

TLC1078, TLC1078Y, TLC1079, TLC1079Y LinCMOS™ μ POWER PRECISION OPERATIONAL AMPLIFIERS

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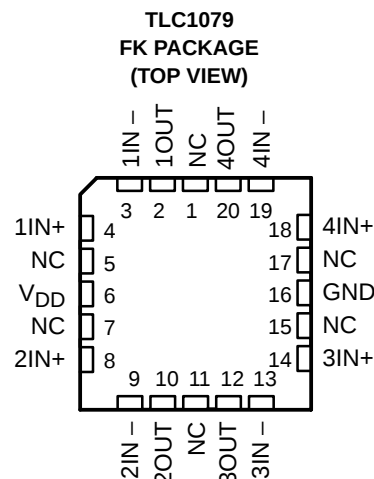
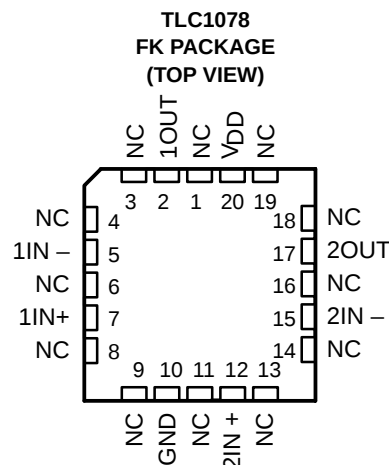
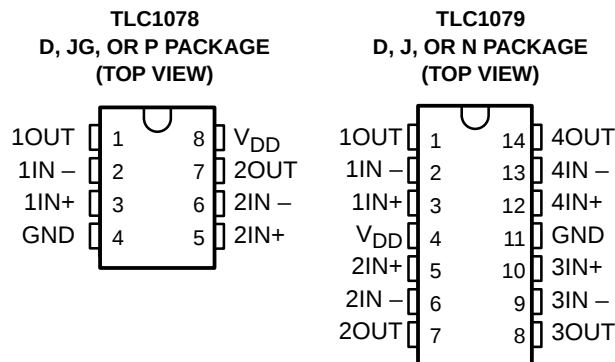
- Power Dissipation as Low as 10 μ W Typ Per Amplifier
- Operates on a Single Silver-Oxide Watch Battery, $V_{DD} = 1.4$ V Min
- $V_{IO} \dots 450 \mu\text{V}/850 \mu\text{V}$ Max in DIP and Small-Outline Package (TLC1078/79)
- Input Offset Voltage Drift $\dots 0.1 \mu\text{V}/\text{Month}$ Typ, Including the First 30 Days
- High-impedance LinCMOS™ Inputs
 $I_B = 0.6$ pA Typ
- High Open-Loop Gain $\dots 800000$ Typ
- Output Drive Capability > 20 mA
- Slew Rate $\dots 47$ V/ms Typ
- Common-Mode Input Voltage Range Extends Below the Negative Rail
- Output Voltage Range Includes Negative Rail
- On-Chip ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel

description

The TLC107x operational amplifiers offer ultra-low offset voltage, high gain, 110-kHz bandwidth, 47-V/ms slew rate, and just 150- μ W power dissipation per amplifier.

With a supply voltage of 1.4 V, common-mode input to the negative rail, and output swing to the negative rail, the TLC107xC is an ideal solution for low-voltage battery-operated systems. The 20-mA output drive capability means that the TLC107x can easily drive small resistive and large capacitive loads when needed, while maintaining ultra-low standby power dissipation.

Since this device is functionally compatible as well as pin compatible with the TLC27L2/4 and TLC27L7/9, the TLC107x easily upgrades existing designs that can benefit from its improved performance.



NC – No internal connection



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description (continued)

The TLC107x incorporates internal ESD-protection circuits that will prevent functional failures at voltages up to 2000 V as tested under MIL-PRF-38535, Method 3015.2; however, care should be exercised when handling these devices as exposure to ESD may result in degradation of the device parametric performance. The TLC107x design also inhibits latch-up of the device inputs and outputs even with surge currents as large as 100 mA.

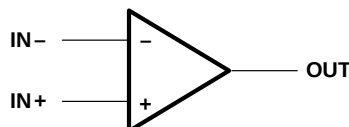
The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C. The wide range of packaging options includes small-outline and chip-carrier versions for high-density system applications.

AVAILABLE OPTIONS

T _A	PACKAGED DEVICES						CHIP FORM [‡] (Y)
	SMALL OUTLINE [†] (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	CERAMIC DIP (JG)	PLASTIC DIP (N)	PLASTIC DIP (P)	
0°C to 70°C	TLC1078CD TLC1079CD	—	—	—	TLC1079CN	TLC1078CP	TLC1078Y TLC1079Y
–40°C to 85°C	TLC1078ID TLC1079ID	—	—	—	TLC1079IN	TLC1078IP	—
–55°C to 125°C	TLC1078MD TLC1079MD	TLC1078MFK TLC1079MFK	TLC1079MJ	TLC1078MJG	TLC1079MN	TLC1078MP	—

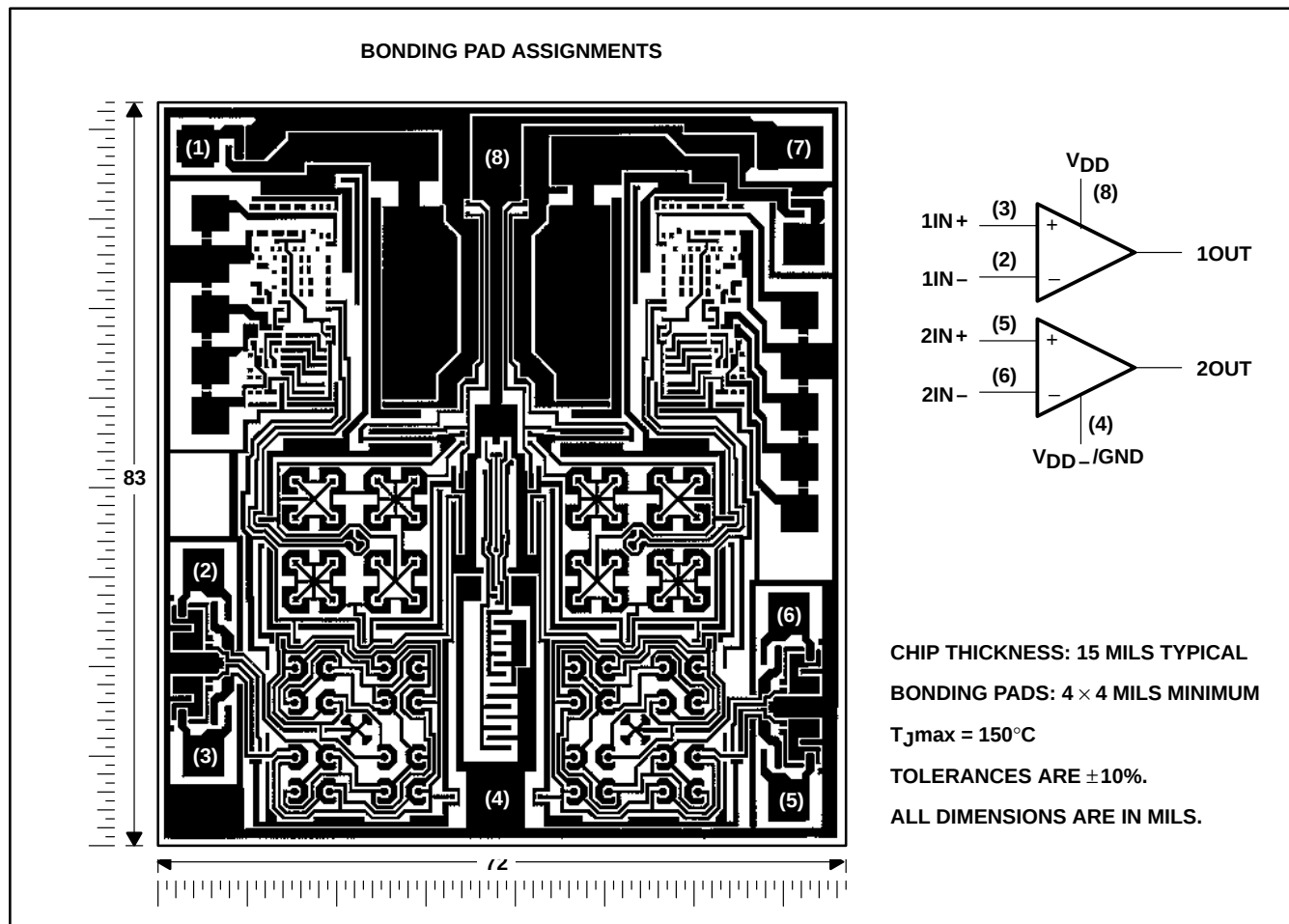
[†] The D package is available taped and reeled. Add the suffix R to the device type (e.g., TLC1078CDR).

[‡] Chip forms are tested 25°C only.

symbol (each amplifier)

TLC1078Y chip information

This chip, when properly assembled, displays characteristics similar to the TLC1078C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips can be mounted with conductive epoxy or a gold-silicon preform.



