TLC2801Z, TLC2801Y
Advanced LinCMOS™ LOW-NOISE PRECISION OPERATIONAL AMPLIFIERS

SLOS116B – JULY 1982 – REVISED SEPTEMBER 1996

- **Low Input Noise Voltage:**
  $35\ \text{nV}/\sqrt{\text{Hz}}$ Max at f = 10 Hz
  $15\ \text{nV}/\sqrt{\text{Hz}}$ Max at f = 1 kHz
- **Low Input Offset Voltage:**
  500 µV Max at $T_A = 25°C$
  1.5 mV Max at T_A = Full Range
- **Excellent Offset Voltage Stability With Temperature . . . 4 µV/°C Typ**
- **Low Input Bias Current:**
  1 pA Typ at $T_A = 25°C$
  250 pA Typ at $T_A = 150°C$
- **Specified for Both Single-Supply and Split-Supply Operation**
- **Common-Mode Input Voltage Range Includes the Negative Rail**

description

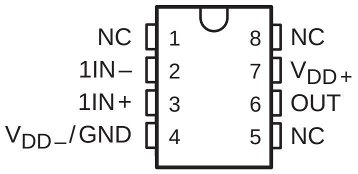
The TLC2801 is a precision, low-noise operational amplifier manufactured using Texas Instruments Advanced LinCMOS™ process. The TLC2801 combines the noise performance of the lowest-noise JFET amplifiers with the dc precision available previously only in bipolar amplifiers. The Advanced LinCMOS™ process uses silicon-gate technology to obtain input offset voltage stability with temperature and time that far exceeds that obtainable using metal-gate technology. In addition, this technology makes possible input impedance levels that meet or exceed levels offered by top-gate JFET and expensive dielectric-isolated devices.

The combination of excellent dc and noise performance with a common-mode input voltage range that includes the negative rail makes the TLC2801 an ideal choice for high-impedance, low-level signal conditioning applications in either single-supply or split-supply configurations.

The device inputs and output are designed to withstand –100-mA surge currents without sustaining latch-up. In addition, internal ESD-protection circuits prevent functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2; however, care should be exercised in handling these devices as exposure to ESD may result in degradation of the device parametric performance.

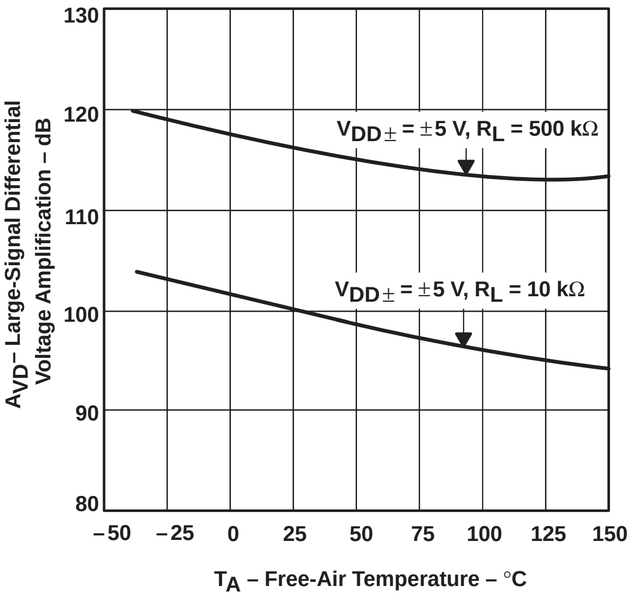
The TLC2801 is characterized for operation over the temperature range of –40°C to 150°C.

D OR P PACKAGE
(TOP VIEW)



