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

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- Supply Current . . . 300 μA Max
- High Unity-Gain Bandwidth . . . 2 MHz Typ
- High Slew Rate . . . 0.45 V/μs Min
- Supply-Current Change Over Military Temp Range . . . 10 μA Typ at V<sub>CC +</sub> = ± 15 V
- Specified for Both 5-V Single-Supply and ±15-V Operation
- Phase-Reversal Protection

- High Open-Loop Gain . . . 6.5 V/μV (136 dB) Typ
- Low Offset Voltage . . . 100 μV Max
- Offset Voltage Drift With Time 0.005 μV/mo Typ
- Low Input Bias Current . . . 50 nA Max
- Low Noise Voltage . . . 19 nV/√Hz Typ

#### description

The 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  $0^{\circ}$ C to  $70^{\circ}$ C. The I-suffix devices are characterized for operation from  $-40^{\circ}$ C to  $85^{\circ}$ C. The M-suffix devices are characterized for operation over the full military temperature range of  $-55^{\circ}$ C to  $125^{\circ}$ C.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



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

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#### **TLE2021 AVAILABLE OPTIONS**

				PACKAGEI	DEVICES			CUID
TA	V <sub>IO</sub> max AT 25°C	SMALL OUTLINE <sup>†</sup> (D)	SSOP <sup>‡</sup> (DB)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP‡ (PW)	CHIP FORM§ (Y)
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	-	ı	-	TLE2021AIP TLE2021IP	ı	-
-55°C to 125°C	100 μV 200 μV 500 μV	— TLE2021AMD TLE2021MD		TLE2021BMFK TLE2021AMFK TLE2021MFK	TLE2021BMJG TLE2021AMJG TLE2021MJG	— TLE2021AMP TLE2021MP	_	

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

#### **TLE2022 AVAILABLE OPTIONS**

				PACKAGE	D DEVICES			O.U.D
TA	V <sub>IO</sub> max AT 25°C	SMALL OUTLINE† (D)	SSOP‡ (DB)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP <sup>‡</sup> (PW)	CHIP FORM§ (Y)
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	_	ı	_	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).

#### **TLE2024 AVAILABLE OPTIONS**

			PACKAGED	DEVICES		CHIP
TA	V <sub>IO</sub> max AT 25°C					
0°C to 70°C	500 μV 750 μV 1000 μV	TLE2024BCDW TLE2024ACDW TLE2024CDW	I	1	TLE2024BCN TLE2024ACN TLE2024CN	— — TLE2024Y
-40°C to 85°C	500 μV 750 μV 1000 μV	TLE2024BIDW TLE2024AIDW TLE2024IDW	I	1	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	_

<sup>§</sup> Chip forms are tested at 25°C only.



<sup>‡</sup> The DB and PW packages are only available left-end taped and reeled.

<sup>§</sup> Chip forms are tested at 25°C only.

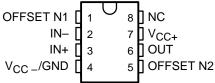
<sup>&</sup>lt;sup>‡</sup>The DB and PW packages are only available left-end taped and reeled.

<sup>§</sup> Chip forms are tested at 25°C only.

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

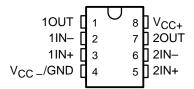
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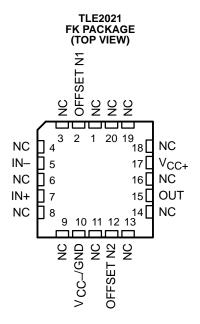


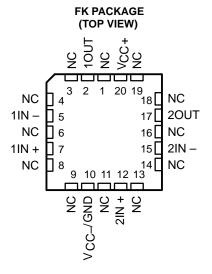
NC - No internal connection

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



NC - No internal connection

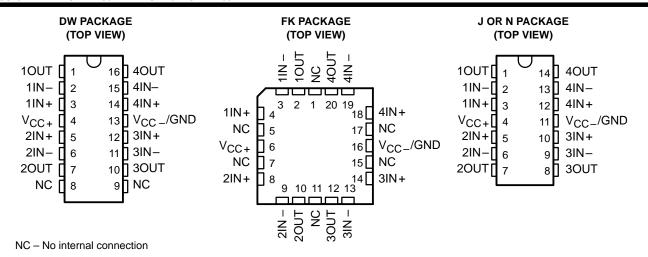






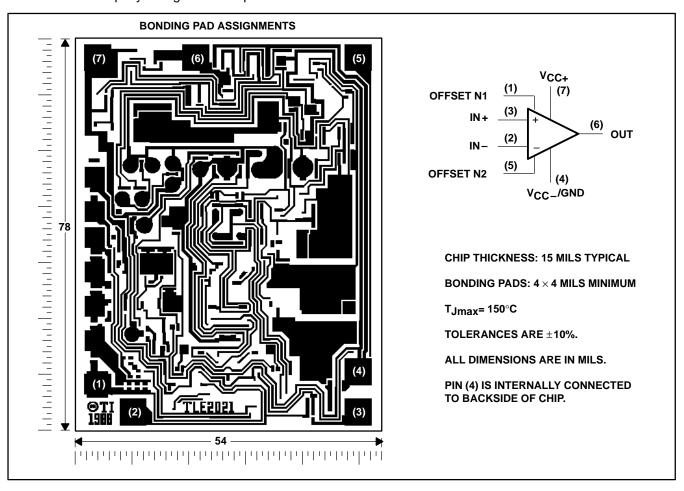
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#### TLE2021Y chip information

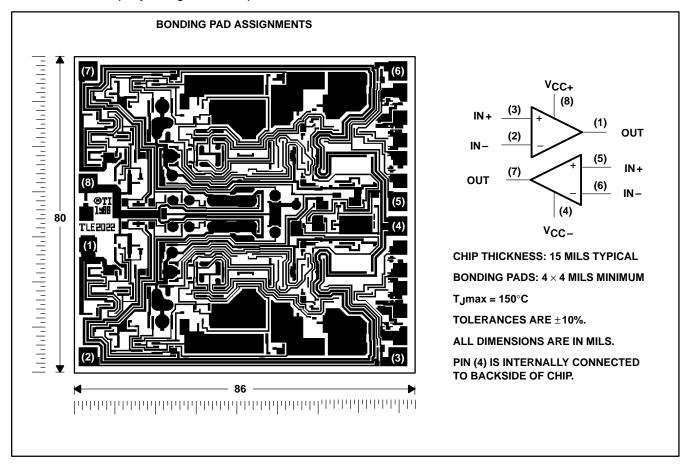
This chip, when properly assembled, display characteristics similar to the TLE2021. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.



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#### **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.

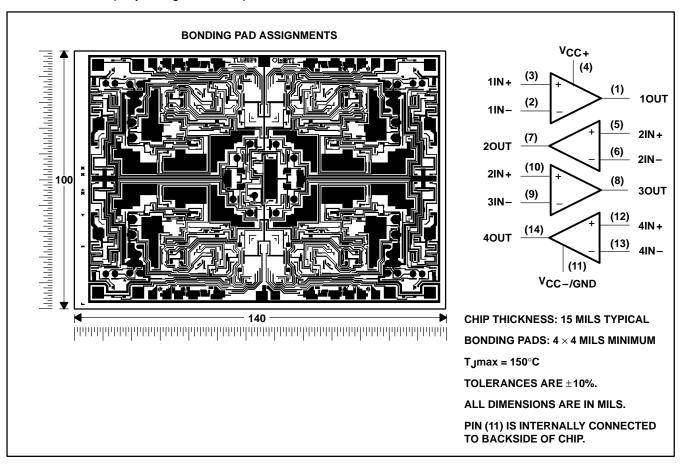


# TLE202xA, TLE202xB, TLE202xY EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

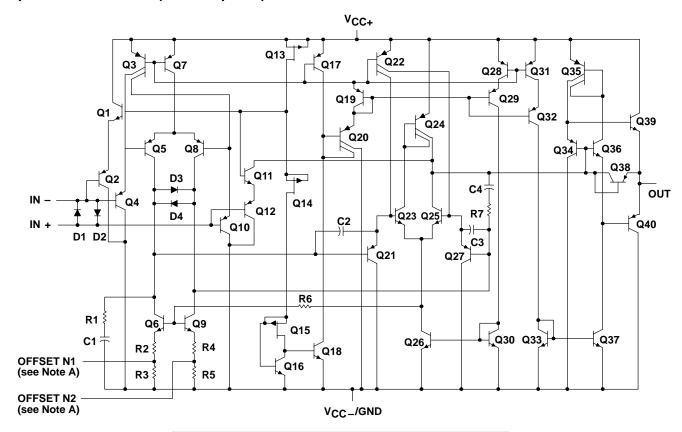
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#### **TLE2024Y chip information**

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.



#### equivalent schematic (each amplifier)



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

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

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

Supply voltage, V <sub>CC+</sub> (see Note 1)	20 V
Supply voltage, V <sub>CC</sub> (see Note 1)	20 V
Differential input voltage, V <sub>ID</sub> (see Note 2)	
Input voltage range, V <sub>I</sub> (any input, see Note 1)	
Input current, I <sub>I</sub> (each input)	
Output current, IO (each output): TLE2021	
TLE2022	
TLE2024	±40 mA
Total current into V <sub>CC+</sub>	80 mA
Total current out of V <sub>CC</sub>	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 <sub>A</sub> : 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 <sub>stq</sub>	
Case temperature for 60 seconds, T <sub>C</sub> : FK package	
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, DP, P, or PW pa	
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C

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

- NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between V<sub>CC+</sub>, and V<sub>CC-</sub>.
  - Differential voltages are at IN+ with respect to IN-. 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	$T_{\mbox{A}} \le 25^{\circ}\mbox{C}$ POWER RATING	DERATING FACTOR ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING	T <sub>A</sub> = 125°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 SU	FFIX	I SUF	FIX	M SU	UNIT	
	MIN	MAX	MIN	MAX	MIN	MAX	ONIT	
Supply voltage, V <sub>CC</sub>	±2	±20	±2	±20	±2	±20	V	
Common mode input voltage V/s	$V_{CC} = \pm 5 V$	0	3.5	0	3.2	0	3.2	V
Common-mode input voltage, V <sub>IC</sub>	$V_{CC\pm} = \pm 15 \text{ V}$	-15	13.5	-15	13.2	-15	13.2	V
Operating free-air temperature, TA			70	-40	85	-55	125	°C



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

80 2	MAX 200 μV 300 μV/°C μV/mo 6
2 0.005	300 μV μV/°C μV/mo
0.005	300 μV/°C μV/mo
0.005	μV/mo
0.2	6
	۰ ۱ ۵۸
	10 nA
25	70 pA
	90 nA
to	
)	
4.3	
!	
0.7	0.8
С	0.85 V
1.5	
110	-10
	dB
120	dB
	аь
200 3	300
	300 μA
5	μА
0 5 0 0 5 4 9	0 to 5 4 0 0 0 5 4 4.3 9 0.7 3 1.5 3 5 110 0 5 120 0 200

† Full range is 0°C to 70°C.

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

		•	•		, 00		•				,		
	DADAMETED	TEST COMPITIONS	- +	Т	LE20210	;	TL	.E2021A0	;	TL	E2021B0	;	
	PARAMETER	TEST CONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
V	lanut offeet voltege		25°C		120	500		80	200		40	100	/
VIO	Input offset voltage		Full range			750			500			200	μV
αΛΙΟ	Temperature coefficient of input offset voltage		Full range		2			2			2		μV/°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		μV/mo
li o	Input offset current		25°C		0.2	6		0.2	6		0.2	6	nA
IO	input onset current		Full range			10			10			10	IIA
lin.	Input bias current		25°C		25	70		25	70		25	70	nA
lВ	input bias current		Full range			90			90			90	IIA
			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		
VICR	Common-mode input voltage range	R <sub>S</sub> = 50 Ω	Full range	-15 to 13.5			-15 to 13.5			–15 to 13.5			V
V-0.4	Maximum positive peak		25°C	14	14.3		14	14.3		14	14.3		V
VOM+	output voltage swing	R <sub>L</sub> = 10 kΩ	Full range	13.9			13.9			13.9			v
Von	Maximum negative peak		25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
VOM –	output voltage swing		Full range	-13.7			-13.7			-13.7			v
A <sub>VD</sub>	Large-signal differential	$V_0 = \pm 10 \text{ V},$	25°C	1	6.5		1	6.5		1	6.5		V/μV
AVD	voltage amplification	$R_L = 10 \text{ k}\Omega$	Full range	1			1			1			ν/μν
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR} \min$	25°C	100	115		100	115		100	115		dB
OWNER	Common mode rejection ratio	$R_S = 50 \Omega$	Full range	96			96			96			QD.
ksvr	Supply-voltage rejection ratio	$V_{CC \pm} = \pm 2.5 \text{ V}$	25°C	105	120		105	120		105	120		dB
NOVK	(ΔVCC/ΔVIO)	to ± 15 V	Full range	100			100			100			<u> </u>
lcc	Supply current		25°C		240	350		240	350		240	350	μΑ
		$V_O = 0$ , No load	Full range			350			350			350	,
ΔICC	Supply-current change over operating temperature range		Full range		6			6			6		μΑ

† Full range is 0°C to 70°C.

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

	PARAMETER	TEST COND	PIONE	T <sub>A</sub> †	Τl	E20220	;	TL	E2022A	C	TLI	E2022B	O	UNIT
	FARAIVIETER	TEST CONDI	ITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
VIO	Input offset voltage			25°C			600			400			250	μV
٧١٥	input onset voltage			Full range			800			550			400	μν
αVIO	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
li o	Input offset current			25°C		0.5	6		0.4	6		0.3	6	nA
10	input onset current			Full range			10			10			10	ΠA
l.s	Input bias current			25°C		35	70		33	70		30	70	nA
IB	input bias current			Full range			90			90			90	IIA
V	Common-mode input	R <sub>S</sub> = 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		٧
VICR	/ICR voltage range	KS = 50 12		Full range	0 to 3.5			0 to 3.5			0 to 3.5			V
V	High lovel output voltage			25°C	4	4.3		4	4.3		4	4.3		V
VOH	High-level output voltage	R <sub>L</sub> = 10 kΩ		Full range	3.9			3.9			3.9			V
V/01	Low-level output voltage	K_ = 10 K22		25°C		0.7	0.8		0.7	0.8		0.7	0.8	V
VOL	Low-level output voltage			Full range			0.85			0.85			0.85	V
AVD	Large-signal differential	V <sub>O</sub> = 1.4 V to 4 V,	Pr = 10 kO	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V/µV
AVD	voltage amplification	VO = 1.4 V 10 4 V,	IVE = 10 K22	Full range	0.3			0.4			0.5			ν/μν
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	25°C	85	100		87	102		90	105		dB
OWNER	Common mode rejection ratio	VIC - VICRIIIII,	115 - 50 22	Full range	80			82			85			uВ
ksvr	Supply-voltage rejection ratio	V <sub>CC</sub> = 5 V to 30 V		25°C	100	115		103	118		105	120		dB
SVK	$(\Delta V_{CC} \pm /\Delta V_{IO})$	.00=0 1 10 30 1		Full range	95			98			100			45
Icc	Supply current			25°C		450	600		450	600		450	600	μΑ
		V <sub>O</sub> = 2.5 V,	No load	Full range			600			600			600	μ
ΔICC	Supply current change over operating temperature range	VO = 2.5 V, No load		Full range		7			7			7		μΑ
t Eull ron	go is 0°C to 70°C			· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·									

<sup>†</sup> Full range is 0°C to 70°C.

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

	PARAMETER	TEST CON	DITIONS	T <sub>A</sub> †	Т	LE20220	;	TL	E2022A	С	Τι	E2022B	С	UNIT	
	PARAMETER	1EST CON	DITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII	
\/: <b>-</b>	Innut offeet voltege			25°C		150	500		120	300		70	150	μV	
VIO	Input offset voltage			Full range			700			450			300	μν	
αΛΙΟ	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C	
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μV/mo	
1	Innut offeet eurrent			25°C		0.5	6		0.4	6		0.3	6	nA	
10	Input offset current			Full range			10			10			10	nA	
1	Innut high ourrent	1		25°C		35	70		33	70		30	70	nA	
¹IB	Input bias current			Full range			90			90			90	TIA.	
VICR	Common-mode input	R <sub>S</sub> = 50 Ω		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	
VICR	voltage range	11/5 = 50 22		Full range	-15 to 13.5			-15 to 13.5			-15 to 13.5			•	
V <sub>OM</sub> +	Maximum positive peak output voltage swing			25°C Full range	14 13.9	14.3		14 13.9	14.3		14 13.9	14.3		٧	
		$R_L = 10 \text{ k}\Omega$		25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1			
V <sub>OM</sub> -	Maximum negative peak output voltage swing			Full range	-13.7	17.1		-13.7	17.1		-13.7	17.1		V	
			-	25°C	0.8	4		10.7	7		1.5	10			
AVD	Large-signal differential voltage amplification	$V_0 = \pm 10 \text{ V},$	$R_L = 10 \text{ k}\Omega$	Full range	0.8			1			1.5			V/µV	
				25°C	95	106		97	109		100	112			
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}min,$	$R_S = 50 \Omega$	Full range	91			93			96			dB	
	Supply-voltage rejection ratio			25°C	100	115		103	118		105	120			
ksvr	$(\Delta V_{CC\pm}/\Delta V_{IO})$	$V_{CC\pm} = \pm 2.5 \text{ V to}$	o ±15 V	Full range	95			98			100			dB	
				25°C		550	700		550	700		550	700		
lcc	Supply current		Natara	No to a d	Full range			700			700			700	μΑ
ΔlCC	Supply current change over operating temperature range	v <sub>O</sub> = 0,	$V_{O} = 0$ , No load			9			9			9		μА	

† Full range is 0°C to 70°C.

