National Semiconductor

LH2003/LH2033
100 MHz Video Buffer

General Description

The LH2003/LH2033 is a high speed monolithic open loop buffer designed to provide up to 100 mA drive at frequencies from DC to 100 MHz and slew rates of 1200 V/μs. It is oscillation free driving into capacitive loads and features internal current limiting to protect under overload conditions.

The LH2003/LH2033 is intended for a wide range of buffer applications. Its high speed makes it ideally suited for closed loop buffer applications with wide band op-amps, as well as open loop applications such as driving co-ax cables and twisted pairs.

The following devices are available:

Order Number	Temperature Range	Package
LH2003CN	−25°C to +85°C	Plastic DIP
LH2003CJ	−25°C to +85°C	Ceramic DIP
LH2003J	−55°C to +125°C	Ceramic DIP
LH2003CH	−25°C to +85°C	8-Lead T0-5
LH2003H	−55°C to +125°C	8-Lead T0-5
LH2033CN	−25°C to +85°C	Plastic DIP
LH2033CJ	−25°C to +85°C	Ceramic DIP
LH2033J	−55°C to +125°C	Ceramic DIP

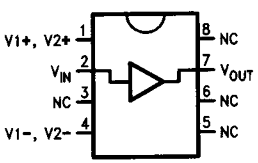
Features

- Differential Gain 0.1%
- Differential Phase 0.1°
- 100 mA continuous output current guaranteed
- Short circuit protected
- Wide bandwidth—100 MHz
- High slew rate—1200 V/μs
- High input impedance—2 MΩ
- Low quiescent current drain
- LH2003N, J—Pin compatible with EL2003
- LH2033—Pin compatible with HA3-5033, HA7-5033, EL2033
- LH2003H—Pin compatible with HA2-5002, EL2003H

Applications

- Co-ax cable driver
- Flash converter driver
- Video DAC buffer
- Op amp booster

Connection Diagrams



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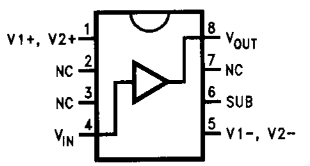
Order Number LH2003CN, LH2003CJ, and LH2003J
See NS Package Number N08E (LH2003CN)
See NS Package Number J08A (LH2003CJ, LH2003J)



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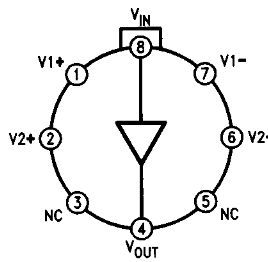
Order Number LH2033CN, LH2033CJ, and LH2033J
See NS Package Number N08E (LH2033CN)
See NS Package Number J08A (LH2033CJ, LH2033J)



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Top View
Order Number LH2003CH, LH2003H
See NS Package Number H08C

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Absolute Maximum Ratings (Note 4)

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

V_S	Supply Voltage ($V^+ - V^-$)	±18V or 36V
V_{IN}	Input Voltage (Note 1)	±15V or V_S
I_{IN}	Input Current (Note 1)	±50 mA
P_D	Power Dissipation	(Note 5)
	Output Short Circuit Duration (Note 2)	Continuous
T_{ST}	Storage Temperature	−65°C to +150°C
	Lead Temperature (Soldering, <10 seconds)	+300°C
T_J max	Junction Temperature	
	Metal Can and Ceramic DIP	+175°C
	Plastic DIP	+150°C

Operating Ratings

T_A	Temperature Range:	
	LH2003/2033	−55°C to +125°C
	LH2003C/2033C	−25°C to +85°C
	Thermal Resistance	(Note 6)
θ_{JC},	J Package	40°C/W
θ_{JA},	J Package	125°C/W
θ_{JC},	H Package	55°C/W
θ_{JA},	H Package	190°C/W
θ_{JA},	N Package	95°C/W

DC Electrical Characteristics V_S ±15V R_S = 50Ω (Note 2)

