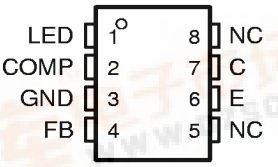
TPS5904, TPS5904A
OPTOISOLATED FEEDBACK AMPLIFIERS

SOES016D – MAY 1995 – REVISED JANUARY 1998

- 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)

DCS OR P PACKAGE
(TOP VIEW)



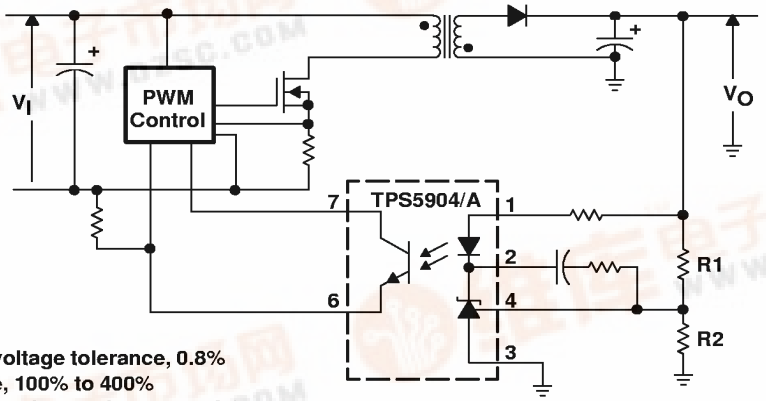
NC – No internal connection

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°C to 100°C. Each device is supplied in an 8-pin DIP or in an 8-pin gull-wing surface-mount package (DCS).

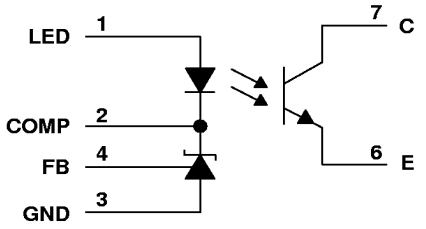
typical application



TPS5904: Reference-voltage tolerance, 0.8%
CTR Range, 100% to 400%
TPS5904A: Reference-voltage tolerance, 0.4%
CTR Range, 150% to 300%

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.

functional block diagram



Terminal Functions

TERMINAL NAME	TERMINAL 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_A = 25°C (see Note 1) . . . . . 250 mW
Input LED current, $I_{I(LED)}$ . . . . . 50 mA
Input LED voltage, $V_{I(LED)}$ . . . . . 37 V
Input diode reverse voltage . . . . . 6 V
Output power dissipation at (or below) T_A = 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_A = 25°C (see Note 3) . . . . . 350 mW
Operating free-air temperature range, T_A . . . . . –40°C to 100°C
Storage temperature range, T_{stg} . . . . . –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°C (unless otherwise noted)

input

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_F	Light-emitting diode forward voltage		$V_{O(COMP)} = V_{I(FB)}$, See Figure 1	$I_{I(LED)}$ = 10 mA,		1.2	1.4	V
I_R	Light-emitting diode reverse current		V_R = 6 V				10	μA
V_{ref}	Reference voltage	TPS5904	$V_{O(COMP)} = V_{I(FB)}$, See Figure 1	$I_{I(LED)}$ = 10 mA,	2.48	2.5	2.52	V
		TPS5904A			2.49	2.5	2.51	
$V_{ref(dev)}$	Deviation of reference voltage over temperature		$V_{O(COMP)} = V_{I(FB)}$, T_A = 25°C to 100°C,	$I_{I(LED)}$ = 10 mA, See Figure 1		25		mV
$\frac{\Delta V_{ref}}{\Delta V_{I(LED)}}$	Ratio of reference voltage change-to-change in input light-emitting-diode voltage		$\Delta V_{I(LED)}$ = 4 V to 37 V, See Figure 2	$I_{I(LED)}$ = 10 mA,		–1.1	–2	mV/V
$I_{I(FB)}$	Feedback input current		$I_{I(LED)}$ = 10 mA, See Figure 3	R3 = 10 kΩ ,		1.5	3	μA
$I_{ref(dev)}$	Deviation of reference input current over temperature		$I_{I(LED)}$ = 10 mA, T_A = 25°C to 100°C,	R3 = 10 kΩ, See Figure 3		0.5		μA
$I_{DRV(min)}$	Minimum drive current		$V_{O(COMP)} = V_{I(FB)}$,	See Figure 1		0.45	1	mA
$I_{I(off)}$	Off-state input light-emitting-diode current		$V_{I(LED)}$ = 37 V, See Figure 4	$V_{I(FB)}$ = 0,		0.18	0.5	μA
$\lvert Z_{ka} \rvert$†	Regulator output impedance		$V_{O(COMP)} = V_{I(FB)}$, $I_{O(COMP)}$ = 1 mA to 50 mA	f ≤ 1 kHz,		0.1		Ω

