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

FEATURES

- **SO Package with Standard Pinout**
- **Supply Current per Amplifier: 17μA Max**
- **Offset Voltage: 70μV Max**
- Offset Current: 250pA Max
- Input Bias Current: 5nA Max
- Voltage Noise: 0.9μV_{P-P}, 0.1Hz to 10Hz
- Current Noise: 1.5pA_{P-P}, 0.1Hz to 10Hz
- Offset Voltage Drift: 0.5μV/°C
- Gain Bandwidth Product: 85kHz
- Slew Rate: 0.04V/μs
- Single Supply Operation
  - Input Voltage Range Includes Ground
  - Output Swings to Ground while Sinking Current
  - No Pull-Down Resistors 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®2178 is a micropower dual op amp in a surface mount standard 8-pin configuration, the LT2179 is a micropower quad op amp offered in a surface mount 14-pin package. Both devices are optimized for single supply operation at 5V. Specifications are also provided at ±15V supply.

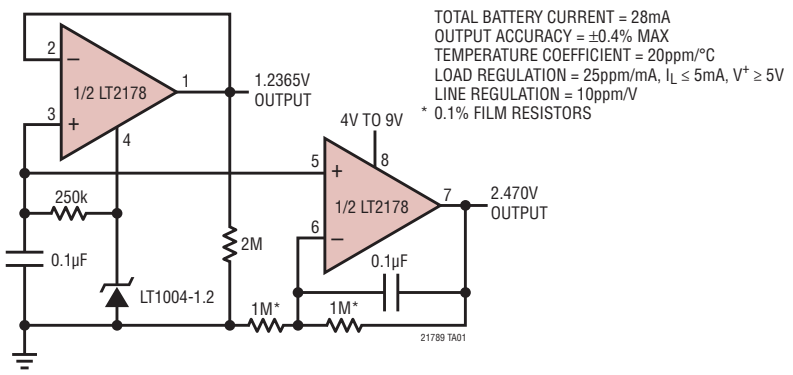
The extremely low supply current is combined with true precision specifications: offset voltage is 30μV and offset current is 50pA. Both offset parameters have low drift with temperature. The 1.5pA_{P-P} current noise and picoampere offset current permit the use the megohm level source resistors without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

The LT2178/LT2179 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.

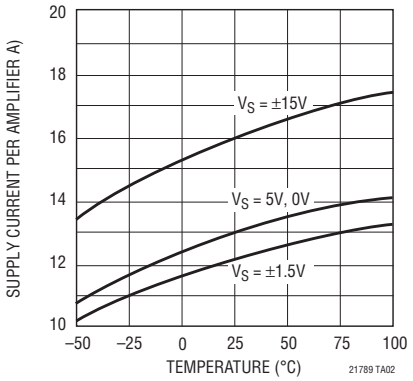
For surface mount applications where three times higher supply current is acceptable, the micropower LT1077 single, LT2078 dual and LT2079 quad are recommended. The LT1077/LT2078/LT2079 have significantly higher bandwidth, slew rate, lower voltage noise and better output drive capability. For applications requiring DIP packages refer to the LT1178/LT1179.

TYPICAL APPLICATION

Self-Buffered, Dual Output, Micropower Reference



Supply Current vs Temperature

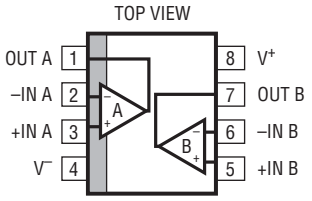


ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±22V
Differential Input Voltage ..... ±30V
Input Voltage ..... Equal to Positive Supply Voltage
..... 5V Below Negative Supply Voltage
Output Short-Circuit Duration ..... Indefinite

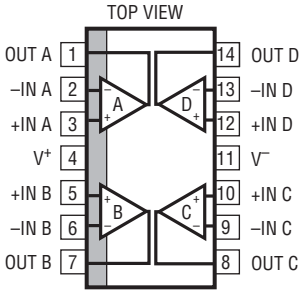
Specified Temperature Range
Commercial ..... 0°C to 70°C
Industrial ..... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PIN CONFIGURATION



S8 PACKAGE
8-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 190°C/W



S PACKAGE
14-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 150°C/W

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LT2178ACS8#PBF	LT2178ACS8#TRPBF	2178A	8-Lead Plastic SO	0°C to 70°C
LT2178AIS8#PBF	LT2178AIS8#TRPBF	2178AI	8-Lead Plastic SO	–40°C to 85°C
LT2178CS8#PBF	LT2178CS8#TRPBF	2178	8-Lead Plastic SO	0°C to 70°C
LT2178IS8#PBF	LT2178IS8#TRPBF	2178I	8-Lead Plastic SO	–40°C to 85°C
LT2179ACS#PBF	LT2179ACS#TRPBF	2179A	14-Lead Plastic SO	0°C to 70°C
LT2179CS#PBF	LT2179CS#TRPBF	2179	14-Lead Plastic SO	0°C to 70°C
LT2179IS#PBF	LT2179IS#TRPBF	2179I	14-Lead Plastic SO	–40°C to 85°C
LEAD BASED FINISH	**TAPE AND REEL**	**PART MARKING**	**PACKAGE DESCRIPTION**	**TEMPERATURE RANGE**
LT2178ACS8	LT2178ACS8#TR	2178A	8-Lead Plastic SO	0°C to 70°C
LT2178AIS8	LT2178AIS8#TR	2178AI	8-Lead Plastic SO	–40°C to 85°C
LT2178CS8	LT2178CS8#TR	2178	8-Lead Plastic SO	0°C to 70°C
LT2178IS8	LT2178IS8#TR	2178I	8-Lead Plastic SO	–40°C to 85°C
LT2179ACS	LT2179ACS#TR	2179A	14-Lead Plastic SO	0°C to 70°C
LT2179CS	LT2179CS#TR	2179	14-Lead Plastic SO	0°C to 70°C
LT2179IS	LT2179IS#TR	2179I	14-Lead Plastic SO	–40°C to 85°C

