

FEATURES

- 17 μ A Max Supply Current per Amplifier
- 70 μ V Max Offset Voltage
- 250pA Max Offset Current
- 5nA Max Input Bias Current
- 0.9 μ V_{P-P} 0.1Hz to 10Hz Voltage Noise
- 1.5pA_{P-P} 0.1Hz to 10Hz Current Noise
- 0.5 μ V/ $^{\circ}$ C Offset Voltage Drift
- 85kHz Gain-Bandwidth Product
- 0.04V/ μ s Slew Rate
- Single Supply Operation:
 - Input Voltage Range Includes Ground
 - Output Swings to Ground While Sinking Current
 - No Pull Down Resistors are Needed
- Output Sources and Sinks 5mA Load Current

APPLICATIONS

- Battery or Solar Powered Systems
 - Portable Instrumentation
 - Remote Sensor Amplifier
 - Satellite Circuitry
- Micropower Sample-and-Hold
- Thermocouple Amplifier
- Micropower Filters

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DESCRIPTION

The LT[®]1178 is a micropower dual op amp in the standard 8-pin configuration; the LT1179 is a micropower quad op amp offered in the standard 14-pin packages. Both devices are optimized for single supply operation at 5V. Specifications are also provided at ± 15 V supplies.

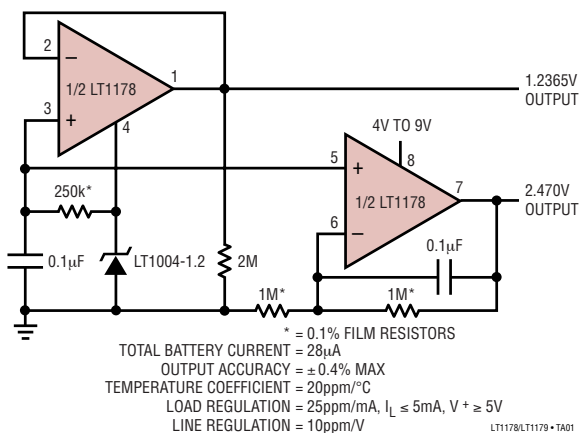
The extremely low supply current is combined with true precision specifications: offset voltage is 30 μ V, offset current is 50pA. Both offset parameters have low drift with temperature. The 1.5pA_{P-P} current noise and picoampere offset current permit the use of megaohm level source resistors without introducing serious errors. Voltage noise, at 0.9 μ V_{P-P}, is remarkably low considering the low supply current.

Both the LT1178 and LT1179 can be operated from a single supply (as low as one lithium cell or two NiCd batteries). The input range goes below ground. The all-NPN output stage swings to within a few millivolts of ground while sinking current—no power consuming pull down resistors are needed.

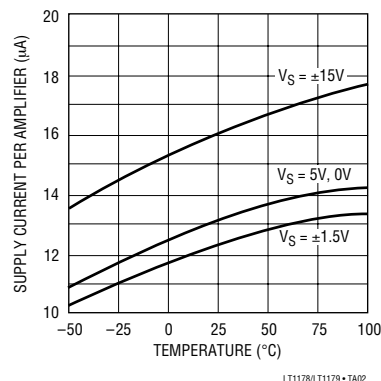
For applications where three times higher supply current is acceptable, the micropower LT1077 single, LT1078 dual and LT1079 quad are recommended. The LT1077/78/79 have significantly higher bandwidth, slew rate, lower voltage noise and better output drive capability.

TYPICAL APPLICATION

Self-Buffered, Dual Output, Micropower Reference



Supply Current vs Temperature



LT1178/LT1179

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage $\pm 22\text{V}$
 Differential Input Voltage $\pm 30\text{V}$
 Input Voltage Equal to Positive Supply Voltage
 Input Voltage 5V Below Negative Supply Voltage
 Output Short-Circuit Duration Indefinite

Operating Temperature Range
 LT1178I/LT1179I -40°C to 85°C
 LT1178C/LT1178S/LT1179C/LT1179S 0°C to 70°C
 Storage Temperature Range -65°C to 150°C
 Lead Temperature (Soldering, 10 sec.) 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW OUT A 1 -IN A 2 IN A 3 V- 4 +IN B 5 -IN B 6 OUT B 7 V+ 8 H PACKAGE 8-LEAD TO-5 METAL CAN	ORDER PART NUMBER LT1178ACH LT1178CH	TOP VIEW OUT A 1 -IN A 2 +IN A 3 V- 4 OUT B 7 -IN B 6 -IN B 5 +IN B 8 N PACKAGE 8-LEAD PDIP $T_{JMAX} = 100^{\circ}\text{C}$, $\theta_{JA} = 150^{\circ}\text{C/W}$ J PACKAGE 8-LEAD CERDIP	ORDER PART NUMBER LT1178ACN8 LT1178CN8 LT1178IN8	TOP VIEW +IN A 1 V- 2 +IN B 3 -IN B 4 -IN A 8 OUT A 7 OUT B 6 V+ 5 S8 PACKAGE 8-LEAD PLASTIC SO $T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 200^{\circ}\text{C/W}$	ORDER PART NUMBER LT1178S8 PART MARKING 1178
TOP VIEW OUT A 1 -IN A 2 +IN A 3 V+ 4 +IN B 5 -IN B 6 OUT B 7 OUT C 8 -IN C 9 +IN C 10 V- 11 +IN D 12 -IN D 13 OUT D 14 N PACKAGE 14-LEAD PDIP $T_{JMAX} = 110^{\circ}\text{C}$, $\theta_{JA} = 130^{\circ}\text{C/W}$ J PACKAGE 14-LEAD CERAMIC DIP	ORDER PART NUMBER LT1179ACN LT1179CN LT1179IN	Not Recommended. Use LT1178S8 for New Designs. TOP VIEW NC 1 OUT A 2 -IN A 3 IN A 4 V- 5 +IN B 6 -IN B 7 OUT B 8 NC 9 V+ 10 +IN C 11 -IN C 12 OUT C 13 NC 14 -IN D 15 OUT D 16 SW PACKAGE 16-LEAD PLASTIC SO WIDE $T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 90^{\circ}\text{C/W}$	ORDER PART NUMBER LT1178SW LT1179SW	TOP VIEW OUT A 1 -IN A 2 +IN A 3 V+ 4 +IN B 5 -IN B 6 OUT B 7 OUT C 8 -IN C 9 +IN C 10 V- 11 +IN D 12 -IN D 13 OUT D 14 NC 15 NC 16 SW PACKAGE 16-LEAD PLASTIC SO WIDE $T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 90^{\circ}\text{C/W}$	

