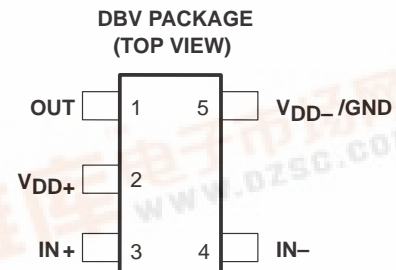


TLV2731, TLV2731Y Advanced LinCMOS™ RAIL-TO-RAIL LOW-POWER SINGLE OPERATIONAL AMPLIFIERS

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- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 15 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Fully Specified for Single-Supply 3-V and 5-V Operation**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **High Gain Bandwidth . . . 2 MHz at V_{DD} = 5 V with 600 Ω Load**
- **High Slew Rate . . . 1.6 V/μs at V_{DD} = 5 V**
- **Wide Supply Voltage Range 2.7 V to 10 V**
- **Macromodel Included**



description

The TLV2731 is a single low-voltage operational amplifier available in the SOT-23 package. It offers 2 MHz of bandwidth and 1.6 V/μs of slew rate for applications requiring good ac performance. The device exhibits rail-to-rail output performance for increased dynamic range in single or split supply applications. The TLV2731 is fully characterized at 3 V and 5 V and is optimized for low-voltage applications.

The TLV2731, exhibiting high input impedance and low noise, is excellent for small-signal conditioning of high-impedance sources, such as piezoelectric transducers. Because of the micropower dissipation levels combined with 3-V operation, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature with single- or split-supplies makes this family a great choice when interfacing with analog-to-digital converters (ADCs). The device can also drive 600-Ω loads for telecom applications.

With a total area of 5.6mm², the SOT-23 package only requires one-third the board space of the standard 8-pin SOIC package. This ultra-small package allows designers to place single amplifiers very close to the signal source, minimizing noise pick-up from long PCB traces.

AVAILABLE OPTIONS

T _A	V _{IO} max AT 25°C	PACKAGED DEVICES	SYMBOL	CHIP FORM‡ (Y)
		SOT-23 (DBV)†		
0°C to 70°C	3 mV	TLV2731CDBV	VALC	TLV2731Y
-40°C to 85°C	3 mV	TLV2731IDBV	VALI	

† The DBV package available in tape and reel only.

‡ Chip forms are tested at T_A = 25°C only.

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.

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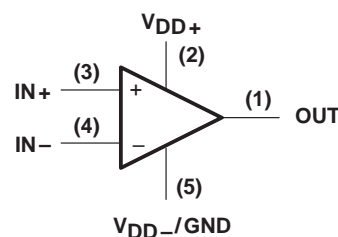
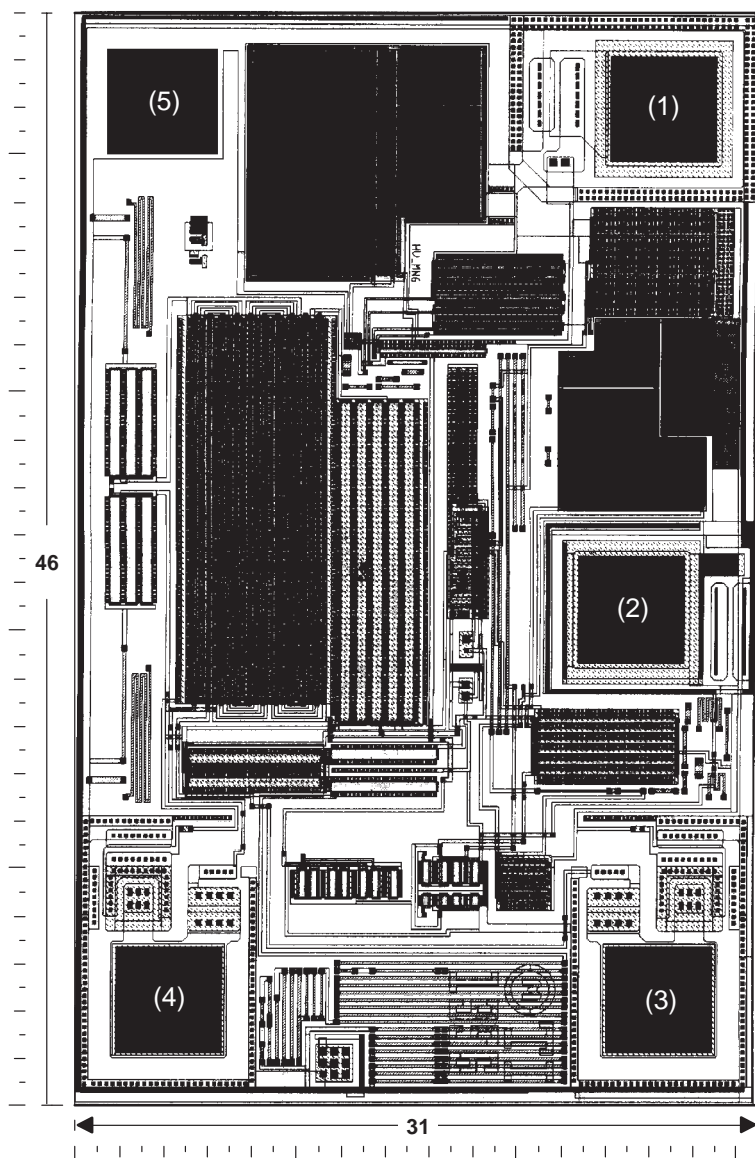
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TLV2731Y chip information

This chip, when properly assembled, displays characteristics similar to the TLV2731C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.

BONDING PAD ASSIGNMENTS



CHIP THICKNESS: 10 MILS TYPICAL

BONDING PADS: 4 × 4 MILS MINIMUM

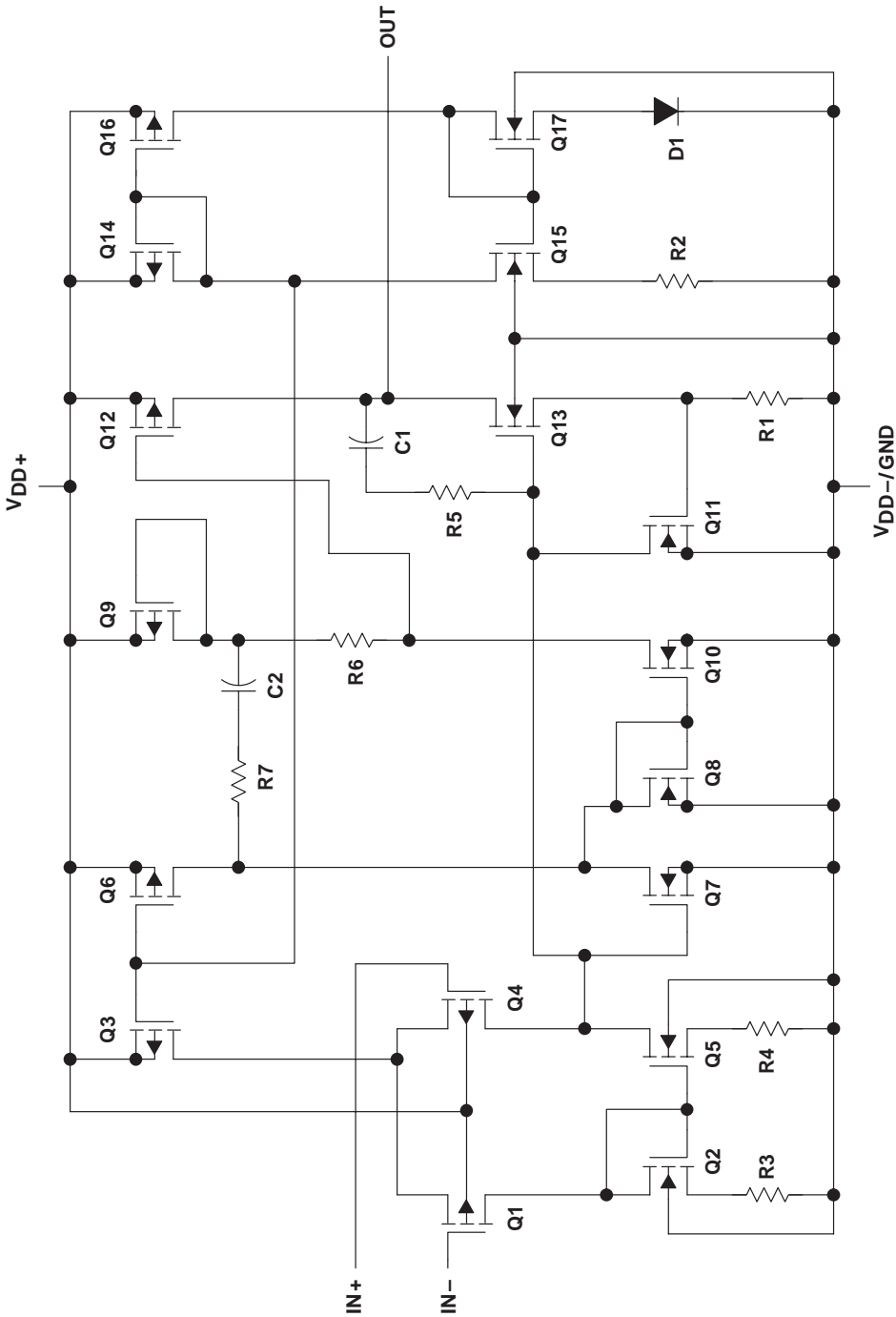
$T_{jmax} = 150^{\circ}\text{C}$

TOLERANCES ARE $\pm 10\%$.

ALL DIMENSIONS ARE IN MILS.

PIN (2) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.

equivalent schematic



COMPONENT COUNT†	
Transistors	23
Diodes	5
Resistors	11
Capacitors	2

† Includes both amplifiers and all ESD, bias, and trim circuitry

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

Supply voltage, V_{DD} (see Note 1)	12 V
Differential input voltage, V_{ID} (see Note 2)	$\pm V_{DD}$
Input voltage range, V_I (any input, see Note 1)	$-0.3\text{ V to }V_{DD}$
Input current, I_I (each input)	$\pm 5\text{ mA}$
Output current, I_O	$\pm 50\text{ mA}$
Total current into V_{DD+}	$\pm 50\text{ mA}$
Total current out of V_{DD-}	$\pm 50\text{ mA}$
Duration of short-circuit current (at or below) 25°C (see Note 3)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : TLV2731C	$0^\circ\text{C to }70^\circ\text{C}$
TLV2731I	$-40^\circ\text{C to }85^\circ\text{C}$
Storage temperature range, T_{stg}	$-65^\circ\text{C to }150^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DBV package	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 V_{DD-} .
2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below $V_{DD-} - 0.3\text{ V}$.
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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
DBV	150 mW	1.2 mW/ $^\circ\text{C}$	96 mW	78 mW

recommended operating conditions

	TLV2731C		TLV2731I		UNIT
	MIN	MAX	MIN	MAX	
Supply voltage, V_{DD} (see Note 1)	2.7	10	2.7	10	V
Input voltage range, V_I	V_{DD-}	$V_{DD+} - 1.3$	V_{DD-}	$V_{DD+} - 1.3$	V
Common-mode input voltage, V_{IC}	V_{DD-}	$V_{DD+} - 1.3$	V_{DD-}	$V_{DD+} - 1.3$	V
Operating free-air temperature, T_A	0	70	-40	85	$^\circ\text{C}$

NOTE 1: All voltage values, except differential voltages, are with respect to V_{DD-} .

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electrical characteristics at specified free-air temperature, $V_{DD} = 3\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2731C			TLV2731I			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{DD±} = ±1.5 V, V _{IC} = 0, V _O = 0, R _S = 50 Ω		Full range	0.7		3	0.7		3	mV
α _{VIO}	Temperature coefficient of input offset voltage				0.5		0.5		μV/°C		
Input offset voltage long-term drift (see Note 4)				25°C	0.003		0.003		μV/mo		
I _{IO}	Input offset current			25°C	0.5		0.5		pA		
				Full range	150		150				
I _{IB}	Input bias current			25°C	1		1		pA		
		Full range	150		150						
V _{ICR}	Common-mode input voltage range	R _S = 50 Ω, V _{IO} ≤ 5 mV		25°C	0 to 2	−0.3 to 2.2	0 to 2	−0.3 to 2.2	V		
				Full range	0 to 1.7		0 to 1.7				
V _{OH}	High-level output voltage	I _{OH} = −1 mA		25°C	2.87		2.87		V		
		I _{OH} = −2 mA		25°C	2.74		2.74				
				Full range	2.3		2.3				
V _{OL}	Low-level output voltage	V _{IC} = 1.5 V, I _{OL} = 50 μA		25°C	10		10		mV		
		V _{IC} = 1.5 V, I _{OL} = 500 μA		25°C	100		100				
				Full range	300		300				
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 1.5 V, V _O = 1 V to 2 V	R _L = 600 Ω [‡]	25°C	1	1.6	1	1.6	V/mV		
			R _L = 1 MΩ [‡]	Full range	0.3		0.3				
					25°C	250		250			
r _{id}	Differential input resistance			25°C	10 ¹²		10 ¹²		Ω		
r _{ic}	Common-mode input resistance			25°C	10 ¹²		10 ¹²		Ω		
c _{ic}	Common-mode input capacitance	f = 10 kHz		25°C	6		6		pF		
z _O	Closed-loop output impedance	f = 1 MHz, A _V = 1		25°C	156		156		Ω		
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 1.7 V, V _O = 1.5 V, R _S = 50 Ω		25°C	60	70	60	70	dB		
				Full range	55		55				
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	70	96	70	96	dB		
				Full range	70		70				
I _{DD}	Supply current	V _O = 1.5 V, No load		25°C	750	1200	750	1200	μA		
				Full range	1500		1500				

† Full range for the TLV2731C is 0°C to 70°C. Full range for the TLV2731I is –40°C to 85°C.

