

EXCALIBUR HIGH-SPEED LOW-POWER PRECISION OPERATIONAL AMPLIFIERS

SLOS191 – FEBRUARY 1997

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

description

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

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

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

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

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

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

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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TLE2021 AVAILABLE OPTIONS

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

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

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

§ Chip forms are tested at 25°C only.

TLE2022 AVAILABLE OPTIONS

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

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

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

§ Chip forms are tested at 25°C only.

TLE2024 AVAILABLE OPTIONS

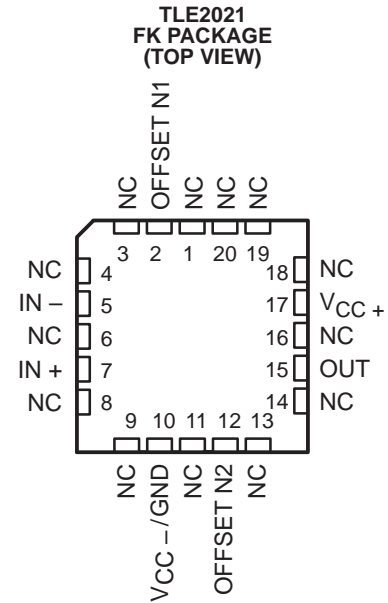
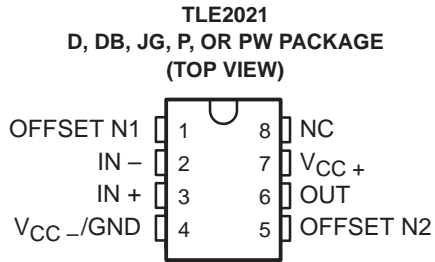
T _A	V _{IO} max AT 25°C	PACKAGED DEVICES				CHIP FORM† (Y)
		SMALL OUTLINE (DW)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	
0°C to 70°C	500 µV 750 µV 1000 µV	TLE2024BCDW TLE2024ACDW TLE2024CDW	—	—	TLE2024BCN TLE2024ACN TLE2024CN	— — TLE2024Y
-40°C to 85°C	500 µV 750 µV 1000 µV	TLE2024BIDW TLE2024AIDW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

† Chip forms are tested at 25°C only.

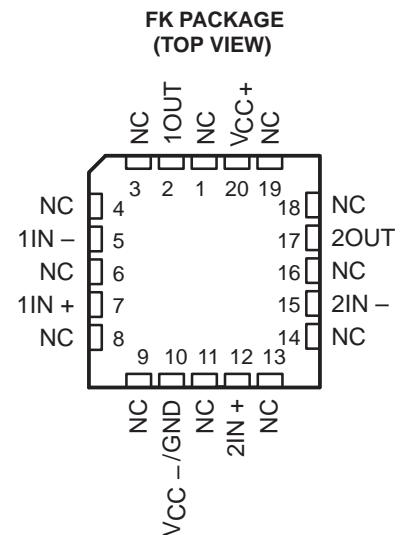
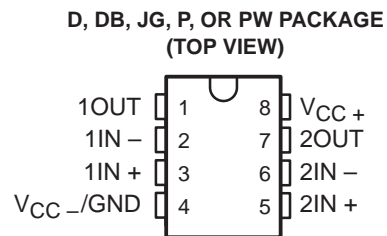
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description (continued)



NC – No internal connection

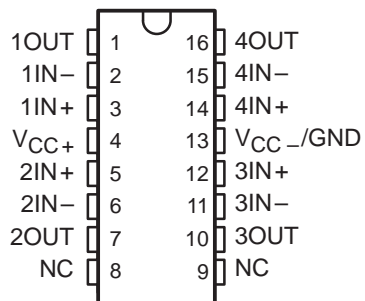


NC – No internal connection

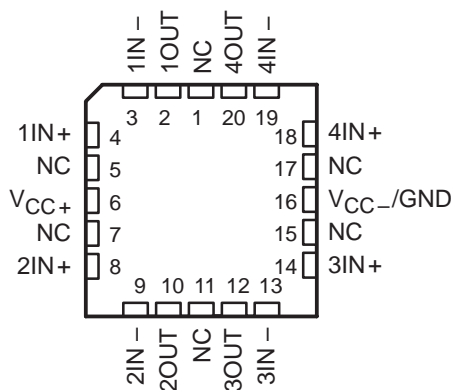
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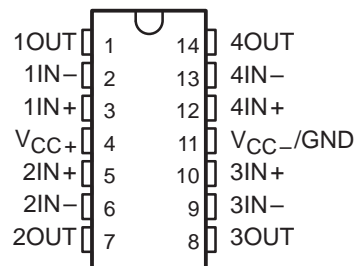
**DW PACKAGE
(TOP VIEW)**



**FK PACKAGE
(TOP VIEW)**



**J OR N PACKAGE
(TOP VIEW)**



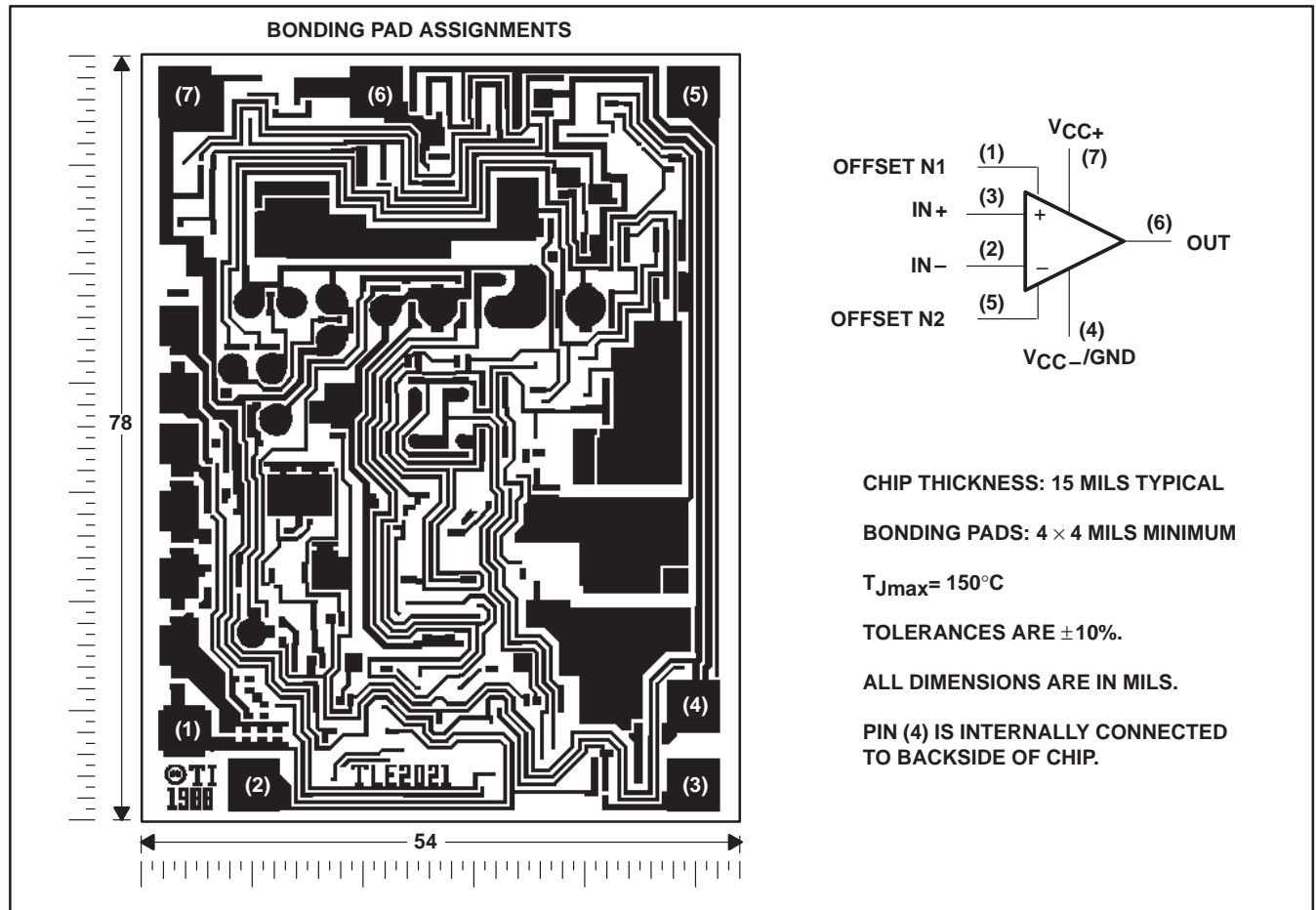
NC – No internal connection

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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.

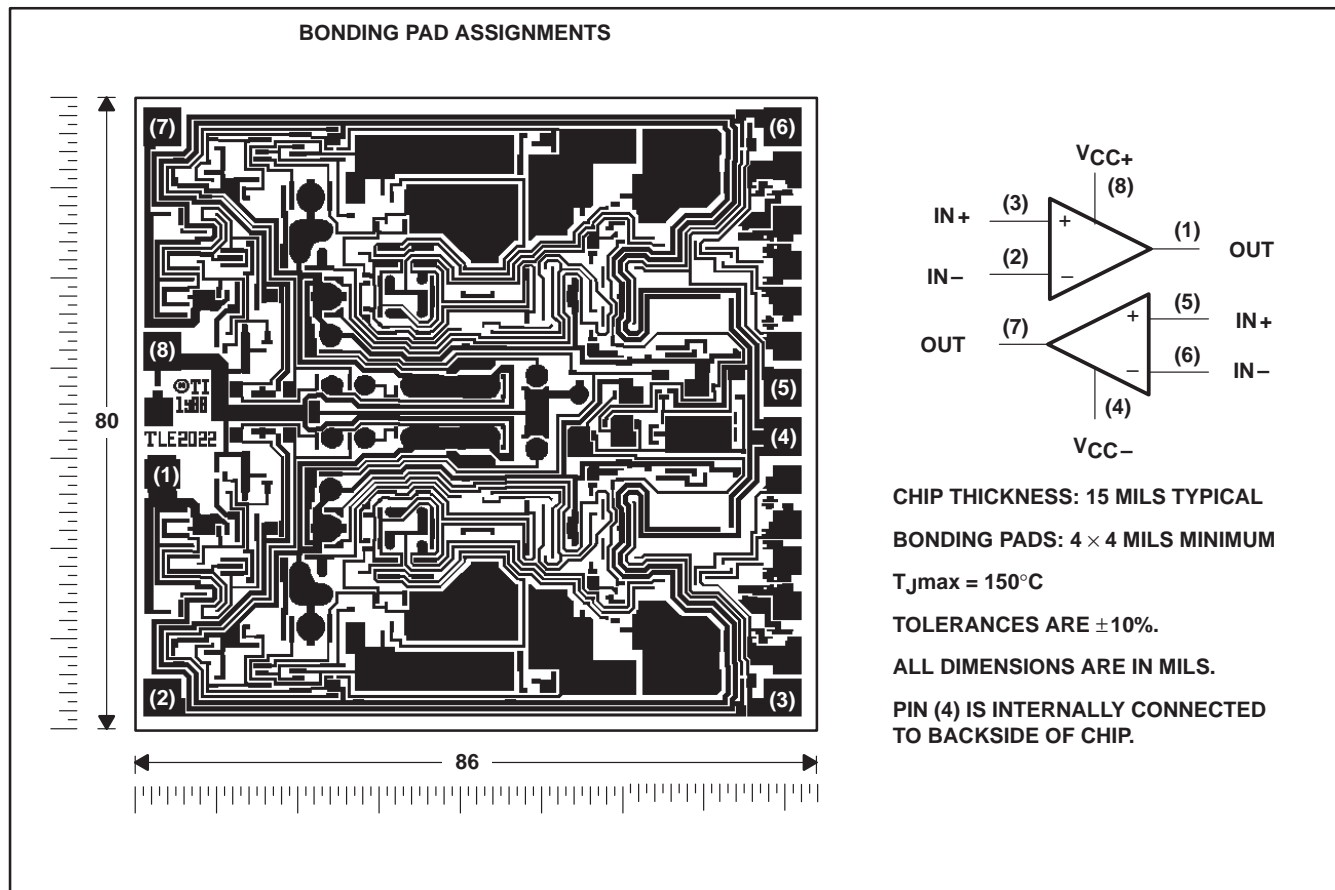


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TLE2022Y chip information

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.

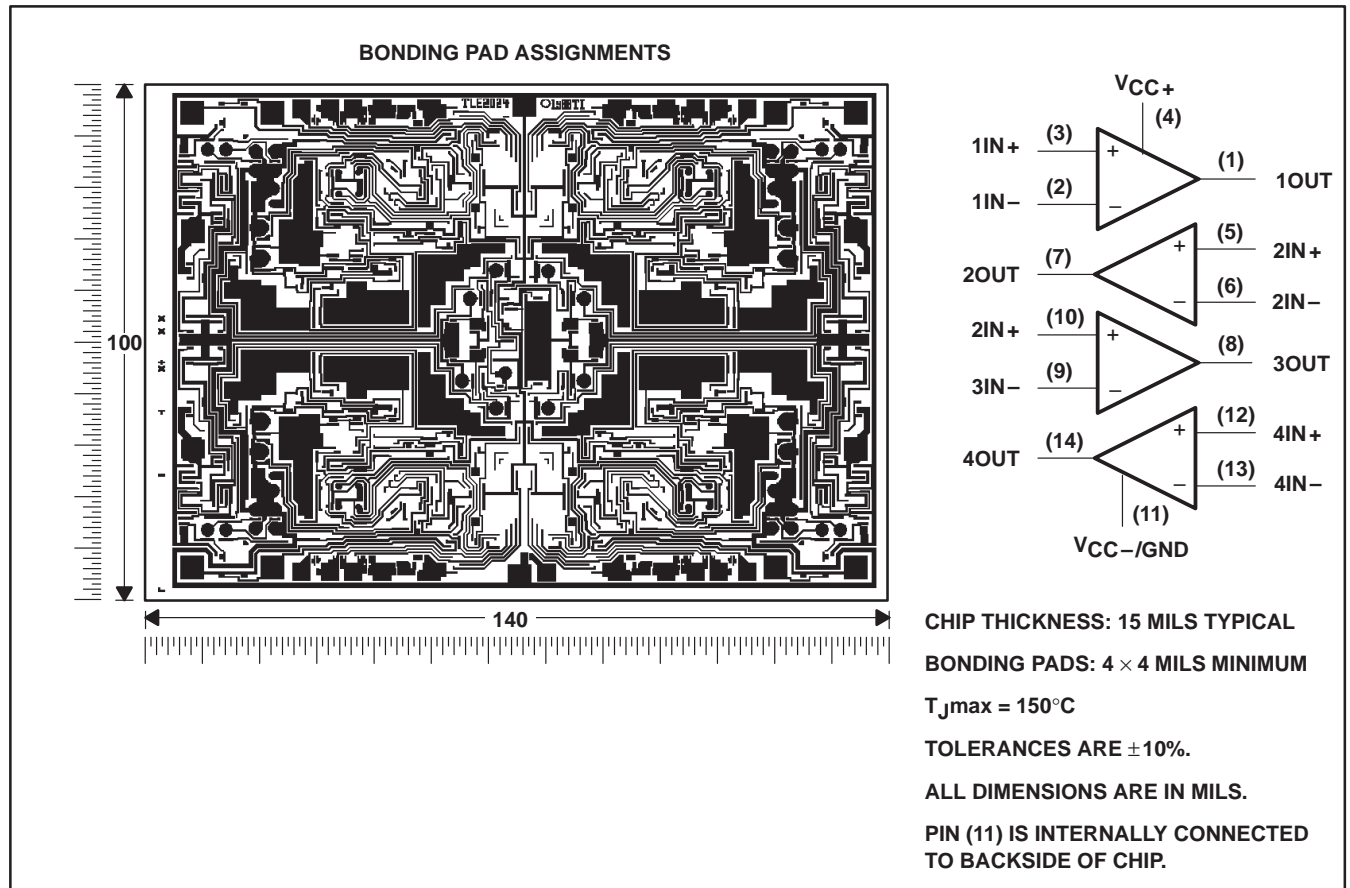


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TLE2024Y chip information

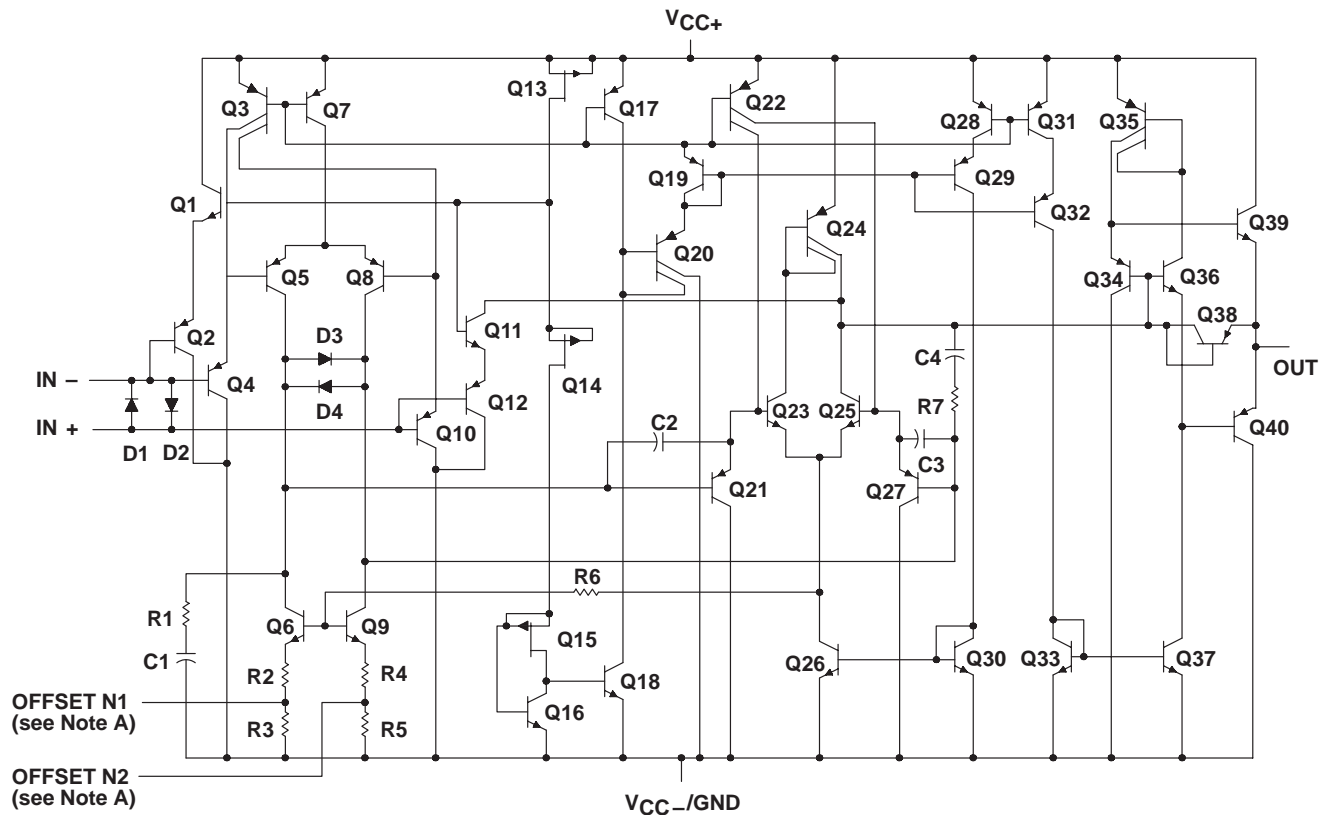
This chip, when properly assembled, displays characteristics similar to the TLE2024. Thermal compression or ultrasonic bonding may be used on the doped aluminum-bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.



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equivalent schematic (each amplifier)



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

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

Supply voltage, V_{CC+} (see Note 1)	20 V
Supply voltage, V_{CC-} (see Note 1)	-20 V
Differential input voltage, V_{ID} (see Note 2)	± 0.6 V
Input voltage range, V_I (any input, see Note 1)	$\pm V_{CC}$
Input current, I_I (each input)	± 1 mA
Output current, I_O (each output): TLE2021	± 20 mA
TLE2022	± 30 mA
TLE2024	± 40 mA
Total current into V_{CC+}	80 mA
Total current out of V_{CC-}	80 mA
Duration of short-circuit current at (or below) 25°C (see Note 3)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A : C suffix	0°C to 70°C
I suffix	-40°C to 85°C
M suffix	-55°C to 125°C
Storage temperature range, T_{stg}	-65°C to 150°C
Case temperature for 60 seconds, T_C : FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, DP, P, or PW package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C

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

- NOTES:
- All voltage values, except differential voltages, are with respect to the midpoint between V_{CC+} and V_{CC-} .
 - 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.
 - The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

DISSIPATION RATING TABLE

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

recommended operating conditions

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

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

PARAMETER	TEST CONDITIONS	T _A †	TLE2021C			TLE2021AC			TLE2021BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}		25°C	120	100	300	120	100	300	120	80	200	μV
		Full range	850	600	600	850	600	600	300	300	300	
αV _{IO}		Full range	2	2	2	2	2	2	2	2	2	μV/°C
Input offset voltage long-term drift (see Note 4)	V _{IC} = 0, R _S = 50 Ω	25°C	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	μV/mo
I _{IO}		25°C	0.2	0.2	6	0.2	0.2	6	0.2	0.2	6	nA
		Full range	10	10	10	10	10	10	10	10	10	
I _{IB}		25°C	25	25	70	25	25	70	25	25	70	nA
		Full range	90	90	90	90	90	90	90	90	90	
V _{ICR}	Common-mode input voltage range	25°C	0 to 3.5	-0.3 to 3.5	0 to 4	0 to 3.5	-0.3 to 3.5	0 to 4	0 to 3.5	-0.3 to 3.5	0 to 4	V
		Full range	0 to 3.5	0 to 3.5	0 to 4	0 to 3.5	0 to 3.5	0 to 4	0 to 3.5	0 to 3.5	0 to 4	
V _{OH}	High-level output voltage	25°C	4	4	4.3	4	4	4.3	4	4	4.3	V
		Full range	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	
V _{OL}	Low-level output voltage	25°C	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.7	0.8	V
		Full range	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
A _{VD}	Large-signal differential voltage amplification	25°C	0.3	1.5	1.5	0.3	1.5	1.5	0.3	1.5	1.5	V/μV
		Full range	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
CMRR	Common-mode rejection ratio	25°C	85	110	110	85	110	110	85	110	110	dB
		Full range	80	80	80	80	80	80	80	80	80	
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{IO})	25°C	105	120	120	105	120	120	105	120	120	dB
		Full range	100	100	100	100	100	100	100	100	100	
I _{CC}	Supply current	25°C	170	170	230	170	170	230	170	170	230	μA
		Full range	230	230	230	230	230	230	230	230	230	
ΔI _{CC}	Supply-current change over operating temperature range	Full range	5	5	5	5	5	5	5	5	5	μA

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

PARAMETER	TEST CONDITIONS	T _A †	TLE2021C			TLE2021AC			TLE2021BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}		25°C	120	120	500	80	80	200	40	40	100	μV
		Full range			750			500			200	
αV _{IO}		Full range		2			2			2		μV/°C
Input offset voltage long-term drift (see Note 4)	V _{IC} = 0, R _S = 50 Ω	25°C		0.006			0.006			0.006		μV/mo
I _{IO}		25°C		0.2	6		0.2	6		0.2	6	nA
		Full range			10			10			10	
I _{IB}		25°C		25	70		25	70		25	70	nA
		Full range			90			90			90	
V _{ICR}	Common-mode input voltage range	25°C	-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		V
		Full range	-15 to 13.5			15 to 13.5			15 to 13.5			
V _{OM+}	Maximum positive peak output voltage swing	25°C	14	14.3		14	14.3		14	14.3		V
		Full range	13.9			13.9			13.9			
V _{OM-}	Maximum negative peak output voltage swing	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.7			-13.7			-13.7			
A _{VD}	Large-signal differential voltage amplification	25°C	1	6.5		1	6.5		1	6.5		V/μV
		Full range	1			1			1			
CMRR	Common-mode rejection ratio	25°C	100	115		100	115		100	115		dB
		Full range	96			96			96			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{IO})	25°C	105	120		105	120		105	120		dB
		Full range	100			100			100			
I _{CC}	Supply current	25°C	200	200	300	200	200	300	200	200	300	μA
		Full range	300			300			300			
ΔI _{CC}	Supply-current change over operating temperature range	Full range		6			6			6		μA

