | HA-5033-2 |      |     | HA-5033-5 |      |     | UNITS  |
|-------------------------------------|---------------------------------------------|------------|-----------|------|-----|-----------|------|-----|--------|
|                                     |                                             |            | MIN       | TYP  | MAX | MIN       | TYP  | MAX |        |
| Overshoot                           |                                             | 25         | -         | 3    | -   | -         | 3    | -   | %      |
| Slew Rate (Note 4)                  |                                             | 25         | 1         | 1.1  | -   | 1         | 1.1  | -   | V/ns   |
| Settling Time to 0.1%               |                                             | 25         | -         | 50   | -   | -         | 50   | -   | ns     |
| Differential Phase Error (Note 5)   |                                             | 25         | -         | 0.02 | -   | -         | 0.02 | -   | Degree |
| Differential Gain Error (Note 5)    |                                             | 25         | -         | 0.03 | -   | -         | 0.03 | -   | %      |
| <b>POWER SUPPLY CHARACTERISTICS</b> |                                             |            |           |      |     |           |      |     |        |
| Supply Current                      |                                             | 25         | -         | 21   | 25  | -         | 21   | 25  | mA     |
|                                     |                                             | Full       | -         | 21   | 30  | -         | 21   | 30  | mA     |
| Power Supply Rejection Ratio        |                                             | Full       | 54        | -    | -   | 54        | -    | -   | dB     |
| Harmonic Distortion                 | $V_{\text{IN}} = 1V_{\text{RMS}}$ at 100kHz | 25         | -         | <0.1 | -   | -         | <0.1 | -   | %      |

**NOTES:**

- $V_{\text{SUPPLY}} = \pm 15\text{V}$ ,  $V_{\text{OUT}} = \pm 10\text{V}$ ,  $R_L = 1\text{k}\Omega$ .
- Differential gain and phase error are nonlinear signal distortions found in video systems and are defined as follows: Differential gain error is defined as the change in amplitude at the color subcarrier frequency as the picture signal is varied from blanking to white level. Differential phase error is defined as the change in the phase of the color subcarrier as the picture signal is varied from blanking to white level.  $R_L = 300\Omega$ .

**Test Circuits and Waveforms**

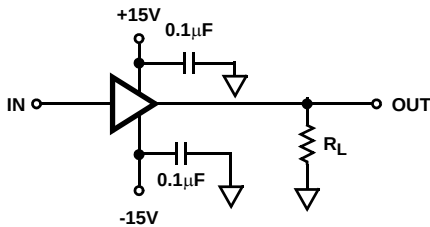


FIGURE 1. SLEW RATE AND SETTLING TIME

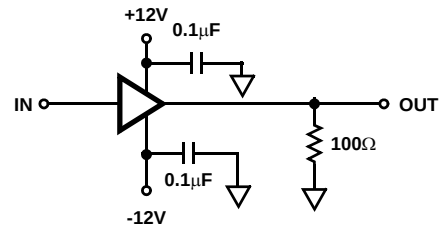


FIGURE 2. TRANSIENT RESPONSE

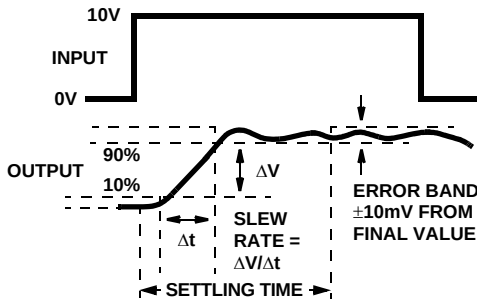


FIGURE 3. SETTLING TIME AND SLEW RATE

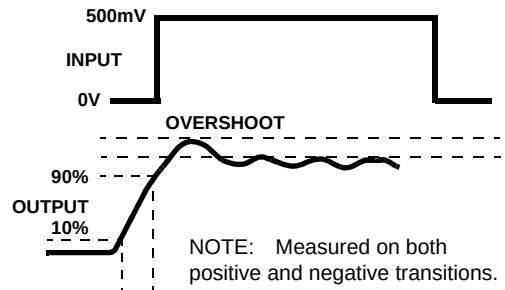
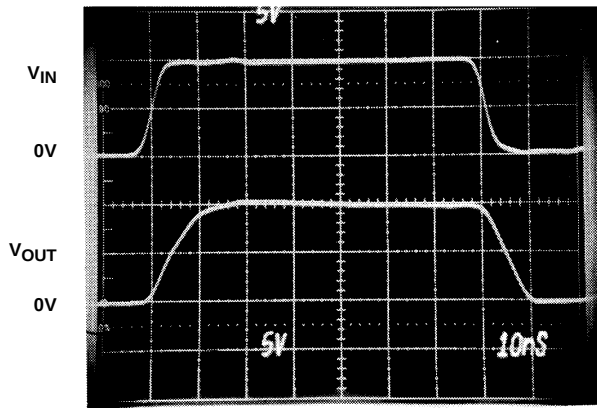