Consult LTC Marketing for parts specified with wider operating temperature ranges.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS	LT2178AC/LT2178AI LT2179AC MIN	TYP	MAX	LT2178C/LT2178I LT2179C/LT2179I MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT2178 LT2179		30 35	70 100		40 40	120 150	µV 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
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		μV_{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 12		 0.6	 2 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 3) 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		6.5 0.2 120	9 0.6 160		6.5 0.2 120	9 0.6 160	mV mV mV
		Output High, No Load Output High, 2k to GND	4.2 3.5	4.4 3.8		4.2 3.5	4.4 3.8		V V
SR	Slew Rate	A_V = 1, C_L = 10pF (Note 3)	0.013	0.025		0.013	0.025		V/µs
GBW	Gain Bandwidth Product	$f_O \le$ 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, RL = 10k		110			110		dB
	Minimum Supply Voltage	(Note 4)		2	2.2		2	2.2	V

The ● denotes the specifications which apply over the full operating temperature range. V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, –40°C ≤ T_A ≤ 85°C for I-grades, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS		LT2178AI MIN	TYP	MAX	LT2178I/LT2179I MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT2178 LT2179	● ●		70 80	270 300		95 100	370 400	µV µV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift	LT2178 (Note 5) LT2179	●		0.4 0.5	1.8 3		0.5 0.6	2.3 3.5	µV/°C µV/°C
I_{OS}	Input Offset Current		●		0.07	0.70		0.1	1	nA
I_B	Input Bias Current		●		3	7		4	8	nA
CMRR	Common Mode Rejection Ratio	V_{CM} = 0.05V to 3.2V	●	86	100		84	98		dB
PSRR	Power Supply Rejection Ratio	V_S = 3V to 12V	●	88	100		86	100		dB

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range. V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, –40°C ≤ T_A ≤ 85°C for I-grades, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS		LT2178AI MIN	LT2178AI TYP	LT2178AI MAX	LT2178I/LT2179I MIN	LT2178I/LT2179I TYP	LT2178I/LT2179I MAX	UNITS
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 4V, No Load (Note 3)	●	75	350		50	350		V/mV
		V_O = 0.05V to 3.5V, R_L = 50k	●	40	130		30	130		V/mV
	Maximum Output Voltage Swing	Output Low, No Load	●		9	13		9	13	mV
		Output Low, I_{SINK} = 100µA	●		160	220		160	220	mV
		Output High, No Load	●	3.9	4.2		3.9	4.2		V
		Output High, 2k to GND	●	3	3.7		3	3.7		V
I_S	Supply Current per Amplifier		●		15	24		15	27	µA

The ● denotes the specifications which apply over the full operating temperature range. V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, 0°C ≤ T_A ≤ 70°C, unless otherwise noted. (Note 7)

SYMBOL	PARAMETER	CONDITIONS		LT2178AC/LT2179AC MIN	LT2178AC/LT2179AC TYP	LT2178AC/LT2179AC MAX	LT2178C/LT2179C MIN	LT2178C/LT2179C TYP	LT2178C/LT2179C MAX	UNITS
V_{OS}	Input Offset Voltage	LT2178	●		50	170		65	250	V/mV
		LT2179	●		60	200		70	290	V/mV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift	LT2178 (Note 5)	●		0.4	1.8		0.5	2.5	mV
		LT2179	●		0.5	3		0.6	3.5	mV
I_{OS}	Input Offset Current		●		0.06	0.35		0.06	0.5	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 3)	●	150	500		80	500		V/mV
		V_O = 0.05V to 3.5V, R_L = 50k	●	55	160		45	160		V/mV
	Maximum Output Voltage Swing	Output Low, No Load	●		8	11		8	11	mV
		Output Low, I_{SINK} = 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

V_S = ±15V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT2178AC/LT2178AI LT2179AC MIN	LT2178AC/LT2178AI LT2179AC TYP	LT2178AC/LT2178AI LT2179AC MAX	LT2178C/LT2178I LT2179C/LT2179I MIN	LT2178C/LT2178I LT2179C/LT2179I TYP	LT2178C/LT2178I LT2179C/LT2179I MAX	UNITS
V_{OS}	Input Offset Voltage	LT2178		70	300		90	400	µV
		LT2179		80	350		100	450	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	–15.3		–15	–15.3		V
CMRR	Common Mode Rejection Ratio	V_{CM} = 13.5V to –15V	96	106		93	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	±14.2		±13	±14.2		V
		R_L = 2k	±11	±12.7		±11	±12.7		V
SR	Slew Rate	A_V = 1	0.02	0.04		0.02	0.04		V/µs

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range. V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, –40°C ≤ T_A ≤ 85°C for I-grades, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS	LT2178AC/LT2178AI LT2179AC MIN	TYP	MAX	LT2178C/LT2178I LT2179C/LT2179I MIN	TYP	MAX	UNITS
GBW	Gain Bandwidth Product	f_O ≤ 5kHz		85			85		kHz
I_S	Supply Current per Amplifier			16	21		17	25	µA

