

TLE202x, TLE202xA, TLE202xB, TLE202xY EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

SLOS191 – FEBRUARY 1997

- Supply Current . . . 230 μ A Max
- High Unity-Gain Bandwidth . . . 2 MHz Typ
- High Slew Rate . . . 0.45 V/ μ s Min
- Supply-Current Change Over Military Temp Range . . . 10 μ A Typ at $V_{CC} \pm \pm 15$ V
- Specified for Both 5-V Single-Supply and ± 15 -V Operation
- Phase-Reversal Protection
- High Open-Loop Gain . . . 6.5 V/ μ V (136 dB) Typ
- Low Offset Voltage . . . 100 μ V Max
- Offset Voltage Drift With Time 0.005 μ V/mo Typ
- Low Input Bias Current . . . 50 nA Max
- Low Noise Voltage . . . 19 nV/ $\sqrt{\text{Hz}}$ Typ

description

The TLE202x, TLE202xA, and TLE202xB devices are precision, high-speed, low-power operational amplifiers using a new Texas Instruments Excalibur process. These devices combine the best features of the OP21 with highly improved slew rate and unity-gain bandwidth.

The complementary bipolar Excalibur process utilizes isolated vertical pnp transistors that yield dramatic improvement in unity-gain bandwidth and slew rate over similar devices.

The addition of a bias circuit in conjunction with this process results in extremely stable parameters with both time and temperature. This means that a precision device remains a precision device even with changes in temperature and over years of use.

This combination of excellent dc performance with a common-mode input voltage range that includes the negative rail makes these devices the ideal choice for low-level signal conditioning applications in either single-supply or split-supply configurations. In addition, these devices offer phase-reversal protection circuitry that eliminates an unexpected change in output states when one of the inputs goes below the negative supply rail.

A variety of available options includes small-outline and chip-carrier versions for high-density systems applications.

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.

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



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TLE2021 AVAILABLE OPTIONS

T _A	V _{IOMAX} AT 25°C	PACKAGED DEVICES						CHIP FORMS [§] (Y)
		SMALL OUTLINE† (D)	SSOP‡ (DB)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	
0°C to 70°C	200 µV 500 µV	TLE2021ACD TLE2021CD	TLE2021CDBLE	—	—	TLE2021ACP TLE2021CP	— TLE2021CPWLE	— TLE2021Y
–40°C to 85°C	200 µV 500 µV	TLE2021AID TLE2021ID	—	—	—	TLE2021AIP TLE2021IP	—	—
–55°C to 125°C	100 µV 200 µV 500 µV	— TLE2021AMD TLE2021MD	—	TLE2021BMFK TLE2021AMFK TLE2021MFK	TLE2021BMJG TLE2021AMJG TLE2021MJG	— TLE2021AMP TLE2021MP	—	—

† The D packages are available taped and reeled. To order a taped and reeled part, add the suffix R (e.g., TLE2021CDR).

‡ The DB and PW packages are only available left-end taped and reeled.

§ Chip forms are tested at 25°C only.

TLE2022 AVAILABLE OPTIONS

T _A	V _{IOMAX} AT 25°C	PACKAGED DEVICES						CHIP FORMS [§] (Y)
		SMALL OUTLINE† (D)	SSOP‡ (DB)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	
0°C to 70°C	150 µV 300 µV 500 µV	TLE2022BCD TLE2022ACD TLE2022CD	— — TLE2022CDBLE	—	—	— TLE2022ACP TLE2022CP	— — TLE2022CPWLE	— — TLE2022Y
–40°C to 85°C	150 µV 300 µV 500 µV	TLE2022BID TLE2022AID TLE2022ID	—	—	—	— TLE2022AIP TLE2022IP	—	—
–55°C to 125°C	150 µV 300 µV 500 µV	— TLE2022AMD TLE2022MD	—	— TLE2022AMFK TLE2022MFK	TLE2022BMJG TLE2022AMJG TLE2022MJG	— TLE2022AMP TLE2022MP	—	—

† The D packages are available taped and reeled. To order a taped and reeled part, add the suffix R (e.g., TLE2022CDR).

‡ The DB and PW packages are only available left-end taped and reeled.

† Chip forms are tested at 25°C only.

TLE2024 AVAILABLE OPTIONS

T _A	V _{IOMAX} AT 25°C	PACKAGED DEVICES				CHIP FORM† (Y)
		SMALL OUTLINE (DW)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	
0°C to 70°C	500 µV 750 µV 1000 µV	TLE2024BCDW TLE2024ACDW TLE2024CDW	—	—	TLE2024BCN TLE2024ACN TLE2024CN	— — TLE2024Y
–40°C to 85°C	500 µV 750 µV 1000 µV	TLE2024BIDW TLE2024AIDW TLE2024IDW	—	—	TLE2024BIN TLE2024AIN TLE2024IN	—
–55°C to 125°C	500 µV 750 µV 1000 µV	TLE2024BMDW TLE2024AMDW TLE2024MDW	TLE2024BMFK TLE2024AMFK TLE2024MFK	TLE2024BMJ TLE2024AMJ TLE2024MJ	TLE2024BMN TLE2024AMN TLE2024MN	—

† Chip forms are tested at 25°C only.

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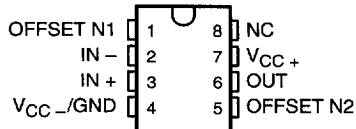
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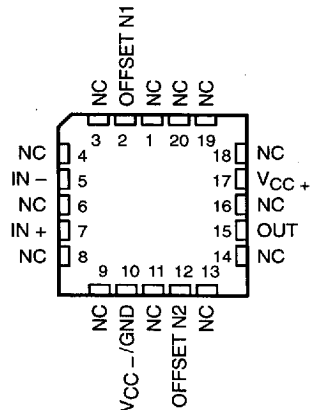
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description (continued)

TLE2021
D, DB, JG, P, OR PW PACKAGE
(TOP VIEW)

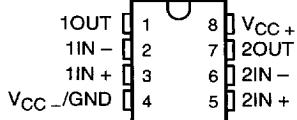


TLE2021
FK PACKAGE
(TOP VIEW)

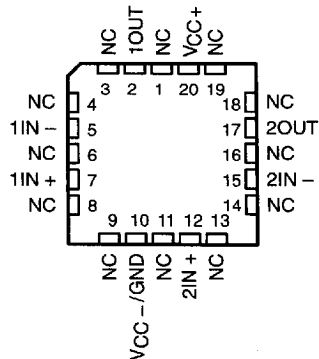


NC – No internal connection

D, DB, JG, P, OR PW PACKAGE
(TOP VIEW)



FK PACKAGE
(TOP VIEW)



NC – No internal connection

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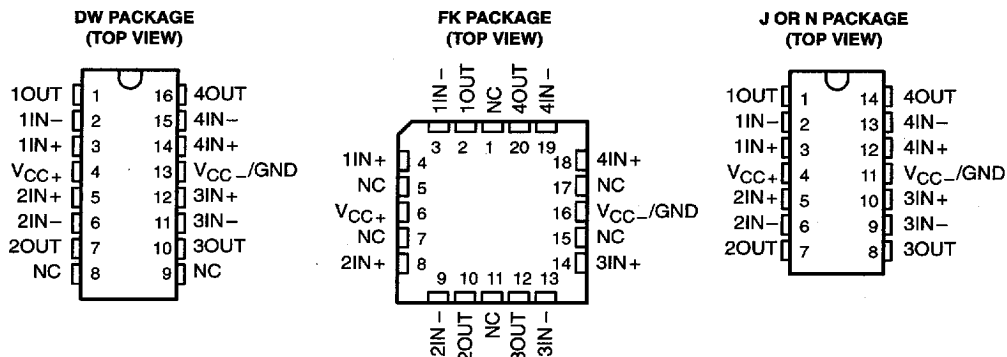
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NC – No internal connection

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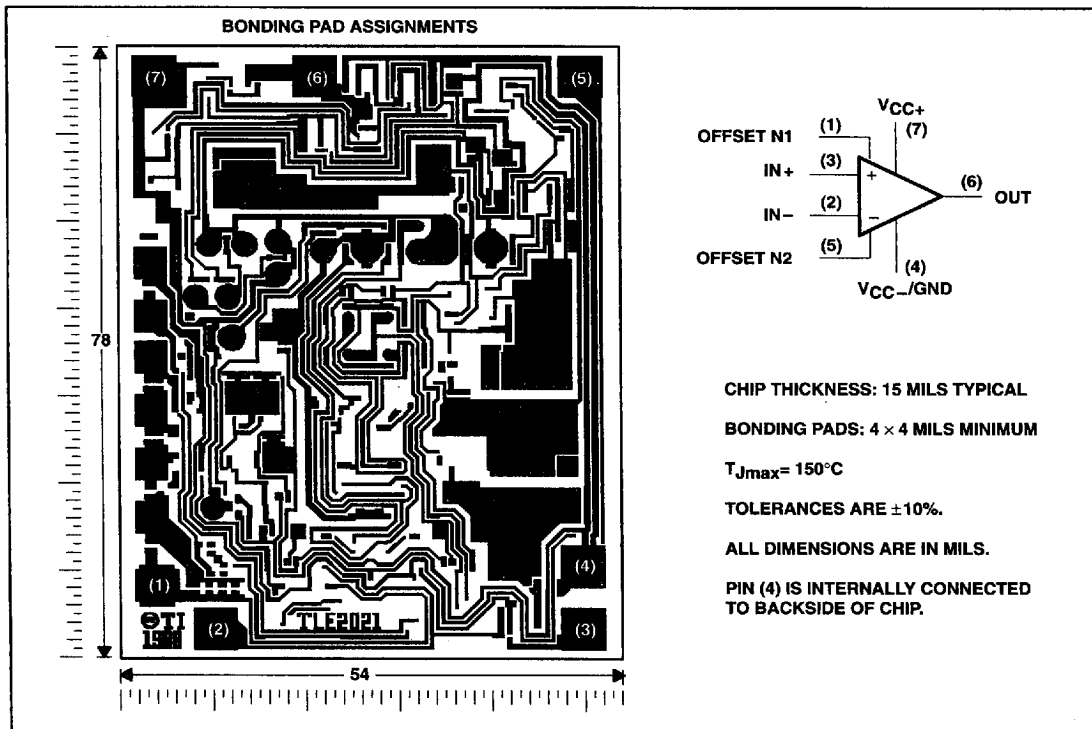
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TLE2021Y chip information

This chip, when properly assembled, display characteristics similar to the TLE2021. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.



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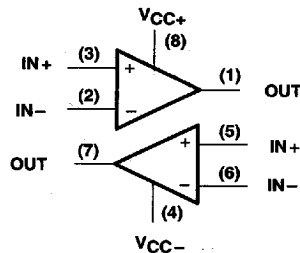
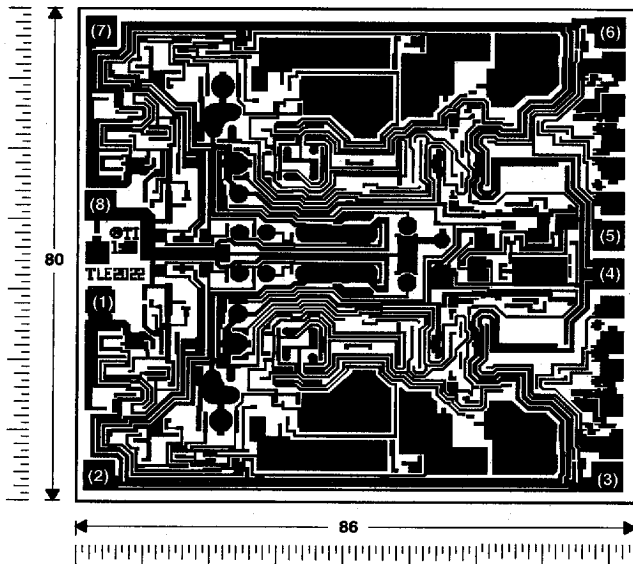
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TLE2022Y chip information

This chip, when properly assembled, displays characteristics similar to TLE2022. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.

BONDING PAD ASSIGNMENTS



CHIP THICKNESS: 15 MILS TYPICAL

BONDING PADS: 4 × 4 MILS MINIMUM

T_{Jmax} = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

PIN (4) IS INTERNALLY CONNECTED
TO BACKSIDE OF CHIP.

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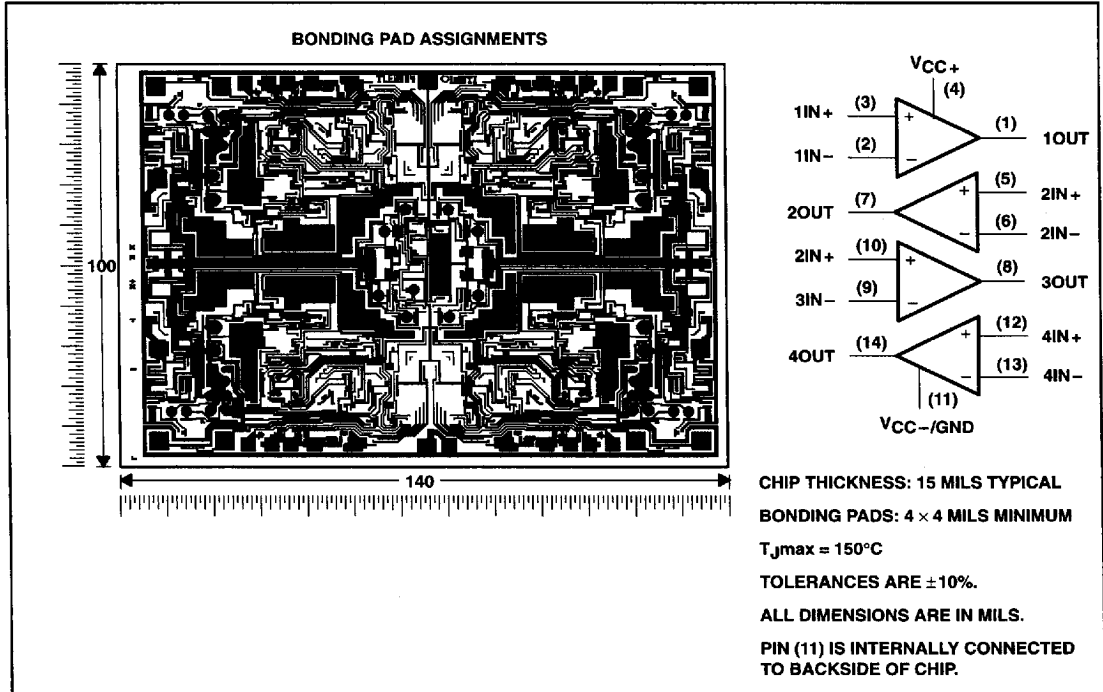
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TLE2024Y chip information

This chip, when properly assembled, displays characteristics similar to the TLE2024. Thermal compression or ultrasonic bonding may be used on the doped aluminum-bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.



