17μA Max, Dual and Quad, Single Supply, Precision Op Amps

FEATURES

- 17μA Max Supply Current per Amplifier
- 70μV Max Offset Voltage
- 250pA Max Offset Current
- 5nA Max Input Bias Current
- 0.9μV$_{P-P}$ 0.1Hz to 10Hz Voltage Noise
- 1.5pA$_{P-P}$ 0.1Hz to 10Hz Current Noise
- 0.5μV/°C Offset Voltage Drift
- 85kHz Gain-Bandwidth Product
- 0.04V/μs 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

LT, LTC and LT are registered trademarks of Linear Technology Corporation.

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 ±15V supplies.

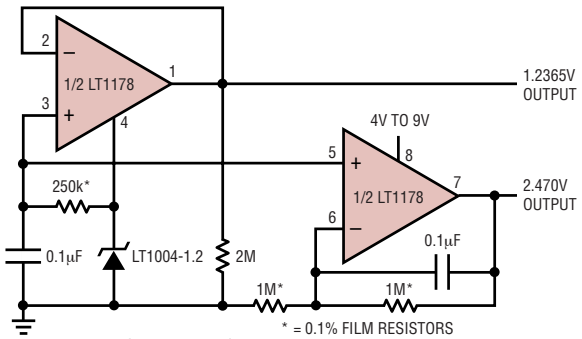
The extremely low supply current is combined with true precision specifications: offset voltage is 30μV, offset current is 50pA. Both offset parameters have low drift with temperature. The 1.5pAp-p current noise and picoampere offset current permit the use of megaohm level source resistors without introducing serious errors. Voltage noise, at 0.9μVp-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

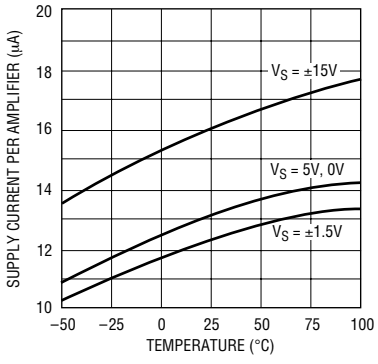
Self-Buffered, Dual Output, Micropower Reference



* = 0.1% FILM RESISTORS
TOTAL BATTERY CURRENT = 28μA
OUTPUT ACCURACY = ±0.4% MAX
TEMPERATURE COEFFICIENT = 20ppm/°C
LOAD REGULATION = 25ppm/mA, $I_L \leq 5mA$, $V^+ \geq 5V$
LINE REGULATION = 10ppm/V

LT1178/LT1179 • TA01

Supply Current vs Temperature



LT1178/LT1179 • TA02

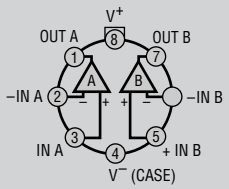
ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage ..... ±22V
Differential Input Voltage ..... ±30V
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

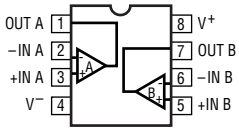


H PACKAGE
8-LEAD TO-5 METAL CAN

ORDER PART NUMBER

LT1178ACH
LT1178CH

TOP VIEW



N PACKAGE
8-LEAD PDIP
T_{JMAX} = 100°C, θ_{JA} = 150°C/W

J PACKAGE 8-LEAD CERDIP

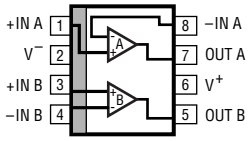
OBSOLETE PACKAGE
Consider the N8 or S8 Package for Alternate Source

ORDER PART NUMBER

LT1178ACN8
LT1178CN8
LT1178IN8

LT1178ACJ8
LT1178CJ8

TOP VIEW



S8 PACKAGE
8-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 200°C/W

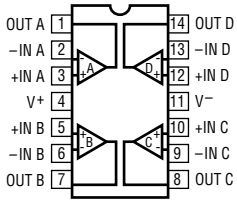
ORDER PART NUMBER

LT1178S8

PART MARKING

1178

TOP VIEW



N PACKAGE
14-LEAD PDIP
T_{JMAX} = 110°C, θ_{JA} = 130°C/W

J PACKAGE 14-LEAD CERAMIC DIP

OBSOLETE PACKAGE
Consider the N14 Package for Alternate Source

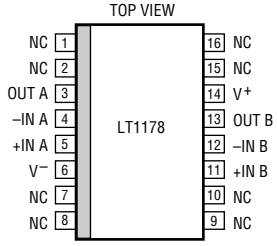
ORDER PART NUMBER

LT1179ACN
LT1179CN
LT1179IN

LT1179ACJ
LT1179CJ

Not Recommended. Use LT1178S8 for New Designs.

TOP VIEW

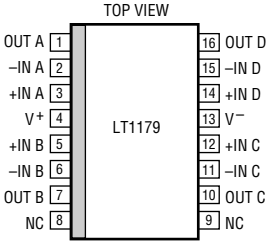


SW PACKAGE
16-LEAD PLASTIC SO WIDE
T_{JMAX} = 150°C, θ_{JA} = 90°C/W

ORDER PART NUMBER

LT1178SW
LT1179SW

TOP VIEW



SW PACKAGE
16-LEAD PLASTIC SO WIDE
T_{JMAX} = 150°C, θ_{JA} = 90°C/W

LT11778/1179 • POI01

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 similiar performance with standard pinout, see the LT2178.

