



# OP-01

## INVERTING HIGH-SPEED OPERATIONAL AMPLIFIER

Precision Monolithics Inc.

### FEATURES

- Fast Settling Time .....  $1\mu\text{s}$  to  $0.1\%$  Max
- High Slew Rate .....  $12\text{V}/\mu\text{s}$  Min
- Power Bandwidth .....  $150\text{kHz}$  Min
- Low Power Consumption .....  $90\text{mW}$  Max
- Excellent DC Specifications
- Internally Compensated
- Ideal DAC Output Amplifier
- MIL-STD-883 Processing Available
- Fits Standard 741 Sockets
- Low Cost
- Available in Die Form

### ORDERING INFORMATION †

$T_A = 25^\circ\text{C}$ $V_{OS}$ MAX (mV)	PACKAGE			OPERATING TEMPERATURE RANGE
	TO-99	CERDIP 8-PIN	PLASTIC 8-PIN	
0.7	OP01J*	—	—	MIL
0.7	—	—	OP01HP	COM
5.0	OP01GJ	—	—	MIL
5.0	OP01CJ	OP01CZ	OP01CP	COM

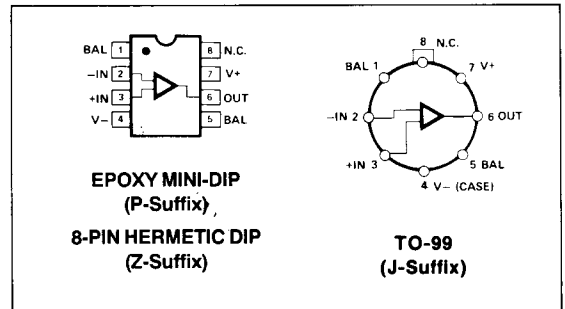
\* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

† Burn-in is available on commercial and industrial temperature range parts in CerDIP, plastic DIP, and TO-can packages. For ordering information, see 1990/91 Data Book, Section 2.

and excellent DC input characteristics. An internal feed-forward frequency compensation network provides simplicity of application — no external capacitors are required for stable, high-speed performance. The fast output response is achieved without sacrifice of input bias current or power consumption. A 250kHz typical power bandwidth is attained with a small-signal bandwidth of only 2.5MHz, thus board layout is non-critical. The OP-01 is completely protected at both input and output, fits standard 741 sockets, and is offset nulled with a  $10\text{k}\Omega$  potentiometer.

The fast output response combined with excellent settling time makes the OP-01 ideal for use as a D/A converter output amplifier.

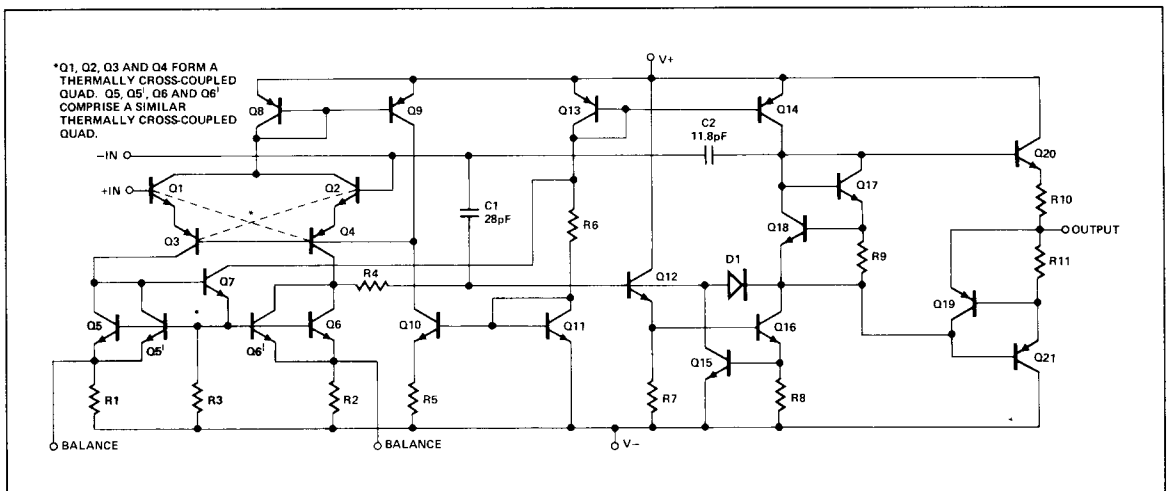
### PIN CONNECTIONS



### GENERAL DESCRIPTION

The OP-01 series of monolithic inverting high-speed operational amplifiers combines high slew rate, fast settling time