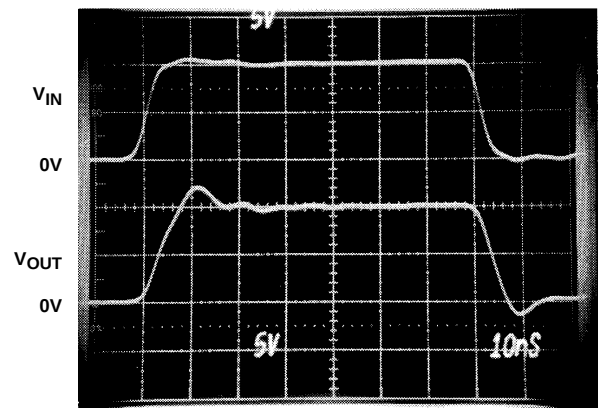
FIGURE 4. RISE TIME AND OVERSHOOT

# Test Circuits and Waveforms (Continued)



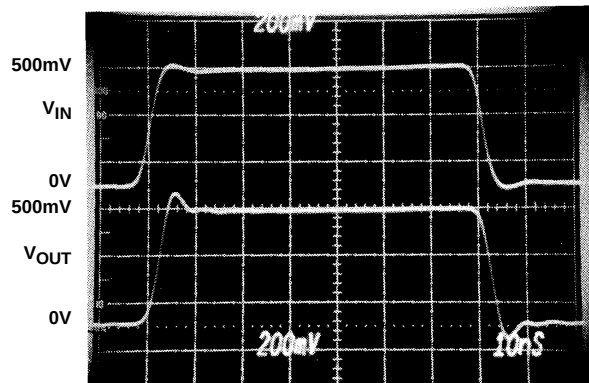
$T_A = 25^\circ\text{C}$ ,  $R_S = 50\Omega$ ,  $R_L = 100\Omega$

+10V RESPONSE



$T_A = 25^\circ\text{C}$ ,  $R_S = 50\Omega$ ,  $R_L = 1\text{k}\Omega$

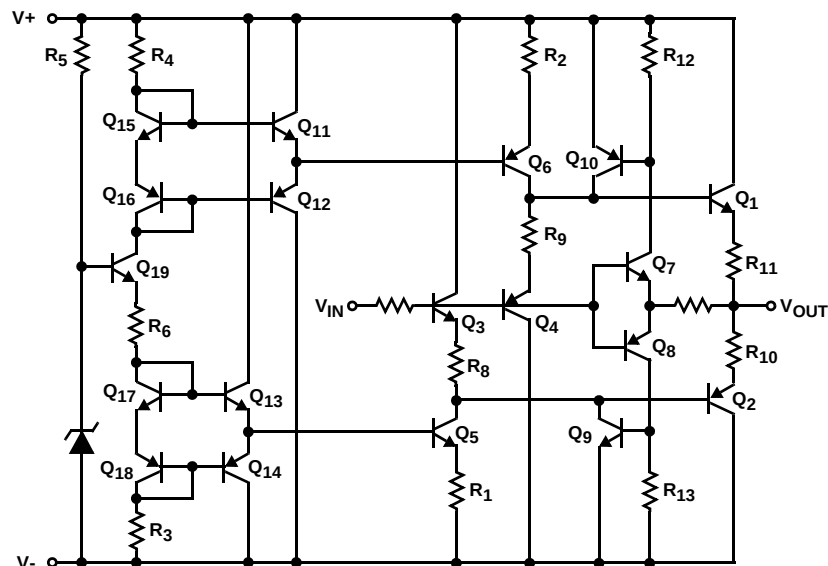
+10V RESPONSE



$T_A = 25^\circ\text{C}$ ,  $R_S = 50\text{W}$ ,  $R_L = 100\text{W}$

PULSE RESPONSE

## Schematic Diagram



## Application Information

### Layout Considerations

The wide bandwidth of the HA-5033 necessitates that high frequency circuit layout procedures be followed. Failure to follow these guidelines can result in marginal performance.

Probably the most crucial of the RF/video layout rules is the use of a ground plane. A ground plane provides isolation and minimizes distributed circuit capacitance and inductance which will degrade high frequency performance. This ground plane shielding can also incorporate the metal case of the HA-5033 since pin #2 is internally tied to the package. This feature allows the user to make metal to metal contact between the ground plane and the package, which extends shielding, provides additional heat sinking and eliminates the use of a socket, IC sockets contribute inter-lead capacitance which limits device bandwidth and should be avoided.

For the PDIP, pin 6 can be tied to either supply, grounded, or simply not used. But to optimize device performance and improve isolation, it is recommended that this pin be grounded.

Other considerations are proper power supply bypassing and keeping the input and output connections as short as possible which minimizes distributed capacitance and reduces board space.

### Power Supply Decoupling

For optimum device performance, it is recommended that the positive and negative power supplies be bypassed with capacitors to ground. Ceramic capacitors ranging in value from 0.01μF to 0.1μF will minimize high frequency variations

in supply voltage. Solid tantalum capacitors 1μF or larger will optimize low frequency performance.

It is also recommended that the bypass capacitors be connected close to the HA-5033 (preferably directly to the supply pins).

Figure 5 is based on:

$$P_{DMAX} = \frac{T_{JMAX} - T_A}{\theta_{JA}}$$

Where:  $T_{JMAX}$  = Maximum Junction Temperature of the Device  
 $T_A$  = Ambient Temperature

