

# 17 $\mu$ A Max, Dual and Quad, Single Supply, Precision Op Amps

## FEATURES

- 17 $\mu$ A Max Supply Current per Amplifier
- 70 $\mu$ V Max Offset Voltage
- 250pA Max Offset Current
- 5nA Max Input Bias Current
- 0.9 $\mu$ Vp-p 0.1Hz to 10Hz Voltage Noise
- 1.5pAp-p 0.1Hz to 10Hz Current Noise
- 0.5 $\mu$ V/ $^{\circ}$ C Offset Voltage Drift
- 85kHz Gain-Bandwidth-Product
- 0.04V/ $\mu$ 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

## DESCRIPTION

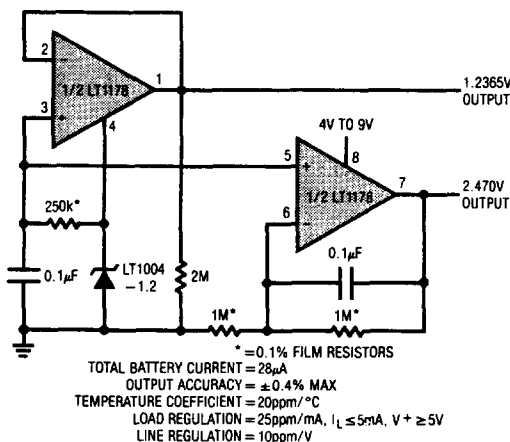
The LT1178 is a micropower dual op amp in the standard 8-pin configuration; the LT1179 is a micropower quad op amp offered in the standard 14-pin packages. Both devices are optimized for single supply operation at 5V. Specifications are also provided at  $\pm 15$ V supplies.

The extremely low supply current is combined with true precision specifications: offset voltage is 30 $\mu$ V, 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 0.9 $\mu$ Vp-p, is remarkably low considering the low supply current.

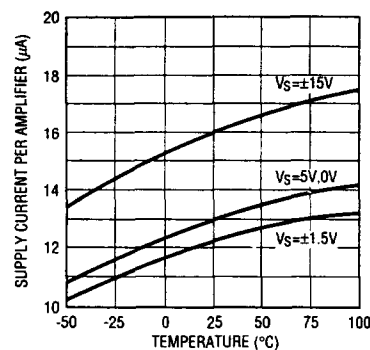
Both the LT1178 and LT1179 can be operated from a single supply (as low as one lithium cell or two Ni-cad batteries). The input range goes below ground. The all-NPN output stage swings to within a few millivolts of ground while sinking current—no power consuming pull down resistors are needed.

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.

Self-Buffered, Dual Output, Micropower Reference



Supply Current vs Temperature



# ABSOLUTE MAXIMUM RATINGS

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

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

# PACKAGE/ORDER INFORMATION

<p>TOP VIEW          OUTPUT A 1          -IN A 2          +IN A 3          V- (CASE) 4          +IN B 5          -IN B 6          OUTPUT B 7          V+ 8          H PACKAGE          8-LEAD TO-5 METAL CAN</p>	<p>ORDER PART NUMBER  <b>LT1178ACH</b>  <b>LT1178CH</b></p>	<p>TOP VIEW          OUTPUT A 1          -IN A 2          +IN A 3          V- 4          +IN B 5          -IN B 6          OUTPUT B 7          V+ 8          J PACKAGE          8-LEAD CERAMIC DIP          N PACKAGE          8-LEAD PLASTIC DIP</p>	<p>ORDER PART NUMBER  <b>LT1178ACJ8</b>  <b>LT1178CJ8</b>  <b>LT1178ACN8</b>  <b>LT1178CN8</b>  <b>LT1178IN8</b></p>	<p>TOP VIEW          OUTPUT A 1          -IN A 2          +IN A 3          V+ 4          +IN B 5          -IN B 6          OUTPUT B 7          OUTPUT C 8          -IN C 9          +IN C 10          V- 11          +IN D 12          -IN D 13          OUTPUT D 14          J PACKAGE          14-LEAD CERAMIC DIP          N PACKAGE          14-LEAD PLASTIC DIP</p>	<p>ORDER PART NUMBER  <b>LT1179ACJ</b>  <b>LT1179CJ</b>  <b>LT1179ACN</b>  <b>LT1179CN</b>  <b>LT1179IN</b></p>
<p>TOP VIEW          NC 1          NC 2          OUTPUT A 3          -IN A 4          +IN A 5          V- 6          NC 7          NC 8          NC 9          NC 10          +IN B 11          -IN B 12          OUTPUT B 13          V+ 14          NC 15          NC 16          S PACKAGE          16-LEAD PLASTIC SOL</p>	<p>ORDER PART NUMBER  <b>LT1178S</b></p>	<p>TOP VIEW          OUTPUT A 1          -IN A 2          +IN A 3          V+ 4          +IN B 5          -IN B 6          OUTPUT B 7          NC 8          NC 9          OUTPUT C 10          -IN C 11          +IN C 12          V- 13          +IN D 14          -IN D 15          OUTPUT D 16          S PACKAGE          16-LEAD PLASTIC SOL</p>	<p>ORDER PART NUMBER  <b>LT1179S</b></p>		