The ● denotes the specifications which apply over the full operating temperature range. V_S = ±15V, –40°C ≤ T_A ≤ 85°C for I-grades, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		LT2178AI MIN	TYP	MAX	LT2178I/LT2179I MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT2178 LT2179	● ●		100 100	650 650		130 130	740 740	µV µV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift	LT2178 (Note 5) LT2179	●		0.6 0.7	1.8 3		0.7 0.9	2.5 4	µV/°C µV/°C
I_{OS}	Input Offset Current		●		0.07	0.7		0.1	1	nA
I_B	Input Bias Current		●		3	7		4	8	nA
A_{VOL}	Large-Signal Voltage Gain	V_O = ±10V, R_L = 50k	●	150	500		100	500		V/mV
CMRR	Common Mode Rejection Ratio	V_{CM} = 13V, –14.9V	●	90	105		88	103		dB
PSRR	Power Supply Rejection Ratio	V_S = 0V, 5V to ±18V	●	92	110		88	109		dB
	Maximum Output Voltage Swing	R_L = 5k	●	±11	±13.5		±11	±13.5		V
I_S	Supply Current per Amplifier		●		18	28		19	30	µA

The ● denotes the specifications which apply over the full operating temperature range. V_S = ±15V, 0°C ≤ T_A ≤ 70°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		LT2178AC/LT2179AC MIN	TYP	MAX	LT2178C/LT2179C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT2178 LT2179	● ●		100 120	480 550		130 150	660 750	µV µV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift	LT2178 (Note 5) LT2179	●		0.6 0.7	1.5 3		0.7 0.9	2.5 4	µV/°C 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	R_L = 5k	●	93	110		91	110		dB
	Maximum Output Voltage Swing	R_L = 5k	●	±11	±13.6		±11	±13.6		V
I_S	Supply Current per Amplifier		●		17	24		18	28	µA

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers, i.e., out of 100 LT2179s (or 100 LT2178s) 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 = ±2.5V, 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.

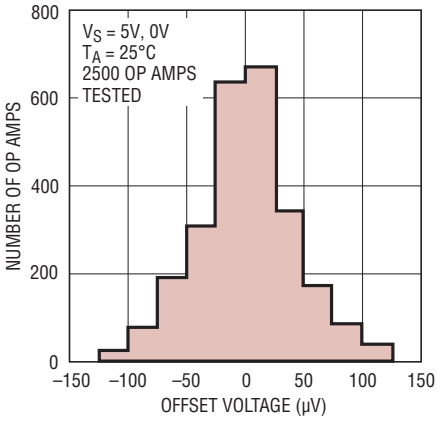
Note 6: This parameter is not 100% tested.

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

Note 8: The LT2178C/LT2179C are designed, characterized and expected to meet the industrial temperature limits, but are not tested at –40°C and 85°C. I-grade parts are guaranteed.