$\theta_{JA}$  = Junction to Ambient Thermal Resistance

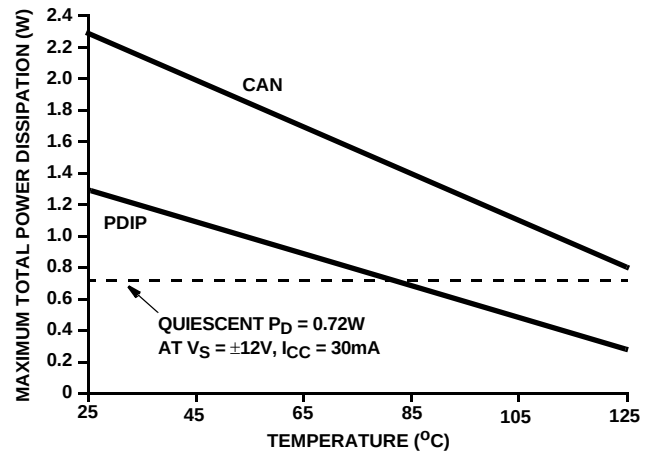


FIGURE 5. MAXIMUM POWER DISSIPATION vs TEMPERATURE

### Typical Applications (Also see Application Note AN548)

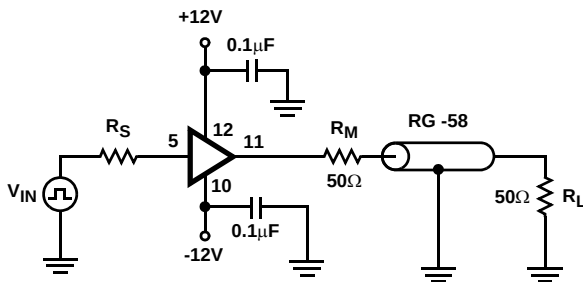


FIGURE 6. VIDEO COAXIAL LINE DRIVER 50Ω SYSTEM

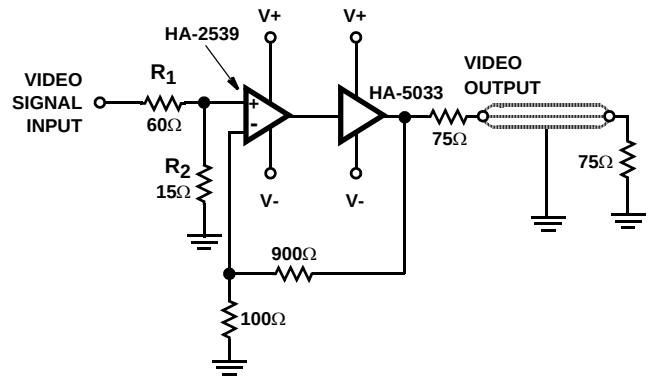
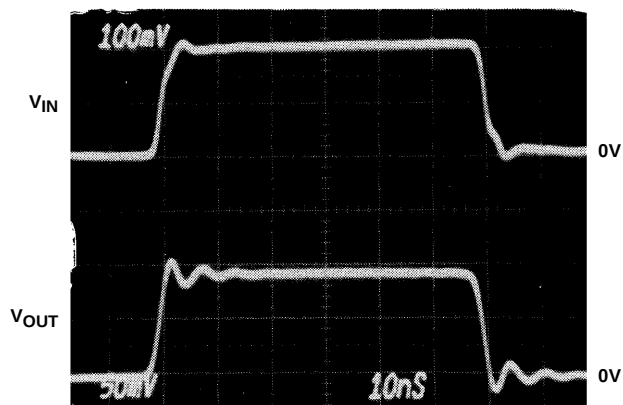


FIGURE 7. VIDEO GAIN BLOCK

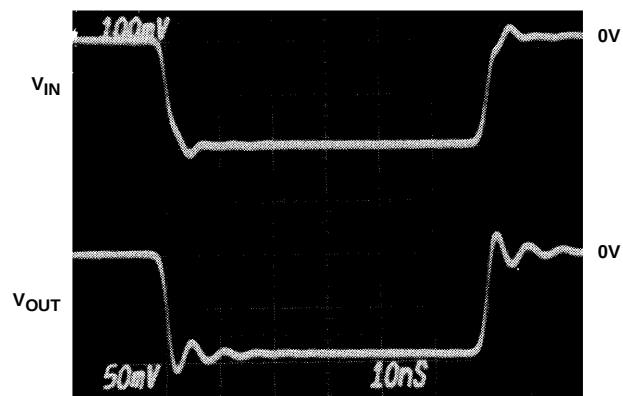
# Typical Applications (Also see Application Note AN548) (Continued)



$T_A = 25^\circ\text{C}$ ,  $R_S = 50\Omega$ ,  $R_M = R_L = 50\Omega$

$$V_O = V_{IN} \left[ \frac{R_L}{R_L + R_M} \right] = \left[ \frac{1}{2} \right] V_{IN}$$

POSITIVE PULSE RESPONSE



$T_A = 25^\circ\text{C}$ ,  $R_S = 50\Omega$ ,  $R_M = R_L = 50\Omega$

$$V_O = V_{IN} \left[ \frac{R_L}{R_L + R_M} \right] = \left[ \frac{1}{2} \right] V_{IN}$$