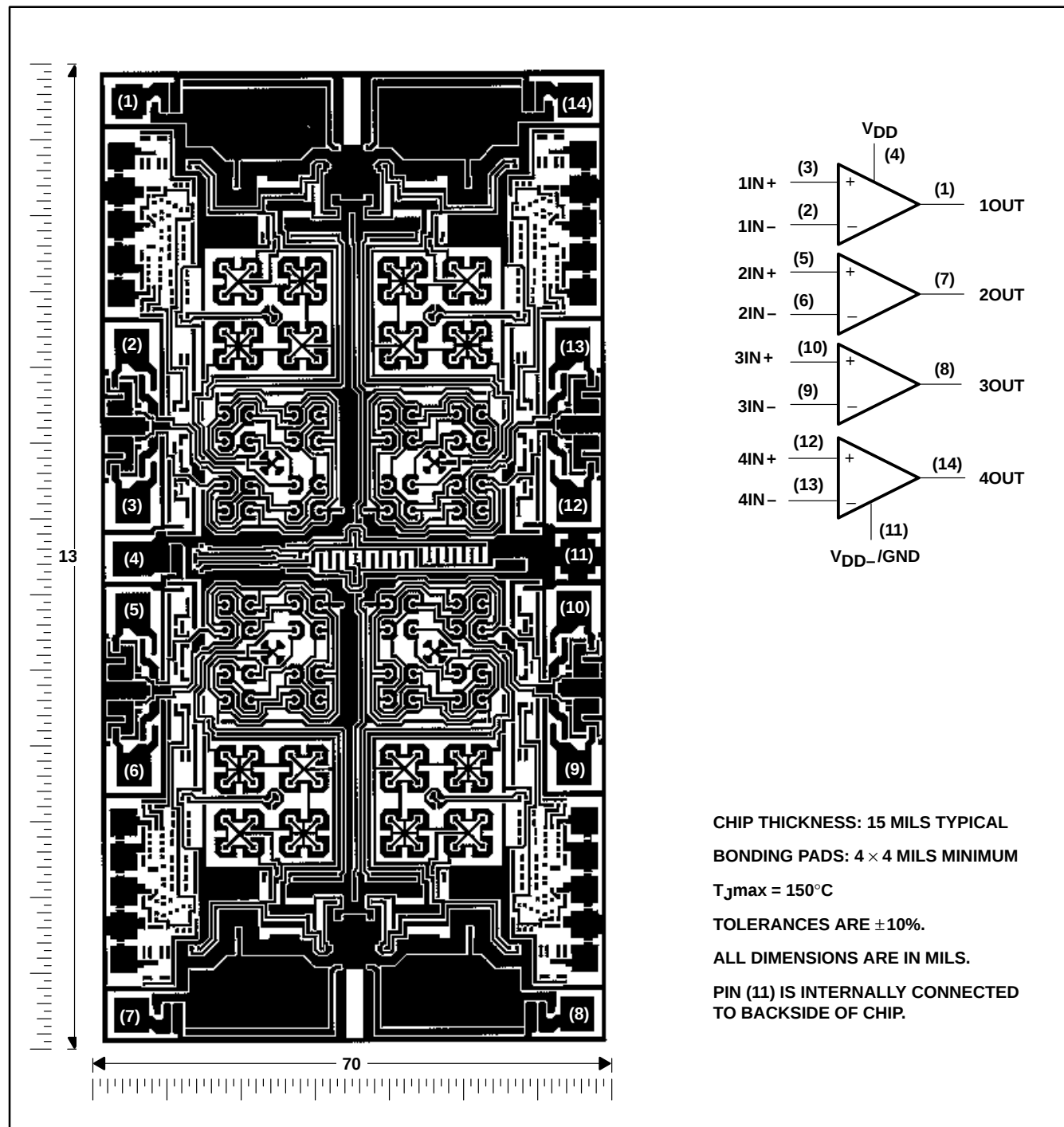
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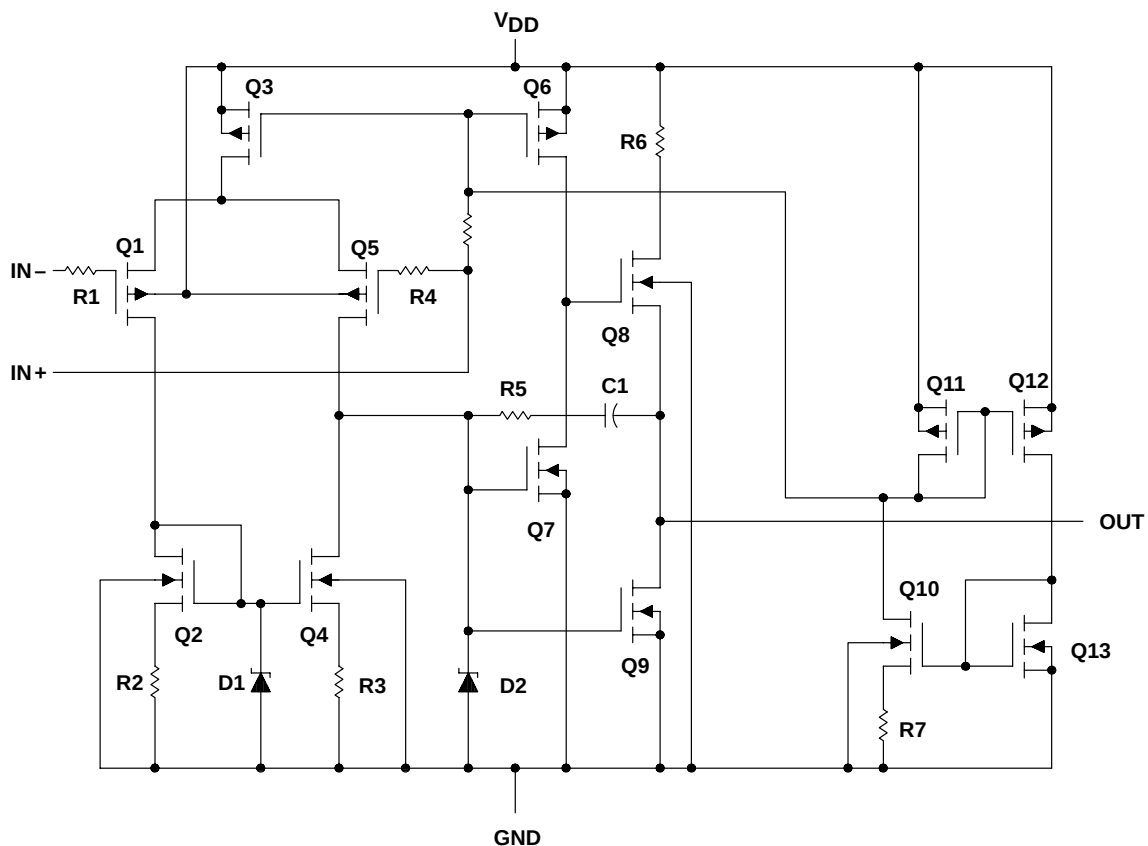
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TLC1079Y chip information

This chip, when properly assembled, display characteristics similar to the TLC1079C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips can be mounted with conductive epoxy or a gold-silicon preform.



equivalent schematic (each amplifier)



ACTUAL DEVICE COMPONENT COUNT		
COMPONENT	TLC1078	TLC1079
Transistors	38	76
Resistors	16	32
Diodes	12	24
Capacitors	2	4

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

Supply voltage, V_{DD} (see Note 1)	18 V
Differential input voltage, V_{ID} (see Note 2)	$\pm V_{DD}$
Input voltage range, V_I (any input)	–0.3 V to V_{DD}
Input current, I_I (each input)	± 5 mA
Output current, I_O (each output)	± 30 mA
Total current into V_{DD} (see Note 3)	45 mA
Duration of short-circuit at (or below) $T_A = 25^\circ\text{C}$ (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	-65°C to 150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or P package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C

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

NOTES: 1. All voltage values, except differential voltages, are with respect to network ground.
2. Differential voltages are at $IN+$ with respect to $IN-$.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation ratings are not exceeded.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D–8	725 mW	$5.8 \text{ mW}/^\circ\text{C}$	464 mW	377 mW	145 mW
D–14	950 mW	$7.6 \text{ mW}/^\circ\text{C}$	608 mW	494 mW	190 mW
FK	1375 mW	$11.0 \text{ mW}/^\circ\text{C}$	880 mW	715 mW	275 mW
J	1375 mW	$11.0 \text{ mW}/^\circ\text{C}$	880 mW	715 mW	275 mW
JG	1050 mW	$8.4 \text{ mW}/^\circ\text{C}$	672 mW	546 mW	210 mW
N	1150 mW	$9.2 \text{ mW}/^\circ\text{C}$	736 mW	598 mW	230 mW
P	1000 mW	$8.0 \text{ mW}/^\circ\text{C}$	640 mW	520 mW	200 mW

recommended operating conditions

		C SUFFIX		I SUFFIX		M SUFFIX		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{DD}		1.4	16	3	16	4	16	V
Common-mode input voltage, V_{IC}	$V_{DD} = 5 \text{ V}$	–0.2	4	–0.2	4	0	4	V
	$V_{DD} = 10 \text{ V}$	–0.2	9	–0.2	9	0	9	
Operating free-air temperature, T_A		0	70	–40	85	–55	125	$^\circ\text{C}$

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electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T _A [†]	TLC1078C						UNIT
				V _{DD} = 5 V			V _{DD} = 10 V			
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _O = 1.4 V, R _S = 50 Ω, V _{IC} = 0, R _I = 1 MΩ	25°C		160	450		180	600	μV
			Full range			800			950	
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 70°C		1.1			1		μV/°C
I _{IO}	Input offset current (see Note 4)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2	25°C		0.1	60		0.1	60	pA
			70°C		7	300		7	300	
I _{IB}	Input bias current (see Note 4)		25°C		0.6	60		0.7	60	pA
			70°C		40	600		50	600	
V _{ICR}	Common-mode input voltage range (see Note 5)		25°C	−0.2 to 4	−0.3 to 4.2		−0.2 to 9	−0.3 to 9.2	V	
			Full range	−0.2 to 3.5		−0.2 to 8.5		V		
V _{OH}	High-level output voltage	V _{ID} = 100 mV, R _L = 1 MΩ	25°C	3.2	4.1		8.2	8.9	V	
			0°C	3.2	4.1		8.2	8.9		
			70°C	3.2	4.2		8.2	8.9		
V _{OL}	Low-level output voltage	V _{ID} = −100 mV, I _{OL} = 0	25°C		0	25		0	25	mV
			0°C		0	25		0	25	
			70°C		0	25		0	25	
A _{VD}	Large-signal differential voltage amplification	R _L = 1 MΩ, See Note 6	25°C	250	525		500	850	V/mV	
			0°C	250	680		500	1010		
			70°C	200	380		350	660		
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICRmin}	25°C	70	95		75	97	dB	
			0°C	70	95		75	97		
			70°C	70	95		75	97		
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _O = 1.4 V	25°C	75	98		75	98	dB	
			0°C	75	98		75	98		
			70°C	75	98		75	98		
I _{DD}	Supply current (two amplifiers)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2, No load	25°C		20	34		29	46	μA
			0°C		24	42		36	66	
			70°C		16	28		22	40	

† Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V}$ to 2 V ; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V}$ to 6 V .

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electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T _A [†]	TLC1079C						UNIT
				V _{DD} = 5 V			V _{DD} = 10 V			
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _O = 1.4 V, V _{IC} = 0, R _S = 50 Ω, R _I = 1 MΩ	25°C	190	850	200	1150	μV		
			Full range	1200			1500			
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 70°C	1.1		1		μV/°C		
I _{IO}	Input offset current (see Note 4)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2	25°C	0.1	60	0.1	60	pA		
			70°C	7	300	7	300			
I _{IB}	Input bias current (see Note 4)		25°C	0.6	60	0.7	60	pA		
			70°C	40	600	50	600			
V _{ICR}	Common mode input voltage range (see Note 5)		25°C	−0.2 to 4	−0.3 to 4.2	−0.2 to 9	−0.3 to 9.2	V		
			Full range	−0.2 to 3.5		−0.2 to 8.5		V		
V _{OH}	High-level output voltage	V _{ID} = 100 mV, R _L = 1 MΩ	25°C	3.2	4.1	8.2	8.9	V		
			0°C	3.2	4.1	8.2	8.9			
			70°C	3.2	4.2	8.2	8.9			
V _{OL}	Low-level output voltage	V _{ID} = −100 mV, I _{OL} = 0	25°C	0	25	0	25	mV		
			0°C	0	25	0	25			
			70°C	0	25	0	25			
A _{VD}	Large-signal differential voltage amplification	R _L = 1 MΩ, See Note 6	25°C	250	525	500	850	V/mV		
			0°C	250	700	500	1010			
			70°C	200	380	350	660			
CMRR	Common mode rejection ratio	V _{IC} = V _{ICRmin}	25°C	70	95	75	97	dB		
			0°C	70	95	75	97			
			70°C	70	95	75	97			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 5 V to 10 V, V _O = 1.4 V	25°C	75	98	75	98	dB		
			0°C	75	98	75	98			
			70°C	75	98	75	98			
I _{DD}	Supply current (four amplifiers)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2, No load	25°C	40	68	57	92	μA		
			0°C	48	84	72	132			
			70°C	31	56	44	80			

† Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V to }2\text{ V}$; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V to }6\text{ V}$.



