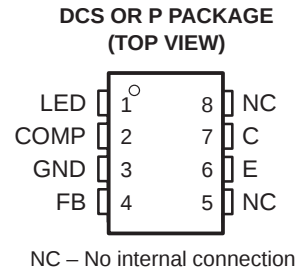


- **TL1431 Precision Programmable Reference (2.5 V) and an Optocoupler in a Single Package**
- **Reference Voltage Tolerance**
  - TPS5904     0.8%
  - TPS5904A   0.4%
- **Controlled Optocoupler CTRs:**
  - TPS5904     100% to 400%
  - TPS5904A   150% to 300%
- **High Withstand Voltage (WTV), 7500 V Peak for 1 Minute**
- **Safety Regulatory Approvals**
  - UL . . . File Number E65085
  - FIMKO, SEMKO, NEMKO, DEMKO
    - EN60065/IEC 65
    - EN60950/IEC 950
  - VDE 0884, Level 4 (6000-V Insulation)

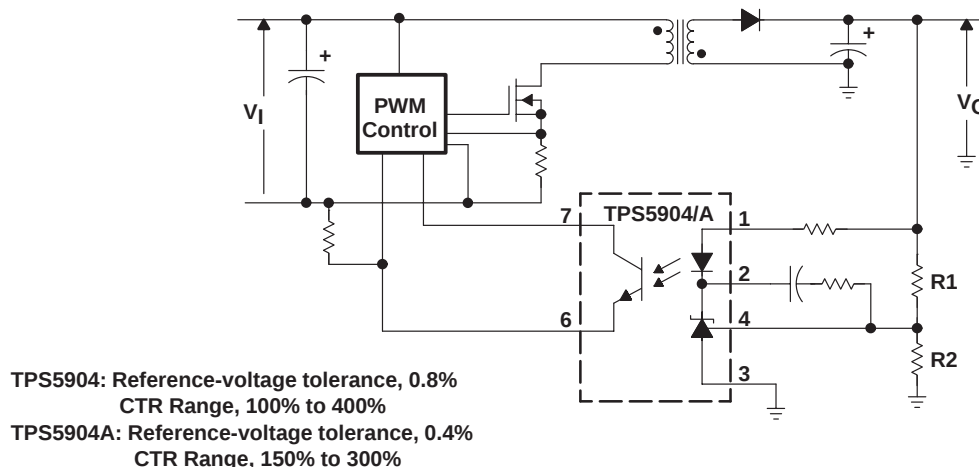


## description

The TPS5904 and TPS5904A optoisolated feedback amplifiers consist of the industry standard TL1431 precision programmable reference and an optocoupler. Reference-voltage tolerance for the TPS5904 is 0.8%, and for the TPS5904A, 0.4%. The devices are primarily intended for use as the error-amplifier/reference/isolation-amplifier element in isolated ac-to-dc power supplies and dc/dc converters. The optocoupler is a gallium-arsenide (GaAs) light-emitting diode that emits at a wavelength of 940 nm, combined with a silicon phototransistor. The current transfer ratio (CTR) ranges from 100% to 400% in the standard version. The TPS5904A version with a 150%-to-300% CTR is available for higher-performance applications. When using the TPS5904 or TPS5904A, power-supply designers can reduce component count and save space in tightly packaged designs. The tight-tolerance reference eliminates the need for adjustments in many applications.

The TPS5904 and TPS5904A are characterized for operation from  $-40^{\circ}\text{C}$  to  $100^{\circ}\text{C}$ . Each device is supplied in an 8-pin DIP or in an 8-pin gull-wing surface-mount package (DCS).

## typical application

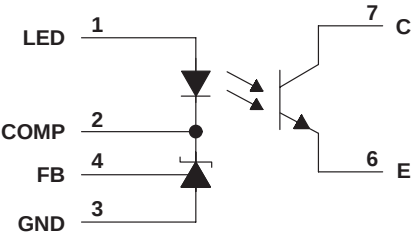


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TPS5904, TPS5904A
OPTOISOLATED FEEDBACK AMPLIFIERS

SOES016D – MAY 1995 – REVISED JANUARY 1998

functional block diagram



Terminal Functions

| TERMINAL<br>NAME | NO.  | I/O | DESCRIPTION                             |
|------------------|------|-----|-----------------------------------------|
| C                | 7    |     | Phototransistor collector               |
| COMP             | 2    | O   | Light-emitting diode and TL431 cathodes |
| E                | 6    |     | Phototransistor emitter                 |
| FB               | 4    | I   | Feedback                                |
| GND              | 3    |     | Ground                                  |
| LED              | 1    | I   | Light-emitting diode anode              |
| NC               | 5, 8 |     | No connection                           |