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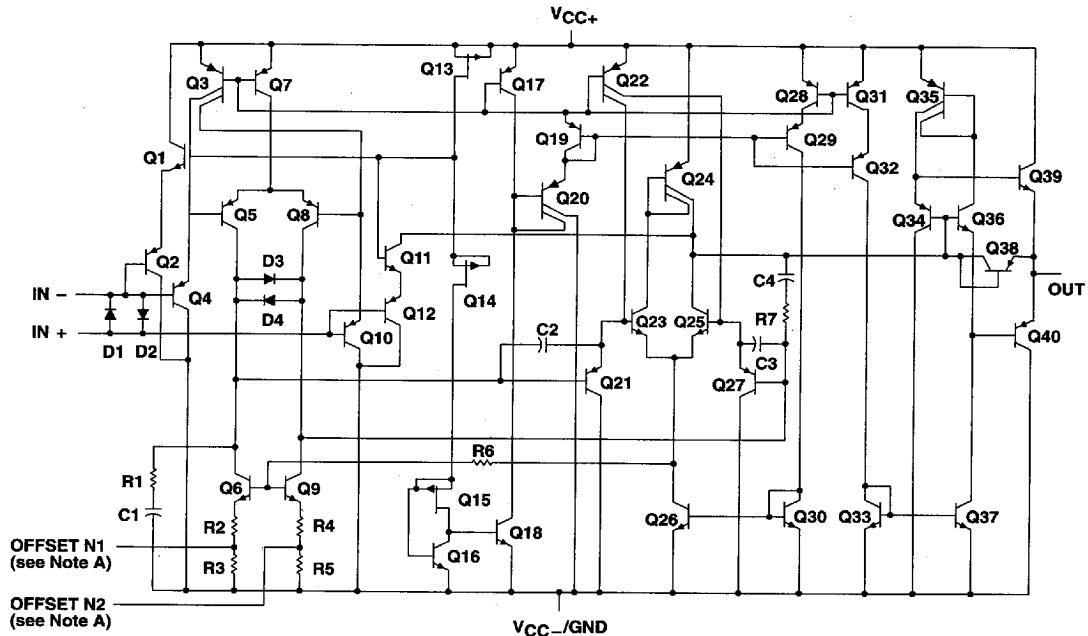
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equivalent schematic (each amplifier)



ACTUAL DEVICE COMPONENT COUNT			
COMPONENT	TLE2021	TLE2022	TLE2024
Transistors	40	80	160
Resistors	7	14	28
Diodes	4	8	16
Capacitors	4	8	16

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

Supply voltage, V_{CC+} (see Note 1)	20 V
Supply voltage, V_{CC-} (see Note 1)	–20 V
Differential input voltage, V_{ID} (see Note 2)	± 0.6 V
Input voltage range, V_I (any input, see Note 1)	$\pm V_{CC}$
Input current, I_I (each input)	± 1 mA
Output current, I_O (each output): TLE2021	± 20 mA
TLE2022	± 30 mA
TLE2024	± 40 mA
Total current into V_{CC+}	80 mA
Total current out of V_{CC-}	80 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : C suffix	0°C to 70°C
I suffix	–40°C to 85°C
M suffix	–55°C to 125°C
Storage temperature range, T_{stg}	–65°C to 150°C
Case temperature for 60 seconds, T_C : FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, DP, P, or PW 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_{CC+} and V_{CC-} .
2. Differential voltages are at I_N+ with respect to I_N- . Excessive current flows if a differential input voltage in excess of approximately ± 600 mV is applied between the inputs unless some limiting resistance is used.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D–8	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
DB–8	525 mW	4.2 mW/°C	336 mW	—	—
DW–16	1025 mW	8.2 mW/°C	656 mW	533 mW	205 mW
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
J–14	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG–8	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
N–14	1150 mW	9.2 mW/°C	736 mW	598 mW	230 mW
P–8	1000 mW	8.0 mW/°C	640 mW	520 mW	200 mW
PW–8	525 mW	4.2 mW/°C	336 mW	—	—

recommended operating conditions

		C SUFFIX		I SUFFIX		M SUFFIX		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}		± 2	± 20	± 2	± 20	± 2	± 20	V
Common-mode input voltage, V_{IC}	$V_{CC} \pm 5$ V	0	3.5	0	3.2	0	3.2	V
	$V_{CC} \pm \pm 15$ V	–15	13.5	–15	13.2	–15	13.2	
Operating free-air temperature, T_A		0	70	–40	85	–55	125	°C

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TLE2021 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A †	TLE2021C			TLE2021AC			TLE2021BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO} Input offset voltage	V _{IC} = 0, R _S = 50 Ω	25°C		120	600		100	300		80	200	μV
α _{VIO} Temperature coefficient of input offset voltage		Full range			850			600			300	
Input offset voltage long-term drift (see Note 4)		Full range		2			2			2		μV/°C
I _{IO} Input offset current		25°C		0.005			0.005			0.005		μV/mV
I _{IB} Input bias current	V _{IC} = 0, R _S = 50 Ω	25°C		0.2	6		0.2	6		0.2	6	nA
		Full range			10			10			10	
		25°C		25	70		25	70		25	70	
		Full range			90			90			90	
V _{ICR} Common-mode input voltage range	R _S = 50 Ω	25°C	0 to 3.5	-0.3 to 4	0 to 3.5	0 to 3.5	-0.3 to 4	0 to 3.5	0 to 3.5	-0.3 to 4	0 to 3.5	V
Full range		0 to 3.5			0 to 3.5			0 to 3.5				
V _{OH} High-level output voltage	R _L = 10 kΩ	25°C	4	4.3		4	4.3		4	4.3		V
V _{OL} Low-level output voltage		Full range	3.9			3.9			3.9			
A _{VD} Large-signal differential voltage amplification	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C		0.7	0.8		0.7	0.8		0.7	0.8	V
		Full range			0.85			0.85			0.85	
CMRR Common-mode rejection ratio	V _{IC} = V _{ICRmin} , R _S = 50 Ω	25°C	0.3	1.5		0.3	1.5		0.3	1.5		V/μV
Δ _{SVR} Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{IO})		Full range	0.3			0.3			0.3			
I _{CC} Supply current	V _O = 2.5 V, No load	25°C	85	110		85	110		85	110		dB
		Full range	80			80			80			
ΔI _{CC} Supply-current change over operating temperature range	V _O = 2.5 V, No load	25°C	105	120		105	120		105	120		dB
		Full range	100			100			100			
	V _O = 2.5 V, No load	25°C		170	230		170	230		170	230	μA
		Full range		230	230		230	230		230	230	μA
		Full range	5			5			5			μA

† 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.



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TLE2021 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLE2021C			TLE2021AC			TLE2021BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	120	500		80	200		40	100		μV
		Full range		750			500			200		
α_{VIO} Temperature coefficient of input offset voltage		Full range	2			2			2			$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.006			0.006			0.006			$\mu\text{V}/\text{mo}$
		25°C	0.2	6		0.2	6		0.2	6		nA
I_{IO} Input offset current		Full range		10			10			10		
		25°C	25	70		25	70		25	70		nA
I_{IB} Input bias current		Full range		90			90			90		
		25°C	-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		V
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range	-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		
		25°C	14	14.3		14	14.3		14	14.3		V
V_{OM+} Maximum positive peak output voltage swing		Full range	13.9			13.9			13.9			V
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.7			-13.7			-13.7			V
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	1	6.5		1	6.5		1	6.5		$\text{V}/\mu\text{V}$
		Full range	1			1			1			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\text{ min}, R_S = 50\ \Omega$	25°C	100	115		100	115		100	115		dB
		Full range	96			96			96			dB
KSVR Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC} = \pm 2.5\text{ V}$ to $\pm 15\text{ V}$	25°C	105	120		105	120		105	120		dB
		Full range	100			100			100			dB
I_{CC} Supply current	$V_O = 0, \text{ No load}$	25°C	200	300		200	300		200	300		μA
		Full range		300			300			300		
ΔI_{CC} Supply-current change over operating temperature range		Full range		6			6			6		μA

† 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.



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TLE2022 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A †	TLE2022C			TLE2022AC			TLE2022BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO} Input offset voltage	V _{IC} = 0, R _S = 50 Ω	25°C			600			400			250	μV
Temperature coefficient of input offset voltage		Full range			800			550			400	
Input offset voltage long-term drift (see Note 4)		Full range		2			2			2		
I _{IO} Input offset current			25°C		0.005			0.005			0.005	
I _{IB} Input bias current		25°C		0.5	6		0.4	6		0.3	6	nA
		Full range			10			10			10	
		25°C		35	70		33	70		30	70	
		Full range			90			90			90	
V _{ICR} Common-mode input voltage range	R _S = 50 Ω	25°C	0	-0.3 to 3.5	4	0	-0.3 to 3.5	4	0	-0.3 to 3.5	4	V
		Full range	0	0 to 3.5		0	0 to 3.5		0	0 to 3.5		
V _{OH} High-level output voltage	R _L = 10 kΩ	25°C	4	4.3		4	4.3		4	4.3		V
Full range		3.9			3.9			3.9				
25°C			0.7	0.8		0.7	0.8		0.7	0.8		
Full range				0.85			0.85			0.85		
A _{VD} Large-signal differential voltage amplification	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V
Full range		0.3			0.4			0.5				
CMRR Common-mode rejection ratio	V _{IC} = V _{ICRmin} , R _S = 50 Ω	25°C	85	100		87	102		90	105		dB
k _{SVR} Supply-voltage rejection ratio (ΔV _{CC} ± ΔV _{IO})	V _{CC} = 5 V to 30 V	Full range	80			82			85			dB
		25°C	100	115		103	118		105	120		
		Full range	95			98			100			
I _{CC} Supply current	V _O = 2.5 V, No load	25°C		450	600		450	600		450	600	μA
Full range				600			600			600		
ΔI _{CC} Supply current change over operating temperature range		Full range		7			7			7		μA

† 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.



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TLE2022 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TA†	TLE2022C			TLE2022AC			TLE2022BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	25°C	150	500	500	120	300	300	70	150	150	μV
α _{VIO}	Temperature coefficient of input offset voltage	Full range			700			450			300	μV/°C
	Input offset voltage long-term drift (see Note 4)	Full range			2			2			2	μV/°C
I _{IO}	Input offset current	25°C		0.006			0.006			0.006		μV/mo
I _{IB}	Input bias current	25°C		0.5	6		0.4	6		0.3	6	nA
		Full range			10			10			10	nA
		25°C		35	70		33	70		30	70	nA
		Full range			90			90			90	nA
V _{ICR}	Common-mode input voltage range	25°C	-15	-15.3		-15	-15.3		-15	-15.3		V
		Full range	13.5	14		13.5	14		13.5	14		V
		Full range	-15	to		-15	to		-15	to		V
		Full range	13.5	to		13.5	to		13.5	to		V
V _{OM+}	Maximum positive peak output voltage swing	25°C	14	14.3		14	14.3		14	14.3		V
V _{OM-}	Maximum negative peak output voltage swing	25°C	13.9	13.9		13.9	13.9		13.9	13.9		V
A _{VD}	Large-signal differential voltage amplification	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.7	-13.7		-13.7	-13.7		-13.7	-13.7		V
		25°C	0.8	4		1	7		1.5	10		V/μV
		Full range	0.8			1			1.5			V/μV
CMRR	Common-mode rejection ratio	25°C	95	106		97	109		100	112		dB
		Full range	91			93			96			dB
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})	25°C	100	115		103	118		105	120		dB
		Full range	95			98			100			dB
I _{CC}	Supply current	25°C		550	700		550	700		550	700	μA
ΔI _{CC}	Supply current change over operating temperature range	Full range			700			700			700	μA
		Full range			9			9			9	μA

† 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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TLE2024 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLE2024C			TLE2024AC			TLE2024BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C			1100			850			600	μV
		Full range			1300			1050			800	
α_{VIO} Temperature coefficient of input offset voltage		Full range		2						2		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.005						0.005		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C		0.6	6			6		0.4	6	nA
	$R_S = 50\ \Omega$	Full range			10			10			10	
I_{IB} Input bias current		25°C		45	70			40		35	70	nA
		Full range			90			90			90	
V_{ICR} Common-mode input voltage range		25°C	0	-0.3	to 3.5	0	-0.3	to 3.5	0	-0.3	to 3.5	V
		Full range			0 to 3.5			0 to 3.5			0 to 3.5	
V_{OH} High-level output voltage	$R_L = 10\text{ k}\Omega$	25°C	3.9	4.2		3.9	4.2		4	4.3		V
		Full range		3.7			3.7			3.8		
V_{OL} Low-level output voltage		25°C		0.7	0.8		0.7	0.8		0.7	0.8	V
		Full range			0.95			0.95			0.95	
Large-signal differential voltage amplification		25°C	0.2	1.5		0.3	1.5		0.4	1.5		V/ μV
A_{VD}	$V_O = 1.4\text{ V to }4\text{ V}$, $R_L = 10\text{ k}\Omega$	Full range	0.1			0.1			0.1			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $R_S = 50\ \Omega$	25°C	80	90		82	92		85	95		dB
		Full range	80			82			85			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to }30\text{ V}$	25°C	98	112		100	115		103	117		dB
		Full range	93			95			98			
I_{CC} Supply current	$V_O = 2.5\text{ V}$, No load	25°C		800	1200			800		800	1200	μA
		Full range			1200			1200			1200	
ΔI_{CC} Supply current change over operating temperature range		Full range		15			15			15		μA

† Full range is $0^\circ\text{C to }70^\circ\text{C}$.

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.



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TLE2024 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TA†	TLE2024C			TLE2024AC			TLE2024BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C			1000			750			500	μ V
		Full range			1200			950			700	μ V
α_{VIO} Temperature coefficient of input offset voltage		Full range										μ V/°C
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0$, $R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μ V/mo
I_{IO} Input offset current		25°C		0.6	6		0.5	6		0.4	6	nA
		Full range			10			10			10	nA
I_{IB} Input bias current		25°C		50	70		45	70		40	70	nA
		Full range			90			90			90	nA
V_{ICR} Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15	-15.3		-15	-15.3		-15	-15.3		V
		Full range	13.5	14		13.5	14		13.5	14		V
		Full range	-15			-15			-15			V
		Full range	13.5			13.5			13.5			V
V_{OM+} Maximum positive peak output voltage swing		25°C	13.8	14.1		13.9	14.2		14	14.3		V
		Full range	13.7			13.8			13.9			V
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10 \text{ k}\Omega$	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.6			-13.6			-13.6			V
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10$ V, $R_L = 10 \text{ k}\Omega$	25°C	0.4	2		0.8	4		1	7		V/ μ V
		Full range	0.4			0.8			1			V/ μ V
$CMRR$ Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $R_S = 50 \Omega$	25°C	92	102		94	105		97	108		dB
		Full range	88			90			93			dB
KS_{VR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm 2.5$ V to ± 15 V	25°C	98	112		100	115		103	117		dB
		Full range	93			95			98			dB
I_{CC} Supply current	$V_O = 0$, No load	25°C		1050	1400		1050	1400		1050	1400	μ A
		Full range			1400			1400			1400	μ A
ΔI_{CC} Supply current change over operating temperature range		Full range		20			20			20		μ A

† 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.



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TLE2021 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A [†]	TLE2021I			TLE2021AI			TLE2021BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	120	600	300	100	300	600	80	200	300	μV
α_{VIO} Temperature coefficient of input offset voltage		Full range		950								$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		Full range	2			2			2			$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current		25°C	0.005			0.005			0.005			$\mu\text{V}/\text{mV}$
I_{IB} Input bias current		25°C	0.2	6	6	0.2	6	6	0.2	6	6	nA
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	Full range		10	10		10	10		10	10	nA
		25°C	25	70	70	25	70	70	25	70	70	nA
		Full range		90	90		90	90		90	90	nA
V_{OL} Low-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C	0	-0.3	0	-0.3	0	0	0	-0.3	0	V
		Full range	-15	to 3.2	to 3.2	15	to 3.2	to 3.2	0	to 3.2	to 3.2	V
		Full range	3.9			3.9			3.9			V
V_{OH} High-level output voltage	$V_O = 1.4\text{ V to }4\text{ V}; R_L = 10\ \text{k}\Omega$	25°C	4	4.3	4	4.3	4	4.3	4	4.3	4	V
V_{OL} Low-level output voltage		Full range	3.9			3.9			3.9			V
A_{VD} Large-signal differential voltage amplification		25°C	0.7	0.8	0.8	0.7	0.8	0.8	0.7	0.8	0.8	V
$CMRR$ Common-mode rejection ratio	$V_{IC} = V_{ICR}\text{ min}, R_S = 50\ \Omega$	Full range	0.3	1.5	0.3	1.5	0.3	1.5	0.3	1.5	0.3	V/ μV
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)		25°C	0.25			0.25			0.25			V/ μV
I_{CC} Supply current		Full range	85	110	110	85	110	110	85	110	110	μA
ΔI_{CC} Supply-current change over operating temperature range	$V_O = 2.5\text{ V}, \text{No load}$	25°C	80			80			80			μA
		Full range	105	120	120	105	120	120	105	120	120	μA
		Full range	100			100			100			μA

[†] 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.