‡ Referenced to 1.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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operating characteristics at specified free-air temperature, $V_{DD} = 3\text{ V}$

PARAMETER		TEST CONDITIONS		T_A †	TLV2731C			TLV2731I			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1.1\text{ V to }1.9\text{ V}, R_L = 600\ \Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$		25°C	0.75	1.25		0.75	1.25		V/ μs
				Full range	0.5			0.5			
V_n	Equivalent input noise voltage	$f = 10\text{ Hz}$		25°C		105			105		nV/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		25°C		16			16		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		25°C		1.4			1.4		μV
		$f = 0.1\text{ Hz to }10\text{ Hz}$		25°C		1.5			1.5		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
THD+N	Total harmonic distortion plus noise	$V_O = 1\text{ V to }2\text{ V}, f = 20\text{ kHz}, R_L = 600\ \Omega^\ddagger$	$A_V = 1$	25°C		0.285%			0.285%		
			$A_V = 10$			7.2%			7.2%		
		$V_O = 1\text{ V to }2\text{ V}, f = 20\text{ kHz}, R_L = 600\ \Omega^\S$	$A_V = 1$	25°C		0.014%			0.014%		
			$A_V = 10$			0.098%			0.098%		
			$A_V = 100$			0.13%			0.13%		
	Gain-bandwidth product	$f = 10\text{ kHz}, C_L = 100\text{ pF}^\ddagger$	$R_L = 600\ \Omega^\ddagger$	25°C		1.9			1.9		MHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V}, R_L = 600\ \Omega^\ddagger$	$A_V = 1, C_L = 100\text{ pF}^\ddagger$	25°C		60			60		kHz
t_s	Settling time	$A_V = -1, \text{ Step} = 1\text{ V to }2\text{ V}, R_L = 600\ \Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$	To 0.1%	25°C		0.9			0.9		μs
			To 0.01%			1.5			1.5		
ϕ_m	Phase margin at unity gain	$R_L = 600\ \Omega^\ddagger$	$C_L = 100\text{ pF}^\ddagger$	25°C		50°			50°		
	Gain margin			25°C		8			8		dB

† Full range is -40°C to 85°C .

‡ Referenced to 1.5 V

§ Referenced to 0 V

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

PARAMETER		TEST CONDITIONS		T _A [†]	TLV2731C			TLV2731I			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{DD±} = ±2.5 V, V _{IC} = 0, V _O = 0, R _S = 50 Ω		Full range	0.7		3	0.7		3	mV
α _{VIO}	Temperature coefficient of input offset voltage				0.5		0.5		μV/°C		
Input offset voltage long-term drift (see Note 4)				25°C	0.003		0.003		μV/mo		
I _{IO}	Input offset current			25°C	0.5		0.5		pA		
				Full range	150		150				
I _{IB}	Input bias current			25°C	1		1		pA		
		Full range	150		150						
V _{ICR}	Common-mode input voltage range	R _S = 50 Ω, V _{IO} ≤ 5 mV		25°C	0 to 4	−0.3 to 4.2	0 to 4	−0.3 to 4.2	V		
				Full range	0 to 3.7		0 to 3.7				
V _{OH}	High-level output voltage	I _{OH} = −1 mA		25°C	4.9		4.9		V		
		I _{OH} = −4 mA		25°C	4.6		4.6				
				Full range	4.3		4.3				
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, I _{OL} = 500 μA		25°C	80		80		mV		
		V _{IC} = 2.5 V, I _{OL} = 1 mA		25°C	160		160				
				Full range	500		500				
A _{VD}	Large-signal differential voltage amplification	V _{IC} = 2.5 V, V _O = 1 V to 4 V	R _L = 600 Ω [‡]	25°C	1	1.5	1	1.5	V/mV		
			R _L = 1 MΩ [‡]	Full range	0.3		0.3				
				25°C	400		400				
r _{id}	Differential input resistance			25°C	10 ¹²		10 ¹²		Ω		
r _{ic}	Common-mode input resistance			25°C	10 ¹²		10 ¹²		Ω		
c _{ic}	Common-mode input capacitance	f = 10 kHz		25°C	6		6		pF		
z _o	Closed-loop output impedance	f = 1 MHz, A _V = 1		25°C	138		138		Ω		
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 2.7 V, V _O = 2.5 V, R _S = 50 Ω		25°C	60	70	60	70	dB		
				Full range	55		55				
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 4.4 V to 8 V, V _{IC} = V _{DD} /2, No load		25°C	70	96	70	96	dB		
				Full range	70		70				
I _{DD}	Supply current	V _O = 2.5 V, No load		25°C	850	1300	850	1300	μA		
				Full range	1600		1600				

† Full range for the TLV2731C is 0°C to 70°C. Full range for the TLV2731I is –40°C to 85°C.

‡ Referenced to 2.5 V

NOTE 5: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER		TEST CONDITIONS		T_A †	TLV2731C			TLV2731I			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1.5\text{ V to }3.5\text{ V},$ $C_L = 100\text{ pF}‡$	$R_L = 600\text{ }\Omega‡$	25°C	1	1.6		1	1.6		V/ μs
				Full range	0.7			0.7			
V_n	Equivalent input noise voltage	$f = 10\text{ Hz}$		25°C		100			100		nV/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		25°C		15			15		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$		25°C		1.4			1.4		μV
		$f = 0.1\text{ Hz to }10\text{ Hz}$		25°C		1.5			1.5		
I_n	Equivalent input noise current			25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
THD+N	Total harmonic distortion plus noise	$V_O = 1.5\text{ V to }3.5\text{ V},$ $f = 20\text{ kHz},$ $R_L = 600\text{ }\Omega‡$	$A_V = 1$	25°C		0.409%			0.409%		
			$A_V = 10$			3.68%			3.68%		
		$V_O = 1.5\text{ V to }3.5\text{ V},$ $f = 20\text{ kHz},$ $R_L = 600\text{ }\Omega§$	$A_V = 1$	25°C		0.018%			0.018%		
			$A_V = 10$			0.045%			0.045%		
			$A_V = 100$			0.116%			0.116%		
	Gain-bandwidth product	$f = 10\text{ kHz},$ $C_L = 100\text{ pF}‡$	$R_L = 600\text{ }\Omega‡$	25°C		2			2		MHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V},$ $R_L = 600\text{ }\Omega‡$	$A_V = 1,$ $C_L = 100\text{ pF}‡$	25°C		300			300		kHz
t_s	Settling time	$A_V = -1,$ Step = $1.5\text{ V to }3.5\text{ V},$ $R_L = 600\text{ }\Omega‡$, $C_L = 100\text{ pF}‡$	To 0.1%	25°C		0.95			0.95		μs
			To 0.01%			2.4			2.4		
ϕ_m	Phase margin at unity gain	$R_L = 600\text{ }\Omega‡$	$C_L = 100\text{ pF}‡$	25°C		48°			48°		
	Gain margin			25°C		8			8		dB

† Full range is -40°C to 85°C .

‡ Referenced to 2.5 V

§ Referenced to 0 V

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electrical characteristics at $V_{DD} = 3\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS			TLV2731Y			UNIT
					MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{DD} ± = ±1.5 V, R _S = 50 Ω	V _{IC} = 0,	V _O = 0,	750			μV
I _{IO}	Input offset current				0.5			pA
I _{IB}	Input bias current				1			pA
V _{ICR}	Common-mode input voltage range	V _{IO} ≤5 mV, R _S = 50 Ω			−0.3 to 2.2			V
V _{OH}	High-level output voltage	I _{OH} = −1 mA			2.87			V
V _{OL}	Low-level output voltage	V _{IC} = 1.5 V, I _{OL} = 50 μA			10			mV
		V _{IC} = 1.5 V, I _{OL} = 500 μA			100			
A _{VD}	Large-signal differential voltage amplification	V _O = 1 V to 2 V	R _L = 600 Ω†		1.6			V/mV
			R _L = 1 MΩ†		250			
r _{id}	Differential input resistance				10 ¹²			Ω
r _{ic}	Common-mode input resistance				10 ¹²			Ω
c _{ic}	Common-mode input capacitance	f = 10 kHz			6			pF
z _o	Closed-loop output impedance	f = 1 MHz, A _V = 1			156			Ω
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 1.7 V, V _O = 0, R _S = 50 Ω			70			dB
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V, V _{IC} = 0, No load			96			dB
I _{DD}	Supply current	V _O = 0, No load			750			μA

† Referenced to 1.5 V

electrical characteristics at $V_{DD} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TLV2731Y			UNIT
				MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _{DD} ± = ±1.5 V, R _S = 50 Ω	V _{IC} = 0, V _O = 0,	710			μV
I _{IO}	Input offset current			0.5			pA
I _{IB}	Input bias current			1			pA
V _{ICR}	Common-mode input voltage range	V _{IO} ≤5 mV, R _S = 50 Ω		−0.3 to 4.2			V
V _{OH}	High-level output voltage	I _{OH} = −1 mA		4.9			V
V _{OL}	Low-level output voltage	V _{IC} = 2.5 V, I _{OL} = 500 μA		80			mV
		V _{IC} = 2.5 V, I _{OL} = 1 mA		160			
A _{VD}	Large-signal differential voltage amplification	V _O = 1 V to 2 V	R _L = 600 Ω†	15			V/mV
			R _L = 1 MΩ†	400			
r _{id}	Differential input resistance			10 ¹²			Ω
r _{ic}	Common-mode input resistance			10 ¹²			Ω
c _{ic}	Common-mode input capacitance	f = 10 kHz		6			pF
z _O	Closed-loop output impedance	f = 1 MHz,	A _V = 1	138			Ω
CMRR	Common-mode rejection ratio	V _{IC} = 0 to 1.7 V,	V _O = 0,	R _S = 50 Ω		70	dB
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 2.7 V to 8 V,	V _{IC} = 0,	No load		96	dB
I _{DD}	Supply current	V _O = 0,	No load		850		μA

† Referenced to 2.5 V

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TYPICAL CHARACTERISTICS

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A_{VD}	Large-signal differential voltage amplification	vs Frequency vs Free-air temperature	22, 23 24, 25
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I_{DD}	Supply current	vs Supply voltage	33
SR	Slew rate	vs Load capacitance vs Free-air temperature	34 35
V_O	Inverting large-signal pulse response	vs Time	36, 37
V_O	Voltage-follower large-signal pulse response	vs Time	38, 39
V_O	Inverting small-signal pulse response	vs Time	40, 41
V_O	Voltage-follower small-signal pulse response	vs Time	42, 43
V_n	Equivalent input noise voltage	vs Frequency	44, 45
	Noise voltage (referred to input)	Over a 10-second period	46
THD + N	Total harmonic distortion plus noise	vs Frequency	47
	Gain-bandwidth product	vs Free-air temperature vs Supply voltage	48 49
	Gain margin	vs Load capacitance	50, 51
ϕ_m	Phase margin	vs Frequency vs Load capacitance	22, 23 52, 53
B_1	Unity-gain bandwidth	vs Load capacitance	54, 55

