19-0127; Rev. 1; 11/98

MAXIM

17µA Max, Dual/Quad, Single-Supply, Precision Op Amps

General Description

The MAX478 and MAX479 are dual and quad micropower, precision op amps available in 8-pin and 14-pin DIP and small-outline packages, respectively. Both devices feature an extremely low, 17µA max supply current per op amp, 70µV max offset voltage, 2.2µV/°C max offset voltage drift (0.5µV/°C typ), and 250pA max input offset current.

The MAX478 and MAX479 operate from a single supply. The input voltage range includes ground, and the output swings to within a few millivolts of ground, which eliminates pull-down resistors and saves power.

Both devices are optimized for single 3V and 5V supply operation, with guaranteed specifications at each supply voltage. Specifications for ±15V operation are also provided.

Applications

Battery- or Solar-Powered Systems:
- Portable Instrumentation
- Remote Sensor Amplifier
- Satellite Circuitry

Micropower Sample-and-Hold

Thermocouple Amplifier

Micropower Filters

Single Lithium Cell Powered Systems

Features

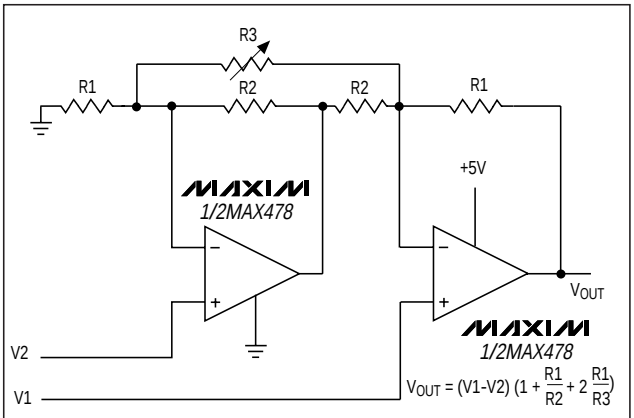
- **17µA Max Supply Current (MAX478A/MAX479A)**
- **70µV Max Offset Voltage (MAX478A)**
- **Single-Supply Operation:**
  Input Voltage Range Includes Ground
  Output Swings to Ground While Sinking Current
  No Pull-Down Resistors Required
- **Dual Op Amp in 8-Pin DIP/SO Package (MAX478)**
  Quad Op Amp in 14-Pin DIP/SO Package (MAX479)
- **250pA Max Input Offset Current (MAX478A/MAX479A)**
- **0.5µV/°C Offset-Voltage Drift**
- **Output Sources and Sinks 5mA Load Current**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX478ACPA	0°C to +70°C	8 Plastic DIP
MAX478CPA	0°C to +70°C	8 Plastic DIP
MAX478CSA	0°C to +70°C	8 SO
MAX478C/D	0°C to +70°C	Dice*
MAX478EPA	-40°C to +85°C	8 Plastic DIP
MAX478ESA	-40°C to +85°C	8 SO
MAX479ACPD	0°C to +70°C	14 Plastic DIP
MAX479CPD	0°C to +70°C	14 Plastic DIP
MAX479CSD	0°C to +70°C	14 SO
MAX479EPD	-40°C to +85°C	14 Plastic DIP
MAX479ESD	-40°C to +85°C	14 SO

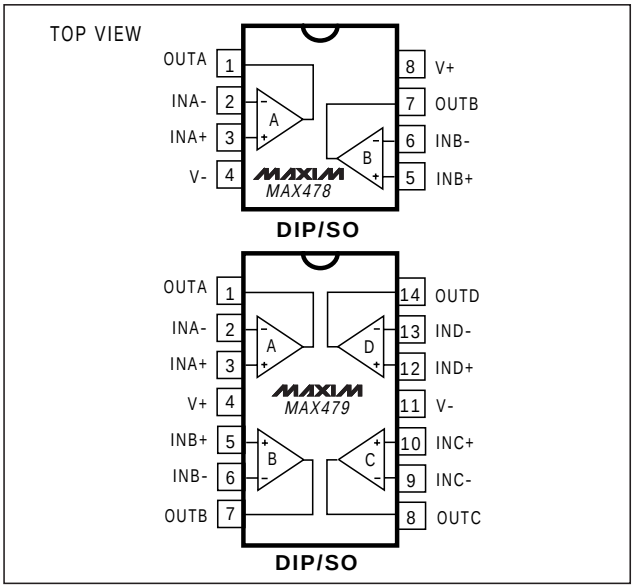
** Dice are specified at T_A = +25°C, DC parameters only.*