NC – No internal connection

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE



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AVAILABLE OPTIONS

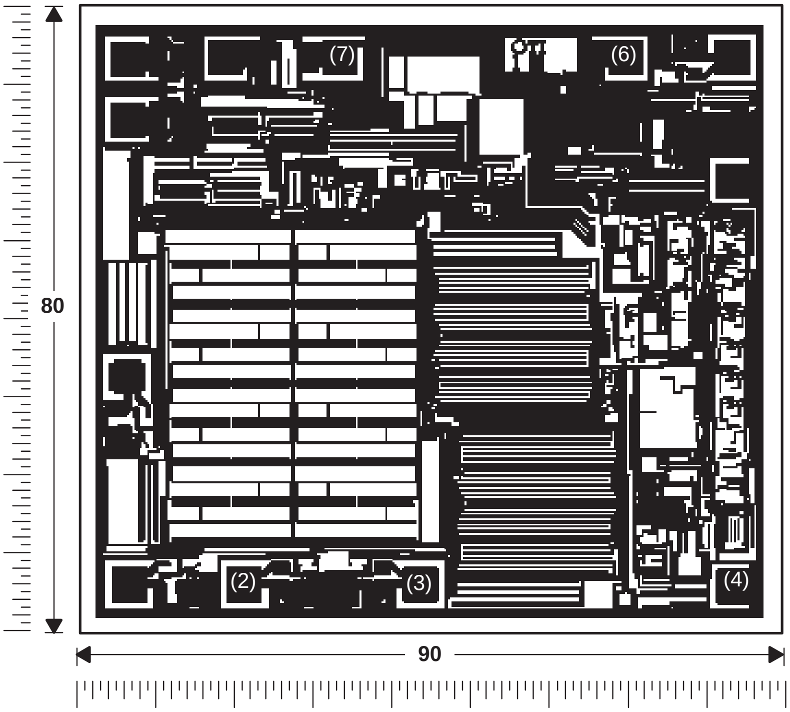
T_A	V_{IO}max AT 150°C	PACKAGED DEVICES		CHIP FORM (Y)
		SMALL OUTLINE (D)	PLASTIC DIP (P)	
–40°C to 150°C	1.5 mV	TLC2801ZD	TLC2801ZP	TLC2801Y

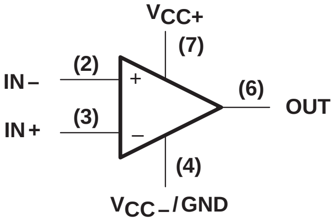
The D packages are available taped and reeled. Add R suffix to the device type when ordering (e.g., TLC2801ZDR).

TLC2801Y chip information

This chip, properly assembled, displays characteristics similar to the TLC2801. 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.

BONDING PAD ASSIGNMENTS





CHIP THICKNESS: 15 TYPICAL

BONDING PADS: 4 × 4 MINIMUM

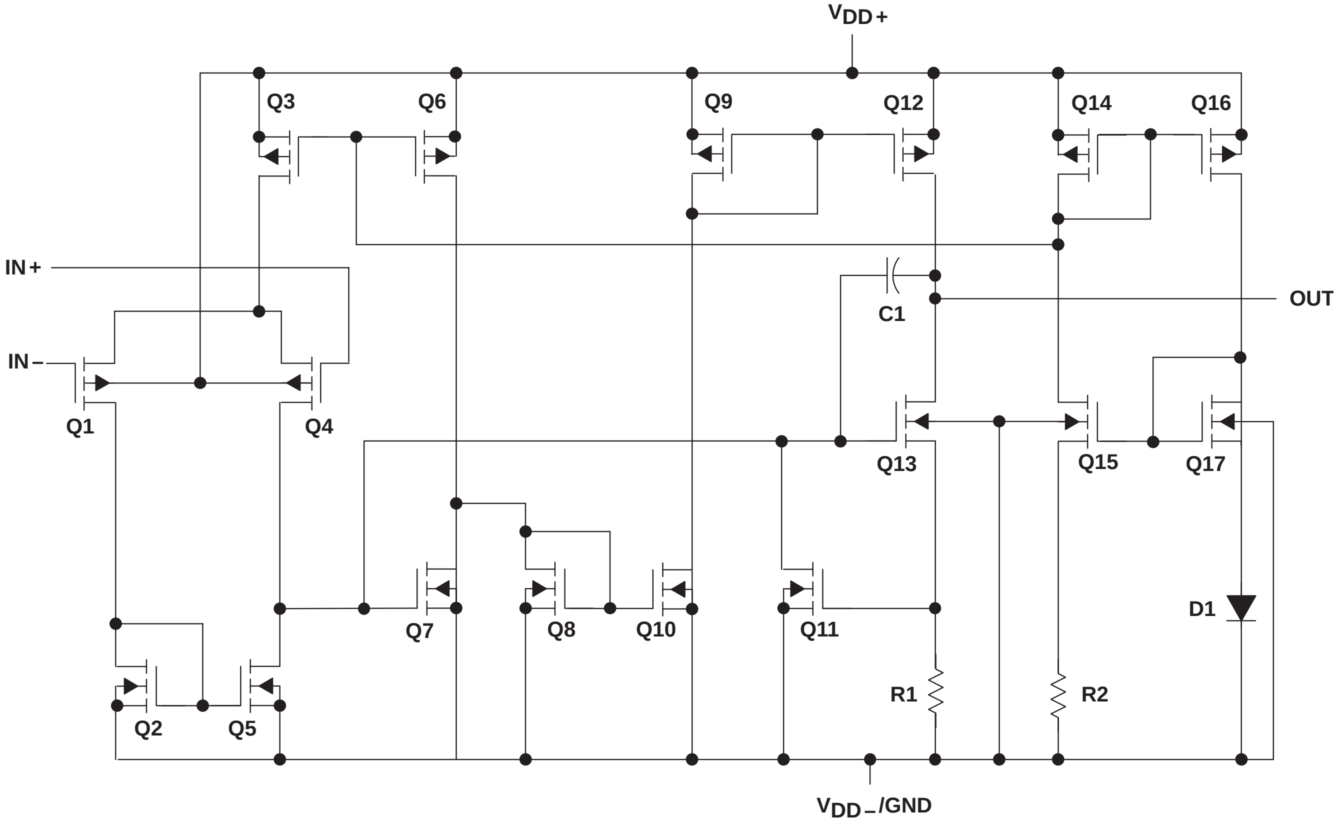
$T_J$max= 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

