LM6310

LM6310 High Speed Low Power Operational Amplifier with TRI-STATE(RM) Output

Literature Number: SNOS789A

National Semiconductor

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LM6310
High Speed Low Power Operational Amplifier with TRI-STATE® Output

General Description

The LM6310 is a video speed operational amplifier with a fast, easy to use disable function. This disable function puts the amplifier output into a high impedance state. This makes the LM6310 ideal for distributed video multiplexing, where channels can be on different boards. This can enhance manufacturing flexibility by making it easy to add or delete options to basic designs.

The disable function can also be used for half-duplex communication. The disable function also reduces power consumption. The LM6310 uses a current feedback design for improved gain flatness, making it a good choice for high quality video designs. Operating from ±5V supplies, the LM6310 is ideal for low power designs.

Features

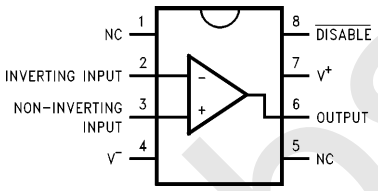
- 90 MHz −3 dB bandwidth
- TRI-STATE output disable to high impedance
- Disable time < 25 ns
- TTL/CMOS compatible disable input
- Typical differential gain 0.05%
- Typical differential Phase 0.33°
- 60 mA output current
- Typical supply current < 4.5 mA
- < 1 mA current when disabled
- Specified for ±5V operation

Applications

- Cable TV Set Top Boxes
- Video Multiplexers and Multimedia Cards
- Virtual Reality and Desktop Video
- Portable Video
- Video Distribution

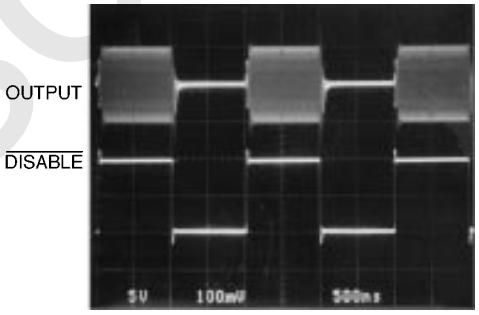
Connection Diagram

8-Pin DIP/SO-8



TL/H/12545–1

Top View



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Package	Ordering Information	NSC Drawing Number	Package Marking	Transport Media
8-Pin DIP	LM6310IN	N08E	LM6310IN	Rails
8-Pin SO-8	LM6310IM	M08A	LM6310IM	Rails
8-Pin SO-8	LM6310IMX	M08A	LM6310IM	2.5k Units Tape and Reel

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Absolute Maximum Ratings (Note 1)

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

ESD Tolerance (Note 2)	1500V
Differential Input Voltage	±2V
Voltage at Input/Output Pin	(V+)+0.1V, (V−)−0.1V
Supply Voltage ($V^+ - V^-$)	12V
Current at Input Pin	±5 mA
Current at Output Pin (Note 3)	±80 mA
Current at Power Supply Pin	80 mA
Lead Temp. (soldering, 10 sec.)	260°C
Storage Temperature Range	−65°C to +150°C
Junction Temperature (Note 4)	150°C

Operating Ratings (Note 1)

Supply Voltage	$V^- = -5V$, $V^+ = +5V$
Junction Temperature Range	
LM6310I	$-40°C \le T_J \le +85°C$
Thermal resistance (θ_{JA})	
N Package, 8-pin Molded DIP	125°C/W
SO-8 Package, 8-Pin Surface Mount	165°C/W

±5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25°C$, $V^+ = 5V$, $V^- = -5V$, $V_{CM} = V_O = 0V$ and $R_L = 100\Omega$. **Boldface** limits apply at the temperature extremes

Symbol	Parameter	Conditions	Typ (Note 5)	LM6310I Limit (Note 6)	Units
V_{OS}	Input Offset Voltage		1	5 **9**	mV max
TCV_{OS}	Input Offset Voltage Average Drift		30		µV/°C
I_B	Input Bias Current Non-Inverting (+) Input		0.2	1.5 **3.0**	µA max
I_B	Input Bias Current Inverting (−) Input		2	8 **14**	µA max
R_{IN}	Input Resistance Non-Inverting (+) Input		6		MΩ
R_{IN}	Input Resistance Inverting (−) Input		180		Ω
CMRR	Common Mode Rejection Ratio	$-1.0V \le V_{CM} \le +1.0V$	50	43 **40**	db min
+PSRR	Positive Power Supply Rejection Ratio	$V^+ = 4.5V$ to $5.5V$ $V^- = -5.0V$	52	46 **42**	db min
−PSRR	Negative Power Supply Rejection Ratio	$V^+ = 5.0V$ $V^- = -4.5V$ to $-5.5V$	52	46 **42**	db min
C_{IN}	Common-Mode Input Capacitance		2		pF
V_O	Output Swing	$R_L = 100\Omega$	3.5	3.1 **2.4**	V min
			−2.8	−2.7 **−1.6**	V max
		$R_L = \infty$	4.0	3.9 **3.7**	V min
			−3.3	−3.2 **−2.8**	V max

Obsolete

±5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25°C$, $V^+ = 5V$, $V^- = -5V$, $V_{CM} = V_O = 0V$ and $R_L = 100\Omega$. **Boldface** limits apply at the temperature extremes (Continued)

