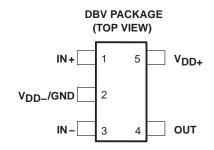
- Output Swing Includes Both Supply Rails
- Low Noise . . . 21 nV/ $\sqrt{\text{Hz}}$  Typ at f = 1 kHz
- Low Input Bias Current . . . 1 pA Typ
- Very Low Power . . . 11 μA Per Channel Typ
- Common-Mode Input Voltage Range Includes Negative Rail
- Wide Supply Voltage Range 2.7 V to 10 V
- Available in the SOT-23 Package
- Macromodel Included

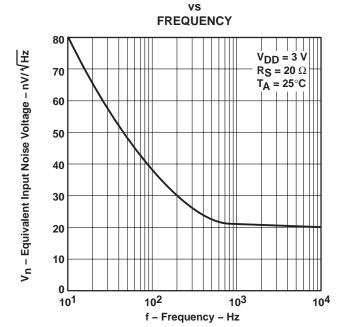
#### description

The TLV2211 is a single low-voltage operational amplifier available in the SOT-23 package. It consumes only 11  $\mu A$  (typ) of supply current and is ideal for battery-power applications. Looking at Figure 1, the TLV2211 has a 3-V noise level of 22 nV/\sqrt{Hz} at 1kHz; 5 times lower than competitive SOT-23 micropower solutions. The device exhibits rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLV2211 is fully characterized at 3 V and 5 V and is optimized for low-voltage applications.

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 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).



#### **EQUIVALENT INPUT NOISE VOLTAGE**<sup>†</sup>



<sup>†</sup> All loads are referenced to 1.5 V.

Figure 1. Equivalent Input Noise Voltage Versus Frequency

#### **AVAILABLE OPTIONS**

ľ	_	V AT 0500	PACKAGED DEVICES	OVMDOL	CHIP FORM <sup>‡</sup>
	TA	V <sub>IO</sub> max AT 25°C	SOT-23 (DBV) <sup>†</sup>	SYMBOL	(Y)
ľ	0°C to 70°C	3 mV	TLV2211CDBV	VACC	TI V2211Y
	-40°C to 85°C	3 mV	TLV2211IDBV	VACI	ILVZZIII

<sup>†</sup>The DBV package available in tape and reel 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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<sup>‡</sup> Chip forms are tested at  $T_A = 25$ °C only.

#### description (continued)

With a total area of 5.6mm<sup>2</sup>, 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. TI has also taken special care to provide a pinout that is optimized for board layout (see Figure 2). Both inputs are separated by GND to prevent coupling or leakage paths. The OUT and IN – terminals are on the same end of the board to provide negative feedback. Finally, gain setting resistors and decoupling capacitor are easily placed around the package.

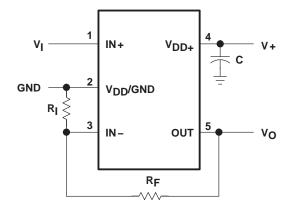
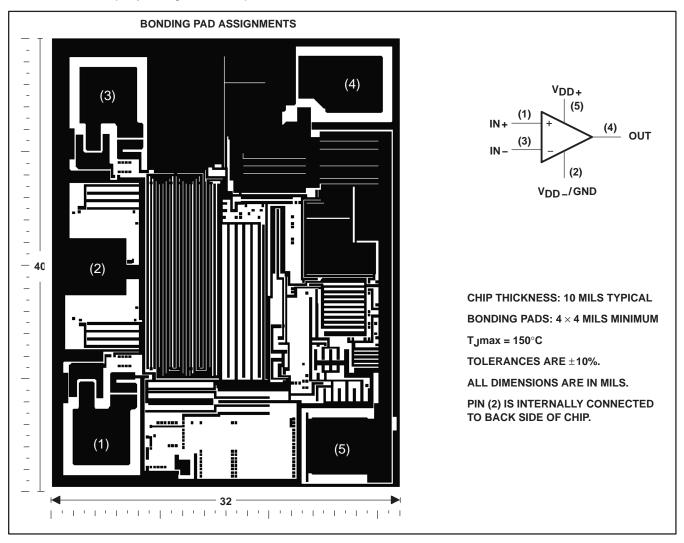


Figure 2. Typical Surface Mount Layout for a Fixed-Gain Noninverting Amplifier

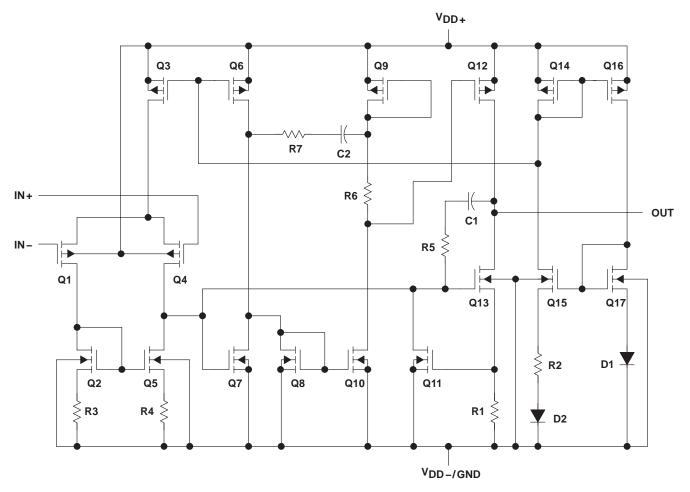


#### **TLV2211Y chip information**

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.



#### equivalent schematic



COMPONENT COUNT							
Transistors	23						
Diodes	6						
Resistors	11						
Capacitors	2						

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

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

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

Supply voltage, V <sub>DD</sub> (see Note 1)	
Differential input voltage, V <sub>ID</sub> (see Note 2)	±V <sub>DD</sub>
Input voltage range, V <sub>I</sub> (any input, see Note 1)	
Input current, I <sub>I</sub> (each input)	±5 mĀ
Output current, I <sub>O</sub>	±50 mA
Total current into V <sub>DD+</sub>	±50 mA
Total current out of V <sub>DD</sub>	±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 <sub>A</sub> : TLV2211C	0°C to 70°C
TLV2211I	–40°C to 85°C
Storage temperature range, T <sub>sta</sub>	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DBV package	je 260°C

<sup>†</sup> 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<sub>DD</sub> \_.
  - 2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below Vpp = -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	$T_{\mbox{A}} \le 25^{\circ}\mbox{C}$ Power rating	DERATING FACTOR ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING
DBV	150 mW	1.2 mW/°C	96 mW	78 mW

#### recommended operating conditions

	TLV2211C MIN MAX		TL		
			MIN	MAX	UNIT
Supply voltage, V <sub>DD</sub> (see Note 1)	2.7	10	2.7	10	V
Input voltage range, V <sub>I</sub>	V <sub>DD</sub> _	V <sub>DD+</sub> -1.3	V <sub>DD</sub> _	V <sub>DD+</sub> -1.3	V
Common-mode input voltage, V <sub>IC</sub>	$V_{DD-}$	V <sub>DD+</sub> -1.3	$V_{DD-}$	V <sub>DD+</sub> -1.3	V
Operating free-air temperature, TA	0	70	-40	85	°C

NOTE 1: All voltage values, except differential voltages, are with respect to VDD \_.



