19-0286; Rev 1; 8/94

MAXIM

Precision Operational Amplifier

General Description

The MXL1001 offers significant specification improvement over earlier precision operational amplifiers and is pin-compatible with the industry-standard LT1001. Particular attention has been paid to the optimization of key parameters such as input offset voltage, common-mode rejection, and power-supply rejection. In addition, the high-performance MXL1001C commercial temperature device provides considerable cost savings when compared to equivalent grades of competing precision amplifiers.

The input offset voltage of all units is less than 60µV, allowing the premium military device, the MXL1001AM, to be specified at 15µV max. Power dissipation is close to half that of the industry-standard OP-07 precision op amp, without sacrificing noise or speed performance. A useful by-product of lower dissipation is decreased warm-up drift.

Applications

Thermocouple Amplifiers

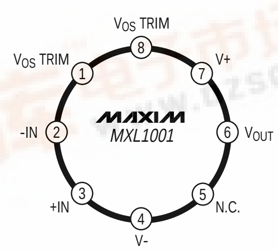
Low-Level Signal Processing

Strain Gauge Amplifiers

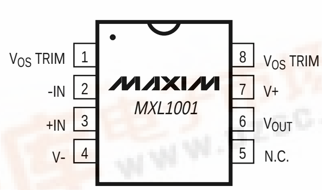
High-Accuracy Data Acquisition

Pin Configuration

TOP VIEW



TO-99



DIP/SO

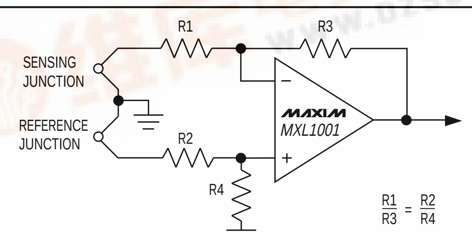
Features

- **Guaranteed Low Offset Voltage**
  - **MXL1001AM: 15µV max**
  - **MXL1001C: 60µV max**
- **Guaranteed Low Drift**
  - **MXL1001AM: 0.6µV/°C max**
  - **MXL1001C: 1.0µV/°C max**
- **Guaranteed Low Bias Current**
  - **MXL1001AM: 2nA max**
  - **MXL1001C: 4nA max**
- **Guaranteed CMRR**
  - **MXL1001AM: 114dB min**
  - **MXL1001C: 110dB min**
- **Guaranteed PSRR**
  - **MXL1001AM: 110dB min**
  - **MXL1001C: 106dB min**
- **Low Power Dissipation**
  - **MXL1001AM: 75mW max**
  - **MXL1001C: 80mW max**
- **Low Noise: 0.3µV$_{p\text{-}p}$**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MXL1001ACN8	0°C to +70°C	8 Plastic DIP
MXL1001CN8	0°C to +70°C	8 Plastic DIP
MXL1001ACS8	0°C to +70°C	8 SO
MXL1001CS8	0°C to +70°C	8 SO
MXL1001ACJ8	0°C to +70°C	8 CERDIP
MXL1001CJ8	0°C to +70°C	8 CERDIP
MXL1001ACH	0°C to +70°C	8 TO-99
MXL1001CH	0°C to +70°C	8 TO-99
MXL1001AMJ8	-55°C to +125°C	8 CERDIP
MXL1001MJ8	-55°C to +125°C	8 CERDIP
MXL1001AMH	-55°C to +125°C	8 TO-99
MXL1001MH	-55°C to +125°C	8 TO-99

