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Ultra-Low Offset Voltage Operational Amplifier

MAX400

General Description

The MAX400 guaranteed maximum 10 μ V offset error is the lowest input offset voltage of any commercially available (nonchopper) monolithic amplifier. The MAX400 represents a 2.5 times improvement over the highest grade OP07 (the OP07A), and a 5 times improvement over the best commercial temperature range device (OP07E). The offset voltage drift is guaranteed to be a maximum of 0.3 μ V/ $^{\circ}$ C which is also an improvement over the OP07 family.

For the ultimate in DC performance (5 μ V maximum offset voltage and 0.05 μ V/ $^{\circ}$ C maximum offset voltage drift) the MAX420 and MAX430 series of $\pm$ 15V monolithic, chopper-stabilized amplifiers should be consulted.

Applications

Precision Amplifiers
Thermocouple Amplifiers
Low-Level Signal Processing
Medical Instrumentation
Strain Gauge Amplifiers
High-Accuracy Data Acquisition

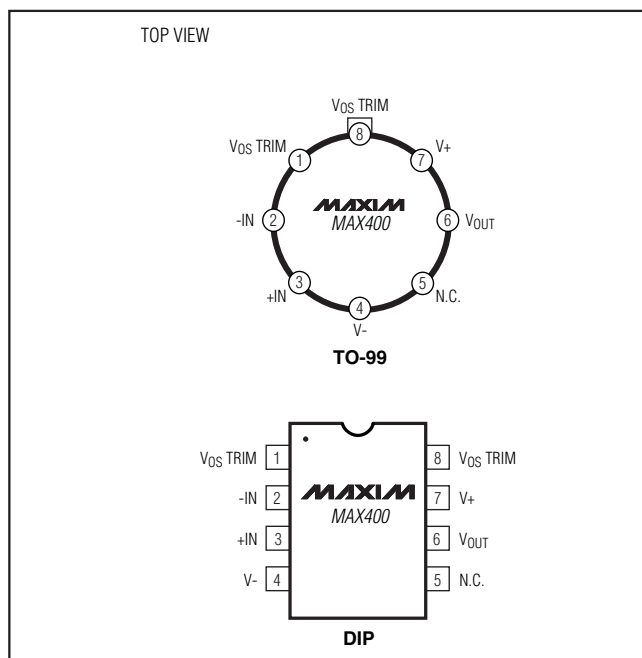
Features

- ◆ Ultra-Low Offset Voltage: 10 μ V (max)
- ◆ Ultra-Low Offset Voltage Drift: 0.2 μ V/ $^{\circ}$ C
- ◆ Ultra Stable vs. Time: 0.2 μ V/month
- ◆ Ultra-Low Noise: 0.35 μ Vp-p
- ◆ Wide Supply Voltage: $\pm$ 3V to $\pm$ 18V
- ◆ High Common-Mode Input: $\pm$ 14V
- ◆ No External Components Required
- ◆ Fits OP07, AD510, 725, 108A/308A Sockets

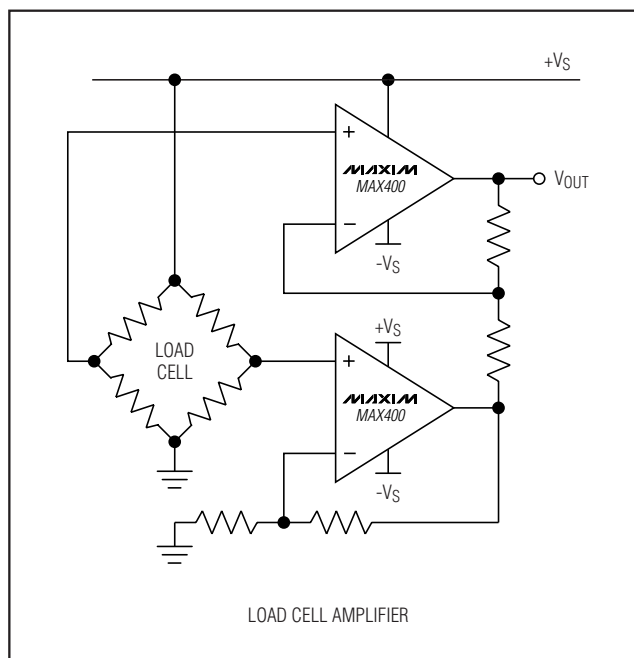
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX400MJA	-55 $^{\circ}$ C to +125 $^{\circ}$ C	8 CERDIP
MAX400MTV	-55 $^{\circ}$ C to +125 $^{\circ}$ C	8 TO-99
MAX400EJA	-40 $^{\circ}$ C to +85 $^{\circ}$ C	8 CERDIP
MAX400ETV	-40 $^{\circ}$ C to +85 $^{\circ}$ C	8 TO-99
MAX400CTV	0 $^{\circ}$ C to +70 $^{\circ}$ C	8 TO-99
MAX400CPA	0 $^{\circ}$ C to +70 $^{\circ}$ C	8 Plastic Dip
MAX400CSA	0 $^{\circ}$ C to +70 $^{\circ}$ C	8 SO