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

	PARAMETER	TEST CONDI	ITIONS			LE2024C	ا :	TL	E2024A	.c	TL	E2024B	,c	UNIT
	PARAMETER		TIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
V <sub>IO</sub>	Input offset voltage		,	25°C			1100			850			600	μV
VIO			,	Full range			1300			1050			800	μ,
$\alpha_{\text{VIO}}$	Temperature coefficient of input offset voltage		,	Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	R <sub>S</sub> = 50 Ω	25°C		0.005			0.005			0.005		μV/mo
	Innut offeet ourrent	1	I	25°C	( <u> </u>	0.6	6		0.5	6		0.4	6	
110	Input offset current	1	I	Full range	ſ		10			10			10	nA
i	larest bing gurrant		I	25°C	(	45	70		40	70		35	70	
IВ	Input bias current			Full range	(		90			90			90	nA
) / <sub>1</sub>	Common-mode input voltage	D 500		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
VICR	range	$R_S = 50 \Omega$	!	Full range	0 to 3.5			0 to 3.5			0 to 3.5			V
	LP-E level entent veltere			25°C	3.9	4.2		3.9	4.2		4	4.3		V
VOH	High-level output voltage	5 4010	I	Full range	3.7			3.7			3.8			\ \ \
\/	Law lawel output voltone	$R_L = 10 \text{ k}\Omega$	I	25°C	(	0.7	0.8		0.7	0.8		0.7	0.8	V
VOL	Low-level output voltage		I	Full range	(		0.95			0.95			0.95	\ \ \
Λ. σ	Large-signal differential	V= - 1.4.V to 4.V	Di = 10 kO	25°C	0.2	1.5		0.3	1.5		0.4	1.5		\//\/
AVD	voltage amplification	$V_0 = 1.4 \text{ V to 4 V},$	$R_L = 10 \text{ k}\Omega$	Full range	0.1			0.1			0.1			V/μV
CMRR	Common made rejection retio	V:a - Vianmin	Do = 50.0	25°C	80	90		82	92		85	95		dB
CIVIKK	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	Full range	80			82			85			uь
ke)/D	Supply-voltage rejection ratio	V <sub>CC</sub> = 5 V to 30 V		25°C	98	112		100	115		103	117		dB
ksvr	$(\Delta V_{CC}/\Delta V_{IO})$	ACC = 2 A 10 20 A		Full range	93			95			98			uБ
loo	Supply current			25°C		800	1200		800	1200		800	1200	μΑ
Icc		V <sub>O</sub> = 2.5 V,	No load	Full range			1200			1200			1200	μΛ
$\Delta$ ICC	Supply current change over operating temperature range			Full range		15			15			15		μА
-		-												

† Full range is 0°C to 70°C.

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

		<del>-</del>			_									
	PARAMETER	TEST CONI	OITIONS	T <sub>A</sub> †	Т	LE20240	C	Τl	E2024A	С	TL	E2024B	С	UNIT
	PARAMETER	IESI CONL	DITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
\/. o	Input offset voltage			25°C			1000			750			500	μV
VIO	input onset voltage			Full range			1200			950			700	μν
$\alpha_{VIO}$	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μV/mo
1	Input offset current	1		25°C		0.6	6		0.5	6		0.4	6	nA
10	input offset current			Full range			10			10			10	nA
1	lanut higo gurrant	1		25°C		50	70		45	70		40	70	nA
ΙΒ	Input bias current			Full range			90			90			90	nA
V	Common-mode input voltage	D 50.0		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
VICR	range	$R_S = 50 \Omega$		Full range	-15 to 13.5			-15 to 13.5			-15 to 13.5			V
V <sub>OM+</sub>	Maximum positive peak output voltage swing	<b>D</b> 4010		25°C Full range	13.8 13.7	14.1		13.9 13.8	14.2		14 13.9	14.3		V
\/	Maximum negative peak output	$R_L = 10 \text{ k}\Omega$		25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
VOM-	voltage swing			Full range	-13.6			-13.6			-13.6			V
Δ	Large-signal differential	V <sub>O</sub> = ±10 V,	R <sub>I</sub> = 10 kΩ	25°C	0.4	2		0.8	4		1	7		V/µV
AVD	voltage amplification	$VO = \pm 10 \text{ V},$	K[ = 10 K22	Full range	0.4			0.8			1			ν/μν
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	R <sub>S</sub> = 50 Ω	25°C	92	102		94	105		97	108		dB
CIVIKK	Common-mode rejection ratio	VIC = VICRIIIIII,	NS = 50 22	Full range	88			90			93			uБ
kSVR	Supply-voltage rejection ratio	$V_{CC\pm} = \pm 2.5 \text{ V to}$	n +15 V	25°C	98	112		100	115		103	117		dB
"21K	$(\Delta V_{CC} \pm /\Delta V_{IO})$	VUU± - ± 2.5 V ((	J = 10 V	Full range	93			95			98			45
Icc	Supply current			25°C		1050	1400		1050	1400		1050	1400	μА
		$V_{O} = 0$ ,	No load	Full range			1400			1400			1400	μ.,
$\Delta$ ICC	Supply current change over operating temperature range			Full range		20			20			20		μΑ
-														

† Full range is 0°C to 70°C.

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

	PARAMETER	TEST CONDITIONS	T. †	Т	LE2021		TL	E2021A	J	TL	E2021E	SI .	UNIT
	PARAMETER	TEST CONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
VIO	Input offset voltage		25°C		120	600		100	300		80	200	μV
VIO			Full range			950			600			300	μν
αΛΙΟ	Temperature coefficient of input offset voltage		Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0$ , $R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
li a	Input offset current		25°C		0.2	6		0.2	6		0.2	6	nA
10	input onset current		Full range			10			10			10	TIA
lin.	Input bias current		25°C		25	70		25	70		25	70	nA
lВ	input bias current		Full range			90			90			90	IIA
				0	-0.3		0	-0.3		0	- 0.3		
			25°C	to	to		to	to		to 3.5	to		
VICR	Common-mode input voltage range	$R_S = 50 \Omega$		3.5	4		3.5	4			4		V
			Full range	0 to			0 to			0 to			
			i uli range	3.2			3.2			3.2			
.,			25°C	4	4.3		4	4.3		4	4.3		.,
VOH	High-level output voltage	B 4010	Full range	3.9			3.9			3.9			V
,,		$R_L = 10 \text{ k}\Omega$	25°C		0.7	0.8		0.7	0.8		0.7	0.8	
VOL	Low-level output voltage		Full range		•	0.9			0.9			0.9	V
	Large-signal differential	$V_{O} = 1.4 \text{ V to 4 V},$	25°C	0.3	1.5		0.3	1.5		0.3	1.5		
AVD	voltage amplification	R <sub>L</sub> = 10 kΩ	Full range	0.25			0.25	-		0.25			V/µV
CMDD	Common mode minuting asting	V <sub>IC</sub> = V <sub>ICR</sub> min,	25°C	85	110		85	110		85	110		-10
CMRR	Common-mode rejection ratio	$R_S = 50 \Omega$	Full range	80			80			80			dB
1.	Supply-voltage rejection ratio	V 5.V to 20.V	25°C	105	120		105	120		105	120		-10
ksvr	(ΔVCC/ΔVIO)	$V_{CC} = 5 \text{ V to } 30 \text{ V}$	Full range	100			100			100			dB
laa	Supply ourront		25°C		200	300		200	300		200	300	
ICC	Supply current	$V_0 = 2.5 V$ ,	Full range			300			300			300	μΑ
ΔlCC	Supply-current change over operating temperature range	No load	Full range		6			6			6		μΑ
		•	•								-		

† Full range is – 40°C to 85°C.

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

							_				-		
	DADAMETED	TEST CONDITIONS	T. T	1	LE2021		T	LE2021A	/I	Т	LE2021B	I	UNIT
	PARAMETER	TEST CONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
V	Input offset voltage		25°C		120	500		80	200		40	100	μV
VIO	input onset voitage		Full range			850			500			200	μν
ανιο	Temperature coefficient of input offset voltage		Full range		2			2			2		μV/°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		μV/mo
1.0	Input offset current		25°C		0.2	6		0.2	6		0.2	6	nA
110	input onset current		Full range			10			10			10	ΠA
1.5	Input bias current		25°C		25	70		25	70		25	70	nA
IВ	input bias current		Full range			90			90			90	ΠA
,,	Common-mode input voltage range	B 50.0	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		,
VICR		R <sub>S</sub> = 50 Ω	Full range	-15 to 13.2			-15 to 13.2			-15 to 13.2			V
V <sub>OM</sub> +	Maximum positive peak output voltage swing		25°C Full range	14 13.9	14.3		14 13.9	14.3		14 13.9	14.3		٧
Ţ.,	Maximum negative peak output	$R_L = 10 \text{ k}\Omega$	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		.,
VOM –	voltage swing		Full range	-13.6			-13.6	-		-13.6			٧
	Large-signal differential	V <sub>O</sub> = 10 V,	25°C	1	6.5		1	6.5		1	6.5		\// \/
AVD	voltage amplification	$R_L = 10 \text{ k}\Omega$	Full range	0.75			0.75			0.75			V/µV
OMPD	Occurred made activities and	V <sub>IC</sub> = V <sub>ICR</sub> min,	25°C	100	115		100	115		100	115		JD.
CMRR	Common-mode rejection ratio	$R_S = 50 \Omega$	Full range	96			96			96			dB
	Supply-voltage rejection ratio	$V_{CC \pm} = \pm 2.5 V$	25°C	105	120		105	120		105	120		40
ksvr	(ΔVCC/ΔVIO)	to ± 15 V	Full range	100			100			100			dB
la a	Supply ourrent		25°C		240	350		240	350		240	350	
lcc	Supply current	V <sub>O</sub> = 0 V, No load	Full range			350			350			350	μΑ
ΔlCC	Supply-current change over operating temperature range	$\int_{0}^{\infty} V(t) = 0$ V, NO load	Full range		7			7			7		μА

<sup>†</sup> Full range is – 40°C to 85°C.

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

DADAMETED	TEST COND	ITIONS	Tat	Т	LE2022I		ΤL	E2022A	J	TL	E2022B	SI .	UNIT
FARAMETER	TEST COND	IIIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	ONIT
Innut offset voltage			25°C			600			400			250	μV
mpat onoct voltage			Full range			800			550			400	μν
Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
lanut affact ourrent			25°C		0.5	6		0.4	6		0.3	6	nA
input offset current			Full range			10			10			10	nA
Input higo ourrent			25°C		35	70		33	70		30	70	nA
input bias current			Full range			90			90			90	nA
Common-mode input	Po - 50 O		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
voltage range	KS = 50 12		Full range	0 to 3.2			0 to 3.2			0 to 3.2			V
I link lavel autout valtage			25°C	4	4.3		4	4.3		4	4.3		V
nign-level output voltage	D: 40 kg		Full range	3.9			3.9			3.9			V
Low lovel output voltage	K[ = 10 K22		25°C		0.7	0.8		0.7	0.8		0.7	0.8	V
Low-level output voltage			Full range			0.9			0.9			0.9	V
Large-signal differential	\/a	D: 40 kO	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V/µV
voltage amplification	VO = 1.4 V to 4 V,	K[ = 10 K22	Full range	0.2			0.2			0.2			ν/μν
Common made rejection ratio	\/.	D- 50.0	25°C	85	100		87	102		90	105		dB
Common-mode rejection ratio	VIC = VICRIIIIII,	KS = 50 12	Full range	80			82			85			uБ
Supply-voltage rejection ratio	V00 = 5 V to 30 V		25°C	100	115		103	118		105	120		dB
$(\Delta V_{CC\pm}/\Delta V_{IO})$	VCC = 3 V 10 30 V		Full range	95			98			100			ub
Supply current			25°C		450	600		450	600		450	600	μА
Cappiy durion	Vo = 2.5 V.	No load	Full range			600			600			600	μι
Supply current change over operating temperature range		. 13 1000	Full range		15			15			15		μΑ
	Input offset voltage Input offset voltage long-term drift (see Note 4)  Input offset current  Input offset current  Common-mode input voltage range  High-level output voltage  Large-signal differential voltage amplification  Common-mode rejection ratio  Supply-voltage rejection ratio  (ΔVCC±/ΔVIO)  Supply current  Supply current change over	Input offset voltage         Temperature coefficient of input offset voltage         Input offset voltage long-term drift (see Note 4)         Input offset current         Input bias current         Common-mode input voltage range         High-level output voltage         Low-level output voltage         Large-signal differential voltage amplification $V_O = 1.4 \text{ V to 4 V}$ ,         Common-mode rejection ratio ( $\Delta V_{CC \pm}/\Delta V_{IO}$ ) $V_{CC} = 5 \text{ V to 30 V}$ Supply-voltage rejection ratio ( $\Delta V_{CC \pm}/\Delta V_{IO}$ ) $V_{CC} = 5 \text{ V to 30 V}$ Supply current       Supply current change over operating temperature range			$ \begin{array}{ c c c c c } \hline \textbf{PARAMETER} & \textbf{TEST CONDITIONS} & \textbf{TAT} & \textbf{MIN} \\ \hline \textbf{Input offset voltage} \\ \hline \textbf{Temperature coefficient of input offset voltage} \\ \hline \textbf{Input offset voltage long-term drift (see Note 4)} \\ \hline \textbf{Input offset current} \\ \hline \textbf{Input offset current} \\ \hline \textbf{Input bias current} \\ \hline \textbf{Common-mode input voltage range} \\ \hline \textbf{High-level output voltage} \\ \hline \textbf{Low-level output voltage} \\ \hline \textbf{Large-signal differential voltage amplification} \\ \hline \textbf{Common-mode rejection ratio} \\ \hline \textbf{Supply-voltage rejection ratio} \\ \hline \textbf{Supply current} \\ \hline \textbf{Supply current change over operating temperature range} \\ \hline \textbf{Supply current change over operating temperature range} \\ \hline \textbf{Full range} \\ \hline \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \hline \textbf{Full range} $	PARAMETER         TEST CONDITIONS         TAT         MIND         TYP           Input offset voltage         Pull range         25°C         Full range         2           Input offset voltage long-term drift (see Note 4)         VIC = 0,         RS = 50 Ω         25°C         0.005           Input offset current         Full range         25°C         0.5           Input bias current         RS = 50 Ω         Trull range         25°C         0.5           Common-mode input voltage arange         RS = 50 Ω         Trull range         0         -0.3           Low-level output voltage         RL = 10 kΩ         Full range         3.9         -0.7           Low-level output voltage         Pull range         3.9         -0.7         -0.7           Large-signal differential voltage amplification         VO = 1.4 V to 4 V, RL = 10 kΩ         Full range         0.2         1.5           Common-mode rejection ratio (ΔVCC±/ΔV O)         VIC = V CRmin, RS = 50 Ω         25°C         85         100           Supply-voltage rejection ratio (ΔVCC±/ΔV O)         VCC = 5 V to 30 V         Full range         -25°C         450           Supply current change over operating temperature range         Trull range         -15         -15 <td>  Part   Part  </td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN    </td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP    </td> <td>PARAMETER         TEST CONDITIONS         TAT         MIN         TYP         MAX         MIN         TYP         MAX           Input offset voltage         25°C         0         500         0         550           Imput offset voltage long-term drift (see Note 4)         VIC = 0.         RS = 50 Ω         25°C         0.005         <td< td=""><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MI</td><td>  PARAMETER   TEST COND   TE</td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP</td></td<></td>	Part   Part	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP	PARAMETER         TEST CONDITIONS         TAT         MIN         TYP         MAX         MIN         TYP         MAX           Input offset voltage         25°C         0         500         0         550           Imput offset voltage long-term drift (see Note 4)         VIC = 0.         RS = 50 Ω         25°C         0.005 <td< td=""><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MI</td><td>  PARAMETER   TEST COND   TE</td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP</td></td<>	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MI	PARAMETER   TEST COND   TE	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP   MIN   MIN   TYP   MAX   MIN   TYP   MIN   MIN   TYP

† Full range is –40°C to 85°C.

