

- **B Grade Is 100% Tested for Noise**
 30 nV/ $\sqrt{\text{Hz}}$ Max at $f = 10 \text{ Hz}$
 12 nV/ $\sqrt{\text{Hz}}$ Max at $f = 1 \text{ kHz}$
- **Low Input Offset Voltage . . . 500 μV Max**
- **Excellent Offset Voltage Stability With Temperature . . . 0.5 $\mu\text{V}/^\circ\text{C}$ Typ**
- **Rail-to-Rail Output Swing**
- **Low Input Bias Current**
 1 pA Typ at $T_A = 25^\circ\text{C}$
- **Common-Mode Input Voltage Range Includes the Negative Rail**
- **Fully Specified For Both Single-Supply and Split-Supply Operation**

description

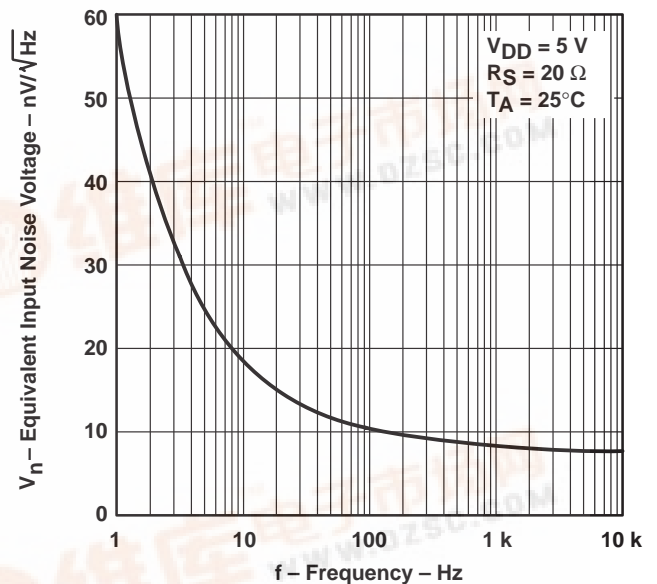
The TLC220x, TLC220xA, TLC220xB, and TLC220xY are precision, low-noise operational amplifiers using Texas Instruments Advanced LinCMOS™ process. These devices combine the noise performance of the lowest-noise JFET amplifiers with the dc precision available previously only in bipolar amplifiers. The Advanced LinCMOS™ process uses silicon-gate technology to obtain input offset voltage stability with temperature and time that far exceeds that obtainable using metal-gate technology. In addition, this technology makes possible input impedance levels that meet or exceed levels offered by top-gate JFET and expensive dielectric-isolated devices.

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

The device inputs and outputs are designed to withstand -100-mA surge currents without sustaining latch-up. In addition, internal ESD-protection circuits prevent functional failures at voltages up to 2000 V as tested under MIL-PRF-38535, Method 3015.2; however, care should be exercised in handling these devices as exposure to ESD may result in degradation of the parametric performance.

The C-suffix devices are characterized for operation from 0°C to 70°C . The I-suffix devices are characterized for operation from -40°C to 85°C . The M-suffix devices are characterized for operation over the full military temperature range of -55°C to 125°C .

**TYPICAL EQUIVALENT
 INPUT NOISE VOLTAGE
 vs
 FREQUENCY**



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.

Advanced LinCMOS is a trademark of Texas Instruments Incorporated.

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.



Copyright © 1997, Texas Instruments Incorporated

On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201 AVAILABLE OPTIONS

T _A	V _{IO} max AT 25°C	V _n max f = 10 Hz AT 25°C	V _n max f = 1 kHz AT 25°C	PACKAGED DEVICES				CHIP FORM‡ (Y)
				SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	
0°C to 70°C	200 μV 200 μV 500 μV	35 nV/√Hz 30 nV/√Hz —	15 nV/√Hz 12 nV/√Hz —	TLC2201ACD TLC2201BCD TLC2201CD	—	—	TLC2201ACP TLC2201BCP TLC2201CP	TLC2201Y
–40°C to 85°C	200 μV 200 μV 500 μV	35 nV/√Hz 30 nV/√Hz —	15 nV/√Hz 12 nV/√Hz —	TLC2201AID TLC2201BID TLC2201ID	—	—	TLC2201AIP TLC2201BIP TLC2201IP	—
–55°C to 125°C	200 μV 200 μV 500 μV	35 nV/√Hz 30 nV/√Hz —	15 nV/√Hz 12 nV/√Hz —	TLC2201AMD TLC2201BMD TLC2201MD	TLC2201AMFK TLC2201BMFK TLC2201MFK	TLC2201AMJG TLC2201BMJG TLC2201MJG	TLC2201AMP TLC2201BMP TLC2201MP	—

† The D packages are available taped and reeled. Add R suffix to device type (e.g. TLC220xBCDR).

‡ Chip forms are tested at 25°C only.

TLC2202 AVAILABLE OPTIONS

T _A	V _{IO} max AT 25°C	V _n max f = 10 Hz AT 25°C	V _n max f = 1 kHz AT 25°C	PACKAGED DEVICES				CHIP FORM‡ (Y)
				SMALL OUTLINE† (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	
0°C to 70°C	500 μV 500 μV 1 mV	30 nV/√Hz 35 nV/√Hz —	12 nV/√Hz 15 nV/√Hz —	TLC2202BCD TLC2202ACD TLC2202CD	— — —	— — —	TLC2202BCP TLC2202ACP TLC2202CP	TLC2202Y
–40°C to 85°C	500 μV 500 μV 1 mV	30 nV/√Hz 35 nV/√Hz —	12 nV/√Hz 15 nV/√Hz —	TLC2202BID TLC2202AID TLC2202ID	— — —	— — —	TLC2202BIP TLC2202AIP TLC2202IP	—
–55°C to 125°C	500 μV 500 μV 1 mV	30 nV/√Hz 35 nV/√Hz —	12 nV/√Hz 15 nV/√Hz —	TLC2202BMD TLC2202AMD TLC2202MD	TLC2202BMFK TLC2202AMFK TLC2202MFK	TLC2202BMJG TLC2202AMJG TLC2202MJG	TLC2202BMP TLC2202AMP TLC2202MP	—

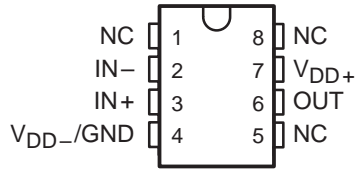
† The D packages are available taped and reeled. Add R suffix to device type (e.g. TLC220xBCDR).

‡ Chip forms are tested at 25°C only.

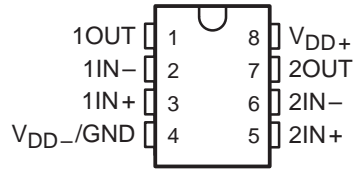
TLC220x, TLC220xA, TLC220xB, TLC220xY Advanced LinCMOS™ LOW-NOISE PRECISION OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

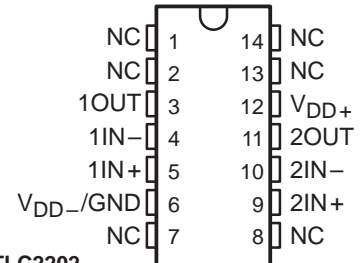
TLC2201
D, JG, OR P PACKAGE
(TOP VIEW)



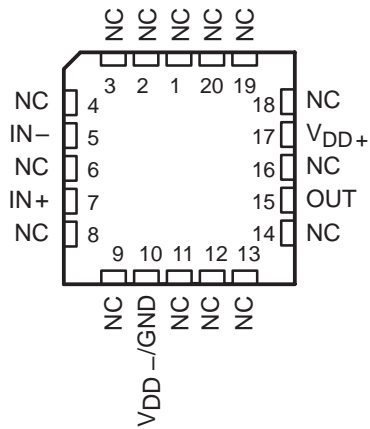
TLC2202
JG OR P PACKAGE
(TOP VIEW)



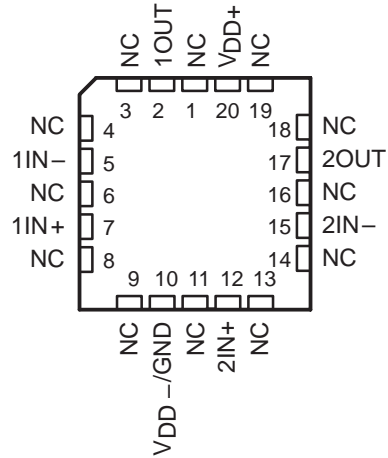
TLC2202
D PACKAGE
(TOP VIEW)



TLC2201
FK PACKAGE
(TOP VIEW)



TLC2202
FK PACKAGE
(TOP VIEW)

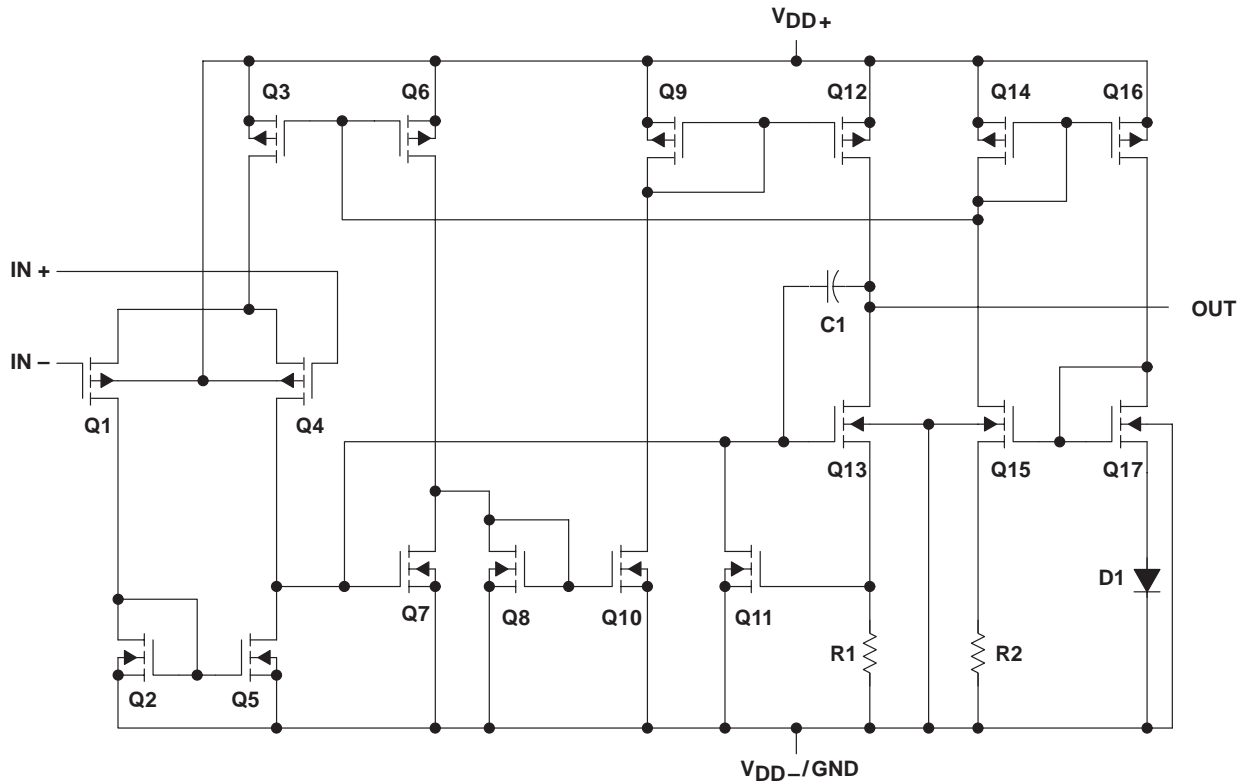


NC – No internal connection

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

equivalent schematic (each amplifier)



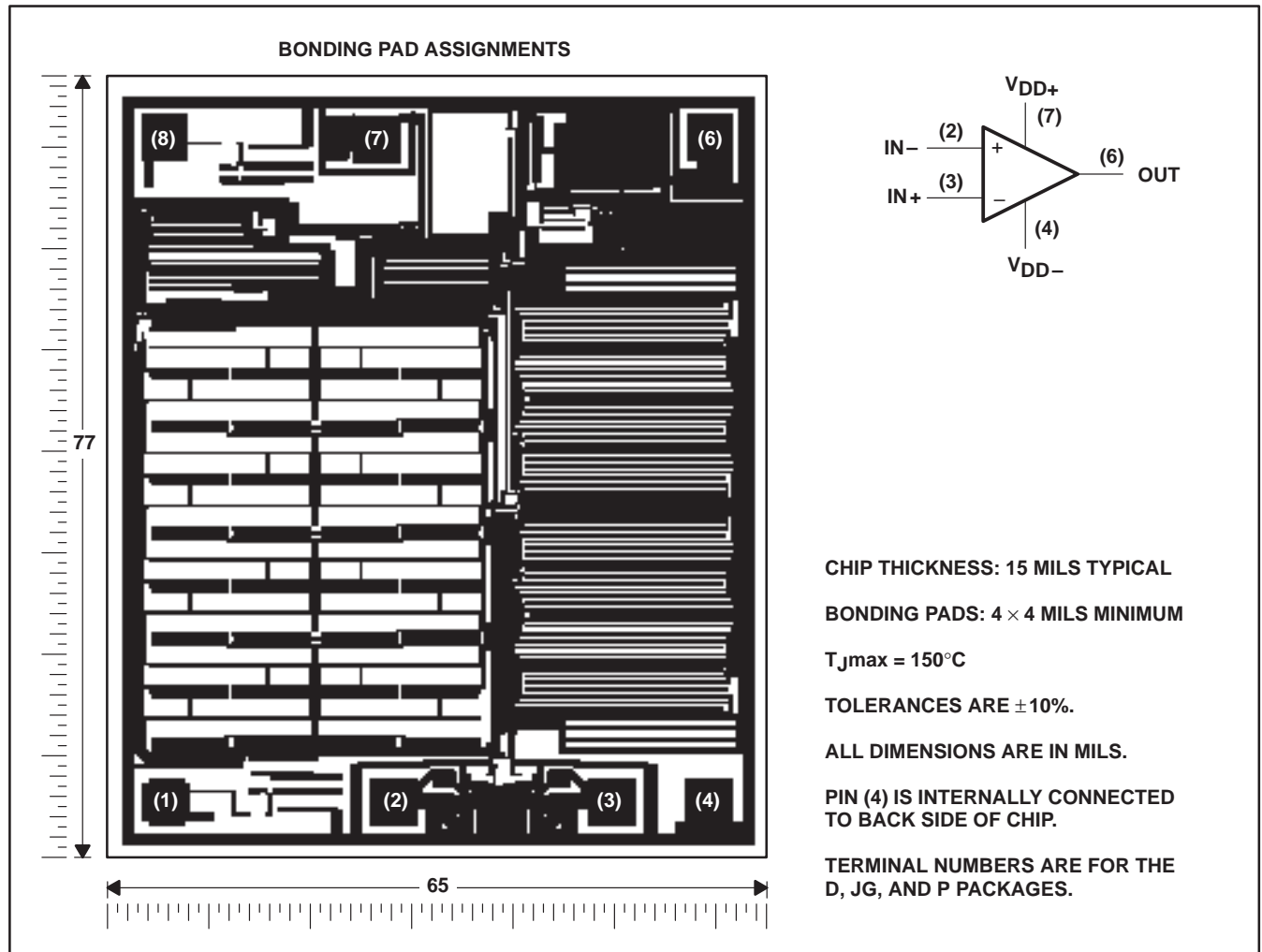
ACTUAL DEVICE COMPONENT COUNT		
COMPONENT	TLC2201	TLC2202
Transistors	17	34
Resistors	2	2
Diodes	1	4
Capacitors	1	2

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201Y chip information

This chip, when properly assembled, displays characteristics similar to the TLC2201C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding path. Chips may be mounted with conductive epoxy or a gold-silicon preform.

