# MDC3105LT1

Motorola Preferred Device

*Advance Information*

# Integrated Relay/Solenoid Driver

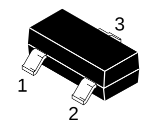
- Optimized to Switch 3 V to 5 V Relays from a 5 V Rail
- Compatible with "TX" and "TQ" Series Telecom Relays Rated up to 300 mW at 3 V to 5 V
- Features Low Input Drive Current
- Internal Zener Clamp Routes Induced Current to Ground Rather Than Back to Supply
- Guaranteed Off State with No Input Connection
- Supports Large Systems with Minimal Off–State Leakage
- ESD Resistant in Accordance with the 2000 V Human Body Model
- Provides a Robust Driver Interface Between Relay Coil and Sensitive Logic Circuits

**Applications include:**

- Telecom Line Cards and Telephony
- Industrial Controls
- Security Systems
- Appliances and White Goods
- Automated Test Equipment
- Automotive Controls

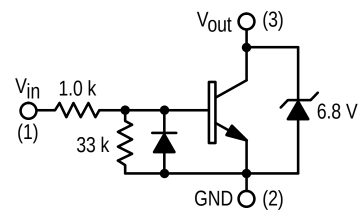
This device is intended to replace an array of three to six discrete components with an integrated SMT part. It is available in a SOT–23 package. It can be used to switch other 3 to 5 Vdc Inductive Loads such as solenoids and small DC motors.

**RELAY/SOLENOID DRIVER
SILICON MONOLITHIC
CIRCUIT BLOCK**




**CASE 318–08, STYLE 6
SOT–23 (TO–236AB)**

**INTERNAL CIRCUIT DIAGRAM**




**MAXIMUM RATINGS**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Power Supply Voltage | $V_{CC}$ | 6.0 | Vdc |
| Recommended Operating Supply Voltage | $V_{CC}$ | 2.0–5.5 | Vdc |
| Input Voltage | $V_{in(fwd)}$ | 6.0 | Vdc |
| Reverse Input Voltage | $V_{in(rev)}$ | –0.5 | Vdc |
| Output Sink Current — Continuous | $I_O$ | 300 | mA |
| Junction Temperature | $T_J$ | 150 | °C |
| Operating Ambient Temperature Range | $T_A$ | –40 to +85 | °C |
| Storage Temperature Range | $T_{stg}$ | –65 to +150 | °C |

**THERMAL CHARACTERISTICS**

| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Total Device Dissipation(1)<br>Derate above 25°C | $P_D$ | 225 | mW |
| Thermal Resistance Junction to Ambient | $R_{\theta JA}$ | 556 | °C/W |

1. FR–5 PCB of 1″ x 0.75″ x 0.062″, $T_A$ = 25°C

Thermal Clad is a trademark of the Bergquist Company.

**Preferred** devices are Motorola recommended choices for future use and best overall value.

This document contains information on a new product. Specifications and information herein are subject to change without notice.



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**ELECTRICAL CHARACTERISTICS** ($T_A$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| Output Zener Breakdown Voltage (@ IT = 10 mA Pulse) | $V_{(BRout)}$<br>$V_{(–BRout)}$ | 6.4<br>— | 6.8<br>–0.7 | 7.2<br>— | V |
| Output Leakage Current @ 0 Input Voltage<br>($V_{out}$ = 5.5 Vdc, $V_{in}$ = O.C., $T_A$ = 25°C)<br>($V_{out}$ = 5.5 Vdc, $V_{in}$ = O.C., $T_A$ = 85°C) | $I_{OO}$ | —<br>— | —<br>— | 5.0<br>30 | µA |
| **ON CHARACTERISTICS** | | | | | |
| Input Bias Current @ $V_{in}$ = 4.0 Vdc<br>($I_O$ = 250 mA, $V_{out}$ = 0.4 Vdc, $T_A$ = –40°C)<br>(correlated to a measurement @ 25°C) | $I_{in}$ | — | 2.5 | — | mAdc |
| Output Saturation Voltage<br>($I_O$ = 250 mA, $V_{in}$ = 4.0 Vdc, $T_A$ = –40°C)<br>(correlated to a measurement @ 25°C) | | — | 0.2 | 0.4 | Vdc |
| Output Sink Current — Continuous<br>($T_A$ = –40°C, $V_{CE}$ = 0.4 Vdc, $V_{in}$ = 4.0 Vdc )<br>(correlated to a measurement @ 25°C) | $I_{C(on)}$ | 250 | — | — | mA |