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

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

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

PARAMETER	TEST CONDITIONS	T_A †	TLE2022C			TLE2022AC			TLE2022BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	150	500	500	120	300	300	70	150	150	μ V
		Full range		700	700		450	450		300	300	
αV_{IO} Temperature coefficient of input offset voltage		Full range	2			2			2			μ V/°C
Input offset voltage long-term drift (see Note 4)	$V_{IC} = 0, R_S = 50 \Omega$	25°C	0.006			0.006			0.006			μ V/mo
I_{IO} Input offset current		25°C	0.5	6	6	0.4	6	6	0.3	6	6	nA
		Full range		10	10		10	10		10	10	
I_{IB} Input bias current		25°C	35	70	70	33	70	70	30	70	70	nA
		Full range		90	90		90	90		90	90	
V_{ICR} Common-mode input voltage range	$R_S = 50 \Omega$	25°C	-15 to 13.5	-15.3 to 14	-15 to 14	-15 to 13.5	-15.3 to 14	-15 to 14	-15 to 13.5	-15.3 to 14	-15 to 14	V
		Full range	-15 to 13.5	-15 to 13.5	-15 to 13.5	-15 to 13.5	-15 to 13.5	-15 to 13.5	-15 to 13.5	-15 to 13.5	-15 to 13.5	
V_{OM+} Maximum positive peak output voltage swing		25°C	14	14.3	14.3	14	14.3	14.3	14	14.3	14.3	V
		Full range	13.9			13.9			13.9			
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10 \text{ k}\Omega$	25°C	-13.7	-14.1	-14.1	-13.7	-14.1	-14.1	-13.7	-14.1	-14.1	V
		Full range	-13.7	-13.7	-13.7	-13.7	-13.7	-13.7	-13.7	-13.7	-13.7	
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10$ V, $R_L = 10 \text{ k}\Omega$	25°C	0.8	4	4	1	7	7	1.5	10	10	V/ μ V
		Full range	0.8			1			1.5			
$CMRR$ Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50 \Omega$	25°C	95	106	106	97	109	109	100	112	112	dB
		Full range	91			93			96			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC\pm} = \pm 2.5$ V to ± 15 V	25°C	100	115	115	103	118	118	105	120	120	dB
		Full range	95			98			100			
I_{CC} Supply current	$V_O = 0, \text{ No load}$	25°C	550	700	700	550	700	700	550	700	700	μ A
		Full range		700	700		700	700		700	700	
ΔI_{CC} Supply current change over operating temperature range		Full range	9			9			9			μ A

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	TA †	TLE2024C			TLE2024AC			TLE2024BC			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
V _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C	1100		850		600				μV		
αV _{IO}		Full range	1300		1050		800						
Input offset voltage long-term drift (see Note 4)		Full range	2		2		2				μV/°C		
I _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C	0.005		0.005		0.005				μV/mo		
Input offset current		25°C	0.6		6		6				nA		
		Full range	10		10		10						
I _{IB}	25°C	45		70		40		35		70	nA		
	Full range	90		90		90		90		90	nA		
V _{ICR}	R _S = 50 Ω	25°C	0 to 3.5	-0.3 to 4	0 to 3.5	-0.3 to 4	0 to 3.5	-0.3 to 4	0 to 3.5	-0.3 to 4	V		
Common-mode input voltage range		Full range	0 to 3.5		0 to 3.5		0 to 3.5		0 to 3.5		0 to 3.5	V	
		25°C	3.9		4.2		3.9		4.2		4	4.3	V
V _{OH}	R _L = 10 kΩ	25°C	3.7		3.7		3.8		3.8		V		
High-level output voltage		Full range	0.7		0.8		0.7		0.8		0.7	0.8	V
		25°C	0.95		0.95		0.95		0.95		0.95	0.95	V
V _{OL}	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.2		0.3		0.4		0.4		V/μV		
Large-signal differential voltage amplification		Full range	0.1		0.1		0.1		0.1		0.1	V/μV	
		25°C	80		90		82		92		85	95	dB
CMRR	V _{IC} = V _{ICRmin} , R _S = 50 Ω	25°C	80		80		82		82		85	dB	
Common-mode rejection ratio		Full range	98		112		100		115		103	117	dB
		25°C	93		93		95		95		98	98	dB
k _{SVR}	V _{CC} = 5 V to 30 V	25°C	800		1200		800		1200		800	1200	μA
Supply current		Full range	1200		1200		1200		1200		1200	1200	μA
		25°C	15		15		15		15		15	15	μA
I _{CC}	V _O = 2.5 V, No load	25°C	15		15		15		15		15	μA	
Supply current change over operating temperature range		Full range	15		15		15		15		15	15	μA
		25°C	15		15		15		15		15	15	μA

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	T _A †	TLE2024C			TLE2024AC			TLE2024BC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}		25°C	1000		750		500				μV	
αV _{IO}	Temperature coefficient of input offset voltage	Full range	1200		950		700				μV/°C	
		Full range	2		2		2				μV/°C	
I _{IO}	Input offset voltage long-term drift (see Note 4)	25°C	0.006		0.006		0.006				μV/mo	
		25°C	0.6		6		6				nA	
I _{IB}	Input offset current	Full range	10		10		10				nA	
		25°C	50		70		45		40		nA	
I _{IB}	Input bias current	Full range	90		90		90				nA	
		25°C	-15 to 13.5		-15.3 to 14		-15.3 to 14		-15 to 13.5		V	
V _{ICR}	Common-mode input voltage range	Full range	-15 to 13.5		-15 to 13.5		-15 to 13.5				V	
V _{OM+}	Maximum positive peak output voltage swing	25°C	13.8	14.1	13.9	14.2	14	14.3			V	
		Full range	13.7		13.8		13.9		13.9		V	
V _{OM-}	Maximum negative peak output voltage swing	25°C	-13.7	-14.1	-13.7	-14.1	-13.7	-14.1			V	
		Full range	-13.6		-13.6		-13.6		-13.6		V	
AVD	Large-signal differential voltage amplification	25°C	0.4	2	0.8	4	1	7			V/μV	
CMRR	Common-mode rejection ratio	Full range	0.4		0.8		1				V/μV	
		25°C	92	102	94	105	97	108			dB	
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})	Full range	88		90		93				dB	
		25°C	98	112	100	115	103	117			dB	
I _{CC}	Supply current	Full range	93		95		98				μA	
		25°C	1050	1400	1050	1400	1050	1400			μA	
ΔI _{CC}	Supply current change over operating temperature range	Full range	1400		1400		1400				μA	
		Full range	20		20		20				μA	

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	TA †	TLE2021I			TLE2021AI			TLE2021BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO} Input offset voltage		25°C	120	100	300	100	100	300	80	80	200	μV
		Full range	950	600	600						300	
α _{VIO} Temperature coefficient of input offset voltage		25°C	2	2		2	2		2	2		μV/°C
		Full range										
Input offset voltage long-term drift (see Note 4)	V _{IC} = 0, R _S = 50 Ω	25°C	0.005	0.005		0.005	0.005		0.005	0.005		μV/mo
		Full range										
I _{IO} Input offset current		25°C	0.2	0.2	6	0.2	0.2	6	0.2	0.2	6	nA
		Full range	10	10	10	10	10	10	10	10	10	
I _{IB} Input bias current		25°C	25	25	70	25	25	70	25	25	70	nA
		Full range	90	90	90	90	90	90	90	90	90	
V _{ICR} Common-mode input voltage range	R _S = 50 Ω	25°C	0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		V
		Full range	-15 to 3.2	15 to 3.2		15 to 3.2	15 to 3.2		0 to 3.2	0 to 3.2		
V _{OH} High-level output voltage	R _L = 10 kΩ	25°C	4	4.3		4	4.3		4	4.3		V
		Full range	3.9	3.9		3.9	3.9		3.9	3.9		
V _{OL} Low-level output voltage		25°C	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.7	0.8	V
		Full range	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
A _{VD} Large-signal differential voltage amplification	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.3	1.5		0.3	1.5		0.3	1.5		V/μV
		Full range	0.25	0.25		0.25	0.25		0.25	0.25		
CMRR Common-mode rejection ratio	V _{IC} = V _{ICR} min, R _S = 50 Ω	25°C	85	110		85	110		85	110		dB
		Full range	80	80		80	80		80	80		
k _{SVR} Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{IO})	V _{CC} = 5 V to 30 V	25°C	105	120		105	120		105	120		dB
		Full range	100	100		100	100		100	100		
I _{CC} Supply current	V _O = 2.5 V, No load	25°C	170	170	230	170	170	230	170	170	230	μA
		Full range	230	230	230	230	230	230	230	230	230	
ΔI _{CC} Supply-current change over operating temperature range		25°C	6	6		6	6		6	6		μA
		Full range										

† Full range is -40°C to 85°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	T_A †	TLE2021I			TLE2021AI			TLE2021BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C	120	120	500	80	80	200	40	40	100	μV
αV_{IO} Temperature coefficient of input offset voltage	Input offset voltage long-term drift (see Note 4)	Full range	850			500			200			
		Full range	2			2			2			$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	0.006			0.006			0.006			$\mu\text{V}/\text{mo}$
		Full range	0.2			0.2			0.2			nA
I_{IB} Input bias current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C	25	25	70	25	25	70	25	25	70	nA
		Full range	90			90			90			nA
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	-15	-15.3	to	-15	-15.3	to	-15	-15.3	to	V
		Full range	13.5 14			13.5 14			13.5 14			V
V_{OM+} Maximum positive peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	14	14.3		14	14.3		14	14.3		V
		Full range	13.9			13.9			13.9			V
V_{OM-} Maximum negative peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	-13.7	-14.1		-13.7	-14.1		-13.7	-14.1		V
		Full range	-13.6			-13.6			-13.6			V
AVD Large-signal differential voltage amplification	$V_O = 10\ \text{V}, R_L = 10\ \text{k}\Omega$	25°C	1	6.5		1	6.5		1	6.5		$\text{V}/\mu\text{V}$
		Full range	0.75			0.75			0.75			$\text{V}/\mu\text{V}$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\ \text{min}, R_S = 50\ \Omega$	25°C	100	115		100	115		100	115		dB
		Full range	96			96			96			dB
kSVR Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC} \pm = \pm 2.5\ \text{V}$ to $\pm 15\ \text{V}$	25°C	105	120		105	120		105	120		dB
		Full range	100			100			100			dB
I_{CC} Supply current	$V_O = 0\ \text{V}, \text{No load}$	25°C	200	200	300	200	200	300	200	200	300	μA
		Full range	300			300			300			μA
ΔI_{CC} Supply-current change over operating temperature range		Full range	7			7			7			μA

† Full range is -40°C to 85°C .
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	T _A †	TLE2022I			TLE2022AI			TLE2022BI			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
V _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C			600			400			250	μV	
αV _{IO}		Full range			800			550			400		
		Full range		2					2			2	μV/°C
I _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C		0.005			0.005			0.005		μV/mo	
		25°C		0.5		6		0.4		0.3		6	nA
		Full range				10						10	
I _{IB}	V _{IC} = 0, R _S = 50 Ω	25°C			35			33			30	70	nA
		25°C			70			70				70	
		Full range				90			90			90	
V _{ICR}	R _S = 50 Ω	25°C	0	-0.3	0	-0.3	0	-0.3	0	-0.3	0	-0.3	V
		25°C	to	to	to	to	to	to	to	to	to	to	
		Full range	3.5	4	3.5	4	3.5	4	3.5	4	3.5	4	
V _{OH}	R _L = 10 kΩ	25°C	4	4.3	4	4.3	4	4.3	4	4.3	4	4.3	V
		25°C	3.9		3.9		3.9		3.9		3.9		
		Full range											
V _{OL}	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.3	1.5	0.4	1.5	0.4	1.5	0.5	1.5	0.5	1.5	V
		25°C	0.2		0.2		0.2		0.2		0.2		
		Full range											
CMRR	V _{IC} = V _{ICRmin} , R _S = 50 Ω	25°C	85	100	87	102	90	105	90	105	90	105	dB
		25°C	80		82		85		85		85		
		Full range											
k _{SVR}	V _{CC} = 5 V to 30 V	25°C	100	115	103	118	105	120	105	120	105	120	dB
		25°C	95		98		100		100		100		
		Full range											
I _{CC}	V _O = 2.5 V, No load	25°C	450	600	450	600	450	600	450	600	450	600	μA
		25°C	600		600		600		600		600		
		Full range											
ΔI _{CC}	V _O = 2.5 V, No load	25°C		15		15		15		15		15	μA
		25°C											
		Full range											

† Full range is -40°C to 85°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

PARAMETER	TEST CONDITIONS	T _A †	TLE2022I			TLE2022AI			TLE2022BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}		25°C	150	500	500	120	300	300	70	150	150	μV
		Full range		700	700		450	450		300	300	
αV _{IO}		Full range	2			2			2			μV/°C
Input offset voltage		25°C	0.006			0.006			0.006			μV/mo
Temperature coefficient of input offset voltage		25°C	0.5	6	6	0.4	6	6	0.3	6	6	nA
Input offset voltage long-term drift (see Note 4)		Full range		10	10		10	10		10	10	
I _{IO}		25°C	35	70	70	33	70	70	30	70	70	nA
I _{IB}		Full range		90	90		90	90		90	90	
V _{ICR}		25°C	-15 to 13.5	-15.3 to 14	-15.3 to 14	-15 to 13.5	-15.3 to 14	-15.3 to 14	-15 to 13.5	-15.3 to 14	-15.3 to 14	V
Common-mode input voltage range		Full range	-15 to 13.2	-15.3 to 13.2	-15.3 to 13.2	-15 to 13.2	-15.3 to 13.2	-15.3 to 13.2	-15 to 13.2	-15.3 to 13.2	-15.3 to 13.2	
V _{OM+}		25°C	14	14.3	14.3	14	14.3	14.3	14	14.3	14.3	V
Maximum positive peak output voltage swing		Full range	13.9			13.9			13.9			
V _{OM-}		25°C	-13.7	-14.1	-14.1	-13.7	-14.1	-14.1	-13.7	-14.1	-14.1	V
Maximum negative peak output voltage swing		Full range	-13.6			-13.6			-13.6			
AVD		25°C	0.8	4	4	1	7	7	1.5	10	10	V/μV
Large-signal differential voltage amplification		Full range	0.8			1			1.5			
CMRR		25°C	95	106	106	97	109	109	100	112	112	dB
Common-mode rejection ratio		Full range	91			93			96			
k _{SVR}		25°C	100	115	115	103	118	118	105	120	120	dB
Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})		Full range	95			98			100			
I _{CC}		25°C	550	700	700	550	700	700	550	700	700	μA
Supply current		Full range		700	700		700	700		700	700	
ΔI _{CC}		Full range	30			30			30			μA
Supply current change over operating temperature range		Full range										

† Full range is -40°C to 85°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

PARAMETER	TEST CONDITIONS	TA †			TLE2024I			TLE2024AI			TLE2024BI			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	25°C			1100			850			600			μV
αV_{IO}	Temperature coefficient of input offset voltage	Full range			1300			1050			800			$\mu\text{V}/^\circ\text{C}$
	Input offset voltage long-term drift (see Note 4)	Full range			2			2			2			$\mu\text{V}/\text{mo}$
I_{IO}	Input offset current	25°C			0.005			0.005			0.005			nA
I_{IB}	Input bias current	25°C			0.6			0.5			0.4			nA
		Full range			10			10			10			nA
		25°C			45			40			35			nA
		Full range			90			90			90			nA
V_{ICR}	Common-mode input voltage range	25°C			0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		0 to 3.5	-0.3 to 4		V
		Full range			0 to 3.2	0 to 4		0 to 3.2	0 to 4		0 to 3.2	0 to 4		V
V_{OM+}	Maximum positive peak output voltage swing	25°C			3.9	4.2		3.9	4.2		4	4.3		V
V_{OM-}	Maximum negative peak output voltage swing	Full range			3.7			3.7			3.8			V
A_{VD}	Large-signal differential voltage amplification	25°C			0.7	0.8		0.7	0.8		0.7	0.8		V
		Full range			0.95			0.95			0.95			V
$CMRR$	Common-mode rejection ratio	25°C			0.2	1.5		0.3	1.5		0.4	1.5		V/ μV
		Full range			0.1			0.1			0.1			V/ μV
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	25°C			80	90		82	92		85	95		dB
		Full range			80			82			85			dB
I_{CC}	Supply current	25°C			98	112		100	115		103	117		dB
		Full range			93			95			98			dB
ΔI_{CC}	Supply current change over operating temperature range	25°C			800	1200		800	1200		800	1200		μA
		Full range			1200			1200			1200			μA
		Full range			30			30			30			μA

† Full range is -40°C to 85°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

PARAMETER	TEST CONDITIONS	T _A †	TLE2024I			TLE2024AI			TLE2024BI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}		25°C										μV
αV _{IO}		Full range										μV/°C
Input offset voltage		Full range										μV
Temperature coefficient of input offset voltage		Full range										μV/°C
Input offset voltage long-term drift (see Note 4)		Full range										μV/mo
I _{IO}		25°C										nA
Input offset current		25°C										nA
Input bias current		Full range										nA
V _{ICR}		25°C										V
Common-mode input voltage range		Full range										V
V _{OM+}		25°C										V
Maximum positive peak output voltage swing		Full range										V
V _{OM-}		25°C										V
Maximum negative peak output voltage swing		Full range										V
AVD		25°C										V/μV
Large-signal differential voltage amplification		Full range										V/μV
CMRR		25°C										dB
Common-mode rejection ratio		Full range										dB
k _{SVR}		25°C										dB
Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})		Full range										dB
I _{CC}		25°C										μA
Supply current		Full range										μA
ΔI _{CC}		Full range										μA
Supply current change over operating temperature range		Full range										μA

† Full range is -40°C to 85°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	T _A [†]	TLE2021M			TLE2021AM			TLE2021BM			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
V _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C	120	100	300	100	100	300	80	80	200	μV	
Temperature coefficient of input offset voltage		Full range	1100			600			300				
Input offset voltage long-term drift (see Note 4)		Full range	2	2	2	2	2	2	2	2	2		μV/°C
I _{IO}	V _{IC} = 0, R _S = 50 Ω	25°C	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	μV/mo	
Input offset current		25°C	0.2	0.2	6	0.2	0.2	6	0.2	0.2	6		nA
Input bias current		Full range	10			10			10				
V _{ICR}	R _S = 50 Ω	25°C	0	-0.3	0	-0.3	0	-0.3	0	-0.3	0	V	
		Full range	to 3.5			to 3.5			to 3.5				
		Full range	4			4			4				
V _{OH}	R _L = 10 kΩ	25°C	4	4.3	4	4.3	4	4.3	4	4.3	4	V	
High-level output voltage		Full range	3.8			3.8			3.8				
Low-level output voltage		25°C	0.7	0.7	0.8	0.7	0.7	0.8	0.7	0.7	0.8		
A _{VD}	V _O = 1.4 V to 4 V, R _L = 10 kΩ	25°C	0.3	1.5	0.3	1.5	0.3	1.5	0.3	1.5	0.3	V/μV	
Large-signal differential voltage amplification		Full range	0.1			0.1			0.1				
Common-mode rejection ratio		25°C	85	110	85	110	85	110	85	110	85		
k _{SVR}	V _{IC} = V _{ICRmin} , R _S = 50 Ω	25°C	80	80	80	80	80	80	80	80	80	dB	
Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})		25°C	105	120	105	120	105	120	105	120	105		
Supply current		Full range	100			100			100				
ΔI _{CC}	V _O = 2.5 V, No load	25°C	170	170	230	170	170	230	170	170	230	μA	
Supply current change over operating temperature range		Full range	230			230			230				
		Full range	9			9			9				

[†] Full range is -55°C to 125°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	T_A †	TLE2021M			TLE2021AM			TLE2021BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}		25°C	120	120	500	80	80	200	40	40	100	μV
		Full range		2	1000		2	500		2	200	
αV_{IO}		Full range										$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)	$R_S = 50\ \Omega$	25°C		0.006			0.006			0.006		$\mu\text{V}/\text{mo}$
I_{IO}		25°C	0.2	0.2	6	0.2	0.2	6	0.2	0.2	6	nA
		Full range			10			10			10	
I_{IB}		25°C	25	25	70	25	25	70	25	25	70	nA
		Full range			90			90			90	
V_{ICR}	$R_S = 50\ \Omega$	25°C	-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		-15 to 13.5	-15.3 to 14		V
		Full range										
V_{OM+}		25°C	14	14.3		14	14.3		14	14.3		V
		Full range										
V_{OM-}	$R_L = 10\ \text{k}\Omega$	25°C	-13.7 to -13.6	-14.1 to -14.1		-13.7 to -13.6	-14.1 to -14.1		-13.7 to -13.6	-14.1 to -14.1		V
		Full range										
AVD	$V_O = \pm 10\ \text{V}$, $R_L = 10\ \text{k}\Omega$	25°C	1	6.5		1	6.5		1	6.5		$\text{V}/\mu\text{V}$
		Full range										
$CMRR$	$V_{IC} = V_{ICR\text{min}}$, $R_S = 50\ \Omega$	25°C	100	115		100	115		100	115		dB
		Full range										
k_{SVR}	$V_{CC\pm} = \pm 2.5\ \text{V}$ to $\pm 15\ \text{V}$	25°C	105	120		105	120		105	120		dB
		Full range										
I_{CC}	$V_O = 0$, No load	25°C	200	200	300	200	200	300	200	200	300	μA
		Full range			300			300			300	
ΔI_{CC}		Full range		10			10			10		μA

† Full range is -55°C to 125°C .
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	TA †	TLE2022M			TLE2022AM			TLE2022BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage		25°C			600			400			250	μV
αV_{IO} Temperature coefficient of input offset voltage		Full range			800			550			400	$\mu\text{V}/^\circ\text{C}$
Input offset voltage long-term drift (see Note 4)		Full range		2			2			2		$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_{IC} = 0, R_S = 50\ \Omega$	25°C		0.005			0.005			0.005		$\mu\text{V}/\text{mo}$
I_{IB} Input bias current		25°C	0.5		6		0.4		6	0.3		nA
		Full range			10			10			10	nA
		25°C	35		70		33		70	30		nA
		Full range			90			90			90	nA
V_{ICR} Common-mode input voltage range	$R_S = 50\ \Omega$	25°C	0 to 3.5	-0.3 to 4	0 to 3.2	-0.3 to 4	0 to 3.2	0 to 3.2	-0.3 to 4	0 to 3.5	-0.3 to 4	V
V_{OH} High-level output voltage		25°C	4	4.3		4	4.3		4	4.3		V
V_{OL} Low-level output voltage	$R_L = 10\ \text{k}\Omega$	Full range	3.8			3.8			3.8			V
A_{VD} Large-signal differential voltage amplification	$V_O = 1.4\text{ V to }4\text{ V}, R_L = 10\ \text{k}\Omega$	25°C	0.3	1.5		0.4	1.5		0.5	1.5		V/ μV
		Full range	0.1			0.1			0.1			V/ μV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, R_S = 50\ \Omega$	25°C	85	100		87	102		90	105		dB
		Full range	80			82			85			dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to }30\text{ V}$	25°C	100	115		103	118		105	120		dB
		Full range	95			98			100			dB
I_{CC} Supply current	$V_O = 2.5\text{ V},$ No load	25°C	450	600		450	600		450	600		μA
ΔI_{CC} Supply current change over operating temperature range		Full range	600			600			600			μA
		Full range		37			37			37		μA

† Full range is -55°C to 125°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	T _A †	TLE2022M			TLE2022AM			TLE2022BM			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}		25°C	150	500	500	120	300	70	150	150	μV	
αV _{IO}		Full range		700	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 _{IC} = 0, R _S = 50 Ω	25°C	0.006			0.006		0.006		0.006	μV/mo	
I _{IO}		25°C	0.5	6	6	0.4	6	0.3	6	6	nA	
		Full range		10	10		10		10		nA	
I _{IB}		25°C	35	70	70	33	70	30	70	70	nA	
		Full range		90	90		90		90		nA	
V _{ICR}	Common-mode input voltage range	25°C	-15 to 13.5	-15.3 to 14	-15 to 14	-15 to 13.5	-15.3 to 14	-15 to 13.5	-15.3 to 14	-15 to 14	V	
		Full range	-15 to 13.2	-15 to 14	-15 to 13.2	-15 to 13.2	-15 to 14	-15 to 13.2	-15 to 14	-15 to 13.2	V	
V _{OM+}	Maximum positive peak output voltage swing	25°C	14	14.3	14.3	14	14.3	14	14.3	14	V	
		Full range	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	V	
V _{OM-}	Maximum negative peak output voltage swing	25°C	-13.7	-14.1	-14.1	-13.7	-14.1	-13.7	-14.1	-13.7	V	
		Full range	-13.6	-13.6	-13.6	-13.6	-13.6	-13.6	-13.6	-13.6	V	
AVD	Large-signal differential voltage amplification	25°C	0.8	4	4	1	7	1.5	10	10	V/μV	
		Full range	0.8	0.8	0.8	1	1	1.5	1.5	1.5	V/μV	
CMRR	Common-mode rejection ratio	25°C	95	106	106	97	109	100	112	112	dB	
		Full range	91	91	91	93	93	96	96	96	dB	
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})	25°C	100	115	115	103	118	105	120	120	dB	
		Full range	95	95	95	98	98	100	100	100	dB	
I _{CC}	Supply current	25°C	550	700	700	550	700	550	700	700	μA	
		Full range	700	700	700	700	700	700	700	700	μA	
ΔI _{CC}	Supply current change over operating temperature range	Full range	60	60	60	60	60	60	60	60	μA	