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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 1)	LT1178AC/1179AC			LT1178I/C/S/1179I/C/S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage	LT1178 LT1179 LT1178S LT1179S		30 35	70 100		40 40	120 150	$\mu V$ $\mu V$
$\frac{\Delta V_{OS}}{\Delta Time}$	Long Term Input Offset Voltage Stability			0.5			0.6		$\mu V/Mo$
$I_{OS}$	Input Offset Current			0.05	0.25		0.05	0.35	nA
$I_B$	Input Bias Current			3	5		3	6	nA
$e_n$	Input Noise Voltage	0.1Hz to 10Hz (Note 2)		0.9	2.0		0.9		$\mu V_{p-p}$
	Input Noise Voltage Density	$f_o = 10Hz$ (Note 2) $f_o = 1000Hz$ (Note 2)		50 49	75 65		50 49		$nV/\sqrt{Hz}$ $nV/\sqrt{Hz}$
$i_n$	Input Noise Current	0.1Hz to 10Hz (Note 2)		1.5	2.5		1.5		$pA_{p-p}$
	Input Noise Current Density	$f_o = 10Hz$ (Note 2) $f_o = 1000Hz$		0.03 0.01	0.07		0.03 0.01		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
	Input Resistance Differential Mode Common-Mode	(Note 3)	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

**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 1)	LT1178AC/1179AC			LT1178JC/S/1179JC/S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
A <sub>VOL</sub>	Large Signal Voltage Gain	V <sub>O</sub> = 0.03V to 4V, No Load (Note 3)	140	700		110	700		V/mV
		V <sub>O</sub> = 0.03V to 3.5V, R <sub>L</sub> = 50k	80	200		70	200		V/mV
	Maximum Output Voltage Swing	Output Low, No Load		6.5	9		6.5	9	mV
		Output Low, 2k to GND		0.2	0.6		0.2	0.6	mV
		Output Low, I <sub>SINK</sub> = 100μA		120	160		120	160	mV
		Output High, No Load	4.2	4.4		4.2	4.4		V
		Output High, 2k to GND	3.5	3.8		3.5	3.8		V
SR	Slew Rate	A <sub>V</sub> = +1, C <sub>L</sub> = 10pF (Note 3)	0.013	0.025		0.013	0.025		V/μs
GBW	Gain Bandwidth Product	f <sub>o</sub> ≤ 5kHz		60			60		kHz
I <sub>S</sub>	Supply Current per Amplifier	V <sub>S</sub> = ±1.5V, V <sub>O</sub> = 0V		13	18		14	21	μA
				12	17		13	20	μA
	Channel Separation	ΔV <sub>IN</sub> = 3V, R <sub>L</sub> = 10k		130			130		dB
	Minimum Supply Voltage	(Note 4)		2.0	2.2		2.0	2.2	V

**ELECTRICAL CHARACTERISTICS**  $V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, -40^\circ C \leq T_A \leq 85^\circ C$  for I grades,  $0^\circ C \leq T_A \leq 70^\circ C$  for S grades, unless noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS		LT1178I/1179I			LT1178S/1179S			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>OS</sub>	Input Offset Voltage	LT1178	●	80	315		120	650		μV
			LT1179	●	80	345		130	800	
ΔV <sub>OS</sub> /ΔT	Input Offset Voltage Drift	(Note 5)	●	0.6	3.0		0.8	4.5		μV/°C
I <sub>OS</sub>	Input Offset Current		●	0.07	0.7		0.06	0.50		nA
I <sub>B</sub>	Input Bias Current		●	4	8		3	7		nA
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = 0.05V to 3.2V I grade V <sub>CM</sub> = 0V to 3.4V S grade	●	84	98		86	100		dB
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> = 3.0V to 12V I grade V <sub>S</sub> = 2.5V to 12V S grade	●	86	100		88	102		dB
A <sub>VOL</sub>	Large Signal Voltage Gain	V <sub>O</sub> = 0.05V to 4V, No Load (Note 3)	●	55	350		80	500		V/mV
		V <sub>O</sub> = 0.05V to 3.5V, R <sub>L</sub> = 50k	●	35	130		45	160		V/mV
	Maximum Output Voltage Swing	Output Low, No Load	●		9	13		8	11	mV
		Output Low, I <sub>SINK</sub> = 100μA	●		160	220		140	190	mV
		Output High, No Load	●	3.9	4.2		4.1	4.3		V
		Output High, 2k to GND	●	3.0	3.7		3.3	3.8		V
				●						
I <sub>S</sub>	Supply Current per Amplifier		●	15	27		15	24		μA

**ELECTRICAL CHARACTERISTICS**  $V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, 0^\circ C \leq T_A \leq 70^\circ C$ , unless noted.