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operating characteristics at specified free-air temperature

PARAMETER	TEST CONDITIONS	T _A	TLC1078C						UNIT
			V _{DD} = 5 V			V _{DD} = 10 V			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1	25°C	32			47			V/ms
		0°C	35			51			
		70°C	27			38			
V _n Equivalent input noise voltage	f = 1 kHz, R _S = 20 Ω	25°C	68			68			nV/√Hz
B ₁ Unity-gain bandwidth	C _L = 20 pF, See Figure 2	25°C	85			110			kHz
		0°C	100			125			
		70°C	65			90			
φ _m Phase margin at unity gain	C _L = 20 pF, See Figure 2	25°C	34°			38°			
		0°C	36°			40°			
		70°C	30°			34°			

operating characteristics at specified free-air temperature

PARAMETER	TEST CONDITIONS	T _A	TLC1079C						UNIT
			V _{DD} = 5 V			V _{DD} = 10 V			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1	25°C	32			47			V/ms
		0°C	35			51			
		70°C	27			38			
V _n Equivalent input noise voltage	f = 1 kHz, R _S = 20 Ω	25°C	68			68			nV/√Hz
B ₁ Unity-gain bandwidth	C _L = 20 pF, See Figure 2	25°C	85			110			kHz
		0°C	100			125			
		70°C	65			90			
φ _m Phase margin at unity gain	C _L = 20 pF, See Figure 2	25°C	34°			38°			
		0°C	36°			40°			
		70°C	30°			34°			



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electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T _A [†]	TLC1078I						UNIT
				V _{DD} = 5 V			V _{DD} = 10 V			
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _O = 1.4 V, R _S = 50 Ω, V _{IC} = 0, R _I = 1 MΩ	25°C	160		450	180		600	μV
			Full range			950			1100	
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 85°C	1.1			1			μV/°C
I _{IO}	Input offset current (see Note 4)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2	25°C	0.1		60	0.1		60	pA
			85°C	24		1000	26		1000	
I _{IB}	Input bias current (see Note 4)		25°C	0.6		60	0.7		60	pA
		85°C	200		2000	220		2000		
V _{ICR}	Common-mode input voltage range (see Note 5)		25°C	−0.2 to 4	−0.3 to 4.2		−0.2 to 9	−0.3 to 9.2		V
			Full range	−0.2 to 3.5			−0.2 to 8.5			V
V _{OH}	High-level output voltage	V _{ID} = 100 mV, R _L = 1 MΩ	25°C	3.2	4.1		8.2	8.9		V
			−40°C	3.2	4.1		8.2	8.9		
			85°C	3.2	4.2		8.2	8.9		
V _{OL}	Low-level output voltage	V _{ID} = −100 mV, I _{OL} = 0	25°C	0		25	0		25	mV
			−40°C	0		25	0		25	
			85°C	0		25	0		25	
A _{VD}	Large-signal differential voltage amplification	R _L = 1 MΩ, See Note 6	25°C	250	525		500	850		V/mV
			−40°C	250	900		500	1550		
			85°C	150	300		250	585		
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICRmin}	25°C	70	95		75	97		dB
			−40°C	70	95		75	97		
			85°C	70	95		75	97		
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _O = 1.4 V	25°C	75	98		75	98		dB
			−40°C	75	98		75	98		
			85°C	75	98		75	98		
I _{DD}	Supply current (two amplifiers)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2, No load	25°C	20		34	29		46	μA
			−40°C	31		54	50		86	
			85°C	15		26	20		36	

† Full range is –40°C to 80°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V}$ to 2 V ; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V}$ to 6 V .



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electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T _A [†]	TLC1079I						UNIT
				V _{DD} = 5 V			V _{DD} = 10 V			
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _O = 1.4 V, V _{IC} = 0, R _S = 50 Ω, R _I = 1 MΩ	25°C	190 850		200 1150		μV		
			Full range	1350		1650				
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 85°C	1.1		1		μV/°C		
I _{IO}	Input offset current (see Note 4)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2	25°C	0.1	60	0.1	60	pA		
			85°C	24	1000	26	1000			
I _{IB}	Input bias current (see Note 4)		25°C	0.6	60	0.7	60	pA		
			85°C	200	2000	220	2000			
V _{ICR}	Common-mode input voltage range (see Note 5)		25°C	−0.2 to 4	−0.3 to 4.2	−0.2 to 9	−0.3 to 9.2	V		
			Full range	−0.2 to 3.5		−0.2 to 8.5		V		
V _{OH}	High-level output voltage		25°C	3.2	4.1	8.2	8.9	V		
			−40°C	3.2	4.1	8.2	8.9			
			85°C	3.2	4.2	8.2	8.9			
V _{OL}	Low-level output voltage		25°C	0	25	0	25	mV		
			−40°C	0	25	0	25			
			85°C	0	25	0	25			
A _{VD}	Large-signal differential voltage amplification		25°C	250	525	500	850	V/mV		
			−40°C	250	900	500	1550			
			85°C	150	330	250	585			
CMRR	Common-mode rejection ratio		25°C	70	95	75	97	dB		
			−40°C	70	95	75	97			
			85°C	70	95	75	97			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})		25°C	75	98	75	98	dB		
			−40°C	75	98	75	98			
			85°C	75	98	75	98			
I _{DD}	Supply current (four amplifiers)		25°C	40	68	57	92	μA		
			−40°C	62	108	98	172			
			85°C	29	52	40	72			

† Full range is -40°C to 85°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V to }2\text{ V}$; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V to }6\text{ V}$.

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operating characteristics at specified free-air temperature

PARAMETER	TEST CONDITIONS	T _A	TLC1078I						UNIT
			V _{DD} = 5 V			V _{DD} = 10 V			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1	25°C	32			47			V/ms
		−40°C	39			59			
		85°C	25			34			
V _n Equivalent input noise voltage	f = 1 kHz, R _S = 20 Ω	25°C	68			68			nV/√Hz
B ₁ Unity-gain bandwidth	C _L = 20 pF, See Figure 2	25°C	85			110			kHz
		−40°C	130			155			
		85°C	55			80			
ϕ _m Phase margin at unity gain	C _L = 20 pF, See Figure 2	25°C	34°			38°			
		−40°C	38°			40°			
		85°C	28°			32°			

operating characteristics at specified free-air temperature

PARAMETER	TEST CONDITIONS	T _A	TLC1079I						UNIT
			V _{DD} = 5 V			V _{DD} = 10 V			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1	25°C	32			47			V/ms
		−40°C	39			59			
		85°C	25			34			
V _n Equivalent input noise voltage	f = 1 kHz, R _S = 20 Ω	25°C	68			68			nV/√Hz
B ₁ Unity-gain bandwidth	C _L = 20 pF, See Figure 2	25°C	85			110			kHz
		−40°C	130			155			
		85°C	55			80			
ϕ _m Phase margin at unity gain	C _L = 20 pF, See Figure 2	25°C	34°			38°			
		−40°C	38°			42°			
		85°C	28°			32°			



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electrical characteristics at specified operating free-air temperature

PARAMETER		TEST CONDITIONS	T _A [†]	TLC1078M						UNIT
				V _{DD} = 5 V			V _{DD} = 10 V			
				MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _O = 1.4 V, V _{IC} = 0, R _S = 50 Ω, R _L = 1 MΩ	25°C	160	450	180	600	μV		
			Full range	1250		1400				
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 125°C	1.4		1.4		μV/°C		
I _{IO}	Input offset current (see Note 4)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2	25°C	0.1	60	0.1	60	pA		
			125°C	1.4	15	1.8	15	nA		
I _{IB}	Input bias current (see Note 4)		25°C	0.6	60	0.7	60	pA		
			125°C	9	35	10	35	nA		
V _{ICR}	Common-mode input voltage range (see Note 5)		25°C	0 to 4	–0.3 to 4.2	0 to 9	–0.3 to 9.2	V		
			Full range	0 to 3.5		0 to 8.5		V		
V _{OH}	High-level output voltage	V _{ID} = 100 mV, R _L = 1 MΩ	25°C	3.2	4.1	8.2	8.9	V		
			–55°C	3.2	4.1	8.2	8.8			
			125°C	3.2	4.2	8.2	9			
V _{OL}	Low-level output voltage	V _{ID} = –100 mV, I _{OL} = 0	25°C	0 25		0 25		mV		
			–55°C	0 25		0 25				
			125°C	0 25		0 25				
A _{VD}	Large-signal differential voltage amplification	R _L = 1 MΩ , See Note 6	25°C	250	525	500	850	V/mV		
			–55°C	250	950	500	1750			
			125°C	35	200	75	380			
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICRmin}	25°C	70	95	75	97	dB		
			–55°C	70	95	75	97			
			125°C	70	85	75	91			
k _{SVR}	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _O = 1.4 V	25°C	75	98	75	98	dB		
			–55°C	70	98	70	98			
			125°C	70	98	70	98			
I _{DD}	Supply current (two amplifiers)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2, No load	25°C	20	34	29	46	μA		
			–55°C	35	60	56	96			
			125°C	14	24	18	30			

† Full range is –55°C to 125°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V}$ to 2 V ; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V}$ to 6 V .



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electrical characteristics at specified free-air temperature

PARAMETER		TEST CONDITIONS	T _A [†]	TLC1079M						UNIT	
				V _{DD} = 5 V			V _{DD} = 10 V				
				MIN	TYP	MAX	MIN	TYP	MAX		
V _{IO}	Input offset voltage	V _O = 1.4 V, V _{IC} = 0, R _S = 50 Ω, R _I = 1 MΩ	25°C		190	850		200	1150	μV	
			Full range			1600			1900		
α _{VIO}	Temperature coefficient of input offset voltage		25°C to 125°C		1.4			1.4		μV/°C	
I _{IO}	Input offset current (see Note 4)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2	25°C		0.1	60		0.1	60	pA	
			125°C		1.4	15		1.8	15	nA	
I _{IB}	Input bias current (see Note 4)		25°C		0.6	60		0.7	60	pA	
			125°C		9	35		10	35	nA	
V _{ICR}	Common mode input voltage range (see Note 5)		25°C		0 to 4	–0.3 to 4.2		0 to 9	–0.3 to 9.2	V	
			Full range		0 to 3.5		0 to 8.5		V		
V _{OH}	High-level output voltage	V _{ID} = 100 mV, R _L = 1 MΩ	25°C		3.2	4.1		8.2	8.9	V	
			–55°C		3.2	4.1		8.2	8.9		
			125°C		3.2	4.2		8.2	9		
V _{OL}	Low-level output voltage	V _{ID} = –100 mV, I _{OL} = 0	25°C			0	25		0	25	mV
			–55°C			0	25		0	25	
			125°C			0	25		0	25	
A _{VD}	Large-signal differential voltage amplification	R _L = 1 MΩ, See Note 6	25°C		250	525		500	850	V/mV	
			–55°C		250	950		500	1750		
			125°C		35	200		75	380		
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICRmin}	25°C		70	95		75	97	dB	
			–55°C		70	95		75	97		
			125°C		70	85		75	91		
k _{SVR}	Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	V _{DD} = 5 V to 10 V, V _O = 1.4 V	25°C		75	98		75	98	dB	
			–55°C		70	98		70	98		
			125°C		70	98		70	98		
I _{DD}	Supply current (four amplifiers)	V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2, No load	25°C		40	68		57	92	μA	
			–55°C		69	120		111	192		
			125°C		27	48		35	60		

† Full range is –55°C to 125°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V to }2\text{ V}$; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V to }6\text{ V}$.



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operating characteristics at specified free-air temperature

PARAMETER	TEST CONDITIONS	T _A	TLC1078M						UNIT
			V _{DD} = 5 V			V _{DD} = 10 V			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1	25°C	32			47			V/ms
		–55°C	41			63			
		125°C	20			27			
V _n Equivalent input noise voltage	f = 1 kHz, R _S = 20 Ω	25°C	68			68			nV/√Hz
B ₁ Unity-gain bandwidth	C _L = 20 pF, See Figure 2	25°C	85			110			kHz
		–55°C	140			165			
		125°C	45			70			
φ _m Phase margin at unity gain	C _L = 20 pF, See Figure 2	25°C	34°			38°			
		–55°C	39°			43°			
		125°C	25°			29°			

operating characteristics at specified free-air temperature

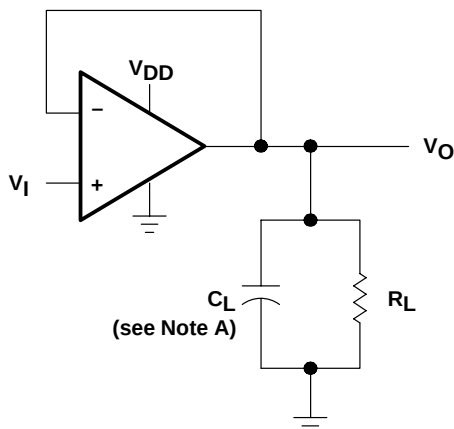
PARAMETER	TEST CONDITIONS	T _A	TLC1079M						UNIT
			V _{DD} = 5 V			V _{DD} = 10 V			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR Slew rate at unity gain	R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1	25°C	32			47			V/ms
		–55°C	41			63			
		125°C	20			27			
V _n Equivalent input noise voltage	f = 1 kHz, R _S = 20 Ω	25°C	68			68			nV/√Hz
B ₁ Unity-gain bandwidth	C _L = 20 pF, See Figure 2	25°C	85			110			kHz
		–55°C	140			165			
		125°C	45			70			
		25°C	34°			38°			
ϕ _m Phase margin at unity gain	C _L = 20 pF, See Figure 2	–55°C	39°			43°			
		125°C	25°			29°			

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PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