NEGATIVE PULSE RESPONSE

## Typical Performance Curves

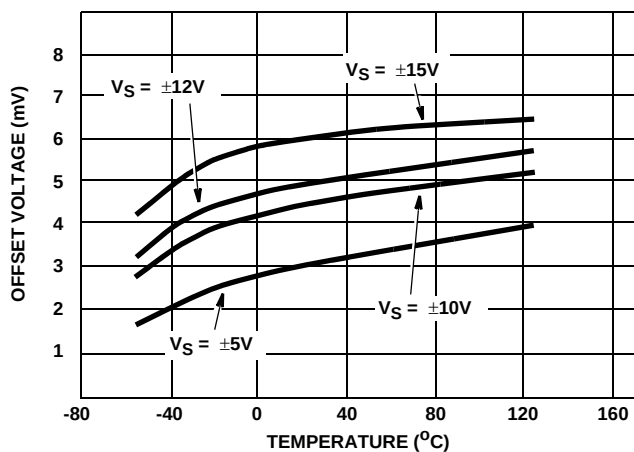


FIGURE 8. INPUT OFFSET VOLTAGE vs TEMPERATURE

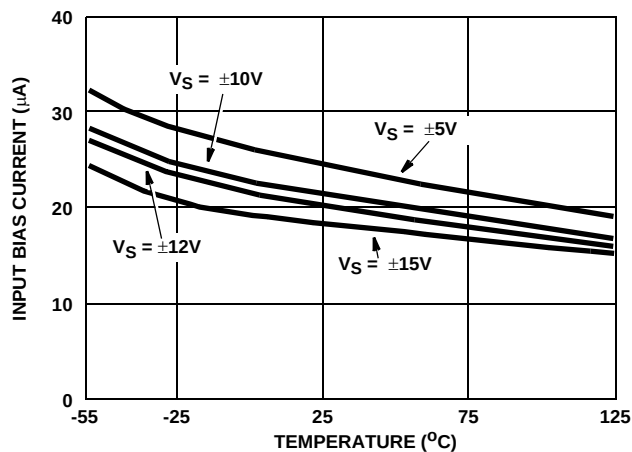


FIGURE 9. INPUT BIAS CURRENT vs TEMPERATURE

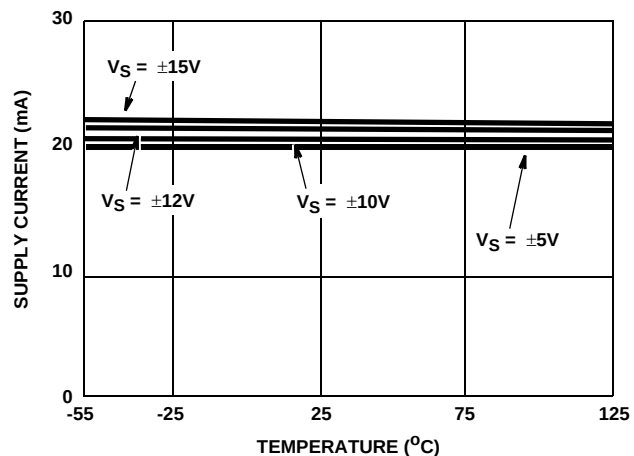


FIGURE 10. SUPPLY CURRENT vs TEMPERATURE

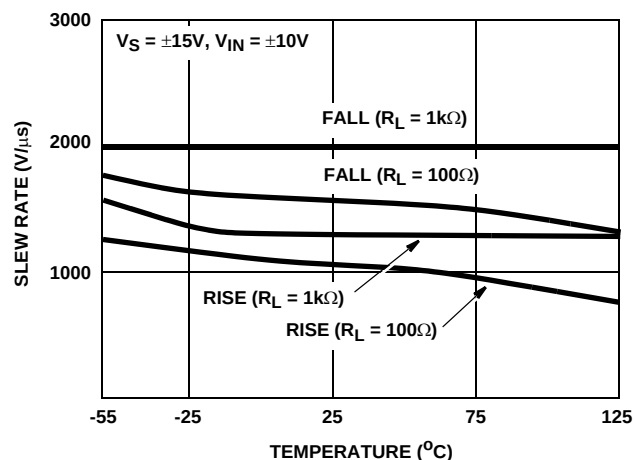


FIGURE 11. SLEW RATE vs TEMPERATURE

## Typical Performance Curves (Continued)

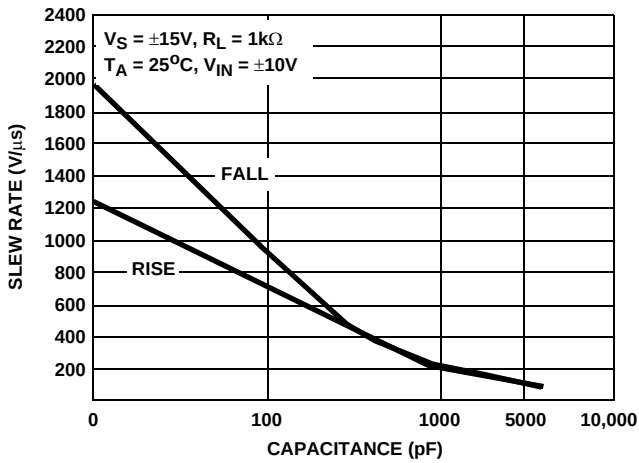