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS (NOTE 2)	LT1178AC/LT1179AC MIN	LT1178AC/LT1179AC TYP	LT1178AC/LT1179AC MAX	LT1178I/C/S/LT1179I/C/S MIN	LT1178I/C/S/LT1179I/C/S TYP	LT1178I/C/S/LT1179I/C/S MAX	UNITS
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
$\frac{\Delta V_{OS}}{\Delta Time}$	Long Term Input Offset Voltage Stability			0.5			0.6		µV/Mo
I_{OS}	Input Offset Current			0.05	0.25		0.05	0.35	nA

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS (NOTE 2)	LT1178AC/LT1179AC MIN	LT1178AC/LT1179AC TYP	LT1178AC/LT1179AC MAX	LT1178I/C/S/LT1179I/C/S MIN	LT1178I/C/S/LT1179I/C/S TYP	LT1178I/C/S/LT1179I/C/S MAX	UNITS
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_O = 10Hz (Note 3) f_O = 1000Hz (Note 3)		50 49	75 65		50 49		nV/√Hz nV/√Hz
i_n	Input Noise Current	0.1Hz to 10Hz (Note 3)		1.5	2.5		1.5		pAp-p
	Input Noise Current Density	f_O = 10Hz (Note 3) f_O = 1000Hz		0.03 0.01	0.07		0.03 0.01		pA/√Hz pA/√Hz
	Input Resistance Differential Mode Common Mode	(Note 4)	 0.8	 2.0 12		 0.6	 2.0 12		 GΩ GΩ
	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} = 100μA Output High, No Load Output High 2k to GND	 4.2 3.5	6.5 0.2 120 4.4 3.8	9 0.6 160	 4.2 3.5	6.5 0.2 120 4.4 3.8	9 0.6 160	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_O ≤ 5kHz		60			60		kHz
I_S	Supply Current per Amplifier	 V_S = ±1.5V, V_O = 0V		13 12	18 17		14 13	21 20	μA μA
	Channel Separation	ΔV_{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°C ≤ T_A ≤ 85°C for I grades, 0°C ≤ T_A ≤ 70°C for SW grades, V_S = 5V, 0V; V_{CM} = 0.1V, V_O = 1.4V, unless noted. (Note 7)

SYMBOL	PARAMETER	CONDITIONS		LT1178I/LT1179I MIN	LT1178I/LT1179I TYP	LT1178I/LT1179I MAX	LT1178SW/LT1179SW MIN	LT1178SW/LT1179SW TYP	LT1178SW/LT1179SW MAX	UNITS
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	µV/°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} = 0.05V to 3.2V I grade V_{CM} = 0V to 3.4V S grade	●	84	98		86	100		dB
PSRR	Power Supply Rejection Ratio	V_S = 3.0V to 12V I grade V_S = 2.5V to 12V S grade	●	86	100		88	102		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 4V, No Load (Note 4) V_O = 0.05V to 3.5V, R_L = 50k	● ●	55 35	350 130		80 45	500 160		V/mV V/mV
	Maximum Output Voltage Swing	Output Low, No Load Output Low, I_{SINK} = 100µA Output High, No Load Output High, 2k to GND	● ● ● ●	 3.9 3.0	9 160 4.2 3.7	13 220	 4.1 3.3	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°C ≤ T_A ≤ 70°C, V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178AC/LT1179AC MIN	LT1178AC/LT1179AC TYP	LT1178AC/LT1179AC MAX	LT1178C/S8/LT1179C MIN	LT1178C/S8/LT1179C TYP	LT1178C/S8/LT1179C MAX	UNITS
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	µV/°C µV/°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} = 0V to 3.4V	●	90	101		86	100		dB
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 12V	●	90	102		88	102		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 4V, No Load (Note 4) V_O = 0.05V to 3.5V, R_L = 50k	● ●	105 55	500 160		80 45	500 160		V/mV V/mV
	Maximum Output Voltage Swing	Output Low, No Load Output Low, I_{SINK} = 100µA Output High, No Load Output High, 2k to GND	● ● ● ●	 4.1 3.3	8 140 4.3 3.8	11 190	 4.1 3.3	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 $V_S = \pm 15V$, $T_A = 25°C$, unless noted.