† Full range is 0°C to 70°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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

PARAMETER	TEST CONDITIONS	TA †		TLE2024M			TLE2024AM			TLE2024BM			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	
V_{IO}	Input offset voltage	25°C		1100		850		600					μV
αV_{IO}	Temperature coefficient of input offset voltage	Full range		1300		1050		800					$\mu\text{V}/^\circ\text{C}$
	Input offset voltage long-term drift (see Note 4)	Full range		2		2		2					$\mu\text{V}/\text{mo}$
I_{IO}	Input offset current	25°C		0.005		0.005		0.005					nA
I_{IB}	Input bias current	25°C		0.6		6		6					nA
		Full range		10		10		10					nA
		25°C		45		70		40					nA
		Full range		90		90		90					nA
V_{ICR}	Common-mode input voltage range	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	0 to 3.5	-0.3 to 4		V
		Full range		0 to 3.2	0 to 4	0 to 3.2	0 to 4	0 to 3.2	0 to 4	0 to 3.2	0 to 4		V
V_{OM+}	Maximum positive peak output voltage swing	25°C		3.9	4.2	3.9	4.2	3.9	4.2	3.9	4.3		V
V_{OM-}	Maximum negative peak output voltage swing	Full range		3.7		3.7		3.7		3.8			V
A_{VD}	Large-signal differential voltage amplification	25°C		0.2	1.5	0.3	1.5	0.4	1.5	0.4	1.5		V/ μV
		Full range		0.1		0.1		0.1		0.1			V/ μV
$CMRR$	Common-mode rejection ratio	25°C		80	90	82	92	85	95	85	95		dB
		Full range		80		82		85		85			dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	25°C		98	112	100	115	103	117	98	117		dB
		Full range		93		95		98		98			dB
I_{CC}	Supply current	25°C		800	1200	800	1200	800	1200	800	1200		μA
		Full range		1200		1200		1200		1200			μA
ΔI_{CC}	Supply current change over operating temperature range	Full range		50		50		50		50			μA

† Full range is -55°C to 125°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150^\circ\text{C}$ extrapolated to $T_A = 25^\circ\text{C}$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

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

† Full range is -55°C to 125°C.
 NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at T_A = 150°C extrapolated to T_A = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

PARAMETER	TEST CONDITIONS	T _A	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain V _O = 1 V to 3 V, See Figure 1	25°C		0.5			0.5			0.5		V/μs
V _n	Equivalent input noise voltage (see Figure 2)	25°C		21	50		21	50		21		nV/Hz
		25°C		17	30		17	30		17		
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	25°C		0.16			0.16			0.16		μV
		25°C		0.47			0.47			0.47		
I _n	Equivalent input noise current	25°C		0.09			0.09			0.9		pA/Hz
B ₁	Unity-gain bandwidth	25°C		1.2			1.2			1.2		MHz
φ _m	Phase margin at unity gain	25°C		42°			42°			42°		

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

PARAMETER	TEST CONDITIONS	T _A †	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain V _O = 1 V to 3 V, See Figure 1	25°C	0.45	0.65		0.45	0.65		0.45	0.65		V/μs
		Full range	0.45			0.42			0.45			
V _n	Equivalent input noise voltage (see Figure 2)	25°C		19	50		19	50		19		nV/Hz
		25°C		15	30		15	30		15		
V _{N(PP)}	Peak-to-peak equivalent input noise voltage	25°C		0.16			0.16			0.16		μV
		25°C		0.47			0.47			0.47		
I _n	Equivalent input noise current	25°C		0.09			0.09			0.09		pA/Hz
B ₁	Unity-gain bandwidth	25°C		2			2			2		MHz
φ _m	Phase margin at unity gain	25°C		46°			46°			46°		

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

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

PARAMETER	TEST CONDITIONS	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1									V/ μs
V_n	Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$									nV/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$									
$V_N(\text{PP})$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }1\text{ Hz}$									μV
		$f = 0.1\text{ to }10\text{ Hz}$									
I_n	Equivalent input noise current	0.1									pA/ $\sqrt{\text{Hz}}$
B1	Unity-gain bandwidth	1.7									MHz
ϕ_m	Phase margin at unity gain	47°									47°

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

PARAMETER	TEST CONDITIONS	T_A †	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	25°C	0.45									V/ μs
		Full range	0.45									
V_n	Equivalent input noise voltage (see Figure 2)	25°C	19									nV/ $\sqrt{\text{Hz}}$
		25°C	15									
$V_N(\text{PP})$	Peak-to-peak equivalent input noise voltage	25°C	0.16									μV
		25°C	0.47									
I_n	Equivalent input noise current	25°C	0.1									pA/ $\sqrt{\text{Hz}}$
B1	Unity-gain bandwidth	25°C	2.8									MHz
ϕ_m	Phase margin at unity gain	25°C	52°									52°

† Full range is 0°C to 70°C.

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

PARAMETER	TEST CONDITIONS	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	$V_O = 1\text{ V to }3\text{ V}$, See Figure 1									$\text{V}/\mu\text{s}$
V_n	Equivalent input noise voltage (see Figure 2)	$f = 10\text{ Hz}$									$\text{nV}/\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$									
		$f = 0.1\text{ to }1\text{ Hz}$									
$V_n(\text{PP})$	Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ to }10\text{ Hz}$									μV
I_n	Equivalent input noise current	0.1									$\text{pA}/\sqrt{\text{Hz}}$
B1	Unity-gain bandwidth	1.7									MHz
ϕ_m	Phase margin at unity gain	47°									

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

PARAMETER	TEST CONDITIONS	T_A^\dagger	C SUFFIX			I SUFFIX			M SUFFIX			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain	25°C	0.45									$\text{V}/\mu\text{s}$
V_n	Equivalent input noise voltage (see Figure 2)	Full range	0.42									
		25°C	19									$\text{nV}/\sqrt{\text{Hz}}$
		25°C	15									
$V_n(\text{PP})$	Peak-to-peak equivalent input noise voltage	25°C	0.16									μV
		25°C	0.47									
I_n	Equivalent input noise current	25°C	0.1									$\text{pA}/\sqrt{\text{Hz}}$
B1	Unity-gain bandwidth	25°C	2.8									MHz
ϕ_m	Phase margin at unity gain	25°C	52°									

† Full range is 0°C to 70°C.

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

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

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

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

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

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

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

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

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

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

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

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

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

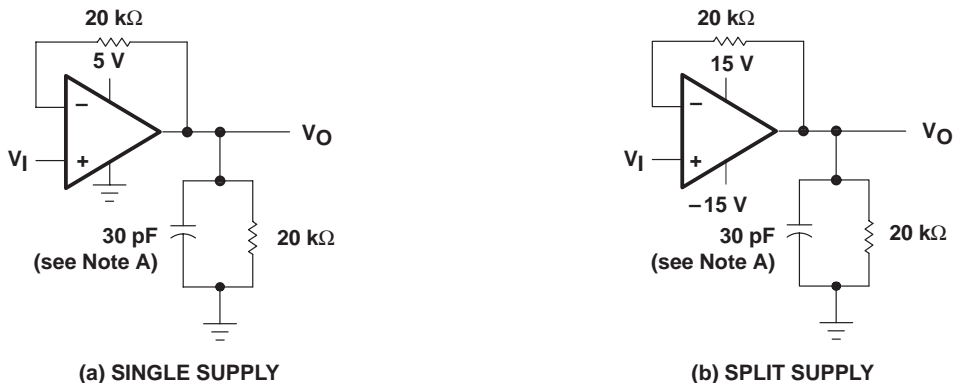
TLE2024Y operating characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

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

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PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

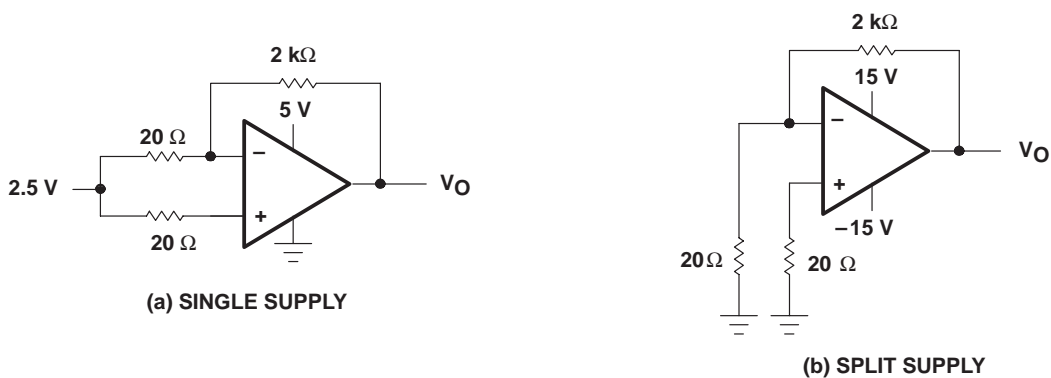
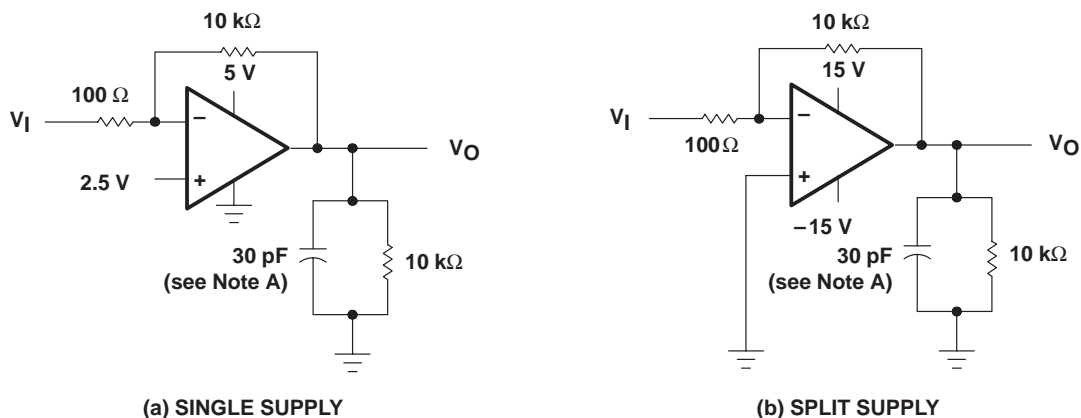


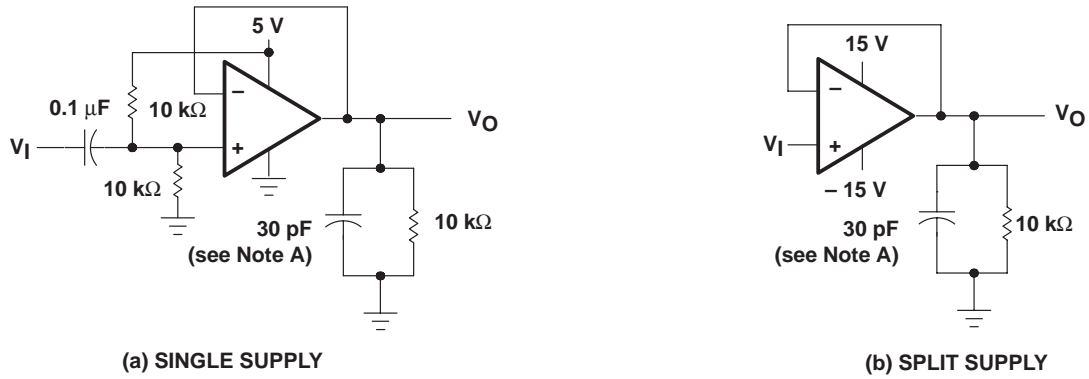
Figure 2. Noise-Voltage Test Circuit



NOTE A: C_L includes fixture capacitance.

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

PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes fixture capacitance.