SYMBOL	PARAMETER	CONDITIONS		LT1178AC/1179AC			LT1178C/1179C			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>OS</sub>	Input Offset Voltage	LT1178	●	50	170		65	250		μV
			LT1179	●	60	200		70	290	
ΔV <sub>OS</sub> /ΔT	Input Offset Voltage Drift	(Note 5)	●	0.5	2.2		0.6	3.0		μV/°C
I <sub>OS</sub>	Input Offset Current		●	0.06	0.35		0.06	0.50		nA
I <sub>B</sub>	Input Bias Current		●	3	6		3	7		nA
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = 0V to 3.4V	●	90	101		86	100		dB
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> = 2.5V to 12V	●	90	102		88	102		dB
A <sub>VOL</sub>	Large Signal Voltage Gain	V <sub>O</sub> = 0.05V to 4V, No Load (Note 3)	●	105	500		80	500		V/mV
		V <sub>O</sub> = 0.05V to 3.5V, R <sub>L</sub> = 50k	●	55	160		45	160		V/mV
	Maximum Output Voltage Swing	Output Low, No Load	●		8	11		8	11	mV
		Output Low, I <sub>SINK</sub> = 100μA	●		140	190		140	190	mV
		Output High, No Load	●	4.1	4.3		4.1	4.3		V
		Output High, 2k to GND	●	3.3	3.8		3.3	3.8		V
				●						
I <sub>S</sub>	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/1179AC			LT1178I/C/S/1179I/C/S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage	LT1178S LT1179S		80	350		100	480	$\mu V$
							150	900	$\mu V$
							160	1050	$\mu V$
$I_{OS}$	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 $\pm 18V$	96	112		94	112		dB
$A_{VOL}$	Large Signal Voltage Gain	$V_O = \pm 10V, R_L = 50k$	300	1200		250	1000		V/mV
		$V_O = \pm 10V, \text{No Load}$	600	2500		400	2500		V/mV
$V_{OUT}$	Maximum Output Voltage Swing	$R_L = 50k$	$\pm 13.0$	$\pm 14.2$		$\pm 13.0$	$\pm 14.2$		V
		$R_L = 2k$	$\pm 11.0$	$\pm 12.7$		$\pm 11.0$	$\pm 12.7$		V
SR	Slew Rate	$A_V = +1$	0.02	0.04		0.02	0.04		V/ $\mu s$
GBW	Gain Bandwidth Product	$f_o \leq 5kHz$		85			85		kHz
$I_S$	Supply Current per Amplifier			16	21		17	25	$\mu A$

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**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, -40^\circ C \leq T_A \leq 85^\circ C$  for I grades,  $0^\circ C \leq T_A \leq 70^\circ C$  for S grades, unless noted.

SYMBOL	PARAMETER	CONDITIONS	LT1178I/1179I			LT1178S/1179S			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage	LT1178	●	130	740		190	1150	$\mu V$
		LT1179	●	130	740		200	1300	$\mu V$
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 5)	●	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	$R_L = 5k$	●	$\pm 11.0$	$\pm 13.5$		$\pm 11.0$	$\pm 13.5$	V
$I_S$	Supply Current per Amplifier		●	19	30		18	28	$\mu A$

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, 0^\circ C \leq T_A \leq 70^\circ C$ , unless noted.

SYMBOL	PARAMETER	CONDITIONS	LT1178AC/1179AC			LT1178C/1179C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage		●	100	480		130	660	$\mu V$
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 5)	●	0.6	2.8		0.7	4.0	$\mu V/^\circ C$
$I_{OS}$	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	$V_O = \pm 10V, R_L = 50k$	●	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 $\pm 18V$	●	93	110		91	110	dB
	Maximum Output Voltage Swing	$R_L = 5k$	●	$\pm 11.0$	$\pm 13.6$		$\pm 11.0$	$\pm 13.6$	V
$I_S$	Supply Current per Amplifier		●	17	24		18	28	$\mu A$

The ● denotes the specifications which apply over the full operating temperature range.