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

				_										
	DADAMETED	TEOT 00M	DITIONS	T. #	1	LE2022I		Т	LE2022A	ı	T	LE2022B	_	
	PARAMETER	TEST CON	DITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
	land offertualtens			25°C		150	500		120	300		70	150	
VIO	Input offset voltage			Full range			700			450			300	μV
ανιο	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μV/mo
li o	Input offset current	1		25°C		0.5	6		0.4	6		0.3	6	nA
lio	input onset current			Full range			10			10			10	IIA
1	Input higo ourrent	1		25°C		35	70		33	70		30	70	nA
¹IB	Input bias current			Full range			90			90			90	TIA.
					- 15	-15.3		- 15	-15.3		- 15	-15.3		
				25°C	to	to		to	to		to	to		
VICR	Common-mode input	$R_S = 50 \Omega$			13.5	14		13.5	14		13.5	14		٧
	voltage range			Full range	– 15 to			– 15 to			– 15 to			
				I dil fallige	13.2			13.2			13.2			
	Maximum positive peak			25°C	14	14.3		14	14.3		14	14.3		
VOM +	output voltage swing			Full range	13.9			13.9			13.9			V
1.,	Maximum negative peak	$R_L = 10 \text{ k}\Omega$		25°C	- 13.7	- 14.1		- 13.7	- 14.1		- 13.7	- 14.1		
VOM –	output voltage swing			Full range	- 13.6	-		- 13.6	-		- 13.6	-		V
	Large-signal differential			25°C	0.8	4		1	7		1.5	10		
AVD	voltage amplification	$V_0 = \pm 10 \text{ V},$	$R_L = 10 \text{ k}\Omega$	Full range	0.8	-		1	-		1.5	-		V/µV
				25°C	95	106		97	109		100	112		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	Full range	91			93			96			dB
<u>.                                    </u>	Supply-voltage rejection ratio		. 45.17	25°C	100	115		103	118		105	120		
ksvr	$(\Delta V_{CC\pm}/\Delta V_{IO})$	$V_{CC} = \pm 2.5 \text{ V to}$	±15 V	Full range	95			98			100	-		dB
1.	Our about a sum and			25°C		550	700		550	700		550	700	_
lcc	Supply current	\	Nolood	Full range		-	700		-	700		-	700	μΑ
ΔICC	Supply current change over operating temperature range	V <sub>O</sub> = 0,	No load	Full range		30			30			30		μΑ

†Full range is -40°C to 85°C.

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

DADAMETED	TEST COND	ITIONS	T. †	Т	LE2024I		TL	E2024A	l l	TL	.E2024B	E	UNIT
PARAMETER	TEST COND	ITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
Input offset voltage			25°C			1100			850			600	μV
·			Full range			1300			1050			800	μν
Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
Input offset current			25°C		0.6	6		0.5	6		0.4	6	nA
input onset current			Full range			10			10			10	IIA
Input hise current			25°C		45	70		40	70		35	70	nA
input bias current			Full range			90			90			90	ПА
Common-mode input voltage	D- 50 O		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
range	KS = 50 12		Full range	0 to 3.2			0 to 3.2			0 to 3.2			V
Maximum positive peak			25°C	3.9	4.2		3.9	4.2		4	4.3		V
output voltage swing	P 10 kO		Full range	3.7			3.7			3.8			V
Maximum negative peak	KL = 10 K22		25°C		0.7	8.0		0.7	0.8		0.7	8.0	V
output voltage swing			Full range			0.95			0.95			0.95	V
Large-signal differential	Vo = 1.4.V to 4.V	Ri = 10 kO	25°C	0.2	1.5		0.3	1.5		0.4	1.5		V/µV
voltage amplification	VO = 1.4 V 10 4 V,	11 - 10 122	Full range	0.1			0.1			0.1			ν/μν
Common-mode rejection ratio	Vic = Vicpmin	Re = 50 O	25°C	80	90		82	92		85	95		dB
Common mode rejection ratio	VIC - VICKIIIII,	113 - 00 22	Full range	80			82			85			ub.
Supply-voltage rejection ratio	Vcc+ = ±2.5 V to +	15 V	25°C	98	112		100	115		103	117		dB
$(\nabla \Lambda^{CC\mp}/\nabla \Lambda^{IO})$	- CO ± = = = = 0 + 10 ±	• • •	Full range	93			95			98			
Supply current			25°C		800	1200		800	1200		800	1200	μΑ
	$V_{O} = 0$ ,	No load	Full range			1200			1200			1200	F .
Supply current change over operating temperature range	-		Full range		30			30			30		μΑ
	Input offset voltage Input offset voltage long-term drift (see Note 4) Input offset current Input bias current  Common-mode input voltage range  Maximum positive peak output voltage swing  Maximum negative peak output voltage swing  Large-signal differential voltage amplification  Common-mode rejection ratio  Supply-voltage rejection ratio (ΔVCC±/ΔVIO)  Supply current  Supply current change over	Input offset voltage         Temperature coefficient of input offset voltage         Input offset voltage long-term drift (see Note 4)         Input offset current         Input bias current         Common-mode input voltage range         Maximum positive peak output voltage swing         Maximum negative peak output voltage swing         Large-signal differential voltage amplification         Common-mode rejection ratio $V_O = 1.4 \text{ V to 4 V}$ ,         Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ ) $V_{CC\pm} = \pm 2.5 \text{ V to } \pm 2.5 \text{ V to }$	Input offset voltage         Temperature coefficient of input offset voltage         Input offset voltage long-term drift (see Note 4) $VIC = 0$ , $R_S = 50 \Omega$ Input offset current         Input offset current         Input bias current         R <sub>S</sub> = 50 Ω         Maximum positive peak output voltage swing         Maximum negative peak output voltage swing         Large-signal differential voltage amplification $V_O = 1.4 \text{ V to 4 V}$ , $R_L = 10 \text{ k}\Omega$ Common-mode rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ ) $V_{CC\pm} = \pm 2.5 \text{ V to } \pm 15 \text{ V}$ Supply current $V_O = 0$ , No load	$ \begin{array}{c} \mbox{Input offset voltage} \\ \mbox{Temperature coefficient of input offset voltage} \\ \mbox{Input offset voltage long-term drift (see Note 4)} \\ \mbox{Input offset current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{Input bias current} \\ \mbox{R}_{S} = 50  \Omega \\ \mbox{Input bias current} \\ \mbo$	PARAMETER       TEST CONDITIONS       TA\$       MIN         Input offset voltage       Pull range       Full range         Temperature coefficient of input offset voltage       Full range       Full range         Input offset voltage long-term drift (see Note 4)       VIC = 0,       RS = 50 Ω       25°C       Full range         Common-mode input voltage range       RS = 50 Ω       RS = 50 Ω       25°C       To	$ \begin{array}{ c c c c c } \hline \textbf{PARAMETER} & \textbf{TEST CONDITIONS} & \textbf{TA}^{\scriptsize \textbf{TA}} & \textbf{MIN} & \textbf{TYP} \\ \hline \textbf{Input offset voltage} \\ \hline \textbf{Temperature coefficient of input offset voltage} \\ \hline \textbf{Input offset voltage long-term drift (see Note 4)} \\ \hline \textbf{Input offset current} \\ \hline \textbf{Input offset current} \\ \hline \textbf{Input bias current} \\ \hline \textbf{Common-mode input voltage range} \\ \hline \textbf{RS} = 50  \Omega \\ \hline \textbf{RS} = 50  \Omega \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply-voltage rejection ratio} \\ \hline \textbf{Supply current} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline \textbf{Full range} \\ \hline \textbf{Supply current change over} \\ \hline Supply $	Input offset voltage   Temperature coefficient of input offset voltage   Temperature coefficient of input offset voltage   Input offset voltage long-term drift (see Note 4)   V <sub>IC</sub> = 0, R <sub>S</sub> = 50 Ω   R <sub>S</sub> = 50 Ω   Efull range   R <sub>S</sub> = 50 Ω   Common-mode input voltage range   R <sub>S</sub> = 50 Ω   R <sub></sub>	TAΛ MIN         TYP         MAX         MIN           Input offset voltage         25°C         1100         1300           Temperature coefficient of input offset voltage         Full range         2         1300           Input offset voltage long-term drift (see Note 4)         VIC = 0,         RS = 50 Ω         25°C         0.005         6           Input offset current         25°C         0.005         10	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN	PARAMETER   TEST CONDITIONS   TAT   MIN TYP   MAX   MIN TYP	Parametre   Par	PARAMETER   TEST CONDITIONS   TAT   MAX   MIN   TYP   MIN   MIN

† Full range is -40°C to 85°C.

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

		=		-		•••		•				•		
	DADAMETED	TEST COM	NTIONS	- +	1	LE2024	ı	Т	LE2024A	VI	T	LE2024B	BI	UNIT
	PARAMETER	TEST CONI	CNOILIC	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
V. 0	Input offset voltage			25°C			1000			750			500	μV
VIO	input onset voltage			Full range			1200			950			700	μν
$\alpha_{VIO}$	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μV/mo
lio.	Input offset current			25°C		0.6	6		0.5	6		0.4	6	nA
ΙΟ	input onset current			Full range			10			10			10	IIA
IIB	Input bias current			25°C		50	70		45	70		40	70	nA
ΙΒ	input bias current			Full range			90			90			90	11/5
	Common-mode input voltage	B 50.0		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		.,
VICR	range	$R_S = 50 \Omega$		Full range	-15 to 13.2			-15 to 13.2			-15 to 13.2			V
V <sub>OM+</sub>	Maximum positive peak output voltage swing	<b>D</b> 4010		25°C Full range	13.8 13.7	14.1		13.9 13.7	14.2		14 13.8	14.3		V
V <sub>OM</sub> -	Maximum negative peak output voltage swing	R <sub>L</sub> = 10 kΩ		25°C Full range	-13.7 -13.6	-14.1		-13.7 -13.6	-14.1		-13.7 -13.6	-14.1		٧
	Large-signal differential		,	25°C	0.4	2		0.8	4		1	7		
AVD	voltage amplification	$V_0 = \pm 10 \text{ V},$	$R_L = 10 \text{ k}\Omega$	Full range	0.4			0.8			1			V/µV
				25°C	92	102		94	105		97	108		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	Full range	88			90	•		93			dB
ksvr	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	$V_{CC\pm} = \pm 2.5 \text{ V to}$	o ±15 V	25°C Full range	98 93	112		100 95	115		103 98	117		dB
				25°C		1050	1400		1050	1400		1050	1400	
Icc	Supply current		No local	Full range			1400			1400		-	1400	μΑ
ΔI <sub>CC</sub>	Supply current change over operating temperature range	V <sub>O</sub> = 0,	No load	Full range		50			50			50		μΑ
-		•		-					_					

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

	PARAMETER	TEST COND	DITIONS	T <sub>A</sub> †	TI	LE2021N	Л	TL	E2021AI	М	TLE	E2021B	М	UNIT
	FARAMETER	TEST COND		'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
VIO	Input offset voltage			25°C		120	600		100	300		80	200	μV
VIO	input onset voltage	_		Full range			1100			600			300	μν
αVIO	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
1	Innut affact current			25°C		0.2	6		0.2	6		0.2	6	
10	Input offset current			Full range			10			10			10	nA
	land bigg gurrant	1		25°C		25	70		25	70		25	70	- A
lВ	Input bias current			Full range			90			90			90	nA
				7	0	-0.3		0	-0.3		0	-0.3		
	,			25°C	to	to		to	to		to	to		
VICR	Common-mode input	$R_S = 50 \Omega$			3.5	4		3.5	4		3.5	4		
YICK	voltage range	1.3 - 33		!	0			0			0			
	,			Full range	to 3.2			to 3.2			to 3.2			
<u> </u>		<del></del>		1 2500					4.0			4.0		
VOH	High-level output voltage			25°C	4	4.3		4	4.3		4	4.3		V
		$R_L = 10 \text{ k}\Omega$		Full range	3.8			3.8			3.8			$\vdash$
VOL	Low-level output voltage	-		25°C	——	0.7	0.8		0.7	0.8	<u> </u>	0.7	0.8	V
		<b></b>		Full range	—		0.95			0.95			0.95	ļ
AVD	Large-signal differential	$V_0 = 1.4 \text{ V to 4 V},$	$R_L = 10 \text{ k}\Omega$	25°C	0.3	1.5		0.3	1.5		0.3	1.5		V/μV
	voltage amplification	1 0		Full range	0.1			0.1			0.1			
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	25°C	85	110		85	110		85	110		dB
Civil (i	Odminon mode rejection rate	VIC - VICKIIII.,		Full range	80			80			80			<u> </u>
kov.p	Supply-voltage rejection ratio	V <sub>CC</sub> = 5 V to 30 V		25°C	105	120		105	120		105	120		dB
ksvr	$(\Delta VCC^{\pm}/\Delta VIO)$	VCC = 3 V 10 33 V		Full range	100			100			100			ub
	Supply current			25°C		170	230		170	230		170	230	μА
ICC	Зирріу сипені	V <sub>O</sub> = 2.5 V,	No load	Full range			230			230			230	μΛ
ΔlCC	Supply current change over operating temperature range		NO IOAG	Full range		9			9			9		μΑ
	· · · · · · · · · · · · · · · · · · ·													

† Full range is –55°C to 125°C.

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

DADAMETED	TEST CON	DITIONS	- +	Т	LE2021N	/	TL	E2021A	М	TL	.E2021B	М	
PARAMETER	TEST CON	DITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
Land Market Land			25°C		120	500		80	200		40	100	
input offset voltage			Full range			1000			500			200	μV
Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μV/mo
Input offset current	1		25°C		0.2	6		0.2	6		0.2	6	nA
input onset current			Full range			10			10			10	Ш
Input hise current	1		25°C		25	70		25	70		25	70	nA
input bias current			Full range			90			90			90	ПА
Common-mode input			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		.,
voltage range	$RS = 50 \Omega$		Full range	-15 to 13.2			-15 to 13.2			-15 to 13.2			V
Maximum positive peak output voltage swing	D 4010		25°C Full range	14 13.8	14.3		14 13.8	14.3		14 13.8	14.3		V
Maximum negative peak	RΓ = 10 KΩ		25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		
output voltage swing			Full range	-13.6			-13.6			-13.6			V
Large-signal differential	V- 140V	D: 40 l-0	25°C	1	6.5		1	6.5		1	6.5		\//\/
voltage amplification	$VO = \pm 10 V$	K[ = 10 K22	Full range	0.5			0.5			0.5			V/μV
Common mode rejection retio	\/ \/ min	Do 50.0	25°C	100	115		100	115		100	115		dB
Common-mode rejection ratio	VIC = VICRIIIII,	KS = 50 12	Full range	96			96			96			uБ
Supply-voltage rejection ratio	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	2 ± 15 \/	25°C	105	120		105	120		105	120		dB
$(\Delta V_{CC\pm}/\Delta V_{IO})$	VCC±=± 2.5 V to	J ± 13 V	Full range	100			100			100			ub
Supply current			25°C		200	300		200	300		200	300	
Зарріу сапені	$V_{\Omega} = 0$ .	No load	Full range			300			300			300	μΑ
Supply current change over operating temperature range			Full range		10			10			10		μΑ
	Input offset voltage Input offset voltage long-term drift (see Note 4)  Input offset current  Input bias current  Common-mode input voltage range  Maximum positive peak output voltage swing  Maximum negative peak output voltage swing  Large-signal differential voltage amplification  Common-mode rejection ratio  Supply-voltage rejection ratio  Supply current  Supply current	Input offset voltage         Temperature coefficient of input offset voltage         Input offset voltage long-term drift (see Note 4)         Input offset current         Input offset current         Input bias current         Common-mode input voltage range         Maximum positive peak output voltage swing         Maximum negative peak output voltage swing         Large-signal differential voltage amplification $V_O = \pm 10 \text{ V}$ Common-mode rejection ratio $V_{IC} = V_{IC}Rmin$ Supply-voltage rejection ratio ( $\Delta V_{CC} \pm /\Delta V_{IO}$ ) $V_{CC} \pm 2.5 \text{ V to}$ Supply current $V_O = 0$ Supply current change over	Input offset voltage         Temperature coefficient of input offset voltage         Input offset voltage long-term drift (see Note 4) $V_{IC} = 0$ , $R_S = 50 \Omega$ Input offset current         Input bias current         Common-mode input voltage range $R_S = 50 \Omega$ Maximum positive peak output voltage swing $R_L = 10 \text{ k}\Omega$ Maximum negative peak output voltage swing $V_C = \pm 10 \text{ k}\Omega$ Large-signal differential voltage amplification $V_C = \pm 10 \text{ k}\Omega$ Common-mode rejection ratio ( $\Delta V_{CC} \pm \Delta V_{IO}$ ) $V_{IC} = V_{IC}R_{min}$ , $R_S = 50 \Omega$ Supply-voltage rejection ratio ( $\Delta V_{CC} \pm \Delta V_{IO}$ ) $V_{CC} \pm \Delta V_{IC} = 0$ , No load         Supply current $V_{O} = 0$ , No load	Input offset voltage  Temperature coefficient of input offset voltage Input offset current  Input offset current  Input offset current  Input bias current $ R_S = 50 \Omega $ Maximum positive peak output voltage swing  Maximum negative peak output voltage swing  Large-signal differential voltage amplification  Common-mode rejection ratio $ Common-mode rejection ratio (\Delta V_{CC\pm}/\Delta V_{IO})  Supply-voltage rejection ratio  Supply current  Supply current  Full range   25^{\circ}C  Full range  Full range$	PARAMETER       TEST CONDITIONS       TA\$ MIN         Input offset voltage         Input offset voltage long-term drift (see Note 4) $V_{IC} = 0$ , $R_S = 50 \Omega$ $Eull range$ Full range         Large-signal differential voltage amplification $R_S = 50 \Omega$	PARAMETER   TEST CONDITIONS   TAT   MiN   TYP	Input offset voltage  Input offset voltage  Input offset voltage long-term drift (see Note 4)  Input offset current  Input offset current  Input offset current  R <sub>S</sub> = 50 Ω $25^{\circ}$ C	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   Max   MIN   TYP   Max   MIN   TYP   Max   MIN   MI	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN	PARAMETER   TEST CONDITIONS   TAT   MIN TYP   MAX   MIN TYP	PARAMETER   TEST CONDITIONS   TAT   MIN TYP   MAX   MIN   TYP   MAX   TYP   TYP	PARAMETER   TEST CONTIONS   TEST CONTIONS

† Full range is –55°C to 125°C.