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)†

|                                                                                     |                               |
|-------------------------------------------------------------------------------------|-------------------------------|
| Input power dissipation at (or below) T <sub>A</sub> = 25°C (see Note 1)            | 250 mW                        |
| Input LED current, I <sub>I(LED)</sub>                                              | 50 mA                         |
| Input LED voltage, V <sub>I(LED)</sub>                                              | 37 V                          |
| Input diode reverse voltage                                                         | 6 V                           |
| Output power dissipation at (or below) T <sub>A</sub> = 25°C (see Note 2)           | 150 mW                        |
| Output collector-to-emitter voltage                                                 | 35 V                          |
| Output emitter-to-collector voltage                                                 | 7 V                           |
| Output collector current                                                            | 50 mA                         |
| Total continuous power dissipation at (or below) T <sub>A</sub> = 25°C (see Note 3) | 350 mW                        |
| Operating free-air temperature range, T <sub>A</sub>                                | –40°C to 100°C                |
| Storage temperature range, T <sub>stg</sub>                                         | –55°C to 150°C                |
| Total input-to-output voltage                                                       | 7.5 kV peak or dc (5.3 kVrms) |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds                        | 260°C                         |
| Flammability                                                                        | (see Note 4)                  |

† 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. Derate linearly from 25°C at a rate of 2.95 mW/°C.
  - 2. Derate linearly from 25°C at a rate of 1.76 mW/°C.
  - 3. Derate linearly from 25°C at a rate of 4.12 mW/°C.
  - 4. Optocoupler total-package flame retardancy is tested to IEC695-2-2 using a flame application time of 30 seconds. Outer mold compound is verified to meet UL 94V-0.

**electrical characteristics,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)**

**input**

| PARAMETER                                                |                                                                                   | TEST CONDITIONS                                                                                                            | MIN | TYP  | MAX  | UNIT          |
|----------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|-----|------|------|---------------|
| $V_F$                                                    | Light-emitting diode forward voltage                                              | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>See Figure 1                                                                    |     | 1.2  | 1.4  | V             |
| $I_R$                                                    | Light-emitting diode reverse current                                              | $V_R = 6\text{ V}$                                                                                                         |     |      | 10   | $\mu\text{A}$ |
| $V_{\text{ref}}$                                         | Reference voltage                                                                 | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>See Figure 1                                                                    |     | 2.48 | 2.52 | V             |
|                                                          |                                                                                   |                                                                                                                            |     | 2.49 | 2.51 |               |
| $V_{\text{ref}}(\text{dev})$                             | Deviation of reference voltage over temperature                                   | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>$T_A = 25^\circ\text{C}$ to $100^\circ\text{C}$ ,<br>See Figure 1               |     | 25   |      | mV            |
| $\frac{\Delta V_{\text{ref}}}{\Delta V_{I(\text{LED})}}$ | Ratio of reference voltage change-to-change in input light-emitting-diode voltage | $\Delta V_{I(\text{LED})} = 4\text{ V}$ to $37\text{ V}$ ,<br>See Figure 2                                                 |     | -1.1 | -2   | mV/V          |
| $I_{I(\text{FB})}$                                       | Feedback input current                                                            | $I_{I(\text{LED})} = 10\text{ mA}$ ,<br>See Figure 3                                                                       |     | 1.5  | 3    | $\mu\text{A}$ |
| $I_{\text{ref}}(\text{dev})$                             | Deviation of reference input current over temperature                             | $I_{I(\text{LED})} = 10\text{ mA}$ ,<br>$T_A = 25^\circ\text{C}$ to $100^\circ\text{C}$ ,<br>See Figure 3                  |     | 0.5  |      | $\mu\text{A}$ |
| $I_{\text{DRV}}(\text{min})$                             | Minimum drive current                                                             | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>See Figure 1                                                                    |     | 0.45 | 1    | mA            |
| $I_{I(\text{off})}$                                      | Off-state input light-emitting-diode current                                      | $V_{I(\text{LED})} = 37\text{ V}$ ,<br>See Figure 4                                                                        |     | 0.18 | 0.5  | $\mu\text{A}$ |
| $ Z_{\text{kal}} ^\dagger$                               | Regulator output impedance                                                        | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>$I_{O(\text{COMP})} = 1\text{ mA}$ to $50\text{ mA}$ ,<br>$f \leq 1\text{ kHz}$ |     | 0.1  |      | $\Omega$      |

<sup>†</sup> This symbol is not currently listed within EIA or JEDEC standards for semiconductor symbology.

**output**

| PARAMETER                   |                                     | TEST CONDITIONS                                 | MIN | TYP | MAX | UNIT |
|-----------------------------|-------------------------------------|-------------------------------------------------|-----|-----|-----|------|
| $I_{\text{CEO}}$            | Collect dark current                | $V_{\text{CE}} = 35\text{ V}$ ,<br>See Figure 5 |     |     | 100 | nA   |
| $V_{(\text{BR})\text{ECO}}$ | Emitter-collector voltage breakdown | $I_E = 100\text{ }\mu\text{A}$                  | 7   |     |     | V    |