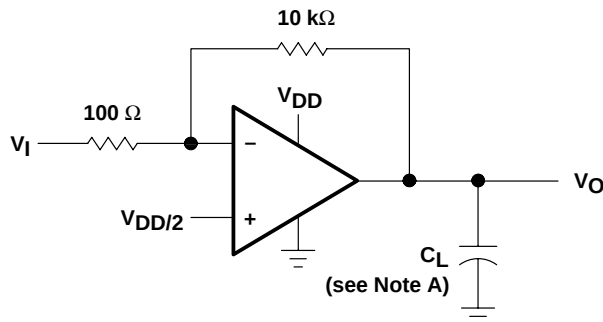


Figure 2. Unity-Gain Bandwidth and Phase-Margin Test Circuit

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
α_{VIO}	Temperature coefficient of input offset voltage	Distribution	3 – 6
I_{IB}	Input bias current	vs Free-air temperature	7
I_{IO}	Input offset current	vs Free-air temperature	7
V_{IC}	Common-mode input voltage	vs Supply voltage	8
V_{OH}	High-level output voltage	vs High-level output current vs Supply voltage vs Free-air temperature	9, 10 11 12
V_{OL}	Low-level output voltage	vs Common-mode input voltage vs Differential input voltage vs Free-air temperature vs Low-level output current	13, 14 15 16 17, 18
A_{VD}	Large-signal differential voltage amplification	vs Supply voltage vs Free-air temperature vs Frequency	19 20 21, 22
V_{OM}	Maximum peak output voltage	vs Frequency	23
I_{DD}	Supply current	vs Supply voltage vs Free-air temperature	24 25
SR	Slew rate	vs Supply voltage vs Free-air temperature	26 27
	Normalized slew rate	vs Free-air temperature	28
V_n	Equivalent input noise voltage	vs Frequency	29
B_1	Unity-gain bandwidth	vs Supply voltage vs Free-air temperature	30 31
ϕ_m	Phase margin	vs Supply voltage vs Free-air temperature vs Capacitive load	32 33 34
	Phase shift	vs Frequency	21, 22

TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC1078
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT

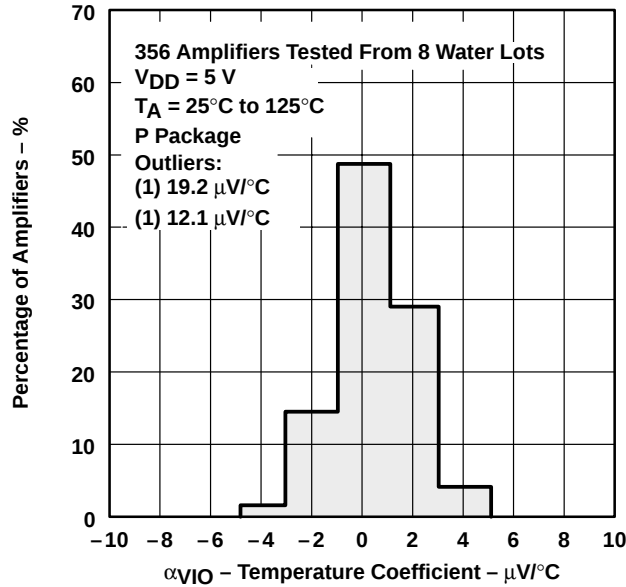


Figure 3

DISTRIBUTION OF TLC1078
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT

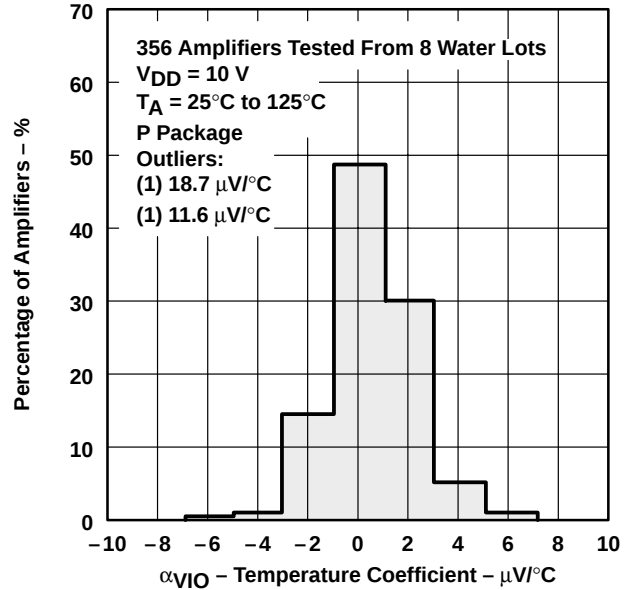


Figure 4

DISTRIBUTION OF TLC1079
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT

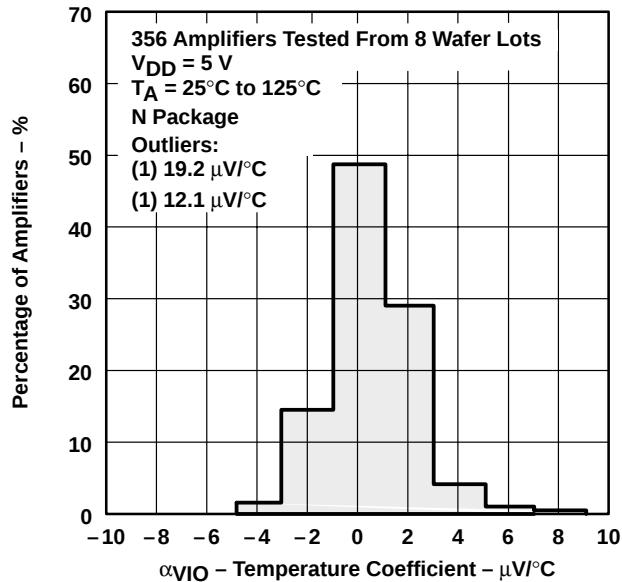


Figure 5

DISTRIBUTION OF TLC1079
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT

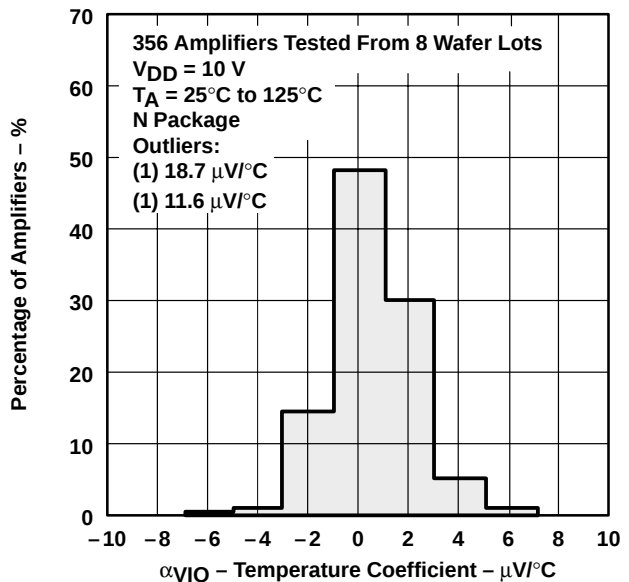
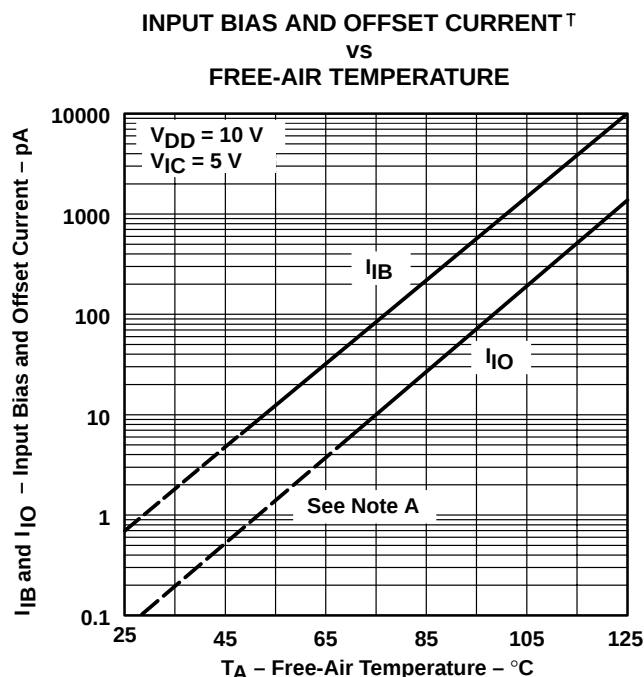


Figure 6

TYPICAL CHARACTERISTICS



NOTE A: The typical values of input bias current and input offset current below 5 pA were determined mathematically.

Figure 7

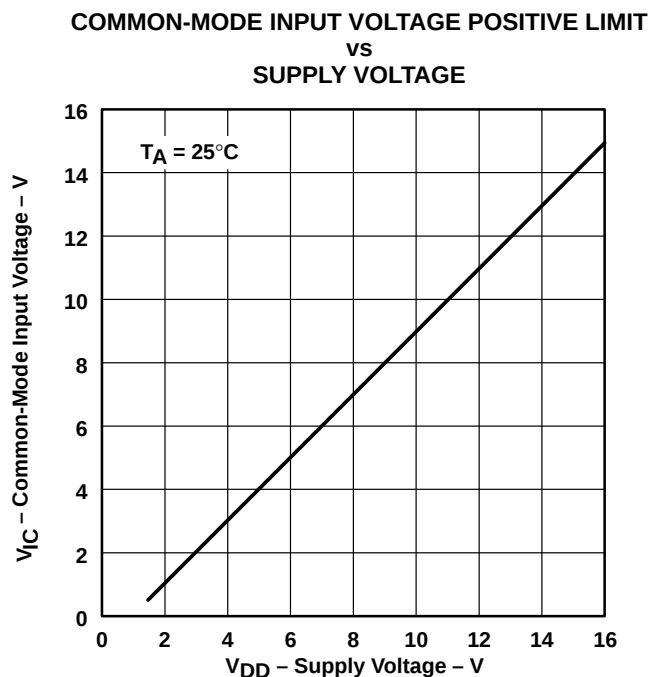


Figure 8

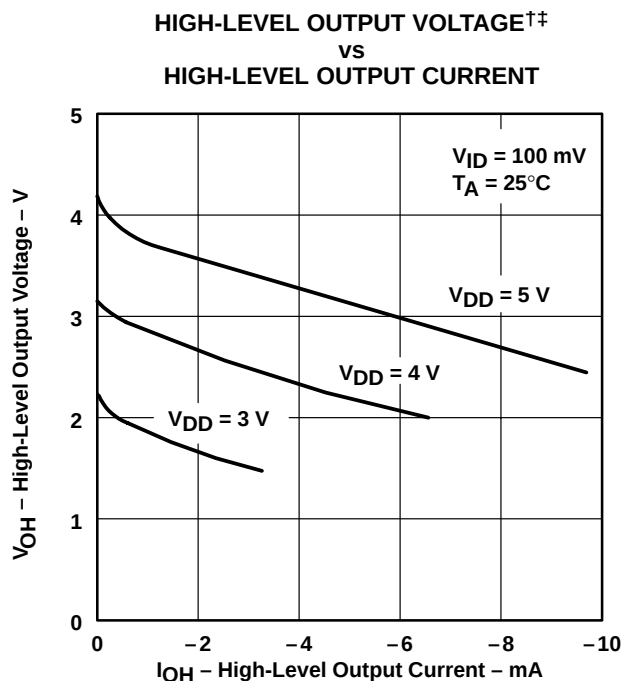


Figure 9

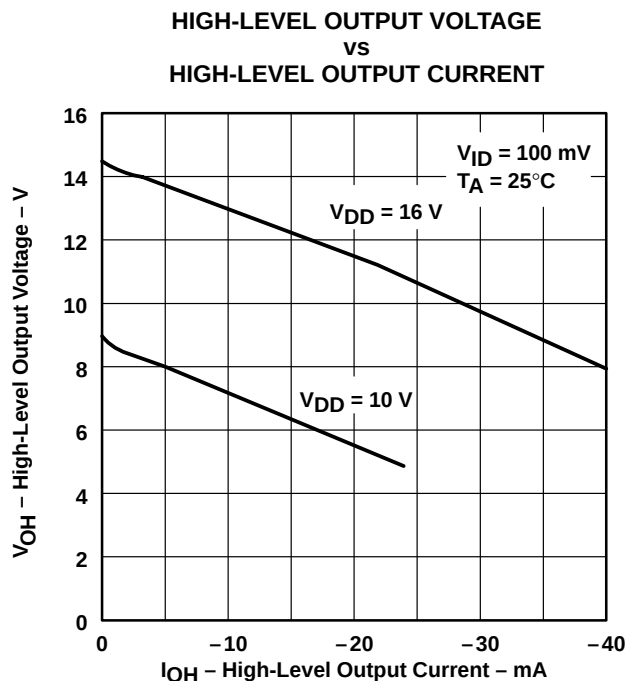


Figure 10

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

‡ The $V_{DD} = 3\text{ V}$ curve does not apply to the TLC107xM.