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

	PARAMETER	TEST COND	ITIONS	T <sub>A</sub> †	TI	_E2022N	Λ	TL	E2022A	М	TL	E2022B	M	UNIT
	PARAMETER	TEST COND	IIIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
VIO	Input offset voltage			25°C			600			400			250	μV
10	mpar oncor voltage			Full range			800			550			400	μν
αNIO	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
lio.	Input offset current			25°C		0.5	6		0.4	6		0.3	6	nA
IIO	input onset current			Full range			10			10			10	IIA
lin	Input bias current			25°C		35	70		33	70		30	70	nA
IB	input bias current			Full range			90			90			90	ПА
	Common-mode input			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		
VICR	voltage range	$R_S = 50 \Omega$		Full range	0 to 3.2			0 to 3.2			0 to 3.2			V
V	Lligh lovel output voltage			25°C	4	4.3		4	4.3		4	4.3		V
VOH	High-level output voltage	B 10 kO		Full range	3.8			3.8			3.8			V
V/01	Low-level output voltage	$R_L = 10 \text{ k}\Omega$		25°C		0.7	0.8		0.7	0.8		0.7	0.8	V
VOL	Low-level output voltage			Full range			0.95			0.95			0.95	V
AVD	Large-signal differential	V <sub>O</sub> = 1.4 V to 4 V,	$R_{I} = 10 \text{ k}\Omega$	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V/µV
, vD	voltage amplification	vo = 111 v to 1 v,		Full range	0.1			0.1			0.1			νημι
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	25°C	85	100		87	102		90	105		dB
		TIC TICK		Full range	80			82			85			
k <sub>SVR</sub>	Supply-voltage rejection ratio	V <sub>CC</sub> = 5 V to 30 V		25°C	100	115		103	118		105	120		dB
<u> </u>	$(\Delta V_{CC\pm}/\Delta V_{IO})$			Full range	95	456	200	98	456	200	100	450	225	
Icc	Supply current			25°C		450	600	-	450	600		450	600	μΑ
ΔICC	Supply current change over operating temperature range	V <sub>O</sub> = 2.5 V,	No load	Full range Full range		37	000		37	000		37	000	μΑ
+	:- FF0C t- 40F0C							-	-					

† Full range is -55°C to 125°C.

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

	TEST COM	DITIONS	T. †	Т	LE2022N	Λ	TL	E2022A	М	TL	E2022B	M	LINUT	
PARAMETER	I IEST CON	DITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT	
lanut effect veltage			25°C		150	500		120	300		70	150	/	
input offset voltage			Full range			700			450			300	μV	
Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C	
Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.006			0.006			0.006		μV/mo	
Input offset current			25°C		0.5	6		0.4	6		0.3	6	nA	
input onset current			Full range			10			10			10	ПА	
Input hise current			25°C		35	70		33	70		30	70	nA	
input bias current			Full range			90			90			90	ПА	
				-15	-15.3		-15	-15.3		-15	-15.3			
			25°C	to	to		to	to		to	to			
•	$R_S = 50 \Omega$				14			14			14		V	
voltage range			Full range	ı			_			_				
			i dii range	13.2			13.2			13.2				
Maximum positive peak			25°C	14	14.3		14	14.3		14	14.3			
output voltage swing			Full range	13.9			13.9	_		13.9			V	
Maximum negative peak	$R_L = 10 \text{ k}\Omega$		25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1			
output voltage swing			Full range	-13.6	-		-13.6	-		-13.6	-		V	
Large-signal differential			25°C	0.8	4		1	7		1.5	10			
voltage amplification	$V_0 = \pm 10 \text{ V},$	$R_L = 10 \text{ k}\Omega$	Full range	0.8			1	-		1.5	-		V/µV	
	., ., .		25°C	95	106		97	109		100	112			
Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	$R_S = 50 \Omega$	Full range	91			93			96	-		dB	
Supply-voltage rejection ratio			25°C	100	115		103	118		105	120			
$(\Delta V_{CC\pm}/\Delta V_{IO})$	$V_{CC\pm} = \pm 2.5 \text{ V to}$	±15 V	Full range	95			98	-		100			dB	
0			25°C		550	700		550	700		550	700		
Supply current	\/- 0	Nolood	Full range			700			700			700	μΑ	
Supply current change over operating temperature range	v <sub>O</sub> = 0,	ino ioad	Full range		60			60			60		μΑ	
	Input offset voltage Input offset voltage long-term drift (see Note 4)  Input offset current  Input offset current  Common-mode input voltage range  Maximum positive peak output voltage swing  Maximum negative peak output voltage swing  Large-signal differential voltage amplification  Common-mode rejection ratio  Supply-voltage rejection ratio  (ΔVCC± /ΔVIO)  Supply current  Supply current change over	Input offset voltage         Temperature coefficient of input offset voltage         Input offset voltage long-term drift (see Note 4)         Input offset current         Input offset current         Input bias current         Rs = 50 Ω         Maximum positive peak output voltage swing         Maximum negative peak output voltage swing         Large-signal differential voltage amplification $V_O = \pm 10 \text{ V}$ ,         Common-mode rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ ) $V_{IC} = V_{ICR}$ min,         Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ ) $V_{CC\pm} = \pm 2.5 \text{ V to}$ Supply current $V_O = 0$ ,			PARAMETER       TEST CONDITIONS       TAT       MINDITIONS       TAT       Full range       Coll In Full range <th c<="" td=""><td>PARAMETER       TEST CONDITIONS       TAT       MIN       TYP         Input offset voltage       25°C       150         Full range       2         Full range       2         Input offset voltage long-term drift (see Note 4)       <math>V_{IC} = 0</math>, <math>R_S = 50 \Omega</math> <math>25^{\circ}C</math>       0.006         Input offset current       <math>25^{\circ}C</math>       0.5         Input bias current       <math>25^{\circ}C</math>       35         Common-mode input voltage range       <math>R_S = 50 \Omega</math> <math>25^{\circ}C</math>       35         Maximum positive peak output voltage swing       <math>R_S = 50 \Omega</math> <math>R_S </math></td><td>  Input offset voltage   Pull range   Pull</td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN    </td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP    </td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN TYP MAX MIN TYP MAX MAN MAN MAN MAN MAN TYP MAX MAN MAN MAN MAN TYP MAX MAN MAN MAN MAN MAN MAN MAN MAN MAN MAN</td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   MAX   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN</td><td>  PARAMETER   TEST CONDITIONS   TAT   MIN TYP MAX MIN</td><td>  PARAMETER   TEST CONTINON   TAT   TAT  </td></th>	<td>PARAMETER       TEST CONDITIONS       TAT       MIN       TYP         Input offset voltage       25°C       150         Full range       2         Full range       2         Input offset voltage long-term drift (see Note 4)       <math>V_{IC} = 0</math>, <math>R_S = 50 \Omega</math> <math>25^{\circ}C</math>       0.006         Input offset current       <math>25^{\circ}C</math>       0.5         Input bias current       <math>25^{\circ}C</math>       35         Common-mode input voltage range       <math>R_S = 50 \Omega</math> <math>25^{\circ}C</math>       35         Maximum positive peak output voltage swing       <math>R_S = 50 \Omega</math> <math>R_S </math></td> <td>  Input offset voltage   Pull range   Pull</td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN    </td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP    </td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN TYP MAX MIN TYP MAX MAN MAN MAN MAN MAN TYP MAX MAN MAN MAN MAN TYP MAX MAN MAN MAN MAN MAN MAN MAN MAN MAN MAN</td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   MAX   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN</td> <td>  PARAMETER   TEST CONDITIONS   TAT   MIN TYP MAX MIN</td> <td>  PARAMETER   TEST CONTINON   TAT   TAT  </td>	PARAMETER       TEST CONDITIONS       TAT       MIN       TYP         Input offset voltage       25°C       150         Full range       2         Full range       2         Input offset voltage long-term drift (see Note 4) $V_{IC} = 0$ , $R_S = 50 \Omega$ $25^{\circ}C$ 0.006         Input offset current $25^{\circ}C$ 0.5         Input bias current $25^{\circ}C$ 35         Common-mode input voltage range $R_S = 50 \Omega$ $25^{\circ}C$ 35         Maximum positive peak output voltage swing $R_S = 50 \Omega$ $R_S $	Input offset voltage   Pull range   Pull	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP	PARAMETER   TEST CONDITIONS   TAT   MIN TYP MAX MIN TYP MAX MAN MAN MAN MAN MAN TYP MAX MAN MAN MAN MAN TYP MAX MAN	PARAMETER   TEST CONDITIONS   TAT   MIN   TYP   MAX   MIN   TYP   MAX   MIN   TYP   MAX   MIN   MIN   TYP   MAX   MIN   MIN	PARAMETER   TEST CONDITIONS   TAT   MIN TYP MAX MIN	PARAMETER   TEST CONTINON   TAT   TAT

† Full range is 0°C to 70°C.

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

	PARAMETER	TEST COND	ITIONS	T. †	TL	E2024N	1	TL	E2024A	М	TLI	E2024B	M	UNIT
	PARAMETER	TEST COND	ITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
VIO	Input offset voltage			25°C			1100			850			600	μV
10	· ·			Full range		-	1300			1050			800	μι
$\alpha_{\text{VIO}}$	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$	25°C		0.005			0.005			0.005		μV/mo
lio.	Input offset current			25°C		0.6	6		0.5	6		0.4	6	nA
10	input onset current			Full range			10			10			10	ПА
I <sub>IB</sub>	Input bias current			25°C		45	70		40	70		35	70	nA
ПР	mpat blas sancht			Full range			90			90			90	117 (
	Common-mode input voltage	B 500		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		.,
VICR	range	R <sub>S</sub> = 50 Ω		Full range	0 to 3.2			0 to 3.2			0 to 3.2			V
Vou	Maximum positive peak			25°C	3.9	4.2		3.9	4.2		4	4.3		V
VOM+	output voltage swing	R <sub>L</sub> = 10 kΩ		Full range	3.7			3.7			3.8			V
V <sub>OM</sub> -	Maximum negative peak			25°C		0.7	8.0		0.7	8.0		0.7	8.0	V
VOIVI—	output voltage swing			Full range			0.95			0.95			0.95	•
AVD	Large-signal differential	V <sub>O</sub> = 1.4 V to 4 V,	$R_1 = 10 \text{ k}\Omega$	25°C	0.2	1.5		0.3	1.5		0.4	1.5		√/μ√
	voltage amplification	,		Full range	0.1	-		0.1	-		0.1	-		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	25°C	80	90		82	92		85	95		dB
				Full range	80			82			85			
ksvr	Supply-voltage rejection ratio $(\Delta V_{CC\pm}/\Delta V_{IO})$	$V_{CC\pm} = \pm 2.5 \text{ V to } \pm$	:15 V	25°C Full range	98	112		100 95	115		103 98	117		dB
	(4 · CC±/4 · IO/			25°C	93	800	1200	95	800	1200	90	800	1200	
Icc	Supply current			Full range			1200	-		1200		- 000	1200	μΑ
$\Delta$ ICC	Supply current change over operating temperature range	$V_O = 0$ ,	No load	Full range		50			50			50		μА
+ Full ron	go is 55°C to 125°C	-							-					

† Full range is –55°C to 125°C.

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

		-		-		•						-		
	DADAMETED	TEST COM	NITIONS	- +	Т	LE2024N	N	TL	E2024A	М	TL	E2024B	M	UNIT
	PARAMETER	TEST CONI	CHOIL	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
V	Innut offeet veltoge			25°C			1000			750			500	\/
VIO	Input offset voltage			Full range			1200			950			700	μV
ανιο	Temperature coefficient of input offset voltage			Full range		2			2			2		μV/°C
	Input offset voltage long-term drift (see Note 4)	V <sub>IC</sub> = 0,	R <sub>S</sub> = 50 Ω	25°C		0.006			0.006			0.006		μV/mo
lio.	Input offset current	1		25°C		0.6	6		0.5	6		0.4	6	nA
IIO	input onset current			Full range			10			10			10	ΠA
lin.	Input bias current	1		25°C		50	70		45	70		40	70	nA
IB	input bias current			Full range			90			90			90	IIA
, , , , , , , , , , , , , , , , , , ,	Common-mode input voltage	D 50.0		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
VICR	range	$R_S = 50 \Omega$		Full range	-15 to 13.2			-15 to 13.2			-15 to 13.2			V
V <sub>OM+</sub>	Maximum positive peak output voltage swing	<b>D</b> 4010		25°C Full range	13.8 13.7	14.1		13.9 13.7	14.2		14 13.8	14.3		٧
V <sub>OM</sub> -	Maximum negative peak output voltage swing	R <sub>L</sub> = 10 kΩ		25°C Full range	-13.7 -13.6	-14.1		-13.7 -13.6	-14.1		-13.7 -13.6	-14.1		٧
	Large-signal differential		,	25°C	0.4	2		0.8	4		1	7		
AVD	voltage amplification	$V_0 = \pm 10 \text{ V},$	$R_L = 10 \text{ k}\Omega$	Full range	0.4			0.8			1			V/µV
			_	25°C	92	102		94	105		97	108		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$	Full range	88			90	-		93			dB
ksvr	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	V <sub>CC±</sub> = ± 2.5 V to	o ±15 V	25°C Full range	98 93	112		100 95	115		103 98	117		dB
				25°C	"	1050	1400	"	1050	1400	<u> </u>	1050	1400	
lcc	Supply current	V <sub>O</sub> = 0,	No load	Full range			1400			1400			1400	μΑ
$\Delta$ ICC	Supply current change over operating temperature range	V() = 0,	INU IUAU	Full range		85			85			85		μΑ
_														

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

	PARAMETER	TEST CONDITIONS	T. '	С	SUFFIX		15	SUFFIX		М	SUFFIX		UNIT
	PARAMETER	TEST CONDITIONS	TA	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V <sub>O</sub> = 1 V to 3 V, See Figure 1	25°C		0.5			0.5			0.5		V/μs
V	Equivalent input noise voltage	f = 10 Hz	25°C		21	50		21	50		21		nV/Hz
v <sub>n</sub>	(see Figure 2)	f = 1 kHz	25°C		17	30		17	30		17		110/112
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Peak-to-peak equivalent input	f = 0.1 to 1 Hz	25°C		0.16			0.16			0.16		μV
V <sub>N(PP)</sub>	noise voltage	f = 0.1 to 10 Hz	25°C		0.47			0.47	7		0.47		μν
In	Equivalent input noise current		25°C		0.09			0.09			0.9		pA/Hz
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3	25°C		1.2			1.2			1.2		MHz
φm	Phase margin at unity gain	See Figure 3	25°C		42°			42°			42°		

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

	PARAMETER	TEST CONDITIONS	- +	С	SUFFIX		I	SUFFIX		М	SUFFIX	<u> </u>	UNIT
	PARAMETER	TEST CONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V <sub>O</sub> = 1V to 3 V, See Figure 1	25°C	0.45	0.65		0.45	0.65		0.45	0.65		V/us
SIX	Siew rate at unity gain	VO = 1V to 3 V, See Figure 1	Full range	0.45			0.42			0.45			ν/μ5
V	Equivalent input noise voltage	f = 10 Hz	25°C		19	50		19	50		19		nV/Hz
Vn	(see Figure 2)	f = 1 kHz	25°C		15	30		15	30		15		IIV/IIZ
V	Peak-to-peak equivalent input	f = 0.1 to 1 Hz	25°C		0.16			0.16			0.16		\/
VN(PP)	noise voltage	f = 0.1 to 10 Hz	25°C		0.47			0.47			0.47		μV
In	Equivalent input noise current		25°C		0.09			0.09			0.09		pA/Hz
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3	25°C		2			2			2		MHz
φm	Phase margin at unity gain	See Figure 3	25°C		46°			46°			46°		

<sup>†</sup> 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.