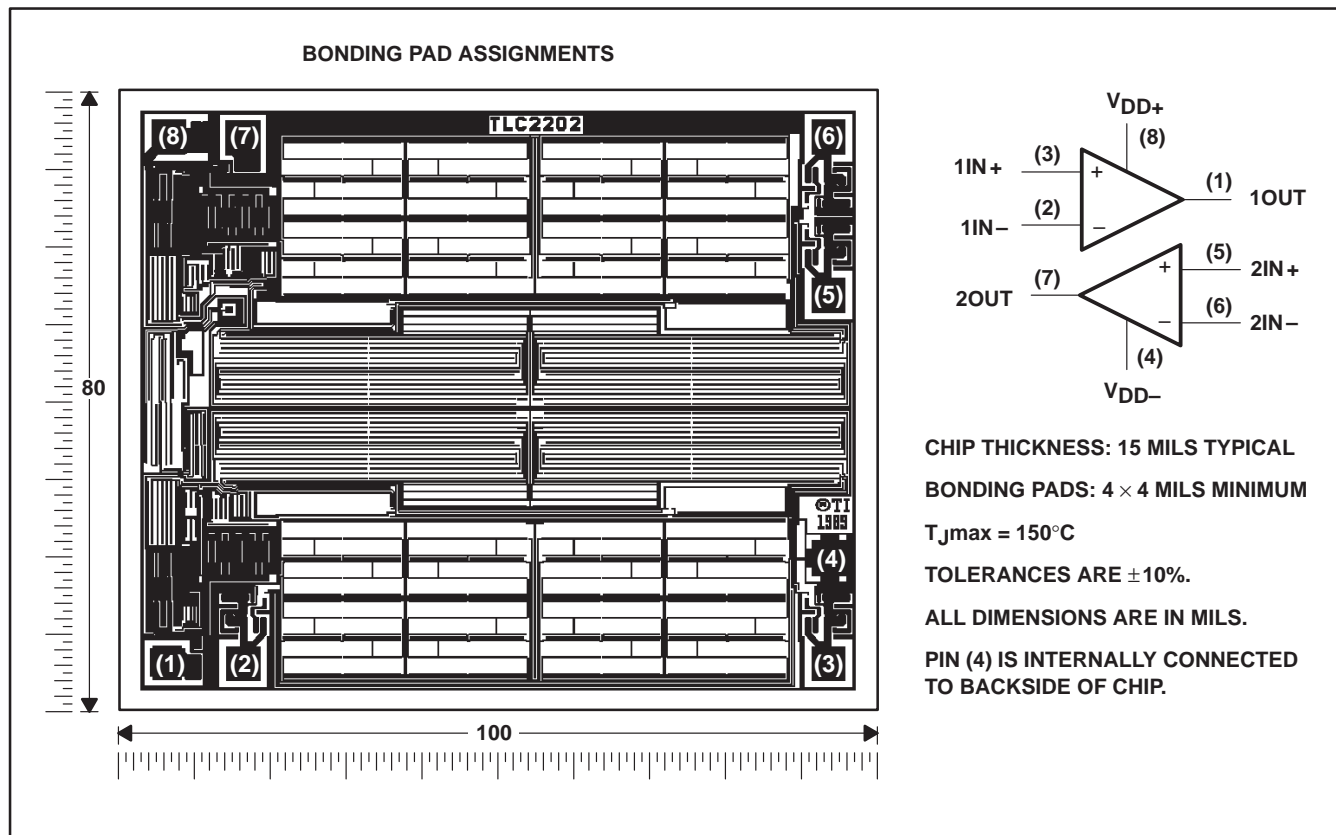


TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202Y chip formation

This chip, when properly assembled, displays characteristics similar to the TLC2202C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.



TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

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

Supply voltage, V_{DD+} (see Note 1)	8 V
Supply voltage, V_{DD-}	–8 V
Differential input voltage, V_{ID} (see Note 2)	± 16 V
Input voltage, V_I (any input)	± 8 V
Input current, I_I (each input)	± 5 mA
Output current, I_O (each output)	± 50 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : C suffix	0°C to 70°C
I suffix	–40°C to 85°C
M suffix	–55°C to 125°C
Storage temperature range	–65°C to 150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or P package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values except differential voltages are with respect to the midpoint between V_{DD+} and V_{DD-} .
2. Differential voltages are at $IN+$ with respect to $IN-$.
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	$T_A \leq 25^\circ\text{C}$	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$	$T_A = 85^\circ\text{C}$	$T_A = 125^\circ\text{C}$
	POWER RATING		POWER RATING	POWER RATING	POWER RATING
D–8	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
D–14	950 mW	7.6 mW/°C	608 mW	494 mW	190 mW
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW	200 mW

recommended operating conditions

	C SUFFIX		I SUFFIX		M SUFFIX		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, $V_{DD\pm}$	± 2.3	± 8	± 2.3	± 8	± 2.3	± 8	V
Common-mode input voltage, V_{IC}	V_{DD-}	$V_{DD+} - 2.3$	V_{DD-}	$V_{DD+} - 2.3$	V_{DD-}	$V_{DD+} - 2.3$	V
Operating free-air temperature, T_A	0	70	–40	85	–55	125	°C

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201C electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201C			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	500	μV	
		Full range	600			
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5		pA	
		Full range	100			
I_{IB} Input bias current		25°C	1		pA	
		Full range	100			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7		V	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
		Full range	4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	-4.7	-4.9	V	
		Full range	-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	400	560	V/mV	
		Full range	300			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	90	100		
		Full range	70			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	Full range	85		dB	
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	90	110	dB	
		Full range	85			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.1	1.5	mA	
		Full range	1.5			

† Full range is 0°C to 70°C.

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

TLC2201C operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201C			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	2	2.7	$\text{V}/\mu\text{s}$	
		Full range	1.5			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C	18		$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C	8			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C	0.5		μV	
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C	0.7			
I_n Equivalent input noise current		25°C	0.6		$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9		MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	48°			

† Full range is 0°C to 70°C.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201C electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AC			TLC2201BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	80	200		80	200	μV	
		Full range			300		300		
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5			0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5			0.5		pA	
		Full range			100		100		
I_{IB} Input bias current		25°C	1			1		pA	
		Full range			100		100		
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7			-5 to 2.7	V		
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	-4.7	-4.9		-4.7	-4.9	V	
		Full range	-4.7			-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	400	560		400	560	V/mV	
		Full range	300			300			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	90	100		90	100		
		Full range	70			70			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	90	115		90	115	dB	
		Full range	85			85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	90	110		90	110	dB	
		Full range	85			85			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C		1.1	1.5		1.1	1.5	mA
		Full range			1.5		1.5		

† Full range is 0°C to 70°C.

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201C operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AC			TLC2210BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C	2	2.7		2	2.7		V/ μs
		Full range	1.5			1.5			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μV
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		1.9			1.9		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		48°			48°		

† Full range is 0°C to 70°C.

NOTE 5: This parameter is tested on a sample basis for the TLC2201A and on all devices for the TLC2201B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201C electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201C			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, \quad R_S = 50\ \Omega$	25°C		100	500	μV
		Full range			600	
α_{VIO} Temperature coefficient of input offset voltage		Full range		0.5		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005	$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C		0.5		pA
		Full range			100	
I_{IB} Input bias current	25°C		1		pA	
	Full range			100		
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7		V	
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
		Full range	4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0 50	mV	
		Full range		50		
A_{VD} Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V},$ $R_L = 500\ \text{k}\Omega$	25°C	150	315	V/mV	
		Full range	100			
	$V_O = 1\ \text{V to } 4\ \text{V},$ $R_L = 10\ \text{k}\Omega$	25°C	25	55		
		Full range	15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, \quad V_O = 0,$ $R_S = 50\ \Omega$	25°C	90	110	dB	
		Full range	85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.6\ \text{V to } 16\ \text{V}$	25°C	90	110	dB	
		Full range	85			
I_{DD} Supply current	$V_O = 2.5\ \text{V}, \quad \text{No load}$	25°C		1 1.5	mA	
		Full range		1.5		

† Full range is 0°C to 70°C.

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

TLC2201C operating characteristics at specified free-air temperature, $V_{DD} = 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201C			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\ \text{V to } 2.5\ \text{V},$ $R_L = 10\ \text{k}\Omega, \quad C_L = 100\ \text{pF}$	25°C	1.8	2.5	$\text{V}/\mu\text{s}$	
		Full range	1.3			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C		18	$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C		0.5	μV	
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6	$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, \quad R_L = 10\ \text{k}\Omega,$ $C_L = 100\ \text{pF}$	25°C		1.8	MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, \quad C_L = 100\ \text{pF}$	25°C		45°		

† Full range is 0°C to 70°C.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201C electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AC			TLC2201BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	80	200		80	200	μV	
		Full range			300		300		
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5			0.5			pA
		Full range			100		100		
I_{IB} Input bias current		25°C	1			1			pA
		Full range			100		100		
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7			0 to 2.7			V
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C	0 50			0 50			mV
		Full range	50			50			
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		150	315	V/mV	
		Full range	100			100			
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		25	55		
		Full range	15			15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	90	110		90	110	dB	
		Full range	85			85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD} \pm / \Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	90	110		90	110	dB	
		Full range	85			85			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C	1 1.5			1 1.5			mA
		Full range	1.5			1.5			

† Full range is 0°C to 70°C.

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201C operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AC			TLC2210BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V},$ $R_L = 10\text{ k}\Omega, C_L = 100\text{ pF}$	25°C	1.8	2.5		1.8	2.5		V/ μs
		Full range	1.3			1.3			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μV
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\text{ kHz}, R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		1.8			1.8		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega, C_L = 100\text{ pF}$	25°C		45°			45°		

† Full range is 0°C to 70°C.

NOTE 5: This parameter is tested on a sample basis for the TLC2201A and on all devices for the TLC2201B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202C electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise specified)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202C			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		100	1000	μV
		Full range			1150	
αV_{IO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		0.5		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005	$\mu\text{V}/\text{mo}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		0.5		pA
		Full range			100	
I_{IB} Input bias current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		1		pA
		Full range			100	
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range		-5 to 2.7		V
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C		4.7	4.8	V
		Full range			4.7	
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C		-4.7	-4.9	V
		Full range			-4.7	
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C		300	560	V/mV
		Full range			200	
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C		50	100	
		Full range			25	
CMRR Common-mode rejection ratio	$V_O = 0, V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C		80	115	dB
		Full range			80	
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C		80	110	dB
		Full range			80	
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C		1.8	2.7	mA
		Full range			2.7	

† Full range is 0°C to 70°C.

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

TLC2202C operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202C			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.8	2.7	$\text{V}/\mu\text{s}$
		Full range			1.3	
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C		18		$\text{nV}/\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C		0.5		μV
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6		$\text{fA}/\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.9		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		48°		

† Full range is 0°C to 70°C.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202C electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AC			TLC2202BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	80	500		80	500	μV	
		Full range		650		650			
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5			0.5			pA
		Full range	100			100			
I_{IB} Input bias current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	1			1			pA
		Full range	100			100			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7			-5 to 2.7		V	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-4.7	-4.9		-4.7	-4.9	V	
		Full range	-4.7			-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	300	560		300	560	V/mV	
		Full range	200			200			
	$V_O = \pm 4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	50	100		50	100		
		Full range	25			25			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	80	115		80	115	dB	
		Full range	80			80			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\text{ V to } \pm 8\text{ V}$	25°C	80	110		80	110	dB	
		Full range	80			80			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C		1.8	2.7		1.8	2.7	mA
		Full range	2.7			2.7			

† Full range is 0°C to 70°C.

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

TLC2202C operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AC			TLC2202BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\text{ V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8	2.7		1.8	2.7	V/ μs	
		Full range	1.3			1.3			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\ \text{Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C	0.5			0.5			μV
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C	0.7			0.7			
I_n Equivalent input noise current		25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9			1.9			MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	48°			48°			

† Full range is 0°C to 70°C.

NOTE 5: This parameter is tested on a sample basis for the TLC2202A and on all devices for the TLC2202B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202C electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202C			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	1000		μV
		Full range		1150		
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	Full range		100		pA
I_{IB} Input bias current		25°C	1			
		Full range		100		
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7			V
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		V
		Full range	4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0	50	mV
		Full range			50	
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		V/mV
		Full range	100			
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		
		Full range	15			
CMRR Common-mode rejection ratio	$V_O = 0, V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	75	110		dB
		Full range	75			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	80	110		dB
		Full range	80			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.7	2.6		mA
		Full range		2.6		

† Full range is 0°C to 70°C.

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

TLC2202C operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202C			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.6	2.5		V/ μs
		Full range	1.1			
V_n Equivalent input noise voltage	f = 10 Hz	25°C		18		$\text{nV}/\sqrt{\text{Hz}}$
	f = 1 kHz	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz	25°C		0.5		μV
	f = 0.1 to 10 Hz	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6		$\text{fA}/\sqrt{\text{Hz}}$
Gain-bandwidth product	f = 10 kHz, $R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.9		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		47°		

† Full range is 0°C to 70°C.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202C electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AC			TLC2202BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	80	500		80	500	μV	
		Full range			650		650		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5			0.5			pA
		Full range	100			100			
I_{IB} Input bias current		25°C	1			1			pA
		Full range	100			100			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7			0 to 2.7		V	
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C	0 50			0 50			mV
		Full range	50			50			
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		150	315	V/mV	
		Full range	100			100			
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		25	55		
		Full range	15			15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	75	110		75	110	dB	
		Full range	75			75			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	80	110		80	110	dB	
		Full range	80			80			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C	1.7 2.6			1.7 2.6			mA
		Full range	2.6			2.6			

† Full range is 0°C to 70°C.

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

TLC2202C operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AC			TLC2202BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.6	2.5		1.6	2.5	V/ μs	
		Full range	1.1			1.1			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\ \text{Hz}$	25°C	18 35			18 30			nV/ $\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C	8 15			8 12			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\ \text{Hz}$	25°C	0.5			0.5			μV
	$f = 0.1\text{ to }10\ \text{Hz}$	25°C	0.7			0.7			
I_n Equivalent input noise current		25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9			1.9			MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	47°			47°			

† Full range is 0°C to 70°C.

NOTE 5: This parameter is tested on a sample basis for the TLC2202A and on all devices for the TLC2202B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201I electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201I			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	500	μV	
		Full range	650			
αV_{IO} Temperature coefficient of input offset voltage		Full range	0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5		pA	
		Full range	150			
I_{IB} Input bias current		25°C	1		pA	
		Full range	150			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7		V	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
		Full range	4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	-4.7	-4.9	V	
		Full range	-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	400	560	V/mV	
		Full range	250			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	90	100		
		Full range	65			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	90	115	dB	
		Full range	85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	90	110	dB	
		Full range	85			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.1	1.5	mA	
		Full range	1.5			

† Full range is -40°C to 85°C .

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

TLC2201I operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201I			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	2	2.7	$\text{V}/\mu\text{s}$	
		Full range	1.4			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C	18		$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C	8			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C	0.5		μV	
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C	0.7			
I_n Equivalent input noise current		25°C	0.6		$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9		MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	48°			

† Full range is -40°C to 85°C .

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201I electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AI			TLC2210BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	80	200		80	200	μV	
		Full range			350		350		
α_{VIO} Temperature coefficient of input offset voltage		Full range		0.5			0.5	$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
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	$R_S = 50\ \Omega$	Full range	-5 to 2.7			-5 to 2.7	V		
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	-4.7	-4.9		-4.7	-4.9	V	
		Full range	-4.7			-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	400	560		400	560	V/mV	
		Full range	250			250			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	90	100		90	100		
		Full range	65			65			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	90	115		90	115	dB	
		Full range	85			85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	90	110		90	110	dB	
		Full range	85			85			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C		1.1	1.5		1.1	1.5	mA
		Full range			1.5		1.5		

† Full range is -40°C to 85°C .

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201I operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AI			TLC2210BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C	2	2.7		2	2.7		V/ μs
		Full range	1.4			1.4			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μV
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6	fA/ $\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		1.9			1.9	MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		48°			48°		

† Full range is -40°C to 85°C .

NOTE 5: This parameter is tested on a sample basis for the TLC2201A and on all devices for the TLC2201B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC22011 electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC22011			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		100	500	μV
		Full range			650	
α_{VIO} Temperature coefficient of input offset voltage		Full range		0.5		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005	$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C		0.5		pA
		Full range			150	
I_{IB} Input bias current	25°C		1		pA	
	Full range			150		
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7		V	
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
		Full range	4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0 50	mV	
		Full range		50		
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315	V/mV	
		Full range	100			
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		
		Full range	15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	90	110	dB	
		Full range	85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	90	110	dB	
		Full range	85			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C		1 1.5	mA	
		Full range		1.5		

† Full range is -40°C to 85°C .