Symbol	Parameter	Conditions	Typ (Note 5)	LM6310I Limit (Note 6)	Units
I_{SC}	Output Current	10Ω to 0V Sourcing	60	44 **20**	mA min
R_{OUT}	Output Resistance	Closed Loop	0.06		Ω max
I_S	Supply Current for Normal Operation Mode	$\overline{\text{DISABLE}}$ (Pin 8) > 2.0V	3.5	4.5 **5.0**	mA max
I_S	Supply Current Powerdown (TRI-STATE) Mode	$\overline{\text{DISABLE}}$ (Pin 8) < 0.8V	0.8	1.0 **1.2**	mA max

±5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25°C$, $V^+ = 5V$, $V^- = -5V$, $V_{CM} = V_O = 0V$ and $R_L = 100\Omega$. **Boldface** limits apply at the temperature extremes

Symbol	Parameter	Conditions	Typ (Note 5)	LM6310I Limit (Note 6)	Units
SR	Slew Rate	$A_V = +2$, 2V Output Pulse	300		V/μs
−3 dB BW	−3db Bandwidth	$A_V = +2$	90		MHz
Dg	Differential Gain (Note 7)	$A_V = +2$, 150Ω Load (75Ω Back-Terminated) 1 kΩ Pull-Down to −5V on Output	0.05		%
Dp	Differential Phase (Note 7)	$A_V = +2$, 150Ω Load (75Ω Back-Terminated) 1 kΩ Pull-Down to −5V on Output	0.33		°
e_n	Input-Referred Voltage Noise	f = 1 MHz	5		$\frac{nV}{\sqrt{Hz}}$
	Input-Referred Current Noise Non-Inverting (−) Input	f = 1 MHz	3		$\frac{pA}{\sqrt{Hz}}$
	Input-Referred Current Noise Inverting (−) Input	f = 1 MHz	12		$\frac{pA}{\sqrt{Hz}}$
t_{ON}	Turn On Time	$\overline{\text{DISABLE}}$ (Pin 8) Low to High	50		ns
t_{OFF}	Turn Off Time	$\overline{\text{DISABLE}}$ (Pin 8) High to Low	25		ns
	Output Isolation	Output Isolation from Inputs when $\overline{\text{DISABLE}}$ = Low 10 MHz	55		db

Note 1: 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 specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical characteristics.

Note 2: Human body model, 1.5 kΩ in series with 100 pF.

Note 3: Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C.

Note 4: The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

Note 5: Typical values represent the most likely parametric norm.

Note 6: All limits are guaranteed by testing or statistical analysis.

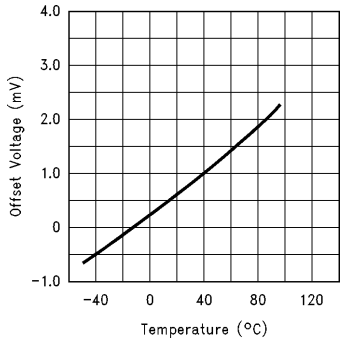
Note 7: Differential Gain and Phase performance is sensitive to layout. Follow layout suggestions in text for best results.

Obsolete

Typical Performance Characteristics

$A_V = +2$, $R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted

LM6310 Input Offset Voltage vs Temperature



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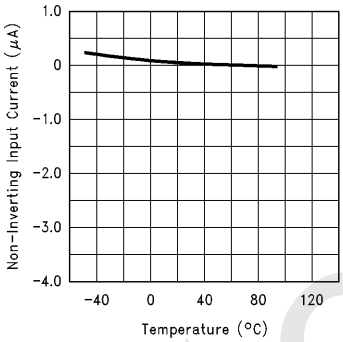
LM6310 Non-Inverting Input Current vs Temperature



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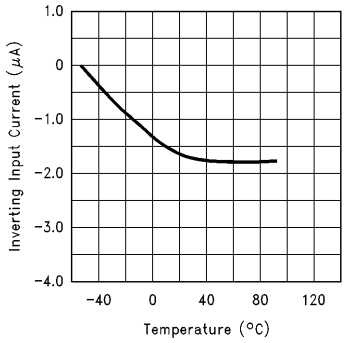
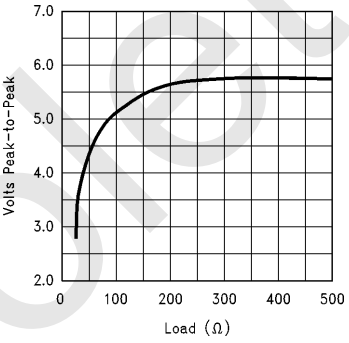
LM6310 Inverting Input Current vs Temperature



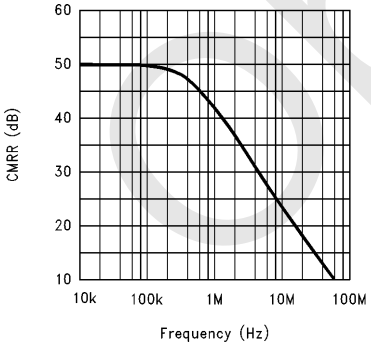
TL/H/12545–5

Output Voltage Swing vs Load (Volts Peak-to-Peak)