Typical Operating Circuit



MICROPOWER, HIGH INPUT IMPEDANCE DIFFERENTIAL AMPLIFIER WITH VARIABLE GAIN IN 8-PIN DIP/SO

Pin Configurations



17µA Max, Dual/Quad, Single-Supply, Precision Op Amps

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 ..... Continuous
Continuous Power Dissipation (T_A = +70°C):
8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
14-Pin Plastic DIP (derate 10.00mW/°C above +70°C) .. 800mW
14-Pin Wide SO (derate 9.52mW/°C above +70°C) ... 762mW

Operating Temperature Ranges:
MAX47_ACP_/C_ _ ..... 0°C to +70°C
MAX47_E_ _ ..... -40°C to +85°C
Storage Temperature Range ..... -65°C to +150°C
Lead Temperature (soldering, 10sec) ..... +300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: 5V

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

PARAMETER	SYMBOL	CONDITIONS	MAX478AC MAX479AC			MAX478C/E MAX479C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	MAX478ACP/CP/EP		30	70		40	120	µV
		MAX479ACP/CP/EP		35	100		40	150	
		MAX478CS/ES					80	180	
		MAX479CS/ES					90	250	
Long-Term Input Offset-Voltage Stability	$\frac{\Delta V_{OS}}{\Delta Time}$			0.5			0.6		µV/Mo.
Input Offset Current	I_{OS}			0.05	0.25		0.05	0.35	nA
Input Bias Current	I_B			3	5		3	6	nA
Input Noise Voltage	e_n	0.1Hz to 10Hz (Note 1)		0.9	2.0		0.9		μV_{p-p}
Input Noise Voltage Density		f_O = 10Hz (Note 1)		50	75		50		$nV/\sqrt{Hz}$
		f_O = 1000Hz (Note 1)		49	65		49		
Input Noise Current	i_n	0.1Hz to 10Hz (Note 1)		1.5	2.5		1.5		pA_{p-p}
Input Noise Current Density		f_O = 10Hz (Note 1)		0.03	0.07		0.03		$pA/\sqrt{Hz}$
		f_O = 1000Hz		0.01			0.01		
Input Resistance	R_{IN}	Differential mode (Note 1)	0.8	2.0		0.6	2.0		GΩ
		Common mode		12			12		
Input Voltage Range	$V_{IN\ (CM)}$	Upper limit	3.5	3.9		3.5	3.9		V
		Lower limit	0	-0.3		0	-0.3		
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0V to 3.5V	93	103		90	102		dB
Power-Supply Rejection Ratio	PSRR	V_S = 2.2V to 12V	94	104		92	104		dB
Large-Signal Voltage Gain	A_{VOL}	V_O = 0.03V to 4V, no load (Note 1)	140	700		110	700		V/mV
		V_O = 0.03V to 3.5V, R_L = 50kΩ	80	200		70	200		

ELECTRICAL CHARACTERISTICS: 5V (continued)

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

PARAMETER	SYMBOL	CONDITIONS	MAX478AC MAX479AC			MAX478C/E MAX479C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage Swing	V_{OUT}	Output low, no load		6.5	9.0		6.5	9.0	mV
		Output low, 2kΩ to GND		0.2	0.6		0.2	0.6	
		Output low, I_{SINK} = 100µA		120	160		120	160	
		Output high, no load	4.2	4.4		4.2	4.4		V
		Output high, 2kΩ to GND	3.5	3.8		3.5	3.8		
Slew Rate	SR	A_V = +1, C_L = 1pF (Note 1)	0.013	0.025		0.013	0.025		V/µs
Gain-Bandwidth Product	GBW	$f_O \le$ 5kHz		60			60		kHz
Supply Current per Amplifier	I_S			13	18		14	21	µA
		V_S = ±1.5V, V_O = 0V		12	17		13	20	
Channel Separation		ΔV_{IN} = 3V, R_L = 10kΩ		130			130		dB
Minimum Supply Voltage	V_S	(Note 2)		2.0	2.2		2.0	2.2	V