Symbol	Parameter	Conditions		LH2003/LH2033			Units
				Min	Typ	Max	
V_{OS}	Output Offset Voltage	V_{IN} = 0V, R_L = ∞	T_A = 25°C	−40	5	+40	mV
			Over Temp	−50		+50	
I_{IN}	Input Current	V_{IN} = 0V, R_L = ∞	T_A = 25°C	−25	5	+25	μA
			Over Temp	−50		+50	
R_{IN}	Input Resistance	V_{IN} = ±12V, R_L = 100Ω	T_A = 25°C	1	2		MΩ
			Over Temp	0.1			
A_{V1}	Voltage Gain	V_{IN} ±12V, R_L = 1 kΩ	T_A = 25°C	0.98	0.99		V/V
			Over Temp		0.97		
A_{V2}	Voltage Gain	V_{IN} ±6V, R_L = 50Ω	T_A = 25°C	0.83	0.90		V/V
			Over Temp	0.80			
A_{V3}	Voltage Gain	V_{IN} = ±3V, R_L = 50Ω, V_S = ±5V	T_A = 25°C	0.82	0.89		V/V
			Over Temp	0.79			
V_{01}	Output Voltage Swing	V_{IN} = ±14V, R_L = 1 kΩ	T_A = 25°C	±13	±13.5		V
			Over Temp	±12.5			
V_{02}	Output Voltage Swing	V_{IN} = ±12V, R_L = 100Ω	T_A = 25°C	±10.5	±11.3		V
			Over Temp	±10			
R_{OUT}	Output Resistance	V_{IN} = ±2V, R_L = 50Ω	T_A = 25°C		7	10	Ω
			Over Temp			12	
I_{OUT}	Output Current (Note 3)	V_{IN} = ±12V, V_{OUT} = ±10V	T_A = 25°C	±105	±230		mA
			Over Temp	±100			
I_S	Supply Current	V_{IN} = 0V, R_L = ∞	T_A = 25°C		10	15	mA
			Over Temp			20	
PSRR	Power Supply Rejection	V_{IN} = 0V, R_L = ∞, V_S = ±4.5V to ±18V	T_A = 25°C	60	80		dB
			Over Temp	50			

Note 1: If V_{IN} exceeds the absolute maximum ratings, or $V_{IN} - V_{OUT}$ exceeds ±7.5V, the input current needs to be limited to maximum 50 mA.

Note 2: Specification applies for V_S = ±15V, R_L = 50Ω unless otherwise specified. "Over Temp." numbers apply over the operating temperature range. Electrical tests are performed with high speed automated test equipment, so that $T_J = T_A$, unless otherwise noted.

Note 3: Input and output voltages are forced to +12V, +10V and −12V, −10V respectively and the output current is measured.

Note 4: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.

Note 5: The maximum power dissipation is a function of maximum junction temperature (T_J max), total thermal resistance (θ_{JA}), and ambient temperature (T_A). The maximum allowable power dissipation at any ambient temperature is $P_D = T_J \text{ max} - T_A)/\theta_{JA}$.

Note 6: For operating at elevated temperatures, the device must be derated based on the thermal resistance (θ_{JA}) and T_J max. $T_J = T_A + P_D\ \theta_{JA}$. An external heatsink will be necessary for the H package to prevent exceeding T_J max in elevated ambients.

AC Electrical Characteristics $V_S = \pm 15V$ $R_S = 50\Omega$ (Note 2)

Symbol	Parameter	Conditions	LH2003/LH2033			Units
			Min	Typ	Max	
SR_1	Slew Rate	$V_{IN} = \pm 10V$ $R_L = 1\ k\Omega$ Tested at $V_{OUT} = \pm 5V$	600	1200		V/µs
SR_2	Slew Rate	$V_{IN} = \pm 5V$ $R_L = 50\Omega$ Tested at $V_{OUT} = \pm 2.5V$		400		V/µs
BW	Band Width	$R_L = 50\Omega$ $V_{IN} = 0\ dBm$		100		MHz
THD	Distortion	$V_{IN} = 4\ V_{RMS}$, 1 kHz $R_L = 50\Omega$		0.2		%

Note 1: If V_{IN} exceeds the absolute maximum ratings, or $V_{IN} - V_{OUT}$ exceeds ±7.5V, the input current needs to be limited to maximum 50 mA.

Note 2: Specification applies for $V_S = \pm 15V$, $R_L = 50\Omega$ unless otherwise specified. **Boldface** numbers apply over the operating temperature range. Numbers in standard typeface apply at $T_A = 25°C$. Electrical tests are performed with high speed automated test equipment, so that $T_J = T_A$, unless otherwise noted.

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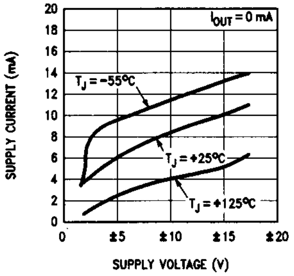
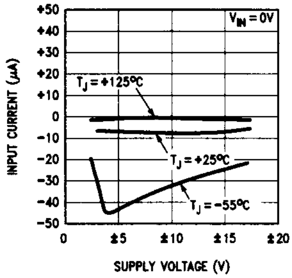
Typical Performance Characteristics (Continued)

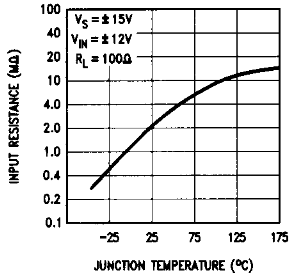
Quiescent Supply Current vs Supply Voltage