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

TLC22011 operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC22011			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8	2.5	$\text{V}/\mu\text{s}$	
		Full range	1.2			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C		18	$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\ \text{Hz}$	25°C		0.5	μV	
	$f = 0.1\text{ to }10\ \text{Hz}$	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6	$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.8	MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		45°		

† Full range is -40°C to 85°C .

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201I electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AI			TLC2201BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	80	200		80	200	μA	
		Full range			350		350		
α_{VIO} Temperature coefficient of input offset voltage		Full range		0.5			0.5	$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
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	$R_S = 50\ \Omega$	Full range	0 to 2.7			0 to 2.7	V		
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0	50		0	50	mV
		Full range			50			50	
A_{VD} Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		150	315	V/mV	
		Full range	100			100			
	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		25	55		
		Full range	15			15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	90	110		90	110	dB	
		Full range	85			85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD} \pm / \Delta V_{IO}$)	$V_{DD} = 4.6\ \text{V to } 16\ \text{V}$	25°C	90	110		90	110	dB	
		Full range	85			85			
I_{DD} Supply current	$V_O = 2.5\ \text{V}, \text{ No load}$	25°C		1	1.5		1	1.5	mA
		Full range			1.5			1.5	

† Full range is -40°C to 85°C .

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201I operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AI			TLC2210BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C	1.8	2.5		1.8	2.5		V/ μs
		Full range	1.2			1.2			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μV
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		1.8			1.8		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		45°			45°		

† Full range is -40°C to 85°C .

NOTE 5: This parameter is tested on a sample basis for the TLC2201A and on all devices for the TLC2201B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202I electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202I			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	1000	μV	
		Full range	1200			
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5		μV/°C	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005	μV/mo	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	150		pA	
I_{IB} Input bias current		25°C	1			
		Full range	150			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	–5 to 2.7		V	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
V_{OM-} Maximum negative peak output voltage swing		Full range	4.7			
		25°C	–4.7	–4.9	V	
		Full range	–4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	300	560	V/mV	
		Full range	150			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	50	100		
		Full range	25			
CMRR Common-mode rejection ratio	$V_O = 0, R_S = 50\ \Omega, V_{IC} = V_{ICRmin}$	25°C	80	115	dB	
		Full range	80			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	80	110	dB	
		Full range	80			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.8	2.7	mA	
		Full range	2.7			

† Full range is –40°C to 85°C.

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

TLC2202I operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202I			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8	2.7	V/μs	
		Full range	1.2			
V_n Equivalent input noise voltage	f = 10 Hz	25°C	18		nV/√Hz	
	f = 1 kHz	25°C	8			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz	25°C	0.5		μV	
	f = 0.1 to 10 Hz	25°C	0.7			
I_n Equivalent input noise current		25°C	0.6		fA/√Hz	
Gain-bandwidth product	f = 10 kHz, $R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9		MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	48°			

† Full range is –40°C to 85°C.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202I electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AI			TLC2202BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	80	500		80	500	μV	
		Full range	700			700			
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5			0.5			pA
		Full range	150			150			
I_{IB} Input bias current		25°C	1			1			pA
		Full range	150			150			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	–5 to 2.7			–5 to 2.7			V
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
Full range		4.7			4.7				
V_{OM-} Maximum negative peak output voltage swing		25°C	–4.7	–4.9		–4.7	–4.9	V	
		Full range	–4.7			–4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	300	560		300	560	V/mV	
		Full range	150			150			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	50	100		50	100		
		Full range	25			25			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	80	115		80	115	dB	
		Full range	80			80			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} \pm 2.3\ \text{V}$ to $\pm 8\ \text{V}$	25°C	80	110		80	110	dB	
		Full range	80			80			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.8	2.7		1.8	2.7	mA	
		Full range	2.7			2.7			

† Full range is -40°C to 85°C .

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

TLC2202I operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AI			TLC2202BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8	2.7		1.8	2.7	V/ μs	
		Full range	1.2			1.2			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\ \text{Hz}$	25°C	18 35			18 30			nV/ $\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C	8 15			8 12			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1$ to $1\ \text{Hz}$	25°C	0.5			0.5			μV
	$f = 0.1$ to $10\ \text{Hz}$	25°C	0.7			0.7			
I_n Equivalent input noise current		25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9			1.9			MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	48°			48°			

† Full range is -40°C to 85°C .

NOTE 5: This parameter is tested on a sample basis for the TLC2202A and on all devices for the TLC2202B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202I electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202I			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	1000		μV
		Full range		1200		
α_{VIO} Temperature coefficient of input offset voltage		Full range		0.5		$\mu\text{V}/^\circ\text{C}$
	Input offset voltage long-term drift (see Note 4)	25°C	0.001	0.005		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	Full range		150		pA
I_{IB} Input bias current		25°C		1		
		Full range			150	
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7			V
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		V
		Full range		4.7		
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0	50	mV
		Full range			50	
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		V/mV
		Full range		100		
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		
	Full range		15			
CMRR Common-mode rejection ratio	$V_O = 0, V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	75	110		dB
		Full range		75		
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	80	110		dB
		Full range		80		
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C		1.7	2.6	mA
		Full range			2.6	

† Full range is -40°C to 85°C .

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

TLC2202I operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202I			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.6	2.5		$\text{V}/\mu\text{s}$
		Full range		1		
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C		18		$\text{nV}/\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\ \text{Hz}$	25°C		0.5		μV
	$f = 0.1\text{ to }10\ \text{Hz}$	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6		$\text{fA}/\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.9		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		47°		

† Full range is -40°C to 85°C .

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202I electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AI			TLC2202BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	80	500		80	500	μV	
		Full range		700		700			
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5			0.5			pA
		Full range	150			150			
I_{IB} Input bias current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	1			1			pA
		Full range	150			150			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7			0 to 2.7		V	
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C	0 50			0 50			mV
		Full range	50			50			
A_{VD} Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		150	315	V/mV	
		Full range	100			100			
	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		25	55		
		Full range	15			15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	75	110		75	110	dB	
		Full range	75			75			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.6\ \text{V to } 16\ \text{V}$	25°C	80	110		80	110	dB	
		Full range	80			80			
I_{DD} Supply current	$V_O = 2.5\ \text{V}, \text{ No load}$	25°C	1.7 2.6			1.7 2.6			mA
		Full range	2.6			2.6			

† Full range is -40°C to 85°C

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

TLC2202I operating characteristics at specified free-air temperature, $V_{DD} = 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AI			TLC2202BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\ \text{V to } 2.5\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.6	2.5		1.6	2.5	$\text{V}/\mu\text{s}$	
		Full range	1			1			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\ \text{Hz}$	25°C	18 35			18 30			nV/ $\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C	8 15			8 12			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C	0.5			0.5			μV
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C	0.7			0.7			
I_n Equivalent input noise current		25°C	0.6			0.6			fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9			1.9			MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	47°			47°			

† Full range is -40°C to 85°C

NOTE 5: This parameter is tested on a sample basis for the TLC2202A and on all devices for the TLC2202B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201M electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201M			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	500	μV	
		Full range	700			
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5		pA	
		Full range	500			
I_{IB} Input bias current	25°C	1		pA		
	Full range	500				
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7		V	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
		Full range	4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	-4.7	-4.9	V	
		Full range	-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	400	560	V/mV	
		Full range	200			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	90	100		
		Full range	45			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	90	115	dB	
		Full range	85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	90	110	dB	
		Full range	85			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.1	1.5	mA	
		Full range	1.5			

† Full range is -55°C to 125°C .

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

TLC2201M operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201M			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	2	2.7	$\text{V}/\mu\text{s}$	
		Full range	1.3			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C	18		$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C	8			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C	0.5		μV	
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C	0.7			
I_n Equivalent input noise current		25°C	0.6		$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.9		MHz	
ϕ_m Phase margin	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	48°			

† Full range is -55°C to 125°C .

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201M electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AM			TLC2210BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	80	200		80	200	μV	
		Full range		400		400			
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5			0.5		$\mu\text{V}/^\circ\text{C}$	
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5			0.5		pA	
		Full range		500		500			
I_{IB} Input bias current	25°C	1			1		pA		
	Full range		500		500				
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7			-5 to 2.7	V		
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	-4.7	-4.9		-4.7	-4.9	V	
		Full range	-4.7			-4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	400	560		400	560	V/mV	
		Full range	200			200			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	90	100		90	100		
		Full range	45			45			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	90	115		90	115	dB	
		Full range	85			85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	90	110		90	110	dB	
		Full range	85			85			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.1	1.5		1.1	1.5	mA	
		Full range		1.5			1.5		

† Full range is -55°C to 125°C .

NOTE 4: Typical values are based on the input offset voltage shift observable through 168 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.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201M operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AM			TLC2201BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C	2	2.7		2	2.7		V/ μ s
		Full range	1.3			1.3			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μ V
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6	fA/ $\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		1.9			1.9	MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		48°			48°		

† Full range is -55°C to 125°C .

NOTE 5: This parameter is tested on a sample basis for the TLC2201A and on all devices for the TLC2201B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201M electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201M			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	100	500	μV	
		Full range	700			
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5	$\mu\text{V}/^\circ\text{C}$		
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005*	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5	pA		
		Full range	500			
I_{IB} Input bias current	25°C	1	pA			
	Full range	500				
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7	V		
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
		Full range	4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C	0	50	mV	
		Full range	50			
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315	V/mV	
		Full range	75			
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		
		Full range	10			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50\ \Omega$	25°C	90	110	dB	
		Full range	85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	90	110	dB	
		Full range	85			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C	1	1.5	mA	
		Full range	1.5			

*On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C .

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

TLC2201M operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201M			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8	2.5	$\text{V}/\mu\text{s}$	
		Full range	1.1			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C	18		$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C	8			
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\ \text{Hz}$	25°C	0.5		μV	
	$f = 0.1\text{ to }10\ \text{Hz}$	25°C	0.7			
I_n Equivalent input noise current		25°C	0.6		$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8		MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	45°			

† Full range is -55°C to 125°C .

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201M electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AM			TLC2210BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	80	200		80	200	μV	
		Full range			400		400		
α_{VIO} Temperature coefficient of input offset voltage		Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005		0.001	0.005	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current		25°C	0.5			0.5			pA
		Full range			500		500		
I_{IB} Input bias current	25°C	1			1			pA	
	Full range			500		500			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7		0 to 2.7		V		
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0	50		0	50	V
		Full range			50			50	
AVD Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		150	315	V/mV	
		Full range	75			75			
	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		25	55		
		Full range	10			10			
$CMRR$ Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}, V_O = 0, R_S = 50\ \Omega$	25°C	90	110		90	110	dB	
		Full range	85			85			
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = 4.6\ \text{V to } 16\ \text{V}$	25°C	90	110		90	110	dB	
		Full range	85			85			
I_{DD} Supply current	$V_O = 2.5\ \text{V}, \text{ No load}$	25°C	1.1	1.5		1.1	1.5	mA	
		Full range			1.5		1.5		

† Full range is -55°C to 125°C .

NOTE 4: Typical values are based on the input offset voltage shift observable through 168 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.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201M operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2201AM			TLC2201BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C	1.8	2.5		1.8	2.5		V/ μ s
		Full range	1.1			1.1			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35		18	30	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15		8	12	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μ V
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		1.8			1.8		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		45°			45°		

† Full range is -55°C to 125°C .

NOTE 5: This parameter is tested on a sample basis for the TLC2201A and on all devices for the TLC2201B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202M electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202M			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		100	1000	μV
		Full range			1250	
α_{VIO} Temperature coefficient of input offset voltage		Full range		0.5		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005*	$\mu\text{V}/\text{mo}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	Full range			500	pA
I_{IB} Input bias current		25°C		1		
		Full range			500	
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-5 to 2.7		V	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8	V	
V_{OM-} Maximum negative peak output voltage swing		Full range	4.7			
		25°C	-4.7	-4.9	V	
Full range		-4.7				
A_{VD} Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	300	560	V/mV	
		Full range	100			
	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	50	100		
		Full range	25			
CMRR Common-mode rejection ratio	$V_O = 0, V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	80	115	dB	
		Full range	80			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$)	$V_{DD} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	80	110	dB	
		Full range	80			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.8	2.7	mA	
		Full range		2.7		

* On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C.

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

TLC2202M operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202M			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C	1.8	2.7	$\text{V}/\mu\text{s}$	
		Full range	1.1			
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C		18	$\text{nV}/\sqrt{\text{Hz}}$	
	$f = 1\ \text{kHz}$	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C		0.5	μV	
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6	$\text{fA}/\sqrt{\text{Hz}}$	
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.9	MHz	
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		48°		

† Full range is -55°C to 125°C.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202M electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AM			TLC2202BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	80	500		80	500	μV	
		Full range		750		750			
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005*		0.001	0.005*	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5			0.5			pA
		Full range		500		500			
I_{IB} Input bias current		25°C	1			1			pA
		Full range		500		500			
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	–5 to 2.7			–5 to 2.7			V
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OM-} Maximum negative peak output voltage swing		25°C	–4.7	–4.9		–4.7	–4.9	V	
		Full range	–4.7			–4.7			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C	300	560		300	560	V/mV	
		Full range	100			100			
	$V_O = \pm 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	50	100		50	100		
		Full range	25			25			
CMRR Common-mode rejection ratio	$V_O = 0, V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	80	115		80	115	dB	
		Full range	80			80			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD\pm} = \pm 2.3\ \text{V to } \pm 8\ \text{V}$	25°C	80	110		80	110	dB	
		Full range	80			80			
I_{DD} Supply current	$V_O = 0, \text{ No load}$	25°C	1.8 2.7			1.8 2.7			mA
		Full range		2.7			2.7		

*On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C .

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202M operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AM			TLC2202BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 2.3\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C	1.8	2.7		1.8	2.7		V/ μ s
		Full range	1.1			1.1			
V_n Equivalent input noise voltage (see Note 5)	$f = 10\text{ Hz}$	25°C		18	35*		18	30*	nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	25°C		8	15*		8	12*	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.5			0.5		μ V
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.7			0.7		
I_n Equivalent input noise current		25°C		0.6			0.6		fA/ $\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		1.9			1.9		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$	25°C		48°			48°		

*On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C .

NOTE 5: This parameter is tested on a sample basis for the TLC2202A and on all devices for the TLC2202B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202M electrical characteristics at specified free-air temperatures, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202M			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		100	1000	μV
		Full range			1250	
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range		0.5		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.001	0.005*	$\mu\text{V}/\text{mo}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	Full range			500	pA
I_{IB} Input bias current		25°C		1		
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C		4.7	4.8	V
		Full range		4.7		
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0	50	mV
		Full range			50	
A_{VD} Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 500\ \text{k}\Omega$	25°C		150	315	V/mV
		Full range		75		
	$V_O = 1\ \text{V to } 4\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C		25	55	
		Full range		10		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C		75	110	dB
		Full range		75		
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD} = 4.6\ \text{V to } 16\ \text{V}$	25°C		80	110	dB
		Full range		80		
I_{DD} Supply current	$V_O = 2.5\ \text{V}, \text{ No load}$	25°C		1.7	2.6	mA
		Full range			2.6	

*On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C .

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

TLC2202M operating characteristics at specified free-air temperature, $V_{DD} = 5\ \text{V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202M			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 0.5\ \text{V to } 2.5\ \text{V}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.6	2.5	$\text{V}/\mu\text{s}$
		Full range		0.9		
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$	25°C		18		$\text{nV}/\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$	25°C		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$	25°C		0.5		μV
	$f = 0.1\ \text{to } 10\ \text{Hz}$	25°C		0.7		
I_n Equivalent input noise current		25°C		0.6		$\text{fA}/\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}, R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		1.9		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega, C_L = 100\ \text{pF}$	25°C		47°		

† Full range is -55°C to 125°C .