**coupler**

| PARAMETER                   |                                      | TEST CONDITIONS                                                                                                                  | MIN  | TYP | MAX  | UNIT |
|-----------------------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|------|-----|------|------|
| CTR                         | Current transfer ratio               | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>$V_{\text{CE}} = 5\text{ V}$ ,<br>$I_{I(\text{LED})} = 5\text{ mA}$ ,<br>See Figure 6 | 100% |     | 400% |      |
|                             |                                      |                                                                                                                                  | 150% |     | 300% |      |
| $V_{\text{CE}}(\text{sat})$ | Collector-emitter saturation voltage | $V_O(\text{COMP}) = V_{I(\text{FB})}$ ,<br>$I_C = 1\text{ mA}$ ,<br>$I_{I(\text{LED})} = 10\text{ mA}$ ,<br>See Figure 6         |      | 0.1 | 0.2  | V    |
| $V_{\text{iso}}^\dagger$    | Isolation voltage                    | $I_{IO} = 10\text{ }\mu\text{A}$ ,<br>$f = 60\text{ Hz}$                                                                         | 7500 |     |      | V    |
| $C_{io}$                    | Input to output capacitance          | $V_{IO} = 0$ ,<br>$f = 1\text{ kHz}$                                                                                             |      | 0.6 |      | pF   |

<sup>†</sup> This symbol is not currently listed within EIA or JEDEC standards for semiconductor symbology.