LT11778/1179 • PO10

Consult LTC Marketing for parts specified with wider operating temperature ranges. Please note that the LT1178S8 surface mount pinout differs from that of the LT1178 standard plastic or ceramic dual-in-line packages. For similar performance with standard pinout, see the LT2178.

ELECTRICAL CHARACTERISTICS $V_S = 5\text{V}$, 0V ; $V_{CM} = 0.1\text{V}$, $V_O = 1.4\text{V}$, $T_A = 25^{\circ}\text{C}$, unless noted.

SYMBOL	PARAMETER	CONDITIONS (NOTE 2)	LT1178AC/LT1179AC			LT1178I/C/S/LT1179I/C/S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1178		30	70		40	120	μV
		LT1179		35	100		40	150	μV
		LT1178SW					80	450	μV
		LT1179SW					90	600	μV
		LT1178S8					60	180	μV
$\frac{\Delta V_{OS}}{\Delta \text{Time}}$	Long Term Input Offset Voltage Stability			0.5			0.6		$\mu\text{V/Mo}$
I_{OS}	Input Offset Current			0.05	0.25		0.05	0.35	nA

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ELECTRICAL CHARACTERISTICS

$V_S = 5V, 0V; V_{CM} = 0.1V, V_O = 1.4V, T_A = 25^\circ C$, unless noted.

SYMBOL	PARAMETER	CONDITIONS (NOTE 2)	LT1178AC/LT1179AC			LT1178I/C/S/LT1179I/C/S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
I_B	Input Bias Current			3	5		3	6	nA
e_n	Input Noise Voltage	0.1Hz to 10Hz (Note 3)		0.9	2.0		0.9		μV_{P-P}
	Input Noise Voltage Density	$f_0 = 10Hz$ (Note 3) $f_0 = 1000Hz$ (Note 3)		50 49	75 65		50 49		$nV/\sqrt{Hz}$ $nV/\sqrt{Hz}$
i_n	Input Noise Current	0.1Hz to 10Hz (Note 3)		1.5	2.5		1.5		pA _{p-p}
	Input Noise Current Density	$f_0 = 10Hz$ (Note 3) $f_0 = 1000Hz$		0.03 0.01	0.07		0.03 0.01		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
	Input Resistance Differential Mode Common Mode	(Note 4)	0.8	2.0 12		0.6	2.0 12		$G\Omega$ $G\Omega$
	Input Voltage Range		3.5 0	3.9 -0.3		3.5 0	3.9 -0.3		V V
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0V$ to 3.5V	93	103		90	102		dB
PSRR	Power Supply Rejection Ratio	$V_S = 2.2V$ to 12V	94	104		92	104		dB
A_{VOL}	Large Signal Voltage Gain	$V_O = 0.03V$ to 4V, No Load (Note 4) $V_O = 0.03V$ to 3.5V, $R_L = 50k$	140 80	700 200		110 70	700 200		V/mV V/mV
	Maximum Output Voltage Swing	Output Low, No Load Output Low, 2k to GND Output Low, $I_{SINK} = 100\mu A$ Output High, No Load Output High 2k to GND		6.5 0.2 120 4.2 3.5	9 0.6 160		6.5 0.2 120 4.4 3.8		mV mV mV V V
SR	Slew Rate	$A_V = 1, C_L = 10pF$ (Note 4)	0.013	0.025		0.013	0.025		V/ μs
GBW	Gain Bandwidth Product	$f_0 \leq 5kHz$		60			60		kHz
I_S	Supply Current per Amplifier	$V_S = \pm 1.5V, V_O = 0V$		13 12	18 17		14 13	21 20	μA μA
	Channel Separation	$\Delta V_{IN} = 3V, R_L = 10k$		130			130		dB
	Minimum Supply Voltage	(Note 5)		2.0	2.2		2.0	2.2	V

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range of $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ for I grades, $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ for SW grades, $V_S = 5\text{V}$, 0V ; $V_{CM} = 0.1\text{V}$, $V_O = 1.4\text{V}$, unless noted. (Note 7)

SYMBOL	PARAMETER	CONDITIONS		LT1178I/LT1179I			LT1178SW/LT1179SW			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1178 LT1179	● ●		80 80	315 345	120 130	650 800		μV μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 6)	●		0.6	3.0	0.8	4.5		$\mu\text{V}/^{\circ}\text{C}$
I_{OS}	Input Offset Current		●		0.07	0.7	0.06	0.50		nA
I_B	Input Bias Current		●		4	8	3	7		nA
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0.05\text{V}$ to 3.2V I grade $V_{CM} = 0\text{V}$ to 3.4V S grade	●	84	98		86	100		dB
PSRR	Power Supply Rejection Ratio	$V_S = 3.0\text{V}$ to 12V I grade $V_S = 2.5\text{V}$ to 12V S grade	●	86	100		88	102		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = 0.05\text{V}$ to 4V , No Load (Note 4) $V_O = 0.05\text{V}$ to 3.5V , $R_L = 50\text{k}$	● ●	55 35	350 130		80 45	500 160		V/mV V/mV
	Maximum Output Voltage Swing	Output Low, No Load Output Low, $I_{SINK} = 100\mu\text{A}$ Output High, No Load Output High, 2k to GND	● ● ● ●		9 160 4.2 3.7	13 220		8 140 4.3 3.8	11 190	mV mV V V
I_S	Supply Current per Amplifier		●		15	27	15	24		μA