Figure 4. Small-Signal Pulse-Response Test Circuit

typical values

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

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Table of Graphs

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

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TYPICAL CHARACTERISTICS

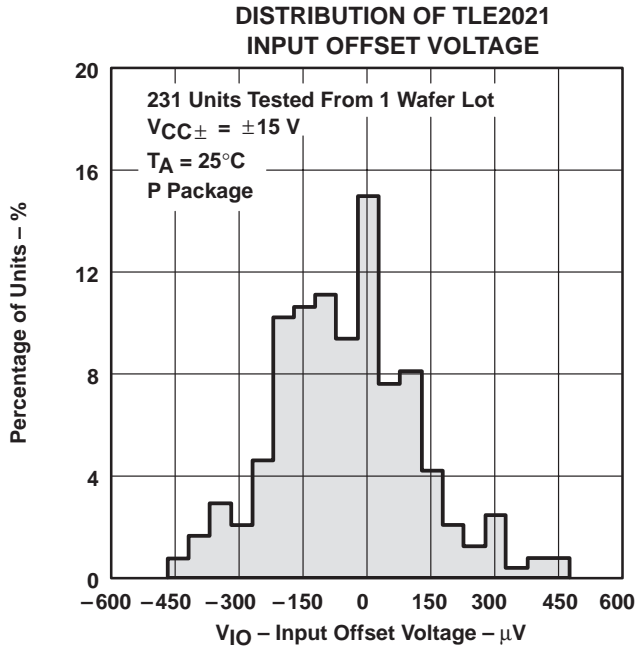


Figure 5

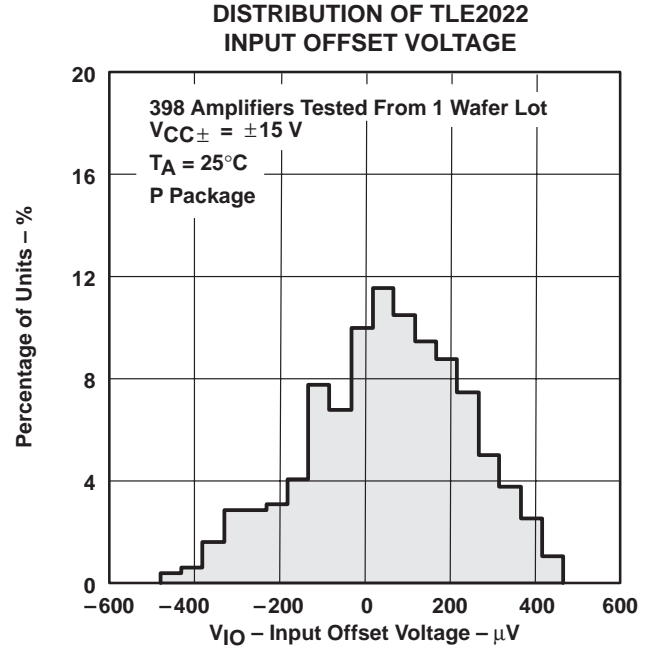


Figure 6

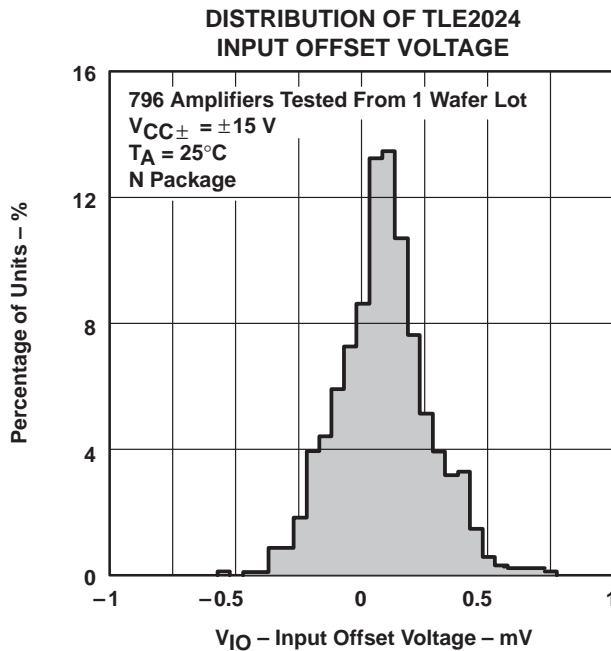


Figure 7

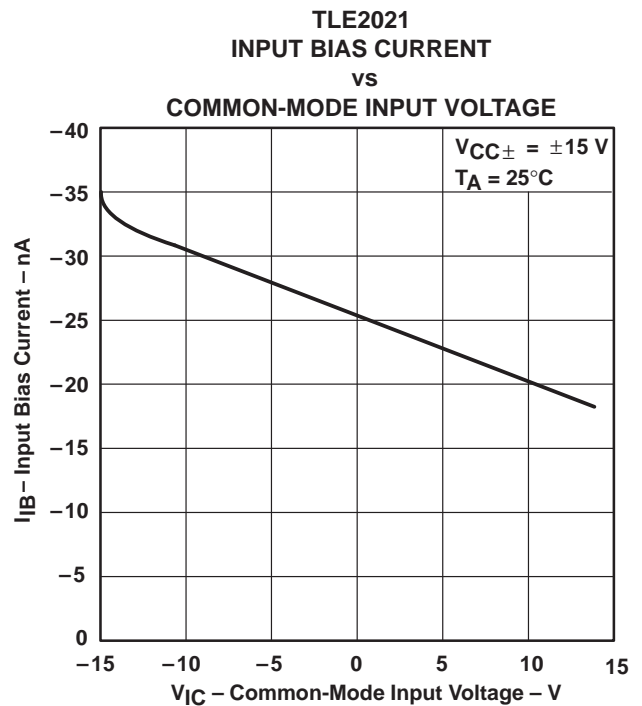


Figure 8

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TYPICAL CHARACTERISTICS

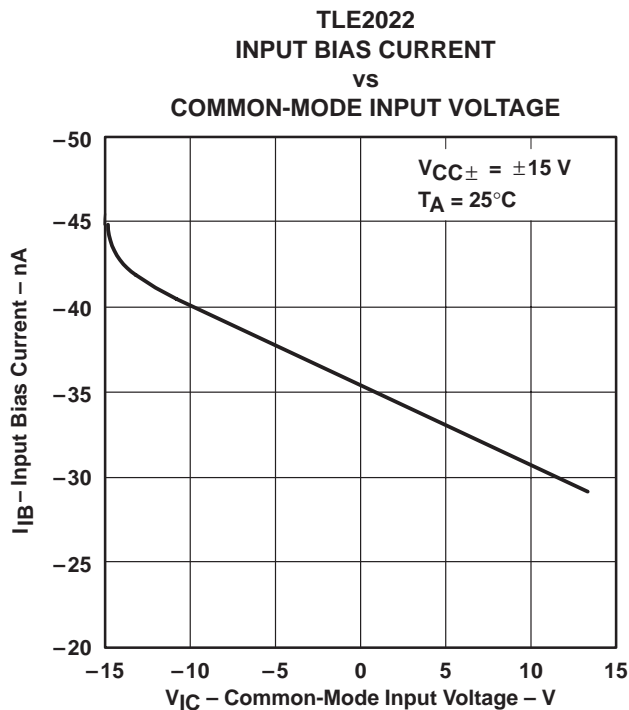


Figure 9

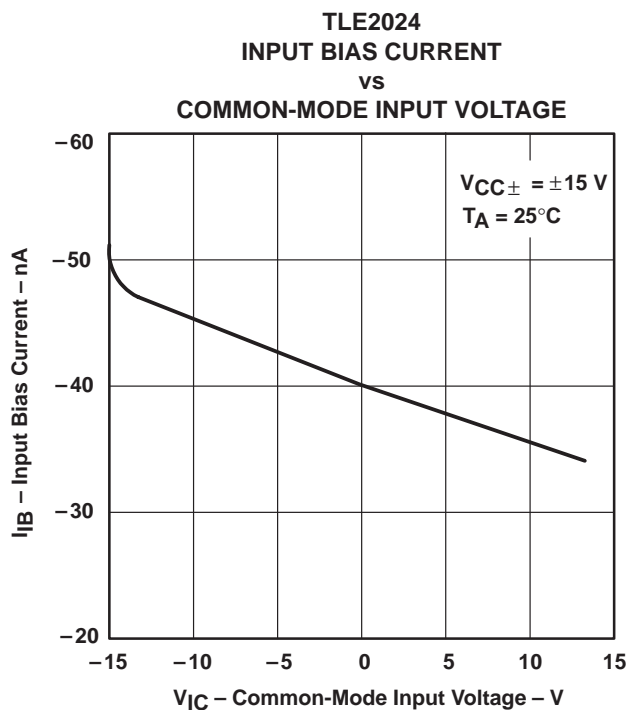


Figure 10

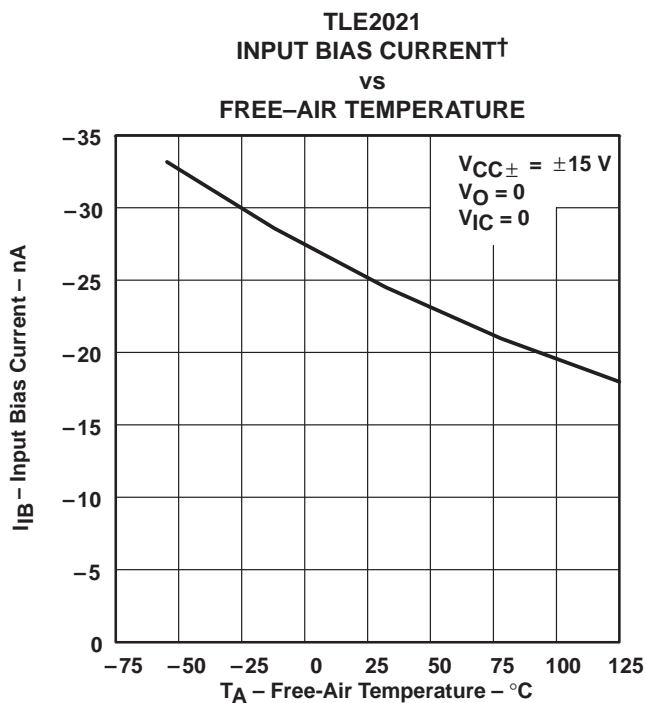


Figure 11

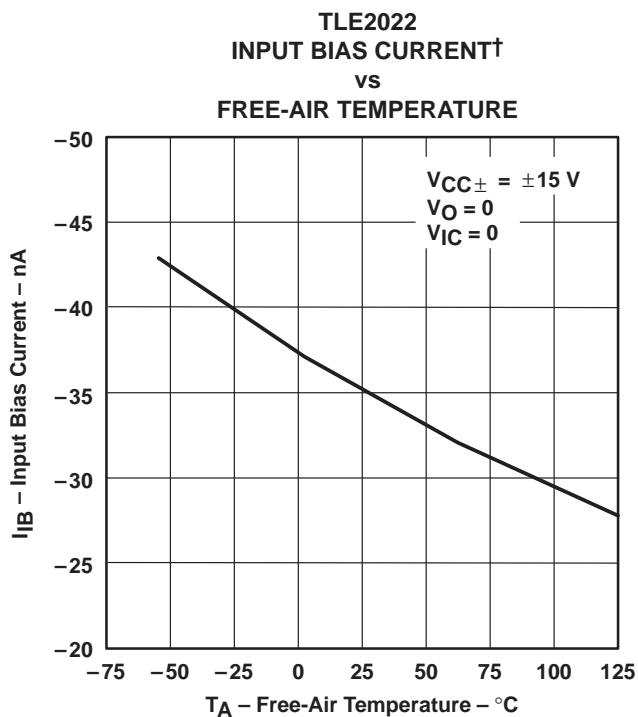


Figure 12

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

TYPICAL CHARACTERISTICS

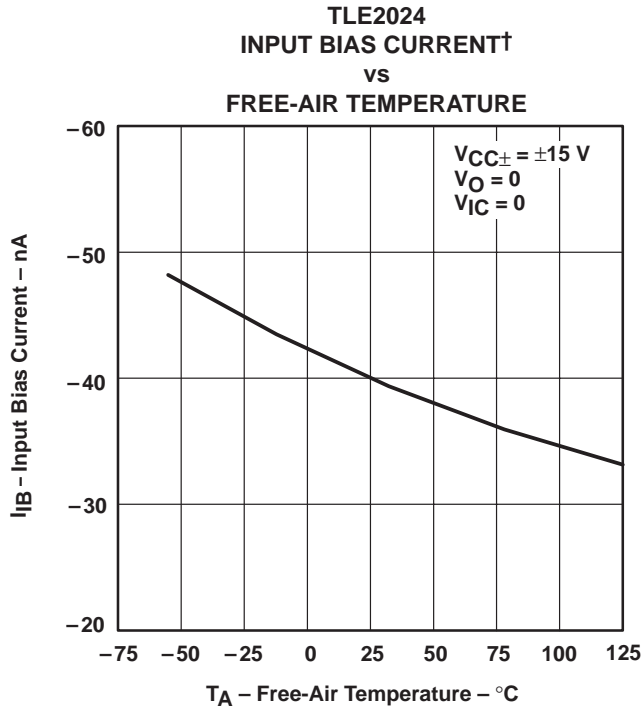


Figure 13

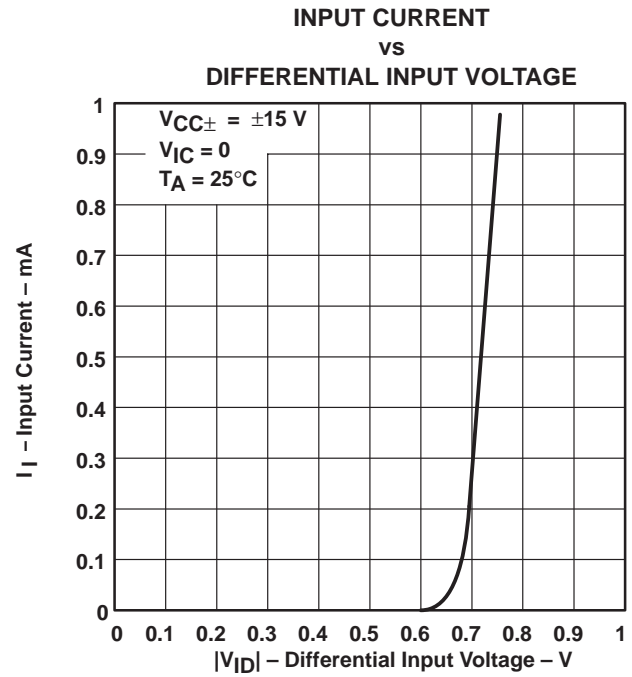


Figure 14

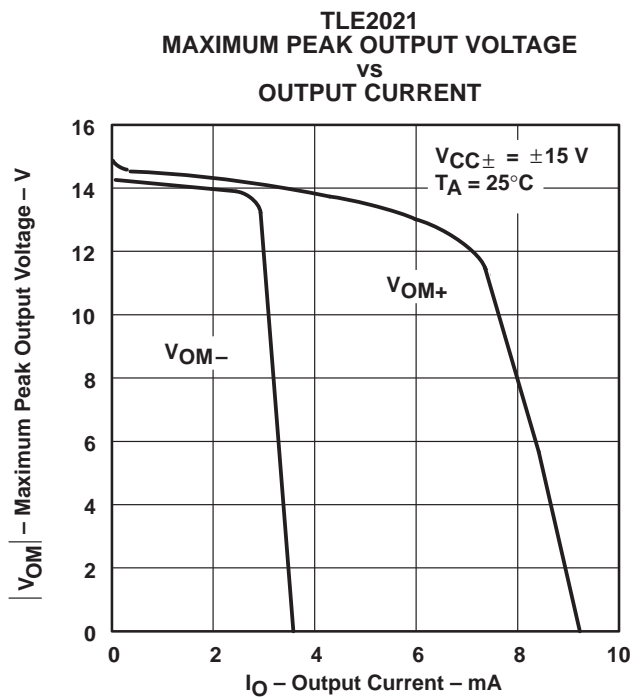


Figure 15

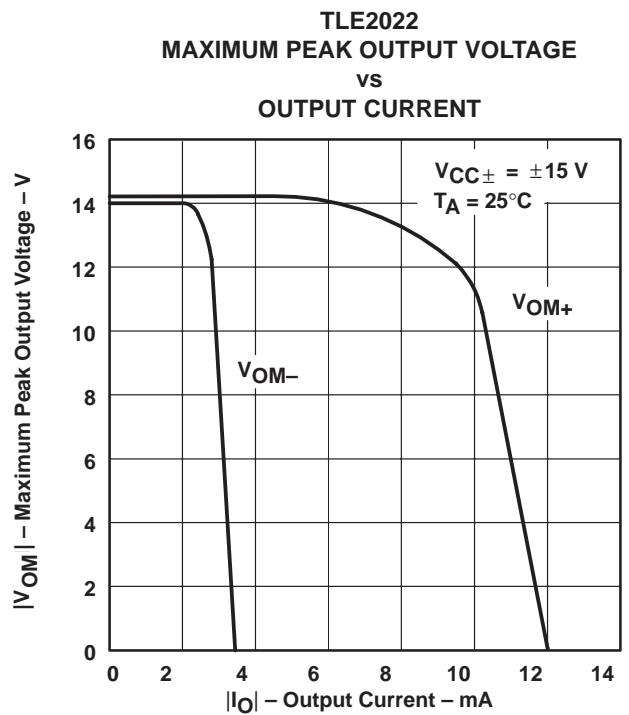


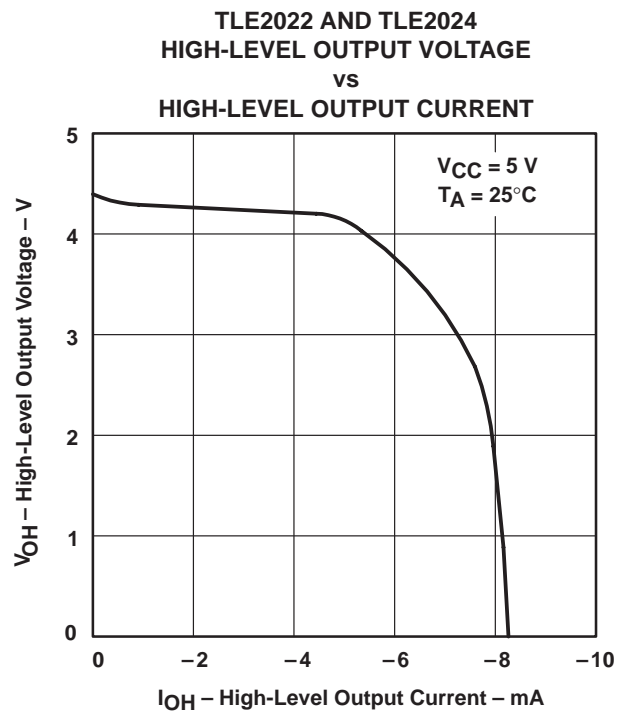
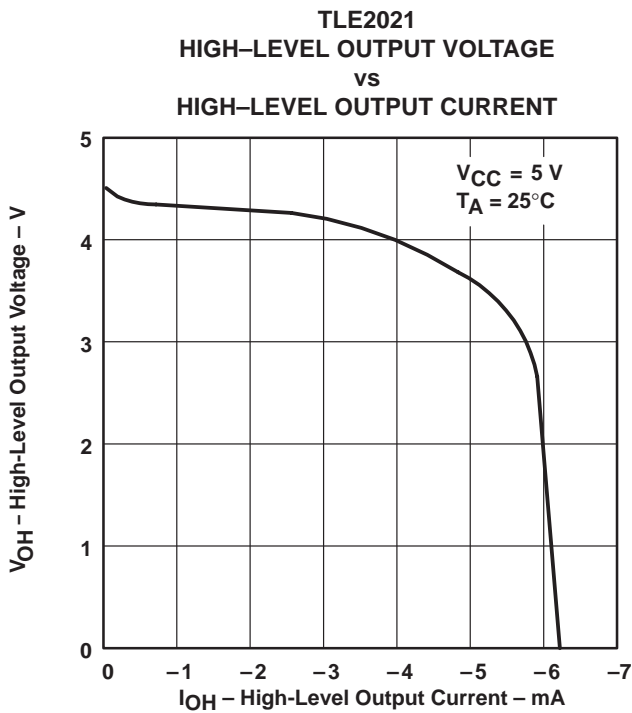
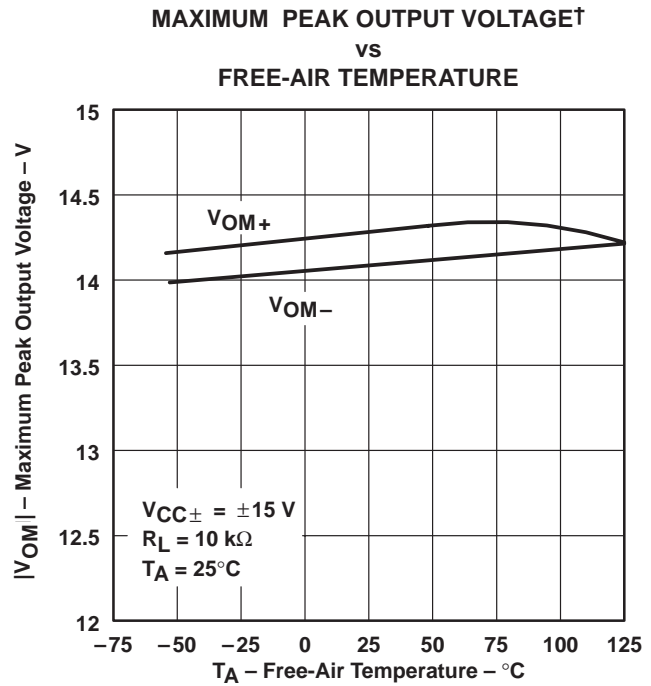
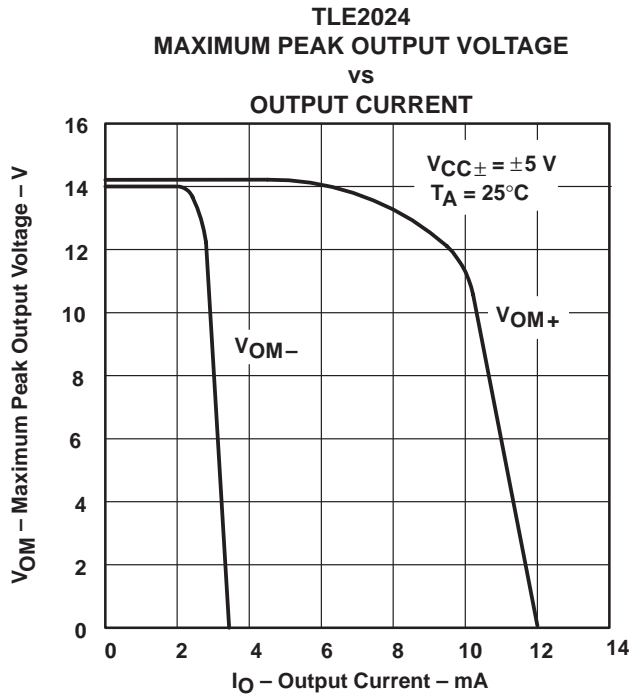
Figure 16

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

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

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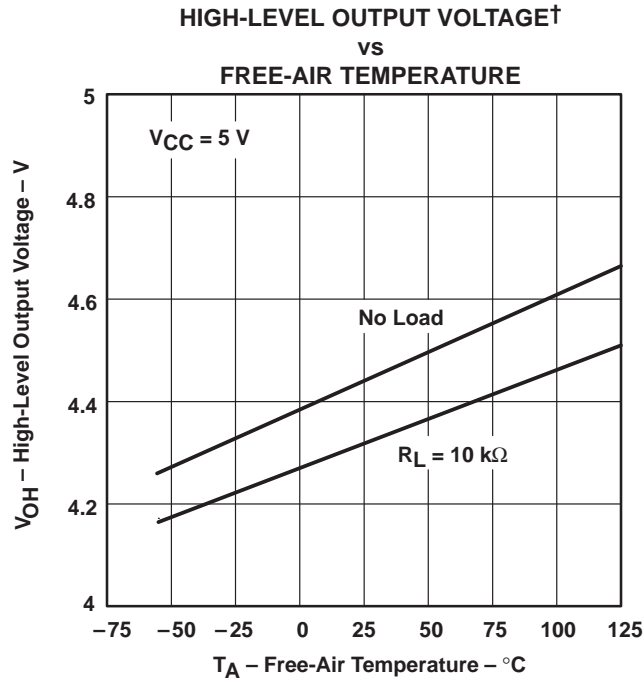


Figure 21

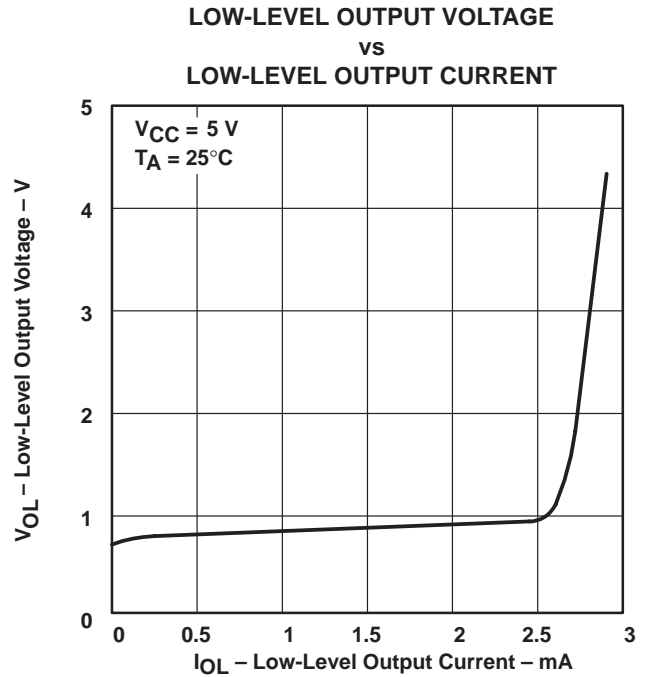


Figure 22

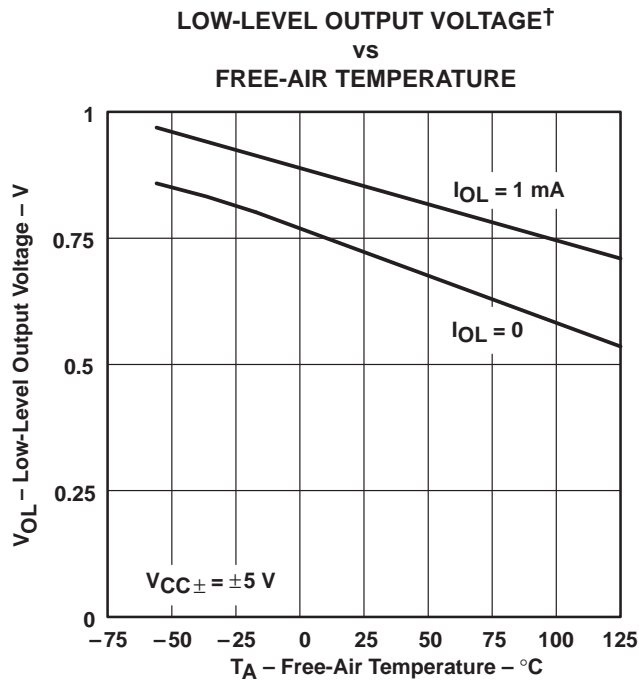


Figure 23

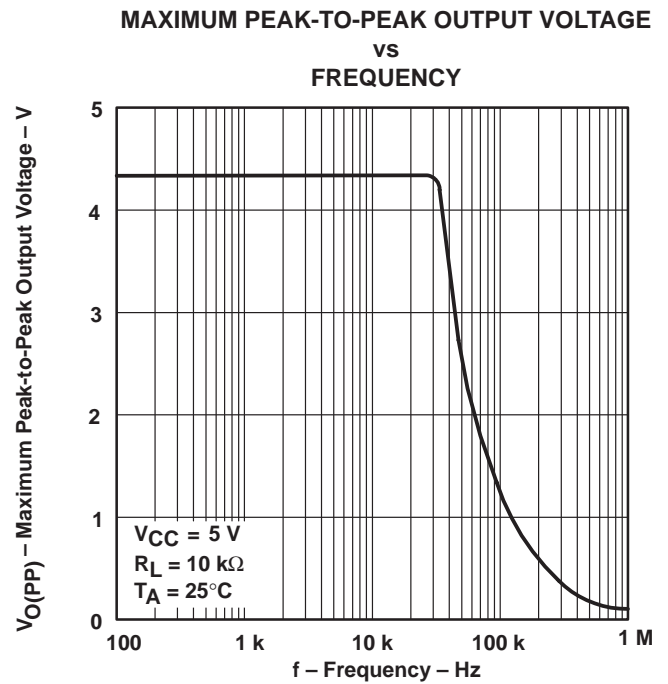


Figure 24

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

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TYPICAL CHARACTERISTICS

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
 vs
 FREQUENCY

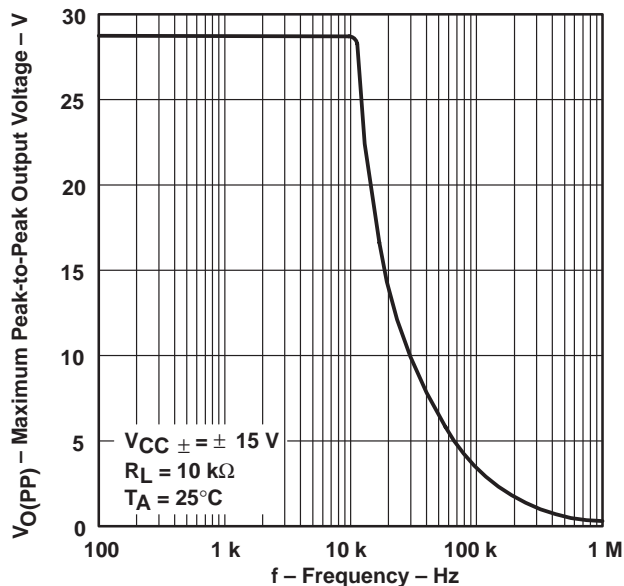


Figure 25

LARGE-SIGNAL DIFFERENTIAL VOLTAGE
 AMPLIFICATION AND PHASE SHIFT
 vs
 FREQUENCY

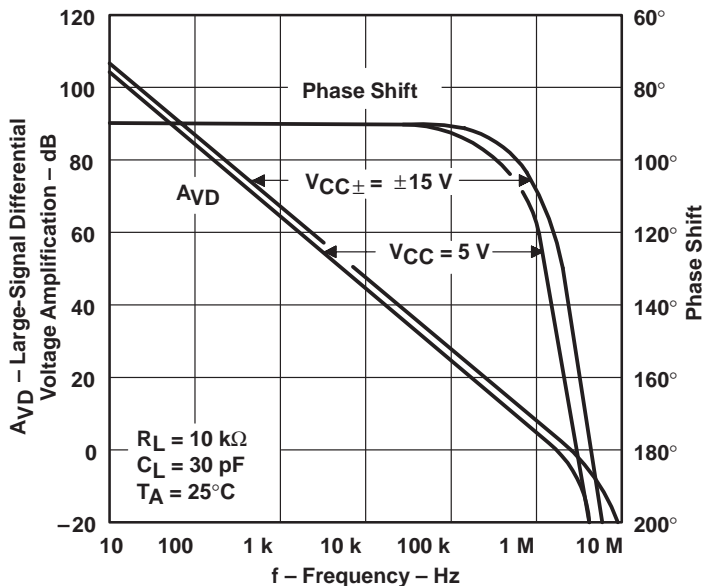


Figure 26

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

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TYPICAL CHARACTERISTICS

TLE2021
LARGE-SCALE DIFFERENTIAL VOLTAGE
AMPLIFICATION†
vs
FREE-AIR TEMPERATURE

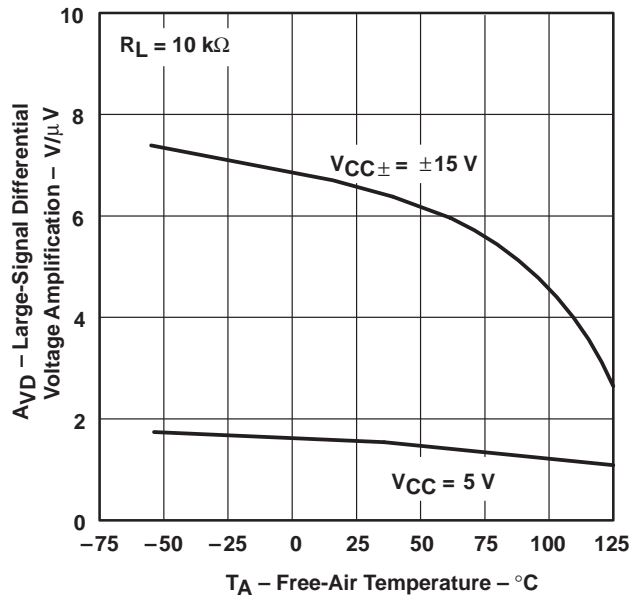


Figure 27

TLE2022
LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION†
vs
FREE-AIR TEMPERATURE