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202M electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AM			TLC2202BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	80	500		80	500	μV	
		Full range			750		750		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	Full range	0.5			0.5			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C	0.001	0.005*		0.001	0.005*	$\mu\text{V}/\text{mo}$	
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.5			0.5			pA
		Full range			500		500		
I_{IB} Input bias current		25°C	1			1			pA
		Full range			500		500		
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	0 to 2.7			0 to 2.7		V	
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	4.7	4.8		4.7	4.8	V	
		Full range	4.7			4.7			
V_{OL} Maximum low-level output voltage	$I_O = 0$	25°C		0	50		0	50	mV
		Full range			50			50	
A_{VD} Large-signal differential voltage amplification	$V_O = 1\text{ V to }4\text{ V}, R_L = 500\ \text{k}\Omega$	25°C	150	315		150	315	V/mV	
		Full range	75			75			
	$V_O = 1\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	25	55		25	55		
		Full range	10			10			
CMRR Common-mode rejection ratio	$V_O = 0, V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	75	110		75	110	dB	
		Full range	75			75			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD} \pm / \Delta V_{IO}$)	$V_{DD} = 4.6\text{ V to }16\text{ V}$	25°C	80	110		80	110	dB	
		Full range	80			80			
I_{DD} Supply current	$V_O = 2.5\text{ V}, \text{ No load}$	25°C	1.7	2.6		1.7	2.6	mA	
		Full range			2.6		2.6		

* On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202M operating characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	TLC2202AM			TLC2202BM			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX		
SR	Slew rate at unity gain	$V_O = 0.5\text{ V to }2.5\text{ V},$ $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C	1.6	2.5		1.6	2.5	V/ μ s	
			Full range	0.9			1.1			
V_n	Equivalent input noise voltage (see Note 5)	f = 10 Hz	25°C		18	35*		18	30*	nV/ $\sqrt{\text{Hz}}$
			25°C		8	15*		8	12*	
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 to 10 Hz	25°C		0.5			0.5		μ V
			25°C		0.7			0.7		
I_n	Equivalent input noise current		25°C		0.6			0.6	fA/ $\sqrt{\text{Hz}}$	
	Gain-bandwidth product	f = 10 kHz, $R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		1.9			1.9	MHz	
ϕ_m	Phase margin at unity gain	$R_L = 10\text{ k}\Omega,$ $C_L = 100\text{ pF}$	25°C		47°			47°		

*On products compliant to MIL-PRF-38535, Class B, this parameter is not production tested.

† Full range is -55°C to 125°C

NOTE 5: This parameter is tested on a sample basis for the TLC2202A and on all devices for the TLC2202B. For other test requirements, please contact the factory. This statement has no bearing on testing or nontesting of other parameters.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2201Y electrical characteristics at $V_{DD\pm} = \pm 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLC2201Y			UNIT
		MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$		100		μV
Input offset voltage long-term drift (see Note 4)			0.001		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current			0.5		pA
I_{IB} Input bias current			1		pA
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$		4.8		V
V_{OL} Maximum low-level output voltage	$I_O = 0$		0		mV
A_{VD} Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}$, $R_L = 500\ \Omega$		55		V/mV
	$V_O = 1\ \text{V to } 4\ \text{V}$, $R_L = 10\ \Omega$		55		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}$, $V_O = 0$, $R_S = 50\ \Omega$		110		dB
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD\pm} / \Delta V_{IO}$)	$V_{DD} = 4.6\ \text{to } 16\ \text{V}$		110		dB
I_{DD} Supply current per amplifier	$V_O = 2.5\ \text{V}$, No load		1		mA

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 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.

TLC2201Y operating characteristics at $V_{DD\pm} = \pm 5\ \text{V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	TLC2201Y			UNIT
		MIN	TYP	MAX	
SR Positive slew rate at unity gain	$V_O = \pm 0.5\ \text{to } 2.5\ \text{V}$, $R_L = 10\ \text{k}\Omega$, $C_L = 100\ \text{pF}$		2.5		$\text{V}/\mu\text{s}$
V_n Equivalent input noise voltage	$f = 10\ \text{Hz}$		18		$\text{nV}/\sqrt{\text{Hz}}$
	$f = 1\ \text{kHz}$		8		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$		0.5		μV
	$f = 0.1\ \text{to } 10\ \text{Hz}$		0.7		
I_n Equivalent input noise current			0.6		$\text{pA}/\sqrt{\text{Hz}}$
Gain-bandwidth product	$f = 10\ \text{kHz}$, $R_L = 10\ \text{k}\Omega$, $C_L = 100\ \text{pF}$		1.8		MHz
ϕ_m Phase margin at unity gain	$R_L = 10\ \text{k}\Omega$, $C_L = 100\ \text{pF}$		48°		

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TLC2202Y electrical characteristics, $V_{DD} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TLC2202Y			UNIT
			MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$		100		μV
	Input offset voltage long-term drift (see Note 4)			0.001		$\mu\text{V}/\text{mo}$
I_{IO}	Input offset current			0.5		pA
I_{IB}	Input bias current			1		pA
V_{OH}	Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$		4.8		V
V_{OL}	Maximum low-level output voltage	$I_O = 0$		0		mV
A_{VD}	Large-signal differential voltage amplification	$V_O = 1\ \text{V to } 4\ \text{V}$, $R_L = 500\ \Omega$		315		V/mV
		$V_O = 1\ \text{V to } 4\ \text{V}$, $R_L = 10\ \Omega$		55		
CMRR	Common-mode rejection ratio	$V_O = 0$, $V_{ICR\text{min}}$, $R_S = 50\ \Omega$		110		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DCC}/\Delta V_{IO}$)	$V_{DD} = 4.6\ \text{to } 16\ \text{V}$		110		dB
I_{DD}	Supply current	$V_O = 2.5\ \text{V}$, No load		1.7		mA

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 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.

TLC2202Y operating characteristics at $V_{DD} = 5\ \text{V}$, $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	TLC2202Y			UNIT
			MIN	TYP	MAX	
SR	Positive slew rate at unity gain	$V_O = 0.5\ \text{V to } 2.5\ \text{V}$, $R_L = 10\ \text{k}\Omega$, $C_L = 100\ \text{pF}$		2.5		$\text{V}/\mu\text{s}$
V_n	Equivalent input noise voltage	$f = 10\ \text{Hz}$		18		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\ \text{kHz}$		8		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\ \text{to } 1\ \text{Hz}$		0.5		μV
		$f = 0.1\ \text{to } 10\ \text{Hz}$		0.7		
I_n	Equivalent input noise current			0.6		$\text{pA}/\sqrt{\text{Hz}}$
B_1	Gain-bandwidth product	$f = 10\ \text{kHz}$, $C_L = 100\ \text{pF}$		1.9		MHz
ϕ_m	Phase margin at unity gain	$R_L = 10\ \text{k}\Omega$, $C_L = 100\ \text{pF}$		47°		

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

PARAMETER MEASUREMENT INFORMATION

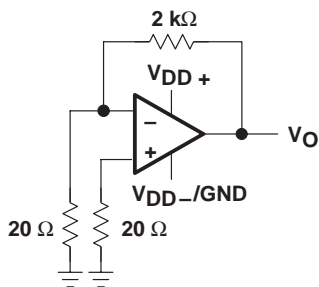
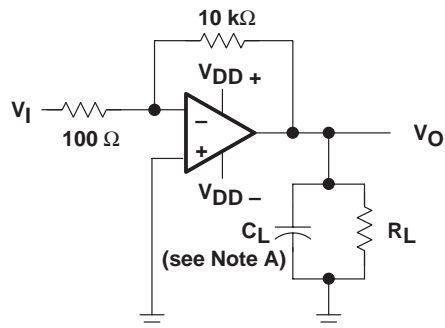
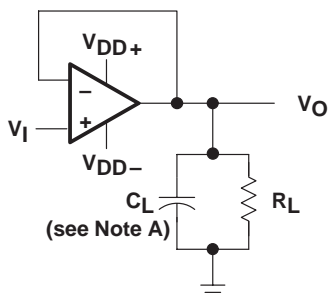


Figure 1. Noise-Voltage Test Circuit



NOTE A: C_L includes fixture capacitance.

Figure 2. Phase-Margin Test Circuit



NOTE A: C_L includes fixture capacitance.

Figure 3. Slew-Rate Test Circuit

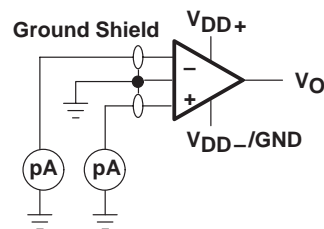


Figure 4. Input-Bias and Offset-Current Test Circuit

typical values

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

input bias and offset current

At the picoamp bias current level of the TLC220x, TLC220xA, and TLC220xB, accurate measurement of the bias current becomes difficult. Not only does this measurement require a picoammeter, but test socket leakages can easily exceed the actual device bias currents. To measure these small currents, Texas Instruments uses a two-step process. The socket leakage is measured using picoammeters with bias voltages applied but with no device in the socket. The device is then inserted in the socket, and a second test measuring both the socket leakage and the device input bias current is performed. The two measurements are then subtracted algebraically to determine the bias current of the device.

noise

Texas Instruments offers automated production noise testing to meet individual application requirements. Noise voltage at $f = 10$ Hz and $f = 1$ kHz is 100% tested on every TLC2201B device, while lot sample testing is performed on the TLC220xA. For other noise requirements, please contact the factory.

TLC220x, TLC220xA, TLC220xB, TLC220xY
Advanced LinCMOS™ LOW-NOISE PRECISION
OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

Table of Graphs

		FIGURE	
V _{IO}	Input offset voltage	Distribution	5, 6
I _{IB}	Input bias current	vs Common-mode input voltage	7
		vs Free-air temperature	8
V _{OM}	Maximum peak output voltage	vs Output current	9
		vs Free-air temperature	10
V _{O(PP)}	Maximum peak-to-peak output voltage	vs Frequency	11
V _{OH}	High-level output voltage	vs Frequency	12
		vs High-level output current	13
		vs Free-air temperature	14
V _{OL}	Low-level output voltage	vs Low-level output current	15
		vs Free-air temperature	16
A _{VD}	Large-signal differential voltage amplification	vs Frequency	17
		vs Free-air temperature	18
I _{OS}	Short-circuit output current	vs Supply voltage	19
		vs Free-air temperature	20
CMRR	Common-mode rejection ratio	vs Frequency	21
I _{DD}	Supply current	vs Supply voltage	22
		vs Free-air temperature	23, 24
	Pulse response	Small signal	25, 26
		Large signal	27, 28
SR	Slew rate	vs Supply voltage	29
		vs Free-air temperature	30
	Noise voltage (referred to input)	0.1 to 1 Hz	31
		0.1 to 10 Hz	32
	Gain-bandwidth product	vs Supply voltage	33, 34
		vs Free-air temperature	35
ϕ _m	Phase margin	vs Supply voltage	36, 37
		vs Free-air temperature	38, 39
	Phase shift	vs Frequency	17