PIN (4) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.

equivalent schematic



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{DD+} (see Note 1)	8 V
Supply voltage, V_{DD-} (see Note 1)	–8 V
Differential input voltage, V_{ID} (see Note 2)	±16 V
Input voltage range, V_I (any input, see Note 1)	±8 V
Input current, I_I (each input)	±5 mA
Output current, I_O	±50 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Operating free-air temperature range, T_A	–40°C to 150°C
Storage temperature range	–65°C to 175°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

† 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, except differential voltages, are with respect to the midpoint between $V_{DD\pm}$ and V_{DD-}.
2. Differential voltages are at the noninverting input with respect to the inverting point.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, $V_{DD\pm}$	±2.3	±8	V
Common-mode input voltage, V_{IC}	V_{DD-}	$V_{DD+}-2.3$	V
Operating free-air temperature, T_A	–40	150	°C

electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLC2801Z			UNIT
				MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C		100	500	µV
			Full range			1500	
α_{VIO}	Temperature coefficient of input offset voltage		–55°C to 150°C		4		µV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005	µV/mo
I_{IO}	Input offset current		25°C		0.5		pA
			Full range			3	nA
I_{IB}	Input bias current		25°C		1		pA
			Full range			30	nA
V_{ICR}	Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	–5 to 2.7			V
V_{OM+}	Maximum positive peak output voltage swing	$R_L = 10\ k\Omega$	25°C	4.7	4.8		V
			Full range	4.5			
V_{OM-}	Maximum negative peak output voltage swing		25°C	–4.7	–4.9		V
			Full range	–4.5			
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 4$ V, $R_L = 500\ k\Omega$	25°C	300	460		V/mV
			Full range	100			
		$V_O = \pm 4$ V, $R_L = 10\ k\Omega$	25°C	50	100		
			Full range	15			
CMRR	Common-mode rejection ratio	$V_O = 0$, $V_{IC} = V_{ICR}\text{min}$, $R_S = 50\ \Omega$	25°C	90	115		dB
			Full range	85			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3$ V to ± 8 V	25°C	90	110		dB
			Full range	85			
I_{DD}	Supply current	$V_O = 0$, No load	25°C		1.1	1.5	mA
			Full range			1.5	

operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5$ V

PARAMETER		TEST CONDITIONS	T_A†	TLC2801Z			UNIT
				MIN	TYP	MAX	
SR	Slew rate unity gain	$V_O = \pm 2.3$ V, $R_L = 10\ k\Omega$, $C_L = 100$ pF	25°C	2	2.7		V/µs
			Full range	1			
V_n	Equivalent input noise voltage	f = 10 Hz	25°C		18	35	nV/√Hz
		f = 1 kHz			8	15	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz	25°C		0.5		µV
		f = 0.1 to 10 Hz			0.7		
I_n	Equivalent input noise current		25°C		0.6		fA/√Hz
	Gain-bandwidth product	f = 10 kHz, $R_L = 10\ k\Omega$, $C_L = 100$ pF	25°C		1.9		MHz
ϕ_m	Phase margin at unity gain	$R_L = 10\ k\Omega$, $C_L = 100$ pF	25°C		48°		