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TLE2021 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A †	TLE2021			TLE2021AI			TLE2021BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO} Input offset voltage		25°C	120	500		80	200		40	100		μV
		Full range		850			500			200		
α _{VIO} Temperature coefficient of input offset voltage		Full range										μV/°C
Input offset voltage long-term drift (see Note 4)	V _{IC} = 0, R _S = 50 Ω	25°C		0.006			0.006			0.006		μV/mo
I _{IO} Input offset current		25°C		0.2	6		0.2	6		0.2	6	nA
		Full range			10			10			10	
I _{IB} Input bias current		25°C		25	70		25	70		25	70	nA
		Full range			90			90			90	
V _{ICR} Common-mode input voltage range	R _S = 50 Ω	25°C	-15	-15.3		-15	-15.3		-15	-15.3		V
			to	to		to	to		to	to		
			13.5	14		13.5	14		13.5	14		
		Full range	-15			15			15			
			to			to			to			
			3.2			3.2			3.2			
V _{OM +} Maximum positive peak output voltage swing	R _L = 10 kΩ	25°C	14	14.3		14	14.3		14	14.3		V
		Full range	13.9			13.9			13.9			
V _{OM -} Maximum negative peak output voltage swing		25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.6			-13.6			-13.6			
A _{VD} Large-signal differential voltage amplification	V _O = 10 V, R _L = 10 kΩ	25°C	1	6.5		1	6.5		1	6.5		V/μV
		Full range	0.75			0.75			0.75			
CMRR Common-mode rejection ratio	V _{IC} = V _{ICR} min, R _S = 50 Ω	25°C	100	115		100	115		100	115		dB
		Full range	96			96			96			
K _{SVR} Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{IO})	V _{CC} ± = ± 2.5 V to ± 15 V	25°C	105	120		105	120		105	120		dB
		Full range	100			100			100			
I _{CC} Supply current	V _O = 0 V, No load	25°C	200	300		200	300		200	300		μA
		Full range		300			300			300		
ΔI _{CC} Supply-current change over operating temperature range		Full range										μA

† 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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TLE2022 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T _A †	TLE2022I			TLE2022AI			TLE2022BI			UNIT	
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
V _{IO}	Input offset voltage	V _{I/C} = 0, R _S = 50 Ω	25°C			600			400			250	μV	
α _{VIO}	Temperature coefficient of input offset voltage		Full range			800			550			400		
	Input offset voltage long-term drift (see Note 4)		Full range		2				2			2	μV/°C	
I _{IO}	Input offset current		25°C		0.005				0.005			0.005	μV/mV	
			25°C		0.5	6			0.4	6		0.3	6	nA
		Full range				10			10			10		
I _{IB}	Input bias current	25°C			35	70		33	70		30	70	nA	
		Full range				90			90			90		
V _{ICR}	Common-mode input voltage range	R _S = 50 Ω	25°C	0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		V	
			Full range		0 to 3.2		0 to 3.2		0 to 3.2		0 to 3.2			
V _{OH}	High-level output voltage		25°C		4	4.3		4	4.3		4	4.3		V
			Full range		3.9		3.9		3.9		3.9			
V _{OL}	Low-level output voltage		25°C			0.7	0.8		0.7	0.8		0.7	0.8	V
		Full range				0.9			0.9			0.9		
A _{VD}	Large-signal differential voltage amplification	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V/μV	
			Full range		0.2		0.2		0.2		0.2			
CMRR	Common-mode rejection ratio		25°C	85	100		87	102	90	105				dB
			Full range		80		82		85					
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC} ±/ΔV _{I/O})		25°C	100	115		103	118	105	120				dB
		Full range		95		98		100						
I _{CC}	Supply current	V _O = 2.5 V, No load	25°C		450	600		450	600		450	600	μA	
			Full range			600			600			600		
ΔI _{CC}	Supply current change over operating temperature range		Full range		15			15			15			μA

† 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.



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TLE2022 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	TLE2022		TLE2022AI		TLE2022BI		UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50 \Omega$	25°C	150	150	500	120	120	300	μV
α_{VIO} Temperature coefficient of input offset voltage		Full range			700			450	
Input offset voltage long-term drift (see Note 4)		Full range		2			2		$\mu V/^\circ C$
I_{IO} Input offset current		25°C		0.006			0.006		$\mu V/mo$
I_{IB} Input bias current	$R_S = 50 \Omega$	25°C	0.5	0.5	6	0.4	0.4	6	nA
		Full range			10			10	
		25°C	35	35	70	33	33	70	nA
		Full range			90			90	
V_{ICR} Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15 to 15.3	-15 to 15.3	-15 to 15.3	-15 to 15.3	-15 to 15.3	-15 to 15.3	V
		Full range	-15 to 13.5	-15 to 14	-15 to 13.2	-15 to 13.5	-15 to 14	-15 to 13.2	
		25°C	14	14	14.3	14	14	14.3	V
		Full range	13.9	13.9	13.9	13.9	13.9	13.9	
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10 k\Omega$	25°C	-13.7	-13.7	-14.1	-13.7	-13.7	-14.1	V
		Full range	-13.6	-13.6	-13.6	-13.6	-13.6	-13.6	
		25°C	0.8	0.8	4	1	1	7	V/ μV
		Full range	0.8	0.8		1	1		
$CMRR$ Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $R_S = 50 \Omega$	25°C	95	95	106	97	109	112	dB
		Full range	91	91		93		96	
		25°C	100	100	115	103	118	120	dB
		Full range	95	95		98		100	
I_{CC} Supply current	$V_O = 0$, No load	25°C		550	700		550	700	μA
		Full range			700			700	
		Full range		30			30		μA
		Full range							

† 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 $T_A = 150^\circ C$ extrapolated to $T_A = 25^\circ C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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TLE2024 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A †	TLE2024I		TLE2024AI		TLE2024BI		UNIT		
			MIN	TYP	MAX	MIN	TYP	MAX			
V _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C			1100			850	μV		
α _{VIO}		Full range			1300			1050			
		Full range		2			2				
Input offset voltage long-term drift (see Note 4)			25°C		0.005			0.005		μV/mo	
I _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C		0.6	6		0.5	6	nA		
Input offset current		Full range			10			10			
		25°C		45	70		40	70			
I _{IB}			Full range			90			90	nA	
V _{ICR}	R _S = 50 Ω	25°C	0	-0.3 to 3.5	4		0	-0.3 to 3.5	4	V	
		Full range		0		0		0			
				3.2		3.2		3.2			
V _{OM+}	R _L = 10 kΩ	25°C	3.9	4.2		3.9	4.2	4	4.3	V	
Maximum positive peak output voltage swing		Full range		3.7		3.7		3.8			
		25°C		0.7	0.8		0.7	0.8	0.7	0.8	
V _{OM-}		Full range			0.95			0.95	0.95	V	
A _{VD}	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.2	1.5		0.3	1.5	0.4	1.5	V/μV	
CMRR	V _{IC} = V _{ICRmin} , R _S = 50 Ω	Full range		0.1		0.1		0.1			
		25°C		80	90		82	92	85	95	dB
		Full range		80		82		85			
k _{SVR}	V _{CC±} = ±2.5 V to ±15 V	25°C	98	112		100	115	103	117	dB	
I _{OC}	V _O = 0, No load	Full range		93		95		98			
		25°C			800	1200		800	1200		μA
		Full range			1200			1200			
ΔI _{CC}		Full range			30			30		μA	

† 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.



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TLE2024 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A [†]	TLE2024I		TLE2024AI		TLE2024BI		UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	25°C			1000			750	μV
α _{VIO}	Temperature coefficient of input offset voltage	Full range			1200			950	μV
		Full range			2			2	μV/°C
	Input offset voltage long-term drift (see Note 4)	25°C			0.006			0.006	μV/mo
I _{IO}	Input offset current	25°C			0.6			6	nA
		Full range			10			10	nA
I _{IB}	Input bias current	25°C			50			70	nA
		Full range			90			90	nA
V _{ICR}	Common-mode input voltage range								
		V _{IC} = 0, R _S = 50 Ω							
		25°C	-15	-15.3	to 15.3	-15	-15.3	to 15.3	V
V _{OM+}	Maximum positive peak output voltage swing								
		25°C	13.5	14	13.5	14	13.5	14	V
		Full range	-15	to 13.2	-15	to 13.2	-15	to 13.2	V
V _{OM-}	Maximum negative peak output voltage swing								
		25°C	13.8	14.1	13.9	14.2	14	14.3	V
		Full range	13.7	13.7	13.7	13.7	13.8	13.8	V
A _{VD}	Large-signal differential voltage amplification								
		25°C	-13.7	-14.1	-13.7	-14.1	-13.7	-14.1	V
		Full range	-13.6	-13.6	-13.6	-13.6	-13.6	-13.6	V
CMRR	Common-mode rejection ratio								
		25°C	0.4	2	0.8	4	1	7	V/μV
		Full range	0.4	0.4	0.8	0.8	1	1	V/μV
KSVR	Supply-voltage rejection ratio (ΔV _{CC} ± ΔV _{IO})								
		25°C	92	102	94	105	97	108	dB
		Full range	88	88	90	90	93	93	dB
I _{CC}	Supply current								
		25°C	98	112	100	115	103	117	μA
		Full range	93	93	95	95	98	98	μA
ΔI _{CC}	Supply current change over operating temperature range								
		25°C	1050	1400	1050	1400	1050	1400	μA
		Full range	1400	1400	1400	1400	1400	1400	μA
ΔI _{CC}	Supply current change over operating temperature range								
		Full range	50	50	50	50	50	50	μA

[†] 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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TLE2021 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLE2021M			TLE2021AM			TLE2021BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C										μV
Temperature coefficient of input offset voltage		Full range										$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		Full range										$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C										nA
I_{IB} Input bias current	$R_S = 50\ \Omega$	25°C										nA
Common-mode input voltage range		Full range										V
V_{ICR}		25°C										V
V_{OH} High-level output voltage		Full range										V
V_{OL} Low-level output voltage	$R_L = 10\ \text{k}\Omega$	25°C										V
Large-signal differential voltage amplification		Full range										V/ μV
CMRR Common-mode rejection ratio		25°C										dB
kSVR Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)		Full range										dB
I_{CC} Supply current	No load	25°C										μA
Supply current change over operating temperature range		Full range										μA
ΔI_{CC}		25°C										μA
		Full range										μA

† 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.



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TLE2021 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLE2021M			TLE2021AM			TLE2021BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C		120	500		80	200		40	100	μ V
		Full range			1000			500			200	
α_{VIO} Temperature coefficient of input offset voltage		Full range		2			2			2		μ V/°C
Input offset voltage long-term drift (see Note 4)		Full range										
I_{IO} Input offset current	$V_{IC} = 0$, $R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μ V/mV
		25°C		0.2	6		0.2	6		0.2	6	nA
		Full range			10			10			10	
I_{IB} Input bias current		25°C		25	70		25	70		25	70	nA
		Full range			90			90			90	
V_{ICR} Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15	-15.3		-15	-15.3		-15	-15.3		V
		Full range	-15	to		-15	to		-15	to		
			13.5	14		13.5	14		13.5	14		
			-15	to		-15	to		0	to		
			13.2			13.2			13.2			
V_{OM+} Maximum positive peak output voltage swing		25°C	14	14.3		14	14.3		14	14.3		V
		Full range	13.8			13.8			13.8			
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10 \text{ k}\Omega$	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.6			-13.6			-13.6			
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10$ V, $R_L = 10 \text{ k}\Omega$	25°C	1	6.5		1	6.5		1	6.5		V/ μ V
		Full range	0.5			0.5			0.5			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $R_S = 50 \Omega$	25°C	100	115		100	115		100	115		dB
		Full range	96			96			96			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm 2.5$ V to ± 15 V	25°C	105	120		105	120		105	120		dB
		Full range	100			100			100			
I_{CC} Supply current	$V_O = 0$, No load	25°C		200	300		200	300		200	300	μ A
ΔI_{CC} Supply current change over operating temperature range		Full range			300			300			300	
		Full range		10			10			10		μ A

† 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.



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TLE2022 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A [†]	TLE2022M			TLE2022AM			TLE2022BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C			600			400			250	μV
		Full range			800			550			400	
α _{VIO}		Full range	2			2			2			μV/°C
Input offset voltage long-term drift (see Note 4)		25°C		0.005			0.005			0.005		μV/mo
I _{IO}		25°C		0.5	6		0.4	6		0.3	6	nA
I _{IB}	Full range	Full range			10			10			10	
		25°C		35	70		33	70		30	70	nA
	Full range	Full range			90			90			90	
V _{ICR}	R _S = 50 Ω	25°C	0	–0.3		0	–0.3		0	–0.3		V
			to	to		to	to		to	to		
		Full range	3.5	4		3.5	4		3.5	4		
V _{OH}	R _L = 10 kΩ	25°C	0			0			0			V
			to	to		to	to		to	to		
		Full range	3.2			3.2			3.2			
V _{OL}		25°C	4	4.3		4	4.3		4	4.3		
		Full range	3.8			3.8			3.8			
A _{VD}		25°C		0.7	0.8		0.7	0.8		0.7	0.8	
		Full range		0.95			0.95			0.95		
CMRR	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V/μV
		Full range	0.1			0.1			0.1			
k _{SVR}	V _{IC} = V _{ICRmin} , R _S = 50 Ω	25°C	85	100		87	102		90	105		dB
		Full range	80			82			85			
I _{CC}	V _{CC} = 5 V to 30 V	25°C	100	115		103	118		105	120		dB
		Full range	95			98			100			
ΔI _{CC}	V _O = 2.5 V, No load	25°C		450	600		450	600		450	600	μA
		Full range		600			600			600		
		Full range		37			37			37		μA

[†] 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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TLE2022 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A [†]	TLE2022M		TLE2022AM		TLE2022BM		UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	25°C		150	500		120	300	μ V
		Full range			700			450	
α_{VIO}	Temperature coefficient of input offset voltage	Full range		2			2		μ V/°C
	Input offset voltage long-term drift (see Note 4)			0.006			0.006		μ V/mo
I_{IO}	Input offset current	25°C		0.5	6		0.4	6	nA
		Full range			10			10	
I_{IB}	Input bias current	25°C		35	70		33	70	nA
		Full range			90			90	
V_{ICR}	Common-mode input voltage range	25°C	-15	-15.3		-15	-15.3		V
		Full range	13.5	14		13.5	14		
			-15			-15			
			13.2			13.2			
V_{OM+}	Maximum positive peak output voltage swing	25°C	14	14.3		14	14.3		V
		Full range	13.9			13.9			
V_{OM-}	Maximum negative peak output voltage swing	25°C	-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.6			-13.6			
A_{VD}	Large-signal differential voltage amplification	25°C	0.8	4		1	7		V/ μ V
		Full range	0.8			1			
$CMRR$	Common-mode rejection ratio	25°C	95	106		97	109		dB
		Full range	91			93			
$KSVR$	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	25°C	100	115		103	118		dB
		Full range	95			98			
I_{CC}	Supply current	25°C	550	700		550	700		μ A
		Full range		700			700		
ΔI_{CC}	Supply current change over operating temperature range	Full range	60			60			μ A

[†] 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.



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TLE202x, TLE202xA, TLE202xB, TLE202xY
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TLE2024 electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A †	TLE2024M			TLE2024AM			TLE2024BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$	25°C		1100				850			600	μV
		Full range		1300				1050			800	
α_{VIO} Temperature coefficient of input offset voltage		Full range		2			2			2		$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		25°C		0.005				0.005			0.005	$\mu\text{V}/\text{mo}$
I_{IO} Input offset current		25°C		0.6	6		0.5	6		0.4	6	nA
I_{IB} Input bias current		Full range		10				10			10	
		25°C		45	70		40	70		35	70	nA
		Full range		90				90			90	
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		V
		Full range	0 to 3.2			0 to 3.2			0 to 3.2			
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	3.9	4.2		3.9	4.2		4	4.3		V
		Full range	3.7			3.7			3.8			
V_{OM-} Maximum negative peak output voltage swing		25°C		0.7	0.8		0.7	0.8		0.7	0.8	V
		Full range		0.95			0.95			0.95		
A_{VD} Large-signal differential voltage amplification	$V_O = 1.4\text{ V to }4\text{ V}$, $R_L = 10\ \text{k}\Omega$	25°C	0.2	1.5		0.3	1.5		0.4	1.5		V/ μV
		Full range	0.1			0.1			0.1			
$CMRR$ Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $R_S = 50\ \Omega$	25°C	80	90		82	92		85	95		dB
		Full range	80			82			85			
KS_{VR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC} \pm = \pm 2.5\text{ V to } \pm 15\text{ V}$	25°C	98	112		100	115		103	117		dB
		Full range	93			95			98			
I_{CC} Supply current	No load	25°C		800	1200		800	1200		800	1200	μA
		Full range		1200			1200			1200		
ΔI_{CC} Supply current change over operating temperature range	$V_O = 0$	Full range		50			50			50		μA

† 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.