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

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

	PARAMETER	TEST COND	ITIONS	T. †	TI	_V2211	С	Т	LV2211	I	
	PARAWETER	TEST COND	ITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
VIO	Input offset voltage					0.47	3		0.47	3	mV
αΝΙΟ	Temperature coefficient of input offset voltage	V 14.5.V	V 0	Full range		1			1		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{DD\pm} = \pm 1.5 \text{ V},$ $V_{O} = 0,$	$V_{IC} = 0$ , RS = 50 $\Omega$	25°C		0.003			0.003		μV/mo
ΙO	Input offset current			Full range		0.5	60		0.5	60	pА
$I_{IB}$	Input bias current			Full range		1	60		1	60	pА
VICR	Common-mode input voltage range	V <sub>IO</sub>   ≤5 mV,	R <sub>S</sub> = 50 Ω	25°C	0 to 2	-0.3 to 2.2		0 to 2	-0.3 to 2.2		V
	voltage range			Full range	to 1.7			to 1.7			
		$I_{OH} = -100  \mu A$		25°C		2.94			2.94		
∨он	High-level output voltage	J 050 A		25°C		2.85			2.85		V
	voltage	I <sub>OH</sub> = -250 μA		Full range	2.5			2.5			
		$V_{IC} = 1.5 V,$	$I_{OL} = 50 \mu\text{A}$	25°C		15			15		
VoL	Low-level output voltage	V 45V	. 500 4	25°C		150			150		mV
	vollago	V <sub>IC</sub> = 1.5 V,	$I_{OL} = 500 \mu\text{A}$	Full range			500			500	
	Large-signal		R <sub>L</sub> = 10 kΩ <sup>‡</sup>	25°C	3	7		3	7		
$A_{VD}$	differential voltage	VO = 1 V to 2 V		2 V	Full range	1			1		
	amplification	VO = 1 V to 2 V	$R_L = 1 M\Omega^{\ddagger}$	25°C		600			600		
r <sub>i(d)</sub>	Differential input resistance			25°C		10 <sup>12</sup>			10 <sup>12</sup>		Ω
r <sub>i(c)</sub>	Common-mode input resistance			25°C		10 <sup>12</sup>			10 <sup>12</sup>		Ω
c <sub>i(c)</sub>	Common-mode input capacitance	f = 10 kHz,		25°C		5			5		pF
z <sub>o</sub>	Closed-loop output impedance	f = 7 kHz,	A <sub>V</sub> = 1	25°C		200			200		Ω
CMDD	Common-mode	$V_{IC} = 0 \text{ to } 1.7 \text{ V},$	V <sub>O</sub> = 1.5 V,	25°C	65	83		65	83		10
CMRR	rejection ratio	$R_S = 50 \Omega$		Full range	60			60			dB
ksvr	Supply voltage rejection ratio	V <sub>DD</sub> = 2.7 V to 8 V,	$V_{IC} = V_{DD}/2$	25°C	80	95		80	95		dB
0710	(ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	INO IOAU		Full range	80			80			ub
IDD	Supply current	V <sub>O</sub> = 1.5 V,	No load	25°C		11	25		11	25 μA	
טט.		VU = 1.5 V,	140 1000	Full range			30			30	μΑ

 $<sup>\</sup>sp{\uparrow}$  Full range for the TLV2211C is 0°C to 70°C. Full range for the TLV2211I is – 40°C to 85°C.



<sup>‡</sup>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.

# TLV2211, TLV2211Y Advanced LinCMOS™ RAIL-TO-RAIL MICROPOWER SINGLE OPERATIONAL AMPLIFIERS SLOS156E - MAY 1996 - REVISED SEPTEMBER 2006

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

	DADAMETED	TEST SOUD	ITIONIO	- +	Т	LV22110	С	1	LV2211	I		
	PARAMETER	TEST COND	IIIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNIT	
		V= 44V+=40V	B. 10 kgt	25°C	0.01	0.025		0.01	0.025			
SR	Slew rate at unity gain	$V_O = 1.1 \text{ V to } 1.9 \text{ V},$ $C_L = 100 \text{ pF}^{\ddagger}$	KL = 10 K22+,	Full range	0.005			0.005			V/µs	
.,	Equivalent input noise	f = 10 Hz		25°C		80			80		nV/√ <del>Hz</del>	
V <sub>n</sub>	voltage	f = 1 kHz		25°C		22			22		nv/√Hz	
V >	Peak-to-peak equivalent	f = 0.1 Hz to 1 Hz		25°C		660			660		nV	
V <sub>N</sub> (PP)	input noise voltage	f = 0.1 Hz to 10 Hz		25°C		880			880			
In	Equivalent input noise current			25°C		0.6			0.6		fA/√Hz	
	Gain-bandwidth product	f = 10 kHz, C <sub>L</sub> = 100 pF <sup>‡</sup>	$R_L = 10 \text{ k}\Omega^{\ddagger}$ ,	25°C		56			56		kHz	
B <sub>OM</sub>	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	
φm	Phase margin at unity gain	$R_L = 10 \text{ k}\Omega^{\ddagger}$ ,	C <sub>L</sub> = 100 pF <sup>‡</sup>	25°C		56°			56°			
	Gain margin	,		25°C		20	•		20	•	dB	

