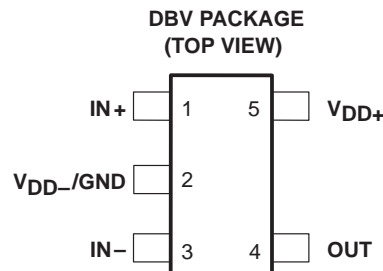


- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 21 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Very Low Power . . . 13 μA Per Channel Typ**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **Wide Supply Voltage Range 2.7 V to 10 V**
- **Available in the SOT-23 Package**
- **Macromodel Included**



## description

The TLV2211 is a single operational amplifier manufactured using the Texas Instruments Advanced LinCMOS™ process. These devices are optimized and fully specified for single-supply 3-V and 5-V operation. For this low-voltage operation combined with micropower dissipation levels, the input noise voltage performance has been dramatically improved using optimized design techniques for CMOS-type amplifiers. Another added benefit is that these amplifiers exhibit rail-to-rail output swing. The output dynamic range can be extended using the TLV2211 with loads referenced midway between the rails. The common-mode input voltage range is wider than typical standard CMOS-type amplifiers. To take advantage of this improvement in performance and to make this device available for a wider range of applications,  $V_{ICR}$  is specified with a larger maximum input offset voltage test limit of  $\pm 5$  mV, allowing a minimum of 0 to 2-V common-mode input voltage range for a 3-V power supply.

### AVAILABLE OPTIONS

$T_A$	$V_{IOmax}$ AT 25°C	PACKAGED DEVICES	SYMBOL	CHIP FORM (Y)
		SOT-23 (DBV)†		
0°C to 70°C	3 mV	TLV2211CDBV	VACC	TLV2211Y
-40°C to 85°C	3 mV	TLV2211IDBV	VACI	

† The DBV package available in tape and reel only.

The Advanced LinCMOS process uses a silicon-gate technology to obtain input offset voltage stability with temperature and time that far exceeds that obtainable using metal-gate technology. This technology also makes possible input-impedance levels that meet or exceed levels offered by top-gate JFET and expensive dielectric-isolated devices.

The TLV2211, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources such as piezoelectric transducers. Because of the low power 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 these devices excellent choices when interfacing directly to analog-to-digital converters (ADCs). All of these features combined with its temperature performance make the TLV2211 ideal for remote pressure sensors, temperature control, active voltage-resistive (VR) sensors, accelerometers, hand-held metering, and many other applications.



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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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

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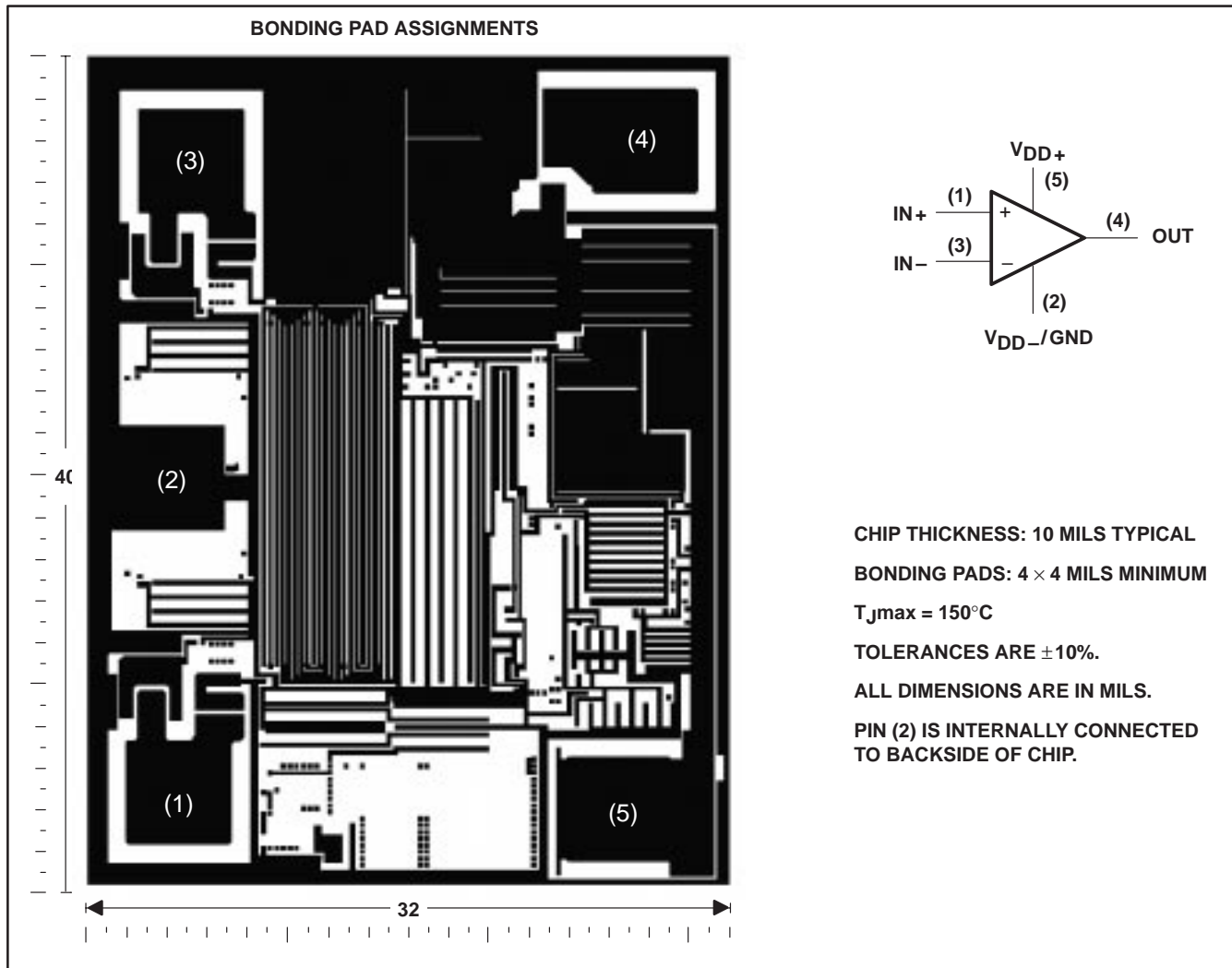
**description (continued)**

The device inputs and outputs are designed to withstand a 100-mA surge current without sustaining latch-up. In addition, internal ESD-protection circuits prevent functional failures up to 2000 V as tested under MIL-PRF-38535; however, care should be exercised when handling these devices as exposure to ESD may result in degradation of the device parametric performance. Additional care should be exercised to prevent  $V_{DD+}$  supply-line transients under powered conditions. Transients of greater than 20 V can trigger the ESD-protection structure, inducing a low-impedance path to  $V_{DD-}/GND$ . Should this condition occur, the sustained current supplied to the device must be limited to 100 mA or less. Failure to do so could result in a latched condition and device failure.



**TLV2211Y chip information**

This chip, when properly assembled, displays characteristics similar to the TLV2211C. 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.

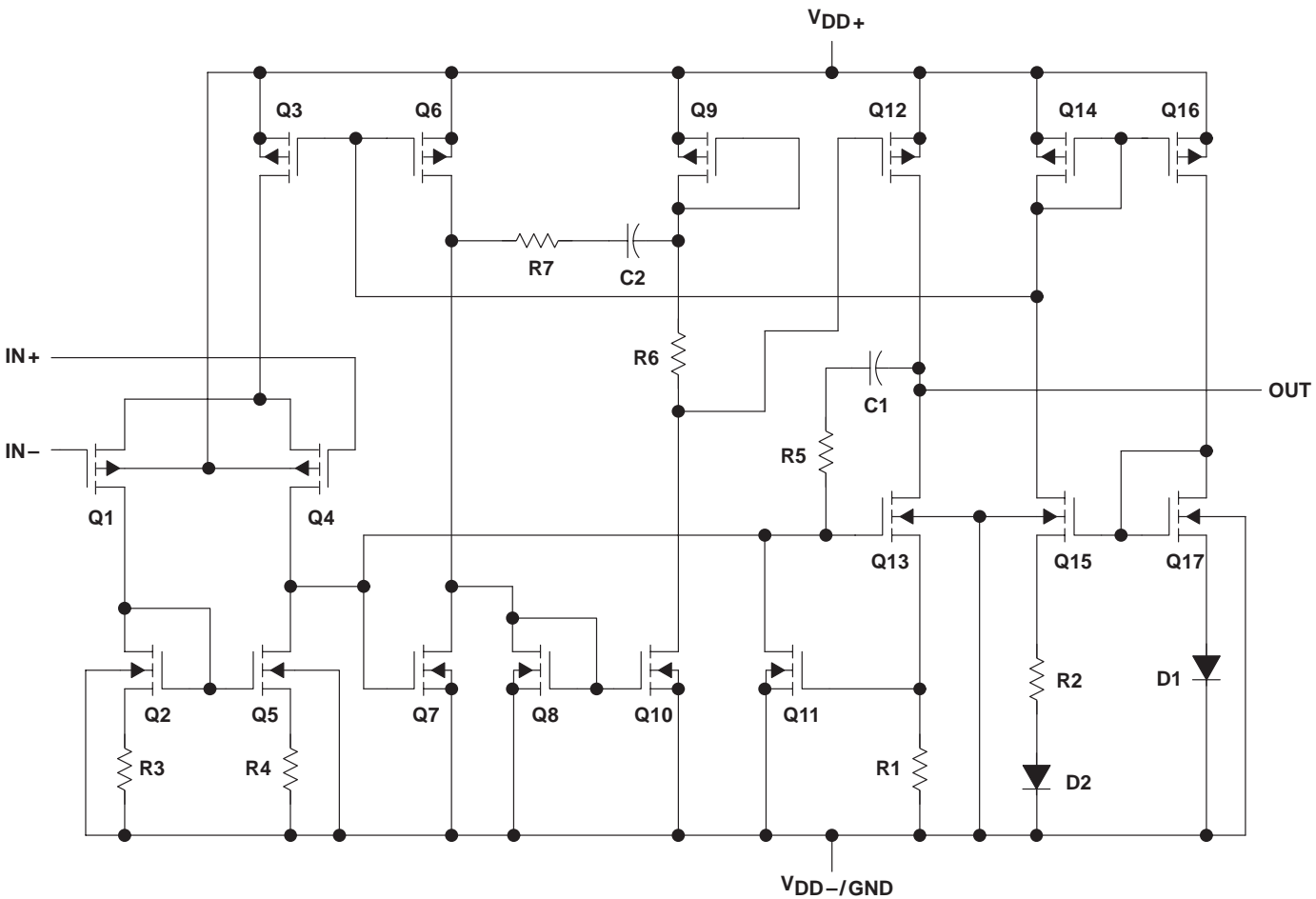


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equivalent schematic



COMPONENT COUNT†	
Transistors	23
Diodes	6
Resistors	11
Capacitors	2

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

**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 V to $V_{DD}$
Input current, $I_I$ (each input)	$\pm 5$ mA
Output current, $I_O$	$\pm 50$ mA
Total current into $V_{DD+}$	$\pm 50$ mA
Total current out of $V_{DD-}$	$\pm 50$ 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, $T_A$ : TLV2211C	0°C to 70°C
TLV2211I	–40°C to 85°C
Storage temperature range, $T_{stg}$	–65°C to 150°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  $V_{DD-} - 0.3$  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/°C	96 mW	78 mW

**recommended operating conditions**

	TLV2211C		TLV2211I		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	°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	$T_A$ †	TLV2211C			TLV2211I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD\pm} = \pm 1.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	Full range	0.47 3			0.47 3000			mV
$\alpha_{VIO}$ Temperature coefficient of input offset voltage			1			1			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003			$\mu\text{V}/\text{mo}$
$I_{IO}$ Input offset current		Full range	0.5 150			0.5 150			pA
$I_{IB}$ Input bias current		Full range	1 150			1 150			pA
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$	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	$I_{OH} = -100\ \mu\text{A}$ $I_{OH} = -250\ \mu\text{A}$	25°C	2.94			2.94			V
		25°C	2.85			2.85			
		Full range	2.5			2.5			
$V_{OL}$ Low-level output voltage	$V_{IC} = 1.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$ $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	25°C	15			15			mV
		25°C	150			150			
		Full range	500			500			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}$ , $V_O = 1\text{ V to } 2\text{ V}$	25°C	$R_L = 10\ \text{k}\Omega$ ‡		3 7		3 7		V/mV
			Full range		1		1		
		25°C	$R_L = 1\ \text{M}\Omega$ ‡		600		600		
$r_{i(d)}$ Differential input resistance		25°C	10 <sup>12</sup>			10 <sup>12</sup>			$\Omega$
$r_{i(c)}$ Common-mode input resistance		25°C	10 <sup>12</sup>			10 <sup>12</sup>			$\Omega$
$C_{i(c)}$ Common-mode input capacitance	$f = 10\ \text{kHz}$ ,	25°C	5			5			pF
$z_o$ Closed-loop output impedance	$f = 7\ \text{kHz}$ , $A_V = 1$	25°C	200			200			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to } 1.7\text{ V}$ , $R_S = 50\ \Omega$ , $V_O = 1.5\text{ V}$	25°C	65 83			65 83			dB
		Full range	60			60			
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V to } 8\text{ V}$ , No load, $V_{IC} = V_{DD}/2$	25°C	80 95			80 95			dB
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 1.5\text{ V}$ , No load	25°C	11 25			11 25			$\mu\text{A}$
		Full range	30			30			

† Full range for the TLV2211C is 0°C to 70°C. Full range for the TLV2211I 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.