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC2201
 INPUT OFFSET VOLTAGE

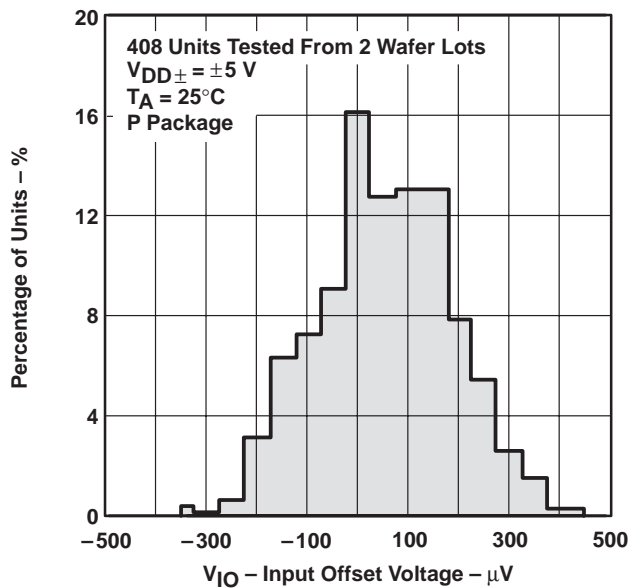


Figure 5

TLC2202
 DISTRIBUTION OF
 INPUT OFFSET VOLTAGE

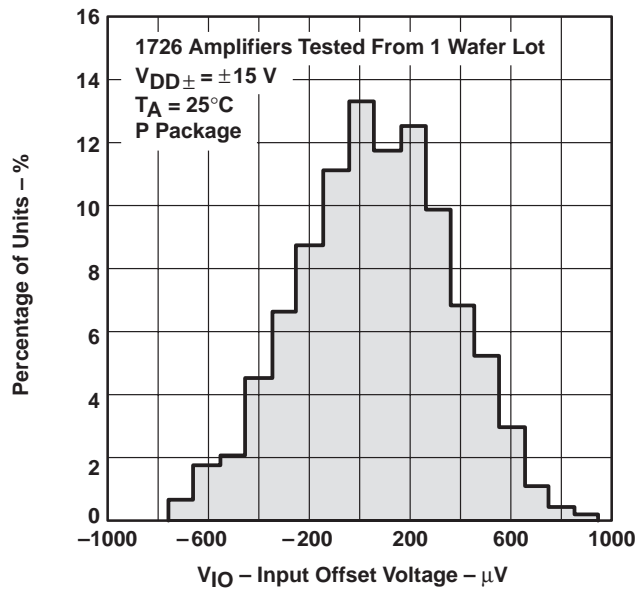


Figure 6

INPUT BIAS CURRENT
 vs
 COMMON-MODE INPUT VOLTAGE

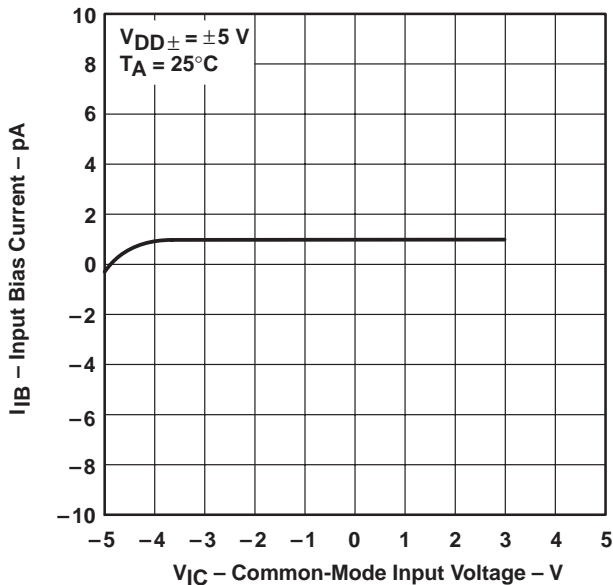


Figure 7

INPUT BIAS CURRENT†
 vs
 FREE-AIR TEMPERATURE

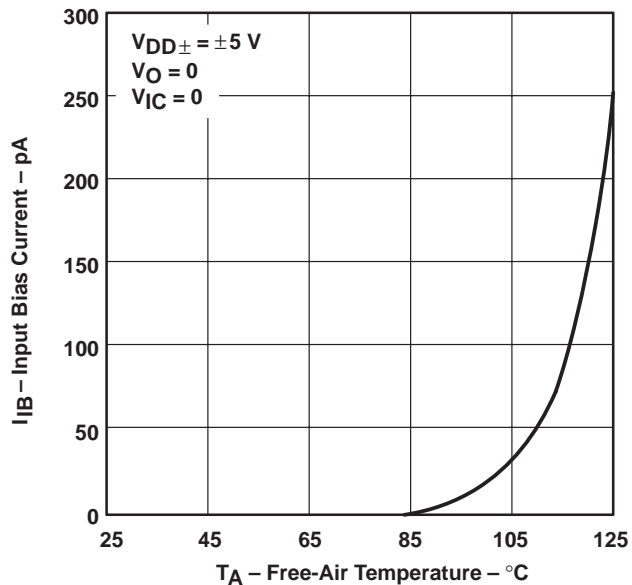


Figure 8

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

TYPICAL CHARACTERISTICS

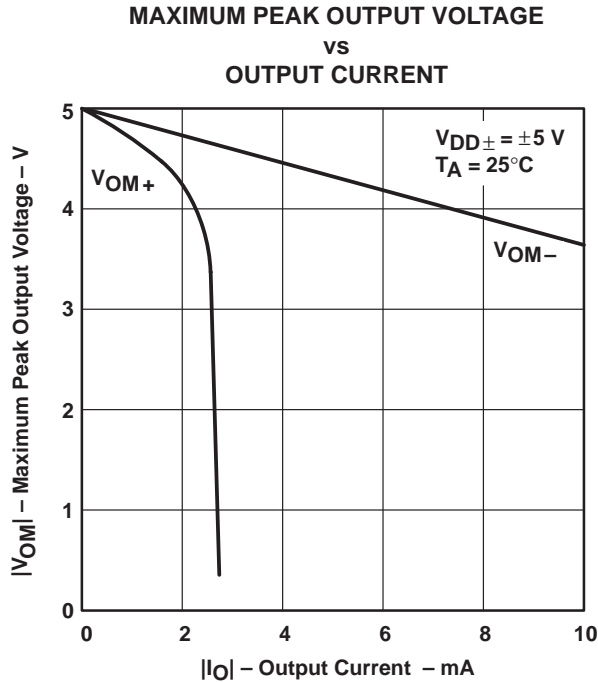


Figure 9

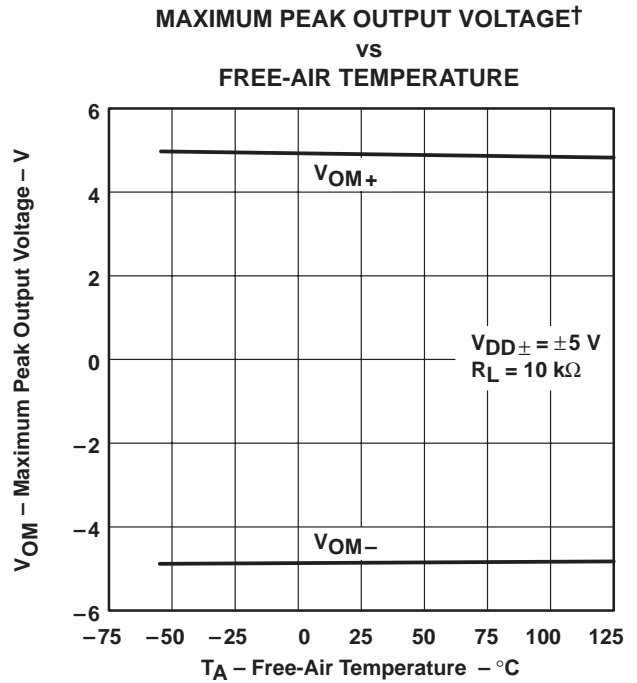


Figure 10

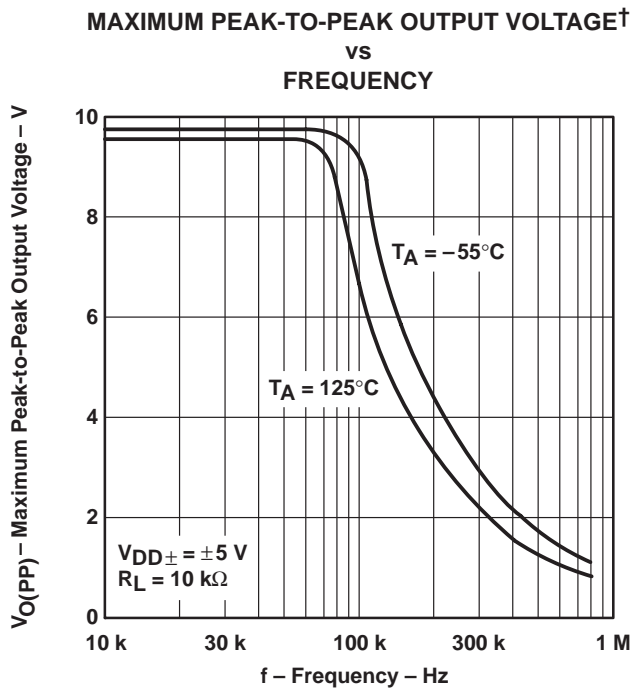


Figure 11

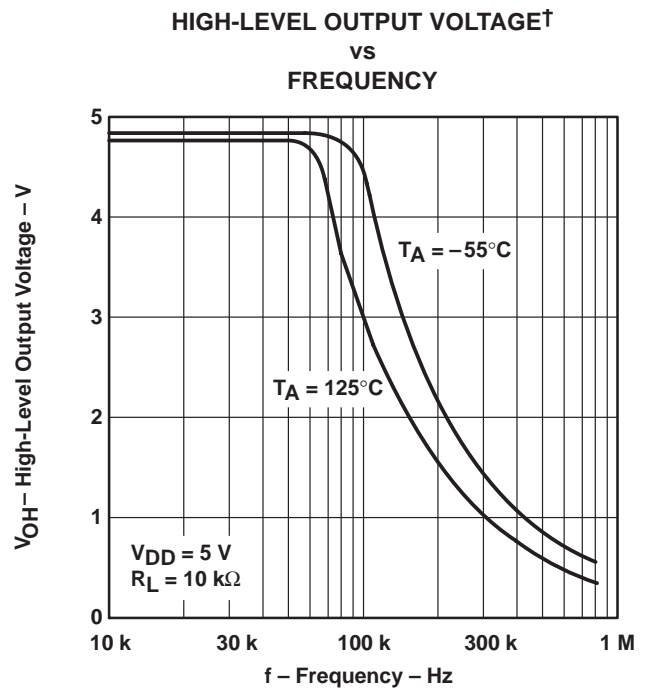


Figure 12

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

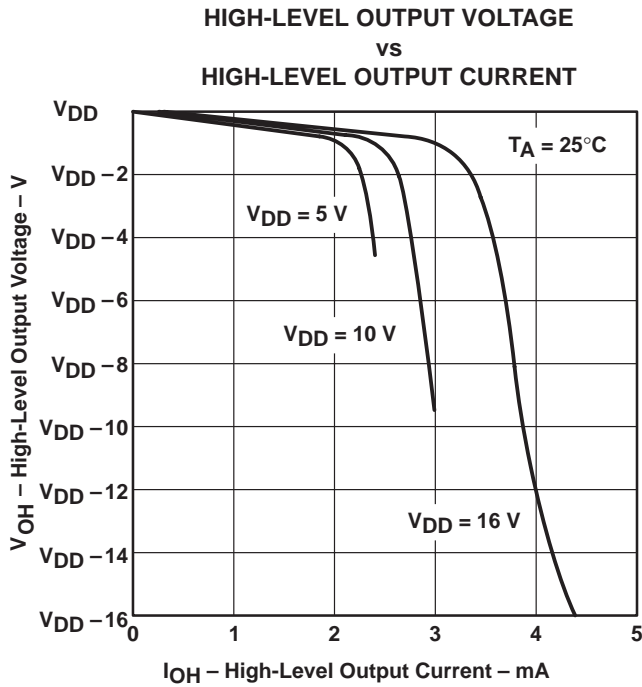


Figure 13

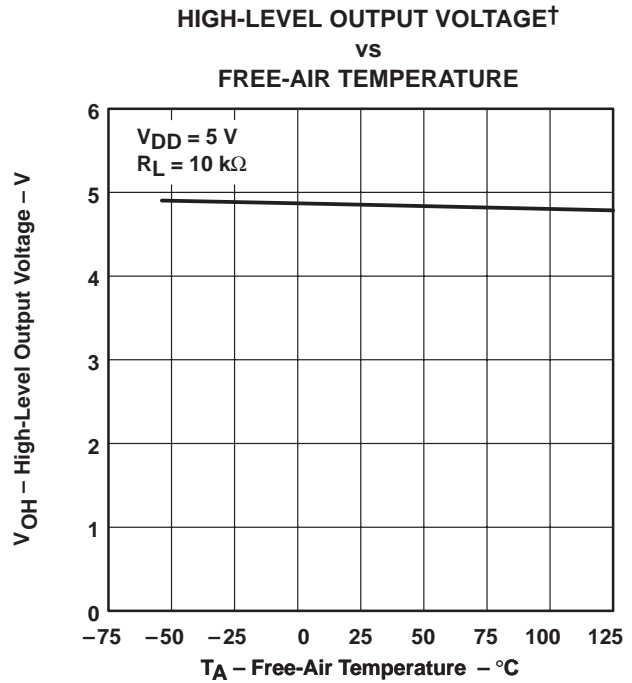


Figure 14

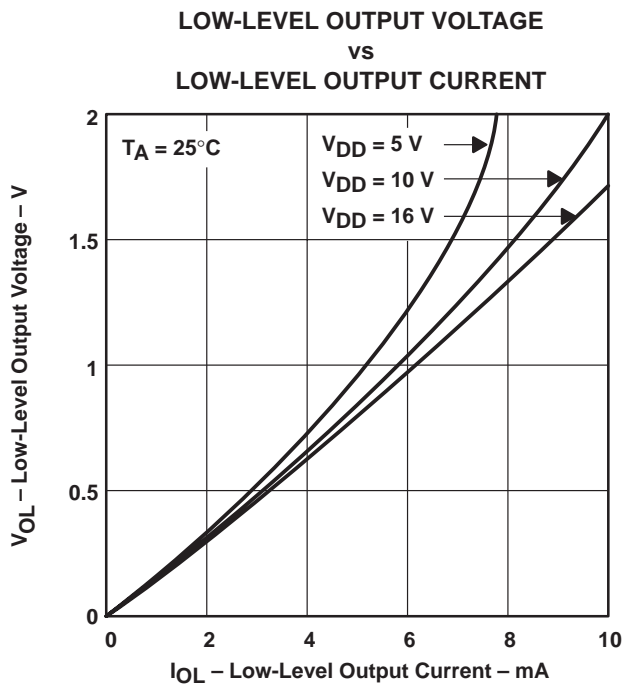


Figure 15

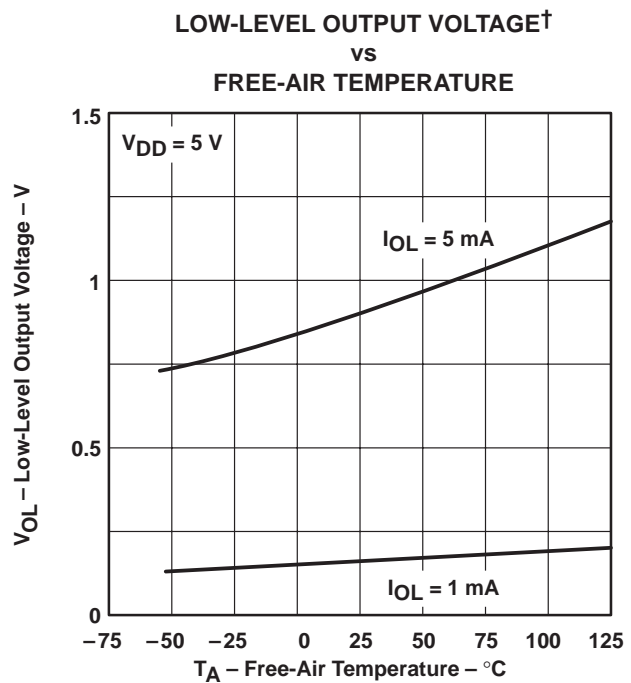


Figure 16

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

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE
 AMPLIFICATION AND PHASE SHIFT
 vs
 FREQUENCY