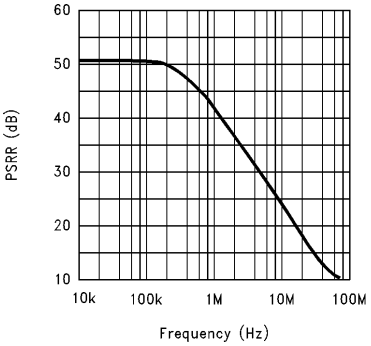
TL/H/12545–6

LM6310 Common Mode Rejection Ratio vs Frequency



TL/H/12545–7

LM6310 Power Supply Rejection Ratio vs Frequency



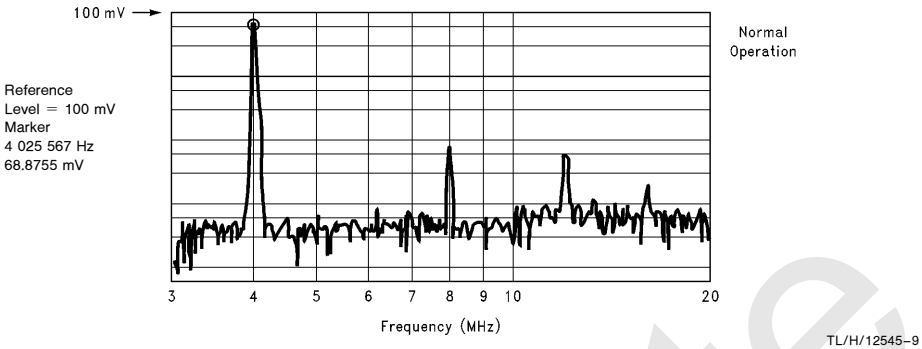
TL/H/12545–8

Obsolete

Typical Performance Characteristics

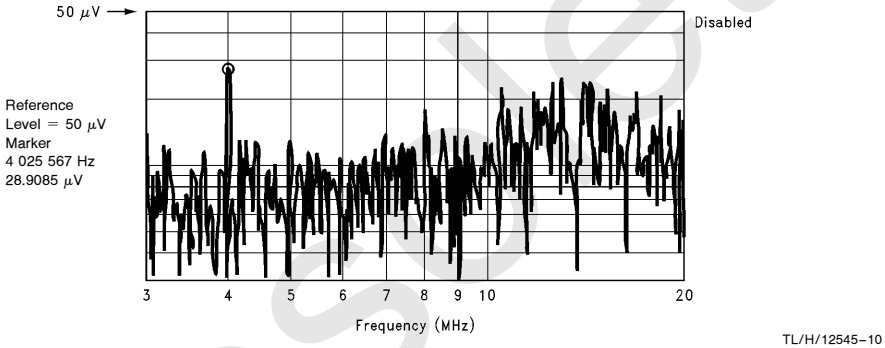
$A_V = +2$, $R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted (Continued)

Output Signal Isolation in Disable Mode



TL/H/12545–9

LM6310 Normal Operation. $\overline{\text{Disable}}$ = High.
Note reference level is 100 mV.
4 MHz signal is at 69 mV.



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LM6310 $\overline{\text{Disable}}$ = Low.
Note that the reference level is 50 μV.
The 4 MHz signal is near the noise level, attenuated > 1000:1.

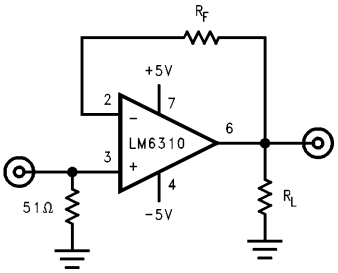
Obsolete

Typical Performance Characteristics (Continued)

$R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted

Gain of +1

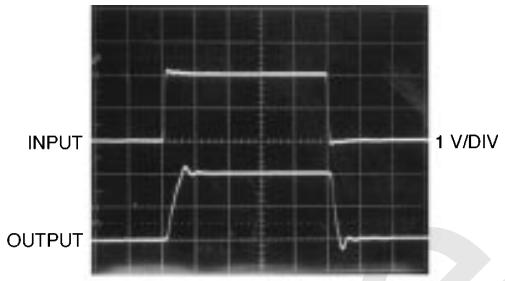
$A_V = +1$ Non-Inverting



TL/H/12545–11

See Application Information for discussion of R_F value for $A_V = +1$

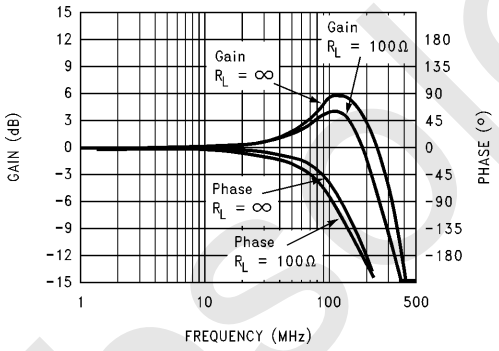
$A_V = +1$ Pulse Response



TL/H/12545–12

Note: $R_F = 1\ k\Omega$

$A_V = +1$ Gain and Phase vs Frequency



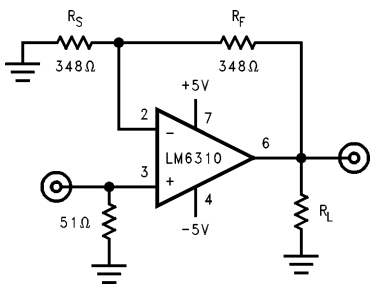
TL/H/12545–13

Obsolete

Typical Performance Characterisitcs (Continued)

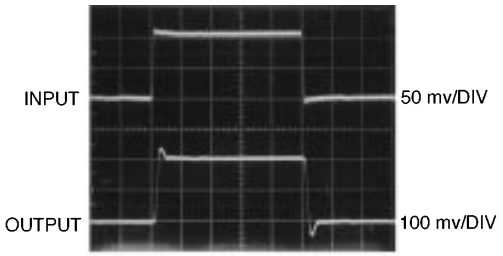
$R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted

Gain of +2
$A_V = +2$ Non-Inverting



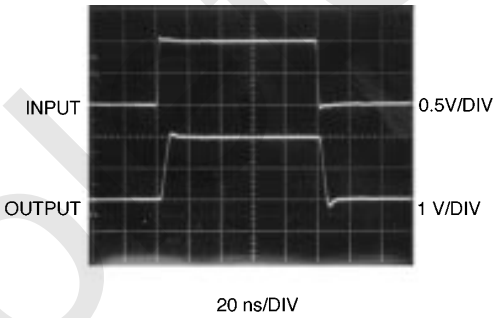
TL/H/12545–14

$A_V = +2$ Small Signal Pulse Response



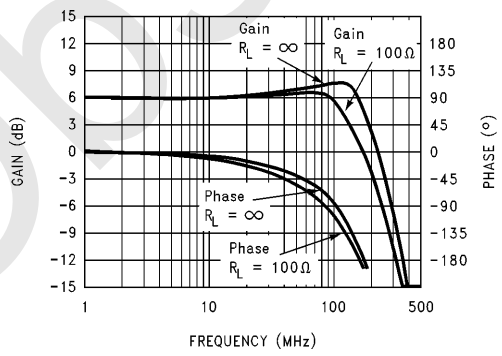
TL/H/12545–15

$A_V = +2$ Large Signal Pulse Response



TL/H/12545–16

$A_V = +2$ Gain and Phase vs Frequency



TL/H/12545–17

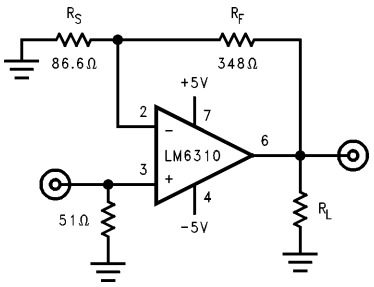
Obsolete

Typical Performance Characteristics (Continued)

$R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted

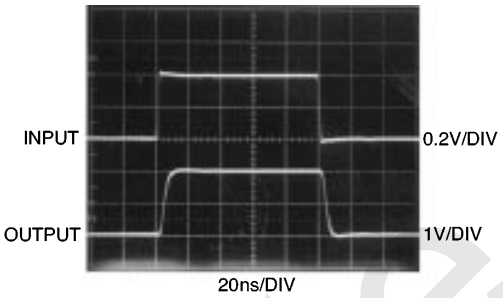
Gain of +5

$A_V = +5$ Non-Inverting



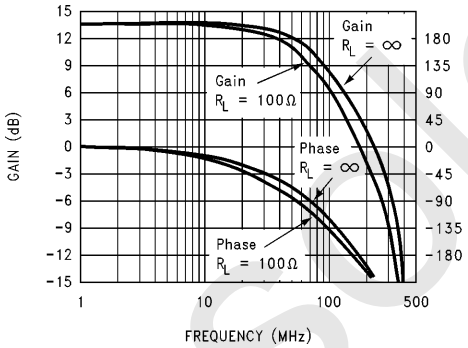
TL/H/12545–18

$A_V = +5$ Pulse Response



TL/H/12545–19

$A_V = +5$ Gain and Phase vs Frequency



TL/H/12545–20

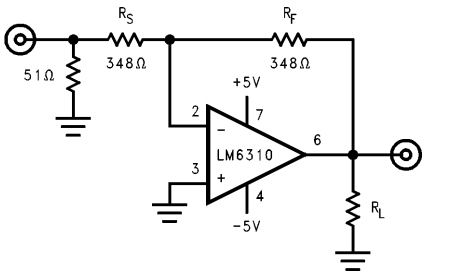
Obsolete

Typical Performance Characteristics (Continued)

$R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted

Gain of −1

$A_V = -1$ Inverting



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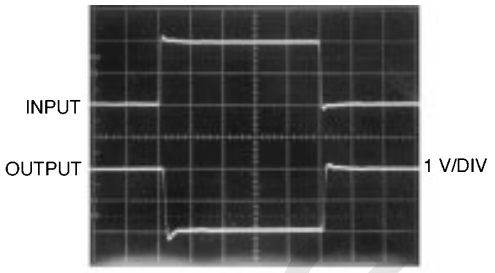
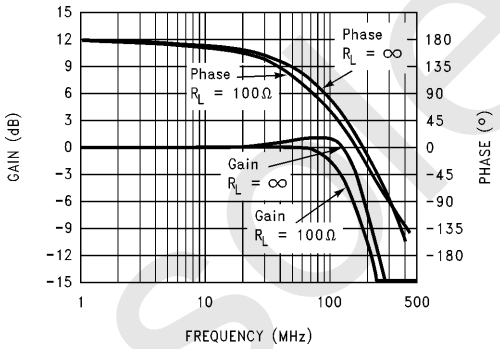
$A_V = -1$ Pulse Response



TL/H/12545–22

$A_V = -1$ Gain and Phase vs Frequency



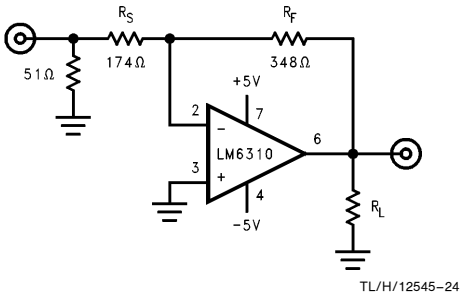
TL/H/12545–23

Obsolete

Typical Performance Characteristics (Continued)

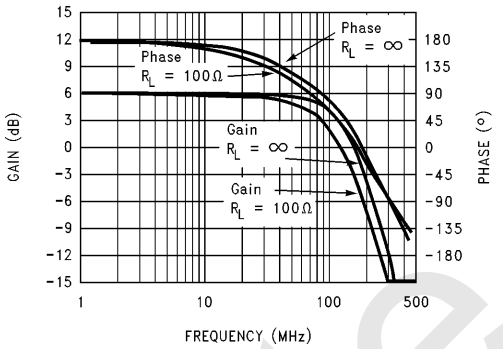
$R_F = 348\Omega$, $V+ = +5V$, $V- = -5V$, $R_L = 100\Omega$, $T_J = 25°C$ unless otherwise noted