<sup>†</sup> Full range is –40°C to 85°C. ‡ Referenced to 1.5 V

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

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

METER	TEST COND	IIIONS	I TAI	TLV2211C TLV2211I							
			T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNIT	
offset voltage					0.45	3		0.45	3	mV	
erature cient of input voltage			Full range		0.5			0.5		μV/°C	
offset voltage erm drift lote 5)	$V_{DD\pm} = \pm 2.5 \text{ V},$ $V_{O} = 0,$	$V_{IC} = 0$ , RS = 50 $\Omega$	25°C		0.003			0.003		μV/mo	
offset current			25°C		0.5	60		0.5	60	pA	
oias current					1			1		pA	
non-mode input e range	V <sub>IO</sub>   ≤5 mV	R <sub>S</sub> = 50 Ω	25°C	0 to 4	-0.3 to 4.2		0 to 4	-0.3 to 4.2	100	V	
			Full range	to 3.5			to 3.5				
tt	$I_{OH} = -100  \mu A$		25°C		4.95			4.95			
voltage	Jour - 250 "A		25°C		4.875			4.875		V	
	ΙΟΗ = -230 μΑ		Full range	4.5			4.5				
	$V_{IC} = 2.5 V,$	$I_{OL} = 50 \mu A$	25°C		12			12			
	V10 = 2.5 V	lo 500 \	25°C		120			120		mV	
	ν <sub>1</sub> C = 2.5 ν,	IOL = 500 μA	Full range			500			500		
-signal	\\ 0.5\\	9.5.V	25°C	6	12		6	12			
ntial		_	Full range	3			3			V/mV	
e amplification	ŭ	$R_L = 1 M\Omega^{\ddagger}$	25°C		800			800			
ential input ance			25°C		1012			1012		Ω	
non-mode esistance			25°C		1012			1012		Ω	
non-mode capacitance	f = 10 kHz,		25°C		5			5		pF	
d-loop impedance	f = 7 kHz,	A <sub>V</sub> = 1	25°C		200			200		Ω	
non-mode on ratio	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$ $R_S = 50 \Omega$	V <sub>O</sub> = 2.5 V,	25°C	70 70	83		70 70	83		dB	
					05			05			
on ratio	$V_{DD} = 4.4 \text{ V to 8 V},$ No load	$V_{IC} = V_{DD}/2$ ,	Full range	80	90		80	90		dB	
(ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )		25°C		13	25		13	25	25		
/ current	$V_0 = 2.5 V$	No load								μΑ	
	erature ient of input voltage iffset voltage erm drift lote 5)  offset current  offset current	prature ient of input voltage offset voltage arm drift volte 5)  offset voltage offset voltage arm drift volte 5)  offset current  offset current  offset current  offset current	Frature ient of input voltage offset voltage offset voltage offset voltage offset voltage offset voltage offset current of ion-mode input of a range	$\begin{array}{c} \text{Trature} \\ \text{ient of input} \\ \text{voltage} \\ \text{iffset voltage} \\ \text{iffset voltage} \\ \text{ore 5}) \\ \text{offset current} \\ \text{ore 6} \\ \text{ore 5}) \\ \text{ore 6} \\ \text{ore 5}) \\ \text{ore 6} \\ \text{ore 6} \\ \text{ore 7} \\ \text{ore 6} \\ \text{ore 7} \\ \text{ore 8} \\ \text{ore 9} \\ \text{ore 10} \\ \text{ore 9} \\ \text{ore 10} \\ o$	Farature ient of input voltage signal nitial e amplification $P(I) = 100  P(I) = $		$ \begin{array}{c} \text{Trature} \\ \text{eint of input} \\ \text{voltage} \\ \text{offset voltage} \\ \text{ern drift} \\ \text{ote 5} \\ ) \\ \text{offset current} \\ \\ \text{on-mode input} \\ \text{or ange} \\ \\ \text{ote 5} \\ ) \\ \text{v}_{O} = 0, \\ \\ \text{N}_{O} = 0, \\ \text{N}_{O} = 0, \\ \\ \text{N}_{O} = 0, $	$ \begin{array}{c} \text{trature} \\ \text{eint of input} \\ \text{voictage} \\ \text{offset voltage} \\ \text{orde 5} \\ \text{out of 5} \\ \text{out of 5} \\ \text{out of 5} \\ \text{offset current} \\ \text{on-mode input} \\ \text{e range} \\ \end{array} \begin{array}{c} V_{DD\pm} = \pm 2.5 \text{ V},  V_{IC} = 0, \\ V_{O} = 0, \\ R_{S} = 50  \Omega \\ \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ \text{O}.003 \\ \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ \text{O}.003 \\ \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ \text{Full range} \\ \text{O}.5 \\ \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ \text{I} \\ \text{O}.003 \\ \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ \text{Full range} \\ \text{I} \\ \text{Full range} \\ \end{array} \begin{array}{c} 150 \\ \text{I} \\ \text{O}.003 \\ \end{array} \begin{array}{c} 0 \\ \text{Full range} \\ \text{I} \\ $	Full range   Second Province   Second Provinc	Full range   Signal   Parameter   Param	

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



<sup>‡</sup>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		- +	Т	LV2211	С	1	LV2211	I	UNIT		
	PARAMETER	TEST COND	ITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII	
		Va 45Vta25V	B. 40 kgt	25°C	0.01	0.025		0.01	0.025			
SR	Slew rate at unity gain	$V_O = 1.5 \text{ V to } 3.5 \text{ V},$ $C_L = 100 \text{ pF}^{\ddagger}$	$RL = 10 \; K 22+,$	Full range	0.005			0.005			V/µs	
.,	Equivalent input noise	f = 10 Hz		25°C		72			72		->/// <del>  -</del>	
Vn	voltage	f = 1 kHz		25°C		21			21		nV/√Hz	
\/	Peak-to-peak equivalent	f = 0.1 Hz to 1 Hz		25°C		600			600		nV	
V <sub>N(PP)</sub>	input noise voltage	f = 0.1 Hz to 10 Hz		25°C		800			800			
In	Equivalent input noise current			25°C		0.6			0.6		fA/√ <del>Hz</del>	
	Gain-bandwidth product	f = 10 kHz, C <sub>L</sub> = 100 pF‡	$R_L = 10 \text{ k}\Omega^{\ddagger}$ ,	25°C		65			65		kHz	
B <sub>OM</sub>	Maximum output-swing bandwidth	$V_{O(PP)} = 2 V,$ $R_{L} = 10 \text{ k}\Omega^{\ddagger},$	$A_V = 1,$ $C_L = 100 \text{ pF}^{\ddagger}$	25°C		7			7		kHz	
φm	Phase margin at unity gain	$R_L = 10 \text{ k}\Omega^{\ddagger}$ ,	C <sub>L</sub> = 100 pF <sup>‡</sup>	25°C		56°			56°			
	Gain margin	, , ,		25°C		22			22		dB	

<sup>†</sup> 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	TEG	ST CONDITIONS		TI	LV2211Y	′	LINUT
	PARAMETER	163	ST CONDITIONS		MIN	TYP	MAX	UNIT
VIO	Input offset voltage	., ., .,		.,		0.47		mV
IIO	Input offset current	$V_{DD\pm} = \pm 1.5 \text{ V},$ $R_S = 50 \Omega$	$V_O = 0$ ,	$V_{IC} = 0$ ,		0.5	60	pА
I <sub>IB</sub>	Input bias current	11/5 = 30 22				1	60	pА
VICR	Common-mode input voltage range	V <sub>IO</sub>   ≤5 mV,	$R_S = 50 \Omega$			-0.3 to 2.2		V
.,	LPale lavel autout vallage	$I_{OH} = -100  \mu A$				2.94		.,
VOH High-level output voltage		ΙΟΗ = -200 μΑ				2.85		V
.,	Law lawal autout valtage	V <sub>IC</sub> = 0,	I <sub>OL</sub> = 50 μA			15		\/
VOL	Low-level output voltage	V <sub>IC</sub> = 0,	I <sub>OL</sub> = 500 μA			150		mV
	Large-signal differential	., , _,		$R_L = 10 \text{ k}\Omega^{\dagger}$		7		
AVD	voltage amplification	$V_{IC} = 1.5 V,$	$V_O = 1 V \text{ to } 2 V$	$R_L = 1 M\Omega^{\dagger}$	600			V/mV
r <sub>i(d)</sub>	Differential input resistance			•		10 <sup>12</sup>		Ω
r <sub>i(c)</sub>	Common-mode input resistance					1012		Ω
<sup>C</sup> i(c)	Common-mode input capacitance	f = 10 kHz				5		pF
z <sub>O</sub>	Closed-loop output impedance	f = 7 kHz,	Ay = 1			200		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = 0 \text{ to } 1.7 \text{ V},$	V <sub>O</sub> = 1.5 V,	$R_S = 50 \Omega$		83		dB
ksvr	Supply voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	V <sub>DD</sub> = 2.7 V to 8 V,	$V_{IC} = V_{DD}/2,$	No load	_	95	_	dB
$I_{DD}$	Supply current	V <sub>O</sub> = 1.5 V,	No load			11		μΑ