The ● denotes specifications which apply over the full operating temperature range of $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$, $V_S = 5\text{V}$, 0V , $V_{CM} = 0.1\text{V}$, $V_O = 1.4\text{V}$, unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178AC/LT1179AC			LT1178C/S8/LT1179C			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1178 LT1178S8 LT1179	● ● ●		50 60	170 200	65 85 70	250 350 290		μV μV μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 6) LT1178S8	● ●		0.5	2.2	0.6 0.6	3.0 3.5		$\mu\text{V}/^{\circ}\text{C}$ $\mu\text{V}/^{\circ}\text{C}$
I_{OS}	Input Offset Current		●		0.06	0.35	0.06	0.50		nA
I_B	Input Bias Current		●		3	6	3	7		nA
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0\text{V}$ to 3.4V	●	90	101		86	100		dB
PSRR	Power Supply Rejection Ratio	$V_S = 2.5\text{V}$ to 12V	●	90	102		88	102		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = 0.05\text{V}$ to 4V , No Load (Note 4) $V_O = 0.05\text{V}$ to 3.5V , $R_L = 50\text{k}$	● ●	105 55	500 160		80 45	500 160		V/mV V/mV
	Maximum Output Voltage Swing	Output Low, No Load Output Low, $I_{SINK} = 100\mu\text{A}$ Output High, No Load Output High, 2k to GND	● ● ● ●		8 140 4.3 3.8	11 190		8 140 4.3 3.8	11 190	mV mV V V
I_S	Supply Current per Amplifier		●		14	21	15	24		μA

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $T_A = 25^\circ C$, unless noted.

SYMBOL	PARAMETER	CONDITIONS	LT1178AC/LT1179AC			LT1178I/C/S/LT1179I/C/S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1178SW LT1179SW LT1178S8		80	350		100 150 160 120	480 900 1050 350	μV μV μV μV
I_{OS}	Input Offset Current			0.05	0.25		0.05	0.35	nA
I_B	Input Bias Current			3	5		3	6	nA
	Input Voltage Range		13.5 -15.0	13.9 -15.3		13.5 -15.0	13.9 -15.3		V V
CMRR	Common Mode Rejection Ratio	$V_{CM} = 13.5V, -15V$	97	106		94	106		dB
PSRR	Power Supply Rejection Ratio	$V_S = 5V, 0V$ to $\pm 18V$	96	112		94	112		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10V, R_L = 50k$ $V_O = \pm 10V$, No Load	300 600	1200 2500		250 400	1000 2500		V/mV V/mV
V_{OUT}	Maximum Output Voltage Swing	$R_L = 50k$ $R_L = 2k$	± 13.0 ± 11.0	± 14.2 ± 12.7		± 13.0 ± 11.0	± 14.2 ± 12.7		V V
SR	Slew Rate	$A_V = 1$	0.02	0.04		0.02	0.04		V/ μs
GBW	Gain Bandwidth Product	$f_0 \leq 5kHz$		85			85		kHz
I_S	Supply Current per Amplifier			16	21		17	25	μA

The ● denotes specifications which apply over the full operating temperature range of $-40^\circ C \leq T_A \leq 85^\circ C$ for I grades, $0^\circ C \leq T_A \leq 70^\circ C$ for SW grades, $V_S = \pm 15V$, unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178I/LT1179I			LT1178SW/LT1179SW			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1178 LT1179	● ●		130 130	740 740		190 200	1150 1300	μV μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 6)	●		0.7	4.0		0.9	5.5	$\mu V/^\circ C$
I_{OS}	Input Offset Current		●		0.07	0.7		0.06	0.35	nA
I_B	Input Bias Current		●		4	8		3	7	nA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10V, R_L = 50k$	●		100	500		150	750	V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = 13V, -14.9V$	●		88	103		91	104	dB
PSRR	Power Supply Rejection Ratio	$V_S = 5V, 0V$ to $\pm 18V$	●		88	109		91	110	dB
	Maximum Output Voltage Swing	$R_L = 5k$	●		± 11.0	± 13.5		± 11.0	± 13.5	V
I_S	Supply Current per Amplifier		●		19	30		18	28	μA

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range of $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$, $V_S = \pm 15\text{V}$, unless noted.

The ● denotes specifications which apply over the full operating temperature range of $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$, $V_S = \pm 15\text{V}$, unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178AC/LT1179AC			LT1178C/S8/LT1179C			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1178S8	●		100	480		130	660	μV
			●					150	540	μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 6) LT1178S8	●		0.6	2.8		0.7	4.0	$\mu\text{V}/^{\circ}\text{C}$
			●					0.7	3.8	$\mu\text{V}/^{\circ}\text{C}$
I_{OS}	Input Offset Current		●		0.06	0.35		0.06	0.35	nA
I_B	Input Bias Current		●		3	6		3	7	nA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10\text{V}$, $R_L = 50\text{k}$	●	200	800		150	750		V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = 13\text{V}$, -15V	●	94	104		91	104		dB
PSRR	Power Supply Rejection Ratio	$V_S = 5\text{V}$, 0V to $\pm 18\text{V}$	●	93	110		91	110		dB
	Maximum Output Voltage Swing	$R_L = 5\text{k}$	●	± 11.0	± 13.6		± 11.0	± 13.6		V
I_S	Supply Current per Amplifier		●		17	24		18	28	μA

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers; (i.e., out of 100 LT1179s, or 100 LT1178s, typically 240 op amps, or 120, will be better than the indicated specification).