**Note 1:** 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 2:** This parameter is tested on a sample basis only. All noise parameters are tested with  $V_S = \pm 2.5, V_O = 0V$ .

**Note 3:** This parameter is guaranteed by design and is not tested.

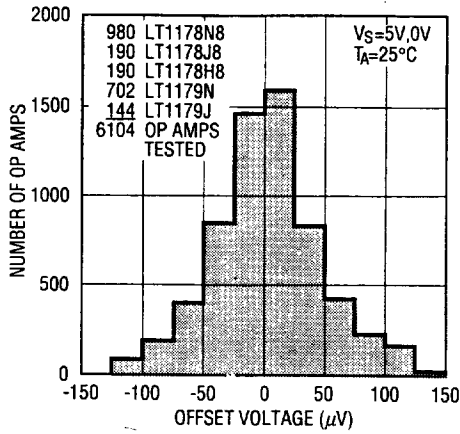
**Note 4:** Power supply rejection ratio is measured at the minimum supply voltage. The op amps actually work at 1.7V supply but with a typical offset skew of  $-300\mu V$ .

**Note 5:** This parameter is not 100% tested.

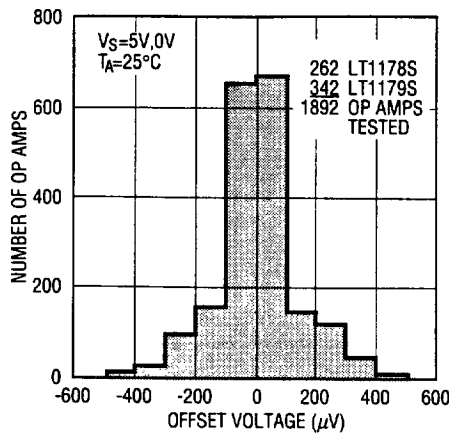
**Note 6:** During testing at  $-40^\circ C$ , the 5V power supply turn on time is less than 0.5 seconds.

# TYPICAL PERFORMANCE CHARACTERISTICS

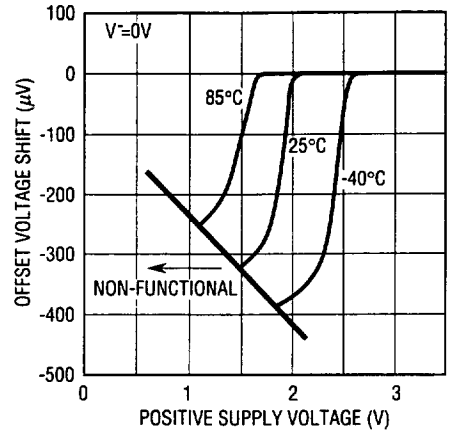
**Input Offset Voltage Distribution  
N, J, H Package**



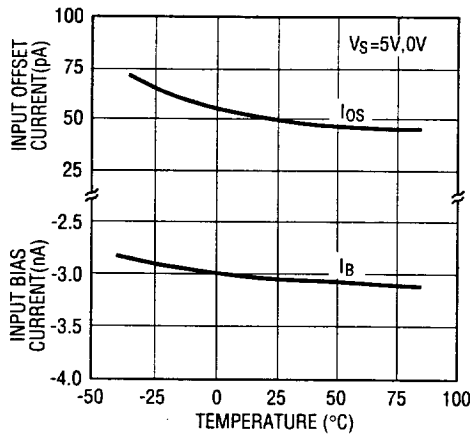
**Input Offset Voltage Distribution  
Surface Mount Package**



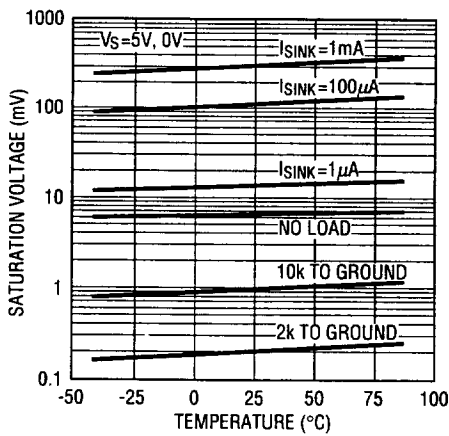
**Minimum Supply Voltage**



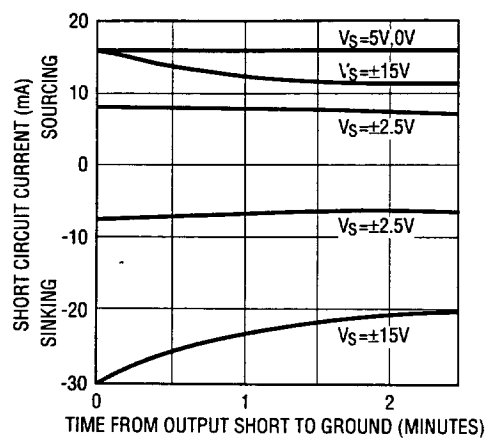
**Input Bias and Offset Currents vs  
Temperature**