# TPS5904, TPS5904A OPTOISOLATED FEEDBACK AMPLIFIERS

SOES016D – MAY 1995 – REVISED JANUARY 1998

## PARAMETER MEASUREMENT INFORMATION

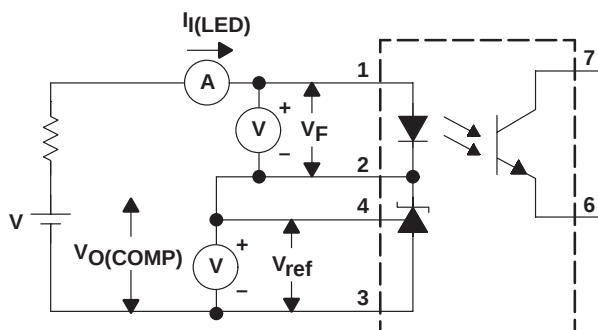


Figure 1.  $V_{ref}$ ,  $V_F$ ,  $I_{min}$  Test Circuit

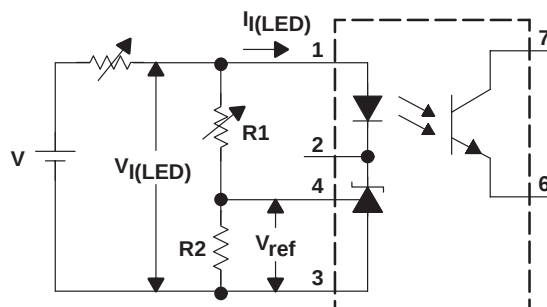


Figure 2.  $\Delta V_{ref}/\Delta V_{I(LED)}$  Test Circuit

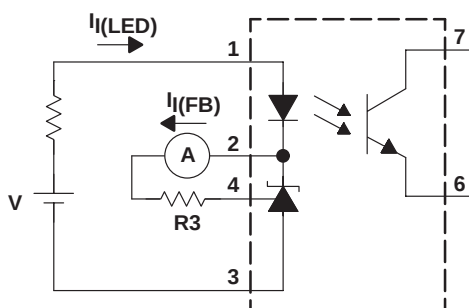


Figure 3.  $I_{I(FB)}$  Test Circuit