### SIMPLIFIED SCHEMATIC



**ABSOLUTE MAXIMUM RATINGS** (Note 1)

Total Supply Voltage, OP-01, OP-01H, OP-01N, OP-01NT, OP-01G, OP-01GT .....	±22V
OP-01G, OP-01C, OP-01GR .....	±20V
Differential Input Voltage .....	±30V
Input Voltage (Note 2) .....	±15V
Short-Circuit Duration .....	Indefinite
Operating Temperature Range	
OP-01, OP-01G .....	-5°C to +125°C
OP-01H, OP-01C .....	0°C to +70°C
Junction Temperature ( $T_j$ ) .....	-65°C to +150°C
Storage Temperature	
J and Z Packages .....	-65°C to +150°C
P Packages .....	-65°C to +150°C

Lead Temperature (Soldering, 60 sec) ..... +300°C

PACKAGE TYPE	$\theta_{JA}$ (NOTE 3)	$\theta_{JC}$	UNITS
TO-99 (J)	170	24	°C/W
8-Pin Hermetic DIP (Z)	162	26	°C/W
8-Pin Plastic DIP (P)	110	50	°C/W

**NOTES:**

1. Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.
2. For supply voltages less than ±15V, the maximum input voltage is the supply voltage.
3.  $\theta_{JA}$  is specified for worst case mounting conditions, i.e.,  $\theta_{JA}$  is specified for device in socket for TO, CerDIP and P-DIP packages.

**ELECTRICAL CHARACTERISTICS** at  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-01 OP-01H			OP-01G OP-01C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$V_{OS}$	$R_S \leq 20k\Omega$	—	0.3	0.7	—	2.0	5.0	mV
Input Offset Current	$I_{OS}$		—	0.5	2.0	—	2.0	20	nA
Input Bias Current	$I_B$		—	18	30	—	25	100	nA
Input Voltage Range	IVR		±12	±13	—	±12	±13	—	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 10V$ $R_S \leq 20k\Omega$	85	110	—	80	100	—	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5V$ to $\pm 20V$ $R_S \leq 20k\Omega$	—	10	60	—	100	150	$\mu V/V$
Output Voltage Swing	$V_O$	$R_L \geq 5k\Omega$ $R_L \geq 2k\Omega$	±12.5 ±12.0	±13.5 ±13.0	—	±12.5 ±12.0	±13.5 ±13.0	—	V
Large-Signal Voltage Gain	$A_{VO}$	$R_L \geq 2k\Omega$ $V_O = \pm 10V$	50	100	—	25	75	—	V/mV
Power Consumption	$P_d$	$V_{OUT} = 0$	—	50	90	—	50	90	mW
Settling Time to 0.1% (Summing Node Error)	$t_S$	$A_V = -1$ (Notes 1, 2) $V_{IN} = 5V$	—	0.7	1.0	—	0.7	1.0	$\mu s$
Slew Rate (Notes 2, 3)	SR	$A_V = -1$ $R_S = 3k$ to $5k\Omega$	12	18	—	12	18	—	V/ $\mu s$
Large-Signal Bandwidth (Notes 3, 4)			150	250	—	150	250	—	kHz
Small-Signal Bandwidth (Notes 3, 4)			1.5	2.5	—	1.5	2.5	—	MHz
Risetime	$t_r$	$A_V = -1$ $V_{IN} = 50mV$	—	150	—	—	150	—	ns
Overshoot	OS		—	2	—	—	2	—	%

**NOTES:**

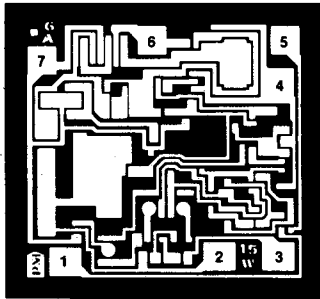
1.  $R_L = 25k\Omega$ ;  $C_L = 50pF$ . See Settling Time Test Circuit.
2. Sample tested.
3. See applications information.
4. Guaranteed by design.