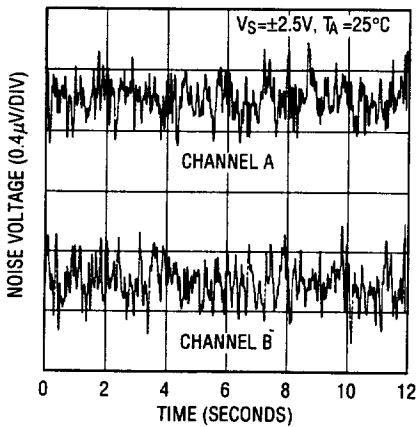
**Output Saturation vs Temperature  
vs Sink Current**



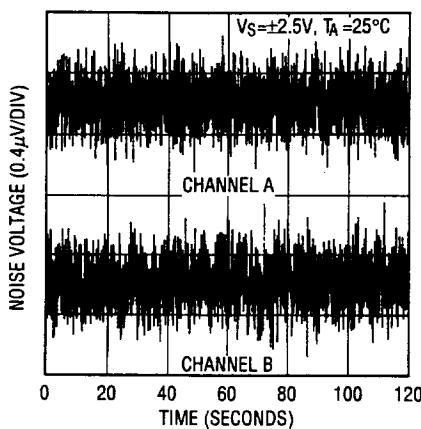
**Short Circuit Current**



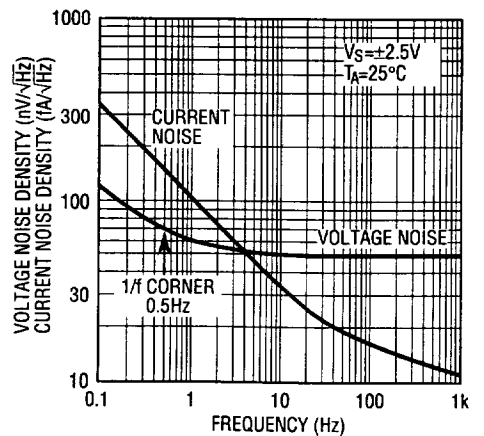
**0.1Hz to 10Hz Noise**



**0.01Hz to 10Hz Noise**

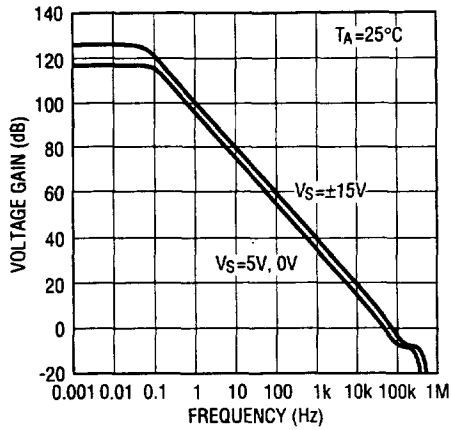


**Noise Spectrum**

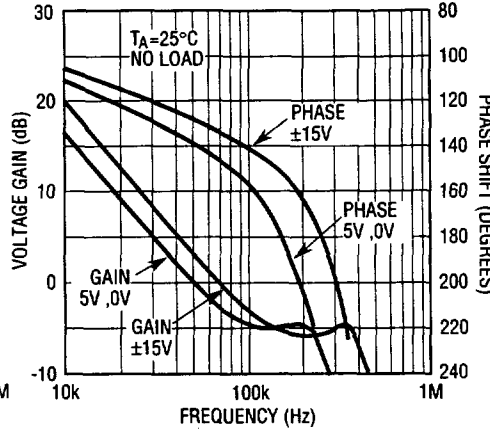


# TYPICAL PERFORMANCE CHARACTERISTICS

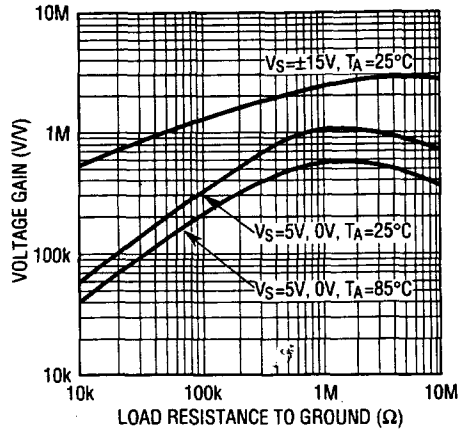
**Voltage Gain vs Frequency**



**Gain, Phase vs Frequency**

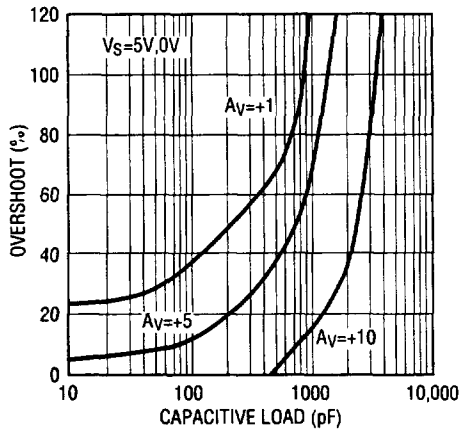