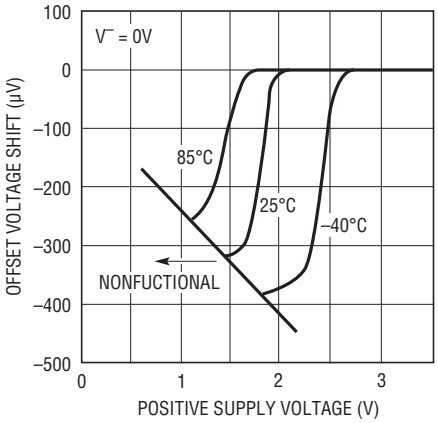
TYPICAL PERFORMANCE CHARACTERISTICS

Distribution of Input Offset Voltage



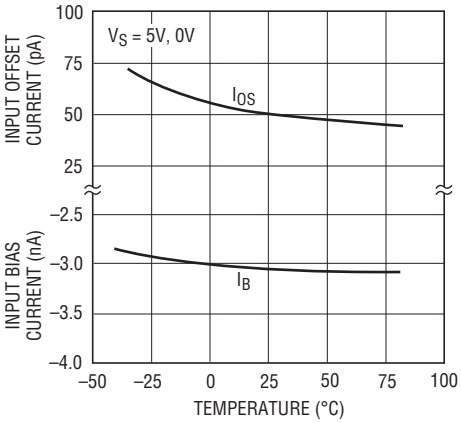
21789 G01

Minimum Supply Voltage



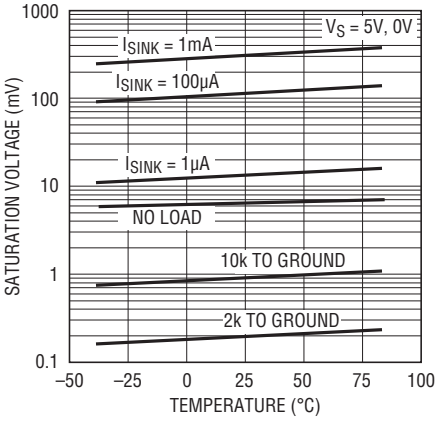
21789 G02

Input Bias and Offset Currents vs Temperature



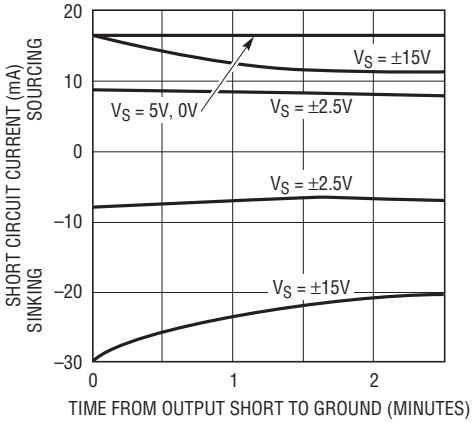
21789 G03

Output Saturation vs Temperature vs Sink Current



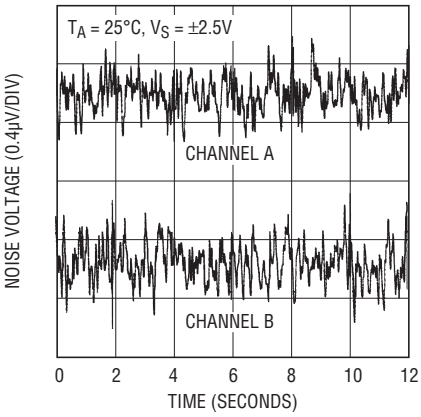
21789 G04

Short-Circuit Current



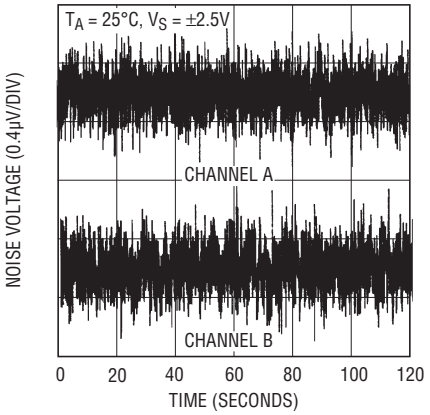
21789 G05

0.1Hz to 10Hz Noise



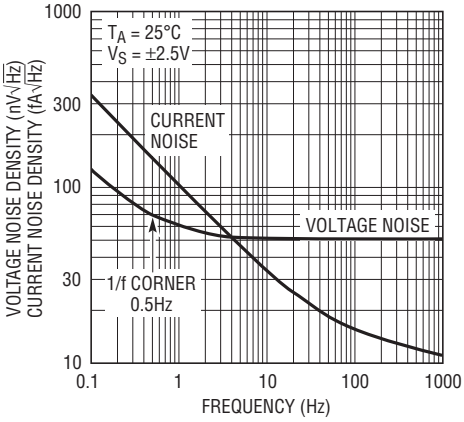
21789 G06

0.01Hz to 10Hz Noise



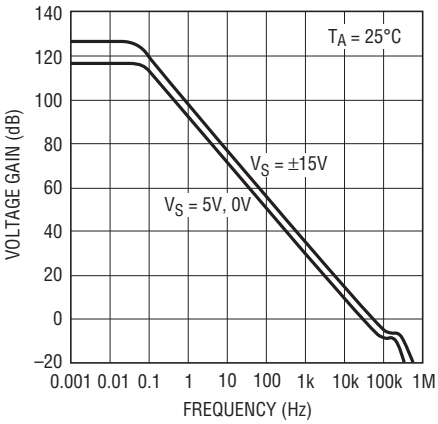
21789 G07

Noise Spectrum



21789 G08