ELECTRICAL CHARACTERISTICS: 5V

(V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, T_A = 0°C to +70°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MAX478AC MAX479AC			MAX478C MAX479C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	MAX478ACP/CP		50	170		65	250	µV
		MAX479ACP/CP		60	200		70	290	
		MAX478CS					120	300	
		MAX479CS					130	400	
Input Offset Voltage Drift	$\frac{\Delta V_{OS}}{\Delta T}$	MAX47_ACP/CP (Note 1)		0.5	2.2		0.6	3.0	µV/°C
		MAX47_CS (Note 1)					0.8	4.5	
Input Offset Current	I_{OS}			0.06	0.35		0.06	0.50	nA
Input Bias Current	I_B			3	6		3	7	nA
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0V to 3.4V	90	101		86	100		dB
Power-Supply Rejection Ratio	PSRR	V_S = 2.5V to 12V	90	102		88	102		dB
Large-Signal Voltage Gain	A_{VOL}	V_O = 0.05V to 4V, no load (Note 1)	105	500		80	500		V/mV
		V_O = 0.05V to 3.5V, R_L = 50kΩ	55	160		45	160		
Output Voltage Swing	V_{OUT}	Output low, no load		8	11		8	11	mV
		Output low, I_{SINK} = 100µA		140	190		140	190	
		Output high, no load	4.1	4.3		4.1	4.3		V
		Output high, 2kΩ to GND	3.3	3.8		3.3	3.8		
Supply Current per Amplifier	I_S			14	21		15	24	µA

ELECTRICAL CHARACTERISTICS: 5V

(V_S = 5V, 0V, V_{CM} = 0.1V, V_O = 1.4V, T_A = -40°C to +85°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MAX478EP MAX479EP			MAX478ES MAX479ES			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	MAX478		80	315		150	400	µV
		MAX479		80	345		160	530	
Input Offset Voltage Drift	$\frac{\Delta V_{OS}}{\Delta T}$	(Note 1)		0.6	3.0		0.8	4.5	µV/°C
Input Offset Current	I_{OS}			0.07	0.7		0.07	0.7	nA
Input Bias Current	I_B			4	8		4	8	nA
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0.05V to 3.2V	84	98		84	98		dB
Power-Supply Rejection Ratio	PSRR	V_S = 3.0V to 12V	86	100		86	100		dB
Large-Signal Voltage Gain	A_{VOL}	V_O = 0.05V to 4V, no load (Note 1)	55	350		55	350		V/mV
		V_O = 0.05V to 3.5V, R_L = 50kΩ	35	130		35	130		
Output Voltage Swing	V_{OUT}	Output low, no load		9	13		9	13	mV
		Output low, I_{SINK} = 100µA		160	220		160	220	
		Output high, no load	3.9	4.2		3.9	4.2		V
		Output high, 2kΩ to GND	3.0	3.7		3.0	3.7		
Supply Current per Amplifier	I_S			15	27		15	27	µA

ELECTRICAL CHARACTERISTICS: 3V

(V_S = 3V, 0V, V_{CM} = 0.1V, V_O = 0.8V, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MAX478AC MAX479AC			MAX478C/E MAX479C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	MAX478ACP/CP/EP		30	90		40	140	µV
		MAX479ACP/CP/EP		35	120		40	170	
		MAX478CS/ES					80	200	
		MAX479CS/ES					90	270	
Input Offset Current	I_{OS}			0.05			0.05		nA
Input Bias Current	I_B			3			3		nA
Input Noise Voltage	e_N	0.1Hz to 10Hz		1.0			1.0		$µV_{p-p}$
Input Voltage Range	$V_{IN\ (CM)}$	Upper limit	1.7	1.9		1.7	1.9		V
		Lower limit	0	-0.3		0	-0.3		
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0V to 1.7V	93	103		90	102		dB
Power-Supply Rejection Ratio	PSRR	V_S = 2.2V to 12V	94	104		92	104		dB
Large-Signal Voltage Gain	A_{VOL}	V_O = 0.03V to 2V, no load (Note 1)	100	600		100	600		V/mV
		V_O = 0.03V to 1.5V, R_L = 50kΩ	30	180		30	180		
Output Voltage Swing	V_{OUT}	Output low, no load		6	9		6	9	mV
		Output low, 2kΩ to GND		0.2	0.6		0.2	0.6	
		Output high, no load	2.2	2.4		2.2	2.4		V
		Output high, 2kΩ to GND	1.8	2.0		1.8	2.0		
Gain-Bandwidth Product	GBW	$f_O \le$ 5kHz		50			50		kHz
Supply Current per Amplifier	I_S			12	17		13	20	µA
Minimum Supply Voltage	V_S				2.2			2.2	V
		With 300µV V_{OS} degradation		1.7			1.7		