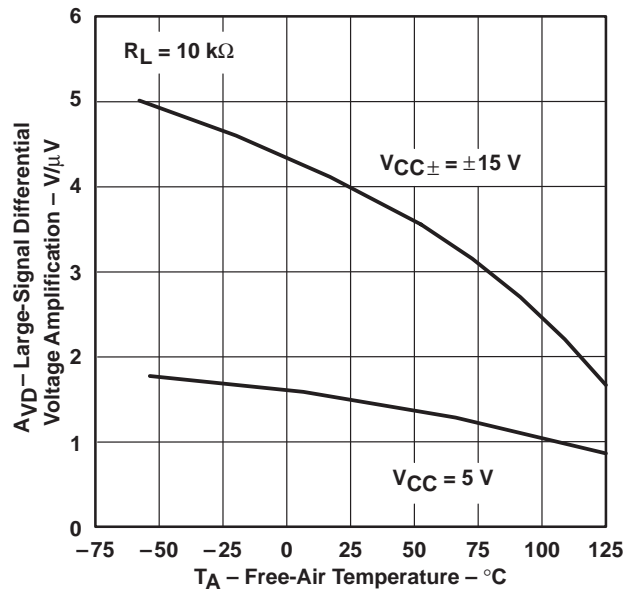


Figure 28

TLE2024
LARGE-SCALE DIFFERENTIAL VOLTAGE
AMPLIFICATION†
vs
FREE-AIR TEMPERATURE

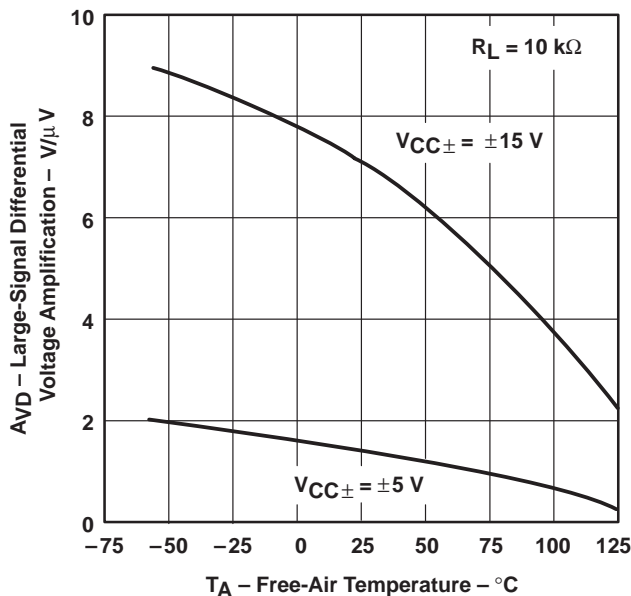


Figure 29

TLE2021
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE

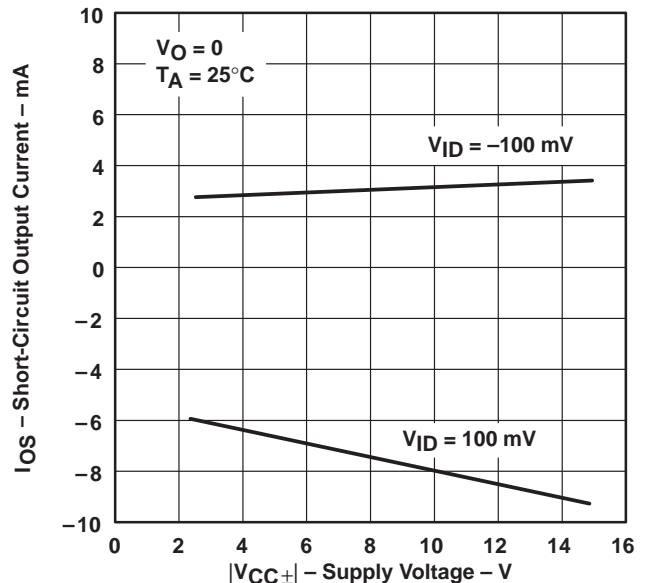


Figure 30

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

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TYPICAL CHARACTERISTICS

TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE

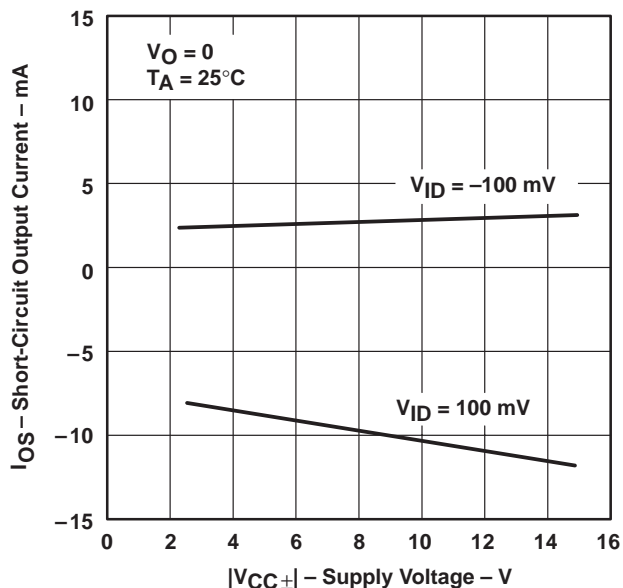


Figure 31

TLE2021
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE

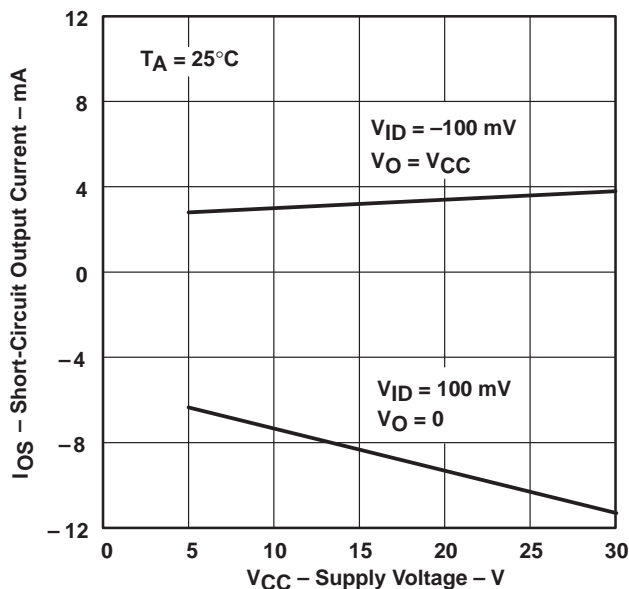


Figure 32

TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE

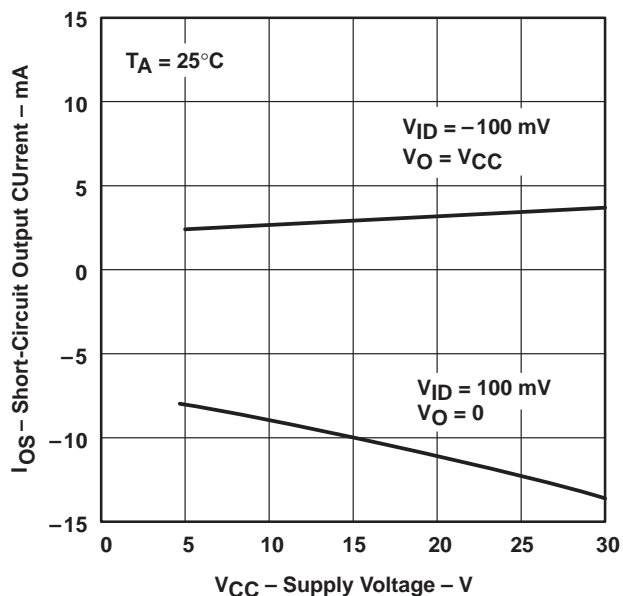


Figure 33

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

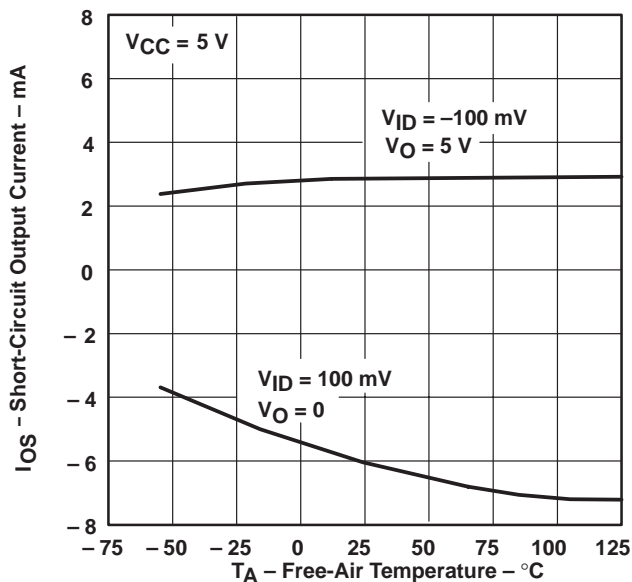


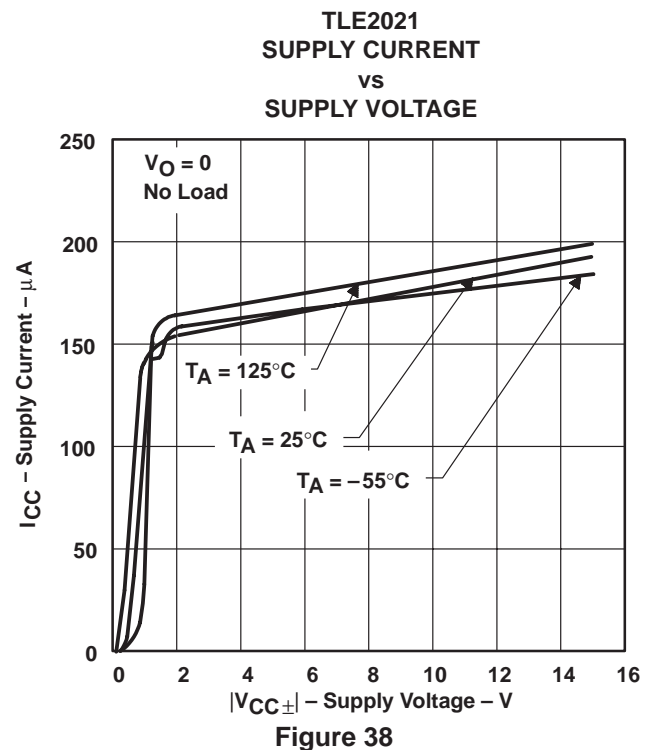
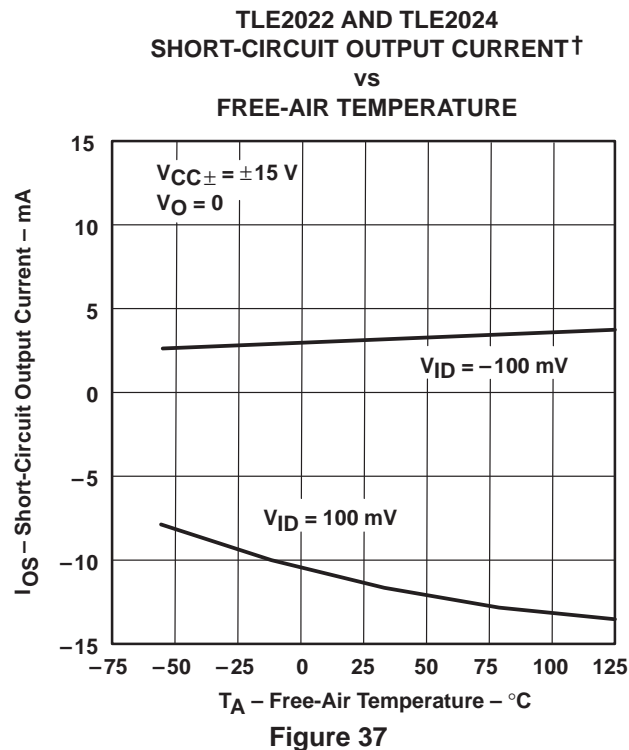
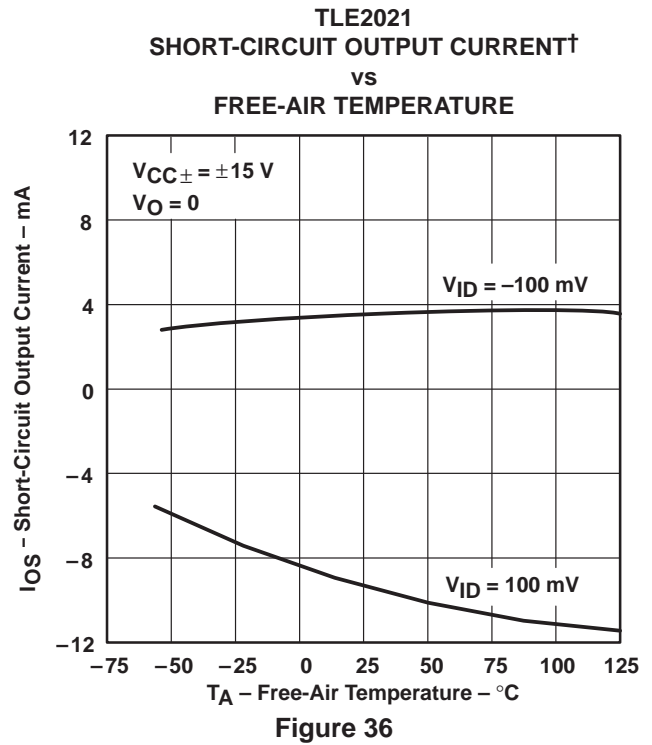
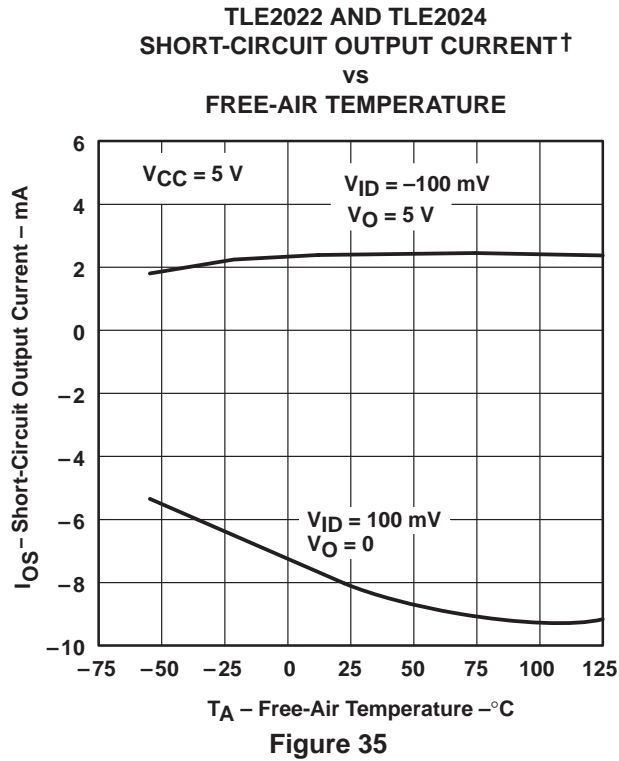
Figure 34

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

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

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TYPICAL CHARACTERISTICS



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

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

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TYPICAL CHARACTERISTICS

TLE2022
 SUPPLY CURRENT
 vs
 SUPPLY VOLTAGE

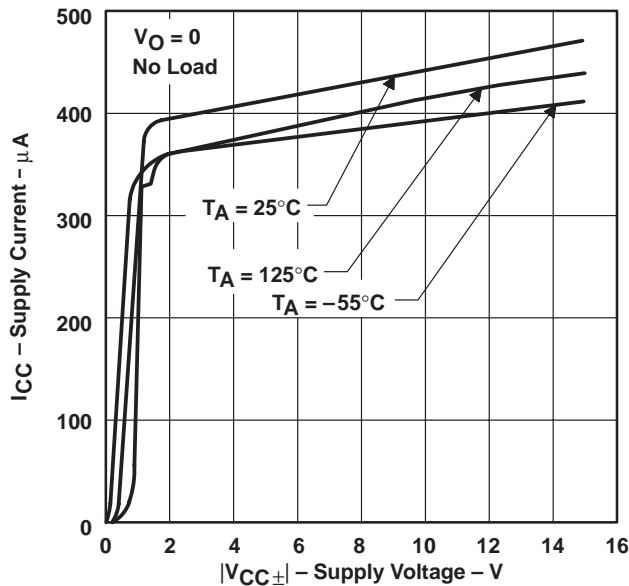


Figure 39

TLE2024
 SUPPLY CURRENT
 vs
 SUPPLY VOLTAGE

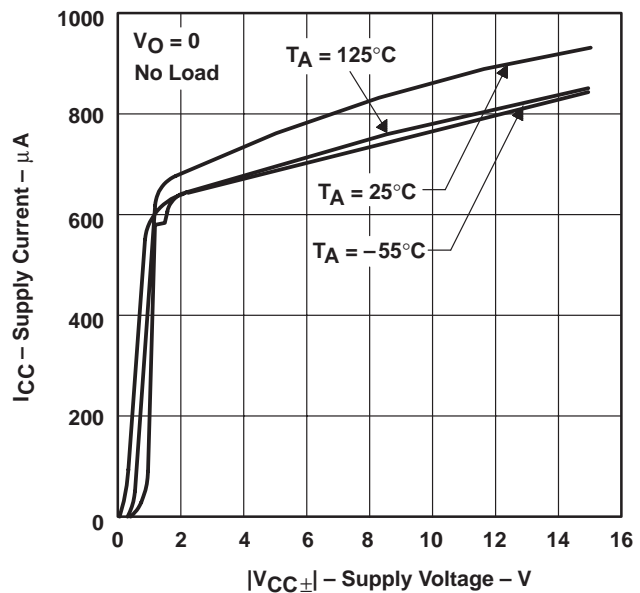


Figure 40

TLE2021
 SUPPLY CURRENT†
 vs
 FREE-AIR TEMPERATURE

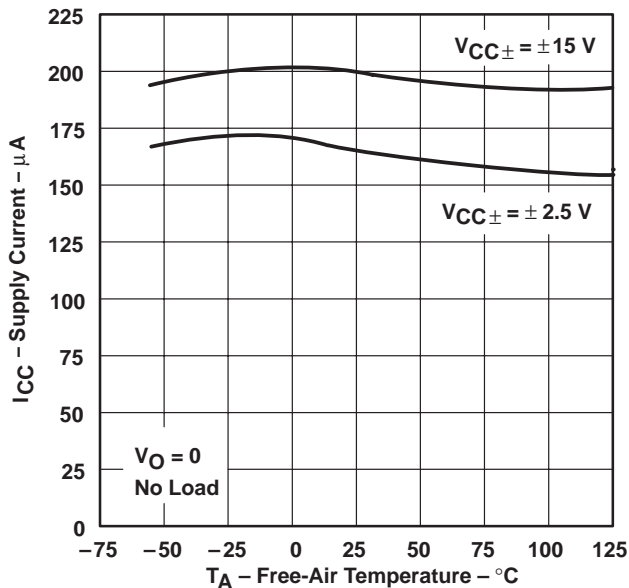


Figure 41

TLE2022
 SUPPLY CURRENT†
 vs
 FREE-AIR TEMPERATURE

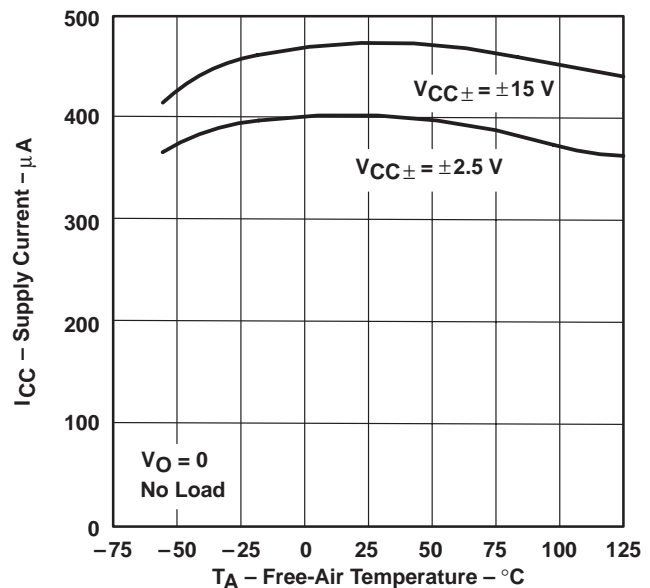


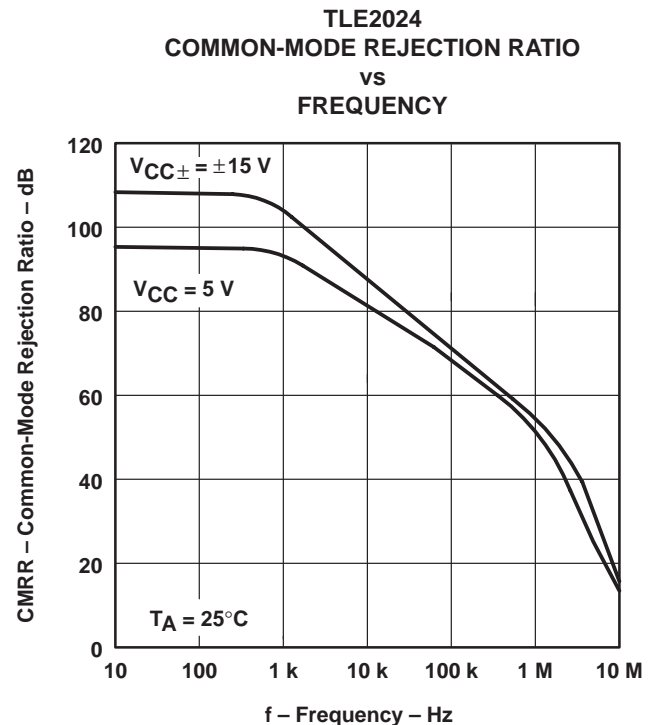
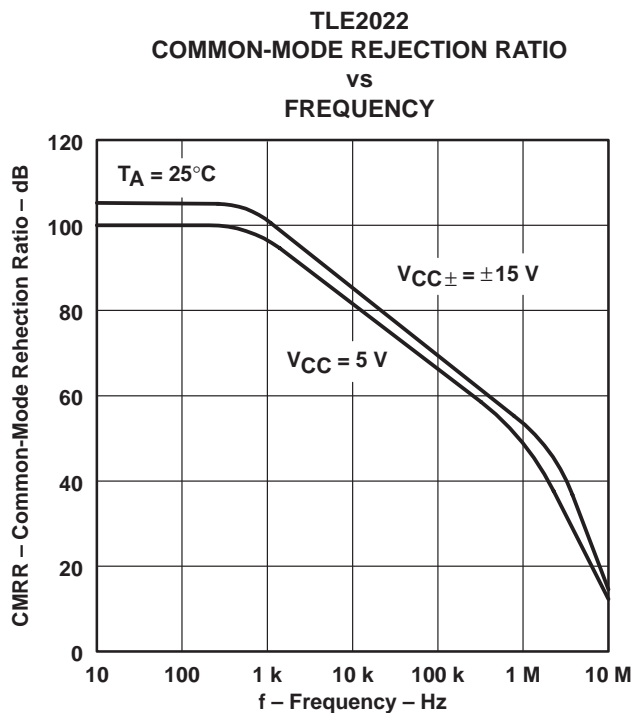
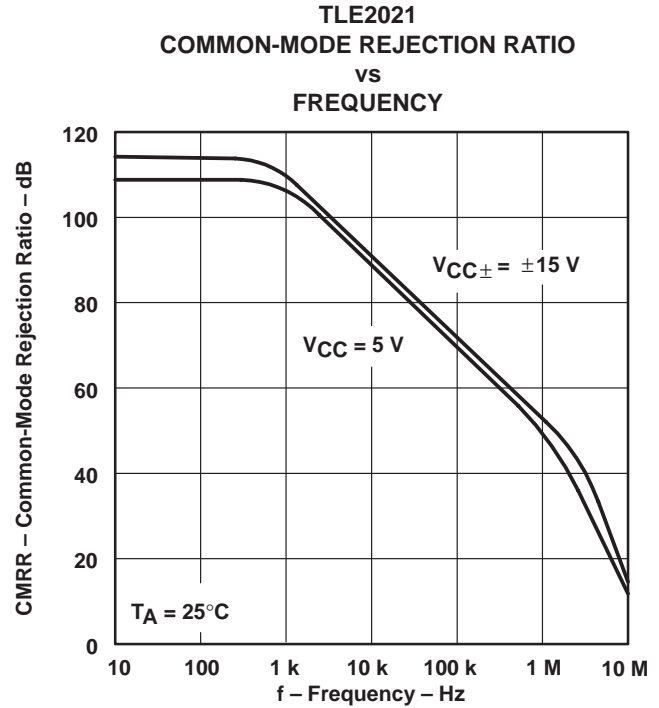
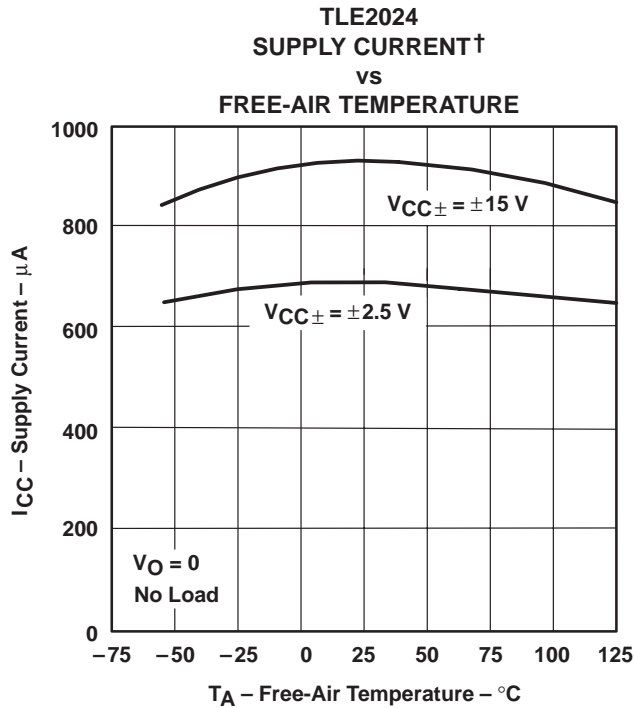
Figure 42