<sup>†</sup> Referenced to 1.5 V



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

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# electrical characteristics at $V_{DD}$ = 5 V, $T_{A}$ = 25°C (unless otherwise noted)

PARAMETER			TEST CONDITIONS						
	PARAMETER	l les	SI CONDITIONS		MIN	TYP	MAX	UNIT	
VIO	Input offset voltage					0.45		mV	
lio	Input offset current	$V_{DD} \pm = \pm 2.5 \text{ V},$ $R_{S} = 50 \Omega$	$V_{IC} = 0$ ,	$V_O = 0$ ,		0.5	60	рА	
I <sub>IB</sub>	Input bias current	NS = 30 32				1	60	рΑ	
VICR	Common-mode input voltage range	V <sub>IO</sub>   ≤5 mV,	$R_S = 50 \Omega$			-0.3 to 4.2		٧	
.,	LPak lavel extend only	$I_{OH} = -100  \mu A$				4.95			
VOH	High-level output voltage	$I_{OH} = -250  \mu A$				4.875		V	
.,	Law law law and a set work walks are	V <sub>IC</sub> = 2.5 V,	I <sub>OL</sub> = 50 μA			12			
VOL	Low-level output voltage	V <sub>IC</sub> = 2.5 V,	$I_{OL} = 500  \mu A$			120		mV	
	Large-signal differential	V 05V		$R_L = 10 \text{ k}\Omega^{\dagger}$		12		.,, .,	
AVD	voltage amplification	$V_{IC} = 2.5 V,$	$V_O = 1 V \text{ to } 4 V$	$R_L = 1 M\Omega^{\dagger}$	800			V/mV	
<sup>r</sup> i(d)	Differential input resistance			•		1012		Ω	
r <sub>i(c)</sub>	Common-mode input resistance					1012		Ω	
<sup>C</sup> i(c)	Common-mode input capacitance	f = 10 kHz				5		pF	
z <sub>o</sub>	Closed-loop output impedance	f = 7 kHz,	A <sub>V</sub> = 1			200		Ω	
CMRR	Common-mode rejection ratio	$V_{IC} = 0 \text{ to } 2.7 \text{ V},$	V <sub>O</sub> = 2.5 V,	R <sub>S</sub> = 50 Ω		83		dB	
ksvr	Supply voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	V <sub>DD</sub> = 4.4 V to 8 V,	$V_{IC} = V_{DD}/2$ ,	No load		95		dB	
$I_{DD}$	Supply current	V <sub>O</sub> = 2.5 V,	No load			13		μΑ	

<sup>†</sup> Referenced to 1.5 V



### **Table of Graphs**

			FIGURE
V <sub>IO</sub>	Input offset voltage	Distribution vs Common-mode input voltage	3, 4 5, 6
ανιο	Input offset voltage temperature coefficient	Distribution	7, 8
I <sub>IB</sub> /I <sub>IO</sub>	Input bias and input offset currents	vs Free-air temperature	9
VI	Input voltage	vs Supply voltage vs Free-air temperature	10 11
V <sub>OH</sub>	High-level output voltage	vs High-level output current	12, 15
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VO(PP)	Maximum peak-to-peak output voltage	vs Frequency	17
IOS	Short-circuit output current	vs Supply voltage vs Free-air temperature	18 19
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A <sub>VD</sub>	Differential voltage amplification	vs Load resistance vs Frequency vs Free-air temperature	22 23, 24 25, 26
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	Gain margin	vs Load capacitance	52
B <sub>1</sub>	Unity-gain bandwidth	vs Load capacitance	53



# DISTRIBUTION OF TLV2211 INPUT OFFSET VOLTAGE

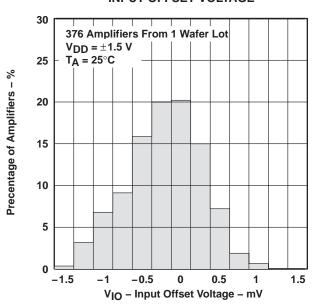


Figure 3

**INPUT OFFSET VOLTAGE**<sup>†</sup>

### •

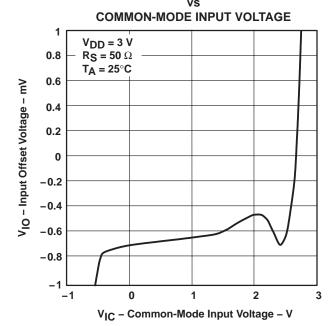


Figure 5

# DISTRIBUTION OF TLV2211 INPUT OFFSET VOLTAGE

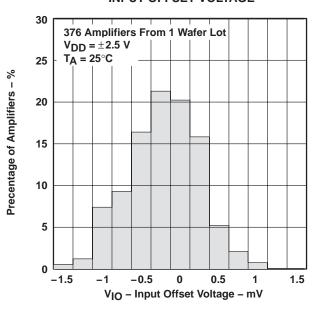


Figure 4

# INPUT OFFSET VOLTAGE† vs

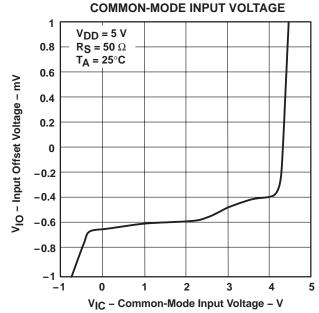


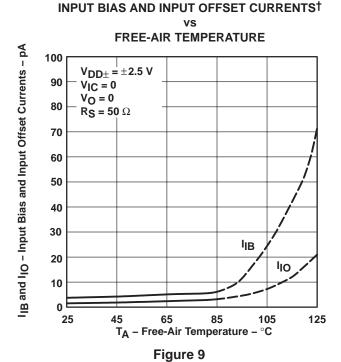
Figure 6

†For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.