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

output

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

coupler

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
CTR	Current transfer ratio	TPS5904	$V_{O(COMP)} = V_{I(FB)}$, V_{CE} = 5 V,	$I_{I(LED)}$ = 5 mA, See Figure 6	100%		400%	
		TPS5904A			150%		300%	
$V_{CE(sat)}$	Collector-emitter saturation voltage		$V_{O(COMP)} = V_{I(FB)}$, I_C = 1 mA,	$I_{I(LED)}$ = 10 mA, See Figure 6		0.1	0.2	V
V_{iso}†	Isolation voltage		I_{IO} = 10 μA,	f = 60 Hz	7500			V
C_{io}	Input to output capacitance		V_{IO} = 0,	f = 1 kHz		0.6		pF

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

PARAMETER MEASUREMENT INFORMATION

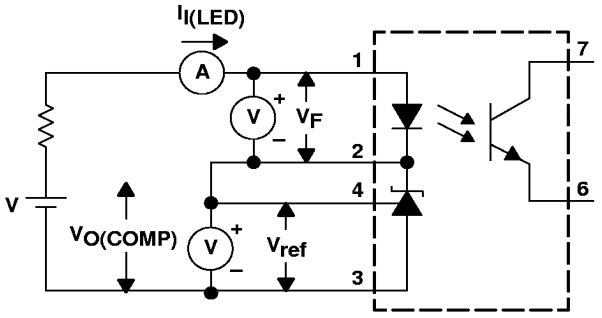


Figure 1. V_{ref}, V_F, I_{min} Test Circuit

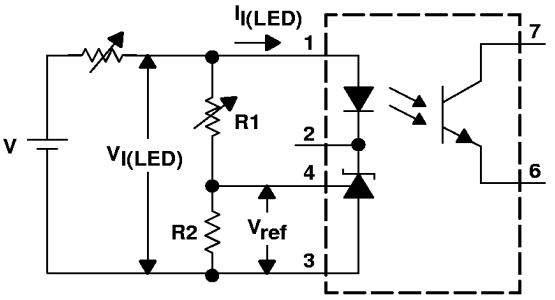


Figure 2. $\Delta V_{ref}/\Delta V_{I(LED)}$ Test Circuit