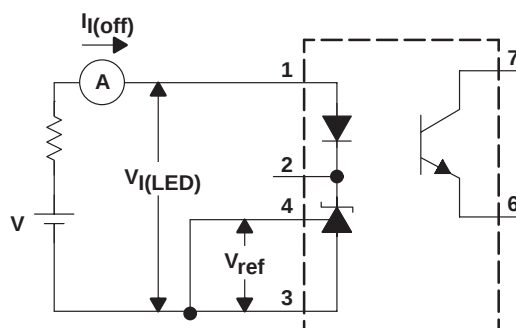


Figure 4.  $I_{I(off)}$  Test Circuit

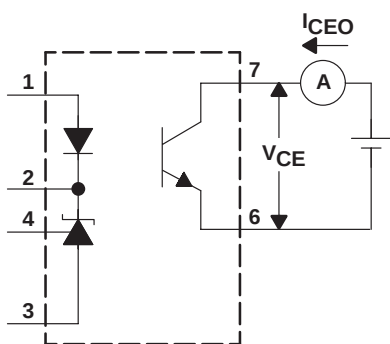


Figure 5.  $I_{CEO}$  Test Circuit

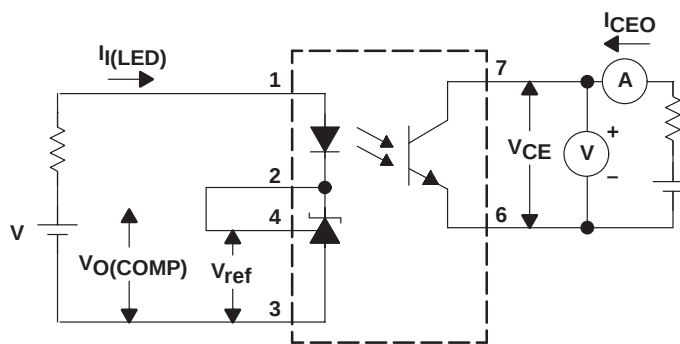


Figure 6. CTR,  $V_{CE(sat)}$  Test Circuit

TYPICAL CHARACTERISTICS

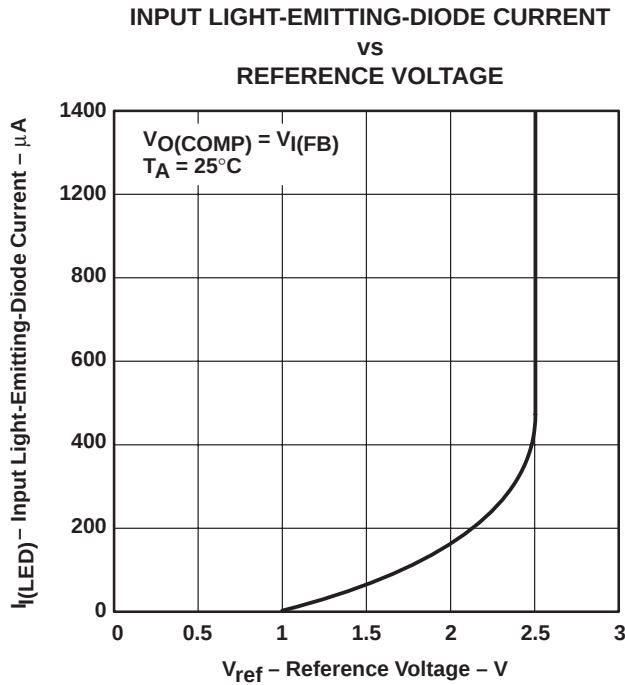


Figure 7

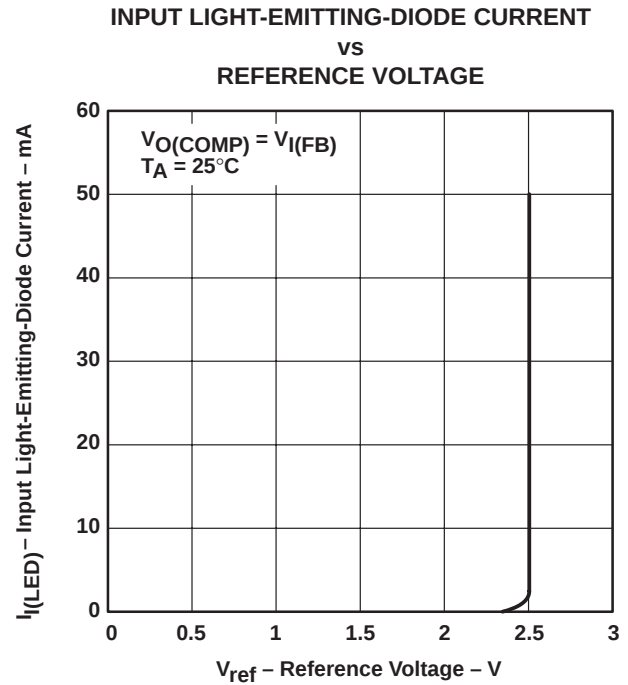


Figure 8