SYMBOL	PARAMETER	CONDITIONS	LT1178AC/LT1179AC MIN	LT1178AC/LT1179AC TYP	LT1178AC/LT1179AC MAX	LT1178I/C/S/LT1179I/C/S MIN	LT1178I/C/S/LT1179I/C/S TYP	LT1178I/C/S/LT1179I/C/S MAX	UNITS
V_{OS}	Input Offset Voltage			80	350		100	480	µV
		LT1178SW					150	900	µV
		LT1179SW					160	1050	µV
		LT1178S8					120	350	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	13.9		13.5	13.9		V
			–15.0	–15.3		–15.0	–15.3		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 ±18V	96	112		94	112		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = ±10V, R_L = 50k	300	1200		250	1000		V/mV
		V_O = ±10V, No Load	600	2500		400	2500		V/mV
V_{OUT}	Maximum Output Voltage Swing	R_L = 50k	±13.0	±14.2		±13.0	±14.2		V
		R_L = 2k	±11.0	±12.7		±11.0	±12.7		V
SR	Slew Rate	A_V = 1	0.02	0.04		0.02	0.04		V/µs
GBW	Gain Bandwidth Product	f_O ≤ 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 $-40°C \le T_A \le 85°C$ for I grades, $0°C \le T_A \le 70°C$ for SW grades, $V_S = \pm 15V$, unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178I/LT1179I MIN	LT1178I/LT1179I TYP	LT1178I/LT1179I MAX	LT1178SW/LT1179SW MIN	LT1178SW/LT1179SW TYP	LT1178SW/LT1179SW MAX	UNITS
V_{OS}	Input Offset Voltage	LT1178	●		130	740		190	1150	µV
		LT1179	●		130	740		200	1300	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 6)	●		0.7	4.0		0.9	5.5	µV/°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 = ±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 ±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°C ≤ T_A ≤ 70°C, V_S = ±15V, unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178AC/LT1179AC MIN	LT1178AC/LT1179AC TYP	LT1178AC/LT1179AC MAX	LT1178C/S8/LT1179C MIN	LT1178C/S8/LT1179C TYP	LT1178C/S8/LT1179C MAX	UNITS
V_{OS}	Input Offset Voltage		●		100	480		130	660	µV
		LT1178S8	●					150	540	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 6)	●		0.6	2.8		0.7	4.0	µV/°C
		LT1178S8	●					0.7	3.8	µV/°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 = ±10V, R_L = 50k	●	200	800		150	750		V/mV
CMRR	Common Mode Rejection Ratio	V_{CM} = 13V, –15V	●	94	104		91	104		dB
PSRR	Power Supply Rejection Ratio	V_S = 5V, 0V to ±18V	●	93	110		91	110		dB
	Maximum Output Voltage Swing	R_L = 5k	●	±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 = ±2.5, V_O = 0V.

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

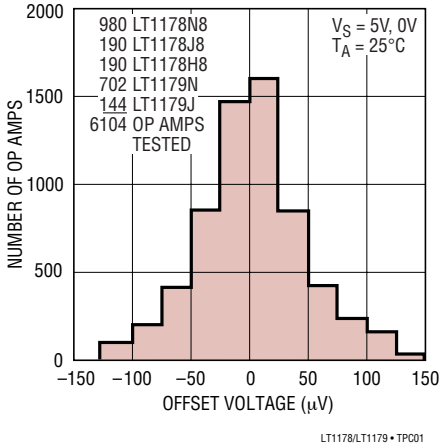
Note 5: Power supply rejection ratio is measured at the minimum supply voltage. The op amps actually work at 1.7V supply but with a typical offset skew of –300µV.

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.

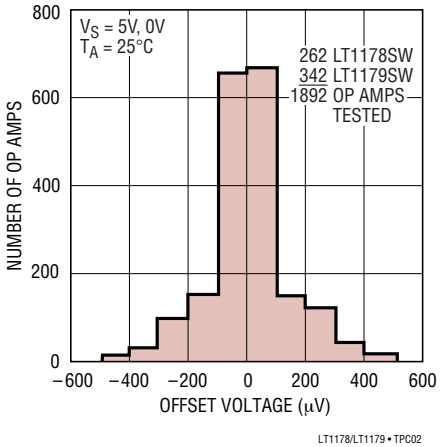
TYPICAL PERFORMANCE CHARACTERISTICS

Input Offset Voltage Distribution N, J, H Package



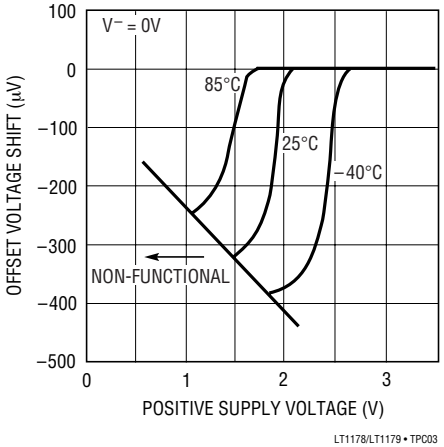
LT1178/LT1179 • TPC01

Input Offset Voltage Distribution Surface Mount Package



LT1178/LT1179 • TPC02

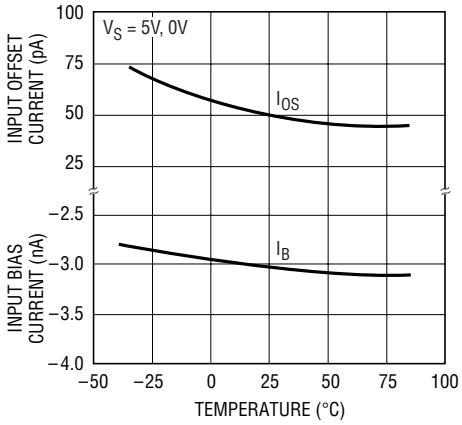
Minimum Supply Voltage



LT1178/LT1179 • TPC03

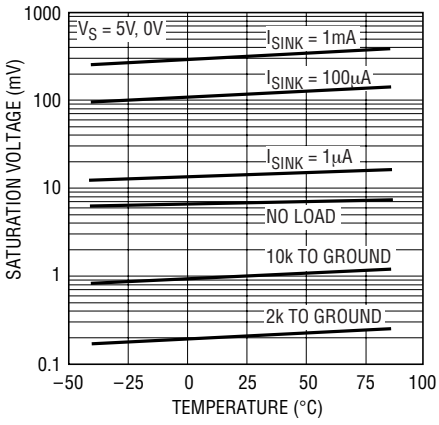
TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias and Offset Currents vs Temperature