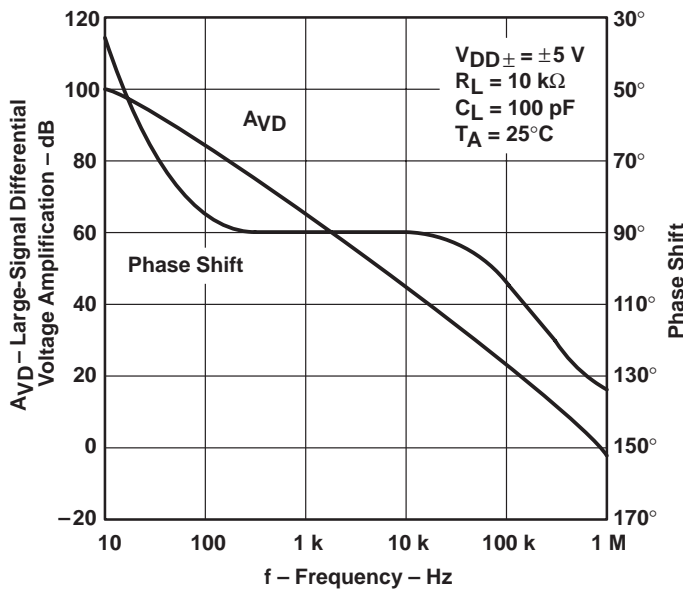


Figure 17

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

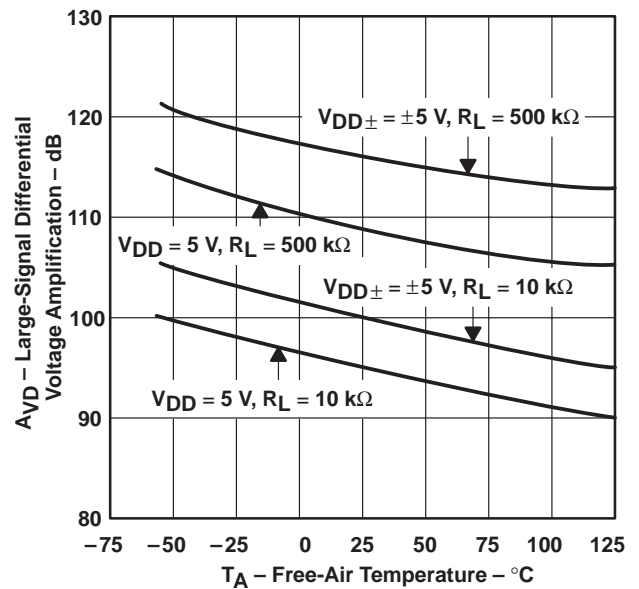


Figure 18

SHORT-CIRCUIT OUTPUT CURRENT
 vs
 SUPPLY VOLTAGE

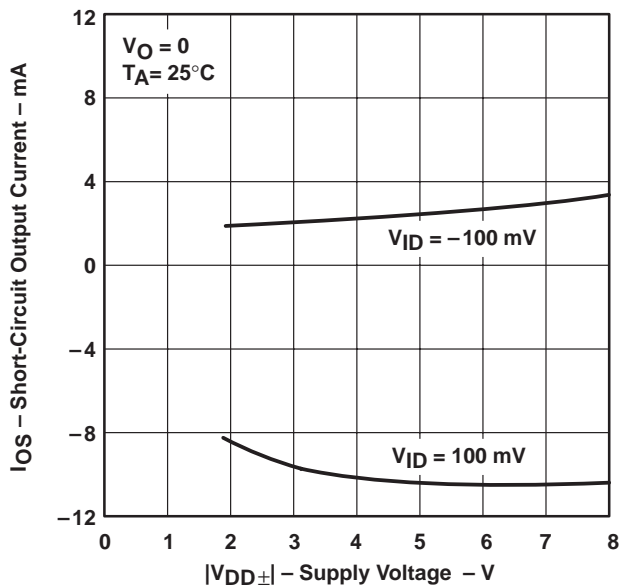


Figure 19

SHORT-CIRCUIT OUTPUT CURRENT†
 vs
 FREE-AIR TEMPERATURE

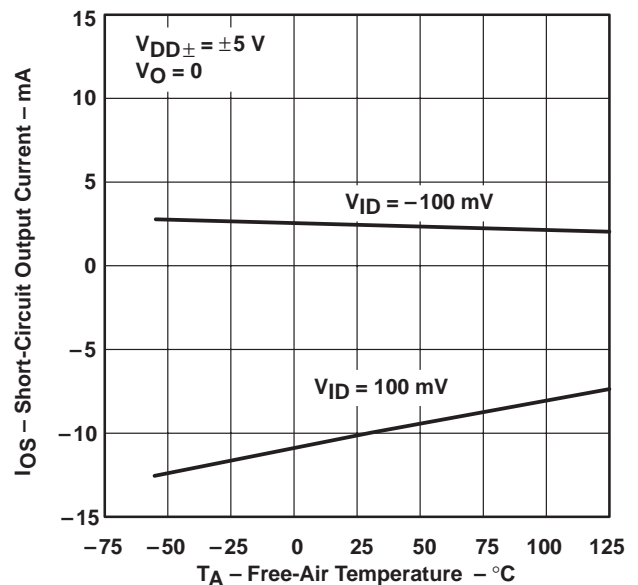


Figure 20

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

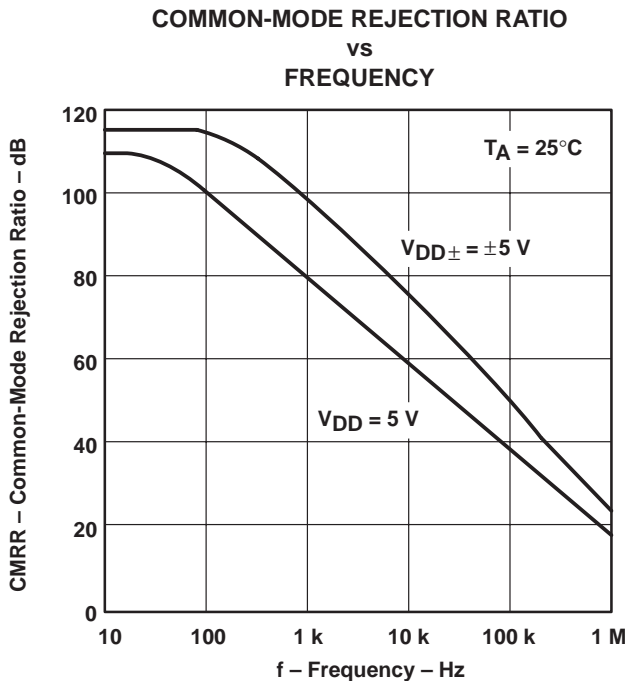


Figure 21

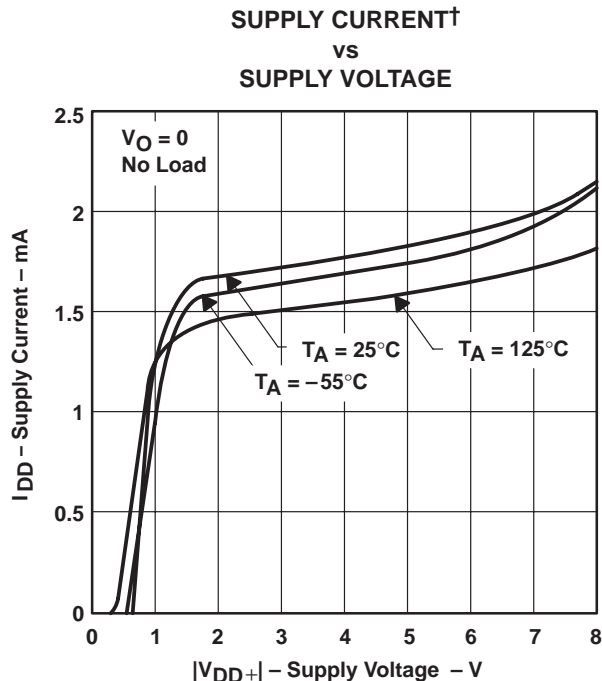


Figure 22

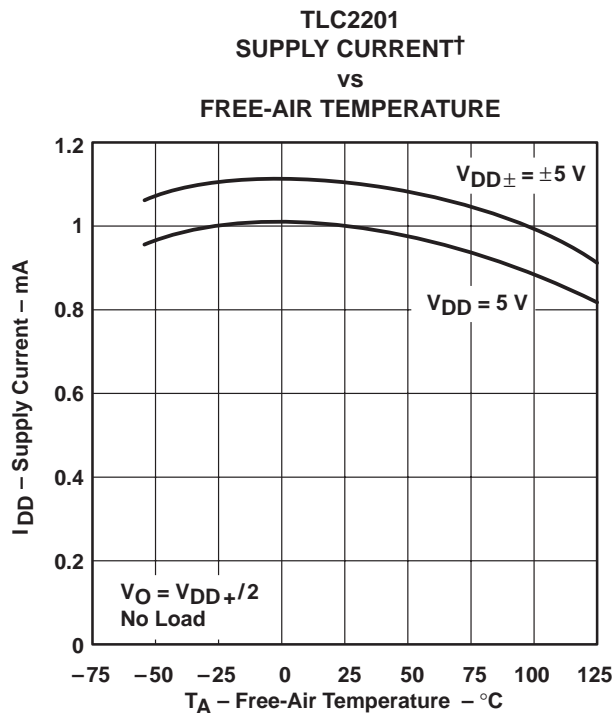


Figure 23

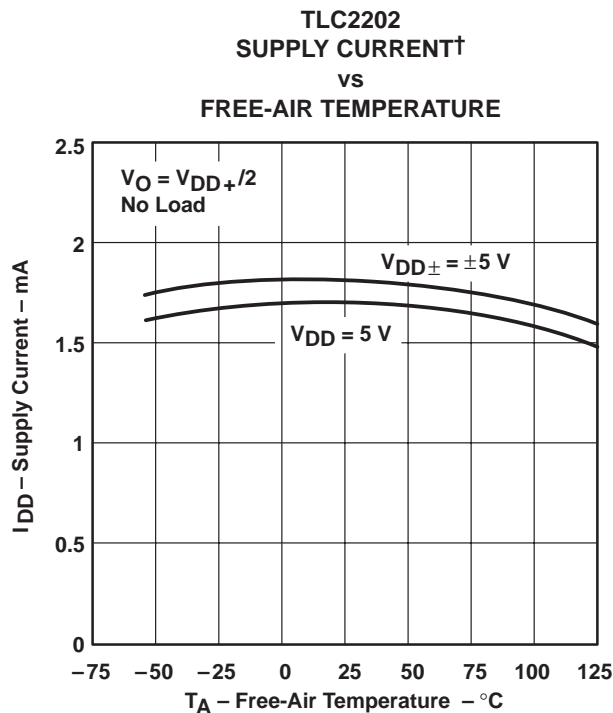


Figure 24

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

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER
 SMALL-SIGNAL
 PULSE RESPONSE