### TYPICAL APPLICATION–DEPENDENT SWITCHING PERFORMANCE

**SWITCHING CHARACTERISTICS**

| Characteristic | Symbol | $V_{CC}$ | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Propagation Delay Times: | | | | | | ns |
| High to Low Propagation Delay; Figures 1, 2 (5.0 V 74HC04) | $t_{PHL}$ | 5.5 | — | 55 | — | |
| Low to High Propagation Delay; Figures 1, 2 (5.0 V 74HC04) | $t_{PLH}$ | 5.5 | — | 430 | — | |
| High to Low Propagation Delay; Figures 1, 3 (3.0 V 74HC04) | $t_{PHL}$ | 5.5 | — | 85 | — | |
| Low to High Propagation Delay; Figures 1, 3 (3.0 V 74HC04) | $t_{PLH}$ | 5.5 | — | 315 | — | |
| High to Low Propagation Delay; Figures 1, 4 (5.0 V 74LS04) | $t_{PHL}$ | 5.5 | — | 55 | — | |
| Low to High Propagation Delay; Figures 1, 4 (5.0 V 74LS04) | $t_{PLH}$ | 5.5 | — | 2385 | — | |
| Transition Times: | | | | | | ns |
| Fall Time; Figures 1, 2 (5.0 V 74HC04) | $t_f$ | 5.5 | — | 45 | — | |
| Rise Time; Figures 1, 2 (5.0 V 74HC04) | $t_r$ | 5.5 | — | 160 | — | |
| Fall Time; Figures 1, 3 (3.0 V 74HC04) | $t_f$ | 5.5 | — | 70 | — | |
| Rise Time; Figures 1, 3 (3.0 V 74HC04) | $t_r$ | 5.5 | — | 195 | — | |
| Fall Time; Figures 1, 4 (5.0 V 74LS04) | $t_f$ | 5.5 | — | 45 | — | |
| Rise Time; Figures 1, 4 (5.0 V 74LS04) | $t_r$ | 5.5 | — | 2400 | — | |
| Input Slew Rate(1) | $\Delta V/\Delta t$ in | 5.5 | TBD | — | — | V/ms |