TYPICAL CHARACTERISTICS

HIGH-LEVEL OUTPUT VOLTAGE
 vs
 SUPPLY VOLTAGE

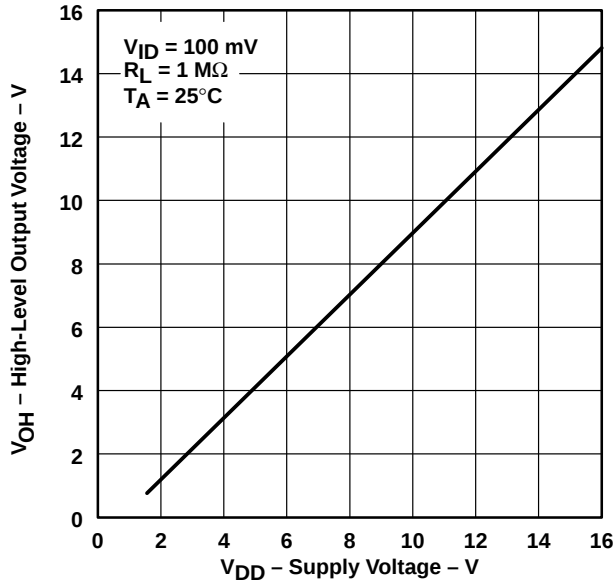


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE†
 vs
 FREE-AIR TEMPERATURE

