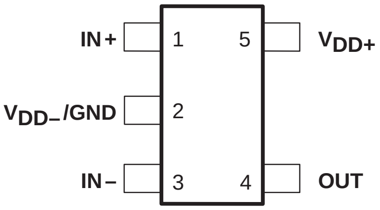
TLV2211, TLV2211Y
Advanced LinCMOS™ RAIL-TO-RAIL MICROPOWER SINGLE OPERATIONAL AMPLIFIERS

SLOS156B – MAY 1996 – REVISED JANUARY 1997

- **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**

DBV PACKAGE
(TOP VIEW)



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 ± 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_{IO}max 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.

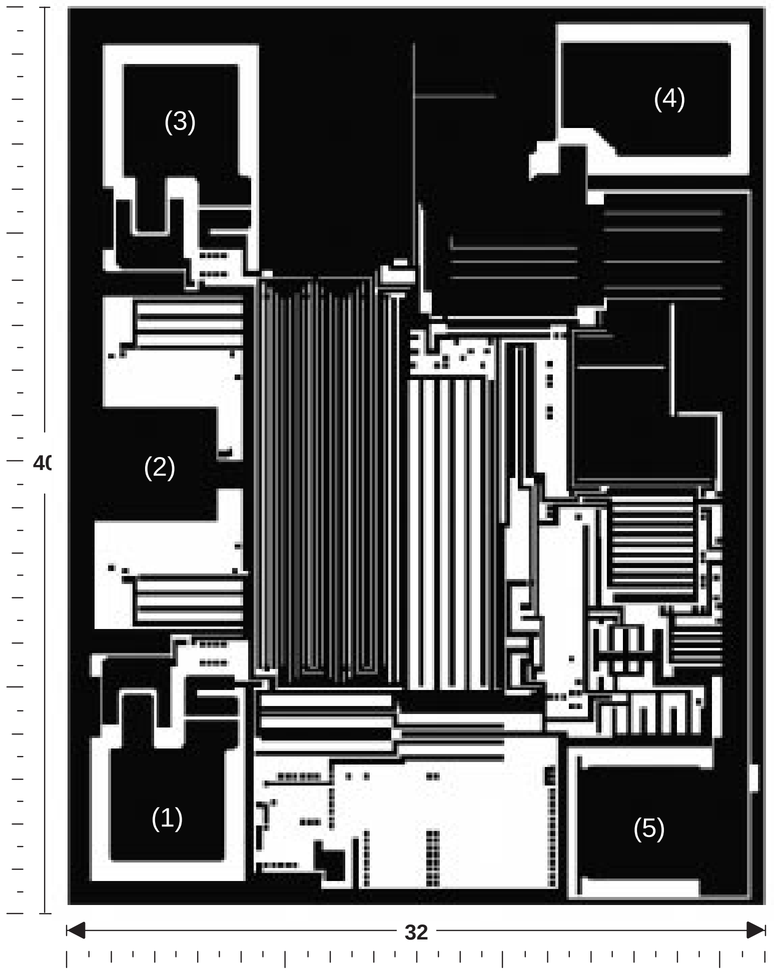
description (continued)

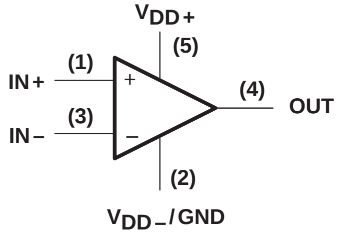
The device inputs and outputs are designed to withstand a 100-mA surge current without sustaining latch-up. In addition, internal ESD-protection circuits prevent functional failures up to 2000 V as tested under MIL-PRF-38535; however, care should be exercised when handling these devices as exposure to 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.

BONDING PAD ASSIGNMENTS





CHIP THICKNESS: 10 MILS TYPICAL

BONDING PADS: 4 × 4 MILS MINIMUM

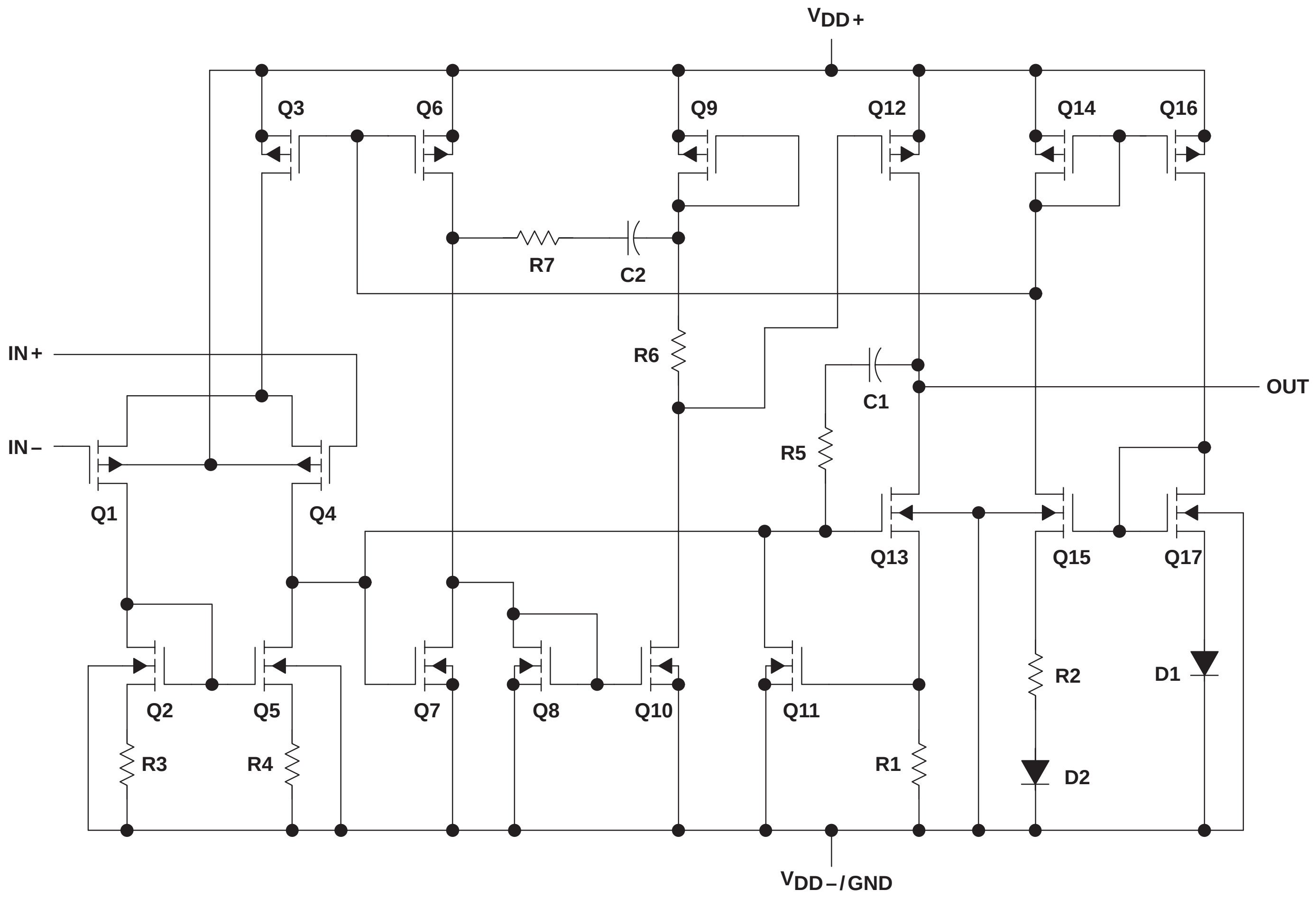
$T_J$max = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

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

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)	±5 mA
Output current, I_O	±50 mA
Total current into V_{DD+}	±50 mA
Total current out of V_{DD-}	±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	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ 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-}.

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

PARAMETER		TEST CONDITIONS	T_A†	TLV2211C			TLV2211I			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{DD\pm} = \pm 1.5$ V, $V_{IC} = 0$, $V_O = 0$, $R_S = 50\ \Omega$	Full range		0.47	3		0.47	3000	mV
α_{VIO}	Temperature coefficient of input offset voltage				1			1		µV/°C
	Input offset voltage long-term drift (see Note 4)		25°C		0.003			0.003		µV/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	$\lvert V_{IO} \rvert \le 5$ 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	$I_{OH} = -100$ µA	25°C		2.94			2.94		V
		$I_{OH} = -250$ µA	25°C		2.85			2.85		
			Full range	2.5			2.5			
V_{OL}	Low-level output voltage	$V_{IC} = 1.5$ V, $I_{OL} = 50$ µA	25°C		15			15		mV
		$V_{IC} = 1.5$ V, $I_{OL} = 500$ µA	25°C		150			150		
			Full range			500			500	
A_{VD}	Large-signal differential voltage amplification	$V_{IC} = 1.5$ V, $V_O = 1$ V to 2 V, $R_L = 10$ kΩ‡	25°C	3	7		3	7		V/mV
			Full range	1			1			
		$R_L = 1$ MΩ‡	25°C		600			600		
$r_{i(d)}$	Differential input resistance		25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance		25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz,	25°C		5			5		pF
z_o	Closed-loop output impedance	f = 7 kHz, $A_V = 1$	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = 0$ to 1.7 V, $V_O = 1.5$ V, $R_S = 50\ \Omega$	25°C	65	83		65	83		dB
			Full range	60			60			
k_{SVR}	Supply voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$)	$V_{DD} = 2.7$ V to 8 V, $V_{IC} = V_{DD}/2$, No load	25°C	80	95		80	95		dB
			Full range	80			80			
I_{DD}	Supply current	$V_O = 1.5$ V, No load	25°C		11	25		11	25	µA
			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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

operating characteristics at specified free-air temperature, V_{DD} = 3 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 V to 1.9 V, R_L = 10 kΩ‡, C_L = 100 pF‡	25°C	0.01	0.025		0.01	0.025		V/μs
			Full range	0.005			0.005			
V_n	Equivalent input noise voltage	f = 10 Hz	25°C		80			80		nV/√Hz
		f = 1 kHz	25°C		22			22		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		660			660		μV
		f = 0.1 Hz to 10 Hz	25°C		880			880		
I_n	Equivalent input noise current		25°C		0.6			0.6		fA /√Hz
	Gain-bandwidth product	f = 10 kHz, R_L = 10 kΩ‡, C_L = 100 pF‡	25°C		56			56		kHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 1 V, A_V = 1, R_L = 10 kΩ‡, C_L = 100 pF‡	25°C		7			7		kHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ‡, C_L = 100 pF‡	25°C		56°			56°		
	Gain margin		25°C		20			20		dB