# **DISTRIBUTION OF TLV2211 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT** 50 32 Amplifiers From 1 Wafer Lot $V_{DD} = \pm 1.5 \text{ V}$ P Package 40 T<sub>A</sub> = 25°C Percentage of Amplifiers - % 30 20 10 0 -3 -2 $\alpha_{\mbox{VIO}}$ – Temperature Coefficient – $\mu\mbox{V}\slash{\mbox{V}}\slash{\mbox{°}}\slash{\mbox{c}}$

Figure 7



DISTRIBUTION OF TLV2211 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

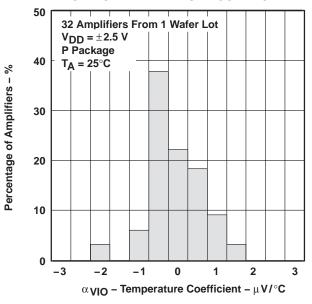
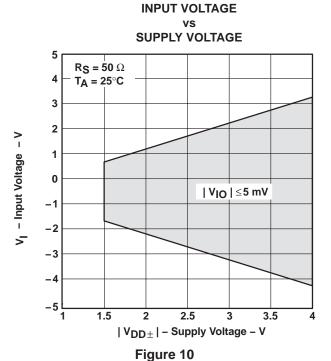
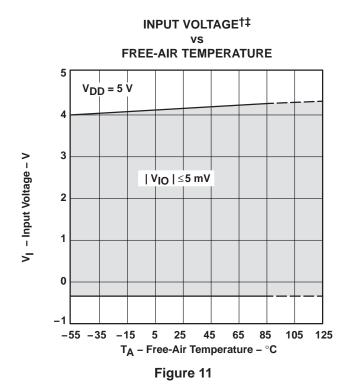


Figure 8

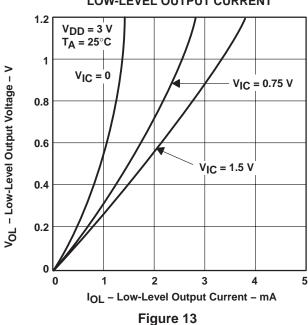


†Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

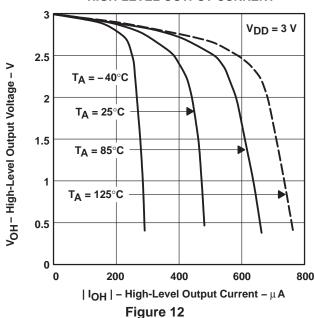




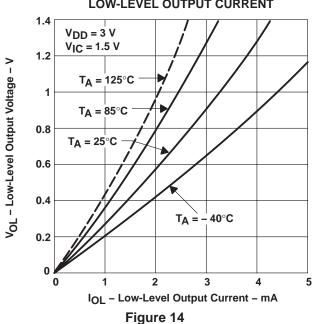




# HIGH-LEVEL OUTPUT VOLTAGE†‡ vs HIGH-LEVEL OUTPUT CURRENT



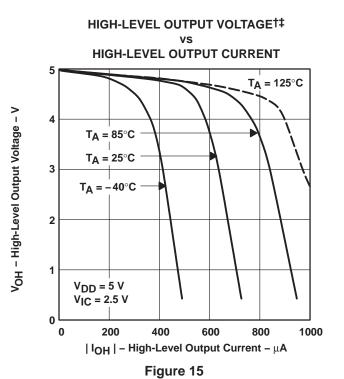
# LOW-LEVEL OUTPUT VOLTAGE†‡ vs LOW-LEVEL OUTPUT CURRENT



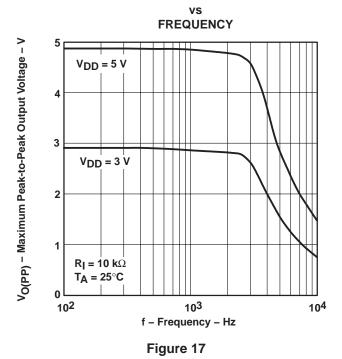
<sup>†</sup>Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

<sup>‡</sup> For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.

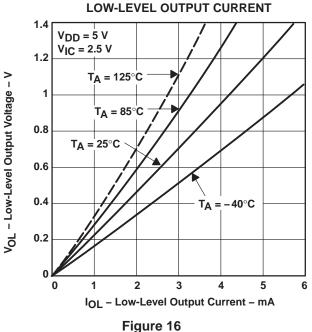




MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE‡



LOW-LEVEL OUTPUT VOLTAGE†‡
vs



# SHORT-CIRCUIT OUTPUT CURRENT vs

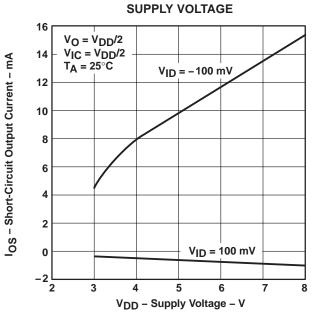


Figure 18

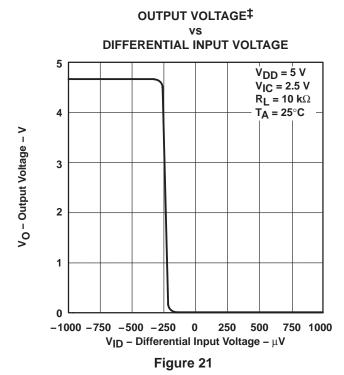
<sup>‡</sup> For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.

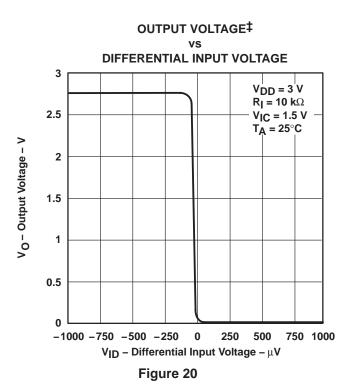


<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

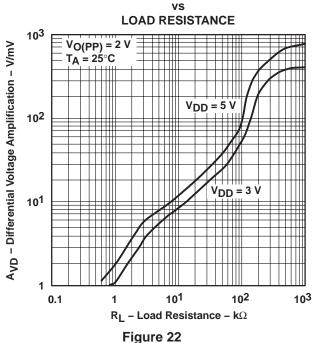
#### SHORT-CIRCUIT OUTPUT CURRENT<sup>†‡</sup> FREE-AIR TEMPERATURE 14 $V_{DD} = 5 V$ $V_{IC} = 2.5 V$ IOS - Short-Circuit Output Current - mA 12 $V_0 = 2.5 \text{ V}$ 10 $V_{ID} = -100 \text{ mV}$ 8 2 $V_{ID} = 100 \text{ mV}$ 0 \_ -75 -50 -25 25 50 75 100 125 T<sub>A</sub> - Free-Air Temperature - °C







### DIFFERENTIAL VOLTAGE AMPLIFICATION‡



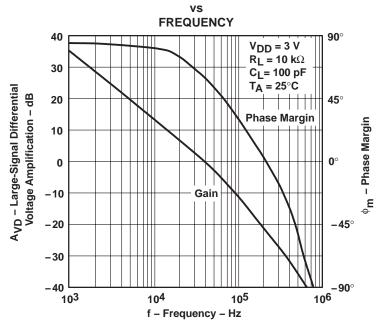
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

<sup>‡</sup> For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.