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

	PARAMETER	TEST CONDITIONS	С	SUFFIX		1	SUFFIX		М	SUFFIX		UNIT
	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V <sub>O</sub> = 1 V to 3 V, See Figure 1		0.5			0.5			0.5		V/μs
V	Equivalent input noise voltage	f = 10 Hz		21	50		21	50		21		nV/√Hz
v <sub>n</sub>	(see Figure 2)	f = 1 kHz		17	30		17	30		17		NV/VIIZ
\/\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz		0.16			0.16			0.16		μV
VN(PP)	reak-to-peak equivalent input noise voitage	f = 0.1 to 10 Hz		0.47			0.47			0.47		μν
In	Equivalent input noise current			0.1			0.1			0.1		pA/√ <del>Hz</del>
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3		1.7			1.7			1.7		MHz
φm	Phase margin at unity gain	See Figure 3		47°			47°			47°		

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

DADAMETED	TEST COL	IDITIONS	T. †	С	SUFFIX		I	SUFFIX		М	SUFFIX		UNIT
PARAMETER	TEST CON	IDITIONS	'A'	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
Claus rate at units gain	V= +40.V	Coo Figure 4	25°C	0.45	0.65		0.45	0.65		0.45	0.65		V/us
Siew rate at unity gain	$VO = \pm 10 \text{ V},$	See Figure 1	Full range	0.45			0.42			0.4			V/μS
Equivalent input noise	f = 10 Hz		25°C		19	50		19	50		19		->4//11=
voltage (see Figure 2)	f = 1 kHz		25°C		15	30		15	30		15		nV/√Hz
Peak-to-peak equivalent	f = 0.1 to 1 Hz		25°C		0.16			0.16			0.16		\/
input noise voltage	f = 0.1 to 10 Hz		25°C		0.47			0.47			0.47		μV
Equivalent input noise current			25°C		0.1			0.1			0.1		pA/√ <del>Hz</del>
Unity-gain bandwidth	See Figure 3		25°C		2.8			2.8			2.8		MHz
Phase margin at unity gain	See Figure 3		25°C		52°			52°			52°		
	voltage (see Figure 2)  Peak-to-peak equivalent input noise voltage  Equivalent input noise current  Unity-gain bandwidth	Slew rate at unity gain $V_O = \pm 10 \text{ V}$ ,  Equivalent input noise voltage (see Figure 2)  Peak-to-peak equivalent input noise voltage  Equivalent input noise current  Unity-gain bandwidth  V_O = $\pm 10 \text{ V}$ , $f = 10 \text{ Hz}$ $f = 0.1 \text{ to } 1 \text{ Hz}$ $f = 0.1 \text{ to } 10 \text{ Hz}$	Slew rate at unity gain $V_O = \pm 10 \text{ V}$ , See Figure 1  Equivalent input noise voltage (see Figure 2) $f = 10 \text{ Hz}$ Peak-to-peak equivalent input noise voltage $f = 0.1 \text{ to } 1 \text{ Hz}$ Equivalent input noise current  Unity-gain bandwidth See Figure 3	Slew rate at unity gain $V_O = \pm 10 \text{ V}, \qquad \text{See Figure 1} \qquad \frac{25^{\circ}\text{C}}{\text{Full range}}$ Equivalent input noise voltage (see Figure 2) $\begin{array}{l} f = 10 \text{ Hz} \\ f = 1 \text{ kHz} \\ \text{Peak-to-peak equivalent} \\ \text{input noise voltage} \end{array}$ $\begin{array}{l} f = 0.1 \text{ to } 1 \text{ Hz} \\ \text{f} = 0.1 \text{ to } 10 \text{ Hz} \\ \text{Equivalent input noise current} \\ \text{Unity-gain bandwidth} \end{array}$ $\begin{array}{l} 25^{\circ}\text{C} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{See Figure 1} \\ \text{Full range} \\ \text{See C} \\ \text{Full range} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{Full range} \\ \text{See Figure 1} \\ \text{Full range} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{Full range} \\ \text{See Figure 3} \\ \text{See Figure 3} \\ \text{Full range} \\ \text{See Figure 3} \\ \text{Full range} \\ \text{See Figure 3} \\ \text{Full range} \\ Full ran$	PARAMETERTEST CONDITIONS $T_A T$ Slew rate at unity gain $V_O = \pm 10 \text{ V}$ , $V_O = \pm 10 \text{ V}$ See Figure 1 $25^{\circ}\text{C}$ $0.45$ Equivalent input noise voltage (see Figure 2) $f = 10 \text{ Hz}$ $25^{\circ}\text{C}$ Peak-to-peak equivalent input noise voltage $f = 0.1 \text{ to } 1 \text{ Hz}$ $25^{\circ}\text{C}$ Equivalent input noise current $f = 0.1 \text{ to } 10 \text{ Hz}$ $25^{\circ}\text{C}$ Unity-gain bandwidthSee Figure 3 $25^{\circ}\text{C}$	PARAMETERTEST CONDITIONS $T_{A}^{T}$ MINTYPSlew rate at unity gain $V_{O} = \pm 10 \text{ V}$ , $V_{O} = \pm 10 \text{ V}$ See Figure 1 $25^{\circ}\text{C}$ $0.45$ $0.65$ Equivalent input noise voltage (see Figure 2) $f = 10 \text{ Hz}$ $25^{\circ}\text{C}$ $19$ Peak-to-peak equivalent input noise voltage $f = 0.1 \text{ to } 1 \text{ Hz}$ $25^{\circ}\text{C}$ $0.16$ Equivalent input noise current $f = 0.1 \text{ to } 10 \text{ Hz}$ $25^{\circ}\text{C}$ $0.47$ Equivalent input noise current $25^{\circ}\text{C}$ $0.1$ Unity-gain bandwidthSee Figure 3 $25^{\circ}\text{C}$ $2.8$	Slew rate at unity gain $V_{O} = \pm 10 \text{ V}, \qquad \text{See Figure 1} \qquad \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	PARAMETER         TEST CONDITIONS $T_AT$ MIN         TYP         MAX         MIN         TYP           Slew rate at unity gain $V_O = \pm 10 \text{ V}$ , $V_O = \pm 10 \text$	PARAMETER         TEST CONDITIONS $T_{A}^{T}$ MIN         TYP         MAX         MIN         TYP         MAX           Slew rate at unity gain $V_{O} = \pm 10 \text{ V}$ , $V_{O} = $	PARAMETER         TEST CONDITIONS         TAT         MIN         TYP         MAX         MIN         O.45         0.45         U.45         CO.45         0.42         U.45         U.45	PARAMETER         TEST CONDITIONS         TAT         MIN         TYP         MAX         MIN         TYP         MAX	PARAMETER         TEST CONDITIONS $T_AT$ MIN         TYP         MAX         MIN         TYP         MAX         MIN         TYP         MAX           Slew rate at unity gain $V_O = \pm 10 \text{ V}$ , $V_O = \pm $

† Full range is 0°C to 70°C.

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

	PARAMETER	TEST CONDITIONS	С	SUFFIX		1.5	SUFFIX		М	SUFFIX		UNIT
	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V <sub>O</sub> = 1 V to 3 V, See Figure 1		0.5			0.5			0.5		V/μs
V	Equivalent input noise voltage (see Figure 2)	f = 10 Hz		21	50		21	50		21		nV/√ <del>Hz</del>
v <sub>n</sub>	Equivalent input noise voitage (see Figure 2)	f = 1 kHz		17	30		17	30		17		NV/V ⊓Z
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz		0.16			0.16			0.16		μV
VN(PP)	reak-to-peak equivalent input noise voltage	f = 0.1 to 10 Hz		0.47			0.47			0.47		<u>'</u>
In	Equivalent input noise current			0.1			0.1			0.1		pA/√Hz
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3		1.7			1.7			1.7		MHz
φm	Phase margin at unity gain	See Figure 3		47°			47°			47°		

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

	PARAMETER	TEST CONDITIONS	T. t	С	SUFFIX		I	SUFFIX		М	SUFFIX		UNIT
	PARAMETER	TEST CONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNII
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
SK	Siew rate at unity gain	VO = ±10 V, See Figure 1	Full range	0.45			0.42			0.4			ν/μδ
\ <u>'</u>	Equivalent input noise voltage	f = 10 Hz	25°C		19	50		19	50		19		nV/√ <del>Hz</del>
V <sub>n</sub>	(see Figure 2)	f = 1 kHz	25°C		15	30		15	30		15		nv/√Hz
V	Peak-to-peak equivalent input noise	f = 0.1 to 1 Hz	25°C		0.16			0.16			0.16		μV
V <sub>N(PP)</sub>	voltage	f = 0.1 to 10 Hz	25°C		0.47			0.47			0.47		μν
In	Equivalent input noise current		25°C		0.1			0.1			0.1		pA/√ <del>Hz</del>
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3	25°C		2.8			2.8			2.8		MHz
φm	Phase margin at unity gain	See Figure 3	25°C		52°			52°			52°		

† Full range is 0°C to 70°C.

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

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# TLE2021Y electrical characteristics at $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

	PARAMETER	TEST CONE	NTIONE	Τι	E2021Y	′	UNIT
	PARAMETER	TEST CONL	DITIONS	MIN	TYP	MAX	UNII
V <sub>IO</sub>	Input offset voltage				150		μV
	Input offset voltage long-term drift (see Note 4)	\/.o = 0	$R_S = 50 \Omega$		0.005		μV/mo
lιο	Input offset current	$V_{IC} = 0,$	KS = 50.22		0.5		nA
l <sub>IB</sub>	Input bias current				35		nA
VICR	Common-mode input voltage range	R <sub>S</sub> = 50 Ω			- 0.3 to 4		٧
Vон	Maximum high-level output voltage	D. 40 kO			4.3		V
VOL	Maximum low-level output voltage	$R_L = 10 \text{ k}\Omega$			0.7		V
AVD	Large-signal differential voltage amplification	$V_0 = 1.4 \text{ to } 4 \text{ V},$	$R_L = 10 \text{ k}\Omega$		1.5		V/µV
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	$R_S = 50 \Omega$		100		dB
ksvr	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	$V_{CC} = 5 \text{ V to } 30 \text{ V}$	/		115		dB
Icc	Supply current	V <sub>O</sub> = 2.5 V,	No load		400		μΑ

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.

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

	PARAMETER	TEST CONDITIONS	TI	E2021\	<u>′</u>	UNIT
	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNII
SR	Slew rate at unity gain	$V_O = 1 V \text{ to } 3 V$		0.5		V/μs
V	Equivalent input poice veltage	f = 10 Hz		21		->/// <del>  </del>
Vn	Equivalent input noise voltage	f = 1 kHz		17		nV/√Hz
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz		0.16		μV
VN(PP)	reak-to-peak equivalent input hoise voltage	f = 0.1 to 10 Hz		0.47		μν
In	Equivalent input noise current			0.1		pA/√ <del>Hz</del>
B <sub>1</sub>	Unity-gain bandwidth			1.7		MHz
φm	Phase margin at unity gain			47°		

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

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# TLE2022Y electrical characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

	PARAMETER	TEST CON	DITIONS	TL	E2022Y		UNIT
	PARAMETER	I EST CONI	DITIONS	MIN	TYP	MAX	UNIT
V <sub>IO</sub>	Input offset voltage				150	600	μV
	Input offset voltage long-term drift (see Note 4)	) V:a = 0	$R_S = 50 \Omega$		0.005		μV/mo
IЮ	Input offset current	VIC = 0,	RS = 50.22		0.5		nA
Iв	Input bias current				35		nA
VICR	Common-mode input voltage range	R <sub>S</sub> = 50 Ω			- 0.3 to 4		V
Vон	Maximum high-level output voltage	D. 40 kg			4.3		V
VOL	Maximum low-level output voltage	$R_L = 10 \text{ k}\Omega$			0.7		V
AVD	Large-signal differential voltage amplification	$V_0 = 1.4 \text{ to } 4 \text{ V},$	R <sub>L</sub> = 10 kΩ		1.5		V/µV
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR} \min$	$R_S = 50 \Omega$		100		dB
ksvr	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	$V_{CC} = 5 \text{ V to } 30 \text{ V}$	/		115		dB
ICC	Supply current	V <sub>O</sub> = 2.5 V,	No load		450		μΑ

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.

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

	PARAMETER	TEST CONDITIONS	TLE2022Y	UNIT
	PARAMETER	TEST CONDITIONS	MIN TYP MAX	UNIT
SR	Slew rate at unity gain	V <sub>O</sub> = 1 V to 3 V, See Figure 1	0.5	V/μs
V	Equivalent input paige voltage (see Figure 2)	f = 10 Hz	21	->4/ <del>   -</del>
V <sub>n</sub>	Equivalent input noise voltage (see Figure 2)	f = 1 kHz	17	nV/√Hz
\/\.\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Dock to neck equivalent input noise veltage	f = 0.1 to 1 Hz	0.16	/
VN(PP)	Peak-to-peak equivalent input noise voltage	f = 0.1 to 10 Hz	0.47	μV
In	Equivalent input noise current		0.1	pA/√ <del>Hz</del>
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3	1.7	MHz
φm	Phase margin at unity gain	See Figure 3	47°	

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

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

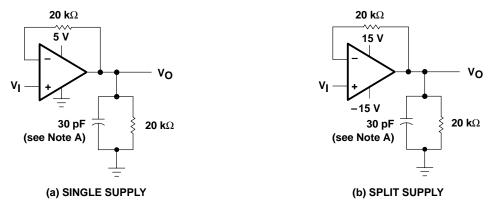
	DADAMETED	TEST CONDI	TIONS	TI	E2024Y	,	UNIT
	PARAMETER	IEST CONDI	TIONS	MIN	TYP	MAX	UNII
	Input offset voltage long-term drift (see Note 4)				0.005		μV/mo
IIO	Input offset current	V <sub>IC</sub> = 0,	$R_S = 50 \Omega$		0.6		nA
I <sub>IB</sub>	Input bias current				45		nA
VICR	Common-mode input voltage range	R <sub>S</sub> = 50 Ω			-0.3 to 4		V
Vон	High-level output voltage	D. 40 kO			4.2		V
VOL	Low-level output voltage	$R_L = 10 \text{ k}\Omega$			0.7		V
AVD	Large-signal differential voltage amplification	$V_0 = 1.4 \text{ V to 4 V},$	R <sub>L</sub> = 10 kΩ		1.5		V/μV
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min,	R <sub>S</sub> = 50 Ω		90		dB
ksvr	Supply-voltage rejection ratio $(\Delta V_{CC}/\Delta V_{IO})$	V <sub>CC</sub> = 5 V to 30 V			112		dB
ICC	Supply current	$V_0 = 2.5 V$ ,	No load		800		μΑ

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.

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

PARAMETER		TEST CONDITIONS	TLE2024Y			LINUT
		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V <sub>O</sub> = 1 V to 3 V, See Figure 1		0.5		V/µs
Vn	Equivalent input noise voltage (see Figure 2)	f = 10 Hz		21		nV/√ <del>Hz</del>
		f = 1 kHz		17		
V <sub>N(PP)</sub>	Peak-to-peak equivalent input noise voltage	f = 0.1 to 1 Hz		0.16		μV
		f = 0.1 to 10 Hz		0.47		
In	Equivalent input noise current			0.1		pA/√Hz
B <sub>1</sub>	Unity-gain bandwidth	See Figure 3		1.7		MHz
φm	Phase margin at unity gain	See Figure 3		47°	·	

#### PARAMETER MEASUREMENT INFORMATION



NOTE A: C<sub>L</sub> includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

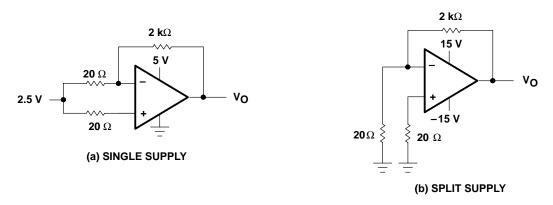
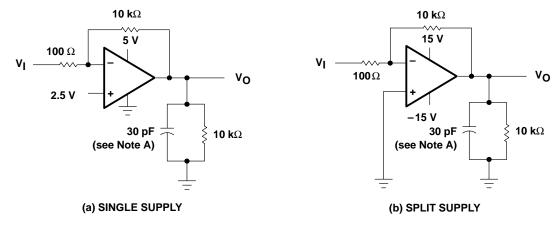


Figure 2. Noise-Voltage Test Circuit



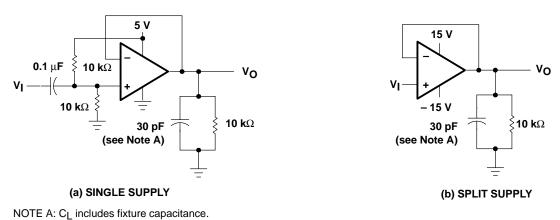
NOTE A: CL includes fixture capacitance.