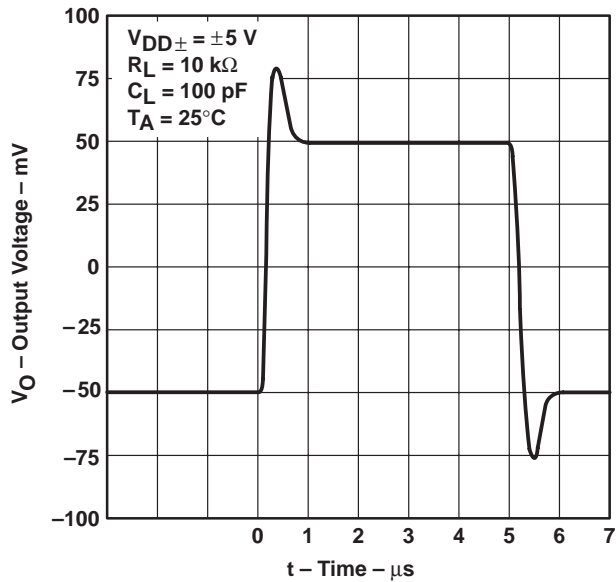


Figure 25

VOLTAGE-FOLLOWER
 SMALL-SIGNAL
 PULSE RESPONSE

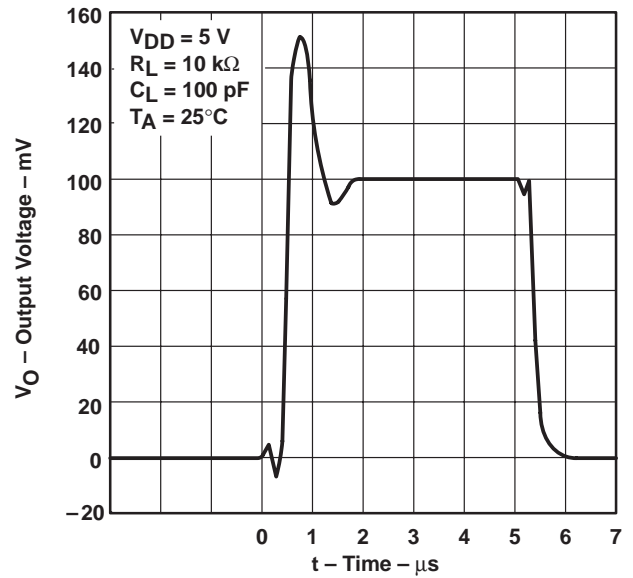


Figure 26

VOLTAGE-FOLLOWER
 LARGE-SIGNAL
 PULSE RESPONSE

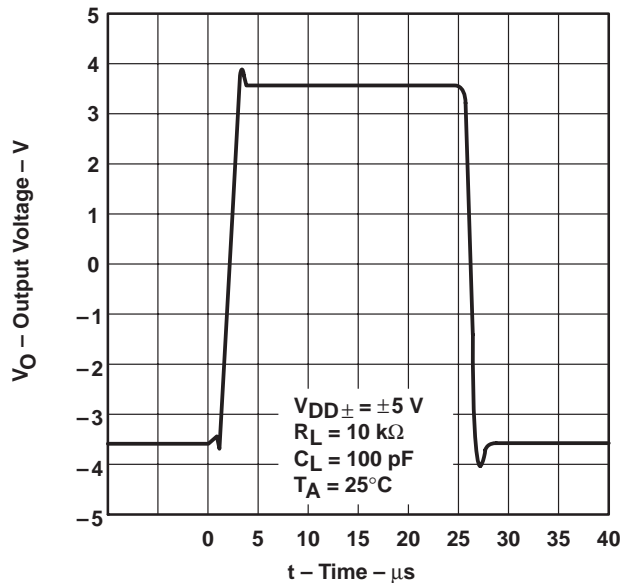


Figure 27

VOLTAGE-FOLLOWER
 LARGE-SIGNAL
 PULSE RESPONSE

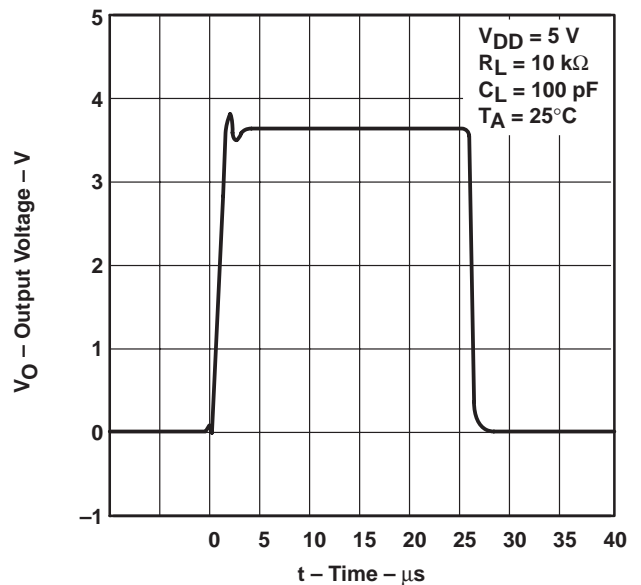


Figure 28

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

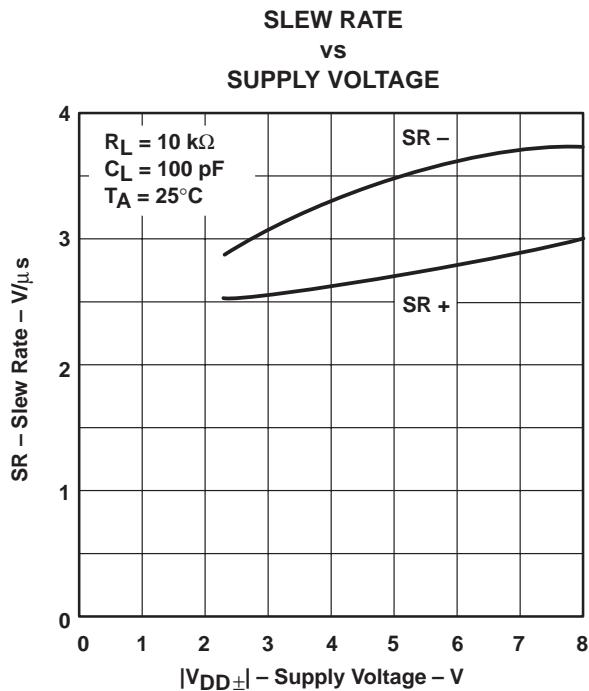


Figure 29

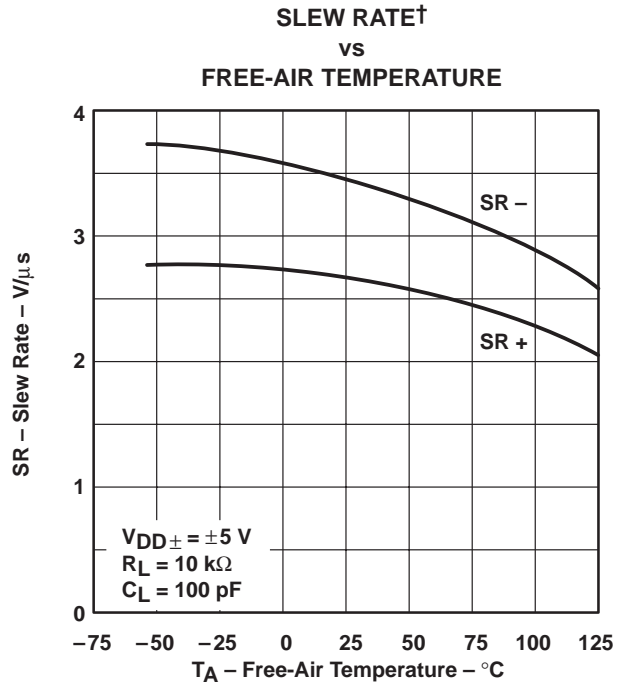


Figure 30

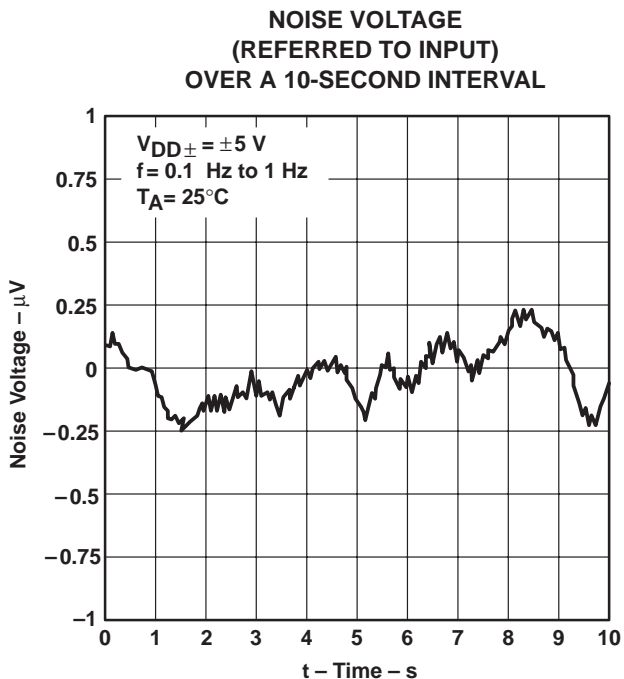


Figure 31

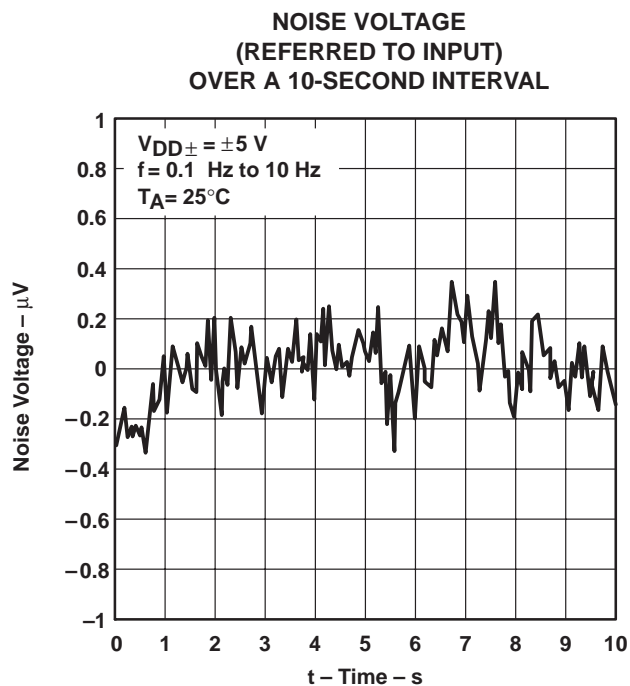


Figure 32

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

TYPICAL CHARACTERISTICS

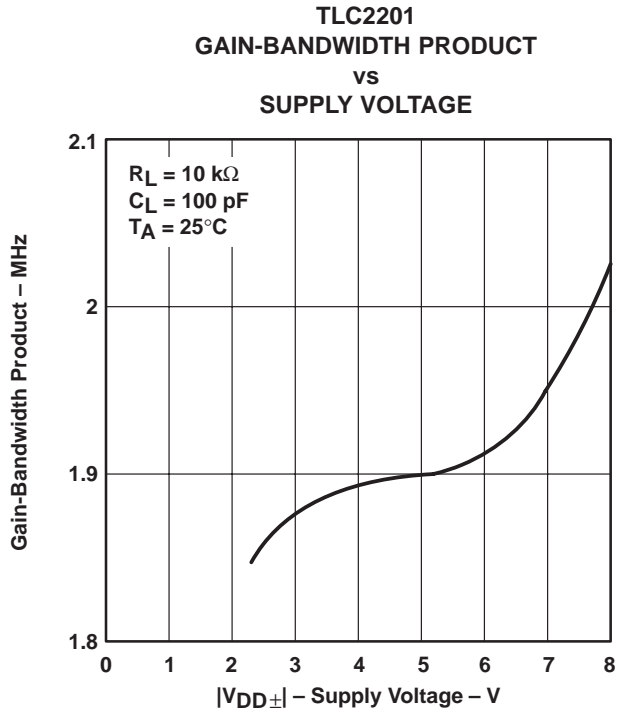


Figure 33

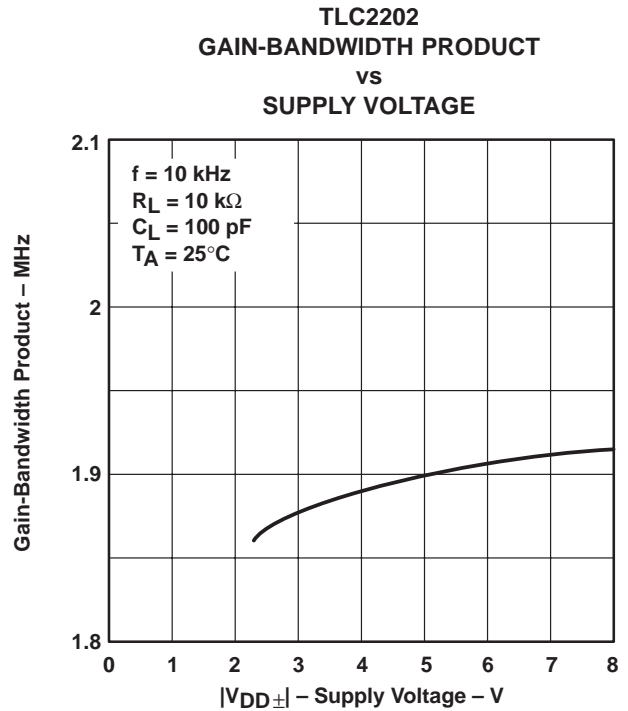


Figure 34

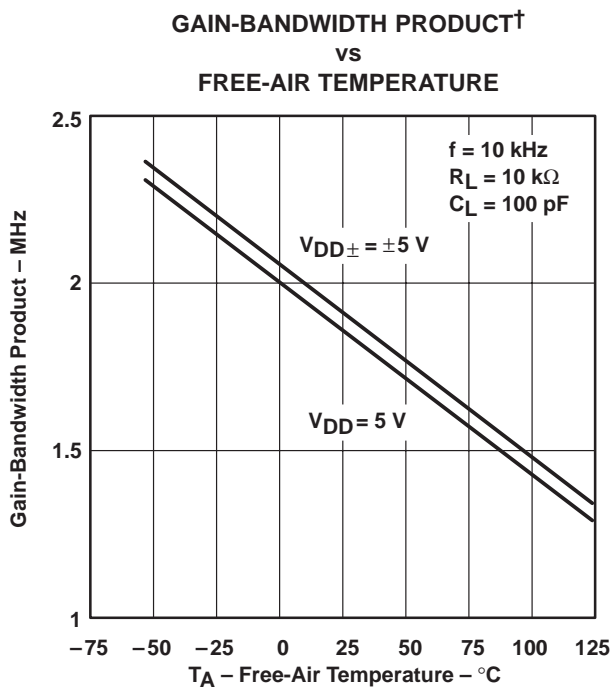


Figure 35

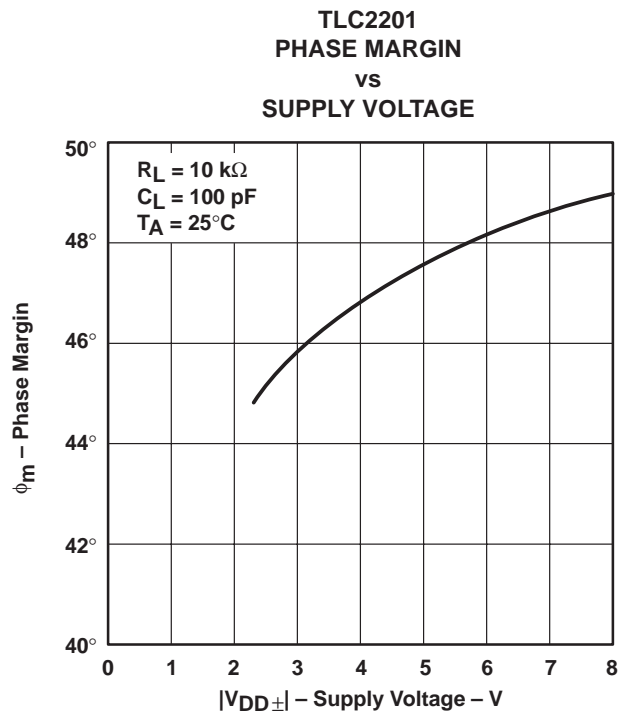


Figure 36

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

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

TLC2202
 PHASE MARGIN
 vs
 SUPPLY VOLTAGE

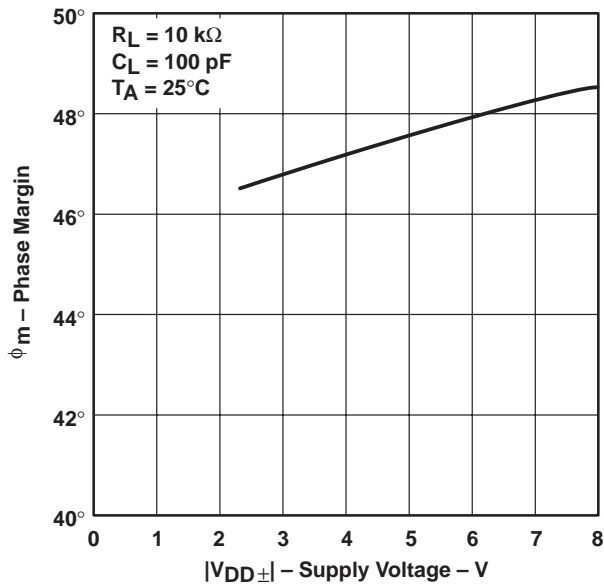


Figure 37

TLC2201
 PHASE MARGIN†
 vs
 FREE-AIR TEMPERATURE

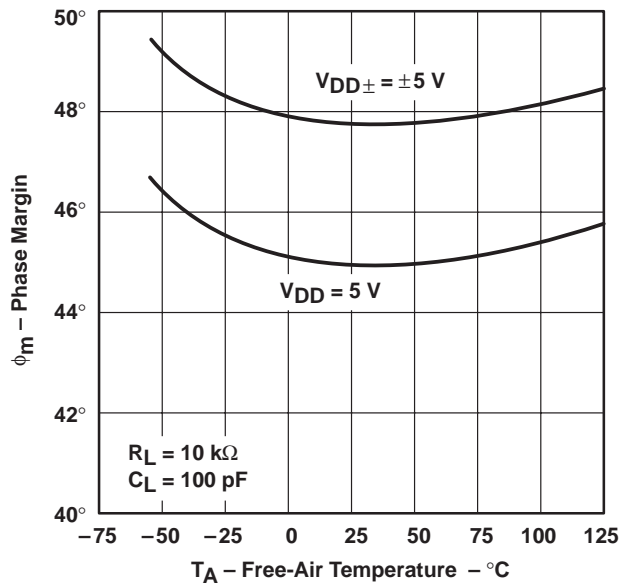


Figure 38

TLC2202
 PHASE MARGIN†
 vs
 FREE-AIR TEMPERATURE

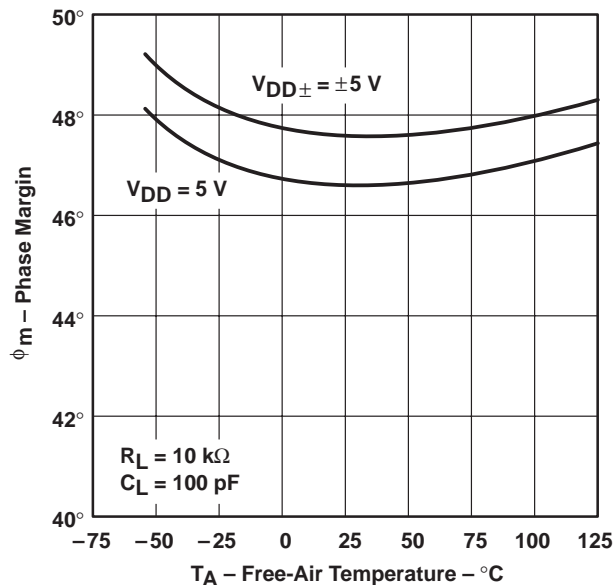


Figure 39

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

APPLICATION INFORMATION

latch-up avoidance

Because CMOS devices are susceptible to latch-up due to their inherent parasitic thyristors, the TLC220x, TLC220xA, and TLC220xB inputs and outputs are designed to withstand –100-mA surge currents without sustaining latch-up; however, techniques reducing the chance of latch-up should be used whenever possible. Internal protection diodes should not be forward biased in normal operation. Applied input and output voltages should not exceed the supply voltage by more than 300 mV. Care should be exercised when using capacitive coupling on pulse generators. Supply transients should be shunted by the use of decoupling capacitors (0.1 μ F typical) located across the supply rails as close to the device as possible.

electrostatic discharge protection

These devices use internal ESD-protection circuits that prevent functional failures at voltages at or below 2000 V. Care should be exercised in handling these devices as exposure to ESD may result in degradation of the device parametric performance.

macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSPice*™. The Boyle macromodel (see Note 5) and subcircuit in Figure 40 were generated using the TLC220x typical electrical and operating characteristics at 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

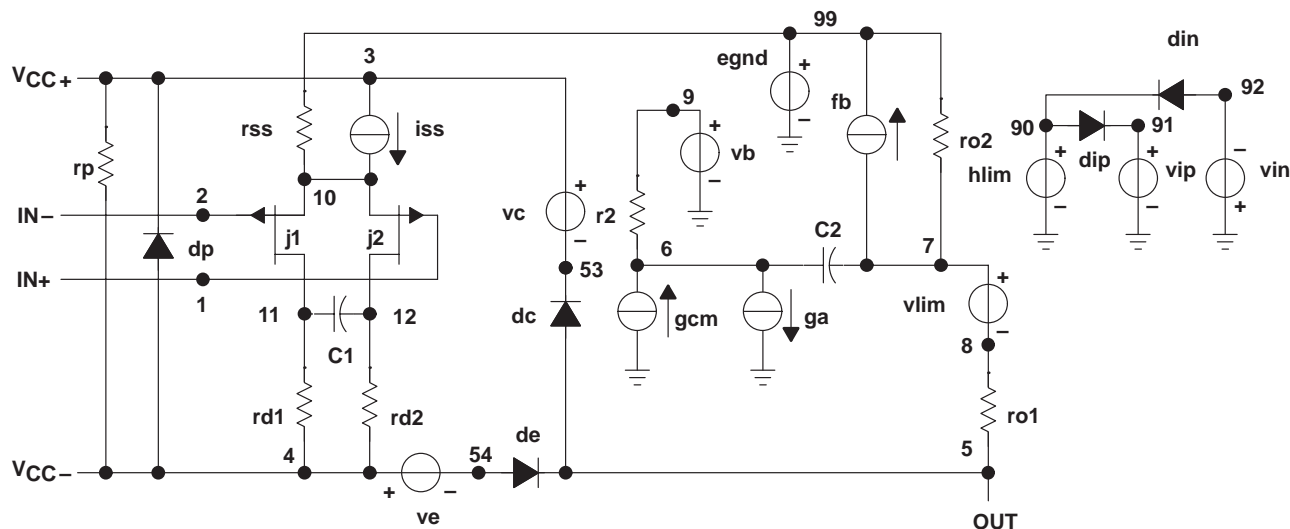
NOTE 5: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

APPLICATION INFORMATION

macromodel information (continued)



```
.subckt TLC220x 1 2 3 4 5
*
c1 11 12 8.51E-12
c2 6 7 50.00E-12
cpsr 85 86 79.6E-9
dcm+ 81 82 dx
dcm- 83 81 dx
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
ecmr 84 99 (2,99) 1
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
epsr 85 0 poly(1) (3,4) -200E-6 20E-6
ense 89 2 poly(1) (88,0) 100E-6 1
fb 7 99 poly(6) vb vc ve vlp vln
+ vpsr 0 + 895.9E3 -90E3 90E3 90E3 -90E3 895E3
ga 6 0 11 12 314.2E-6
gcm 0 6 10 99 1.295E-9
gpsr 85 86 (85,86) 100E-6
grd1 60 11 (60,11) 3.141E-4
grd2 60 12 (60,12) 3.141E-4
hlim 90 0 vlim 1k
hcmr 80 1 poly(2) vcm+ vcm- 0 1E2 1E2
irp 3 4 965E-6
iss 3 10 dc 135.0E-6
iio 2 0 .5E-12
i1 88 0 1E-21
j1 11 89 10 jx
j2 12 80 10 jx
r2 6 9 100.0E3
rcm 84 81 1k
rn1 88 0 1500
ro1 8 5 188
ro2 7 99 187
rss 10 99 1.481E6
vad 60 4 -.3v
vcm+ 82 99 2.2
vcm- 83 99 -4.5
vb 9 0 dc 0
vc 3 53 dc .9
ve 54 4 dc .8
vlim 7 8 dc 0
vlp 91 0 dc 2.8
vln 0 92 dc 2.8
vpsr 0 86 dc 0
.model dx d(is=800.0E-18)
.model jx pjf(is=500.0E-15 beta=1.462E-3
+ vto=-.155 kf=1E-17)
.endsx
```