**Voltage Gain vs Load Resistance**

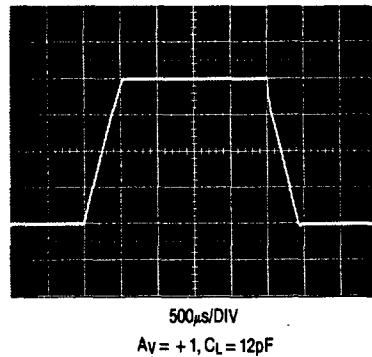


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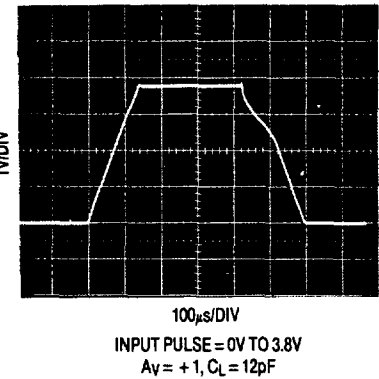
**Capacitive Load Handling**



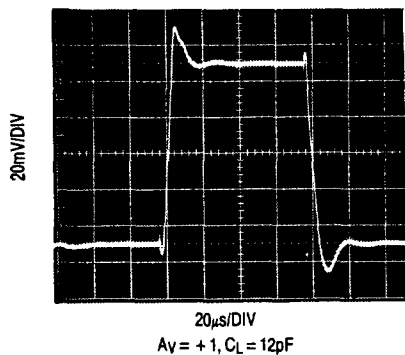
**Large Signal Transient Response VS = ±15V**



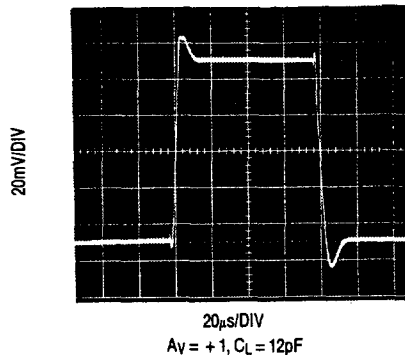
**Large Signal Transient Response VS = 5V, 0V**



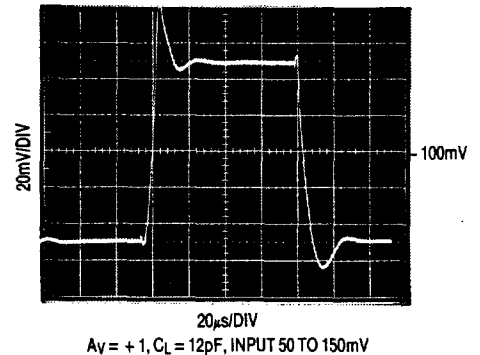
**Small Signal Transient Response VS = ±2.5V**