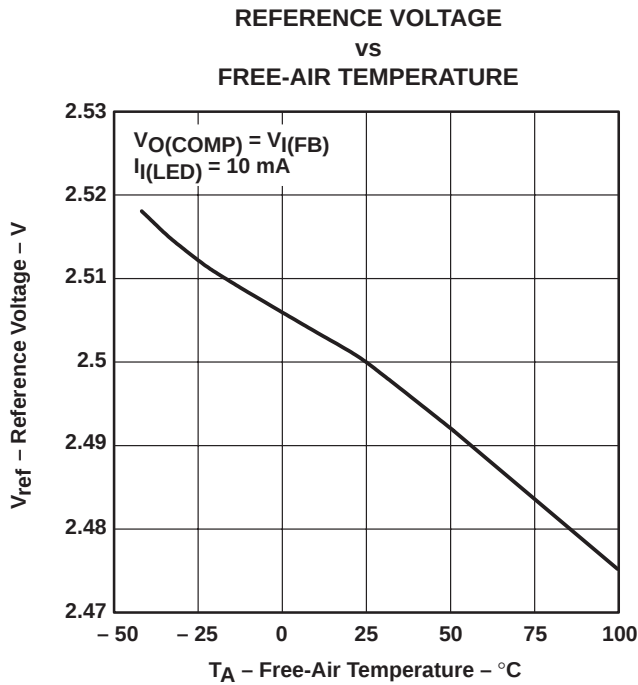


Figure 9

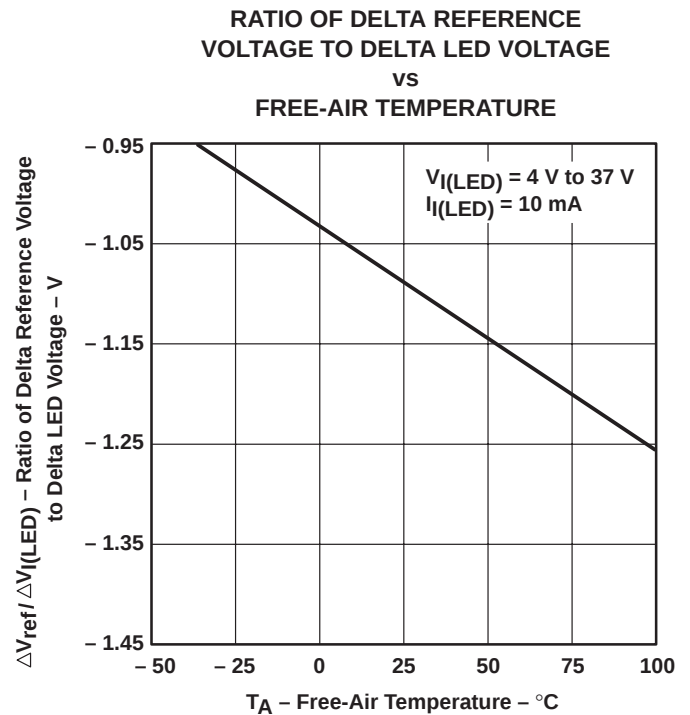


Figure 10

# TPS5904, TPS5904A OPTOISOLATED FEEDBACK AMPLIFIERS

SOES016D – MAY 1995 – REVISED JANUARY 1998

## TYPICAL CHARACTERISTICS

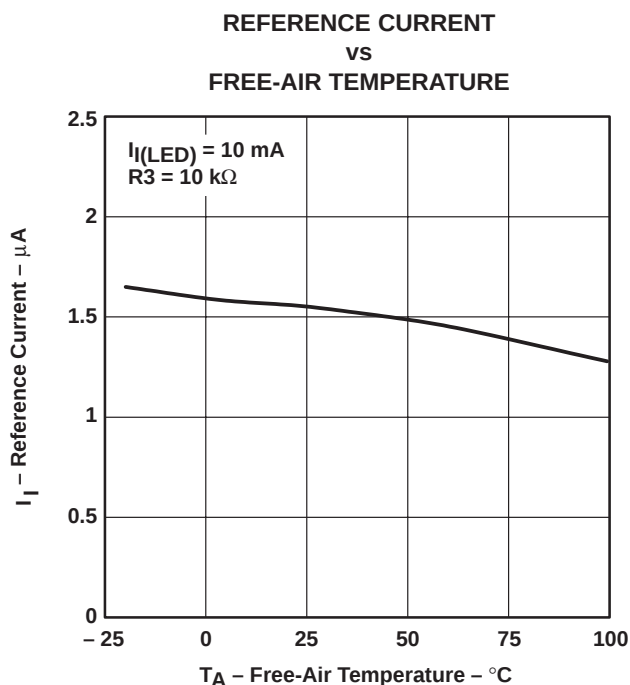


Figure 11

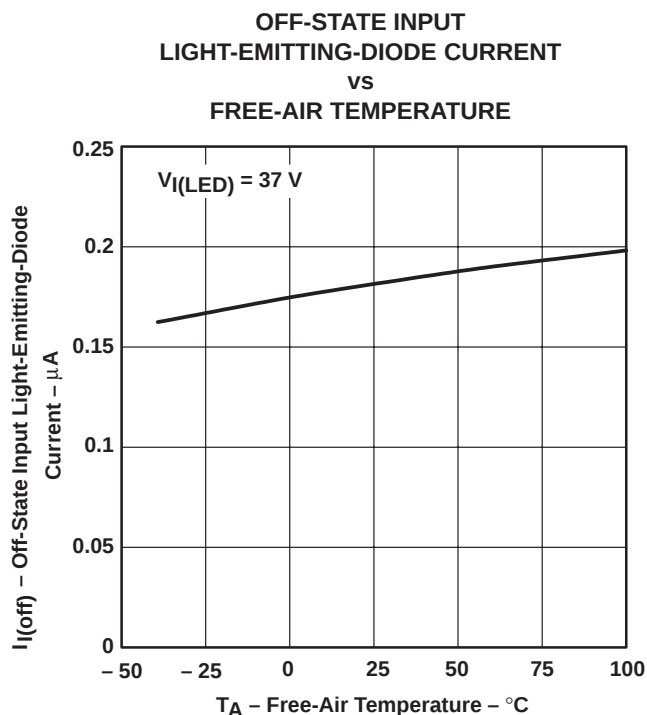


Figure 12

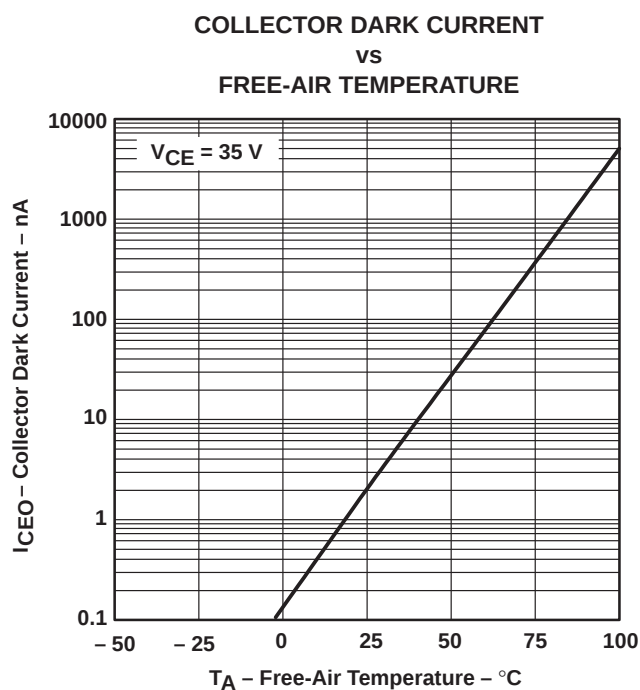


Figure 13