† Full range is –40°C to 150°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

electrical characteristics at specified free-air temperature, V_{DD} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	TLC2801Z			UNIT
				MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{IC} = 0, R_S = 50 Ω	25°C		100	500	µV
			Full range			1500	
α_{VIO}	Temperature coefficient of input offset voltage		Full range		4		µV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005	µV/mo
I_{IO}	Input offset current		25°C		0.5		pA
			Full range			3	
I_{IB}	Input bias current		25°C		1		pA
			Full range			30	
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω	Full range	–5 to 2.7			V
V_{OH}	Maximum high-level output voltage	R_L = 10 kΩ	25°C	4.7	4.8		V
			Full range	4.4			
V_{OL}	Maximum low-level output voltage		25°C		0	50	mV
			Full range			50	
A_{VD}	Large-signal differential voltage amplification	V_O = 1 V to 4 V, R_L = 500 kΩ	25°C	150	315		V/mV
			Full range	50			
		V_O = 1 V to 4 V, R_L = 10 kΩ	25°C	25	55		
			Full range	5			
CMRR	Common-mode rejection ratio	V_O = 0, V_{IC} = V_{ICR}min, R_S = 50 Ω	25°C	90	110		dB
			Full range	85			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	V_{DD} = 4.6 V to 16 V	25°C	90	110		dB
			Full range	85			
I_{DD}	Supply current	V_O = 0, No load	25°C		1.1	1.5	mA
			Full range			1.5	

operating characteristics at specified free-air temperature, V_{DD} = 5 V

PARAMETER		TEST CONDITIONS	T_A†	TLC2801Z			UNIT
				MIN	TYP	MAX	
SR	Slew rate unity gain	V_O = 0.5 V to 2.5 V, R_L = 10 kΩ, C_L = 100 pF	25°C	1.8	2.5		V/µs
			Full range	0.8			
V_n	Equivalent input noise voltage	f = 10 Hz	25°C		18	35	nV/$\sqrt{Hz}$
		f = 1 kHz	25°C		8	15	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz	25°C		0.5		µV
		f = 0.1 to 10 Hz	25°C		0.7		
I_n	Equivalent input noise current		25°C		0.6		fA/$\sqrt{Hz}$
	Gain-bandwidth product	f = 10 kHz, R_L = 10 kΩ, C_L = 100 pF	25°C		1.8		MHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ, C_L = 100 pF	25°C		45°		

† Full range is –40°C to 150°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

electrical characteristics at V_{DD} = 5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TLC2801Z			UNIT
				MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{IC}= 0,	R_S = 50 Ω		100	500	µV
	Input offset voltage long-term drift (see Note 4)				0.001	0.005	µV/mo
I_{IO}	Input offset current				0.5		pA
I_{IB}	Input bias current				1		pA
V_{ICR}	Common-mode input voltage range	R_S = 50 Ω	R_S = 50 Ω	0 to 2.7			V
V_{OH}	Maximum high-level output voltage	R_L = 10 kΩ	R_L = 10 kΩ	4.7	4.8		V
V_{OL}	Maximum low-level output voltage	I_O = 0	I_O = 0		0	50	mV
A_{VD}	Large-signal differential voltage amplification	V_O = 1 V to 4 V,	R_L = 500 kΩ	150	315		V/mV
		V_O = 1 V to 4 V,	R_L = 10 kΩ	25	55		
CMRR	Common-mode rejection ratio	V_O = 0, R_S = 50 Ω	V_{IC} = V_{ICR}min, R_S = 50 Ω	90	110		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	V_{DD} = 4.6 V to 16 V	V_{DD} = 4.6 V to 16 V	90	110		dB
I_{DD}	Supply current	V_O = 2.5 V,	No load		1	1.5	mA