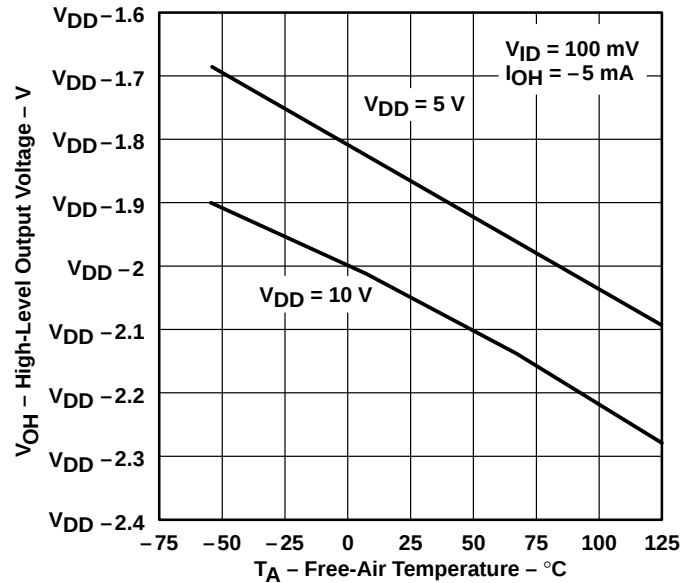


Figure 12

LOW-LEVEL OUTPUT VOLTAGE
 vs
 COMMON-MODE INPUT VOLTAGE

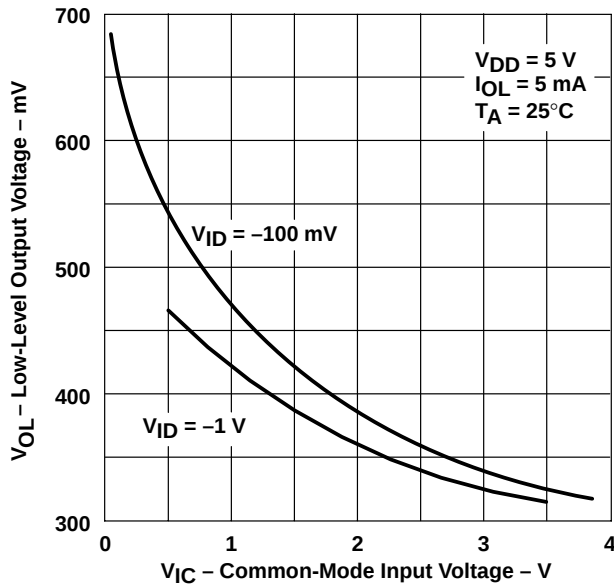


Figure 13

LOW-LEVEL OUTPUT VOLTAGE
 vs
 COMMON-MODE INPUT VOLTAGE

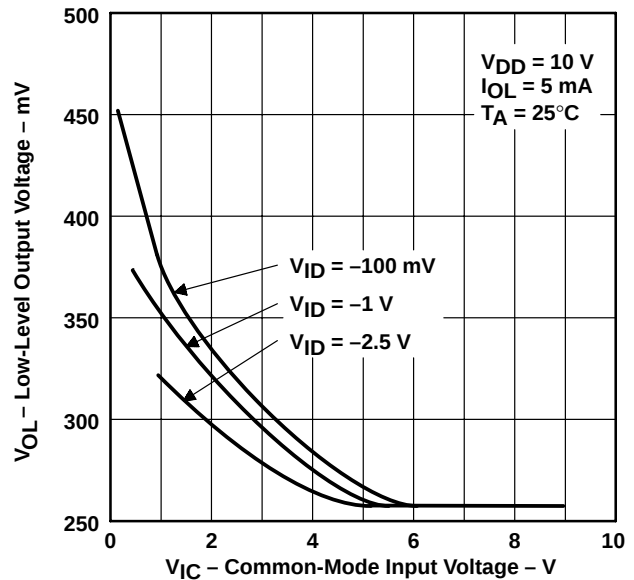


Figure 14

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

TYPICAL CHARACTERISTICS

LOW-LEVEL OUTPUT VOLTAGE
vs
DIFFERENTIAL INPUT VOLTAGE

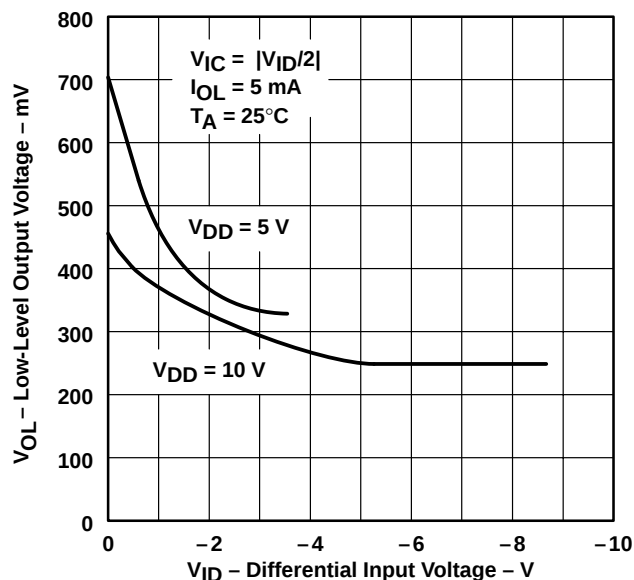


Figure 15

LOW-LEVEL OUTPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE

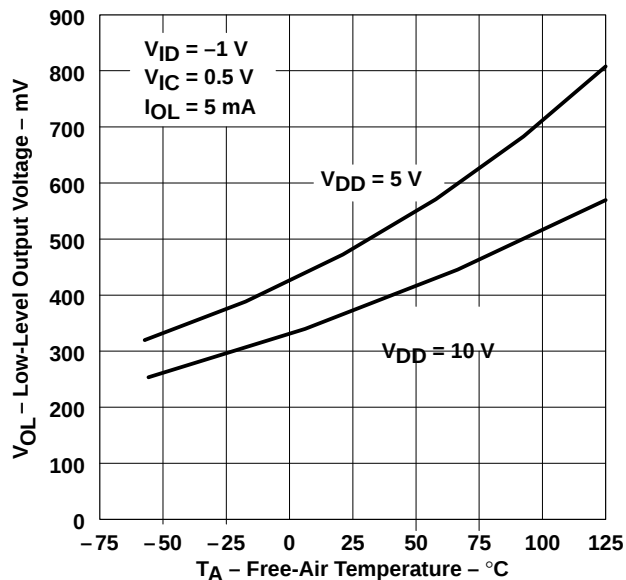


Figure 16

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

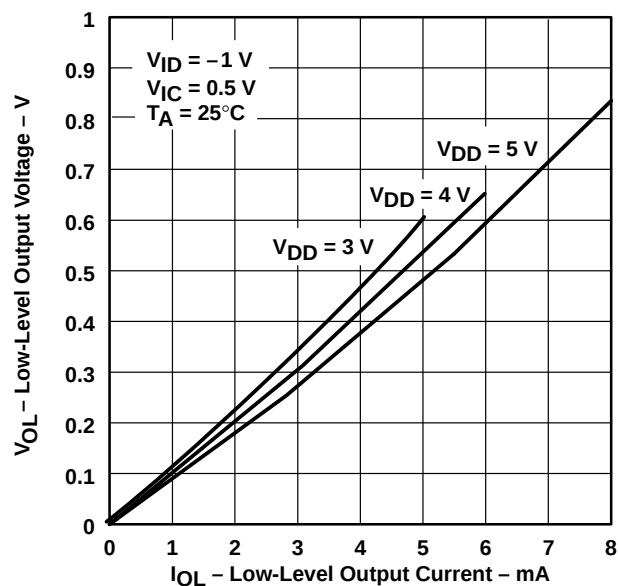


Figure 17

LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

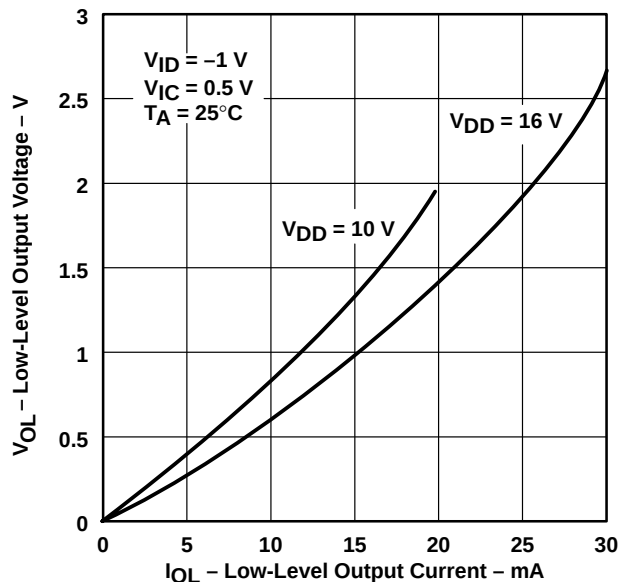


Figure 18

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

TYPICAL CHARACTERISTICS

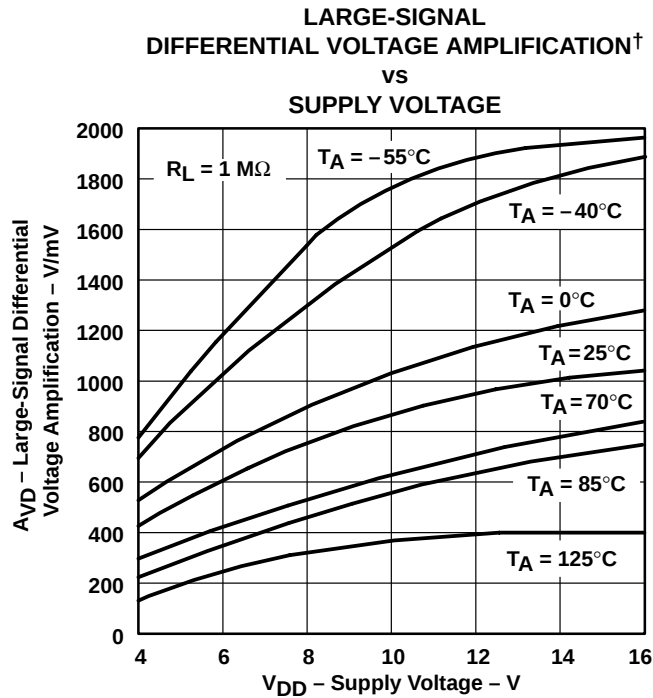


Figure 19

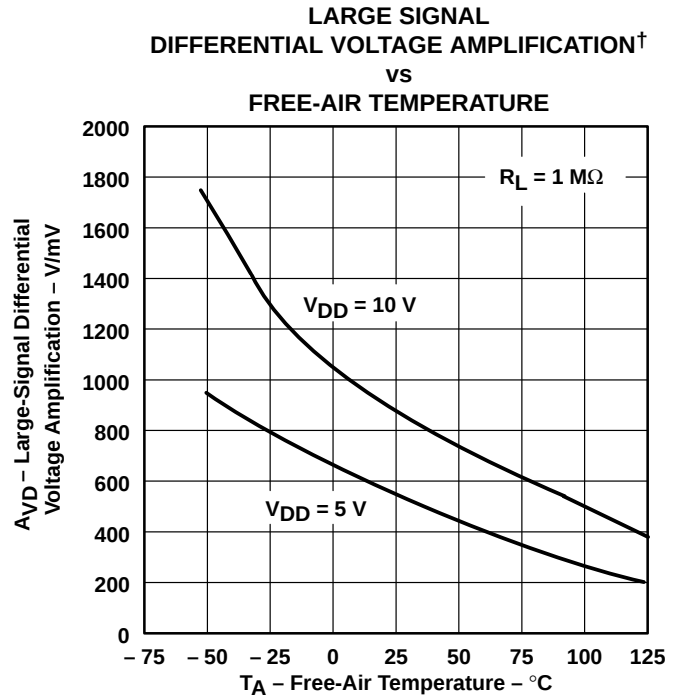


Figure 20

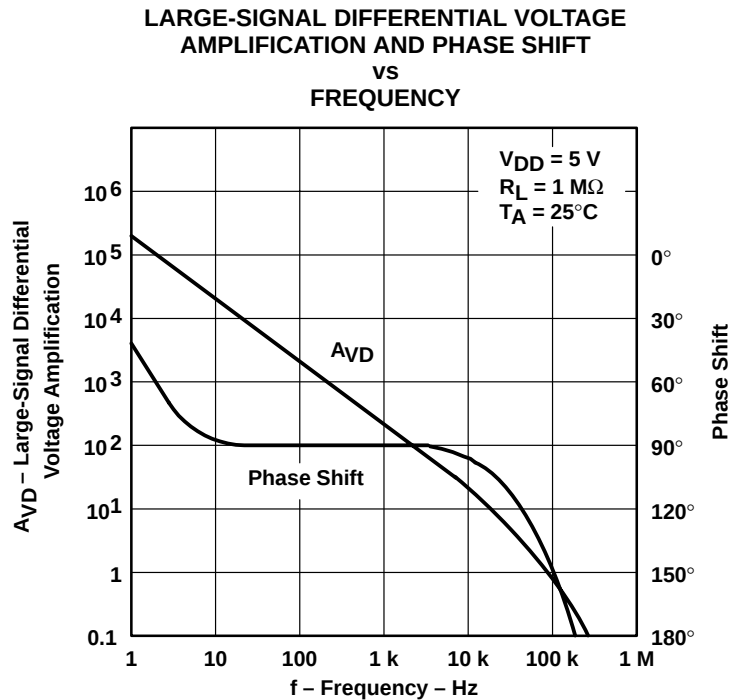


Figure 21

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

TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY

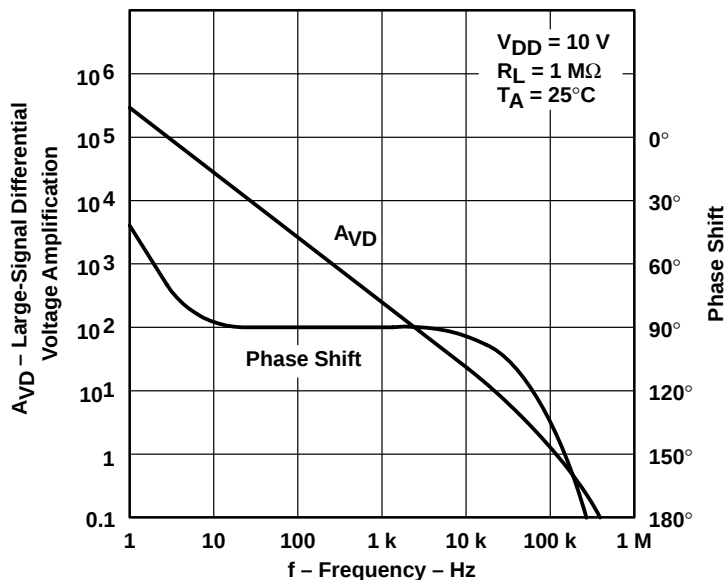


Figure 22

MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY

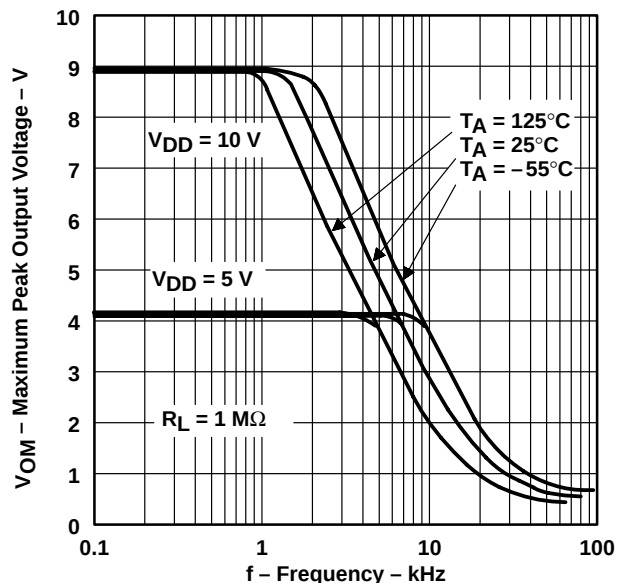


Figure 23

SUPPLY CURRENT† vs SUPPLY VOLTAGE

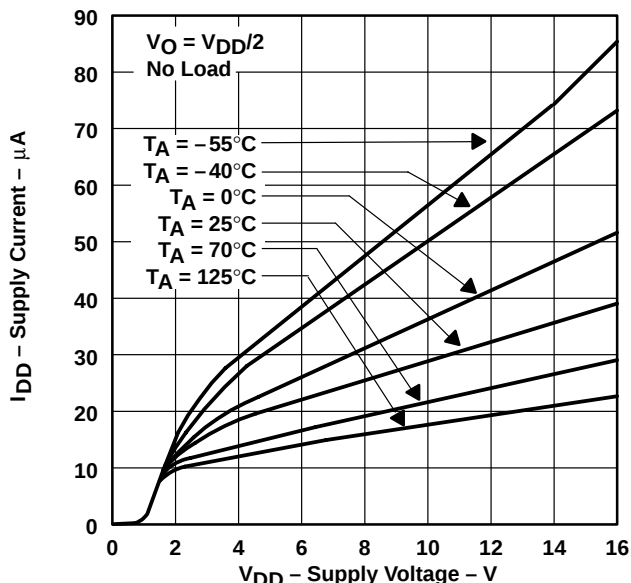


Figure 24

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

TYPICAL CHARACTERISTICS

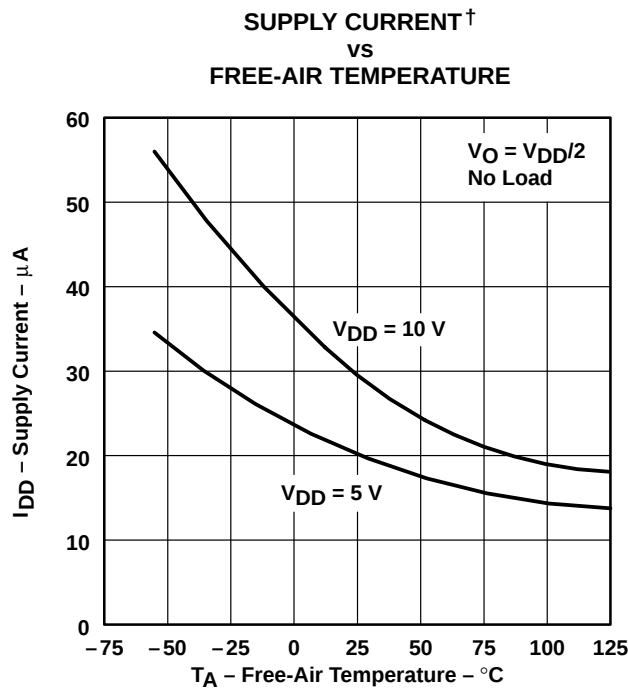


Figure 25

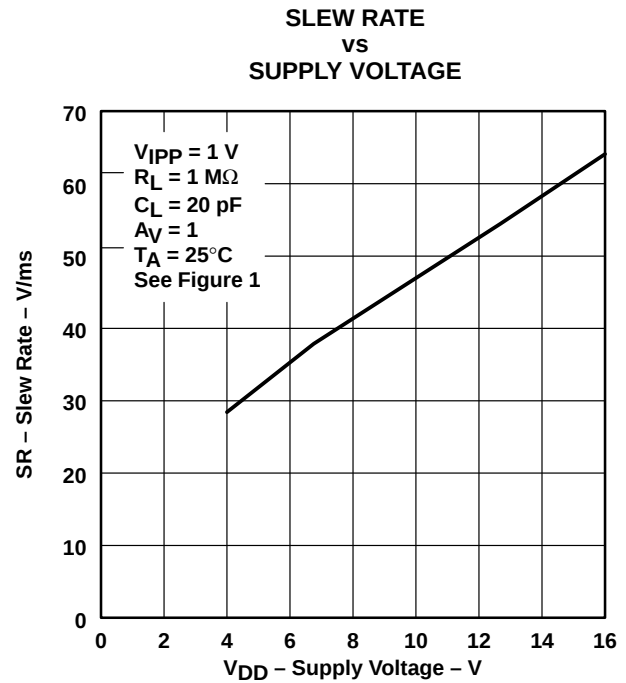


Figure 26

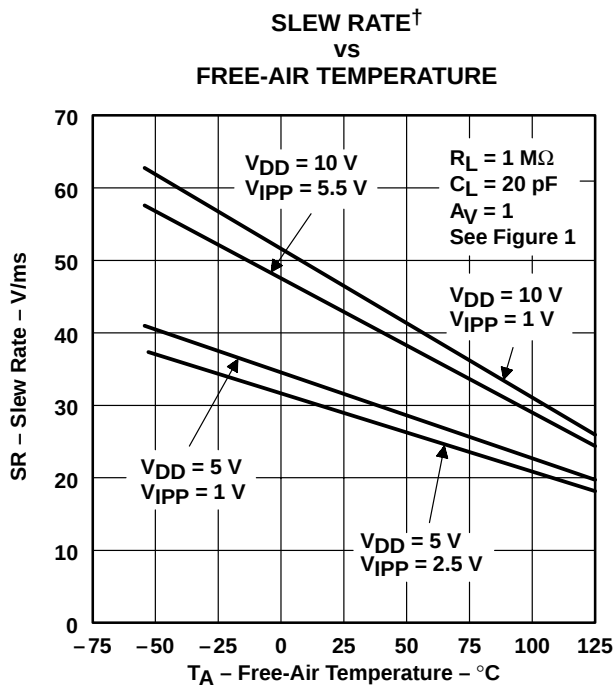


Figure 27

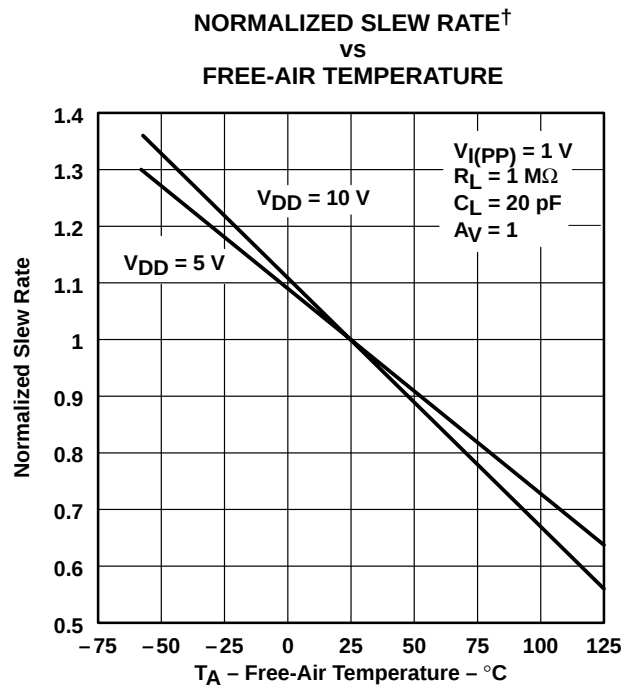


Figure 28

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

TYPICAL CHARACTERISTICS

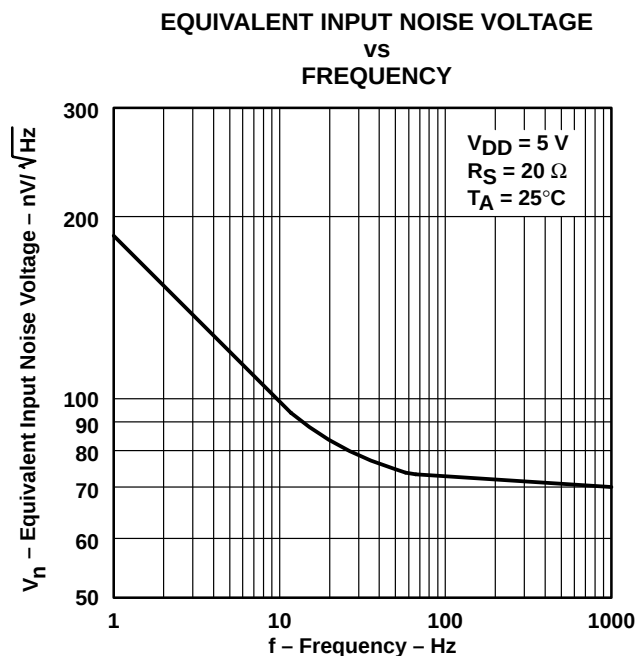


Figure 29

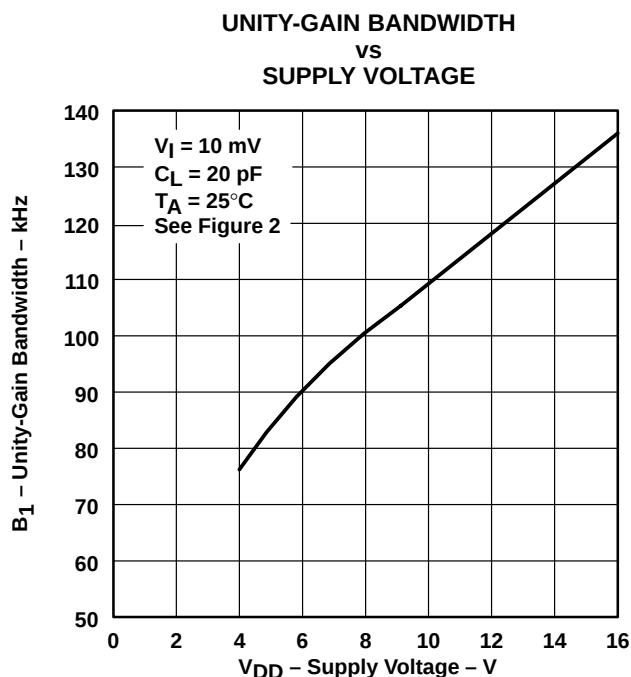


Figure 30

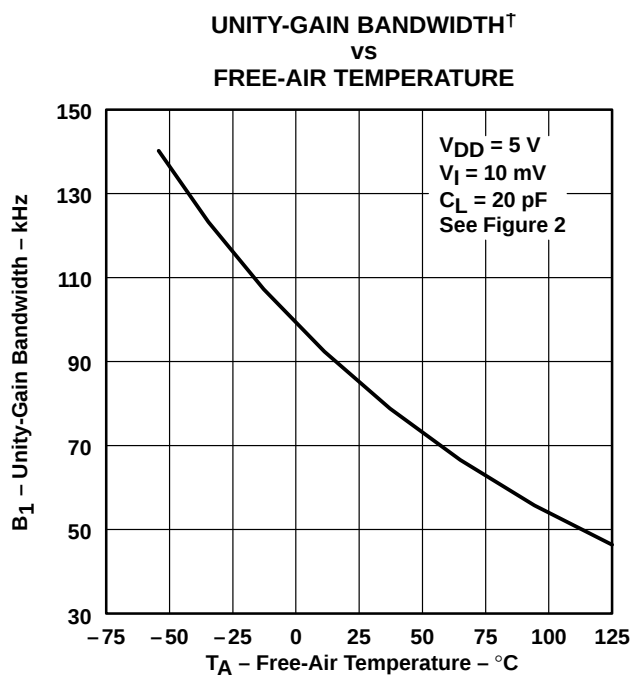


Figure 31

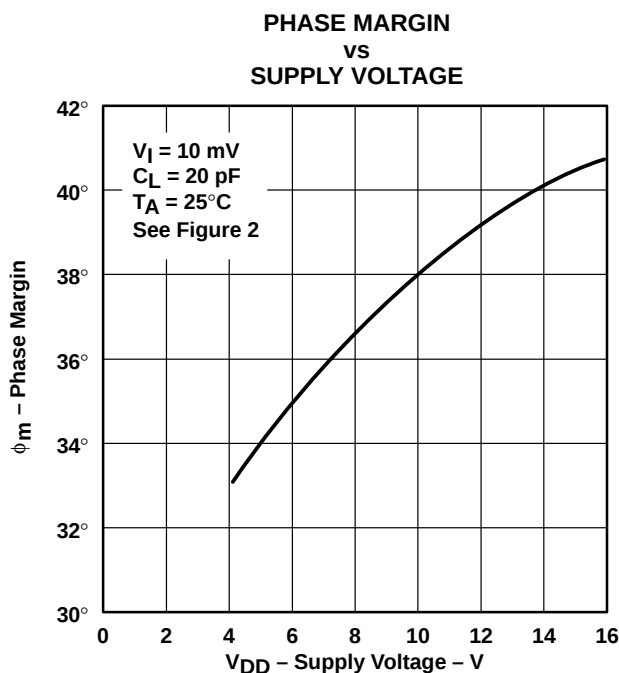


Figure 32

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

TYPICAL CHARACTERISTICS

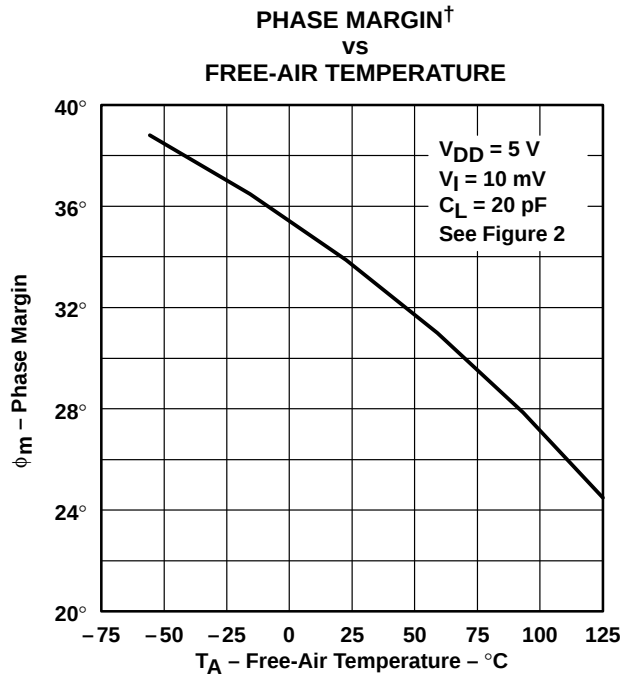


Figure 33

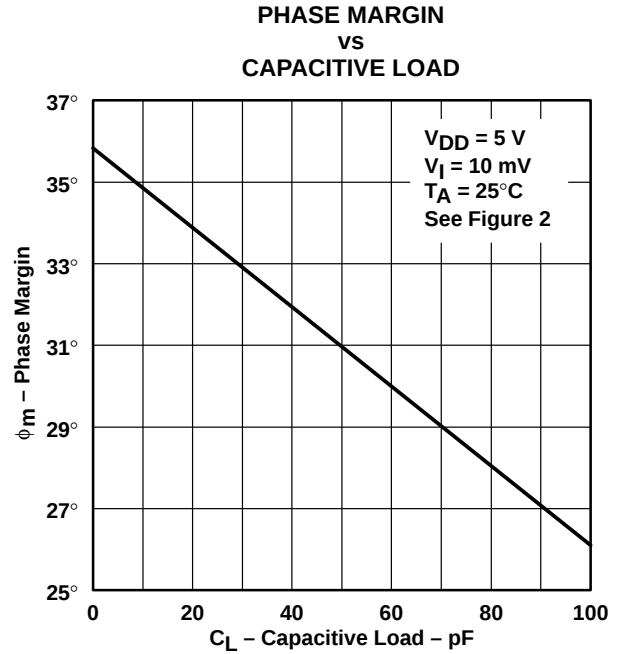


Figure 34