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

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

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TYPICAL CHARACTERISTICS



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

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

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TYPICAL CHARACTERISTICS

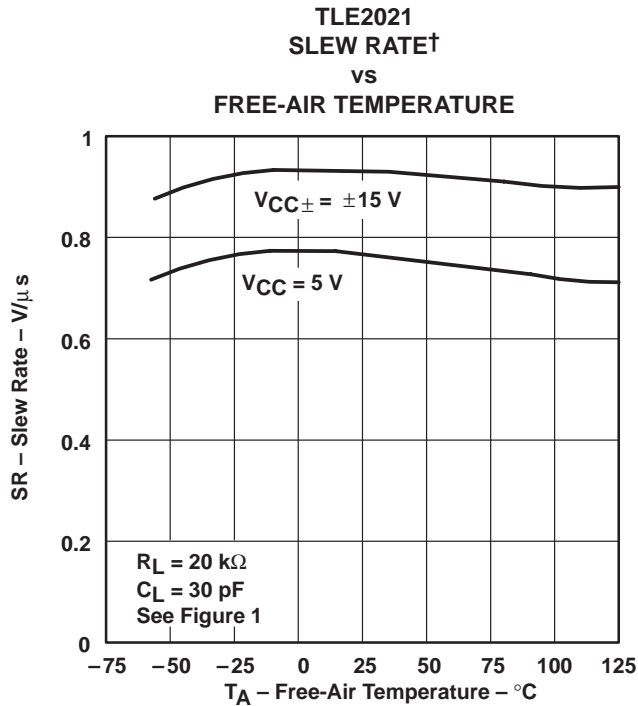


Figure 47

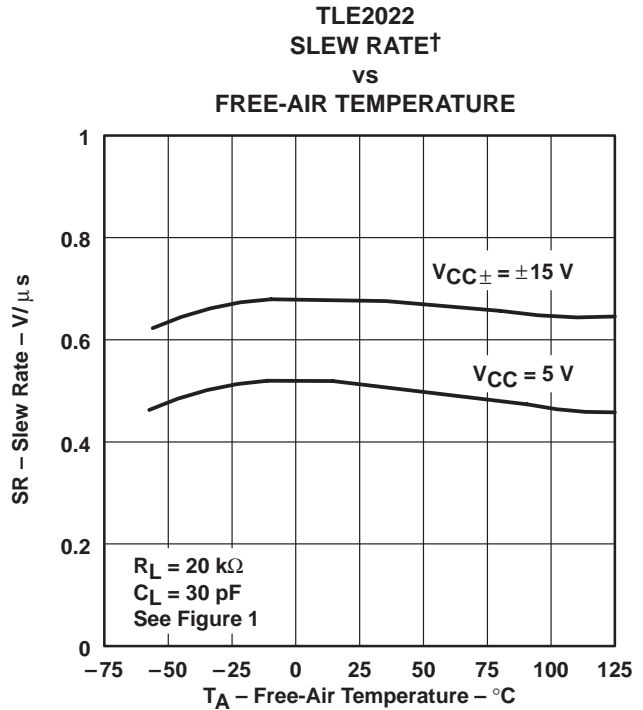


Figure 48

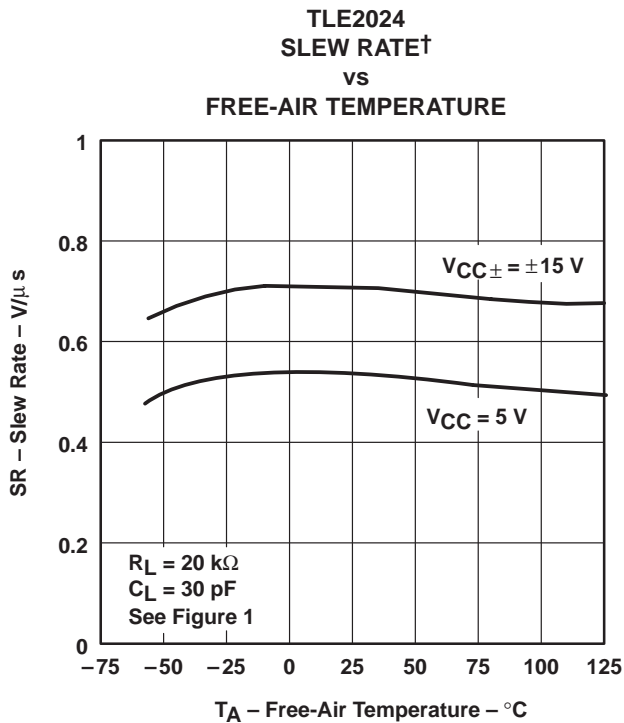


Figure 49

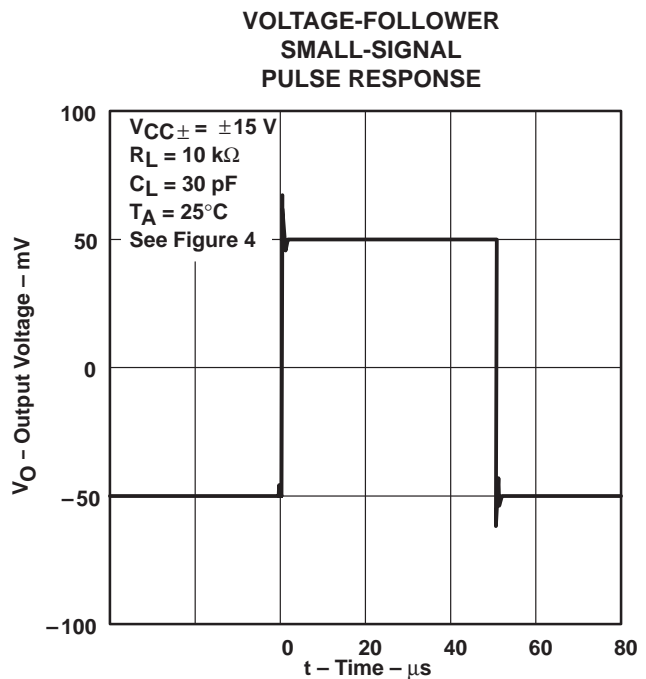


Figure 50

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

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

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TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