FIGURE 12. SLEW RATE vs LOAD CAPACITANCE

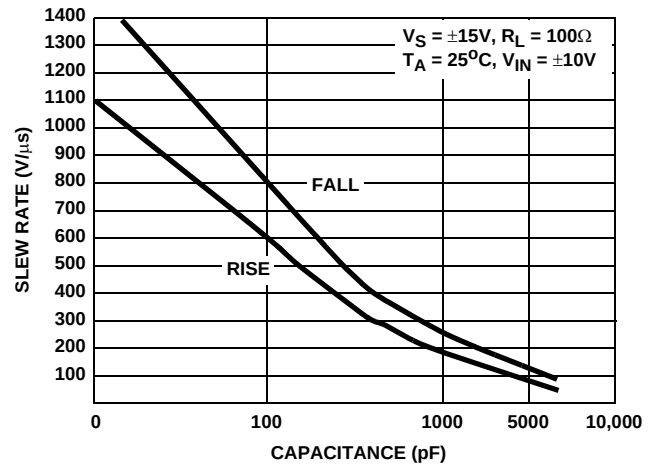


FIGURE 13. SLEW RATE vs LOAD CAPACITANCE

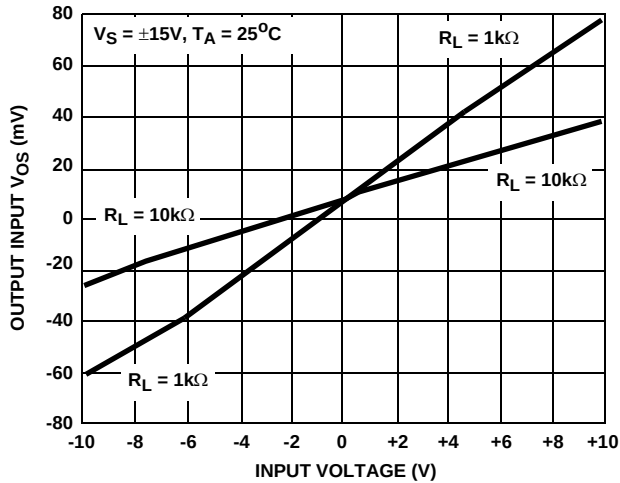


FIGURE 14. GAIN ERROR vs INPUT VOLTAGE

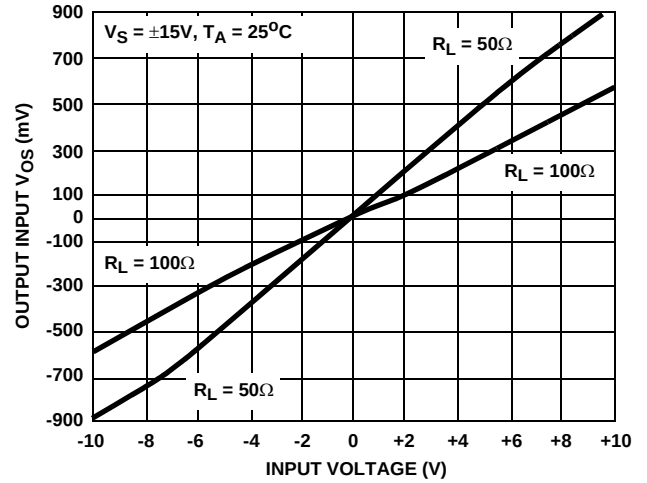


FIGURE 15. GAIN ERROR vs INPUT VOLTAGE

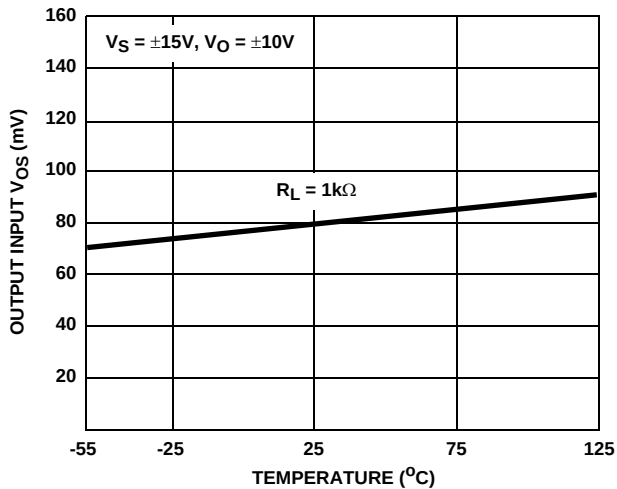
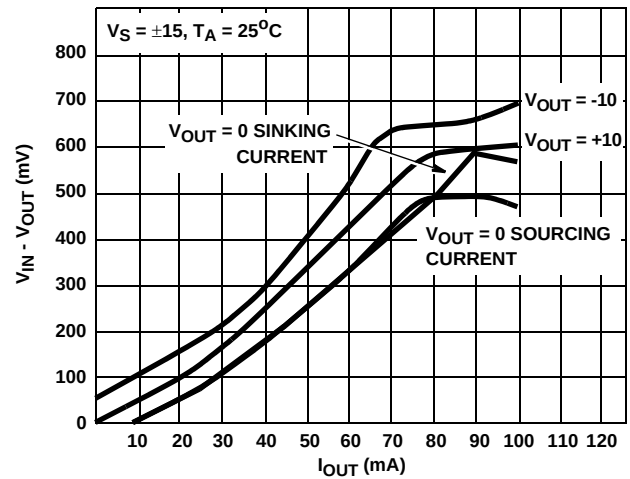


FIGURE 16. GAIN ERROR vs TEMPERATURE

FIGURE 17.  $V_{IN} - V_{OUT}$  vs  $I_{OUT}$

Typical Performance Curves (Continued)