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TLE2024 electrical characteristics at specified free-air temperature, $V_{CC} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T _A †	TLE2024M			TLE2024AM			TLE2024BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	25°C			1000			750			500	μV
α _{VIO}	Temperature coefficient of input offset voltage	Full range			1200			950			700	μV
	Input offset voltage long-term drift (see Note 4)	Full range		2			2			2		μV/°C
I _{IO}	Input offset current	25°C		0.006			0.006			0.006		μV/mo
		25°C		0.6	6		0.5	6		0.4	6	nA
		Full range			10			10			10	nA
I _{IB}	Input bias current	25°C		50	70		45	70		40	70	nA
		Full range			90			90			90	nA
V _{ICR}	Common-mode input voltage range	25°C	–15 to 13.5	–15.3 to 14		–15 to 13.5	–15.3 to 14		–15 to 13.5	–15.3 to 14		V
		Full range	–15 to 13.2			–15 to 13.2			–15 to 13.2			V
V _{OM+}	Maximum positive peak output voltage swing	25°C	13.8	14.1		13.9	14.2		14	14.3		V
		Full range	13.7			13.7			13.8			V
V _{OM–}	Maximum negative peak output voltage swing	25°C	–13.7	–14.1		–13.7	–14.1		–13.7	–14.1		V
		Full range	–13.6			–13.6			–13.6			V
A _{VD}	Large-signal differential voltage amplification	25°C	0.4	2		0.8	4		1	7		V/μV
		Full range	0.4			0.8			1			V/μV
CMRR	Common-mode rejection ratio	25°C	92	102		94	105		97	108		dB
		Full range	88			90			93			dB
KS _{VR}	Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{IO})	25°C	98	112		100	115		103	117		dB
		Full range	93			95			98			dB
I _{CC}	Supply current	25°C		1050	1400		1050	1400		1050	1400	μA
		Full range			1400			1400			1400	μA
ΔI _{CC}	Supply current change over operating temperature range	Full range		85			85			85		μA

† 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°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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TLE2021 operating characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	T_A	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1		0.5			0.5			0.5		V/ μs
V_n	Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$		21	50		21	50		21		nV/Hz
		$f = 1\text{ kHz}$		17	30		17	30		17		nV/Hz
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$		0.16			0.16			0.16		μV
		$f = 0.1\text{ to }10\text{ Hz}$		0.47			0.47			0.47		μV
I_n	Equivalent input noise current			0.09			0.09			0.09		pA/Hz
B_1	Unity-gain bandwidth	See Figure 3		1.2			1.2			1.2		MHz
ϕ_m	Phase margin at unity gain	See Figure 3		42°			42°			42°		

TLE2021 operating characteristics at specified free-air temperature, $V_{CC} = \pm 15\text{ V}$

PARAMETER	TEST CONDITIONS	T_A †	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1		0.45	0.65		0.45	0.65		0.45	0.65	V/ μs
V_n	Equivalent input noise voltage (see Figure 2)	Full range		0.45			0.42			0.45		V/ μs
		$f = 10\text{ Hz}$		19	50		19	50		19		nV/Hz
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	$f = 1\text{ kHz}$		15	30		15	30		15		nV/Hz
		$f = 0.1\text{ to }1\text{ Hz}$		0.16			0.16			0.16		μV
I_n	Equivalent input noise current	$f = 0.1\text{ to }10\text{ Hz}$		0.47			0.47			0.47		μV
				0.09			0.09			0.09		pA/Hz
B_1	Unity-gain bandwidth	See Figure 3		2			2			2		MHz
ϕ_m	Phase margin at unity gain	See Figure 3		46°			46°			46°		

† Full range is 0°C to 70°C for the C-suffix devices, -40°C to 85°C for the I-suffix devices, and -55°C to 125°C for the M-suffix devices.



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TLE2022 operating characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1		0.5			0.5			0.5		V/ μs
V_n Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$		21	50		21	50		21		nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$		17	30		17	30		17		
	$f = 0.1\text{ to }1\text{ Hz}$		0.16			0.16			0.16		μV
$V_n(\text{PP})$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }10\text{ Hz}$		0.47			0.47			0.47		pA/ $\sqrt{\text{Hz}}$
I_n Equivalent input noise current			0.1			0.1			0.1		MHz
B_1 Unity-gain bandwidth	See Figure 3		1.7			1.7			1.7		
ϕ_m Phase margin at unity gain	See Figure 3		47°			47°			47°		

TLE2022 operating characteristics at specified free-air temperature, $V_{CC} = \pm 15\text{ V}$

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 10\text{ V}$, See Figure 1	25°C	0.45	0.65		0.45	0.65		0.45	0.65		V/ μs
V_n Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$	Full range	0.45			0.42			0.4			
	$f = 1\text{ kHz}$	25°C		19	50		19	50		19		nV/ $\sqrt{\text{Hz}}$
	$f = 0.1\text{ to }1\text{ Hz}$	25°C		15	30		15	30		15		
$V_n(\text{PP})$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C		0.16			0.16			0.16		μV
	$f = 0.1\text{ to }10\text{ Hz}$	25°C		0.47			0.47			0.47		
		25°C		0.1			0.1			0.1		pA/ $\sqrt{\text{Hz}}$
I_n Equivalent input noise current		25°C		2.8			2.8			2.8		MHz
B_1 Unity-gain bandwidth	See Figure 3	25°C		52°			52°			52°		
ϕ_m Phase margin at unity gain	See Figure 3	25°C										

† Full range is 0°C to 70°C.



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TLE2024 operating characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1	0.5			0.5			0.5			V/ μs
V_n Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$	21	50		21	50		21	50		nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$	17	30		17	30		17	30		
$V_n(\text{PP})$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	0.16			0.16			0.16			μV
	$f = 0.1\text{ to }10\text{ Hz}$	0.47			0.47			0.47			
I_n Equivalent input noise current		0.1			0.1			0.1			pA/ $\sqrt{\text{Hz}}$
B_1 Unity-gain bandwidth	See Figure 3	1.7			1.7			1.7			MHz
ϕ_m Phase margin at unity gain	See Figure 3	47°			47°			47°			

TLE2024 operating characteristics at specified free-air temperature, $V_{CC} = \pm 15\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^\dagger$	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = \pm 10\text{ V}$, See Figure 1	25°C	0.45	0.7		0.45	0.7		0.45	0.7		V/ μs
V_n Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$	Full range	0.45			0.42			0.4			
	$f = 1\text{ kHz}$	25°C	19	50		19	50		19	50		nV/ $\sqrt{\text{Hz}}$
$V_n(\text{PP})$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$	25°C	15	30		15	30		15	30		
	$f = 0.1\text{ to }10\text{ Hz}$	25°C	0.16			0.16			0.16			μV
I_n Equivalent input noise current		25°C	0.47			0.47			0.47			pA/ $\sqrt{\text{Hz}}$
B_1 Unity-gain bandwidth	See Figure 3	25°C	0.1			0.1			0.1			MHz
ϕ_m Phase margin at unity gain	See Figure 3	25°C	2.8			2.8			2.8			
		25°C	52°			52°			52°			

† Full range is $0^\circ\text{C to }70^\circ\text{C}$.



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TLE2021Y electrical characteristics at $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLE2021Y			UNIT
		MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$		150		μV
Input offset voltage long-term drift (see Note 4)			0.005		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current			0.5		nA
I_{IB} Input bias current			35		nA
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$		-0.3 to 4		V
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$		4.3		V
V_{OL} Maximum low-level output voltage			0.7		V
A_{VD} Large-signal differential voltage amplification	$V_O = 1.4\text{ to }4\text{ V}$, $R_L = 10\ \text{k}\Omega$		1.5		$\text{V}/\mu\text{V}$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\text{ min.}$, $R_S = 50\ \Omega$		100		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC} \pm / \Delta V_{IO}$)	$V_{CC} = 5\text{ V to }30\text{ V}$		115		dB
I_{CC} Supply current	$V_O = 2.5\text{ V}$, No load		400		μA

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.

TLE2021Y operating characteristics at $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	TLE2021Y			UNIT
		MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$		0.5		$\text{V}/\mu\text{s}$
V_n Equivalent input noise voltage	$f = 10\text{ Hz}$		21		$\text{nV}/\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$		17		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$		0.16		μV
	$f = 0.1\text{ to }10\text{ Hz}$		0.47		
I_n Equivalent input noise current			0.1		$\text{pA}/\sqrt{\text{Hz}}$
B_1 Unity-gain bandwidth			1.7		MHz
ϕ_m Phase margin at unity gain			47°		

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TLE2022Y electrical characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLE2022Y			UNIT
		MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = 0$, $R_S = 50\ \Omega$		150	600	μV
Input offset voltage long-term drift (see Note 4)			0.005		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current			0.5		nA
I_{IB} Input bias current			35		nA
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$		– 0.3 to 4		V
V_{OH} Maximum high-level output voltage	$R_L = 10\ \text{k}\Omega$		4.3		V
V_{OL} Maximum low-level output voltage			0.7		V
A_{VD} Large-signal differential voltage amplification	$V_O = 1.4\text{ to }4\text{ V}$, $R_L = 10\ \text{k}\Omega$		1.5		V/ μV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\text{ min}$, $R_S = 50\ \Omega$		100		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to }30\text{ V}$		115		dB
I_{CC} Supply current	$V_O = 2.5\text{ V}$, No load		450		μA

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.

TLE2022Y operating characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	TLE2022Y			UNIT
		MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1		0.5		V/ μs
V_n Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$		21		nV/ $\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$		17		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$		0.16		μV
	$f = 0.1\text{ to }10\text{ Hz}$		0.47		
I_n Equivalent input noise current			0.1		pA/ $\sqrt{\text{Hz}}$
B_1 Unity-gain bandwidth	See Figure 3		1.7		MHz
ϕ_m Phase margin at unity gain	See Figure 3		47°		

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TLE2024Y electrical characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLE2024Y			UNIT
		MIN	TYP	MAX	
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0$, $R_S = 50\ \Omega$		0.005		$\mu\text{V}/\text{mo}$
I_{IO} Input offset current			0.6		nA
I_{IB} Input bias current			45		nA
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$		–0.3 to 4		V
V_{OH} High-level output voltage	$R_L = 10\ \text{k}\Omega$		4.2		V
V_{OL} Low-level output voltage			0.7		V
A_{VD} Large-signal differential voltage amplification	$V_O = 1.4\text{ V to }4\text{ V}$, $R_L = 10\ \text{k}\Omega$		1.5		$\text{V}/\mu\text{V}$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}$, $R_S = 50\ \Omega$		90		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to }30\text{ V}$		112		dB
I_{CC} Supply current	$V_O = 2.5\text{ V}$, No load		800		μA

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.

TLE2024Y operating characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	TLE2024Y			UNIT
		MIN	TYP	MAX	
SR Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1		0.5		$\text{V}/\mu\text{s}$
V_n Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$		21		$\text{nV}/\sqrt{\text{Hz}}$
	$f = 1\text{ kHz}$		17		
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$		0.16		μV
	$f = 0.1\text{ to }10\text{ Hz}$		0.47		
I_n Equivalent input noise current			0.1		$\text{pA}/\sqrt{\text{Hz}}$
B_1 Unity-gain bandwidth	See Figure 3		1.7		MHz
ϕ_m Phase margin at unity gain	See Figure 3		47°		

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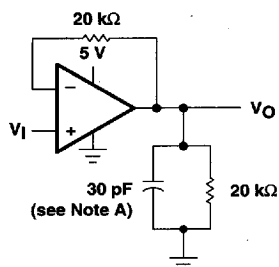
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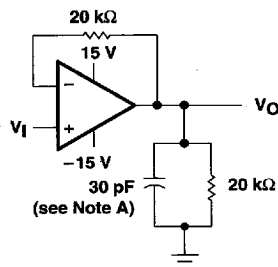
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PARAMETER MEASUREMENT INFORMATION



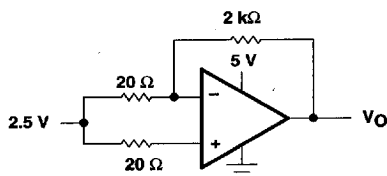
(a) SINGLE SUPPLY



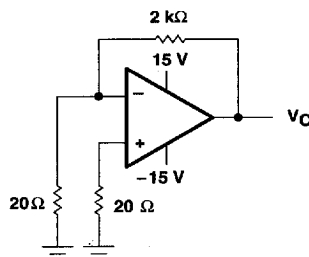
(b) SPLIT SUPPLY

NOTE A: C_L includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

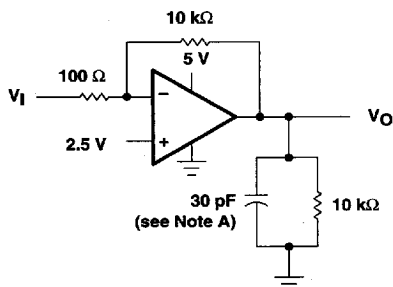


(a) SINGLE SUPPLY

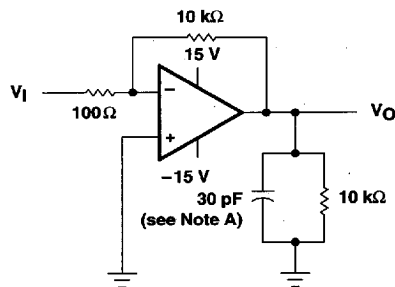


(b) SPLIT SUPPLY

Figure 2. Noise-Voltage Test Circuit



(a) SINGLE SUPPLY



(b) SPLIT SUPPLY

NOTE A: C_L includes fixture capacitance.

Figure 3. Unity-Gain Bandwidth and Phase-Margin Test Circuit

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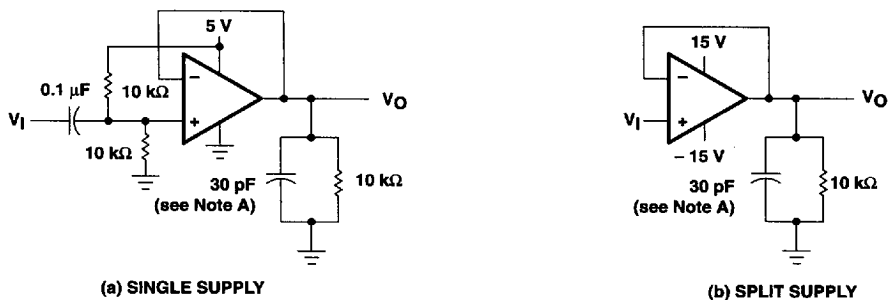


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PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes fixture capacitance.

Figure 4. Small-Signal Pulse-Response Test Circuit

typical values

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

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TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution	5, 6, 7
I_{IB}	Input bias current	vs Common-mode input voltage vs Free-air temperature	8, 9, 10 11, 12, 13
I_I	Input current	vs Differential input voltage	14
V_{OM}	Maximum peak output voltage	vs Output current vs Free-air temperature	15, 16, 17 18
V_{OH}	High-level output voltage	vs High-level output current vs Free-air temperature	19, 20 21
V_{OL}	Low-level output voltage	vs Low-level output current vs Free-air temperature	22 23
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	24, 25
A_{VD}	Large-signal differential voltage amplification	vs Frequency vs Free-air temperature	26 27, 28, 29
I_{OS}	Short-circuit output current	vs Supply voltage vs Free-air temperature	30 – 33 34 – 37
I_{CC}	Supply current	vs Supply voltage vs Free-air temperature	38, 39, 40 41, 42, 43
$CMRR$	Common-mode rejection ratio	vs Frequency	44, 45, 46
SR	Slew rate	vs Free-air temperature	47, 48, 49
	Voltage-follower small-signal pulse response	vs Time	50, 51
	Voltage-follower large-signal pulse response	vs Time	52 – 57
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	0.1 to 1 Hz 0.1 to 10 Hz	58 59
V_n	Equivalent input noise voltage	vs Frequency	60
B_1	Unity-gain bandwidth	vs Supply voltage vs Free-air temperature	61, 62 63, 64
ϕ_m	Phase margin	vs Supply voltage vs Load capacitance vs Free-air temperature	65, 66 67, 68 69, 70
	Phase shift	vs Frequency	26

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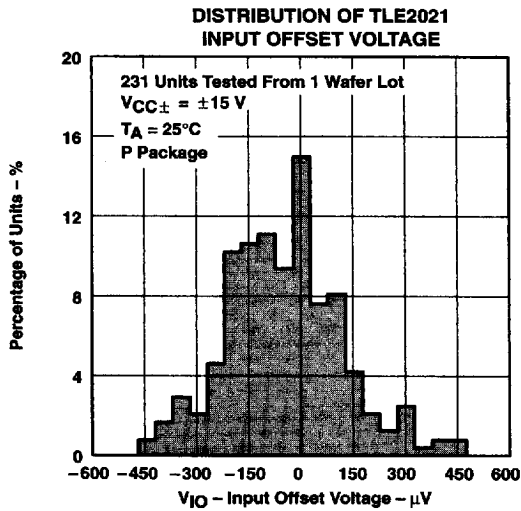