ELECTRICAL CHARACTERISTICS: ±15V

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

PARAMETER	SYMBOL	CONDITIONS	MAX478AC MAX479AC			MAX478C/E MAX479C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}			80	350		100	480	µV
Input Offset Current	I_{OS}			0.05	0.25		0.05	0.35	nA
Input Bias Current	I_B			3	5		3	6	nA
Input Voltage Range	$V_{IN\ (CM)}$	Upper limit	13.5	13.9		13.5	13.9		V
		Lower limit	-15.0	-15.3		-15.0	-15.3		
Common-Mode Rejection Ratio	CMRR	V_{CM} = +13.5V, -15V	97	106		94	106		dB
Power-Supply Rejection Ratio	PSRR	V_S = 5V, 0V to ±15V	96	112		94	112		dB
Large-Signal Voltage Gain	A_{VOL}	V_O = ±10V, R_L = 50kΩ	300	1200		250	1000		V/mV
		V_O = ±10V, no load	600	2500		400	2500		
Output Voltage Swing	V_{OUT}	R_L = 50kΩ	±13.0	±14.2		±13.0	±14.2		V
		R_L = 2kΩ	±11.0	±12.7		±11.0	±12.7		
Slew Rate	SR	A_V = +1V, C_L = 15pF	0.02	0.04		0.02	0.04		V/µs
Gain-Bandwidth Product	GBW	$f_O \leq$ 5kHz		85			85		kHz
Supply Current per Amplifer	I_S			16	21		17	25	µA

ELECTRICAL CHARACTERISTICS: ±15V

(V_S = ±15V, T_A = 0°C to +70°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MAX478AC MAX479AC			MAX478C MAX479C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}			100	480		130	660	µV
Input Offset-Voltage Drift	$\frac{\Delta V_{OS}}{\Delta T}$	MAX47_ACP/CP (Note 1)		0.6	2.8		0.7	4.0	µV/°C
		MAX47_CS (Note 1)					0.9	5.5	
Input Offset Current	I_{OS}			0.06	0.35		0.06	0.35	nA
Input Bias Current	I_B			3	6		3	7	nA
Large-Signal Voltage Gain	A_{VOL}	V_O = ±10V, R_L = 50kΩ	200	800		150	750		V/mV
Common-Mode Rejection Ratio	CMRR	V_{CM} = +13V, -15V	94	104		91	104		dB
Power-Supply Rejection Ratio	PSRR	V_S = 5V, 0V to ±15V	93	110		91	110		dB
Output Voltage Swing	V_{OUT}	R_L = 5kΩ	±11.0	±13.5		±11.0	±13.5		V
Supply Current per Amplifer	I_S			17	24		18	28	µA

ELECTRICAL CHARACTERISTICS: ±15V

(V_S = ±15V, T_A = -40°C to +85°C, unless otherwise noted.)

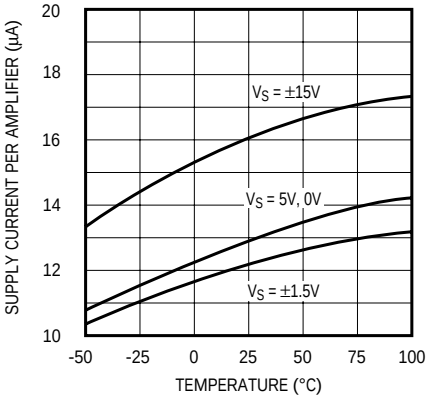
PARAMETER	SYMBOL	CONDITIONS	MAX478EP MAX479EP			MAX478ES MAX479ES			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}			130	740		130	740	µV
Input Offset-Voltage Drift	$\frac{\Delta V_{OS}}{\Delta T}$	(Note 1)		0.7	4.0		0.9	5.5	µV/°C
Input Offset Current	I_{OS}			0.07	0.70		0.07	0.70	nA
Input Bias Current	I_B			4	8		4	8	nA
Large-Signal Voltage Gain	A_{VOL}	V_O = ±10V, R_L = 50kΩ	100	500		100	500		V/mV
Common-Mode Rejection Ratio	CMRR	V_{CM} = +13V, -14.9V	88	103		88	103		dB
Power-Supply Rejection Ratio	PSRR	V_S = 5V, 0V to ±15V	88	109		88	109		dB
Output Voltage Swing	V_{OUT}	R_L = 5kΩ	±11.0	±13.5		±11.0	±13.5		V
Supply Current per Amplifer	I_S			19	30		19	30	µA

Note 1: Guaranteed by design.