$A_V = -2$ Inverting



TL/H/12545–24

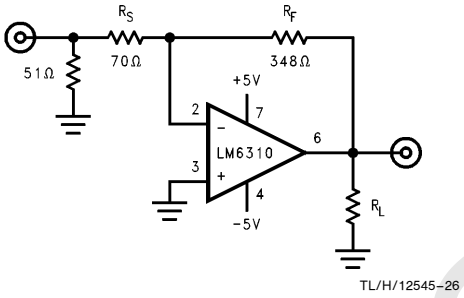
$A_V = -2$ Gain and Phase vs Frequency



TL/H/12545–25

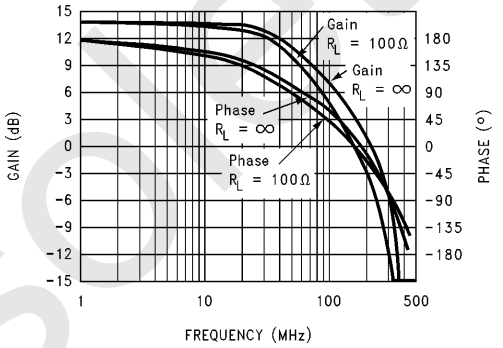
Gain of −5

$A_V = -5$ Inverting



TL/H/12545–26

$A_V = -5$ Gain and Phase vs Frequency



TL/H/12545–28

Obsolete

Application Information

GENERAL INFORMATION

The LM6310 is a high speed complementary bipolar amplifier with good video performance. The output of the LM6310 can be turned off with a logic level signal on the DISABLE pin. The output then goes to a high impedance state (TRI-STATE) which makes it easy to multiplex signals with the LM6310. The LM6310 responds very quickly to the DISABLE input, (under 25 ns) making it useful for video effects and adding or selecting data from video streams, such as TELTEXT.

Note: The LM6310 will operate normally when there is no connection to the DISABLE pin.

The LM6310 has low power consumption for a high speed part, typically < 4.0 mA. When the output is disabled the typical current consumption drops below 1.0 mA. This makes the LM6310 ideal for portable video equipment.

The LM6310 is available in two package types: DIPs for through hole designs, and SO-8 surface mount packages.

The LM6310 uses a current feedback design to achieve good video performance at low current and low cost.

Benefits of the LM6310

The LM6310 provides good video performance for consumer and portable applications at low current and low cost. The disable option can reduce power consumption in portable applications.

The video multiplexing capability of the disable function can also be used to improve the testability of systems by providing an easy means to open the analog signal path and insert test or reference signals.

Since the multiplexing configuration is a function of the output and disable signal wiring, using multiple LM6310's has some strong advantages over a one chip video multiplexer. First, larger multiplexers are possible—with careful layout, up to 8 video inputs can be multiplexed.

Frequently in multiplexer designs, one or more of the input signals will need to be buffered with an amplifier, and the output may also need a buffer or driver amplifier. Wiring up LM6310s to do multiplexing lets the LM6310 act as both the input buffer and the output driver. This can reduce parts and save money. In addition to reducing cost, the signals will go through fewer amplifiers. This can mean improved signal quality in addition to lower cost.

DESIGN ADAPTABILITY AND SYSTEM DESIGN FLEXIBILITY

Using the LM6310 allows more adaptable, cost effective design. If you need a 3 input multiplexer, you can make one, avoiding the extra cost of unused devices of quad multiplexer. If you need a 5 input multiplexer, you can design this with 5 LM6310s, saving the space and cost of two video multiplexer chips.

Using the LM6310 on a distributed multiplexer can improve manufacturing flexibility. You can design a low cost system with the minimal number functions needed for the low end of the market. Additional functions (close captioning, TELETEXT, digital video, information services, etc.) can be designed on to add-in cards. Since the LM6310 will operate normally when the DISABLE input is floating (no connection), the additional functions can be built on the add-in cards. By using LM6310s on both the basic board and the add-in cards, video and other signals can be digitally switched to implement the new add-in functions. Using LM6310s avoids adding the cost of a dedicated multiplexer in the low cost system, and increases design flexibility.

EASY TO USE, COST-EFFECTIVE CURRENT FEEDBACK

When used with good high speed layout in a circuit like those shown in the section on typical performance curves, the LM6310 will provide wide bandwidth, high slew and good video performance. Modern current feedback devices can provide higher bandwidth at lower current and at lower cost than conventional voltage feedback devices.

Note on Performance Curves and Datasheet Limits

Important: *Performance curves represent an average of parts, and are not limits.*

COMMON MODE REJECTION RATIO

The CMRR of 50 dB is valid for inputs which are within 1V of ground for ± 5V supplies. In other words, the input should be within 1V of the center of the V+ and V− power supply rails. Moving the inputs away from the center of the supplies will result in reduced performance and non-linearities.

NON-INVERTING (+) INPUT CURRENT vs TEMPERATURE

This curve is relatively flat over temperature (typically under 1 μA), that even an input source impedance of 2 kΩ will result in only a millivolt shift on the input voltage.

OUTPUT VOLTAGE SWING vs LOAD

This curve shows that almost all of the output swing is available for the 150Ω loads usually used in back-terminated 75Ω video systems.