Figure 5

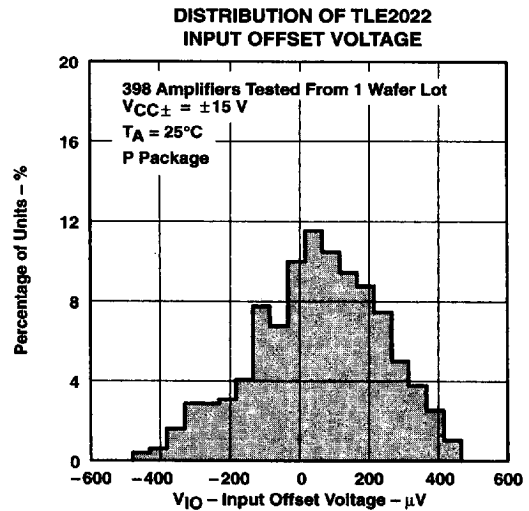


Figure 6

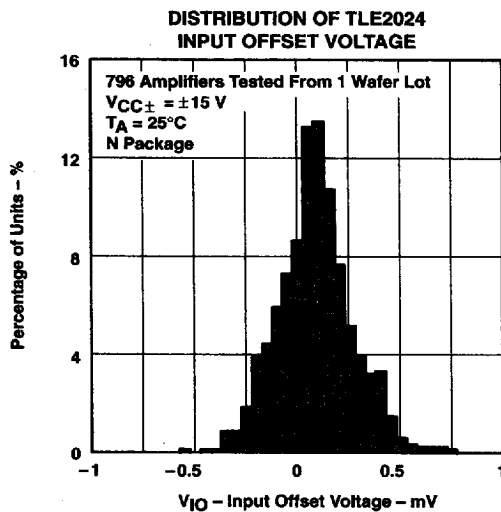


Figure 7

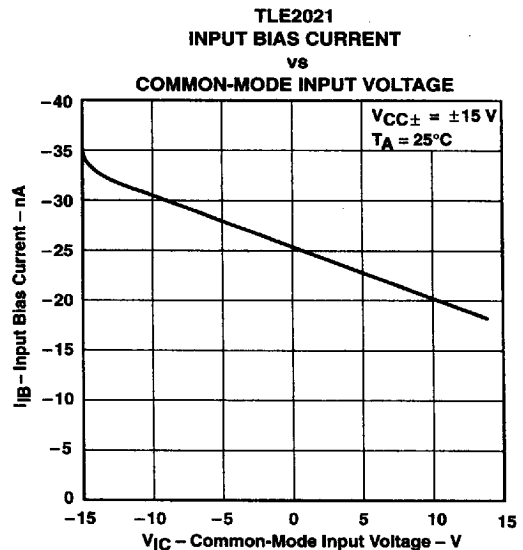


Figure 8

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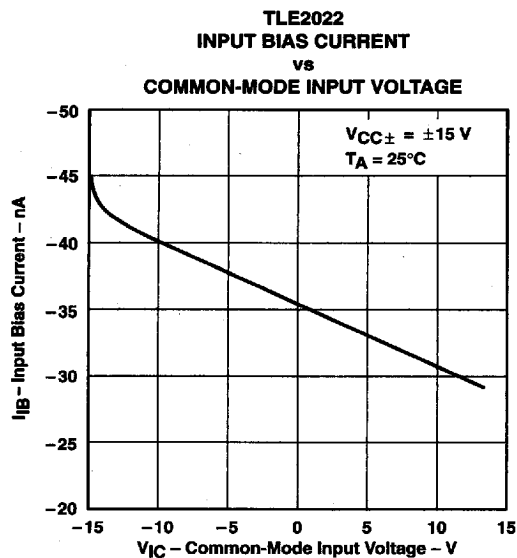


Figure 9

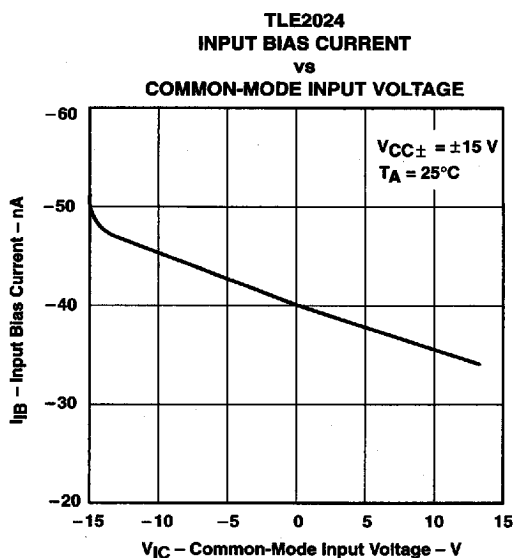


Figure 10

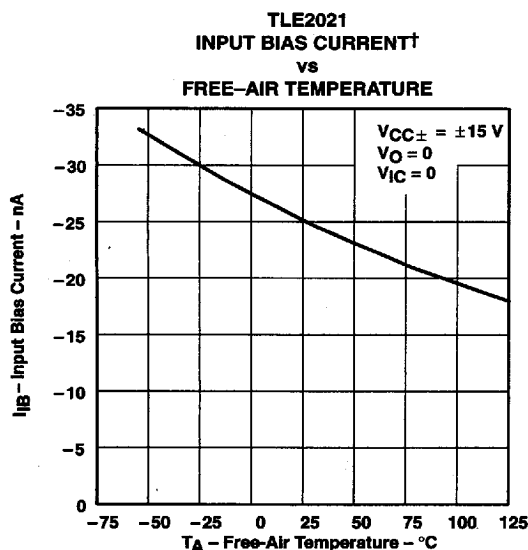


Figure 11

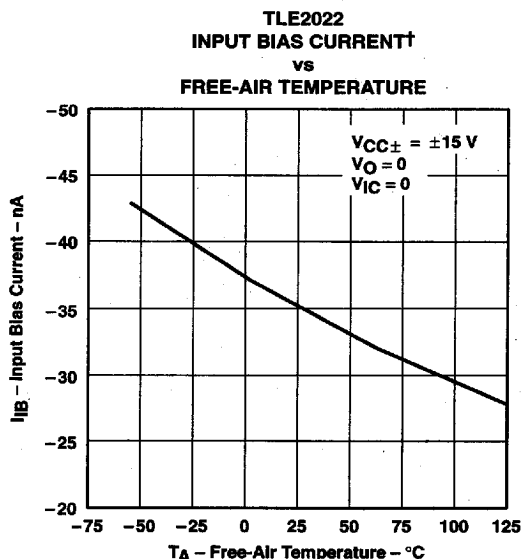


Figure 12

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



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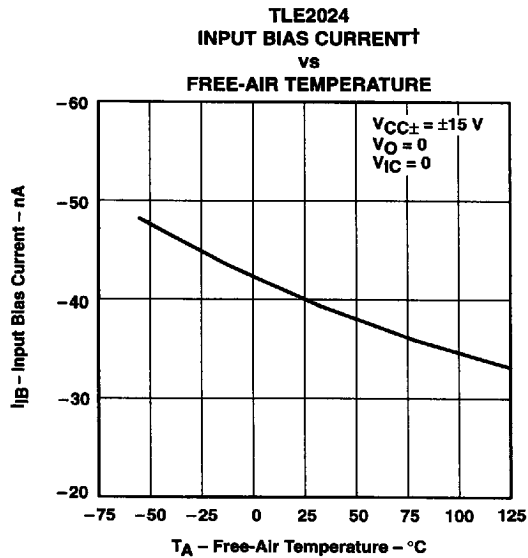


Figure 13

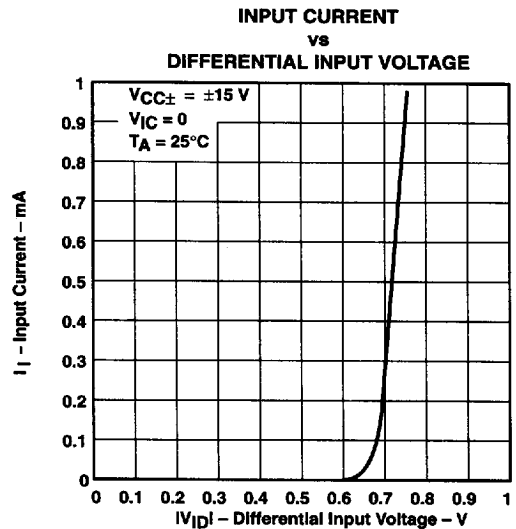


Figure 14

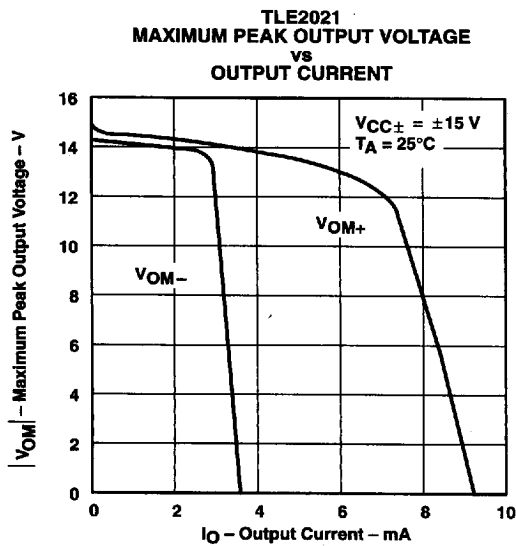


Figure 15

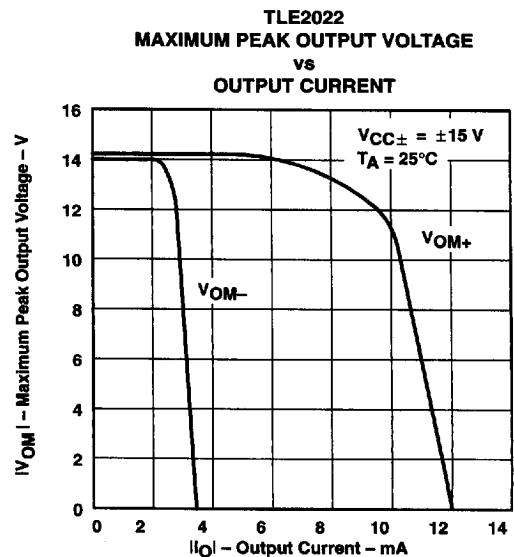


Figure 16

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



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TYPICAL CHARACTERISTICS

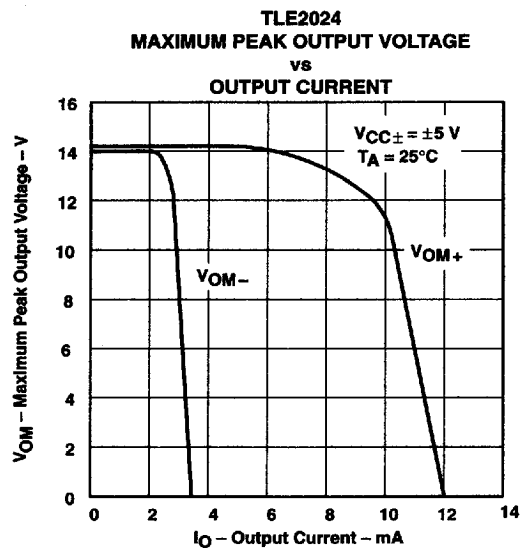


Figure 17

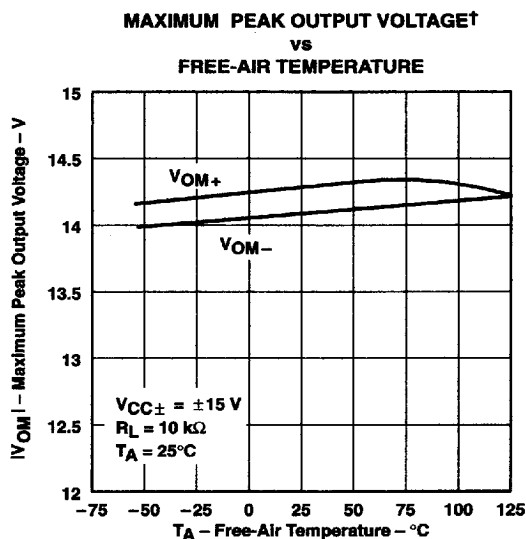


Figure 18

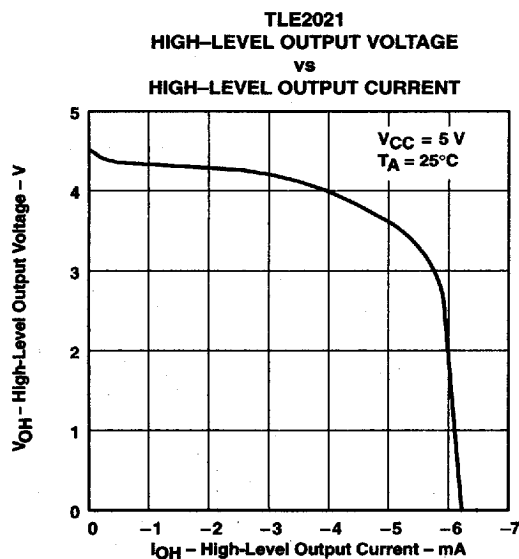


Figure 19

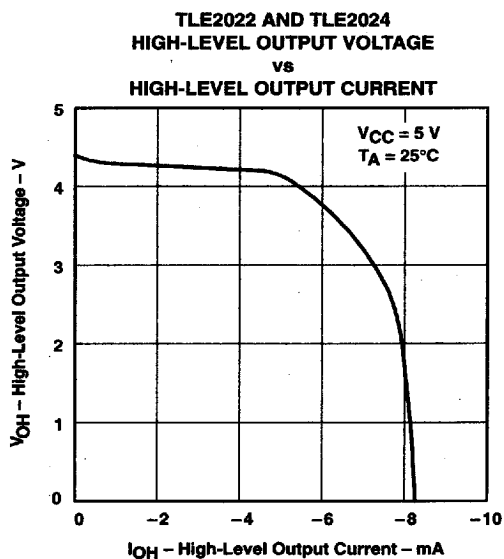


Figure 20

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



TEXAS
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8961724 0107174 996

TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

SLOS191 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

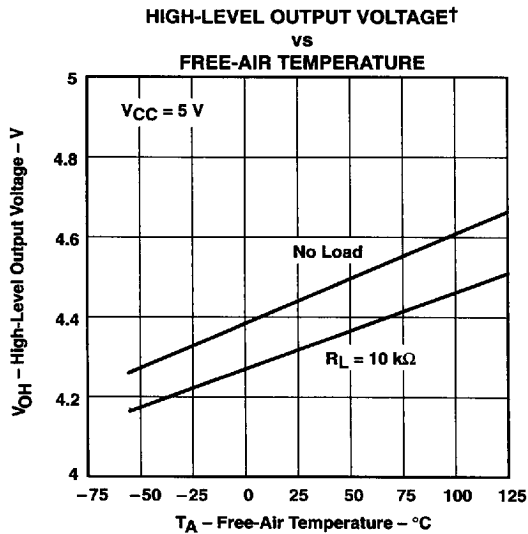


Figure 21

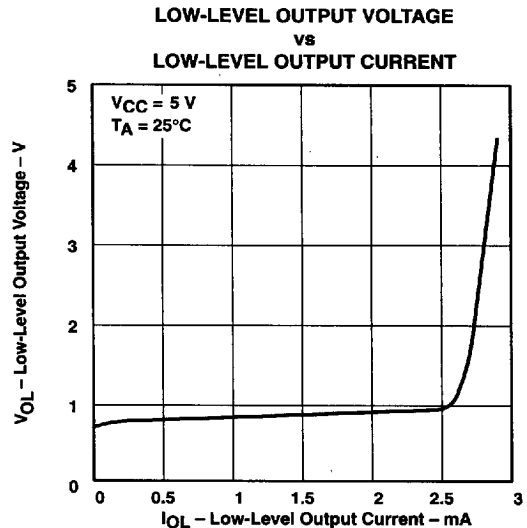


Figure 22

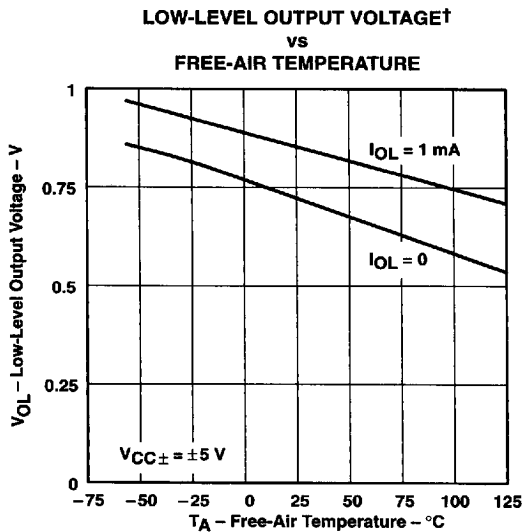


Figure 23

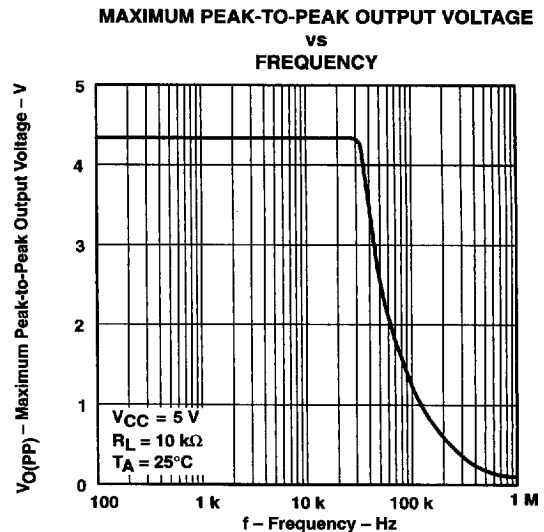


Figure 24

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



TEXAS
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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY

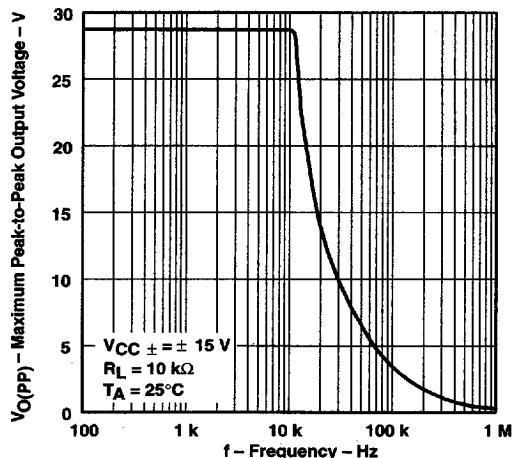


Figure 25

LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY

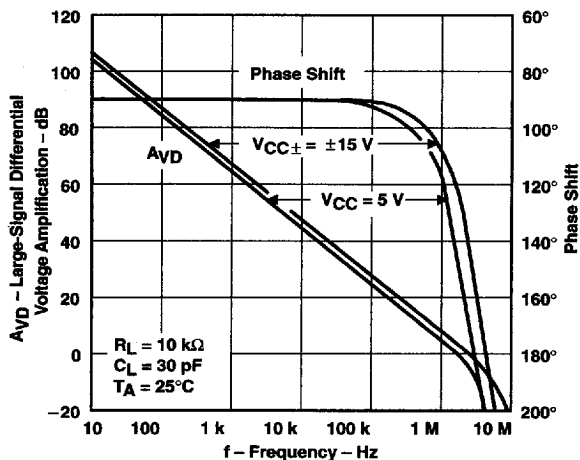


Figure 26

8961724 0107176 769

TEXAS
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TLE202x, TLE202xA, TLE202xB, TLE202xY EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

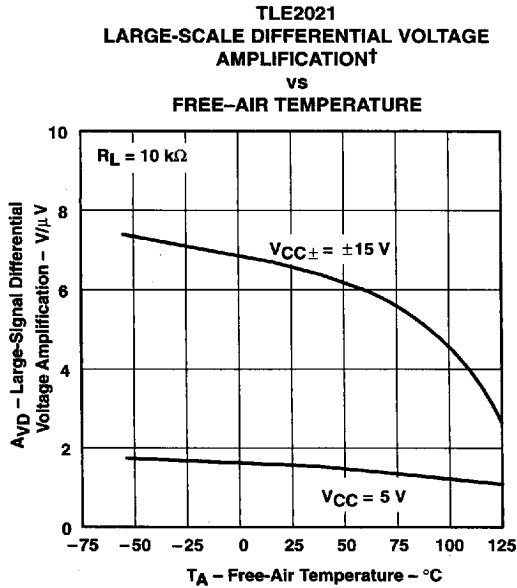


Figure 27

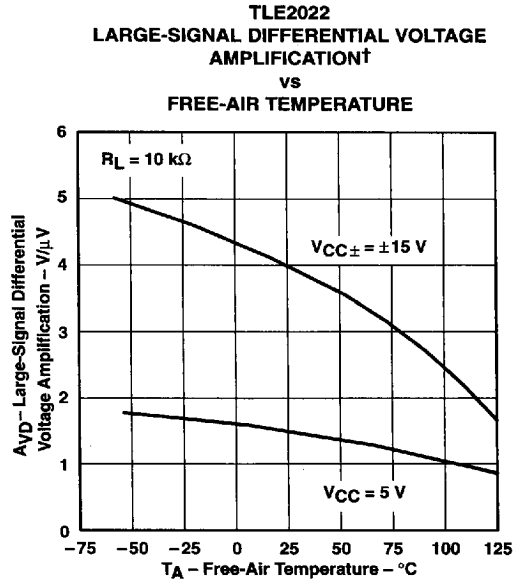


Figure 28

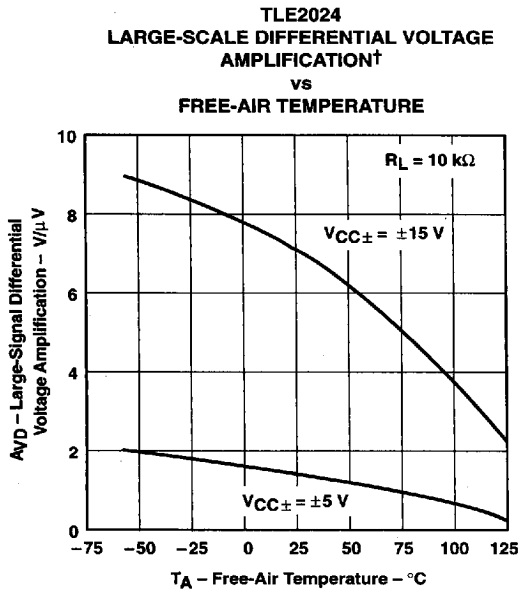


Figure 29

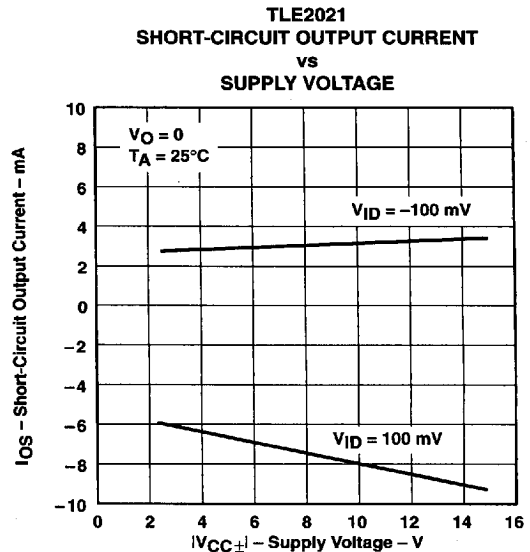


Figure 30

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



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TLE202x, TLE202xA, TLE202xB, TLE202xY EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

**TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE**

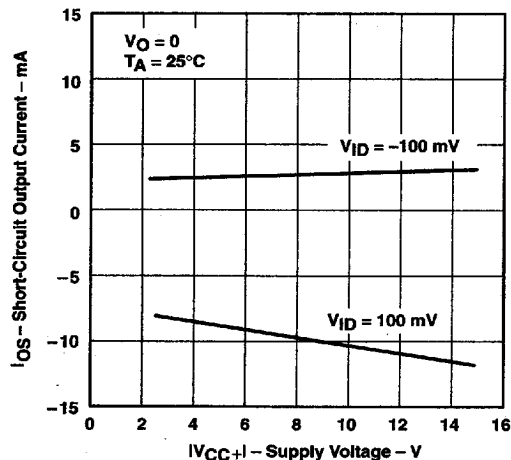


Figure 31

**TLE2021
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE**

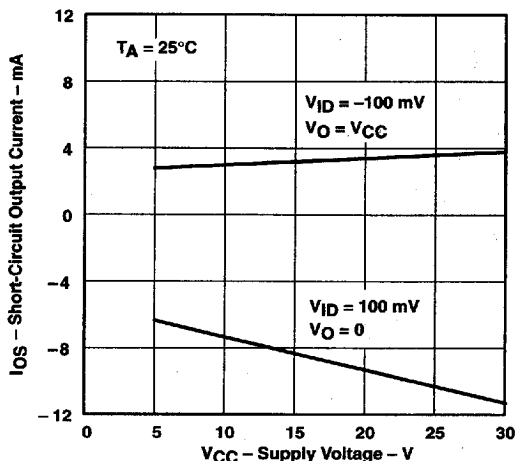


Figure 32

**TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE**

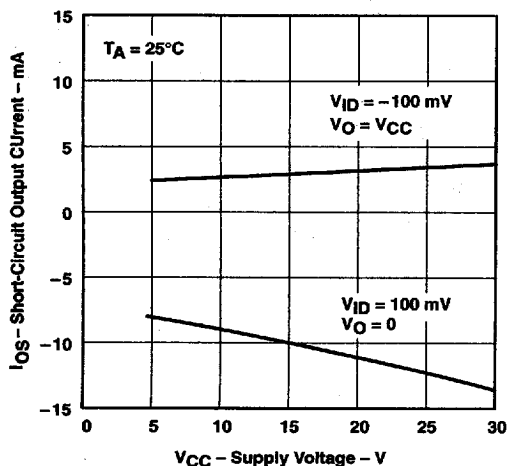


Figure 33

**TLE2021
SHORT-CIRCUIT OUTPUT CURRENT†
vs
FREE-AIR TEMPERATURE**

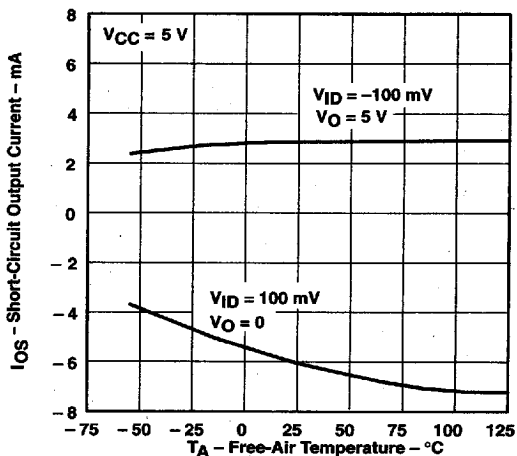


Figure 34

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



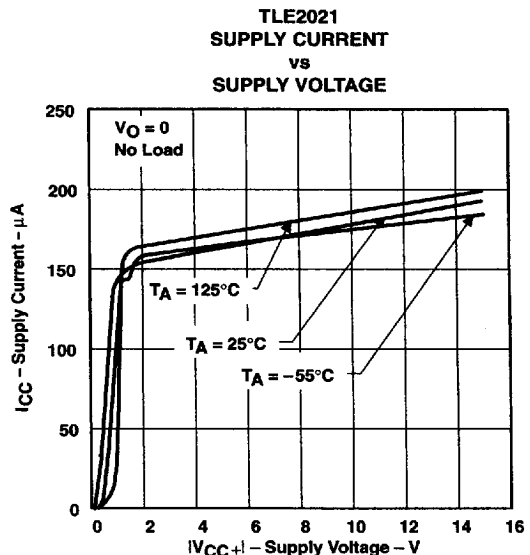
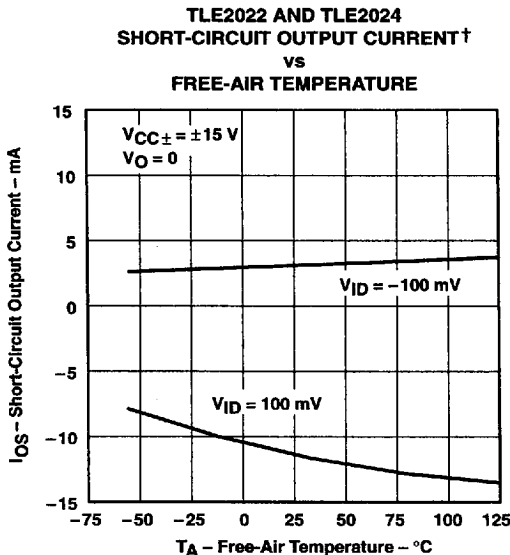
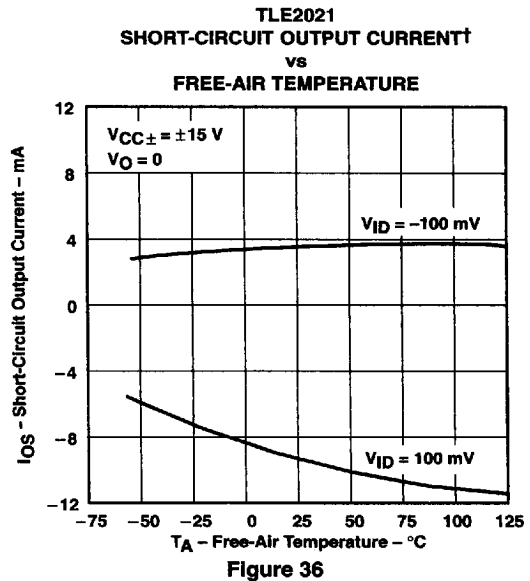
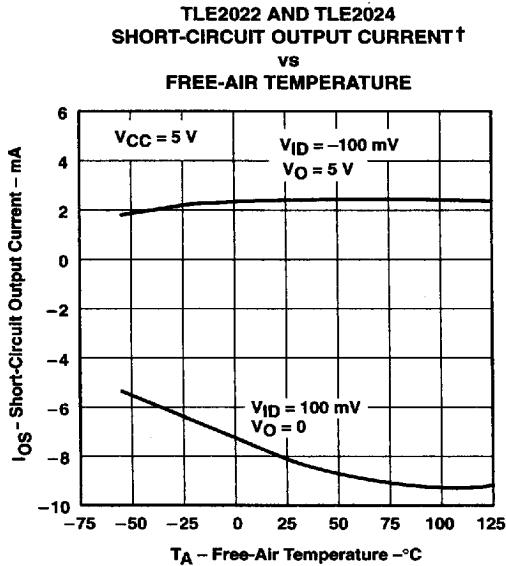
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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
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TYPICAL CHARACTERISTICS



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



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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

TLE2022
SUPPLY CURRENT
vs
SUPPLY VOLTAGE

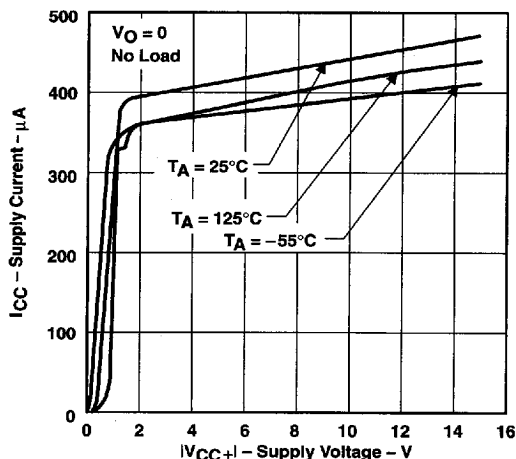


Figure 39

TLE2024
SUPPLY CURRENT
vs
SUPPLY VOLTAGE

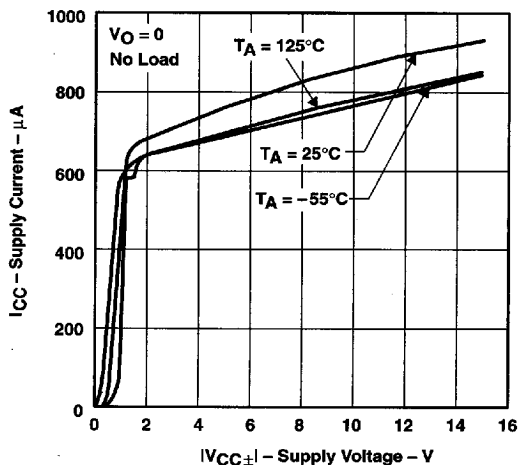


Figure 40

TLE2021
SUPPLY CURRENT†
vs
FREE-AIR TEMPERATURE

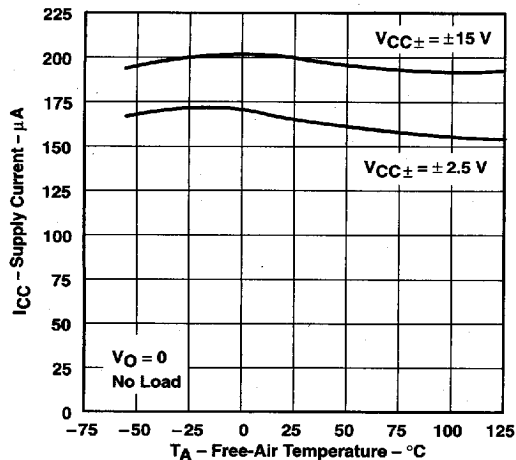


Figure 41

TLE2022
SUPPLY CURRENT†
vs
FREE-AIR TEMPERATURE

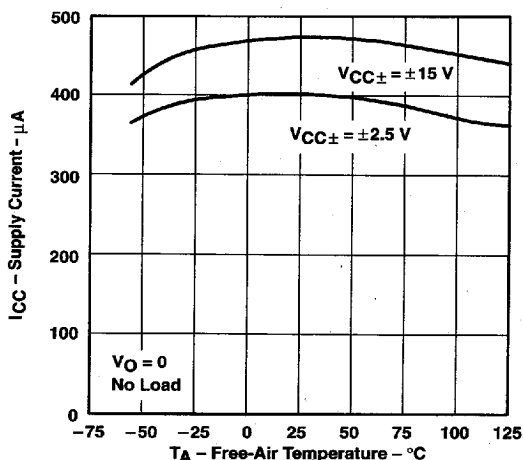


Figure 42

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



TEXAS
INSTRUMENTS

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TLE202x, TLE202xA, TLE202xB, TLE202xY EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