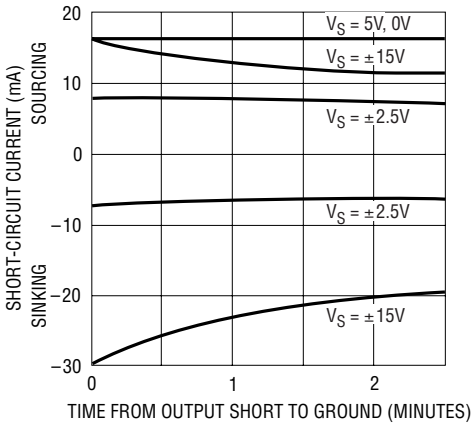
LT1178/LT1179 • TPC04

Output Saturation vs Temperature vs Sink Current



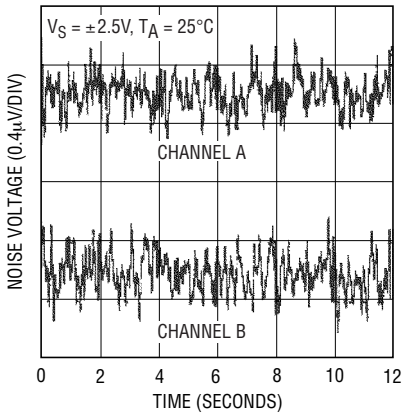
LT1178/LT1179 • TPC05

Short-Circuit Current



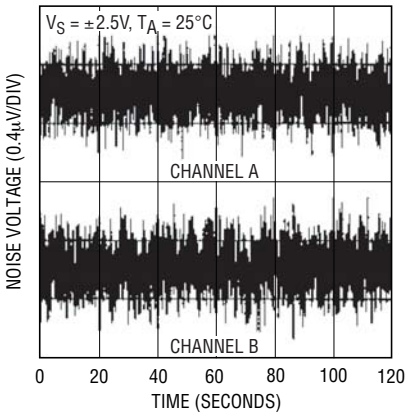
LT1178/LT1179 • TPC06

0.1Hz to 10Hz Noise



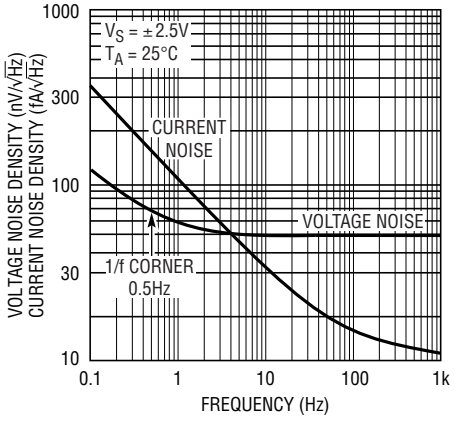
LT1178/LT1179 • TPC07

0.01Hz to 10Hz Noise



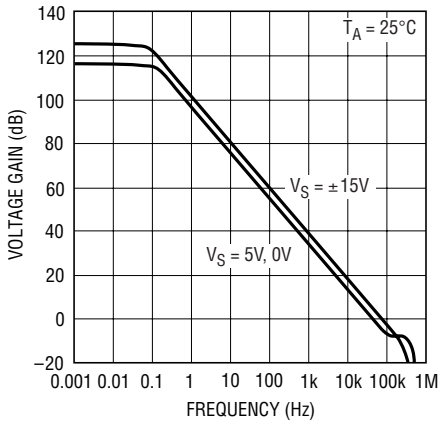
LT1178/LT1179 • TPC08

Noise Spectrum



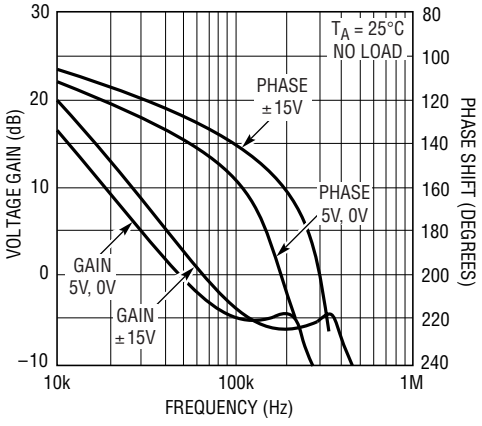
LT1178/LT1179 • TPC09

Voltage Gain vs Frequency



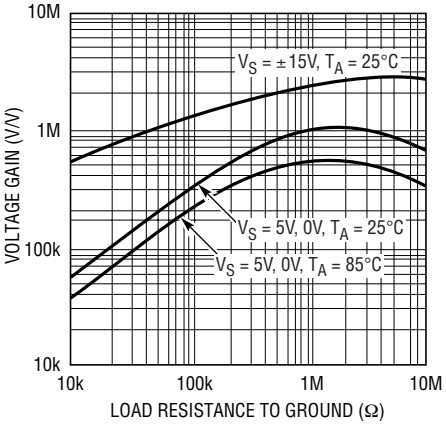
LT1178/LT1179 • TPC10

Gain, Phase vs Frequency



LT1178/LT1179 • TPC11

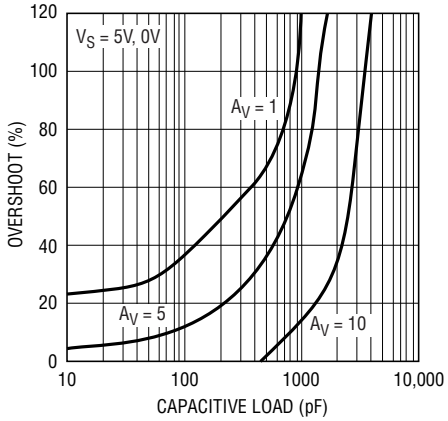
Voltage Gain vs Load Resistance



LT1178/LT1179 • TPC12

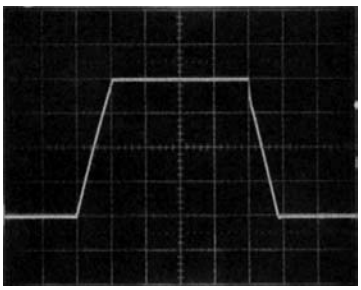