Typical Operating Circuit



HIGH-STABILITY THERMOCOUPLER AMPLIFIER

MXL1001

Precision Operational Amplifier

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V+ to V-) ....±22V
Continuous Power Dissipation 500mW
TO-99(H)—derate at 7.1mW/°C above +80°C
CERDIP(J)—derate at 6.7mW/°C above +75°C
Plastic DIP(P)—derate at 5.6mW/°C above +36°C
Small Outline(S)—derate at 5mW/°C above +55°C
Differential Input Voltage ....±30V
Input Voltage (Note 1)..±22V
Duration of Output Short Circuit ....Indefinite
Operating Temperature Ranges:
MXL1001C_/AC_..0°C to +70°C
MXL1001M_/AM_..-55°C to +125°C
Junction Temperature (T_J)................................-65°C to +160°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10sec) ....+300°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		MXL1001AM MXL1001AC			MXL1001M MXL1001C			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	(Note 2)	MXL1001AM		7	15		18	60	µV
			MXL1001AC		10	25		18	60	
Long-Term Input Offset Voltage Stability	V_{OS}/Time	(Note 3)			0.2	1.0		0.3	1.5	µV/ Month
Input Offset Current	I_{OS}				0.3	2.0		0.4	3.8	nA
Input Bias Current	I_B				±0.5	±2.0		±0.7	±4.0	nA
Input Noise Voltage	$e_{N\ p\text{-}p}$	0.1Hz to 10Hz (Note 4)			0.3	0.6		0.3	0.6	$\mu V_{p\text{-}p}$
Input Noise Voltage Density	e_N	f_O = 10Hz (Note 4)			10.3	18.0		10.5	18.0	nV/√Hz
		f_O = 100Hz (Note 4)			10.0	13.0		10.0	13.0	
		f_O = 1000Hz (Note 4)			9.6	11.0		9.8	11.0	
Input Resistance (Differential Mode)	R_{IN}	(Note 5)		30	100		15	80		MΩ
Input Voltage Range	IVR			±13	±14		±13	±14		V
Common-Mode Rejection Ratio	CMRR	V_{CM} = ±13V		114	126		110	126		dB
Power-Supply Rejection Ratio	PSRR	V_S = ±3V to ±18V		110	123		106	123		dB
Large-Signal Voltage Gain	A_{VO}	R_L ≥ 2kΩ, V_O = ±12V		450	800		400	800		V/mV
		R_L ≥ 1kΩ, V_O = ±10V		300	500		250	500		
Output Voltage Swing	V_O	R_L ≥ 2kΩ		±13.0	±14.0		±13.0	±14.0		V
		R_L ≥ 1kΩ		±12.0	±13.5		±12.0	±13.5		
Slew Rate	SR	R_L ≥ 2kΩ (Note 4)		0.1	0.25		0.1	0.25		V/µs
Closed-Loop Bandwidth	BW	A_{VCL} = +1V (Note 4)		0.4	0.8		0.4	0.8		MHz
Power Consumption	P_D	V_S = ±15V, no load			46	75		48	80	mW
		V_S = ±3V, no load			4	6		4	8	

Note 2: MXL1001A grade V_{OS} is measured one minute after application of power. For all other grades V_{OS} is measured approximately 0.5 seconds 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 2.5µV. Parameter is sample tested.
Note 4: Sample tested.
Note 5: Guaranteed by design.

ELECTRICAL CHARACTERISTICS

(V_S = ±15V, -55°C ≤ T_A ≤ +125°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MXL1001AM			MXL1001M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	(Note 6)		30	60		45	160	µV
Average Temperature Coefficient of Input Offset Voltage	TCV_{OS}			0.2	0.6		0.3	1.0	µV/°C
Input Offset Current	I_{OS}			0.8	4.0		1.2	7.6	nA
Input Bias Current	I_B			±1.0	±4.0		±1.5	±8.0	nA
Input Voltage Range	IVR		±13	±14		±13	±14		V
Common-Mode Rejection Ratio	CMRR	V_{CM} = ±13V	110	122		106	120		dB
Power-Supply Rejection Ratio	PSRR	V_S = ±3V to ±18V	104	117		100	117		dB
Large-Signal Voltage Gain	A_{VO}	R_L ≥ 2kΩ, V_O = ±10V	300	700		200	700		V/mV
Output Voltage Swing	V_O	R_L ≥ 2kΩ	±12.5	±13.5		±12.5	±13.5		V
Power Dissipation	P_D	No load		55	90		60	100	mW