SLOS191 – FEBRUARY 1997

TYPICAL CHARACTERISTICS

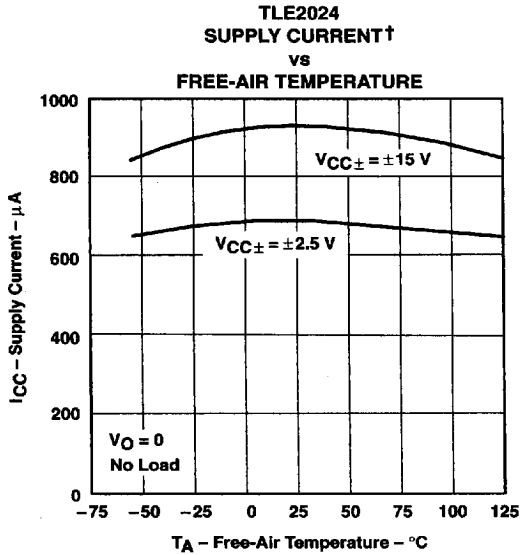


Figure 43

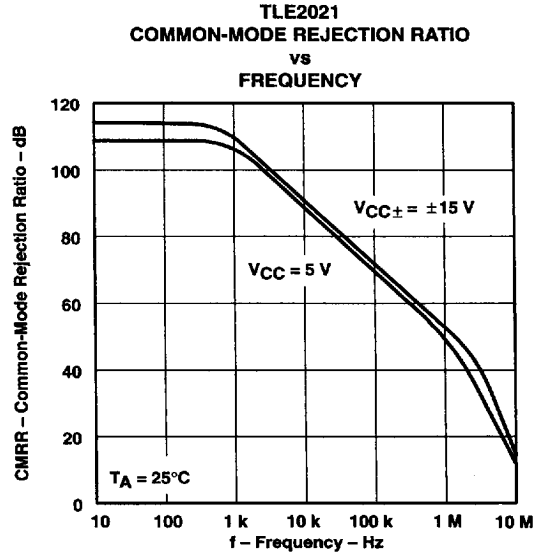


Figure 44

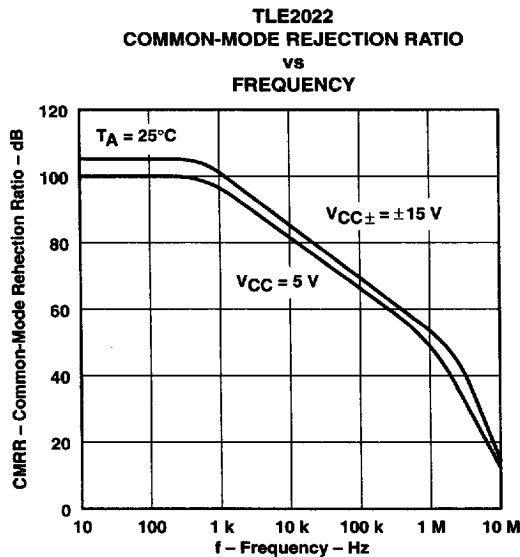


Figure 45

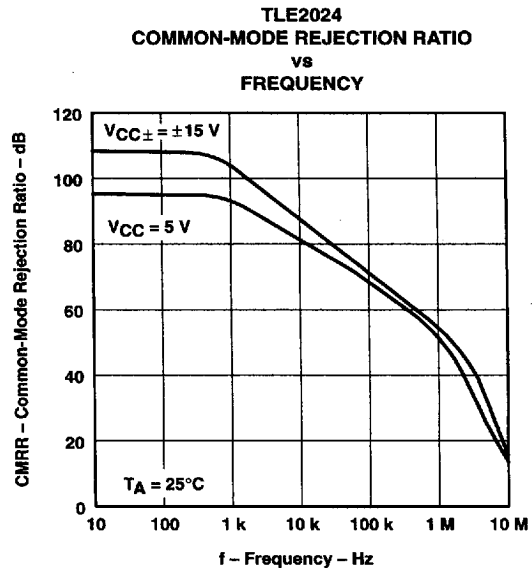


Figure 46

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



**TEXAS
INSTRUMENTS**

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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

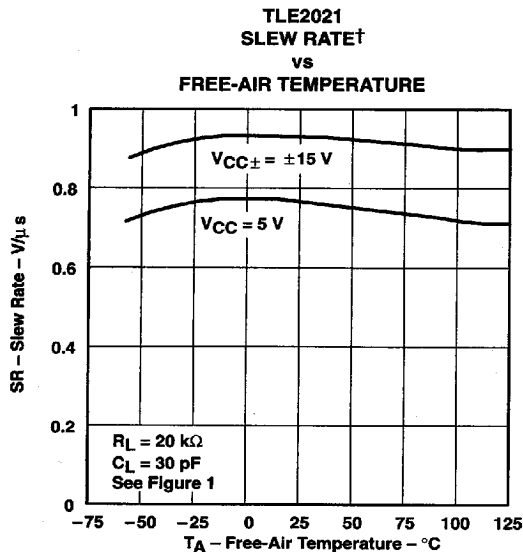


Figure 47

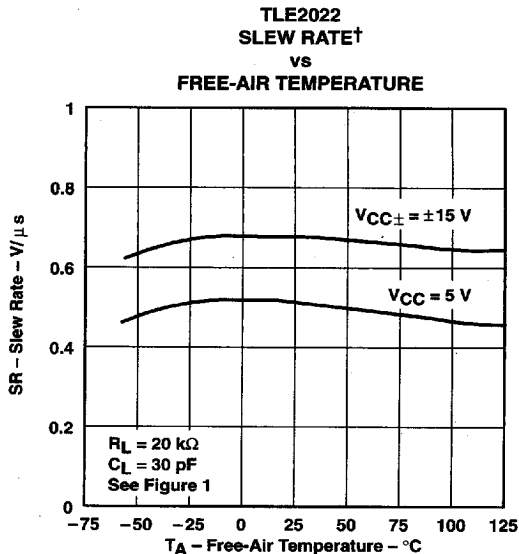


Figure 48

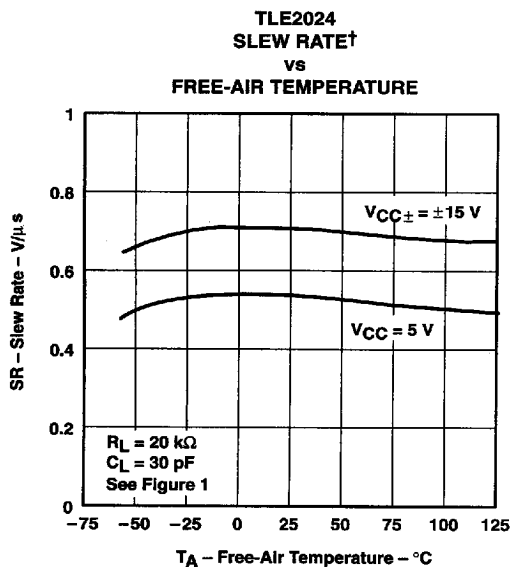


Figure 49

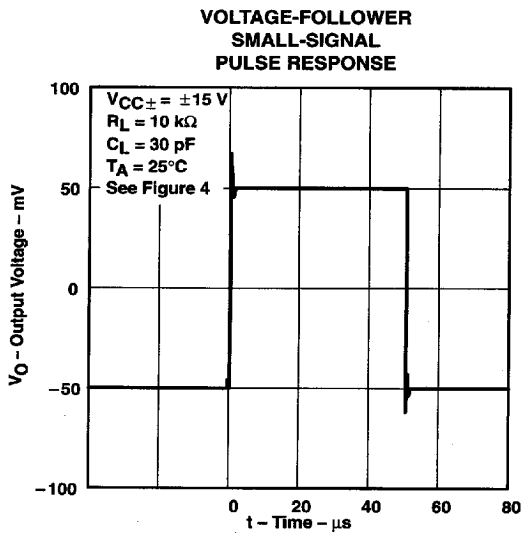


Figure 50

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

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8961724 0107182 T62

TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

**VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE**

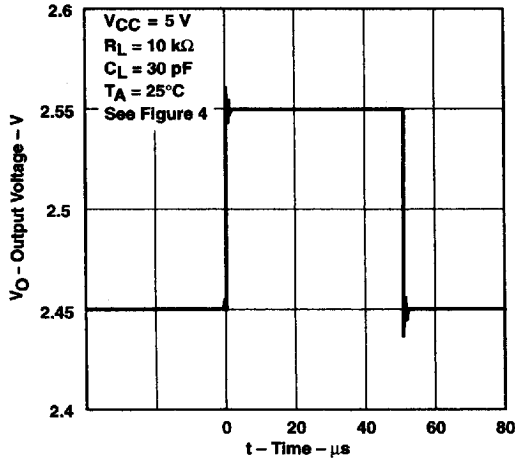


Figure 51

**TLE2021
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE**

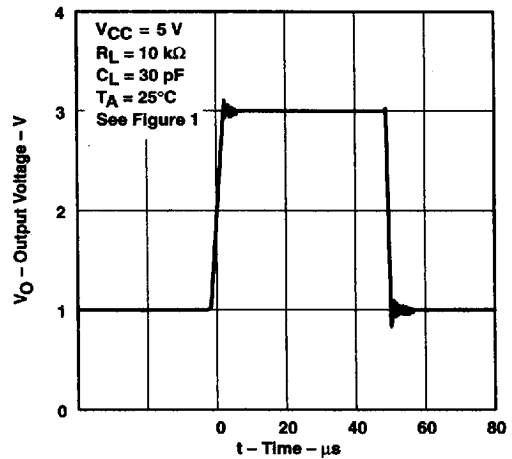


Figure 52

**TLE2022
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE**

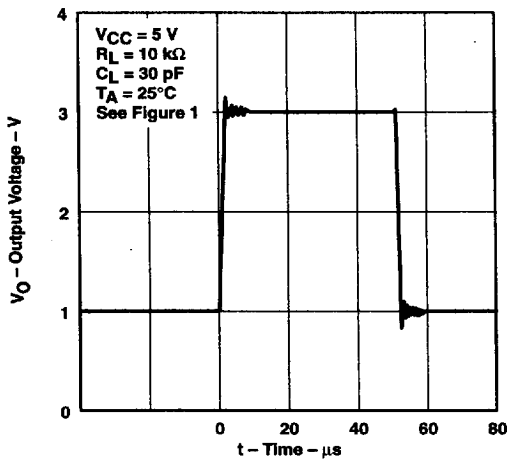


Figure 53

**TLE2024
VOLTAGE-FOLLOWER LARGE-SCALE
PULSE RESPONSE**

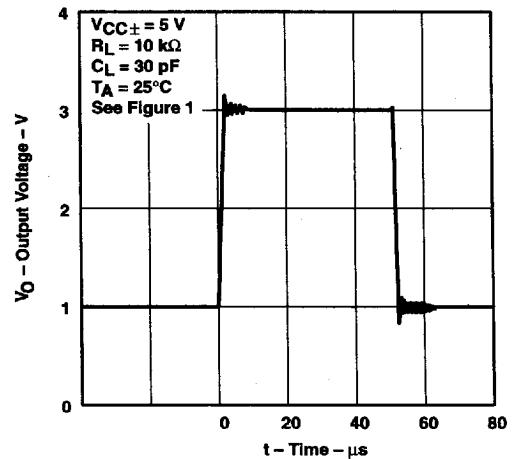


Figure 54

8961724 0107183 9T9



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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS
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TYPICAL CHARACTERISTICS

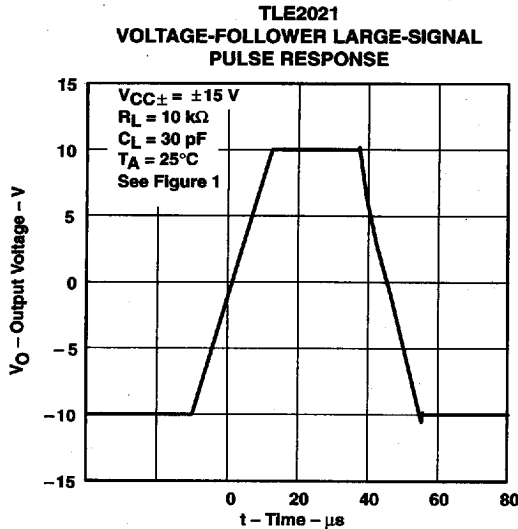


Figure 55

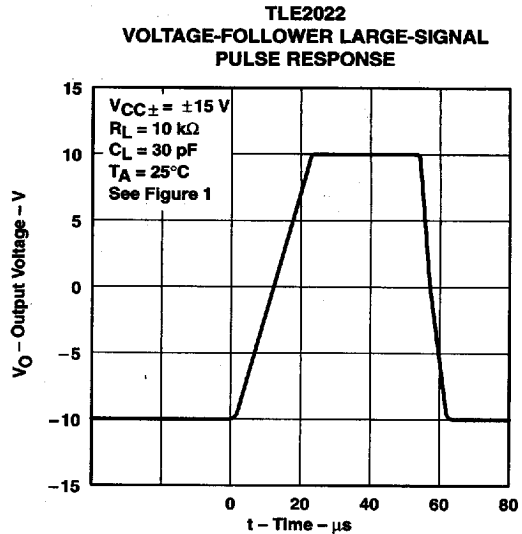


Figure 56

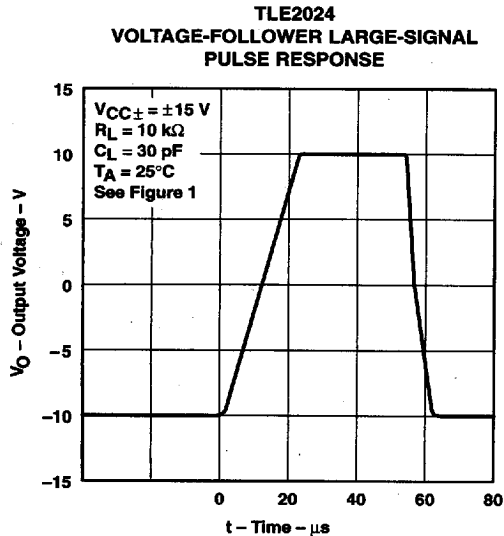


Figure 57

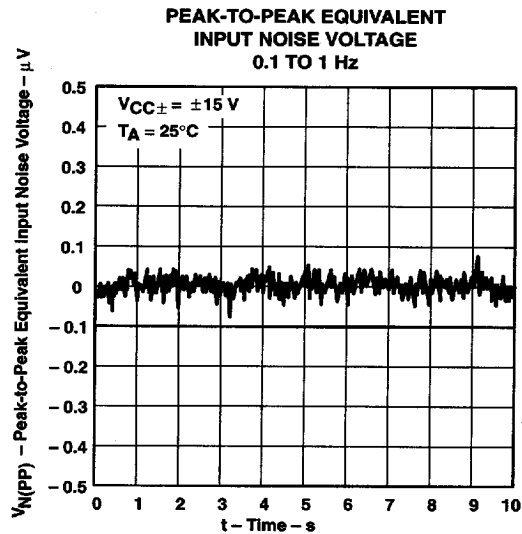


Figure 58

8961724 0107184 835

TEXAS
INSTRUMENTS

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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