1. Minimum input slew rate must be followed to avoid overdissipating the device.

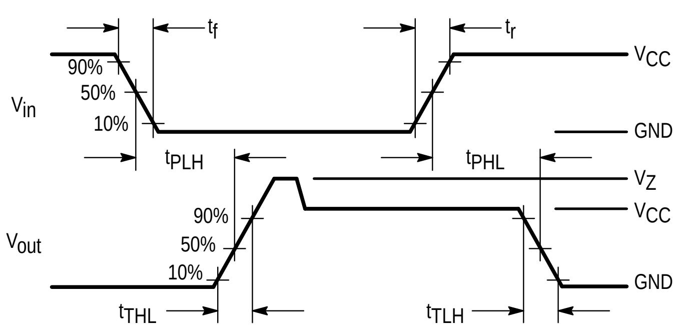



**Figure 1. Switching Waveforms**

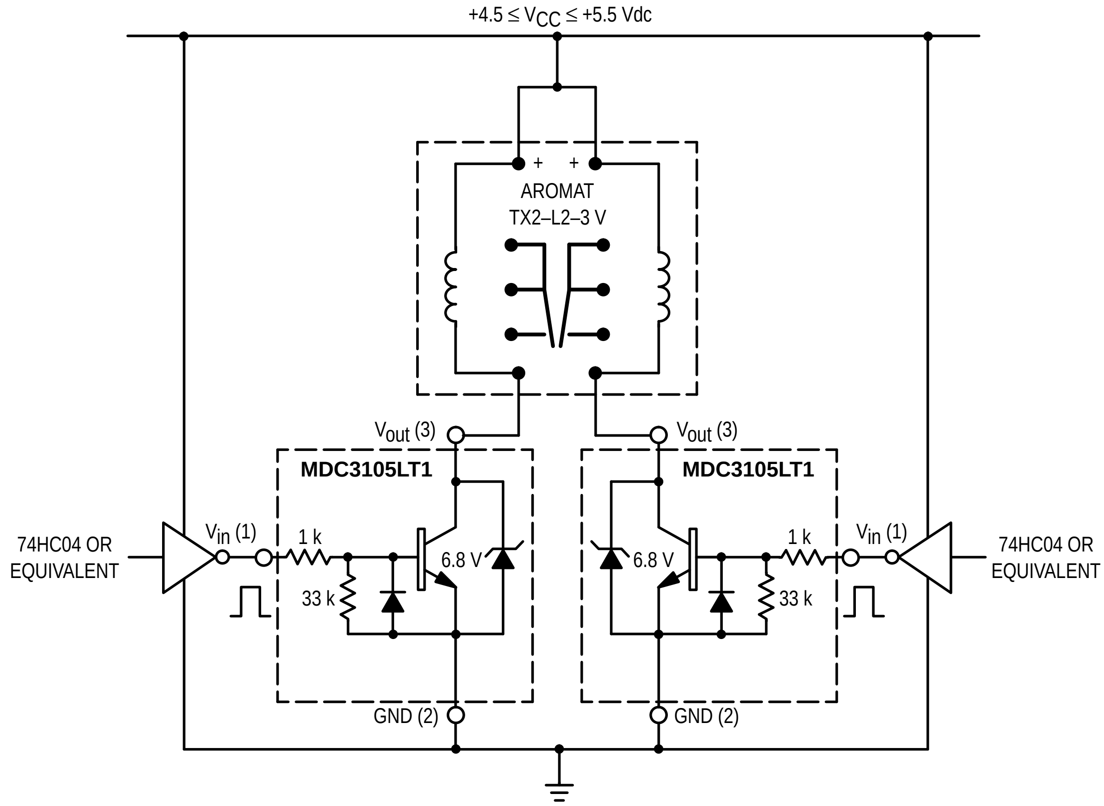



**Figure 2. A 3.0–V, 200–mW Dual Coil Latching Relay Application with 5.0 V–HCMOS Interface**

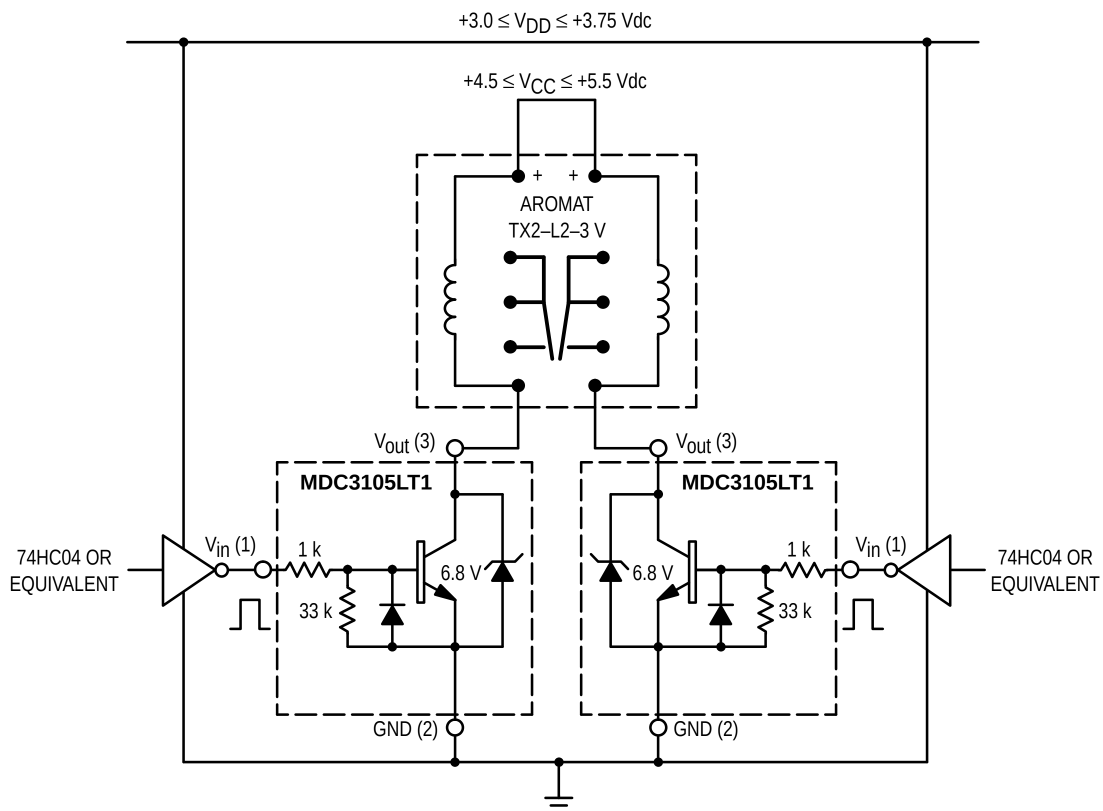