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

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2211C			TLV2211I			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
SR	Slew rate at unity gain	$V_O = 1.1\text{ V to }1.9\text{ V}, R_L = 10\text{ k}\Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$	25°C	0.01	0.025		0.01	0.025	V/ $\mu\text{s}$	
			Full range	0.005			0.005			
$V_n$	Equivalent input noise voltage		25°C	80			80			nV/ $\sqrt{\text{Hz}}$
			25°C	22			22			
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage		25°C	660			660			$\mu\text{V}$
			25°C	880			880			
$I_n$	Equivalent input noise current		25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
	Gain-bandwidth product	$f = 10\text{ kHz}, C_L = 100\text{ pF}^\ddagger, R_L = 10\text{ k}\Omega^\ddagger$	25°C	56			56			kHz
BOM	Maximum output-swing bandwidth	$V_{O(PP)} = 1\text{ V}, R_L = 10\text{ k}\Omega^\ddagger, A_V = 1, C_L = 100\text{ pF}^\ddagger$	25°C	7			7			kHz
$\phi_m$	Phase margin at unity gain	$R_L = 10\text{ k}\Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$	25°C	56°			56°			
	Gain margin		25°C	20			20			dB

† Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

‡ Referenced to 1.5 V

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

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2211C			TLV2211I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD\pm} = \pm 2.5\text{ V}$ , $V_O = 0$ , $V_{IC} = 0$ , $R_S = 50\ \Omega$	Full range	0.45 3			0.45 3			mV
$\alpha_{VIO}$ Temperature coefficient of input offset voltage			0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.003			0.003			$\mu\text{V}/\text{mo}$
$I_{IO}$ 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	$ V_{IO}  \leq 5\text{ mV}$ $R_S = 50\ \Omega$	25°C	0 to 4	-0.3 to 4.2	0 to 4	-0.3 to 4.2	V		
		Full range	0 to 3.5		0 to 3.5				
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$ $I_{OH} = -250\ \mu\text{A}$	25°C	4.95			4.95			V
		25°C	4.875			4.875			
		Full range	4.5			4.5			
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$ $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	25°C	12			12			mV
		25°C	120			120			
		Full range	500			500			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	25°C	$R_L = 10\text{ k}\Omega$ ‡			6 12			V/mV
			Full range			3			
		25°C	$R_L = 1\text{ M}\Omega$ ‡			800			
$r_{i(d)}$ Differential input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$r_{i(c)}$ Common-mode input resistance		25°C	$10^{12}$			$10^{12}$			$\Omega$
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$ ,	25°C	5			5			pF
$z_o$ Closed-loop output impedance	$f = 7\text{ kHz}$ , $A_V = 1$	25°C	200			200			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }2.7\text{ V}$ , $R_S = 50\ \Omega$ , $V_O = 2.5\text{ V}$	25°C	70	83	70	83	dB		
		Full range	70			70			
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }8\text{ V}$ , No load, $V_{IC} = V_{DD}/2$	25°C	80	95	80	95	dB		
		Full range	80			80			
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	25°C	13	25	13	25	$\mu\text{A}$		
		Full range	30			30			

† Full range for the TLV2211C is 0°C to 70°C. Full range for the TLV2211I is -40°C to 85°C.

‡ Referenced to 1.5 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.





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

PARAMETER	TEST CONDITIONS	$T_A$ †	TLV2211C			TLV2211I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1.5\text{ V to }3.5\text{ V}, R_L = 10\text{ k}\Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$	25°C	0.01	0.025		0.01	0.025		V/ $\mu\text{s}$
		Full range	0.005			0.005			
$V_n$ Equivalent input noise voltage	$f = 10\text{ Hz}$	25°C	72			72			nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C	21			21			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }1\text{ Hz}$	25°C	600			600			$\mu\text{V}$
	$f = 0.1\text{ Hz to }10\text{ Hz}$	25°C	800			800			
$I_n$ Equivalent input noise current		25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\text{ kHz}, R_L = 10\text{ k}\Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$	25°C	65			65			kHz
BOM Maximum output-swing bandwidth	$V_{O(PP)} = 2\text{ V}, R_L = 10\text{ k}\Omega^\ddagger, A_V = 1, C_L = 100\text{ pF}^\ddagger$	25°C	7			7			kHz
$\phi_m$ Phase margin at unity gain	$R_L = 10\text{ k}\Omega^\ddagger, C_L = 100\text{ pF}^\ddagger$	25°C	56°			56°			
		Gain margin	25°C	22			22		

† Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

‡ Referenced to 1.5 V

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

PARAMETER	TEST CONDITIONS	TLV2211Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD} \pm \pm 1.5\text{ V}, V_O = 0, V_{IC} = 0, R_S = 50\ \Omega$	0.47			mV
$I_{IO}$ Input offset current		0.5			pA
$I_{IB}$ Input bias current		1			pA
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV}, R_S = 50\ \Omega$	-0.3 to 2.2			V
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$	2.94			V
	$I_{OH} = -200\ \mu\text{A}$	2.85			
$V_{OL}$ Low-level output voltage	$V_{IC} = 0, I_{OL} = 50\ \mu\text{A}$	15			mV
	$V_{IC} = 0, I_{OL} = 500\ \mu\text{A}$	150			
$A_{VD}$ Large-signal differential voltage amplification	$V_{IC} = 1.5\text{ V}, V_O = 1\text{ V to }2\text{ V}$	$R_L = 10\text{ k}\Omega^\ddagger$	7		V/mV
		$R_L = 1\text{ M}\Omega^\ddagger$	600		
$r_{i(d)}$ Differential input resistance		$10^{12}$			$\Omega$
$r_{i(c)}$ Common-mode input resistance		$10^{12}$			$\Omega$
$c_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$	5			pF
$z_o$ Closed-loop output impedance	$f = 7\text{ kHz}, A_V = 1$	200			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }1.7\text{ V}, V_O = 1.5\text{ V}, R_S = 50\ \Omega$	83			dB
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V to }8\text{ V}, V_{IC} = V_{DD}/2, \text{ No load}$	95			dB
$I_{DD}$ Supply current	$V_O = 1.5\text{ V}, \text{ No load}$	11			$\mu\text{A}$

† Referenced to 1.5 V

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

PARAMETER	TEST CONDITIONS	TLV2211Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{DD} \pm = \pm 2.5\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $V_O = 0$ ,	0.45			mV
$I_{IO}$ Input offset current		0.5			pA
$I_{IB}$ Input bias current		1			pA
$V_{ICR}$ Common-mode input voltage range	$ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$	-0.3 to 4.2			V
$V_{OH}$ High-level output voltage	$I_{OH} = -100\ \mu\text{A}$	4.95			V
	$I_{OH} = -250\ \mu\text{A}$	4.875			
$V_{OL}$ Low-level output voltage	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$	12			mV
	$V_{IC} = 2.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$	120			
AVD Large-signal differential voltage amplification	$V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$	$R_L = 10\text{ k}\Omega^\dagger$	12		V/mV
		$R_L = 1\text{ M}\Omega^\dagger$	800		
$r_{i(d)}$ Differential input resistance		10 <sup>12</sup>			$\Omega$
$r_{i(c)}$ Common-mode input resistance		10 <sup>12</sup>			$\Omega$
$C_{i(c)}$ Common-mode input capacitance	$f = 10\text{ kHz}$	5			pF
$Z_o$ Closed-loop output impedance	$f = 7\text{ kHz}$ , $A_V = 1$	200			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = 0\text{ to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$	83			dB
kSVR Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 4.4\text{ V to }8\text{ V}$ , $V_{IC} = V_{DD}/2$ , No load	95			dB
$I_{DD}$ Supply current	$V_O = 2.5\text{ V}$ , No load	13			$\mu\text{A}$

<sup>†</sup> Referenced to 1.5 V



## TYPICAL CHARACTERISTICS

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	Noise voltage (referred to input)	Over a 10-second period
		45
THD + N	Total harmonic distortion plus noise	vs Frequency
		46
	Gain-bandwidth product	vs Free-air temperature vs Supply voltage
		47 48
$\phi_m$	Phase margin	vs Frequency vs Load capacitance
		21, 22 49
	Gain margin	vs Load capacitance
		50
$B_1$	Unity-gain bandwidth	vs Load capacitance
		51

TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLV2211  
 INPUT OFFSET VOLTAGE