OUTPUT SIGNAL ISOLATION IN DISABLE MODE

The top graph shows the spectrum analyzer output of an LM6310 in normal operaiton. The 4 MHz peak has an amplitude of 69 mV. Note that the reference level is 100 millivolts (100 mV), second and third harmonics are present, and the noise floor is towards the bottom of the graph.

With the LM6310 disabled, we need to greatly increase the gain of the spectrum analyzer to see the feedthrough of the 4 MHz signal. Note that the reference level is now 50 microvolts (50 μV) and the noise floor is towards the middle of the graph. The 4 MHz signal now has an amplitude of 28.9 μV, less than one-thousandth the normal signal.

Note that the LM6310 will function normally (output on) with the DISABLE input (pin 8) left floating (not connected).

PULSE RESPONSE AND GAIN vs FREQUENCY FOR $A_V = +1$

The feedback resistor (R_F) value for the pulse response photo is 1 kΩ. A value of 1 kΩ to 2 kΩ is recommended for all voltage follower ($A_V = +1$) circuits using the LM6310. The gain and phase plot for $A_V = +1$ was done with the usual value of $R_F = 348\Omega$ for comparison with the other gain and phase plots.

Obsolete

Application Information (Continued)

Using the LM6310

LIMITS AND PRECAUTIONS

SUPPLY VOLTAGE

The absolute maximum supply voltage which may be applied to the LM6310 is 12V. Designers should not design for more than 10V nominal, and carefully check supply tolerances under all conditions so that the voltages do not exceed the maximum.

DIFFERENTIAL INPUT VOLTAGE

Differential input voltage is the difference in voltage between the non-inverting (+) input and the inverting input (−) of the op amp. The absolute maximum differential input voltage is ±2V across the inputs. This limit also applies when there is no power supplied to the op amp. This may not be a problem in most conventional op amp designs, however, designers should avoid using the LM6310 as comparator or forcing the inputs to different voltages.

Very fast input pulses into high gain circuits may cause the output to saturate, leading to an overload recovery time in the millisecond range. This requires inputs which are faster than those usually used in video systems and gain levels which will push the output of the amplifier toward the limit of its output swing.

LAYOUT AND POWER SUPPLY BYPASSING

Since the LM6310 is a high speed (over 50 MHz) device, good high speed circuit layout practices should be followed. This should include the use of ground planes, adequate power supply bypassing, removing metal from around the input pins to reduce capacitance, and careful routing of the output signal lines to keep them away from the input pins.

The power supply pins should be bypassed on both the negative and positive supply inputs with capacitors placed close to the pins. Surface mount capacitors should be used for best performance, and should be placed as close to the pins as possible. It is generally advisable to use two capacitors at each supply voltage pin. A small surface mount capacitor with a value of around 0.01 μF (10 nF), usually a ceramic type with good RF performance, should be placed closest to the pin. A larger capacitor, usually in the range of 1.0 μF–4.7 μF, should also be placed near the pin. The larger capacitor should be a device with good RF characteristics and low ESR (equivalent series resistance) for best results. Ceramic and tantalum capacitors generally work well as the larger capacitor.

It is very important to reduce capacitance at the input and output pins. The ground plane and any other planes (power, etc.) should be ''opened up'' or removed near the pins. The opening should extend to the middle of the nearest pins as a minimum.

The LM6310 is built on a high performance bipolar process. The transistors used in this process have bandwidths much higher that the LM6310 itself. These transistors have a potential to oscillate or ring at 400 −1 GHz when used in layouts where the components are more than ¼ inch (6 mm) away from the op amp pins. These oscillations may produce apparent shifts in voltage offset or excess current consumption.

To avoid this, keep the input and output resistors as close as possible to their respective pins. Spacing within ⅛ inch (3 mm) or less is recommended for best results.

For best performance, low inductance resistors, such as chip resistors, are recommended. The use of wirewound resistors is strongly not recommended.

DIP devices should use socket pins which are flush with the board. Conventional sockets have additional capacitance and are not recommended. Obviously, the use of wire-wrapped sockets or the ''white plastic'' push in prototype boards is strongly not recommended.

FEEDBACK RESISTOR VALUES (R_F)

Since the LM6310 is a current feedback amplifier, the value of the feedback resistor is important to the performance of the op amp. For circuits other than voltage followers, the fastest pulse response is usually obtained with a resistor value of 348Ω. To get higher gain, decrease the source resistor value (R_S), while leaving the feedback resistor at 348Ω. (Schematics for various gains are shown in the typical performance curves section of this datasheet.)

Current feedback amplifiers generally do not tolerate reactive components in the feedback path. Therefore, do not bypass the feedback resistor (R_F) with a feedback capacitor. This will result in instability.

Overshoot and ringing of the LM6310 can be reduced by increasing the value of the feedback resistor above 348Ω. The value of 348Ω will normally produce a near critically damped pulse response, with about 3%–5% overshoot. Overshoot and bandwidth peaking may be undesirable in some designs. Selecting a larger value for the feedback resistor will reduce the overshoot and bandwidth peaking. Too large a value will reduce the circuit bandwidth and degrade pulse response. Do not place a capacitor across feedback resistor.

For voltage followers ($A_V = +1$) there is no source resistance. A feedback resistor must be used—direct connect from the output to the inverting input will usually result in oscillation. Values in the range of 1 kΩ–2 kΩ usually give good results. The pulse response photo for $A_V = +1$ was obtained with a 1 kΩ feedback resistor.

Since the small stray capacitance from the circuit layout, other components, and specific circuit bandwidth requirements will vary, it is often useful to select final values based on prototypes which are similar in layout to the production circuit boards.