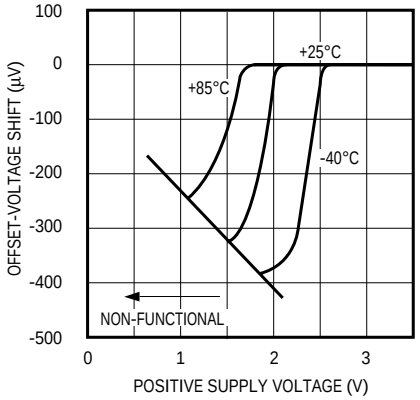
Note 2: Power-supply rejection ratio is measured at the minimum supply voltage. The op amps actually work at 1.7V supply, but with additional input offset-voltage skew.

Typical Operating Characteristics

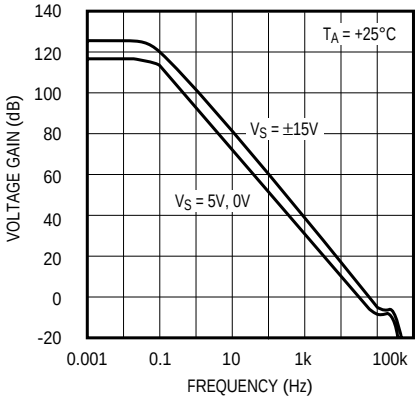
SUPPLY CURRENT vs. TEMPERATURE



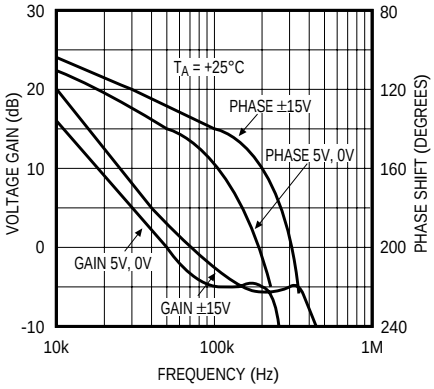
MINIMUM SUPPLY VOLTAGE



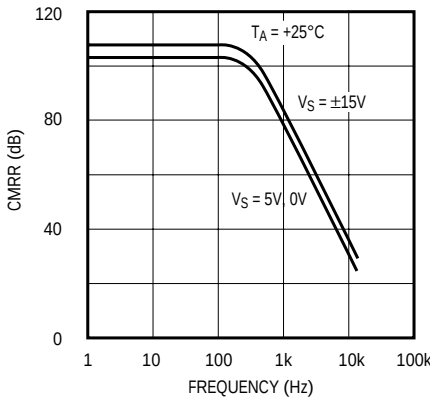
VOLTAGE GAIN vs. FREQUENCY



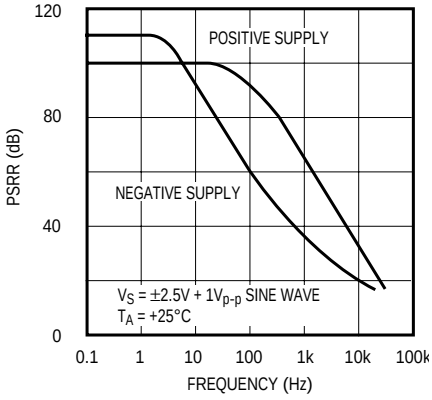
GAIN, PHASE vs. FREQUENCY



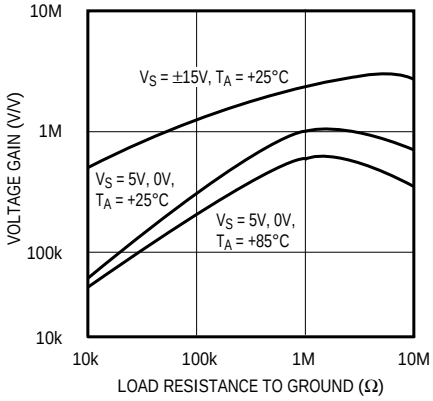
COMMON-MODE REJECTION RATIO vs. FREQUENCY



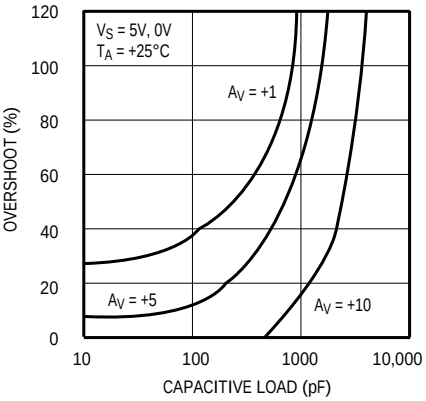
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