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

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

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#### PARAMETER MEASUREMENT INFORMATION



10 1 L. A. OL Includes lixture 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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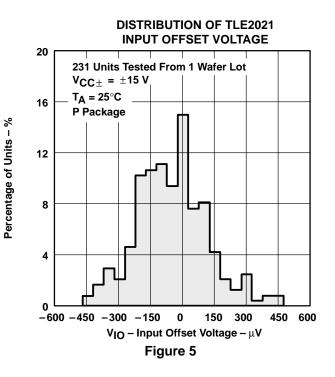
#### **TYPICAL CHARACTERISTICS**

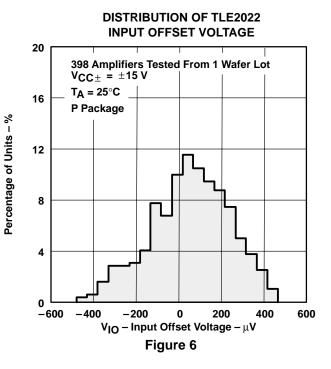
#### **Table of Graphs**

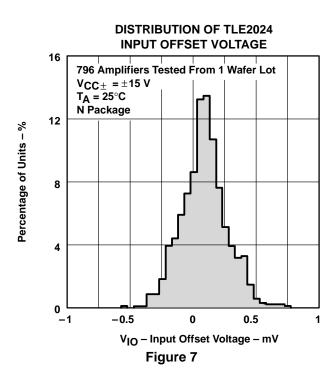
			FIGURE	
V <sub>IO</sub>	Input offset voltage	Distribution	5, 6, 7	
I <sub>IB</sub>	Input bias current	vs Common-mode input voltage vs Free-air temperature	8, 9, 10 11, 12, 13	
lį	Input current	vs Differential input voltage	14	
Vом	Maximum peak output voltage	vs Output current vs Free-air temperature	15, 16, 17 18	
Vон	High-level output voltage	vs High-level output current vs Free-air temperature	19, 20 21	
VOL	Low-level output voltage	vs Low-level output current vs Free-air temperature	22 23	
VO(PP)	Maximum peak-to-peak output voltage	vs Frequency	24, 25	
AVD	Large-signal differential voltage amplification	vs Frequency vs Free-air temperature	26 27, 28, 29	
los	Short-circuit output current	vs Supply voltage vs Free-air temperature	30 – 33 34 – 37	
ICC	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		50, 51	
	Voltage-follower large-signal pulse response		52 – 57	
V <sub>N(PP)</sub>	Peak-to-peak equivalent input noise voltage	0.1 to 1 Hz 0.1 to 10 Hz	58 59	
Vn	Equivalent input noise voltage	vs Frequency	60	
B <sub>1</sub>	Unity-gain bandwidth	vs Supply voltage vs Free-air temperature	61, 62 63, 64	
φm	Phase margin	vs Supply voltage vs Load capacitance vs Free-air temperature	65, 66 67, 68 69, 70	
	Phase shift	vs Frequency	26	

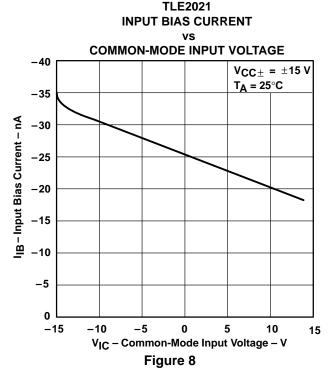
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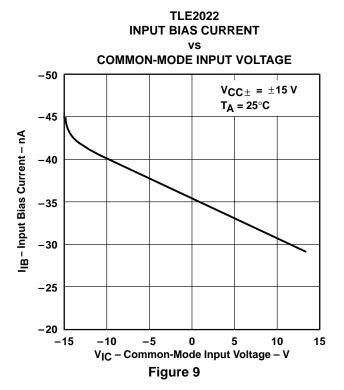
#### TYPICAL CHARACTERISTICS

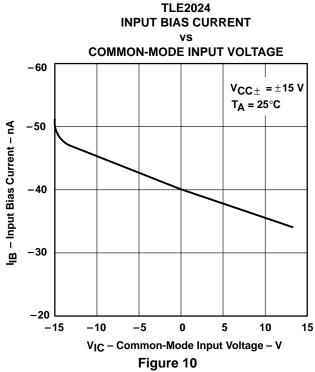


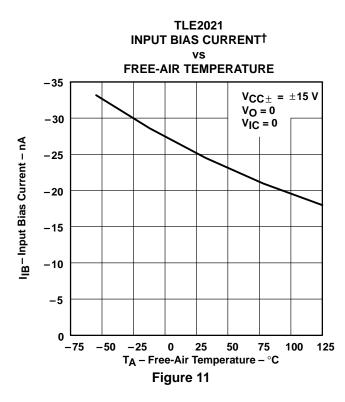


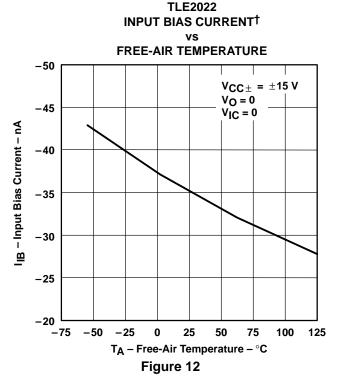






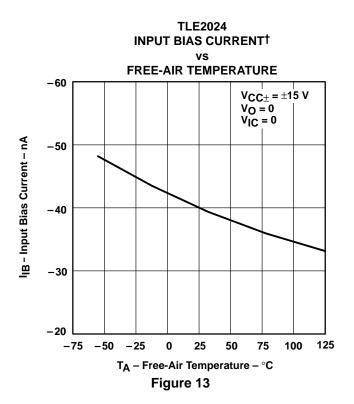






<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.





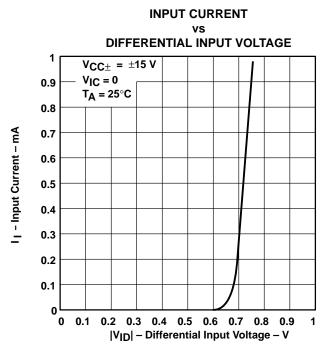
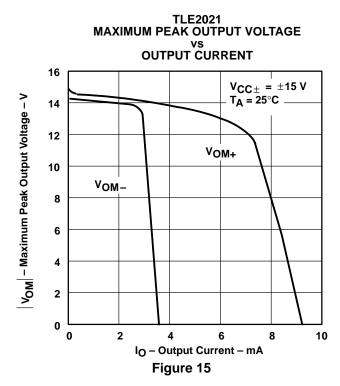
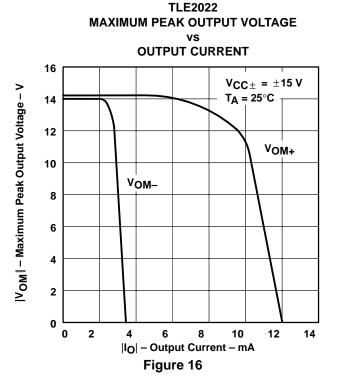


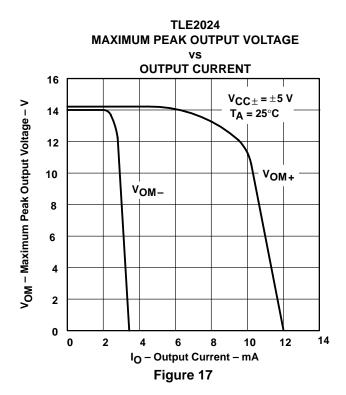
Figure 14

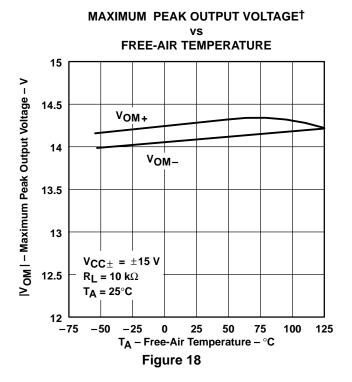




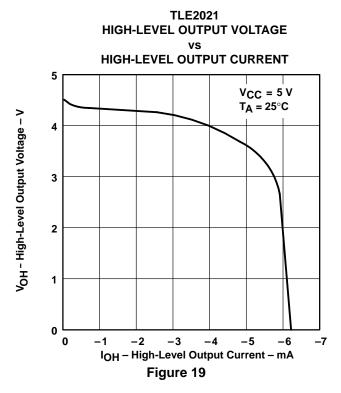
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

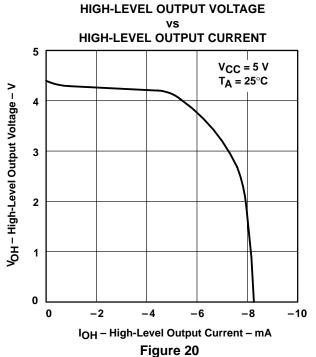






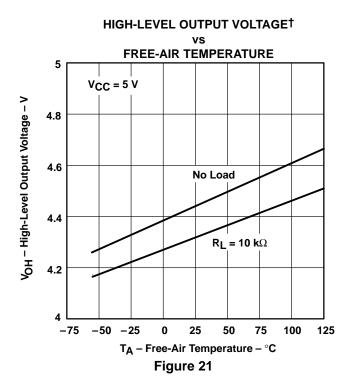
**TLE2022 AND TLE2024** 

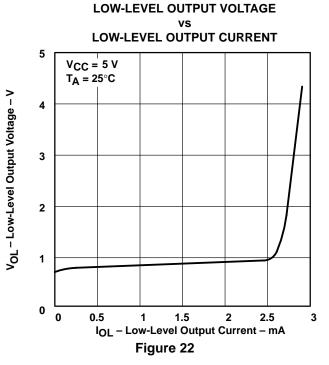


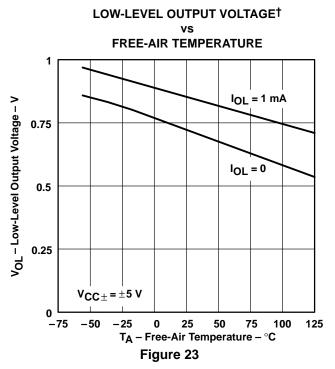


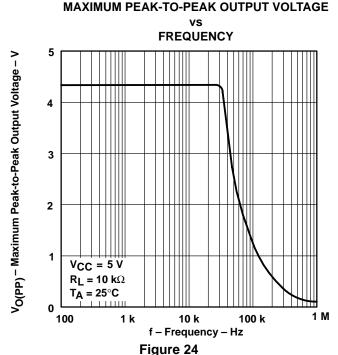
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.











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



#### **MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE**

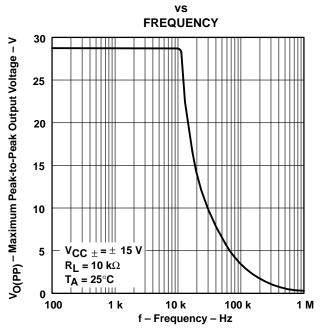


Figure 25

## LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT

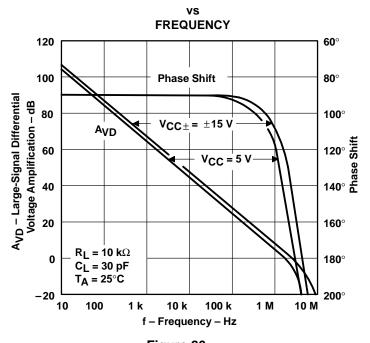


Figure 26

\_75

-50

-25

0

25

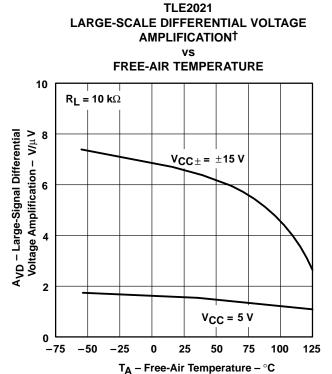
T<sub>A</sub> – Free-Air Temperature – °C Figure 28

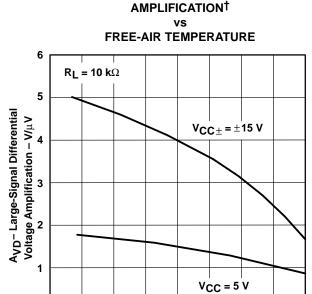
50

75

100

125





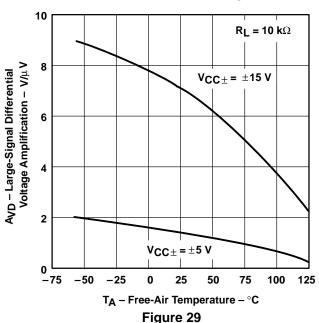
**TLE2022** 

LARGE-SIGNAL DIFFERENTIAL VOLTAGE

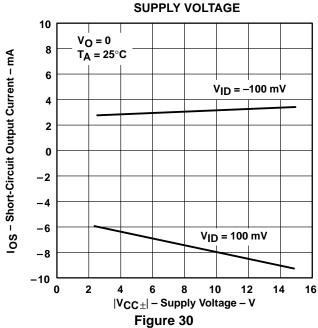
TLE2024 LARGE-SCALE DIFFERENTIAL VOLTAGE AMPLIFICATION<sup>†</sup>

Figure 27

vs FREE-AIR TEMPERATURE



TLE2021
SHORT-CIRCUIT OUTPUT CURRENT
VS
SUPPLY VOLTAGE

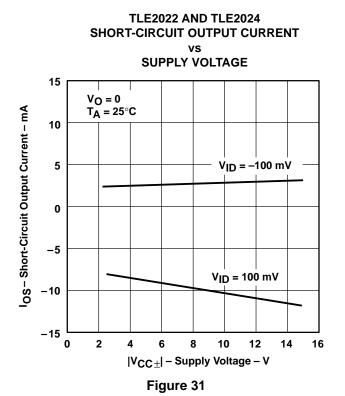


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

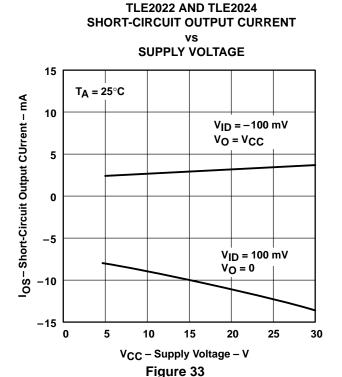


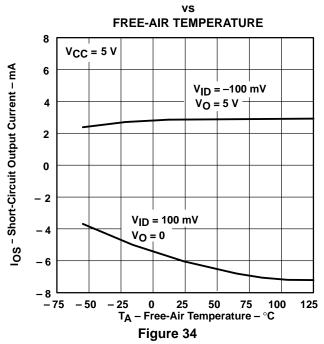
**TLE2021** 

#### TYPICAL CHARACTERISTICS



SHORT-CIRCUIT OUTPUT CURRENT vs **SUPPLY VOLTAGE** 12 T<sub>A</sub> = 25°C IOS - Short-Circuit Output Current - mA 8  $V_{ID} = -100 \text{ mV}$ Vo = Vcc 4 0 -4  $V_{ID} = 100 \text{ mV}$  $V_0 = 0$ -8 - 12 0 5 10 15 20 25 30 V<sub>CC</sub> - Supply Voltage - V Figure 32





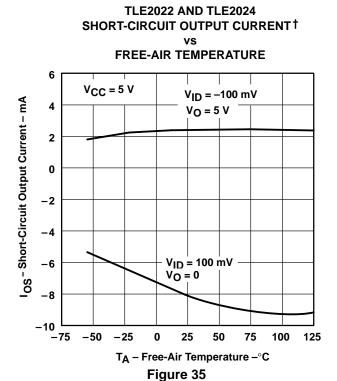
TLE2021

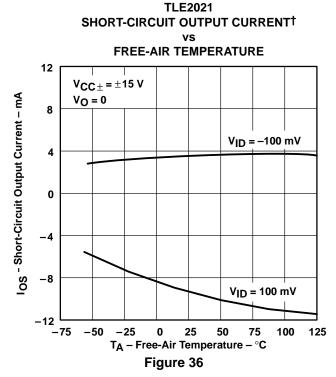
SHORT-CIRCUIT OUTPUT CURRENT<sup>†</sup>

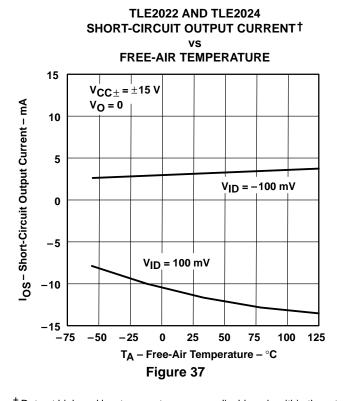
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