Pin Configuration



Typical Operating Circuit



Ultra-Low Offset Voltage Operational Amplifier

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V+ to V-)±22V
 Internal Power Dissipation.....500mW
 TO-99 (T) (derate at 7.1mW/°C above +80°C)
 Hermatic Dip (J) (derate 6.7mW/°C above +75°C)
 Plastic Dip (P) (derate 5.6mW/°C above +36°C)
 Differential Input Voltage±30V
 Input Voltage (Note 1).....±22V
 Storage Temperature Range-65°C to +150°C

Operating Temperature Range
 MAX400M-55°C to +125°C
 MAX400E-40°C to +85°C
 MAX400C0°C to +70°C
 Lead Temperature (soldering, 10s)+300°C
 Duration of Output Short CircuitIndefinite
 Junction Temperature (T_J).....-65°C to +160°C

Note 1: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

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

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

PARAMETER	SYMBOL	CONDITIONS	MAX400M			MAX400C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V _{OS}	(Note 2)		4	10		10	15	μV
Long-Term Input Offset Voltage Stability	V _{OS} /Time	(Note 3)		0.2			0.2		μV/ month
Input Offset Current	I _{OS}			0.3	2.0		0.3	2.0	nA
Input Bias Current	I _B			±0.7	±2.0		±0.7	±2.0	nA
Input Noise Voltage	e _{N(P-P)}	0.1Hz to 10Hz		0.35			0.35		μV _{P-P}
Input Noise-Voltage Density	e _N	f _O = 10Hz		10.3			10.3		nV/√Hz
		f _O = 100Hz		10.0			10.0		
		f _O = 1000Hz		9.6			9.6		
Input Noise Current	I _{N(P-P)}	0.1Hz to 10Hz		14			14		pA _{P-P}
Input Noise-Current Density	I _N	f _O = 10Hz		0.32			0.32		pA/√Hz
		f _O = 100Hz		0.14			0.14		
		f _O = 1000Hz		0.12			0.12		
Input Resistance Differential Mode	R _{IN}	(Note 4)	30	80		20	60		MΩ
Input Resistance Common Mode	R _{INCM}			200			200		GΩ
Input Voltage Range	IVR		±13	±14		±13	±14		V
Common-Mode Rejection Ratio	CMRR	V _{CM} = ±13V	114	126		114	126		dB
Power-Supply Rejection Ratio	PSRR	V _S = ±3V to ±18V		4	10		4	10	μV/V
Large-Signal Voltage Gain	A _{VO}	R _L ≥ 2kΩ, V _O = ±10V	500	1000		500	1000		V/mV
		R _L ≥ 500Ω, V _O = ±0.5V, V _S = ±3V (Note 4)	150	400		150	400		

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MAX400

ELECTRICAL CHARACTERISTICS (continued)

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

PARAMETER	SYMBOL	CONDITIONS	MAX400M			MAX400C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage Swing	V_O	$R_L \geq 10k\Omega$	± 12.5	± 13.0		± 12.5	± 13.0		V
		$R_L \geq 2k\Omega$	± 12.0	± 12.8		± 12.0	± 12.8		
		$R_L \geq 1k\Omega$	± 10.5	± 12.0		± 10.5	± 12.0		
Slew Rate	SR	$R_L \geq 2k\Omega$		0.3			0.3		V/ μS
Closed-Loop Bandwidth	BW	$A_{VCL} = +1V$		0.6			0.6		MHz
Open-Loop Output Resistance	R_O	$V_O = 0V$, $I_O = 0$		60			60		Ω
Power Consumption	P_D	$V_S = \pm 15V$, no load		75	120		75	120	mW
		$V_S = \pm 3V$, no load		4	6		4	6	
Offset Adjustment Range		$R_P = 20k\Omega$		± 4			± 4		mV

Note 2: V_{OS} is measured one minute after application of power.

Note 3: Long-term Input Offset Voltage Stability refers to the average trend line of V_{OS} vs. Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in V_{OS} during the first 30 operating days are typically 2.5 μV – refer to typical performance curves.

Note 4: Guaranteed by design.