**ELECTRICAL CHARACTERISTICS** at  $V_S = \pm 15V$ ,  $-55^\circ C \leq T_A \leq +125^\circ C$  for OP-01, OP-01G and  $0^\circ C \leq T_A \leq +70^\circ C$  for OP-01H, OP-01C, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-01 OP-01H			OP-01G OP-01C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$V_{OS}$	$R_S \leq 20k\Omega$	—	0.4	1.0	—	3.0	6.0	mV
Input Offset Current	$I_{OS}$		—	1	4	—	4	40	nA
Input Bias Current	$I_B$		—	30	50	—	50	200	nA
Input Voltage Range	IVR		$\pm 10$	$\pm 13$	—	$\pm 10$	$\pm 13$	—	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 10V$ $R_S \leq 20k\Omega$	85	110	—	80	100	—	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5V$ to $\pm 20V$ $R_S \leq 20k\Omega$	—	10	60	—	100	150	$\mu V/V$
Large-Signal Voltage Gain	$A_{VO}$	$R_L \geq 2k\Omega$ $V_O = \pm 10V$	30	60	—	15	50	—	V/mV
Output Voltage Swing	$V_O$	$R_L \geq 5k\Omega$ $R_L \geq 2k\Omega$	$\pm 12.5$ $\pm 12.0$	$\pm 13.5$ $\pm 13.0$	—	$\pm 12.5$ $\pm 12.0$	$\pm 13.5$ $\pm 13.0$	—	V
Offset Voltage Drift (Note 1)	$TCV_{OS}$	$R_S \leq 5k\Omega$	—	2	8	—	5	20	$\mu V/^\circ C$

**NOTE:**

1. Sample tested.

**DICE CHARACTERISTICS (125°C TESTED DICE AVAILABLE)**


1. NULL
2. INVERTING INPUT
3. NONINVERTING INPUT
4. V-
5. NULL
6. OUTPUT
7. V+

For additional DICE ordering information, refer to 1990/91 Data Book, Section 2.

DIE SIZE 0.047 × 0.043 inch, 2021 sq. mils  
(1.19 × 1.09 mm, 1.30 sq. mm)

**WAFER TEST LIMITS** at  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$  for OP-01N, OP-01G and OP-01GR devices;  $T_A = 125^\circ C$  for OP-01NT and OP-01GT devices, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-01NT LIMIT	OP-01N LIMIT	OP-01GT LIMIT	OP-01G LIMIT	OP-01GR LIMIT	UNITS
Input Offset Voltage	$V_{OS}$	$R_S \leq 20k\Omega$	1.0	0.7	3.0	2.0	5.0	mV MAX
Input Offset Current	$I_{OS}$		4	2	10	5	20	nA MAX
Input Bias Current	$I_B$		50	30	100	50	100	nA MAX
Input Voltage Range	IVR		$\pm 10$	$\pm 12$	$\pm 10$	$\pm 12$	$\pm 12$	V MIN
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 10V$ $R_S \leq 20k\Omega$	85	85	80	80	80	dB MIN
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5V$ to $\pm 20V$ $R_S \leq 20k\Omega$	60	60	100	100	150	$\mu V/V$ MAX
Output Voltage Swing	$V_{OM}$	$R_L \geq 5k\Omega$ $R_L \geq 2k\Omega$	$\pm 12.5$ $\pm 12.0$	$\pm 12.5$ $\pm 12.0$	$\pm 12.5$ $\pm 12.0$	$\pm 12.5$ $\pm 12.0$	$\pm 12.5$ $\pm 12.0$	V MIN
Large-Signal Voltage Gain	$A_{VO}$	$R_L \geq 2k\Omega$ $V_O = \pm 10V$	30	50	25	50	25	V/mV MIN
Power Consumption	$P_d$	$V_{OUT} = 0$	—	90	—	90	90	mW MAX