Note 3: This parameter is tested on a sample basis only. All noise parameters are tested with $V_S = \pm 2.5$, $V_O = 0\text{V}$.

Note 4: This parameter is guaranteed by design and is not tested.

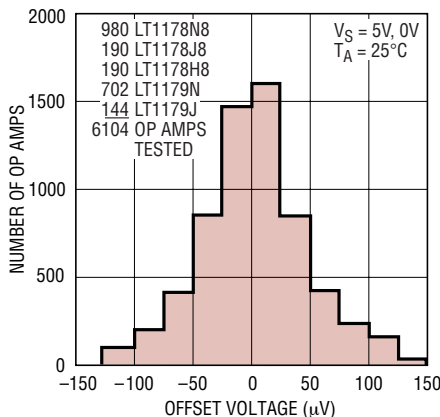
Note 5: Power supply rejection ratio is measured at the minimum supply voltage. The op amps actually work at 1.7V supply but with a typical offset skew of $-300\mu\text{V}$.

Note 6: This parameter is not 100% tested.

Note 7: During testing at -40°C , the 5V power supply turn on-time is less than 0.5 seconds.

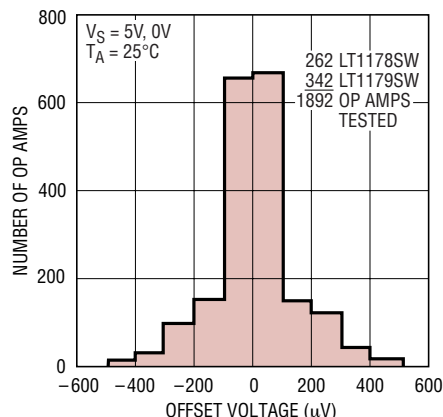
TYPICAL PERFORMANCE CHARACTERISTICS

Input Offset Voltage Distribution
N, J, H Package



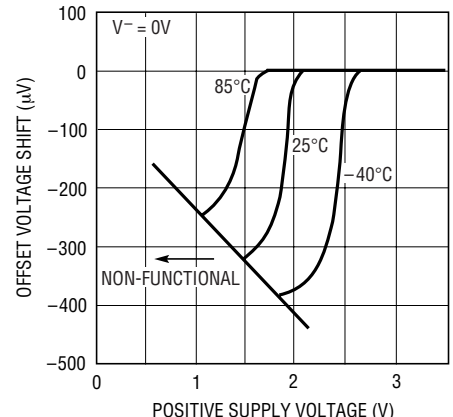
LT1178/LT1179 • TP001

Input Offset Voltage Distribution
Surface Mount Package



LT1178/LT1179 • TP002

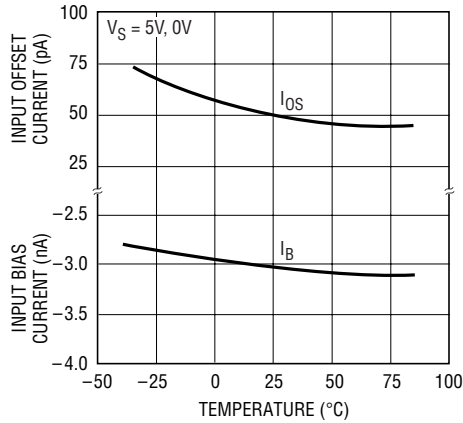
Minimum Supply Voltage



LT1178/LT1179 • TP003

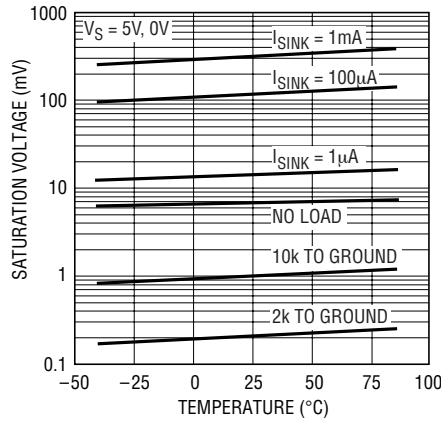
TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias and Offset Currents vs Temperature