† Full range is –40°C to 85°C.
‡ Referenced to 1.5 V

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

PARAMETER		TEST CONDITIONS		T_A†	TLV2211C			TLV2211I			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{DD\pm} = \pm 2.5$ V, $V_O = 0$,	$V_{IC} = 0$, $R_S = 50\ \Omega$	Full range		0.45	3		0.45	3	mV
α_{VIO}	Temperature coefficient of input offset voltage			Full range		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	$\lvert V_{IO} \rvert \le 5$ 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	$I_{OH} = -100$ µA		25°C		4.95			4.95		V
		$I_{OH} = -250$ µA		25°C		4.875			4.875		
				Full range	4.5			4.5			
V_{OL}	Low-level output voltage	$V_{IC} = 2.5$ V,	$I_{OL} = 50$ µA	25°C		12			12		mV
		$V_{IC} = 2.5$ V,	$I_{OL} = 500$ µA	25°C		120			120		
				Full range			500			500	
A_{VD}	Large-signal differential voltage amplification	$V_{IC} = 2.5$ V, $V_O = 1$ V to 4 V	$R_L = 10\ k\Omega$‡	25°C	6	12		6	12		V/mV
				Full range	3			3			
			$R_L = 1\ M\Omega$‡	25°C		800			800		
$r_{i(d)}$	Differential input resistance			25°C		10^{12}			10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance			25°C		10^{12}			10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz,		25°C		5			5		pF
z_o	Closed-loop output impedance	f = 7 kHz,	$A_V = 1$	25°C		200			200		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = 0$ to 2.7 V, $R_S = 50\ \Omega$	$V_O = 2.5$ V,	25°C	70	83		70	83		dB
				Full range	70			70			
k_{SVR}	Supply voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$)	$V_{DD} = 4.4$ V to 8 V, No load	$V_{IC} = V_{DD}/2$,	25°C	80	95		80	95		dB
				Full range	80			80			
I_{DD}	Supply current	$V_O = 2.5$ V,	No load	25°C		13	25		13	25	µA
				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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

operating characteristics at specified free-air temperature, V_{DD} = 5 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 V to 3.5 V, R_L = 10 kΩ‡, C_L = 100 pF‡	25°C	0.01	0.025		0.01	0.025		V/µs
			Full range	0.005			0.005			
V_n	Equivalent input noise voltage	f = 10 Hz	25°C		72			72		nV/√Hz
		f = 1 kHz	25°C		21			21		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 1 Hz	25°C		600			600		µV
		f = 0.1 Hz to 10 Hz	25°C		800			800		
I_n	Equivalent input noise current		25°C		0.6			0.6		fA /√Hz
	Gain-bandwidth product	f = 10 kHz, R_L = 10 kΩ‡, C_L = 100 pF‡	25°C		65			65		kHz
B_{OM}	Maximum output-swing bandwidth	$V_{O(PP)}$ = 2 V, A_V = 1, R_L = 10 kΩ‡, C_L = 100 pF‡	25°C		7			7		kHz
ϕ_m	Phase margin at unity gain	R_L = 10 kΩ‡, C_L = 100 pF‡	25°C		56°			56°		
	Gain margin		25°C		22			22		dB

† Full range is – 40°C to 85°C.
‡ Referenced to 1.5 V

electrical characteristics at V_{DD} = 3 V, T_A = 25°C (unless otherwise noted)

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

† Referenced to 1.5 V

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

PARAMETER		TEST CONDITIONS			TLV2211Y			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{DD}\pm = \pm 2.5$ V, R_S = 50 Ω	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	$\lvert V_{IO} \rvert \le 5$ mV,	R_S = 50 Ω			–0.3 to 4.2		V
V_{OH}	High-level output voltage	I_{OH} = –100 µA				4.95		V
		I_{OH} = –250 µA				4.875		
V_{OL}	Low-level output voltage	V_{IC} = 2.5 V,	I_{OL} = 50 µA			12		mV
		V_{IC} = 2.5 V,	I_{OL} = 500 µA			120		
A_{VD}	Large-signal differential voltage amplification	V_{IC} = 2.5 V,	V_O = 1 V to 4 V	R_L = 10 kΩ†		12		V/mV
				R_L = 1 MΩ†		800		
$r_{i(d)}$	Differential input resistance					10^{12}		Ω
$r_{i(c)}$	Common-mode input resistance					10^{12}		Ω
$c_{i(c)}$	Common-mode input capacitance	f = 10 kHz				5		pF
z_o	Closed-loop output impedance	f = 7 kHz,	A_V = 1			200		Ω
CMRR	Common-mode rejection ratio	V_{IC} = 0 to 2.7 V,	V_O = 2.5 V,	R_S = 50 Ω		83		dB
k_{SVR}	Supply voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{DD} = 4.4 V to 8 V,	$V_{IC} = V_{DD}/2$,	No load		95		dB
I_{DD}	Supply current	V_O = 2.5 V,	No load			13		µA

† Referenced to 1.5 V

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution vs Common-mode input voltage	1, 2 3, 4
α_{VIO}	Input offset voltage temperature coefficient	Distribution	5, 6
I_{IB}/I_{IO}	Input bias and input offset currents	vs Free-air temperature	7
V_I	Input voltage	vs Supply voltage vs Free-air temperature	8 9
V_{OH}	High-level output voltage	vs High-level output current	10, 13
V_{OL}	Low-level output voltage	vs Low-level output current	11, 12, 14
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	15
I_{OS}	Short-circuit output current	vs Supply voltage vs Free-air temperature	16 17
V_O	Output voltage	vs Differential input voltage	18, 19
A_{VD}	Differential voltage amplification	vs Load resistance vs Frequency vs Free-air temperature	20 21, 22 23, 24
z_o	Output impedance	vs Frequency	25, 26
CMRR	Common-mode rejection ratio	vs Frequency vs Free-air temperature	27 28
k_{SVR}	Supply-voltage rejection ratio	vs Frequency vs Free-air temperature	29, 30 31
I_{DD}	Supply current	vs Supply voltage	32
SR	Slew rate	vs Load capacitance vs Free-air temperature	33 34
V_O	Large-signal pulse response	vs Time	35, 36, 37, 38
V_O	Small-signal pulse response	vs Time	39, 40, 41, 42
V_n	Equivalent input noise voltage	vs Frequency	43, 44
	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
ϕ_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

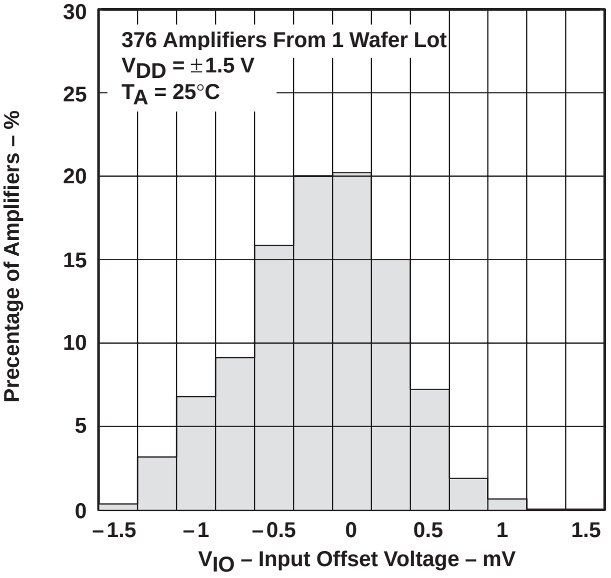


Figure 1

DISTRIBUTION OF TLV2211
INPUT OFFSET VOLTAGE

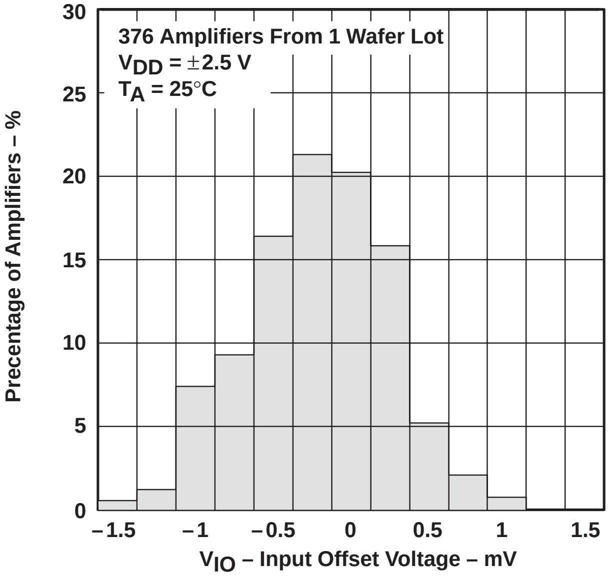


Figure 2

INPUT OFFSET VOLTAGE[†]
vs
COMMON-MODE INPUT VOLTAGE

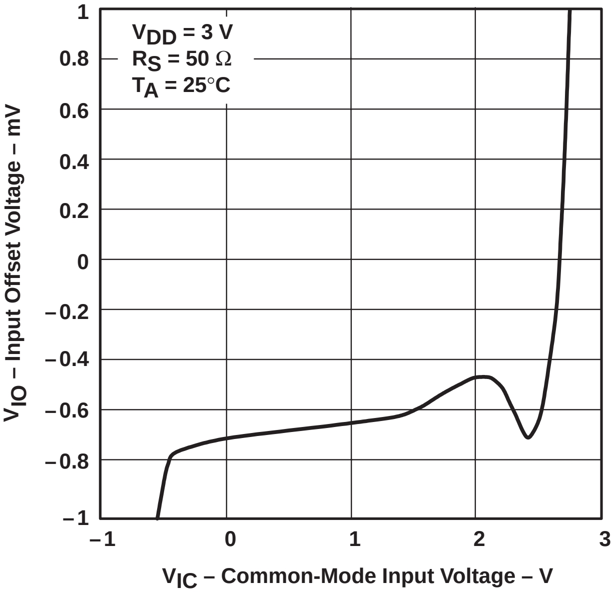


Figure 3

INPUT OFFSET VOLTAGE[†]
vs
COMMON-MODE INPUT VOLTAGE

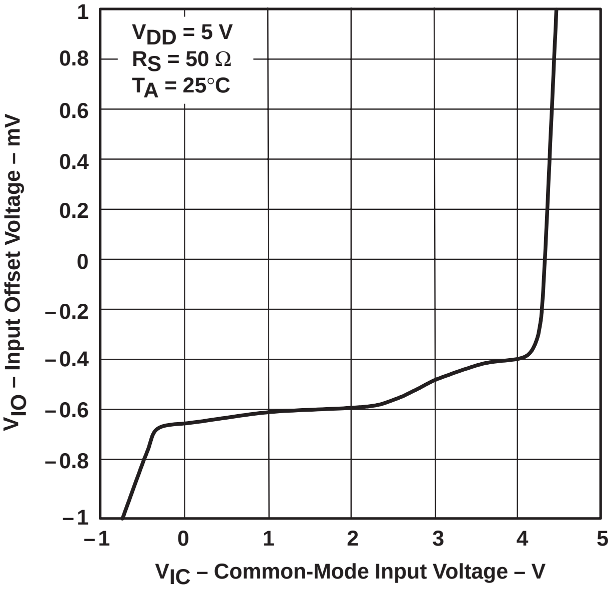


Figure 4

[†] For all curves where V_{DD} = 5 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