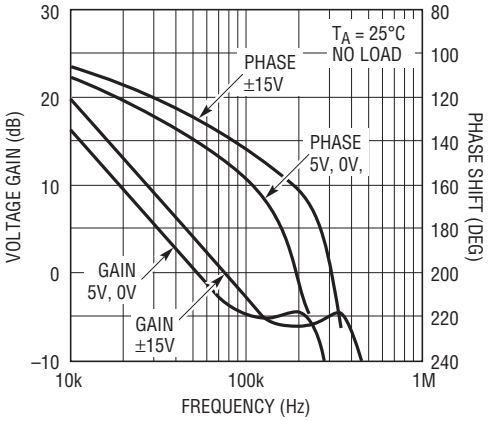
Voltage Gain vs Frequency



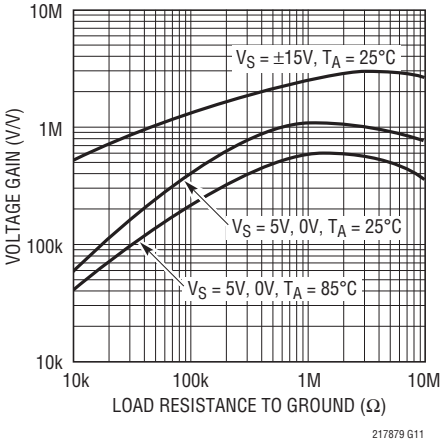
217879 G09

TYPICAL PERFORMANCE CHARACTERISTICS

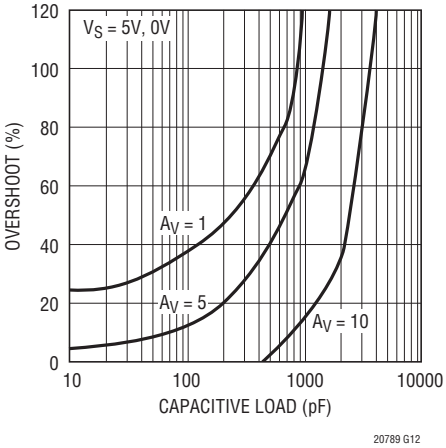
Gain, Phase vs Frequency



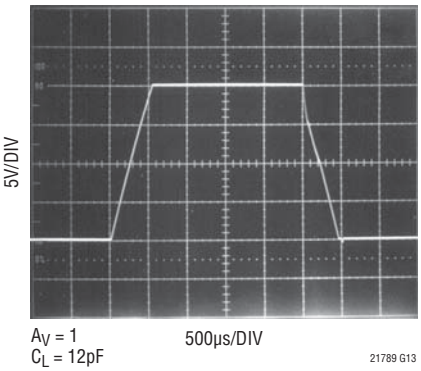
Voltage Gain vs Load Resistance



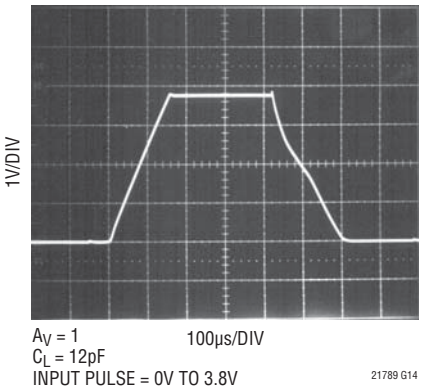
Capacitive Load Handling



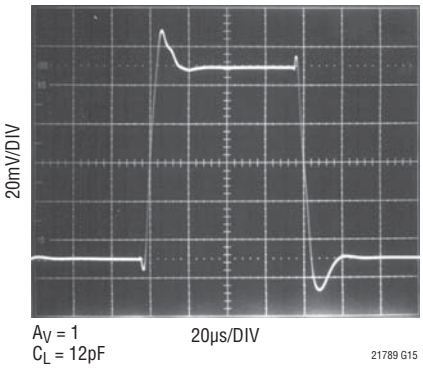
Large-Signal Transient Response $V_S = \pm15V$



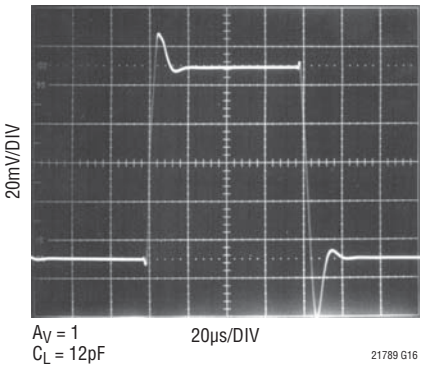
Large-Signal Transient Response $V_S = 5V, 0V$



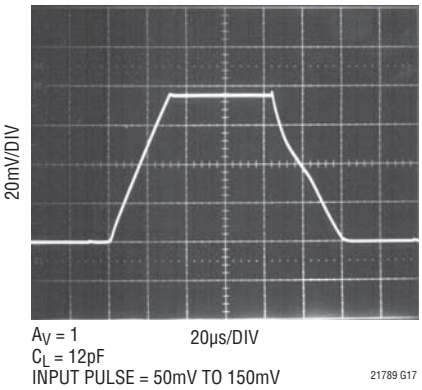
Small-Signal Transient Response $V_S = \pm2.5V$



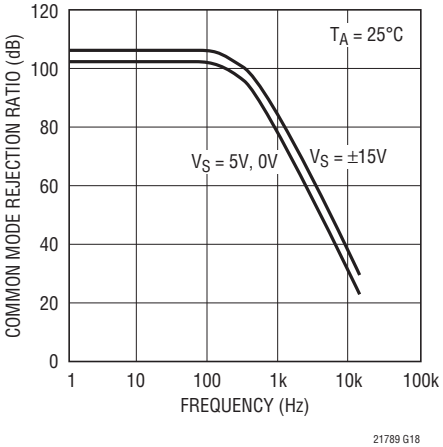
Small-Signal Transient Response $V_S = \pm15V$