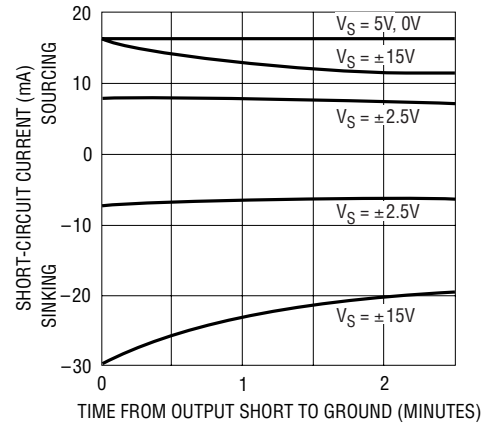
LT1178/LT1179 • TPC04

Output Saturation vs Temperature vs Sink Current



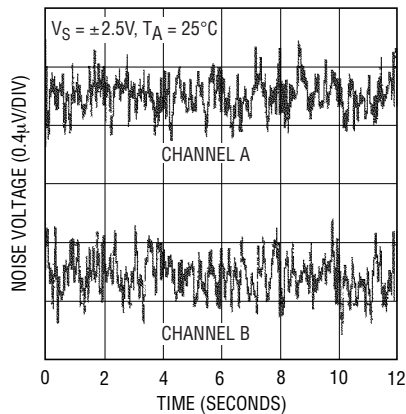
LT1178/LT1179 • TPC05

Short-Circuit Current



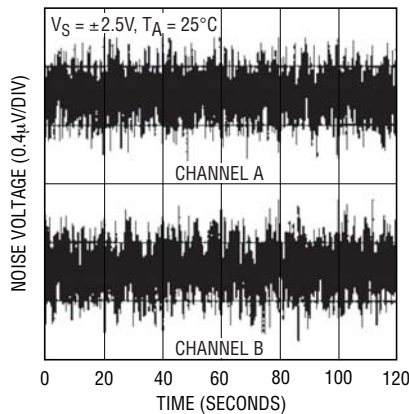
LT1178/LT1179 • TPC06

0.1Hz to 10Hz Noise



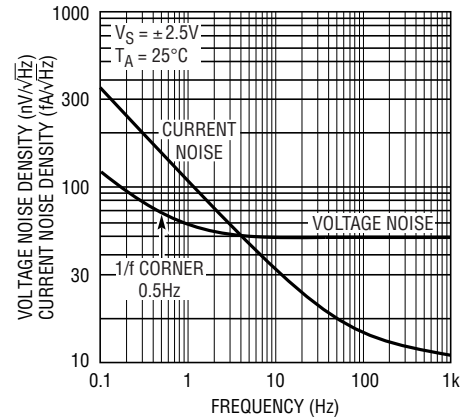
LT1178/LT1179 • TPC07

0.01Hz to 10Hz Noise



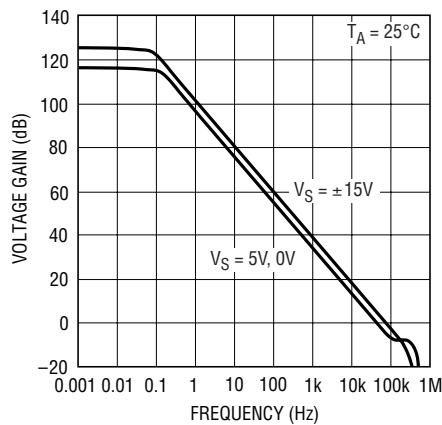
LT1178/LT1179 • TPC08

Noise Spectrum



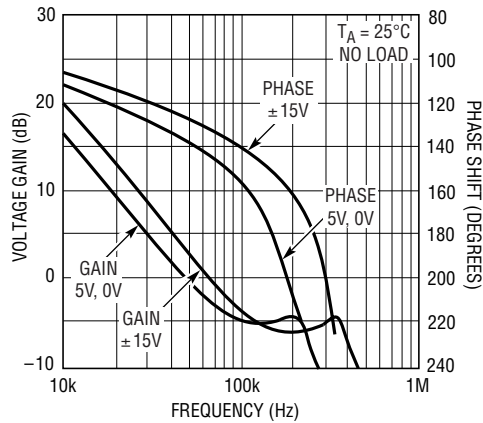
LT1178/LT1179 • TPC09

Voltage Gain vs Frequency



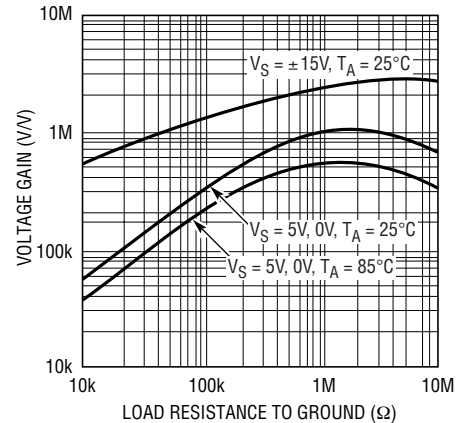
LT1178/LT1179 • TPC10

Gain, Phase vs Frequency



LT1178/LT1179 • TPC11

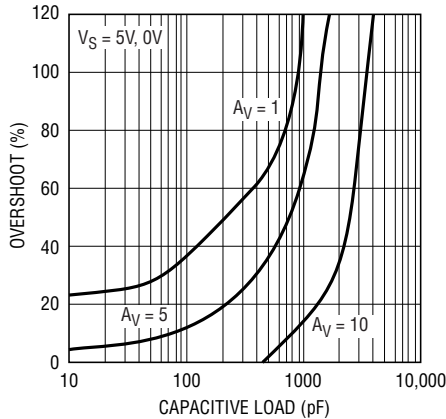
Voltage Gain vs Load Resistance



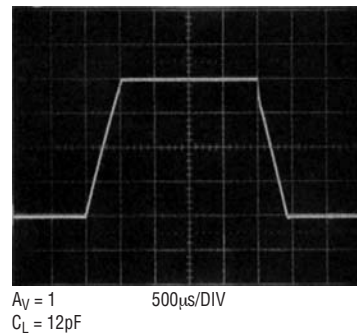
LT1178/LT1179 • TPC12

TYPICAL PERFORMANCE CHARACTERISTICS

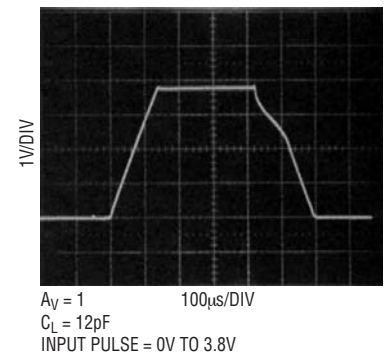
Capacitive Load Handling



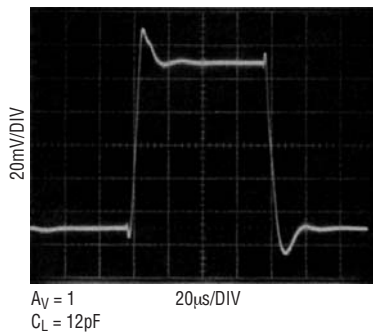
Large-Signal Transient Response
 $V_S = \pm 15V$