DISTRIBUTION OF TLV2211 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

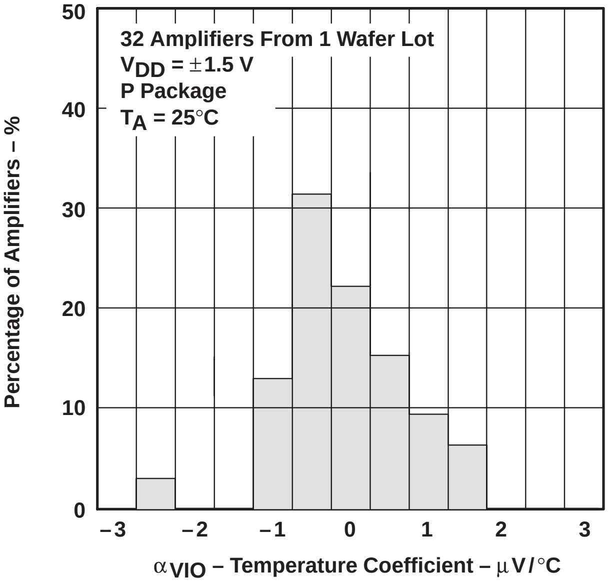


Figure 5

DISTRIBUTION OF TLV2211 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

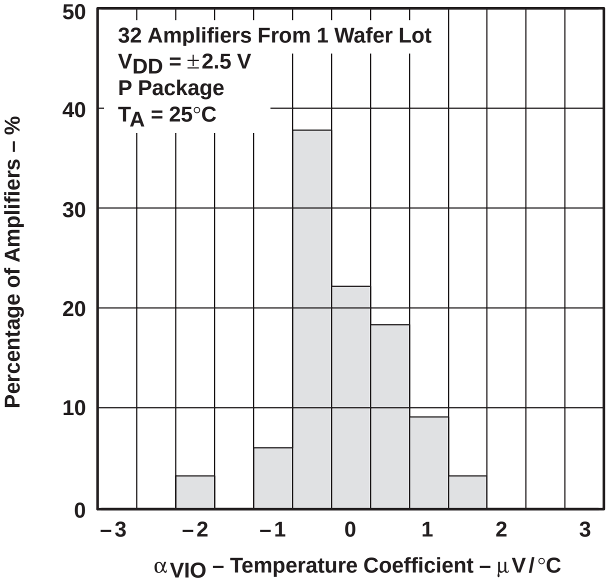


Figure 6

INPUT BIAS AND INPUT OFFSET CURRENTS[†] vs FREE-AIR TEMPERATURE

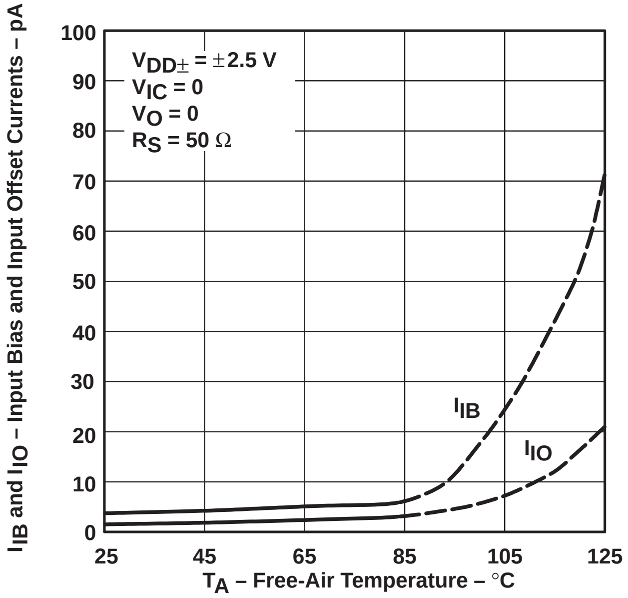


Figure 7

INPUT VOLTAGE vs SUPPLY VOLTAGE

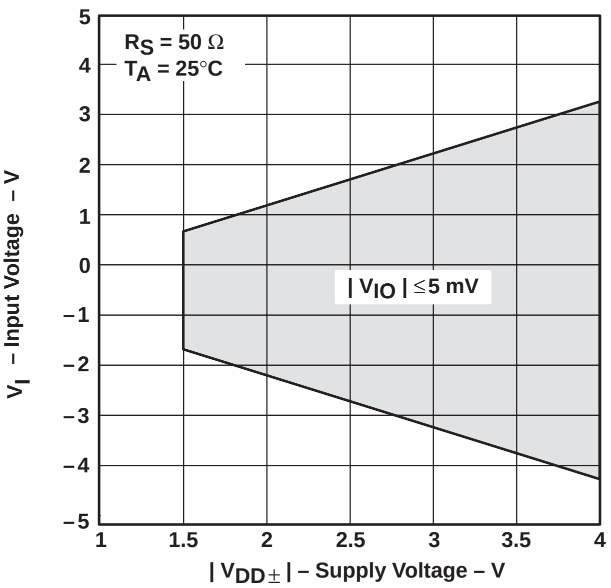


Figure 8

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

TYPICAL CHARACTERISTICS

INPUT VOLTAGE†‡ vs FREE-AIR TEMPERATURE

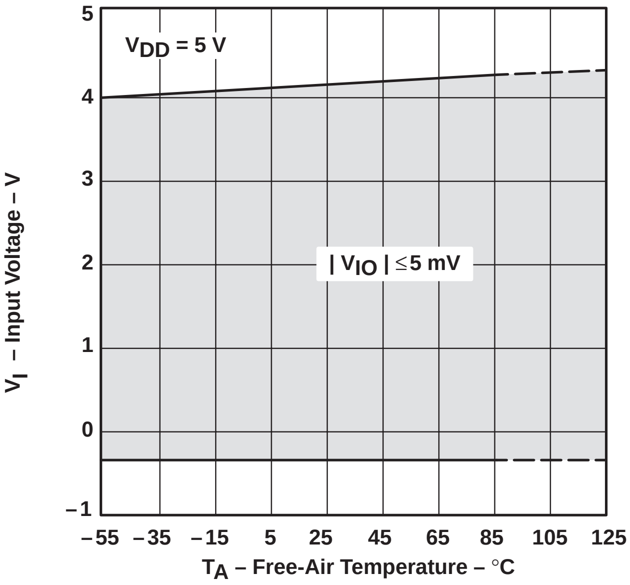


Figure 9

HIGH-LEVEL OUTPUT VOLTAGE†‡ vs HIGH-LEVEL OUTPUT CURRENT

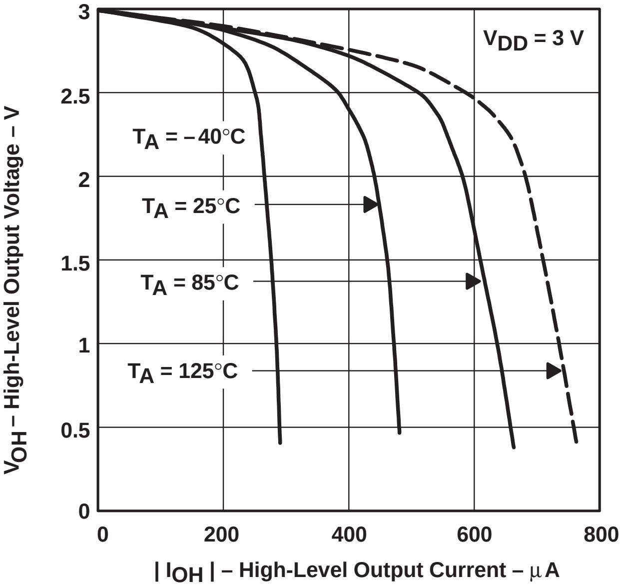


Figure 10

LOW-LEVEL OUTPUT VOLTAGE‡ vs LOW-LEVEL OUTPUT CURRENT

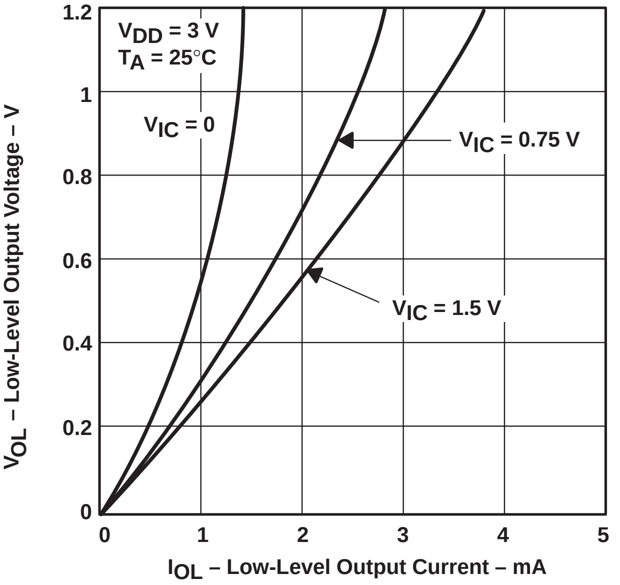


Figure 11

LOW-LEVEL OUTPUT VOLTAGE†‡ vs LOW-LEVEL OUTPUT CURRENT

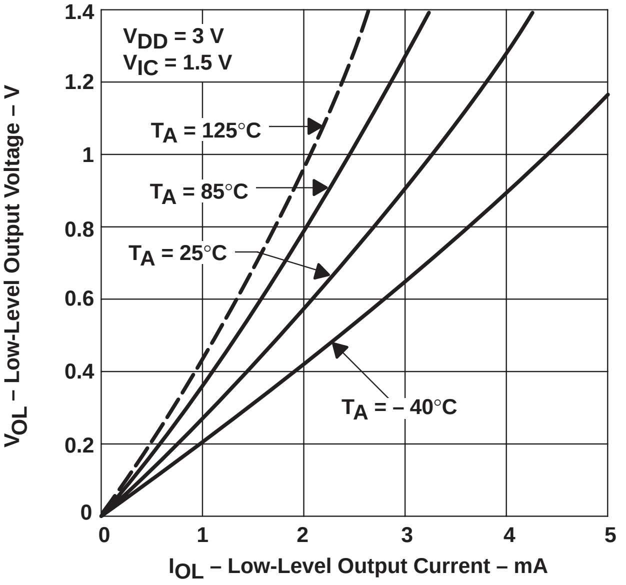


Figure 12

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† 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