Reflections

The output slew rate of the LM6310 is fast enough to produce reflected signals in many cables and long circuit traces. For best pulse performance, it may be necessary to terminate cables and long circuit traces with their characteristic impedance to reduce reflected signals.

Reflections should not be confused with overshoot. Reflections will depend on cable length, while overshoot will depend on load and feedback resistance and capacitance. When determining the type of problem, often removing or drastically shortening the cable will reduce or eliminate reflections. Overshoot can exist without a cable attached to the op amp output.

OBSOLETE

Application Information (Continued)

VIDEO GAIN OF +2

The design of the LM6310 has been optimized for gain of +2 video applications. The differential gain and phase performance of the LM6310 can be improved by adding a 1 kΩ pull down to −5V to the output. See *Figure 1*.

Typical values for differential gain and phase are 0.5% differential gain and 0.1 degree differential phase.

VIDEO MULTIPLEXING

Figure 2 shows a video multiplexer made from two LM6310 and a logic device which can supply TTL equivalent level to the DISABLE pins of the LM6310s. Only one DISABLE line should be high at any one time.

Note that since a floating value on the DISABLE input is the same as a high input, if all of the logic device's output go to a TRI-STATE or high impedance mode, all the LM6310's will turn on. This should be avoided.

Use adequate decoupling on the logic device to reduce noise feedthrough of digital system and power noise to the video signals. If it is not possible to adequately decouple the logic device, consider using a small digital buffer, such as a hex schmidt trigger inverter, which can be decoupled with multiple capacitors and/or ferrite beads to reduce digital noise.

Figure 3 shows a four input video multiplexer. With careful layout, differential gain and phase performance almost as good as a single LM6310 can be achieved.

A single 1 kΩ pull down to −5V should be used. Differential gain of about 0.05% and differential phase of about 0.3 degree are possible with the 4:1 multiplexer.

OTHER AMPLIFIERS WITH OUTPUT DISABLE FUNCTIONS

The LMC6681, LMC6682, and LMC6684 are 1 MHz amplifiers with TRI-STATE outputs which can be used for audio and low frequency multiplexing like the LM6310 is used for video multiplexing.

OTHER HIGH SPEED AND VIDEO AMPLIFIERS

National Semiconductor has an extensive line of high speed amplifiers, with a range of operating voltage from 3V single supply to ±15, and a range of package types, such as the space saving SOT23-5 TinyPaK™ (3.05 mm x 3.00 mm x 1.43 mm—about the size of a grain of rice) and the wide S0-8 for better power dissipation.

This op amp line includes:

LM6171 100 MHz Low Distortion Amplifier with > 3000 V/μs slew rate. Voltage Feedback design draws only 2.5 mA. Specified at ±15V and ±5V supplies.

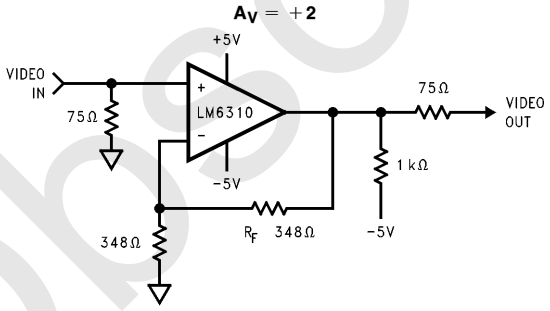
LM7131 TinyPaK (SOT23-5) Video amplifier with 70 MHz gain bandwidth. Specified at 3V, 5V and ±5V supplies.

LM7171 200 MHz Voltage Feedback amplifier with 100 mA output current and 4000 V/μs slew rate. Supply current of 6.5 mA. Specified at ±15V and ±5V.

Information on these parts is available from your National Semiconductor representative.

SPICE MACROMODEL

A SPICE macromodel of the LM6310 and many other National Semiconductor op amps is available at no charge from your National Semiconductor representative.