operating characteristics at V_{DD} = 5 V, T_A = 25°C

PARAMETER		TEST CONDITIONS		TLC2801Z			UNIT
				MIN	TYP	MAX	
SR	Positive slew rate at unity gain	V_O = 0.5 V to 2.5 V, C_L = 100 pF	R_L = 10 kΩ,	1.8	2.5		V/µs
V_n	Equivalent input noise voltage	f = 10 Hz			18		nV/$\sqrt{\text{Hz}}$
		f = 1 kHz			8		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz			0.5		µV
		f = 0.1 to 10 Hz			0.7		
I_n	Equivalent input noise current				0.6		pA/$\sqrt{\text{Hz}}$
	Gain-bandwidth product	f = 10 kHz, C_L = 100 pF	R_L = 10 kΩ,		1.8		MHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ,	C_L = 100 pF		45°		

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

PARAMETER MEASUREMENT INFORMATION

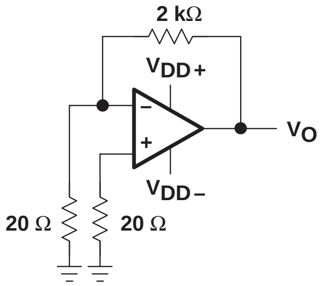
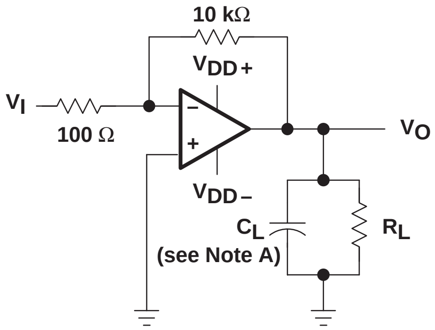
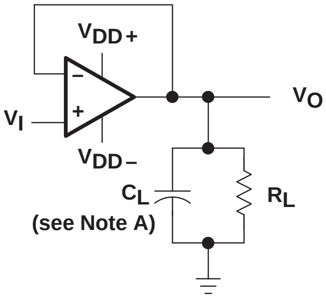


Figure 1. Noise-Voltage Test Circuit



NOTE A: C_L includes fixture capacitance.

Figure 2. Phase-Margin Test Circuit



NOTE A: C_L includes fixture capacitance.

Figure 3. Slew-Rate Test Circuit

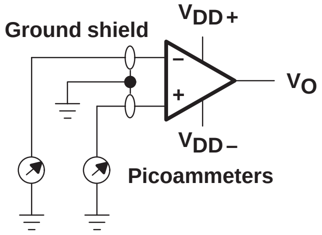


Figure 4. Input-Bias and Offset-Current Test Circuit

typical values

Typical values as presented in this data sheet represents the median (50% point) of device parametric performance.

input bias and offset current

At the picoamp bias-current level typical of the TLC2801, accurate measurement of the bias current becomes difficult. Not only does this measurement require a picoammeter, but test socket leakages can easily exceed the actual device bias currents. To measure these small currents, Texas Instruments uses a two-step process. The socket leakage is measured using picoammeters with bias voltage applied but with no device in the socket. The device is then inserted in the socket and a second test measuring both the socket leakage and the device input bias current is performed. The two measurements are then subtracted algebraically to determine the bias current of the device.

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
I_{IB}	Input bias current	vs Free-air temperature	5
V_{OM}	Maximum peak output voltage	vs Free-air temperature	6
V_{OH}	High-level output voltage	vs Free-air temperature	7
V_{OL}	Low-level output voltage	vs Free-air temperature	8
A_{VD}	Differential voltage amplification	vs Free-air temperature	9
I_{OS}	Short-circuit output current	vs Free-air temperature	10
I_{DD}	Supply current	vs Free-air temperature	11
SR	Slew rate	vs Free-air temperature	12
	Gain-bandwidth product	vs Free-air temperature	13