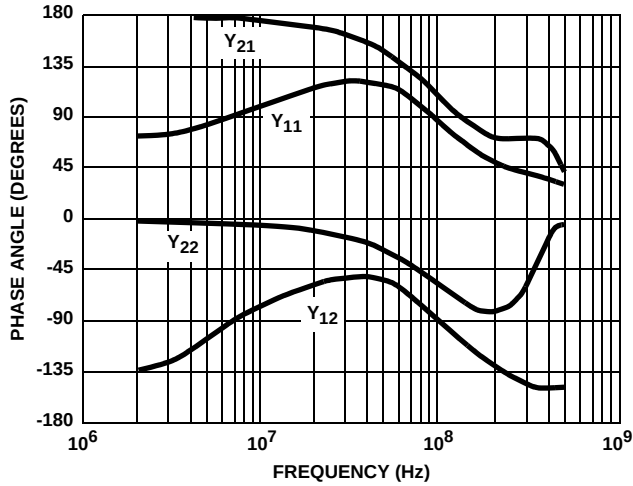


FIGURE 18. Y - PARAMETERS PHASE vs FREQUENCY

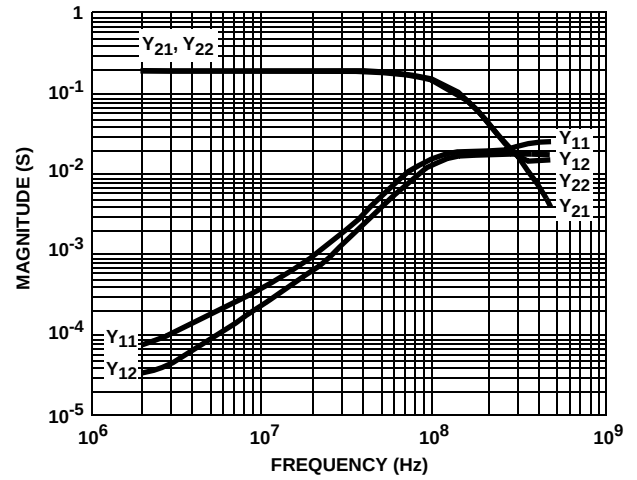


FIGURE 19. Y - PARAMETER MAGNITUDE vs FREQUENCY

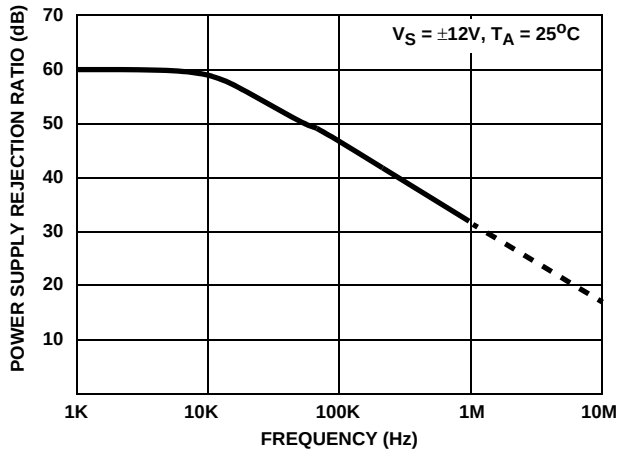


FIGURE 20. POWER SUPPLY REJECTION RATIO vs FREQUENCY

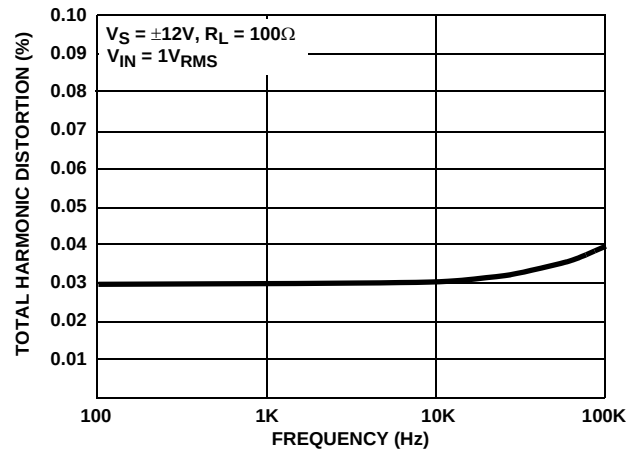


FIGURE 21. TOTAL HARMONIC DISTORTION vs FREQUENCY

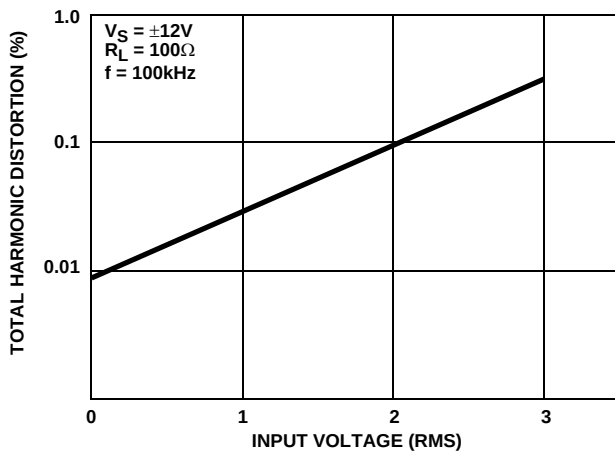


FIGURE 22. TOTAL HARMONIC DISTORTION vs INPUT VOLTAGE

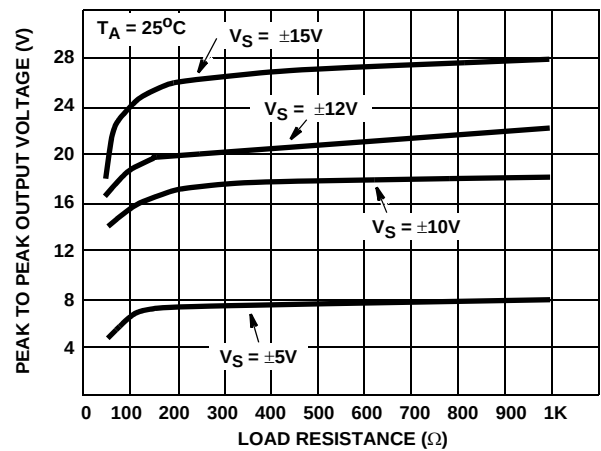


FIGURE 23. OUTPUT VOLTAGE SWING vs LOAD RESISTANCE



# Typical Performance Curves (Continued)

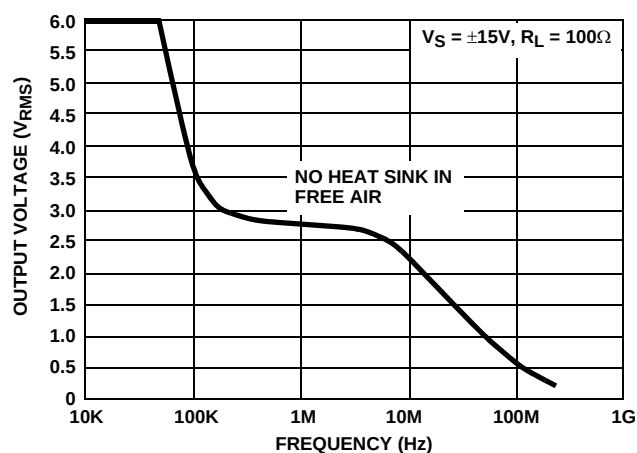


FIGURE 24. OUTPUT SWING vs FREQUENCY (NOTE)