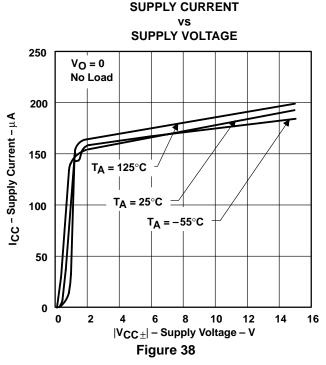


#### TYPICAL CHARACTERISTICS





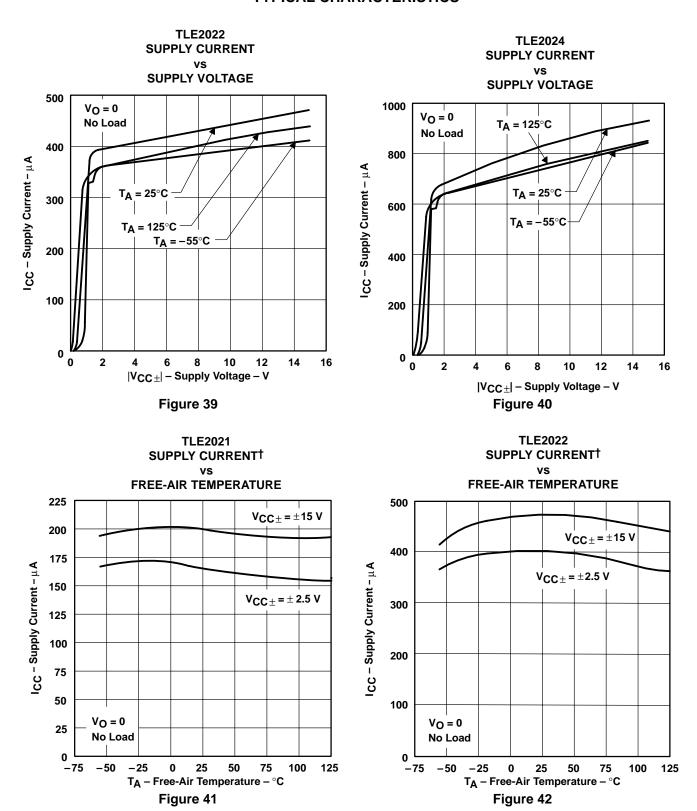




**TLE2021** 

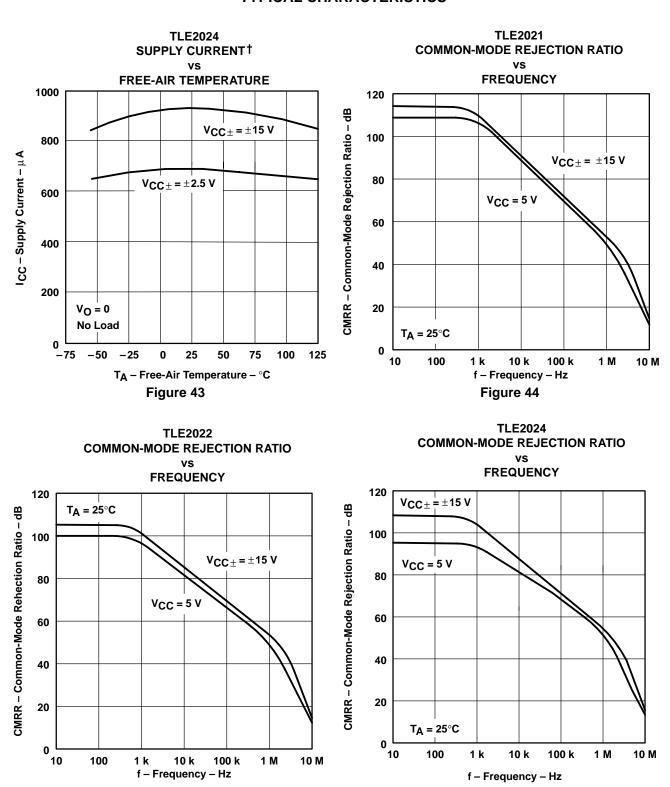
<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.





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



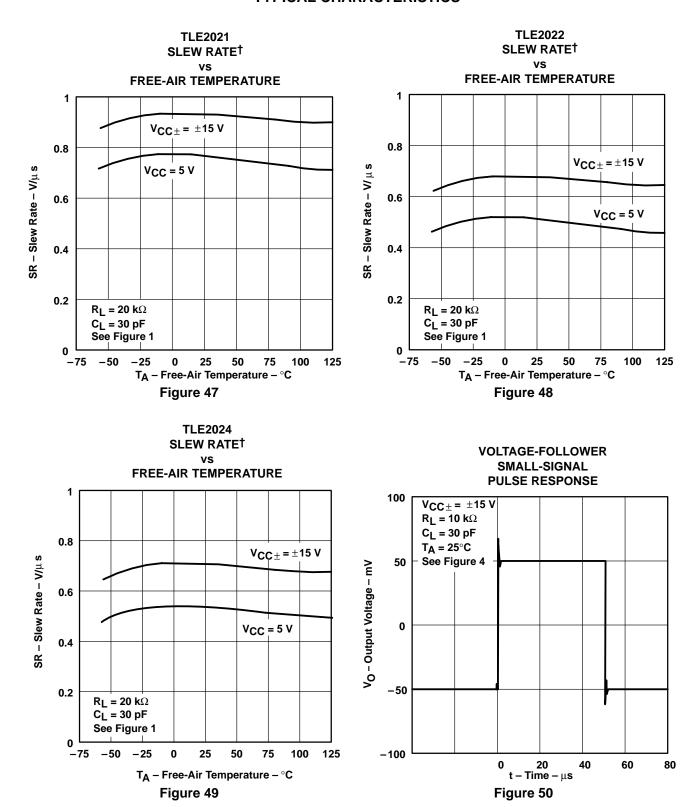


<sup>†</sup> Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

Figure 45

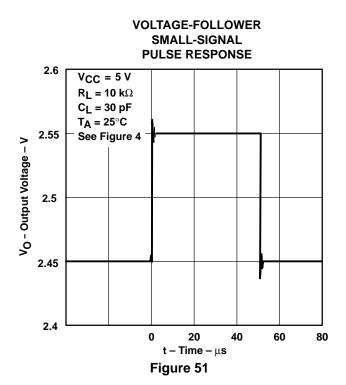


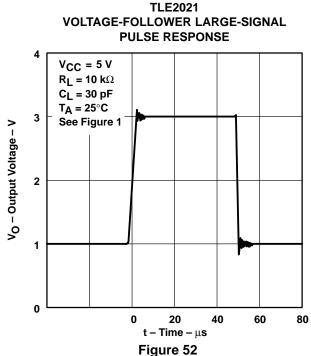
Figure 46



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

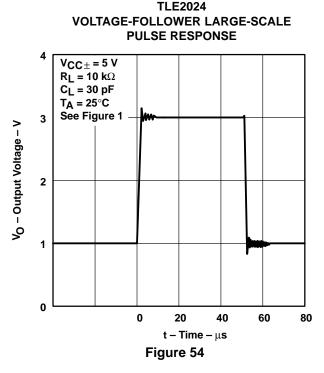


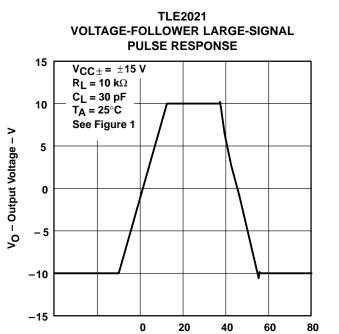




**VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE** V<sub>CC</sub> = 5 V  $R_L = 10 \text{ k}\Omega$  $C_{L}^{-} = 30 \text{ pF}$  $T_A = 25^{\circ}C$ See Figure 1 3 V<sub>O</sub> - Output Voltage - V 1 0 20 80 60 t – Time –  $\mu$ s Figure 53

**TLE2022** 





**TLE2024 VOLTAGE-FOLLOWER LARGE-SIGNAL** 

 $t - Time - \mu s$ 

Figure 55

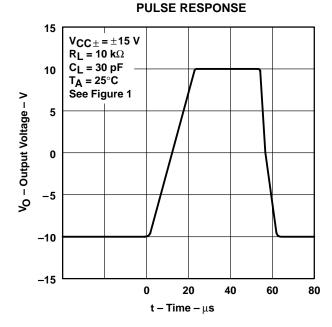
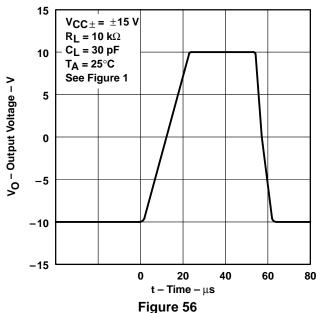
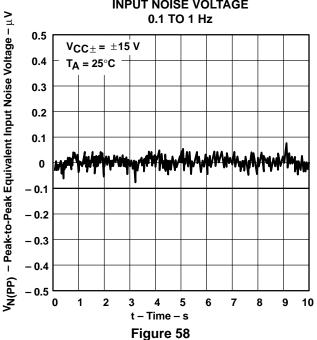


Figure 57

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

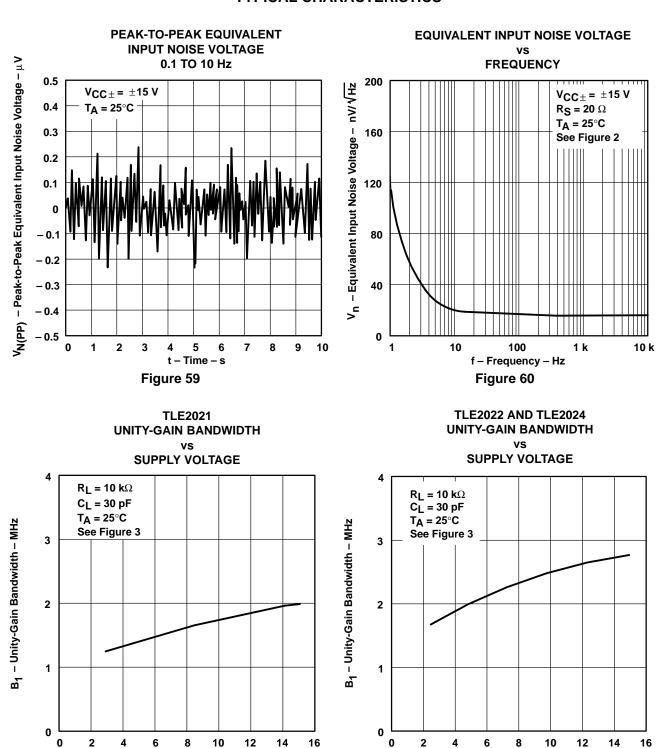


**PEAK-TO-PEAK EQUIVALENT INPUT NOISE VOLTAGE** 





#### TYPICAL CHARACTERISTICS



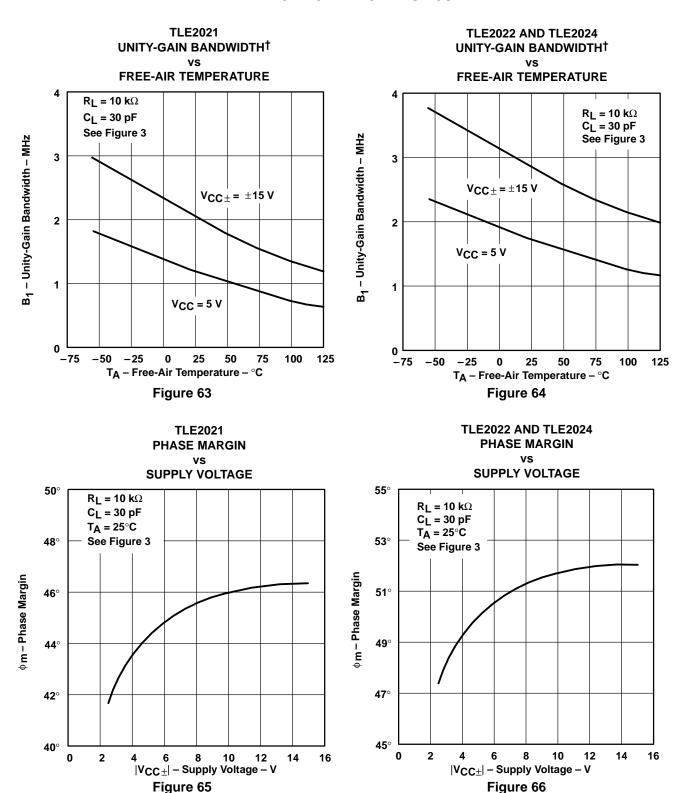


 $|V_{CC\pm}|$  - Supply Voltage - V

Figure 62

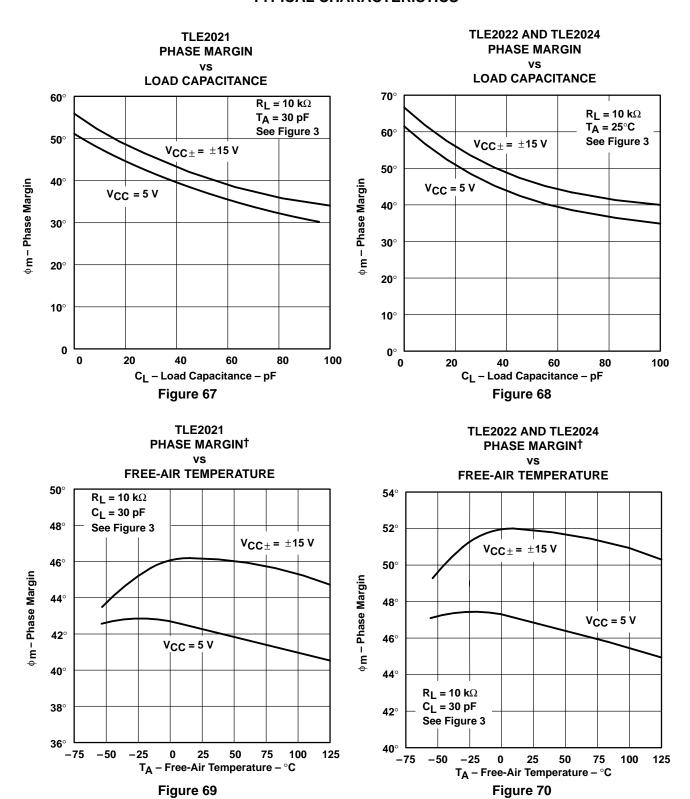
 $|V_{CC\pm}|$  – Supply Voltage – V

Figure 61



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





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



#### **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  $10 \text{ k}\Omega$ , 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).

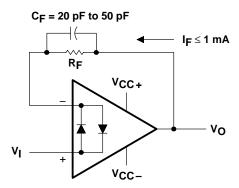


Figure 71. Voltage Follower

#### 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.

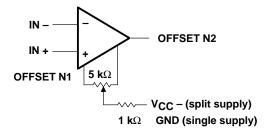


Figure 72. Input Offset Voltage Null Circuit

#### 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 in Figure 73, 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).