ELECTRICAL CHARACTERISTICS

($V_S = \pm 15V$, $T_A = \text{full operating temperature range}$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MAX400M			MAX400C/E			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	(Note 5)		20	40		20	40	μV
Average Temperature Coefficient of Input Offset Voltage	TCV_{OS}	(Note 6)		0.2	0.3		0.2	0.3	$\mu V/^\circ C$
Input Offset Current	I_{OS}			0.8	4.0		0.8	4.0	nA
Average Input Offset Current Drift	TCI_{OS}			5			5		$pA/^\circ C$
Input Bias Current	I_B			± 1.0	± 4.0		± 1.0	± 4.0	nA
Average Input Bias Current Drift	TCI_B			8			8		$pA/^\circ C$
Input Voltage Range	IVC		± 13	± 13.5		± 13	± 13.5		V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 13V$	106	123		106	123		dB
Power-Supply Rejection Ratio	PSRR	$V_S = \pm 3V$ to $\pm 18V$		5	20		5	20	$\mu V/V$
Large-Signal Voltage Gain	A_{VO}	$R_L \geq 2k\Omega$, $V_O = \pm 10V$	200	400		200	400		V/mV
Output Voltage Swing	V_D	$R_L \geq 2k\Omega$	± 12.0	± 12.6		± 12.0	± 12.6		V

Note 5: Offset Voltage is measured one minute after application of power.

Note 6: 100% tested.

Ultra-Low Offset Voltage Operational Amplifier

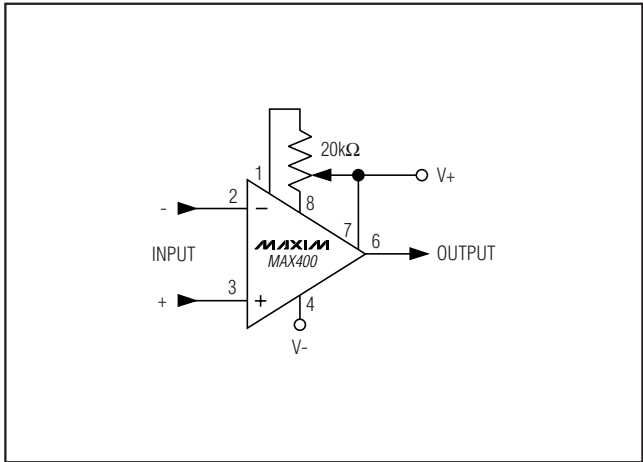


Figure 1. Optional Offset Nulling Circuit

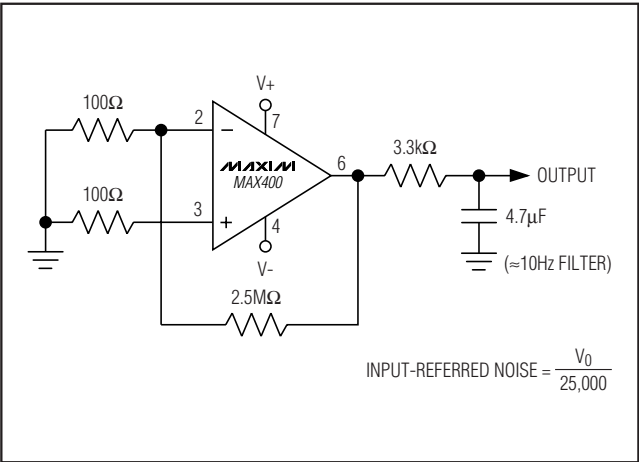
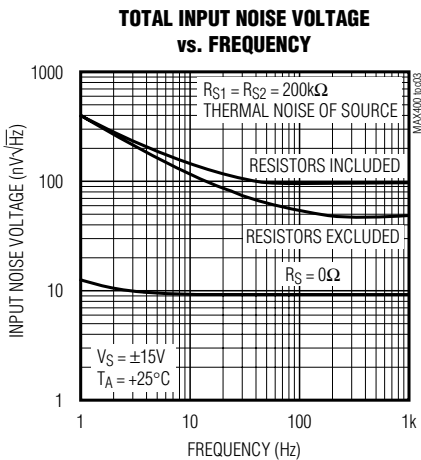
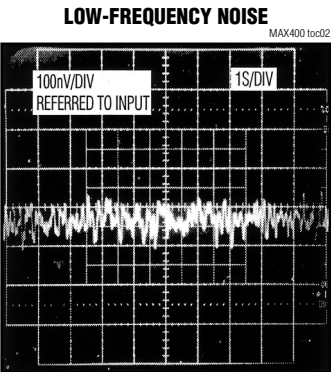
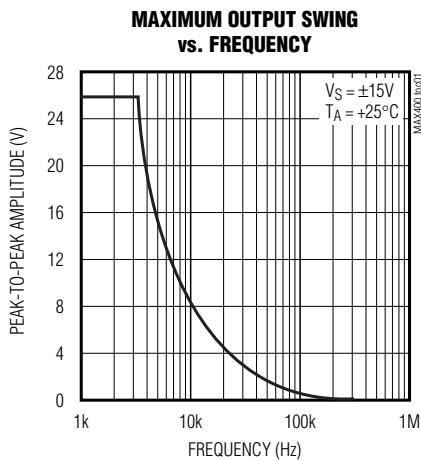