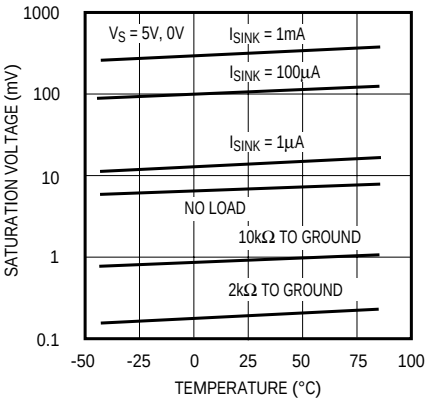
VOLTAGE GAIN vs. LOAD RESISTANCE



CAPACITIVE LOAD HANDLING



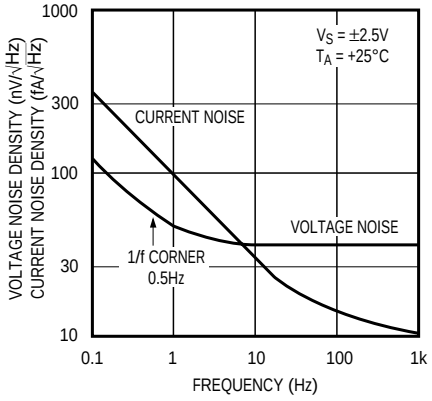
OUTPUT SATURATION vs. TEMPERATURE



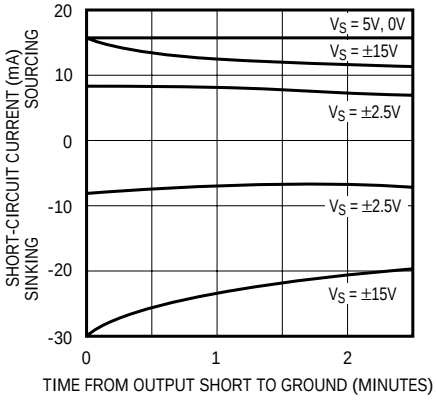
17µA Max, Dual/Quad, Single-Supply, Precision Op Amps

Typical Operating Characteristics (continued)

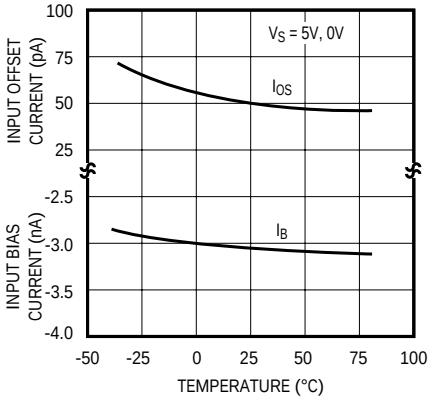
NOISE SPECTRUM



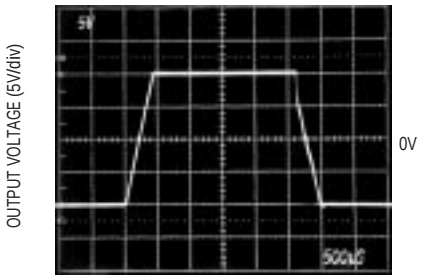
SHORT-CIRCUIT CURRENT



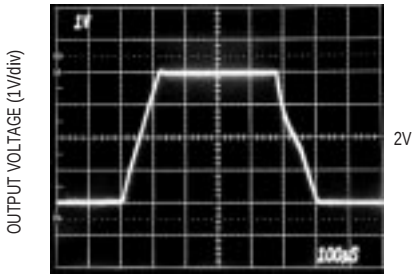
INPUT BIAS AND OFFSET CURRENT vs. TEMPERATURE



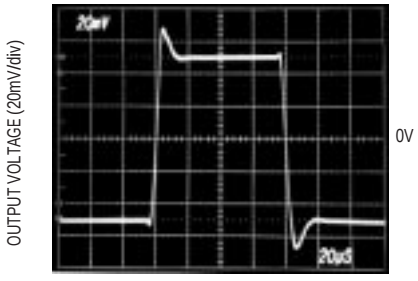
LARGE-SIGNAL TRANSIENT RESPONSE
V_S = ±15V