TYPICAL CHARACTERISTICS

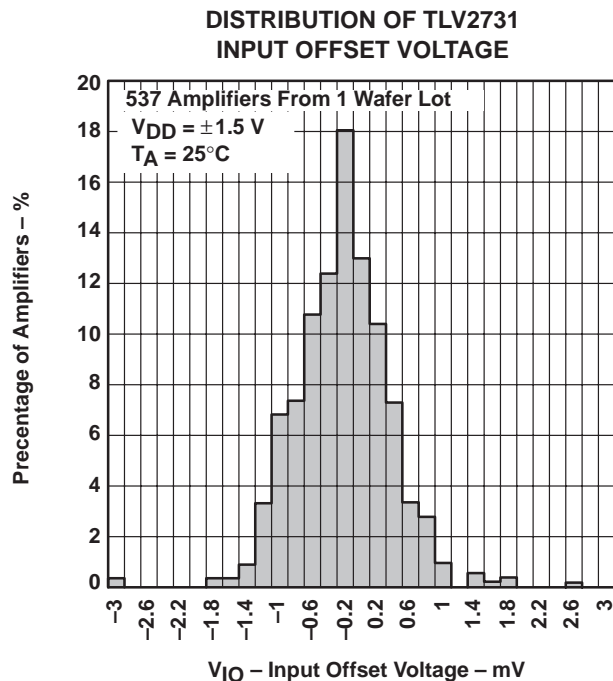


Figure 1

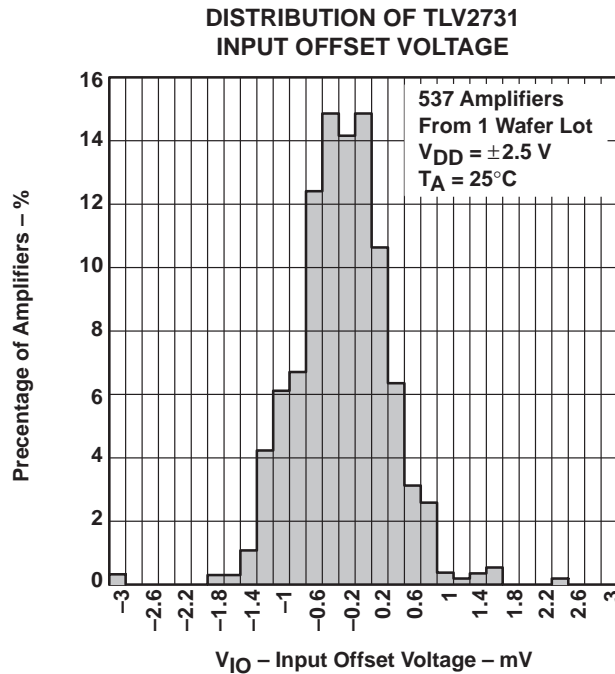


Figure 2

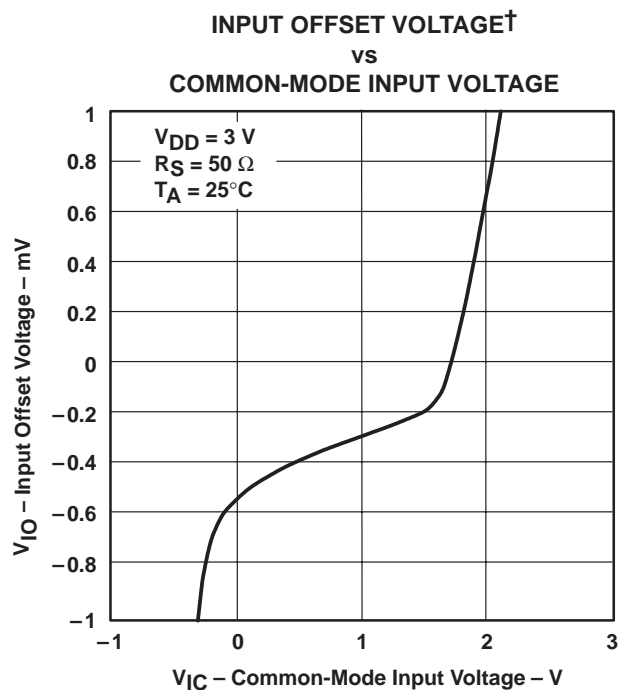


Figure 3

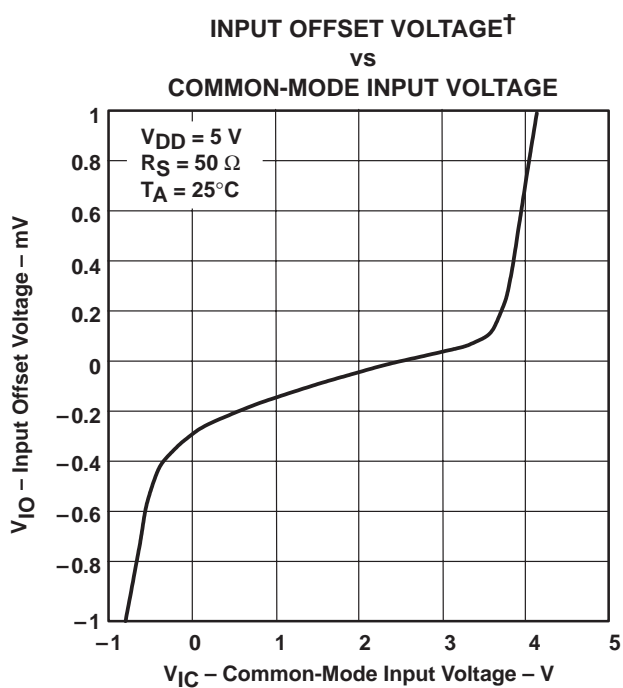


Figure 4

† For all curves where $V_{DD} = 5 \text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3 \text{ V}$, all loads are referenced to 1.5 V.

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TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLV2731 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT†

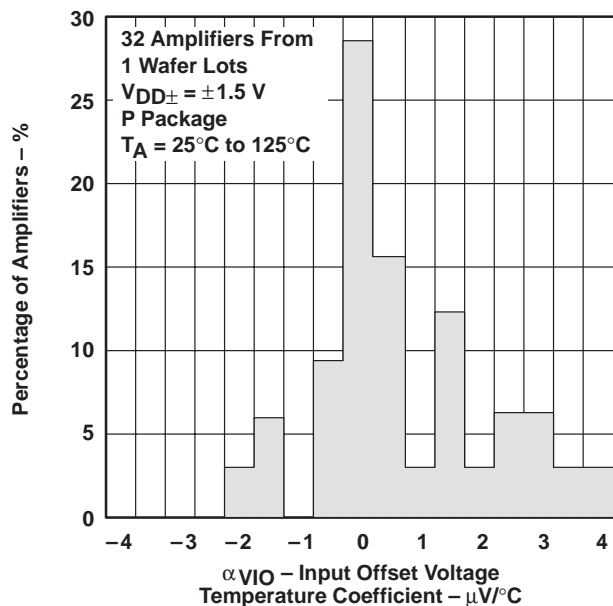


Figure 5

DISTRIBUTION OF TLV2731 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT†

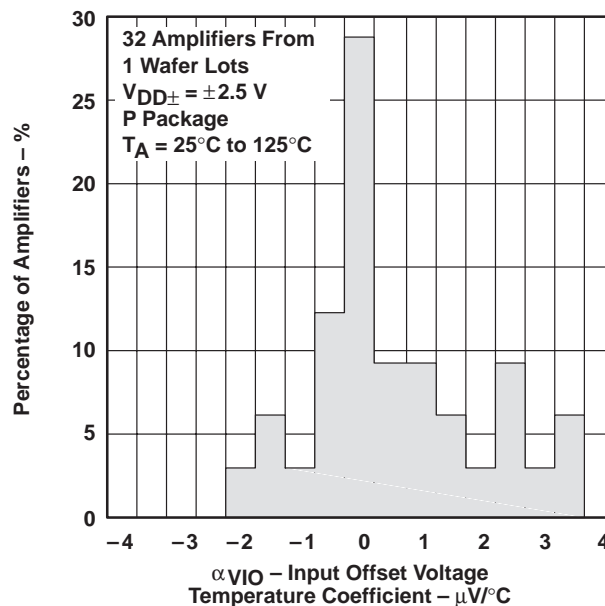


Figure 6

**INPUT BIAS AND INPUT OFFSET CURRENTS†
vs
FREE-AIR TEMPERATURE**

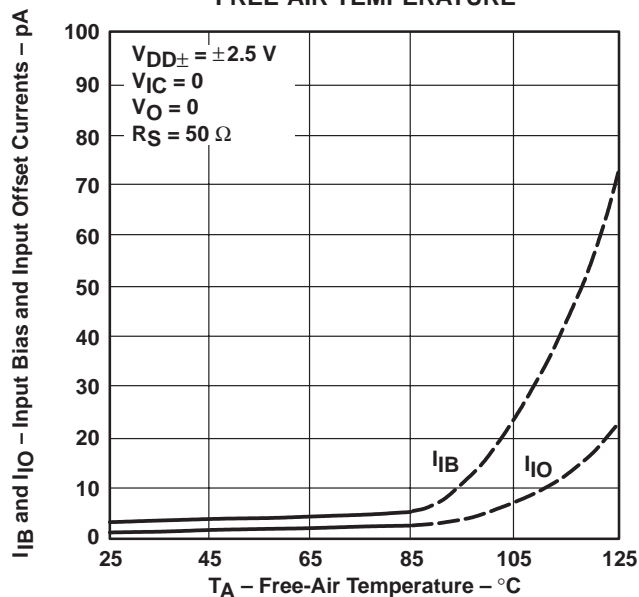


Figure 7

**INPUT VOLTAGE
vs
SUPPLY VOLTAGE**

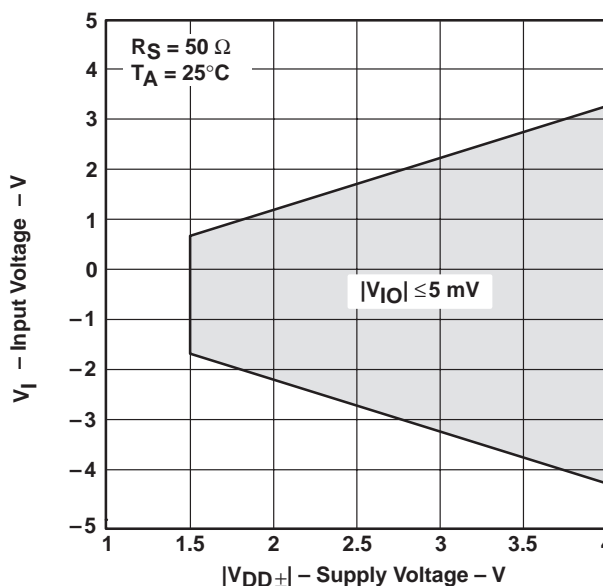


Figure 8

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

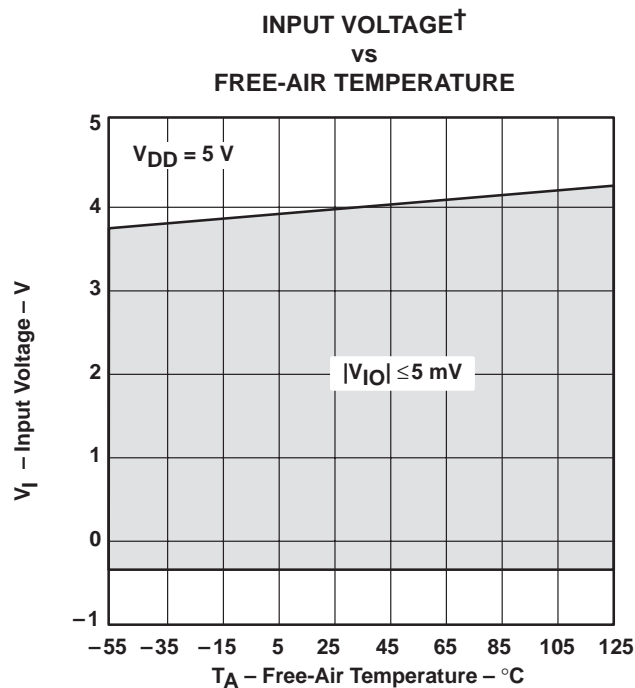


Figure 9

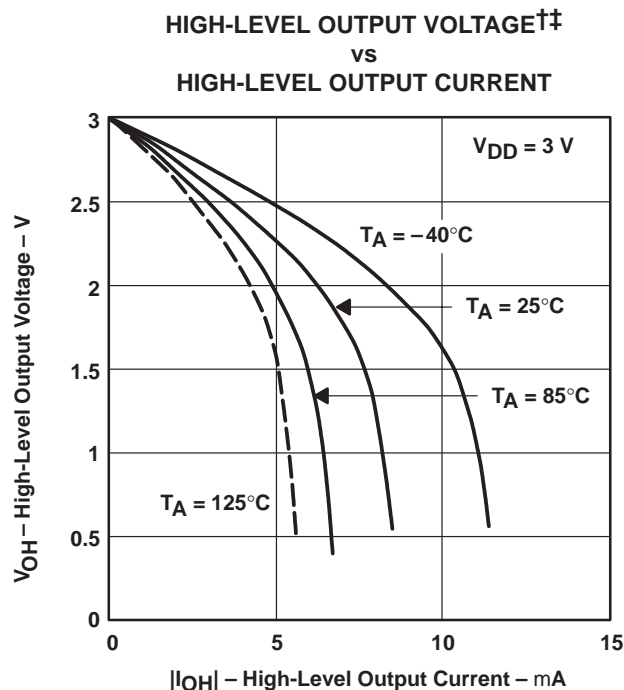


Figure 10

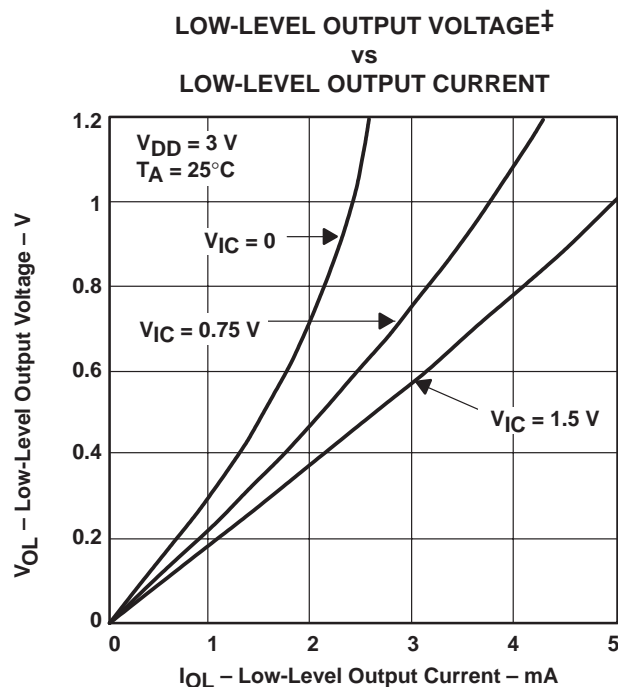


Figure 11

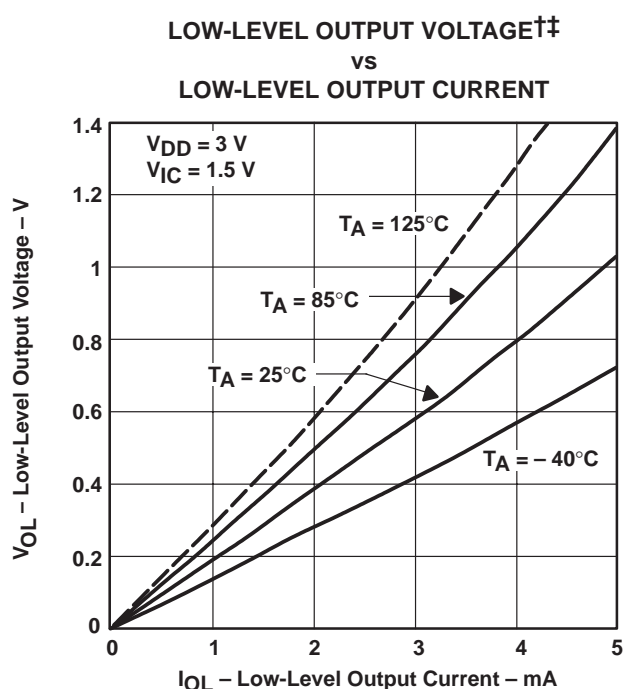


Figure 12

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For all curves where $V_{DD} = 5$ V, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3$ V, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