TYPICAL PERFORMANCE CHARACTERISTICS

Capacitive Load Handling



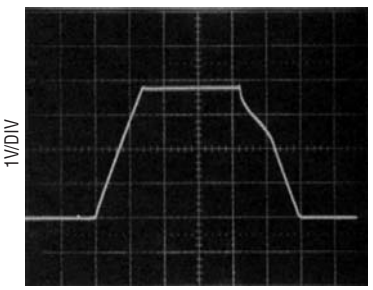
LT1178/LT1179 • TPC13

Large-Signal Transient Response V_S = ±15V



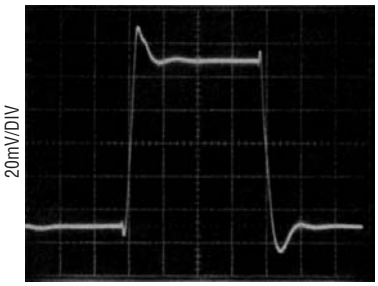
A_V = 1 500µs/DIV
C_L = 12pF

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



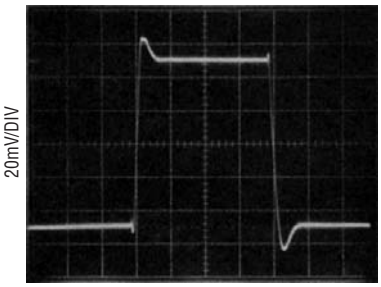
A_V = 1 100µs/DIV
C_L = 12pF
INPUT PULSE = 0V TO 3.8V

Small-Signal Transient Response V_S = ±2.5V



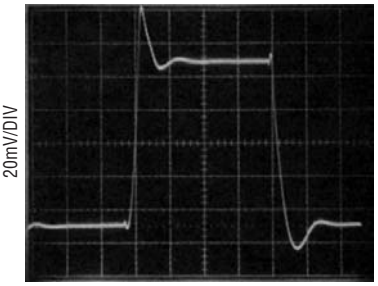
A_V = 1 20µs/DIV
C_L = 12pF

Small-Signal Transient Response V_S = ±15V



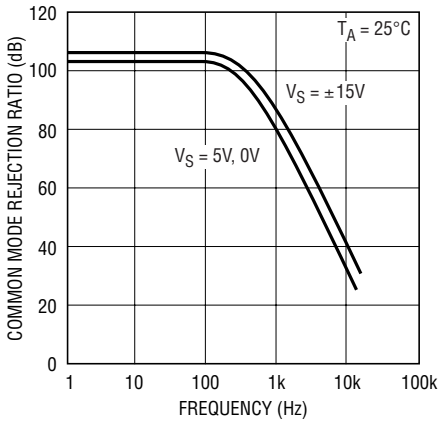
A_V = 1 20µs/DIV
C_L = 12pF

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



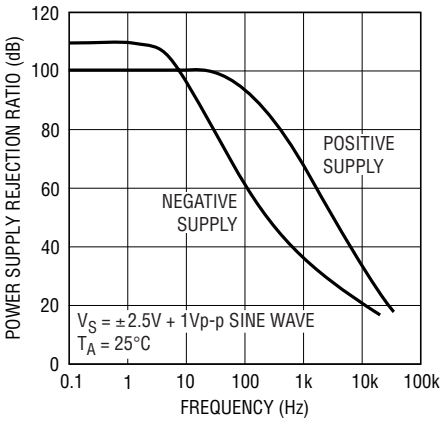
A_V = 1 20µs/DIV
C_L = 12pF
INPUT 50 TO 150mV