**Figure 3. A 3.0–V, 200–mW Dual Coil Latching Relay Application with 3.0 V–HCMOS Interface**

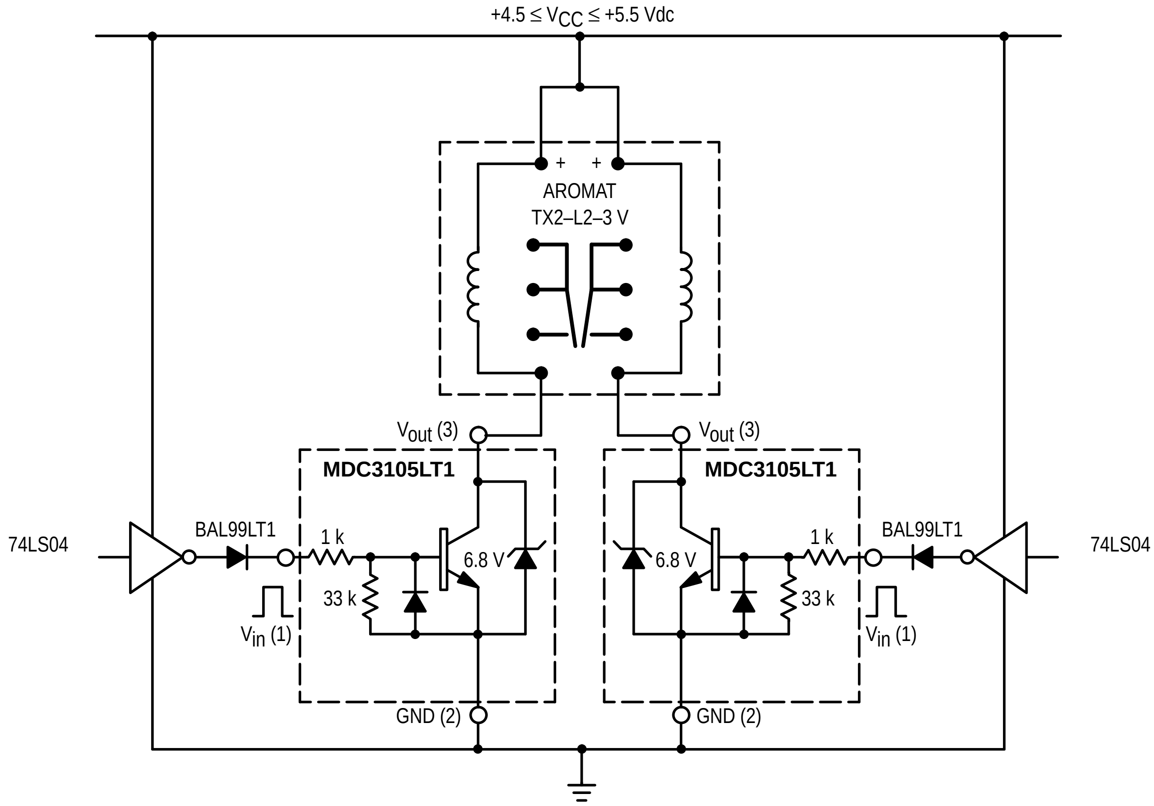
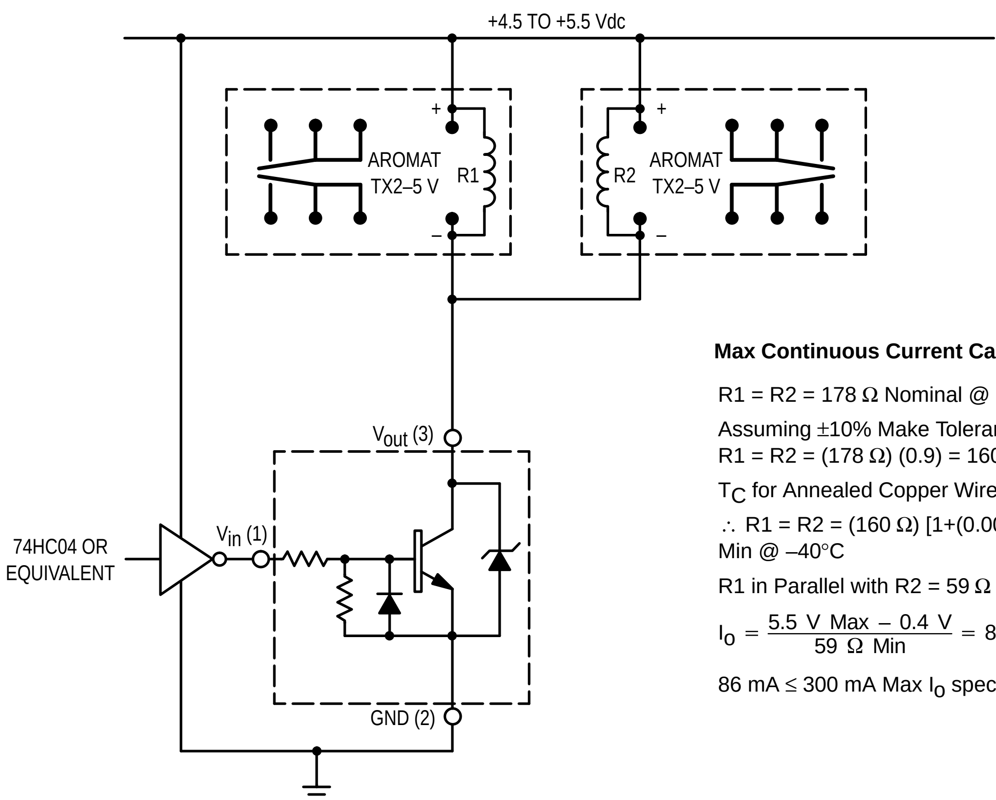