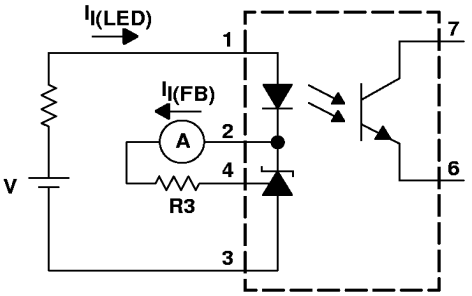


Figure 3. $I_{I(FB)}$ Test Circuit

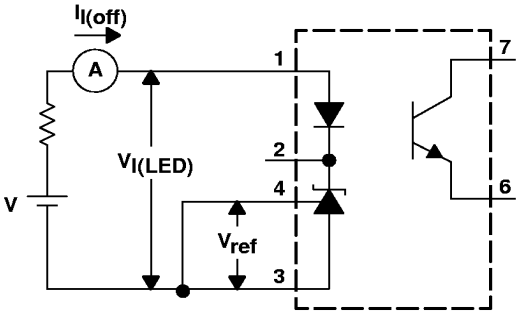


Figure 4. $I_{I(off)}$ Test Circuit

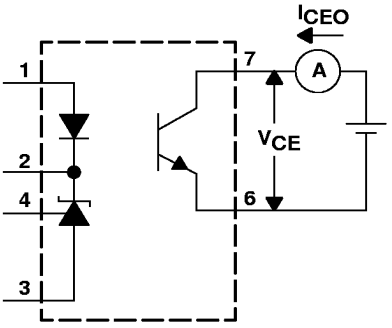


Figure 5. I_{CEO} Test Circuit

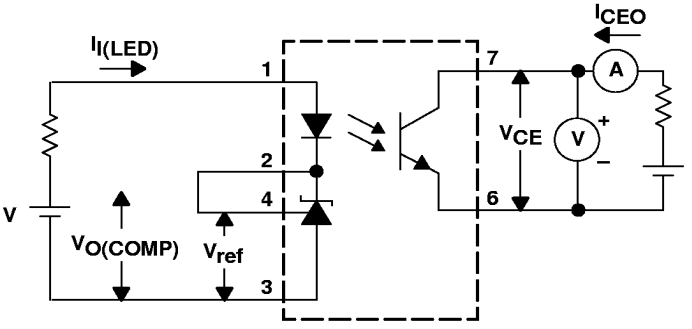


Figure 6. CTR, $V_{CE(sat)}$ Test Circuit

TYPICAL CHARACTERISTICS

INPUT LIGHT-EMITTING-DIODE CURRENT vs REFERENCE VOLTAGE

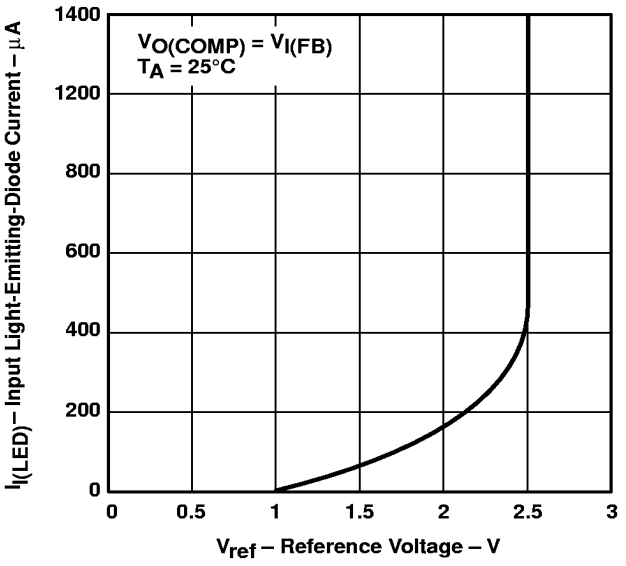