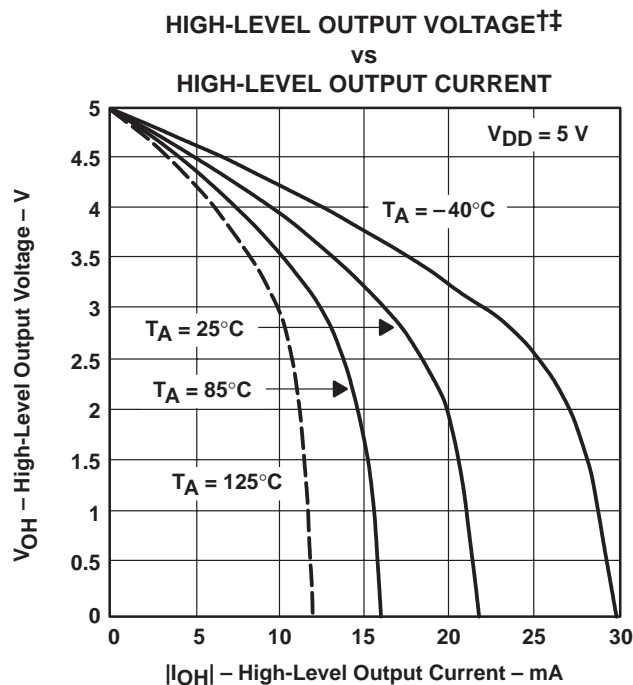


Figure 13

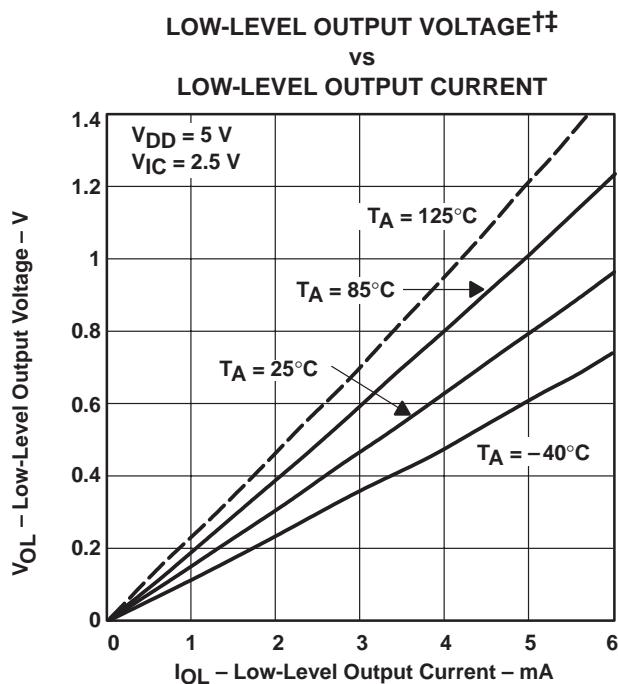


Figure 14

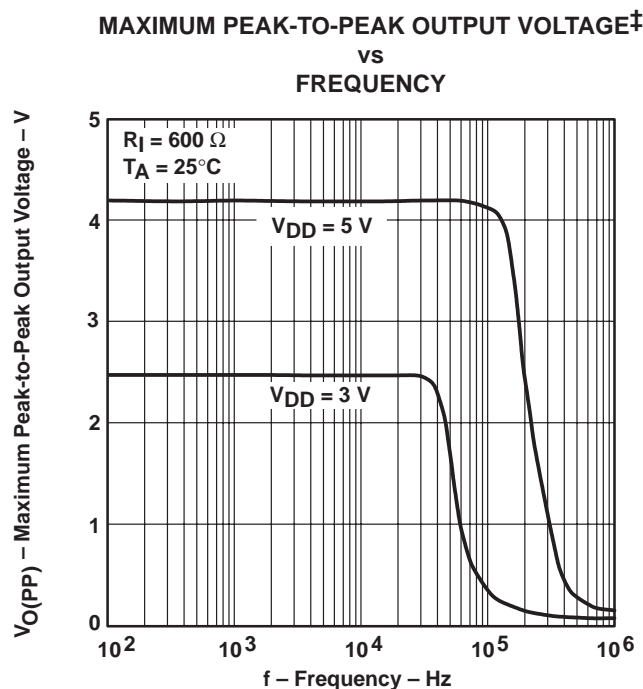


Figure 15

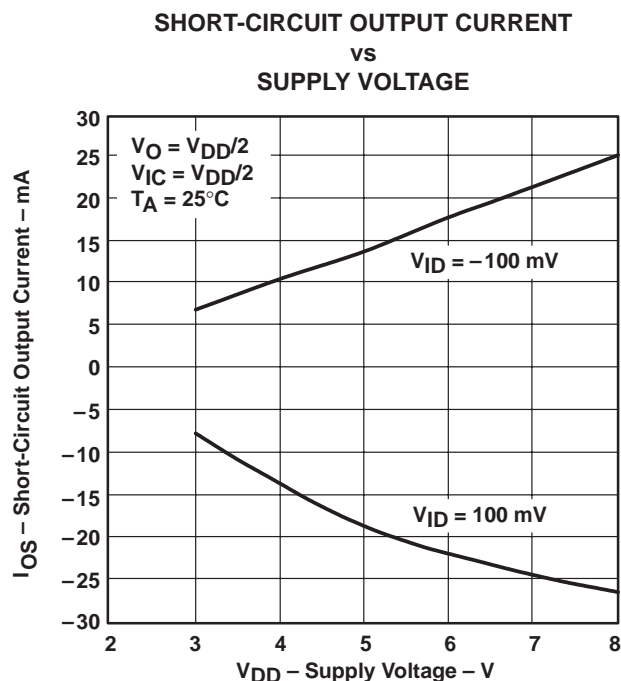


Figure 16

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

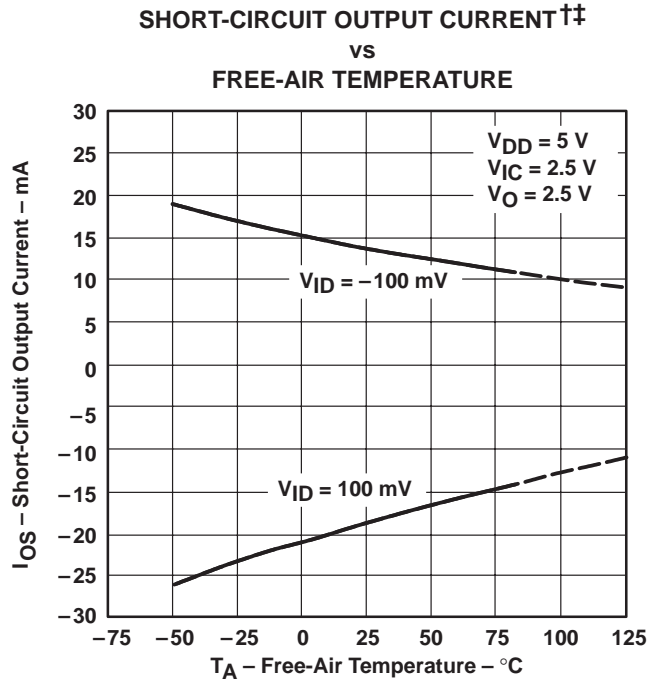


Figure 17

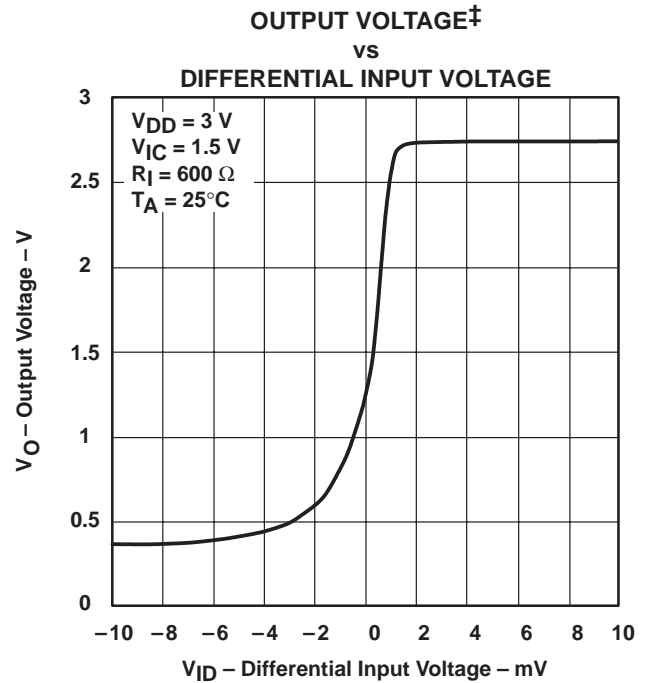


Figure 18

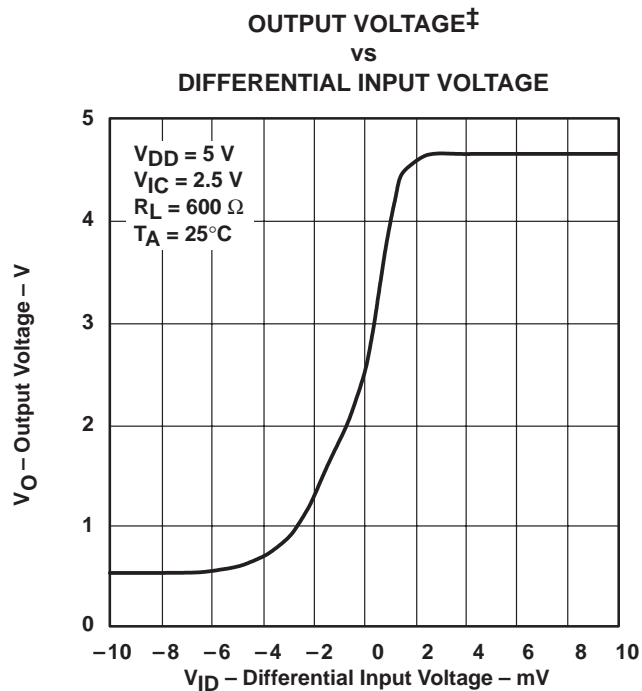


Figure 19

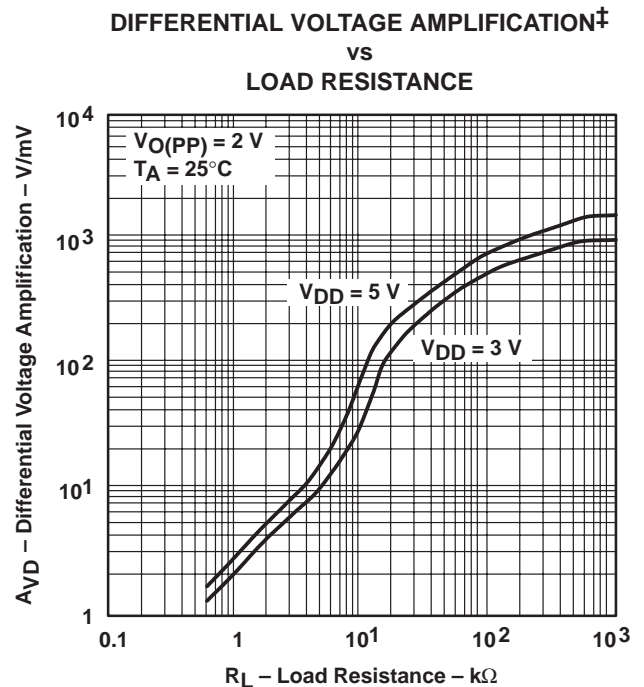


Figure 20

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

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TYPICAL CHARACTERISTICS

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE
 AMPLIFICATION AND PHASE MARGIN†**

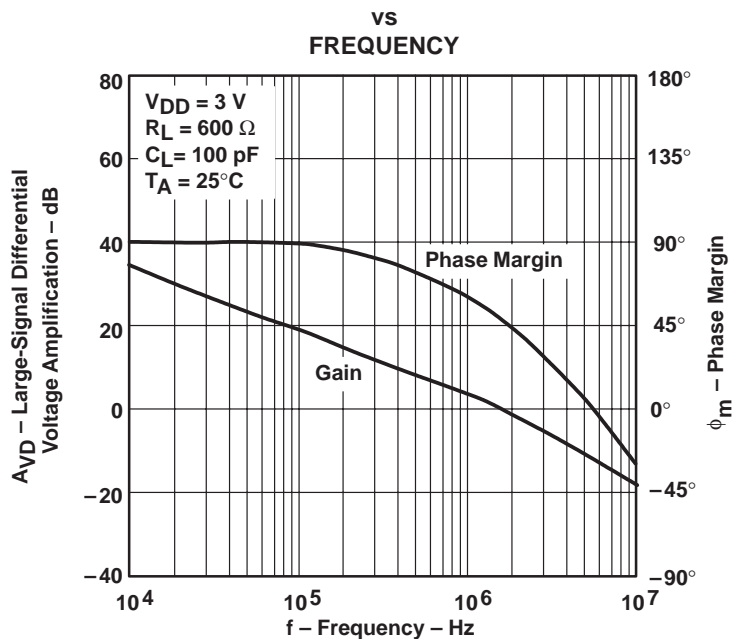


Figure 21

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE
 AMPLIFICATION AND PHASE MARGIN†**