**Small Signal Transient Response VS = ±15V**

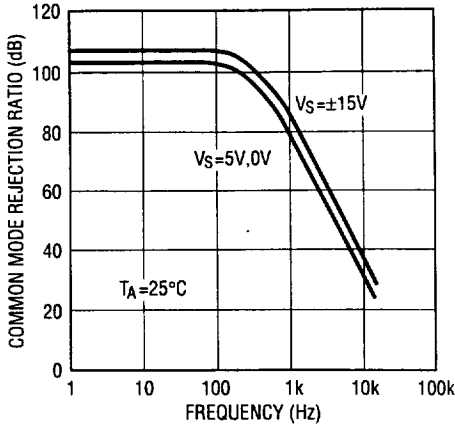


**Small Signal Transient Response VS = 5V, 0V**

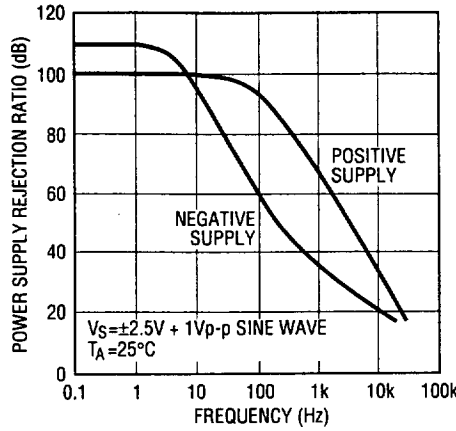


## TYPICAL PERFORMANCE CHARACTERISTICS

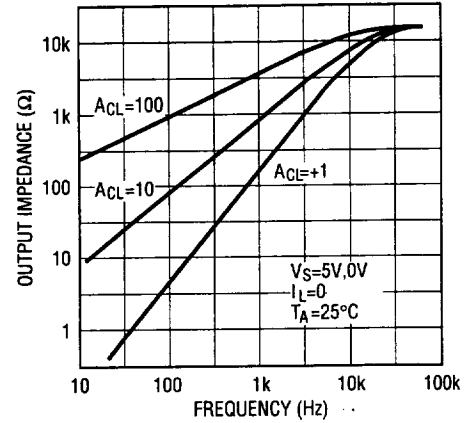
Common Mode Rejection Ratio vs Frequency



Power Supply Rejection Ratio vs Frequency



Closed Loop Output Impedance

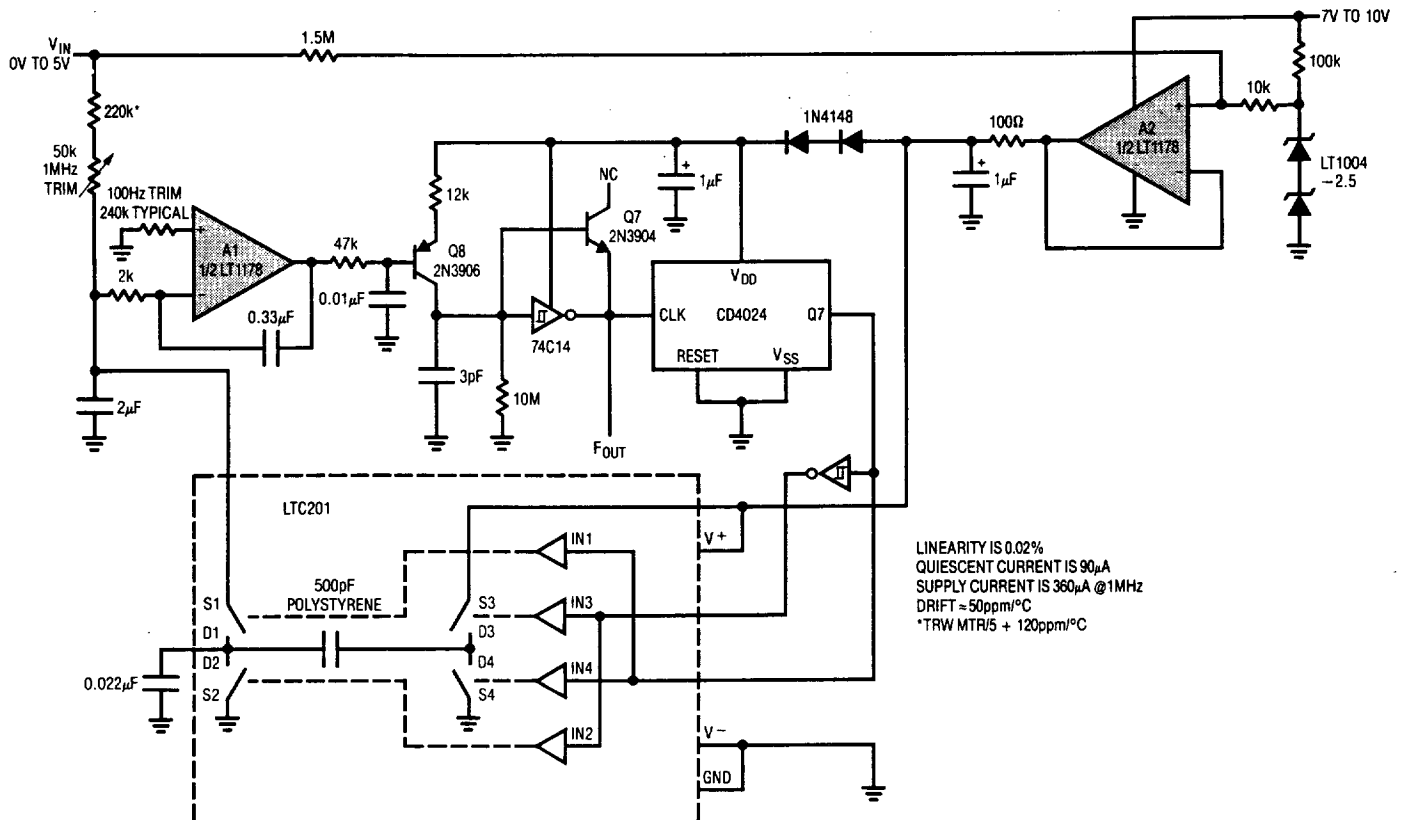


## APPLICATIONS INFORMATION

Please see the LT1078/LT1079 data sheet for applications information. All comments relating to specifications,