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

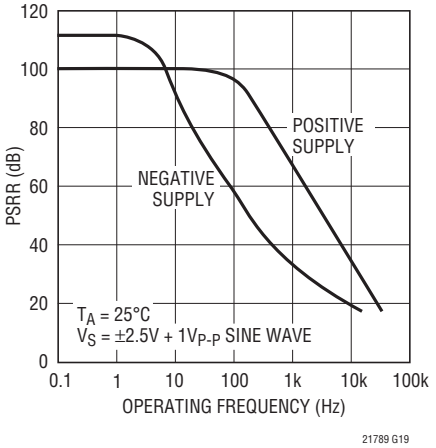


Common Mode Rejection Ratio vs Frequency

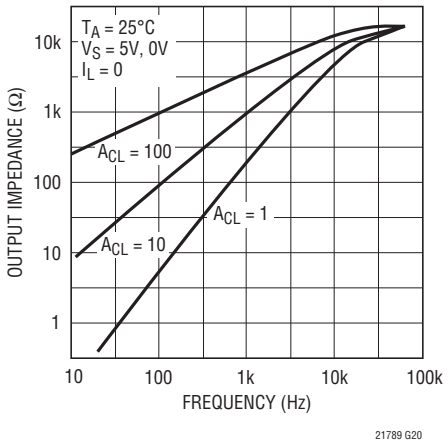


TYPICAL PERFORMANCE CHARACTERISTICS

Power Supply Rejection Ratio vs Frequency

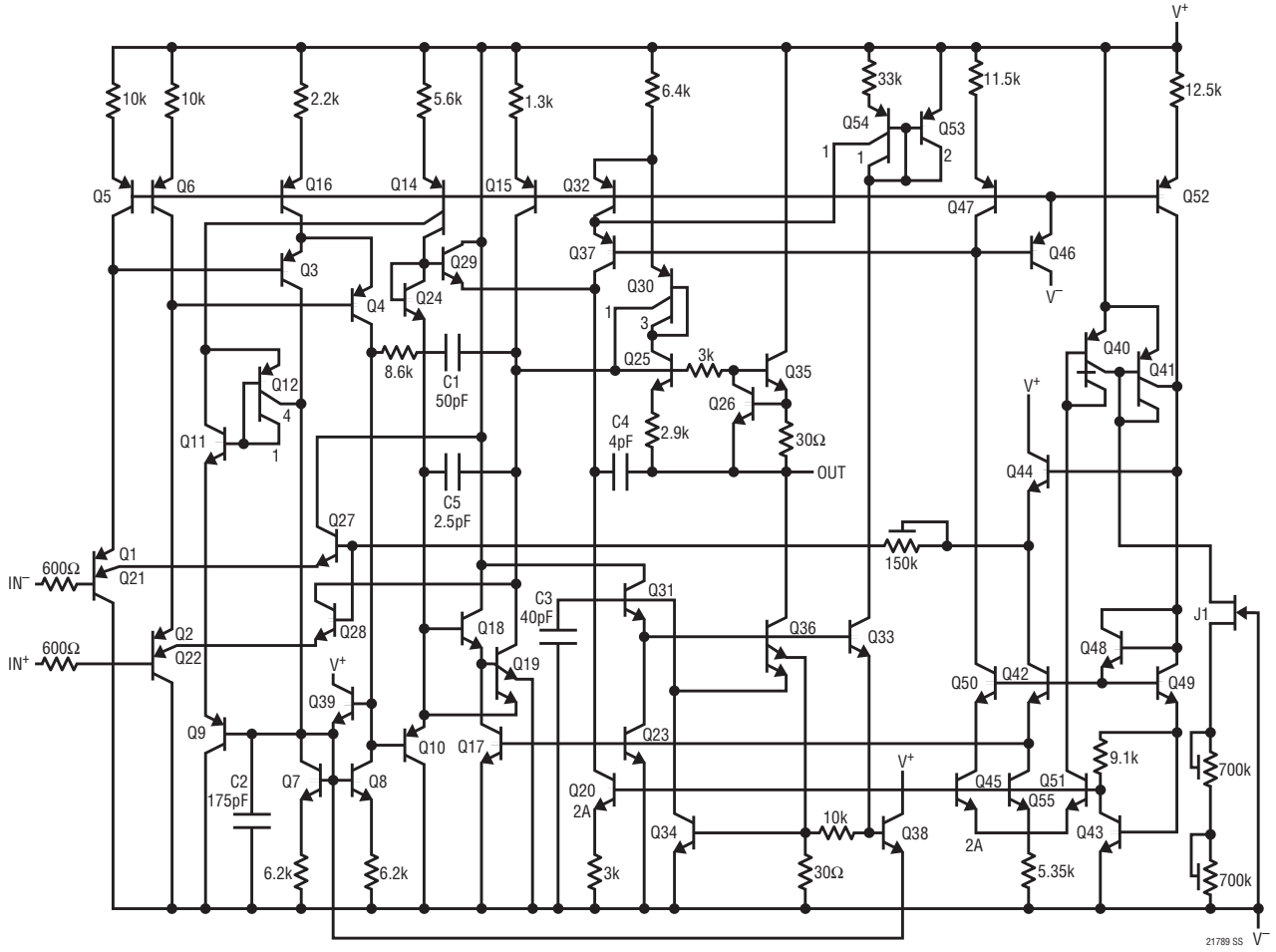


Closed Loop Output Impedance



SIMPLIFIED SCHEMATIC