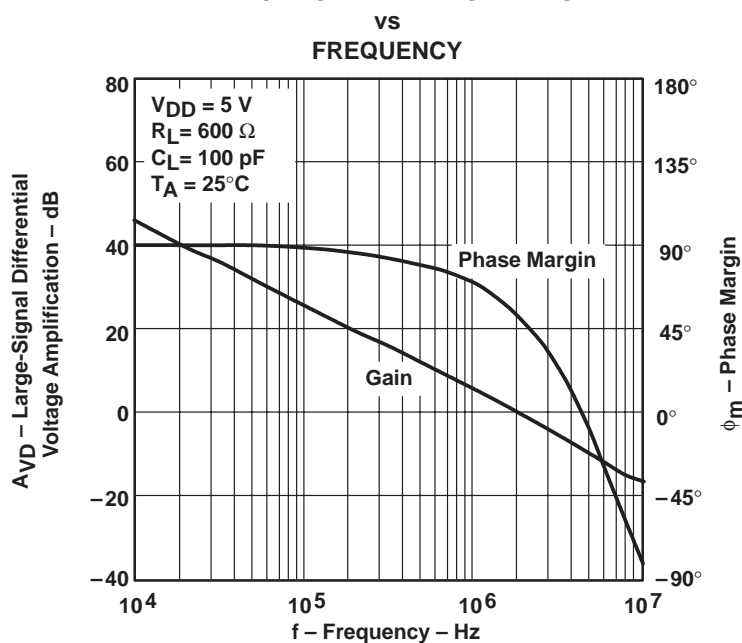


Figure 22

† For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

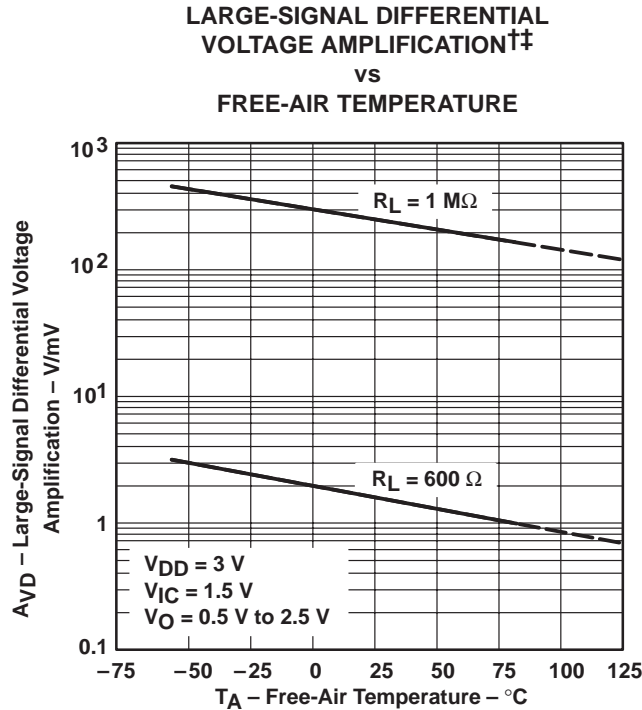


Figure 23

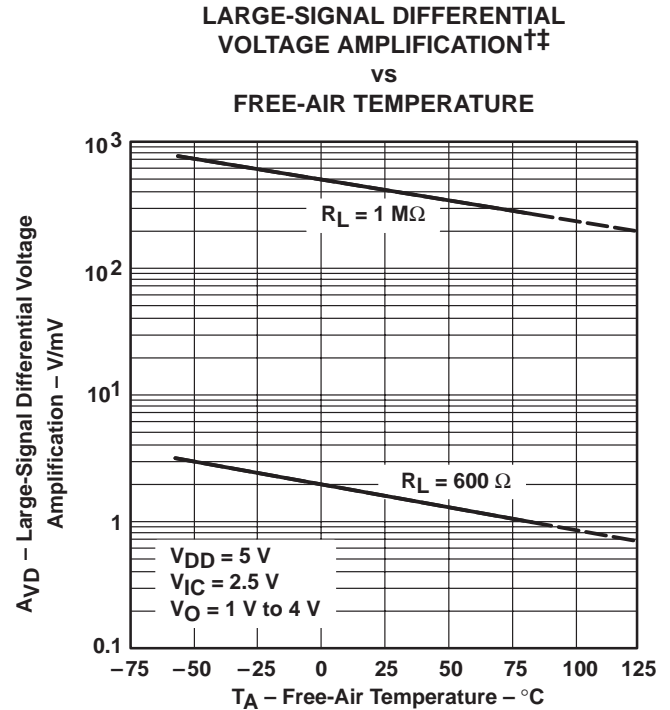


Figure 24

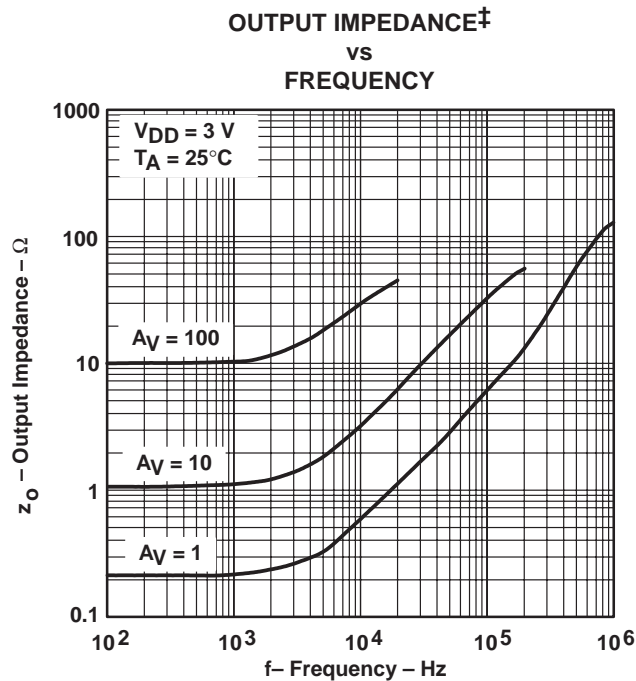


Figure 25

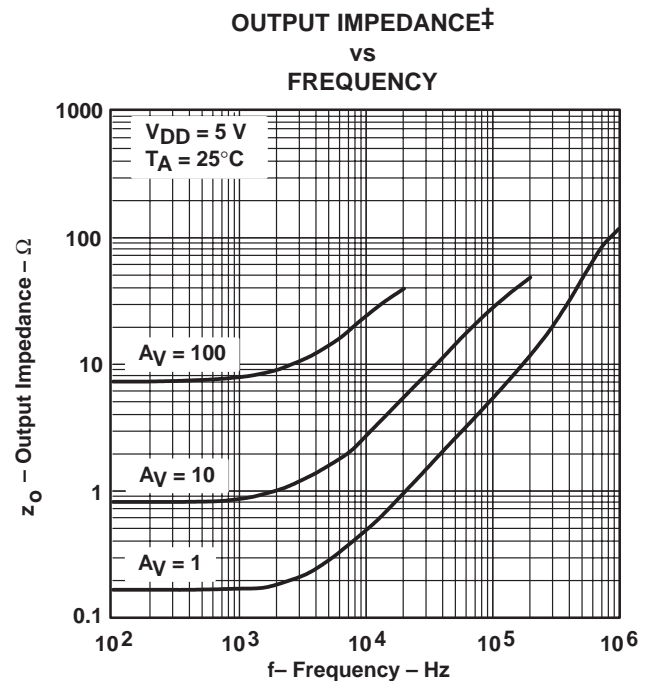


Figure 26

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

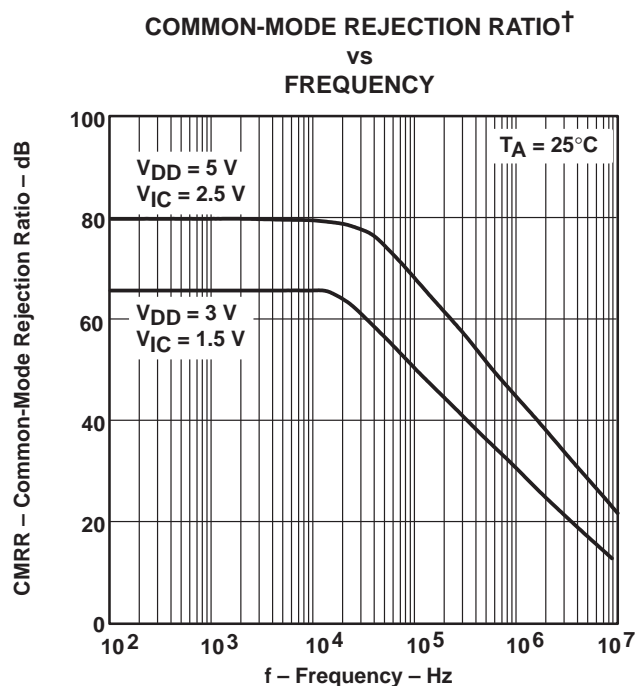


Figure 27

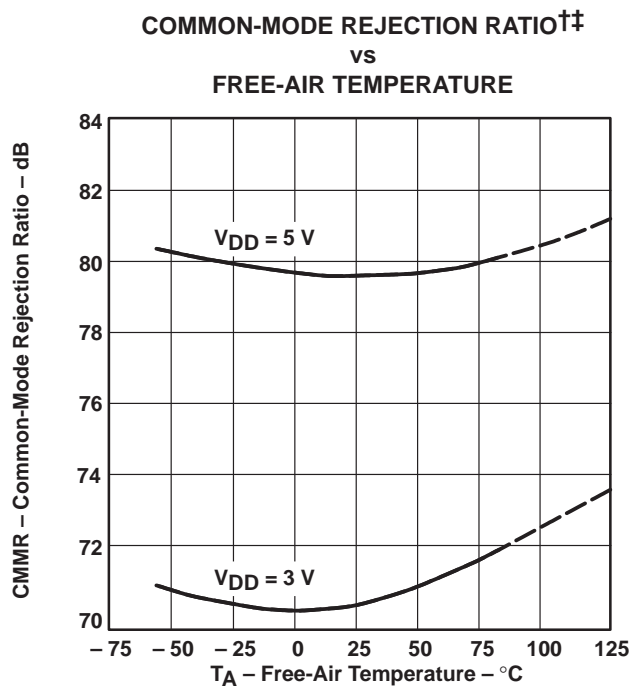


Figure 28

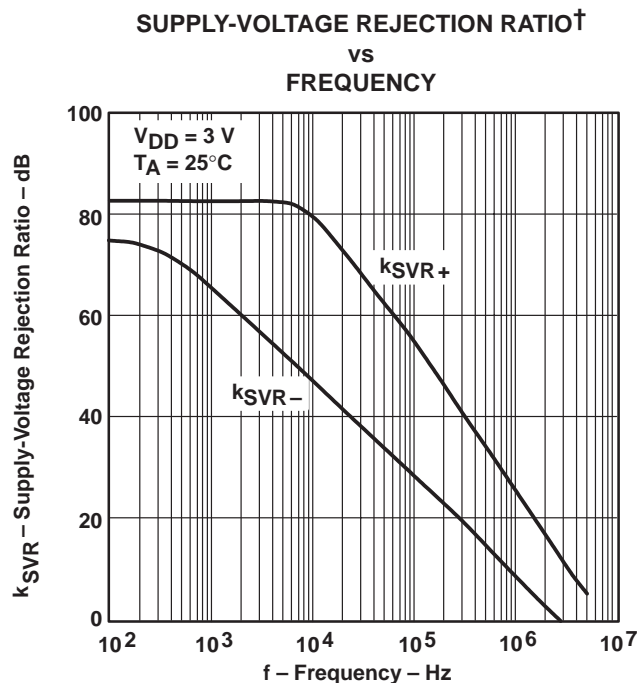


Figure 29

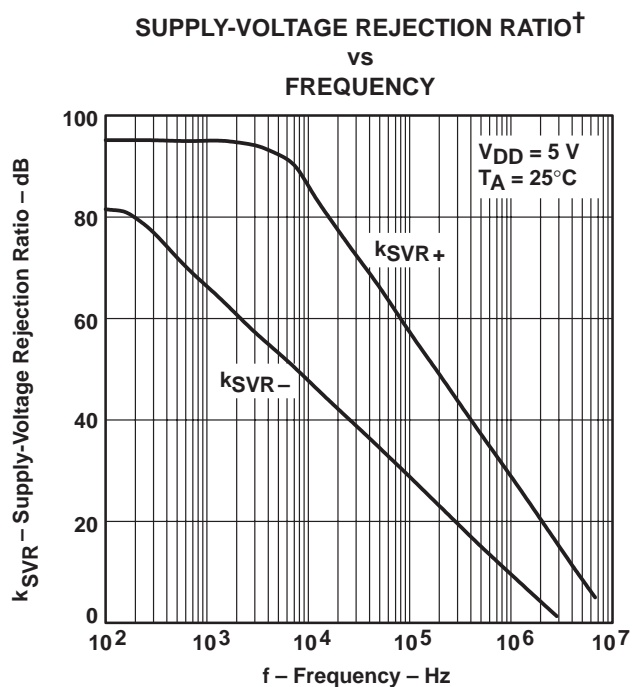


Figure 30

† For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

‡ Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

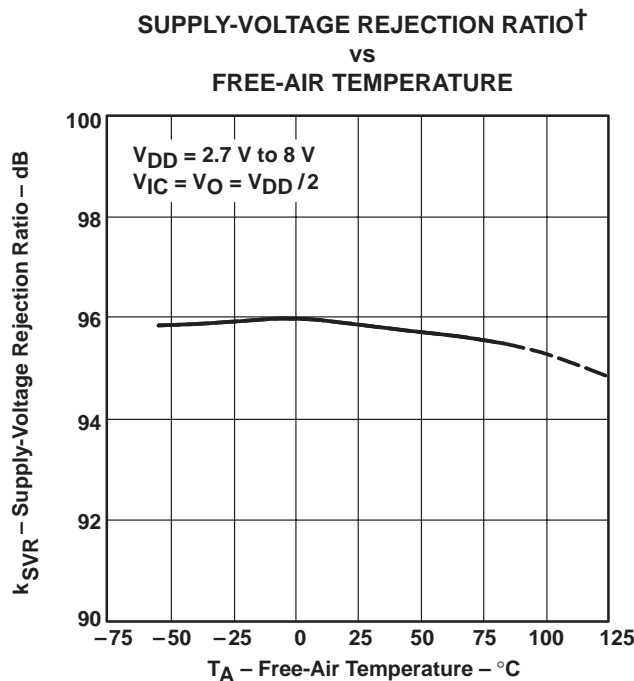


Figure 31

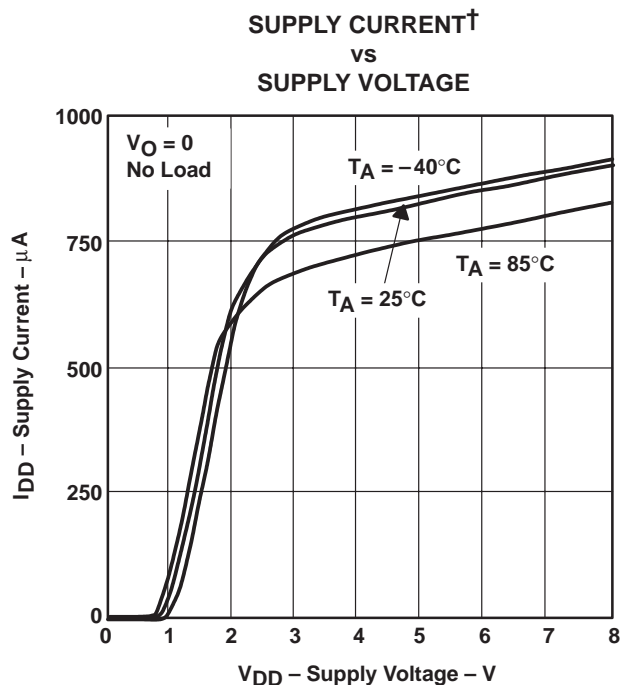


Figure 32

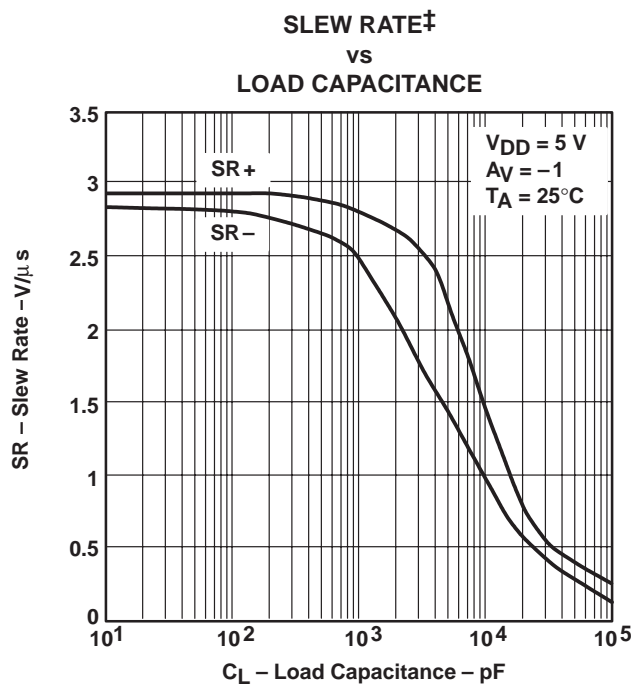


Figure 33

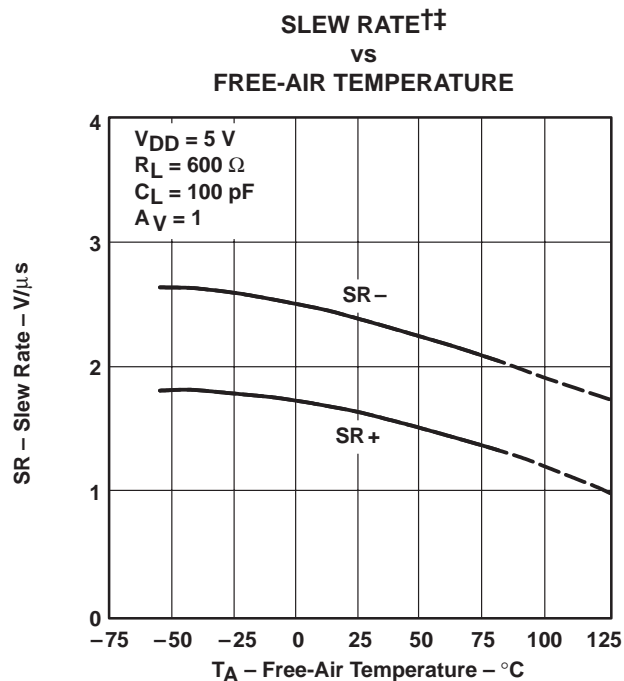


Figure 34

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where $V_{DD} = 5 \text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3 \text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