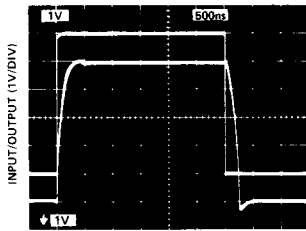
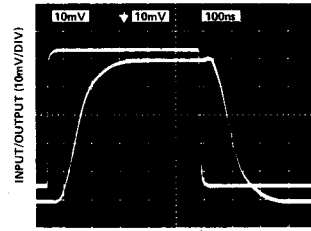
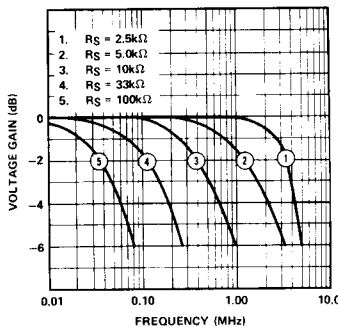
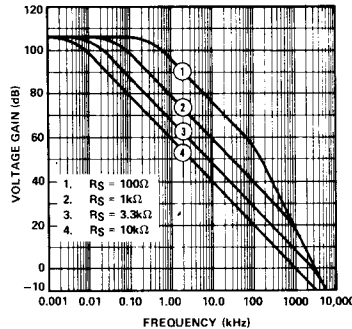
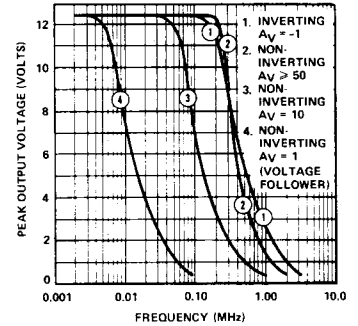
**NOTES:**

For 25°C characteristics of NT & GT devices, see N & G characteristics respectively.

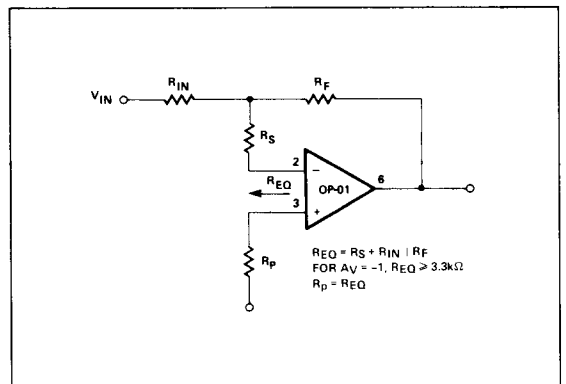
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

**TYPICAL ELECTRICAL CHARACTERISTICS** at  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	ALL GRADES TYPICAL	UNITS
Slew Rate	SR	$A_{VCL} = -1$ , $R_S = 3k\Omega$ to $5k\Omega$	18	V/ $\mu s$
Settling Time to 0.1% (Summing Node Error)	$t_s$	$V_{IN} = 5V$ $A_V = -1$ $R_L = 2k\Omega$ (See Settling Time Test Circuit) $C_L = 50pF$	1.0	$\mu s$
Large-Signal Bandwidth			250	kHz
Small-Signal Bandwidth			2.5	MHz
Risetime	$t_r$	$V_{IN} = 50mV$ $A_V = -1$	150	ns