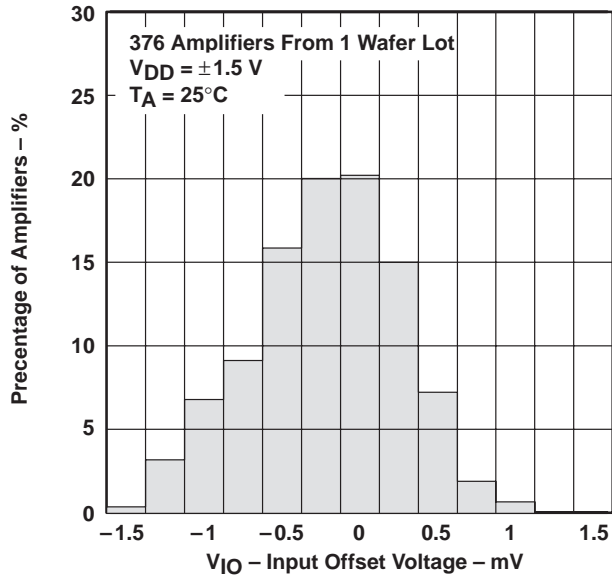


Figure 1

DISTRIBUTION OF TLV2211  
 INPUT OFFSET VOLTAGE

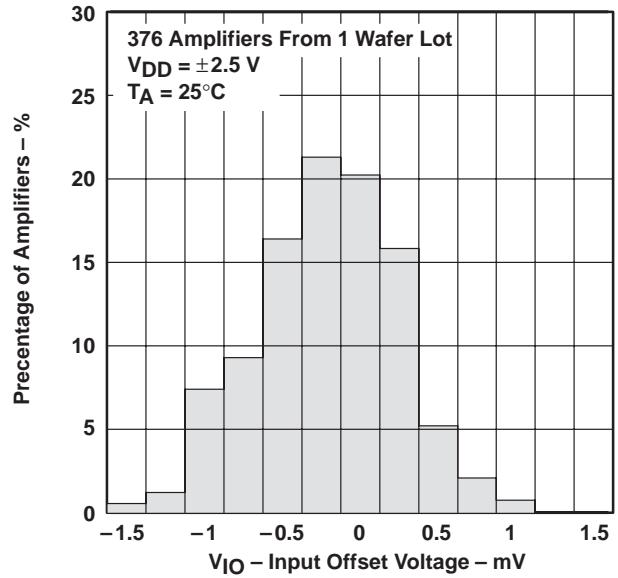


Figure 2

INPUT OFFSET VOLTAGE†  
 vs  
 COMMON-MODE INPUT VOLTAGE

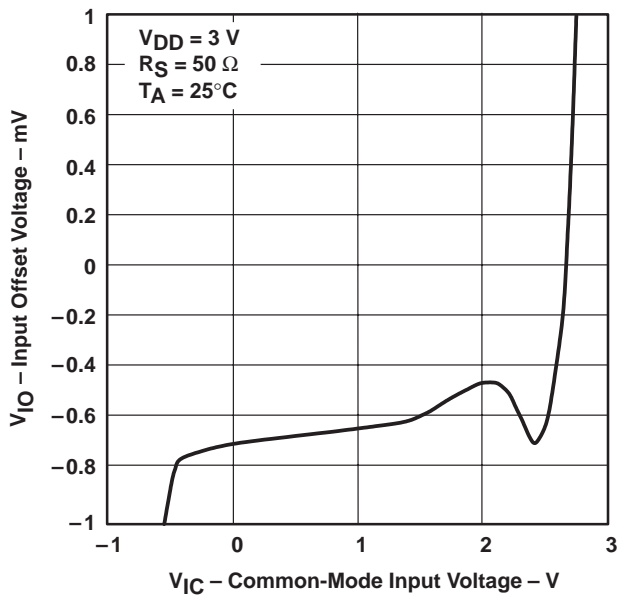


Figure 3

INPUT OFFSET VOLTAGE†  
 vs  
 COMMON-MODE INPUT VOLTAGE

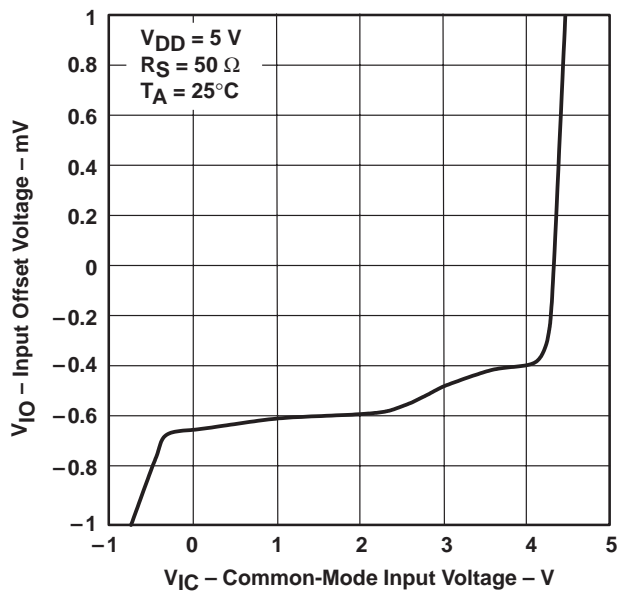
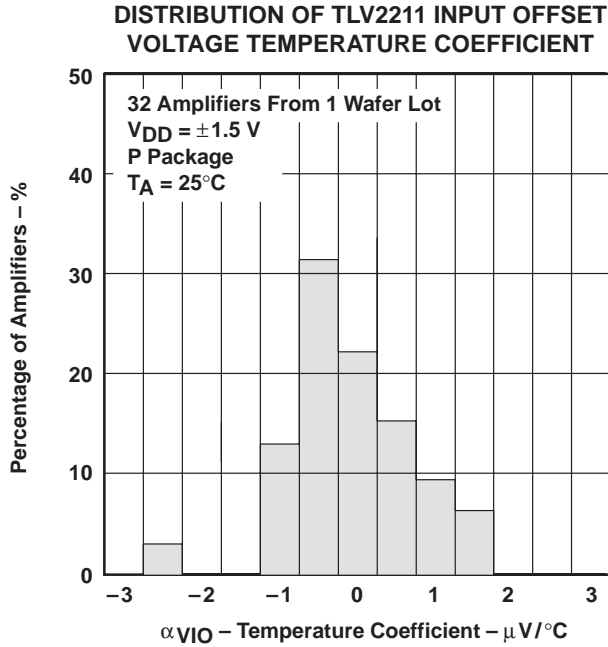


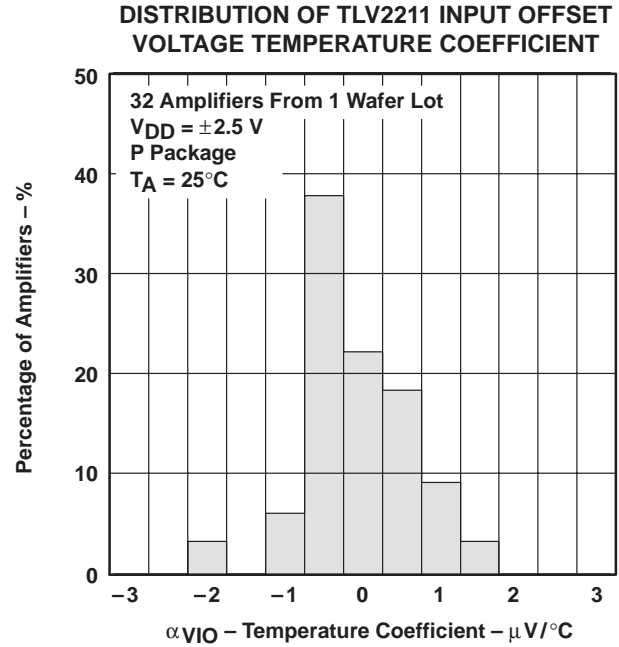
Figure 4

† 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.