HIGH-LEVEL OUTPUT VOLTAGE†‡ vs HIGH-LEVEL OUTPUT CURRENT

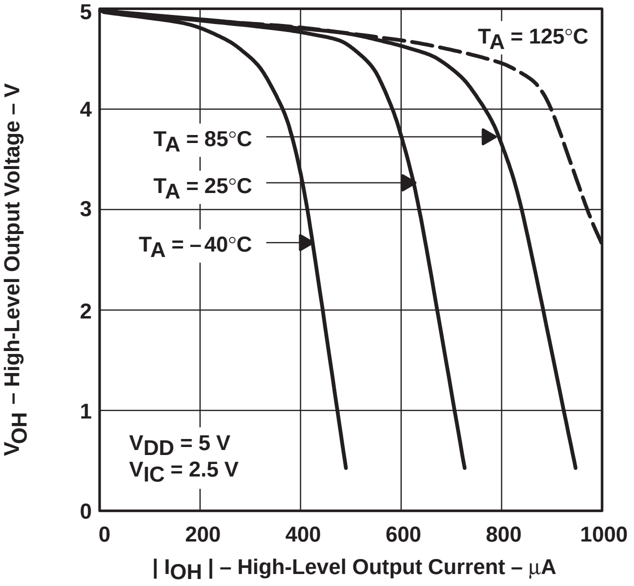

Figure 13

LOW-LEVEL OUTPUT VOLTAGE†‡ vs LOW-LEVEL OUTPUT CURRENT

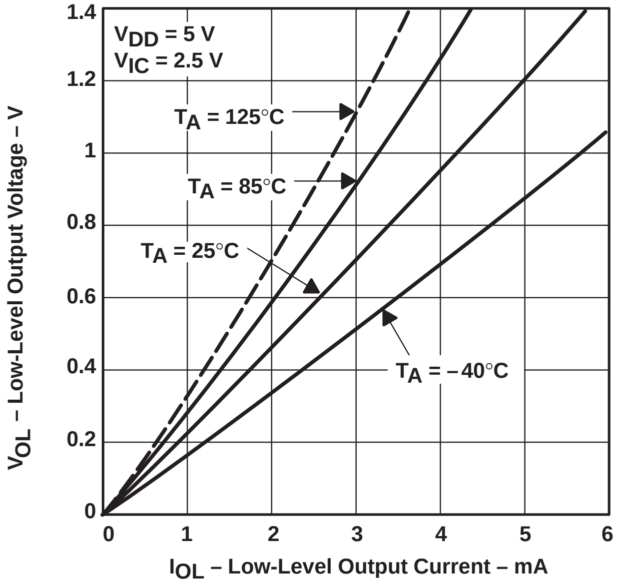

Figure 14

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE‡ vs FREQUENCY

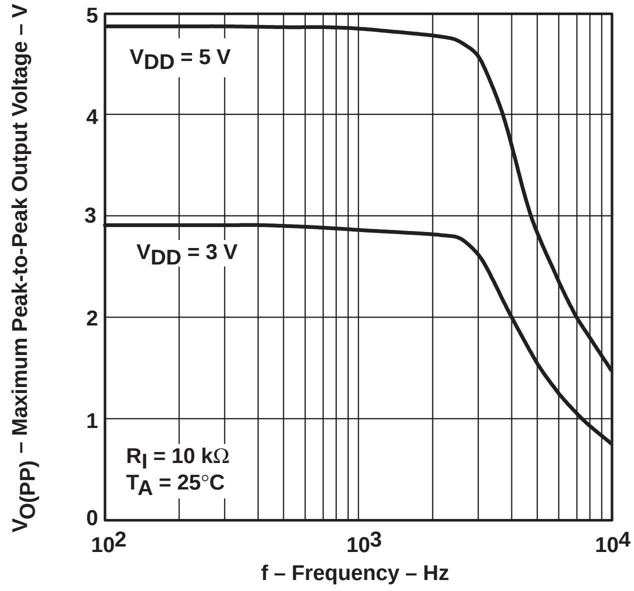

Figure 15

SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

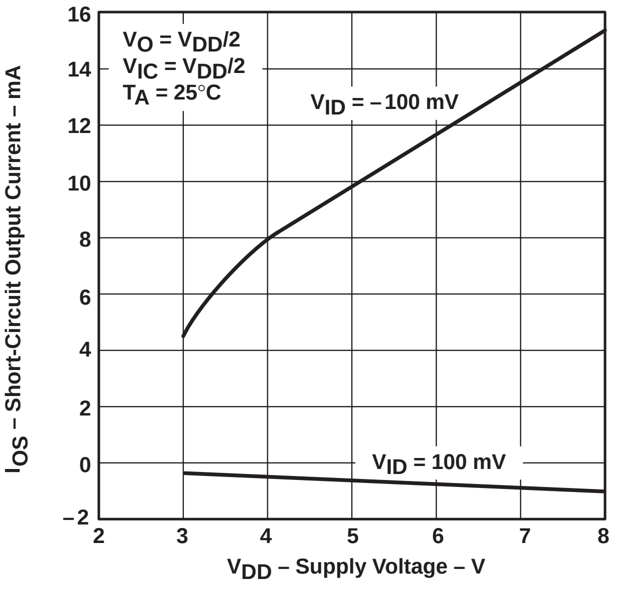

Figure 16

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† 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

SHORT-CIRCUIT OUTPUT CURRENT†‡ vs FREE-AIR TEMPERATURE

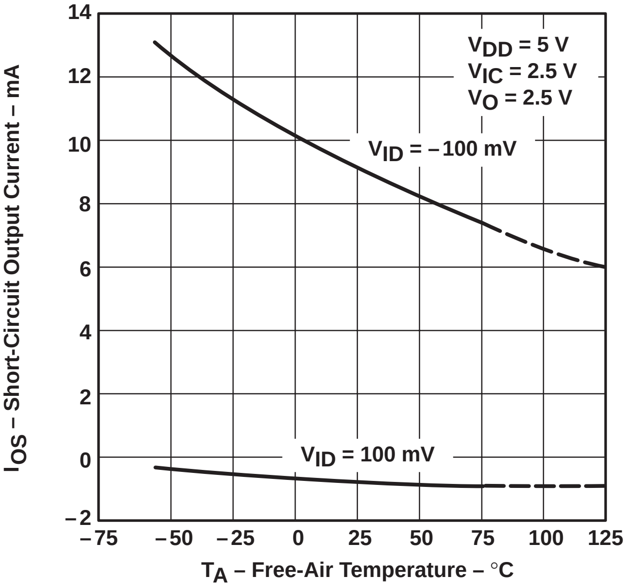

Figure 17

OUTPUT VOLTAGE‡ vs DIFFERENTIAL INPUT VOLTAGE

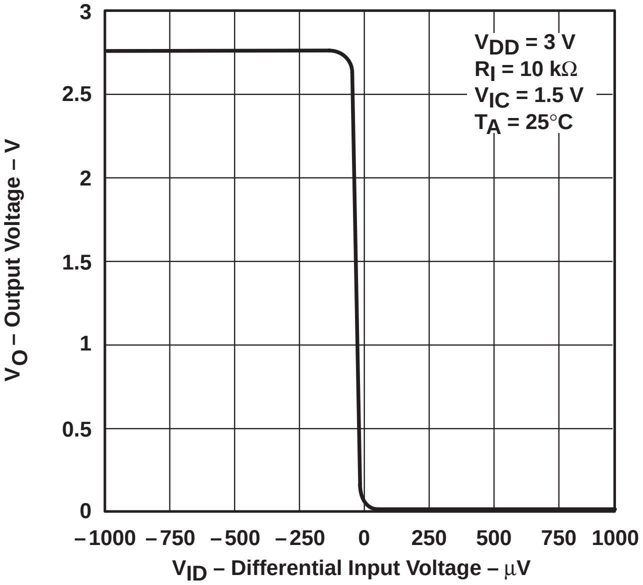

Figure 18

OUTPUT VOLTAGE‡ vs DIFFERENTIAL INPUT VOLTAGE

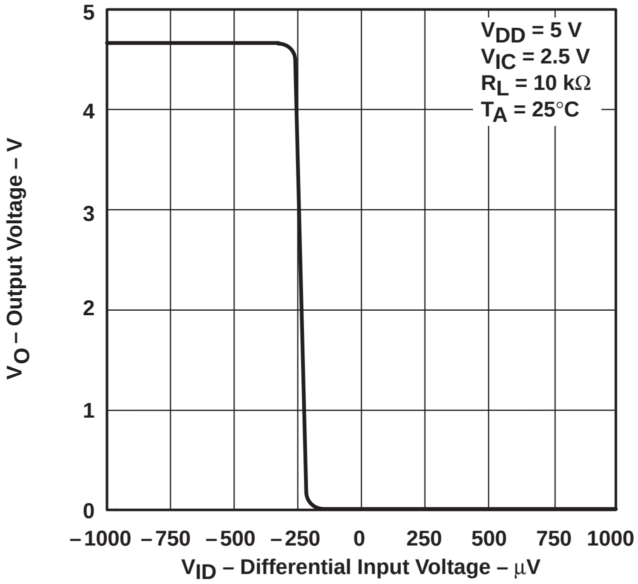

Figure 19

DIFFERENTIAL VOLTAGE AMPLIFICATION‡ vs LOAD RESISTANCE

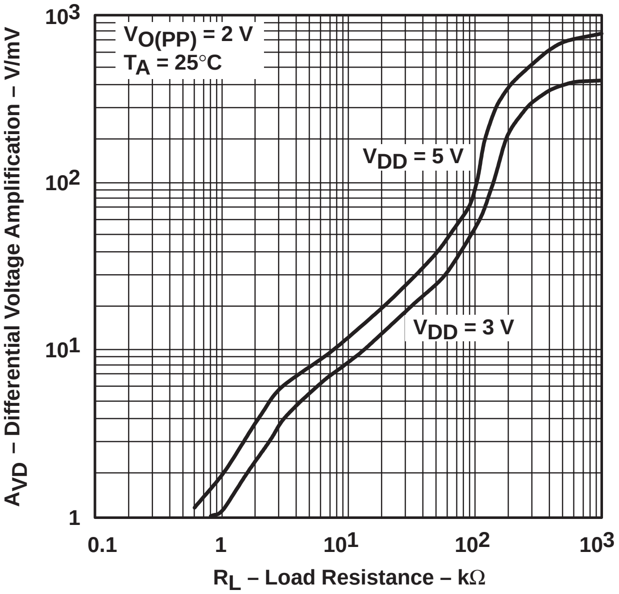

Figure 20

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† 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

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN[†] vs FREQUENCY

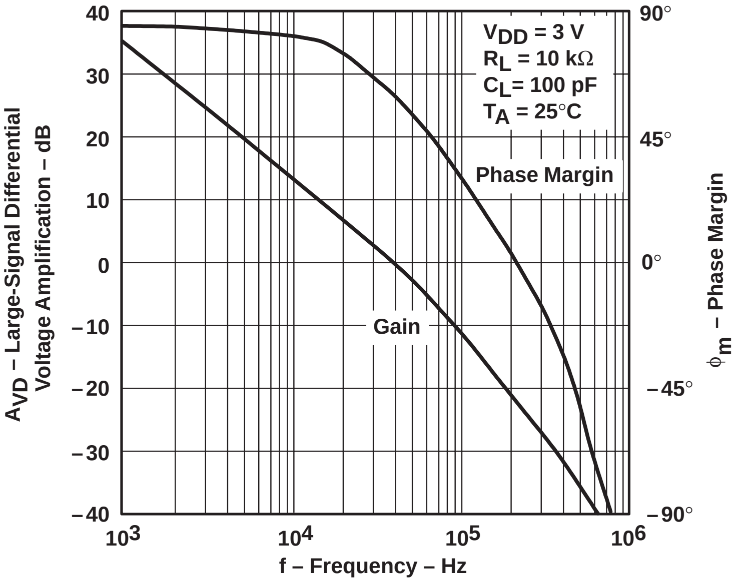

Figure 21

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN[†] vs FREQUENCY

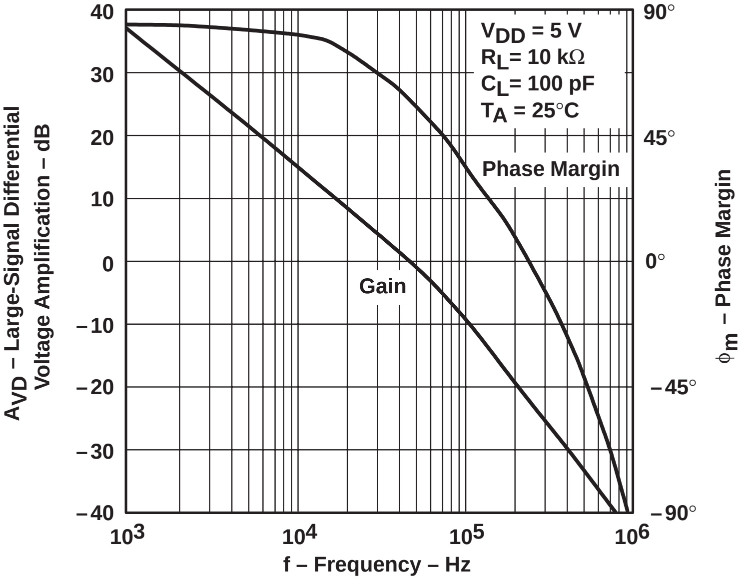

Figure 22

[†] For all curves where V_{DD} = 5 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

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION†‡ vs FREE-AIR TEMPERATURE