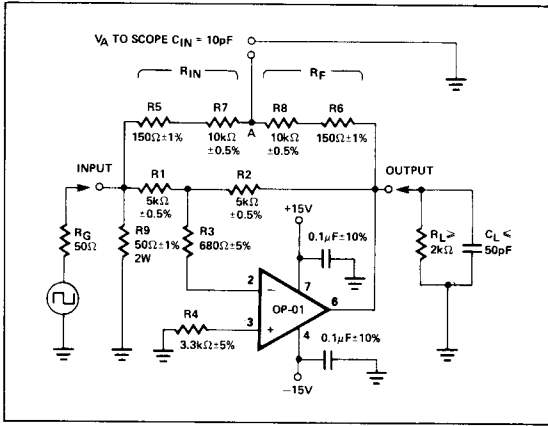
**TYPICAL PERFORMANCE CHARACTERISTICS**
**LARGE-SIGNAL PULSE RESPONSE**

 $V_S = \pm 15V, A_V = -1, R_L = 2k\Omega, C_L = 50pF$ 
**SMALL-SIGNAL PULSE RESPONSE**

 $V_S = \pm 15V, A_V = -1, R_L = 2k\Omega, C_L = 50pF$ 
**UNITY-GAIN BANDWIDTH vs SOURCE RESISTANCE**

**OPEN-LOOP GAIN vs FREQUENCY**

**LARGE-SIGNAL OUTPUT SWING vs FREQUENCY**

**APPLICATIONS INFORMATION**

The OP-01 incorporates an internal feed-forward compensation network to provide fast slewing and settling times in all inverting and moderate-to-high-gain noninverting applications. Unity-gain bandwidth is a function of the total equivalent source resistance seen by the inverting terminal. Proper choice of this resistance will allow the user to maximize bandwidth while assuring proper stability. The equivalent-inverting-terminal-resistance is defined as  $R_{IN} \parallel R_F$ , and it must be greater than  $3.3k\Omega$  to assure stability in all closed-loop gain configurations including unity gain. Should  $R_{IN} \parallel R_F \leq 3.3k\Omega$ , a resistor ( $R_S$ ) may be placed between the inverting input and the sum node to provide the required resistance. (See Fast Inverting Amplifier Diagram.) Lower values of total equivalent resistance may be used to improve bandwidth in higher closed-loop gain configurations, as indicated by the Open-Loop Gain vs. Frequency plot.

**FAST INVERTING AMPLIFIER**


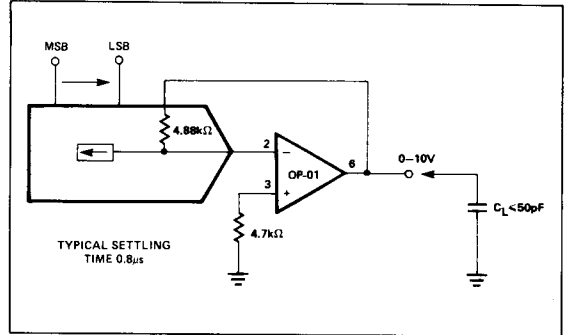
**SETTLING-TIME TEST CIRCUIT**

Settling time may be measured using the circuit shown below. This circuit incorporates the "false sum node" technique to produce accurate, repeatable results. For a 5V input step, 0.1% settling will be achieved when the false sum node settles to within  $\pm 2.5\text{mV}$  of its final value. The oscilloscope used for observation of the false sum node should have wide bandwidth, fast overload recovery time, and be used with a low capacity probe ( $\leq 10\text{pF}$ , including strays). A Tektronix 7504 scope with a 7A11 probe or equivalent is suggested. The pulse generator should have a  $50\Omega$  output impedance and be capable of a 5V rise time in  $\leq 20\text{ns}$  with ringing less than  $2.5\text{mV}$  after  $0.5\mu\text{s}$ . Measurements to 0.1% require  $R_{IN}$  to equal  $R_F$  within 0.01%;  $R_5$  and  $R_6$  are used as trimming resistors to achieve this matching.

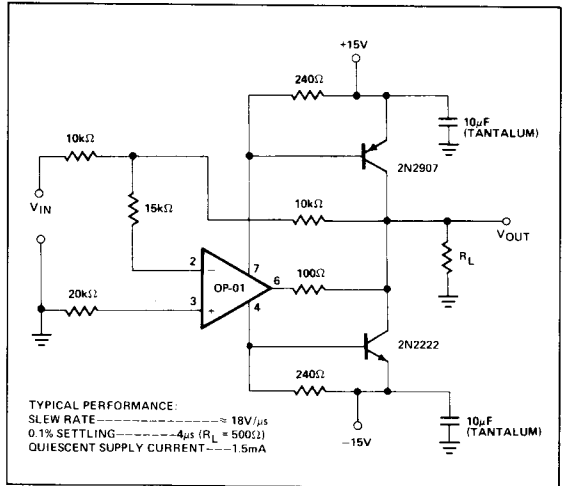


**TYPICAL APPLICATIONS**

**FAST VOLTAGE-OUTPUT D/A CONVERTER**



**PRECISION POWER-BOOSTER CIRCUIT**



**OFFSET NULLING CIRCUIT**