## NOTE:

This curve was obtained by noting the output voltage necessary to produce an observable distortion for a given frequency. If higher distortion is acceptable, then a higher output voltage for a given frequency can be obtained. However, operating the HA-5033 with increased distortion (to the right of curve shown), will also be accompanied by an increase in supply current. The resulting increase in chip temperature must be considered and heat sinking will be necessary to prevent thermal runaway. This characteristic is the result of the output transistor operation. If the signal amplitude or signal frequency or both are increased beyond the curve shown, the NPN, PNP output transistors will approach a condition of being simultaneously on. Under this condition, thermal runaway can occur.

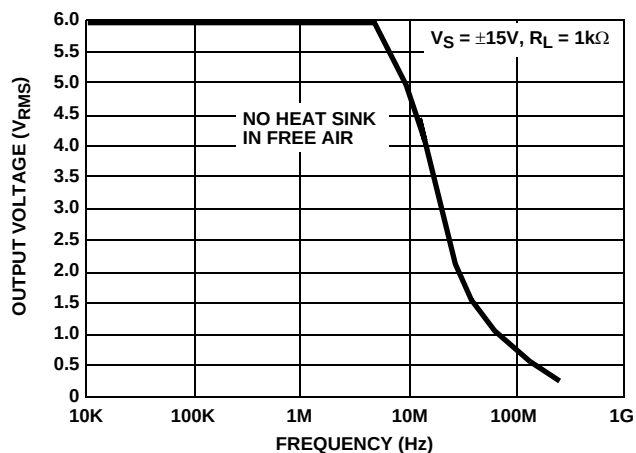


FIGURE 25. OUTPUT SWING vs FREQUENCY (NOTE)

## Die Characteristics

### DIE DIMENSIONS:

51 mils x 67 mils x 19 mils  
1300 $\mu$ m x 1700 $\mu$ m x 483 $\mu$ m

### METALLIZATION:

Type: Al, 1% Cu  
Thickness: 16k $\text{\AA}$   $\pm$  2k $\text{\AA}$

### PASSIVATION:

Type: Nitride ( $\text{Si}_3\text{N}_4$ ) over Silox ( $\text{SiO}_2$ , 5% Phos.)  
Silox Thickness: 12k $\text{\AA}$   $\pm$  2k $\text{\AA}$   
Nitride Thickness: 3.5k $\text{\AA}$   $\pm$  1.5k $\text{\AA}$