Figure 7

INPUT LIGHT-EMITTING-DIODE CURRENT vs REFERENCE VOLTAGE

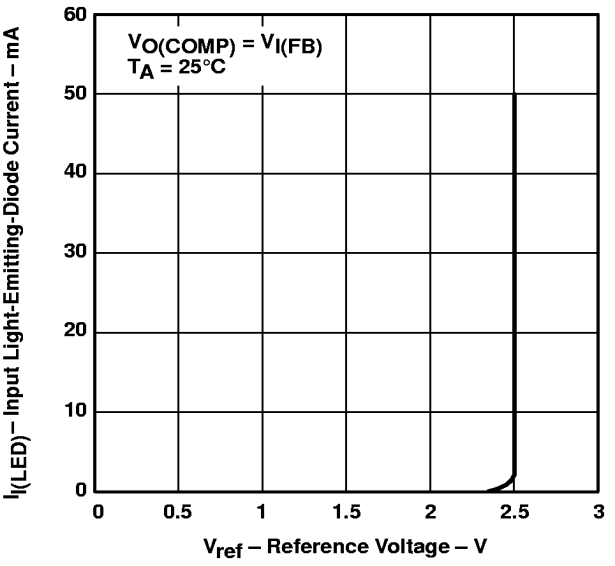


Figure 8

REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE

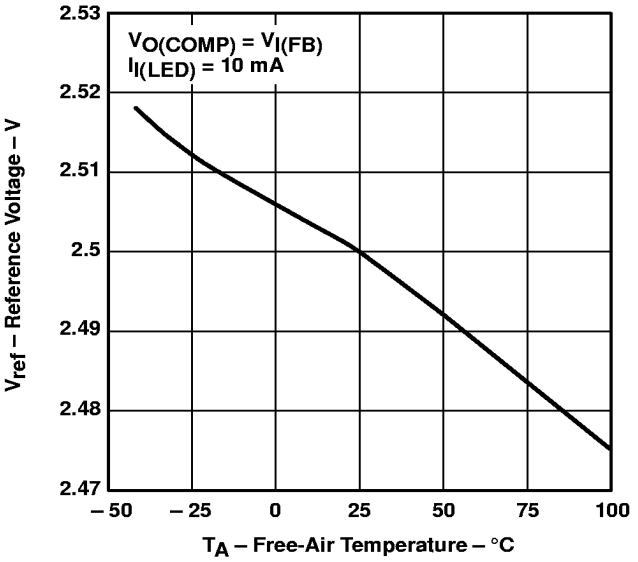


Figure 9

RATIO OF DELTA REFERENCE VOLTAGE TO DELTA LED VOLTAGE vs FREE-AIR TEMPERATURE

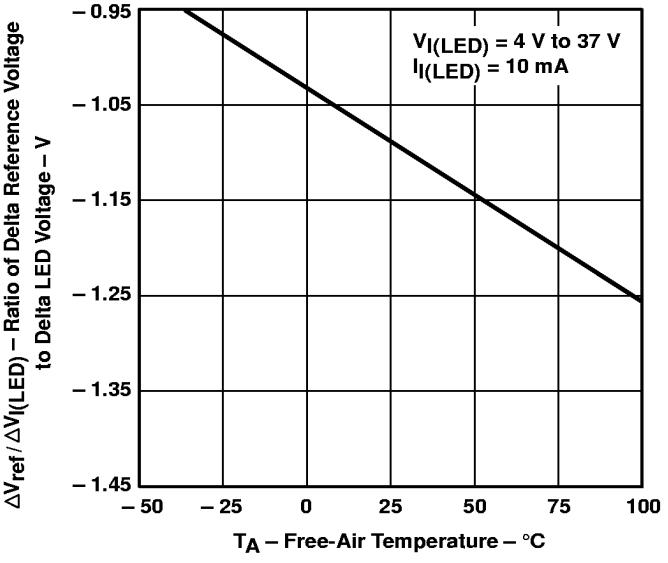


Figure 10

TYPICAL CHARACTERISTICS

REFERENCE CURRENT vs FREE-AIR TEMPERATURE