Common Mode Rejection Ratio vs Frequency



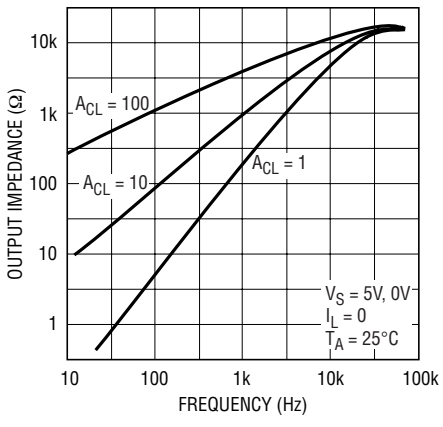
LT1178/LT1179 • TPC19

Power Supply Rejection Ratio vs Frequency



LT1188/LT1189 • TPC20

Closed Loop Output Impedance

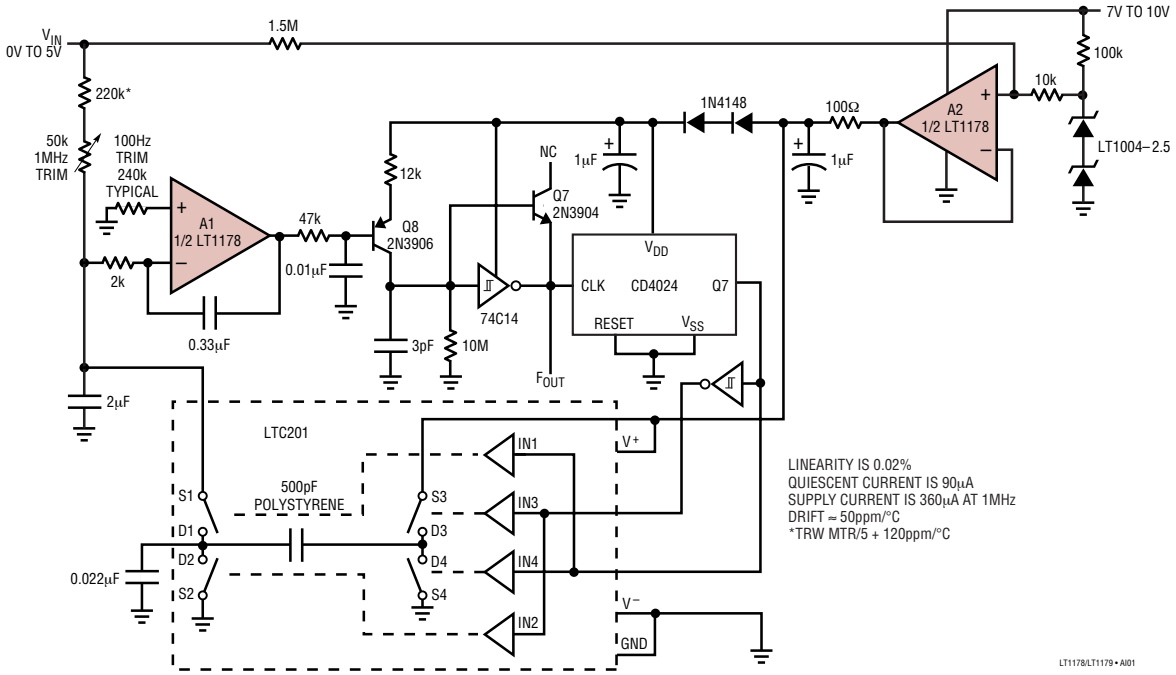


LT1178/1179 • TPC21

APPLICATIONS INFORMATION

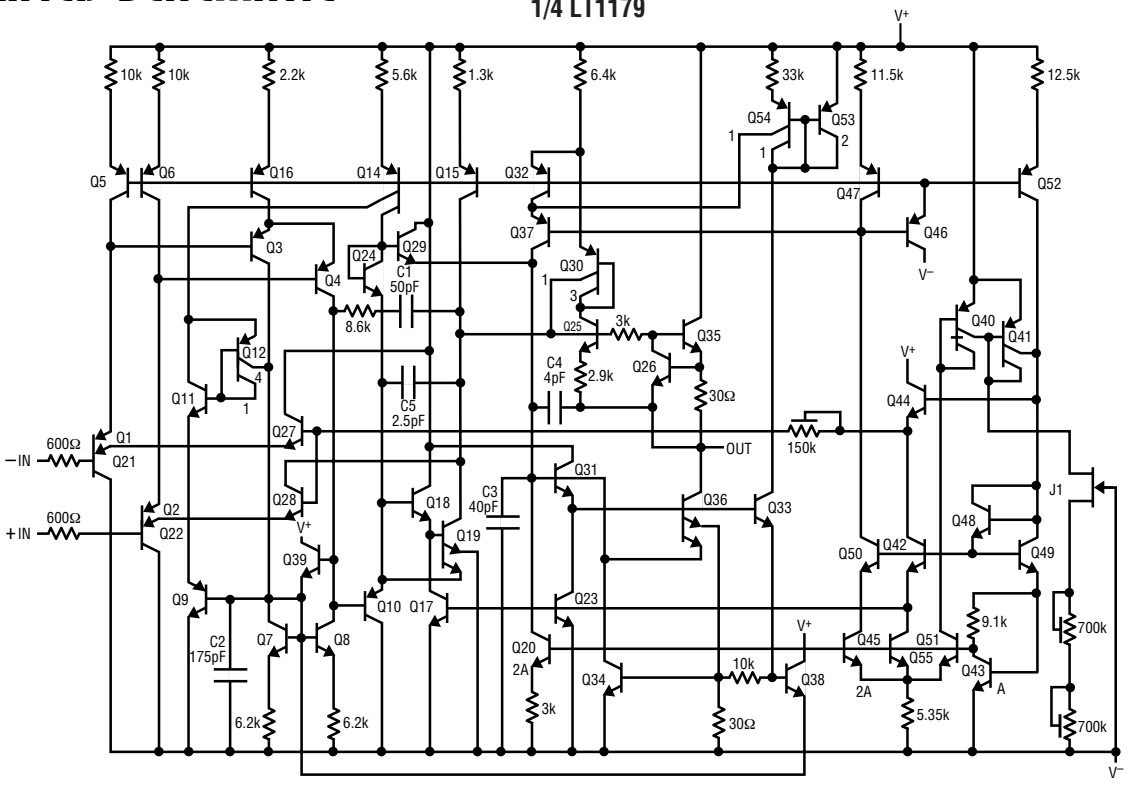
Please see the LT1078/LT1079 data sheet for applications information. All comments relating to specifications, single supply operation and phase reversal protection are directly applicable to the LT1178/LT1179.