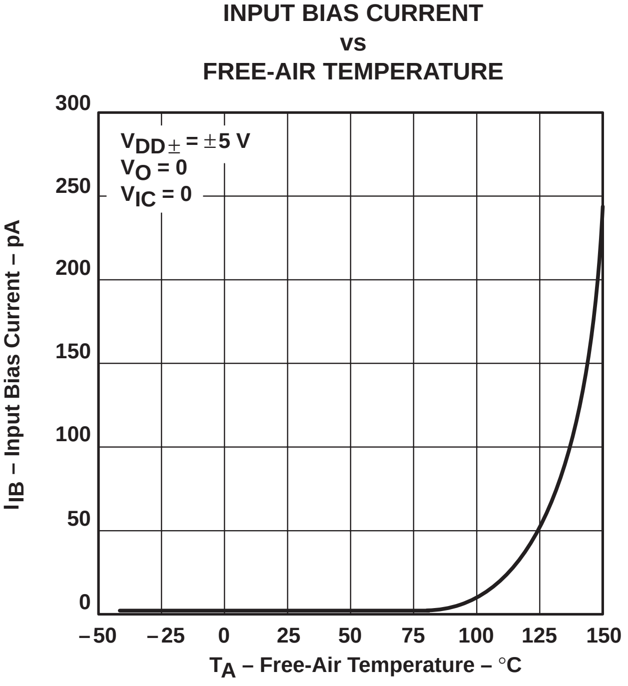


Figure 5

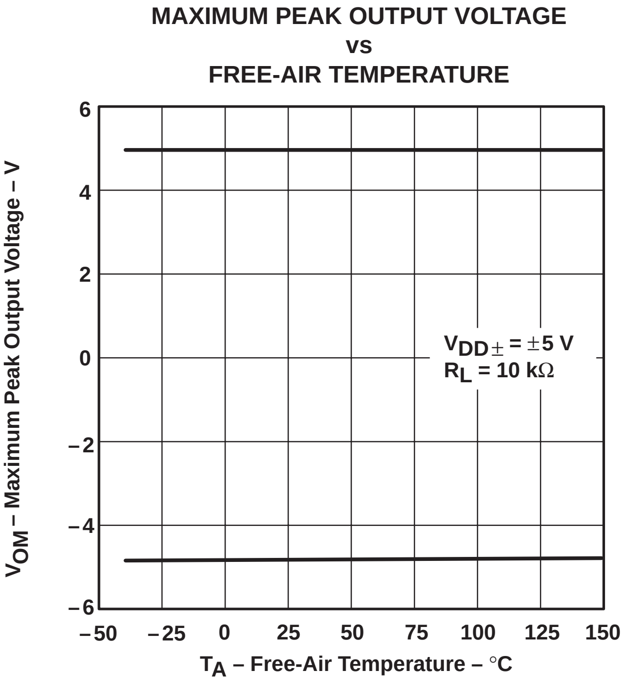


Figure 6

TYPICAL CHARACTERISTICS

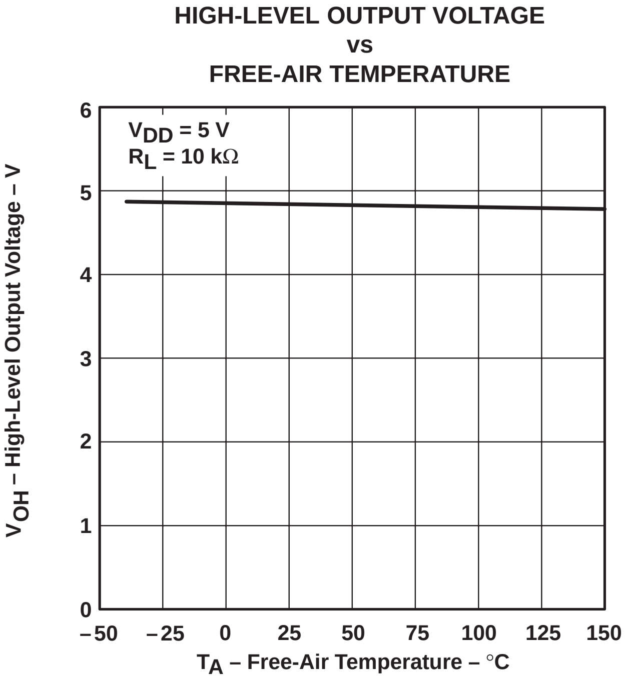


Figure 7