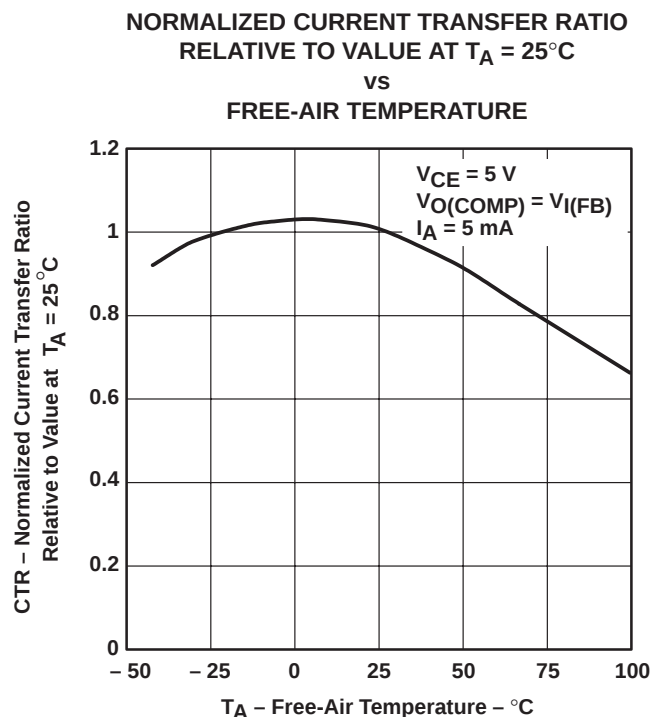


Figure 14

TYPICAL CHARACTERISTICS

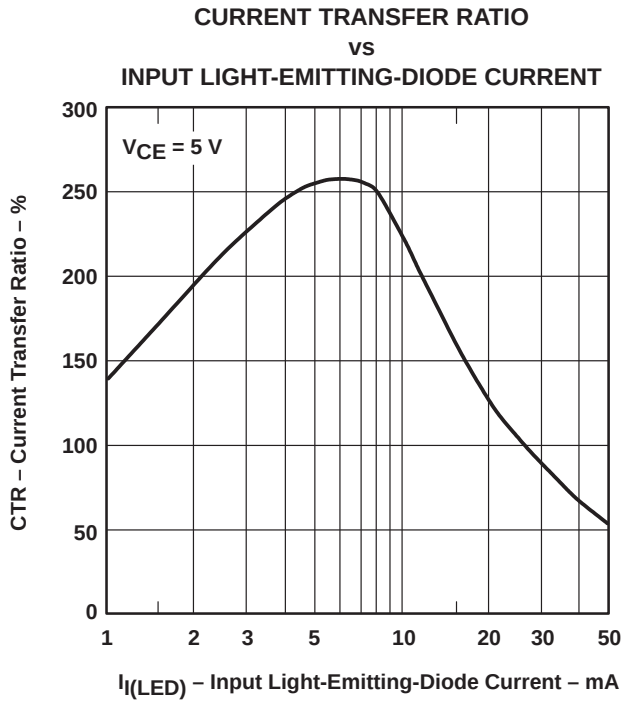


Figure 15

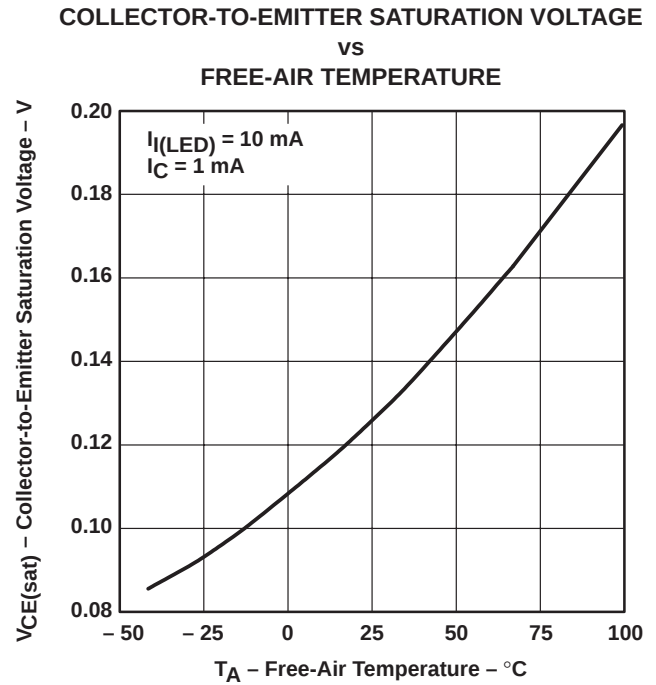


Figure 16

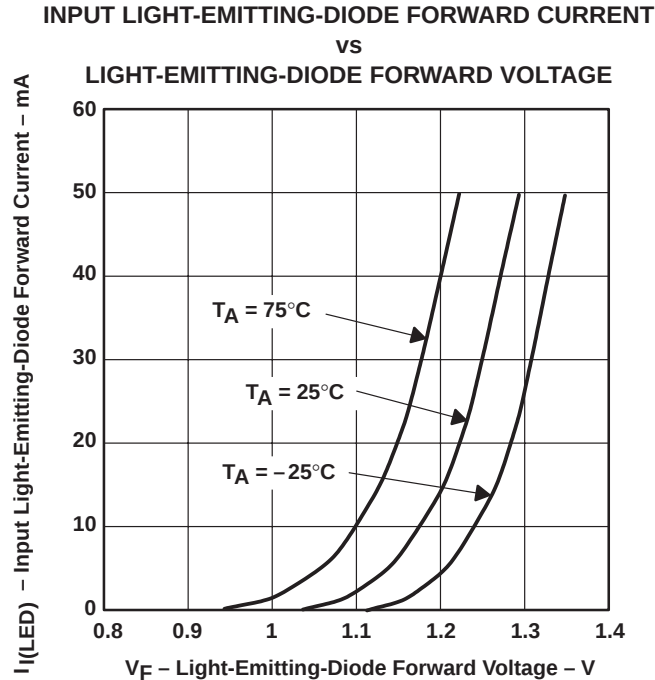


Figure 17

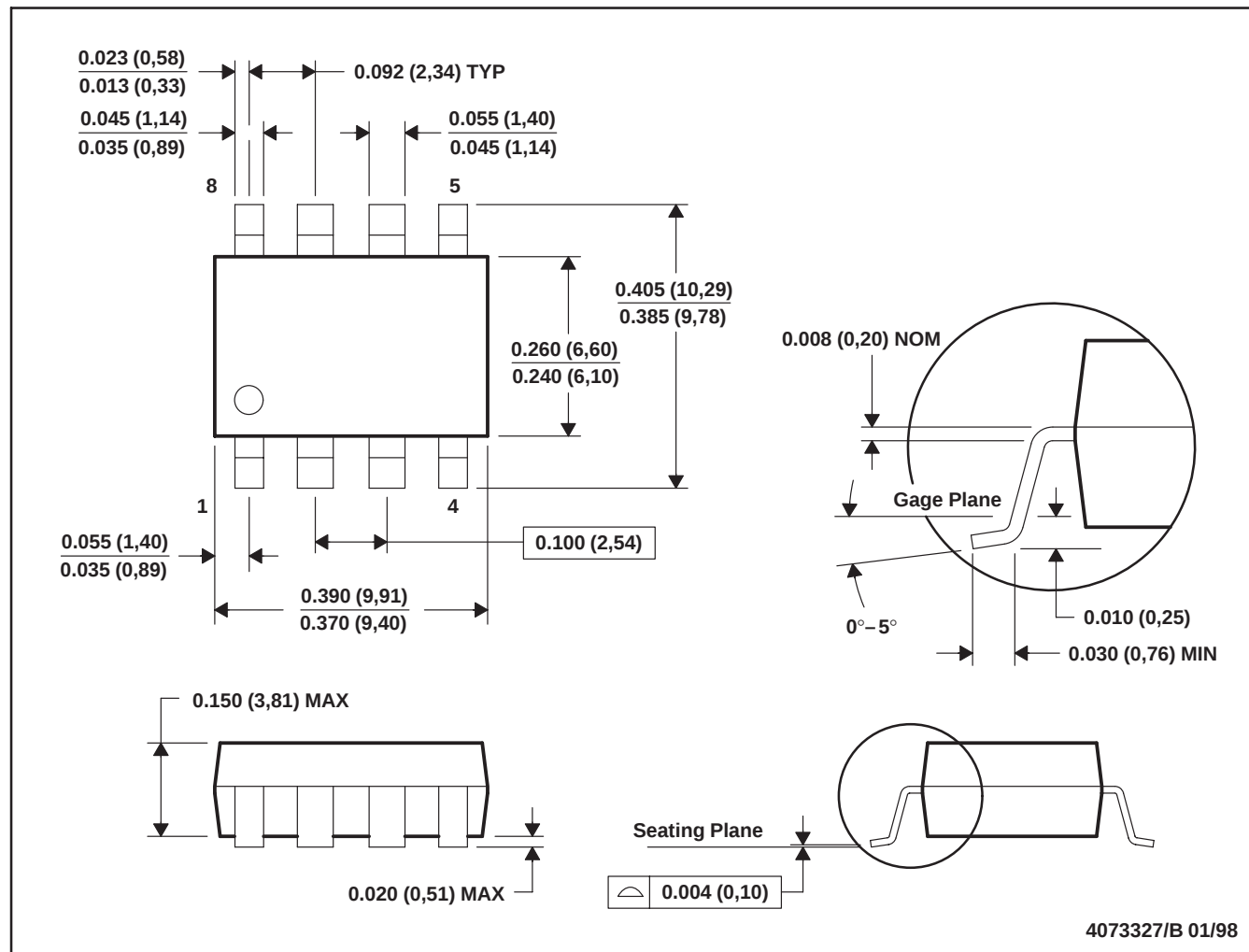
# TPS5904, TPS5904A OPTOISOLATED FEEDBACK AMPLIFIERS

SOES016D – MAY 1995 – REVISED JANUARY 1998

## MECHANICAL DATA

DCS (R-PDSO-G8)