**Figure 4. A 3.0–V, 200–mW Dual Coil Latching Relay Application with TTL Interface**




**Max Continuous Current Calculation**

R1 = R2 = 178 Ω Nominal @ $T_A$ = 25°C

Assuming ±10% Make Tolerance,
R1 = R2 = (178 Ω) (0.9) = 160 Ω Min @ $T_A$ = 25°C

$T_C$ for Annealed Copper Wire is 0.4%/°C

∴ R1 = R2 = (160 Ω) [1+(0.004) (–40°–25°)] = 118 Ω Min @ –40°C

R1 in Parallel with R2 = 59 Ω Min @ –40°C

$$I_O = \frac{5.5\ \text{V Max} - 0.4\ \text{V}}{59\ \Omega\ \text{Min}} = 86\ \text{mA Max}$$

86 mA ≤ 300 mA Max $I_O$ spec.

**Figure 5. Typical 5.0 V, 140 mW Coil Dual Relay Application**

## TYPICAL OPERATING WAVEFORMS

(Circuit of Figure 5)

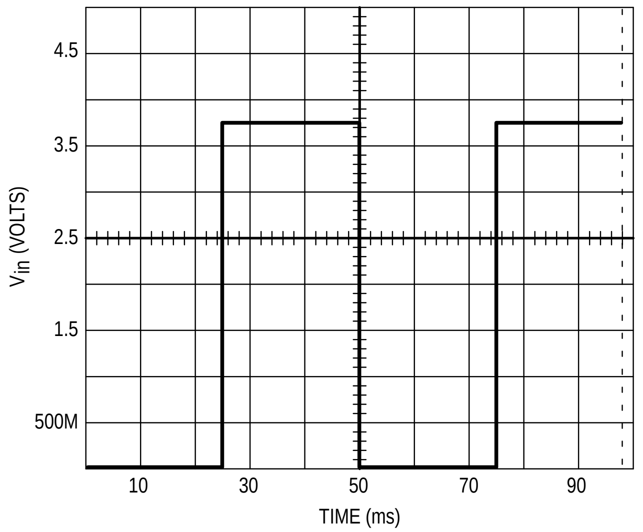



**Figure 6. 20 Hz Square Wave Input**

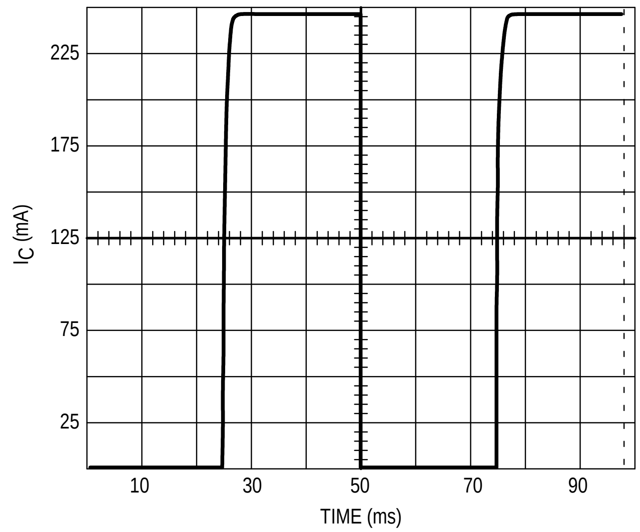



**Figure 7. 20 Hz Square Wave Response**

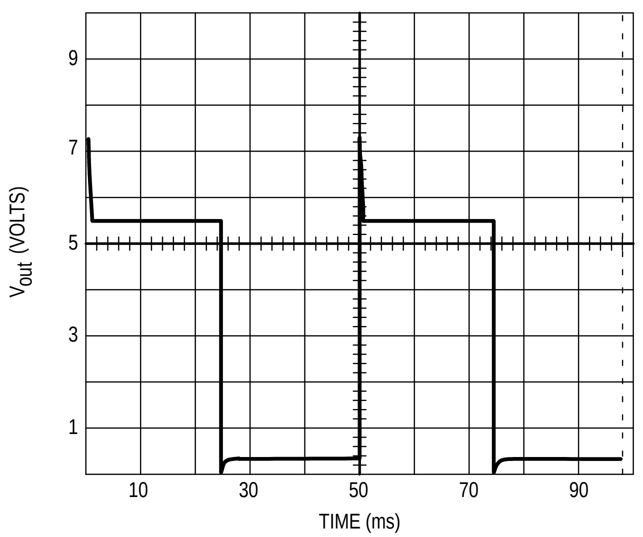



**Figure 8. 20 Hz Square Wave Response**

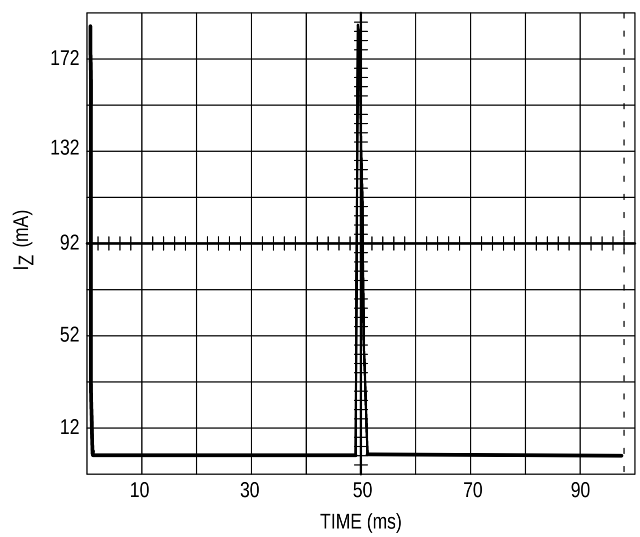



**Figure 9. 20 Hz Square Wave Response**

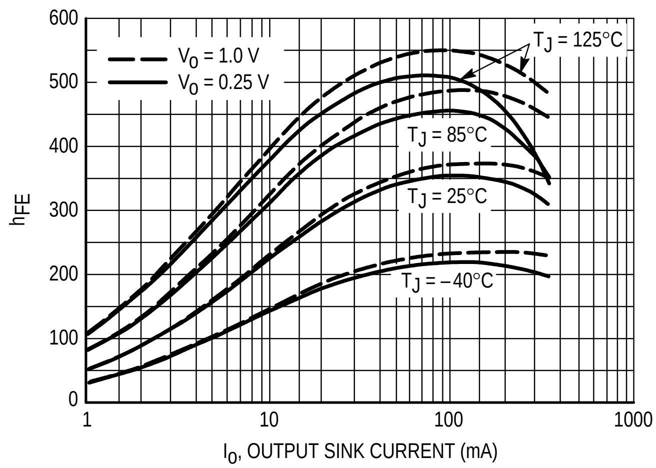



**Figure 10. Pulsed Current Gain**

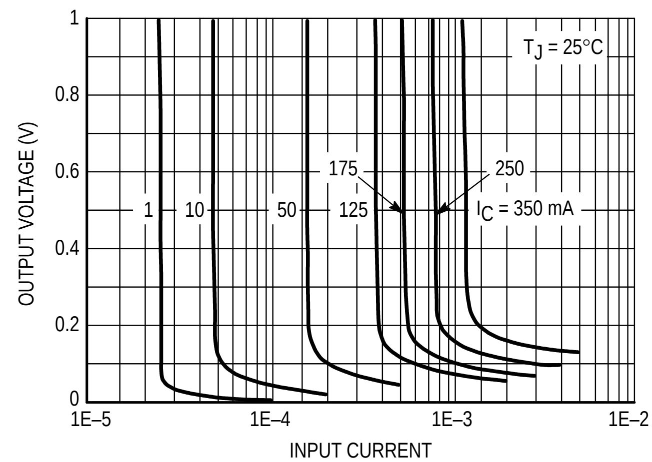
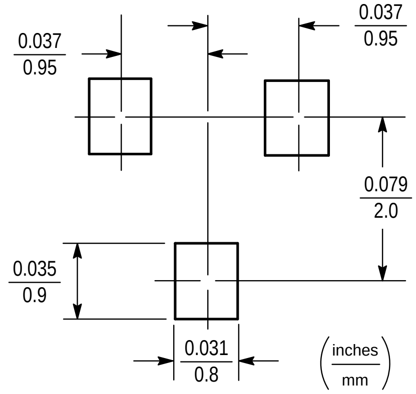



**Figure 11. Collector Saturation Region**

# INFORMATION FOR USING THE SOT–23 SURFACE MOUNT PACKAGE

## MINIMUM RECOMMENDED FOOTPRINT FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to insure proper solder connection interface between the board and the package. With the correct pad geometry, the packages will self align when subjected to a solder reflow process.