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TLC1078CD	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	1078C
TLC1078CD.A	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	1078C
TLC1078CDR	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	1078C
TLC1078CDR.A	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	1078C
TLC1078CP	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	TLC1078CP
TLC1078CP.A	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	TLC1078CP
TLC1078ID	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	1078I
TLC1078ID.A	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	1078I
TLC1078IDR	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	1078I
TLC1078IDR.A	Active	Production	SOIC (D) 8	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	1078I
TLC1078IP	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 85	TLC1078IP
TLC1078IP.A	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 85	TLC1078IP
TLC1079CD	Active	Production	SOIC (D) 14	50 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC1079C
TLC1079CD.A	Active	Production	SOIC (D) 14	50 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC1079C
TLC1079CDR	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-	TLC1079C
TLC1079CDR.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC1079C
TLC1079CN	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-	TLC1079CN
TLC1079CN.A	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	TLC1079CN
TLC1079ID	Active	Production	SOIC (D) 14	50 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-	TLC1079I
TLC1079ID.A	Active	Production	SOIC (D) 14	50 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC1079I
TLC1079IDR	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-	TLC1079I
TLC1079IDR.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC1079I
TLC1079IN	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-	TLC1079IN
TLC1079IN.A	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	TLC1079IN

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC1078CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC1078IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC1079CDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC1079IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