ELECTRICAL CHARACTERISTICS

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

PARAMETER	SYMBOL	CONDITIONS	MXL1001AC			MXL1001C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	(Note 6)		20	60		30	110	µV
Average Temperature Coefficient of Input Offset Voltage	TCV_{OS}			0.2	0.6		0.3	1.0	µV/°C
Input Offset Current	I_{OS}			0.5	3.5		0.6	5.3	nA
Input Bias Current	I_B			±0.7	±3.5		±1.0	±5.5	nA
Input Voltage Range	IVR		±13	±14		±13	±14		V
Common-Mode Rejection Ratio	CMRR	V_{CM} = ±13V	110	124		106	123		dB
Power-Supply Rejection Ratio	PSRR	V_S = ±3V to ±18V	106	120		103	120		dB
Large-Signal Voltage Gain	A_{VO}	R_L ≥ 2kΩ, V_O = ±10V	350	750		250	750		V/mV
Output Voltage Swing	V_O	R_L ≥ 2kΩ	±12.5	±13.8		±12.5	±13.8		V
Power Dissipation	P_D	No load		50	85		55	90	mW

Note 6: MXL1001A grade offset voltage is measured one minute after application of power. For all other grades V_{OS} is measured 0.5 seconds after power on.

Applications Information

The MXL1001 series devices are pin-compatible with the OP-07, OP-05, 725, 108A or 101A amplifiers. The MXL1001 amplifiers can be used to upgrade older designs using these devices, with or without removal of external frequency compensation or nulling components. The MXL1001 can also be used in 741, LF156 or OP-15 applications provided the nulling circuitry is removed.

The MXL1001 is specified over a wide supply voltage range from ±3V to ±18V. Operation with lower supplies is possible down to ±1.2V (two NiCd batteries), however, at this level the device is stable only in closed-loop gains of +2 and above (or inverting gain of one or higher). Unless proper care is exercised, thermocouple effects caused by temperature gradients across dissimilar metals at the input terminal connections, can exceed the inherent offset-voltage drift of the amplifier. Air currents over the device leads should be minimized, package leads should be short, and the two input leads should be as close together as possible and maintained at the same temperature.

Offset-Voltage Adjustment

The input offset voltage of the MXL1001, and its temperature drift, are minimized by zener-zap trimming at the wafer level. If further nulling of V_{OS} is required, this can be performed using a 10kΩ or 20kΩ potentiometer with no degradation of V_{OS} drift with temperature. Trimming to a value other than zero creates a drift of (V_{OS}/300)µV/°C; i.e., if V_{OS} is adjusted to 300µV, the change in drift will be 1µV/°C. The adjustment range with a 10kΩ or 20kΩ potentiometer is approximately ±2.5mV. If less adjustment range is needed, the sensitivity and resolution of the offset nulling can be improved by using a potentiometer of lower ohmic value in conjunction with fixed resistors.

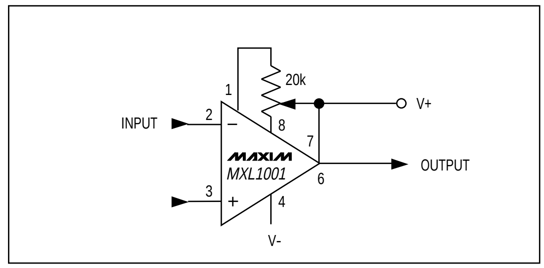
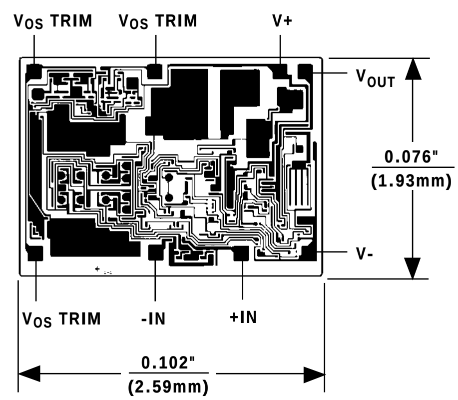


Figure 1. Optional Offset Nulling Circuit

Chip Topography



SUBSTRATE IS CONNECTED TO V-