PLASTIC DUAL SMALL-OUTLINE OPTO COUPLER

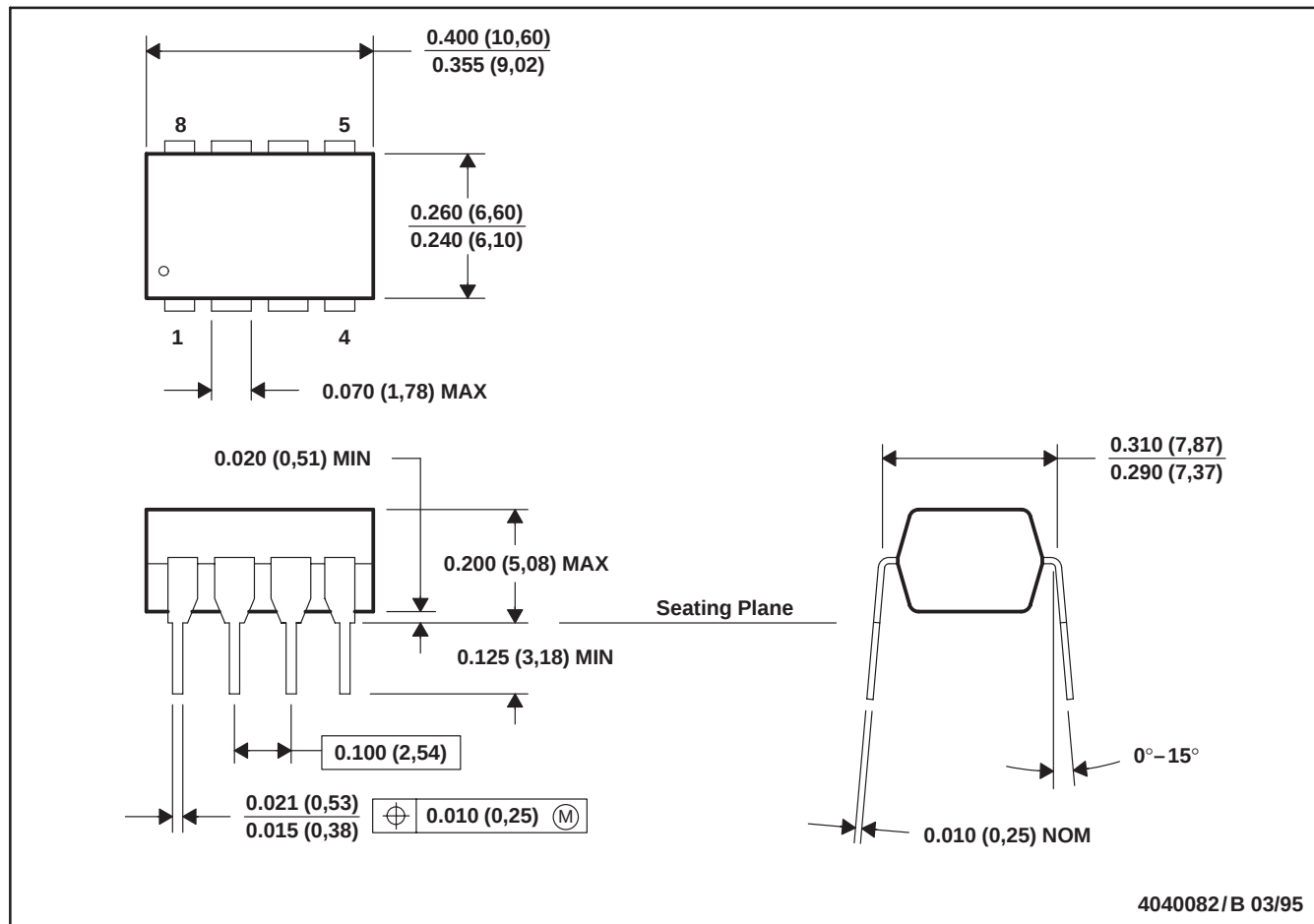


NOTES: A. All linear dimensions are in inches(millimeters).  
B. This drawing is subject to change without notice.

MECHANICAL DATA

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



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

## **IMPORTANT NOTICE**

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.