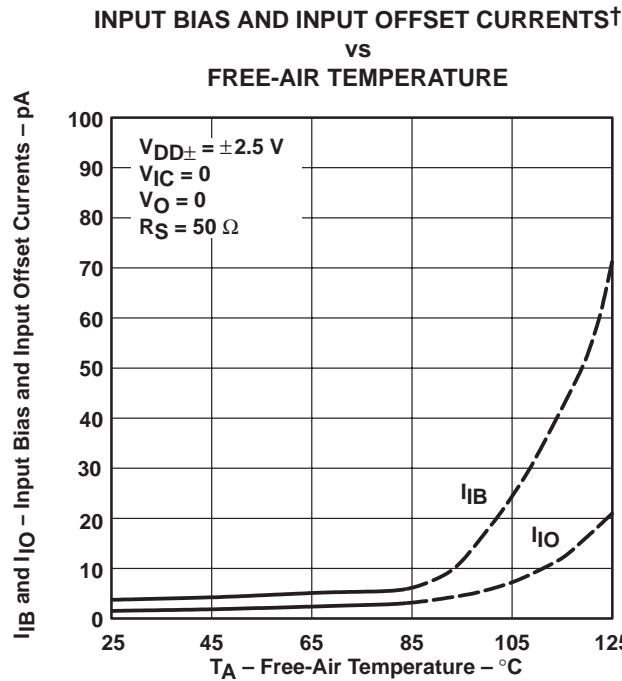
**TYPICAL CHARACTERISTICS**



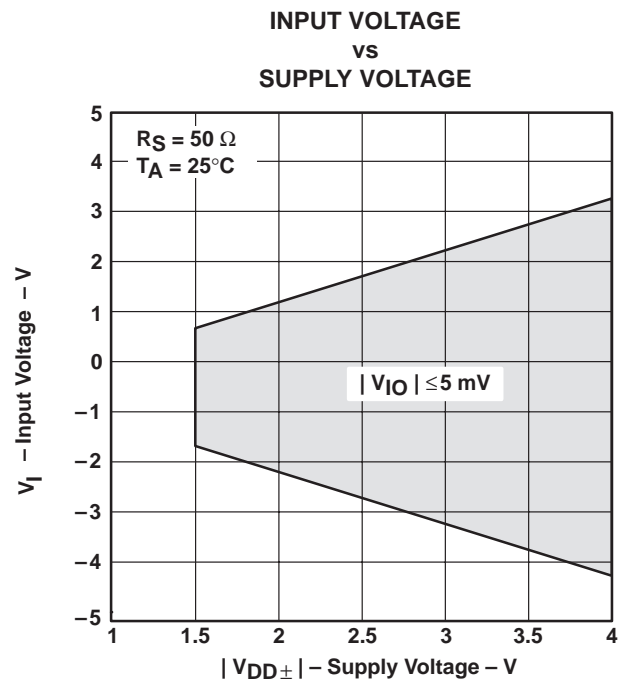
**Figure 5**



**Figure 6**



**Figure 7**



**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

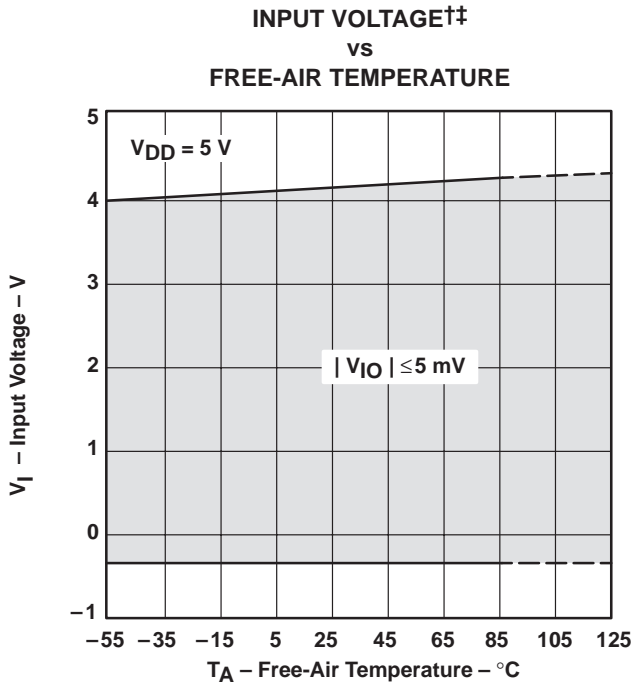


Figure 9

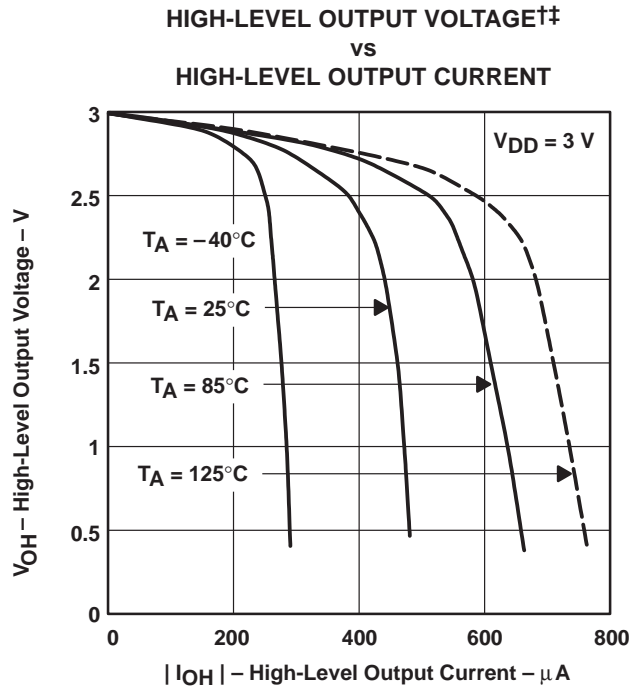


Figure 10

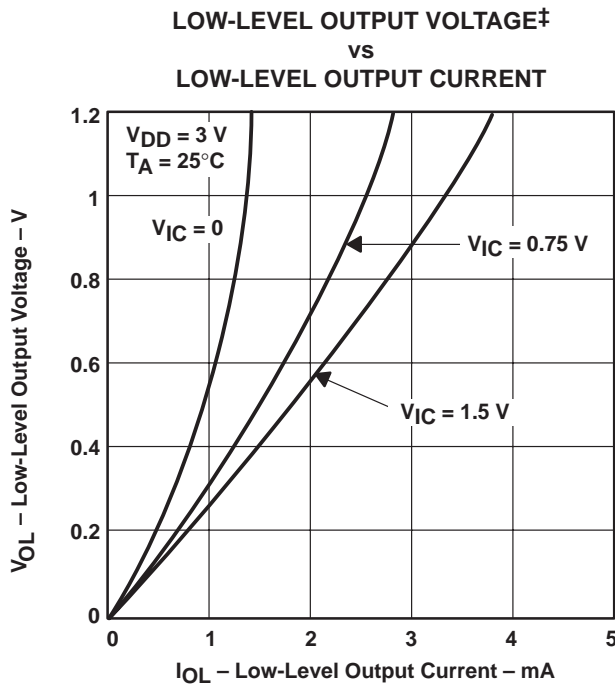


Figure 11

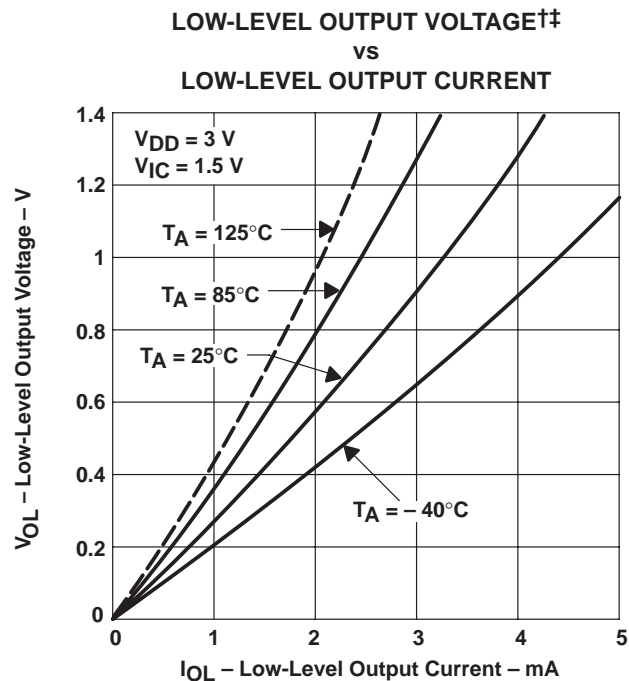
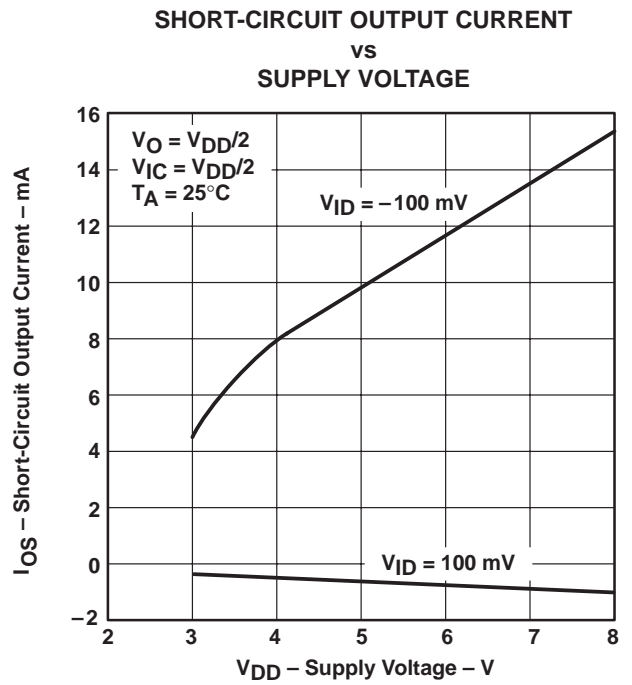
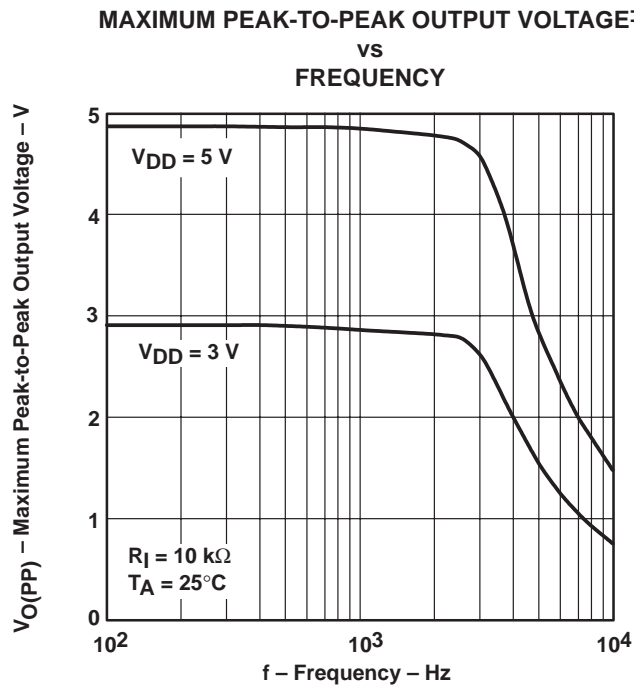
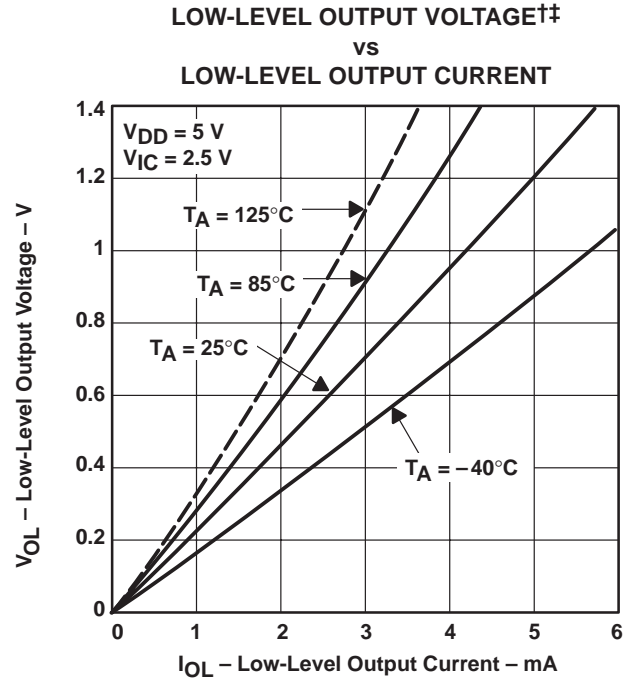
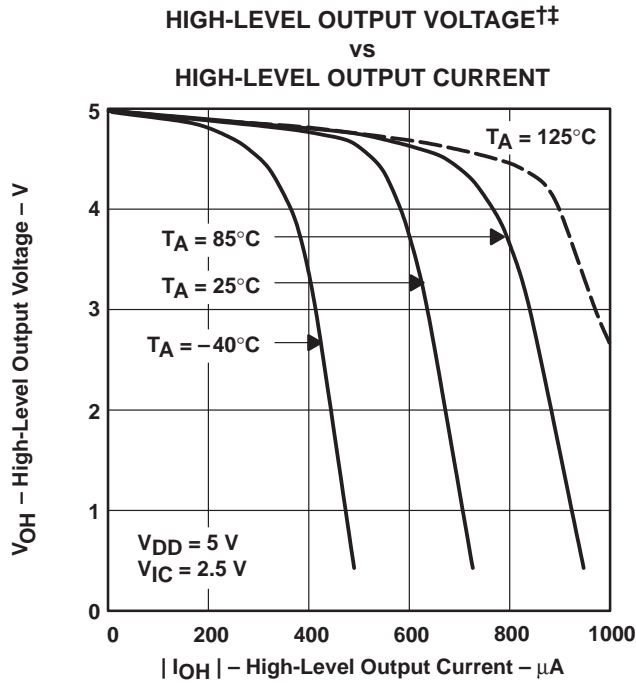


Figure 12

† 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  $V_{DD} = 5\text{ V}$ , 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**



† 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

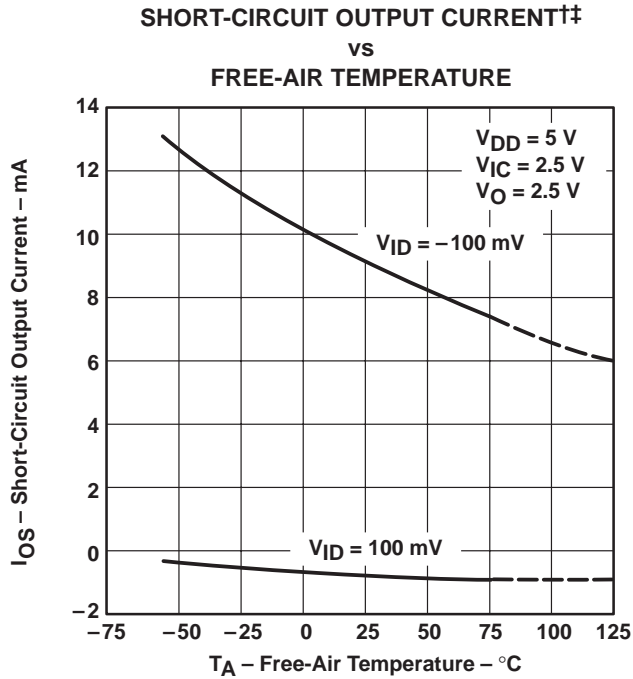


Figure 17

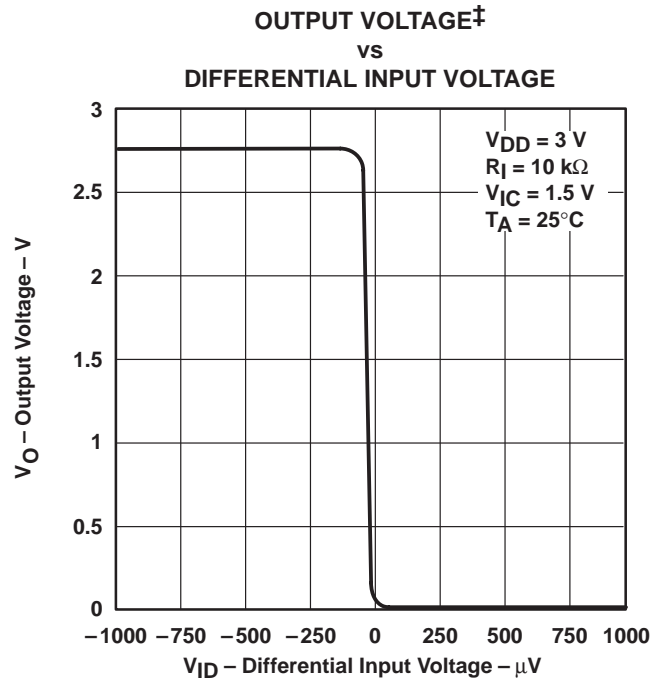


Figure 18

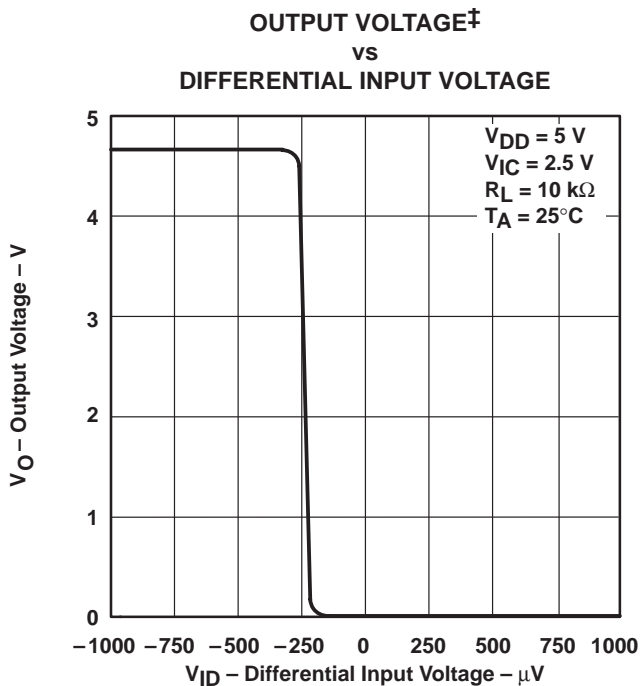


Figure 19

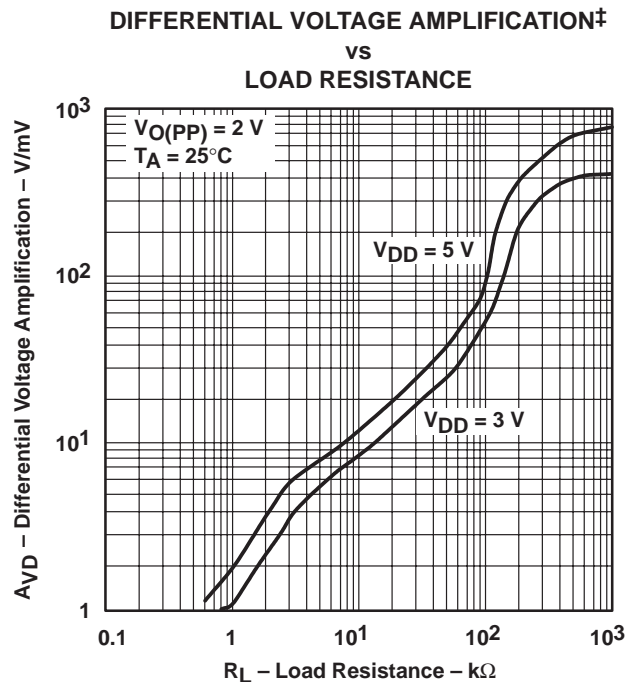


Figure 20

† 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.