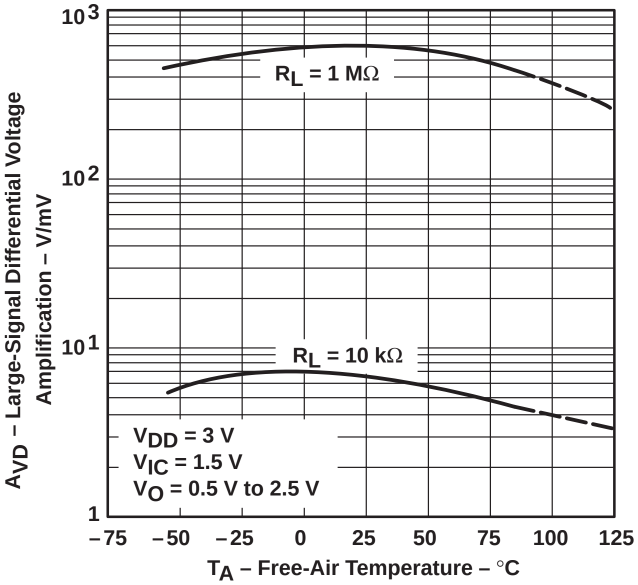

Figure 23

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION†‡ vs FREE-AIR TEMPERATURE

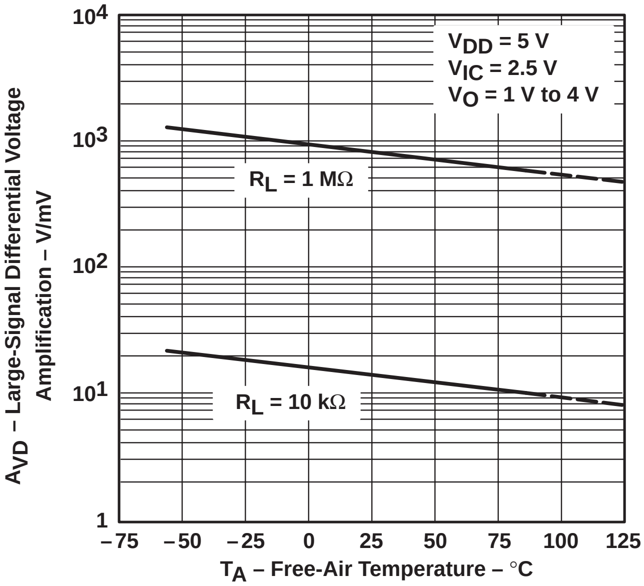

Figure 24

OUTPUT IMPEDANCE‡ vs FREQUENCY

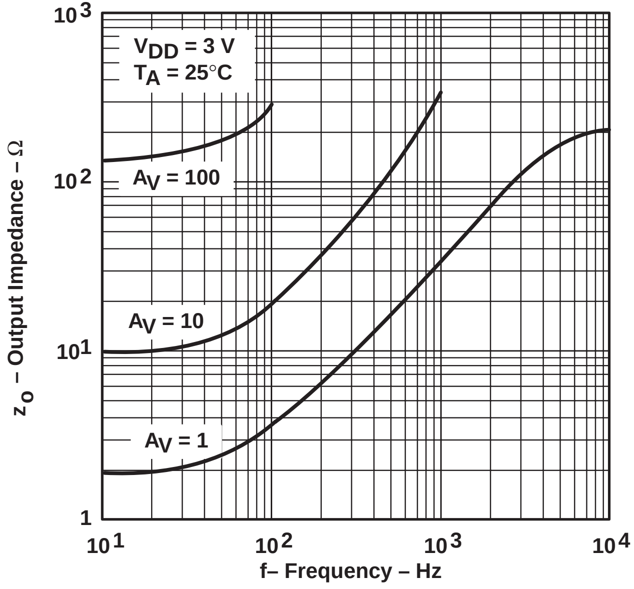

Figure 25

OUTPUT IMPEDANCE‡ vs FREQUENCY

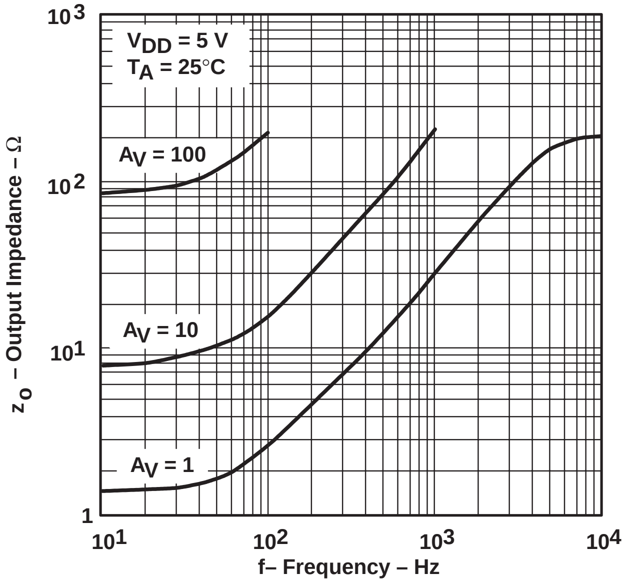

Figure 26

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† 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