**SOT–23**

## SOT–23 POWER DISSIPATION

The power dissipation of the SOT–23 is a function of the pad size. This can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by $T_{J(max)}$, the maximum rated junction temperature of the die, $R_{\theta JA}$, the thermal resistance from the device junction to ambient, and the operating temperature, $T_A$. Using the values provided on the data sheet for the SOT–23 package, $P_D$ can be calculated as follows:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature $T_A$ of 25°C, one can calculate the power dissipation of the device which in this case is 225 milliwatts.

$$P_D = \frac{150°C - 25°C}{556°C/W} = 225 \text{ milliwatts}$$

The 556°C/W for the SOT–23 package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 225 milliwatts. There are other alternatives to achieving higher power dissipation from the SOT–23 package. Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad™. Using a board material such as Thermal Clad, an aluminum core board, the power dissipation can be doubled using the same footprint.

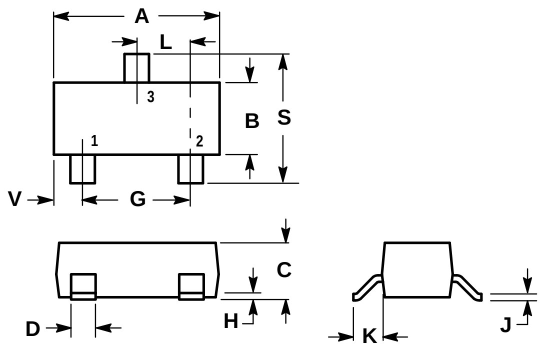
## SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling.

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

## PACKAGE DIMENSIONS




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. MAXIUMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.1102 | 0.1197 | 2.80 | 3.04 |
| B | 0.0472 | 0.0551 | 1.20 | 1.40 |
| C | 0.0350 | 0.0440 | 0.89 | 1.11 |
| D | 0.0150 | 0.0200 | 0.37 | 0.50 |
| G | 0.0701 | 0.0807 | 1.78 | 2.04 |
| H | 0.0005 | 0.0040 | 0.013 | 0.100 |
| J | 0.0034 | 0.0070 | 0.085 | 0.177 |
| K | 0.0140 | 0.0285 | 0.35 | 0.69 |
| L | 0.0350 | 0.0401 | 0.89 | 1.02 |
| S | 0.0830 | 0.1039 | 2.10 | 2.64 |
| V | 0.0177 | 0.0236 | 0.45 | 0.60 |

STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

**CASE 318–08**
**ISSUE AE**

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