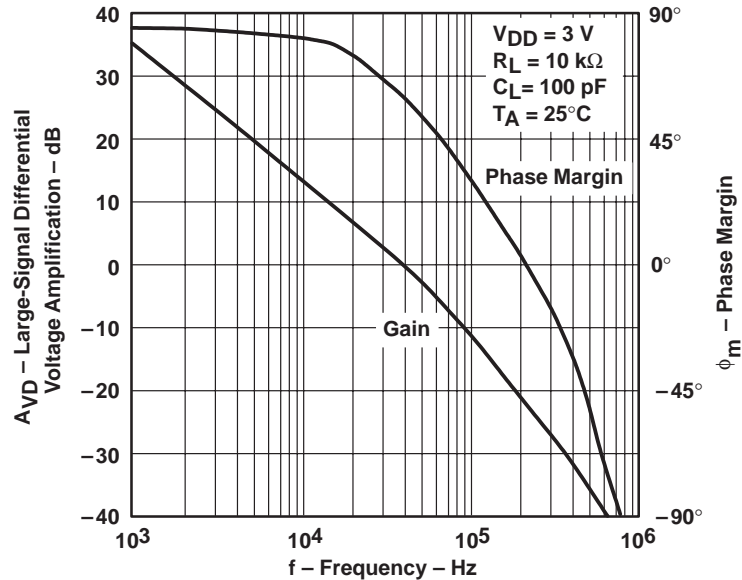


**TYPICAL CHARACTERISTICS**

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

vs

**FREQUENCY**

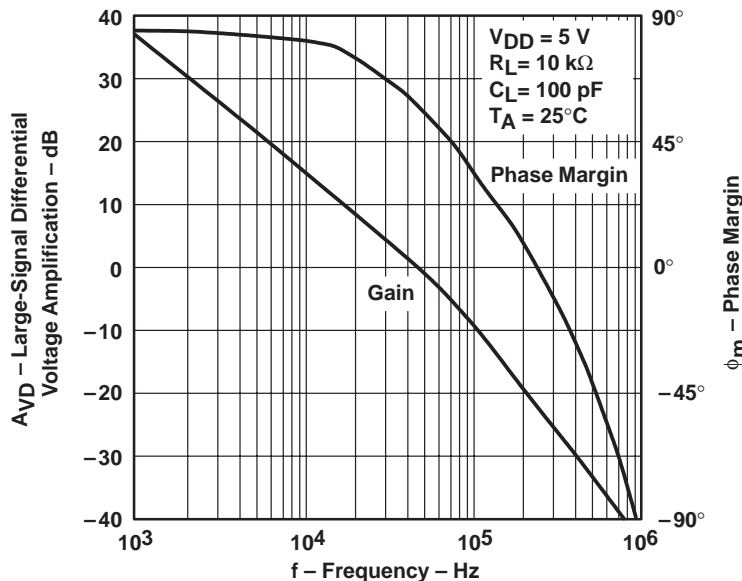


**Figure 21**

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

vs

**FREQUENCY**



**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

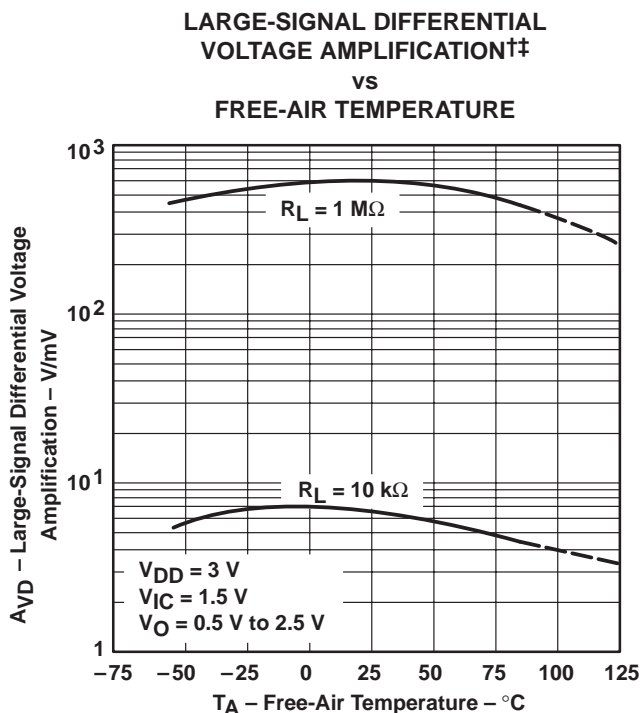


Figure 23

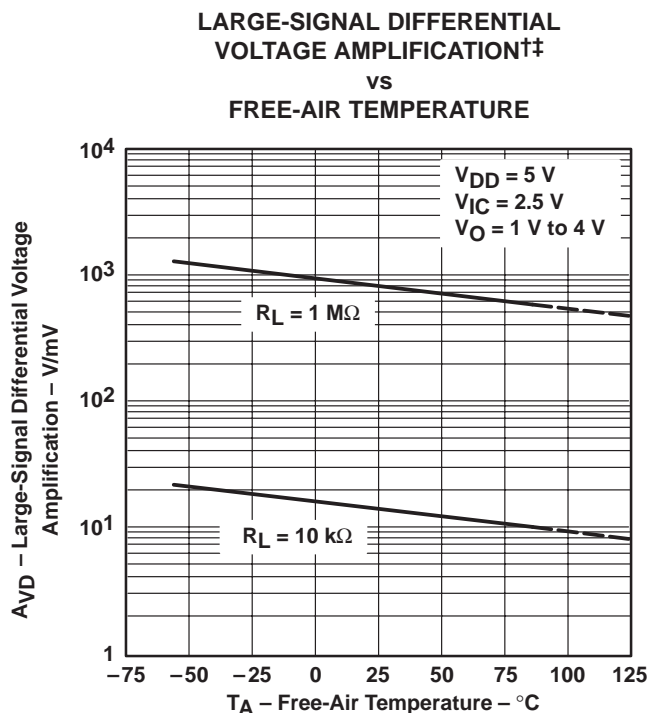


Figure 24

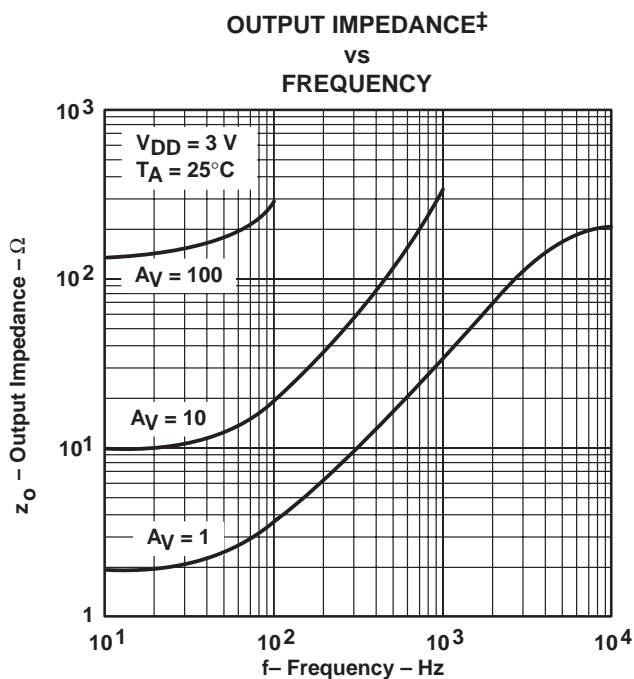


Figure 25

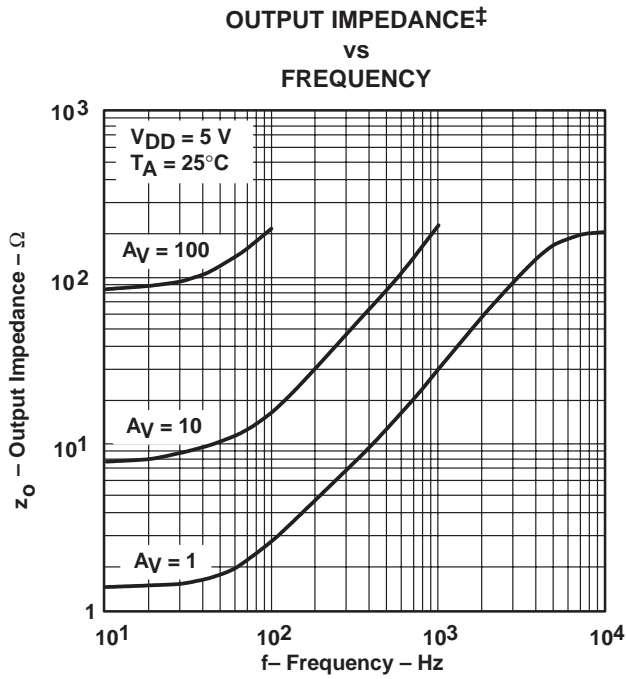
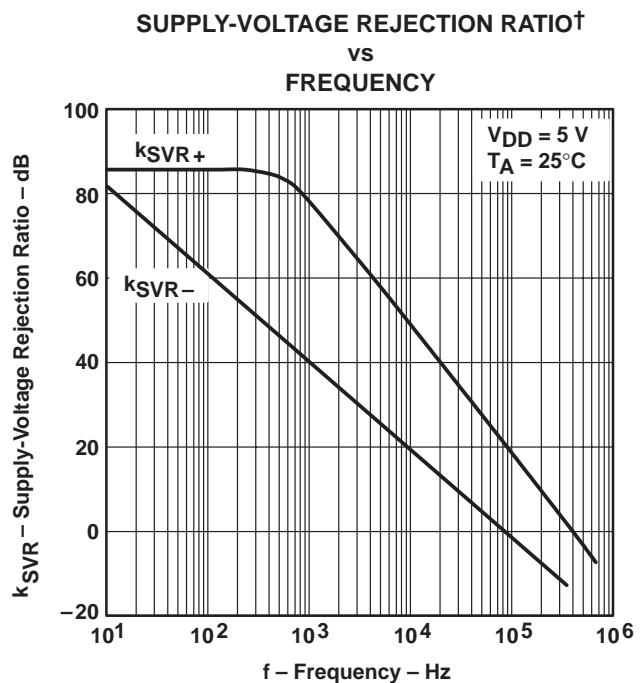
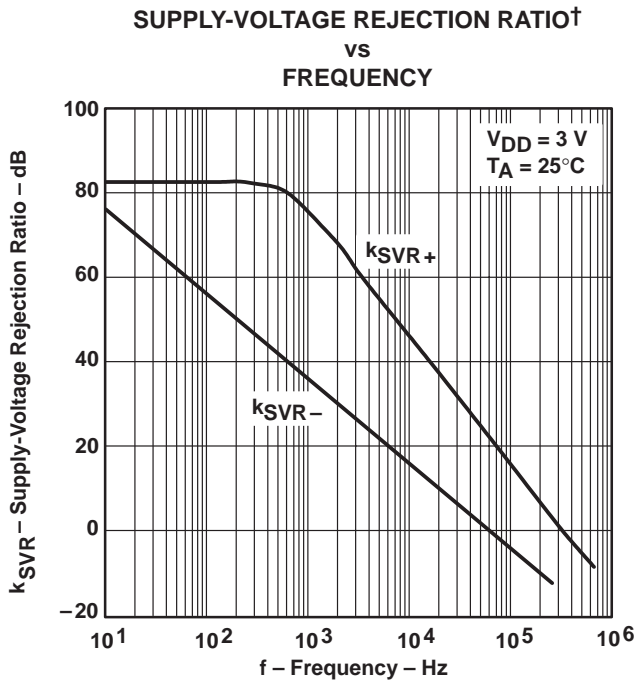
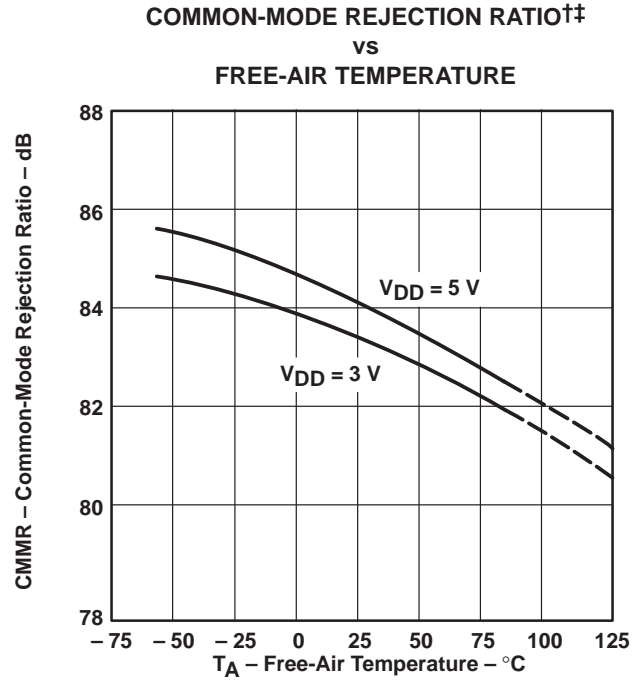
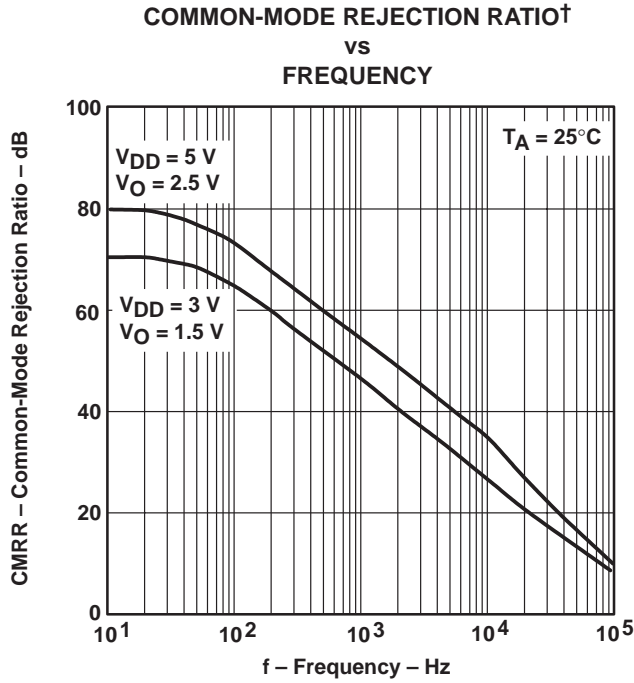