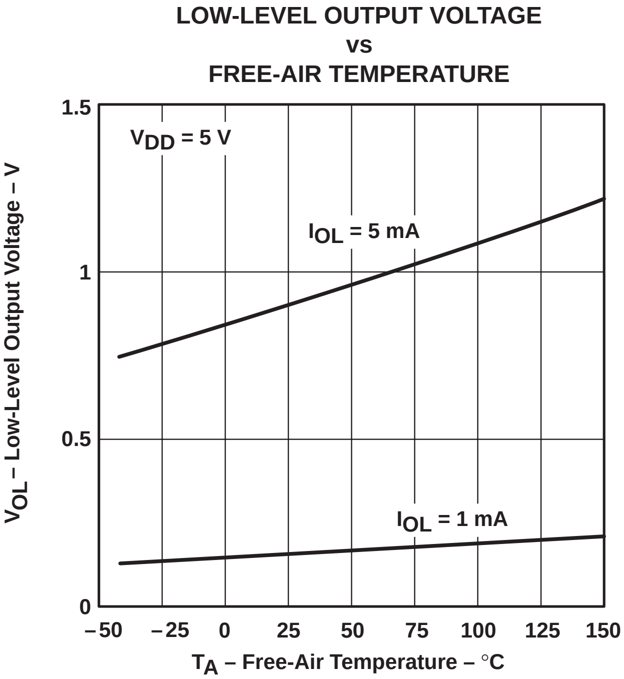


Figure 8

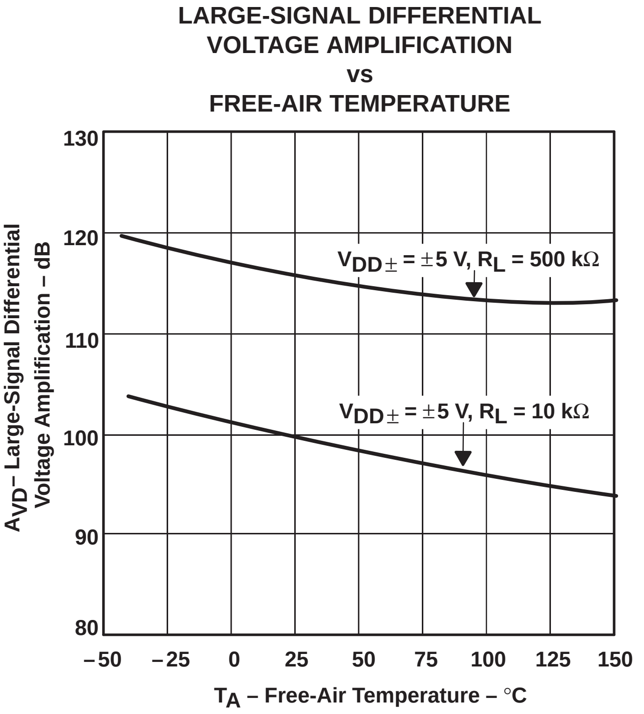


Figure 9

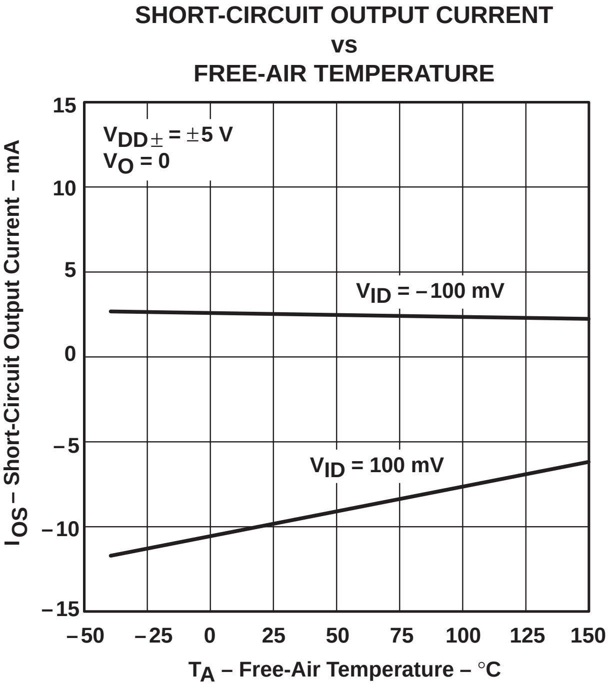


Figure 10

TYPICAL CHARACTERISTICS