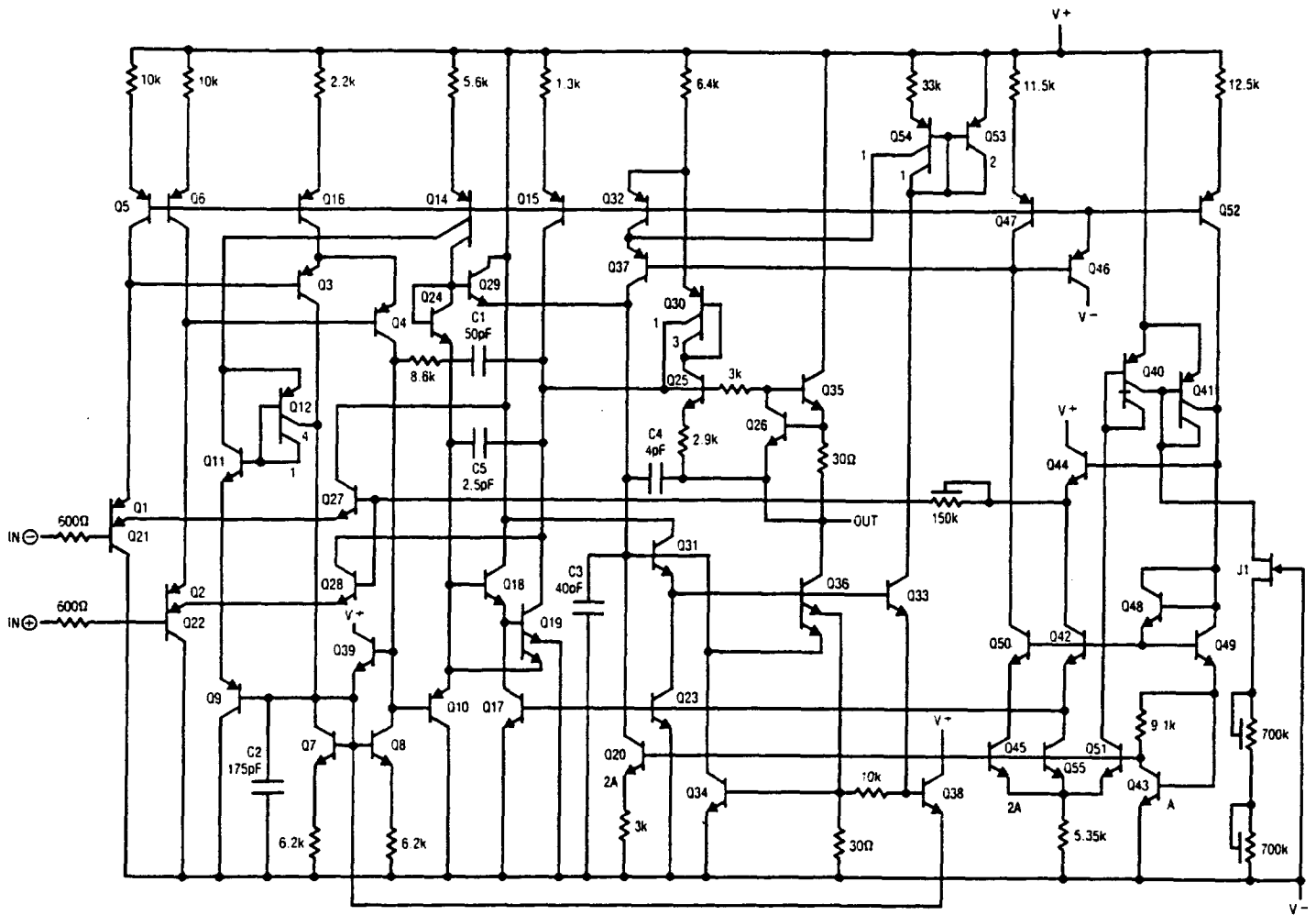
single supply operation and phase reversal protection are directly applicable to the LT1178/LT1179.

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



**SIMPLIFIED SCHEMATIC**

1/2 LT1178  
1/4 LT1179



**2**