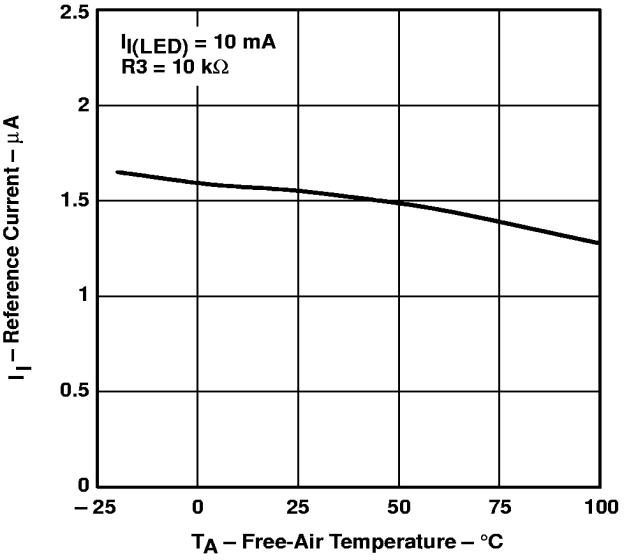


Figure 11

OFF-STATE INPUT LIGHT-EMITTING-DIODE CURRENT vs FREE-AIR TEMPERATURE

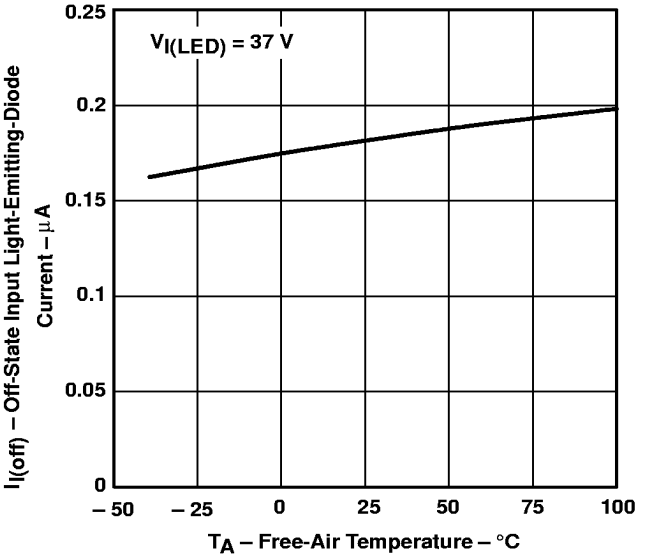


Figure 12

COLLECTOR DARK CURRENT vs FREE-AIR TEMPERATURE

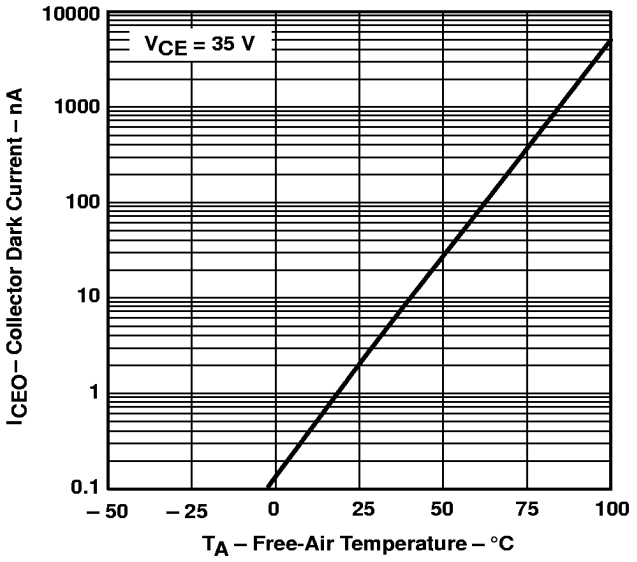


Figure 13

NORMALIZED CURRENT TRANSFER RATIO RELATIVE TO VALUE AT T_A = 25°C vs FREE-AIR TEMPERATURE

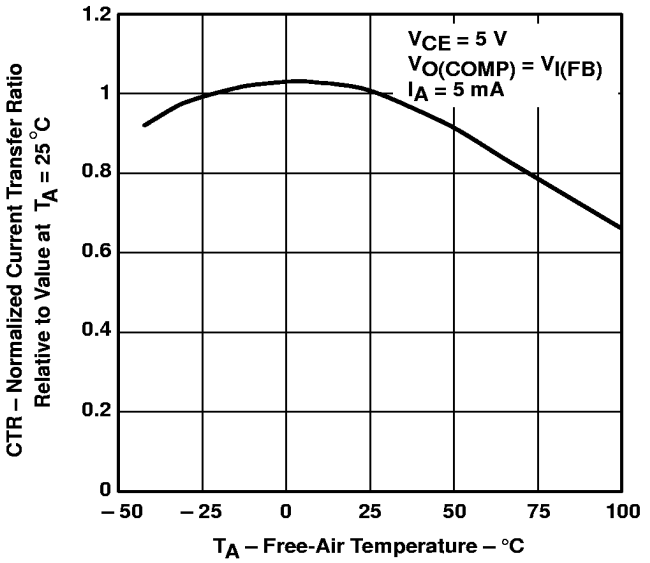


