



**National  
Semiconductor  
Corporation**

**PRELIMINARY**

## LM6164/LM6264/LM6364 High Speed Operational Amplifier

### General Description

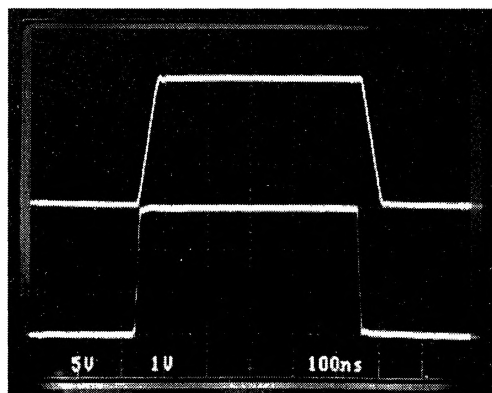
The LM6164 family of high-speed amplifiers exhibits an excellent speed-power product in delivering 300V per  $\mu$ s and 175 MHz GBW (stable to a gain of +5) with only 5 mA of supply current. Further power savings and application convenience are possible by taking advantage of the wide dynamic range in operating supply voltage which extends all the way down to +5V.

These amplifiers are built with National's new VIPTM (Vertically Integrated PNP) process which produces fast PNP transistors that are true complements to the already fast NPN devices. This advanced junction-isolated process delivers high speed performance without the need for complex and expensive dielectric isolation.

### Features

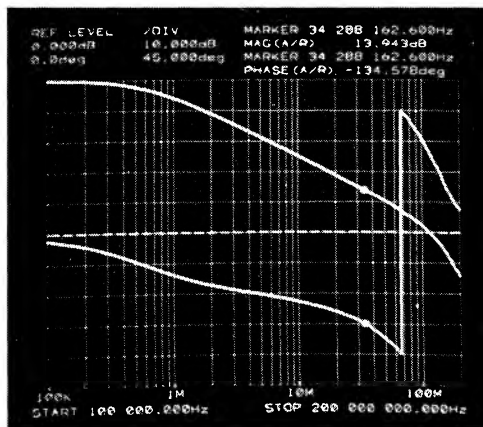
- High Slew Rate 300 V/ $\mu$ s
- High GBW Product 175 MHz
- Low Supply Current 5 mA
- Fast settling 100 ns to 0.1%
- Low differential gain <0.1%
- Low differential phase <0.1°
- Wide Supply Range 4.75V to 32V
- Stable with unlimited capacitive load
- Well behaved; easy to apply

### Typical AC Characteristics



Step Response;  $A_V = +5$

TL/H/9153-1



Gain & Phase;  $A_V = +300$

TL/H/9153-2

## Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ( $V^+ - V^-$ )	36V
Differential Input Voltage (Note 8)	$\pm 8V$
CM Input Voltage ( $V^+ - 0.7V$ ) to ( $V^- - 7V$ )	
Output Short Circuit to Gnd (Note 1)	Continuous
Lead Temp. (Soldering, 10 sec.)	260°C

Storage Temperature Range	$-65^\circ\text{C}$ to $+150^\circ\text{C}$
Operating Temperature Range (Note 2)	
LM6164	$-55^\circ\text{C}$ to $+125^\circ\text{C}$
LM6264	$-25^\circ\text{C}$ to $+85^\circ\text{C}$
LM6364	$0^\circ\text{C}$ to $+70^\circ\text{C}$
Max Junction Temperature (Note 2)	$150^\circ\text{C}$
ESD Tolerance (Notes 8 & 9)	$\pm 700V$