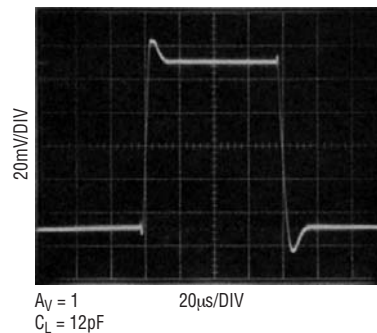
Large-Signal Transient Response
 $V_S = 5V, 0V$



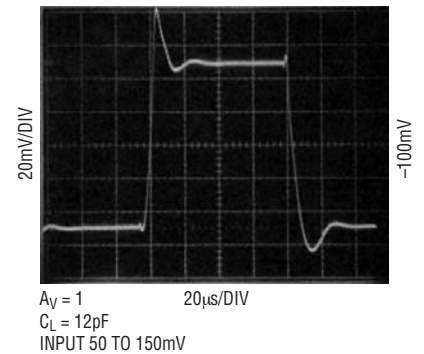
Small-Signal Transient Response
 $V_S = \pm 2.5V$



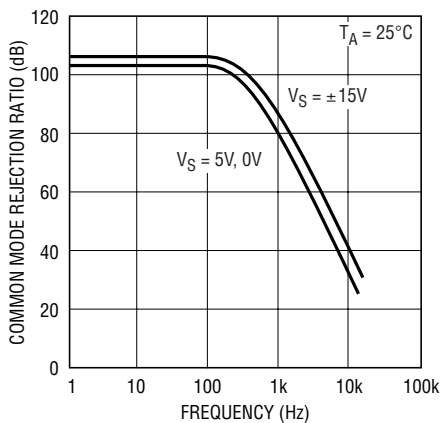
Small-Signal Transient Response
 $V_S = \pm 15V$



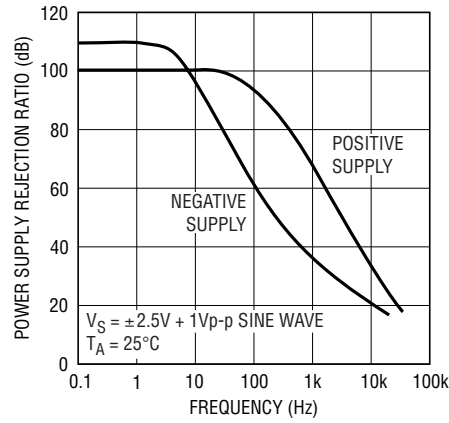
Small-Signal Transient Response
 $V_S = 5V, 0V$



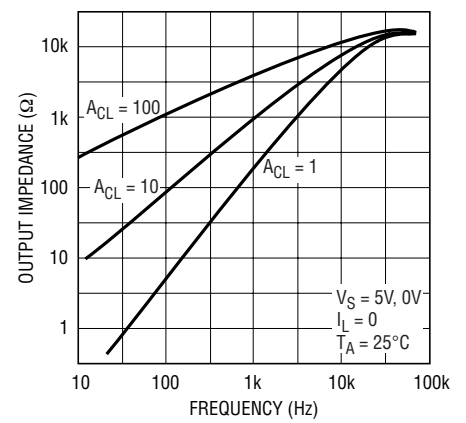
Common Mode Rejection Ratio vs Frequency



Power Supply Rejection Ratio vs Frequency



Closed Loop Output Impedance



supply operation and phase reversal protection are directly applicable to the LT1178/LT1179.

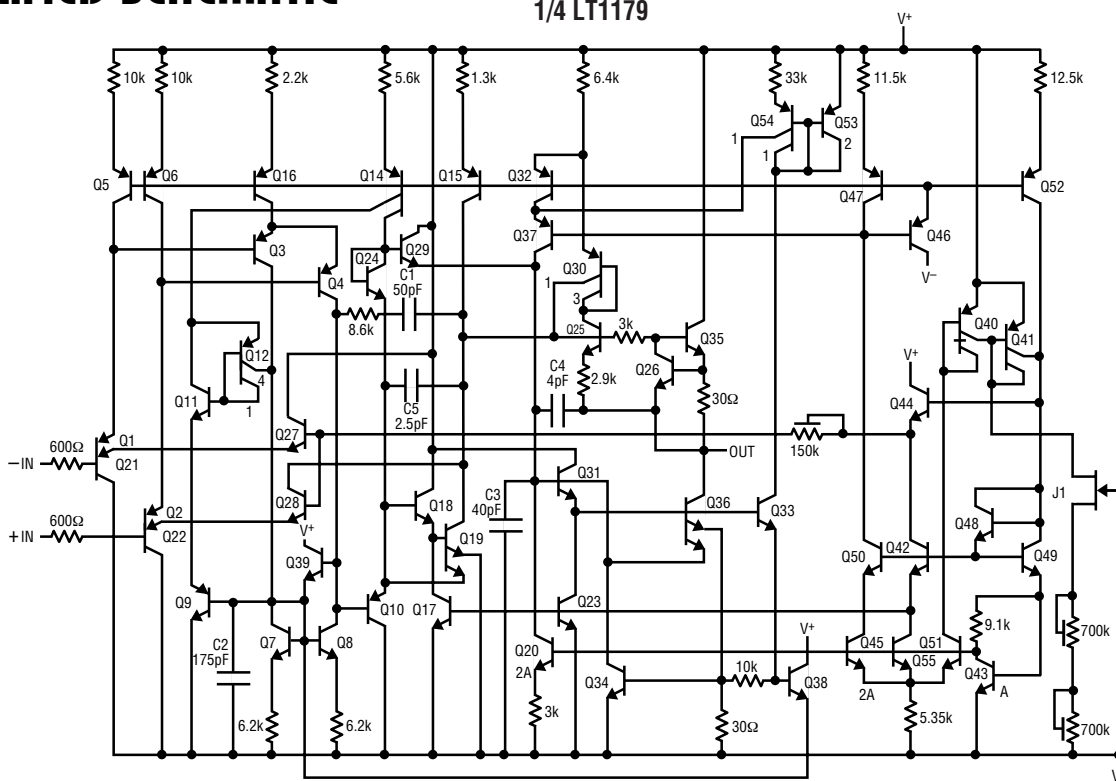
[illegible]