### SUBSTRATE POTENTIAL (POWERED UP):

Unbiased

### TRANSISTOR COUNT:

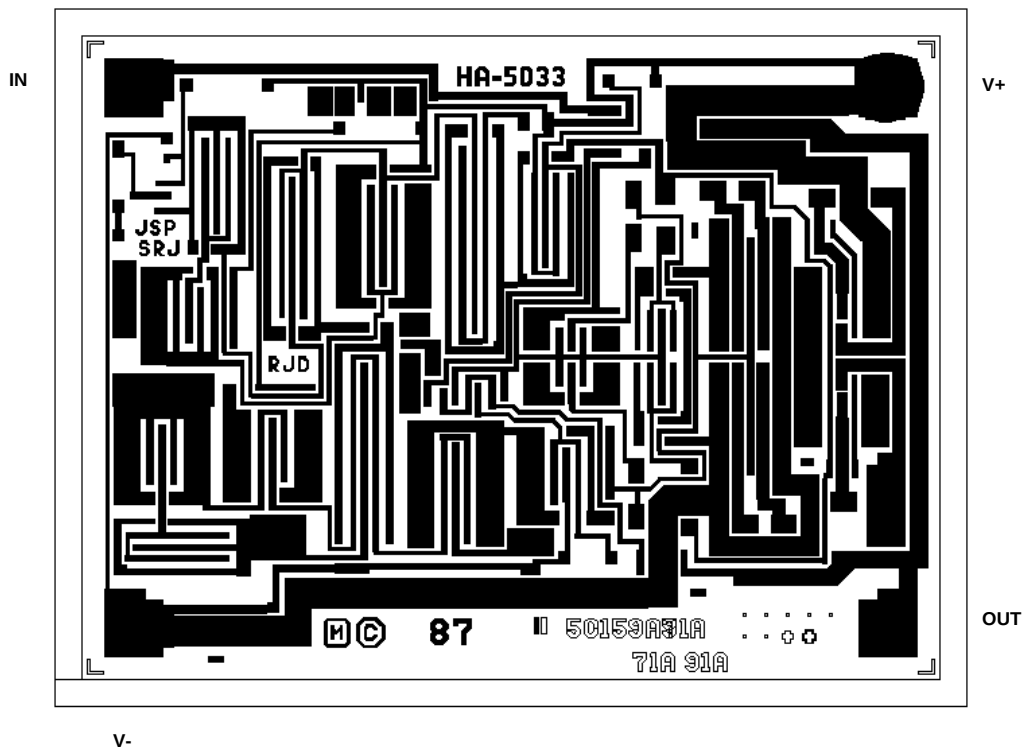
20

### PROCESS:

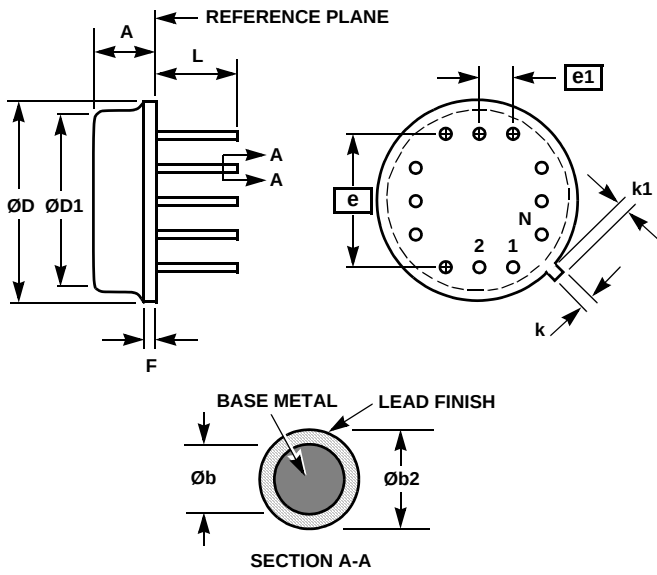
Bipolar Dielectric Isolation

## Metallization Mask Layout

HA-5033



## Metal Can Packages (Can)



**T12.C**  
12 LEAD METAL CAN PACKAGE

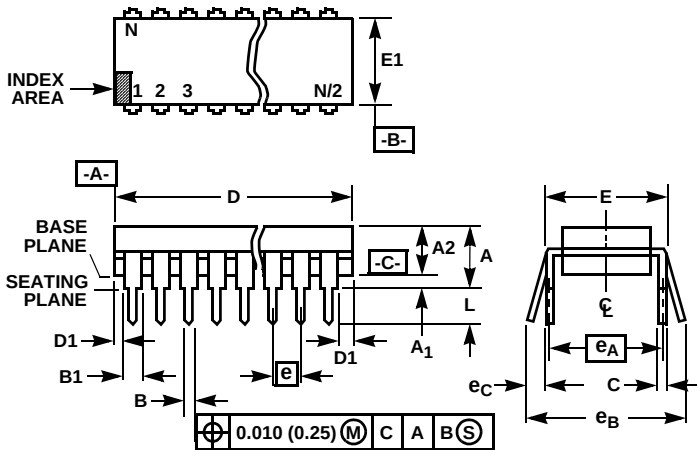
| SYMBOL           | INCHES    |       | MILLIMETERS |       | NOTES |
|------------------|-----------|-------|-------------|-------|-------|
|                  | MIN       | MAX   | MIN         | MAX   |       |
| A                | 0.130     | 0.150 | 3.30        | 3.81  | -     |
| $\varnothing b$  | 0.016     | 0.019 | 0.41        | 0.48  | -     |
| $\varnothing b2$ | 0.016     | 0.021 | 0.41        | 0.53  | -     |
| $\varnothing D$  | 0.585     | 0.615 | 14.86       | 15.62 | -     |
| $\varnothing D1$ | 0.540     | 0.560 | 13.72       | 14.22 | -     |
| e                | 0.400 BSC |       | 10.16 BSC   |       | -     |
| e1               | 0.100 BSC |       | 2.54 BSC    |       | -     |
| F                | 0.020     | 0.040 | 0.51        | 1.02  | -     |
| k                | 0.027     | 0.034 | 0.69        | 0.86  | -     |
| k1               | 0.027     | 0.045 | 0.69        | 1.14  | 2     |
| L                | 0.500     | 0.560 | 12.70       | 14.22 | -     |
| N                | 12        |       | 12          |       | 3     |

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### NOTES:

1. The reference, base, and seating planes are the same for this variation.
2. Measured from maximum diameter of the product.
3. N is the maximum number of terminal positions.
4. Dimensioning and tolerancing per ANSI Y14.5M - 1982.
5. Controlling dimension: INCH.

## Dual-In-Line Plastic Packages (PDIP)



## NOTES:

- Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
- Dimensioning and tolerancing per ANSI Y14.5M-1982.
- Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
- Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
- D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
- E and  $e_A$  are measured with the leads constrained to be perpendicular to datum  $-C-$ .
- $e_B$  and  $e_C$  are measured at the lead tips with the leads unconstrained.  $e_C$  must be zero or greater.
- B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
- N is the maximum number of terminal positions.
- Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

**E8.3 (JEDEC MS-001-BA ISSUE D)**  
**8 LEAD DUAL-IN-LINE PLASTIC PACKAGE**

| SYMBOL | INCHES    |       | MILLIMETERS |       | NOTES |
|--------|-----------|-------|-------------|-------|-------|
|        | MIN       | MAX   | MIN         | MAX   |       |
| A      | -         | 0.210 | -           | 5.33  | 4     |
| A1     | 0.015     | -     | 0.39        | -     | 4     |
| A2     | 0.115     | 0.195 | 2.93        | 4.95  | -     |
| B      | 0.014     | 0.022 | 0.356       | 0.558 | -     |
| B1     | 0.045     | 0.070 | 1.15        | 1.77  | 8, 10 |
| C      | 0.008     | 0.014 | 0.204       | 0.355 | -     |
| D      | 0.355     | 0.400 | 9.01        | 10.16 | 5     |
| D1     | 0.005     | -     | 0.13        | -     | 5     |
| E      | 0.300     | 0.325 | 7.62        | 8.25  | 6     |
| E1     | 0.240     | 0.280 | 6.10        | 7.11  | 5     |
| e      | 0.100 BSC |       | 2.54 BSC    |       | -     |
| $e_A$  | 0.300 BSC |       | 7.62 BSC    |       | 6     |
| $e_B$  | -         | 0.430 | -           | 10.92 | 7     |
| L      | 0.115     | 0.150 | 2.93        | 3.81  | 4     |
| N      | 8         |       | 8           |       | 9     |

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