Micropower 100Hz to 1MHz V-to-F Converter



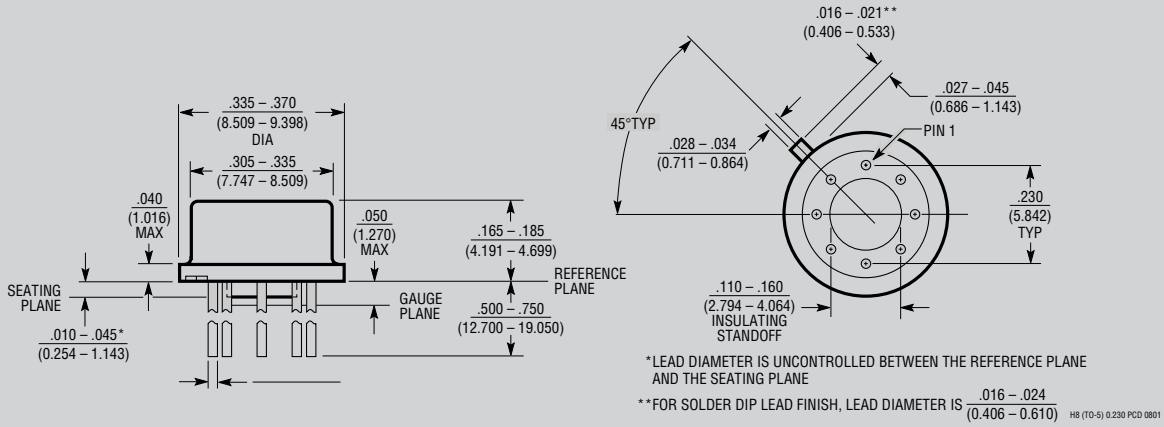
SIMPLIFIED SCHEMATIC

1/2 LT1178
1/4 LT1179

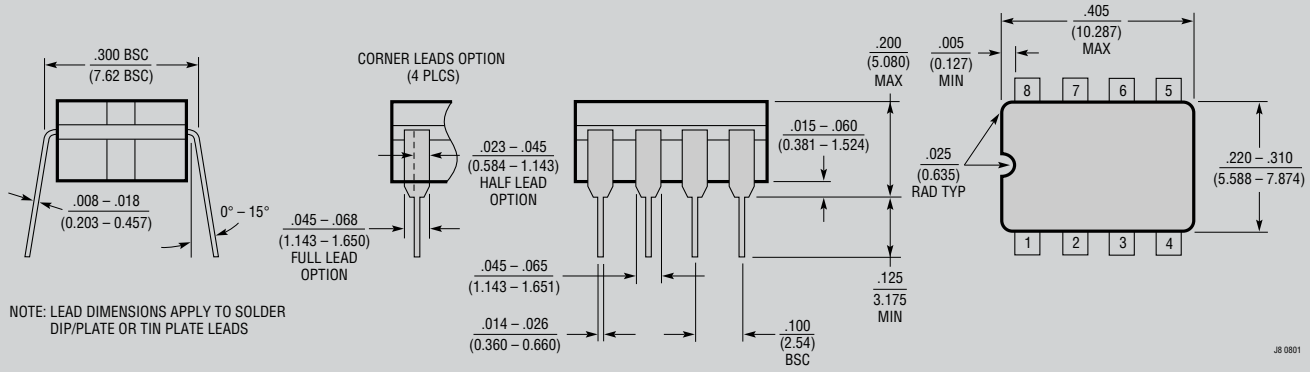


PACKAGE DESCRIPTION

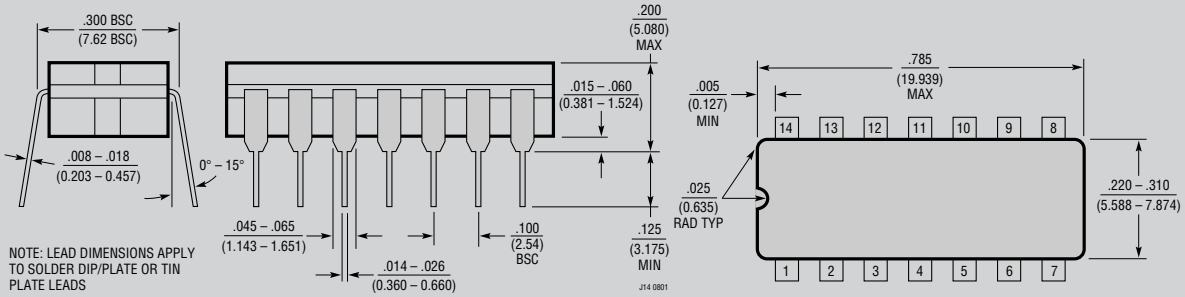
H Package
8-Lead TO-5 Metal Can (.230 Inch PCD)
(Reference LTC DWG # 05-08-1321)