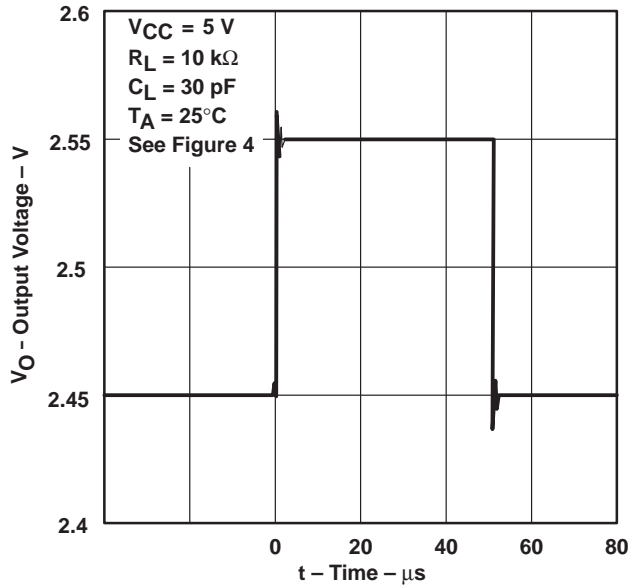


Figure 51

TLE2021
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

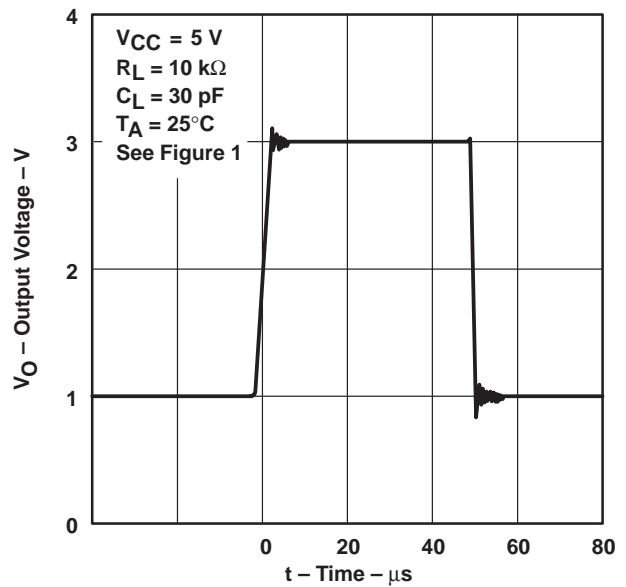


Figure 52

TLE2022
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

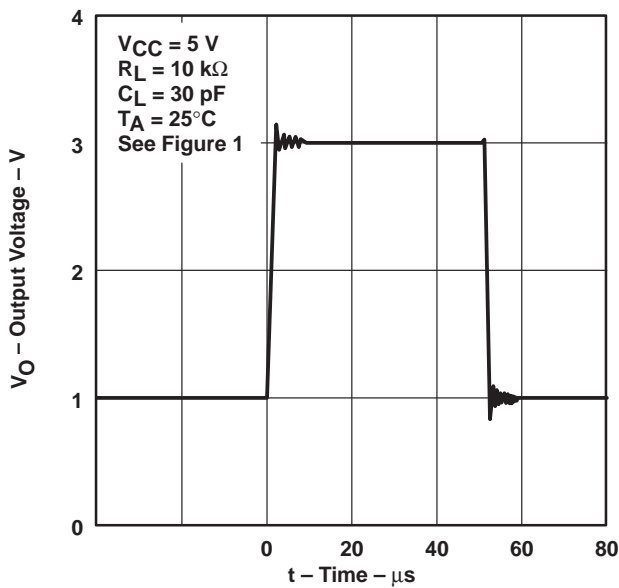


Figure 53

TLE2024
VOLTAGE-FOLLOWER LARGE-SCALE
PULSE RESPONSE

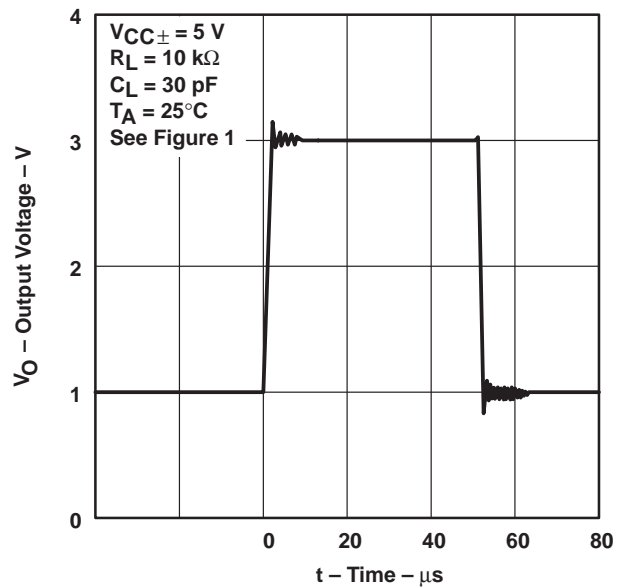


Figure 54

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

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TYPICAL CHARACTERISTICS

TLE2021
 VOLTAGE-FOLLOWER LARGE-SIGNAL
 PULSE RESPONSE

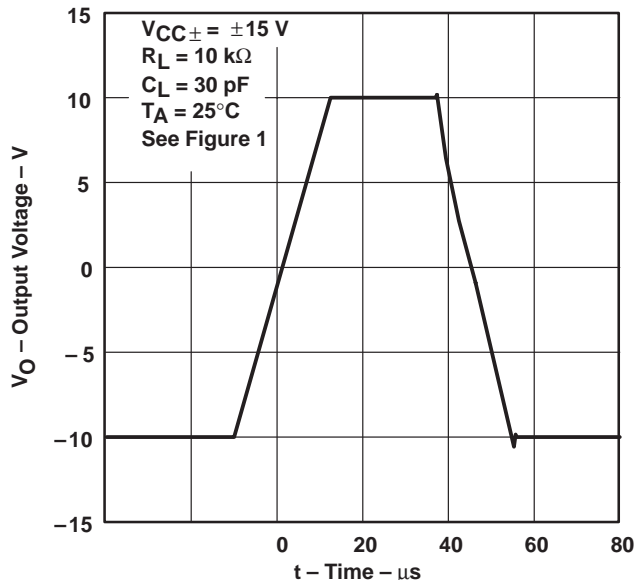


Figure 55

TLE2022
 VOLTAGE-FOLLOWER LARGE-SIGNAL
 PULSE RESPONSE

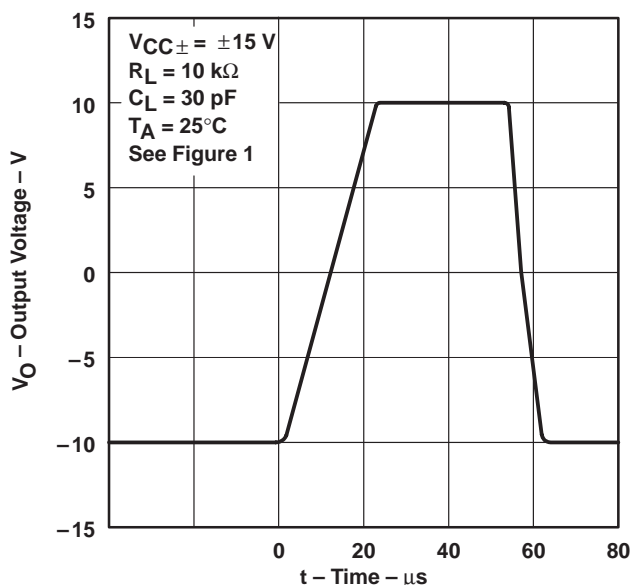


Figure 56

TLE2024
 VOLTAGE-FOLLOWER LARGE-SIGNAL
 PULSE RESPONSE

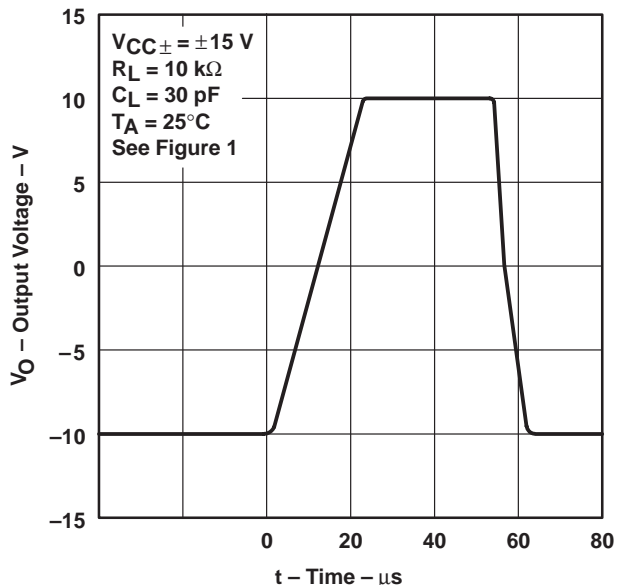


Figure 57

PEAK-TO-PEAK EQUIVALENT
 INPUT NOISE VOLTAGE
 0.1 TO 1 Hz

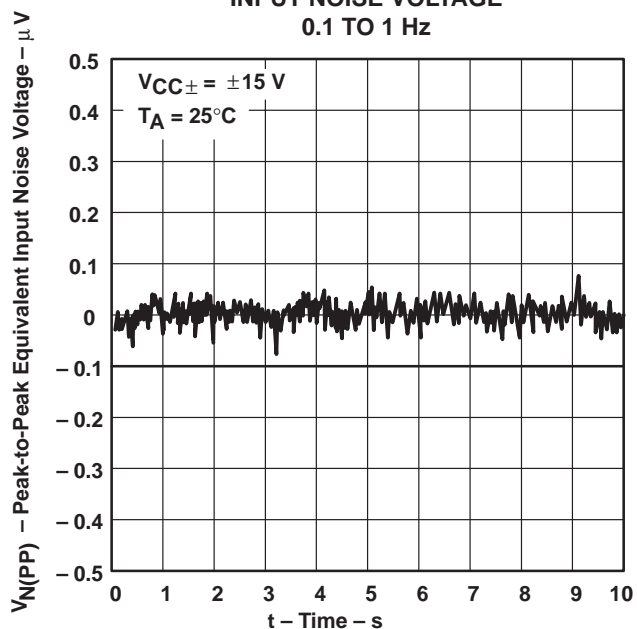


Figure 58

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

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TYPICAL CHARACTERISTICS

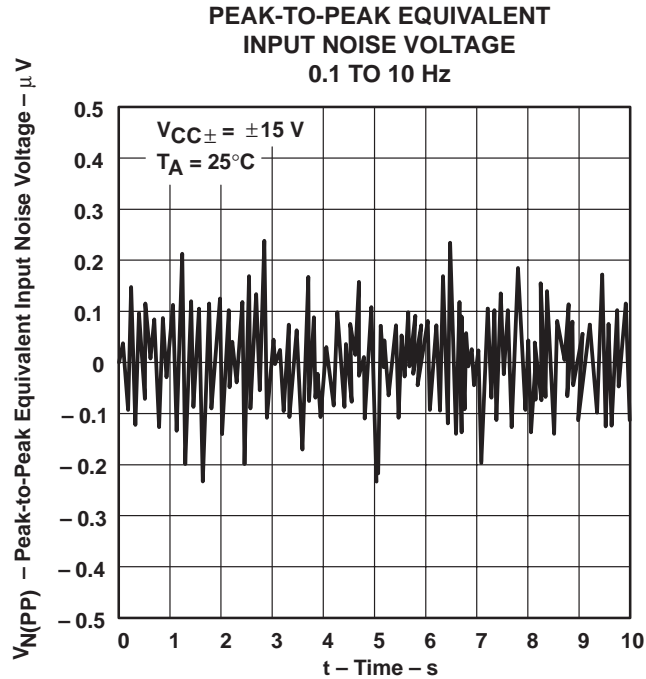


Figure 59

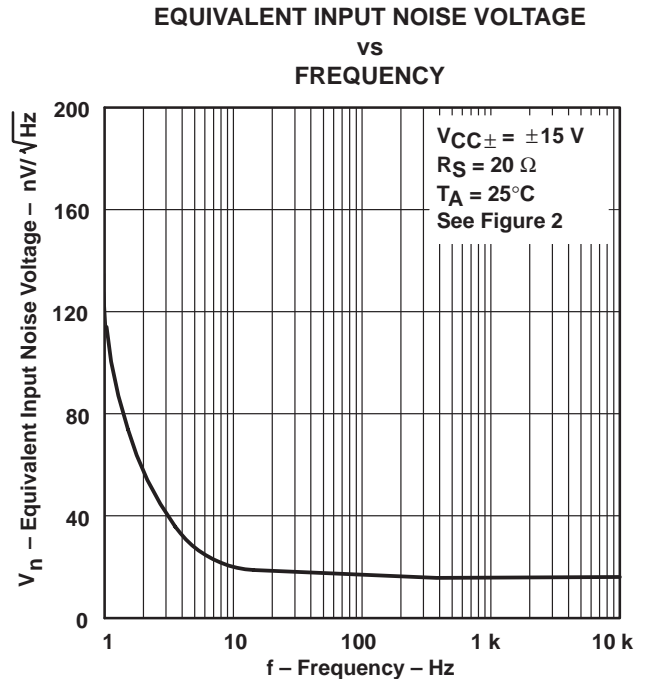


Figure 60

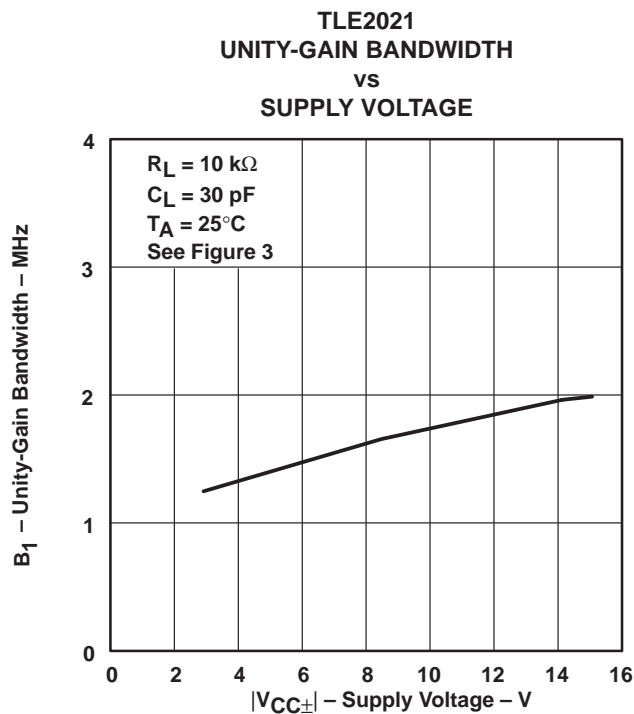


Figure 61

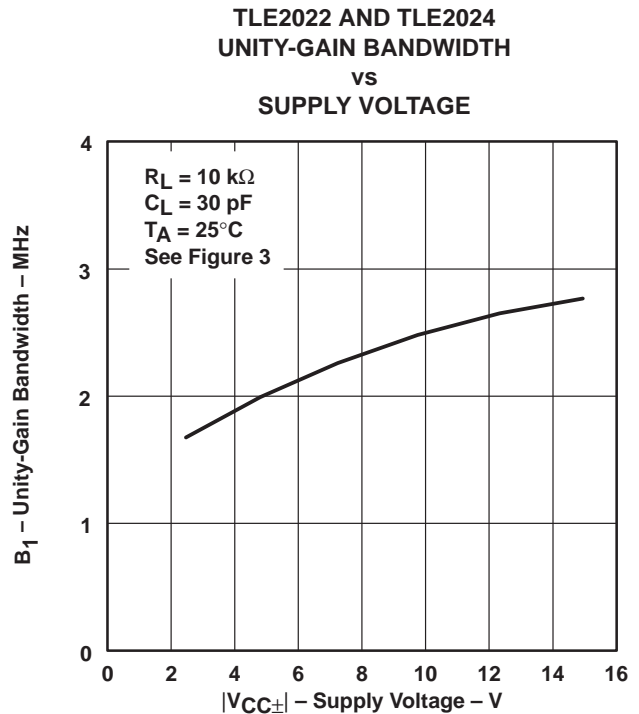


Figure 62

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

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TYPICAL CHARACTERISTICS

**TLE2021
UNITY-GAIN BANDWIDTH†
vs
FREE-AIR TEMPERATURE**

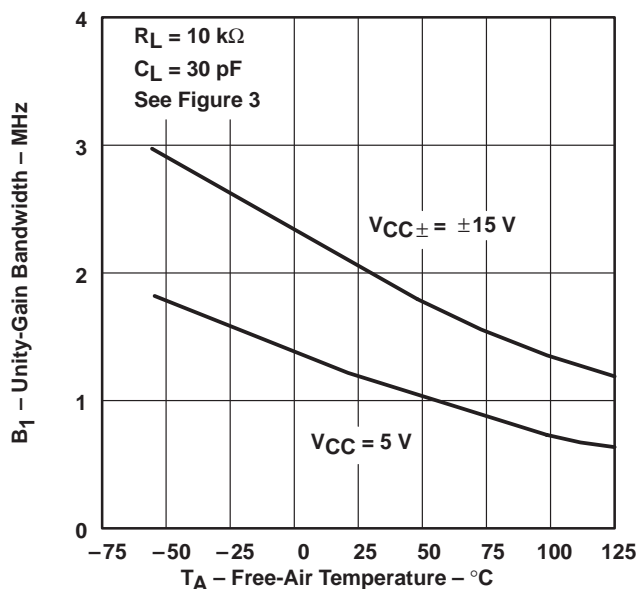


Figure 63

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

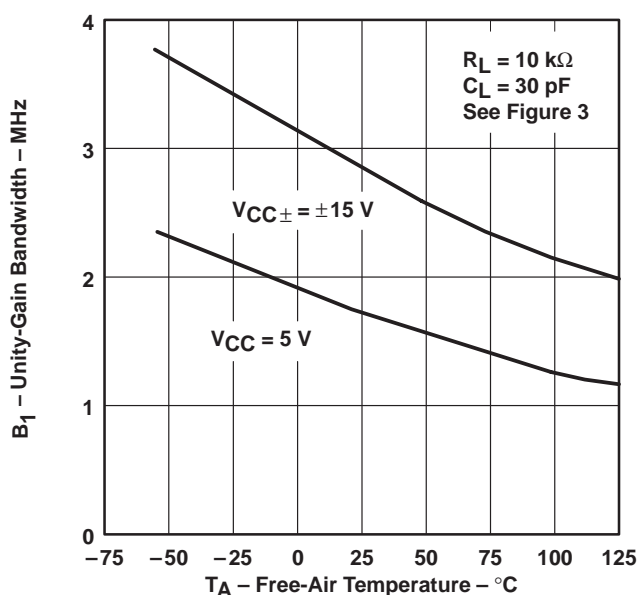


Figure 64

**TLE2021
PHASE MARGIN
vs
SUPPLY VOLTAGE**

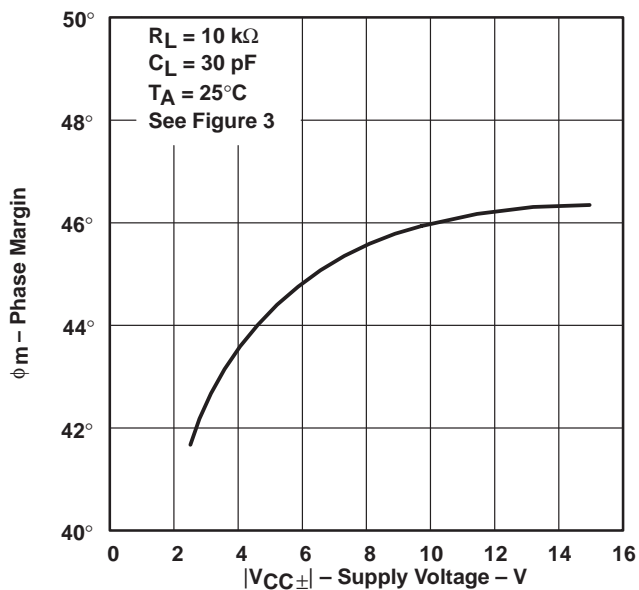


Figure 65

**TLE2022 AND TLE2024
PHASE MARGIN
vs
SUPPLY VOLTAGE**

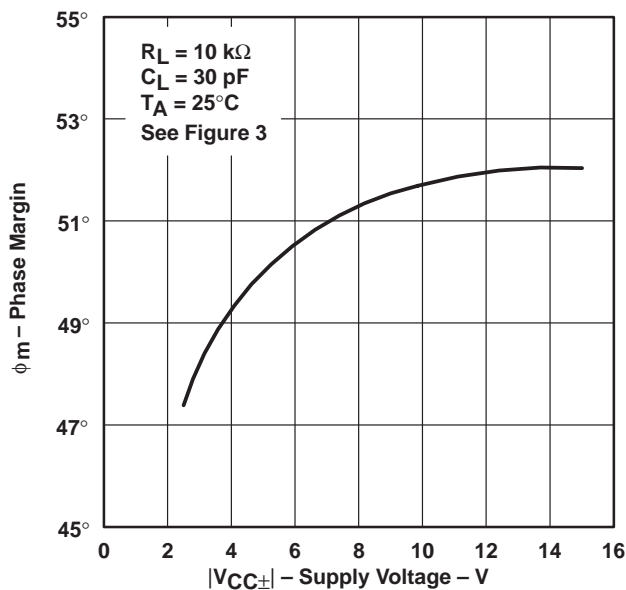


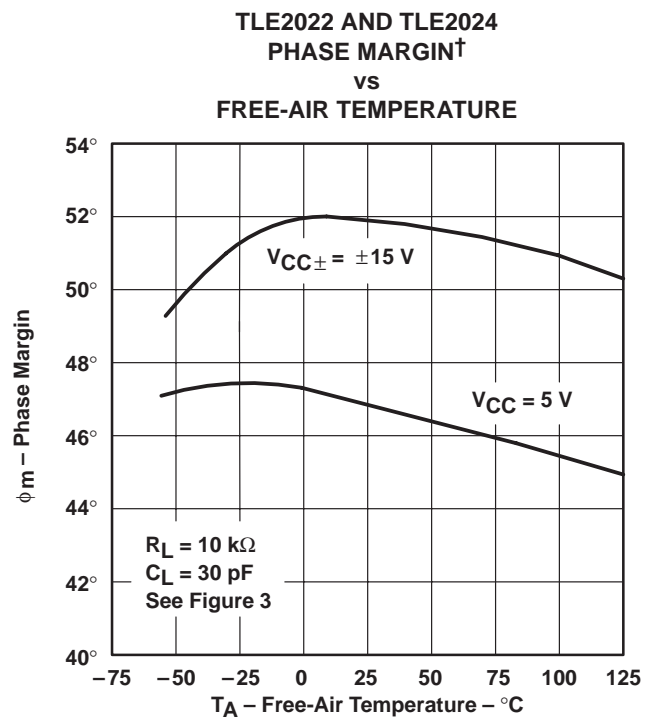
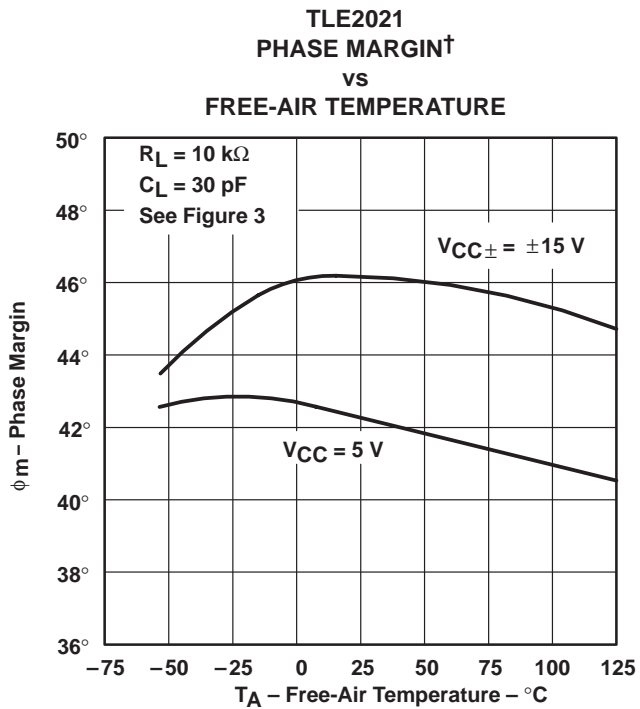
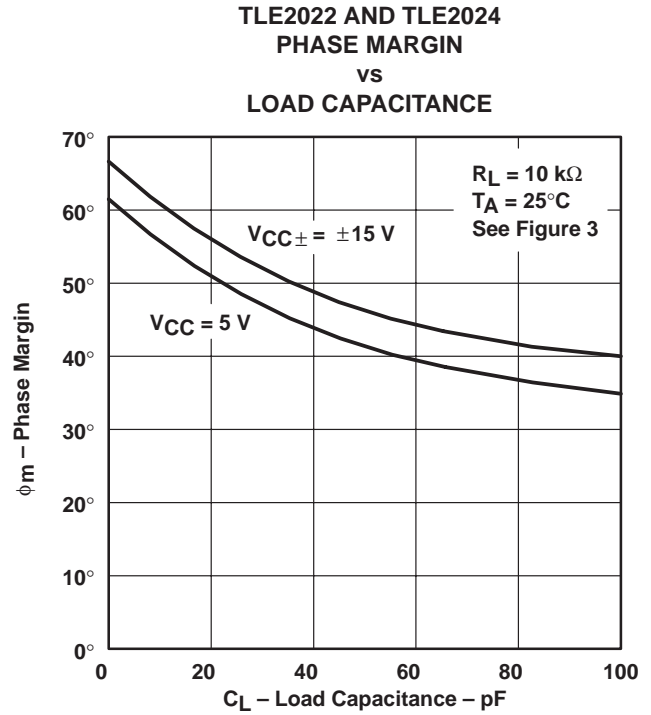
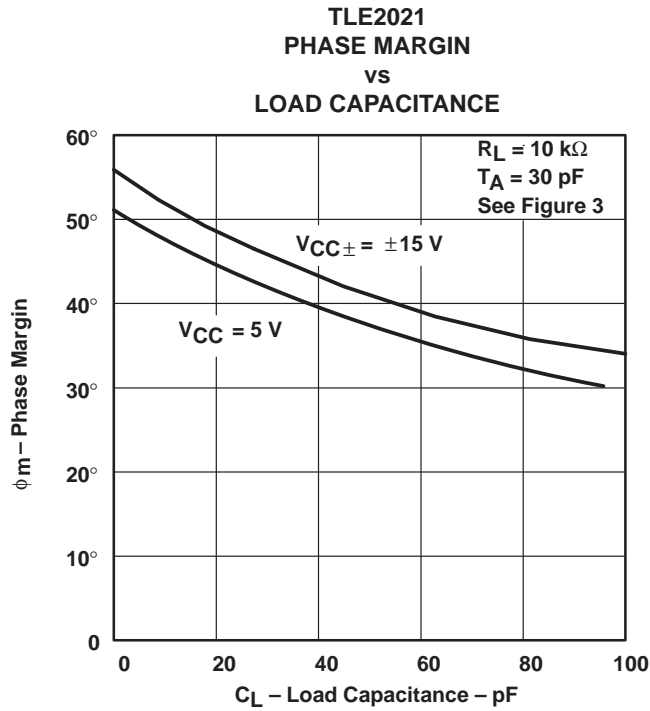
Figure 66

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

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

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TYPICAL CHARACTERISTICS



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

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

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APPLICATION INFORMATION

voltage-follower applications

The TLE202x circuitry includes input-protection diodes to limit the voltage across the input transistors; however, no provision is made in the circuit to limit the current if these diodes are forward biased. This condition can occur when the device is operated in the voltage-follower configuration and driven with a fast, large-signal pulse. It is recommended that a feedback resistor be used to limit the current to a maximum of 1 mA to prevent degradation of the device. This feedback resistor forms a pole with the input capacitance of the device. For feedback resistor values greater than 10 kΩ, 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).

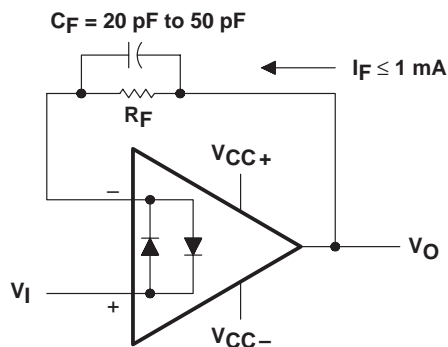


Figure 71. Voltage Follower

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.

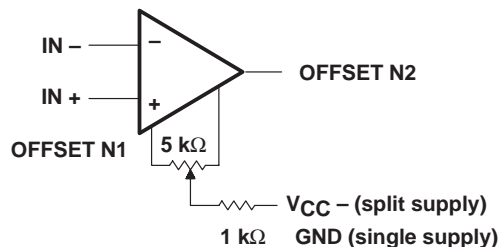


Figure 72. Input Offset Voltage Null Circuit

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

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APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*[™], the model generation software used with Microsim *PSpice*[™]. The Boyle macromodel (see Note 5) and subcircuit in73, Figure 74, and Figure 75 were generated using the TLE202x typical electrical and operating characteristics at 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- | | |
|---|---|
| <ul style="list-style-type: none"> ● Maximum positive output voltage swing ● Maximum negative output voltage swing ● Slew rate ● Quiescent power dissipation ● Input bias current ● Open-loop voltage amplification | <ul style="list-style-type: none"> ● 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).

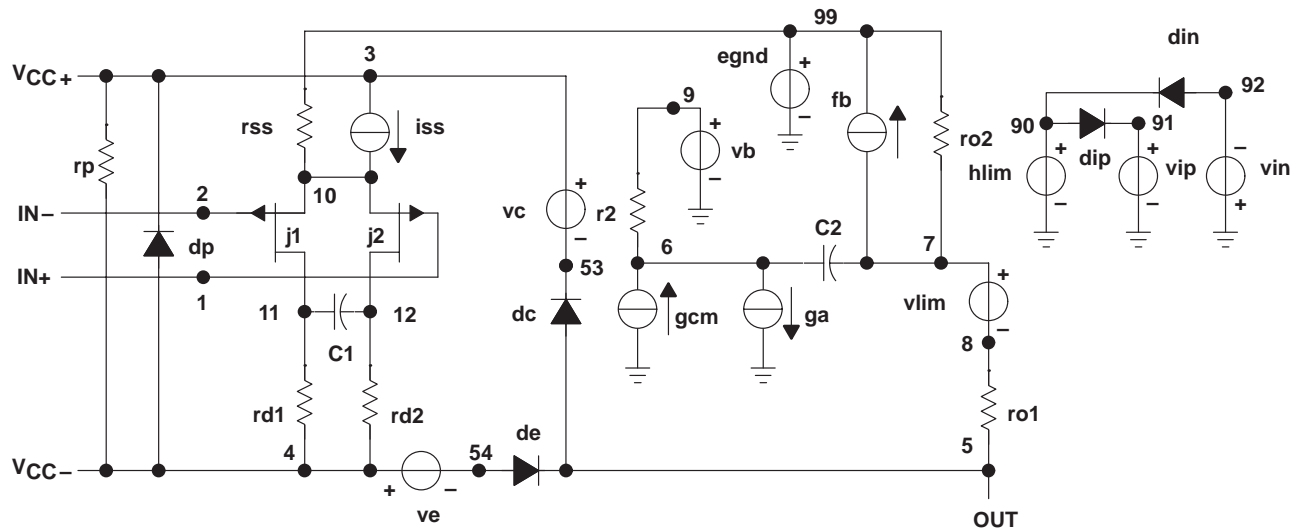


Figure 73. Boyle Subcircuit

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

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```
.SUBCKT TLE2021 1 2 3 4 5
*
c1 11 12 6.244E-12
c2 6 7 13.4E-12
c3 87 0 10.64E-9
cpsr 85 86 15.9E-9
dcm+ 81 82 dx
dcm- 83 81 dx
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
ecmr 84 99 (2 99) 1
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
epsr 85 0 poly(1) (3,4) -60E-6 2.0E-6
ense 89 2 poly(1) (88,0) 120E-6 1
fb 7 99 poly(6) vb vc ve vlp vln vpsr 0 547.3E6
+ -50E7 50E7 50E7 -50E7 547E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 335.2E-12
gpsr 85 86 (85,86) 100E-6
grc1 4 11 (4,11) 1.885E-4
grc2 4 12 (4,12) 1.885E-4
gre1 13 10 (13,10) 6.82E-4
gre2 14 10 (14,10) 6.82E-4
hlim 90 0 vlim 1k