Figure 26

† 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**



† 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

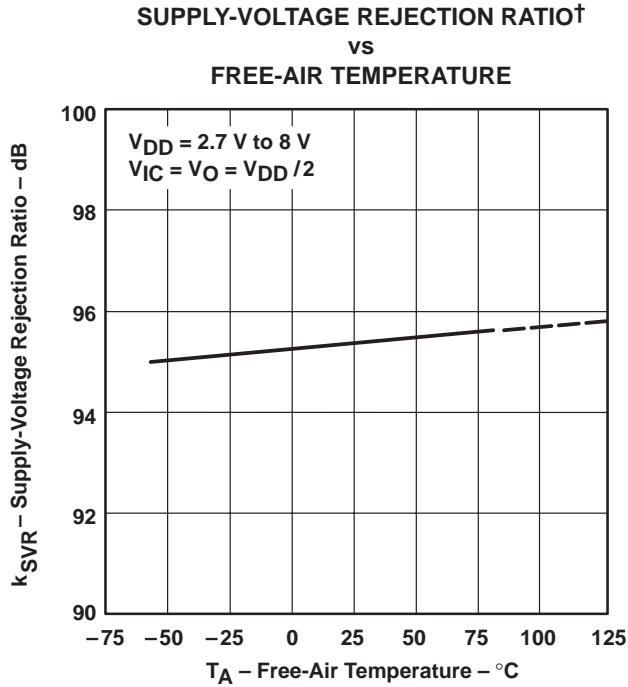


Figure 31

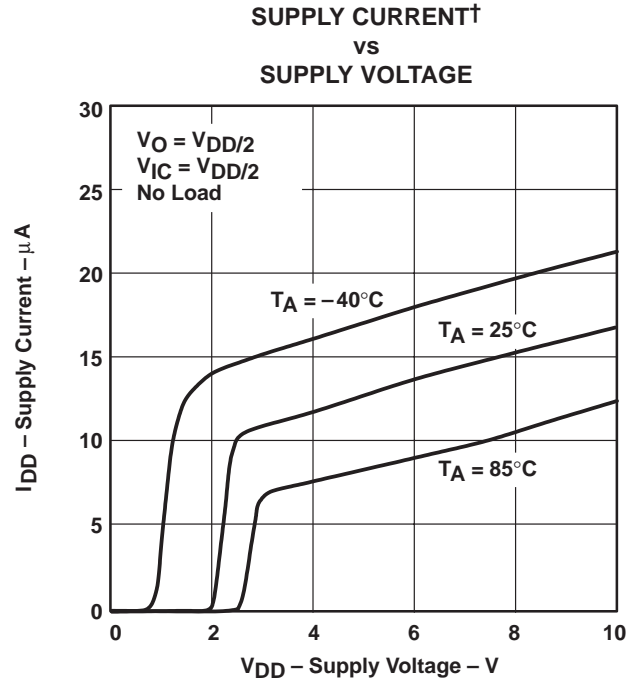


Figure 32

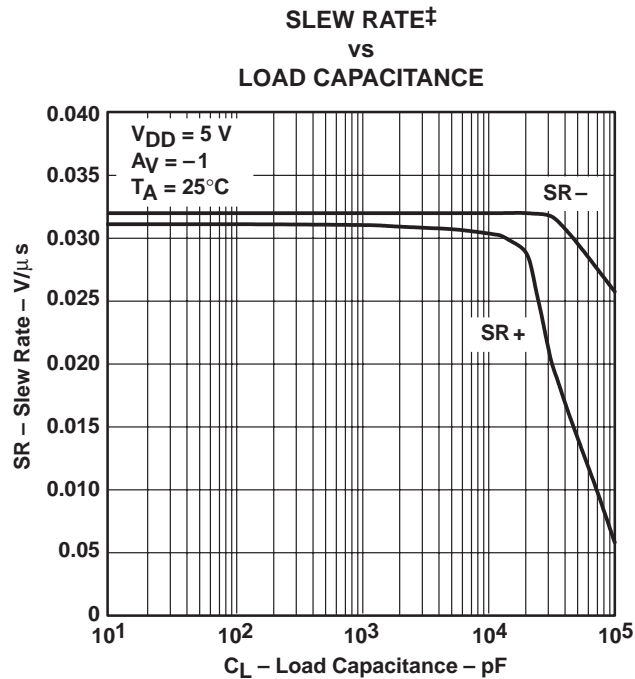


Figure 33

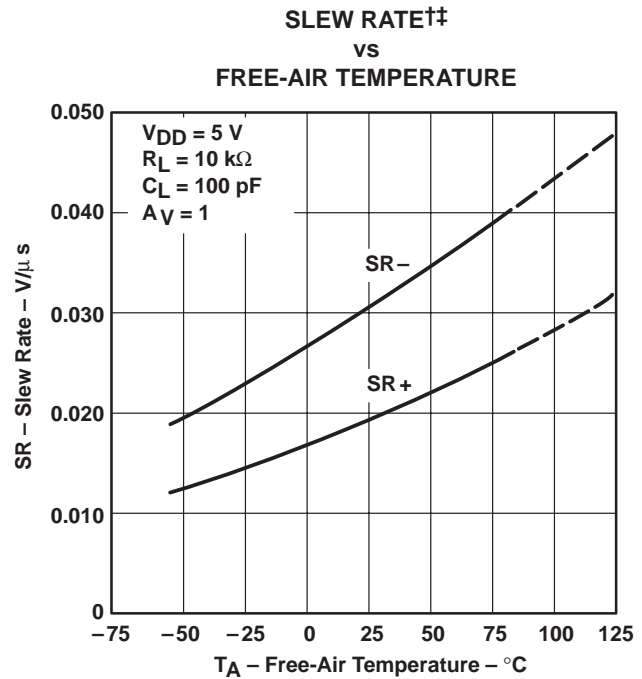


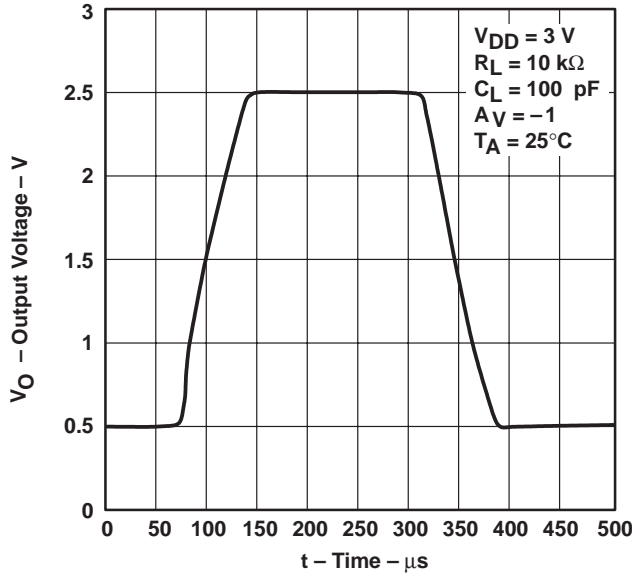
Figure 34

† 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.