COMMON-MODE REJECTION RATIO[†] vs FREQUENCY

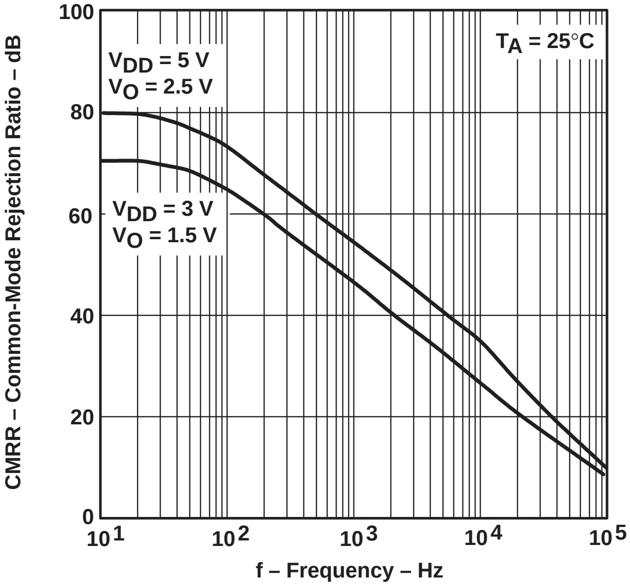

Figure 27

COMMON-MODE REJECTION RATIO[†‡] vs FREQUENCY FREE-AIR TEMPERATURE

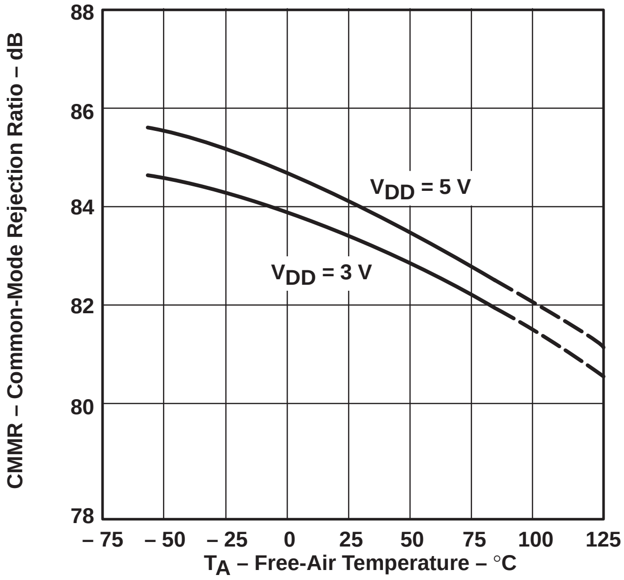

Figure 28

SUPPLY-VOLTAGE REJECTION RATIO[†] vs FREQUENCY

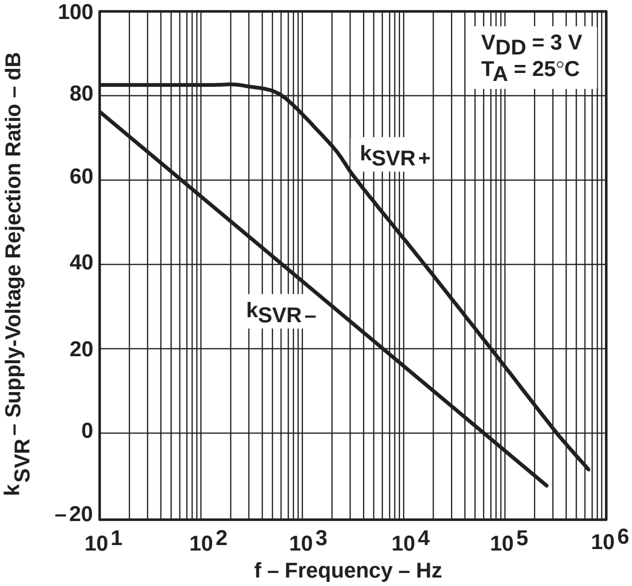

Figure 29

SUPPLY-VOLTAGE REJECTION RATIO[†] vs FREQUENCY

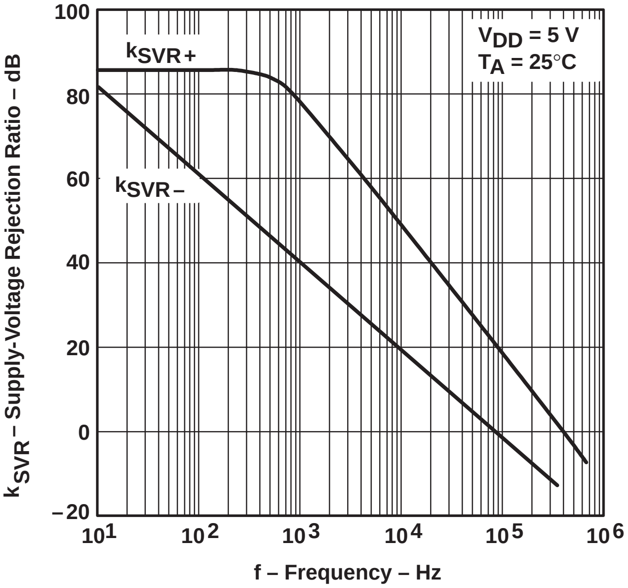

Figure 30

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

TYPICAL CHARACTERISTICS

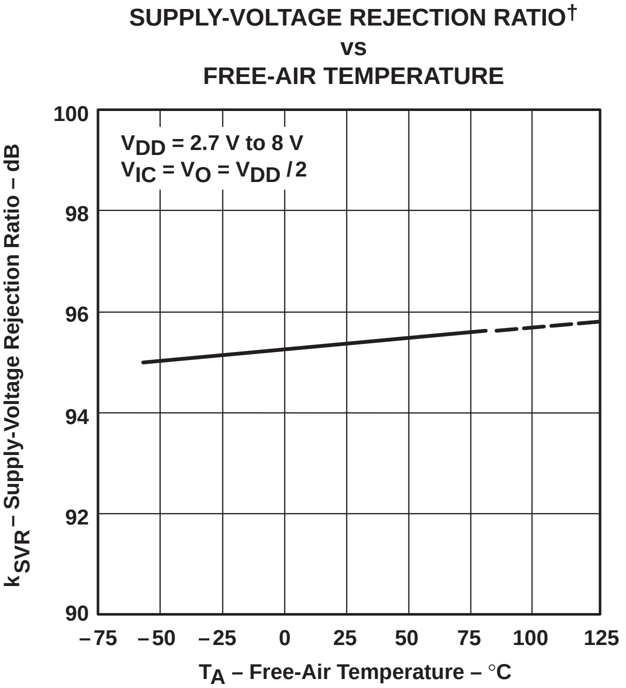

Figure 31

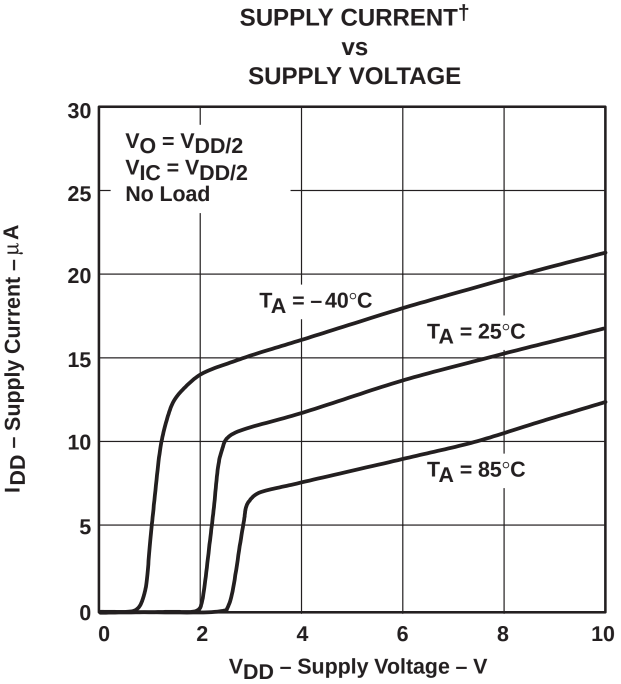

Figure 32

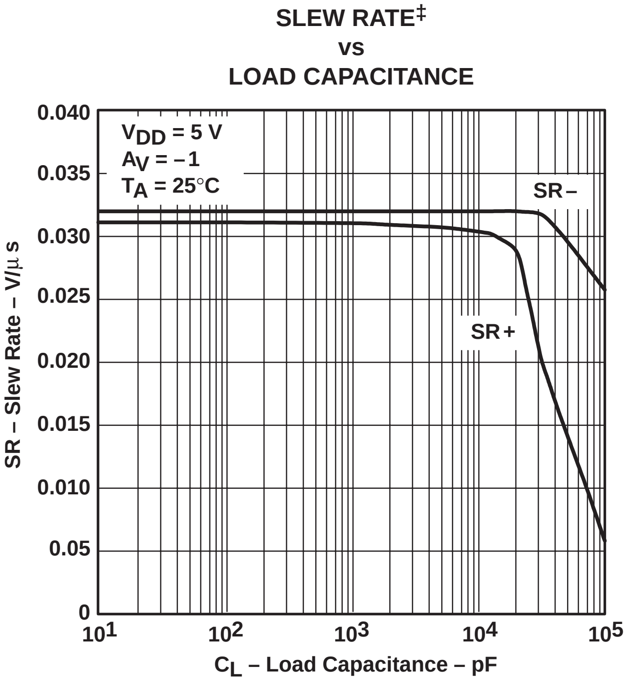

Figure 33

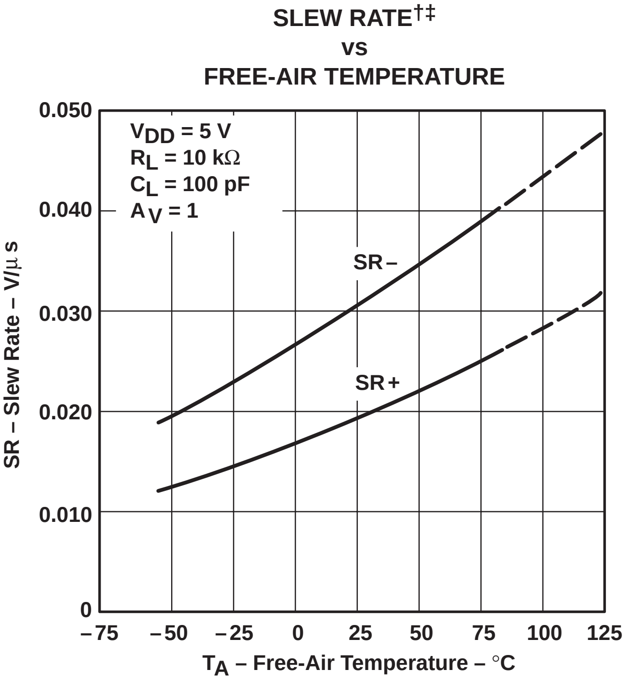

Figure 34

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† 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

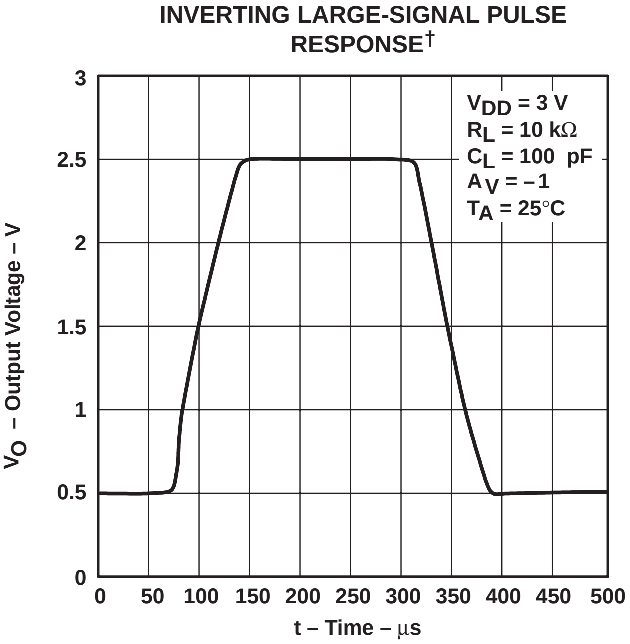

Figure 35

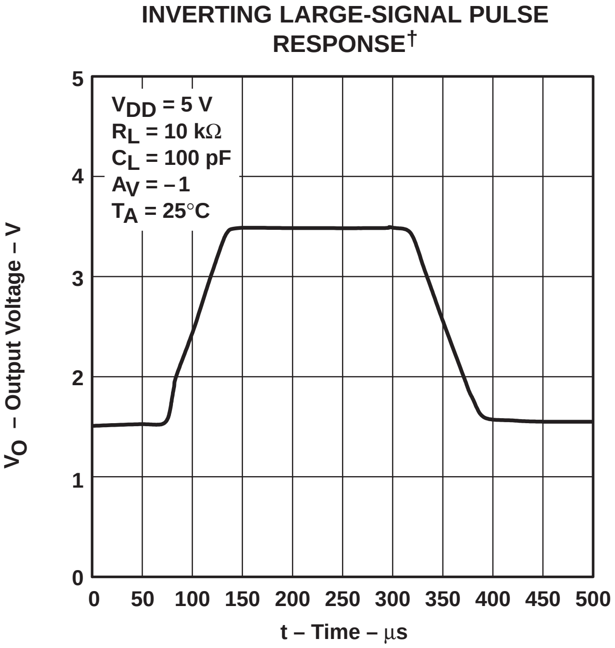

Figure 36

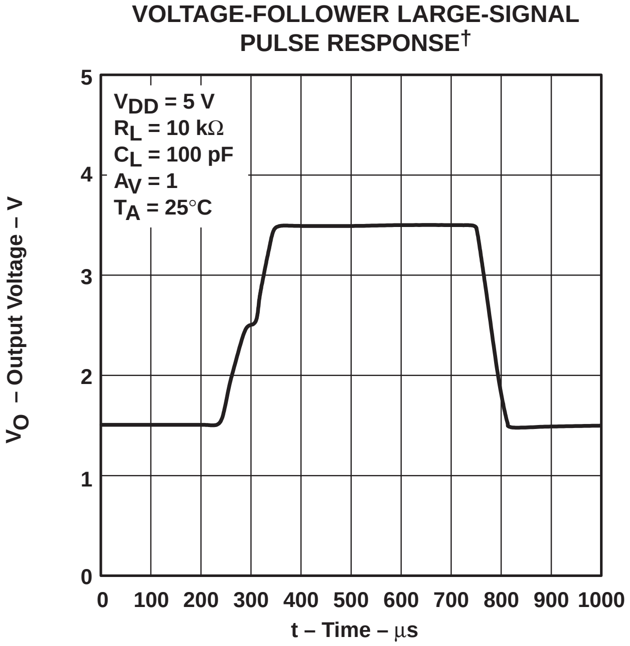

Figure 37

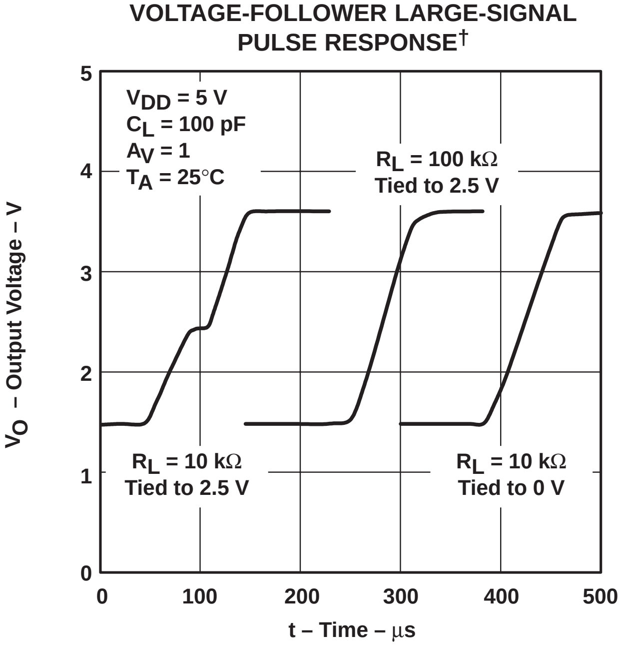

Figure 38

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† 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