#### **TYPICAL CHARACTERISTICS**

# LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN<sup>†</sup>



#### Figure 23

# LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN†

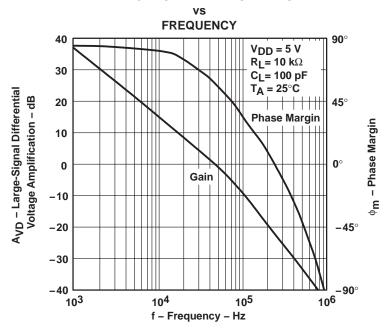


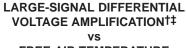
Figure 24

 $\dagger$  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.



### LARGE-SIGNAL DIFFERENTIAL **VOLTAGE AMPLIFICATION†**‡ vs FREE-AIR TEMPERATURE 10<sup>3</sup> $R_L = 1 M\Omega$ A<sub>VD</sub> - Large-Signal Differential Voltage 102 Amplification - V/mV $R_I = 10 \text{ k}\Omega$ $V_{DD} = 3 V$ V<sub>IC</sub> = 1.5 V V<sub>O</sub> = 0.5 V to 2.5 V 25 -50 -25 50 75 T<sub>A</sub> - Free-Air Temperature - °C

Figure 25



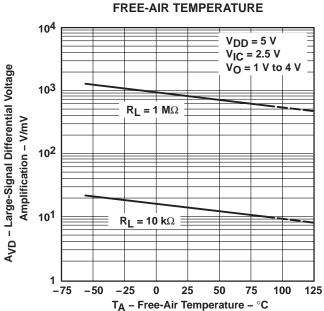
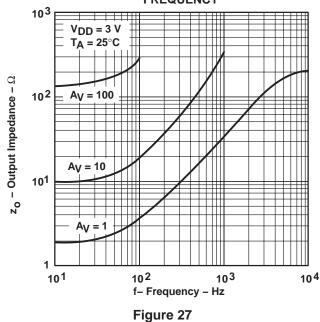


Figure 26





#### **OUTPUT IMPEDANCE**‡

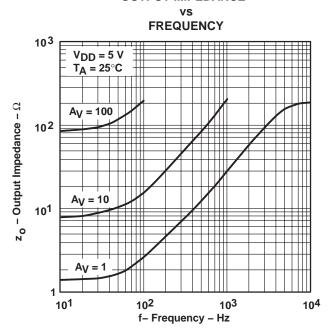


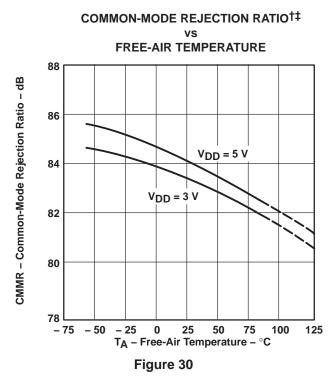
Figure 28

<sup>‡</sup> For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.

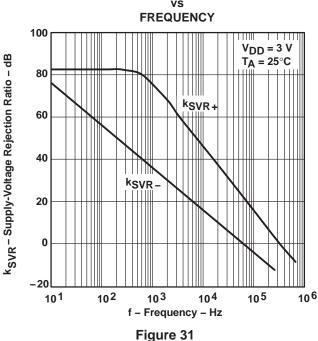


<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

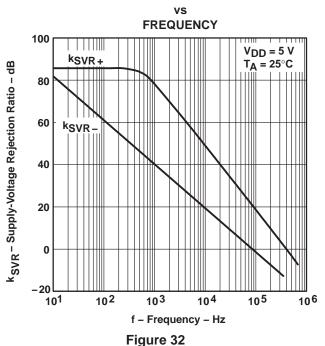
### COMMON-MODE REJECTION RATIO† **FREQUENCY** 100 $T_{\Delta} = 25^{\circ}C$ CMRR - Common-Mode Rejection Ratio - dB $V_{DD} = 5 V$ $V_0 = 2.5 V$ 80 $V_{DD} = 3 V$ 60 $V_0 = 1.5 \text{ V}$ 40 20 101 102 103 104 105 f - Frequency - Hz Figure 29



# SUPPLY-VOLTAGE REJECTION RATIO†



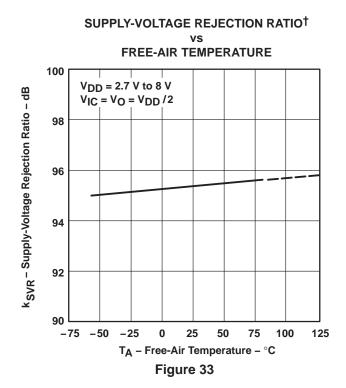
SUPPLY-VOLTAGE REJECTION RATIO†

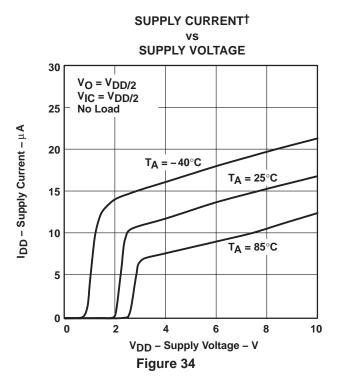


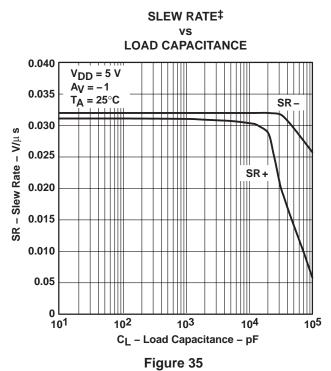
<sup>†</sup> For all curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3 \text{ V}$ , all loads are referenced to 1.5 V.

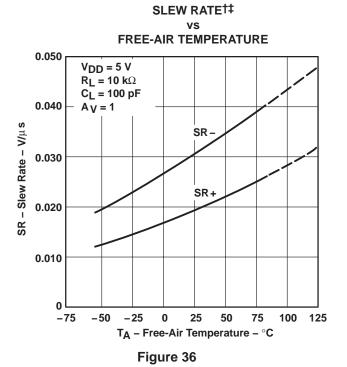
<sup>‡</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.











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

<sup>‡</sup> For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.