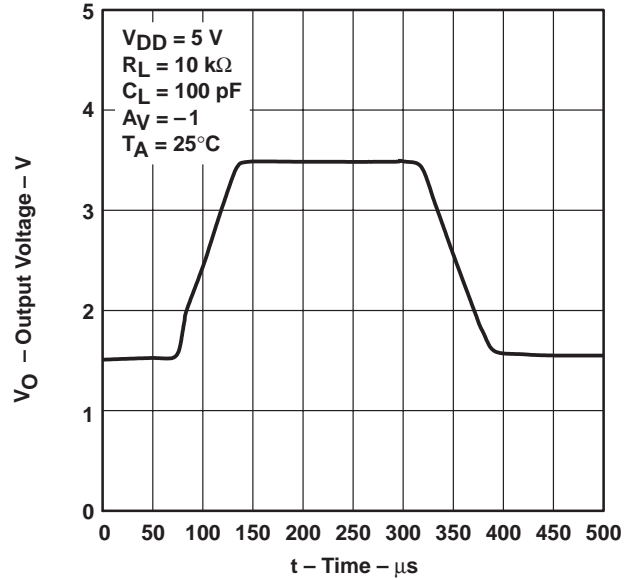
**TYPICAL CHARACTERISTICS**

**INVERTING LARGE-SIGNAL PULSE RESPONSE†**



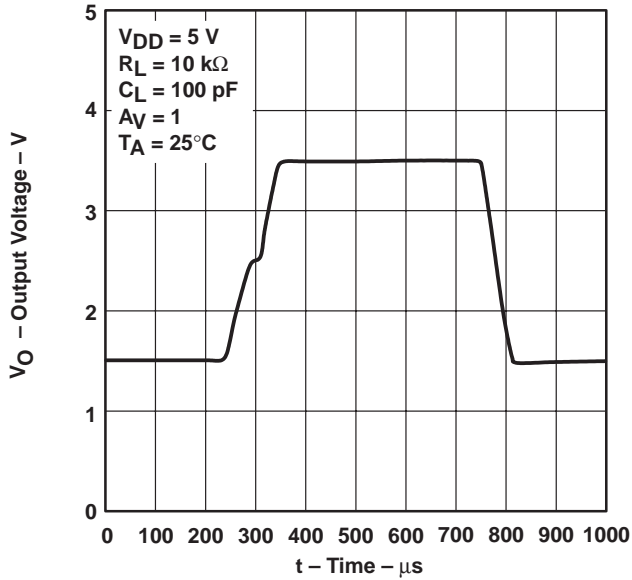
**Figure 35**

**INVERTING LARGE-SIGNAL PULSE RESPONSE†**



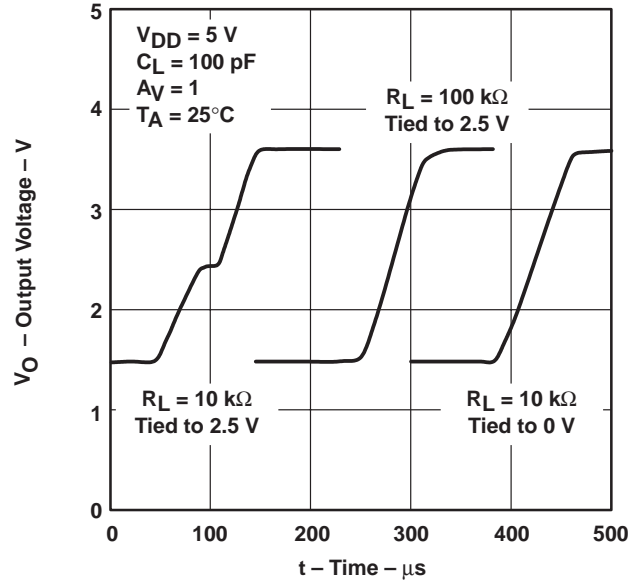
**Figure 36**

**VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE†**



**Figure 37**

**VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE†**



**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

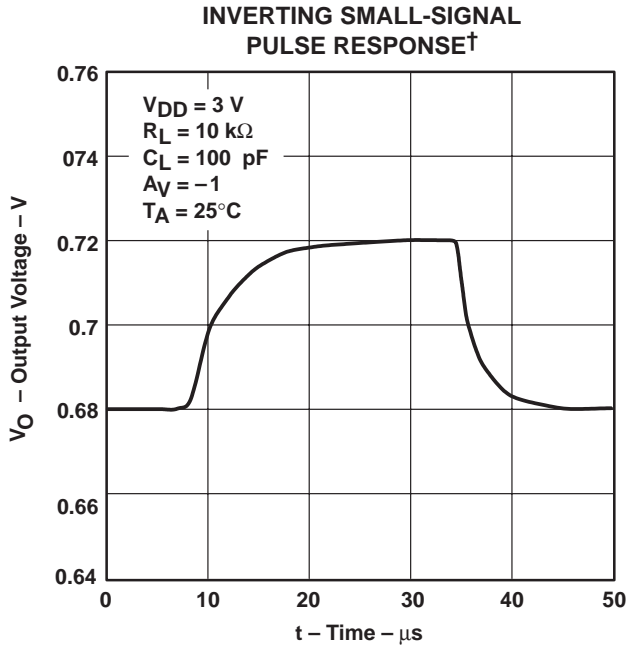


Figure 39

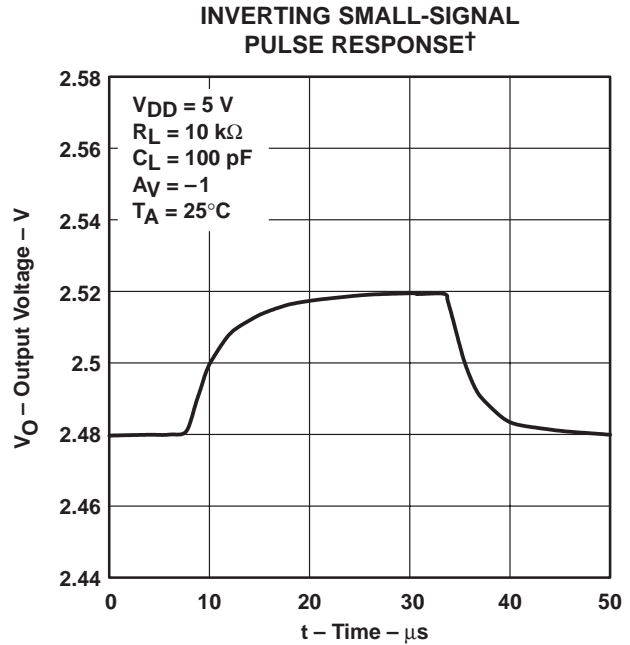


Figure 40

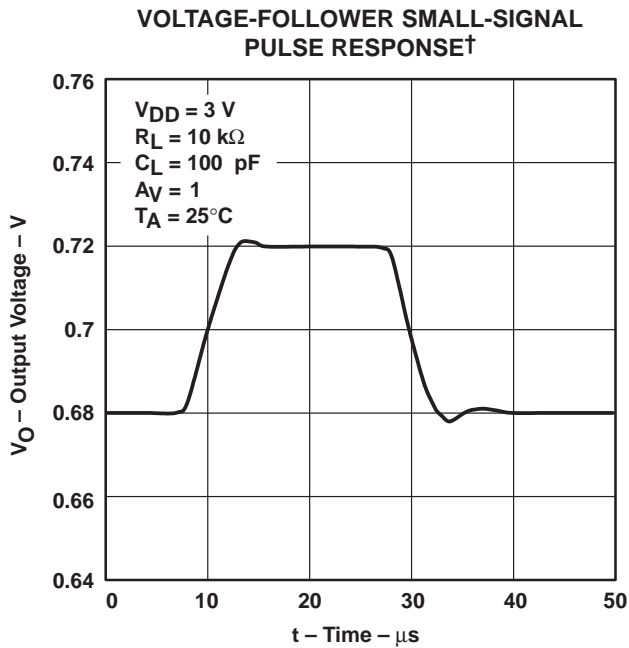


Figure 41

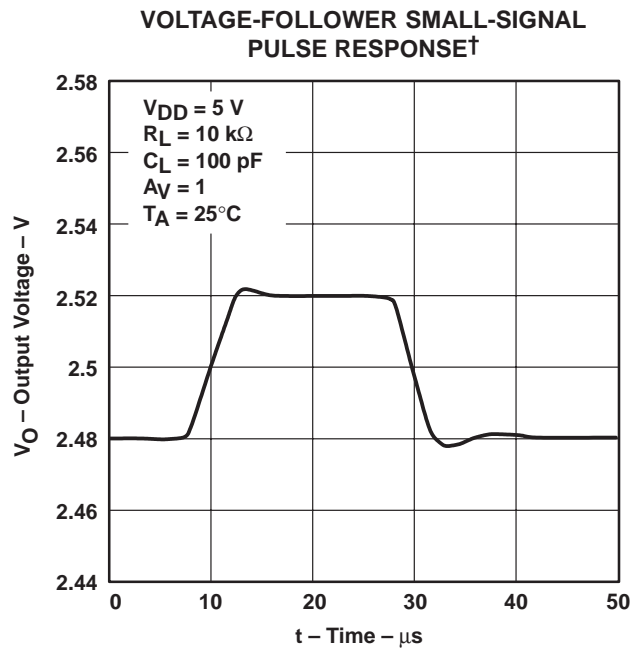
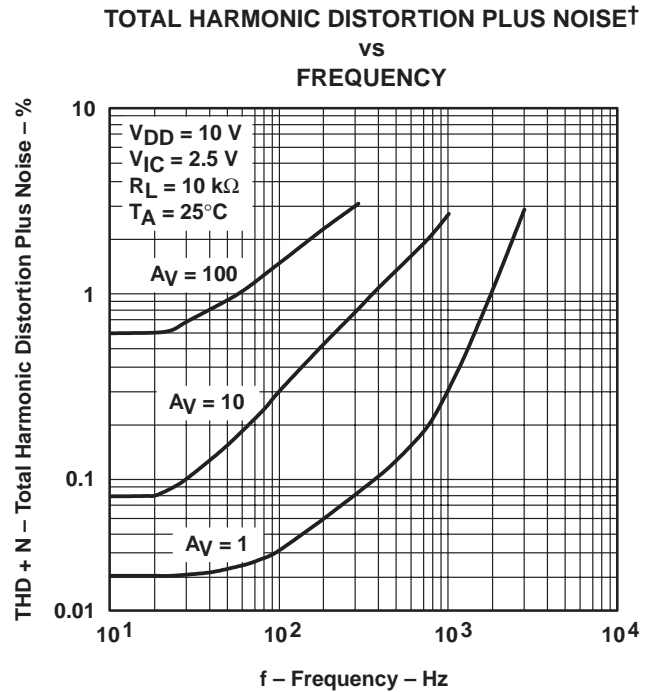
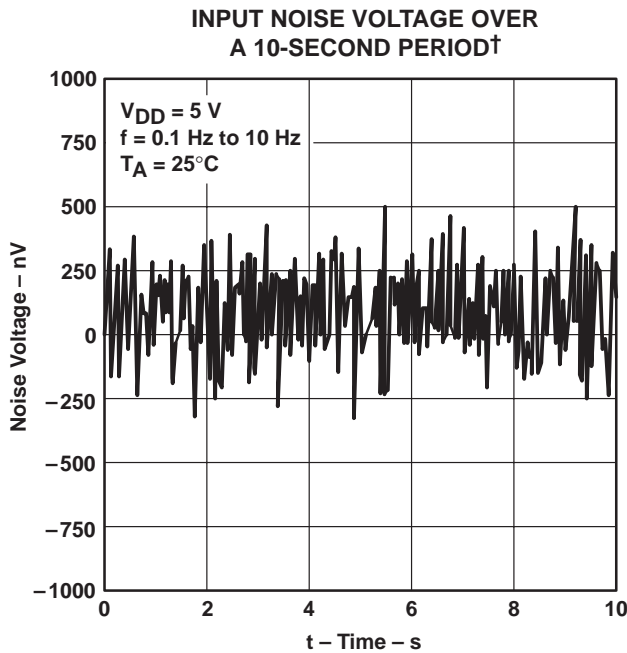
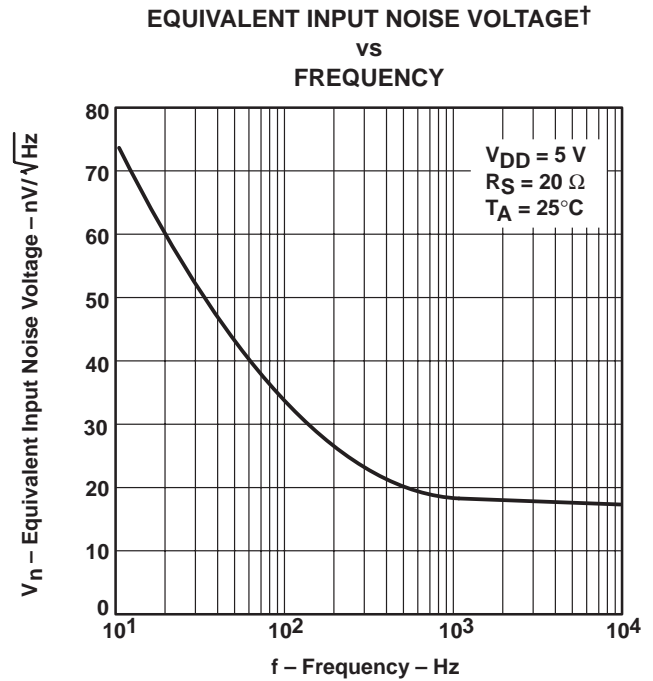
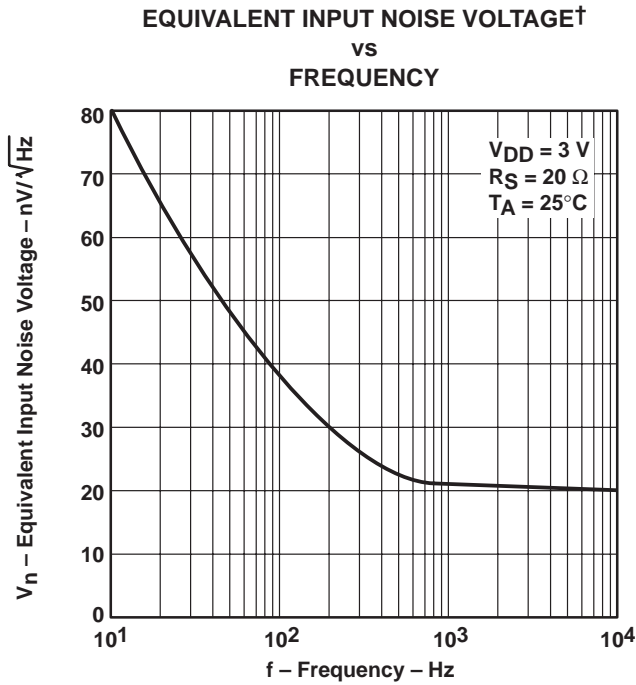