LINEARITY IS 0.02%
QUIESCENT CURRENT IS 90 μ A
SUPPLY CURRENT IS 360 μ A AT 1MHz
DRIFT = 50ppm/ $^{\circ}$ C
*TRW MTR/5 + 120ppm/ $^{\circ}$ C

LT1178/LT1179 • A10

SIMPLIFIED SCHEMATIC

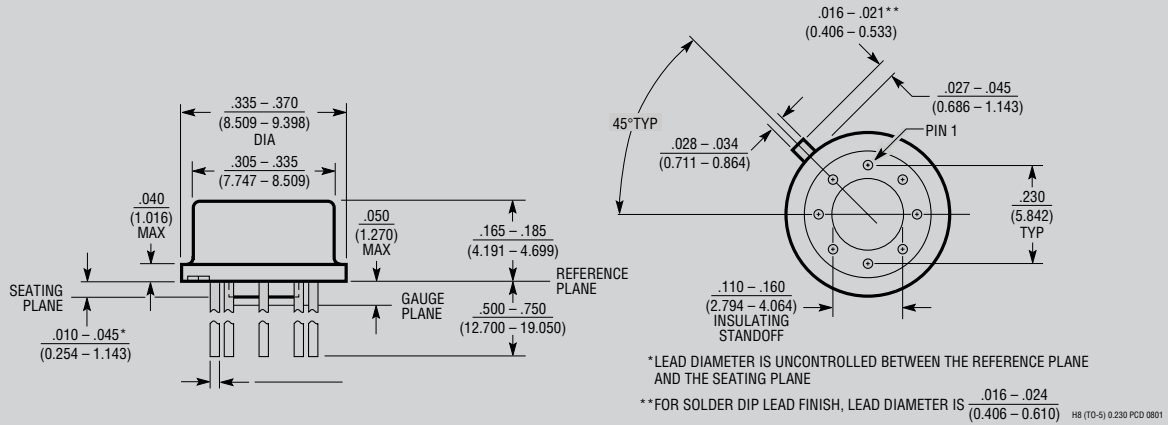
1/2 LT1178
1/4 LT1179



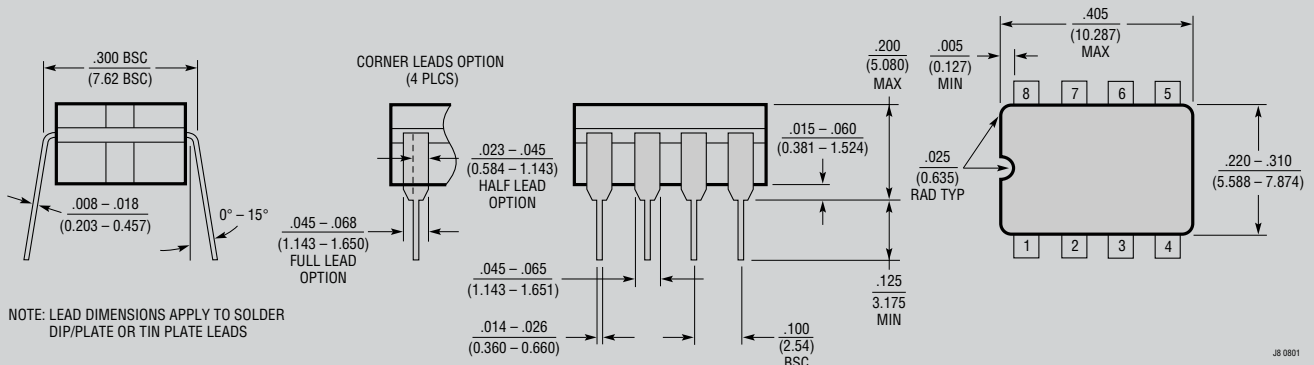
11789fb

PACKAGE DESCRIPTION

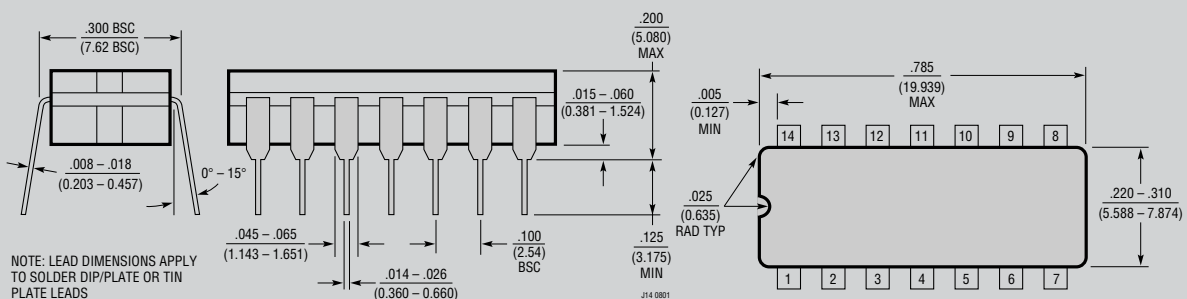
H Package
8-Lead TO-5 Metal Can (.230 Inch PCD)
 (Reference LTC DWG # 05-08-1321)



J8 Package
8-Lead Cerdip (Narrow .300 Inch, Hermetic)
 (Reference LTC DWG # 05-08-1110)