INVERTING SMALL-SIGNAL PULSE RESPONSE†

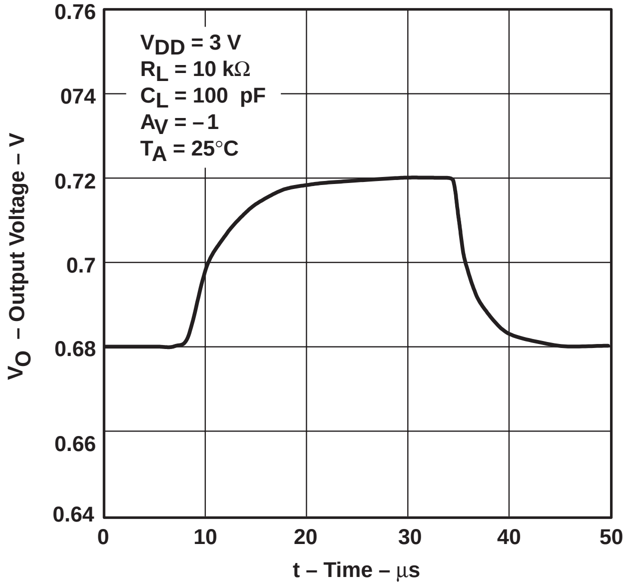

Figure 39

INVERTING SMALL-SIGNAL PULSE RESPONSE†

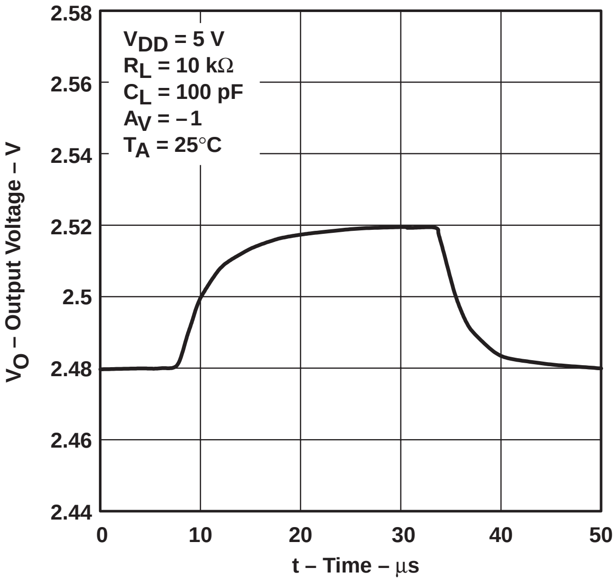

Figure 40

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†

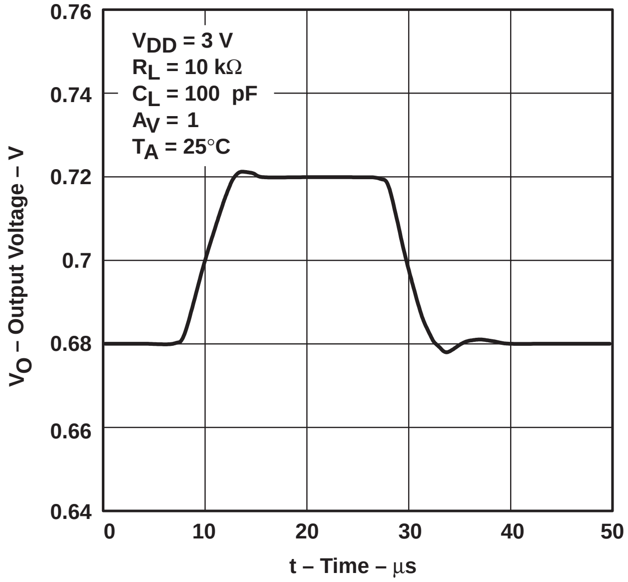

Figure 41

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†

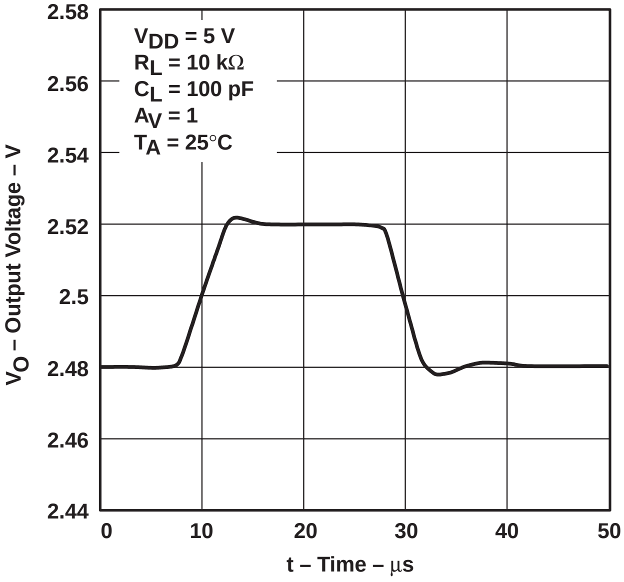

Figure 42

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† 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

EQUIVALENT INPUT NOISE VOLTAGE† vs FREQUENCY

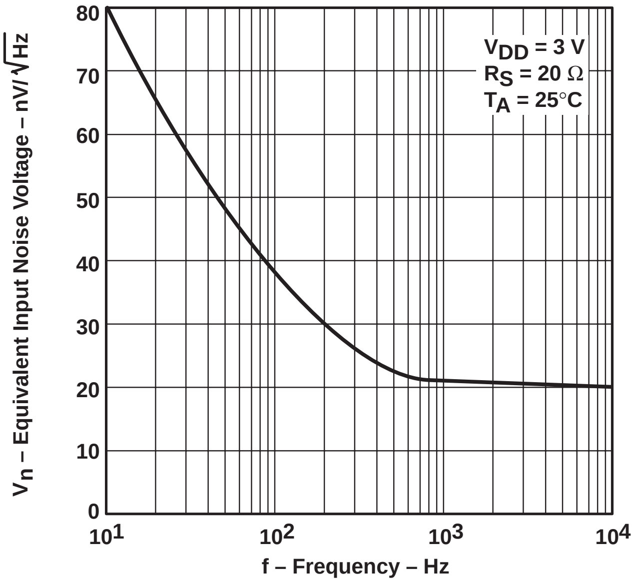

Figure 43

EQUIVALENT INPUT NOISE VOLTAGE† vs FREQUENCY

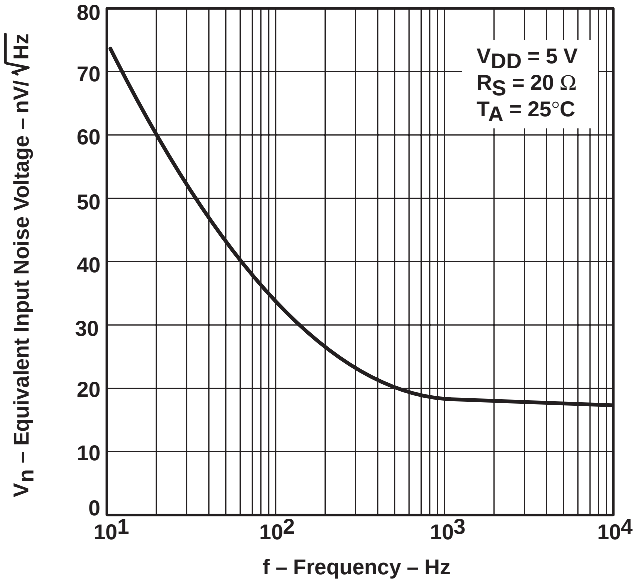

Figure 44

INPUT NOISE VOLTAGE OVER A 10-SECOND PERIOD†

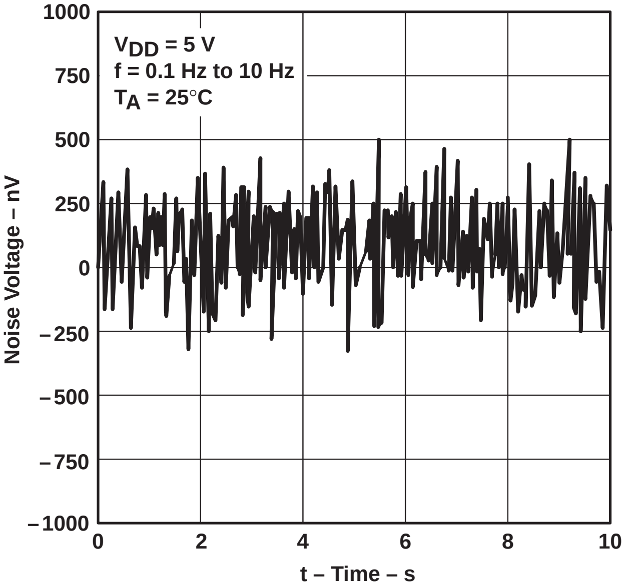

Figure 45

TOTAL HARMONIC DISTORTION PLUS NOISE† vs FREQUENCY

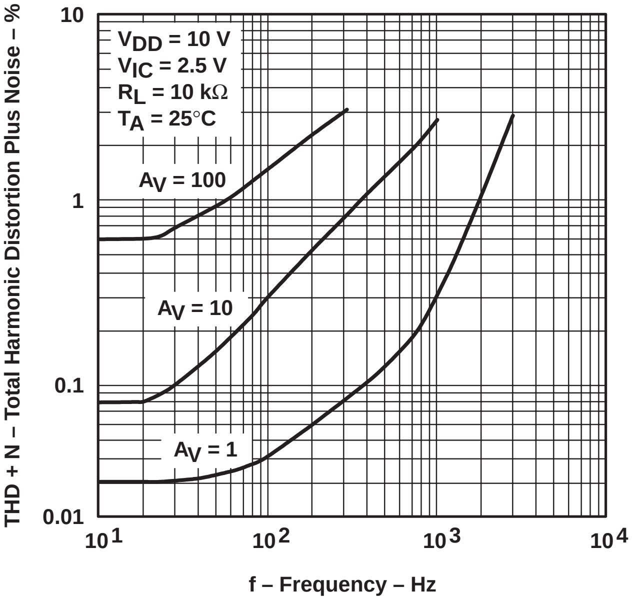

Figure 46

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† 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

GAIN-BANDWIDTH PRODUCT†‡
vs
FREE-AIR TEMPERATURE

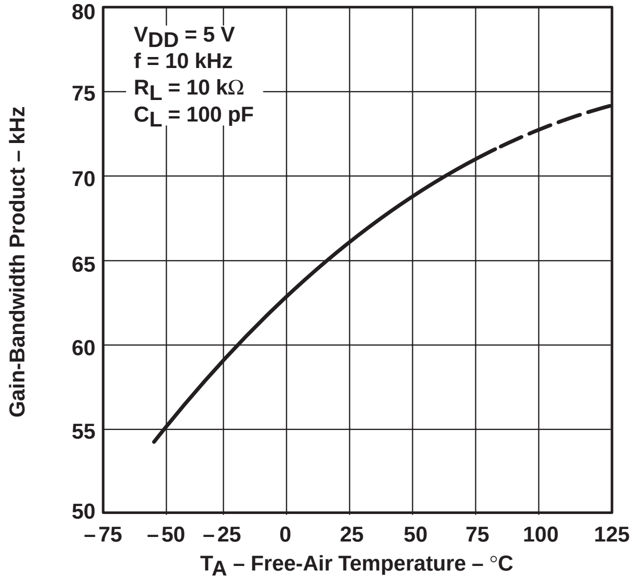

Figure 47

GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

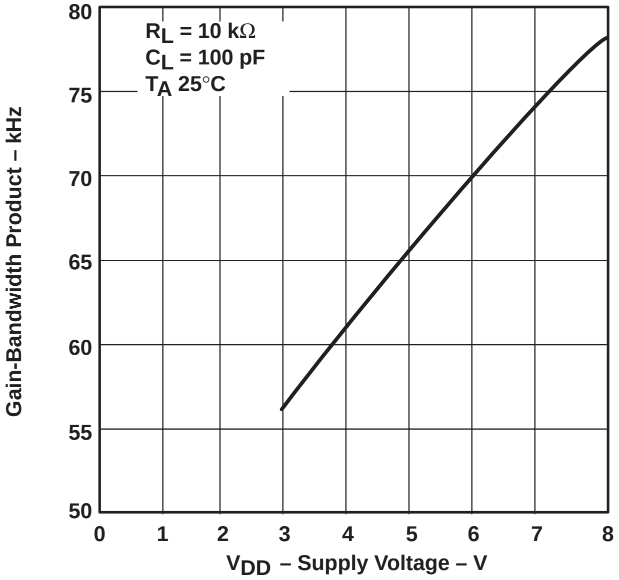

Figure 48

PHASE MARGIN
vs
LOAD CAPACITANCE

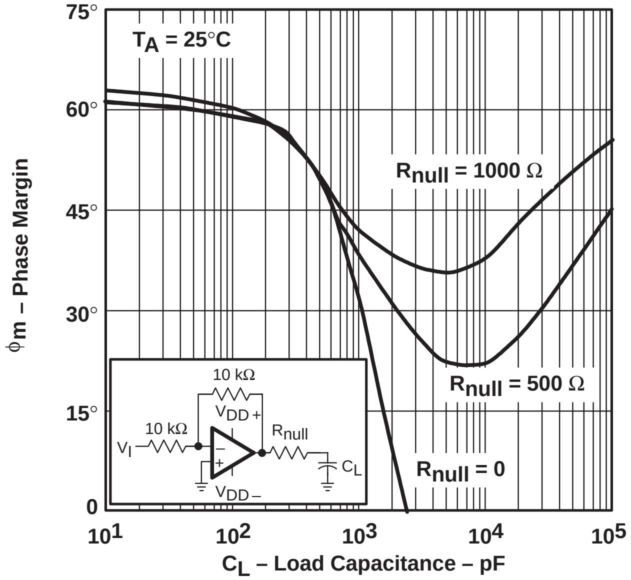

Figure 49

GAIN MARGIN
vs
LOAD CAPACITANCE

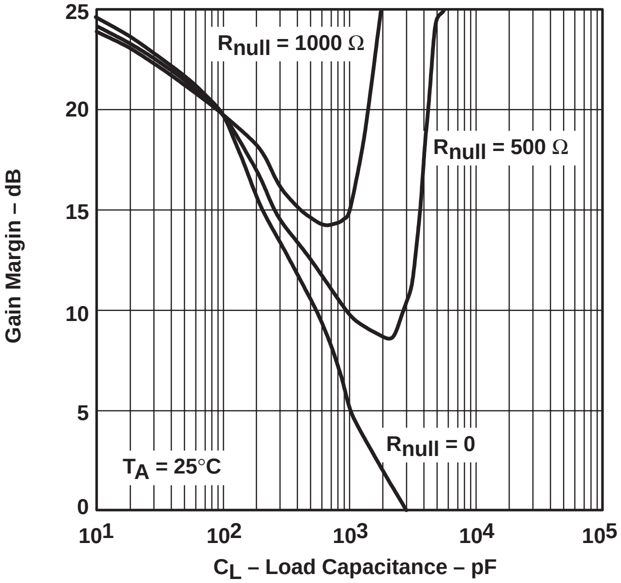

Figure 50

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† 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