Figure 14

TYPICAL CHARACTERISTICS

CURRENT TRANSFER RATIO vs INPUT LIGHT-EMITTING-DIODE CURRENT

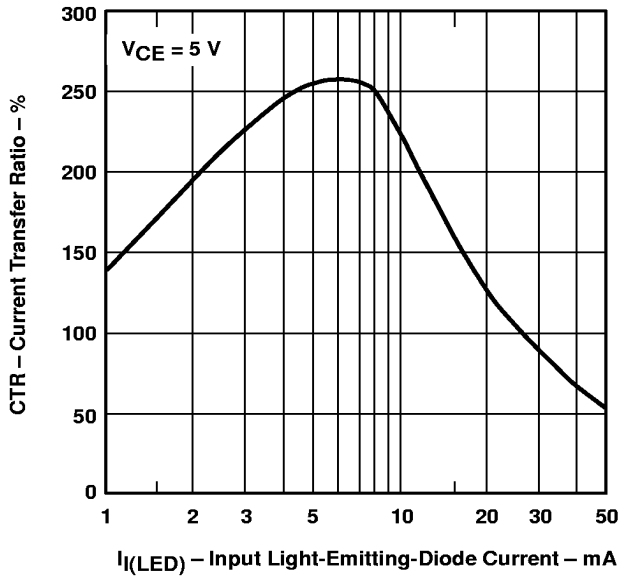


Figure 15

COLLECTOR-TO-EMITTER SATURATION VOLTAGE vs FREE-AIR TEMPERATURE

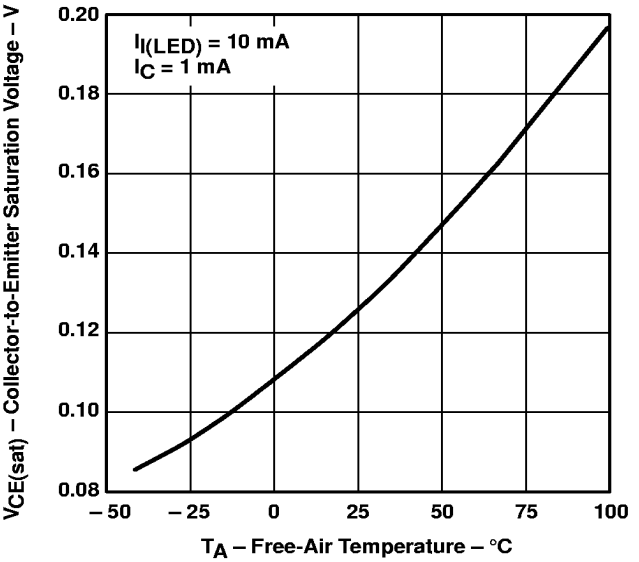


Figure 16

INPUT LIGHT-EMITTING-DIODE FORWARD CURRENT vs LIGHT-EMITTING-DIODE FORWARD VOLTAGE

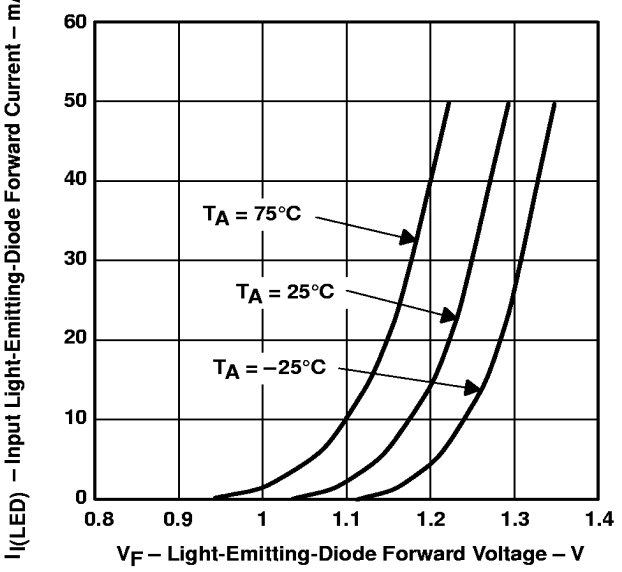
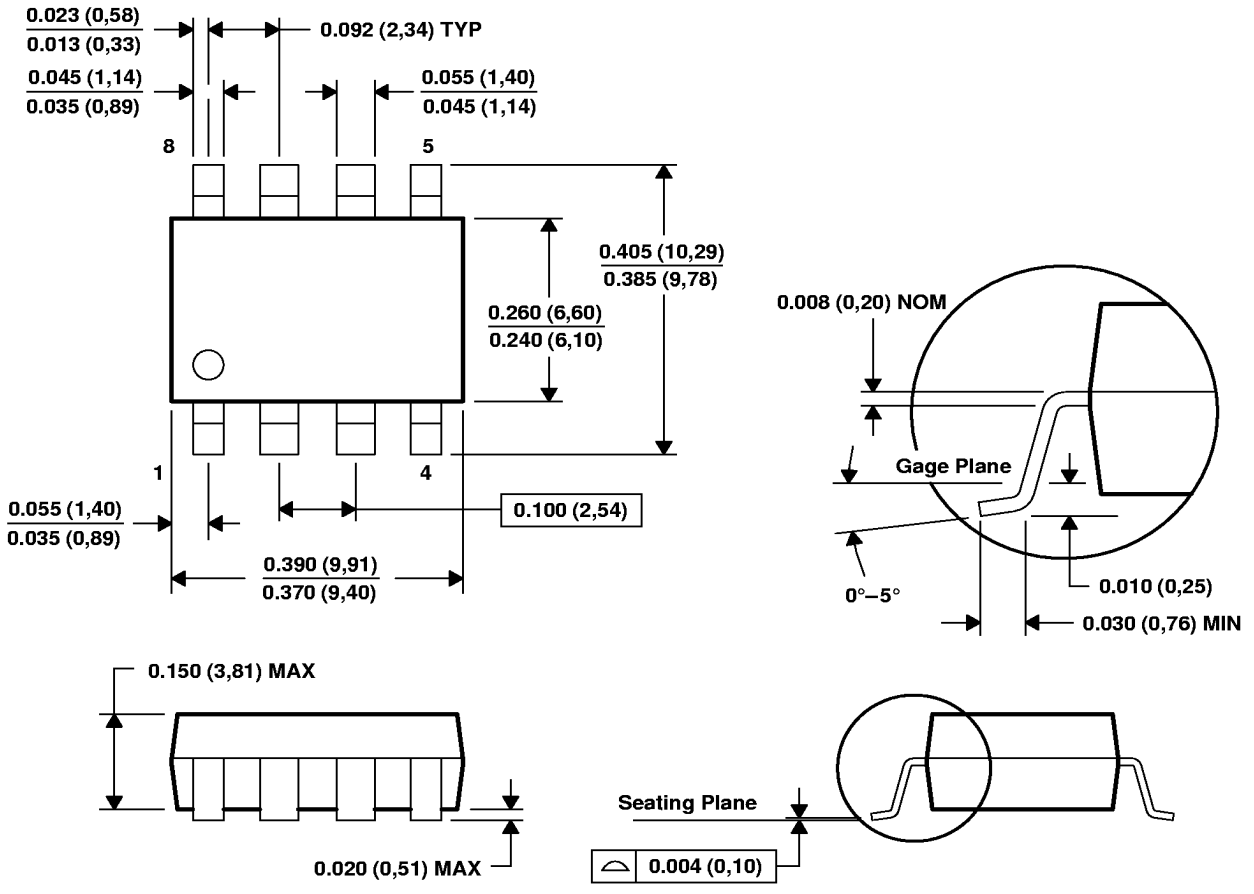