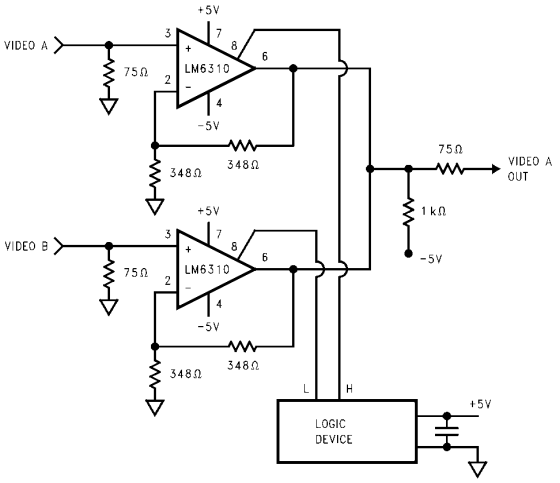


TL/H/12545–29

FIGURE 1. Improving Video Differential Gain and Phase with 1 kΩ pull down to −5V

Obsolete

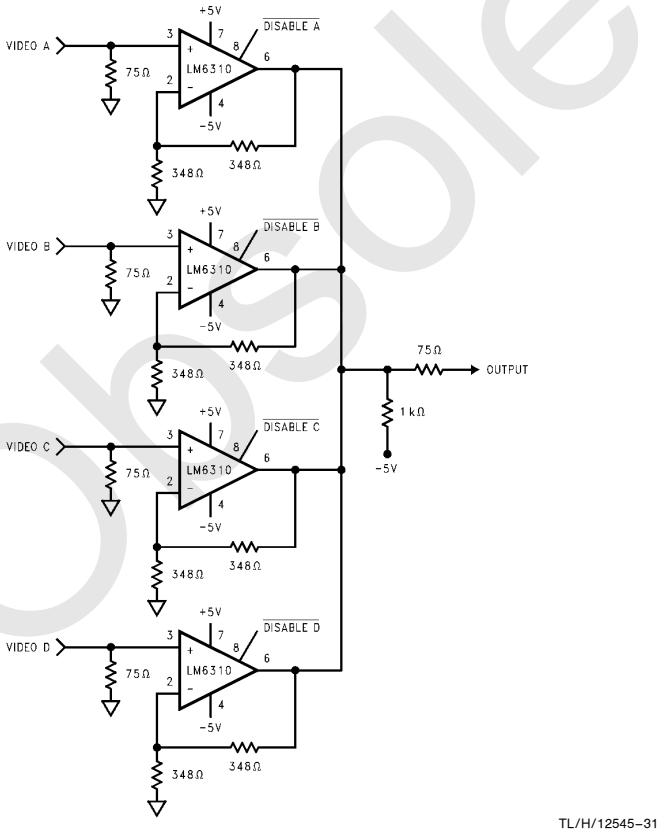
Application Information (Continued)



TL/H/12545–30

Note: Use adequate decoupling on logic device to reduce noise feed through to video signal.

FIGURE 2. Video Multiplexer. Video A Selected



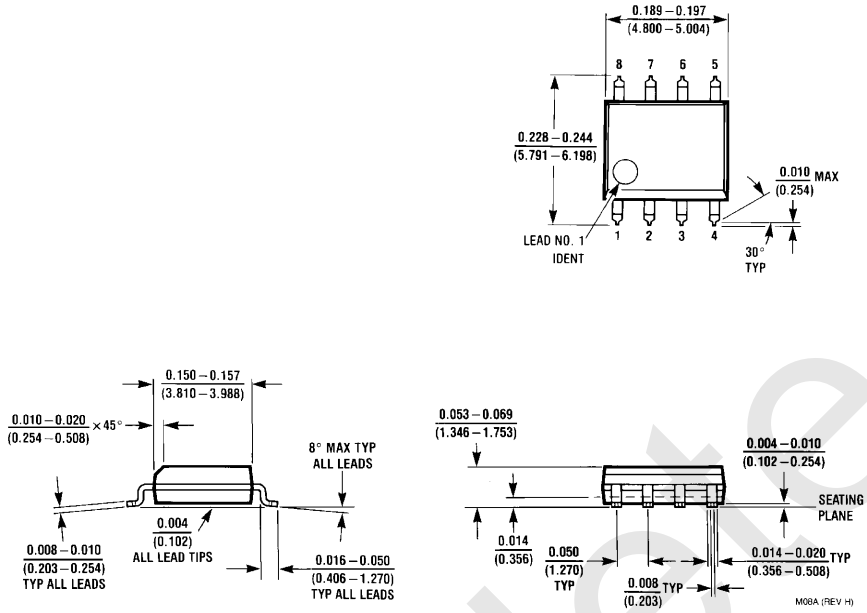
TL/H/12545–31

Note: Only one $\overline{\text{DISABLE}}$ signal should be high at any time, the other 3 signals should be low.

FIGURE 3. Four Input Multiplexer

Obsolete

Physical Dimensions inches (millimeters) unless otherwise noted

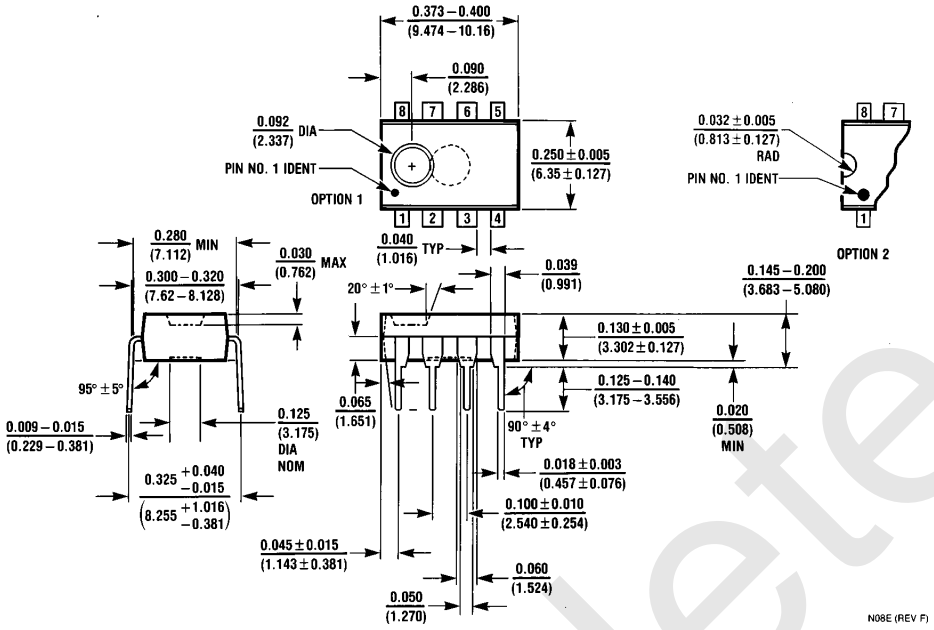


8-Pin Small Outline Package
Order Number LM6310IM or LM6310IMX
NS Package Number M08A

Obsolete

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

Lit. # 108287-001



8-Pin Molded DIP
8-Lead (0.300″ Wide) Molded Dual-In-Line Package
Order Number LM6310IN
NS Package Number N08E

Obsolete

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National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

http://www.national.com

National Semiconductor Europe
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
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National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
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