Figure 42

† 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**



† 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

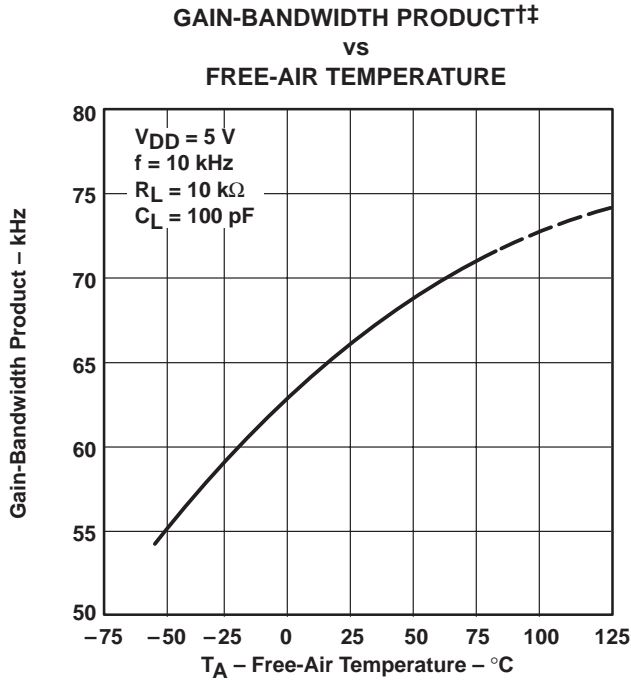


Figure 47

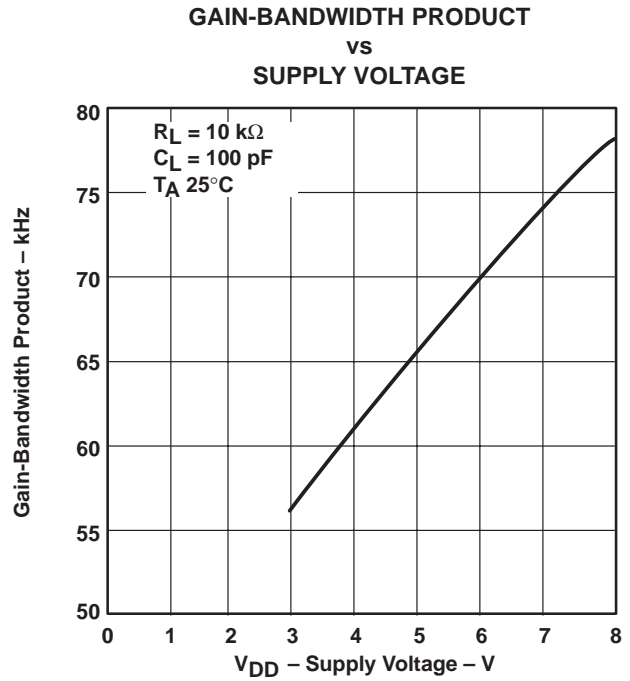


Figure 48

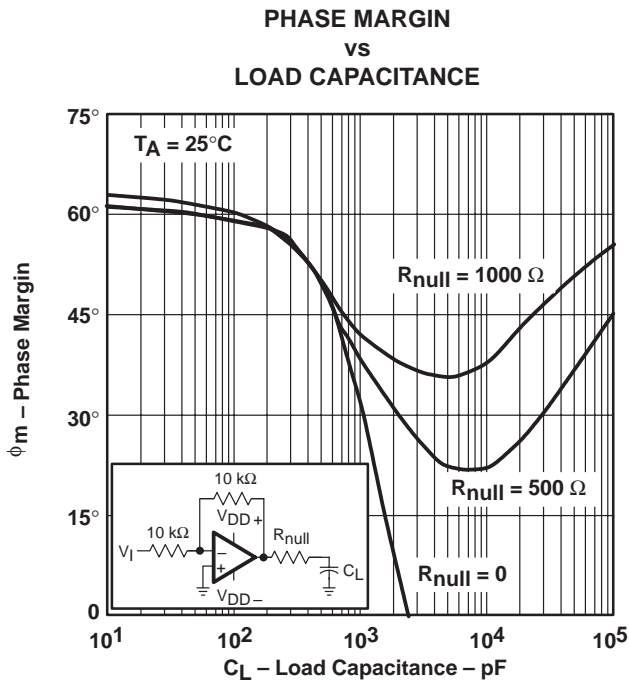


Figure 49

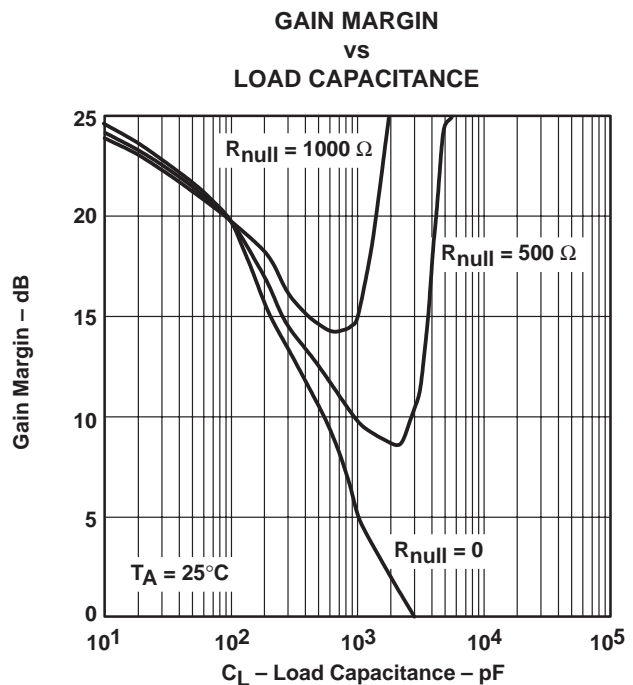


Figure 50

† 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

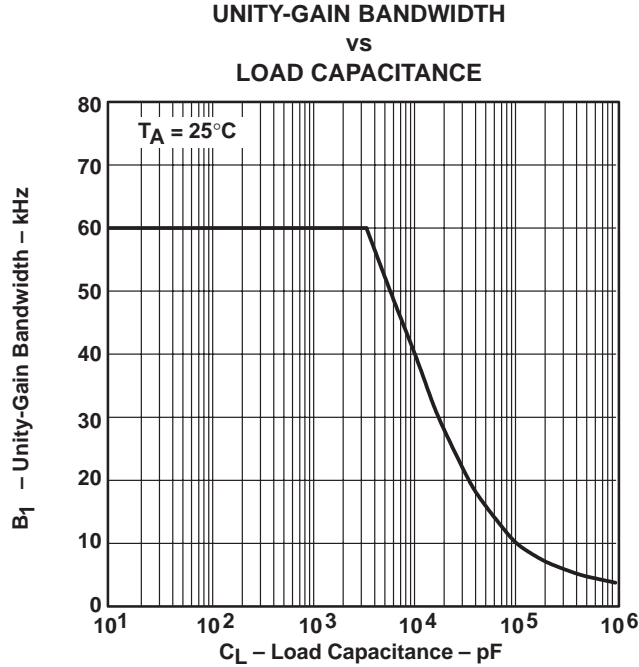


Figure 51

## APPLICATION INFORMATION

### driving large capacitive loads

The TLV2211 is designed to drive larger capacitive loads than most CMOS operational amplifiers. Figure 49 and Figure 50 illustrate its ability to drive loads up to 600 pF while maintaining good gain and phase margins ( $R_{null} = 0$ ).

A smaller series resistor ( $R_{null}$ ) at the output of the device (see Figure 52) improves the gain and phase margins when driving large capacitive loads. Figure 49 and Figure 50 show the effects of adding series resistances of 500  $\Omega$  and 1000  $\Omega$ . The addition of this series resistor has two effects: the first is that it adds a zero to the transfer function and the second 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 improvement in phase margin, equation (1) can be used.

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

where :

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

UGBW = unity-gain bandwidth frequency

$R_{null}$  = output series resistance

$C_L$  = load capacitance

## APPLICATION INFORMATION

### driving large capacitive loads (continued)

The unity-gain bandwidth (UGBW) frequency decreases as the capacitive load increases (see Figure 51). To use equation (1), UGBW must be approximated from Figure 51.

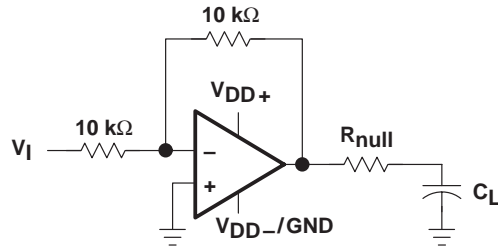


Figure 52. Series-Resistance Circuit

### driving heavy dc loads

The TLV2211 is designed to provide better sinking and sourcing output currents than earlier CMOS rail-to-rail output devices. This device is specified to sink 500  $\mu\text{A}$  and source 250  $\mu\text{A}$  at  $V_{\text{DD}} = 3\text{ V}$  and  $V_{\text{DD}} = 5\text{ V}$  at a maximum quiescent  $I_{\text{DD}}$  of 25  $\mu\text{A}$ . This provides a greater than 90% power efficiency.

When driving heavy dc loads, such as 10 k $\Omega$ , the positive edge under slewing conditions can experience some distortion. This condition can be seen in Figure 37. This condition is affected by three factors.

- Where the load is referenced. When the load is referenced to either rail, this condition does not occur. The distortion occurs only when the output signal swings through the point where the load is referenced. Figure 38 illustrates two 10-k $\Omega$  load conditions. The first load condition shows the distortion seen for a 10-k $\Omega$  load tied to 2.5 V. The third load condition shows no distortion for a 10-k $\Omega$  load tied to 0 V.
- Load resistance. As the load resistance increases, the distortion seen on the output decreases. Figure 38 illustrates the difference seen on the output for a 10-k $\Omega$  load and a 100-k $\Omega$  load with both tied to 2.5 V.
- Input signal edge rate. Faster input edge rates for a step input result in more distortion than with slower input edge rates.

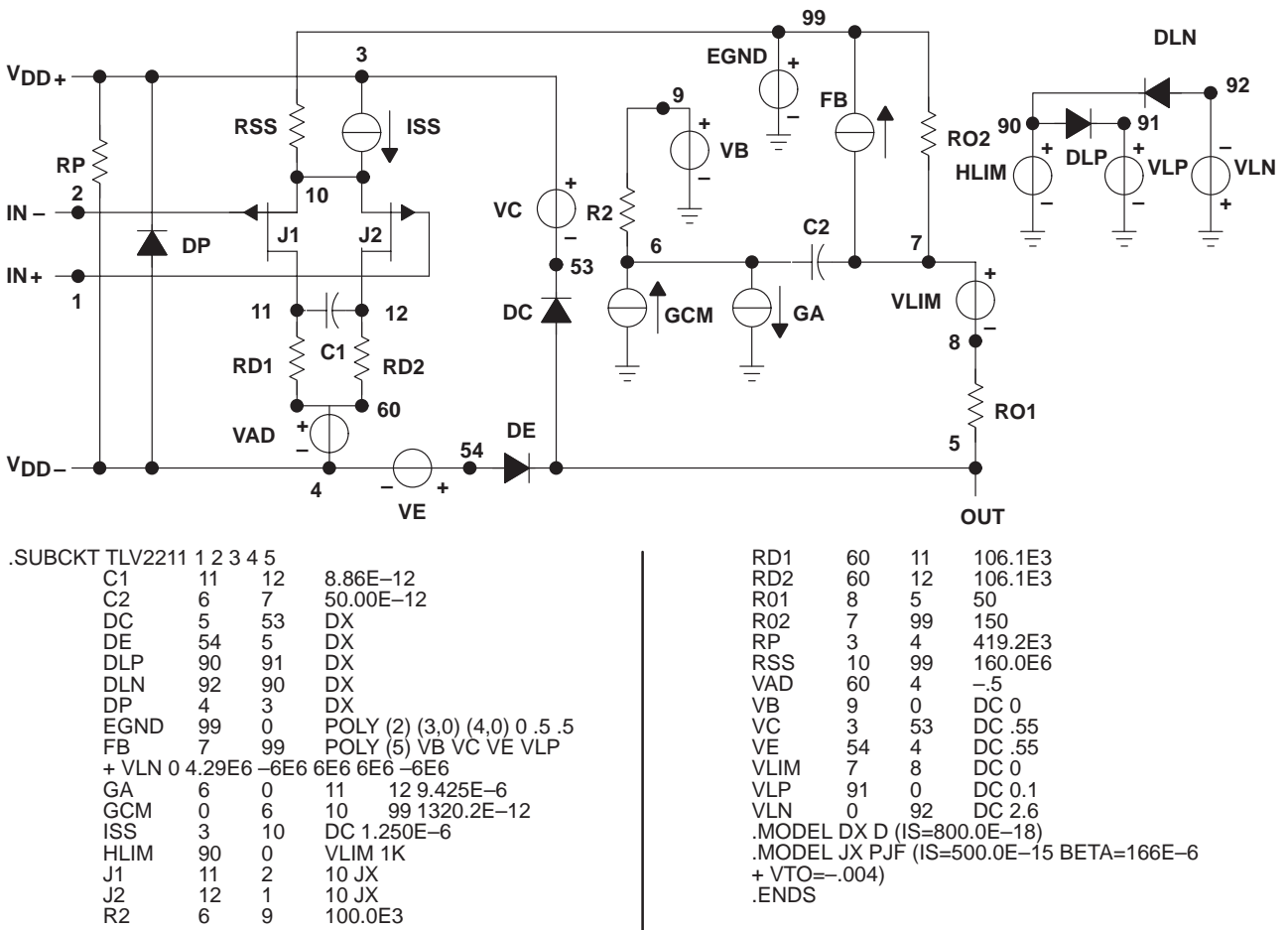
## APPLICATION INFORMATION

### 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 53 are generated using the TLV2211 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 53. Boyle Macromodel and Subcircuit**

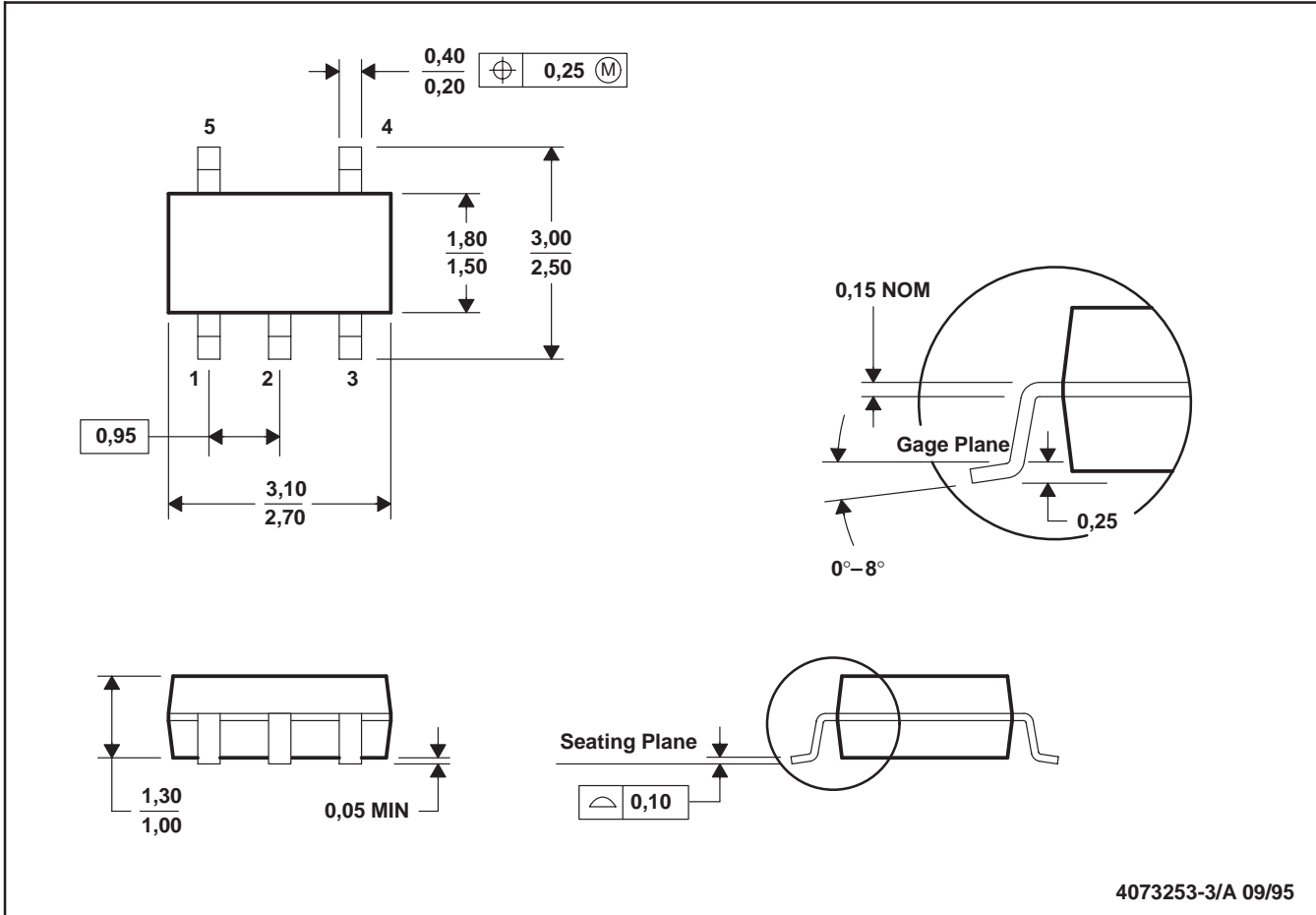
*PSPice* and *Parts* are trademark of MicroSim Corporation.

TLV2211, TLV2211Y  
 Advanced LinCMOS™ RAIL-TO-RAIL  
 MICROWPOWER SINGLE OPERATIONAL AMPLIFIERS  
 SLOS156B – MAY 1996 – REVISED JANUARY 1997

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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