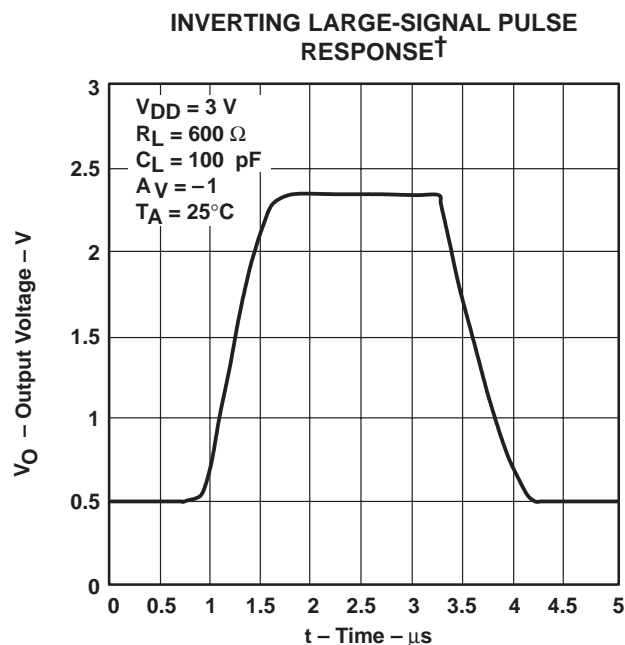


Figure 35

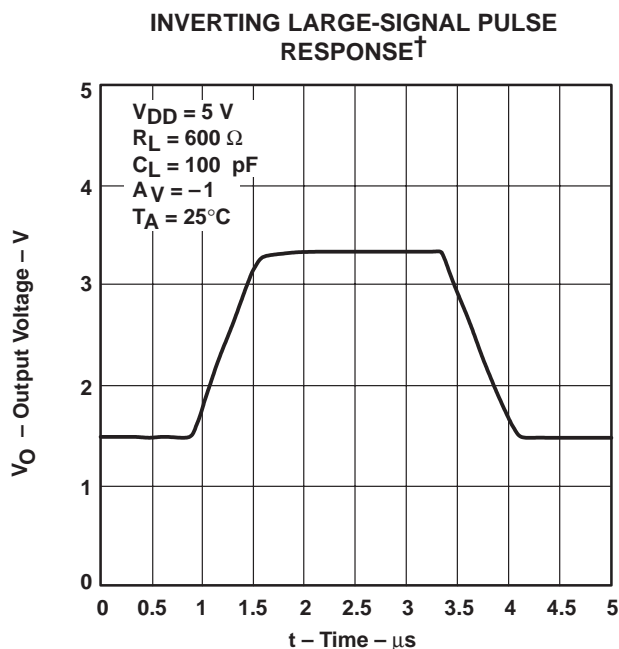


Figure 36

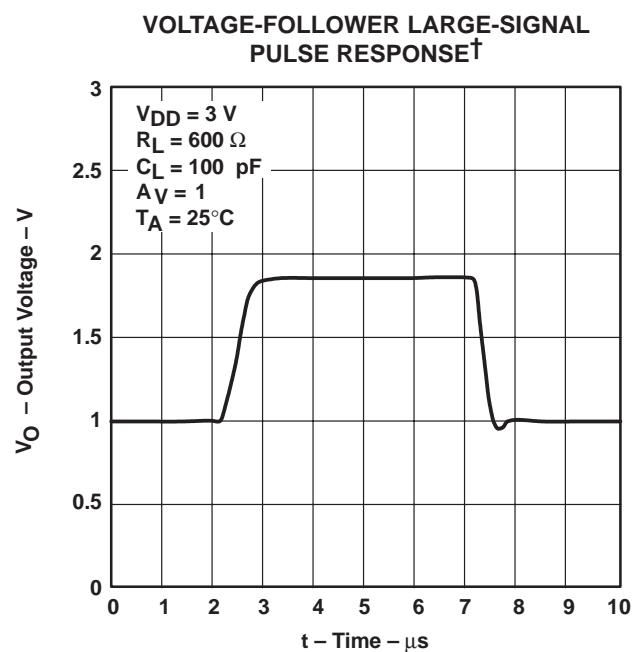


Figure 37

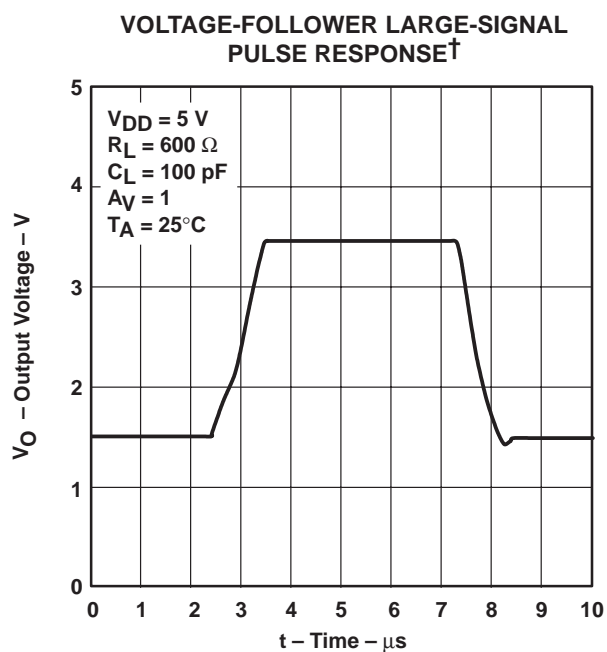


Figure 38

† For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

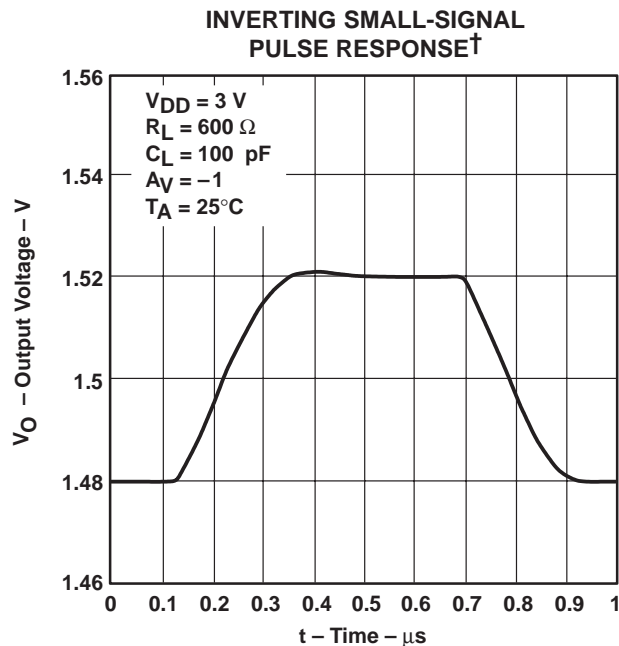


Figure 39

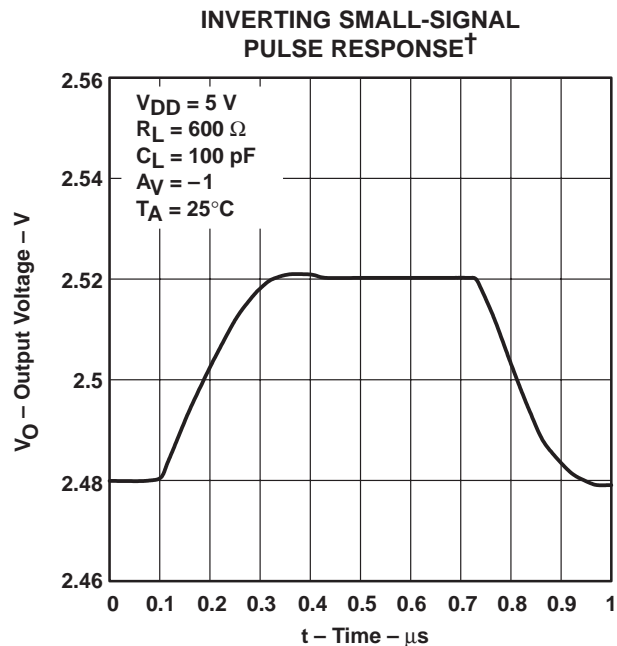


Figure 40

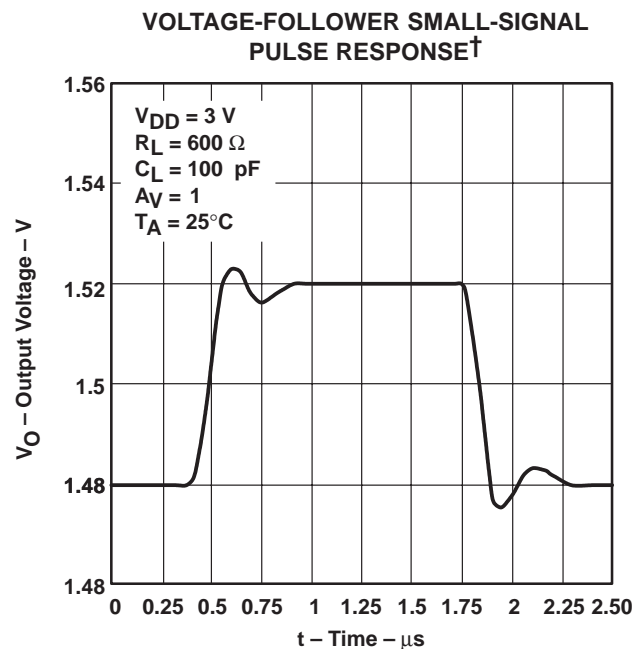


Figure 41

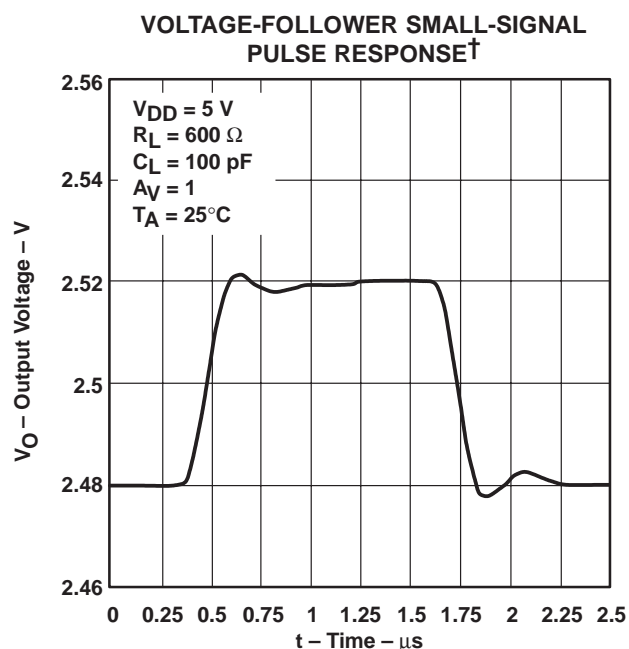


Figure 42

† For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

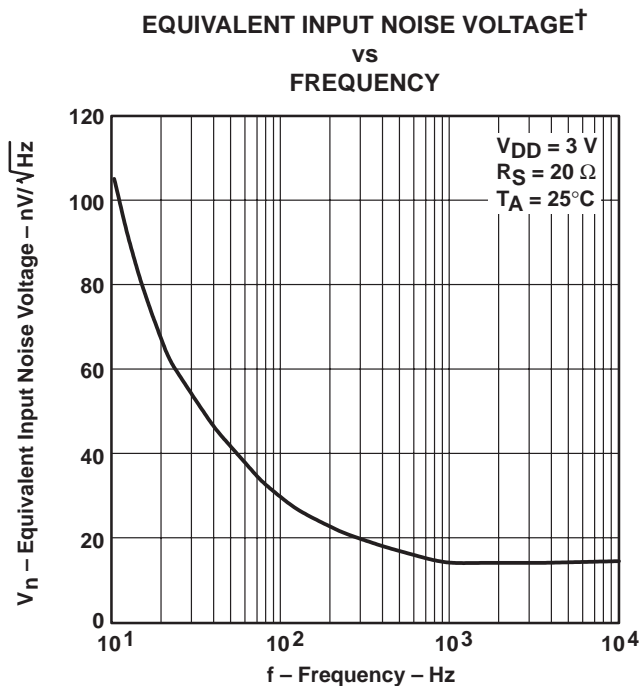


Figure 43

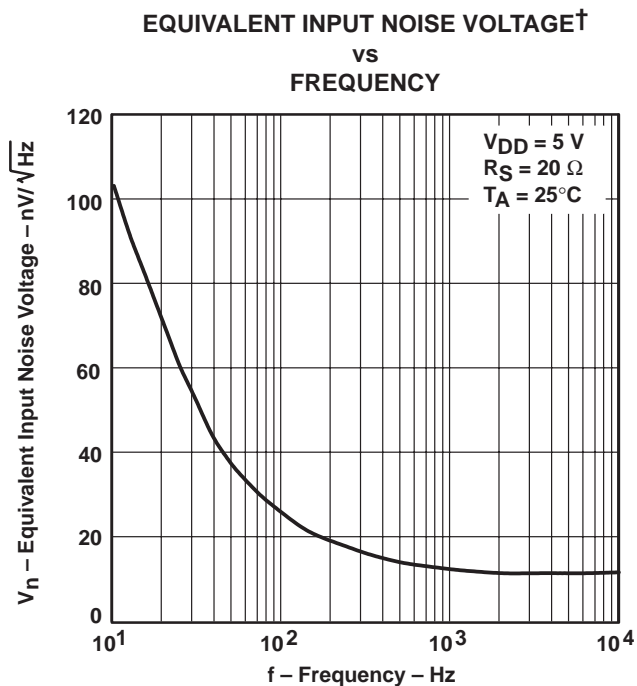


Figure 44

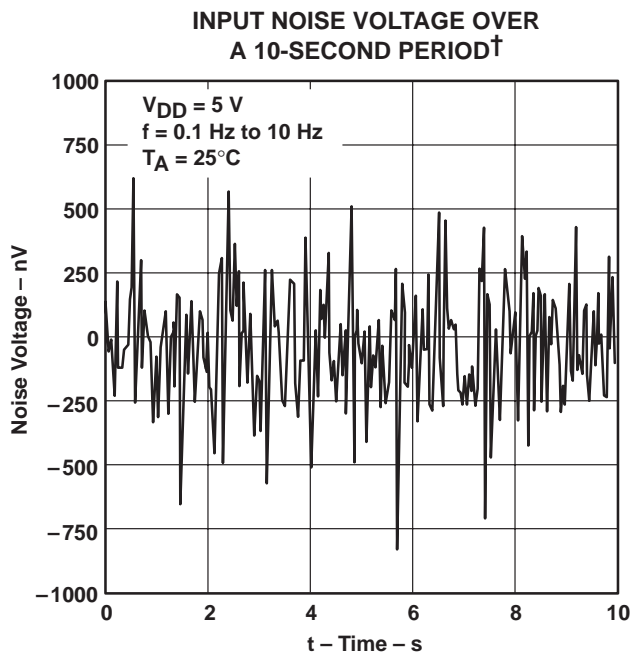


Figure 45

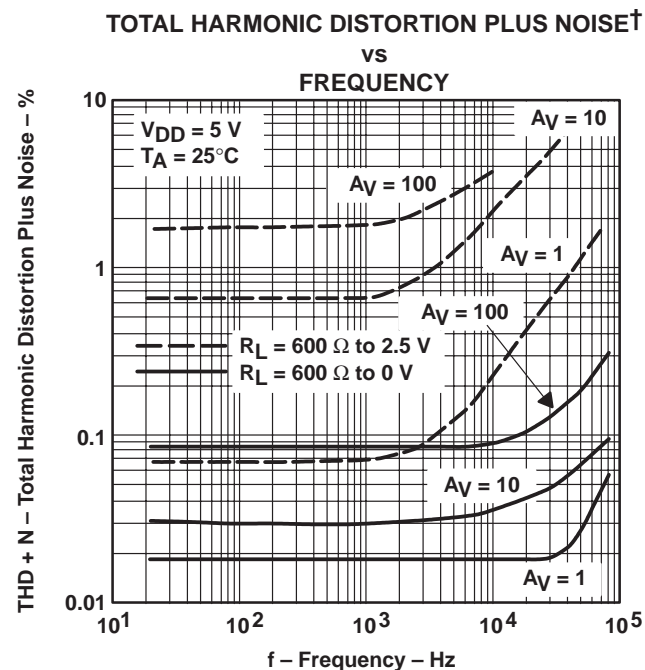


Figure 46

† For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V . For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V .