Figure 40. Boyle Macromodel and Subcircuit

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

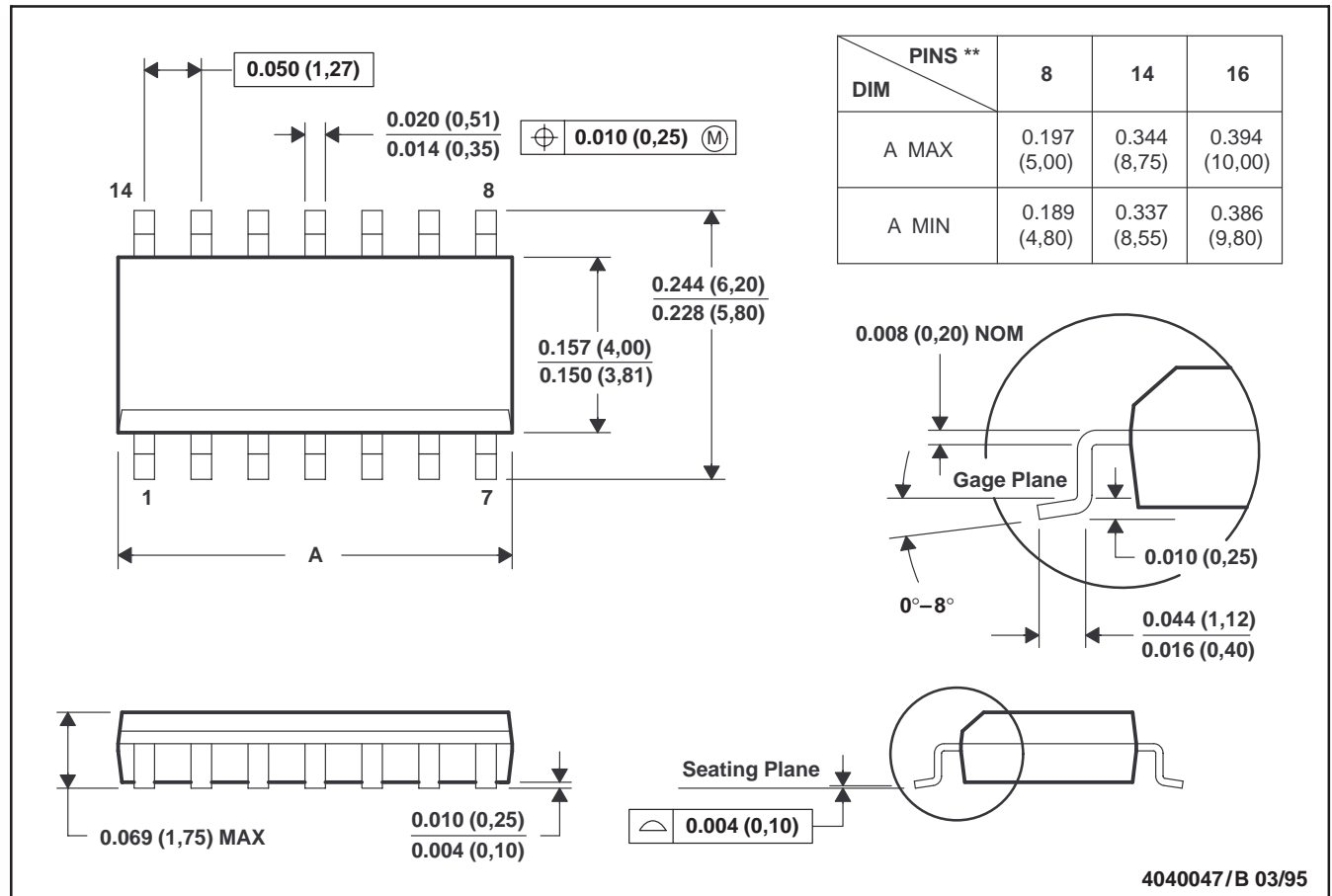
SLOS175 – FEBRUARY 1997

MECHANICAL INFORMATION

D (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
 D. Four center pins are connected to die mount pad.
 E. Falls within JEDEC MS-012

4040047/B 03/95

TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

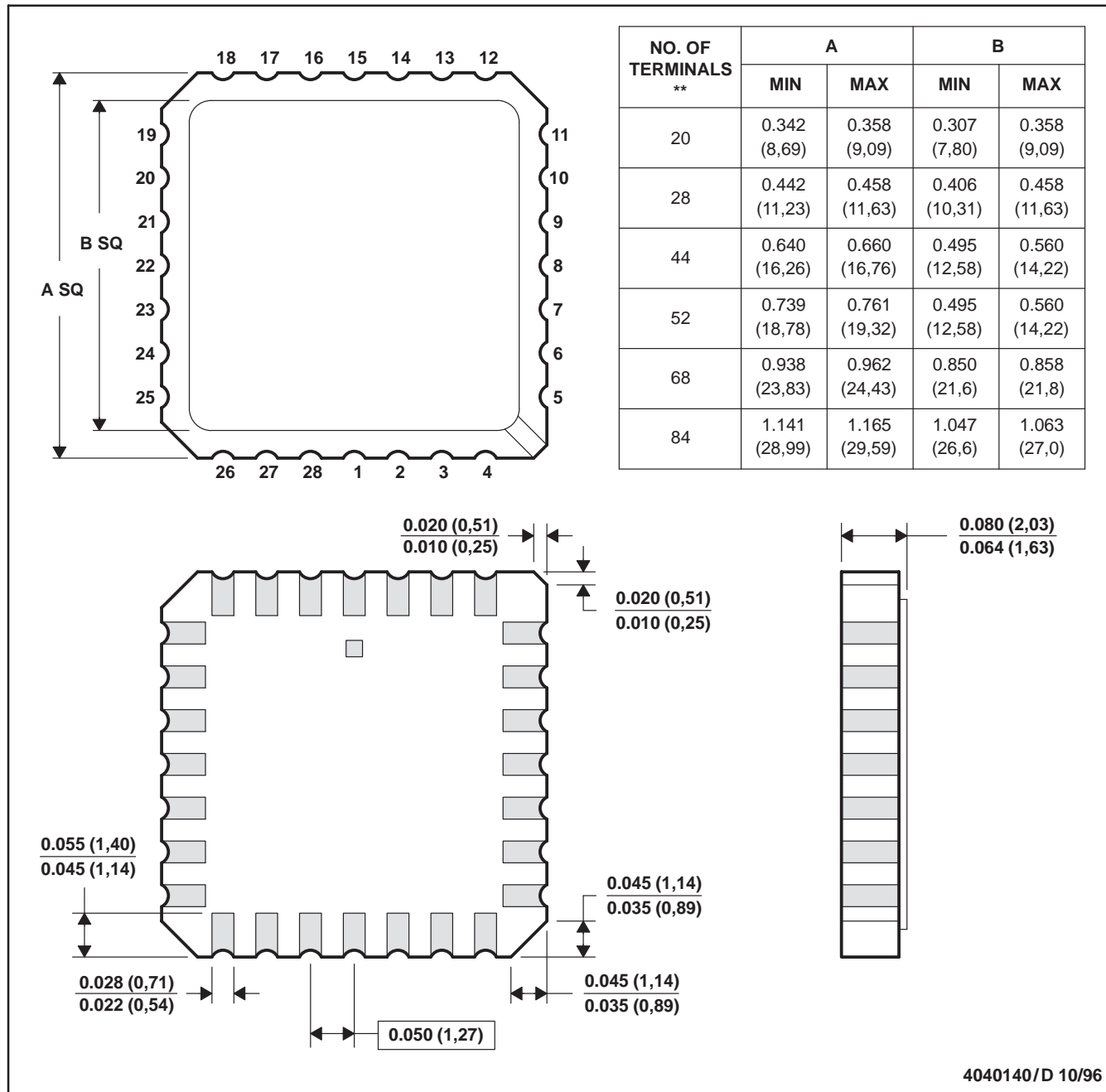
SLOS175 – FEBRUARY 1997

MECHANICAL INFORMATION

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



4040140/D 10/96

- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a metal lid.
 D. The terminals are gold plated.
 E. Falls within JEDEC MS-004

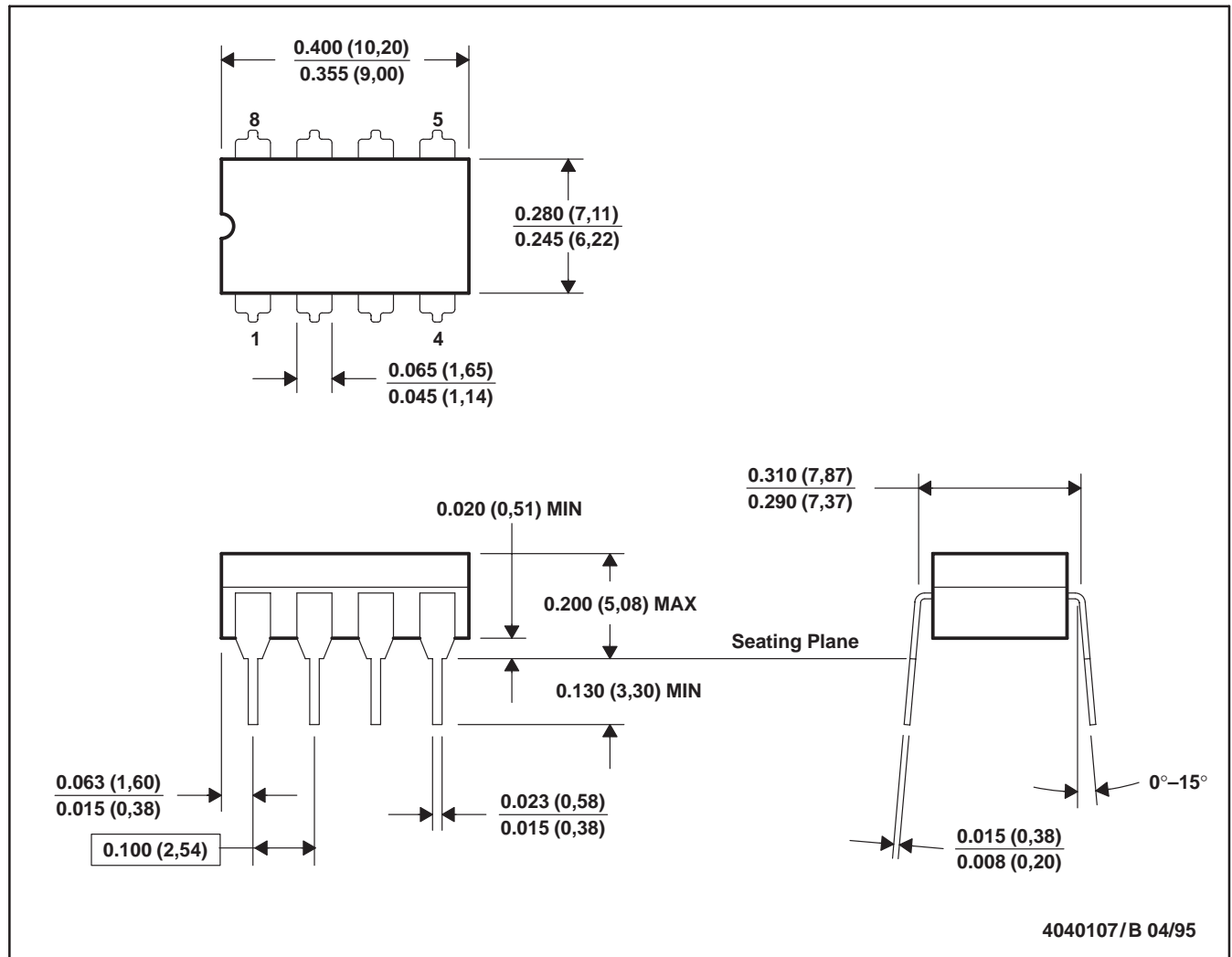
TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

MECHANICAL INFORMATION

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE PACKAGE



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a ceramic lid using glass frit.
 D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only
 E. Falls within MIL-STD-1835 GDIP1-T8

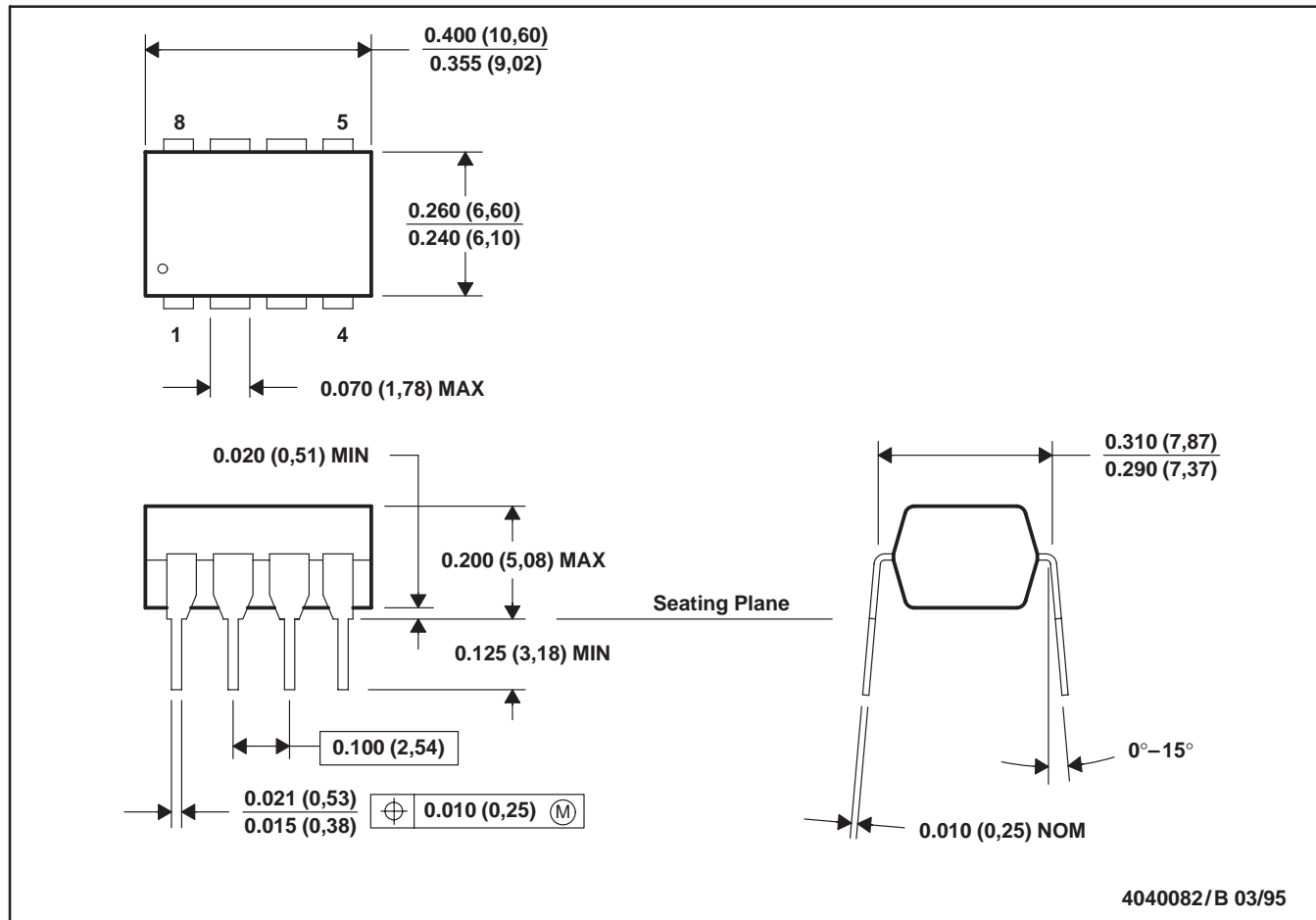
TLC220x, TLC220xA, TLC220xB, TLC220xY
 Advanced LinCMOS™ LOW-NOISE PRECISION
 OPERATIONAL AMPLIFIERS

SLOS175 – FEBRUARY 1997

MECHANICAL INFORMATION

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-9088202M2A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-9088202MPA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
5962-9088204Q2A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-9088204QPA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLC2201ACD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201ACDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201ACP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2201AID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201AIDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201AIP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2201BCD	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
TLC2201BCDR	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
TLC2201BCP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2201BID	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
TLC2201BIDR	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
TLC2201BIP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2201BMP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2201CD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201CDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLC2201CPSR	OBSOLETE	SO	PS	8		None	Call TI	Call TI
TLC2201ID	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201IDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2201IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLC2202ACD	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202ACDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202ACP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2202ACPSR	ACTIVE	SO	PS	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202AID	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202AIP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2202AMFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
TLC2202AMJG	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLC2202AMJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLC2202BCD	OBSOLETE	SOIC	D	14		None	Call TI	Call TI
TLC2202BCDR	OBSOLETE	SOIC	D	14		None	Call TI	Call TI
TLC2202BCP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2202BID	OBSOLETE	SOIC	D	14		None	Call TI	Call TI
TLC2202BIDR	OBSOLETE	SOIC	D	14		None	Call TI	Call TI
TLC2202BIP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2202BMD	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
TLC2202BMP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
TLC2202CD	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202CDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLC2202CPSR	ACTIVE	SO	PS	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202ID	ACTIVE	SOIC	D	14	50	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1YEAR/ Level-1-220C-UNLIM
TLC2202IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
TLC2202MFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
TLC2202MJG	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
TLC2202MJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC

⁽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 JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI

to Customer on an annual basis.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265