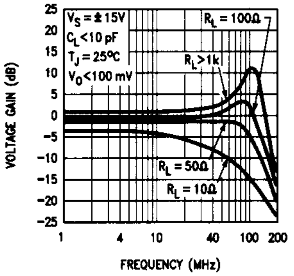
Input Current vs Supply Voltage



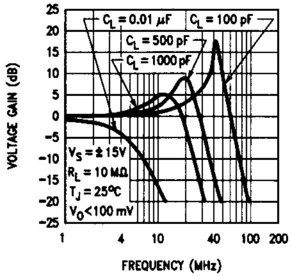
Input Resistance vs Temperature



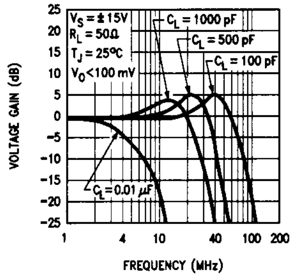
Voltage Gain vs Frequency



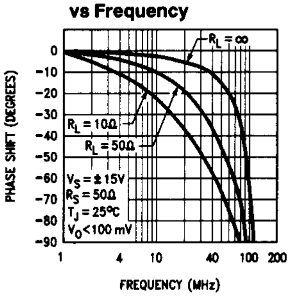
Voltage Gain vs Frequency No Resistive Load



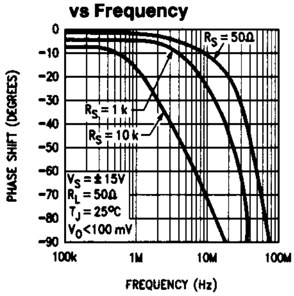
Voltage Gain vs Frequency 50Ω Resistive Load



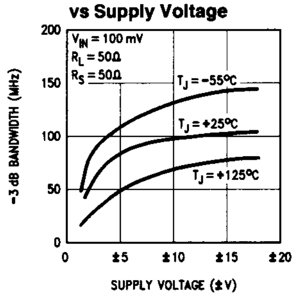
Phase Shift vs Frequency



Phase Shift vs Frequency



Small Signal Bandwidth vs Supply Voltage



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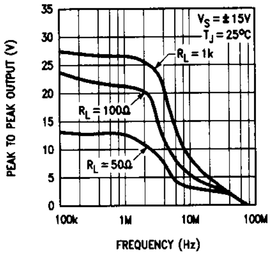
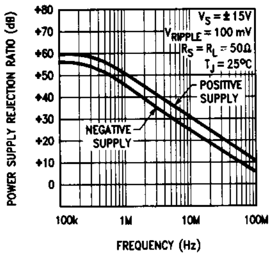
Typical Performance Characteristics (Continued)

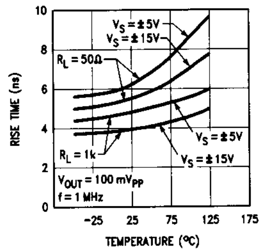
Maximum Undistorted Output Voltage vs Frequency



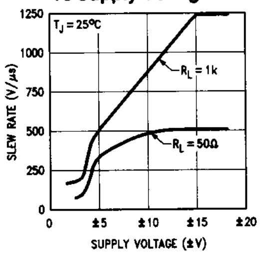
Power Supply Rejection Ratio vs Frequency



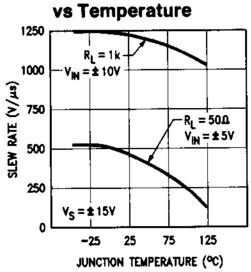
Rise Time vs Temperature



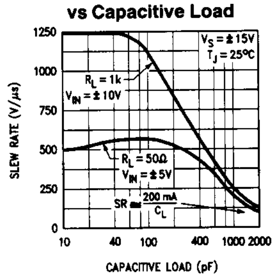
Slew Rate vs Supply Voltage



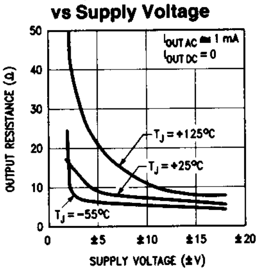
Slew Rate vs Temperature



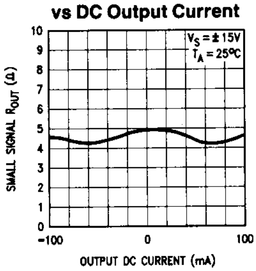
Slew Rate vs Capacitive Load



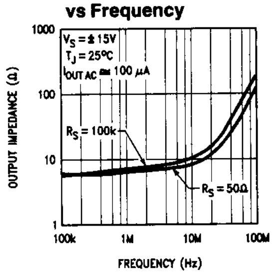
Output Resistance vs Supply Voltage



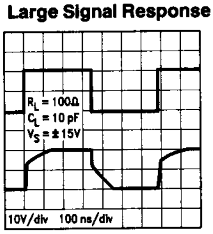
Small Signal Output Resistance vs DC Output Current