## DC Electrical Characteristics (Note 3)

Parameter	Conditions	Typ	LM6164		LM6264		LM6364		Units
			Tested Limit (Note 4)	Design Limit (Note 5)	Tested Limit (Note 4)	Design Limit (Note 5)	Tested Limit (Note 4)	Design Limit (Note 5)	
Input Offset Voltage		2	4 <b>6</b>		4	<b>6</b>	9	<b>11</b>	mV max
Input Offset Voltage Average Drift		6							$\mu\text{V}/^\circ\text{C}$
Input Bias Current		2.5	3 <b>6</b>		3	<b>5</b>	5	<b>6</b>	$\mu\text{A}$ max
Input Offset Current		150	350 <b>800</b>		350	<b>600</b>	1500	<b>1900</b>	nA max
Input Offset Current Average Drift		0.3							nA/ $^\circ\text{C}$
Input Resistance	Differential	100							k $\Omega$
Input Capacitance		3.0							pF
Large Signal Voltage Gain	$V_{\text{OUT}} = \pm 10V$ , $R_L = 2\text{ k}\Omega$ (Note 11)	2.5	1.8 <b>0.9</b>		1.8	<b>1.2</b>	1.3	<b>1.1</b>	V/mV min
	$R_L = 10\text{ k}\Omega$	9							
Input Common-Mode Voltage Range	Supply = $\pm 15V$	+14.0	+13.9 <b>+13.8</b>		+13.9	<b>+13.8</b>	+13.8	<b>+13.7</b>	V min
		-13.5	-13.3 <b>-13.1</b>		-13.3	<b>-13.1</b>	-13.2	<b>-13.1</b>	V min
	Supply = +5V (Note 6)	4.0	3.9 <b>3.8</b>		3.9	<b>3.8</b>	3.8	<b>3.7</b>	V min
		1.5	1.7 <b>1.9</b>		1.7	<b>1.9</b>	1.8	<b>1.9</b>	V max
Common-Mode Rejection Ratio	$-10V \leq V_{\text{CM}} \leq +10V$	105	86 <b>80</b>		86	<b>82</b>	80	<b>78</b>	dB min
Power Supply Rejection Ratio	$\pm 10V \leq V \pm \leq \pm 16V$	96	86 <b>80</b>		86	<b>82</b>	80	<b>78</b>	dB min
Output Voltage Swing	Supply = $\pm 15V$ and $R_L = 2\text{ k}\Omega$	+14.2	+13.5 <b>+13.3</b>		+13.5	<b>+13.3</b>	+13.4	<b>+13.3</b>	V min
		-13.4	-13.0 <b>-12.7</b>		-13.0	<b>-12.8</b>	-12.9	<b>-12.8</b>	V min
	Supply = +5V and $R_L = 2\text{ k}\Omega$ (Note 6)	4.2	3.5 <b>3.3</b>		3.5	<b>3.3</b>	3.4	<b>3.3</b>	V min
		1.3	1.7 <b>2.0</b>		1.7	<b>1.9</b>	1.8	<b>1.9</b>	V max

**DC Electrical Characteristics** (Note 3)

Parameter	Conditions	Typ	LM6164		LM6264		LM6364		Units
			Tested Limit (Note 4)	Design Limit (Note 5)	Tested Limit (Note 4)	Design Limit (Note 5)	Tested Limit (Note 4)	Design Limit (Note 5)	
Output Short Circuit Current	Source	65	30 <b>20</b>		30	<b>25</b>	30	<b>25</b>	mA min
	Sink	65	30 <b>20</b>		30	<b>25</b>	30	<b>25</b>	mA min
Supply Current		5.0	6.5 <b>6.8</b>		6.5	<b>6.7</b>	6.8	<b>6.9</b>	mA max

**AC Electrical Characteristics** (Notes 3 & 7)

Parameter	Conditions	Typ	LM6164		LM6264		LM6364		Units
			Tested Limit (Note 4)	Design Limit (Note 5)	Tested Limit (Note 4)	Design Limit (Note 5)	Tested Limit (Note 4)	Design Limit (Note 5)	
Gain-Bandwidth Product	@ F = 20 MHz	175	140 <b>100</b>		140	<b>120</b>	120	<b>100</b>	MHz min
	V <sub>+</sub> = ±5V	120							
Slew Rate	A <sub>V</sub> = +20 (Note 10)	300	225 <b>200</b>		225	<b>210</b>	200	<b>180</b>	V/μs min
	V <sub>+</sub> = ±5V	200							
Power Bandwidth	V <sub>OUT</sub> = 20 V <sub>PP</sub>	4.5							MHz
Setting Time	10V Step to 0.1% A <sub>V</sub> = -4, R <sub>L</sub> = 2 kΩ	100							ns
Phase Margin	A <sub>V</sub> = +5	45							Deg
Differential Gain	NTSC, A <sub>V</sub> = +10	<0.1							%
Differential Phase	NTSC, A <sub>V</sub> = +10	<0.1							Deg
Input Noise Voltage	F = 10 kHz	8							nV/√Hz
Input Noise Current	F = 10 kHz	1.5							pA/√Hz