Figure 2. Low-Frequency Noise Test Circuit

Typical Operating Characteristics

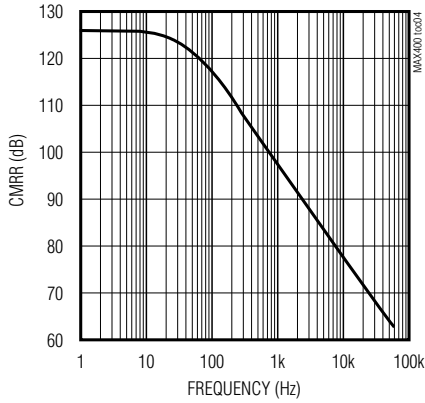


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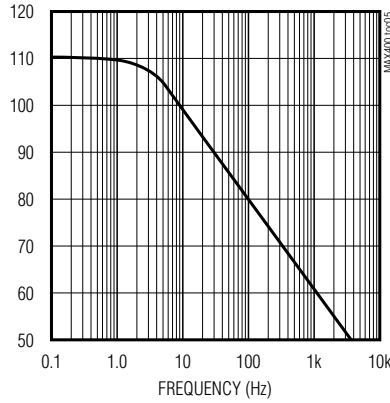
Typical Operating Characteristics (continued)

MAX400

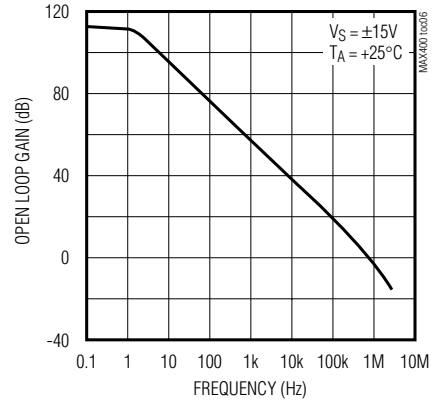
CMRR vs. FREQUENCY



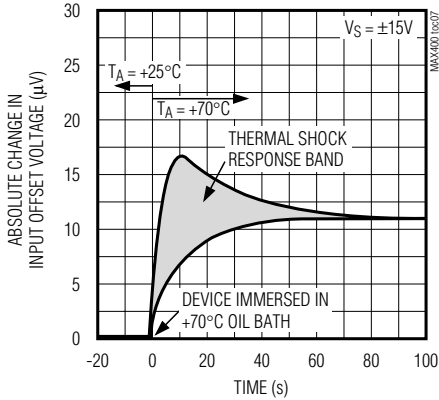
PSRR vs. FREQUENCY



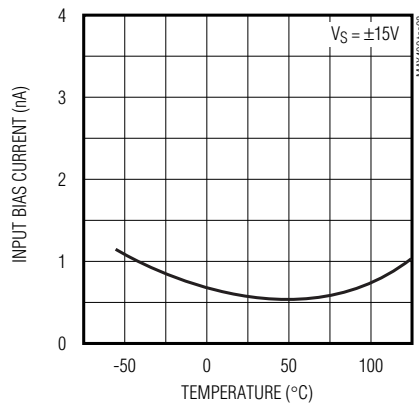
OPEN-LOOP FREQUENCY RESPONSE



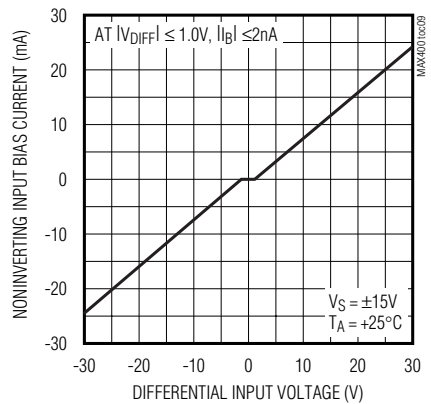
OFFSET VOLTAGE CHANGE DUE TO THERMAL SHOCK



INPUT BIAS CURRENT vs. TEMPERATURE



INPUT BIAS CURRENT vs. DIFFERENTIAL INPUT VOLTAGE



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