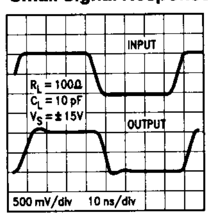
Output Impedance vs Frequency



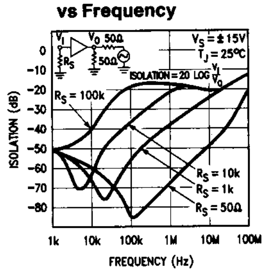
Large Signal Response



Small Signal Response



Reverse Isolation vs Frequency



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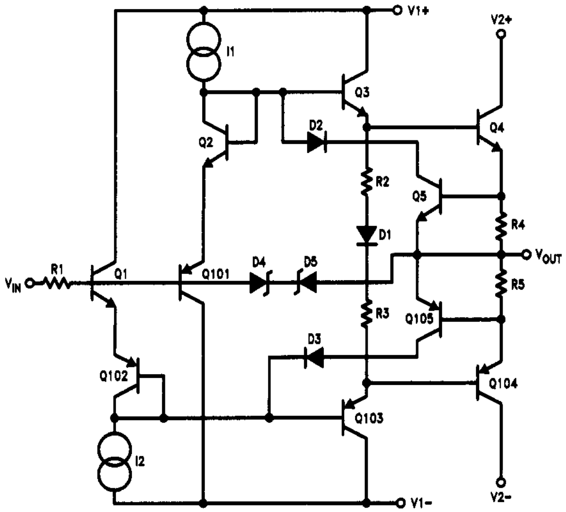
Simplified Schematic



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Applications Information

The LH2003/LH2033 are monolithic open loop buffers with high slew rate and bandwidth. This makes them useful for video frequencies and above.

Supply Voltages

The LH2003/LH2033 can be operated with a difference in voltage supplies of as low as 5V to a maximum of 36V. The supplies do not have to be symmetrical to ground. For optimal performance it is recommended that the power supply pins be decoupled with 0.1 μF capacitors close to the pins (¼ inch), and additional 10 μF which can be located further away (1 inch). In most cases the LH2003/LH2033 will not oscillate even without bypass capacitors, but the performance (slew rate) will be somewhat degraded, and in addition the supplies tend to ring.

The LH2003H and LH2003CH are in metal can and have the collectors of the output transistors pinned out: they are pin compatible with the EL0002H and EL0002CH. The output stage can therefore be operated from a lower supply voltage and the power dissipation is then reduced. However, when the signal level exceeds the output supply voltages, clipping occurs, and the output transistors also require several μs to come out of saturation.

Input

The input of the LH2003/LH2033 can be approximated with a high resistance in parallel with a small capacitor of several pF. There are clamp diodes from input to output to protect the base emitter junctions of the transistors. These diodes are set to 9.5V and can carry 50 mA.

The input voltages should be not more than 0.5V outside the supply voltages, or the recovery will take several 100 ns. For this reason, if clamps are used, they should be Schottky diodes.

Source impedance usually does not cause problems, but sometimes an inductive source impedance or an unterminated cable can cause instabilities, and in this case a resistance of 100Ω to several 100Ω in series with the input of the buffer may be needed.

Current Limiting

The LH2003/LH2033 have internal current limiting to protect the devices. Recovery time from current limit is about 250 ns. For higher temperatures the limit value is less (see graphs).

If the device is run from ±15V supplies, a long-time short to ground will overstress the device thermally, and in this case heatsinking is required (Aavid, Thermalloy, and others make suitable heatsinks).

Gain

The DC gain of the LH2003/LH2033 can be derived from the unloaded gain and the ratio of output and load resistors:

$$A_V = 0.995 \times RL/(RL + R_{OUT})$$

For high frequency gain see graphs. For low loads peaking occurs, it can be reduced by a snubber, which provides load at high frequencies without loading at low frequencies.

Loads

The LH2003/LH2033 is stable for capacitive loads. However, for small capacitive loads, below 1000 pF, ringing occurs. In this case a suitable snubber (e.g. 1000 pF, 30Ω) will help. For higher capacitive loads care has to be taken not to exceed the current capability of the device:

$$I_{MAX} > I = C_{LOAD} \times dV/dt, \text{ or}$$
$$I_{MAX} > I = V_{PEAK} \times 2 \times 3.14 \times f$$

When driving inductive loads, it may be necessary to use clamp diodes in the output to prevent inductive kickback from damaging the device.