hcmr 80 1 poly(2) vcm+ vcm- 0 1E2 1E2
irp 3 4 185E-6
iee 3 10 dc 15.67E-6
iio 2 0 2E-9
i1 88 0 1E-21
q1 11 89 13 qx
q2 12 80 14 qx
R2 6 9 100.0E3
rcm 84 81 1K
ree 10 99 14.76E6
rn1 87 0 2.55E8
rn2 87 88 11.67E3
ro1 8 5 62
ro2 7 99 63
vcm+ 82 99 13.3
vcm- 83 99 -14.6
vb 9 0 dc 0
vc 3 53 dc 1.300
ve 54 4 dc 1.500
vlim 7 8 dc 0
vlp 91 0 dc 3.600
vln 0 92 dc 3.600
vpsr 0 86 dc 0
.model dx d(is=800.0E-18)
.model qx pnp(is=800.0E-18 bf=270)
.ends
```

Figure 74. Boyle Macromodel for the TLE2021

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

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

Figure 75. Boyle Macromodel for the TLE2022

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

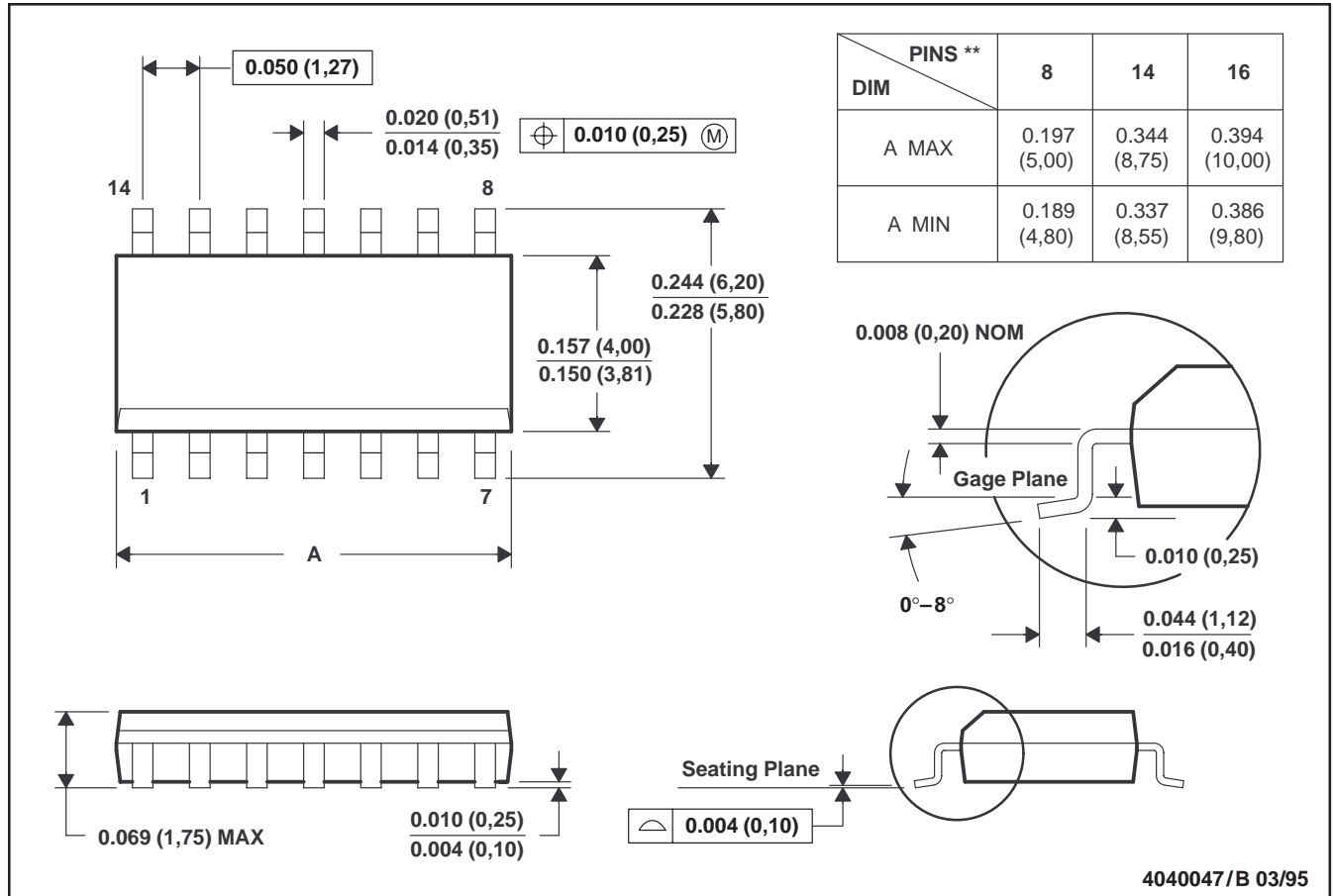
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MECHANICAL INFORMATION

D (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



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

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

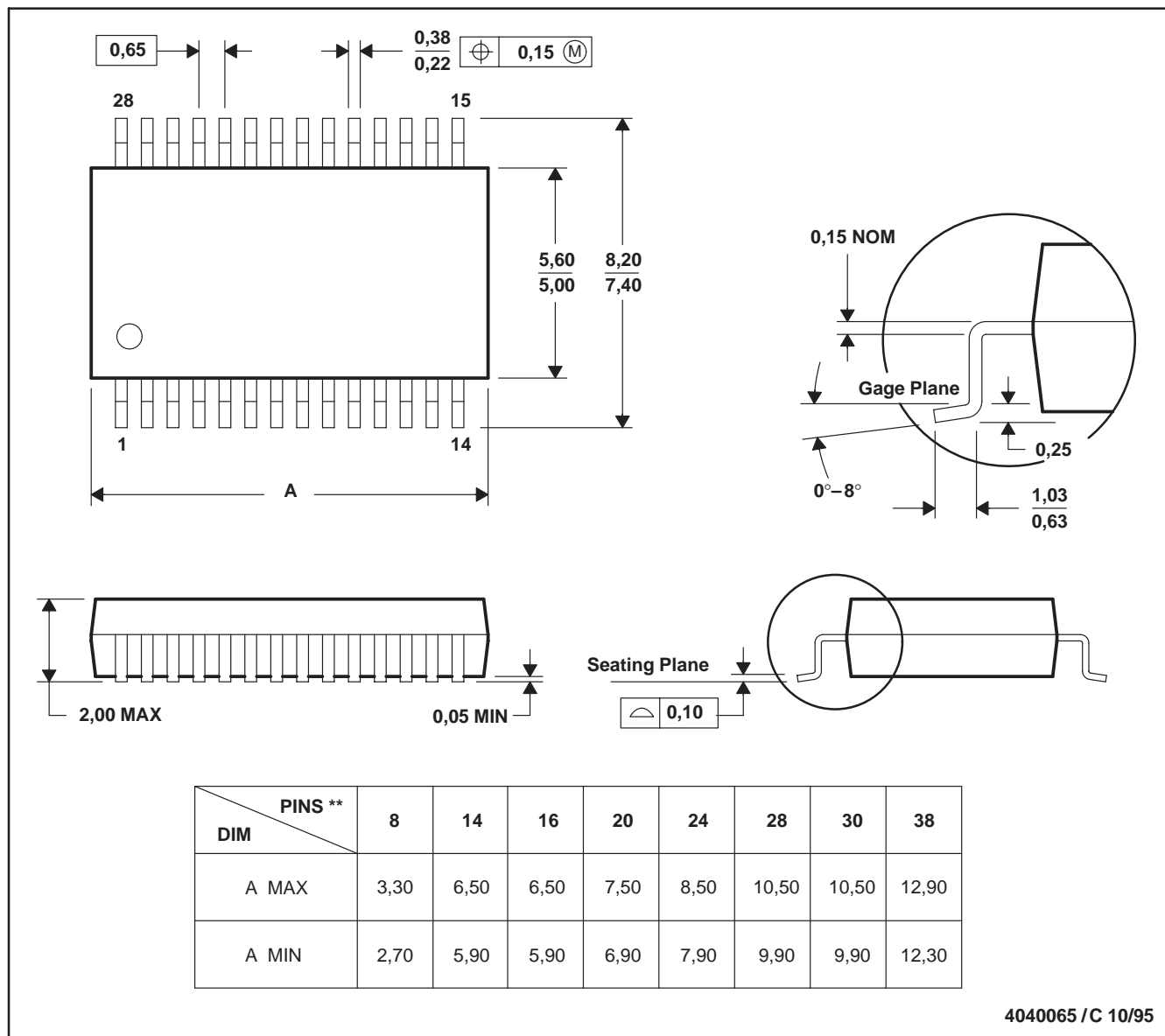
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MECHANICAL INFORMATION

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

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

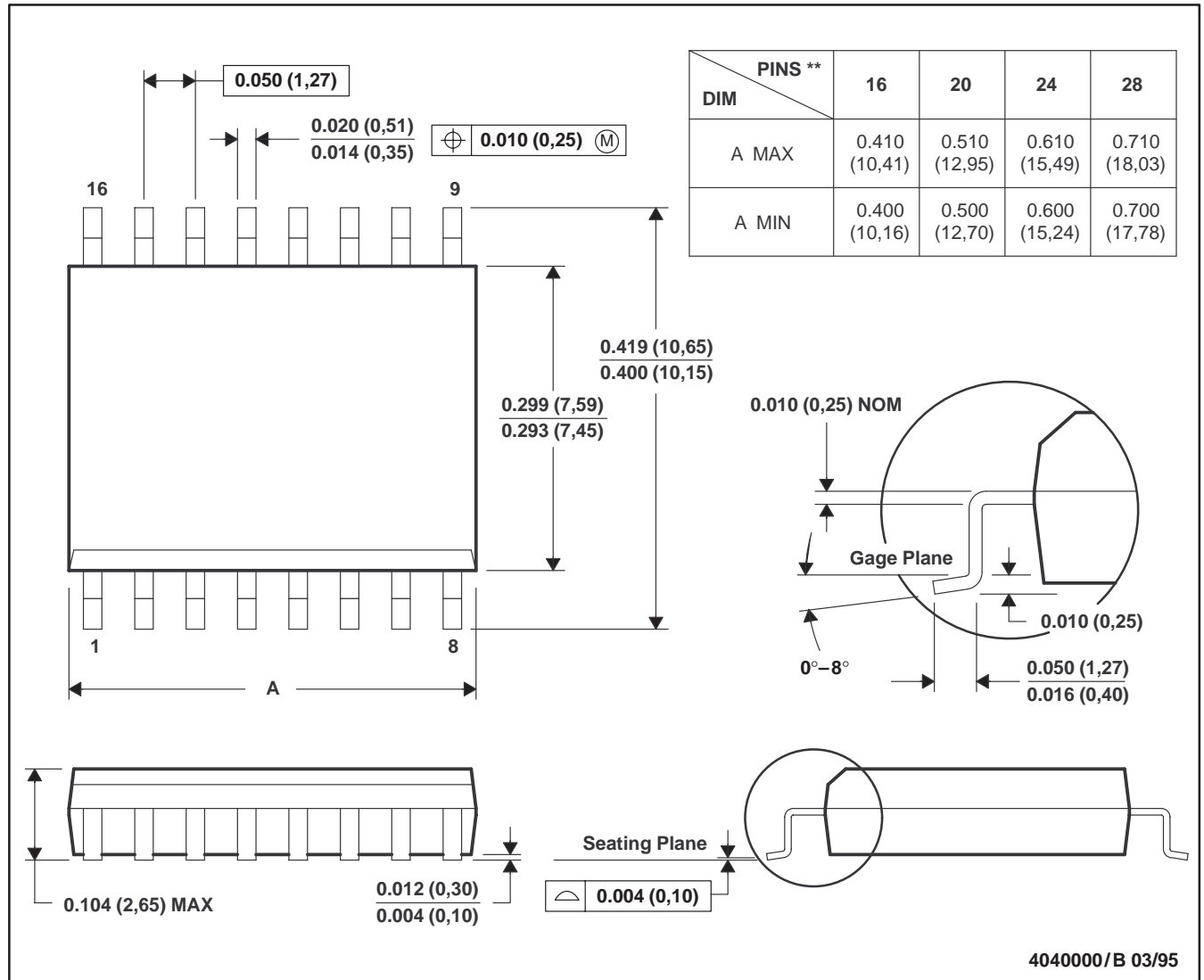
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MECHANICAL INFORMATION

DW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

16 PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 D. Falls within JEDEC MS-013

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

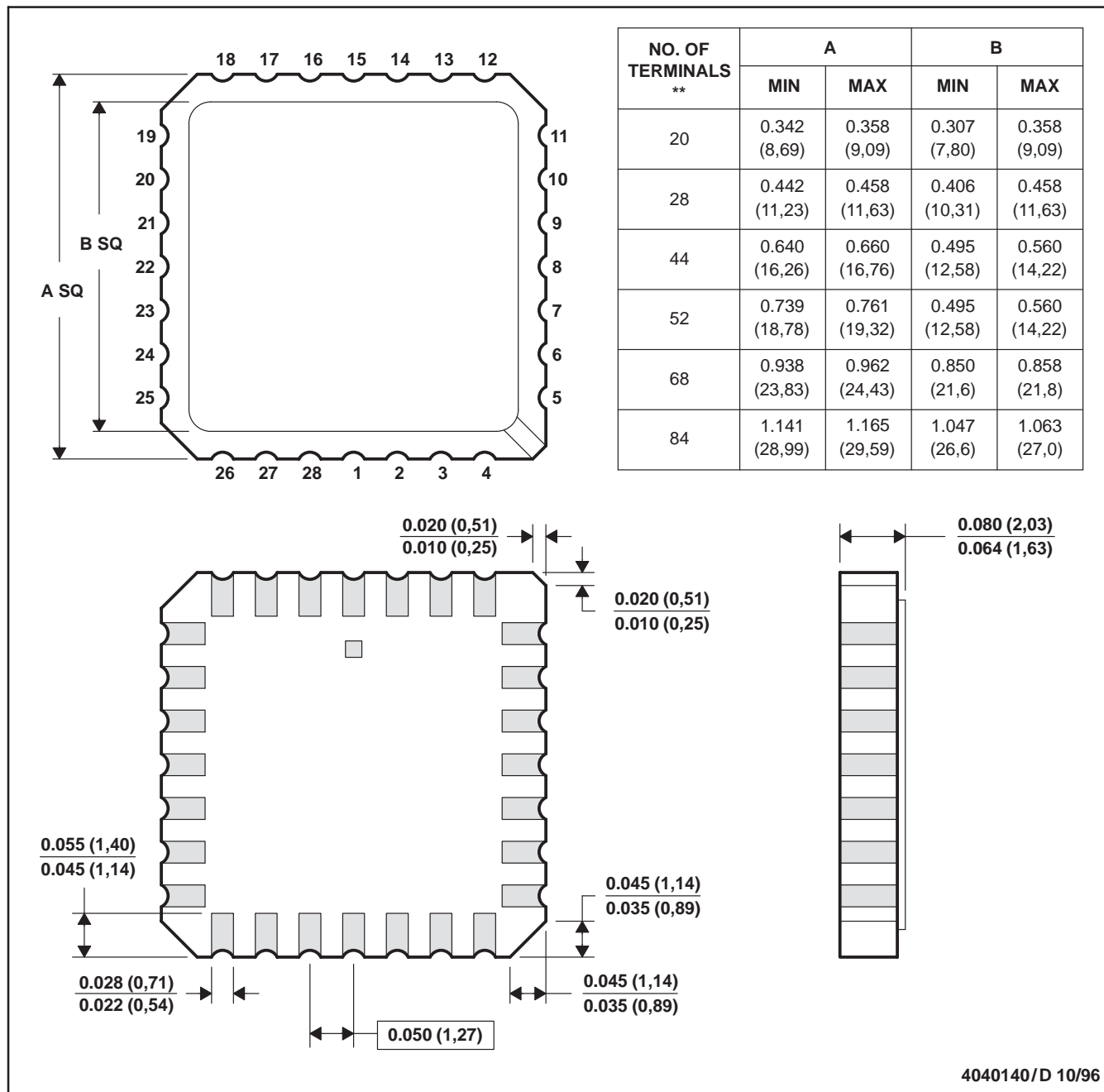
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MECHANICAL INFORMATION

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



4040140/D 10/96

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

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

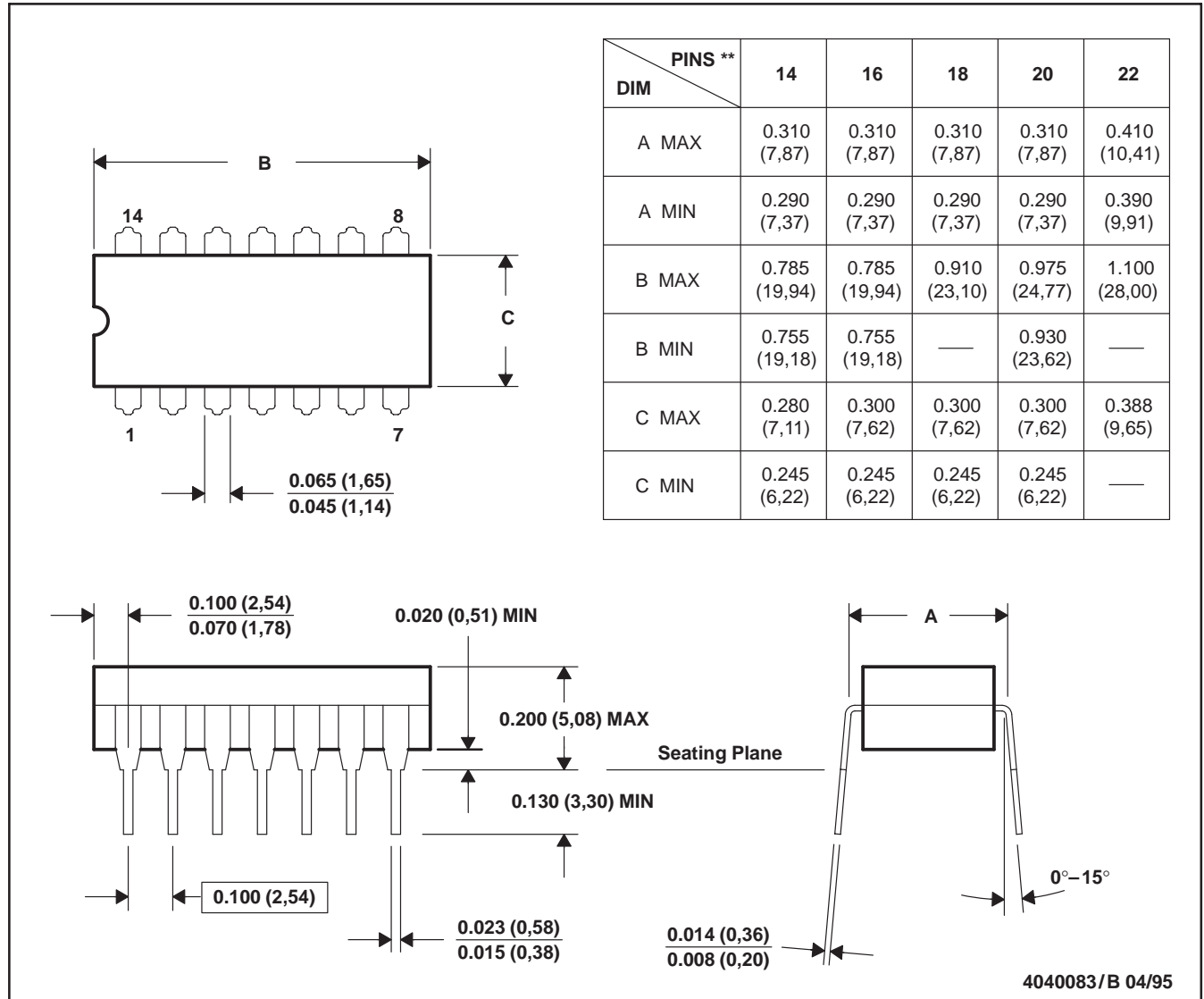
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MECHANICAL INFORMATION

J (R-GDIP-T)**

CERAMIC DUAL-IN-LINE PACKAGE

14 PIN SHOWN



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

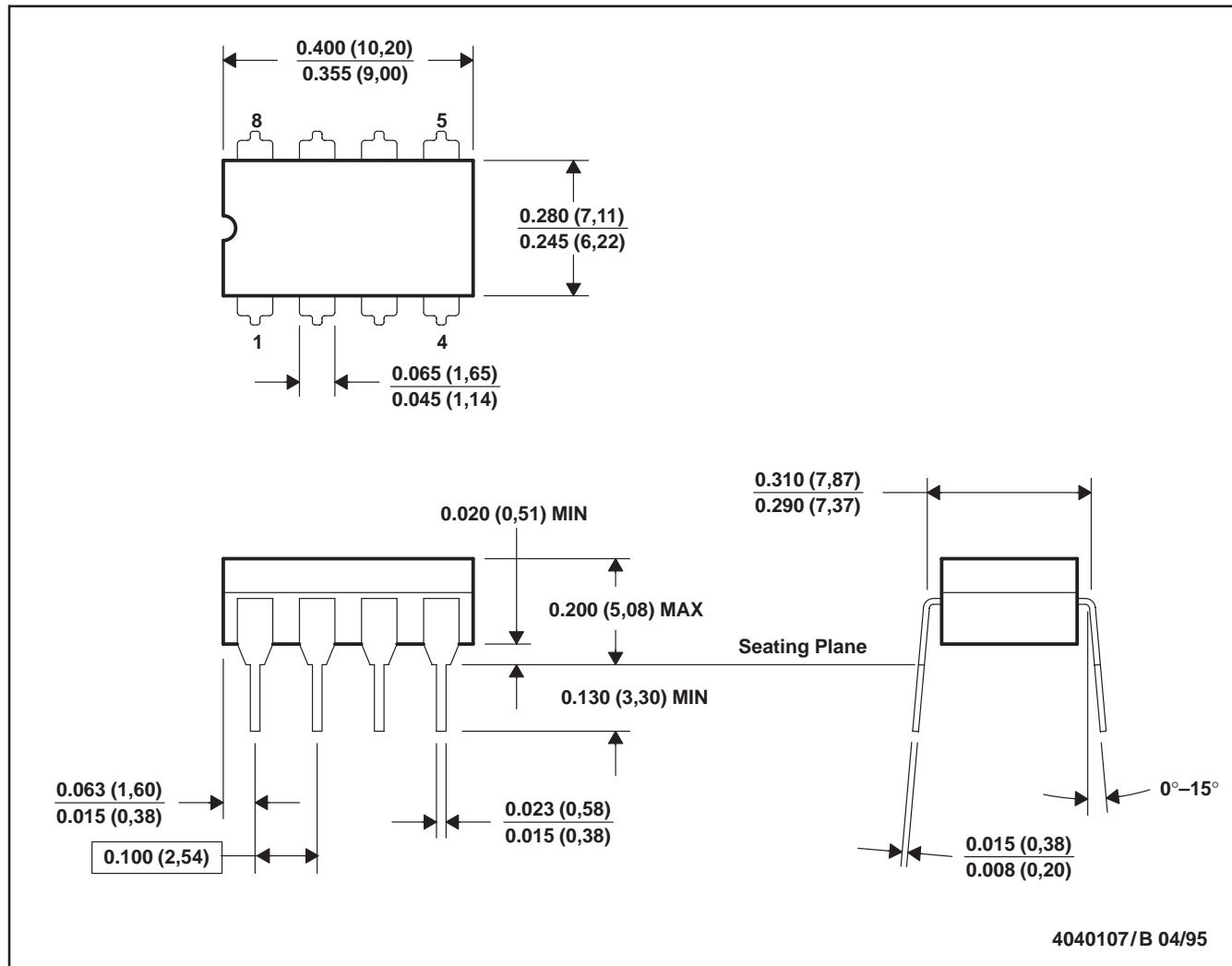
TLE202x, TLE202xA, TLE202xB, TLE202xY
 EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
 OPERATIONAL AMPLIFIERS

SLOS191 – FEBRUARY 1997

MECHANICAL INFORMATION

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE PACKAGE



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

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

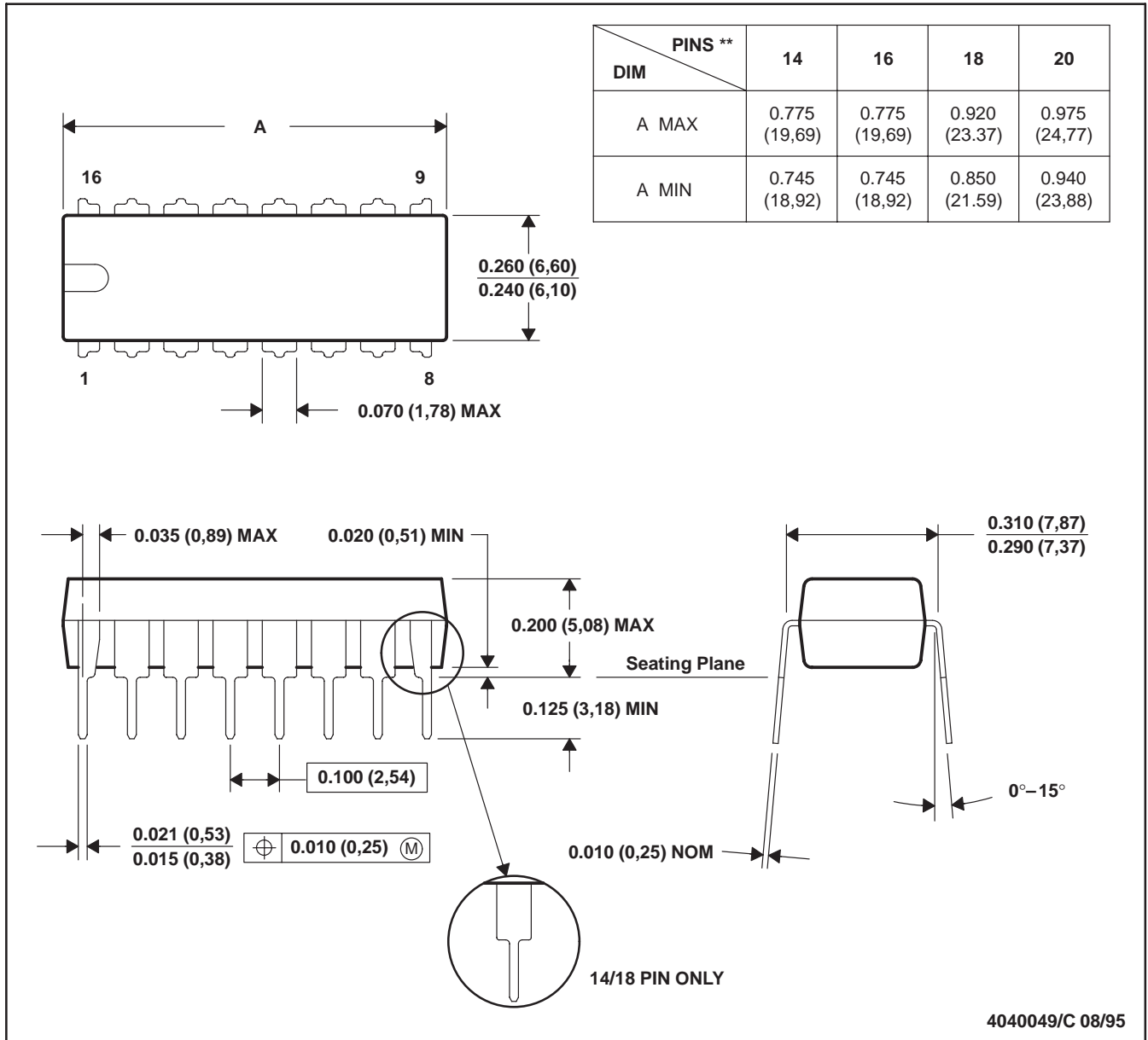
SLOS191 – FEBRUARY 1997

MECHANICAL INFORMATION

N (R-PDIP-T)**

PLASTIC DUAL-IN-LINE PACKAGE

16 PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001 (20 pin package is shorter than MS-001.)

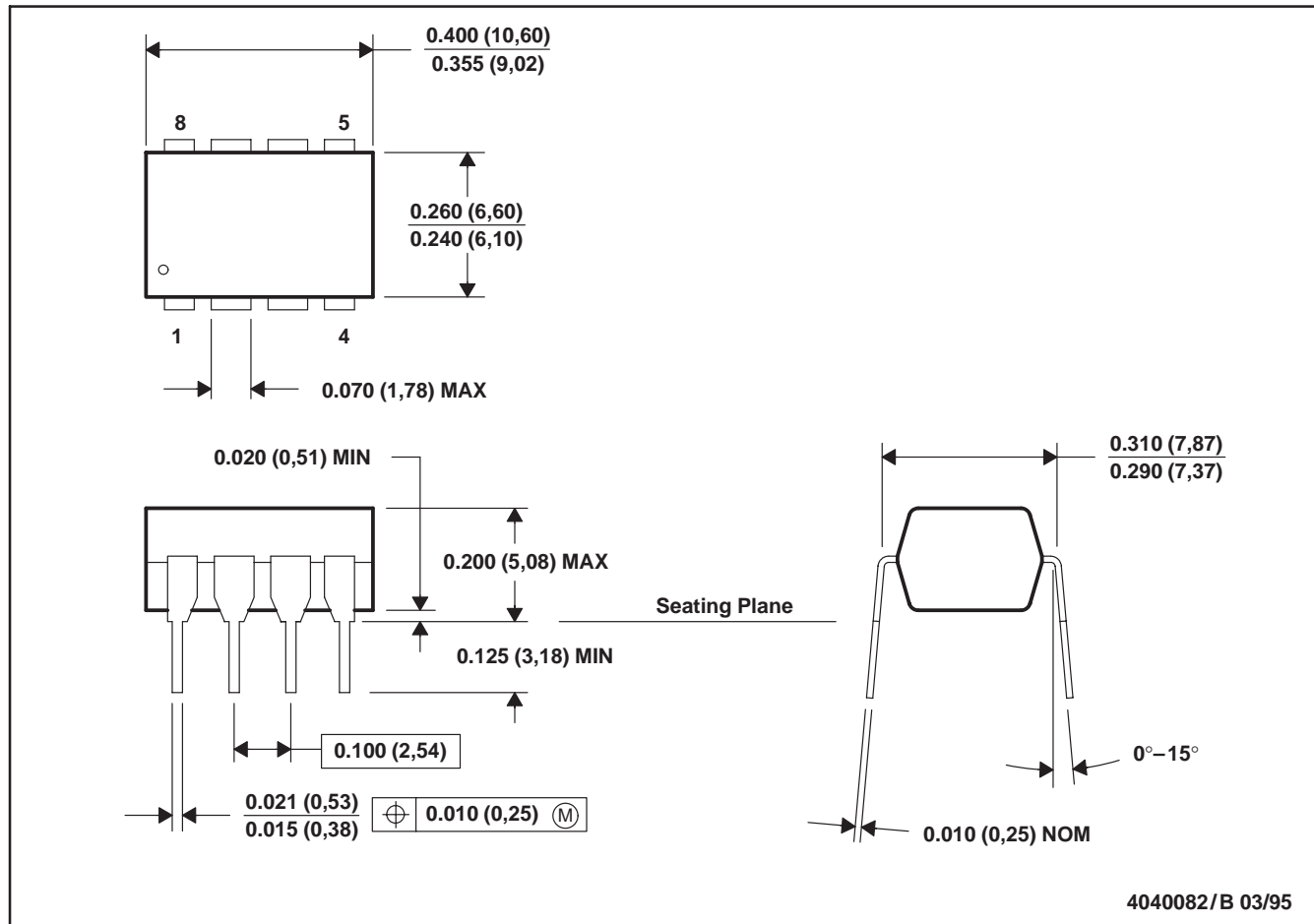
TLE202x, TLE202xA, TLE202xB, TLE202xY
 EXCALIBUR HIGH-SPEED LOW-POWER PRECISION
 OPERATIONAL AMPLIFIERS

SLOS191 – FEBRUARY 1997

MECHANICAL INFORMATION

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



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

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

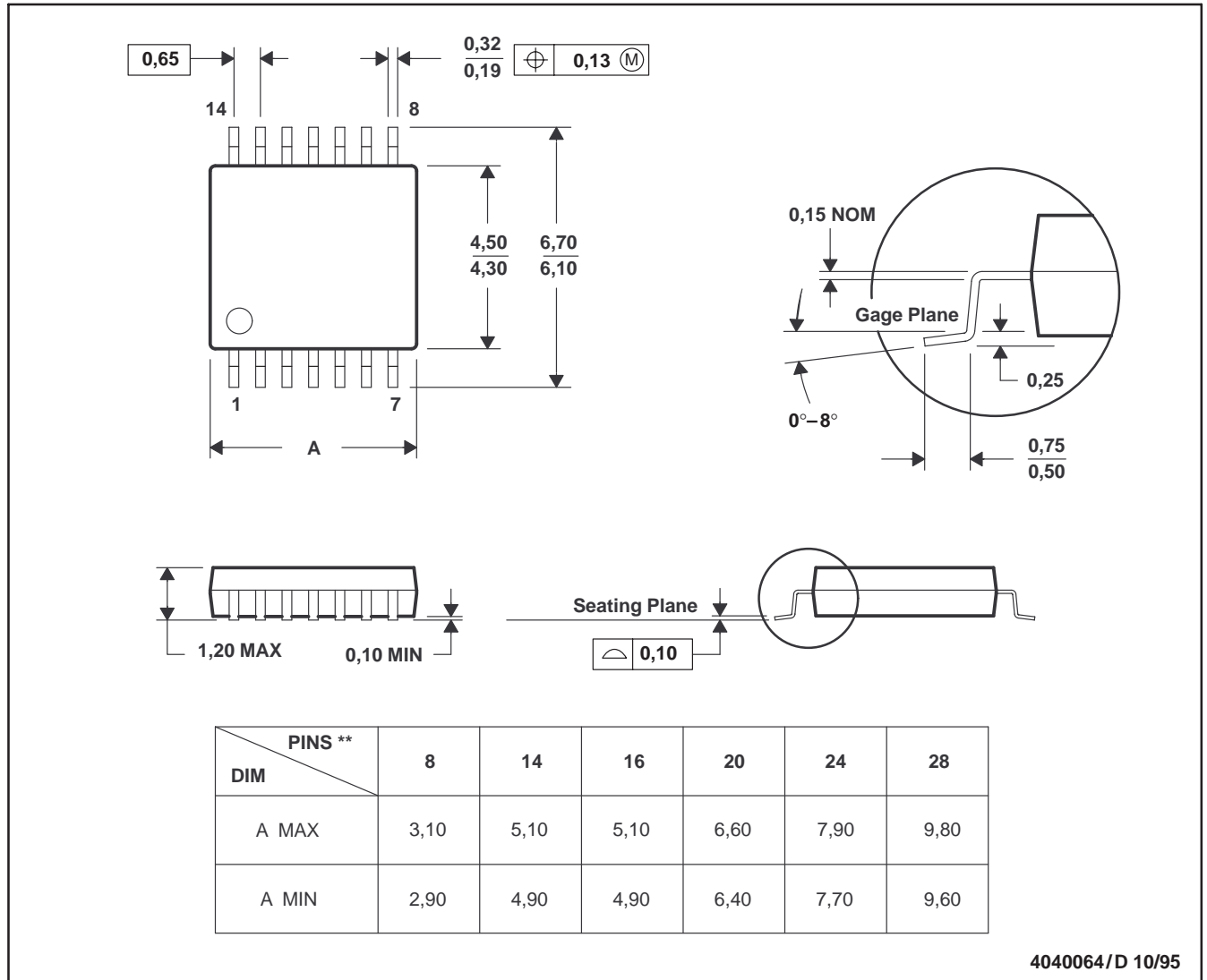
SLOS191 – FEBRUARY 1997

MECHANICAL INFORMATION

PW (R-PDSO-G)**

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



4040064/D 10/95

- 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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