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



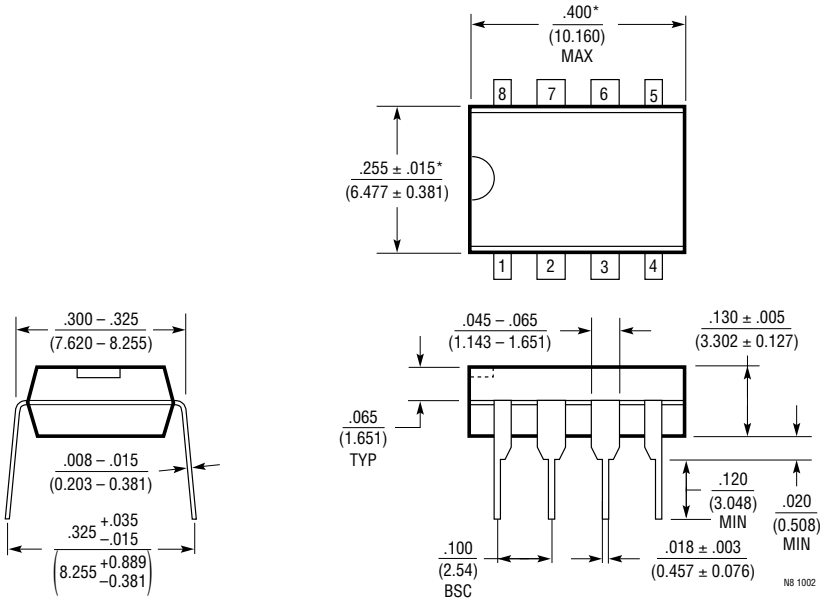
J Package
14-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)



OBSOLETE PACKAGES

PACKAGE DESCRIPTION

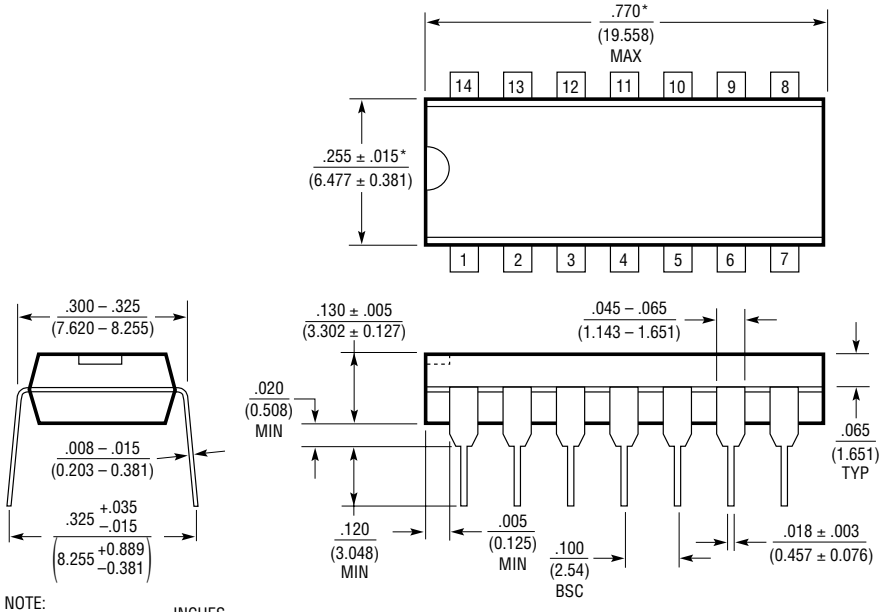
N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)



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)



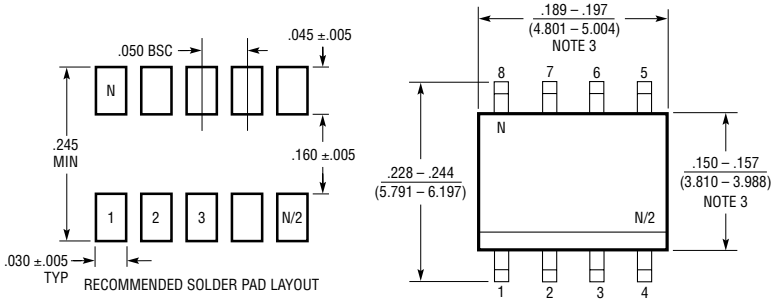
NOTE:
1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$

*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

PACKAGE DESCRIPTION

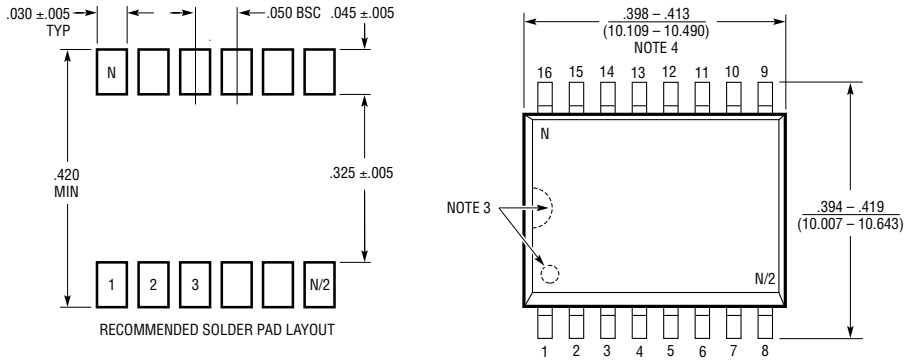
S8 Package
8-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610)



NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{(\text{MILLIMETERS})}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

S08 0502

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



NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{(\text{MILLIMETERS})}$
2. DRAWING NOT TO SCALE
3. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS.
THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS
4. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

S16 (WIDE) 0502

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

LW/TP 1102 1K REV B • PRINTED IN USA

© LINEAR TECHNOLOGY CORPORATION 1991