#### **TYPICAL CHARACTERISTICS**

# **INVERTING LARGE-SIGNAL PULSE RESPONSE**† 3 $V_{DD} = 3 V$ $R_L = 10 \text{ k}\Omega$ $C_L = 100 pF$ 2.5 $A_{V}^{-} = -1$ T<sub>A</sub> = 25°C Vo - Output Voltage - V 2 1.5 0.5 50 100 150 200 250 300 350 400 450 500 t – Time – $\mu$ s Figure 37

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE<sup>†</sup>

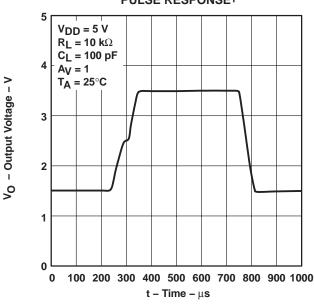
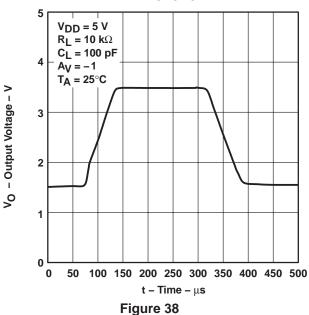
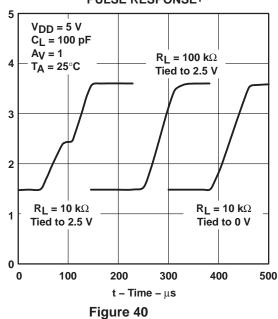


Figure 39

# INVERTING LARGE-SIGNAL PULSE RESPONSE<sup>†</sup>



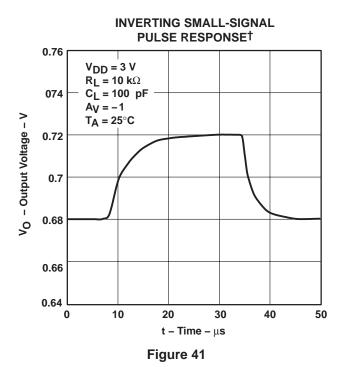
# VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE<sup>†</sup>

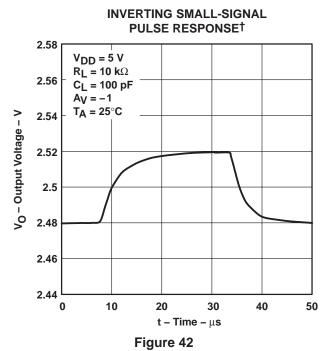


 $\dagger$  For all curves where  $V_{DD} = 5$  V, all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3$  V, all loads are referenced to 1.5 V.

Vo - Output Voltage - V







# VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†

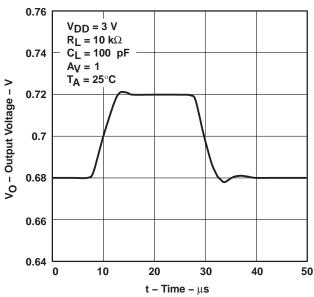


Figure 43

# VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE†

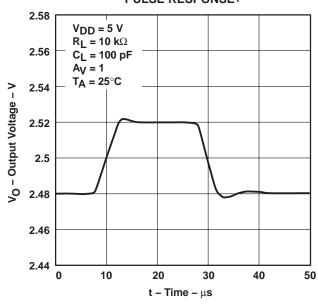


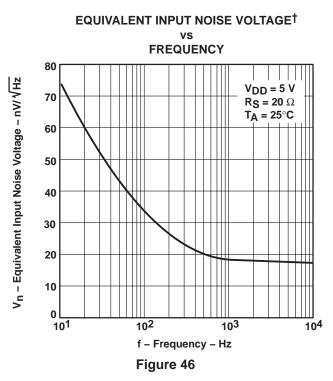
Figure 44

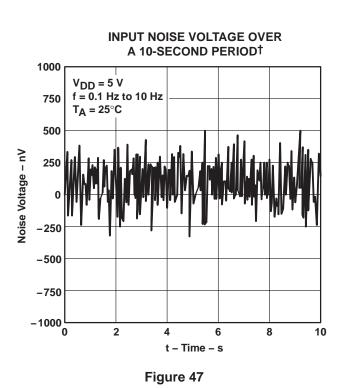
<sup>†</sup> For all curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3 \text{ V}$ , all loads are referenced to 1.5 V.

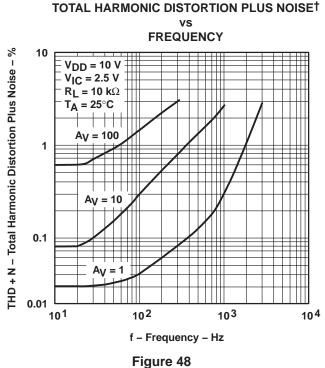


#### **TYPICAL CHARACTERISTICS**

### **EQUIVALENT INPUT NOISE VOLTAGE**<sup>†</sup> **FREQUENCY** 80 V<sub>n</sub> – Equivalent Input Noise Voltage – nV/ √Hz $V_{DD} = 3 V$ $R_S = 20 \Omega$ 70 $T_A = 25^{\circ}C$ 60 50 40 30 20 10 0 10<sup>3</sup> 101 102 104 f - Frequency - Hz Figure 45



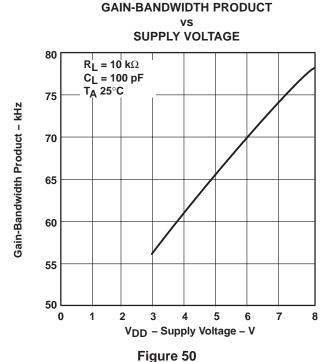




† For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.

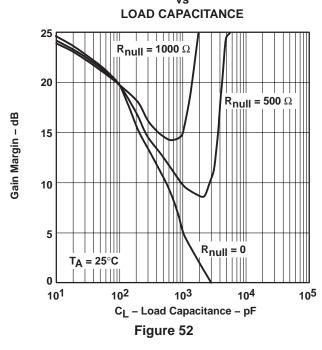


#### GAIN-BANDWIDTH PRODUCT†‡ FREE-AIR TEMPERATURE 80 $V_{DD} = 5 V$ f = 10 kHz $R_L = 10 \text{ k}\Omega$ 75 Gain-Bandwidth Product - kHz $C_L = 100 pF$ 70 65 60 55 50 -75 -50 -25 0 25 50 75 100 125 T<sub>A</sub> - Free-Air Temperature - °C Figure 49

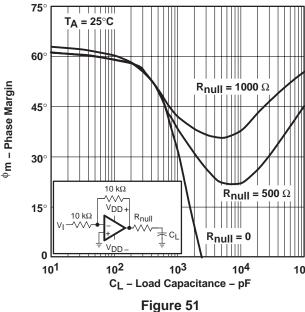








**GAIN MARGIN** 



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

<sup>‡</sup> For all curves where V<sub>DD</sub> = 5 V, all loads are referenced to 2.5 V. For all curves where V<sub>DD</sub> = 3 V, all loads are referenced to 1.5 V.