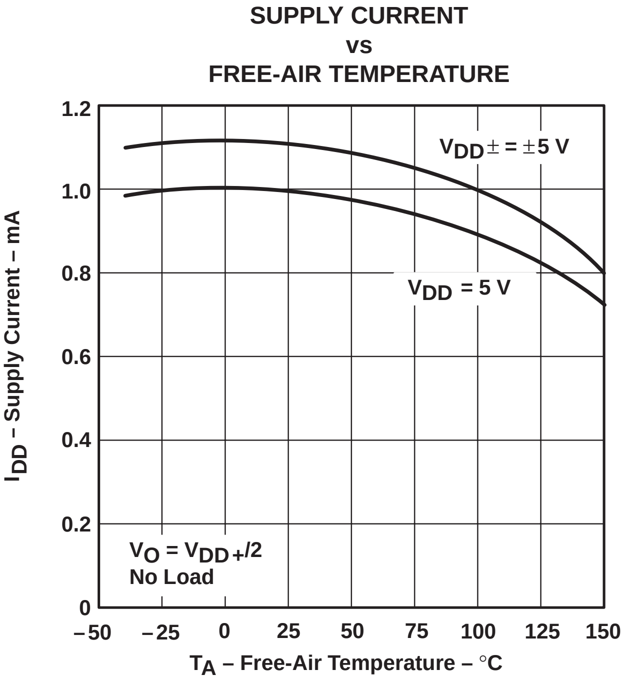


Figure 11

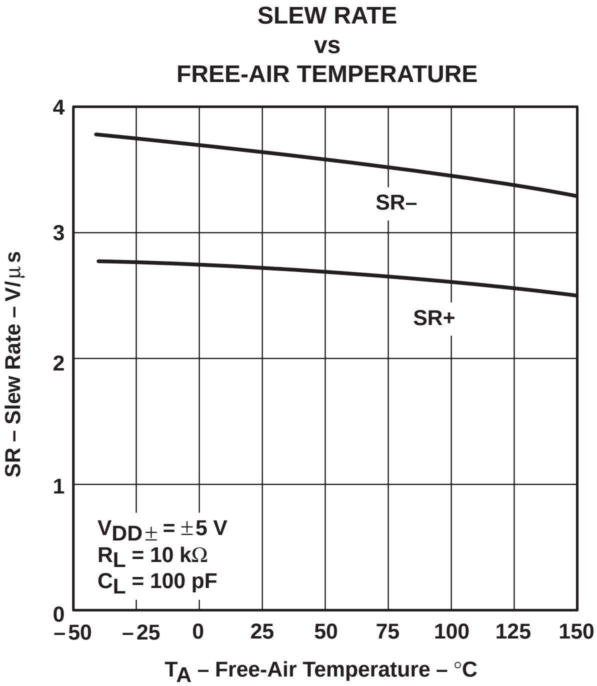


Figure 12

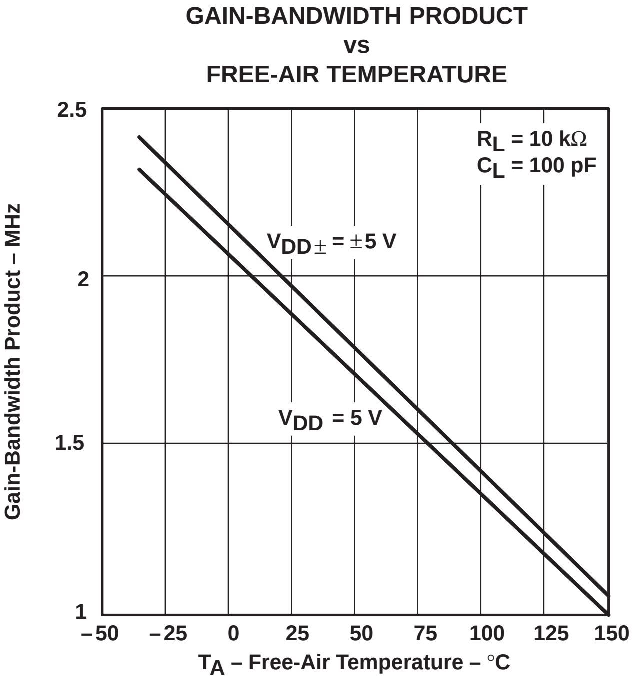


Figure 13

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