**Note 1:** Continuous short-circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C.

**Note 2:** The typical junction-to-ambient thermal resistance of the molded plastic DIP (N) is 105°C/Watt, the molded plastic SO (M) package is 155°C/Watt, the cerdip (J) package is 125°C/Watt, and the TO-5 (H) package is 155°C/Watt. All numbers apply for packages soldered directly into a printed circuit board.

**Note 3:** Unless otherwise specified, all limits guaranteed for T<sub>A</sub> = T<sub>J</sub> = 25°C with supply voltage = ±15V, V<sub>CM</sub> = 0V, and R<sub>L</sub> ≥ 100 kΩ. **Boldface** limits apply over the range listed under "Operating Temperature Range".

**Note 4:** Guaranteed and 100% production tested. These limits are used to calculate outgoing AQL levels.

**Note 5:** Guaranteed but not 100% production tested. These limits are not used to calculate outgoing AQL levels.

**Note 6:** For single supply operation, the following conditions apply: V<sub>+</sub> = 5V, V<sub>-</sub> = 0V, V<sub>CM</sub> = 2.5V, V<sub>OUT</sub> = 2.5V. Pin 1 & Pin 8 (V<sub>OS</sub> Adjust) are each connected to Pin 4 (V<sub>-</sub>) to realize maximum output swing. This connection will degrade V<sub>OS</sub>.

**Note 7:** C<sub>L</sub> ≤ 5 pF.

**Note 8:** In order to achieve optimum AC performance, the input stage was designed without protective clamps. Exceeding the maximum differential input voltage results in reverse breakdown of the base-emitter junction of one of the input transistors and probable degradation of the input parameters (especially V<sub>OS</sub>, I<sub>OS</sub>, and Noise).

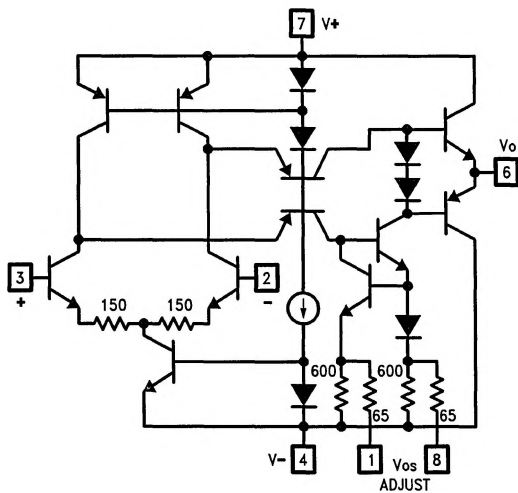
**Note 9:** The average voltage that the weakest pin combinations (those involving Pin 2 or Pin 3) can withstand and still conform to the datasheet limits. The test circuit used consists of the human body model of 100 pF in series with 1500Ω.

**Note 10:** V<sub>IN</sub> = 4V step. For V<sub>+</sub> = ±5V, V<sub>IN</sub> = 1V step.

**Note 11:** Voltage Gain is the total output swing (20V) divided by the input signal required to produce that swing.

## Simplified Schematic &amp; Pin Assignments

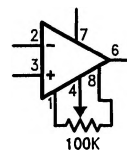
Dual-In-Line Package



TL/H/9153-3

Order Number LM6264J, LM6164J, LM6364N or LM6264N  
See NS Package Number J08A or N08E

Vos Adjust Circuit



TL/H/9153-4