UNITY-GAIN BANDWIDTH vs LOAD CAPACITANCE

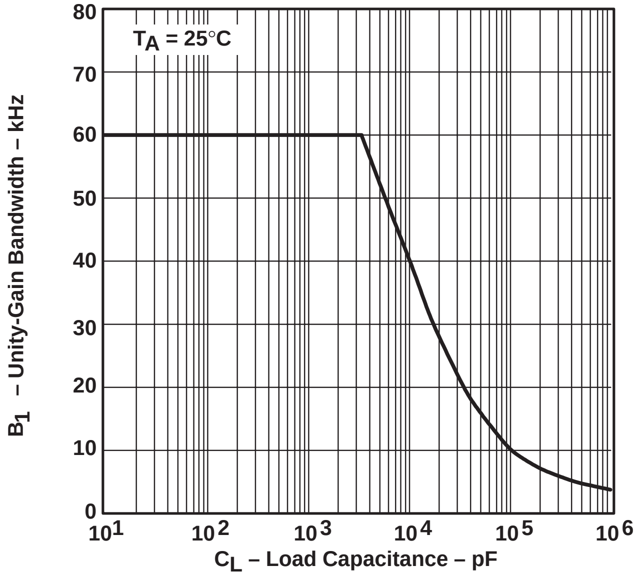


Figure 51

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 Ω and 1000 Ω. 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.

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

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.

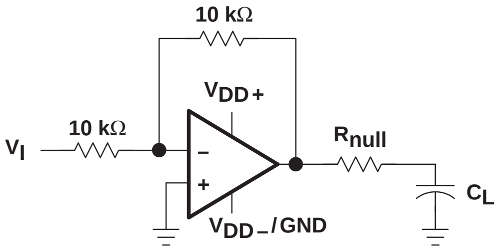


Figure 52. Series-Resistance Circuit

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 µA and source 250 µA at V_{DD} = 3 V and V_{DD} = 5 V at a maximum quiescent I_{DD} of 25 µA. This provides a greater than 90% power efficiency.

When driving heavy dc loads, such as 10 kΩ, 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-kΩ load conditions. The first load condition shows the distortion seen for a 10-kΩ load tied to 2.5 V. The third load condition shows no distortion for a 10-kΩ 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-kΩ load and a 100-kΩ 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.

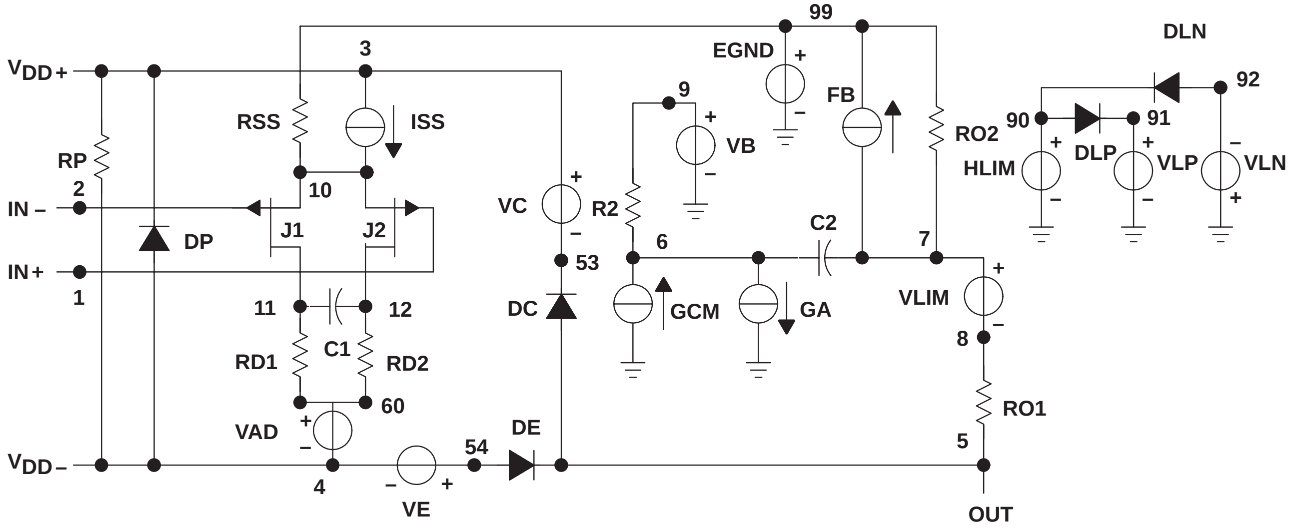
APPLICATION INFORMATION

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°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).



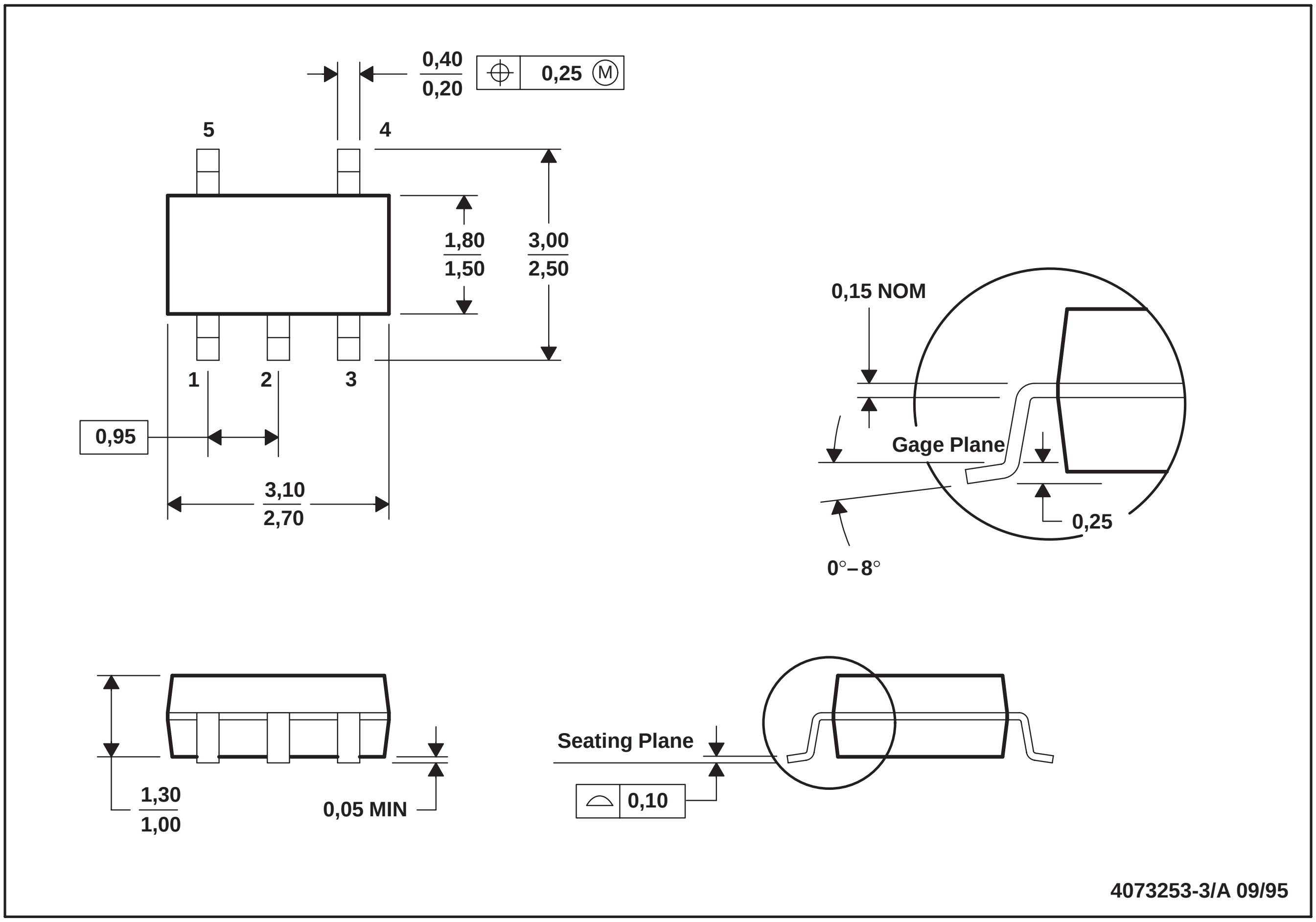
```
.SUBCKT TLV2211 1 2 3 4 5
            C1      11     12      8.86E–12
            C2      6      7       50.00E–12
            DC      5      53      DX
            DE      54     5       DX
            DLP     90     91      DX
            DLN     92     90      DX
            DP      4      3       DX
            EGND    99     0       POLY (2) (3,0) (4,0) 0 .5 .5
            FB      7      99      POLY (5) VB VC VE VLP
            + VLN 0 4.29E6 –6E6 6E6 6E6 –6E6
            GA      6      0       11      12 9.425E–6
            GCM     0      6       10      99 1320.2E–12
            ISS     3      10      DC 1.250E–6
            HLIM    90     0       VLIM 1K
            J1      11     2       10 JX
            J2      12     1       10 JX
            R2      6      9       100.0E3
RD1     60      11      106.1E3
RD2     60      12      106.1E3
R01     8       5       50
R02     7       99      150
RP      3       4       419.2E3
RSS     10      99      160.0E6
VAD     60      4       –.5
VB      9       0       DC 0
VC      3       53      DC .55
VE      54      4       DC .55
VLIM    7       8       DC 0
VLP     91      0       DC 0.1
VLN     0       92      DC 2.6
.MODEL DX D (IS=800.0E–18)
.MODEL JX PJF (IS=500.0E–15 BETA=166E–6
+ VTO=–.004)
.ENDS
```

Figure 53. Boyle Macromodel and Subcircuit

PSpice and *Parts* are trademark of MicroSim Corporation.

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.

PACKAGE OPTION ADDENDUM

4-Mar-2005

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
TLV2211CDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2211CDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2211CDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2211CDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2211IDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2211IDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2211IDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

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Mailing Address: Texas Instruments
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