Figure 17

MECHANICAL DATA

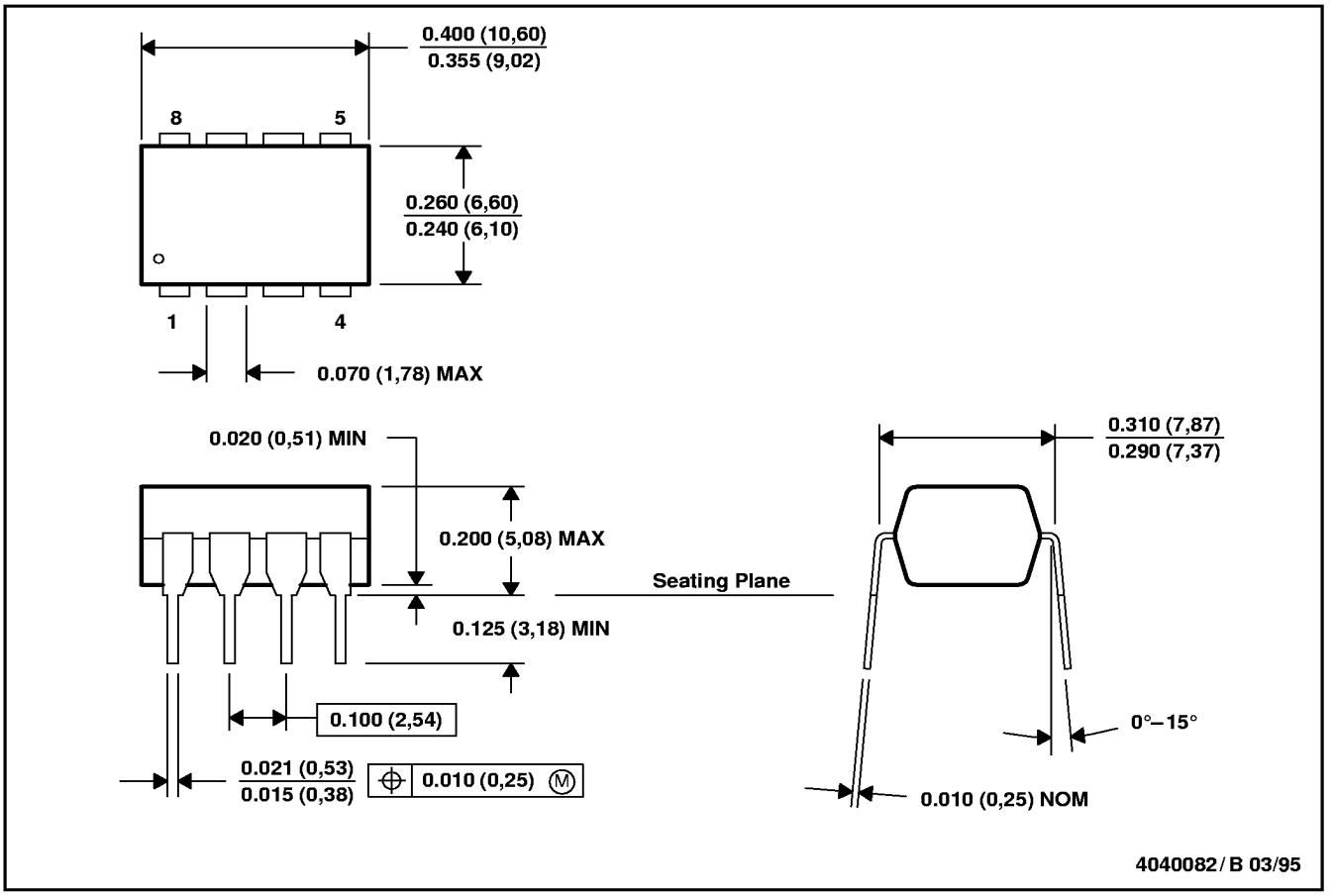
DCS (R-PDSO-G8) **PLASTIC DUAL SMALL-OUTLINE OPTO COUPLER**



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