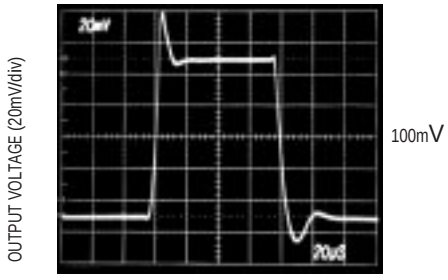
LARGE-SIGNAL TRANSIENT RESPONSE
V_S = 5V, 0V



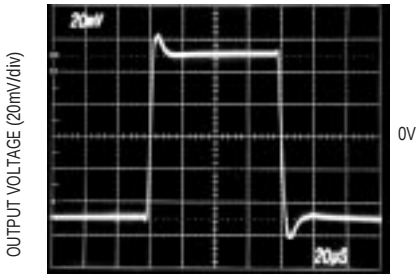
SMALL-SIGNAL TRANSIENT RESPONSE
V_S = ±2.5V



SMALL-SIGNAL TRANSIENT RESPONSE
V_S = 5V, 0V

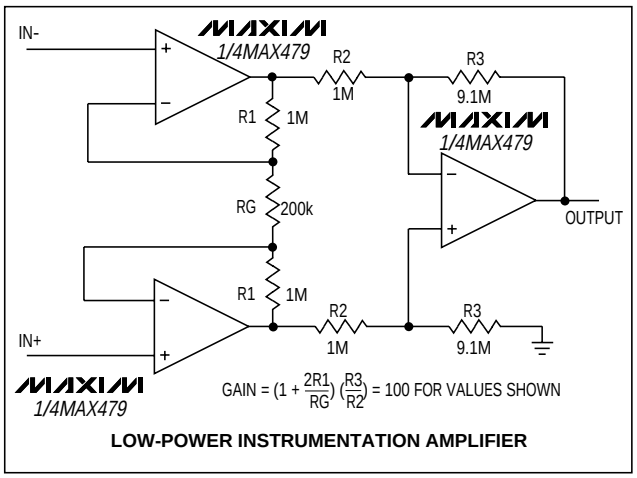


SMALL-SIGNAL TRANSIENT RESPONSE
V_S = ±15V



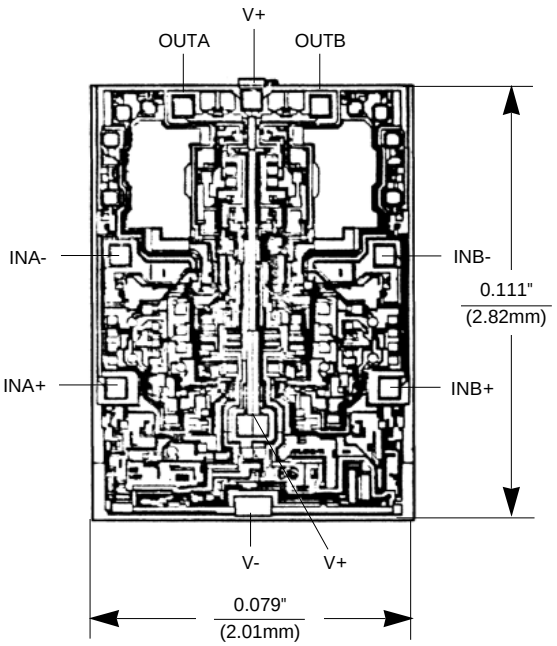
17µA Max, Dual/Quad, Single-Supply, Precision Op Amps