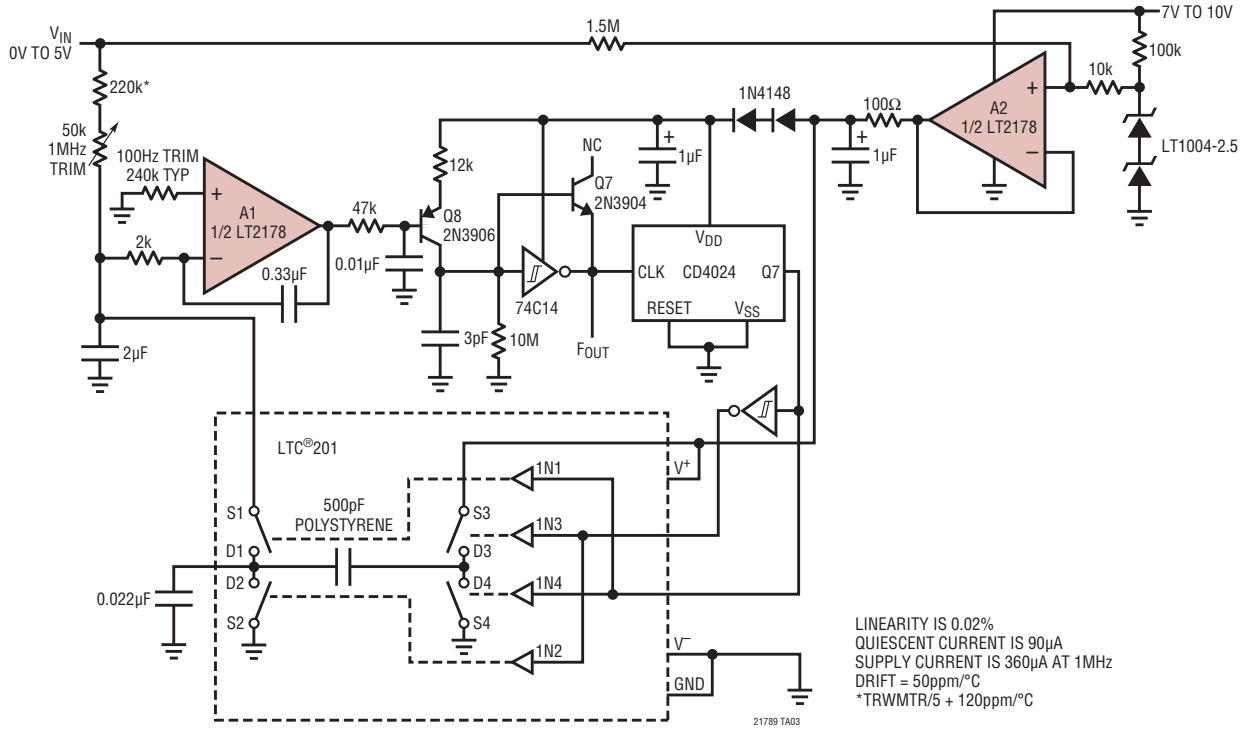
1/2 LT2178
1/4 LT2179



APPLICATIONS INFORMATION

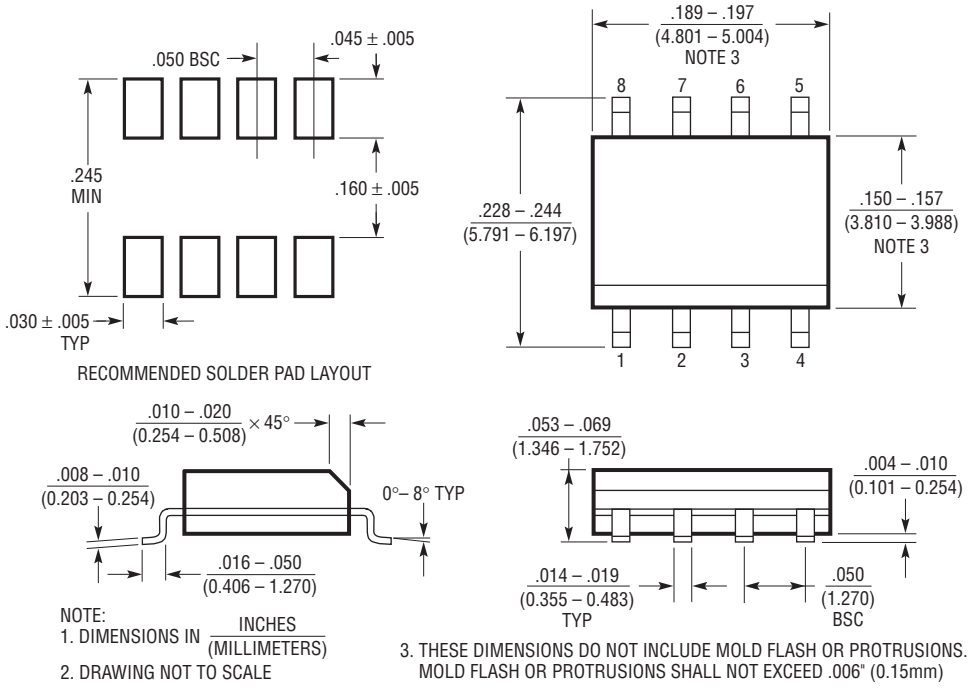
Please see the LT2078/LT2079 data sheet for applications information. All comments relating to specifications, single supply operation and phase reversal protection are directly applicable to the LT2178/LT2179.