TYPICAL CHARACTERISTICS

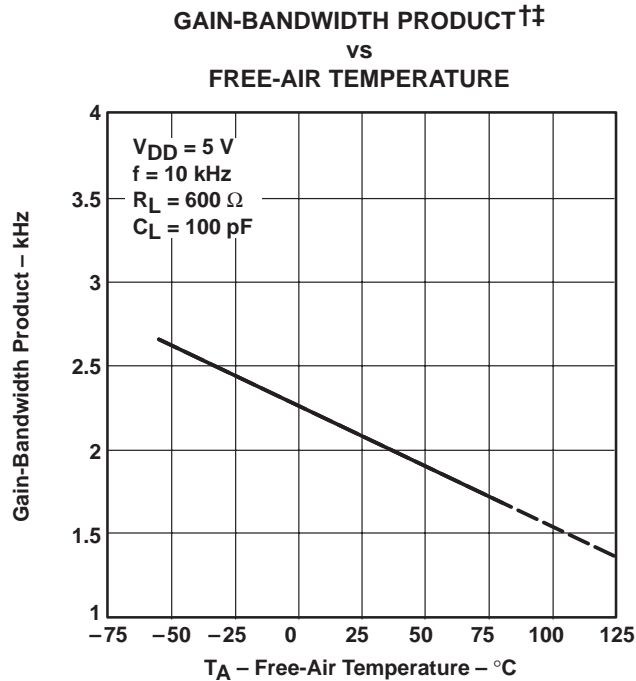


Figure 47

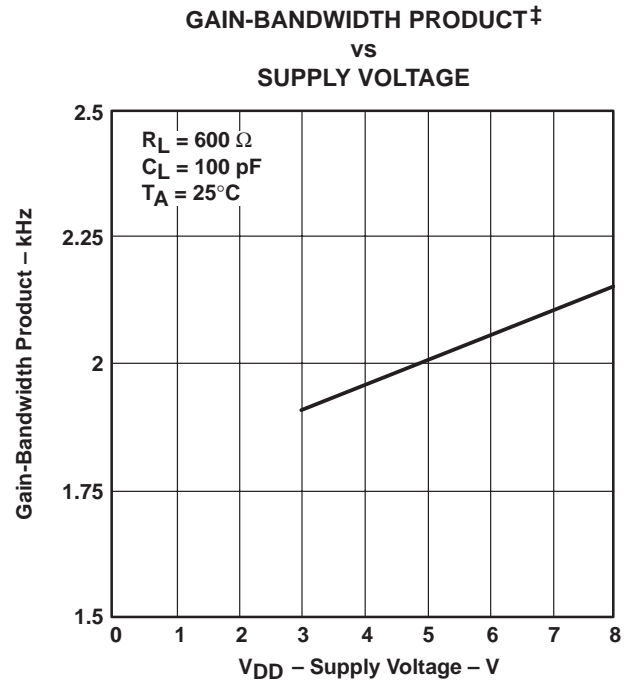


Figure 48

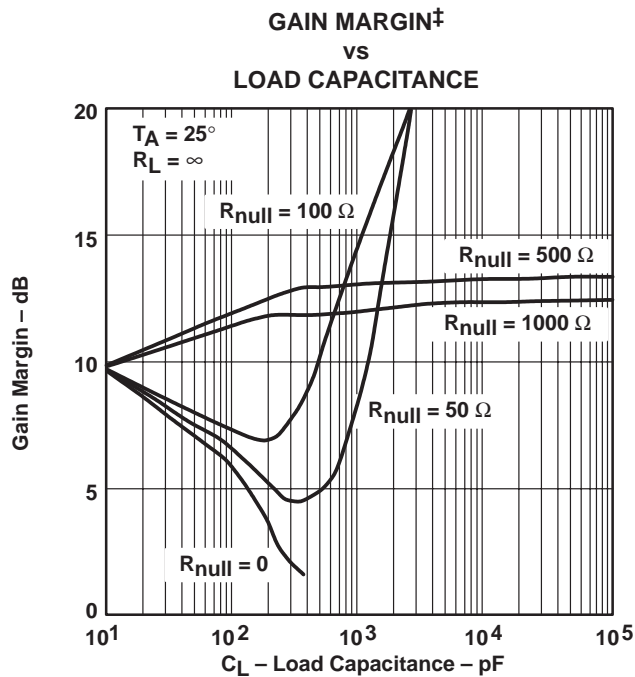


Figure 49

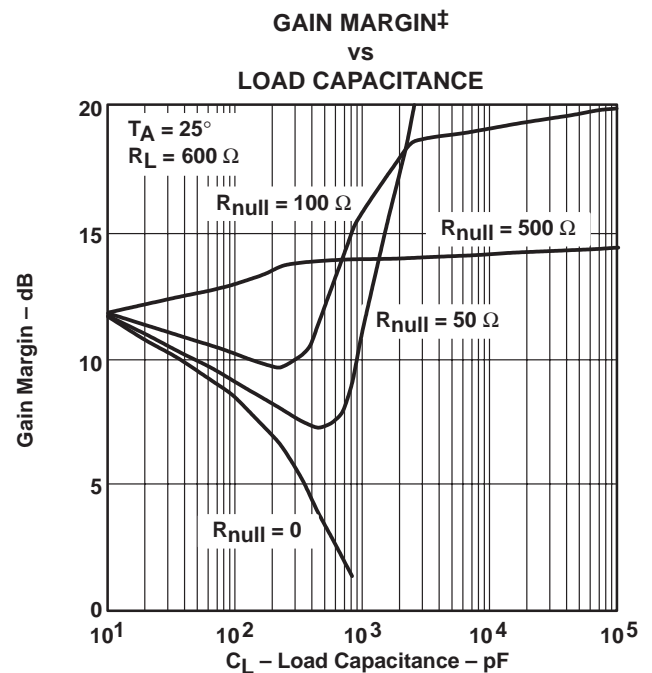


Figure 50

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

TYPICAL CHARACTERISTICS

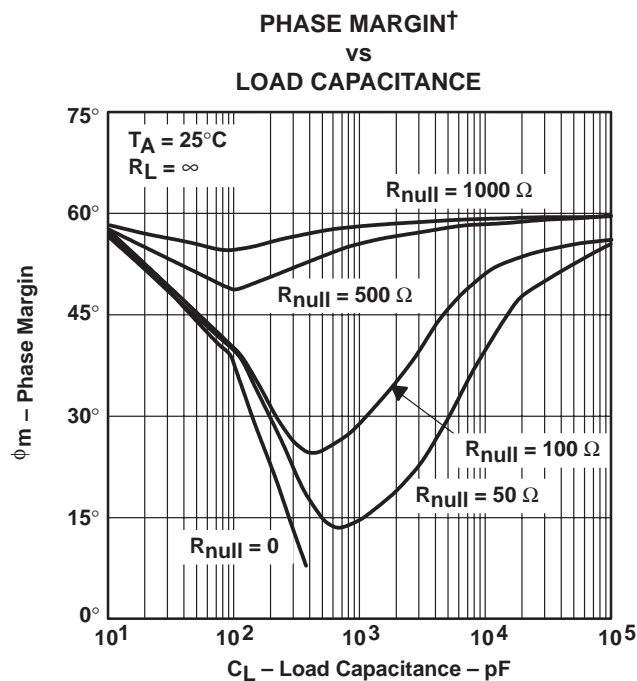


Figure 51

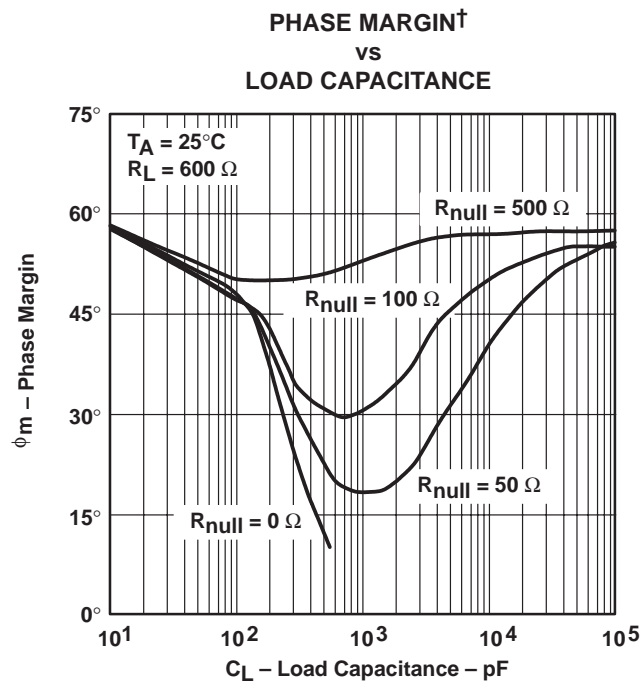


Figure 52

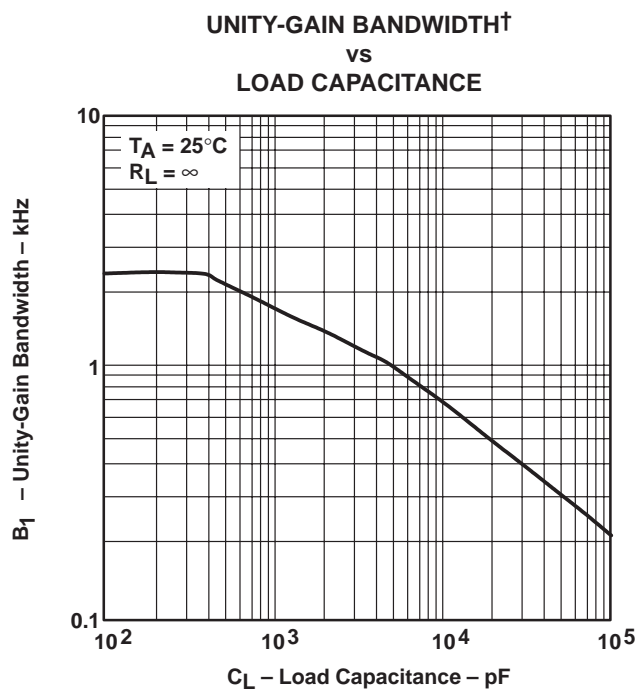


Figure 53

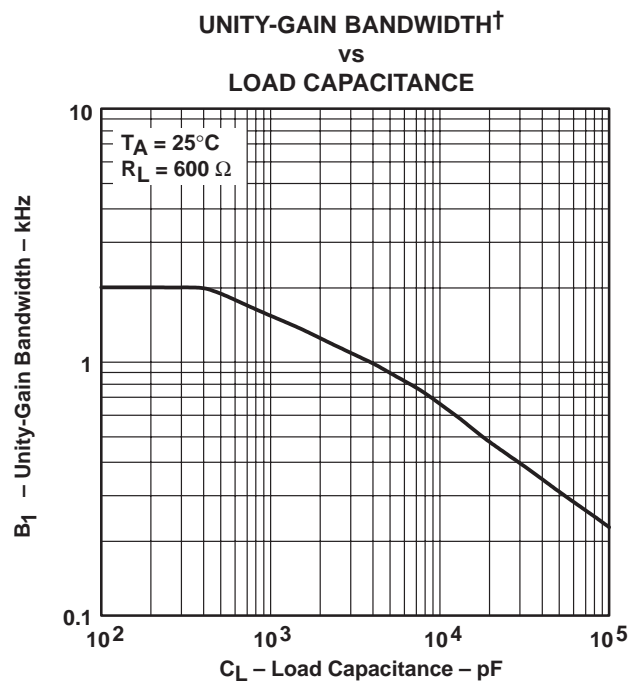


Figure 54

† For all curves where $V_{DD} = 5\text{ V}$, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3\text{ V}$, all loads are referenced to 1.5 V.

APPLICATION INFORMATION

driving large capacitive loads

The TLV2731 is designed to drive larger capacitive loads than most CMOS operational amplifiers. Figure 50 through Figure 55 illustrate its ability to drive loads greater than 100 pF while maintaining good gain and phase margins ($R_{null} = 0$).

A small series resistor (R_{null}) at the output of the device (see Figure 55) improves the gain and phase margins when driving large capacitive loads. Figure 50 through Figure 53 show the effects of adding series resistances of 50 Ω , 100 Ω , 500 Ω , and 1000 Ω . The addition of this series resistor has two effects: the first effect is that it adds a zero to the transfer function and the second effect is that it reduces the frequency of the pole associated with the output load in the transfer function.

The zero introduced to the transfer function is equal to the series resistance times the load capacitance. To calculate the approximate improvement in phase margin, equation 1 can be used.