Typical Application Circuit

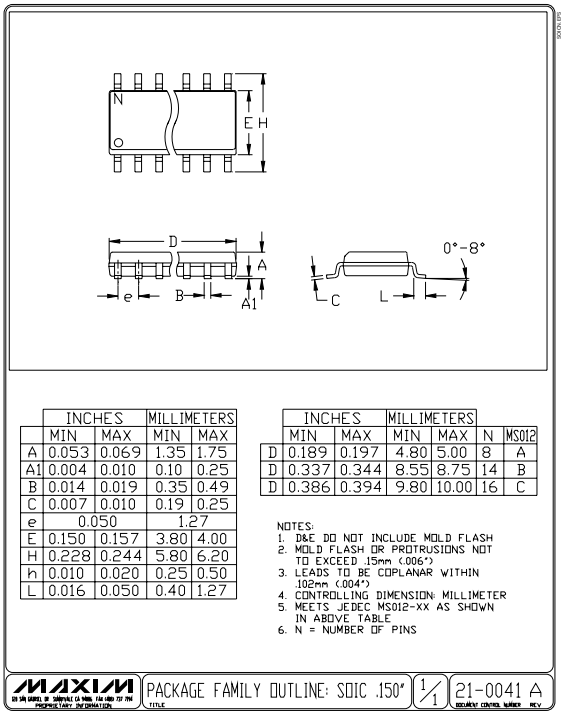


LOW-POWER INSTRUMENTATION AMPLIFIER

Chip Topograqhy



Package Information



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

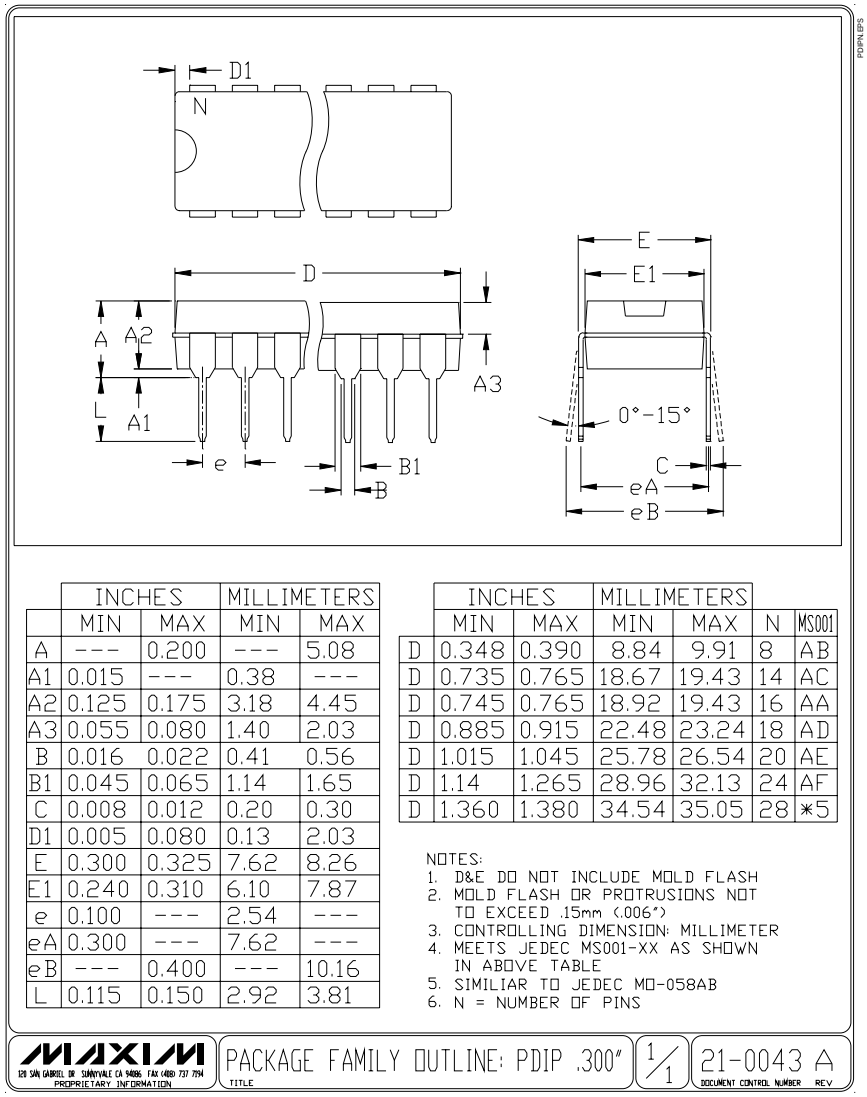
	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

MAXIM | PACKAGE FAMILY OUTLINE: SOIC .150" | 1/1 | 21-0041 A

17µA Max, Dual/Quad, Single-Supply, Precision Op Amps

Package Information (continued)



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.200	---	5.08
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.016	0.022	0.41	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.012	0.20	0.30
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100	---	2.54	---
eA	0.300	---	7.62	---
eB	---	0.400	---	10.16
L	0.115	0.150	2.92	3.81

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS001
D	0.348	0.390	8.84	9.91	8	AB
D	0.735	0.765	18.67	19.43	14	AC
D	0.745	0.765	18.92	19.43	16	AA
D	0.885	0.915	22.48	23.24	18	AD
D	1.015	1.045	25.78	26.54	20	AE
D	1.14	1.265	28.96	32.13	24	AF
D	1.360	1.380	34.54	35.05	28	*5

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MO-058AB
6. N = NUMBER OF PINS

MAXIM — 120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194 — PROPRIETARY INFORMATION

TITLE: PACKAGE FAMILY OUTLINE: PDIP .300" | 1/1 | 21-0043 A — DOCUMENT CONTROL NUMBER — REV