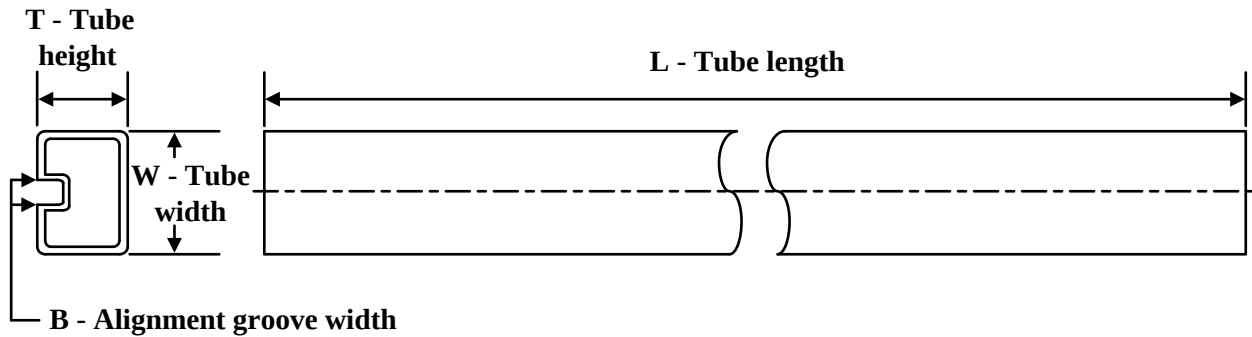
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC1078CDR	SOIC	D	8	2500	353.0	353.0	32.0
TLC1078IDR	SOIC	D	8	2500	353.0	353.0	32.0
TLC1079CDR	SOIC	D	14	2500	350.0	350.0	43.0
TLC1079IDR	SOIC	D	14	2500	350.0	350.0	43.0

TUBE

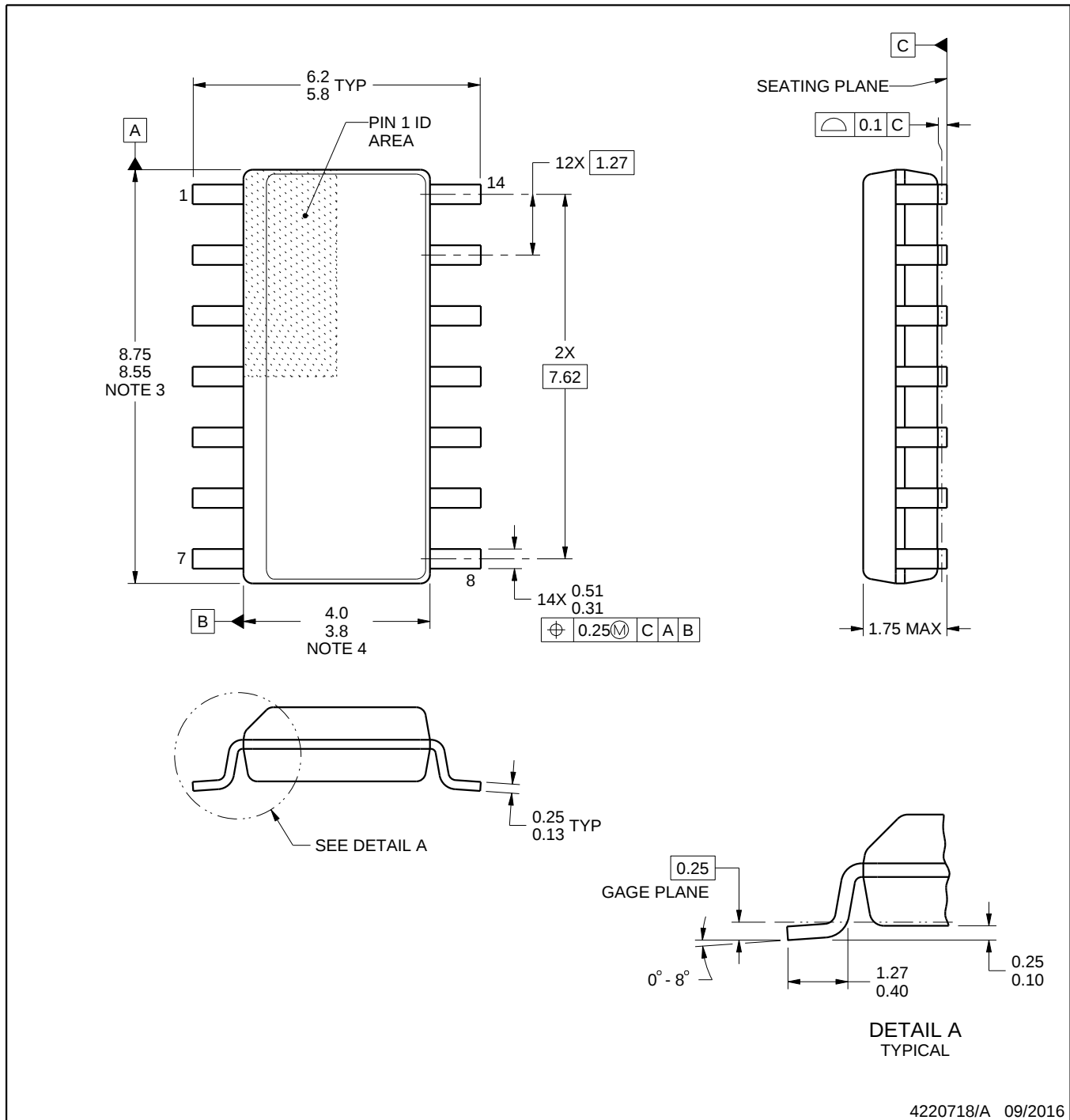


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
TLC1078CD	D	SOIC	8	75	505.46	6.76	3810	4
TLC1078CD	D	SOIC	8	75	507	8	3940	4.32
TLC1078CD.A	D	SOIC	8	75	505.46	6.76	3810	4
TLC1078CD.A	D	SOIC	8	75	507	8	3940	4.32
TLC1078CP	P	PDIP	8	50	506	13.97	11230	4.32
TLC1078CP.A	P	PDIP	8	50	506	13.97	11230	4.32
TLC1078ID	D	SOIC	8	75	505.46	6.76	3810	4
TLC1078ID	D	SOIC	8	75	507	8	3940	4.32
TLC1078ID.A	D	SOIC	8	75	505.46	6.76	3810	4
TLC1078ID.A	D	SOIC	8	75	507	8	3940	4.32
TLC1078IP	P	PDIP	8	50	506	13.97	11230	4.32
TLC1078IP.A	P	PDIP	8	50	506	13.97	11230	4.32
TLC1079CD	D	SOIC	14	50	505.46	6.76	3810	4
TLC1079CD.A	D	SOIC	14	50	505.46	6.76	3810	4
TLC1079CN	N	PDIP	14	25	506	13.97	11230	4.32
TLC1079CN.A	N	PDIP	14	25	506	13.97	11230	4.32
TLC1079ID	D	SOIC	14	50	505.46	6.76	3810	4
TLC1079ID.A	D	SOIC	14	50	505.46	6.76	3810	4
TLC1079IN	N	PDIP	14	25	506	13.97	11230	4.32
TLC1079IN.A	N	PDIP	14	25	506	13.97	11230	4.32

D0014A**PACKAGE OUTLINE****SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT

**NOTES:**

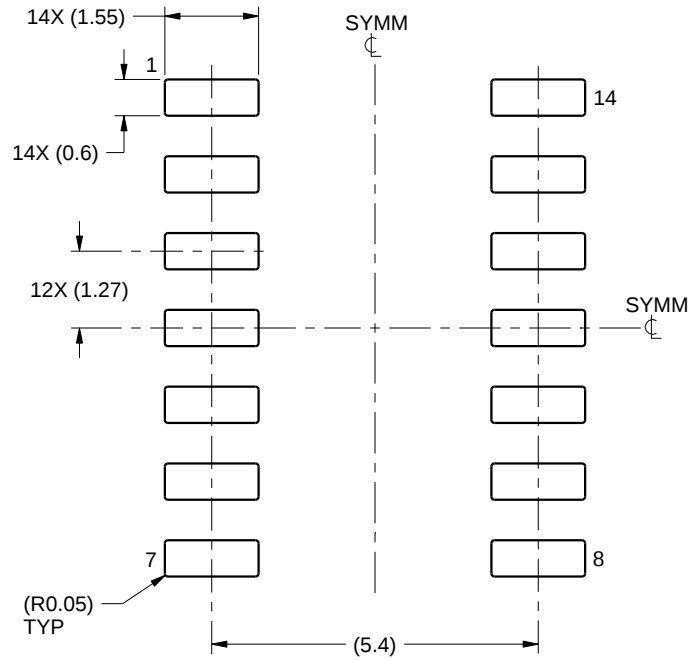
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.

EXAMPLE BOARD LAYOUT

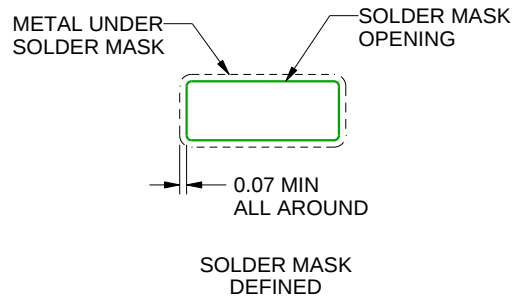
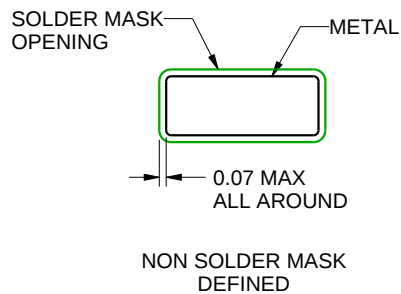
D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:8X

4220718/A 09/2016

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE

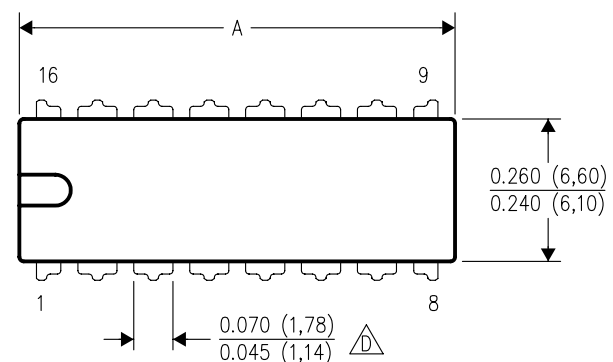


- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MS-001 variation BA.

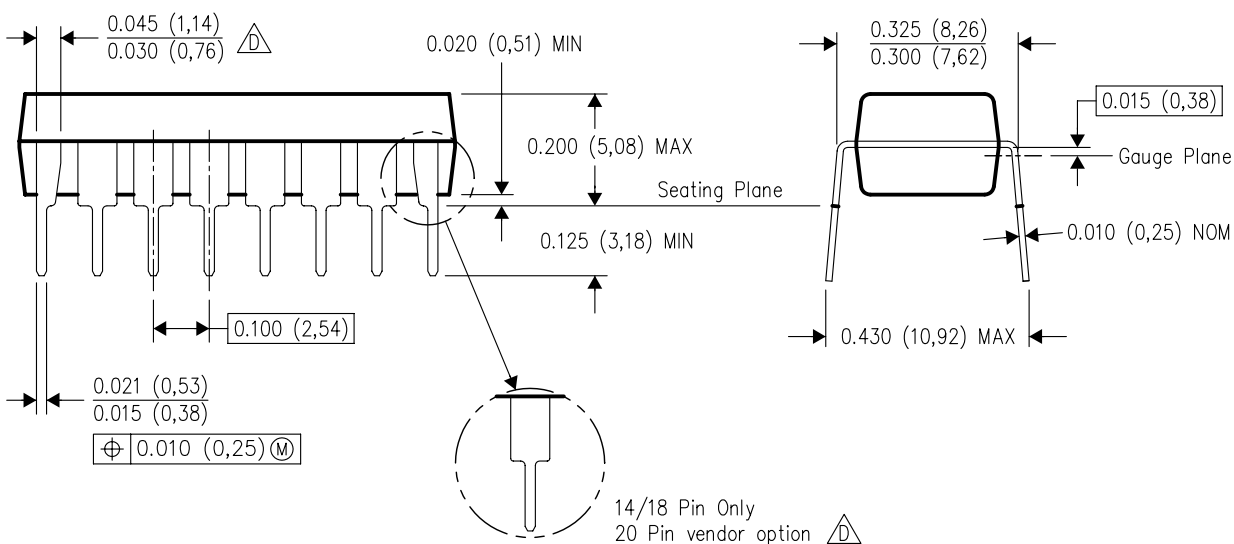
N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD



4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 -  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 -  The 20 pin end lead shoulder width is a vendor option, either half or full width.

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