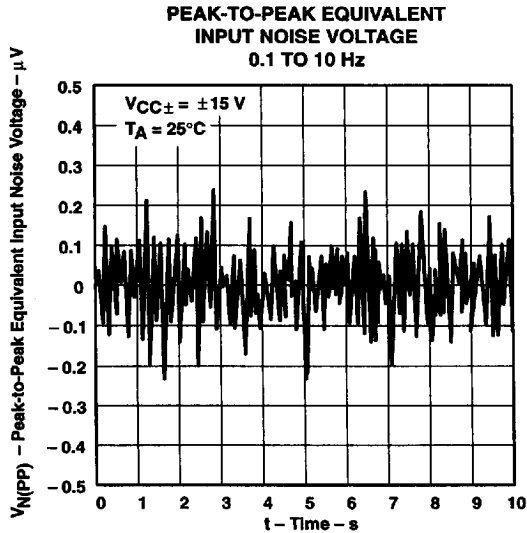


Figure 59

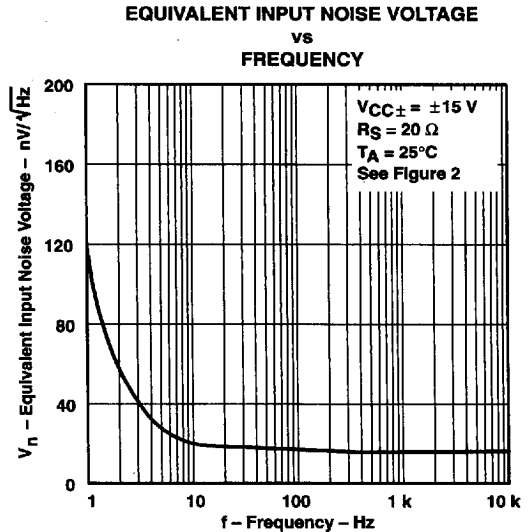


Figure 60

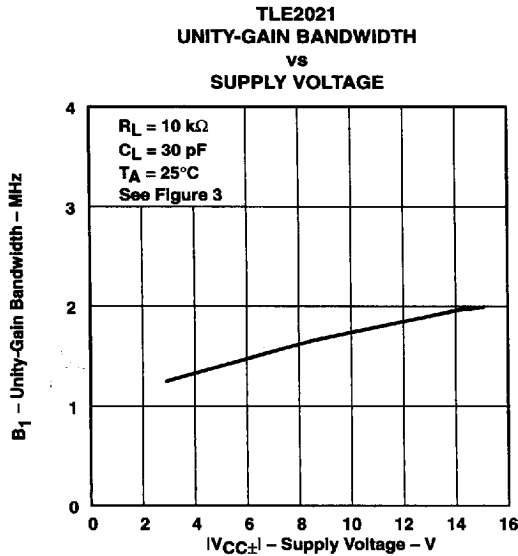


Figure 61

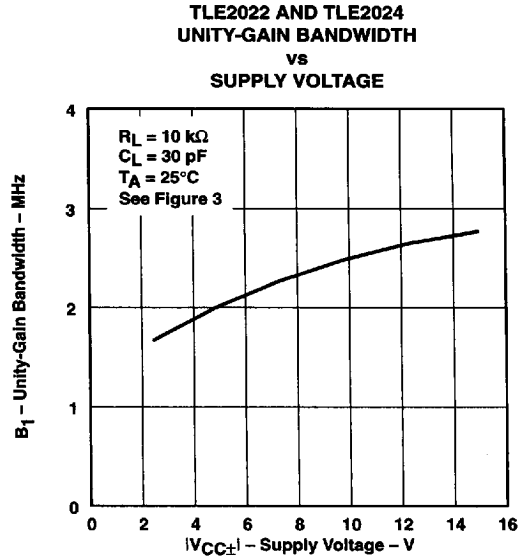


Figure 62

8961724 0107185 771

**TEXAS
INSTRUMENTS**

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6-53

TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

TLE2021
UNITY-GAIN BANDWIDTH†
vs
FREE-AIR TEMPERATURE

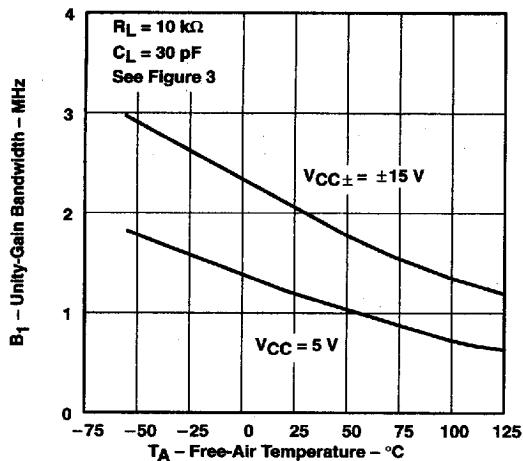


Figure 63

TLE2022 AND TLE2024
UNITY-GAIN BANDWIDTH†
vs
FREE-AIR TEMPERATURE

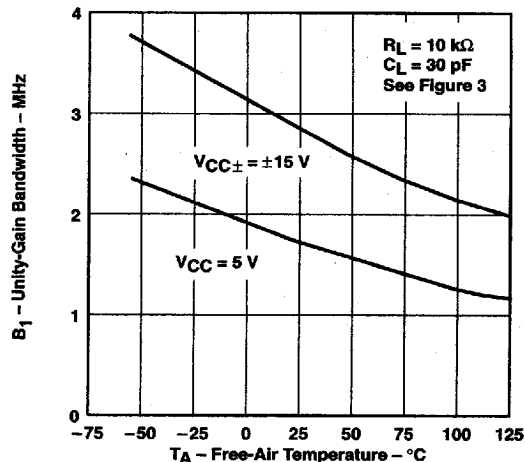


Figure 64

TLE2021
PHASE MARGIN
vs
SUPPLY VOLTAGE

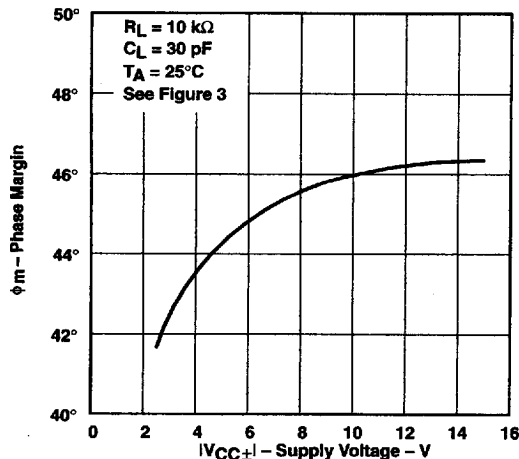


Figure 65

TLE2022 AND TLE2024
PHASE MARGIN
vs
SUPPLY VOLTAGE

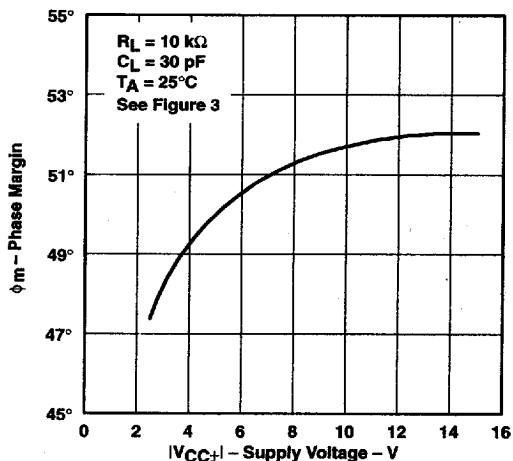


Figure 66

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

TEXAS
INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

8961724 0107186 608

TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

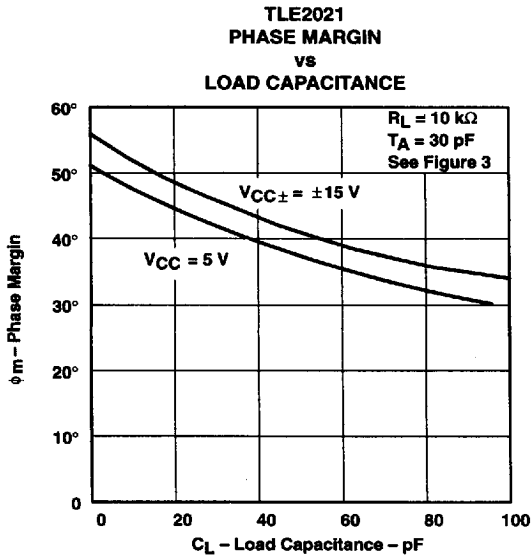


Figure 67

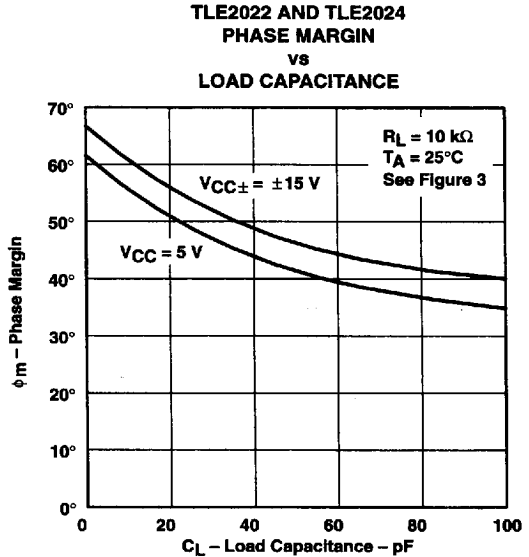


Figure 68

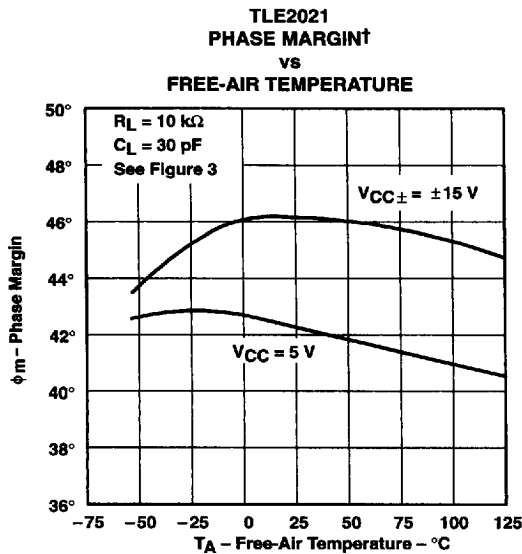


Figure 69

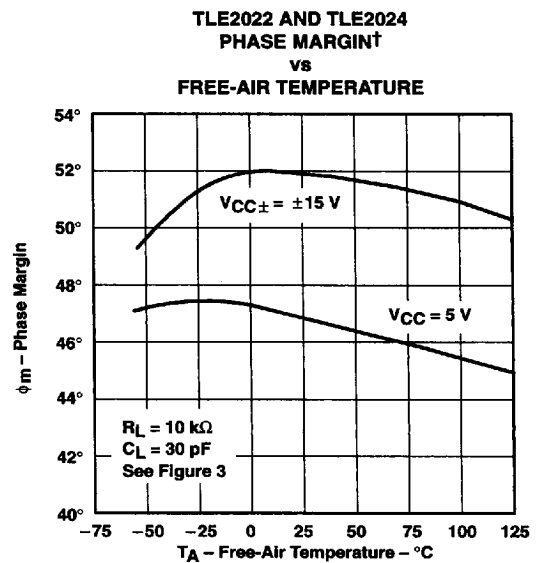


Figure 70

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



TEXAS
INSTRUMENTS

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8961724 0107187 544

TLE202x, TLE202xA, TLE202xB, TLE202xY EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

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APPLICATION INFORMATION

voltage-follower applications

The TLE202x circuitry includes input-protection diodes to limit the voltage across the input transistors; however, no provision is made in the circuit to limit the current if these diodes are forward biased. This condition can occur when the device is operated in the voltage-follower configuration and driven with a fast, large-signal pulse. It is recommended that a feedback resistor be used to limit the current to a maximum of 1 mA to prevent degradation of the device. This feedback resistor forms a pole with the input capacitance of the device. For feedback resistor values greater than 10 k Ω , this pole degrades the amplifier phase margin. This problem can be alleviated by adding a capacitor (20 pF to 50 pF) in parallel with the feedback resistor (see Figure 71).

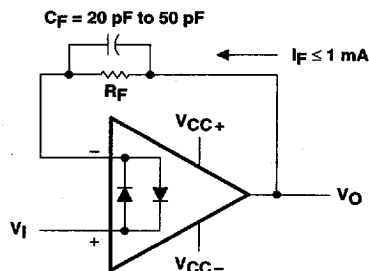


Figure 71. Voltage Follower

Input offset voltage nulling

The TLE202x series offers external null pins that further reduce the input offset voltage. The circuit in Figure 72 can be connected as shown if this feature is desired. When external nulling is not needed, the null pins may be left disconnected.

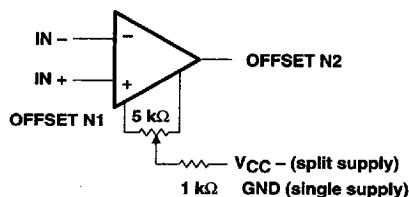


Figure 72. Input Offset Voltage Null Circuit

8961724 0107188 480

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APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 5) and subcircuit in73, Figure 74, and Figure 75 were generated using the TLE202x 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).

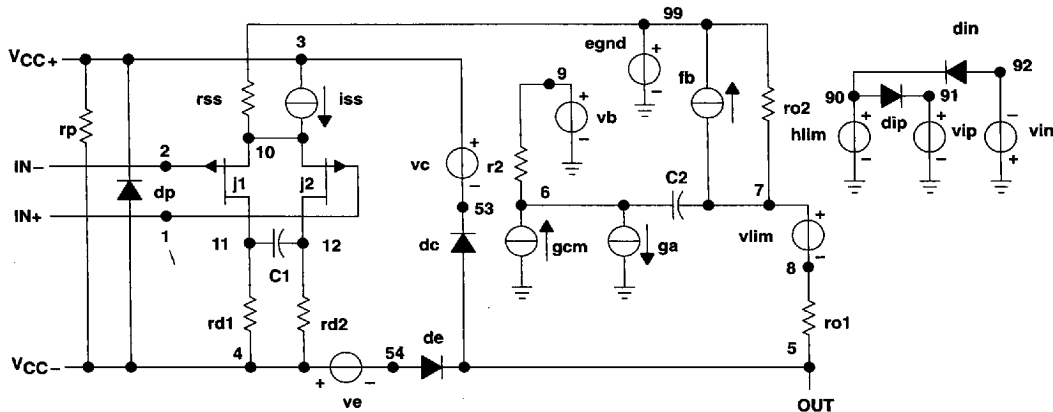


Figure 73. Boyle Subcircuit

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TLE202x, TLE202xA, TLE202xB, TLE202xY
EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
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```
.SUBCKT TLE2021 1 2 3 4 5
*
c1 11 12 6.244E-12
c2 6 7 13.4E-12
c3 87 0 10.64E-9
cpsr 85 86 15.9E-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) -60E-6 2.0E-6
ense 89 2 poly(1) (88,0) 120E-6 1
fb 7 99 poly(6) vb vc ve vlp vln vpsr 0 547.3E6
+ -50E7 50E7 50E7 -50E7 547E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 335.2E-12
gpsr 85 86 (85,86) 100E-6
grc1 4 11 (4,11) 1.885E-4
grc2 4 12 (4,12) 1.885E-4
gre1 13 10 (13,10) 6.82E-4
gre2 14 10 (14,10) 6.82E-4
hlim 90 0 vlim 1k

hcmr 80 1 poly(2) vcm+ vcm- 0 1E2 1E2
irp 3 4 185E-6
iee 3 10 dc 15.67E-6
iio 2 0 2E-9
il 88 0 1E-21
q1 11 89 13 qx
q2 12 80 14 qx
R2 6 9 100.0E3
rcm 84 81 1K
ree 10 99 14.76E6
m1 87 0 2.55E8
m2 87 88 11.67E3
ro1 8 5 62
ro2 7 99 63
vcm+ 82 99 13.3
vcm- 83 99 -14.6
vb 9 0 dc 0
vc 3 53 dc 1.300
ve 54 4 dc 1.500
vlim 7 8 dc 0
vlp 91 0 dc 3.600
vln 0 92 dc 3.600
vpsr 0 86 dc 0
.model dx d(is=800.0E-18)
.model qx pnp(is=800.0E-18 bf=270)
.ends
```

Figure 74. Boyle Macromodel for the TLE2021

```
.SUBCKT TLE2022 1 2 3 4 5
*
c1 11 12 6.814E-12
c2 6 7 20.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0
+ 45.47E6 -50E6 50E6 50E6 -50E6
ga 6 0 11 12 377.9E-6
gcm 0 6 10 99 7.84E-10
iee 3 10 DC 18.07E-6
hlim 90 0 vlim 1k
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3

rc1 4 11 2.842E3
rc2 4 12 2.842E3
ge1 13 10 (10,13) 31.299E-3
ge2 14 10 (10,14) 31.299E-3
ree 10 99 11.07E6
ro1 8 5 250
ro2 7 99 250
rp 3 4 137.2E3
vb 9 0 dc 0
vc 3 53 dc 1.300
ve 54 4 dc 1.500
vlim 7 8 dc 0
vlp 91 0 dc 3
vln 0 92 dc 3
.model dx d(is=800.0E-18)
.model qx pnp(is=800.0E-18 bf=257.1)
.ends
```

Figure 75. Boyle Macromodel for the TLE2022

8961724 0107190 039

 **TEXAS**
INSTRUMENTS

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