$$\Delta\phi_{m1} = \tan^{-1} (2 \times \pi \times \text{UGBW} \times R_{null} \times C_L) \quad (1)$$

where :

$\Delta\phi_{m1}$ = improvement in phase margin

UGBW = unity-gain bandwidth frequency

R_{null} = output series resistance

C_L = load capacitance

The unity-gain bandwidth (UGBW) frequency decreases as the capacitive load increases (see Figure 54 and Figure 55). To use equation 1, UGBW must be approximated from Figure 54 and Figure 55.

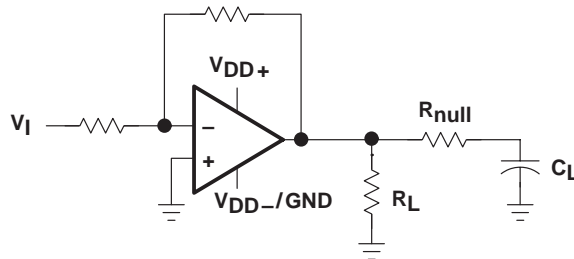


Figure 55. Series-Resistance Circuit

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APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 6) and subcircuit in Figure 57 are generated using the TLV2731 typical electrical and operating characteristics at $T_A = 25^\circ\text{C}$. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 6: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers," *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

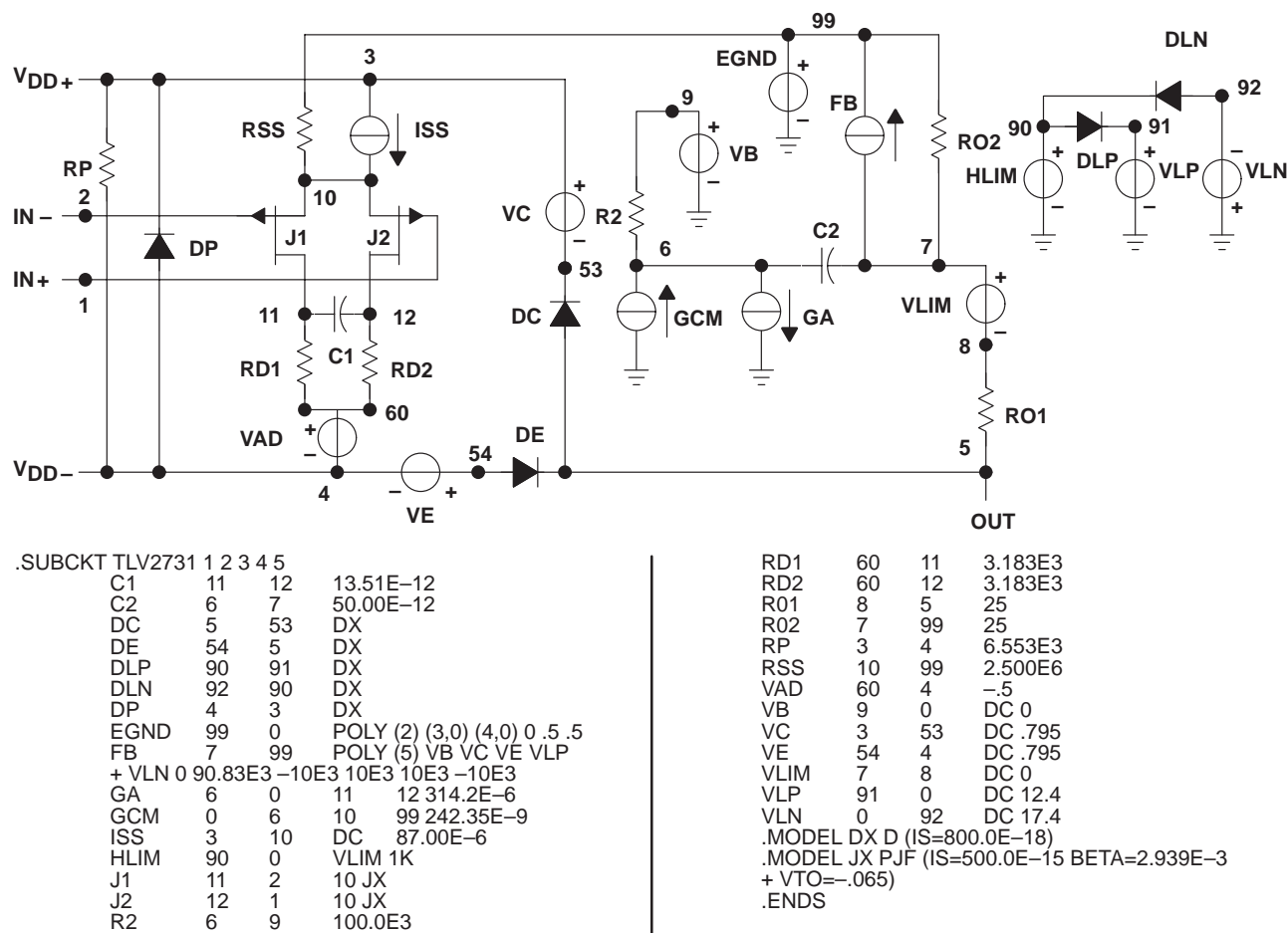


Figure 56. Boyle Macromodel and Subcircuit

PSpice and *Parts* are trademark of MicroSim Corporation.

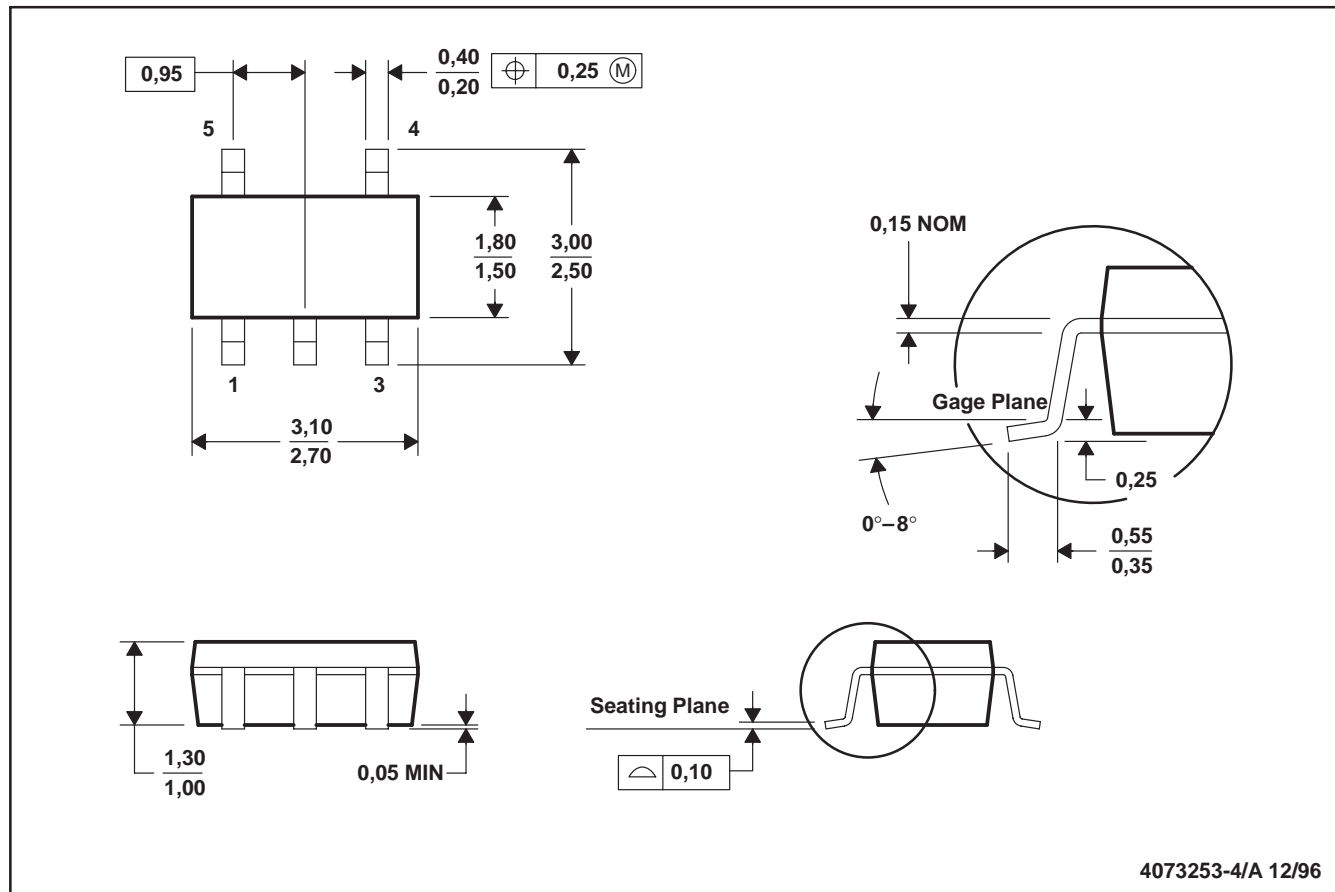
Macromodels, simulation models, or other models provided by TI, directly or indirectly, are not warranted by TI as fully representing all of the specification and operating characteristics of the semiconductor product to which the model relates.



MECHANICAL INFORMATION

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions include mold flash or protrusion.

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