#### TYPICAL CHARACTERISTICS

# UNITY-GAIN BANDWIDTH vs

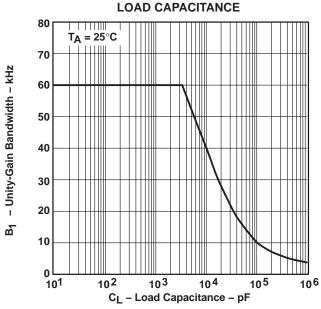


Figure 53

#### **APPLICATION INFORMATION**

#### driving large capacitive loads

The TLV2211 is designed to drive larger capacitive loads than most CMOS operational amplifiers. Figures 51 and 52 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 54) improves the gain and phase margins when driving large capacitive loads. Figures 51 and 52 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.

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

Where

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

UGBW = unity-gain bandwidth frequency

R<sub>null</sub> = output series resistance

C<sub>I</sub> = load capacitance



#### **APPLICATION INFORMATION**

#### driving large capacitive loads (continued)

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

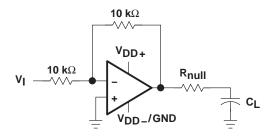


Figure 54. Series-Resistance Circuit

#### 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  $\mu$ A and source 250  $\mu$ A at V<sub>DD</sub> = 3 V and V<sub>DD</sub> = 5 V at a maximum quiescent I<sub>DD</sub> of 25  $\mu$ A. This provides a greater than 90% power efficiency.

When driving heavy dc loads, such as 10 k $\Omega$ , the positive edge can experience some distortion under slewing conditions. This condition can be seen in Figure 39. 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 40 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 40 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  $Parts^{TM}$ , the model generation software used with Microsim  $PSpice^{TM}$ . The Boyle macromodel (see Note 6) and subcircuit in Figure 54 are generated using the TLV2211 typical electrical and operating characteristics at  $T_A = 25^{\circ}C$ . 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).

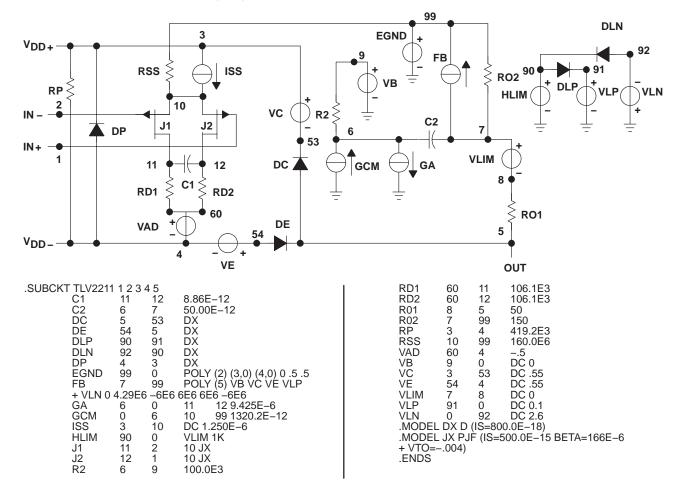


Figure 55. Boyle Macromodel and Subcircuit

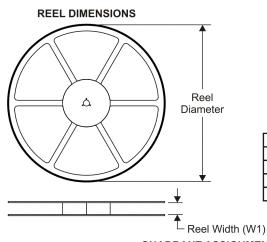
PSpice and Parts are trademark of MicroSim Corporation.

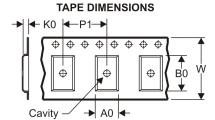




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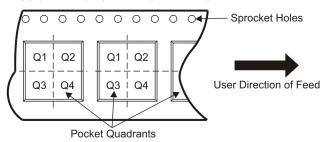
#### TAPE AND REEL INFORMATION





_		
	A0	Dimension designed to accommodate the component width
	B0	Dimension designed to accommodate the component length
		Dimension designed to accommodate the component thickness
	W	Overall width of the carrier tape
Γ	P1	Pitch between successive cavity centers

#### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

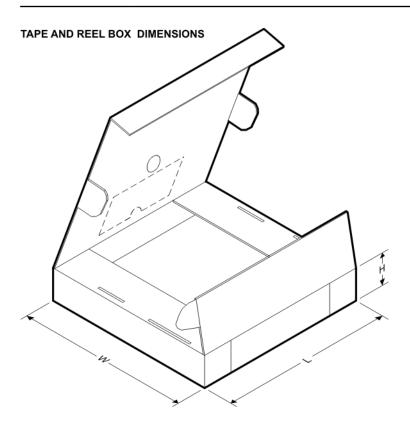


#### \*All dimensions are nominal

Device	Package Type	Package Drawing		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLV2211CDBVR	SOT-23	DBV	5	3000	180.0	9.0	3.15	3.2	1.4	4.0	8.0	Q3
TLV2211CDBVT	SOT-23	DBV	5	250	180.0	9.0	3.15	3.2	1.4	4.0	8.0	Q3
TLV2211IDBVR	SOT-23	DBV	5	3000	180.0	9.0	3.15	3.2	1.4	4.0	8.0	Q3
TLV2211IDBVT	SOT-23	DBV	5	250	180.0	9.0	3.15	3.2	1.4	4.0	8.0	Q3

### PACKAGE MATERIALS INFORMATION

11-Mar-2008

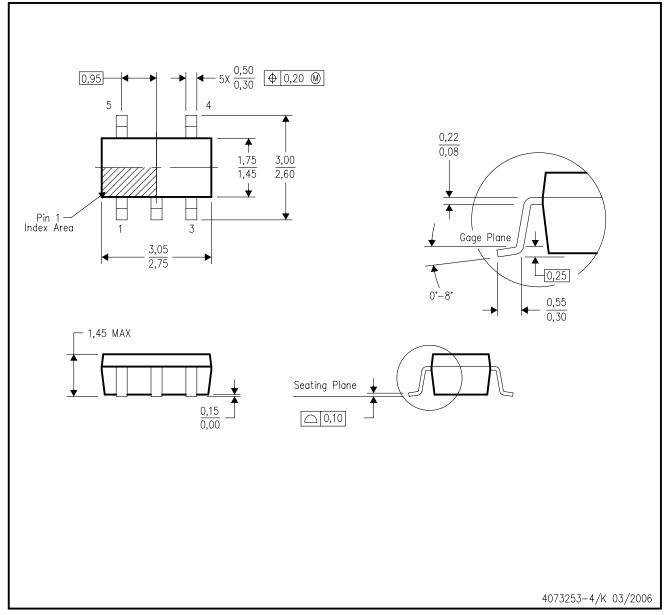


#### \*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2211CDBVR	SOT-23	DBV	5	3000	182.0	182.0	20.0
TLV2211CDBVT	SOT-23	DBV	5	250	182.0	182.0	20.0
TLV2211IDBVR	SOT-23	DBV	5	3000	182.0	182.0	20.0
TLV2211IDBVT	SOT-23	DBV	5	250	182.0	182.0	20.0

# 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 do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- D. Falls within JEDEC MO-178 Variation AA.

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