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

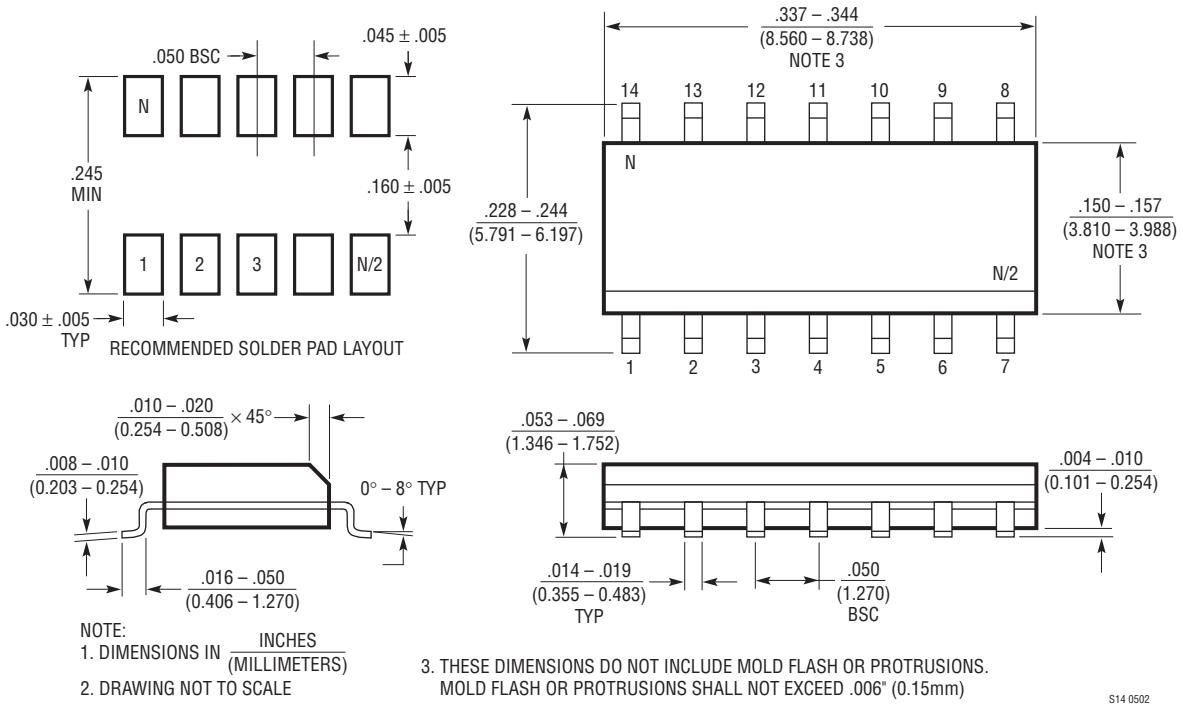


PACKAGE DESCRIPTION

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
(Reference LTC DWG # 05-08-1610)



S Package
14-Lead Plastic Small Outline (Narrow 0.150)
(Reference LTC DWG # 05-08-1610)



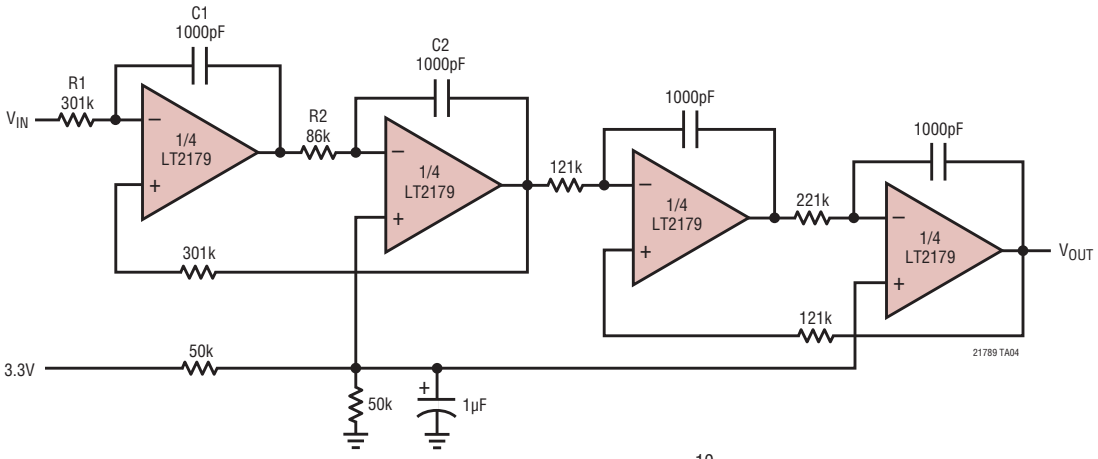
REVISION HISTORY (Revision history begins at Rev C)

REV	DATE	DESCRIPTION	PAGE NUMBER
C	3/10	Correct the part numbers on S Package in the Order Information Section.	2
		Update to graph G04	6

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.

TYPICAL APPLICATION

Single Supply, 1kHz, 4th Order Butterworth Lowpass Filter



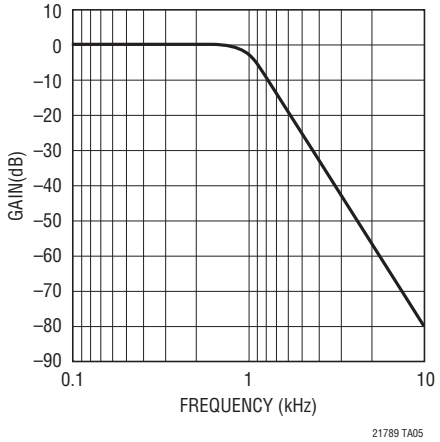
12-BIT ACCURATE SIGNAL RANGE FROM 6mV TO 1.8V ON 3.3V SINGLE SUPPLY.
MAXIMUM OUTPUT OFFSET ERROR IS 448µV.

FOR EACH 2ND ORDER SECTION:

$$W_0^2 = \frac{1}{C1C2R1R2}$$

$$R1 = \frac{1}{W_0QC1}$$

$$R2 = \frac{Q}{W_0C2}$$



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1078/LT1079	Dual/Quad 55µA Max, Single Supply Precision Op Amps	70µV V_{OS} Max and 2.5µV/°C Drift Max, 200kHz BBW, 0.07V/µs Slew Rate, Input/Output Common Mode Includes Ground
LT1211/LT1212	14MHz, 7V/µs Single Supply Dual and Quad Precision Op Amps	275µV V_{OS} Max, 6µV/°C Drift Max Input Voltage Range Includes Ground
LT1490/LT1491	Dual/ Quad Micropower Rail-to-Rail Input and Output Op Amps	Single Supply Input Range: –0.4V to 44V, Micropower 50µA Amplifier, Rail-to-Rail Input and Output, 200kHz GBW
LT2078/LT2079	Dual/Quad 55µA Max, Single Supply Precision Op Amps	70µV V_{OS} Max and 2.5µV/°C Drift Max, 200kHz BBW, 0.07V/µs Slew Rate, Input/Output Common Mode Includes Ground Surface Mount Standard Pinout

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