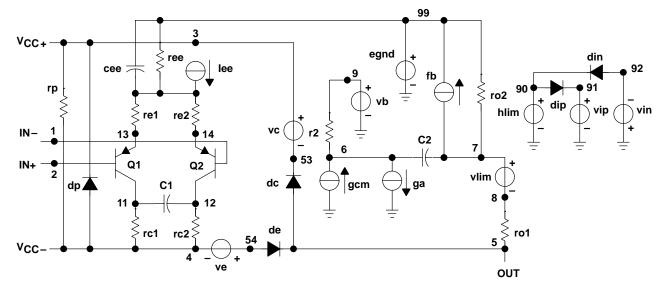


Figure 73. Boyle Subcircuit

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

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```
.SUBCKT TLE2021 12345
                                                                 hcmr 80
                                                                               poly(2) vcm+ vcm- 0 1E2 1E2
                                                                       3
                                                                           4
                                                                               185E-6
  с1
        11
            12 6.244E-12
                                                                 iee
                                                                       3
                                                                           10 dc 15.67E-6
  c2
        6
            7 13.4E-12
                                                                       2
                                                                               2E-9
                                                                           0
                                                                 iiο
  с3
        87
            0 10.64E-9
                                                                 i1
                                                                       88 0
                                                                               1E-21
  cosr
       85
            86 15.9E-9
                                                                       11
                                                                           89
                                                                              13 qx
                                                                 q1
  dcm+ 81
            82 dx
                                                                           80
                                                                              14 qx
                                                                 q2
                                                                       12
       83
            81 dx
  dcm-
                                                                 R2
                                                                       6
                                                                               100.0E3
            53 dx
  dc
        5
                                                                       84
                                                                           81 1K
                                                                 rcm
  de
        54
            5 dx
                                                                              14.76E6
                                                                 ree
                                                                       10
                                                                           99
  dlp
        90
            91 dx
                                                                 rn1
                                                                       87
                                                                           0
                                                                               2.55E8
            90 dx
  dln
        92
                                                                       87
                                                                           88 11.67E3
                                                                 rn2
        4
            3 dx
  dp
                                                                 ro1
                                                                       8
                                                                           5
                                                                               62
  ecmr
       84
            99 (2 99) 1
                                                                 ro2
                                                                       7
                                                                           99 63
            0 poly(2) (3,0) (4,0) 0 .5 .5
  egnd
        99
                                                                           99 13.3
                                                                 vcm+ 82
            0 poly(1) (3,4) -60E-6 2.0E-6
  epsr
                                                                 vcm- 83
                                                                           99
                                                                              -14.6
            2 poly(1) (88,0) 120E-6 1
       89
  ense
                                                                 vb
                                                                           0 dc 0
  fb
            99 poly(6) vb vc ve vlp vln vpsr 0 547.3E6
                                                                       3
                                                                           53 dc 1.300
                                                                 VC
  + -50E7 50E7 50E7 -50E7 547E6
                                                                 ve
                                                                       54
                                                                           4
                                                                               dc 1.500
            0 11 12 188.5E-6
  ga
        6
                                                                 vlim
                                                                       7
                                                                           8
                                                                              dc 0
  gcm
        0
            6 10 99 335.2E-12
                                                                       91
                                                                               dc 3.600
                                                                 vlp
                                                                           0
            86 (85,86) 100E-6
        85
  gpsr
                                                                 vln
                                                                       0
                                                                           92 dc 3.600
  grc1
        4
            11 (4,11) 1.885E-4
                                                                 vpsr 0
                                                                           86 dc 0
        4
             12 (4,12) 1.885E-4
  grc2
                                                               .model dx d(is=800.0E-18)
       13 10 (13,10) 6.82E-4
  gre1
                                                               .model qx pnp(is=800.0E-18 bf=270)
  gre2
       14 10 (14,10) 6.82E-4
        90 0 vlim 1k
```

Figure 74. Boyle Macromodel for the TLE2021

```
.SUBCKT TLE2022 1 2 3 4 5
                                                      rc1
                                                               11 2.842E3
                                                      rc2
                                                              12 2.842E3
 c1
       11 12 6.814E-12
                                                      gel 13 10 (10,13) 31.299E-3
          7 20.00E-12
 c2
                                                      qe2
                                                           14
                                                              10 (10,14) 31.299E-3
          53 dx
 dc
       5
                                                      ree 10 99 11.07E6
 de
       54 5 dx
                                                               5 250
                                                      ro1
                                                           8
     90 91 dx
 dlp
                                                      ro2
                                                           7
                                                               99 250
 dln 92 90 dx
                                                               4 137.2E3
                                                           3
                                                      rp
 dр
       4
          3 dx
                                                      vb
                                                           9
                                                               0 dc 0
 egnd 99
          0 poly(2) (3,0) (4,0) 0 .5 .5
                                                      VC
                                                           3
                                                               53 dc 1.300
 fb
      7
          99 poly(5) vb vc ve vlp vln 0
                                                           54
                                                              4 dc 1.500
                                                      ve
 45.47E6 -50E6 50E6 50E6 -50E6
                                                      vlim 7
                                                               8 dc 0
         11 12 377.9E-6
 ga 6 0
                                                      vlp 91 0 dc 3
 gcm 06
          10 99 7.84E-10
                                                      vln 0
                                                              92 dc 3
          10 DC 18.07E-6
 iee 3
                                                     .model dx d(is=800.0E-18)
 hlim 90
         0 vlim 1k
                                                     .model qx pnp(is=800.0E-18 bf=257.1)
      11 2 13 qx
 q1
                                                     .ends
      12 1 14 qx
 q2
 r2
       6
          9 100.0E3
```

Figure 75. Boyle Macromodel for the TLE2022



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

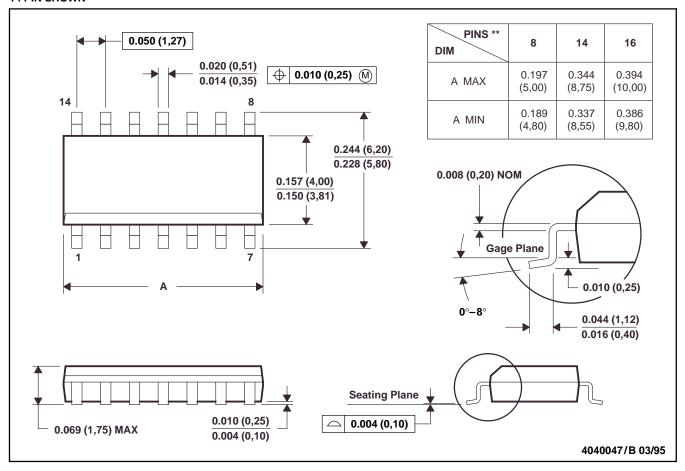
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#### **MECHANICAL INFORMATION**

#### D (R-PDSO-G\*\*)

#### PLASTIC SMALL-OUTLINE PACKAGE

#### 14 PIN SHOWN



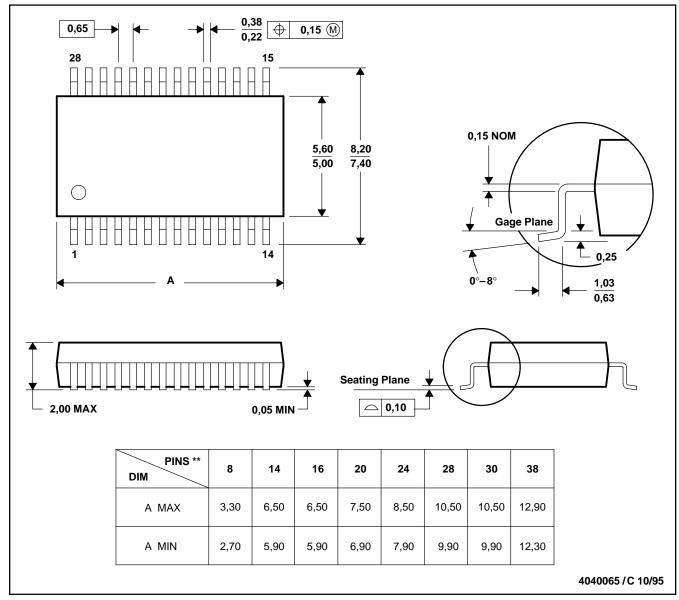
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
- D. Four center pins are connected to die mount pad.
- E. Falls within JEDEC MS-012

#### **MECHANICAL INFORMATION**

#### DB (R-PDSO-G\*\*)

#### PLASTIC SMALL-OUTLINE PACKAGE

#### **28 PIN SHOWN**



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.

D. Falls within JEDEC MO-150

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

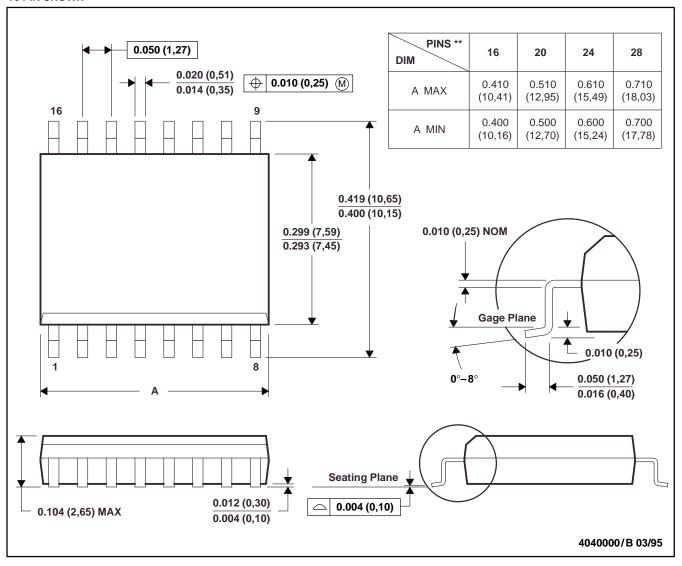
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#### **MECHANICAL INFORMATION**

#### DW (R-PDSO-G\*\*)

#### PLASTIC SMALL-OUTLINE PACKAGE

**16 PIN SHOWN** 



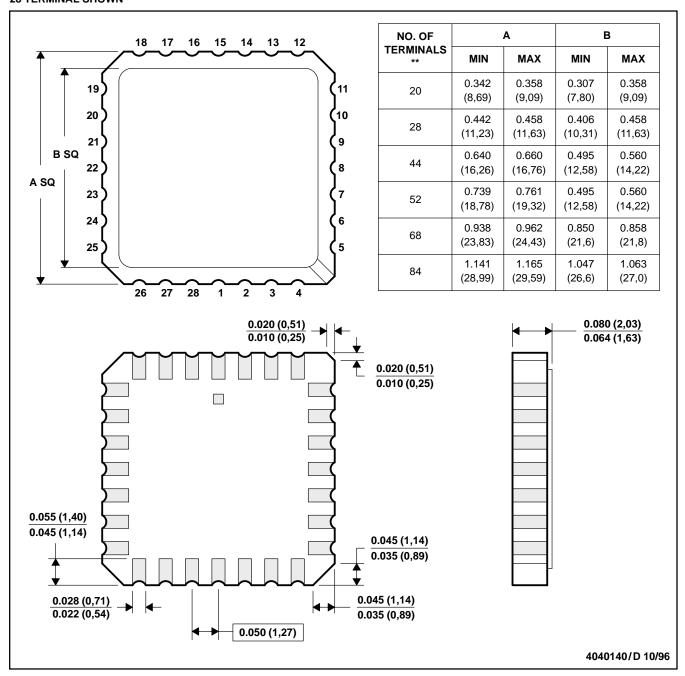
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS-013

#### **MECHANICAL INFORMATION**

#### FK (S-CQCC-N\*\*)

#### 28 TERMINAL SHOWN

#### LEADLESS CERAMIC CHIP CARRIER



- 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



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

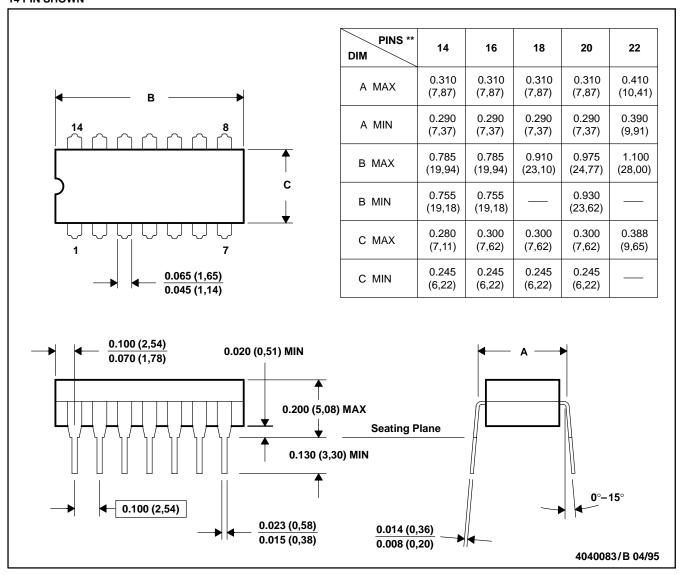
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#### **MECHANICAL INFORMATION**

#### J (R-GDIP-T\*\*)

#### **CERAMIC DUAL-IN-LINE PACKAGE**

### 14 PIN SHOWN



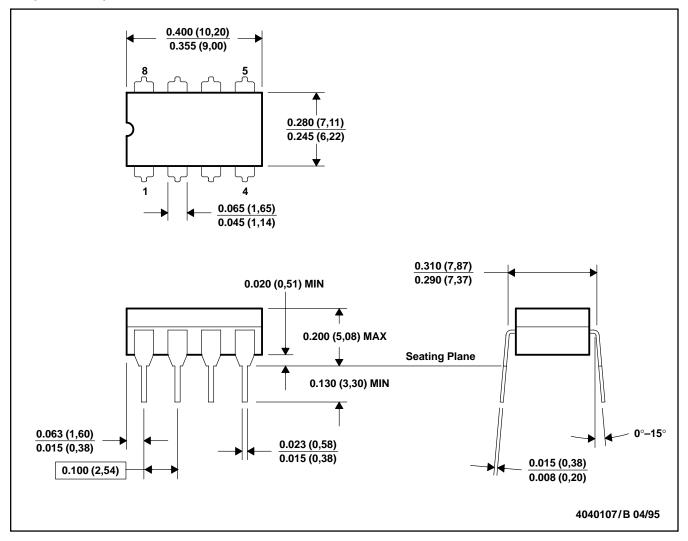
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
- E. Falls within MIL-STD-1835 GDIP1-T14, GDIP1-T16, GDIP1-T18, GDIP1-T20, and GDIP1-T22



#### **MECHANICAL INFORMATION**

#### JG (R-GDIP-T8)

#### **CERAMIC DUAL-IN-LINE PACKAGE**



- 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

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

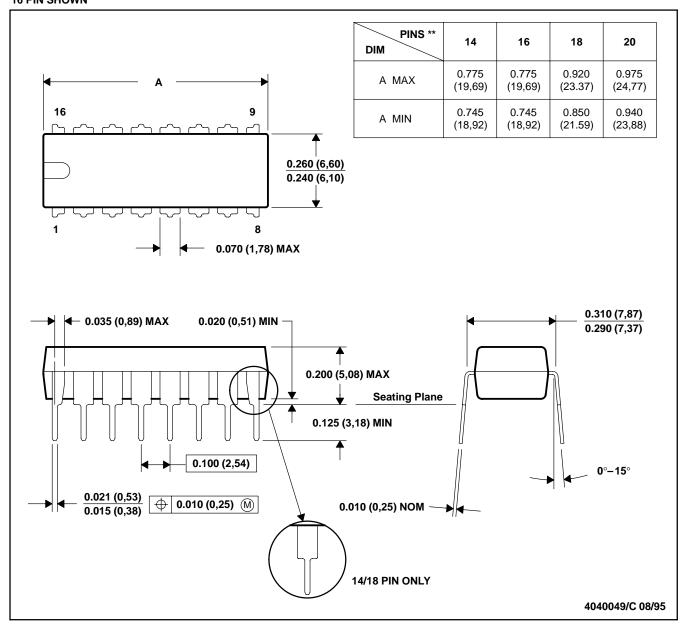
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#### **MECHANICAL INFORMATION**

#### N (R-PDIP-T\*\*)

#### 16 PIN SHOWN

#### PLASTIC DUAL-IN-LINE PACKAGE

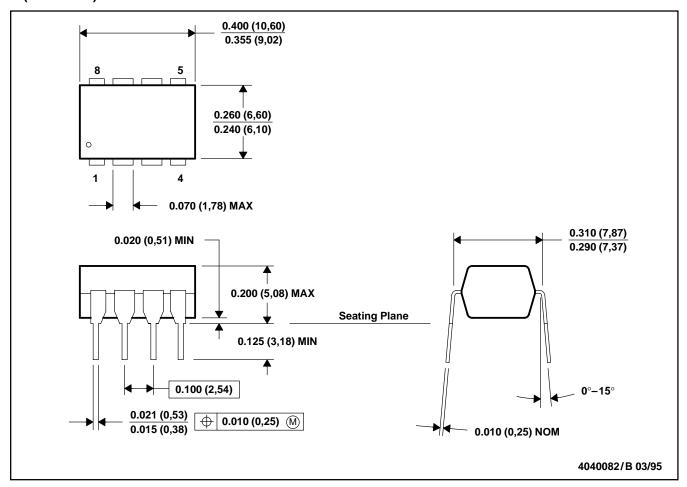


- B. This drawing is subject to change without notice.
- C. Falls within JEDEC MS-001 (20 pin package is shorter then MS-001.)

### **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

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

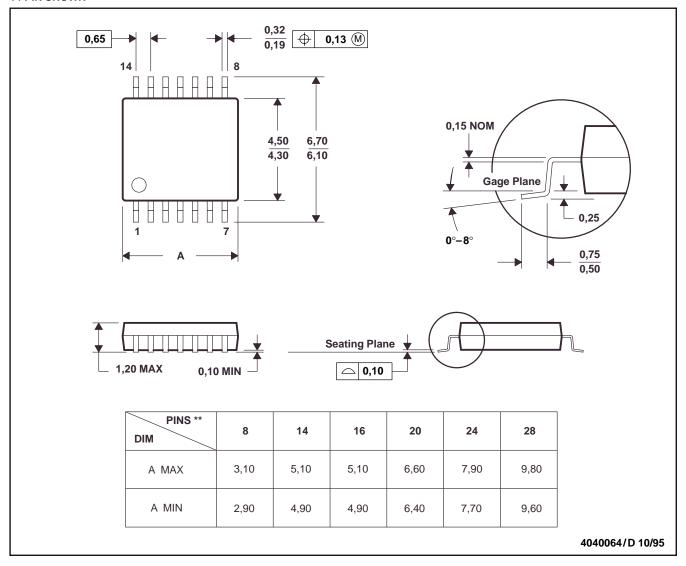
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#### **MECHANICAL INFORMATION**

### PW (R-PDSO-G\*\*)

#### PLASTIC SMALL-OUTLINE PACKAGE

#### 14 PIN SHOWN



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.

D. Falls within JEDEC MO-153

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Mailing Address:

Texas Instruments
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Dallas, Texas 75265

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