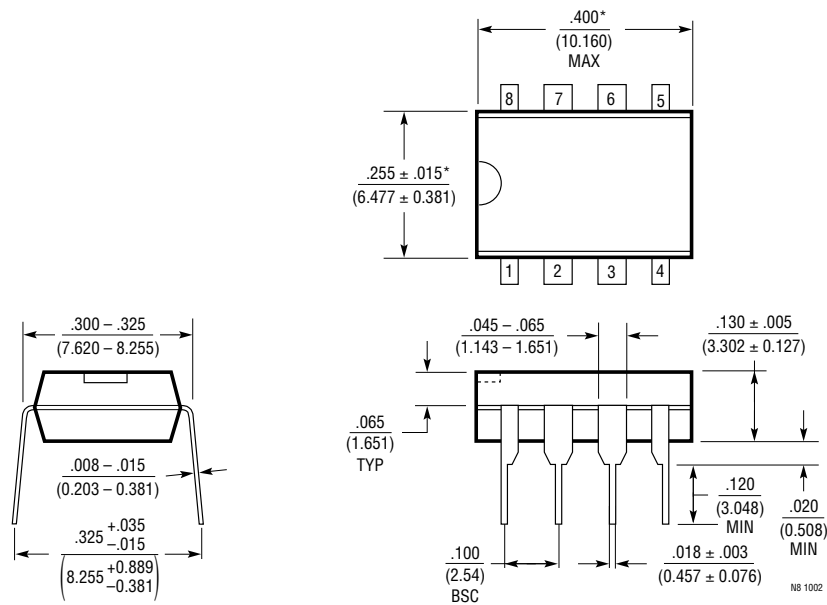
J Package
14-Lead Cerdip (Narrow .300 Inch, Hermetic)
 (Reference LTC DWG # 05-08-1110)



OBSOLETE PACKAGES

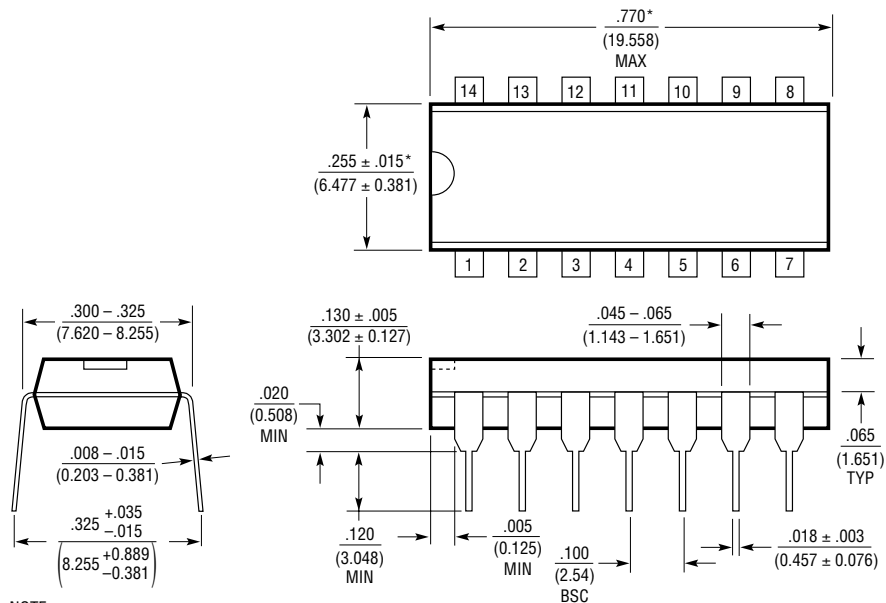
PACKAGE DESCRIPTION

N8 Package 8-Lead PDIP (Narrow .300 Inch) (Reference LTC DWG # 05-08-1510)



NOTE:
1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

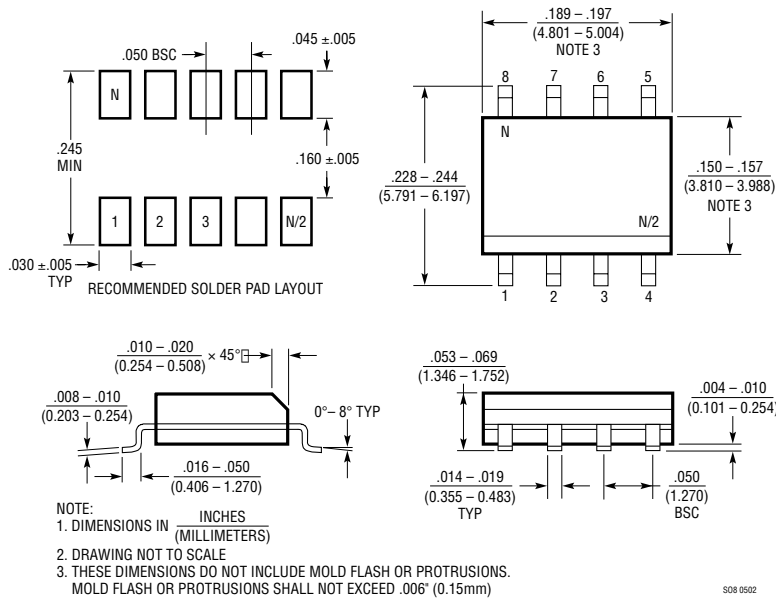
N Package 14-Lead PDIP (Narrow .300 Inch) (Reference LTC DWG # 05-08-1510)



NOTE:
1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

PACKAGE DESCRIPTION

S8 Package 8-Lead Plastic Small Outline (Narrow .150 Inch) (Reference LTC DWG # 05-08-1610)



SW Package 16-Lead Plastic Small Outline (Wide .300 Inch) (Reference LTC DWG # 05-08-1620)

